SOIL TAXONOMY

A Basic System of Soil Classification for Making and Interpreting Soil Surveys

Soil Survey Staff

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Foreword

The Soil Survey Staff, in the context of this book, is the group of soil scientists making and interpreting soil maps in the United States Department of Agriculture, the land-grant universities, and many foreign countries.

This technical description of soil taxonomy defines the categories and classes, gives data and descriptions for selected soils, and explains the meanings of soil class names used in the publication "Soil Series of the United States, Puerto Rico, and the Virgin Islands: Their Taxonomic Classification."

The first six chapters present general principles and concepts and give cross references for definitions of selected criteria. Later chapters discuss the classifica-

1938 system began to show weaknesses. For example, it was increasingly difficult to relate all the soil series to soil families, great soil groups, and higher categories. The reasons for this were that criteria had not been given for soil families and that the criteria for higher categories were not precise. The result was that some soil series fitted no great soil group and others could be classified in two or more great soil groups. Obviously, we faced increasing difficulties in consistent classification of our soils and in making detailed interpretations of the surveys in farming, forestry, and engineering.

The classification effort proceeded through a series of approximations. It was necessary to test these ap-

could list a great many who have taken the time and trouble to write their suggestions, but another large group have made oral suggestions that cannot now be traced. Although the soil scientists of the National Cooperative Soil Survey, of our other colleagues in American universities, and soil scientists in many other countries worked diligently on this enterprise, Guy D. Smith had staff leadership to keep the work organized from 1951 to June 1972. Many American soil scientists have studied soils in the field with their overseas colleagues and many of them have studied soils in the field with us in the United States. These joint field studies generated many ideas that proved to

Special thanks are given to Prof. Dr. Rene Tavernier, Director, Geological Institute, State University at Ghent, Belgium, for his help in organizing the series of meetings at which the various approximations were discussed and criticized by our European colleagues.

Special thanks must also be given to Prof. John L. Heller and to the late Prof. A. L. Leemans who gave freely of their time to help with the nomenclature.

And finally, appreciation is expressed to Dr. Charles E. Kellogg. He early saw the need for improving our system of soil classification and gave vigorous support

Preface

This book gives the present status of the taxonomy being used to make and interpret soil maps in the United States and several other countries. It is the first publication of the complete system.

Following staff discussions of two preliminary approximations, the soils and the classification systems used in Western Europe were studied. At the conclusion of this study, there was an international discussion at Ghent of soil classification problems with representatives of seven national soil surveys then underway in Western Europe. A modification of the 2nd Approximation was discussed, and many suggestions for changes were made at this conference.

The 3rd Approximation was prepared to include as many as possible of the European suggestions. It was tested by the Soil Survey Staff of the U.S. Department of Agriculture and the land grant universities by using its definitions to group the soil series and by studying the groups that resulted. It was made available to those interested at the 5th Congress of the International Society of Soil Science at Leopoldville in 1954. Proposed modifications were again discussed with our European colleagues in 1954 at Ghent. The 4th Approximation, prepared in 1955, was tested by classifying all the recognized soil series to see what kinds of soil were grouped at the various categoric levels above the soil family and what series were split. On the basis of this testing, modifications were made for the 5th Approximation.

The 5th Approximation was distributed at the 6th Congress of the International Society of Soil Science in Paris in 1956 to get the widest possible international review. This approximation was again discussed Soil Survey Staff for placement of the soil series into subgroups and families. The family groupings were tested by comparing the statements that could be made about the series within a family. The test was to determine the extent to which statements about one series had to be modified to fit the other series in the family. If the statements for comparable phases of the various series in a family differed significantly, we considered that there were defects either in the family differentiae or in one of the higher categories. The goal was to achieve families of series about which we could make the largest number of important statements concerning the use of the soil for growing plants and for engineering purposes.

At this time the problems of nomenclature were discussed with some of our European colleagues and with the late Prof. A. L. Leemans, Head of the Classic Language Department of the State University at Ghent, and Prof. John L. Heller, Head of the Department of Classics of the University of Illinois. The form of the nomenclature was suggested by our Belgian colleagues during discussions in Ghent. Lists of alternative names were circulated in correspondence.

During the course of writing the text to accompany the outline of the 6th Approximation, so many changes were made in definitions that it seemed better to issue it as the 7th Approximation. This was distributed at the 7th International Congress of Soil Science at Madison, Wisconsin, in 1960.

Testing of the 7th Approximation by series placement and examination of the statements that could be made about the phases of families revealed that additional changes were needed, particularly in subgroup

was next concentrated on problems in tropical regions. Studies were intensified in Puerto Rico and Hawaii. Proposals for classification were discussed in Brazil in 1964 and also in 1965 at a meeting in Ghent of European pedologists who had worked in tropical regions. Suggestions for changes came from other parts of the world by correspondence.

These and other changes were again summarized in supplements in 1966, 1967, and 1968. They were circulated for staff use in classifying the soils of the United States preparatory to the publication of this volume.

Obviously, this system is not just an American system. Through a series of discussions and through correspondence, experience in Europe and in other continents has been drawn on heavily. It results from a pressing need to have a classification of the thousands of soil series in the United States. But concepts of taxa that had proven to be useful to the soil surveys in a number of countries were compared to find the most useful ones, which then were borrowed. Many of the concepts were quite old and needed modification to be compatible with our present knowledge.

The classification is not equally developed in all parts. The classification of tropical soils and organic soils (Histosols) needs more testing. No proposals have yet been developed for classifying soils that have been altered by flooding for rice and taro. The classification of soils with permafrost is only partly developed, particularly at the subgroup and family levels, for lack of enough detailed mapping.

Many of the definitions of taxa that are extensive in the United States are far from perfect, particularly regarding their soil moisture regimes. These are known in a general way, but more actual measurements are needed to refine the present definitions. We are more confident about the classification of these soils than we are about the definitions. Changes seem certain, and supplements that revise some of the definitions can be expected.

This book assumes knowledge of the "Soil Survey Manual" (Agriculture Handbook No. 18) terminology for describing soils. If the reader is not familiar with the meaning of terms for describing texture, structure, consistence, and color defined by the Manual, he will find it difficult to read this book accurately. For those who lack access to the Manual, definitions of terms for structure, consistence, color, horizons and horizon boundaries, and texture are summarized in appendix I. These definitions are reproduced directly from the Manual, including footnotes, tables, and figures. No attempt has been made to reorder their numbering. The color terminology requires access to a Munsell color chart or to one of the other color charts that can be interpreted in terms of the Munsell system. Readers not familiar with Manual terminology should review the definitions in the appendix in advance of reading the main text. As this book goes to press, work on revision of the Manual is underway. Changes in terminology are under discussion, but the terminology used for descriptions and definitions in this book are available in the appendix. Definitions in appendix II of terms for describing roots and pores were developed after the Manual was printed. Appendix III contains information about field tests of organic soil materials. Appendix IV is a collection of descriptions of soils to illustrate diagnostic features and great groups.

In this book the arrangement of the orders is alphabetic. Within each order, suborders are arranged alphabetically, and great groups are similarly arranged within each suborder. Subgroups also have an alphabetic arrangement except that the typic subgroup always comes first. Soil families and series are listed in the publication "Soil Series of the United States, Puerto Rico, and the Virgin Islands: Their Taxonomic Classification," Soil Conservation Service, U.S. Department of Agriculture.

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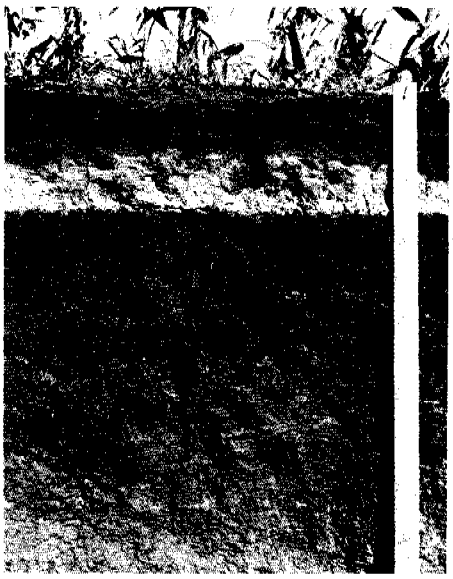


CHAPTER 1

The Soil That We Classify

Soil, as used in this text, is the collection of natural bodies on the earth's surface, in places modified or even made by man of earthy materials, containing living matter and supporting or capable of supporting plants out-of-doors. Its upper limit is air or shallow water. At its margins it grades to deep water or to barren areas of rock or ice. Its lower limit to the not-soil beneath is perhaps the most difficult to define. Soil includes the horizons near the surface that differ from the underlying rock material as a result of interactions, through time, of climate, living organisms, parent materials, and relief. In the few places where it contains thin cemented horizons that are impermeable to roots, soil is as deep as the deepest horizon. More commonly soil grades at its lower margin to hard rock or to earthy materials virtually devoid of roots, animals, or marks of other biologic activity. The lower limit of soil, therefore, is normally the lower limit of biologic activity, which generally coincides with the common rooting depth of native perennial plants. Yet in defining mapping units for detailed soil surveys, lower layers that influence the movement and content of water and air in the soil of the root zone must also be considered.

The word "soil," like many common old words, has several meanings. This is true even within soil science. We can try only to explain the sense in which we use the word here. Soil, in its traditional meaning, is the natural medium for the growth of land plants, whether or not it has discernible soil horizons. This meaning, as old as the word soil itself, is still the common meaning, and the greatest interest in soil is centered on this meaning. Although there are many uses of soil, the people of the world are more concerned with soil because it supports plants that supply food, fibers, drugs, and other wants of men than for any other reason. In this sense soil covers land as a continuum, except on bare rock, in areas of perpetual frost, or on the bare ice of glaciers. In this sense, soil has a thickness that is determined by the depth of rooting of plants.

school to be independent natural bodies, each with a unique morphology resulting from a unique combination of climate, living matter, earthy parent materials, relief, and age of land form. The morphology of each soil, as expressed by a vertical section through the differing horizons, reflected the combined effects of the particular set of genetic factors responsible for its development.

This was a revolutionary concept. The soil scientist did not need to depend wholly on inferences from the underlying rocks, the climate, or other environmental factors, considered singly or collectively; rather, he could go directly to the soil itself and see the integrated expression of all these in its morphology. This concept made it not only possible but necessary to consider all soil characteristics collectively, in terms of a complete, integrated, natural body, rather than individually. Thus the effect of any one characteristic or a difference in any one depends on the others in the combination. Experience has shown that no useful generalizations about single characteristics can be made for all soils. And the characteristics are given weight according to our knowledge gained through research and experience in soil genesis and the responses of soil to management or manipulation. Thus research in genesis and in responses of soils both have vital roles, but they are themselves one step removed from the taxonomy of soils, which is based on combinations of soil characteristics. In short, the new concept made pedology possible.

The Russian concept of soils as independent natural bodies that have genetic horizons led to a concept of soil as the part of earth's crust that has properties reflecting the effects of local and zonal soil-forming agents. The solum in that concept is the set of genetic horizons developed by soil-building forces, but the parent material beneath is not-soil. This concept has limitations. If a solum is 1 or 2 m thick, there is little conflict between the concept of soil as solum and the concept of soil as the natural medium for the growth of land plants. If genetic horizons are thin or absent

conflict and, despite the lack of horizons, included young alluvium and peat in his classification of soil.

Soil, as used in this text, does not need to have discernible horizons, although the presence or absence of horizons and their nature is of extreme importance to its classification. Soil is a natural thing out-of-doors. It has many properties that fluctuate with the seasons. It may be alternately cold and warm or dry and moist. Biologic activity is slowed or stopped if the soil becomes too cold or too dry. Flushes of organic matter come when leaves fall or grasses die. Soil is not a static thing. The pH, the soluble salts, the amount of organic matter and the carbon-nitrogen ratio, the numbers of microorganisms, the soil fauna, the temperature, and the moisture all change with the seasons as well as with more extended periods of time, just as a stream can flood and go dry, change its gradient, or meander. Soil must be viewed in this perspective: what is it like throughout the year,[1] not what is it like at a given moment. Like a stream, a soil cannot be brought into the laboratory or a greenhouse, even as undisturbed monoliths, without changing many of its characteristics, such as temperature, moisture, and biologic regimes.

Since one cannot distinguish precisely under all conditions between what is and is not a part of the soil, a short, precise, general definition is perhaps impossible. The same is true of other well-understood basic words such as house, plant, or stone. Some soil landscapes that support plants gradually thin to open water or to mate existence of mankind is its productivity for plants.

In some places the lower limits of soil can be set only arbitrarily. A *croûte calcaire,* which is hardened caliche, may extend from near the surface to a depth of some 3 to 8 m or more. The upper part of this caliche is normally a part of a modern soil, but the lower part may be a buried caliche of Pliocene age. In such a situation we can only set an arbitrary lower limit of soil at about 1 m but below the limit of present biologic activity.

In the humid Tropics, earthy materials may extend to a depth of many meters with no obvious changes below the upper 1 or 2 m except for an occasional stone line. In many wet soils, gleyed soil material may begin a few centimeters below the surface of a hydromorphic soil and, in some places, continue down for several meters unchanged. The latter condition can arise through the gradual filling of a wet basin in which the A horizon is gradually added to at the surface and becomes gleyed beneath. Finally the A horizon rests on a thick mass of gleyed material which may be relatively uniform. The upper part is soil, but the lower part is not. It was soil but is now buried. In such uncertain situations, we have no alternative but to set the lower limit of soil at the lower limit of biologic activity or of the common rooting of native perennial plants—a matter of 1 or 2 m.

A quite different meaning of the word "soil" is used by many laymen and engineers. In an engineering

study its horizons or layers. This study requires pits or some means of extracting samples of material from the surface to the base of the soil. The visible or tactile properties of samples can be studied in the field. Soil moisture and temperature regimes are studied by observations of changes over time at points selected to be representative. Other properties of a soil must be learned by studies of samples in an appropriate place, usually a laboratory. In other words, we learn about most of the properties of a soil by study of samples extracted to represent a sampling unit, not by study of the whole soil body that we classify. A concept of what to sample must be developed before soils can be classified in a manner that meets the needs of the soil survey, and different concepts might lead to different classifications. The concept presented in this text is not the only one possible, but it is one that follows logically from the definition of soil and from the purposes of this classification.

A soil commonly is not uniform in all its properties. Variability may be due to accidents, events that lack definite order, such as fractures in a hard rock, variations in deposits left by running water, or the placement of seeds by wind or by animals. Particularly, the biotic factors tend to produce variability in a soil. Burrowing animals, taprooted plants, falling trees, and plants that collect different elements do not operate uniformly over large areas. A filled burrow or a trace left by a taproot can result in holes in horizons filled by contrasting materials. Salts collected by a desert shrub remain concentrated below the shrub until it dies.

The transition between two soils that differ in a particular property or set of properties may be of at least two kinds. Normally, a given horizon of one soil disappears over horizontal distance by a gradual weakening of its expression. But in some places it disappears over distance in discontinuous spots, which occur with increasing frequency, either with or without marked decreasing strength of expression.

The transitional forms having discontinuous horizons or horizons that are greatly variable in thickness or other properties are not the rule, but the soils have been troublesome to classify. One must decide whether the area is one soil in which a horizon is discontinuous or variable, or two soils. Trouble cannot be avoided by arbitrarily saying that two soils are present if a diagnostic property or horizon is present in some spots and missing in others. Some limit of area must be set. If one sets no limit, a vertical hole made by a burrowing animal would be considered "not-soil." It would become a soil when filled or, if a coating is present, the coating would be considered a soil. This would be absurd. Such a soil could not support plants, could not have structure, and could not be sampled for determination of its properties. The view that a minimum areal limit to "a soil" cannot be set, if carried to the extreme, leads to other odd conclusions. With this view, if columns or prisms are present, the exteriors of the prisms would be different soils from the interiors wherever there are coatings on the exteriors. In a structureless soil, a definition of the smallest area of "a soil" as equivalent to the size of the largest ped would have no meaning. No escape from a minimum limit to the area of "a soil" seems possible. The concept of the pedon (Gk. *pedon*, ground; rhymes with head on) offers a partial solution to this problem and gives a clear unit for descriptions and for selection of samples.

A pedon has the smallest area for which we should describe and sample the soil to represent the nature and arrangement of its horizons and variability in the other properties that are preserved in samples. A pedon is comparable in some ways to the unit cell of a crystal. It has three dimensions. Its lower limit is the somewhat vague limit between the soil and the "not-soil" below. Its lateral dimensions are large enough to represent the nature of any horizons and variability that may be present. A horizon may vary in thickness or in composition, or it may be discontinuous. The area of a pedon ranges from 1 to 10 m^2, depending on the variability in the soil.

In the usual situation, where all horizons are continuous and of nearly uniform thickness and composition, the pedon has a horizontal area of about 1 m^2. Plate 1A shows the normal situation in which horizons are continuous and relatively uniform in thickness over considerable areas. This soil formed under grass in Story County, Iowa, from late-Wisconsinan drift. Each pedon includes the range of variability that is present in a small area. The shape of the pedon is roughly polygonal. One lateral dimension does not differ greatly from any other. The size of a pedon can be determined only by examination of an area that is appreciably larger than the pedon.

Where horizons are intermittent or cyclic and recur in linear intervals of 2 to 7 m (roughly 7 to 25 ft), the pedon includes one-half the cycle. Thus each pedon includes the range of variability that occurs within these small areas but not necessarily the total variability included in other similar pedons studied over a large area. Where the cycle is less than 2 m, the area of a pedon is about 1 m^2.

Some examples follow to clarify the concept of a pedon that has intermittent horizons. Plate 1B illustrates a soil in which discontinuous horizons recur at intervals of <1 m. In this soil, the area of each pedon is roughly 1 m^2.

This soil is near Brugge, Belgium, in an area that is covered by eolian sand of Wisconsinan (Würm) age. The plow layer, 35 cm thick, is a very dark brown fine sand or loamy fine sand. Most sand grains are free of any visible coatings. The lower boundary of the plow layer is abrupt and irregular and shows many clear spade marks.

The next layer is a discontinuous B horizon that consists of at least three materials. The first of these is a nodular, dark brown (7.5YR 3/4, moist) fine sand. The nodules range from about 5 to 20 cm in diameter and are firm to friable in the interior but have a very firm crust about one-half cm thick. The crust has stronger chroma and redder hue than the interior, suggesting segregation of iron. The interiors of the nodules are free of roots.

The second material is a very friable, massive, grayish brown (10YR 5/2, moist) fine sand, in which there are many fine fibrous roots. It would normally be considered parent material, the C horizon, where it under-

lies the nodules of the B horizon; however, it surrounds the nodules and continues down with little change to a thin, buried muck that has been dated by radiocarbon as Allerod (Two Creeks), about 11,000 years before the present.

The third material is very friable, massive fine sand that is present in gross, more or less tubular forms as much as 60 cm in diameter. The sand is similar to the second material in color but contains many weak fine dark gray to very dark gray lamellae or fibers that are comparable to those found in or below the B horizon of the sandy soils formed under heath.

It is possible in this soil to select columns 1 cm in diameter that, below the Ap horizon, consist entirely of the grayish brown sand that is the C horizon. Columns can also be selected in which the principal component is the sand that contains humus fibers. Other columns pass through one or more of the dark brown nodules. If the minimum lateral dimensions of a pedon were something like 1 cm, the profile illustrated in plate 1B would consist of several kinds of soil that have somewhat contrasting horizons.

It would be more nearly valid to consider this as a single kind of soil in which there are intermittent horizons. The history of this soil has been studied by the staff of the Institute for Soil Survey, IRSIA, Ghent.[2] While under forest it was brown and had no clearly expressed eluvial or illuvial horizons. After clearing of the forest and invasion of the heather (*Calluna vulgaris*), a dark-colored illuvial horizon that contained amorphous compounds or mixtures of organic matter, iron, and aluminum (see spodic horizon) formed. During the 17th and 18th centuries, flax became an important crop in Flanders, and the linen was woven in the farm homes in the winter. To get high yields of high-quality flax, large amounts of manure and chalk were applied to the fields. The influence of the manure and

there are deeper tongues that grade at a depth of about 1 m to a horizon that contains accumulated clay. This horizon of accumulation, a strong-brown (7.5YR 4/6, moist) illuvial sandy clay, is present in about 10 to 20 percent of the area in the form of tongues that are 20 cm to 1 m in diameter and are spaced at intervals of 0.5 m to 2 m. This illuvial horizon rests on the rock at a depth of 2 m or more.

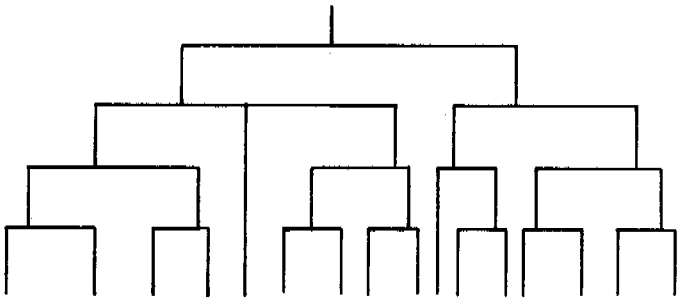
If a soil is considered as an assemblage of horizons, at least three kinds of soil are present in this example. From a genetic viewpoint, it is apparent that the areas where the rock is shallow have contributed both water and clay to form the illuvial B horizon in the deepest tongues. Without the contributions from areas of shallow rock, the deep tongues should be shallower and the clay content lower. The pedons in this soil have a variable size of from 1 to 2.5 m^2.

Other kinds of irregular and intermittent horizons are shown in plates 1D and 2A. Plate 1D shows a soil near Winnipeg, Manitoba, that formed in lacustrine montmorillonitic clay. The thickness of the black A1 horizon varies a few fold within lateral distances of tens of centimeters. The deep tongues of A1 horizon were in depressions in the virgin microrelief, which has been destroyed by cultivation. They now form a polygonal network, with polygons about 1.5 to 3 m in diameter. The size of the pedons ranges from about 1 to 2.5 m^2. Plate 2A shows a soil in New South Wales in which the thickness of the A horizon varies greatly, from 5 to 45 cm, within a distance of 1 or 2 m. Figure 1 shows a similar soil in Texas. Where the A horizon is thickest, there is a bleached horizon above the very fine textured B horizon. The pedons in this soil have an area of from 2 to 7 m^2. The soils shown in plates 1D and 2A developed in swelling clays, and they have irregular or intermittent horizons as a result of the

If soil is considered primarily as the natural medium for growth of plants, it is possible to consider each of the examples illustrated as a part of a single kind of soil in which there are intermittent or cyclic horizons. In each situation it would be difficult to have a mature native perennial plant whose roots were not in contact with most or all of the possible combinations of horizons. It can also be argued in each instance that the intermittent or cyclic nature of the horizons is essential to understanding the genesis and

A soil unit for classification may not everywhere be separated by a clear boundary from the other units that adjoin it. It may grade on its margins to other soil units that have unlike properties. A boundary may be abrupt, as along a vertical scarp, but more commonly a soil boundary is gradual over a distance of a number of meters. A few boundaries may be gradual over a distance of a number of kilometers.

"A soil," the soil that we classify, consists of contiguous similar pedons that are bounded on all sides by



CHAPTER 2

Soil Taxonomy and Soil Classification

The objective of soil taxonomy is to have hierarchies of classes that permit us to understand, as fully as existing knowledge permits, the relationships between soils and also between soils and the factors responsible for their character.

Taxonomy is a narrower term than classification. Classification includes taxonomy,[1] but it also includes classifications for specific practical purposes, such as limitations of soils for use to support foundations of buildings. Taxonomy is the part of classification that is concerned primarily with relationships. Classifications are contrivances made by men to suit their purposes. They are not themselves truths that can be discovered. A perfect classification would have no drawbacks when used for the purpose intended. Each distinctly different purpose, to be served best, demands a different classification.

For the different purposes of the soil survey, we need classes that can be grouped or subdivided and regrouped to permit the largest number and the most precise predictions possible about responses to management and manipulation. Consequently, we need not one but many classifications that can be drawn from the basic taxonomy. Flexibility in the classes of the taxonomic system is achieved by using phases and by the

soils that are waterlogged for extended periods. For other purposes we might want a group that causes us to think of all soils that have a B horizon affected by sodium or of all soils that have a fragipan or permafrost. Some soils might be in several of these groups, so that no matter how we arrange a single hierarchy, we are unable to have all the groups that we want. Therefore, no single hierarchy can best serve all our purposes. The way we attain flexibility in the hierarchy is explained in the discussion of the nomenclature.

As knowledge expands, new facts or closer approximations of truths not only make improvements in classification possible but also make some changes imperative. Thus, classifications are not static but need to change as knowledge expands. It has been said: "Classification is the mirror, in which the present condition of science is reflected; a series of classifications reflect the phases of its development" (author unknown).

A classification is an ordering or arrangement of objects in the mind and distribution of them into compartments. The purpose of a classification is to arrange the ideas of the objects in such order that ideas accompany or succeed one another in a way that gives us the greatest possible command of our knowledge

Taxonomy of soils is a controversial subject. Pedologists are in better agreement on soil genesis and soil chemistry than they are on soil taxonomy. In part, this reflects differences in the purposes for which taxonomic classifications are made and differences in concepts of soil as well as differences in opinion about taxonomy of soils. One cannot say that one taxonomic classification is better than another without reference to the purposes for which both were made, and comparisons of the merits of taxonomies made for different purposes can be useless.

The attributes desired

This taxonomy has been developed to serve the purposes of soil surveys.[4] Soil surveys require many nontaxonomic classifications that can be related to the real bodies of soil and that facilitate comparisons of both similarities and differences among them for a great variety of purposes. These classifications are used to determine whether experience at one place is applicable to the soils of other places. The classifications may have to be used by a pedologist to apply the experience of other men with soils that he has not seen. Many persons with diverse backgrounds and training are expected to use the classifications accurately to transfer experience with the behavior of soils under a variety of uses. These intended uses of the classifications impose some specific requirements on the taxonomy that stands behind the classifications. Insofar as possible, the taxonomy should have the following attributes:

First, the definition of each taxon should carry as nearly as possible the same meaning to each user. We must not say that the soils of a taxon have a high organic-matter content because what is considered high in one place may be considered low in another. Rather, we must specify the amounts as measured by specific methods for specific parts of the soil. Only by such definitions can competent pedologists with diverse backgrounds arrive at the same classification of the same kind of soil.

Second, the taxonomy should be a multicategoric system. We need many taxa in the lower categories because many properties are important to soil use. Specific properties can vary independently of others, and their importance depends on their combination with other properties. Taxa in the lower categories, therefore, must be defined as specifically as possible in terms of many properties. But this creates more taxa in the lower categories than the mind can comprehend. Consequently, the taxa must be grouped on some rational basis into progressively smaller numbers of classes of higher categories in a manner that permits the mind to grasp the concepts and relationships of all taxa. The mind readily grasps 5 to 10 items, but it cannot deal simultaneously with 100 to 1,000 items without some ordering principle. Higher categories for comparing soils of large areas. They have only limited value for transferring experience to a specific site for a specific use. And, as pointed out earlier, the hierarchy should be flexible.

Third, the taxa should be concepts of real bodies of soil that are known to occupy geographic areas. We are concerned with mapping real bodies of soil, and a classification related to these real bodies facilitates the mapping (Cline 1963). So, we should take the soils as they are and find a way to classify them. We should not try to provide for all possible combinations of properties because the classification of kinds of soil that have not been studied should not be prejudiced by a closed system that covers all contingencies. Rather, we should try to provide a means to recognize new taxa when we find new combinations of properties important to our purposes.

Fourth, differentiae should be soil properties that can be observed in the field or that can be inferred either from other properties that are observable in the field or from the combined data of soil science and other disciplines. Some of the most important properties of soil are chemical properties. These cannot be seen or felt, but there is no reason to believe that methods cannot be devised for measuring these properties in the field or in field laboratories if necessary. Soil temperature, soil moisture, and other properties that fluctuate with the seasons are difficult to use in taxonomy unless they can be inferred by reasoning from the combined data of soil science and other disciplines such as meteorology. Soil mineralogy can usually be inferred by reasoning from the combined data of soil science and geology. If there are no data that permit inferences about important but invisible soil properties, it is probably best to defer classifying a soil until we have some knowledge of its important properties. A classification that is based on extremely limited knowledge of an object has little utility.

Fifth, the taxonomy should be capable of modification to fit new knowledge with a minimum of disturbance. It should be possible to add or combine taxa in any category without disturbance to the rest of the system at the same or a higher categorical level. If the highest category can include a number of taxa defined by a variety of properties, the number can be increased or decreased by combining or subdividing taxa whenever experience convinces us that this is advisable. If one taxon in the highest category is divided, no others in that category need be affected. If two or parts of two are combined, only those two or those parts are affected. Obviously, combining taxa at a high level changes classes of lower categories if they are members of those taxa. Adding taxa may have no effect in lower categories if the soils concerned were not included in the system previously. If the addition is a consequence of combining classes, it affects lower categories.

Sixth, the differentiae should keep an undisturbed soil and its cultivated or otherwise man-modified

interpretations become difficult or impossible. Changes produced by a single or repeated plowing that mixes the surface soil to a depth of 18 to 25 cm (7 to 10 in.), for example, should have the least possible effect on the placement of a soil in the taxonomy. Truncation by erosion should not produce changes in the placement of a soil in the taxonomy until horizons important to the use or identification of the soil have been lost. Consequently, insofar as possible, the diagnostic horizons and features should be below these depths. But significant changes in the nature of the soil by man cannot be ignored. If new horizons have formed as the result of man's activities or if the major parts of a soil have been mixed by deep plowing, the present nature of the soil as well as its relation to the undisturbed soil should be reflected to the maximum extent possible.

Seventh, the taxonomy must be capable of providing taxa for all soils in a landscape. Soils form a continuum, but at present we lack the knowledge necessary to classify them as such. To do so we should have to devise a functional system to describe a continuum in many dimensions with an infinite number of classes representing points along these dimensions. There is no reason to think such a classification would be useful at present. Rather, we must break the continuum into a reasonable number of segments that have limited and defined ranges in properties so that we can make quantitative interpretations of soil behavior.

Eighth, the taxonomy should provide for all soils that are known, wherever they may be. Many kinds of soil are poorly represented or are unknown in the United States. We are all unavoidably biased in developing a taxonomy by the extent of a kind of soil. A system that includes all known soils helps us see the soils of the United States in better perspective, particularly if a kind of soil is poorly represented or is very extensive. It also helps us draw on experience in other countries with kinds of soil that are poorly represented or are inextensive in the United States as a whole but that are extensive locally.

Selection of differentiae

We should be able to classify a polypedon by its own properties if the taxonomy is to serve the purpose of the soil survey. If we can do so, the taxa will be defined strictly in terms of soil properties. In soil definitions, a given property such as particle-size distribution, pH, and so on cannot be treated in an identical way for all soils. The significance of a difference in any one property depends on the others in the combination that makes a soil of a certain kind. John Stuart Mill (1891) pointed out that—

> "Causes are preferable, both as being the surest and most direct of marks, and as being themselves the properties on which it is of most use that our attention should be strongly fixed. But the property which is the cause of the chief peculiarities of a class, is unfortunately seldom fitted to serve also as the diagnostic of the class. Instead of the cause, we must generally select some of its more prominent effects, which may serve as marks of the other effects and of the cause."

Soil color and the soil horizons are obvious properties that have been used as differentiating characteristics [5] at high categoric levels in most taxonomies. Color *per se* seems to have no accessory characteristics. For example, if one considers all the soils that have brown color, he can make no statement about them except that they are brown. There are accessory characteristics to some colors in combination with other properties, and the use of color as a differentiating characteristic should be limited to these situations. A more useful classification can be devised if properties that have more accessory properties than color are used as differentiae in the highest categories.

Soil horizons are the result of the dominance of one or more sets of processes over other processes through time. The processes themselves are not now suitable for use as differentiae. The process of illuviation of clay, for example, cannot be observed or measured in a soil. But if illuviation has been a significant process in the genesis of a soil, there should be marks in the soil to show it. These marks need not be the same everywhere, but if we select the proper marks, the classification can reflect the dominance of illuviation over other processes such as those that mix horizons or over forces that prevent movement of clay.

The nature of the horizons is useful to define taxa of soils that have horizons but is useless for soils that do not have them. Of course, the absence of horizons is itself a mark of significance for our purposes. Many important properties of soils, however, are not necessarily reflected by the combinations of horizons, and many important processes do not themselves produce horizons. Intense mixing of soil by animals can destroy horizons. The leaching of bases, particularly calcium, and the cycling of bases by plants in humid climates can be reflected by changes in base status with depth but can be independent of the kinds of horizons in a soil. The horizons, therefore, should not be the sole differentiating characteristics in defining taxa.

Some soil properties influence or control specific processes and, through them, genesis of the soil. Silicate clays cannot form in a soil composed entirely of quartz, and apparently they do not form if a soil is too cold. The soil moisture regime influences the base status of a soil and the formation of horizons of accumulation of illuvial clay or of carbonates. These are examples of soil properties that are causes of other properties and that need consideration when [illegible]

The differentiae should be soil properties, but the most useful properties for the higher categories may be either those that result from soil genesis or those that affect soil genesis because these properties have the greatest number of accessory properties. For example, it is common in soils that the clay percentage increases and then decreases with depth. In many soils, the differences are the result of eluviation and illuviation of the clay. In other soils, they may be only the result of stratification of the materials in which the soil developed. If the horizons are genetic, they have accessory properties, although the accessory properties may vary with the kind of soil. If the climate is humid, the eluvial horizons and at least part of the illuvial horizons are free of finely divided carbonates because carbonates tend to immobilize clay and because the leaching required to form an illuvial horizon is greater than the leaching required to dissolve and remove the carbonates. Time of the order of some thousands of years without significant erosion is required. During this time there is opportunity for nutrients used by plants to be systematically concentrated in various horizons. Under grass in humid temperate regions, phosphorus seems to be concentrated in the surface horizons, a considerable part of it in organic compounds.

If the clay distribution is due solely to stratification of parent materials, few other statements can be made about that soil. The soil may be calcareous or acid. This is why properties that are the result of soil gene-

categories. Those that are important to plant growth but are unrelated to genesis should be considered only for the lowest categories. For example, in soils that are only slightly weathered, the nature and amount of clay may be the result of geologic accidents. If the differences are not extreme, the course of soil genesis is not necessarily affected. Although the difference between illite (hydrous mica) and montmorillonite is important to plant growth, it should be used as a differentiating characteristic only in a low category.

The definitions of the taxa must be as explicit as possible to permit uniform application by many pedologists working independently. But we must emphasize that the definitions as now written will require changes as we gain experience by using the taxonomy and as we learn more about soils. The definitions must be continually tested by the nature and functioning of the soils grouped in a taxon.

Determination of the similarity of one kind of soil to others is not always a simple matter. There may be similarity in particle size (texture) to the members of one taxon and in base status to the members of another. One must decide which property is the more important, and this decision must rest on the nature of the statements that one can make about the classes if the kind of soil is grouped one way or the other. The best grouping should determine the definition, not the definition the grouping. If the grouping has imperfections, so does the definition. For our purpose, the statements are about the nature of the soils and the

area. Quite different phases might be differentiated for the same soils in an area of general farming in contrast to a national forest or an area being developed for housing; or in an irrigated area in contrast to the desert grazing land that is above the irrigation canal. The phases represent a number of classifications superimposed on the taxonomic classification to give part of the flexibility that is needed for the wide variety of uses made of soil. A different classification is needed for each use for which we make interpretations.

Inevitably, the conclusions of a large group of scientists include some compromises of divergent points of view. Members of a group representing unlike interests and experience are likely to see soils differently. Different points of view toward soil produce different ideas about its classification. Consequently, compromises between the conflicting desires of a number of individuals are not only necessary but actually are likely to produce a system that has more general utility than a system that represents a single point of view. Compromise may not be the exact word. The truth has many facets; each person has a somewhat different view of the truth, and no person can see the whole truth clearly. Our goal has been a blending of many views to arrive at an approximation of a classification that seems as reasonable as we can hope to reach with our present knowledge. Our attempt has made us keenly aware of the great gaps in that knowledge. But it has also given us faith in the value of improvement when we realize the utility of the old classifications with all their imperfections.

Probably no one person will approve of all the details of this system; few will be able to agree on all the desirable changes. This, we think, is as it should be at this stage of our knowledge.

CHAPTER 3

Horizons and Properties Diagnostic for the Higher Categories: Mineral Soils

For purposes of taxonomy, it is necessary, first, to define the limits that distinguish mineral soil material from organic soil material and, second, to define the minimum part of a soil that should be mineral if the soil is to be classified as a mineral soil.

Nearly all soils contain more than traces of both mineral and organic components in some horizons, but most soils are dominantly one or the other. The horizons that are less than about 20 to 35 percent organic matter by weight have properties that are more nearly those of mineral than of organic soils. Even with this separation, the volume of organic matter at the upper limit exceeds that of the mineral material in the fine-earth fraction.

Mineral soil material

Mineral soil material either

1. Is never saturated with water for more than a few days and has <20 percent organic carbon by weight; or
2. Is saturated with water for long periods or has been artificially drained, and has
   a. Less than 18 percent organic carbon by weight if 60 percent or more of the mineral fraction is clay;
   b. Less than 12 percent organic carbon by weight if the mineral fraction has no clay; or
   c. A proportional content of organic carbon between 12 and 18 percent if the clay content of the mineral fraction is between zero and 60 percent.

Soil material that has more organic carbon than the amounts just given is considered to be organic material. A full definition of organic soil materials is given in chapter 4.

Distinction between mineral soils and organic soils

Most soils are dominantly mineral material, but

For simplicity in writing definitions of taxa, a distinction between what is meant by a mineral soil and an organic soil is useful. In a mineral soil, the depth of each horizon is measured from the top of the first horizon of mineral material. In an organic soil, the depth of each horizon is measured from the base of the aerial parts of the growing plants or, if there is no continuous plant cover, from the surface of the layer of organic materials. To apply the definitions of many taxa, therefore, one must first decide whether the soil is mineral or organic.

If a soil has both organic and mineral horizons, the relative thickness of the organic and the mineral soil materials must be considered. At some point one must decide that the mineral horizons are more important. This point is arbitrary and depends in part on the nature of the materials. A thick layer of sphagnum has a very low bulk density and contains less organic matter than a thinner layer of well-decomposed muck. It is much easier to measure thickness of layers in the field than it is to determine tons of organic matter per hectare. The definition of a mineral soil, therefore, is based on thickness of the horizons or layers, but the limits of thickness must vary with the kinds of materials. The definition that follows is intended to classify as mineral soils those that have no more organic material than the amount permitted in the histic epipedon, which is defined later in this chapter.

To determine whether a soil is organic or mineral, the thickness of horizons is measured from the surface of the soil whether that is the surface of a mineral or an organic horizon. Thus, any O horizon at the surface is considered an organic horizon if it meets the requirements of organic soil material as defined later, and its thickness is added to that of any other organic horizons to determine the total thickness of organic soil materials.

Definition of mineral soils

Mineral soils, in this taxonomy, are soils that meet one of the following requirements:

earth fraction) makes up more than half the thickness of the upper 80 cm (31 in.);

2. The depth to bedrock is <40 cm and the layer or layers of mineral soil directly above the rock either are 10 cm or more thick or have half or more of the thickness of the overlying organic soil material; or

3. The depth to bedrock is ≥40 cm, the mineral soil material immediately above the bedrock is 10 cm or more thick, and either

   a. Organic soil material is <40 cm thick and is decomposed (consisting of hemic or sapric materials as defined later) or has a bulk density of 0.1 or more; or

   b. Organic soil material is <60 cm thick and either is undecomposed sphagnum or moss fibers or has a bulk density that is <0.1.

This chapter discusses only the diagnostic horizons and properties of soils that have been defined as mineral soils. Diagnostic properties of Histosols, which are the soils that are dominantly organic, are discussed in chapter 4.

The four highest categories of this taxonomy, in order of decreasing rank and increasing numbers of [illegible]

urement of the CO_2 evolved from acid-dichromate digestion. Details of the methods and references to the authors of the methods are in Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples (Soil Conserv. Serv. 1972.)

Diagnostic surface horizons; the epipedon

Six diagnostic horizons that form at the surface are defined. Any horizon, however, may be at the surface of a truncated soil. A horizon that forms at the surface is called an epipedon (Gr. *epi*, over or upon, and *pedon*, soil). The epipedon not only has formed at the surface but it also has been either appreciably darkened by organic matter or eluviated or, as a minimum, rock structure has been destroyed. Such a horizon may become covered by thin deposits of fresh alluvium or by thin eolian deposits without losing its identity as an epipedon. The depth to which an epipedon must be buried to be considered part of a buried soil is defined in chapter 1. Generally a buried horizon lies below a depth of 50 cm or more, usually more

the organic carbon is mostly a matter of a few (1 to 10) hundred years (table 1). A high percentage of the organic matter is so-called "humic acid."

TABLE 1.—*Radiocarbon age of organic carbon in selected mollic epipedons developed under grass*

Soil series	Sub-order	County and state	Depth sampled	Radio-carbon age
			cm	*Years*
Barnes	Boroll	Cavalier, N. Dak.	0–10	350±120
Clarion	Udoll	Pocahontas, Iowa	0–15	440±120
Cresco-Kenyon intergrade	Udoll	Howard, Iowa	0–10	210±130
			10–20	100
Edina	Alboll	Wayne, Iowa	0–15	410±100
Webster	Aquoll	Pocahontas, Iowa	0–15	270±120

Several accessory properties are common in soils that have a mollic epipedon. Most natural environments (not made by man) that produce a mollic epipedon also produce 2:1 lattice clays from minerals that can be altered, preclude serious toxicity from aluminum or manganese, and insure a reasonable reserve of calcium, magnesium, potassium, and of nitrogen if the soil has not been cultivated for a long time. These are accessory properties important to plant growth. The

value darker than 3.5 when moist and 5.5 when dry, and chroma less than 3.5 when moist;[1] the color value normally is at least 1 Munsell unit darker or the chroma is at least 2 units less (both moist and dry) than that of the IC horizon if an IC horizon is present. If only a IIC horizon or an R layer is present, the comparison should be made with the horizon that overlies the IIC. Some parent materials such as loess, cinders, alluvium, or carbonaceous shales also can have dark color and low chroma. Soils formed in such materials may accumulate appreciable amounts of organic matter but have no visible darkening in the epipedon. In this situation, the requirement that the mollic epipedon have lower value or chroma than the IC horizon, or than the next underlying horizon if there is no IC, is waived if (a) the surface horizon (horizons) meets all other requirements for a mollic epipedon and, in addition, has at least 0.6 percent more organic carbon than the IC or the IIC horizon or if (b) the epipedon extends to rock (either a lithic or paralithic contact as defined later).

The mollic epipedon is expected to have dark color and low chroma throughout the major part of its matrix. If the structure is fine granular or fine blocky, the color when broken may be only the color of the coatings. The color of the matrix in such situations can be determined only by crushing or briefly rubbing the sample. Prolonged rubbing should be avoided because it may cause darkening of a sample if soft iron-

the upper 18 cm of soil or the whole soil if the depth to rock, petrocalcic horizon, or duripan is <18 cm:

a. Ten cm or more if the epipedon is underlain directly by a lithic contact; 10 cm or more in soils of shallow families in which the epipedon is underlain directly by a paralithic contact, a petrocalcic horizon, or a duripan, all defined later in this chapter;

b. In other soils the epipedon must be >25 cm thick if its texture is finer than loamy fine sand

soil that has a mollic epipedon that on the average is about 36 cm thick.

Pedon 1 illustrates a soil that has a mollic epipedon and is in a relatively dry climate. The organic-carbon content exceeds 0.6 percent to a depth of only about 30 cm although the color value is darker than 3.5, moist, and 5.5, dry, and the chroma, moist, is less than 3.5 to a depth of 46 cm. The mollic epipedon in this soil, therefore, is 30 cm thick. It includes the A horizon and

accompanied by relatively high base saturation if compared with adjacent soils.

In very arid regions where there is no flooding and where precipitation is so low that there seldom is any vegetation without irrigation, some long-irrigated soils have an epipedon that is like the mollic epipedon in most chemical and physical properties. The properties of the epipedon here are clearly the consequence of the activities of men in supplying water. Such an epipedon is tentatively grouped with the anthropic epipedons, which developed under human habitation. If not irrigated, such an epipedon is dry in all its parts during more than 9 months of the year in more than 7 years out of 10. Further study may indicate the need

Pedon 6 illustrates a soil that has an umbric epipedon. The description and the other data show that the umbric epipedon is about 96 cm (38 in.) thick. The horizons below a depth of 96 cm are too light in color to be part of the umbric epipedon. The base saturation is too low for a mollic epipedon.

Pedon 7 is an example of an umbric epipedon in a soil that has a B horizon that contains illuvial clay (defined later as an argillic horizon). In this soil the umbric epipedon is about 32 cm thick and includes only the A horizon. Although this is a common situation in soils that have an umbric epipedon, there is nothing that prevents the umbric epipedon from including all or part of a B horizon.

that has enough organic carbon to satisfy the minimum requirements under item 2 after the soil has been mixed to a depth of 25 cm.

Most histic epipedons contain at least as much organic carbon as is present in organic soil material as defined in chapter 4. Items 2 and 4 provide for histic epipedons that are composed of mineral soil material after the soil has been plowed to 25 cm or more or mixed to 25 cm. In these, the organic carbon may be

anthropic, plaggen, or histic, or it is both hard and massive when dry. An epipedon is ochric if the Munsell color value after rubbing is 5.5 or higher when dry or 3.5 or higher when moist, if the chroma is 3.5 or more [2], or if the A1 or the Ap horizon that has both low value and low chroma is too thin to be a mollic or an umbric epipedon. Epipedons that have a color value after rubbing lower than 5.5, dry, and lower than 3.5, moist, are also ochric provided they are no darker than the IC horizon and do not have as much as 0.6

too thin to be a mollic or an umbric epipedon. Only the surface soil to a depth of 10 cm is dark enough to meet the requirement of a mollic epipedon. The ochric epipedon in this soil is 36 cm thick.

Pedon 12 illustrates a soil that has an epipedon that is ochric because it is both hard and massive when dry. The surface soil to a depth of about 30 cm has enough organic matter [illegible]

thoroughly or partially dry at some season, argillic horizons are common.

In the light of our present knowledge the most reasonable explanation of the movement of clay is the one that follows. First, the parent material must contain very fine clays or weathering must produce them. Very fine clays carry a negative charge, as does the

by shrinking or swelling must be slow or absent to permit formation of an argillic horizon.

Significance to soil classification

The argillic horizon by itself has little importance to soil classification. It is the accessory properties that are important. The soils in a taxon that included all soils that have an argillic horizon would have almost no other common property. Yet the horizon is a mark of the dominance of translocation of silicate clay over processes that destroy clay or remove it from the soil and over processes that mix horizons. Because the formation of an argillic horizon is relatively slow, its presence indicates that the surface has been relatively stable and that the period of stability has been long enough to develop an apparent equilibrium between formation and decomposition of organic matter. The presence of an argillic horizon indicates that a substantial amount of water has moved through overlying horizons. The amount has been enough to remove soluble materials, including finely divided lime, although some may subsequently have been replaced.

One can say that the presence of an argillic horizon is evidence that climate and vegetation have had opportunity to show their effects in formation of the soil, but one cannot say that the present soil has formed under the present climate and vegetation.

Taken along with other diagnostic features, the argillic horizon has much more meaning than it has by itself. If it is rarely moistened, it probably indicates a soil and surface of such great age that the climate has changed, for in the present environment the rainfall in most years is not enough to moisten the soil to the base of the horizon.

On the steppes, the savannas, and the grasslands of subhumid climates, the argillic horizon is a useful means of distinguishing between surfaces of Holocene or late-Pleistocene age and the older surfaces. The presence of an argillic horizon also correlates well with many other properties of soils that are produced by leaching. In the relatively dry areas of grassland just named, the argillic horizon, in the absence of active mixing of horizons by soil fauna, seems to be a mark of soil age. As time passes, other things being equal, the argillic horizon becomes finer in texture and develops an abrupt upper boundary.

In cool humid regions the argillic horizon seems to be transient. It forms slowly, but there is evidence that with time it is moved to a greater depth in the soil and finally is destroyed. In its place one then finds a cambic or a spodic horizon. These horizons are discussed later.

In humid temperate and tropical regions, the presence of an argillic horizon has still other meanings. In humid, temperate, forested regions, the argillic horizon is mainly a mark of a stable surface and a seasonal moisture deficit. It helps in distinguishing the stable and the unstable surfaces and also in identifying the soils that have a seasonal moisture deficit.

In the humid Tropics the argillic horizon appears to be useful in distinguishing many of the soils that have some weatherable minerals from those that formed in old, completely weathered sediments. We have much to learn, however, about those soils.

It is stressed that the argillic horizon is no more important to soil classification and to soil genesis than many other horizons. It has been used at a higher categoric level in some parts of the system only because that use has produced groupings of soils that have the largest number of common properties that are important to use of the soil.

Appearance

The horizons in which illuvial clay has accumulated, which have been defined as argillic horizons, have a variety of forms. Although positive identification is difficult in some situations, several features are useful for identifying an argillic horizon in most soils. No one feature is common to all argillic horizons and absent from all other horizons, but nearly all argillic horizons have at least two of the common features.

First, if there is an overlying horizon other than an Ap horizon, there is a difference in texture between the eluvial and the illuvial horizon and the boundary generally is clear or abrupt. In some soils the horizon boundary is gradual, and commonly it is irregular. Plates 2D and 6D illustrate clear and irregular boundaries.

The illuvial horizon generally has distinctly finer texture than the overlying eluvial horizon or the underlying parent material if the mantle was uniform throughout its depth. The ratio of clay content of the illuvial horizon to that of the eluvial horizon normally needs to be at least 1.2, and usually it must be larger to be consistently significant in replicated samples. Such an increase of 20 percent or more in the clay content occurs in most pedons within a vertical distance of <15 cm. In a few soils the zone of transition is as great as 30 cm. The lower boundary of the argillic horizon usually is gradual, and commonly it is irregular.

Second, there are coatings of oriented clay on the surfaces of pores and of peds somewhere within or immediately below many illuvial horizons. Very commonly the coatings are present only at the base of the horizon. Plate 3A illustrates the appearance of these coatings. The pore has a thick, dark gray coating, and the ped surface has a thin, brownish coating. The broken surface that reveals the interior of the ped, on the right, has no coating. The scale is 2 mm long. Plate 3B shows the appearance of illuvial clay in sand. Here it coats the sand grains and an occasional pore shows a clay skin.

Third, the ratio of fine clay (particles <0.0002 mm in diameter) to total clay is usually larger in the illuvial horizon than it is in the eluvial horizons or in horizons that underlie the illuvial horizon.

Fourth, rock structure is not evident or is evident in less than half the volume of the illuvial horizon. In this context rock structure refers to weathered rock in which the original shape and relative position of the altered minerals are still evident. Such material is ordinarily called saprolite by pedologists if it retains rock structure.

Fifth, the minerals resistant to weathering, such as quartz and zircon, are commonly less abundant in the illuvial horizon than in the overlying or underlying horizons. This relative scarcity reflects dilution by il-

luvial clay. If the soil contains quartz, the silica-sesquioxide ratio of the illuvial horizon (on a whole-soil basis) is lower than that of the overlying and underlying horizons.

Sixth, the illuvial horizon is parallel or nearly so to the surface of the polypedon. If the soil is or has been cultivated, the epipedon may be truncated on the side slopes, leaving the illuvial horizon on the surface.

Evidences that clay has moved

It is important to recognize that the clay that has moved from one horizon to another is usually only a

differences between horizons tend to disappear. The dependence of the SiO_2 to R_2O_3 ratio on the percentage of clay in a given pedon lends support to the hypothesis that the differences in the amount of clay in the A and the B horizons are largely the result of clay movement. The amount of clay is a function of parent material, climate, relief, vegetation, and time.

Pedon 13 shows its greatest accumulation of clay in the horizon just above the limestone.

To illustrate the difference in the size of clay particles in the various horizons, table 3 shows the particle-size distribution for three pedons, 16, 17, and 18, that

TABLE 2.—*Chemical and mineralogical data for three soils that have argillic horizons*

[Data for the argillic horizons are printed in italics. A blank indicates the analysis was not made. --- indicates the analysis was made but none was detected. Symbols 3A1, 7A2 and 7A3 refer to methods of analysis listed in the appendix]

Depth (centimeters)	Fine-earth fraction (<2 mm in diameter)								Clay fraction (<0.001 mm in diameter)							
	Clay 3A1	K_2O	CaO	SiO_2	Al_2O_3	Fe_2O_3	Free Fe_2O_3	SiO_2: R_2O_3	K_2O	CaO	SiO_2: R_2O_3	Montmorillonite [1] 7A2	Mica [1] 7A2	Vermiculite [1] 7A2	Chlorite [1] 7A2	Kaolinite [2] 7A3
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Ratio*	*Percent*	*Percent*	*Ratio*					
								PEDON 13								
0–15	45.8	1.7	1.1	59.3	18.8	8.0	5.0	4.2	1.5	<0.2	1.7	---	x	x	---	35
15–23	45.8	1.7	1.0	59.9	18.9	7.4	5.1	4.3	1.5	<.2	1.7	---	---	x	---	35
23–40	46.8	1.8	.9	59.3	19.7	7.8	5.0	4.1	1.7	.2	1.7	---	---	x	---	35
40–56	50.0	1.8	.8	58.7	19.6	7.6	5.2	4.1	1.7	.2	1.7	---	---	x	---	*35*
56–92	*75.8*	*1.7*	*.9*	*49.9*	*24.4*	*9.9*	*7.5*	*2.8*	*1.5*	*.2*	*1.8*	---	---	x	---	25
92–110	(impurities in limestone)											---	---	---	---	70
								PEDON 14								
0–15	12.8	2.0	0.5	80.8	8.0	2.5	1.4	14.3	2.5	0.2	3.0	---	x	---	---	[3] 20
15–23	12.4	2.0	.5	80.8	8.0	2.4	1.2	14.3	2.5	.2	3.0	---	x	---	---	[3] 20
23–33	*21.7*	*2.3*	*.5*	*77.4*	*10.5*	*3.6*	*1.8*	*10.2*	*2.5*	*.2*	*2.8*	---	x	---	---	[3] *20*
33–56	*29.5*	*2.2*	*.5*	*73.4*	*11.7*	*5.2*	*2.4*	*8.3*	*2.2*	*.2*	*2.3*	xx	x	---	---	[3] *20*
56–81	*27.2*	*2.2*	*.5*	*75.1*	*11.3*	*5.1*	*2.5*	*8.8*	*2.1*	*.2*	*2.6*	xxx	x	---	---	[3] *20*
81–120	*22.5*	*2.3*	*.5*	*76.4*	*10.6*	*4.7*	*2.5*	*9.5*	*2.3*	*.2*	*2.5*	xx	x	---	---	[3] *15*
120–140	19.9	2.3	.5	76.1	10.3	4.5	2.4	9.8	2.5	.2	2.4	xxx	x	---	---	[3] 20
								PEDON 15								
0–13	11.4	1.2	0.3	86.2	4.8	1.8	0.6	24.6	1.7	0.1	2.5	---	xx	[4] x	---	20
13–18	20.4	1.3	<.1	82.3	7.5	3.2	1.4	14.6	---			x	x	---	---	25
18–36	*49.8*	*1.5*	*.1*	*69.3*	*15.3*	*7.4*	*4.2*	*5.9*	*1.2*	*.1*	*2.1*	xx	x	---	---	*20*
36–48	*44.4*	*1.7*	*.1*	*70.9*	*14.3*	*7.1*	*3.4*	*6.4*	---			xx	x	---	---	*20*
48–79	*37.4*	*1.9*	*.1*	*74.1*	*13.4*	*5.7*	*2.3*	*7.4*	*1.5*	*.1*	*2.4*	xxx	x	---	---	*25*
79–94	*34.3*	*1.7*	*.1*	*75.3*	*12.1*	*5.8*	*2.2*	*8.1*	---			xx	x	---	---	*25*
94–120	31.6	1.9	.1	76.2	11.4	6.4	2.4	8.3	1.6	.1	2.6	xx	[5] x	---	---	20
120–155	32.3	2.0	.2	74.6	10.6	7.2	2.2	8.3	---	---	---	xx	[5] x	---	---	20

[1] x indicates small amount; xx, moderate; xxx, abundant.
[2] Estimated by DTA.
[3] The DTA peak was very diffuse. The estimates have low reliability and probably are too high.
[4] Vermiculite-montmorillonite interstratified material.
[5] Slightly more than in the overlying horizons.

one finds a weak orientation of the silt and clay. No distinct difference in texture between the ped coat and ped interior is evident. The weak orientation of particles in the ped face, shown by the brighter interference color under crossed polarizers (plate 3F), is presumably the result of pressure.

The peds in an argillic horizon have varying stability, and the fragmentation and consolidation of peds may be relatively rapid or slow. Particularly under forests, woody roots can disrupt peds. Decomposition of roots then leaves new planes of weakness. Thus, clay skins that formed on the surface of a ped may later be in the interior of an altered or a different ped as streaks of oriented clay. Shrinking and swelling of peds may have the same effect. Another mechanism that disrupts peds and clay skins is the collapse of pores. Consequently, in many soils, clay skins are few and thin or even absent on peds in the upper part of the argillic horizon. Deeper horizons, because they are subject to less disturbance by roots and to less change in volume, should have more stable peds. The deep horizons commonly show the thickest and most abundant clay skins on ped surfaces.

Pedons 9 and 12 are examples that show thick clay skins in the deep horizons. Pedon 9 formed in Wisconsinan loess that was deposited between about 30,000 and 15,000 years ago. Montmorillonite is the most abundant clay mineral in the argillic horizon. The clay skins, identified by orientation, amount to about 15 percent of the total clay in the main part of the argillic horizon and almost 25 percent of the clay in the next horizon below.

In pedon 12, which formed in saprolite from tonalite, a similar pattern exists. In a similar pedon, the percentage of moved or oriented clay increases from 10 to 30 percent in successive layers of the main part of the argillic horizon. In the transition horizons, the B3 and C1, the percentages of moved clay are 80 and 70 respectively. These are minimum values for moved clay because it is probable that some clay skins have been disrupted by roots or by soil fauna. The data illustrate, however, the normal distribution pattern of clay skins in many argillic horizons in late-Pleistocene sediments or in soils on surfaces of comparable age.

To have thick continuous clay skins on the ped surfaces, the peds must be stable both in time and in size in relation to the rate of illuviation. One does not expect many or thick clay skins in the upper part of an argillic horizon if the eluvial horizon has been thoroughly depleted of clay. In fact, in soils on very old, stable, forested surfaces in a humid climate, there may

TABLE 3.—*Particle-size distribution and ratio of fine clay to total clay in selected soils that have argillic horizons*

[Data for the argillic horizons are printed in italics. Data for pedons 16 and 17 are from the Ohio State University Soil Survey Laboratory. Fine clay data for pedon 18 are from Mogen, C. A., et al., Chestnut, Chernozem, and Associated Soils of Western North Dakota, Soil Sci. Soc. Amer. Proc. 23:56–61, 1959. Other data for pedon 18 are from the SCS Soil Survey Laboratory]

Depth (centimeters)	Particle-size distribution (diameter of particles)									Fine clay: total clay
	2.0 to 1.0 mm	1.0 to 0.5 mm	0.5 to 0.25 mm	0.25 to 0.1 mm	0.1 to 0.05 mm	0.05 to 0.002 mm	Less than 0.002 mm	0.002 to 0.0002 mm	Less than 0.0002 mm	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Ratio*
					PEDON 16					
0–18	2.5	4.7	6.5	10.5	6.2	47.0	22.6	15.8	6.8	0.30
18–25	1.7	4.3	5.7	9.8	6.9	45.4	26.2	18.8	7.4	.28
25–36	*1.7*	*3.4*	*3.9*	*6.3*	*5.1*	*34.3*	*45.3*	*25.1*	*20.2*	*.45*
36–58	*1.5*	*3.0*	*3.3*	*6.2*	*5.9*	*37.3*	*42.8*	*26.6*	*16.2*	*.38*
58–74	2.4	3.7	3.5	6.5	7.4	41.8	34.7	25.2	9.5	.27
74–89	1.8	4.1	3.8	6.1	7.1	44.2	32.9	24.0	8.9	.27
					PEDON 17					
0–18	1.1	1.3	1.9	4.7	6.3	51.6	33.1	24.6	8.5	0.26
18–25	.9	1.1	1.6	4.2	6.7	53.1	32.4	23.2	9.2	.28
25–40	*.7*	*1.0*	*1.3*	*3.1*	*5.6*	*47.9*	*40.4*	*24.6*	*15.8*	*.39*
40–53	*.6*	*1.0*	*1.3*	*2.8*	*4.1*	*45.2*	*45.0*	*25.0*	*20.0*	*.45*
53–71	*.3*	*1.0*	*1.1*	*2.8*	*4.9*	*48.5*	*41.4*	*23.3*	*18.1*	*.44*
71–120	*.5*	*1.3*	*1.6*	*3.2*	*4.7*	*50.7*	*38.0*	*23.3*	*14.7*	*.39*
120–140	1.7	3.5	3.8	7.9	8.6	54.0	20.5	15.6	4.9	.23
140–205	2.0	3.1	3.3	6.1	7.8	57.4	20.3	15.3	5.0	.25
205–250	26.7	14.6	6.2	6.3	3.8	30.1	12.3	9.5	2.8	.23
					PEDON 18					
0–4	[1]3.6	4.1	4.9	11.6	10.6	43.5	21.7	16.4	[2]5.3	0.24
4–8	[1]2.2	4.1	5.2	13.1	11.9	39.2	24.3	16.7	[2]7.6	.31
8–20	[1]*2.3*	*4.7*	*6.0*	*13.9*	*11.5*	*32.3*	*29.3*	*16.4*	[2]*12.9*	*.44*
20–28	[1]*3.7*	*4.5*	*5.8*	*13.8*	*10.9*	*33.0*	*28.3*	*21.3*	[2]*7.0*	*.25*
28–58	[1]3.1	4.2	4.7	11.3	10.7	34.5	31.5	26.8	[2]4.7	.15
58–100	[1]3.8	3.8	4.3	11.7	12.0	36.6	27.8	25.1	[2]2.7	.10
100–150	[1]3.3	3.9	4.0	10.5	10.6	37.7	30.0	26.2	[2]3.8	.13

[1] Organic matter was present along with the sand fraction.
[2] Particles less than 0.0001 mm in diameter.

be no clay skins on or in the peds in the zone of active rooting because ped formation and destruction go on at a rapid rate relative to illuviation. In many such argillic horizons, clay skins are present on and in the peds only in the lower parts.

If the argillic horizon shrinks and swells appreciably during the year, the clay within the peds shows a high degree of stress orientation but clay skins may be present only in pores in the C horizon.

If the clay mineral is a tubular halloysite, optical evidence of orientation of the clay cannot be expected. The evidences of translocation may be present, however, in the form of layered coatings of clay on peds or in pores and abrupt differences in particle-size distribution between the coating and the matrix of the ped.

In the field, the layers of oriented clay on the ped

about 10 percent of the clay that was originally in the eluvial horizon and its accumulation in an illuvial horizon normally produce a difference in texture that can be recognized consistently by trained soil morphologists. In such a soil, the ratio of clay in the illuvial horizon to clay in the eluvial horizon is about 1.2, e.g., 25 percent and 30 percent if the two horizons are of about equal thickness. There are common or many clay skins on the peds and in pores. In most medium-textured soils a ratio of this magnitude seems to make a fairly satisfactory division point for identifying an argillic horizon.

In addition to the increased clay content and the clay skins, we can expect the argillic horizon in this situation to have at least three other properties. The

Pedon 11 illustrates a partly degraded argillic horizon. The A&B horizon from a depth of 36 to 48 cm. coarser sand just below two of the three lamellae that were sampled. The effect of lamellae, even those that

most prominent on ped faces. These evidences should be accompanied by signs of shrinking and swelling in the finer textured horizon in the form of occasional slickensides or pronounced, wavy horizon boundaries that have an amplitude of at least 5 cm in a pedon. Figure 1 shows a soil in which the argillic horizon has all these features.

In thin sections, orientation of clay as a result of pressure may be deduced if the faces of prisms show birefringence in light from crossed polarizers and if the interiors of peds show a large amount of optically oriented clay but no clearly identifiable clay skins.

Pedon 20 illustrates such a soil. There is an obvious lithologic discontinuity at a depth of 19 cm. Differences in the size and amount of sand indicate an overlay above the clay. In this soil the marked maximum in the ratio of fine clay to total clay between the depths of 28 cm and 76 cm is considered adequate evidence for the presence of an argillic horizon.

Some soils that formed in very fine residuum have

The abrupt, irregular boundary between the A and B horizons in this pedon seems to preclude the presence of a biomantle. The similarity in size and composition of sand in the A and B horizons eliminates a sedimentary difference. Destruction of clay in the A horizon could be postulated as an explanation of the differences in clay content of the horizons, but the low activity of the clay and the small proportion of clay that can be identified suggest that destruction of clay has been as important in the B horizon as in the A horizon. The few thin clay skins in the upper part of the B1 horizon, the more common and thicker clay skins below a depth of 1 m, and the gradual decrease in clay skins and in clay content below a depth of 2.5 m all demonstrate the illuvial nature of the B horizon.

Truncated soils and soils formed in anisotropic parent materials.—Stratified parent materials and truncated soils that have lost their surface horizons present different problems in the identification of an argillic horizon. If the eluvial and illuvial horizons

zon forms below an eluvial horizon, but it may be at the surface if a soil has been partially truncated. It has the following properties that can be used for identification:

1. If an eluvial horizon remains and if there is no lithologic discontinuity between it and the argillic horizon, the argillic horizon contains more total clay and more fine clay than the eluvial horizon, as follows. The increases in clay are reached within a vertical distance of 30 cm or less.

least one-third than the ratio in the overlying or the underlying horizon or if it has >8 percent more fine clay. The evidences of pressure may be occasional slickensides or wavy horizon boundaries in the illuvial horizon.

5. If a soil has a lithologic discontinuity between the eluvial horizon and the argillic horizon or if only a plow layer overlies the argillic horizon, the argillic horizon needs to have clay skins in only some part, either in some fine pores or, if peds exist, on some verti-

worms are less common and the illuvial materials accumulate as lamellae directly below the Ap horizon. If the lamellae are 5 mm or more thick, have color value of 4 or less, moist, and chroma of 2 or less, and constitute 5 percent or more by volume of a horizon that is 10 cm or more thick, the horizon is considered an agric horizon.

Pedon 22 illustrates an agric horizon in a humid climate. The agric horizon begins at a depth of 23 cm, the base of the Ap horizon, and extends to a depth of about 130 cm. Below that depth the influence of worms is still evident but the holes and fillings are <5 percent of the volume.

The agric horizon in this soil is also part of an argillic horizon. An agric horizon may form in several of the other diagnostic horizons, but not in a mollic or an anthropic epipedon. A soil in which an illuvial horizon has formed in the mollic epipedon is distinguished by other means.

Natric horizon

The natric horizon (NL. *natrium*, sodium; implying acidity and calcium than magnesium and sodium if (a) the lower subhorizons in the upper 40 cm have a dominance of magnesium and sodium and (b) some horizon within 2 m of the surface has an SAR ≥13 (or ESP ≥15).

Plate 4B shows the appearance of the upper boundary of a natric horizon. In this soil the columns are strongly developed.

The effect of sodium on dispersion of clay and on formation of a B horizon of illuvial clay has long been recognized. The importance of special recognition of an illuvial horizon that is strongly affected by sodium has not been seriously questioned.

The effect of magnesium ions on dispersion of clay is still disputed. Laboratory studies seem to show but slight difference between the effects of magnesium and of calcium. Yet it is common to find poor physical condition in a clay that has a large amount of exchangeable magnesium. The reasons for the poor physical condition are uncertain. Magnesium is considered in the definition of the natric horizon because, as sodium is removed, magnesium follows in the leaching sequence if chlorides are low and sulfates high. If leaching con-

tropical or subtropical regions. Because of the annual leaching, base saturation is low, <50 percent by NH_4OAc.

The sombric horizon has lower color value or chroma, or both, than the overlying horizon and commonly, but not necessarily, contains more organic matter than the overlying horizon. It may have formed in

are separated by an eluvial horizon (A′2) as shown in plate 7B, but under heath vegetation a spodic horizon may rest directly on and may tongue into an argillic horizon. In calcareous parent material, formation of a spodic horizon does not commence until carbonates have been leached from the upper part of the soil. A spodic horizon can form in relatively fresh parent ma-

Hence, if solutions of organic compounds moving through the soil pick up sesquioxides from primary minerals and from part of the spodic horizon, the compounds eventually are precipitated somewhere in the spodic horizon. The movement can be downward because of gravity or it can be lateral or upward. Upward movement due to capillary forces is suggested by the black, humus-rich subhorizon above and on the sides of tongues of the A2 horizon that commonly penetrate at various angles into the spodic horizon. Immobilization of sesquioxides may also be the result of hydrolysis of the organic-metal complex induced by changes in pH or by biological destruction of organic ligands. Some of the specific properties of the immobilized material that becomes the active fraction of a spodic horizon are (1) high concentrations of carboxyl and hydroxyl sites that are destroyed on heating and (2) solubilization of organic matter and sesquioxides on treatment with a strong complexing agent such as sodium pyrophosphate.

Distinctions between spodic and argillic horizons

Argillic horizons are illuvial and so are most spodic horizons. We think that discrete crystalline clay particles are moved within an illuvial horizon and from an eluvial to an illuvial horizon to form an argillic horizon. Hence, in a soil that has an argillic horizon, the

Distinctions between spodic and cambic horizons

A cambic horizon is formed by alteration of parent material in place, resulting in release of iron and formation of structure, or by solution and removal of carbonates. Illuviation is not significant in its genesis. There are two situations in which a spodic and a cambic horizon might be confused in the field. A cambic horizon may grade laterally by imperceptible stages into a spodic horizon as a result of increasing accumulation of organic matter-sesquioxide complexes. A very weakly developed spodic horizon, however, contains more organic matter-sesquioxide complexes relative to the layer-lattice clay than a cambic horizon, and the two kinds of horizons can be separated either on the basis of their morphology or by chemical techniques that are described later.

It may be difficult also to distinguish a spodic horizon from a cambic horizon in a soil that developed in pyroclastic material in a cool perhumid climatic region. Under those conditions, part of the amorphous mineral material in a cambic horizon may form complexes with organic matter that are similar to those of a spodic horizon. In this situation, the distinction may be based on evidence of eluviation and on the typical color pattern of a spodic horizon. If there is an overlying eluvial (albic) horizon that is continuous, we may safely infer that the underlying horizon is illuvial.

Commonly, pellets predominate in the upper part of the horizon and coatings in the lower part. If the coatings are very thick, the horizon may be a cemented ortstein. In a dry soil the coatings may be cracked (plate 5B) and may flake off to form pellets. Plate 5B shows a cemented spodic horizon in thin section. Clay skins, which are discussed in the section on the argillic horizon, are not present on peds or in pores in a spodic horizon. Coatings on sand grains in a spodic horizon, however, may not be distinguishable under a hand lens from thin clay coatings in an argillic horizon.

If an albic horizon overlies a spodic horizon, there is seldom any difficulty in deciding that the origin of the spodic horizon was illuvial. Commonly there is a second maximum of organic carbon in the spodic horizon. In some tropical and subtropical areas, the albic horizon may be extremely thick and the spodic horizon may occur at a depth of >2 m. A buried spodic horizon may be present at even greater depth. The presence of organic carbon and the characteristics of the exchange complex distinguish a cemented spodic horizon (ortstein) from an ironstone layer (petroferric contact, defined in this chapter) at a lithological discontinuity below many soils. In undisturbed soils that do not have an albic horizon, there commonly is a thin, dark eluvial horizon in which many sand grains are free of humus and of sesquioxide coatings. Many spodic horizons, however, are so close to the surface of the mineral soil that the horizons overlying them are easily destroyed by plowing or even by the disturbances that accompany cutting a forest. In some soils, the albic or other overlying horizons seem to have riety of reasons. Some soils, particularly those on calcareous parent materials in cool humid climates, have two horizons of accumulation. The upper horizon contains an accumulation of amorphous materials and the lower contains layer silicate clays. The two are separated by an eluvial horizon. This sequence of horizons is defined later as a bisequum. In this situation a spodic horizon has formed or has begun to form in a clay-depleted eluvial horizon. Other spodic horizons are thin because they rest on a fragipan or on a C or an R horizon. In very cold humid climates, it is normal that any illuvial horizon is one of organic matter and amorphous sesquioxides, but it is thin. Very thin horizons of accumulation are easily destroyed by plowing, trampling by livestock, or logging. To prevent changes in the classification of a soil as a result of such minor disturbances, a minimum depth is required for a spodic horizon, depending on the soil temperature regime. Soil temperature regimes are defined later in this chapter. If the soil temperature regime is frigid or warmer, the spodic horizon must extend deep enough that the field and laboratory criteria listed next can be recognized below a depth of 12.5 cm. If the soil temperature regime is cryic or pergelic, depth limits are waived. This is done because in the coldest soils there is little prospect of serious disturbance of significant areas. If the soil is disturbed, the whole soil is altered and the classification of the disturbed soil probably would be affected.

Identification of the spodic horizon by field criteria alone.—A spodic horizon is identified on the basis of field evidence alone if there is an ortstein that is con-

the spodic horizons so weakly developed that positive identification in the field is impossible.

The chemical characterization of a spodic horizon consists of two parts. The first criterion establishes a minimum degree of expression of the horizon. The reason for this criterion is that the amount and distribution of amorphous material in different spodic horizons vary widely. One soil may contain a large percentage of amorphous material in a thin horizon. Another, particularly in coarse sand, may have only a small percentage but may have a thick horizon of accumulation. It seems essential to set some lower limit for the amount of precipitated material. We can use the high cation-exchange capacity of the amorphous materials to set this limit. Because a part of the exchange capacity is a function of the silicate clay present, a correction must be made for this clay. The amount of accumulation is estimated by an index number that is computed by multiplying the CEC (by sum of cations, stated as meq per 100 g soil), minus half the percentage of measured clay, by the thickness in centimeters horizon by horizon. If the horizon is a

or more of the clay percentage. If the iron is less than 0.1 percent, the extracted elemental Al+C must be one-fifth or more of the clay percentage. Furthermore, the sodium pyrophosphate extraction must remove half or more of the amount of Al and Fe removed by dithionite-citrate extraction. This last criterion serves primarily to distinguish the cambic horizon of a soil formed in pyroclastic materials from a spodic horizon.

Pedon 26 illustrates a soil that has a spodic horizon that can be identified only in the laboratory.

Summary of the limits of a spodic horizon

A spodic horizon is normally a subsurface horizon that underlies an O, A1, Ap, or A2 horizon. It may, however, meet the definition of an ochric or umbric epipedon. A spodic horizon has the morphological or the chemical and physical characteristics that are listed next, and its hue and chroma remain constant with increasing depth or the subhorizon that has the reddest hue or the highest chroma is near the top of the horizon. The color changes within 50 cm from the top of the horizon.[6] If the soil temperature regime is

Placic horizon

The placic horizon (Gr. base of *plax*, flat stone; meaning a thin cemented pan) is a thin, black to dark reddish pan cemented by iron, by iron and manganese, or by an iron-organic matter complex. Its thickness ranges generally from 2 mm to 10 mm. Rarely, it is as thin as 1 mm or as thick as 20 to 40 mm in spots. It may be, but not necessarily, associated with stratification in parent materials. It is in the solum, roughly parallel to the soil surface, and is commonly within the upper 50 cm of the mineral soil. It has a pronounced wavy or even convolute form. It normally occurs as a single pan, not as multiple sheets one underlying another, but in places it may be bifurcated. It is a barrier to water and roots.

An iron-cemented pan is strong brown to dark reddish brown. A pan cemented by iron and manganese or by iron-organic matter complexes is black or reddish black. A single pan may contain two or more layers cemented by different agents. Iron-organic matter cements commonly are present in the upper part of the pan.

The genesis of the placic horizon, often called a thin

gation or removal of free iron oxides along with biologic decomposition of inherited organic matter.

The cambic horizon has lost sesquioxides or bases, including carbonates, or both, through leaching. Gains may have occurred in organic matter and water, but the alteration of the cambic horizon is not the result of additions of mineral substances by illuviation.

A cambic horizon is at the surface in some truncated soils. Otherwise, it is immediately below one of the diagnostic epipedons. It is considered a part of the solum, and it occurs within the zone that normally is reached by roots of native plants. Thus, it normally lies in the position of a B horizon and is considered to be a B horizon in this system of soil classification. Its base must be at least 25 cm (10 in.) below the surface unless the soil temperature regime is cryic or pergelic.

It is the intent to confine the concept of the cambic horizon to one of a horizon that has features representing genetic soil development without mineral accumulation or extreme weathering. For this reason, a horizon that exhibits genetic development is excluded from the concept if it is transitional to a horizon that has more strongly expressed genetic features.

Below many argillic and spodic horizons there is a

do not seem to justify the complication that would have to be introduced if one tried to distinguish clearly the transitional forms. Nevertheless, it is important to understand that cambic horizons vary in appearance and in genetic significance. We should consider the typical forms that the cambic horizon may have under

decreases in a regular manner with increasing depth and reaches a low level in the deep layers. The organic carbon in the cambic horizon that forms in the presence of a fluctuating ground-water level decreases regularly with increasing depth and reaches a level of 0.2 percent or less within a depth of 1.25 m below the sur-

1. A cambic horizon may form in the presence of fluctuating ground water. If ground water is present in a horizon at all times, the color usually is neutral or consists of shades of green or blue. If the color is neutral or consists of shades of green and blue and the hue changes on exposure to air, the horizon is excluded from the concept of the cambic horizon on the assumption that losses of iron have been negligible. If the level of ground water fluctuates, free iron generally is removed from the individual particles of sand, silt, and clay. This iron either is lost from the horizon or is concentrated in the form of concretions or mottles. Gray or grayish and brownish mottled horizons are produced by fluctuating ground water. Mottling alone, however, is not evidence of sufficient alteration for identification of a cambic horizon. The processes of reduction or of reduction and segregation of the iron must have been intense enough to produce a horizon dominated by low chroma. The horizon must have an upper boundary that is <50 cm (20 in.) below the surface. It must have dominant moist colors on ped faces if peds are present or in the matrix if peds are absent, as follows:

some season in most years to a width of 1 cm or more at a depth of 50 cm or the soil has permafrost or (b) there is a histic epipedon consisting of mineral soil materials or a mollic or umbric epipedon overlying the cambic horizon. The biologic regimes that produce these epipedons rich in organic matter also produce a relatively large amount of organic matter at considerable depth, and churning due to soil cracking or freezing can move organic-rich materials to a considerable depth.

Weathering may have affected the easily weatherable minerals. The weathering may have removed lattice iron or may have formed secondary clay minerals, but weathering has not progressed to the point where virtually the only minerals present are clay-size kaolin minerals and free sesquioxides along with quartz and other forms of SiO_2.

Pedon 28 illustrates this kind of cambic horizon. This soil has a mollic epipedon 30 cm thick that rests on the cambic horizon.

2. In the absence of ground water and of carbonates, cambic horizons in soils of temperate humid regions normally are brownish. Because free iron oxides have

tle pore space in the matrix. It differs from an argillic horizon because it has in all subhorizons few or no clay skins that are distinctly finer than the matrix. Under crossed polarizers, the brightness of the inter-

the presence of an underlying horizon that contains a much larger amount of carbonates than the soil morphology indicates have been reprecipitated. Carbonates that are in transit through the cambic horizon may

does not have evidences of significant illuviation and does not have the properties that are diagnostic for an argillic or a spodic horizon. It does not have the cemented or brittle properties that are definitive of the duripans or fragipans that are defined later in this chapter.

Summary of properties

In summary, the cambic horizon is an altered horizon that does not have the dark color, organic-matter content, and structure that are definitive of a histic, a mollic, or an umbric epipedon, and it has

1. Texture that is very fine sand, loamy very fine sand, or finer in the fine-earth (<2 mm) fraction;
2. Soil structure or absence of rock structure in at least half the volume;
3. Significant amounts of weatherable minerals that consist of (a) enough amorphous or 2:1 lattice clay to give a cation-exchange capacity (by NH_4OAc) of more than 16 meq per 100 g clay, or (b) >3 percent weatherable minerals other than muscovite, or (c) >6 percent muscovite;
4. Evidence of alteration in one of the following forms:
   a. Gray colors as defined on page 34 an aquic moisture regime, defined later, or artificial drainage, and one or more of the following properties:
      (1) A regular decrease in the amount of organic carbon with depth and a content of <0.2 percent organic carbon at a depth of 1.25 m below the surface or immediately above a sandy-skeletal substratum that is at a depth of <1.25 m;
      (2) Cracks that open and close in most years and are 1 cm or more wide at a depth 50 cm below the surface;
      (3) Permafrost at some depth;
      (4) A histic epipedon consisting of mineral soil materials or a mollic or umbric epipedon;
   b. Stronger chroma, redder hue, or higher clay content than the underlying horizon;

Oxic horizon

The oxic horizon is intended to characterize a mineral subsurface horizon in an advanced stage of weathering. It is an altered subsurface horizon at least 30 cm (12 in.) thick. It consists of a mixture of hydrated oxides of iron or aluminum, or both, with variable amounts of 1:1 lattice clay[10] and accessory highly insoluble minerals such as quartz sand. Its fine-earth fraction has few or no primary minerals that can weather to release bases, iron, or aluminum. For each 100 grams of clay that it contains, the fine earth holds 10 meq or less of cations from an unbuffered 1N NH_4Cl solution and has a cation-exchange capacity, by NH_4OAc, of 16 meq or less per 100 g clay. The oxic horizon has a lower exchange capacity or a smaller amount of weatherable minerals than the cambic horizon. It differs from the argillic horizon in having few or no clay skins and in having either no increase or a gradual or diffuse increase in the percentage of clay at increasing depth. Its upper boundary is set at the least depth at which the cation-exchange capacity requirements of the oxic horizon are met, but not above 15 cm or the base of the Ap horizon. For diagnostic purposes, its lower boundary is usually set at a depth of 2 m. These properties and limits are discussed later in more detail. Plate 4D illustrates a soil that has an oxic horizon.

Genesis

Oxic horizons generally are in soils of very old, stable geomorphic surfaces. The surface is more likely to be mid Pleistocene or older than late or post Pleistocene. Oxic horizons are not in soils of recent surfaces where the regolith is thin.

If quartz or ironstone pebbles are present, stone lines in or under the oxic horizon are normal. Stone lines are so common that one must consider it probable that oxic horizons are mainly in very old biomantles or transported sediments. Quartz veins can be traced from deep layers through cambic or argillic horizons, but the authors have not seen them in oxic horizons. It should be noted, however, that quartz veins

The age of an oxic horizon is such that minerals weatherable in a warm humid climate are absent or are present only in traces. There is, therefore, no reserve of bases beyond those held on the exchange com-

but others have called it a C horizon. It is considered to be a B horizon in this system.

The boundary between the epipedon and the oxic horizon is normally diffuse unless the soil has been

Oxic horizons are seldom found outside tropical or subtropical climates, and there they are mainly at elevations below 1,500 to 2,000 meters. Within that zone, however, their distribution is largely independent of the present rainfall, suggesting that some formed under much higher rainfall than they receive today.

Most of the soils that have an oxic horizon are nearly level or have relatively gentle slopes; relief commonly is only a few tens of meters. They occur mostly on old high-level surfaces, high terraces, and pediments. The geomorphic position is one in which weathered sediments could have been deposited. It is not one in which recent unweathered sediments could accumulate, nor is it one that would receive ground water that has moved laterally from an area where fresh rock is weathering.

Significance to soil classification

Although much remains to be learned about the gen-

ficult to locate because the epipedon may not be visibly darkened even though it may contain 5 to 10 percent organic matter.

Materials similar to those in the oxic horizon extend in some soils to a depth of many meters without apparent change. The lower boundary of the oxic horizon in such a soil must either be established arbitrarily or remain unknown. For practical reasons, we have set an arbitrary lower boundary at 2 m if the soil material between a depth of 1.7 m and 2 m meets the requirements of the oxic horizon.

A very few soils have an epipedon whose thickness approaches or exceeds 2 m. They are mostly kitchen middens or soils that have been mixed intensively and deeply. We have set the lower boundary of the oxic horizon in these soils at a depth that permits sampling an oxic horizon that is at least 30 cm thick. In this situation the epipedon has all the diagnostic properties of an oxic horizon discussed later except that the

esis of oxic horizons, it is important that weathering

cation-exchange capacity by NH OAc is greater than

fragments that retain the original rock structure (saprolite) are absent or constitute less than 5 percent by volume unless they have been coated and cemented by iron oxides or gibbsite. Such rock structure can usually be recognized readily by varicolored spots of

from 1*N* NH_4Cl solution or, in noncalcareous soils, the sum of extractable bases and KCl-extractable aluminum, (4) exchange capacity at pH 7 (by NH_4OAc), (5) percentage (by volume) of clay skins identifiable in thin sections, and (6) identification of clay minerals.

of cations, after the soil has been saturated with ammonium in an unbuffered 1*N* NH_4Cl solution and washed free of excess salt, is 10 meq or less per 100 g clay, or there are <10 meq of extractable bases plus KCl-extractable aluminum per 100 g clay. These values include any retention by the organic matter or by the silt and sand fractions. For acid soils that do not contain amorphous aluminosilicates, cation retention as just defined is similar to some concepts of the "permanent exchange capacity." Its numerical value in an oxic horizon approximates the sum of extractable bases and KCl-extractable aluminum if the soils are noncalcareous and free of soluble salts. Different diagnostic horizons of soils representative of several suborders are compared in table 4 by giving the measured percentages of organic carbon, clay, and 15-bar water, the extractable bases and aluminum, and the cation-exchange capacity by five methods. The Quillayute, Honakaa, and Haiku soils are all believed to contain amorphous aluminosilicates that have high exchange capacity, and in each of them there are significant differences in the values for "permanent charge," retention of ammonium ions from unbuffered NH_4Cl, retention of ammonium ions at pH 7, and sum of cations. The 15-bar water content and percentage of clay measured by the pipette method indicate that each horizon has >50 percent clay. The clay, silt, and sand fractions in each of the horizons listed, except in the argillic horizon of the Limones soil, seem to be very similar mineralogically to other horizons within each pedon, but there are wide differences between the soils in the nature of the clay.

Cation-exchange capacity. Organic matter, sand, silt, and clay all contribute to the cation-exchange capacity of the oxic horizon. In some soils, the sand, silt, and clay have almost identical mineralogy. In these, the sand and silt are mostly aggregates that do not disperse until the iron is removed. As a rule, the clay is primarily a mixture of 1:1 lattice clay and oxides of iron and aluminum, but some oxic horizons have an appreciable amount of the aluminum-interlayered chlorite that was mentioned previously. If this mineral is absent or is present only in small amounts as shown by X-ray analysis, the cation-exchange capacity of the oxic horizon by NH_4OAc, including any contribution by the organic matter, silt, and sand, is 16 meq or less per 100 g clay as estimated by the methods discussed earlier. This limit is introduced to exclude soils that have an appreciable amount of amorphous clay that has high pH-dependent exchange capacity. Those soils usually have a low "permanent charge" but have moderate to high exchange capacity at pH 7 and pH 8.2 (see the Haiku, Honakaa, and Quillayute soils in table 4).

If X-ray diffraction shows an appreciable 14Å peak, if DTA shows no low-temperature endotherm, and if cation-retention values are within the ranges of the oxic horizon, the limit for cation-exchange capacity by NH_4OAc is waived.

Thin sections. Seldom will there be any need to determine the volume of clay skins. The determination may be needed to distinguish between an argillic horizon and an oxic horizon in a few soils. The limits are discussed under the argillic horizon. An oxic horizon should have no subhorizon that has as much as 1 percent clay skins if the other features of an argillic horizon are present. Thin sections of an oxic horizon show either no preferred orientation of the clay or only the pressure orientation that is discussed under the argillic horizon. Occasional clay skins can be seen in the middle or lower part of some oxic horizons. Pseudomorphs of feldspars and micas should be absent or nearly absent, as these are usually remnants of the original rock structure.

Clay mineralogy. We think that quantitative identification of the clay minerals should seldom be necessary to identify an oxic horizon. The quantitative accuracy of present methods is still subject to debate. If 2:1 lattice clays, other than an aluminum-interlayered chlorite, or amorphous clays that have high pH-dependent charge are present in significant amounts, the "permanent charge" and the cation retention by the clay fraction or the cation-exchange capacity by NH_4OAc, or both, are too high for an oxic horizon. The diagnostic horizons of the Cialitos, Waihuna, and Astoria soils (table 4) contain identifiable 2:1 lattice clays. The horizons reported for the Haiku, Honakaa, and Quillayute soils seem to contain amorphous clays. All of them are clearly excluded from the oxic horizon by their cation-exchange properties except the Haiku, which has a marginal exchange capacity by NH_4OAc of 16.3 meq per 100 g clay (calculated at 2.5 times the 15-bar water). The Haiku horizon, however, is also excluded because it meets the requirements of an argillic horizon.

Summary of properties

In summary, the oxic horizon is a subsurface horizon, exclusive of the argillic or natric horizon, that

1. Is at least 30 cm thick;
2. Has a fine-earth fraction that retains 10 meq or less ammonium ions per 100 g clay from an unbuffered 1*N* NH_4Cl solution (meq of NH_4 retained per 100 g soil × 100 ÷ clay percentage [15] ≤10) or has <10 meq of bases extractable with NH_4OAc plus aluminum extractable with 1*N* KCl per 100 g clay;
3. Has an apparent cation-exchange capacity of the fine-earth fraction of 16 meq or less per 100 g clay by NH_4OAc unless there is an appreciable content of aluminum-interlayered chlorite (meq CEC per 100 g soil × 100 ÷ clay percentage ≤16, clay percentage as in footnote 15);
4. Does not have more than traces of primary aluminosilicates such as feldspars, micas, glass, and ferromagnesian minerals, as discussed earlier;
5. Has texture of sandy loam or finer in the fine-earth fraction and has >15 percent clay;
6. Has mostly gradual or diffuse boundaries between its subhorizons; and
7. Has <5 percent by volume that shows rock structure.

Pedons 32 and 33 illustrate the oxic horizon. In pedon 32 the oxic horizon begins at a depth of 30 cm

[15] The percentage of clay as measured by the pipette method or 2.5 times 15-bar water, whichever value is higher but not more than 100.

TABLE 4.—*Selected characterization data for some oxic, argillic, and cambic horizons and for one sample of saprolite*

[Nd indicates no data; --- indicates none detected]

Name of soil series and state	Horizon	Organic carbon	Clay	15-bar water	Extractable cations		Cation-exchange capacity of clay by—				
					Al^{+++} [1]	Total bases [2]	NH_4Cl at pH 7 [3]	NH_4Cl unadjusted [4]	Permanent charge [5]	NH_4OAc	Sum of cations [6]
		Percent	*Percent*	*Percent*	*meq/100 g soil*	*meq/100 g soil*	([7])	([7])	([7])	([7])	([7])
Pooku, Hawaii	Oxic	1.6	Nd	36.0	0.2	0.2	Nd	0.7	0.4	5.2	Nd
Delicias, P.R.	C2, saprolite	.2	[8] 42.2	26.5	---	3.3	5.0	4.8	5.0	6.9	16.5
Catalina, P.R.	Oxic	1.2	82.1	32.3	2	2.0	9.5	6.2	5	10.7	24.0
Haiku, Hawaii	Argillic [9]	2.0	Nd	38.1	0.4	1.3	Nd	6.8	1.8	16.3	Nd
Cialitos-like, P.R.	Argillic [10]	2.0	81.8	34.1	8.1	2.1	22.4	15.3	12.0	23.3	35.8
Limones, P.R.	Argillic	.3	47.4	22.6	4.3	1.1	12.7	9.9	9.6	14.9	22.5
Waihuna, Hawaii	Cambic [10]	.2	Nd	32.1	---	20.3	Nd	26.5	25.4	27.6	Nd
Astoria, Oreg.	Cambic [10]	.5	[8] 41.6	29.7	32.8	1.4	54.8	45.4	46.1	Nd	64.5
Honakaa, Hawaii	Cambic [9]	5.1	Nd	135	---	0.7	Nd	7.7	0.7	23.0	Nd
Quillayute, Oreg.	Cambic [9]	1.6	[8] 18.1	23.8	1.3	1.2	38.5	13.4	4.2	Nd	54.4

[1] Extractable in 1*N* KCl.
[2] Extractable in NH_4OAc.
[3] Extractable in 1*N* NH_4Cl, pH adjusted with NaOH.
[4] Extractable in 1*N* NH_4Cl, unbuffered.
[5] Bases extractable in NH_4OAc plus Al extractable in 1*N* KCl.
[6] Extractable bases plus extractable acidity measured at pH 8.1.
[7] Meq per 100 g clay or meq per 100 g soil ÷ (2.5 × 15-bar H_2O) if that product is greater than the percentage of clay (but divisor does not exceed 100).
[8] Dispersion was incomplete.
[9] Contains some allophane.
[10] Contains some 2:1 lattice clay.

and extends below 2 m; below 65 cm the material has a net positive charge. There are only traces of bases throughout the soil below 10 cm. The sand and silt fractions have virtually no weatherable minerals. This pedon represents extreme weathering and loss of bases. Because this soil supports little vegetation, the total supply of calcium in the soil and in the plants can barely reach 100 kg per hectare.

Pedon 33 shows less weathering and leaching. The oxic horizon begins at the base of the plow layer and extends to a depth of about 1.85 m. Although the ratio of cation-exchange capacity to measured clay exceeds 16 in the lower 30 cm of the oxic horizon, the ratio estimated by 2.5 times 15-bar water is well below 16. Pedon 33 has been cultivated and has received some lime and fertilizer. Plate 4D is a photograph of this kind of soil.

Duripan

The duripan (L. *durus*, hard, plus pan; meaning hardpan) is a subsurface horizon that is cemented by silica to the degree that fragments from the air-dry horizon do not slake during prolonged soaking in water or in HCl. Duripans vary in the degree of cementation by silica and, in addition, they commonly contain accessory cements, chiefly iron oxides and calcium carbonate. As a consequence, duripans vary in appearance, but all of them have very firm or extremely firm moist consistence and they are always brittle, even after prolonged wetting. They grade into the petrocalcic horizons of semiarid and arid climates, into the fragipans of humid climates, and into noncemented earthy materials.

Genesis

Duripans occur mostly in soils of subhumid Mediterranean or of arid climates, that is, in soils that are usually dry or that are seasonally dry. They have a moisture regime in which soluble silica might be expected to be washed down into but not out of the soil.

The parent materials of soils that have a duripan normally contain only a small amount of calcium. If calcium is abundant, a calcic horizon tends to supplant

Appearance in an arid climate

The strongly cemented duripans of arid climates are usually platy and the plates are roughly 1 to 15 cm thick. Pores and the surfaces of the plates are coated with opal and with some birefringent material that is probably a microcrystalline form of silica. Carbonates generally are present in small to large amounts. Roots commonly are between the plates. The cementation can be destroyed by first soaking in acid to remove any carbonates and then soaking in hot concentrated alkali. If a calcareous laminar layer similar to that of the petrocalcic horizon is present, cementation in at least half of the laminar layer is not destroyed by soaking in acid, but is completely destroyed by soaking in hot concentrated alkali, either as a single treatment or by alternating treatments with acid. Usually the presence on the laminar layer of a continuous, thin opal capping that is insoluble in acid indicates enough cementation by silica to satisfy this requirement. If no laminar layer is present and if the horizon is cemented and satisfies criteria of the calcic horizon, it is a duripan if at least one continuous subhorizon within the horizon does not slake in acid. Usually a nearly continuous layer of secondary silica occurs in the part of the horizon that does not slake in acid.

The forms of duripan that are transitional to regolith in arid climates are massive and are very firm or extremely firm when moist and brittle when wet. Laminar caps of silica and coatings of silica on plates are not essential. For the horizon to be a duripan there must be at least (1) a few vertical opal coatings, (2) some durinodes, or (3) silica pendants on under sides of coarse fragments. In addition, opal or other forms of silica partly fill interstices and form bridges between sand-size mineral grains. Moistened specimens of this form of the duripan commonly show a dull glassy luster when viewed under a hand lens. These forms of the duripan can be penetrated with some difficulty with an auger. Under irrigation such horizons are slowly permeable to water, and they are virtually impenetrable to roots of many plants.

Appearance in a Mediterranean climate

In the forms transitional to regolith, the duripans are only weakly cemented. If the pan is moist, brittle-

thicker than in the weakly cemented pans. Water often stands temporarily on top of the pan during the rainy season. Coatings of iron, manganese, and oriented clay may be observed on many of these pans. Subsequent deposits of opal could engulf such coatings and give rise to a cementation that can be broken down only by repeated alternating treatments with solutions of concentrated acid and alkali. Carbonates may be present above the pan or in any part of it, or they may be completely absent. These observations indicate that carbonates are not an essential part of the pans.

In more humid climates, the duripan has characteristics transitional to the fragipan, which is discussed later, and carbonates and salts are absent in the pan. The opal coatings in pores and on the sides of prisms are absent, and in their place are mottles of gray and strong brown. If the strength of cementation in the pan is such that the dry pan slakes when placed in water, we consider the horizon a fragipan rather than

dry fragment slakes or fractures when placed in water. A fragipan is usually mottled, is slowly or very slowly permeable to water, and has few or many bleached, roughly vertical planes that are faces of coarse or very coarse polyhedrons or prisms. These polyhedrons are illustrated in plates 6A and 6B. Plate 6A shows a soil in which the fragipan has an upper boundary at a depth of about 60 cm. Plate 6B shows the upper surface at a horizontal cut in the pan. Pedon 34 is an example of another soil in which the fragipan is a bit deeper. Most commonly, a fragipan has an abrupt or clear upper boundary at a depth of 33 to 100 cm below the original surface. Thickness ranges from about 15 to 200 cm, and ordinarily the lower boundary is gradual or diffuse. A fragipan is virtually free of roots except along the bleached prism faces. It should be noted that the bleached materials are not brittle when moist although, if clayey, they may be hard when dry. Clay skins may be patchy or discontinuous both on the faces and in the interiors of

would be another noteworthy accident. Fragipans stable when exposed in banks than either the overly-

Significance to soil classification

Any continuous horizon that impedes movement of water and growth of roots is important to soil classification—particularly for interpretations of soils for plant growth and for engineering manipulations. Water stands above the pan in a level soil and moves laterally along the top of the pan if the soil is sloping. Even though the processes that produce the fragipans are imperfectly known, these pans are restricted in their climatic range and natural vegetation and are believed to be genetic.

Identification

There is no known laboratory procedure for identi

Seventh, an air-dry fragment about the size of a fist slakes or fractures when placed in water.

Pedon 34 illustrates a soil that has a fragipan below an argillic horizon. The pan is relatively deep and has its upper boundary at a depth of about 94 cm and its lower boundary at about 150 cm. Despite the humid climate, the slow permeability of the fragipan has caused an accumulation of exchangeable sodium. The only known source of this sodium is the feldspar in the parent material. Release by weathering has exceeded the rate of leaching. The horizon just above the fragipan, where water remains perched, is thought to have been an illuvial horizon before the pan formed but apparently is losing clay at present.

coatings on the sand or silt particles that the hue and chroma of the horizon are determined chiefly by the color of the sand and silt particles.

Limestones and marls are formed by precipitation of calcium carbonate or of calcium and magnesium carbonates just as are calcic horizons. A modern ca

the water table, such soils may occupy depressions. If water was ponded, a soil that has a calcic horizon forms a circular outline around the deeper depressions and also occurs on micro elevations in the depressions.

In the situations just discussed, one might attach a high genetic significance to a calcic horizon. In some other circumstances, however, one can attach little genetic significance to the absolute amount of carbonates in a horizon or layer of carbonate accumulation. Deposition from ground water at a depth of 3 m or more is more nearly a geologic than a pedologic process. In soils formed from calcareous materials on the steppes, the amount of lime in horizons that contain secondary lime is a partial function of the amount of lime in the parent materials. One might consider the presence or absence of a ca horizon to be significant at some categorical level, but one might not be concerned at any categorical level with the absolute amount that makes the distinction between a ca and a calcic horizon.

Pedon 5 is typical of a soil in which there is a calcic horizon of little genetic significance. The mollic epipedon and the natric horizon are significant to the classification of this soil. The presence of a horizon that has secondary carbonates is significant, but the absolute uous horizon that we call the petrocalcic horizon. Such horizons seem to be mainly in soils older than the Holocene. In the early stages of development, a calcic horizon has lime that is soft and disseminated or that has accumulated in hard concretions or both. The petrocalcic horizon is a mark of advanced soil evolution.

The petrocalcic horizon is a continuous, cemented or indurated calcic horizon that is cemented by calcium carbonate or in some places by calcium and some magnesium carbonate. Accessory silica may be present. The petrocalcic horizon is continuously cemented throughout the pedon to the degree that dry fragments do not slake in water. It cannot be penetrated by spade or auger when dry. It is massive or platy, very hard or extremely hard when dry, and very firm or extremely firm when moist. Noncapillary pores are filled, and the petrocalcic horizon is a barrier to roots. Hydraulic conductivity is moderately slow to very slow. The horizon is usually much more than 10 cm (4 in.) thick.

A laminar capping commonly is present but is not required. If one is present, carbonates normally constitute half or more of the weight of the laminar horizon, and the hardness by Moh's scale is 3 or more. Gravel, sand, and silt grains have been separated by

plied by the percentage of $CaCO_3$ equivalent is 200 or more.

Pedon 40 illustrates a soil that has a petrocalcic horizon. The petrocalcic horizon lies between depths of 28 cm and 64 cm. Plate 10D shows a soil with a petrocalcic horizon that has its upper boundary at a depth of about 70 cm and its lower boundary at a depth of about 150 cm.

Petrogypsic horizon

The petrogypsic horizon is a gypsic horizon that is strongly enough cemented with gypsum that dry fragments do not slake in water and that roots cannot enter. The gypsum content commonly is far greater than the minimum requirements for the gypsic horizon and usually exceeds 60 percent. Petrogypsic horizons are restricted to arid climates and to parent materials that are rich in gypsum. They are rare in the

crease in clay content within a very short distance in depth. If the clay content of the ochric epipedon or the albic horizon is <20 percent, the clay content should double within a distance in depth of 7.5 cm or less. If the clay content exceeds 20 percent, the increase in clay content should be at least 20 percent of the fine-earth fraction, for example, from 22 percent to 42 percent, within a distance of 7.5 cm in depth, and the clay content in some part of the argillic horizon should be at least double that of the horizon above.

A transitional horizon normally is not present or is too thin to be sampled. In some soils, however, there may be tonguing or interfingering of albic materials, which are defined later, in parts of the argillic horizon. The horizon boundary in such a soil is irregular or even discontinuous. The sampling of such a mixture as a single horizon might create the impression of a relatively thick transitional horizon, even though the thickness of the actual transition at the contact may

face.

Salic horizon

A salic horizon is a horizon 15 cm or more thick

Amorphous material dominant in the exchange

6. The bulk density of the fine earth fraction is <0.85

The phrase also means that the horizon that has such mottles is saturated with water at some period of the year or the soil is artificially drained. It is also implicit in the meaning that the temperature of the horizon is above the biologic zero, which is about 5° C (41° F), during at least a part of the time that the horizon is saturated.

Many soils have variegated colors that were produced by eluviation of clay, which left skeletans or whole horizons of uncoated silt and sand that have high value and low chroma. Such a soil is illustrated by plate 3A. The color is variegated, but such a horizon does not come within the meaning of the phrase "mottles that have chroma of 2 or less" unless the horizon is saturated with water at some time of the year when the temperature of the horizon is 5° C or more or the soil is artificially drained. If the soil is periodically wet or is drained, there should be some mottles of high chroma that were caused by segregation of iron or some reddish, very dark, soft accumulations of iron and manganese.

n value

The *n* value (Pons and Zonneveld 1965) refers to the relation between the percentage of water under field conditions and the percentages of inorganic clay and of humus. The *n* value is helpful in predicting whether the soil may be grazed by livestock or will support other loads and the degree of subsidence that would occur after drainage. The *n* value can be calculated for mineral soil materials that are not thixotropic by the formula:

$$n = (A - 0.2R) \div (L + 3H)$$

A is the percentage of water in the soil in field condition, calculated on a dry-soil basis; *R* is the percentage of silt plus sand; *L* is the percentage of clay; and *H* is the percentage of organic matter (organic carbon x 1.724).

This formulation is based on experience with soil materials that have humified organic matter and in which illite and other nonexpanding clay minerals are predominant. There are indications that the factor by which the organic matter is multiplied should exceed 3 if the organic matter is incompletely humified. The correction for the water held by the organic matter becomes an increasing source of uncertainty as the ratio of clay to organic matter becomes narrow. In this taxonomy, the *n* value is used only to characterize mineral soils.

Few data are available in the United States for calculations of the *n* value, but the critical *n* value of 0.7 can be approximated closely in the field by a simple test of squeezing the soil in the hand. If the soil flows with difficulty between the fingers, the *n* value is between 0.7 and 1.0. If the soil flows easily between the fingers, the *n* value is 1 or more.

Soils in which the moisture content is periodically reduced below field capacity seldom have an *n* value of 0.7 or more. Most of those that have been permanently saturated are likely to have a high *n* value. Consequently, high *n* values are primarily in soils of tidal marshes, swamps, and shallow lakes; the sediments there have never been above the capillary fringe during drought cycles. A high calculated *n* value may also be characteristic of some soils that were formed from volcanic ash in a perhumid climate. These soils are thixotropic, and the field test is more reliable than the formula for estimating their bearing value.

Organic soil materials

Organic soil materials either

1. Are saturated with water for long periods or are artificially drained, and have 18 percent or more organic carbon if the mineral fraction is 60 percent or more clay, 12 percent or more organic carbon if the mineral fraction has no clay, or a proportional amount of organic carbon between 12 and 18 percent if the clay content is between zero and 60 percent; or
2. Are never saturated with water for more than a few days and have 20 percent or more organic carbon.

Item 1 in this definition covers materials that have been called peat and muck. Item 2 is intended to include materials that have been called "litter" or O horizons. Not all organic soil materials accumulate under water. Leaf litter may rest on a lithic contact and yet may support a forest. The only "soil" in this situation is organic in the sense that the mineral fraction may be appreciably less than half the weight and only a small proportion of the volume of the soil.

Paralithic contact

A paralithic (lithiclike) contact is a boundary between soil and continuous coherent underlying material. It differs from a lithic contact in that the underlying material, if a single mineral, has a hardness by Moh's scale of <3. If the underlying material is not a single mineral, chunks of gravel size that can be broken out disperse more or less completely during 15 hours of end-over-end shaking in water or in sodium hexametaphosphate solution and, when moist, the material can be dug with difficulty with a spade. The material underlying a paralithic contact is normally a partly consolidated sedimentary rock such as sandstone, siltstone, marl, or shale, and its bulk density or consolidation is such that roots cannot enter. There may be cracks in the rock, but the horizontal spacing between cracks should be 10 cm or more.

Particle-size classes

A number of the definitions of taxa have limits that vary with the amounts of sand, silt, clay, and rock fragments in selected horizons or within arbitrary limits of depth. Particle-size classes are also used as differentiae for families and are defined in more detail in chapter 18. They are summarized in this chapter, however, because they are used in some of the definitions of taxa in the chapters that follow.

Particle-size classes, in contrast to classes of soil texture, are based on both the fine earth and the rock fragments. Classes of soil texture are based on the grain-size distribution of the fine-earth fraction, which consists of the particles <2 mm in diameter.

Particles ≥2 mm in diameter are called rock fragments unless they are greater than or equal to the size of a pedon. They differ from coarse fragments in that they include stones and boulders smaller than the limits of a pedon. The limits between classes of particle size do not always follow the limits between classes of texture. The following particle-size classes are used in definitions of some taxa in the higher categories.

Fragmental.—Boulders, stones, cobbles, gravel, and very coarse sand; fines are too few to fill some of the

Generally, plinthite forms in a horizon that is saturated with water at some season. The original segregation of the iron normally is in the form of soft, more or less clayey, red or dark red mottles. The mottles are

illustrates the appearance of such a soil. The upper sequum is about 30 cm (12 in.) thick, and it includes an albic horizon and a spodic horizon. The lower sequum has an eluvial horizon that extends to a depth of about

into the soil but is withdrawn by evapotranspiration, leaving precipitated carbonates and more soluble salts. Between these two regimes there is another possible one in which there is alternation from year to year; leaching occurs in some years but not in all. For consideration of the losses of soluble materials or their accumulation in ca, cs, or sa horizons, these concepts are adequate. For the understanding of biological processes, they leave much to be desired. A soil can be subject to leaching in the winter when it is too cold for optimum biologic activity, and it can be too dry in most of the summer for significant biologic activity. The result is a relatively wide carbon–nitrogen ratio.

The soil moisture regime, as the term is used here, refers to the presence or absence either of ground water or of water held at a tension <15 bars in the soil or in specific horizons by periods of the year. Water held at a tension of 15 bars or more is not available to keep most mesophytic plants alive. The availability of water also is affected by dissolved salts. A soil may be saturated with water that is too salty to be available to most plants, but it would seem better to call such a soil salty rather than dry. Consequently, we consider a horizon to be dry when the moisture tension is 15 bars or more. If water is held at a tension of <15 bars but more than zero, we consider the horizon to be moist. A soil may be continuously moist in some or all horizons throughout the year or for some part of the year. It may be moist in winter and dry in summer or the reverse. In the northern hemisphere, summer refers to the months of June, July, and August, and winter means December, January, and February. A soil or a horizon is considered to be saturated with water when water stands in an unlined borehole close enough to the soil surface or to the horizon in question that the capillary fringe[17] reaches the surface or the top of the horizon.

Significance to soil classification

The moisture regime of a soil is an important property of the soil as well as a determinant of processes that can go on in the soil. During geologic time there have been significant changes in climate. Soils that could have formed only in a humid climate are in some places now preserved in an arid climate. Such soils have relict features that reflect the former moisture regime and other features that reflect the present moisture regime.

The soil moisture regime is only a partial function of climate. Most deep, permeable soils under high and well-distributed rainfall have water that is available to plants most of the time. But soils in an arid climate are not necessarily dry. They may be dry, moist, or saturated, depending on their position in the landscape, because they may receive water from sources other than the rain that falls on them. In the United States there are even raised peats in an arid climate. The extra water may be runoff from rainfall on an adjacent slope or on distant mountains, or it may come from melting snow, seepage, or even natural artesian waters. Soils may also lose part or most of the water that falls on them, particularly if the soil is sloping and the surface horizon has few noncapillary pores. In any given landscape that has uniform climate, adjacent soils may have different moisture regimes.

Each of the moisture regimes in the history of a soil is a factor in the genesis of that soil and is the cause of many accessory characteristics. Most of the accessory characteristics, however, and those most important for interpretations are associated with the present moisture regime, even if some of the earlier moisture regimes differed widely from the present one. For example, it was pointed out in the discussion of the argillic horizon that, before one could form, enough water had to pass through the soil to remove soluble materials such as finely divided carbonates. If the leaching and formation of the argillic horizon took place under conditions more humid than those existing now, the present argillic horizon is not necessarily free from carbonates or other soluble materials. If a soil has water moving into but not through the argillic horizon, carbonates or salts that reach the surface in dust can accumulate in the argillic horizon and even above it. Therefore, if any of the marks of the moisture regime are to be used as diagnostic properties, it is essential to specify the nature of the present moisture regime. Unless this is done, there cannot be any characteristics accessory to those that are diagnostic. It is for this reason that the moisture regime is used in defining classes in the very high categories. There is the added advantage that the moisture regime of most soils is determined by the present climate, and a small-scale map can be interpreted in terms of the many accessory characteristics that are common to most of the soils that have a common climate (see ch. 20). These characteristics include the amount, nature, and distribution of organic matter, the base status of the soil, and the presence or absence of salts. The most important of the interpretations are the potentials for growing different plants and the cultural practices required to grow them.

Estimation

Although there is a very large body of common knowledge about the moisture variations within soils over time, there are few long-time records and still fewer that can be related to the energy concept of soil moisture. The people who work the soils know how the moisture changes with the seasons, but their knowledge is largely qualitative.

A number of methods have been devised to relate soil moisture to meteorological records. All these methods to date have some shortcomings, even for gently sloping soils that depend primarily on precipitation for their moisture. Dew and fog can add appreciable amounts of moisture to some soils, but quantitative data are rare.

The graphs that accompany the descriptions and data for pedons are based on the average values for precipitation, temperature, and potential evapotranspiration. They give an oversimplified picture of the moisture regime of the whole soil rather than of the moisture control section. They are based on the

[17] The capillary fringe is the zone just above the water table (zero gauge pressure) that remains almost saturated (Soil Sci. Soc. Amer. Glossary, 1965, p. 332).

monthly climatological standard normal (1931–60) values of temperature and precipitation, or the best normals available, and the monthly potential evapotranspiration (PE) normals taken from the large Thornthwaite collection covering the world (Mather 1964, 1965). No reduction from potential evapotranspiration was made. A sample graph is shown in figure 6.

better picture. Either procedure gives a crude picture of both.

A model of moisture accretion and depletion has been developed and tested against limited soil moisture observations made over a 20-year period on the Great Plains. The correlation between the calculated and observed moisture in the moisture control section is about 0.8. This model uses monthly precipitation and

can be suspended by capillary forces in a dry sandy soil (Rode 1965). When the suspended water exceeds a critical limit, it drains rapidly at some points into lower soil layers. Water can be suspended in a dry or a moist soil if pore sizes increase with depth, and similar leaks may occur. Figure 7 shows the marks of repeated leakage from a spodic horizon into the underlying sand. Uneven moistening may result from interception of rain by plants. Part of the rain reaches the soil by flowing down the stem of the plant. Some

cm (4 and 12 in.) if the particle-size class is fine-loamy, coarse-silty, fine-silty, or clayey. The control section extends approximately from a depth of 20 cm to a depth of 60 cm (8 to 24 in.) if the particle-size class is coarse-loamy, and from 30 to 90 cm (12 to 35 in.) if the particle-size class is sandy. Obviously, coarse fragments deepen these limits to the extent that the fragments do not absorb and release water. In addition to the particle-size class, differences in structure, differences in pore size distribution and in other factors

plants such as mulga *(Acacia aneura)* in Australia intercept virtually all the rain falling on them. In this situation, the soil is moistened deeply around the stem but remains extremely dry under the canopy of the mulga, while between plants the rain mostly falls directly on the soil. Thus we have in one large pedon three contrasting moisture regimes; in one, the soil is deeply moistened; in the second, which surrounds the first, the soil receives virtually no moisture; in the third, the soil is intermittently moist and dry.

If moistening occurs unevenly, the weighted average depth of moistening in a pedon is used for the limits of the moisture control section.

As a rough guide to the limits, the soil moisture control section lies approximately between 10 and 30

that influence movement and retention of water in the soil also affect the limits of the soil moisture control section.

The classification of the soil series of the United States (Soil Survey Staff 1972) was determined in part by knowledge of the moisture regimes. The definitions of soil moisture regimes that follow were fitted to the boundaries. If future studies show that the classifications of the soils are not in agreement with these definitions, we are more likely to change the definitions than the classifications. Over time, changes in both will doubtless be made. Under the present crude calculations, one may assume that, in a soil at field capacity that has 200 mm of moisture in storage, some part of its moisture control section will be dry after 75 mm of evapotranspiration if there is no additional precipitation. All parts of its moisture control section will be dry after 175 mm of evapotranspiration in the absence of precipitation.

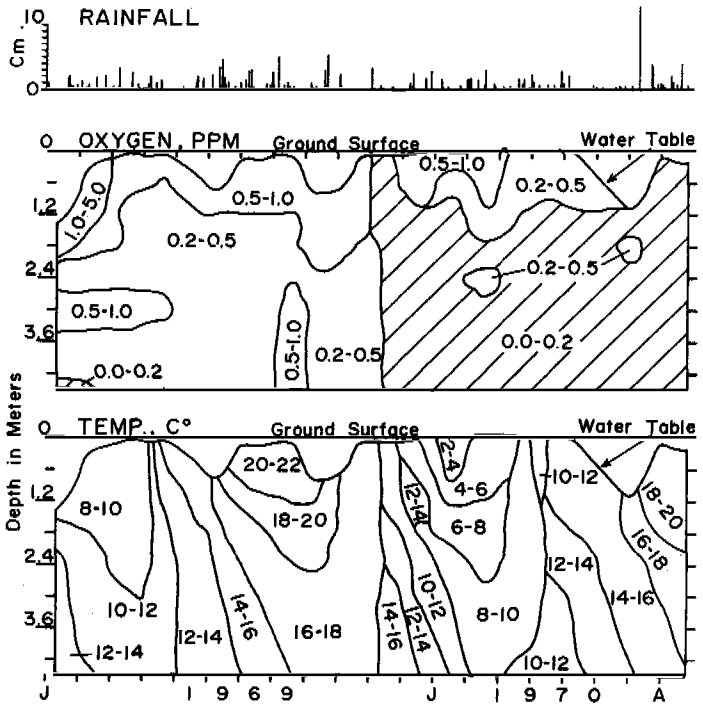


Figure 8.—**Water table, dissolved oxygen, and soil temperature as functions of depth and time during 1969 and part of 1970, illustrating an aquic moisture regime. North Carolina (after Daniels et al. 1973).**

15 cm. In a loamy or clayey soil that does not shrink or swell appreciably, the thickness may be 30 cm or more, depending on the size distribution of the pores.

The duration of the period that the soil must be saturated to have an aquic regime is not known. The duration must be at least a few days, because it is implicit in the concept that dissolved oxygen is virtually absent. Because dissolved oxygen is removed from ground water by respiration of micro-organisms, roots and soil fauna, it is also implicit in the concept that the soil temperature is above biologic zero (5° C) at some time while the soil or the horizon is saturated.

Very commonly, the level of ground water fluctuates with the seasons. The level is highest in the rainy season, or in fall, winter, or spring if cold weather virtually stops evapotranspiration. There are soils, however, in which the ground water is always at or very close to the surface. A tidal marsh and a closed, landlocked depression fed by perennial streams are examples. The moisture regime in these soils is called "peraquic." Although the term is not used as a formative element for names of taxa, it is used in their descriptions as an aid in understanding genesis.

Figure 8 shows the ground water level, temperature, and oxygen in the water, over time, for a soil that has an aquic moisture regime.

Aridic and torric (L. *aridus*, dry, and L. *torridus*,[18] **hot and dry) moisture regimes.**—These terms are used for the same moisture regime but in different categories of the taxonomy.

[18] *Torridus* is not the ideal root, but a better one could not be found. Although soils may not be hot throughout the year, soils that have a torric moisture regime are hot and dry in summer.

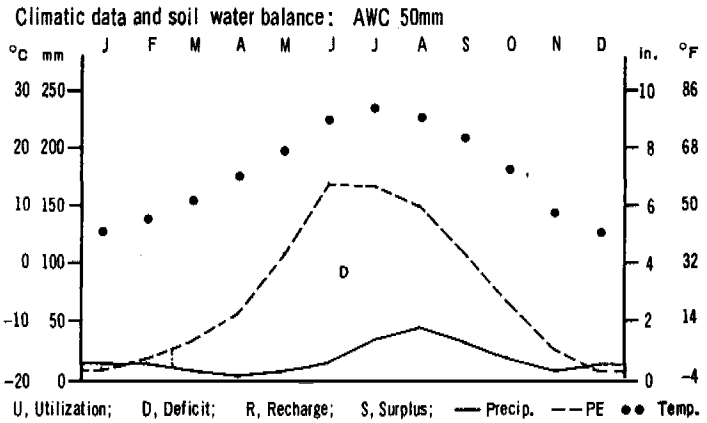


Figure 9.—**Climatic data and soil water balance for a soil that has an aridic (torric) soil moisture regime.**

In the aridic (torric) moisture regime, the moisture control section in most years is

1. Dry in all parts more than half the time (cumulative) that the soil temperature at a depth of 50 cm is above 5° C; and
2. Never moist in some or all parts for as long as 90 consecutive days when the soil temperature at a depth of 50 cm is above 8° C.

Soils that have an aridic or a torric moisture regime are normally in arid climates. A few are in semiarid climates and either have physical properties that keep them dry, such as a crusty surface that virtually precludes infiltration of water, or they are very shallow over bedrock. There is little or no leaching in these moisture regimes, and soluble salts accumulate in the soil if there is a source of them. Figure 9 illustrates climatic data in a region where the soils have aridic or torric moisture regimes.

The limits of soil temperature exclude from these moisture regimes the very cold and dry regions of Greenland and adjacent islands. Such fragmentary data are available on the soils of those regions that no provision is made for their moisture regimes in this taxonomy.

Udic moisture regime.—The udic (L. *udus*, humid) moisture regime implies that in most years the soil moisture control section is not dry in any part for as long as 90 days (cumulative). If the mean annual soil temperature is lower than 22° C and if the mean winter and mean summer soil temperatures at a depth of 50 cm differ by 5° C or more, the soil moisture control section is not dry in all parts for as long as 45 consecutive days in the 4 months that follow the summer solstice in 6 or more years out of 10. In addition, the udic moisture regime requires, except for short periods, a three-phase system, solid-liquid-gas, in part, but not necessarily in all, of the soil when the soil temperature is above 5° C.

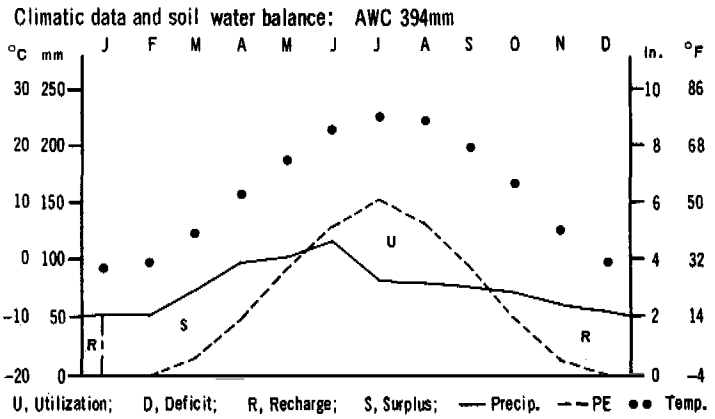


***Figure 10.*—Climatic data and soil water balance for a soil that has a udic soil moisture regime.**

The udic moisture regime is common to the soils of humid climates that have well-distributed rainfall or that have enough rain in summer that the amount of stored moisture plus rainfall is approximately equal to or exceeds the amount of evapotranspiration. Water moves down through the soil at some time in most years.

If precipitation exceeds evapotranspiration in all months of most years, there are occasional brief periods when some stored moisture is used, but the moisture tension rarely becomes as great as 1 bar in the soil moisture control section. The water moves through the soil in all months that it is not frozen. This extremely wet moisture regime is called "perudic" (L. *per*, throughout in time, L. *udus*, moist). The formative element *ud* is used in the names of most taxa to indicate either a udic or a perudic regime. The term "perudic" is not used in names of taxa, but is used in the text if it is relevant to the genesis of the soils.

Figures 10 and 11 illustrate climatic data in regions where soils have udic and perudic moisture regimes, respectively. Note that on the monthly basis, the perudic regime shows a surplus every month of the year. Obviously, if calculations were made on a daily basis, there would be short periods of withdrawal.

Ustic moisture regime.—The ustic (L. *ustus*, burnt, implying dryness) moisture regime is intermediate between the aridic and the udic regime. The concept is one of limited moisture, but the moisture is present at a time when conditions are suitable for plant growth. The ustic moisture regime is not applied to soils that have cryic or pergelic temperature regimes, which are defined later.

If the mean annual soil temperature is 22° C or higher or if the mean summer and winter soil temperatures differ by <5° C at a depth of 50 cm, the soil moisture control section in the ustic moisture regime is dry in some or all parts for 90 or more cumulative days in most years. But the moisture control section is moist in some part for more than 180 cumulative days, or it is continuously moist in some part for at least 90 consecutive days.

If the mean annual soil temperature is lower than 22° C and if the mean summer and winter soil temperatures differ by 5° C or more at a depth of 50 cm, the soil moisture control section in the ustic regime is dry in some or all parts for 90 or more cumulative days in most years. But it is not dry in all parts for more than half the time that the soil temperature is higher than 5° C at a depth of 50 cm (the aridic and torric regimes). Also, it is not dry in all parts for as long as 45 consecutive days in the 4 months that follow the summer solstice in 6 or more years out of 10 if the moisture control section is moist in all parts for 45 or more consecutive days in the 4 months that follow the winter solstice in 6 or more years out of 10 (xeric regime). Figure 12 illustrates climatic data in a region where the soils have ustic moisture regimes.

In tropical and subtropical regions that have either one or two dry seasons, summer and winter have little meaning. In those regions, the ustic regime is that typified in a monsoon climate that has at least one rainy

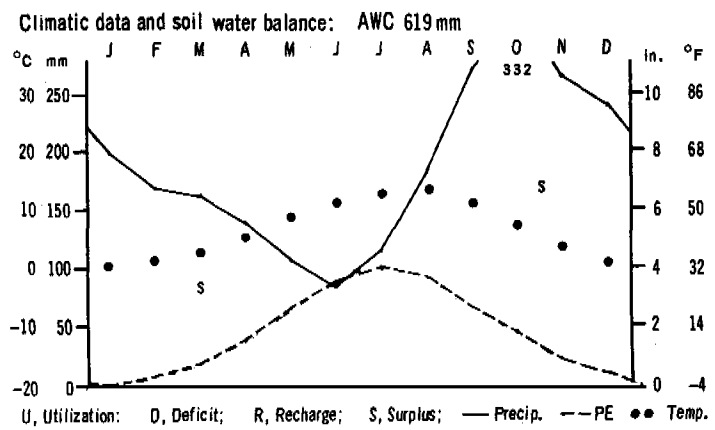


***Figure 11.*—Climatic data and soil water balance for a soil that has a perudic soil moisture regime.**

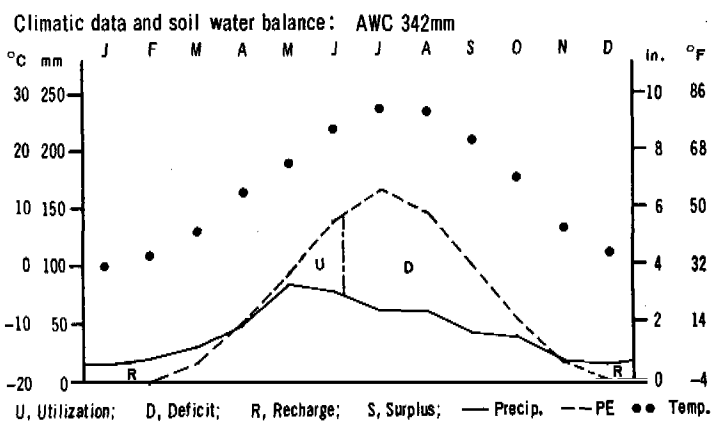


***Figure 12.*—Climatic data and soil water balance for a soil that has an ustic soil moisture regime.**

season of 3 months or more. In temperate regions of subhumid or semiarid climates, the rainy seasons are usually spring and summer or spring and fall, but never winter. Native plants are mostly annuals or they have a dormant period while the soil is dry.

Xeric moisture regime.—The xeric moisture regime (Gr. *xeros,* dry) is that typified in Mediterranean climates, where winters are moist and cool and summers are warm and dry. The moisture, coming in winter when potential evapotranspiration is at a minimum, is particularly effective for leaching. In a xeric moisture regime, the soil moisture control section is dry in all parts for 45 or more consecutive days within the 4 months that follow the summer solstice in 6 or more years out of 10. It is moist in all parts for 45 or more consecutive days within the 4 months that follow the winter solstice in 6 or more years out of 10. The moisture control section is moist in some part more than half the time, cumulative, that the soil temperature at a depth of 50 cm is higher than 5° C, or in 6 or more years out of 10 it is moist in some part for at least 90 consecutive days when the soil temperature at a depth of 50 cm is continuously higher than 8° C. In addition, the mean annual soil temperature is lower than 22° C, and mean summer and mean winter soil temperatures differ by 5° C or more at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower. Figure 13 gives climatic data that typify the xeric moisture regime.

Soil temperature regimes

The temperature of a soil is one of its important properties. Within limits, temperature controls the possibilities for plant growth and for soil formation. Below the freezing point there is no biotic activity, water no longer moves as a liquid and, unless there is frost heaving, time stands still for the soil. Between temperatures of 0° and 5° C, root growth of most plants and germination of most seeds is impossible. A horizon as cold as 5° C is a thermal pan to roots of most plants.

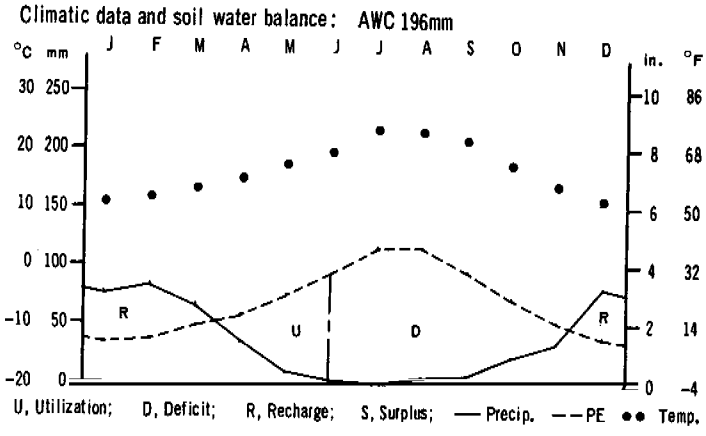


***Figure 13.*—Climatic data and soil water balance for a soil that has a xeric soil moisture regime.**

Biological processes in the soil are controlled in large measure by soil temperature and moisture. Each plant species has its own temperature requirements. In the Antarctic, for example, there is a microscopic plant that grows only at temperatures below 7° C, temperatures at which most other plants are inactive. At the other extreme, germination of seeds of many tropical plants requires a soil temperature of 24° C or higher. Plants have one or more soil-temperature requirements that are met by the soils of their native environment. Similarly, soil fauna have temperature requirements for survival. Soil temperature, therefore, has an important influence on biological, chemical, and physical processes in the soil and on the adaptation of introduced plants (Richards et al. 1952).

At any moment the temperature within a soil varies from horizon to horizon. The temperature near the surface fluctuates with the hours of the day and with the seasons of the year. The fluctuations may be very small or very large according to the environment. Because temperature is so variable, or perhaps because it is not preserved in samples, some pedologists have felt that temperature is not a property of a soil. Most of us who work with soils in a limited geographic area take soil temperature for granted because the temperatures of all the soils in a limited area are similar. We are all inclined to notice the properties that differ among soils and to focus our attention on them.

Each pedon has a characteristic temperature regime that can be measured and described. For most practical purposes, the temperature regime can be described by the mean annual soil temperature, the average seasonal fluctuations from that mean, and the mean warm or cold seasonal soil-temperature gradient within the main root zone, which is the zone from a depth of 5 to 100 cm.

Mean annual soil temperature

Each pedon has a mean annual temperature that is essentially the same in all horizons at all depths in the soil and at depths considerably below the soil. The measured mean annual soil temperature is seldom the same in successive depths at a given location, but the differences are so small that it seems valid and useful to take a single value as the mean annual temperature of a soil. Some representative measurements of the mean annual temperature at various depths in and below selected soils are given in table 5.

The mean annual soil temperature is related most closely to the mean annual air temperature, but this relation is affected to some extent by the amount and distribution of the rain and the amount of snow, the protection by shade and by the O horizons in forests, the slope aspect and gradient, and irrigation. Other factors, such as soil color, texture, and amount of organic matter have negligible effects. These relations have been discussed by Smith et al. (1964).

Fluctuations of soil temperature

The mean annual temperature of a soil is not, of course, a single reading but is an average of a series

TABLE 5.—*Mean annual temperature at various depths in soils and substrata in selected locations* [1]

[--- indicates no record]

Depth (meters)	Bozeman, Mont.	Seattle, Wash.[2]	Urbana, Ill.	Colombo, Ceylon	Jaipur, India	Irkutsk, U.S.S.R.[2]	Belgrade, Yugoslavia [2]
	°C	°C	°C	°C	°C	°C	°C
0.3	6.2	---	11.8	29.7	26.9	---	---
.6	6.3	11.3	11.6	29.8	---	0.7	---
.9	5.7	---	11.8	29.8	26.9	.8	12.9
1.2	6.2	11.0	---	29.8	---	1.1	12.8
1.5	6.3	11.2	---	29.8	---	1.5	12.6
3.0	6.4	11.7	---	29.6	27.2	2.0	12.7
6.1	---	11.6	---	---	27.1	2.5	12.6
9.1	---	11.4	---	---	---	---	12.8
15.2	---	---	---	---	---	---	12.9
Mean annual air temperature	6.0	10.8	10.5	26.6	25	−2	12.2
Length of soil-temperature records (years)	5	2	20	15	20	18	4

[1] Chang, Jen-Hu. Ground temperature. II. Blue Hill Meteorol. Observ., Harvard Univ., Milton, Mass., 300 p. 1958.
[2] Depths are approximate.

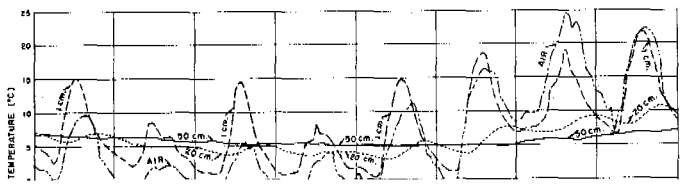
of readings. Near the surface, the readings may fluctuate from the mean fully as much as those of the air temperature, especially if there is no insulating cover. The fluctuations occur as daily and annual cycles, which in most places are made somewhat irregular by weather events. The fluctuations decrease with increasing depth and are ultimately damped out in the substrata in a zone where the temperature is constant and is the same as the mean annual soil temperature.

Daily fluctuations.—Daily changes in air temperature have a significant effect on the temperature of soil horizons to a depth of about 50 cm. The fluctuations may be very large, particularly in soils of dry climates where the daily range in temperature of the upper soil to a depth of 2.5 cm may approach 55° C. At the other extreme, under melting snow, the temperature at the soil surface may be constant throughout the day. In a few places in high mountains very near the Equator the soils have virtually constant temperature.

Daily soil-temperature fluctuations are affected by clouds, vegetation, length of day, soil color, soil slope, soil moisture, air circulation near the ground, and temperature of any rain that falls. Moisture can be exceedingly important in reducing fluctuations in soil temperature. The specific heat of water is roughly five times that of soil minerals and twice that of dry organic matter. The specific heat of water is roughly four times that of a dry surface horizon, and the tend to a greater depth than those of the diurnal cycle. Periods of high or of low temperature tend to last a few days to a week in most of the United States but, like weather patterns in general, they occur at irregular intervals.

Figure 14, after Carson (1961), shows that the soil temperature at a depth of 1 cm is closely related to insolation and to air temperature. Changes in soil temperature at this depth reflect hourly variations in insolation, as shown by the data for April 16 and 17. Temperatures at a depth of 1 cm were also affected by the warm air mass that moved in on April 20. The soil temperature at a depth of 50 cm shows almost no daily fluctuation, but the warm period from April 20 to 23 caused a rise of about 2° C over a 72-hour period. The soil temperature at this depth reflects short-time weather patterns but is essentially independent of the daily temperature cycle.

Cold or warm rains may bring about rapid and marked changes in the temperature of surface hori-



zons, which is part of the influence of weather. Generally, the direct effect of a rain on soil temperature is not measurable 48 hours after the rain ends.

Seasonal fluctuations and soil-temperature gradients in the Tropics.—Seasonal fluctuations of soil temperature are generally small in the intertropical regions between the Tropics of Capricorn and Cancer. Mean annual soil temperatures vary with elevation, but seasonal temperatures vary primarily with clouds and rain. The warmest seasons may be the dry seasons, for the effects of clouds and rain may outweigh those of the angle of the sun's rays.

We have plotted in figure 15 the soil temperature, air temperature, rainfall, and percentage of possible sunshine at Yangambi, Zaire, at an elevation of about 365 m. This figure shows that the soil temperature is higher in winter than in summer. Actually, the soil temperature fluctuates with cloud cover and rain and appears to be most closely correlated with the amount of sunshine. In the Tropics, differences between summer and winter temperatures are small and may be in either direction. The average temperature over a 3-month season is virtually the same at all depths within the upper meter of soil.

As the temperate region is approached, near the Tropic of Cancer for example, soil temperatures in summer are likely to be higher than those in winter, but the differences between the mean summer and the mean winter temperature in the upper meter of soil are usually less than 5° C.

Seasonal fluctuation and soil-temperature gradients in midlatitudes.—Soil temperatures in the 48 conterminous states generally show marked seasonal fluctuations. To illustrate seasonal changes under a midlatitude continental climate such as that in much of the United States, a good record of soil temperatures from Belgrade, Yugoslavia, has been selected. This record is shown graphically in figure 16. The annual cooling and heating waves extend to a depth of 12 m, but the amplitude of variation at this depth is only 0.1° C. At a depth of 14 m, the temperature is constant and is the same as the mean annual soil temperature. These records show clearly that seasonal temperature fluctuations penetrate deeply into the earth, well below the limit of soil.

The depth to the stratum that has constant temperature is not the same in all soils. It is reduced by shallow ground water because water has high specific heat. Records of well-water temperature in the 48 conterminous states show that, in the presence of ground water, the stratum of constant soil temperature occurs at a depth of about 9 m.

Chang (1958a, p. 93) has estimated that, in the absence of ground water, seasonal fluctuations of soil temperature penetrate to a depth of 20 m in Alaska, 15 m in midlatitudes, and 10 m in the Tropics. In dry soils thermal conductivity is low and, although seasonal fluctuations in temperature may be very large, the depth of penetration is no greater than in moist soils. At Jaipur, India (lat. 27° N) the seasonal range in soil temperature at a depth of 6 m was 2.7° C, but at a depth of 14 m it was only 0.2° C (Chang 1958b).

The amplitude of seasonal fluctuations and the timing of periods of warm and cool soil temperature are primarily functions of latitude and climate. In midlatitudes the angle of the sun's rays is most important, but clouds, rain, irrigation water, snow cover, bodies of water, direction and angle of slope, and presence or absence of shallow ground water and of thick O (or-

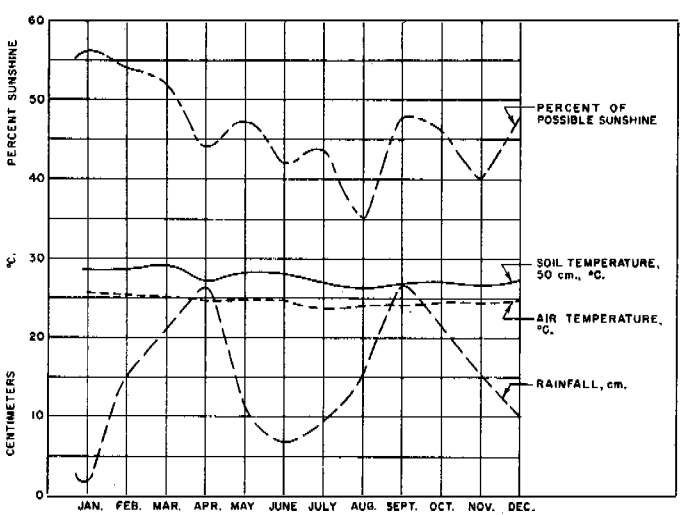


***Figure 15.*—Mean monthly soil temperature at a depth of 50 cm for 1952 at Yangambi, Zaire, and major climatic factors that affect it (after I.N.E.A.C. 1953).**

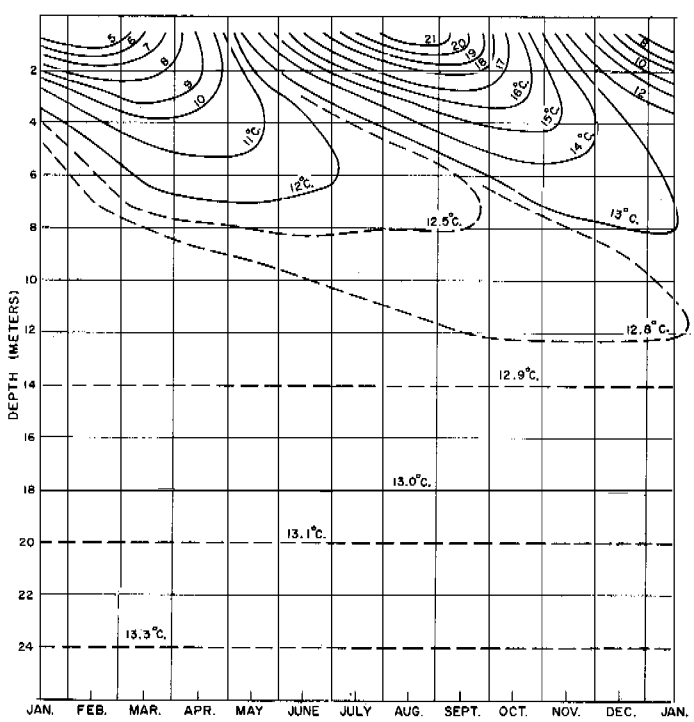


***Figure 16.*—Mean monthly isotherms of ground temperature at Belgrade, Yugoslavia (after Chang 1958b).**

ganic) horizons can all affect the amplitude of fluctua- [illegible] shade have effects, but evaporation is probably the [illegible]

ally in excess of 5° C. That is, the average summer soil temperature is more than 5° C higher than the average winter soil temperature in the upper meter of soil.

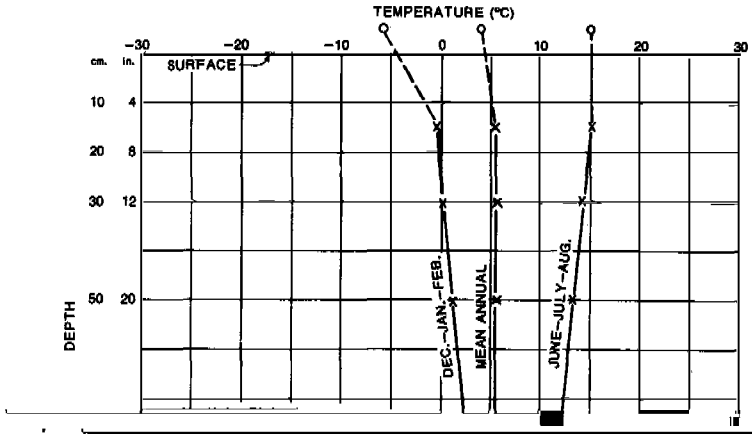
Since the temperatures of soils at high elevations tend to resemble those of soils at high latitudes, the discussion in this section is confined to soils having mean annual temperatures of 8° C or higher. The cold soils at high elevations in the midlatitudes are discussed with the soils of high latitudes.

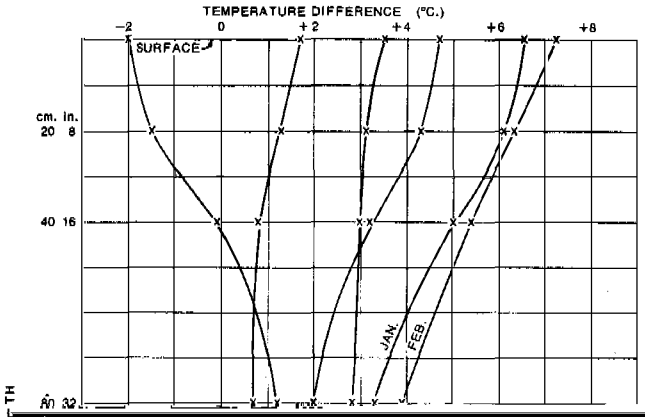
Effect of depth. In a given soil, the closer to the surface, the greater is the amplitude of fluctuation. Seasonal variations of soil temperature are greatest at the surface and decrease with depth until, at a depth of 9 m or more, they disappear (fig. 16). The mean summer, winter, and annual soil temperatures (Chang 1958b) are plotted in figure 17 as a function of depth together with air temperatures for Ames, Iowa, which is in the midlatitudes. If we disregard the upper few centimeters, the changes of the mean seasonal soil temperature with depth are nearly linear, so nearly so that one must conclude that the mean seasonal temperature of soil to any depth within the main zone of rooting is very closely approximated by the mean temperature at the midpoint in depth. The temperature gradient is positive in winter and negative in summer. It is approximately 0.5° C per 10 cm. The gradients seem very similar in most midlatitude soils [illegible] some places.

Effect of ground water. Because of its large latent and specific heat, shallow ground water greatly affects seasonal fluctuations of soil temperature in midlatitudes. The principal effects occur during periods when the soil is freezing or thawing because the latent heat of freezing of water is about 80 times the specific heat.

Effect of aspect and steepness of slope. The aspect (direction) and steepness of slope may affect the deviation of the mean monthly soil temperatures from the annual mean. The effect in winter is large compared to that in summer. South-facing slopes have smaller seasonal fluctuations from the annual mean than north-facing slopes. The effects of aspect increase sharply in high latitudes.

Seasonal fluctuations in high latitudes.—Soils in high latitudes are cold, and the seasonal soil-temperature fluctuations do not approximate a simple sine curve as do those in midlatitudes. We have plotted in figure 18 the mean monthly soil and air temperatures at Mustiala, Finland (Chang 1958b). The air temperature follows a simple sine curve and is above the mean for about 6 months of the year. The soil temperature at a depth of 50 cm, however, is above its mean for only 5 months and below it for 7 months. The asymmetrical soil-temperature fluctuations reflect the combined influence of snow as an insulator during winter


TEMPERATURE (°C)
−30
−20
−10
0
10
20
30
cm.
in.
SURFACE
10
4
20
8
30
12
50
20
DEPTH
DEC.–JAN.–FEB.
MEAN ANNUAL
JUNE–JULY–AUG.


TEMPERATURE DIFFERENCE (°C.)
−2
0
+2
+4
+6
+8
SURFACE
cm.
in.
20
8
40
16
80
32
JAN.
FEB.

drained, cultivated or grass-covered soils can be approximated by subtracting 0.6° C from the mean summer air temperature (fig. 17).

The mean summer temperature of soil at a specific depth can also be estimated. To do this, we can take the average summer temperatures of the upper 100 cm and correct for the temperature-depth gradient by adding or subtracting 0.6° C for each 10 cm above or below a depth of 50 cm. The mean winter temperature of many midlatitude soils can be estimated from the difference between the mean annual and the mean summer temperatures because the differences are of the same magnitude but have opposite signs.

We have seen in figure 16 that the cooling wave at Belgrade extends to a depth of 12 m and that, at this depth, the minimum temperature is reached about 10 months later than at a depth of 1 m. The amplitude of variation at the 12-m depth is less than 0.1° C. This means that the mean annual temperature of a soil in midlatitude can be determined at any time by a single reading at a depth of 13 m. A single reading at a depth of 10 m is within 0.1° C of the mean annual soil temperature. A single reading at a depth of 6 m is within 1° C of the mean annual temperature.

The mean annual temperature of soils underlain by deep regolith can therefore be very closely approximated at any season by measurement in a deep auger boring. In some places there is an even simpler method of determining the mean annual soil temperature. Dug wells generally range in depth from 6 to 18 m. If the water table stands between 9 and 18 m and water is drawn from the well frequently, the temperature of water in the well, which is in equilibrium with the soil temperature, gives the mean annual soil temperature with an error of less than 1° C. Unfortunately, this method is suited only to humid regions where ground water is shallow and is not frozen. Extensive records of well-water temperature have shown that the water temperature between a depth of 9 and 18 m is essentially constant throughout the year. One precaution is necessary; the well must be in use so that water is moving into it from the ground around.

If the soil is shallow and there are no wells, the mean annual soil temperature can be measured over the four seasons only by taking several readings at regular intervals of time. If the soil is expected to be frozen deeply at the time of one or more readings, a special thermometer or a thermocouple can be buried. If the temperature of a soil is measured at a depth below the influence of the daily cycle of fluctuations, say at a depth of 50 cm, four readings equally spaced throughout the year give a very close approximation of the mean annual temperature. For example, the average of readings taken at the 50-cm depth at Vauxhall, Alberta, on January 1, April 1, July 1, and October 1, 1962, differs from the average of two readings each day of the year by only 0.3° C. Greater precision can be had by increasing either the number or the depth of the readings. The mean annual soil temperature computed for any 1 year will also be close to the long-term mean annual, that is, the normal temperature. At Ames, Iowa, for example, the standard deviation of the yearly mean for a 13-year record at the 50-cm depth is only 0.6° C.

Seasonal temperatures bear an almost linear relation to depth within the limits of depth that usually concern soil scientists. By selecting a suitable depth and measuring the temperature on the 15th of June, July, and August, we can derive the average soil temperature for the 3-month summer period. The error will be small only if measurements are made at a depth below the daily temperature fluctuations, that is, at a depth of 50 cm or more. Measurements made at a depth of 50 cm give the average temperature in the upper meter of soil. A test of this method at Vauxhall, Alberta, showed that the average of three measurements taken at a 50-cm depth on June 15, July 15, and August 15, 1962, is within 0.6° C of the mean summer temperature computed from daily readings.

Greater precision can be had mainly by increasing the number of readings, but readings of soil temperature should not be made at depths as shallow as 50 cm for at least 48 hours after a heavy rain.

Classes of soil temperature regimes

The following soil temperature regimes are used in defining classes at various categoric levels in the taxonomy.

Pergelic (L. *per*, throughout in time and space, and L. *gelare*, to freeze; connoting permanent frost).—Soils with a pergelic temperature regime have mean annual temperature lower than 0° C. These are soils that have permafrost if they are moist or dry frost if excess water is not present. It seems likely that the moist and the dry pergelic regimes should be defined separately, but at present we have only fragmentary data on the dry soils of very high latitudes. Plate 8A shows a soil that has a pergelic temperature regime. Ice wedges and lenses are normal in such soils in the United States.

Cryic (Gr. *kryos*, coldness; connoting very cold soils).—In this regime soils have a mean annual temperature higher than 0° C (32° F) but lower than 8° C (47° F).

1. In mineral soils, the mean summer temperature for June, July, and August at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower, is as follows:
   a. If the soil is not saturated with water during some part of the summer and
      (1) There is no O horizon, lower than 15° C (59° F);
      (2) There is an O horizon, lower than 8° C (47° F);
   b. If the soil is saturated with water during some part of the summer and
      (1) There is no O horizon, lower than 13° C (55° F);
      (2) There is an O horizon or a histic epipedon, lower than 6° C (43° F).
2. In organic soils, either
   a. The soil is frozen in some layer within the control section in most years about 2 months after the summer solstice; that is, the soil is very cold in winter but warms up slightly in summer; or
   b. The soil is not frozen in most years below a

depth of 5 cm; that is, the soil is cold throughout the year but, because of marine influence, does not freeze in most years.

Cryic soils that have an aquic moisture regime commonly are churned by frost. Plate 8B shows the characteristic churning of the epipedon by frost. Figure 22 shows characteristic mounds in an organic soil.

Most isofrigid soils with a mean annual soil temperature above 0° C have a cryic temperature regime. A few with organic materials in the upper part are exceptions. Throughout this text all isofrigid soils without permafrost are considered to have a cryic temperature regime.

Frigid.—The frigid regime and some of the others that follow are used chiefly in defining classes of soils in the low categories. In the frigid regime the soil is warmer in summer than one in the cryic regime, but its mean annual temperature is lower than 8° C (47° F), and the difference between mean winter and mean summer soil temperature is more than 5° C (9° F) at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower.

Mesic.—The mean annual soil temperature is 8° C or higher but lower than 15° C (59° F), and the difference between mean summer and mean winter soil temperature is more than 5° C at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower.

Thermic.—The mean annual soil temperature is 15° C (59° F) or higher but lower than 22° C (72° F), and the difference between mean summer and mean winter soil temperature is more than 5° C at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower.

Hyperthermic.—The mean annual soil temperature is 22° C (72° F) or higher, and the difference between mean summer and mean winter soil temperature is more than 5° C at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower.

If the name of a soil temperature regime has the prefix iso, the mean summer and winter soil temperatures for June, July, and August and for December, January, and February differ by less than 5° C at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower.

Isofrigid.—The mean annual soil temperature is lower than 8° C (47° F).

Isomesic.—The mean annual soil temperature is 8° C or higher but lower than 15° C (59° F).

Isothermic.—The mean annual soil temperature is 15° C or higher but lower than 22° C (72° F).

Isohyperthermic.—The mean annual soil temperature is 22 °C or higher.

The limit between isofrigid and isomesic cannot be tested in the United States and is tentative.

Sulfidic materials

Sulfidic materials are waterlogged mineral or organic soil materials that contain 0.75 percent or more sulfur (dry weight), mostly in the form of sulfides and that have less than three times as much carbonate ($CaCO_3$ equivalent) as sulfur. Sulfidic materials accumulate in a soil that is permanently saturated, generally with brackish water. The sulfates in the water are biologically reduced to sulfides as the soil materials accumulate. Sulfidic materials are most common in coastal marshes near the mouths of rivers that carry noncalcareous sediments, but they may occur in fresh-water marshes if there is sulfur in the water. If the soil is drained, the sulfides oxidize and form sulfuric acid. The pH, which normally is near neutrality before drainage, may drop below 2. The acid reacts with the soil to form iron and aluminum sulfates. The iron sulfate, jarosite, segregates and forms the bright-yellow mottles that characterize a sulfuric horizon. The transition from sulfidic materials to a sulfuric horizon normally requires a very few years. A sample of sulfidic materials, if air dried slowly in shade for about 2 months with occasional remoisten-

(Webster's 1967). The term means "to change by touch." Many kinds of thixotropic substances have been identified and studied, including some sesquioxide gels, kaolinite gels, montmorillonite gels, greases, inks, paints, protoplasm, blood coagula, nitrocellulose solutions, and drilling muds. Thixotropy apparently is the result of a kind of structure that, if broken down, can rebuild itself. The breakdown may be caused by one of several actions: by agitation, by shearing, or even by ultrasonic waves. Some natural (untreated) soil materials exhibit this property. A field test of thixotropic soil is this: Press a bit of wet soil between thumb and forefinger; at first it resists deformation, having some rigidity, or elasticity, or both; under increasing pressure the soil can be molded and deformed; under greater pressure, suddenly the soil changes from a plastic solid to a liquid, and the fingers skid. After the soil smears in this fashion, usually free water can be seen on the fingers. In a matter of a second or two the liquefied soil sets again to its original solid state. If a knife blade is pushed into the soil mass in a pit and removed suddenly, it has only a staining of muddy water; if pressed into the soil and slowly pulled out, a large mass of soil adheres to the blade. In the literature of soils of western United States, particularly of Hawaii, the consistence term "smeary" is used to characterize soil materials that are thixotropic.

Tonguing and interfingering

Tonguing of albic materials

Tongues of albic materials consist of penetrations of bleached material that has the color of an albic horizon in an argillic or a natric horizon, along ped surfaces if peds are present. No continuous albic horizon need be present above the tongues. The penetrations have a vertical dimension of >5 cm in any argillic or natric horizon. Their horizontal dimension is 5 mm or more in a fine-textured argillic or natric horizon (clay, silty clay, or sandy clay), 10 mm or more in a moderately fine textured argillic or natric horizon (clay loam, sandy clay loam, or silty clay loam), and 15 mm or more in a medium or coarser textured argillic or natric horizon (silt loam, loam, very fine sandy loam, or coarser). The penetrations must occupy more than 15 percent of the matrix of some part of the argillic or natric horizon before they are considered tongues.

Plate 7D shows a moderately fine textured argillic horizon that has strongly expressed tongues of albic materials.

Interfingering of albic materials

Interfingering of albic materials consists of penetrations of albic materials into an underlying argillic or natric horizon along faces of peds, primarily along vertical faces but to a lesser degree along horizontal faces. No continuous albic horizon need be present. The penetrations are not wide enough to constitute tonguing, but they form continuous skeletans (ped coatings of clean silt or sand defined by Brewer, 1964) >1 mm thick on the vertical ped faces, which means a total width >2 mm between abutting peds. Because quartz is such a common constituent of soils, the skeletans usually appear to be nearly white when dry and light gray when moist, but their color is determined in large part by the color of the sand or silt fraction.

To be recognized as interfingering, all the following requirements must be met in a horizon that is 5 cm or more thick:

1. Half or more of the matrix consists of peds of the argillic or natric horizon;
2. Albic materials are thicker than 2 mm on vertical faces between abutting peds but are too thin to be tongues;
3. Clay skins are present in the peds, at least in pores.

Albic materials meet the following requirements for color. If the value, dry, is 7 or more, or the value, moist, is 6 or more, the chroma is 3 or less. If the value, dry, is 5 or 6 and the value, moist, is 4 or 5, the chroma is closer to 2 than to 3.

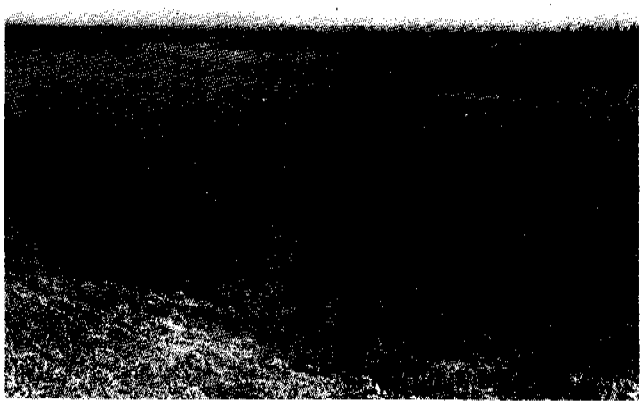
Plate 6D shows interfingering into an argillic horizon that has moderately fine texture.

Weatherable minerals

Several references are made to weatherable minerals in the text of this chapter and later chapters. Obviously, the stability of a mineral in a soil is a partial function of the soil moisture regime. In the context of the references in the definitions of diagnostic horizons and of various taxa, a humid climate is always assumed, either present or past. Minerals that are included in the meaning of weatherable minerals are:

1. Clay minerals: All 2:1 lattice clays except one that is currently considered to be an aluminum-interlayered chlorite. Sepiolite, talc, and glauconite are also included in the meaning of this group of weatherable clay minerals, although they are not everywhere of clay size.
2. Silt- and sand-size minerals (0.02 to 0.2 mm in diameter): Feldspars, feldspathoids, ferromagnesian minerals, glass, micas, zeolites, and apatite.

It should be noted that this is a restricted meaning of weatherable minerals. Calcite, for example, is readily soluble in a humid environment. If it is dissolved, it leaves no trace or residue. Soils that have been intensely and deeply weathered in a humid environment of the past are, in some places, preserved today in an arid environment. Calcite could reappear in one of these soils if it were brought in as dust. The intent is to include, in the context of the meaning of weatherable minerals for this purpose, only those minerals that are unstable in a humid climate relative to other minerals, such as quartz and 1:1 lattice clays, and that are more resistant to weathering than calcite.



CHAPTER 4

Horizons and Properties Diagnostic for the Higher Categories: Organic Soils

Many of the layers that are differentiae for organic soils do not meet the definition of soil horizons and cannot be included in the layers of soil that are commonly called horizons. Rather, they are layers that formed in differing environments during the period of accumulation of the materials that now constitute the soil. Some of the layers that serve as differentiae are soil horizons, but we do not have operational methods that can always distinguish between "horizons" and "layers" that have similar properties. The importance of making a distinction between horizons and layers of organic soils is presently unknown. In the discussion that follows, the term "soil material" is generally used as a broader term to include both horizons and layers.

Organic soil materials

Organic soil materials and organic soils

1. Are saturated with water for long periods or are artificially drained and, excluding live roots, (a) have 18 percent or more organic carbon if the mineral fraction is 60 percent or more clay, (b) have 12 percent or more organic carbon if the mineral fraction has no clay, or (c) have a proportional content of organic carbon between 12 and 18 percent if the clay content of the mineral fraction is between zero and 60 percent; or
2. Are never saturated with water for more than a few days and have 20 percent or more organic carbon.

Item 1 in this definition covers materials that have been called peats and mucks. Item 2 is intended to include what has been called litter or O horizons. Not all organic soil materials accumulate in or under water. Leaf litter may rest on a lithic contact and support a forest. The only soil in this situation is organic in the sense that the mineral fraction is appreciably less than half the weight and is only a small percentage of the volume of the soil.

Definition of organic soils

Organic soils (Histosols) are soils that

surface to one of the following:

a. A depth within 10 cm or less of a lithic or paralithic contact, provided the thickness of the organic soil materials is more than twice that of the mineral soil above the contact; or

b. Any depth if the organic soil material rests on fragmental material (gravel, stones, cobbles) and the interstices are filled with organic materials, or rests on a lithic or paralithic contact; or

2. Have organic materials that have an upper boundary within 40 cm of the surface and

a. Have one of the following thicknesses:

(1) 60 cm or more if three-fourths or more of the volume is moss fibers or the moist bulk density is <0.1 g per cubic centimeter (6.25 lbs per cubic foot);

(2) 40 cm or more if

(a) The organic soil material is saturated with water for long periods (>6 months) or is artificially drained; and

(b) The organic material consists of sapric or hemic materials or consists of fibric materials that are less than three-fourths moss fibers by volume and have a moist bulk density of 0.1 or more; and

b. Have organic soil materials that

(1) Do not have a mineral layer as much as 40 cm thick either at the surface or whose upper boundary is within a depth of 40 cm from the surface; and

(2) Do not have mineral layers, taken cumulatively, as thick as 40 cm within the upper 80 cm.

It is a general rule that a soil is classed as an organic soil (Histosol) either if more than half of the upper 80 cm (32 in.) of soil is organic or if organic soil material of any thickness rests on rock or on fragmental material having interstices filled with organic materials.

Kinds of organic soil materials

Three basic kinds of organic soil materials are dis-

degree of decomposition of the original plant materials. Because of the importance of the fiber content in the definitions of these materials, fibers are defined first and the definitions of the kinds of organic soil materials follow.

Fibers

A fiber is a fragment or piece of plant tissue, excluding live roots, that is large enough to be retained on a 100-mesh sieve (openings 0.15 mm in diameter) and that retains recognizable cellular structure of the plant from which it came. The material is screened after dispersion in sodium hexametaphosphate. Fragments larger than 2 cm in cross section or in their smallest dimension, to be called fibers, must be decomposed enough that they can be crushed and shredded with the fingers. Fragments of wood that are larger than 2 cm in cross section and that are so undecomposed that they cannot be crushed and shredded with the fingers are not considered fibers. Such fragments of undecomposed wood in the form of large branches, logs, and stumps are considered to be coarse fragments, comparable to gravel, stones, and boulders in mineral soils.

The degree of decomposition of organic materials is indicated by the content of fibers. If the material is highly decomposed, fibers are nearly absent. If it is only slightly decomposed, more of the volume, exclusive of the coarse fragments, normally consists of fibers. If the organic materials are moderately decomposed, the fibers may be largely preserved but they are easily broken down by disturbance. For this reason, the percentage of fibers that do not break down when rubbed gives the most realistic field estimate of the degree of decomposition. In addition, the bulk density, and hence the amount of subsidence after drainage, is more closely related to the content of fiber after rubbing than to the content of fiber in the undisturbed condition. A small volume of the wet material is rubbed between the thumb and fingers about 10 times with firm pressure. In the laboratory, the material, after rubbing, may be dispersed in sodium pyrophosphate and washed on a screen.[1] In the field, the rubbed material may be molded into a spherical mass and broken for examination under a hand lens of 10 power or more to estimate the fiber content.

The definitions of fibric, hemic, and sapric soil materials that follow are based in part on the content of fibers before and after rubbing and in part on the solubility of the materials in sodium pyrophosphate.

Many soils have a fiber content such that the soil can be classified solely on the field estimation of the fiber content. In others the field estimates, particularly in marginal situations, are inadequate to classify the materials, and the classification must be based on the

Figure 23.—**Landscape of hill peat or blanket bog dominated by *Sphagnum*. Tasmania.**

Fibric soil materials (L. *fibra*, fiber)

These are the least decomposed of all of the organic soil materials. They contain large amounts of fibers that are well preserved and are readily identifiable as to botanical origin. They commonly have very low bulk density and high water content when saturated. They have a wide geographic distribution, and they occur in environments that are not conducive to processes of alteration and decomposition. Examples of such environments are the cool or cold, perhumid, boreal forest zones, where the raised bogs and hill peats are dominated by *Sphagnum* spp. (fig. 23), the landlocked depressions that have *Hypnum* moss, and the very flat, undrained areas that support a variety of reeds, sedges and grasses. Flat, wet areas occur in glaciated areas in the higher latitudes and also in very wet flatlands of semitropical and tropical areas. An example is the sawgrass (sedge) bogs of the Everglades area in Florida. Fibric materials commonly have bulk density <0.1, fiber content (unrubbed) exceeding two-thirds of the volume, and water content, when saturated, ranging from about 850 percent to more than 3,000 percent of the weight of ovendry material. The colors of these materials commonly are light yellowish brown, dark brown, or reddish brown. Plate 8D illustrates fibric materials that were derived primarily from *Sphagnun* spp.

Fibric soil materials have the following characteristics:

mineral layers, and the material yields a sodium pyrophosphate extract color on white chromatographic paper that has value and chroma of 7/1, 7/2, 8/1, 8/2.

Fibric soil materials that have a rubbed fiber content of four-tenths

aquatic organisms such as algae or diatoms, or (2) derived from underwater and floating aquatic plants and subsequently modified by aquatic animals. They include coprogenous earth (sedimentary peat), diatomaceous earth, and marl. Except for some of the coprogenous earths that contain 30 percent or more organic matter, most of these limnic materials are inorganic. Diatomite is highly siliceous; marl is mainly calcium carbonate. These materials generally occur in the lower part of an organic soil and were formed during an open-water stage of bog development. Even though the nature of the deposits is not diagnostic in the higher categories, it is necessary to define the various kinds of limnic deposits here because the presence of any one of these deposits is itself diagnostic.

Coprogenous earth

A coprogenous earth (sedimentary peat) layer is a

Diatomaceous earth layers normally are more nearly mineral than organic in composition.

Marl

A marl layer is a limnic layer that

1. Has a color value, moist, of 5 or more; and
2. Reacts with dilute HCl to evolve CO_2 and leave disintegrated plant remains.

Marl usually does not change color irreversibly on drying. A layer of marl contains too little organic matter to coat the carbonate, even before it has been shrunk by drying. Most samples of marl from the United States studied to date have an organic-matter content between 4 and 20 percent, inclusive.

Thickness of organic materials (control section)

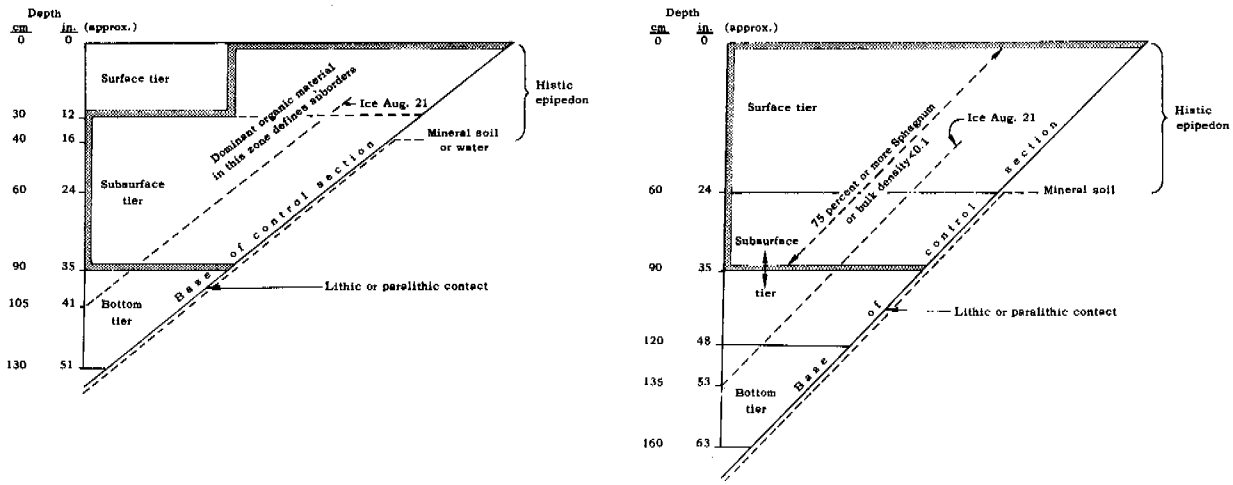


***Figure 25.*—Control section and tiers of organic soils (Histosols).**

Surface tier

The surface tier is the upper 60 cm (24 in.) if (1) the material is fibric and three-fourths or more of the fiber volume is derived from *Sphagnum* or mosses or (2) the material has a bulk density <0.1; otherwise, the surface tier is the top 30 cm (12 in.) exclusive of loose surface litter or living mosses.

A surface mineral layer <40 cm (16 in.) thick is present on some organic soils as a result of flooding, additions by men to increase soil strength or reduce frost hazard, volcanic eruptions, or other causes. If present, it is considered a part of the surface tier, even though it may be >30 cm thick, and the depth then is measured from the top of the mineral layer.

Subsurface tier

The subsurface tier is 60 cm (24 in.) thick unless the control section ends at a lithic or paralithic contact or at water within this depth or unless the soil is frozen at too shallow a depth. In any of these situations the subsurface tier extends from the base of the surface tier to the base of the control section. It in-

The control section is terminated at a shallower depth by water or by a lithic or a paralithic contact, or at a depth 25 cm (10 in.) below a layer that is frozen 2 months after the summer solstice.

Properties significant in classifying suborders, great groups, and subgroups

The classification at the suborder level is generally determined by the dominant kind of organic material in the subsurface tier if that tier is organic throughout its thickness; otherwise it is determined by the dominant kind of organic material in the surface and subsurface tiers. The exceptions are described in chapter 11.

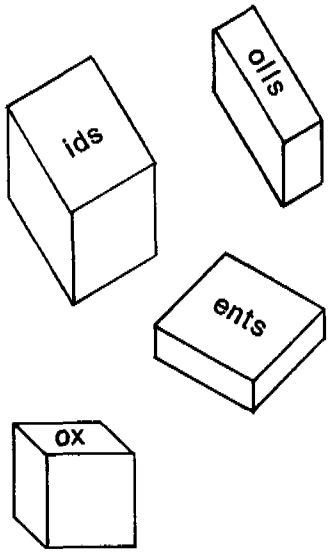
At the great group level, the presence of humilluvic materials, the temperature regime, and the dominance of *Sphagnum* fibers are differentiae. If the soil is drained and cultivated, the temperature regime largely determines its rate of subsidence over a period of years, even with optimum control of the water table. Those soils that have a frigid or a cryic temperature

Limnic.—Limnic materials >5 cm thick are present within the control section.

Lithic.—Organic materials either rest on a lithic contact within the control section or lie within 10 cm of a lithic contact.

Pergelic.—The mean annual soil temperature is 0° C or less (permafrost is present).

Terric.—A mineral layer, but not a limnic material, is 30 cm or more thick, and its upper boundary is within the control section.



CHAPTER 5

The Categories of the System

A category of this system is a set of classes that are defined approximately at the same level of generalization or abstraction and that include all soils. There are six categories in the system. In order of decreasing classes, the categories are order, suborder, great group, subgroup, family, and series.

In one sense, taxonomy is a sorting process. In the highest category of this system, one sorts all kinds of soil into a small number of classes. The number of classes is small enough to permit one to comprehend and remember them and to understand the distinctions between them. The sorting must make distinctions that are meaningful for our purposes. Obviously, when all soils are sorted into a very few classes, such as the ten orders, each order is very heterogeneous with respect to properties that are not used for the sorting and that are not accessory to the properties that are used.

To reduce the heterogeneity requires another sorting in the next lower category, the suborder. Again, the sorting must be meaningful, but the sorting is made in one order at a time and properties relevant to the sorting in one order may have little meaning in another order. In this taxonomy there are now 47 suborders, a number larger than can be remembered conveniently along with all their properties; however, if we focus on the suborders of a single order we have, at the most, seven suborders to understand and re-

Collectively, the thousands of soil series are far beyond our powers of comprehension, but we can sort them category by category, and we seldom need to try to comprehend more than a few of them at any one

Orders

There are 10 orders. They are differentiated by the presence or absence of diagnostic horizons or features that are marks in the soil of differences in the degree and kind of the dominant sets of soil-forming processes that have gone on. If the soils in a given taxon are thought to have had significantly different genesis, the intent has been to sort out the differences in the next lower category.

We know that soil properties must be the consequences of a variety of processes acting on parent materials over time. At this highest category we have looked for distinctions among orders that would be as meaningful as possible for understanding soils and remembering them on a grand scale. We have also looked for distinctions that appear in an orderly fashion in nature. The processes that go on in soils must be orderly in relation to the soil-forming factors, which are climate and living organisms acting on parent materials over time as conditioned by relief. These factors, in turn, have geographic order. We can see in

These orders are not the only possible orders in the taxonomy. The hierarchy is flexible, and other *ad hoc* orders may be defined to emphasize properties not considered in these. The method of doing this is discussed later in connection with the nomenclature.

Alfisols

Soils in the order of Alfisols have marks of processes that translocate silicate clays without excessive depletion of bases and without dominance of the processes that lead to formation of a mollic epipedon. The unique properties of Alfisols are a combination of an ochric or an umbric epidedon, an argillic horizon, a medium to high supply of bases in the soil, and water available to mesophytic plants more than half the year or more than 3 consecutive months during a warm season. Because these soils have water and bases, they are, as a whole, intensively used, but problems with tilth are very common. Figure 26 shows the distribution of organic carbon and clay and the degree of base saturation in a typical Alfisol (pedon 12). Note the shallow penetration of organic carbon, the distinct accumulation of clay at a depth of about 60 cm, and the high degree of base saturation throughout the soil. The horizon of clay accumulation may be thick or, as in this example, relatively thin. Plates 2D, 3A, 4B, 5C, 6A, 7D, 10B, and 10C show representative Alfisols.

41° F), and they never have water continuously available for as long as 90 days when the soil temperature is above 8° C (47° F). Figure 27 shows the distribution of organic carbon, clay, and calcium carbonate in typical Aridisols (pedons 36 and 59). Note the very small amount of organic carbon near the surface and the large amount of accumulated carbonates and clay.

Aridisols are primarily soils of arid areas. They are in places that preclude much entry of water into the soil at present, either under extremely scanty rainfall or under slight rainfall that for one reason or another does not enter the soil. Vegetation, if present, consists of scattered plants, ephemeral grasses and forbs, cacti, and xerophytic shrubs. Some Aridisols furnish limited grazing. If irrigated, many of them are suitable for a wide variety of crops.

Entisols

The absence of marks in the soil of any major set of soil-forming processes is itself an important distinction. There can be no accessory characteristics. The unique properties common to Entisols are dominance of mineral soil materials and absence of distinct pedogenic horizons. Entisols are soils in the sense that they support plants, but they may be in any climate and under any vegetation. The absence of pedogenic horizons may be the result of an inert parent material such as quartz sand, in which horizons do not readily

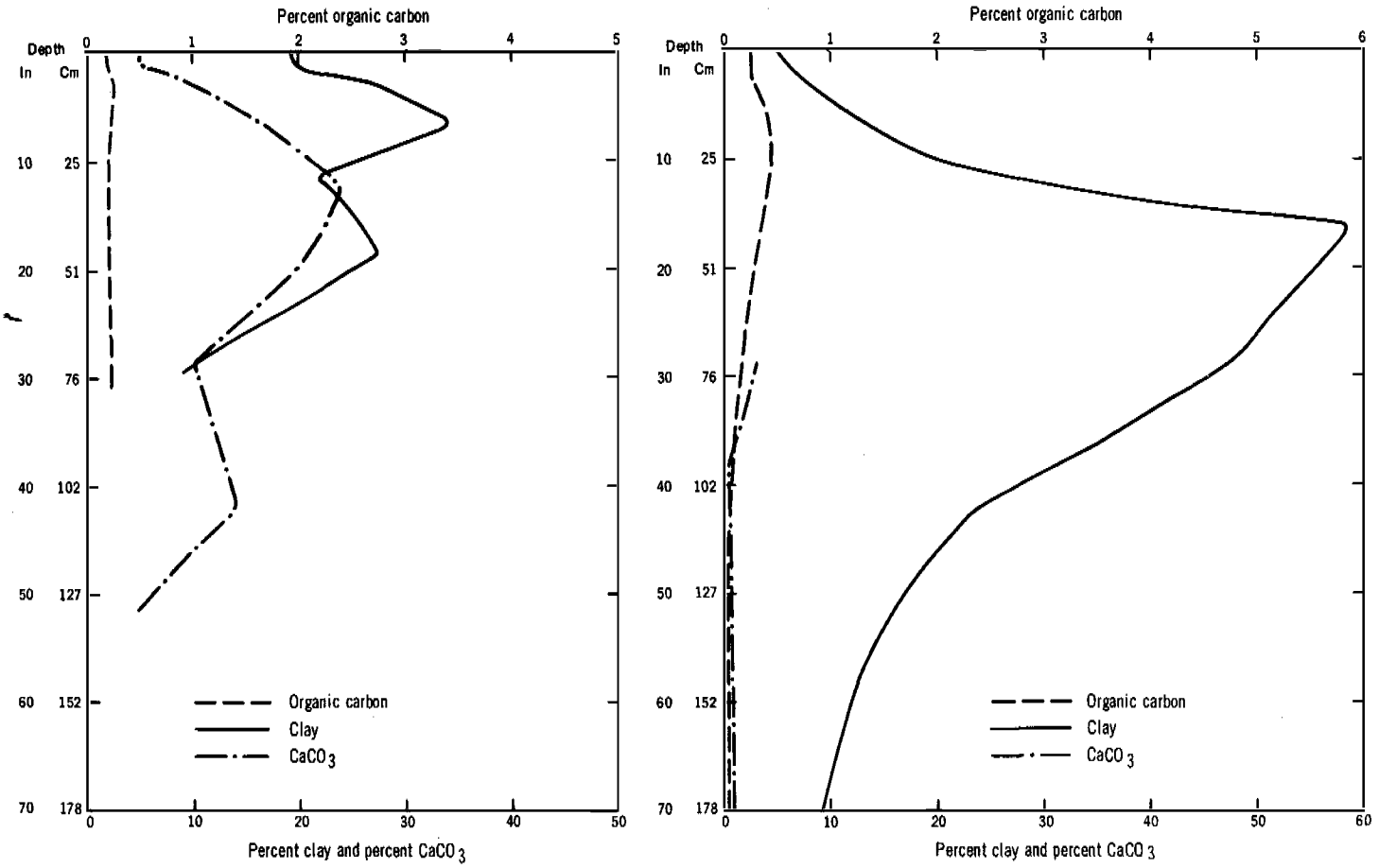


***Figure 27.*—Percentage of clay, organic carbon, and calcium carbonate as functions of depth in two contrasting Aridisols.**

Inceptisols

The unique properties of Inceptisols are a combination of water available to plants during more than half the year or more than 3 consecutive months during a warm season; one or more pedogenic horizons of alteration or concentration with little accumulation of translocated materials other than carbonates or amorphous silica; texture finer than loamy sand; some weatherable minerals; and moderate to high capacity of the clay fraction to retain cations. In addition, Inceptisols do not have one or more of the unique properties of the order of Mollisols, which are the thick, dark surface horizon, the high calcium supply, and the crystalline clays. Figure 29 shows the distribution of organic carbon and the bulk density in two Inceptisols as functions of depth. Clay distribution cannot be measured for the soil in figure 29 (left), which was derived from volcanic ash, so is not given for either of the soils. Pedon 29 is an Inceptisol. Note that there are wide ranges within Inceptisols in the content of organic carbon and in the cation-exchange capacity. Similar variability exists in the degree of base saturation.

Inceptisols can form in almost any but an arid environment, from polar to tropical, and the comparable differences in vegetation are great. Very commonly, Inceptisols have rock at a shallow depth. Most Inceptisols are on relatively young geomorphic surfaces, late Pleistocene or Holocene for the most part. Plates 9B and 9C show Inceptisols that are similar to pedons 74 and 29. Other Inceptisols are shown in plates 2C, 11A, 11B, and 11C.

Mollisols

The unique properties of Mollisols (plates 1D, 2B, 8B, 11D, 12A, and 12B) are a combination of a very dark brown to black surface horizon (mollic epipedon) that makes up more than one-third of the combined thickness of the A and B horizons or that is >25 cm (10 in.) thick and that has structure or soft consistence when dry; a dominance of calcium among the extractable cations in the A1 horizon and the B horizons; a dominance of crystalline clay minerals of moderate or high cation-exchange capacity; and <30 percent clay in some horizon above 50 cm if the soil has deep wide cracks (≥1 cm wide) above this depth at some season. Figure 30 shows the distribution of organic carbon, calcium carbonate, clay, cation-exchange capacity, and degree of base saturation as functions of depth in a typical Mollisol. Note the high de-

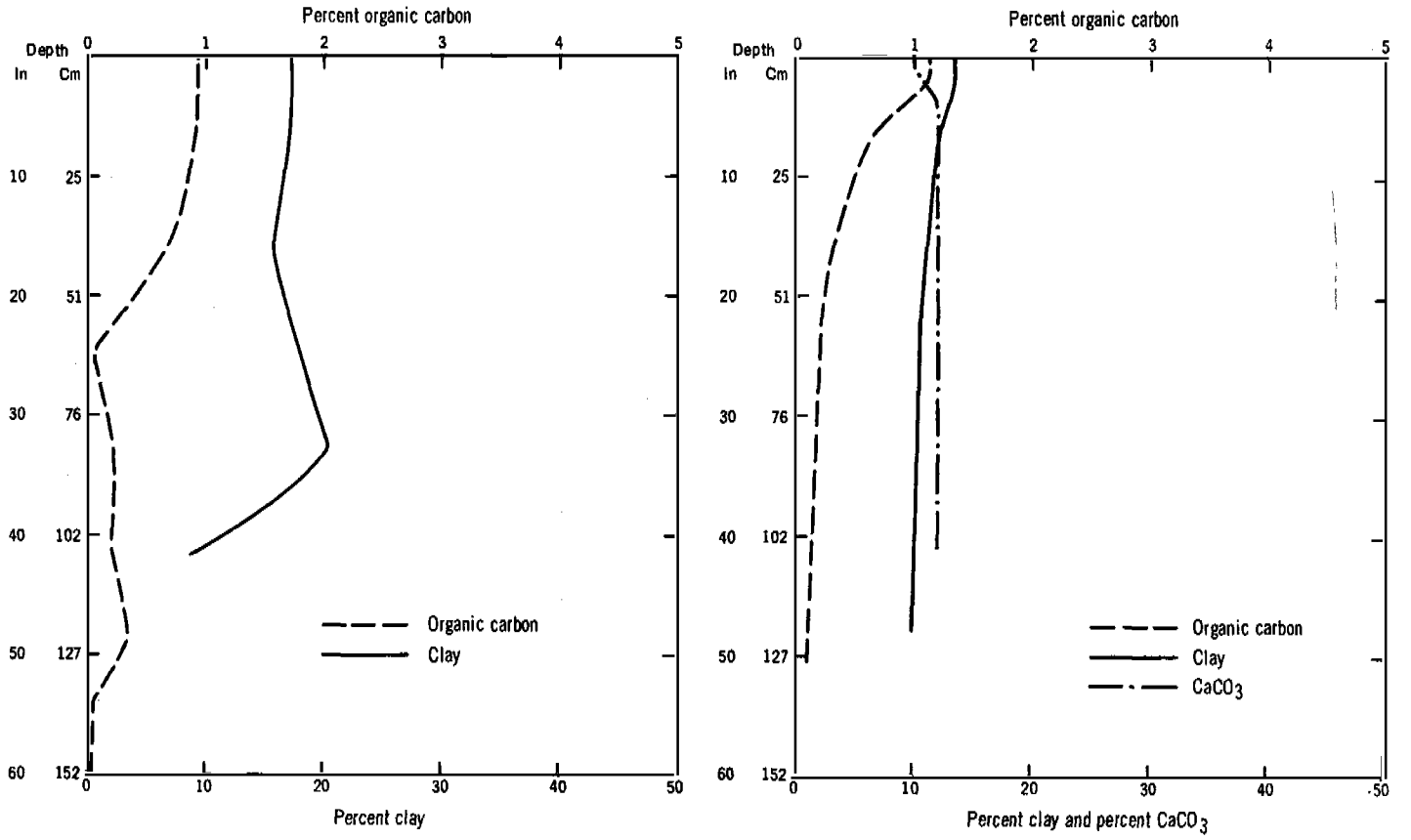


Figure 28.—**Percentages of clay, organic carbon, and calcium carbonate as functions of depth in two contrasting Entisols, left, on a floodplain, and right, on a hillside.**

gree of base saturation and the relatively deep penetration of organic carbon. One or both of the horizons of clay and of carbonate accumulation may be absent in Mollisols.

Mollisols characteristically form under grass in climates that have a moderate to pronounced seasonal moisture deficit. A few form in marshes or on marls in humid climates. Mollisols are the extensive soils of the steppes of Europe, Asia, North America, and South America.

Oxisols

The unique properties of Oxisols are extreme weathering of most minerals other than quartz to kaolin and free oxides; very low activity of the clay fraction; and a loamy or clayey texture (sandy loam or finer).

Figure 31 shows as functions of depth the organic carbon, cation-exchange capacity, total clay, and water-dispersible clay in a typical Oxisol (pedon 32). Note the high content of organic carbon, the low cation-exchange capacity, and the decreasing clay content with depth. The decrease of cation-exchange capacity with depth is due to the decreasing amount of organic matter. Pedon 33 is the Oxisol that is shown in plate 4D.

Oxisols characteristically occur in tropical or subtropical regions on land surfaces that have been stable for a long time. Mostly the surfaces are early Pleistocene or much older. Oxisols develop in a humid climate, but because climates change, some are now in an arid environment.

Spodosols

Spodosols (plates 4C, 7B, and 8C) have marks in at least an upper sequum of dominant processes that translocate humus and aluminum, or humus, aluminum, and iron as amorphous materials. The unique property of Spodosols is a B horizon of accumulation of black or reddish amorphous materials that have high cation-exchange capacity, the spodic horizon. In most undisturbed soils, an albic horizon overlies the B horizon. The spodic horizon has accessory characteristics of being moist or wet, loamy or sandy texture, high pH-dependent exchange capacity, and few bases. Figure 32 shows the distribution of clay and organic carbon, base saturation, cation-exchange capacity, and extractable iron and aluminum as functions of depth in a typical Spodosol (pedon 25). Note that the cation-exchange capacity is related to the amount of organic carbon rather than to the clay.

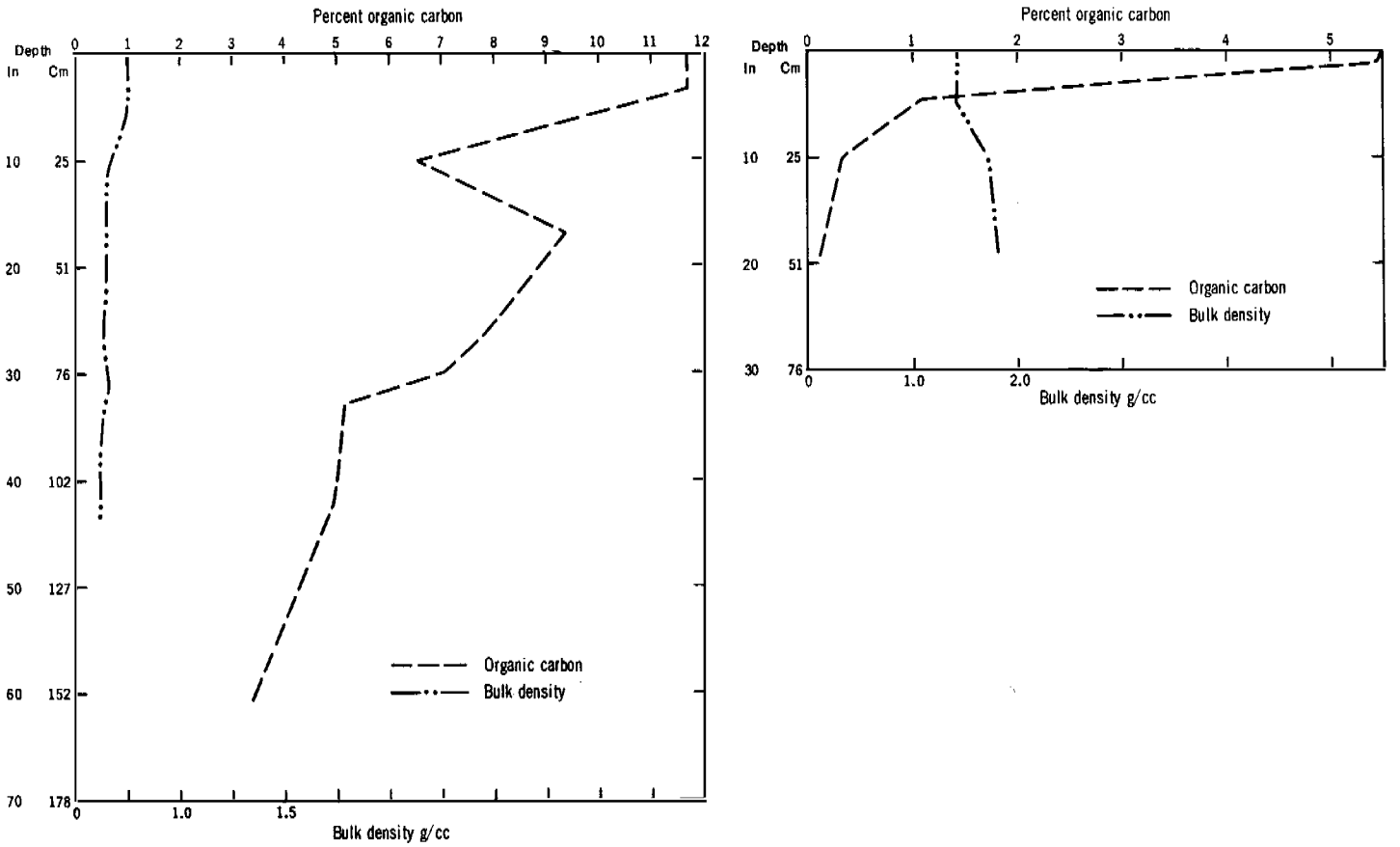


***Figure 29.*—Percentage of organic carbon and bulk densities of two contrasting Inceptisols, left, from volcanic ash, and right, from old alluvium.**

Ultisols

Ultisols (plate 9D), like Alfisols, have marks of clay translocation, but they also have marks of intense leaching that are absent in Alfisols. The unique properties common to Ultisols are an argillic horizon, a low supply of bases, particularly in the lower horizons, and a mean annual soil temperature higher than 8° C (47° F).

Figure 33 shows the distribution of clay, cation-exchange capacity, and base saturation as functions of depth in two Ultisols (pedons 21 and 15). Note that the clay content increases and then decreases with increasing depth, but the horizon of clay accumulation may be thin or thick. The cation-exchange capacity in Ultisols is mostly moderate or low. The decrease in base saturation with depth reflects cycling of bases by plants or additions in fertilizers. In soils that have not been cultivated, the highest base saturation is normally in the few centimeters just beneath the surface. Like Alfisols, the Ultisols have water, but they have few bases. Without fertilizers, they can be used for shifting cultivation, but because they are relatively warm and moist, they can be made highly productive if fertilizers are used.

Vertisols

These soils (plates 10A, 12C, and 12D) have marks of processes that mix the soil regularly and prevent development of diagnostic horizons that one might otherwise expect to find. Because the soil moves, the diagnostic properties have many accessory properties. Among them are high bulk density when dry, very slow hydraulic conductivity when moist, an appreciable rise and fall of the soil surface as the soil becomes moist and then dries, and rapid drying as a result of open cracks. The unique properties common to Vertisols are a high content of clay; pronounced changes in volume with changes in moisture; deep wide cracks ($\geq$1 cm wide at a depth of 50 cm) at some season; and evidences of soil movement in the form of slickensides, gilgai microrelief, and wedge-shaped structural aggregates that are tilted at an angle from the horizontal. Figure 34 shows the distribution of clay, organic carbon, and cation-exchange capacity in a typical Vertisol (pedon 127). Note the relatively low content of organic carbon, the high content of clay, the high cation-exchange capacity, and the lack of marked changes in these properties with depth. At some season, rains come when the cracks are open,

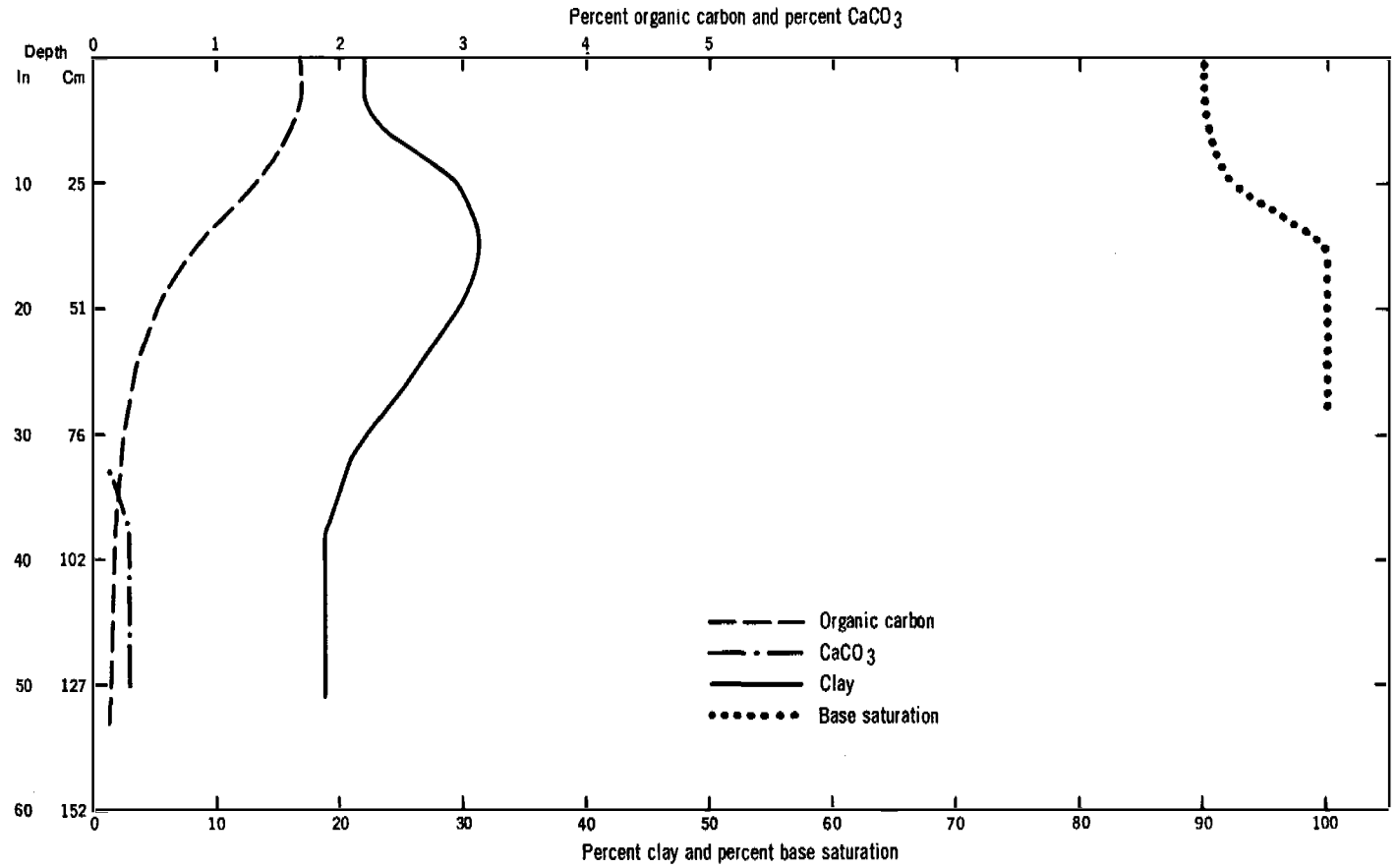


***Figure 30.*—Percentages of clay, organic carbon, base saturation, and calcium carbonate as functions of depth in a representative Mollisol.**

and some of the surface soil falls or washes into the cracks before the whole soil becomes moist and the cracks close. Because of this movement, these soils have been said to swallow themselves. Plate 7C shows slickensides from a Vertisol.

Examples of differences in orders

The preceding discussion illustrates the kinds of marks that have been chosen to differentiate the orders and the sets of processes that they indicate. The Entisols lack distinctive horizons, although they may have stratified layers. Too little has happened in them to provide distinct pedogenic marks in the soil. The Entisol on a hillside has accumulated a little organic carbon, but not enough to darken it appreciably (fig. 28, right). The upper 10 cm of soil have lost a little calcium carbonate, but all of these alterations would be obliterated by the first plowing.

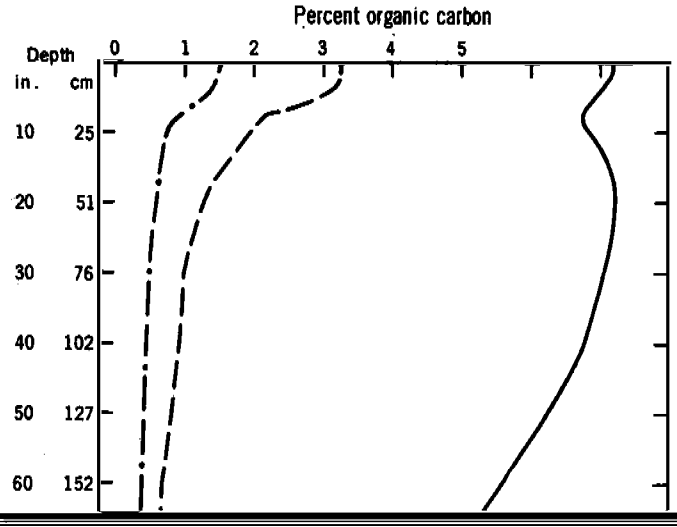
The Vertisol (fig. 34) shows few changes with depth. The organic carbon has penetrated deeply but the amounts are small. There are deep wide cracks, gilgai, abundant slickensides below a depth of 50 cm, and a change in structure but little change in other properties at increasing depth. These are marks of the dominance of self swallowing over most other processes.

The Alfisol (fig. 26) has a distinct horizon of clay accumulation and shallow penetration of organic carbon. Base saturation is high. Too little water has gone through the soil to remove the bulk of the bases. Release of bases from primary minerals or their retention has so far been dominant over leaching and removal of the bases from the soil.

Although Alfisols are defined as having an argillic horizon, such a definition also implies that an eluvial horizon is present or has been present. The eluvial horizon may have been removed by erosion, but the classification of the soil is not changed as a result of truncation until the B horizon has also been lost.

In contrast to Alfisols, the Ultisols (fig. 33) have few exchangeable bases. The few bases that are present in the soil shown in figure 33 have been held by plants against leaching. The soil has virtually no weatherable minerals. The processes of eluviation and illuviation seem the same in Ultisols and Alfisols.

The Spodosol (fig. 32) has negligible evidences of eluviation and illuviation of clay but rather has evidences of eluviation and illuviation of amorphous mixtures or compounds of organic carbon, iron, and aluminum. Retention of bases by the soil or by plants has been negligible, and the effects of leaching of bases are dominant. In contrast to the Ultisols, the cation-ex-



(fig. 28, left). This segregates the very young soils that do not have horizons because there is continuing deposition of new sediments. A third suborder provides for soils on recently eroded slopes (fig. 28, right). This segregates soils that are kept young by removal of soil materials at a rate that is more rapid than that of horizon differentiation. A fourth suborder includes sands that may range from recent to old. If old, either they lack the building blocks for pedogenic horizons or they do not have enough moisture. Although the reasons for absence of horizons in the sands vary, the sands have many common physical properties such as low capacity for moisture retention, rapid hydraulic conductivity, susceptibility to blowing, and so on. The sorting of these differences is continued in the lower categories. The fifth suborder of Entisols provides for soils in which horizons have been mixed, as by deep plowing, where man has destroyed the pedogenic horizons as such but not the fragments

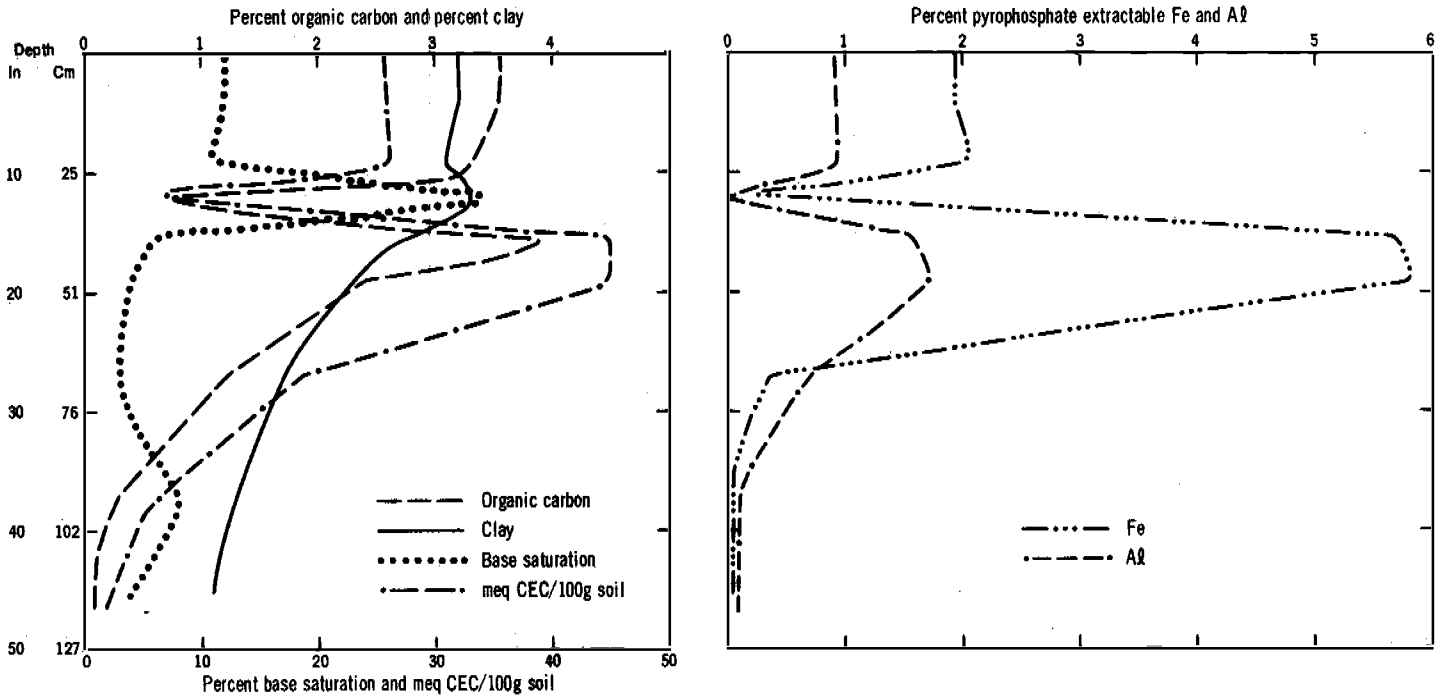


***Figure 32.*—Percentages of clay, organic carbon, base saturation, and pyrophosphate-extractable iron and aluminum, and cation exchange capacity as functions of depth in a representative Spodosol.**

are many times that number. In a few taxa, soil moisture and soil temperature regimes are not defined but

addition to the argillic horizon that is common to all Alfisols, other kinds of horizons may be present. A

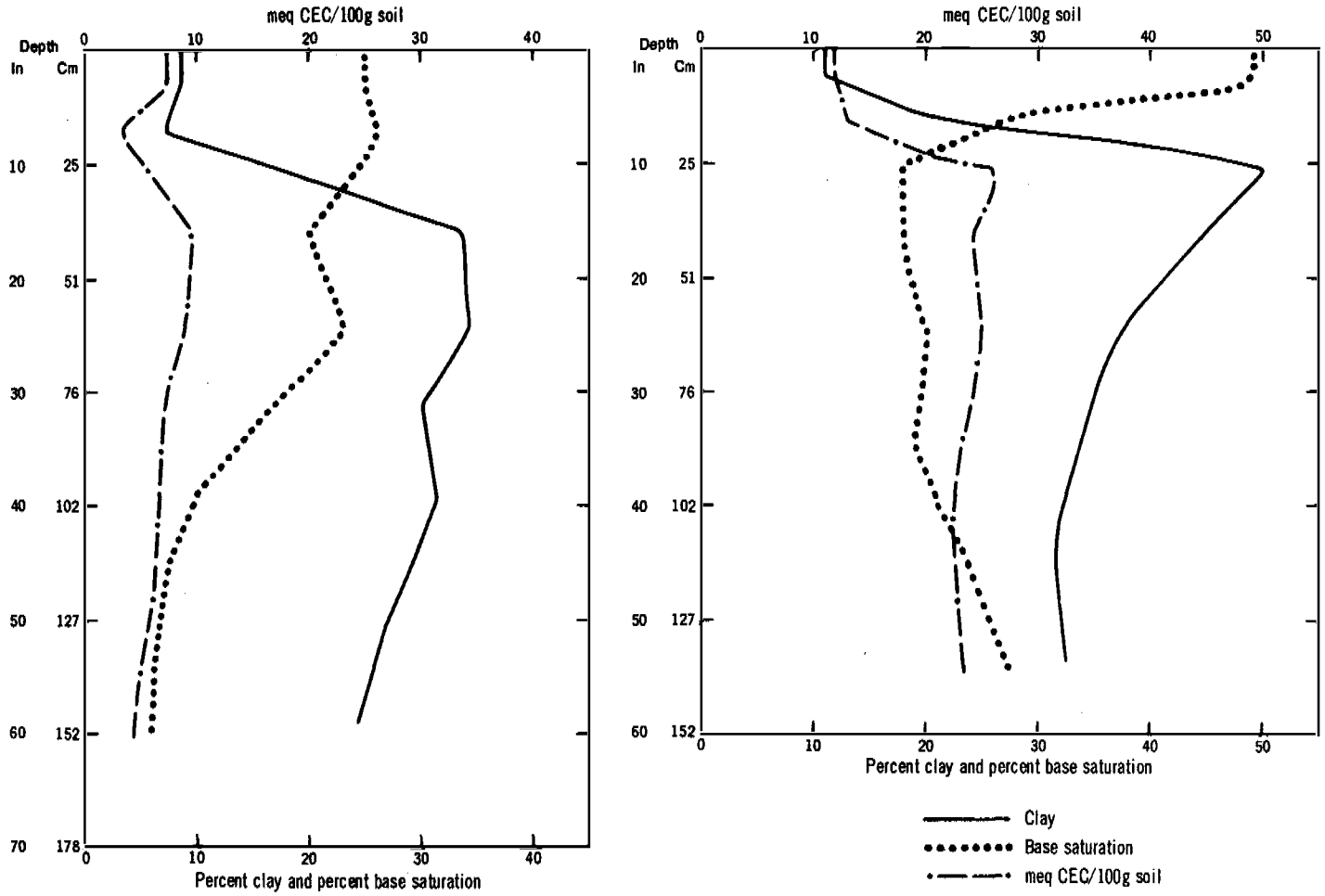


Figure 33.—**Percentages of clay and base saturation and cation exchange capacity as functions of depth in two contrasting Ultisols.**

Subgroups

About 970 subgroups are currently recognized in the United States.

Through the categories of order, suborder, and great group, emphasis has been placed on marks or causes of sets of processes that appear to dominate the course or degree of soil development. In addition to these dominant marks, many soils have properties that, although apparently subordinate, are still marks of important sets of processes. Some of these appear to be marks of sets of processes that are dominant in some other great group, suborder, or order, but in a particular soil they only modify the marks of other processes. For example, some soils have an aquic moisture regime and have throughout their depth gray colors that are mottled with shades of brown, red, or yellow. Other soils have an aquic moisture regime only in their lower horizons, and in those horizons the dominant colors may be shades of brown, red, or yellow with some gray mottles. The effects of ground water are apparent in both sets of soils, but they have less importance in the latter set.

Other properties are marks of sets of processes that are not used as criteria of any taxon at a higher level. For example, a Mollisol at the foot of a slope, where there has been a slow accumulation of materials washed from higher parts of the slope, may have a greatly overthickened mollic epipedon.

Thus, we have three kinds of subgroups:

The central concept of the great group.—This is not necessarily the most extensive subgroup.

The intergrades or transitional forms to other orders, suborders, or great groups.—The properties may be the result of sets of processes that cause one kind of soil to develop from or toward another kind of soil, or otherwise to have intermediate properties between those of two or three great groups. The properties used to define the intergrades may be:

1. Horizons in addition to those definitive of the great group, including an argillic horizon that underlies a spodic horizon as discussed under great groups and a buried horizon such as a thick layer of organic materials that is buried by a thin mineral soil;
2. Intermittent horizons such as those discussed in the section of chapter 1 that deals with the pedon; or

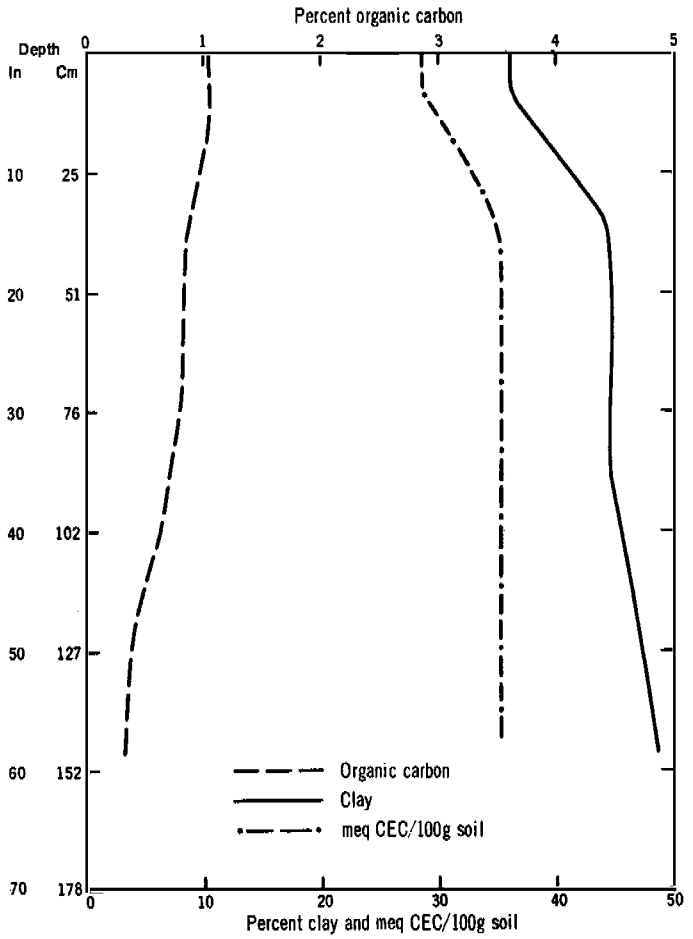


***Figure 34.*—Percentage of clay and organic carbon and cation exchange capacity as functions of depth in a representative Vertisol.**

3. Properties of one or more other great groups that are expressed in a part of the soil but are subordinate to the properties of the great group of which the subgroup is a member. One example of different levels of ground water was given earlier. Another example might be that of an Alfisol that has an ochric epipedon a little too thin or a little too light in color to be a mollic epipedon. This could result from an invasion of grassland by forest or the reverse. Or, it could be the effect of both grass and forest coexisting on the same polypedon.

Extragrades.—These subgroups have some properties that are not representative of the great group but that do not indicate transitions to any other known kind of soil. One example of an overthickened mollic epipedon was given earlier. Other examples would be soils that are very shallow over rock or that have permafrost.

Families

In this category, the intent has been to group the soils within a subgroup having similar physical and chemical properties that affect their responses to management and manipulation for use. The responses of comparable phases of all soils in a family are nearly enough the same to meet most of our needs for practical interpretations of such responses. Soil properties are used in this category without regard to their significance as marks of processes or lack of them. About 4,500 families are currently recognized in the United States.

Families are defined primarily to provide groupings of soils with restricted ranges in

1. Particle-size distribution in horizons of major biologic activity below plow depth;
2. Mineralogy of the same horizons that are considered in naming particle-size classes;
3. Temperature regime;
4. Thickness of the soil penetrable by roots; and
5. A few other properties that are used in defining some families to produce the needed homogeneity.

These properties are important to the movement and retention of water and to aeration, both of which affect soil use for production of plants or for engineering purposes. The differentiae are discussed in more detail in chapter 18.

Series

The series is the lowest category in this system. About 10,500 series have been recognized in the United States, although a number of them have been divided or replaced and do not appear in the present taxonomy. The taxa and many of the differentiae in the series category have been carried over from earlier classifications. Modifications of the original concept of the series category, as well as of the series differentiae, have been made repeatedly over the years (Simonson 1964).

The differentiae used for series are mostly the same as those used for classes in other categories, but the range permitted in one or more properties is less than is permitted in a family or in some other higher category. A series may have virtually the full range that is permitted in a family in several properties, but in one or more properties the range is restricted. The purpose of the series category, like that of the family, is mainly pragmatic, and the taxa in the series category are closely allied to interpretive uses of the system.

Two kinds of distinctions, therefore, are made between series. First, the distinctions between families and between classes of all higher categories are also distinctions between series; a series cannot range across the limits between two families or between two classes of any higher category. Second, distinctions between similar series within a family are restrictions in one or more but not necessarily all of the ranges in properties of the family. Taken collectively, the number of the latter kind of distinctions is too large to be comprehended readily. We can only state the basis for decisions to separate individual series. We must keep in mind the purpose of the taxonomy. It is not an end in itself. Attention is centered on the genetic horizons below the depth of normal plowing or, if they are

thin, faint, or absent, on the zone of major biologic activity below depth of normal plowing.

The differentiae for series in the same family are expected to meet three tests. The first is that properties serving as differentiae can be observed or can be inferred with reasonable assurance. The second is that they must create soil series whose unique range of properties is significantly greater than the normal errors of measurement, observation, or estimate by qualified men. The third is that the differentiae have some relation to horizon differentiation if horizons are present. This significance can be reflected in the nature or degree of expression of one or more horizons. By nature of horizons we mean the composition, including mineralogy, structure, consistence, texture of the subhorizons, moisture and temperature regimes, and so on. If color is accessory to some other property, it too is included. Degree of horizon expression includes thickness, contrast between horizons or subhorizons, and nature of boundaries. If horizons are absent, the nature of the whole zone of major biologic activity below plow depth is considered. The limits of this zone are given in chapter 18.

Important differences, as shown by experience or research to condition or influence the nature of the statements that we can make about the behavior of the soil, should be considered as series differentiae.

A number of soil properties condition the statements we may make about a soil or its use but are not series differentiae. A steep slope or stones on the surface may be very important to the use of a soil in mechanized farming, but they may have virtually no importance to the growth of a forest. If we assume that these soil characteristics are not reflected in the nature of the soil, or in the nature or degree of expression of horizons explained earlier,[1] then they may be used as one of the bases of phases. The phases provide for a utilitarian classification that can be superimposed on the taxonomy at any categoric level to permit more precise interpretations and predictions of the consequence of the various alternative uses of the soil that can be foreseen.

The primary use of soil series in the classification system is to relate the polypedons represented on detailed soil maps to the taxa and to the interpretations that may follow. The dominant kinds of polypedons that are delineated on maps are given the names of series. Polypedons are real things, but series are conceptual. The Miami series, for example, cannot be seen or touched, but the polypedons that we identify as physical entities within the concept of the Miami series can be seen and touched.

Soil series names are used with several meanings that must be kept in mind. We may speak of the Miami series as a taxonomic class, a concept of a narrowly defined kind of soil. Or, we may examine a pedon and say, "This is Miami," meaning that the properties we find in the pedon are those we ascribe to the Miami series and that the pedon is a proper example. We also use Miami as part of the name for an area shown on a soil map if the Miami series is dominant in that area, for example, Miami silt loam, 2 to 6 percent slopes. These are three common meanings of Miami, or of any series name, and all are proper. It is essential, however, to keep in mind that a series, as used in this taxonomy, is conceptual; the meaning is not identical with the meaning intended on soil maps, for an area of Miami soil has inclusions of soils of other series. Inclusions of Miami soil are also permitted in areas named for other series. The application of the taxonomy to soil surveys is discussed in chapter 19.

Soil types

The soil type has been the lowest category in all previous classification systems that we have used in the United States. Types have been distinguished within series on the basis of texture, a single characteristic. At first, the distinction involved the texture of the soil when texture meant a combination of particle size, structure, and consistence. In recent years, when texture has been defined in terms of particle size distribution alone, the texture of the plow layer or of its equivalent in virgin soils was used to distinguish types within a series. Because the significance of the texture or particle size distribution of the plow layer is mainly pragmatic, and the texture classes can be made more useful if adjusted to fit circumstances at a given time, the soil type has not been retained as a category of this system. This mention is made here to explain its disappearance as a category. The texture of the plow layer will commonly be shown in the soil name in published soil surveys as heretofore, but will be considered as a part of the phase name rather than the name of a taxon.

[1] The loss of surface horizons as a result of erosion is reflected in the nature of the soil but is used as one of the bases for phases to facilitate the purposes of the taxonomy. If the series is changed by the loss of a horizon that is not diagnostic in a higher category, relations between the eroded and uneroded soils become unnecessarily complicated for the users of the soil surveys.

CHAPTER 6

Nomenclature[1]

Each taxon requires a name if it is to be used in speech. A good name is short, easy to pronounce, and distinctive in meaning. It is connotative, that is, capable of mnemonic attachment to the concept of the thing itself (Heller 1963). It is useful if the name of a taxon indicates its position in the classification, if similarities in important properties are reflected by similarities in names, if the mnemonic attachments hold in many languages, and if the name fits into many languages without translation.

The nomenclature for this classification was developed with these ends in mind, but there are conflicts between some of them and some compromises and choices have been necessary.

The name of each taxon above the category of series indicates its class in all categories of which it is a member. The name of a soil series indicates only the category of series. Thus, a series name may be recognized as a series, but one cannot tell from the name to what order, suborder, and so on, it belongs.

Table 6 gives a few examples of names of taxa in each category from order to series. Because of the system for assigning names and because most formative elements carry the same meaning in any combination, a name can convey a great deal of information about a soil.

Recognition of names

Orders

Names of orders can be recognized as such because the name of each order ends in *sol* (L. *solum*, soil) with the connecting vowel *o* for Greek roots and *i* for other roots. Each name of an order contains a formative element that begins with the vowel next preceding the connecting vowel and ends with the last consonant preceding the connecting vowel. In the order name Entisol, the formative element is *ent*. In Aridisol, it is *id*. These formative elements are used as endings for the names of suborders, great groups, and subgroups. Thus, the names of all taxa higher than the series that are members of the Entisol order end in *ent* and can be recognized as belonging to the order of Entisol. Names ending in *id* are names of taxa belonging to the order of Aridisols.

Suborders

Names of suborders have exactly two syllables. The first syllable connotes something of the diagnostic properties of the soils. The second is the formative element from the name of the order. Twenty-five formative elements are used with the 10 formative elements from names of the orders to make names of 47 suborders. The suborder of Entisols that have an aquic moisture regime throughout is called Aquents, (L. *aqua*, water, plus *ent* from Entisol). The formative element *aqu* is used with this meaning in 7 of the 10 orders. The suborder of Entisols that consist of very young sediments is called Fluvents (L. *fluvius*, river, plus *ent* from Entisol).

Great groups

The name of a great group consists of the name of a suborder and a prefix that consists of one or two formative elements suggesting something of the diagnostic properties. Names of great groups, therefore, have three or four syllables and end with the name of a suborder. Fluvents that have a cryic temperature regime are called Cryofluvents (Gr. *kryos*, icy cold, plus fluvent). Fluvents that have a torric moisture regime are called Torrifluvents (L. *toridus*, hot and dry).

Subgroups

The name of a subgroup consists of the name of a

[1] This chapter cannot be written without acknowledging the assistance of the late Prof. A. L. Leemans, Head, Classic Language Department, State University of Ghent, and Prof. John L. Heller, Head, Department of the Classics, University of Illinois. Without their assistance the development of the nomenclature would have been impossible. They gave their time freely and, if the nomenclature used in this text proves useful, as we believe it will, soil science is deeply in their debt. It should be emphasized that not all the names proposed met

TABLE 6.—*Examples of names of taxa in each category*

Order	Suborder	Great group	Subgroup	Family [1]	Series
Alfisols					
Aridisols					
Entisols	Aquents				
	Arents				
	Fluvents	Cryofluvents	Typic Cryofluvents	Coarse-loamy, mixed, acid	Susitna.
		Torrifluvents	Typic Torrifluvents	Fine-loamy, mixed (calcareous), mesic.	Jocity and Youngston.
			Vertic Torrifluvents	Clayey over loamy, mixed, (calcareous) hyperthermic.	Glamis.
	Orthents	Cryorthents	Typic Cryorthents	Loamy-skeletal, carbonatic	Swift Creek.
			Pergelic Cryorthents	Loamy-skeletal, mixed (calcareous)	Durelle.
Histosols					

[1] The complete name of a family consists of the name of the subgroup modified by adjectives to describe properties that are defined in chapter 18.

adjective *typic* is used for the subgroup that is thought to typify the great group. Each typic subgroup has, in clearly expressed form, all the diagnostic properties of the order, suborder, and great group to which it belongs. Typic subgroups also have no additional properties indicating a transition to another great group and have no aberrant properties that require special recognition. The Torrifluvents that typify the central concept of the great group are therefore called Typic Torrifluvents. These are not necessarily the most extensive Torrifluvents.

Intergrade subgroups are those that belong to one great group but that have some properties of another order, suborder, or great group. They are named by using the adjectival form of the name of the appropriate taxon as a modifier of the great group name. Thus, the Torrifluvents that have many but not all the properties diagnostic of Vertisols are called Vertic Torrifluvents. Vertic Torrifluvents have some of the properties of Vertisols superimposed on the complete set of diagnostic properties of Torrifluvents.

Extragrade subgroups are those that have important properties that are not representative of the great group but that do not indicate transitions to any other known kind of soil. They are named by modifying the great group name with an adjective that connotes something of the nature of the aberrant properties. Thus, a Cryorthent that has permafrost (a permanently frozen layer) is called a Pergelic Cryorthent (L. *per*, throughout in time and space, plus L. *gelare*, to freeze). This subgroup is listed as an example in table 6.

Families

Names of families are polynomial. Each consists of the name of a subgroup and adjectives, generally three or more, to indicate the particle-size class (11 or more. An example given in table 6 is a family of fine-loamy (particle size), mixed (calcareous), (mineralogy class and subclass), mesic (soil temperature) Typic Torrifluvents.

Series

Names of series as a rule are abstract place names. The name usually is taken from a place near the one where the series was first recognized. It may be the name of a town, a county, or some local feature. Some series in sparsely settled regions have coined names. Most of the series names have been carried over from earlier classifications. Some have been in use since 1900. The name of a series carries no meaning to people who have no other source of information about the soils in it.

Meanings in the names

The Jocity and Youngston series (table 6) are two members of the fine-loamy, mixed (calcareous), mesic family of Typic Torrifluvents. The meaning of each of these terms is defined later, but in a general way the name tells us the following:

Fine-loamy means that from a depth of 25 cm to 1 m there is no marked contrast in particle-size class, the content of clay is between 18 and 35 percent, 15 percent or more of the material is coarser than 0.1 mm in diameter (fine sand to very coarse sand plus gravel), but <35 percent by volume of the material is rock fragments ≥2 mm in diameter (less than about 50 percent by weight). The average texture,[2] then, is more likely to be loam, clay loam, or sandy clay loam. *Mixed* means a mixed mineralogy, that is, there is <40 percent of any one mineral other than quartz in the fraction between 0.02 mm and 2 mm in diameter

annual soil temperature is between 8° and 15° C (47° and 59° F) and the soil temperature fluctuates between summer and winter. In other words, the soil is somewhere in the midlatitudes, summer is warm or hot, and winter is cool or cold.

The meaning of typic varies with the great group. *Torri* indicates a torric (dry) moisture regime. *Fluv* indicates sediments, probably alluvium, because fresh eolian sediments may be sandy, silty or clayey, but are rarely fine-loamy. *Ent*, the final syllable, tells us that the soil is an Entisol and has very weak or no horizons.

We can, therefore, visualize a soil on a flood plain

aberrant feature of a Durargid is that the duripan is brittle and that only about one-third of its volume is cemented into nodules called durinodes, it is considered to intergrade toward the Haplargids—the Argids that do not have a duripan. The name, however, is Haplic Durargid, not Haplargidic Durargid. Only the prior (first) formative element is used in adjectival form if the two great groups are in the same suborder.

Names of intergrades toward a great group in

the soil may be a bit salty, it cannot be extremely salty. It probably has stratification but has no severe limitation for irrigation. Under irrigation, iron chlorosis may be a problem in sensitive plants. If the soil is not irrigated, it can be used only for limited grazing.

Forming names

Two kinds of names have been chosen to indicate intergrades toward a great group in the same order but in a different suborder. If the only aberrant features are color and moisture regime and the hue is too yellow or the chroma is too high or too low for the typic subgroup, the adjectives aeric, aquic, and epiaquic are used. Aeric is shorter and in some instances more descriptive than the formative elements of the suborder or great group names. Aquic is usually the prior formative element of a suborder name. *Epiaquic* suggests

TABLE 7.—*Names of orders, suborders, and great groups*

Order	Suborder	Great group
Alfisols	Aqualfs	Albaqualfs.
		Duraqualfs.
		Fragiaqualfs.
		Glossaqualfs.
		Natraqualfs.
		Ochraqualfs.
		Plinthaqualfs.
		~~Tropaqualfs.~~
		Umbraqualfs.
	Boralfs	Cryoboralfs.
		Eutroboralfs.
		Fragiboralfs.
		Paleboralfs.
	Udalfs	Agrudalfs.
		Ferrudalfs.
		Fragiudalfs.
		Fraglossudalfs.
		Glossudalfs.
		Hapludalfs.
		Natrudalfs.
		Paleudalfs.
		Rhodudalfs.
		~~Tropudalfs.~~
	Ustalfs	Durustalfs.
		Haplustalfs.
		Natrustalfs.
		Paleustalfs.
		Plinthustalfs.
		Rhodustalfs.
	Xeralfs	Durixeralfs.
		Haploxeralfs.
		Natrixeralfs.
		Palexeralfs.
		Plinthoxeralfs.
		Rhodoxeralfs.
Aridisols	Argids	Durargids.
		Haplargids.
		Nadurargids.
		Natrargids.
		Paleargids.
	Orthids	Calciorthids.
		Camborthids.
		Durorthids.
		Gypsiorthids.
		Paleorthids.
		Salorthids.
Entisols	Aquents	Cryaquents.
		Fluvaquents.
		Haplaquents.
		Hydraquents.
		Psammaquents.
		Sulfaquents.
		Tropaquents.
	Arents	Arents.
	Fluvents	Cryofluvents.
		Torrifluvents.
		Tropofluvents.
		Udifluvents.
		Ustifluvents.
		Xerofluvents.
	Orthents	Cryorthents.
		Torriorthents.
Histosols	Fibrists	Borofibrists.
		Cryofibrists.
		Luvifibrists.
		Medifibrists.
		Sphagnofibrists.
		Tropofibrists.
	Folists	Borofolists.
		Cryofolists.
		Tropofolists.
	Hemists	Borohemists.
		Cryohemists.
		Luvihemists.
		Sulfohemists.
		Tropohemists.
	Saprists	Borosaprists.
		Cryosaprists.
		Medisaprists.
		Troposaprists.
Inceptisols	Andepts	Cryandepts.
		Durandepts.
		Dystrandepts.
		Eutrandepts.
		Hydrandepts.
		Placandepts.
		Vitrandepts.
	Aquepts	Andaquepts.
		Cryaquepts.
		Fragiaquepts.
		Halaquepts.
		Haplaquepts.
		Humaquepts.
		Placaquepts.
		Plinthaquepts.
		Sulfaquepts.
		Tropaquepts.
	Ochrepts	Cryochrepts.
		Durochrepts.
		Dystrochrepts.
		Eutrochrepts.
		Fragiochrepts.
		Ustochrepts.
		Xerochrepts.
	Plaggepts	Plaggepts.
	Tropepts	Dystropepts.
		Eutropepts.
		Humitropepts.
		Sombritropepts.
		Ustropepts.
	Umbrepts	Cryumbrepts.
		Fragiumbrepts.
		Haplumbrepts.
		Xerumbrepts.
Mollisols	Albolls	Argialbolls.
		Natralbolls.
	Aquolls	Argiaquolls.
		Calciaquolls.
		Cryaquolls.
		Duraquolls.
		Haplaquolls.
		Natraquolls.
	Borolls	Argiborolls.
		Calciborolls.

TABLE 7.—*Names of orders, suborders, and great groups*—Continued

Order	Suborder	Great group
		Calciustolls.
		Durustolls.
		Haplustolls.
		Natrustolls.
		Paleustolls.
		Vermustolls.
	Xerolls	Argixerolls.
		Calcixerolls.
		Durixerolls.
		Haploxerolls.
		Natrixerolls.
		Palexerolls.
Oxisols	Aquox	~~Gibbsiaquox.~~ Acr
		~~Ochraquox.~~ Ent
		Plinthaquox. Hapl
		~~Umbraquox.~~
	~~Humox.~~	~~Acrohumox.~~
		~~Gibbsihumox.~~
		~~Haplohumox.~~
		~~Sombrihumox.~~
	~~Orthox~~	~~Acrorthox.~~
		~~Eutrorthox.~~
		~~Gibbsiorthox.~~
		~~Haplorthox.~~
		~~Sombriorthox.~~
		~~Umbriorthox.~~
	Torrox	~~Torrox.~~ Acr, Ent, Hapl
	Ustox	Acrustox.
		Eutrustox.
		Sombriustox. Kand
		Haplustox.
Spodosols	Aquods	Cryaquods.
		Duraquods.
		Fragiaquods.
		Haplaquods.
		Placaquods.
		Sideraquods.
		Tropaquods.
	Ferrods	Ferrods.
	Humods	Cryohumods.
		Fragihumods.
		Haplohumods.
		Placohumods.
		Tropohumods.
	Orthods	Cryorthods.
		Fragiorthods.
		Haplorthods.
		Placorthods.
		Troporthods.
Ultisols	Aquults	Albaquults.
		Fragiaquults.
		Ochraquults.
		Paleaquults.
		Plinthaquults.
		~~Tropaquults.~~
		Umbraquults.
	Humults	Haplohumults.
		~~Palehumults.~~
		Plinthohumults.
		Sombrihumults.
		~~Tropohumults.~~
	Udults	Fragiudults.
		Hapludults.
		Paleudults.
		Plinthudults.
		Rhodudults.
		~~Tropudults.~~
	Ustults	Haplustults.
		Paleustults.
		Plinthustults.
		Rhodustults.
	Xerults	Haploxerults.
		Palexerults.
Vertisols	Torrerts	Torrerts.
	Uderts	Chromuderts.
		Pelluderts.
	Usterts	Chromusterts.
		Pellusterts.
	Xererts	Chromoxererts.
		Pelloxererts.

than Aquic Mollic Hapludalf. The general rule is that the simplest possible name is used. If there are several aberrant features, the adjectival forms of one or more great group names may be required.

Names of subgroups not intergrading toward any known kind of soil (extragrades)

Some soils have aberrant properties that are not characteristic of a class in a higher category of any order, suborder, or great group. One example might be taken from the concave polypedons that are at the base of slopes, in depressions, or in other places where new soil material accumulates slowly on the surface. The rate of accumulation of new material may be slower or about the same as the rate of accumulation of organic matter, so that in time a very thick, dark surface horizon develops. In these soils, the C horizon subgroup names. *Pachic* is used to indicate an overthickened epipedon if there is no evidence of new material at the surface.

Other soils lie outside the range of typic subgroups in an opposite direction. Such soils are, in effect, truncated by hard rock and are shallow or are intermittent between rock outcrops. They are, in effect, intergrades

TABLE 8.—*Formative elements in names of soil orders*

Name of order	Formative element in name of order	Derivation of formative element	Pronunciation of formative element
Alfisol	Alf	Meaningless syllable	Pedalfer.
Aridisol	Id	L. *aridus*, dry	Arid.

TABLE 9.—*Formative elements in names of suborders*

Formative element	Derivation	Mnemonicon	Connotation
Alb	L. *albus*, white	Albino	Presence of albic horizon.
And	Modified from ando	Ando	Andolike.
Aqu	L. *aqua*, water	Aquarium	Aquic moisture regime.
Ar	L. *arare*, to plow	Arable	Mixed horizons.
Arg	Modified from argillic horizon; L. *argilla*, white clay.	Argillite	Presence of argillic horizon.
Bor	Gr. *boreas*, northern	Boreal	Cool.
Ferr	L. *ferrum*, iron	Ferruginous	Presence of iron.
Fibr	L. *fibra*, fiber	Fibrous	Least decomposed stage.
Fluv	L. *fluvius*, river	Fluvial	Flood plain.
Fol	L. *folia*, leaf	Foliage	Mass of leaves.
Hem	Gr. *hemi*, half	Hemisphere	Intermediate stage of decomposition.
Hum	L. *humus*, earth	Humus	Presence of organic matter.
Ochr	Gr. base of *ochros*, pale	Ocher	Presence of ochric epipedon.
Orth	Gr. *orthos*, true	Orthophonic	The common ones.
Plagg	Modified from Ger. *plaggen*, sod		Presence of plaggen epipedon.
Psamm	Gr. *psammos*, sand	Psammite	Sand texture.
Rend	Modified from Rendzina		High carbonate content.
Sapr	Gr. *sapros*, rotten	Saprophyte	Most decomposed stage.
Torr	L. *torridus*, hot and dry	Torrid	Torric moisture regime.
Ud	L. *udus*, humid	Udometer	Udic moisture regime.
Umbr	L. *umbra*, shade	Umbrella	Presence of umbric epipedon.
Ust	L. *ustus*, burnt	Combustion	Ustic moisture regime.
Xer	Gr. *xeros*, dry	Xerophyte	Xeric moisture regime.

to not-soil and are called *lithic* subgroups. The names of formative elements in groups of this sort, which are called extragrades, are listed together with their derivation in table 11.

Names of multiple subgroups intergrading between two given great groups

Two or more subgroups in a given great group may be intergrades to the same class of soil or even to not-soil. In one place, for example, the horizons may be continuous, in another, discontinuous, and in a third, buried. Or, in one place properties of two classes are mixed in a single horizon, but in another they exist in separate horizons. A soil of class X may be developing from or toward class Y, producing subgroups that and only the argillic horizon of the Haploxerult intermittent, the name would be Lithic Ruptic-Xerochreptic Haploxerults. If only the lithic portion of each pedon fitted the definition of Haploxerults, the name would be Ruptic-Xerochreptic Lithic-Haploxerults. The general rule is to hyphenate modifiers in the part of the name that they modify. No hyphens are used if the modifier applies to the entire pedon.

If the subgroup is one in which a buried soil is an important part of the present soil, the name includes *thapto* (Gr. *thapto*, buried) as a modifier of the name of the buried soil. Hyphens are used to connect thapto with the name of the buried soil. Thus, soil X that includes a buried soil, Y, is called Thapto-Yic X. A Haplaquept that has a histic epipedon is called a Histic Haplaquept, but a Fluvaquent in which a Histosol has been buried is called a Thapto-Histic Fluvaquent.

TABLE 10.—*Formative elements in names of great groups*

Formative element	Derivation	Mnemonicon	Connotation
Acr	Modified from Gr. *akros*, at the end	Acrolith	Extreme weathering.
Agr	L. *ager*, field	Agriculture	An agric horizon.
Alb	L. *albus*, white	Albino	An albic horizon.
And	Modified from ando	Ando	Andolike.
Arg	Modified from argillic horizon; L. *argilla*, white clay.	Argillite	An argillic horizon.
Bor	Gr. *boreas*, northern	Boreal	Cool.
Calc	L. *calcis*, lime	Calcium	A calcic horizon.
Camb	L.L. *cambiare*, to exchange	Change	A cambic horizon.
Chrom	Gr. *chroma*, color	Chroma	High chroma.
Cry	Gr. *kryos*, icy cold	Crystal	Cold.
Dur	L. *durus*, hard	Durable	A duripan.
Dystr, dys	Modified from Gr. *dys*, ill; dystrophic, infertile.	Dystrophic	Low base saturation.
Eutr, eu	Modified from Gr. *eu*, good; eutrophic, fertile.	Eutrophic	High base saturation.
Ferr	L. *ferrum*, iron	Ferric	Presence of iron.
Fluv	L. *fluvus*, river	Fluvial	Flood plain.
Frag	Modified from L. *fragilis*, brittle	Fragile	Presence of fragipan.
Fragloss	Compound of fra(g) and gloss		See the formative elements frag and gloss.
Gibbs	Modified from gibbsite	Gibbsite	Presence of gibbsite in sheets or nodules.
Gyps	L. *gypsum*, gypsum	Gypsum	Presence of a gypsic horizon.
Gloss	Gr. *glossa*, tongue	Glossary	Tongued.
Hal	Gr. *hals*, salt	Halophyte	Salty.
Hapl	Gr. *haplous*, simple	Haploid	Minimum horizon.
Hum	L. *humus*, earth	Humus	Presence of humus.
Hydr	Gr. *hydor*, water	Hydrophobia	Presence of water.
Luv	Gr. *louo*, to wash	Ablution	Illuvial.
Med	L. *media*, middle	Medium	Of temperate climates.
Nadur	Compound of na(tr) and dur		See the formative elements natr and dur.
Natr	Modified from *natrium*, sodium		Presence of natric horizon.
Ochr	Gr. base of *ochros*, pale	Ocher	Presence of ochric epipedon.
Pale	Gr. *paleos*, old	Paleosol	Excessive development.
Pell	Gr. *pellos*, dusky		Low chroma.
Plac	Gr. base of *plax*, flat stone		Presence of a thin pan.
Plagg	Modified from Ger. *plaggen*, sod		Presence of plaggen epipedon.
Plinth	Gr. *plinthos*, brick		Presence of plinthite.
Psamm	Gr. *psammos*, sand	Psammite	Sand texture.
Quartz	Ger. *quarz*, quartz	Quartz	High quartz content.
Rhod	Gr. base of *rhodon*, rose	Rhododendron	Dark red color.
Sal	L. base of *sal*, salt	Saline	Presence of salic horizon.
Sider	Gr. *sideros*, iron	Siderite	Presence of free iron oxides.
Sombr	F. *sombre*, dark	Somber	A dark horizon.
Sphagn	Gr. *sphagnos*, bog	Sphagnum	Presence of Sphagnum.
Sulf	L. *sulfur*, sulfur	Sulfur	Presence of sulfides or their oxidation products.
Torr	L. *torridus*, hot and dry	Torrid	Torric moisture regime.
Trop	Modified from Gr. *tropikos*, of the solstice	Tropical	Humid and continually warm.
Ud	L. *udus*, humid	Udometer	Udic moisture regime.
Umbr	L. base of *umbra*, shade	Umbrella	Presence of umbric epipedon.
Ust	L. base of *ustus*, burnt	Combustion	Ustic moisture regime.
Verm	L. base of *vermes*, worm	Vermiform	Wormy, or mixed by animals.
Vitr	L. *vitrum*, glass	Vitreous	Presence of glass.
Xer	Gr. *xeros*, dry	Xerophyte	A xeric moisture regime.
Kandi	Kandites (modified from Kandite)		1:1 layer silicate clays

This short name is most useful if the series is a common one that is well known in the locality.

Redundancy in names of families should be avoided. Particle-size class and temperature adjectives should not be used in the family name if they are specified in the subgroup name. Psamments, by definition, all have a sandy particle size. It is therefore redundant to speak of a sandy Psamment. Similarly, all soils in suborders that have the formative element hor in the sub

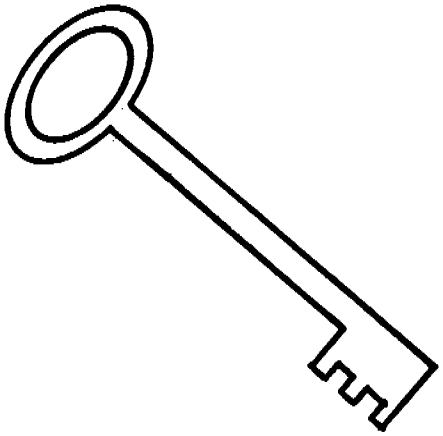
Rules of nomenclature

For uniformity, certain rules are followed.

First, the names are considered to be modern vernacular nouns. In languages that have grammatical gender, they are treated as masculine nouns. While only the names of the orders contain a suffix meaning soil, this meaning is understood to be included in all names. Thus the names are not to be converted to

TABLE 11.—*Adjectives in names of extragrades and their meaning*

Adjective	Derivation	Mnemonicon	Connotation
Abruptic	L. *abruptum*, torn off	Abrupt	Abrupt textural change



CHAPTER 7

Identification of the Taxonomic Class of a Soil

The taxonomic class of a specific soil can be determined by using the keys and definitions that follow in this and other chapters. It is assumed that the reader is familiar with the meanings of the terms used for describing soils that are given in the appendix and with the definitions of diagnostic horizons and features that are given in chapters 3 and 4. The index indicates the pages (boldface type) on which definitions of terms are given.

The keys to orders, suborders, and great groups are scattered throughout the text. The key to the orders follows in this chapter. The reader, in using this key, should turn to the indicated page for the first order in the key that apparently includes the soil with which he is concerned. There he will find a brief general discussion and a definition of the order. The definition, if it is complicated, is arranged in two ways. One arrangement is a complete definition of the order. The other distinguishes that particular order from each of the other orders. These definitions afford a check on the initial placement of the soil in a particular order.

The definition of each order is followed by a key to the suborders of that order. Again, the reader should turn to the indicated page for the first suborder that apparently includes the soil in question. There he will find a brief general discussion of the suborder and a full definition of the suborder as a subdivision of the order. This definition is followed by a key to the great groups of the suborder.

Next, the reader should turn to the indicated page for a brief discussion of the first great group that appears to include the soil in question and a full definition of that great group as a subdivision of the subgroup. It is important to note that there are many subgroups in the world that are not included in this text, either because they are unknown to the authors or because the authors know too little about them to prepare reasonable definitions. The mere fact that a soil apparently would be classified in a particular subgroup does not mean that it should be so classified. The soil may have several aberrant features that would place it in a subgroup that is not defined in this text. The soil being classified should be checked against the description of the pedon that represents the great group and the typic subgroup to be sure that the soil being classified does not have important aberrant features that are not listed as bases for the defined subgroups.

The families and series within the subgroups are not included in this text. The family differentiae are listed and defined in chapter 18 so that the reader can determine the technical family name of the soil in question. The classification of the series and the list of families and their included series for the soils of the 50 states, Puerto Rico, and the Virgin Islands are given in another publication (Soil Series of the United States, Puerto Rico, and the Virgin Islands: Their Taxonomic Classification, 1972). That publication does not include the descriptions or definitions of the series, but descriptions of specific series are available on request from the Soil Conservation Service. No one publication includes descriptions of all the series.

Key to soil orders

In this key and the other keys that follow, the first

contact, provided the thickness of the organic soil materials is more than twice that of the mineral soil above the contact; or

b. Any depth if the organic soil material rests on fragmental material (gravel, stones, cobbles) and the interstices are filled with organic materials, or rests on a lithic or paralithic contact; or

2. Have organic materials that have an upper boundary within 40 cm of the surface and

a. Have one of the following thicknesses:

(1) 60 cm or more if three-fourths or more of the volume is moss fibers or the moist bulk density is <0.1 g per cubic centimeter (6.25 lbs per cubic foot);

(2) 40 cm or more if

(a) The organic soil material is saturated with water for long periods (>6 months) or is artificially drained; and

(b) The organic material consists of sapric or hemic materials or consists of fibric materials that are less than three-fourths moss fibers by volume and have a moist bulk density of 0.1 or more; and

b. Have organic soil materials that

(1) Do not have a mineral layer as much as 40 cm thick either at the surface or whose upper boundary is within 75 cm of the surface; or

b. Have one or more of the following horizons whose upper boundary is within 1 m of the soil surface: a petrocalcic, calcic, gypsic, petrogypsic, or cambic horizon or a duripan; and either

(1) Have an aridic moisture regime, or

(2) Have an ustic or a xeric moisture regime and a conductivity of the saturation extract at 25° C that is 2 mmho per centimeter or more in some subhorizon that is shallower than the least of the following:

(a) A lithic or paralithic contact, petrocalcic horizon, or duripan at a depth of <25 cm;

(b) 1.25 m if the weighted average particle-size class is sandy or sandy-skeletal between a depth of 25 cm and 1 m or between a depth of 25 cm and a lithic or paralithic contact, a petrocalcic horizon, or a duripan if the depth to any of these is <1 m;

(c) 90 cm if the weighted average particle-size class is loamy between a depth of 25 cm and 1 m or between a depth of 25 cm and a lithic or paralithic contact or a duripan if the depth to any of these is <1 m; or

(d) 70 cm if the weighted average particle-size class is clayey between a depth of 25 cm and 1 m or between a depth of 25 cm and lithic or paralithic contact, a

depth 1.8 m below the soil surface or to a lithic or paralithic contact, whichever is least; or

b. If there is a cambic horizon, in all subhorizons to a depth 1.8 m below the soil surface or to a lithic or paralithic contact, whichever is least; and

3. If the exchange complex is dominated by amorphous materials, have, in some subhorizon within a depth of 35 cm or to a lithic or paralithic contact shallower than 35 cm, a bulk density (at ⅓-bar water tension) of the fine-earth fraction of 0.85 or more and have <60 percent vitric volcanic ash,[3] cinders, or other pyroclastic material in the silt, sand, and gravel fractions within this depth, and

4. If the soil temperature regime is isomesic or a warmer iso temperature regime, the soil has one or more of the following:

a. A horizon that has ≥40 percent $CaCO_3$ equivalent in some subhorizon within 1 m of the surface or above a lithic or paralithic contact, whichever is shallower;

b. A lithic or paralithic contact within 50 cm of the surface and <35 percent clay that has montmorillonitic mineralogy in subhorizons that have a total thickness of ≥25 cm or a COLE of ≥0.09 if the moisture regime is udic or ≥0.07 if the moisture regime is ustic;

c. No cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon if accompanied by all the following characteristics:

(1) COLE of ≥0.09 if the moisture regime is udic or of ≥0.07 if the moisture regime is ustic in a horizon or horizons at least 50 cm thick;

(2) A potential linear extensibility of 6 cm or more in the upper 1 m of the soil if the moisture regime is udic, in the upper 1.25 m of the soil if the moisture regime is ustic, or in the whole soil if there is a lithic or paralithic contact between a depth of 50 cm and 1 m (udic) or 1.25 m (ustic); and

(3) More than 35 percent clay in horizons that total 50 cm or more in thickness;

Mollisols, p. 271

[3] Vitric material, as used here, includes glass and also crystalline particles that are coated with glass or with partly devitrified glass.

H. Other soils that

1. Have a argillic or natric horizon but no fragipan; or
2. Have a fragipan that
   a. Is in or underlies an argillic horizon; or
   b. Meets all requirements of an argillic horizon; or
   c. Has clay skins >1 mm thick in some part.

Alfisols, p. 95

I. Other soils that have

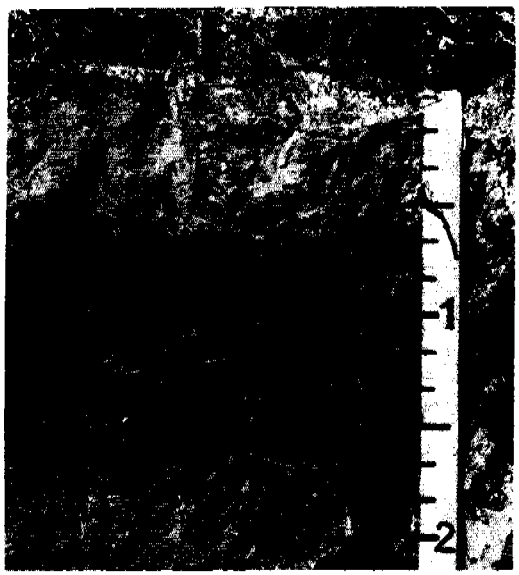
1. One or more of the following:
   a. An umbric, mollic, or plaggen epipedon;
   b. A histic epipedon composed of mineral soil materials and, to a depth of 35 cm or more or to a lithic or paralithic contact if one is shallower than 35 cm, either the soil has a bulk density (at 1/3-bar water retention) in the fine-earth fraction that is <0.85 g per cubic centimeter and the exchange complex is dominated by amorphous materials, or the soil is 60 percent or more (by weight) vitric[3] volcanic ash, cinders, or other vitric pyroclastic material;
   c. A cambic horizon or both an aquic moisture regime and permafrost;
   d. Within 1 m of the surface, a calcic, petrocalcic or placic horizon or a duripan; or
   e. A fragipan;
2. Or one of the following:
   a. A sulfuric horizon whose upper boundary is within 50 cm of the soil surface;
   b. In half or more of the upper 50 cm, an SAR of ≥13[4] (or sodium saturation that is ≥15 percent) that decreases with depth below 50 cm and, within a depth of 1 m, have ground water at some period during the year when the soil is not frozen in any part; or
   c. An n value of ≤0.7 or <8 percent clay in all subhorizons between 20 and 50 cm below the mineral surface;
3. No sulfidic material within 50 cm of the soil surface.

Inceptisols, p. 227

J. Other soils.

Entisols, p. 179

[4] See footnote 3 on p. 28.



CHAPTER 8

Alfisols

The central concept of Alfisols is that of a soil that has an ochric epipedon, an argillic horizon, moderate to high base saturation, and in which water is held at

vertical dimensions of 50 cm or more in an argillic horizon and >10 percent weatherable minerals in the 20- to 200-micron fraction

are open to the surface or to the base of an Ap horizon, either the temperature regime is frigid or colder, or

a. After the soil has been mixed to a depth of 18 cm, there is some subhorizon in the upper 50 cm that has <30 percent clay; or

b. There is no gilgai and, between a depth of 25 cm and 1 m, there are no slickensides close enough to intersect and no wedge-shaped peds that have their long axes tilted 10° to 60° from the horizontal;

5. Do not have a spodic horizon overlying an argillic horizon; and

6. Do not have an oxic horizon overlying an argillic horizon and do not have plinthite that forms a continuous phase within 30 cm of the surface.

Limits between Alfisols and soils of other orders

The definition of Alfisols must provide criteria that separate Alfisols from all other orders. The aggregate of these criteria defines the limits of Alfisols in relation to all other known soils.

1. To distinguish Alfisols from Aridisols, Alfisols must have either

a. An aquic, udic, ustic, or xeric moisture regime; or

b. An epipedon that is both massive and hard or massive and very hard when dry.

2. To distinguish Alfisols from Entisols and Inceptisols, Alfisols must not have a plaggen epipedon and they must have evidence of illuvial clay in the form of one or more of the following:

a. An argillic horizon that is not below a fragipan;

b. A natric horizon;

c. A fragipan that has in some part clay skins at least 1 mm thick.

3. To distinguish Alfisols from Histosols, Alfisols must meet the definition of mineral soils (ch. 3).

4. To distinguish Alfisols from Mollisols, for Alfisols either

a. Both of the following must not meet the requirements for a mollic epipedon with respect to color, organic-carbon content, base saturation, structure, and thickness:

(1) The epipedon; and

(2) The surface horizon when mixed to a depth of 18 cm plus the upper subhorizon of an argillic or natric horizon that is separated from the surface horizon by an albic horizon; or

b. If there is a mollic epipedon, some part of the argillic horizon must have <50 percent base saturation (by NH_4OAc).

5. To distinguish Alfisols from Oxisols, Alfisols must not have either

a. An oxic horizon overlying the argillic horizon; or

b. Plinthite forming a continuous phase within 30 cm of the soil surface.

6. To distinguish Alfisols from Spodosols, Alfisols must not have a spodic horizon above the argillic horizon.

7. To distinguish Alfisols from Ultisols, Alfisols must have one of the following:

a. Tongues of albic material in the argillic horizon that have a vertical dimension of 50 cm or more and >10 percent weatherable minerals in the 20- to 200-micron fraction;

b. A frigid or colder temperature regime;

c. Base saturation of 35 percent or more (by sum of cations) above the critical depths that follow:

(1) If there is no fragipan and the argillic horizon in some part has a hue of 5YR or yellower or has a color value, moist, of 4 or more or a color value, dry, more than one unit higher than the value, moist, the shallowest of

(a) 1.25 m below the upper boundary of the argillic horizon,

(b) 1.8 m below the soil surface, or

(c) Immediately above a lithic or paralithic contact;

(2) If there is no fragipan and the argillic horizon in all parts has a hue redder than 5YR, has a color value, moist, of 3 or less, and has a dry color value no more than one unit higher than the value, moist, or if there is no fragipan and the epipedon has a sandy or sandy-skeletal particle-size distribution throughout and is >50 cm thick, the deepest of

(a) 1.25 m below the upper boundary of the argillic horizon,

(b) 1.8 m below the soil surface, or

(c) Immediately above a lithic or paralithic contact;

(3) If there is a fragipan, the shallower of

(a) 75 cm below the upper boundary of the fragipan, or

(b) Immediately above a lithic or paralithic contact.

8. To distinguish Alfisols from Vertisols, Alfisols must have, if there are cracks at some time in most years that are 1 cm or more wide at a depth of 50 cm and that are open to the surface or to the base of an Ap horizon, either a frigid or colder temperature regime, or

a. After the soil has been mixed to a depth of 18 cm, there is some subhorizon in the upper 50 cm that has <30 percent clay; or

b. There is no gilgai, and, between a depth of 25 cm and 1 m there are no slickensides close enough to intersect and no wedge-shaped sphenoid peds that have their long axes tilted 10° to 60° from the horizontal.

Key to suborders

HA. Alfisols that have an aquic moisture regime or are artificially drained and that have characteristics associated with wetness, namely, mottles, or iron-manganese concretions >2 mm in diameter, or chroma of 2 or less immediately below any Ap

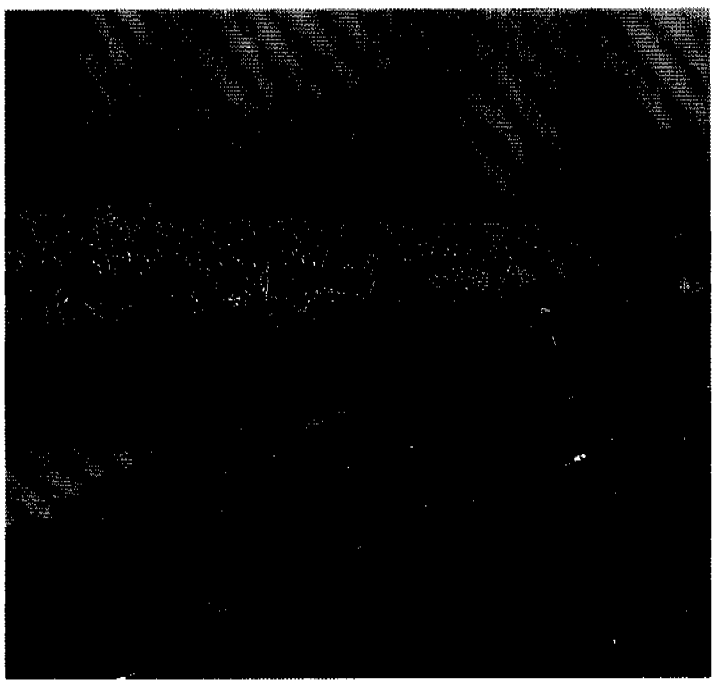


Plate 1A.—Road cut showing horizons that are continuous over lateral distances of many meters. Typic Hapludoll in foreground and background. Cumulic Hapludoll in center. Story County, Iowa.

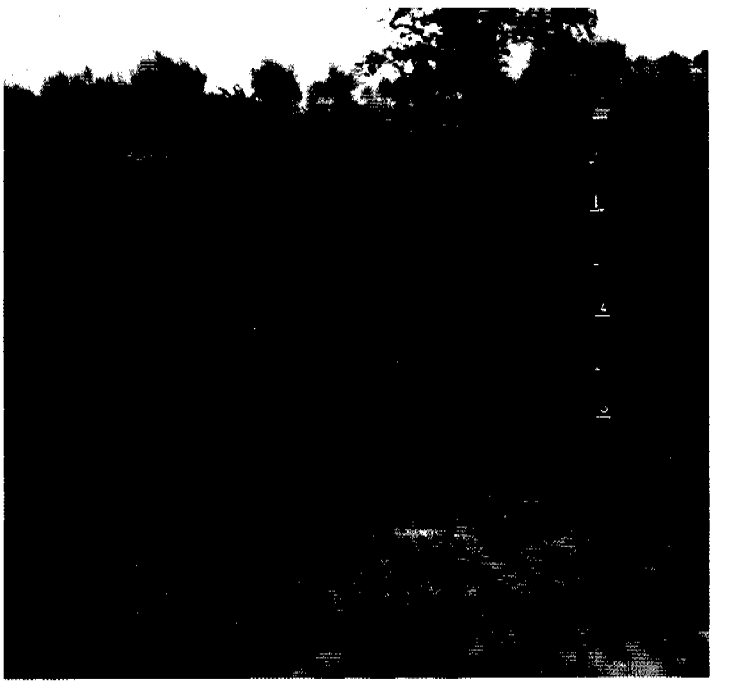


Plate 1B.—Soil having discontinuous horizons as a result of their partial destruction (scale in feet). Belgium.

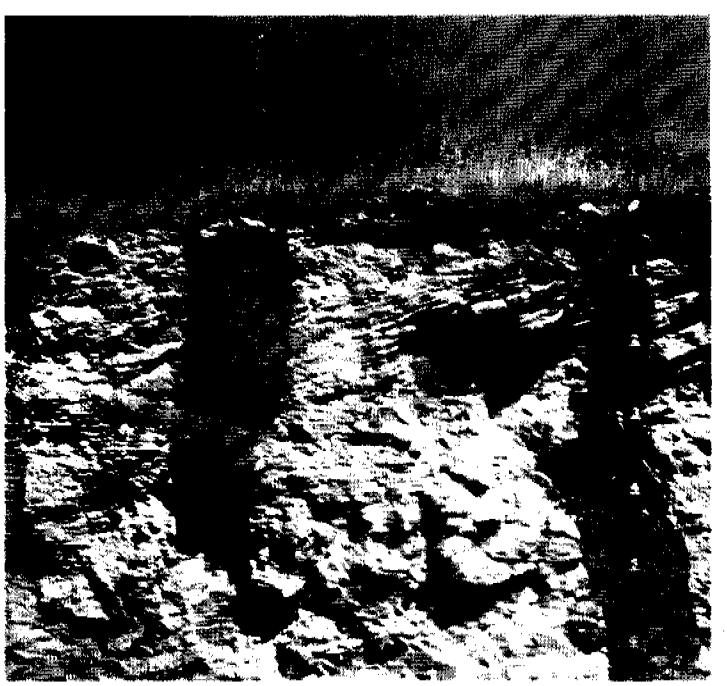


Plate 1C.—Discontinuous horizons that are the result of partial formation (scale in feet). South Australia.

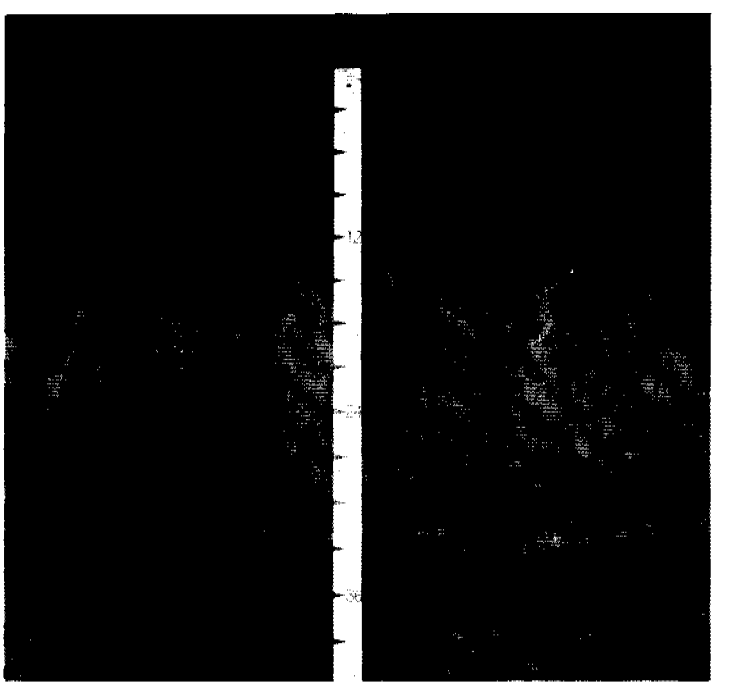


Plate 1D.—Soil horizons with greatly varying thickness as a result of swelling and shrinking (marks at 3-inch intervals). Manitoba, Canada.

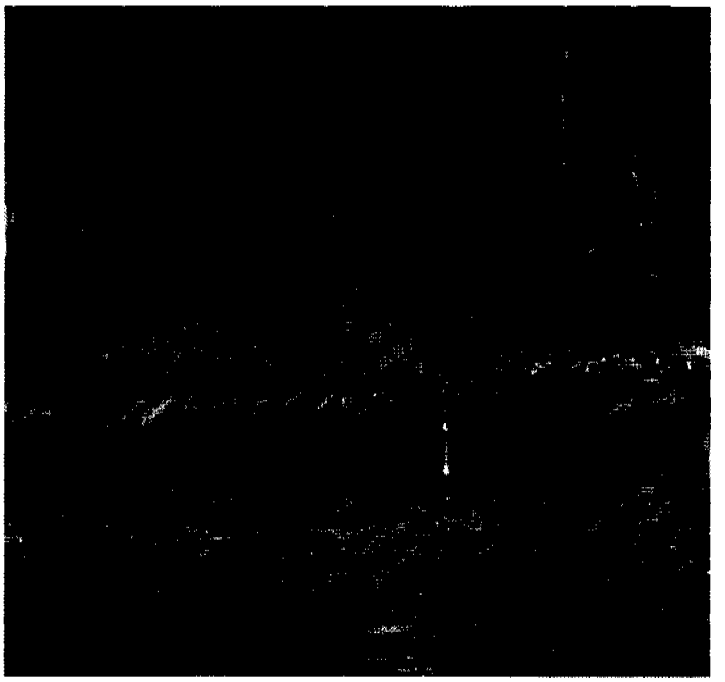


Plate 2A.—Intermittent horizons in a soil as a result of swelling and shrinking (scale in feet). N.S.W., Australia.

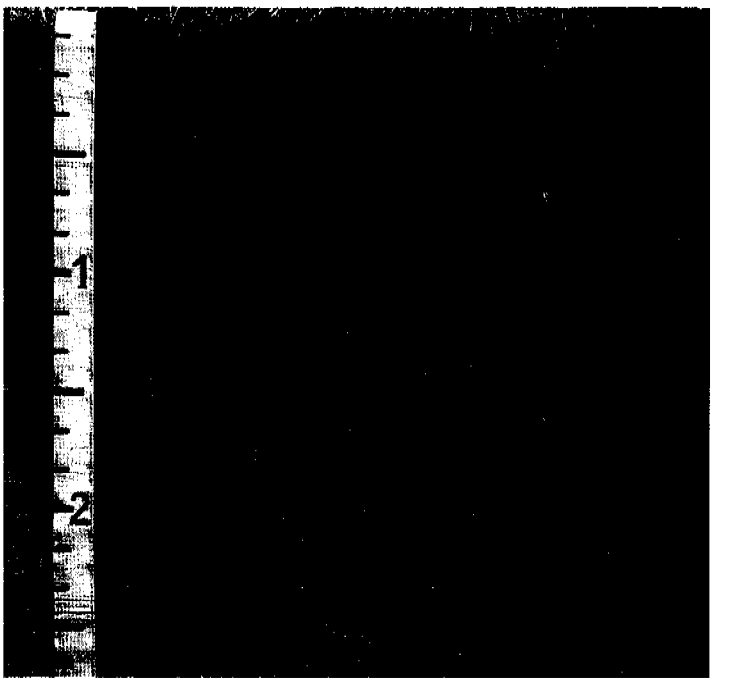


Plate 2B.—Soil having a mollic epipedon with a lower boundary at about 36 cm (15 inches): a Typic Argiudoll (scale in feet). Iowa.

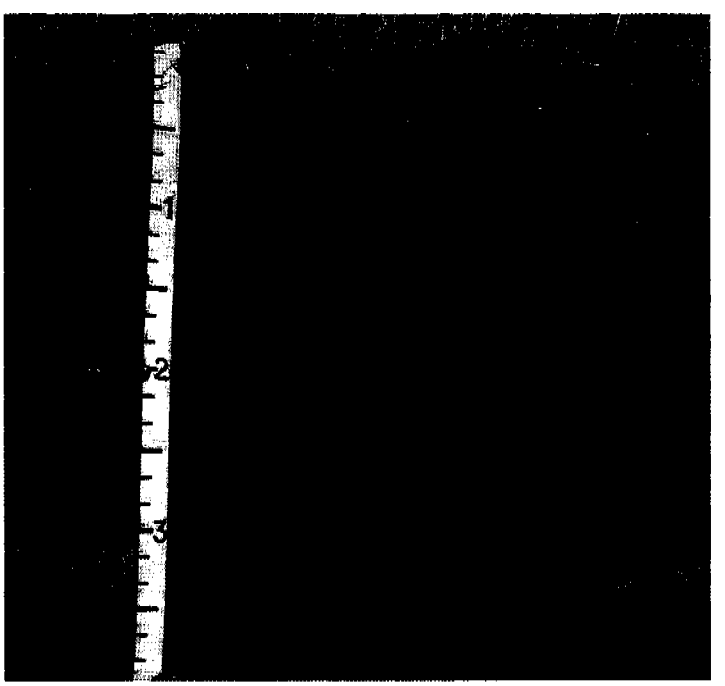
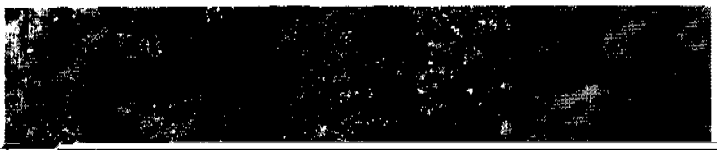


Plate 2C.—A plaggen epipedon with a lower boundary at 3 feet overlies a buried Spodosol (scale in feet). The Netherlands.

Plate 2D.—An ochric epipedon with lower boundary at about 25 cm (10 inches) overlies an argillic horizon: an Ultic Haplustalf (marks at 15-cm intervals). Texas.



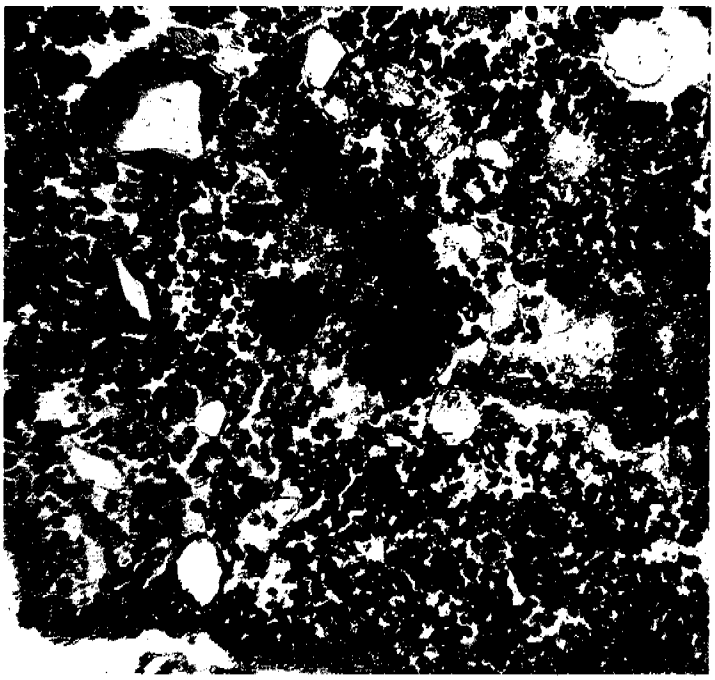


Plate 5A.—Thin section of spodic horizon showing pellets of silt size (plain light). Height of section is 0.2 mm.

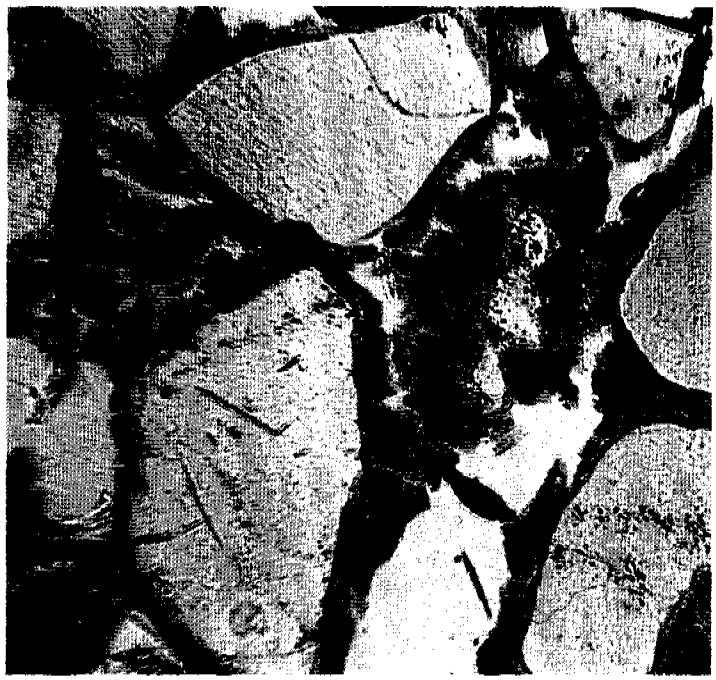


Plate 5B.—Thin section of a cemented spodic horizon (ortstein) showing cracks in coatings (plain light). Height of section is 0.6 mm.

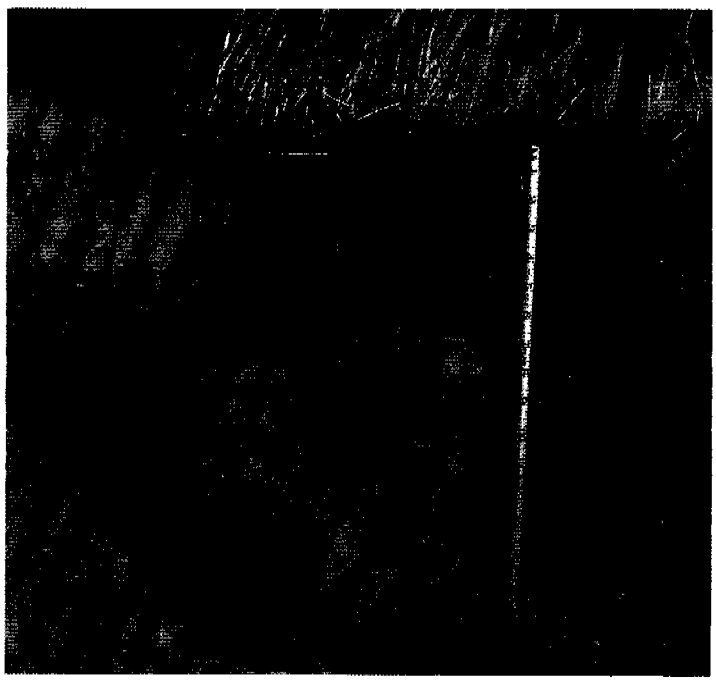


Plate 5C.—A Durixeralf. The upper boundary of the duripan is 18 inches below the surface. Both top and sides of very coarse prisms are coated with opal (scale in inches). California.

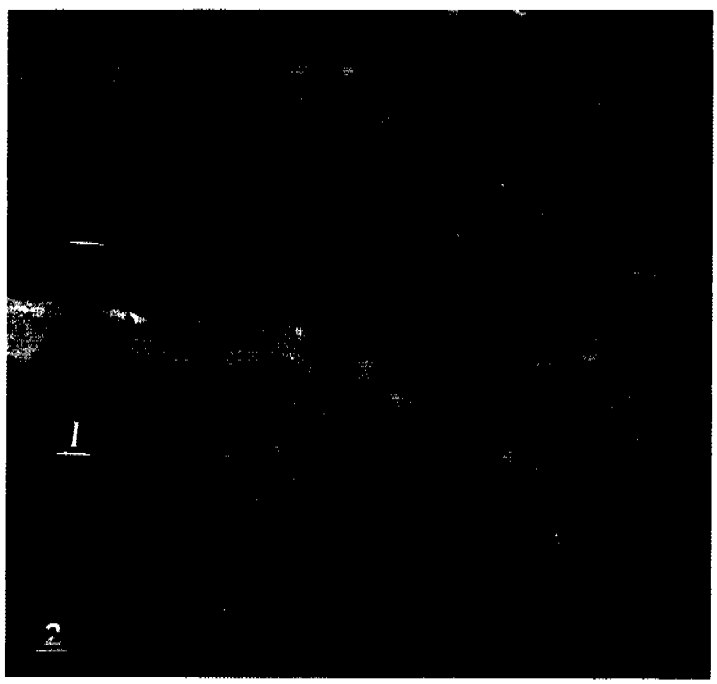


Plate 5D.—A Salorthid. The salic horizon extends from about 4 inches to 1 foot below the surface (scale in feet). Nevada.

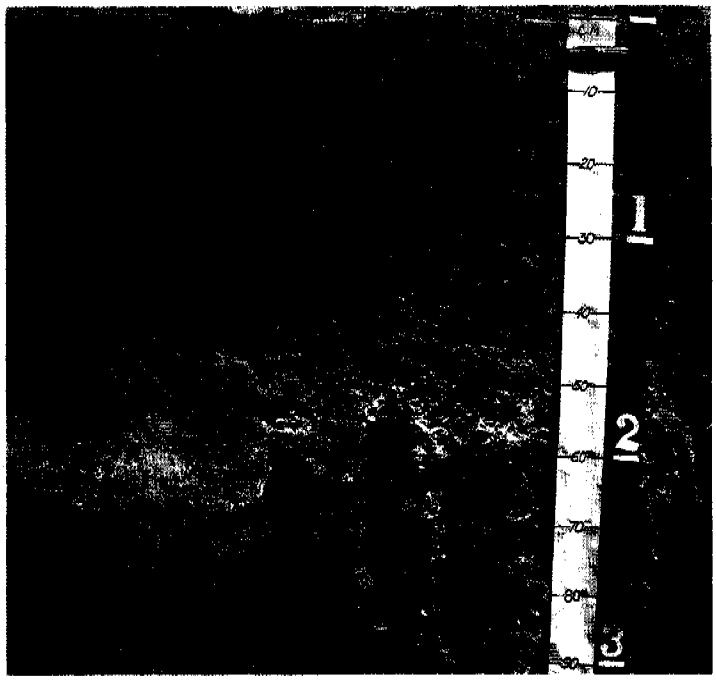


Plate 6A.—Vertical cut in a soil with a fragipan that has an upper boundary about 60 cm below the surface: a Fragiudalf. Tennessee.

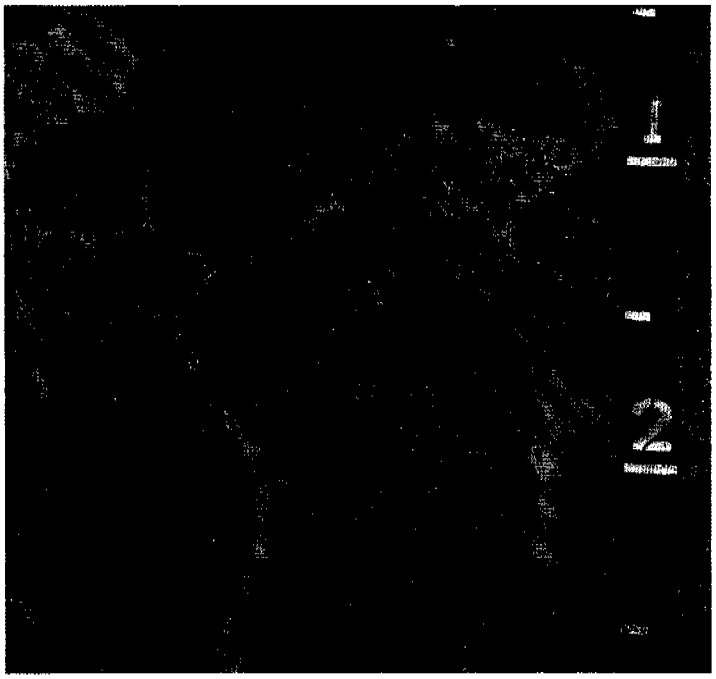


Plate 6B.—Horizontal cut through the fragipan 1.1 m below the surface (scale in feet). Tennessee.

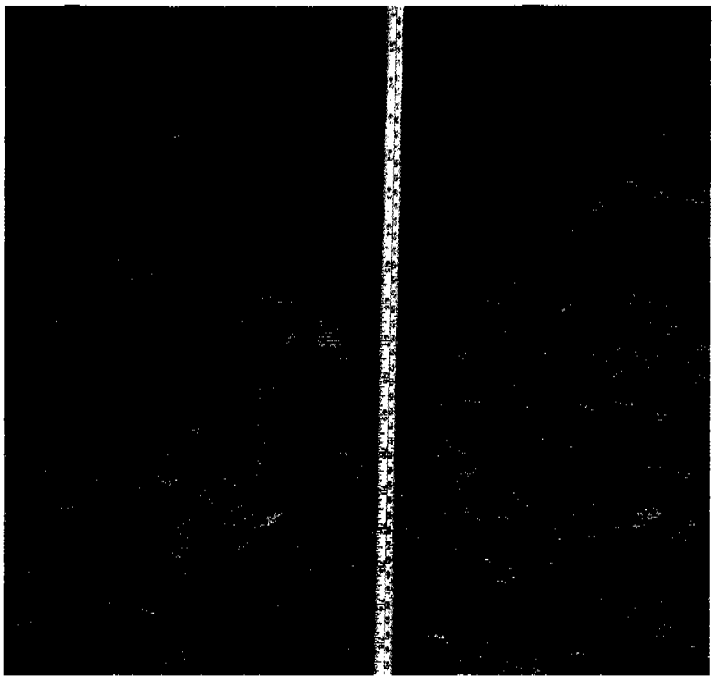


Plate 7A.—Plinthite in the lower part of a Paleudult in North Carolina. Only the darkest red mottles are firm or brittle and capable of irreversible hardening. Length of scale is 50 cm.

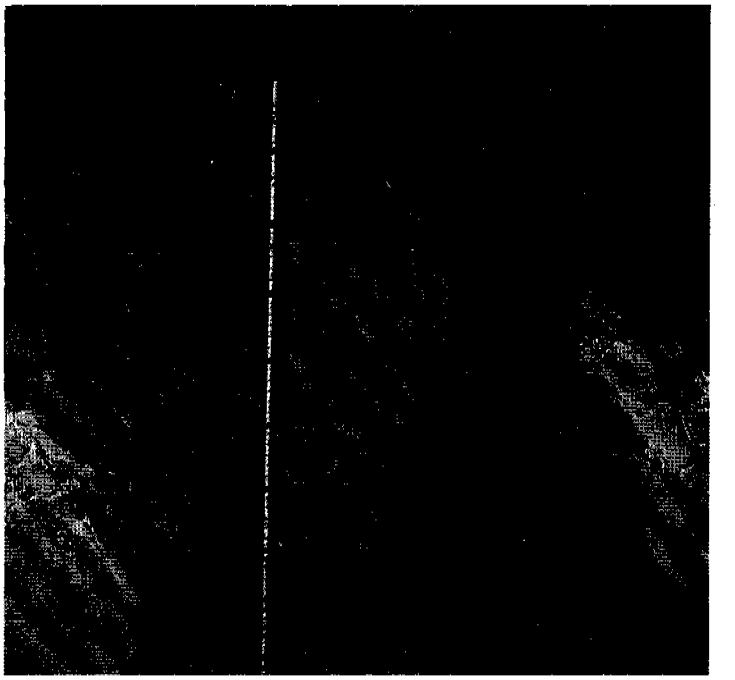


Plate 7B.—A Spodosol with a bisequum. The upper sequum has a spodic horizon and is about 1 foot thick. The lower sequum has an argillic horizon that begins about 30 inches below the surface (marks at 15-cm intervals). Minnesota.

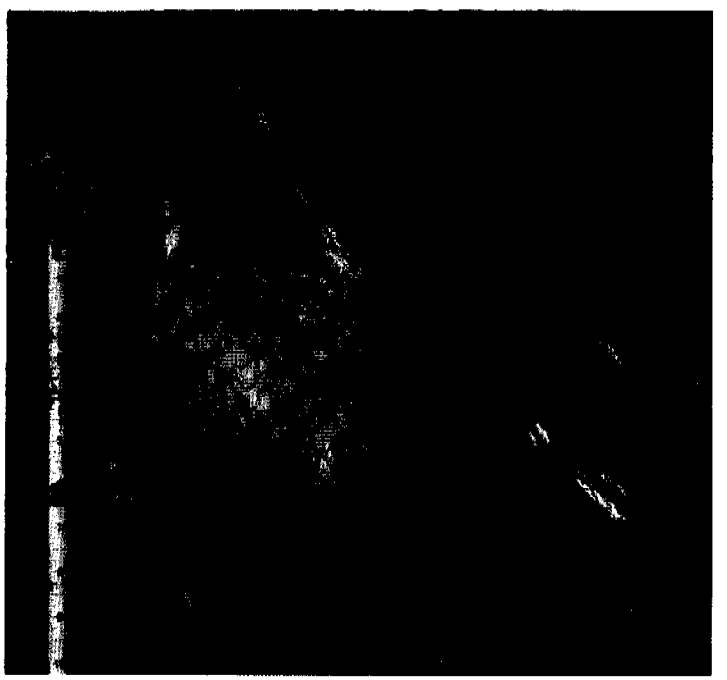


Plate 7C.—Slickensides on soil fragments. Length of scale is 30 cm.

Plate 7D.—A Glossudalf, with tongues of albic material in the argillic horizon between 2 and 6 feet below the surface (scale in feet). Washington.

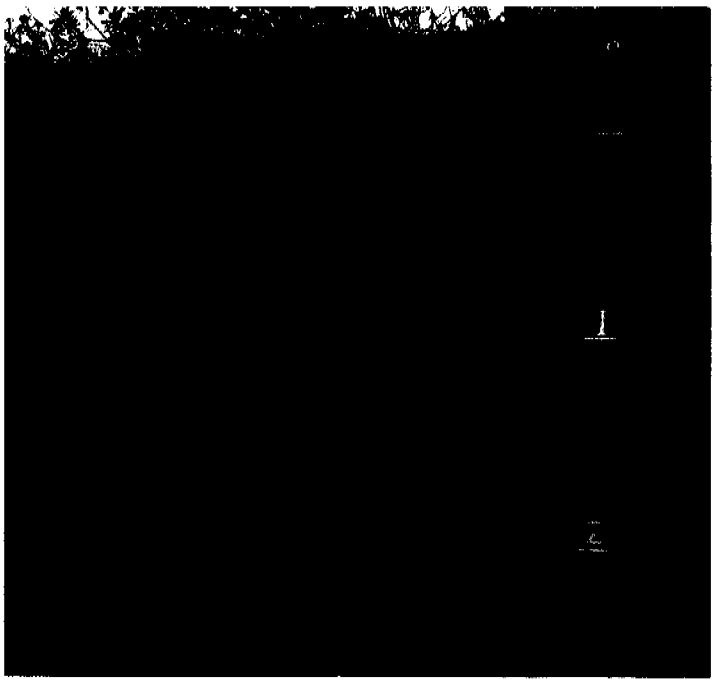


Plate 8A.—Soil with permafrost. A Histic Pergelic Cryaquept (scale in feet). Alaska.

Plate 8B.—Curving streaks reflect churning of a Cryaquoll by freezing and thawing (marks at 15-cm intervals). Saskatchewan.

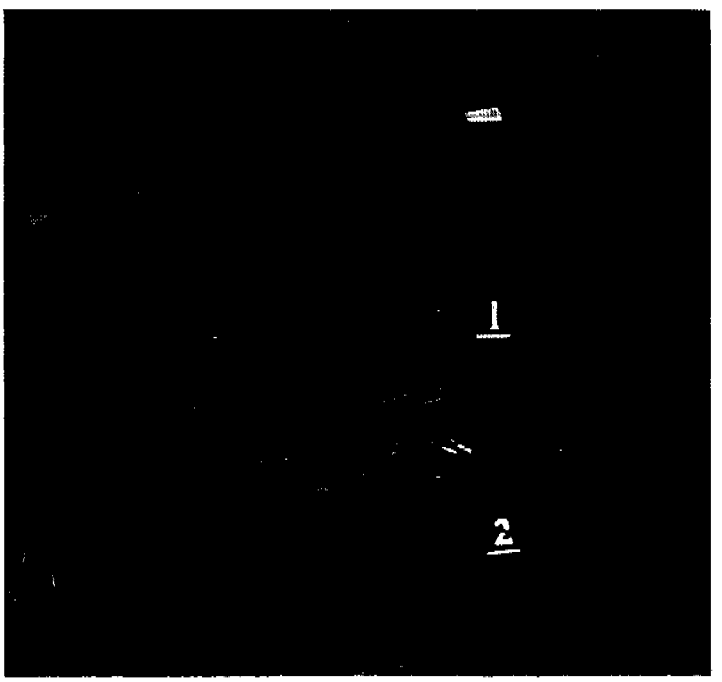


Plate 8C.—A Cryic Placohumod. The placic horizon is about 3 feet below the surface (scale in feet). Alaska.

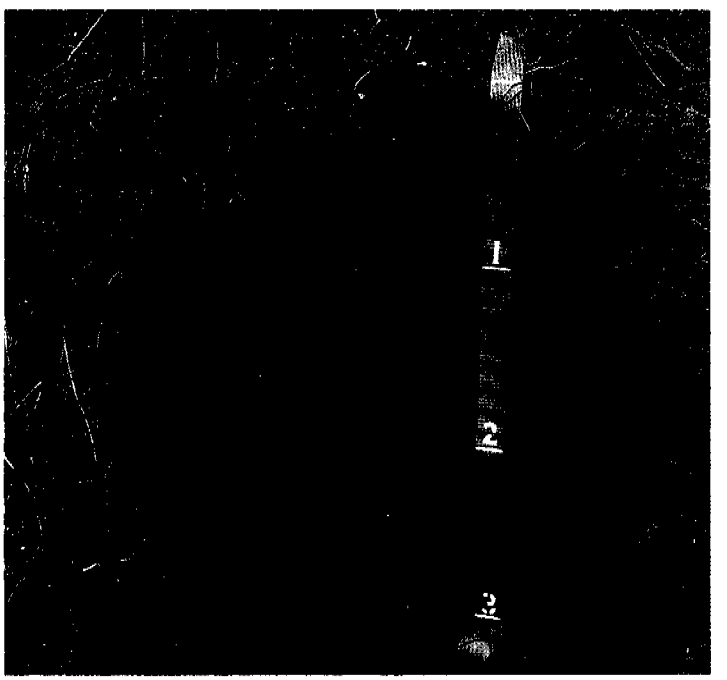


Plate 8D.—A Histosol: a Sphagnofibrist (scale in feet). Minnesota.

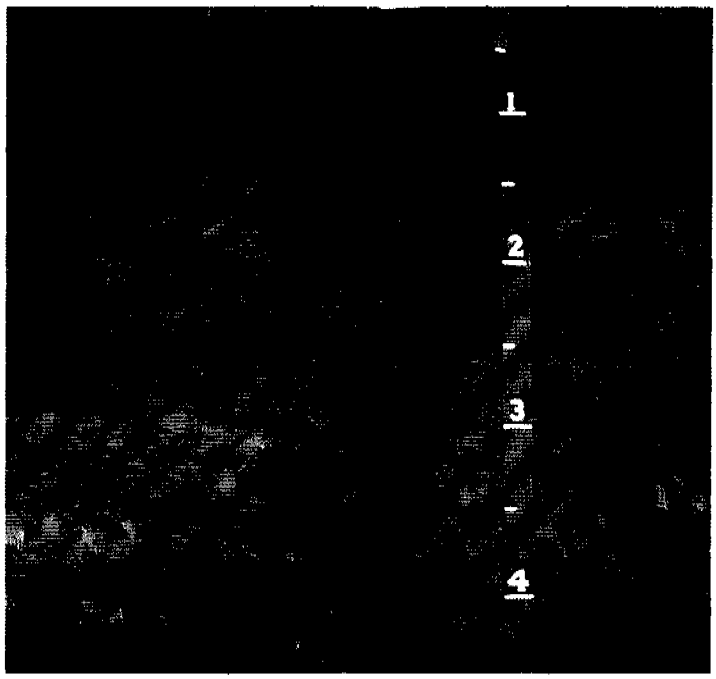


Plate 9A.—An Entisol in recent alluvium: an Ustifluvent (scale in feet). Texas.

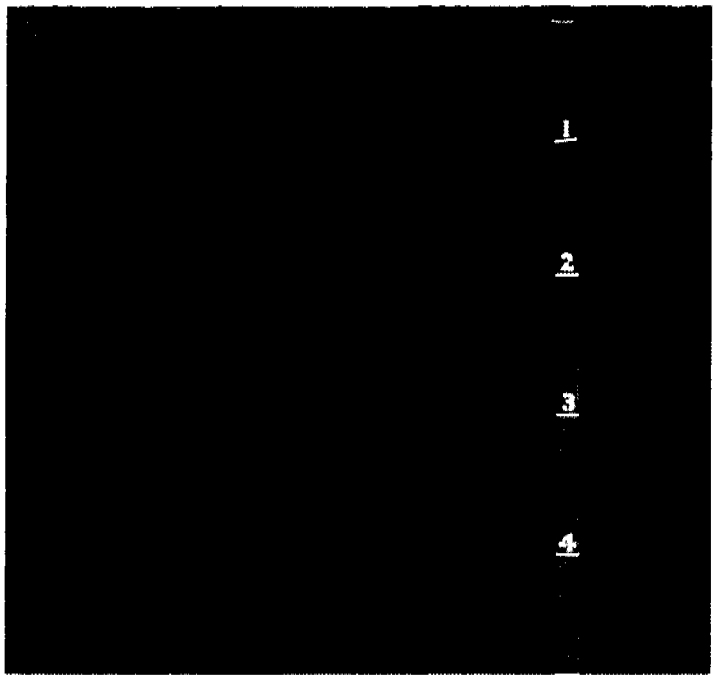
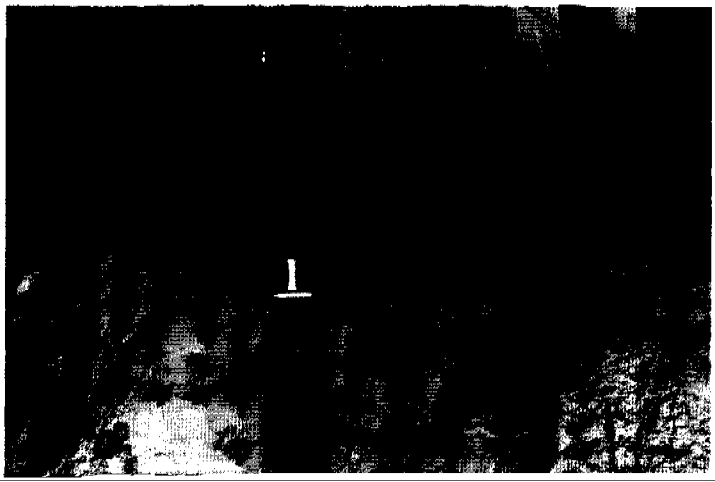
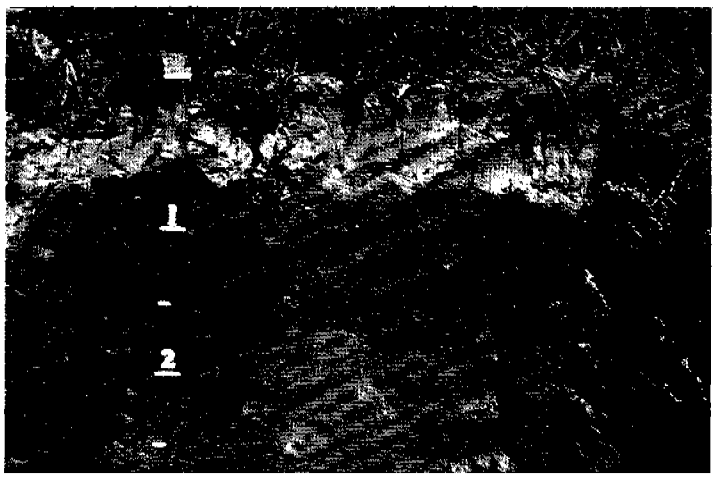


Plate 9B.—An Inceptisol formed in volcanic ash, showing buried A1 horizons: a Hydrandept (marks at 15-cm intervals). Hawaii.





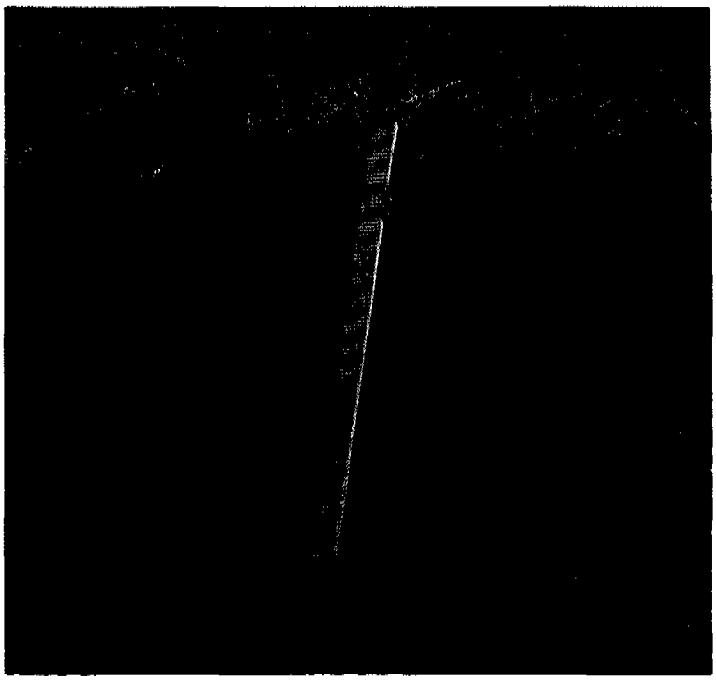


Plate 10A.—A Vertisol: a Typic Pelludert (scale in

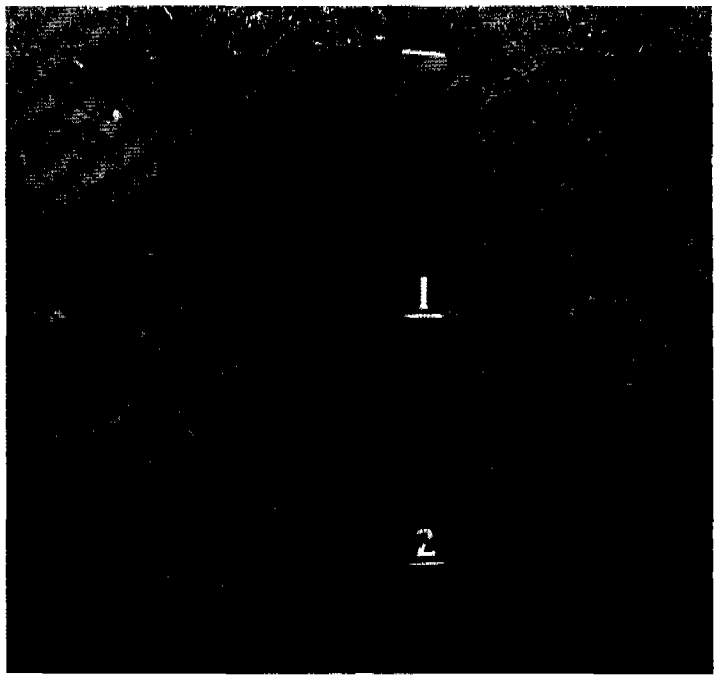
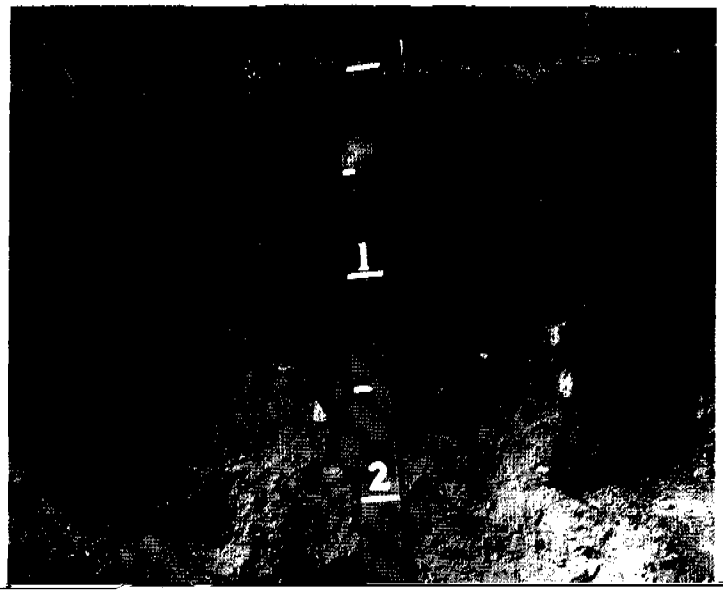


Plate 10B.—An Aqualf (scale in feet). New Zea-

Plate 11A.—An Aquept: a Typic Haplaquept (scale in feet). Maine.

Plate 11B.—A Durandept. Top of duripan is at 3 feet (scale in feet.) Chile.



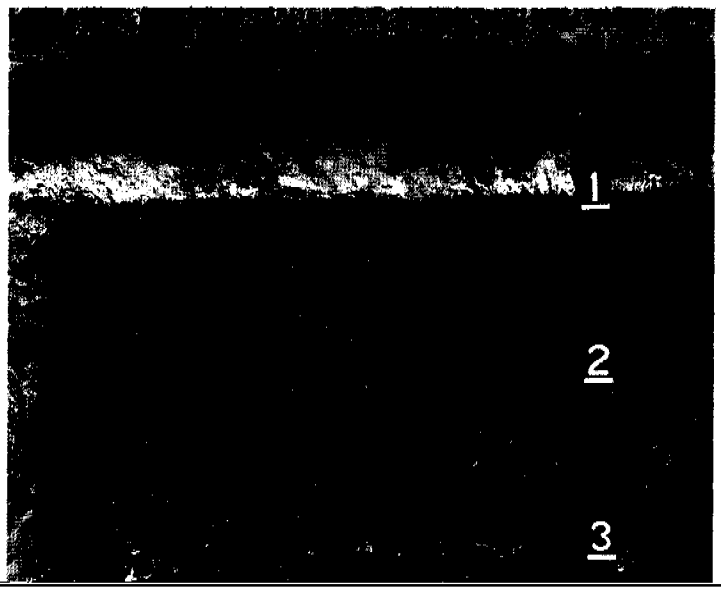
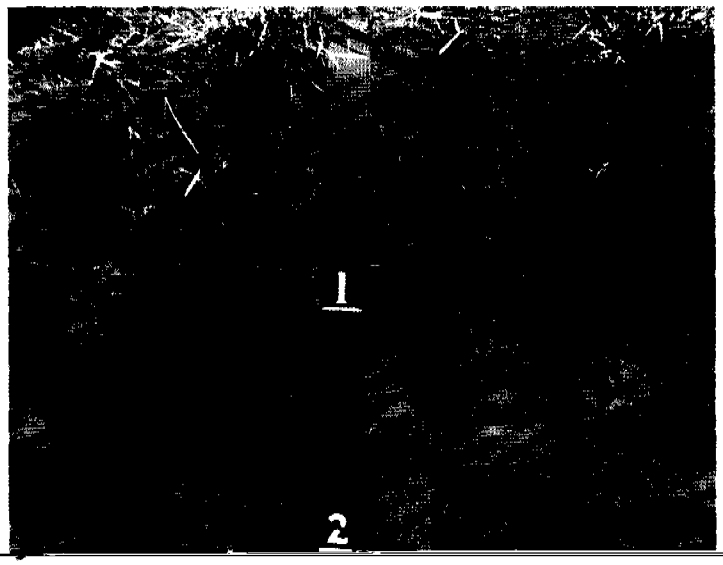
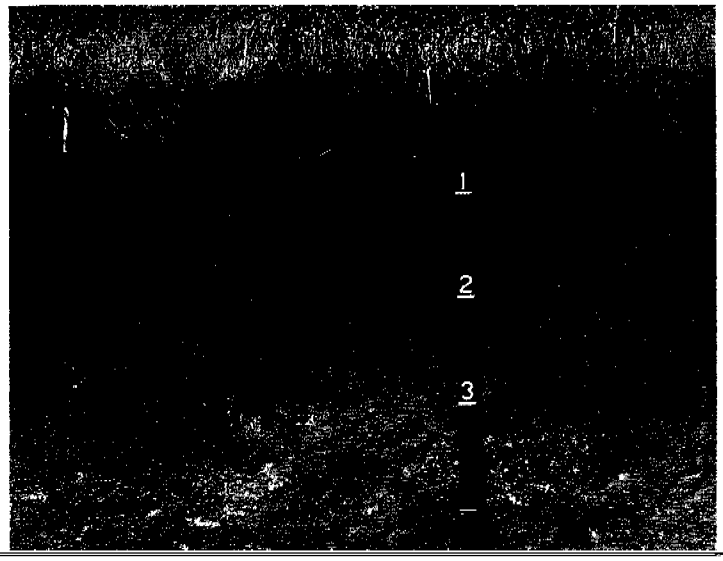


Plate 12A.—A Rendoll. Chalk is below a depth of about one foot (scale in feet). Puerto Rico.

Plate 12B.—An Ustoll (scale in feet). USSR.





horizon or below any dark A1 horizon in which the moist color value is less than 3.5 after the material is rubbed, and one of the following:

1. Dominant chroma of 2 or less[1] in coatings on the surface of peds and mottles within peds of the argillic horizon, or a dominant chroma of 2 or less in the matrix of the argillic horizon and mottles of higher chroma;
2. If there are no mottles in the argillic horizon, a dominant chroma of 1 or less.

Aqualfs, p. 109

HB. Other Alfisols that have

1. A frigid temperature regime but do not have a xeric moisture regime; or
2. A cryic temperature regime.

Boralfs, p. 119

HC. Other Alfisols that have one of the following:

1. An ustic moisture regime;
2. An epipedon that is both massive and hard or very hard when dry and a moisture regime that is aridic

Most Aqualfs, except those that have a frigid temperature regime, have some artificial drainage or other water control and are cultivated. Rice is a common crop on Aqualfs that have a thermic or warmer temperature regime. Before they were cultivated, some were under forest and others were under grass. The evidence suggests that, at some time in the past, nearly all Aqualfs supported forests.

Definition

Aqualfs are Alfisols that (1) either have an aquic moisture regime or are artificially drained and have characteristics associated with wetness, namely, mottles, or iron-manganese concretions >2 mm in diameter, or chroma of 2 or less immediately below any Ap

dryness seems to be essential to the genesis. Consequently, Aqualfs in which the albic horizon is rarely dry are in great groups other than Albaqualfs. Albaqualfs were included with the Planosols with claypans in the 1938 classification.

Definition

Albaqualfs are the Aqualfs that:

1. Have an abrupt textural change between an ochric epipedon or, more commonly, an albic horizon and the argillic horizon and have slow or very slow hydraulic conductivity in the argillic horizon;
2. [illegible]

Distinctions between Typic Albaqualfs and other subgroups

Typic Albaqualfs are the Albaqualfs that

a. Have chroma of 2 or less in 60 percent or more of the mass between the bottom of the A1 or the Ap horizon and a depth of 75 cm;

b. Do not have a layer above a depth of 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water

chroma dominant throughout the upper soil to a depth of 75 cm or more; that have relatively high color value in the plow layer, too high for a mollic epipedon; that

that fit the definition of Vertisols. Generally there is an albic horizon in the major part of each pedon. The repeat distance in the soil shown in plate 2A is the

Definition

Fragiaqualfs are Aqualfs that have a fragipan. The argillic horizon may be above the fragipan, the argillic horizon may be a part of the fragipan, or the fragipan may have evidences of clay movement in the form of clay skins that are thicker than 1 mm in some part of the pan.

Description of a Typic Fragiaqualf

The description of a pedon that has the characteristics of the central concept or typic subgroup of Fragiaqualfs follows. This soil in Shelby County, Ky., formed in Wisconsinan loess. It is being cultivated, but it formerly had a forest vegetation. The mean annual temperature is about 15° C, and the mean annual precipitation is about 1,250 mm. The soil is nearly level, and it is saturated for long periods in winter and early spring. Colors are those of the moist soil.

Ap 0–23 cm. Brown (10YR 5/3) silt loam; weak fine granular structure; very friable; few small concretions; strongly acid; abrupt smooth boundary.

A21g 23–50 cm. Gray (10YR 5/1) silt loam; common, medium mottles of dark grayish brown, brown, and light brownish gray; weak fine granular structure; very friable; common medium pores; common small concretions; very strongly acid; gradual smooth boundary.

A22g 50–80 cm. Gray (10YR 5/1) silt loam; few medium dark brown (10YR 4/3) mottles; weak fine granular structure; friable; somewhat brittle; many small vesicular pores; common dark brown concretions; very strongly acid; clear irregular boundary.

Bx 80–130 cm. Gray (10YR 5/1) light silty clay loam; seams and tubes of gray silt; some very coarse prisms about 15 or 20 cm in diameter part to weak coarse prisms and weak medium subangular blocks; firm; brittle when wet; many very fine and fine pores; clay skins 3 mm thick between large prisms in upper part; many thick clay skins within prisms in upper 10 cm, thin patchy clay skins in lower part, all mostly on vertical faces; many brown concretions; very strongly acid; gradual smooth boundary.

B3g 130–150 cm. Grayish brown (10YR 5/2) silty clay loam; common medium faint mottles of gray and yellowish brown; weak medium subangular blocky structure; friable; many fine pores; common thin black stains in cracks and small holes; many small concretions; medium acid; gradual smooth boundary.

C 150–200 cm. Pale brown (10YR 6/3) silt; many medium mottles of light brownish gray and yellowish brown; friable; massive; medium acid.

Distinctions between Typic Fragiaqualfs and other subgroups

Typic Fragiaqualfs are the Fragiaqualfs that

a. Do not have a mottled horizon between the A1 or Ap horizon and a fragipan that has dominant chroma more than 2 if the hue is 10YR or redder or more than 3 if the hue is 2.5Y or yellower;

b. Have <5 percent plinthite (by volume) in all subhorizons within 1.5 m (60 in.) of the surface;

c. Have an Ap horizon that has either a color value, moist, of 4 or more or a color value, dry, of 6 or more after the soil has been crushed and smoothed; or the upper soil to a depth of 18 cm, after mixing, has these color values;

Aeric Fragiaqualfs are like Typic Fragiaqualfs except for *a*.

Umbric Fragiaqualfs are like Typic Fragiaqualfs except for *c*.

Description of subgroups

Typic Fragiaqualfs.—The central concept or typic subgroup of Fragiaqualfs is fixed on soils that have low chroma dominant in all horizons between the fragipan and the plow layer if one is present, that have a color value in the plow layer that is lighter than that of an umbric epipedon, and that do not have plinthite. The soils are nearly level, and they are saturated for long periods in winter and early spring. Most of these soils in the United States are in the north-central and northeastern states. They are extensive only locally. Most of them are cultivated, but drainage usually is a continuing problem.

Aeric Fragiaqualfs.—These soils are like Typic Fragiaqualfs except they have a chroma more than 2 if the hue is 10YR or redder, or more than 3 if the hue is 2.5Y or yellower, in some subhorizon between the A1 or Ap horizon and the fragipan. The period of saturation with water in these soils is shorter than in the typic subgroup, usually because the slope is slightly greater. These soils are intergrades between Fragiaqualfs and Fragiudalfs.

The soils of this subgroup mostly have enough slope that water does not stand on the surface. They are extensive locally in the glaciated areas of the north-central states but are rare elsewhere in the United States. Most of them in the United States are cultivated.

Umbric Fragiaqualfs.—These soils have a plow layer or an A1 horizon that meets all requirements for an umbric epipedon except thickness. They are known to occur only in Missouri. They had a prairie vegetation before they were cultivated. Most of them are now being cultivated

Glossaqualfs

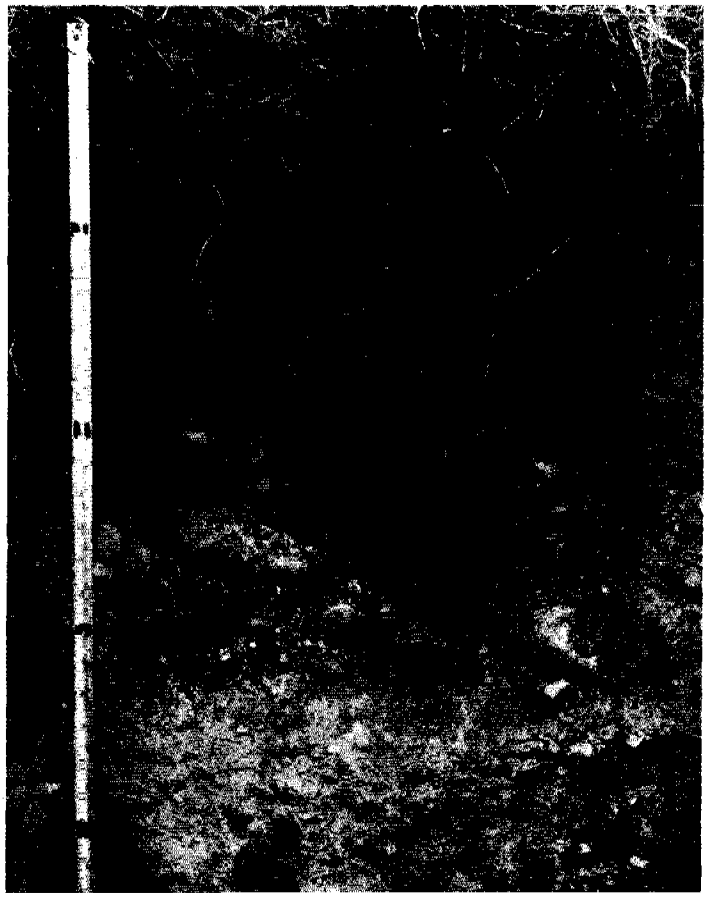
Glossaqualfs are the Aqualfs that have an albic horizon tonguing into an argillic horizon. The tonguing is interpreted as evidence that the argillic horizon has been partly destroyed. Tubular intrusions of albic materials into the argillic horizon may be formed by filling of burrows made by crayfish or of traces of taproots and should not be confused with tongues that surround peds. Figure 35 illustrates tonguing.

Temperature regimes of these soils in the United States range from frigid to thermic. Characteristically, these soils have the most humid climates of the Alfisols, the most water passing through the soil, and a relatively low base saturation for soils of this order. The vegetation of Glossaqualfs before they were cultivated was mostly deciduous hardwood forest. Parent materials are largely basic or calcareous sediments of late-Pleistocene age. The slopes of these soils are nearly level or concave. The soils were considered Planosols in the 1938 classification.

Glossaqualfs are not extensive in the United States. They are mostly in the most northern and southern parts of the range of Aqualfs in the Mississippi Valley and in the Pacific Northwest. Except where the temperature regime is frigid, most of them have been drained and are cultivated.

Definition

Glossaqualfs are the Aqualfs that



concept or typic subgroup of Glossaqualfs follows. This soil, in Pulaski County, Ark., has a mixed forest vegetation of pine and oak trees. It is saturated with water for long periods in winter and spring. The mean annual air temperature is about 17° C, and the average annual precipitation about 1,200 mm. Colors are those of the moist soil.

O1 5–0 cm. Hardwood leaves.

A1 0–7.5 cm. Very dark grayish brown (10YR 3/2) silt loam; few fine faint grayish brown mottles; weak fine granular structure; friable; many fine roots; very strongly acid; abrupt smooth boundary.

A2g 7.5–40 cm. Light gray (2.5Y 7/2) silt loam; common medium distinct yellowish brown (10YR 5/6) and dark yellowish brown (10 YR 4/4) mottles; weak medium subangular blocky structure; friable; many fine, few medium roots; common fine pores; common medium black concretions; very strongly acid; abrupt irregular boundary.

B&Ag 40–70 cm. Gray (10YR 6/1) silty clay and 15 percent tongues 1 to 5 cm wide of light gray (2.5Y 7/2) silt loam; common medium distinct yellowish brown (10YR 5/6) mottles; silty clay has compound weak medium prismatic and moderate medium subangular blocky structure; firm; silt loam is massive; friable; common fine roots; common fine pores; clay skins continuous on peds and in pores of silty clay; prisms have silt coatings; common medium black concretions; very strongly acid; gradual wavy boundary.

B2tg 70–100 cm. Gray (10YR 6/1) silty clay; common fine distinct yellowish brown mottles; compound weak medium prismatic and moderate medium subangular blocky structure; firm, plastic; few fine roots; few fine pores; clay skins continuous on peds and in pores; silt coatings on prisms; common medium black concretions; very strongly acid; gradual wavy boundary.

B3g 100–120 cm. Light brownish gray (2.5Y 6/2) silty clay; few medium and coarse yellowish brown (10YR 5/6)

c. Have an Ap horizon that has either a color value, moist, of 4 or more, or a color value, dry, of 6 or more after the soil has been crushed and smoothed; or the soil to a depth of 18 cm, after mixing, has these col-

the natric horizon. The permeability is so slow that there is thought to be less leaching of sodium than there is release of sodium by the weathering of feldspars. Virtually all these soils in the United States

lic epipedon in the soil to a depth of 18 cm, after mixing, is considered evidence of an intermediate stage between Natraqualfs and Natraquolls. The typic subgroup is not necessarily the most extensive, but it provides what seems to be the best base for defining other subgroups.

These soils are widely scattered in the United States in the Mississippi River Valley and in the western states. Because the polypedons are small, their use is usually determined by the use of their associated soils.

Albic Natraqualfs.—Soils in this subgroup have <15 percent sodium and less sodium and magnesium than calcium and exchange acidity in the upper part of the natric horizon. They are otherwise much like Typic Natraqualfs in defined properties. There are fewer problems of plant nutrition in these soils than in soils of the typic subgroup, where the amount of calcium may be inadequate for many plants. Nevertheless, these soils are rarely productive because moisture relations as a rule are very poor.

Albic Glossic Natraqualfs.—These soils have albic materials tonguing or interfingering into the natric horizon and have more calcium and extractable acidity than magnesium and sodium in the upper part of the natric horizon. They are of small extent. The polypedons are small and are usually closely associated with those of other subgroups of Natraqualfs.

Glossic Natraqualfs.—These soils have tonguing or interfingering of albic materials in the upper part of the natric horizon but are otherwise like Typic Natraqualfs in defined properties. In general, however, the natric horizon is deeper in soils of this subgroup than in Typic Natraqualfs. Plate 4B shows a Glossic Natraqualf in South Australia. In the United States these soils have only small extent. They occur principally in the Mississippi River Valley where the soil temperature regime is thermic. Their use is usually determined by the use made of the associated soils.

Ochraqualfs

Ochraqualfs (plate 10B) are the Aqualfs of midlatitudes that have an ochric epipedon that rests on an argillic horizon without an abrupt textural change if the argillic horizon has slow saturated hydraulic conductivity. They do not have a natric horizon or fragipan or duripan. The ground water fluctuates from a level near the surface to one below the argillic horizon.

Most Ochraqualfs had either a deciduous broadleaf forest or coniferous forest before cultivation. They generally are nearly level, and their parent materials generally are late-Pleistocene sediments. These soils albic and argillic horizons if the saturated hydraulic conductivity of the argillic horizon is slow or very slow; and

4. Have mean summer and mean winter soil temperatures at a depth of 50 cm that differ by 5° C or more.

Pedon 46 is a Typic Ochraqualf, an example of the central concept of Ochraqualfs.

Distinctions between Typic Ochraqualfs and other subgroups

Typic Ochraqualfs are the Ochraqualfs that

a. Have in 60 percent or more of the matrix [5] in all subhorizons between the A1 or Ap horizon and a depth of 75 cm one or more of the following:

(1) If mottled and the mean annual soil temperature is lower than 15° C, chroma, moist, of 2 or less;

(2) If mottled and the mean annual soil temperature is 15° C or more:

(a) If the hue is 2.5Y or redder and the value, moist, is more than 5, the chroma is 2 or less;

(b) If the hue is 2.5Y or redder and the value, moist, is 5 or less, the chroma, moist, is 1 or less;

(c) If the hue is yellower than 2.5Y, the chroma, moist, is 2 or less;

(3) The chroma, moist, is 1 or less whether mottled or not;

b. Do not have a layer above a depth of 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either

(1) A ratio of measured clay to 15-bar water (percentages) or 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Have an Ap horizon that has either a color value, moist, of 4 or more or a color value, dry, of 6 or more after the soil has been crushed and smoothed; or the upper soil to a depth of 18 cm, after mixing, has these color values;

d. Have texture finer than loamy fine sand in some subhorizon within 50 cm of the surface; and

e. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm and at least 30 cm long in some part and that extend upward to the surface or to the base of an Ap or an albic horizon.

Aeric Ochraqualfs are like Typic Ochraqualfs except for *a*.

Aeric Umbric Ochraqualfs are like Typic Ochraqualfs except for *a* and *c* and have an epipedon that meets all the requirements of an umbric epipedon except thickness.

Andaqueptic Ochraqualfs are like Typic Ochraqualfs except for *b* or for *a* and *b*.

Arenic Ochraqualfs are like Typic Ochraqualfs except for *d*, with or without *a*, and have a sandy epipedon between 50 cm and 1 m thick.

Grossarenic Ochraqualfs are like Typic Ochraqualfs

Aeric Umbric Ochraqualfs.—Soils in this subgroup are like Typic Ochraqualfs except they have (a) in

some subhorizon between the A1 or Ap horizon and a depth of 75 cm, chroma in more than 40 percent of the matrix that is too high for the typic subgroup; and (b) either an Ap horizon that has color value, moist, of less than 4 and a color value, dry, of less than 6 or, if undisturbed, the soil to a depth of 18 cm, after mixing, has these colors; and (c) base saturation <50 percent (by NH_4OAc) in the epipedon. These soils occur on the low Atlantic Coastal Plain in the United States. They are not extensive. Most of them are in

percent of the matrix of some subhorizon between the A1 or Ap horizon and a depth of 75 cm, chroma that is too high for the Typic Ochraqualfs and (b) either an Ap horizon that has a color value, moist, that is less than 4 and a color value, dry, that is less than 6, or the surface soil to a depth of 18 cm, after mixing, has these colors and has other properties of a mollic epipedon. A mollic epipedon is permitted in this subgroup if the base saturation in some part of the argillic horizon is <50 percent (by NH_4OAc).

Udollic Ochraqualfs are widely scattered in the glaciated parts of the United States, particularly in the north-central states. Most of them have been cleared and drained and are being cultivated.

Umbric Ochraqualfs.—Soils in this subgroup are like Typic Ochraqualfs except they have (a) either an Ap horizon that has a color value, moist, that is less than 4 and a color value, dry, that is less than 6, or, if undisturbed, the surface soil to a depth of 18 cm, after

Definition

Plinthaqualfs are the Aqualfs that have plinthite that forms a continuous phase or that constitutes half or more of the matrix of some subhorizon of the argillic horizon within 1.25 m of the soil surface.

Tropaqualfs

Tropaqualfs are the Aqualfs of tropical regions that have <50 percent plinthite by volume in all subhorizons to a depth of 1.25 m, and do not have above that depth plinthite that forms a continuous phase. Some, however, have some plinthite. Tropaqualfs have an isomesic or a warmer iso temperature regime. Generally, the dry season is not so pronounced as is that of the Plinthaqualfs. Most of these soils have or have had a vegetation of evergreen broadleaf forest. This group had no clear equivalent in the 1938 classification as modified prior to 1949, but the soils are similar to

c. Do not have a layer above a depth of 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

d. Have either an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more when crushed and smoothed, or the upper soil to a depth of 18 cm has these colors after mixing; and

e. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm and at least 30 cm long in some part and extend upward to the surface or to the base of an Ap or of an albic horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the soil to a depth of 1 m or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Abruptic Tropaqualfs are like Typic Tropaqualfs except for *b*.

Aeric Tropaqualfs are like Typic Tropaqualfs except for *a*.

Description of subgroups

Typic Tropaqualfs.—The concept of Typic Tropaqualfs is more or less parallel to that of Typic Ochraqualfs because soils in this subgroup are not known to occur in the United States. Features that have been excluded from typic subgroups as conventions in other great groups are excluded from this subgroup. The definition is provisional but cannot be tested in the United States.

Abruptic Tropaqualfs.—These soils are not known in the United States but the subgroup has been suggested for other countries.

Aeric Tropaqualfs.—Pedon 47 is an Aeric Tropaqualf. The horizons between 18 and 30 cm and between 43 and 81 cm have chroma too high for Typic Tropaqualfs. These soils occur on gently or moderately [illegible] hyperthermic. They have or have had a forest vegetation. They were considered Humic-Gley soils in the 1938 classification as modified before 1949.

Definition

Umbraqualfs are Aqualfs that

1. Have an umbric epipedon but do not have a fragipan, a natric horizon, or a duripan;
2. Do not have albic materials tonguing in the argillic horizon; and
3. Do not have an abrupt textural change between an albic and an argillic horizon if the saturated hydraulic conductivity of the argillic horizon is slow or very slow; and
4. Have mean summer and mean winter soil temperatures at a depth of 50 cm that differ by 5° C or more.

Description of a Typic Umbraqualf

The description of a pedon that represents the central concept or typic subgroup of Umbraqualfs follows. This soil formed in clayey alluvium on a stream terrace in Washington County, Ark. It is saturated for several months in most years, usually in winter and early in spring. The mean annual air temperature is about 15° C, and the average annual precipitation is about 1,150 mm. The vegetation before cultivation consisted mainly of water-tolerant hardwood trees. Colors are those of the moist soil unless otherwise stated.

Ap 0–15 cm. Very dark brown (10YR 2/2) silt loam, grayish brown (10YR 5/2) dry; weak medium granular structure; friable; many roots; medium acid; abrupt smooth boundary.

A12 15–30 cm. Very dark gray (10YR 3/1) silty clay loam, grayish brown (10YR 5/2) dry; moderate medium angular blocky structure; friable; many roots; few concretions; medium acid; gradual irregular boundary.

B21tg 30–80 cm. Dark gray (10YR 4/1) silty clay, gray (10YR 6/1) dry; mottled with yellowish brown (10YR 5/6) and yellowish red (5YR 4/6); moderate medium blocky structure; firm, plastic; thin patchy clay skins; few soft dark concretions; few roots; strongly acid; diffuse wavy boundary.

B22tg 80–130 cm. Dark gray (10YR 4/1) silty clay, gray (10YR 6/1) dry; coarsely mottled with dark yellowish brown (10YR 4/4); moderate medium blocky structure; firm, plastic; thin patchy clay skins; many dark concretions; few roots; medium acid; clear wavy boundary.

C 130–170 cm. Dark gray (10YR 4/1) and dark brown silty clay; massive; firm; common gravel; many dark hard and soft concretions; few roots; slightly acid.

Distinctions between Typic Umbraqualfs and other subgroups

Typic Umbraqualfs are the Umbraqualfs that [illegible]

2.5 to 30 cm in diameter that constitute >5 percent of the volume, that are cemented by iron, and that lie above and in an irregular or broken upper boundary of the argillic horizon.

The typic subgroup is the only one that has been recognized in the United States to date. Item *a* of the definition of Typic Umbraqualfs provides for an andeptic subgroup, and item *b* has been suggested for a ferrudalfic subgroup.

The Umbraqualfs are not extensive in the United States. Most of them formed in alluvium or in marine deposits and are nearly level. The base saturation in the argillic horizon generally is low enough that liming the surface layer does not change the classification.

Boralfs

Boralfs are the more or less freely drained Alfisols of cool places. In North America, they have a frigid or a cryic temperature regime and most of them have a udic moisture regime.

Boralfs are moderately extensive in North America, eastern Europe, and Asia above 46° north latitude and in some high mountains south of that latitude. They form a belt on the plains between the Mollisols of the grasslands and the Spodosols of the cooler, more humid regions. In the mountains, they tend to form

Key to great groups

HBA. Boralfs that have an argillic horizon with its upper boundary deeper than 60 cm below the mineral surface,[7] that have texture finer than loamy fine sand in some subhorizon above the argillic horizon, and that have albic materials tonguing or interfingering in the argillic horizon.

Paleboralfs, p. 124

HBB. Other Boralfs that have a fragipan.

Fragiboralfs, p. 122

HBC. Other Boralfs that have a natric horizon.

Natriboralfs, p. 124

HBD. Other Boralfs that have a cryic temperature regime.

Cryoboralfs, p. 119

HBE. Other Boralfs that have base saturation (by sum of cations) of 60 percent or more in all subhorizons of the argillic horizon and are dry in some horizon at some time in most years.

Eutroboralfs, p. 121

HBF. Other Boralfs that either are never dry in any horizon in most years or have base saturation (by sum of cations) of <60 percent in some subhorizon of the argillic horizon.

Glossoboralfs, p. 122

Cryoboralfs

These are the Boralfs that have a cryic temperature regime and an argillic horizon that has its upper boundary within 60 cm of the soil surface unless either there is a sandy particle-size class or there is no tonguing or interfingering of albic materials in the argillic horizon. The common sequence of horizons is an O horizon, an albic horizon, and an argillic horizon.

the texture is loamy fine sand or coarser in all subhorizons above the argillic horizon or there is no tonguing or interfingering of albic materials in the argillic horizon; and

3. Do not have a fragipan or a natric horizon.

Pedon 48 illustrates a Typic Cryoboralf.

Distinctions between Typic Cryoboralfs and other subgroups

Typic Cryoboralfs are the Cryoboralfs that

a. Do not have a layer above a depth of 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and has more exchange acid-

Evidences of amorphous clays are normally associated with pyroclastic materials, and soils that have them are excluded from Typic Cryoboralfs because those properties are shared with Andepts. Mottles of low chroma or saturation with water at a depth within 1 m of the surface for extended periods cause a soil to be excluded from the typic subgroup because they are properties shared with Aqualfs. Tongues of albic materials in the argillic horizon are considered abnormal. They are associated with lower base saturation and are the basis for definition of the glossic subgroup. A shallow lithic contact defines lithic subgroups, a convention used throughout the taxonomy.

A soil that has a surface horizon as thick as 15 cm that is dark enough to be near or within the range of a mollic epipedon is excluded from the typic subgroup because the thick dark horizon is believed to indicate a transitional form to Mollisols. An argillic horizon that

Lithic Mollic Cryoboralfs.—Soils in this subgroup have a lithic contact within 50 cm of the surface and,

3. Are dry in some horizon in the moisture control section at some time in most years;

mixing, has a color value, moist, of less than 4. Few of these soils are cultivated, but if there is an Ap horizon, its color value, moist, is 3 or less. The albic horizon in soils of this subgroup is permitted to tongue into the argillic horizon. These soils are rare in the United States.

Mollic Cryoboralfs.—These soils are like Typic Cry-

5. Have an argillic horizon that has its upper boundary within 60 cm of the mineral surface[9] unless either (a) the texture is coarser than loamy very fine sand in all subhorizons above the argillic horizon or (b) there are no albic materials that tongue or interfinger into the argillic horizon.

Pedon 49 illustrates the physical and chemical prop-

this depth are excluded from Typic Eutroboralfs because these properties are shared with Aqualfs. Tongues of albic materials in the argillic horizon are considered abnormal and are a property shared with most Glossoboralfs. A shallow lithic contact defines the lithic subgroup, a convention used throughout the taxonomy. A thick sandy epipedon is considered abnormal and defines the arenic subgroup. Surface horizons to a depth of 18 cm that, after mixing, have the color value of a mollic epipedon, and an Ap horizon that has that color are believed to indicate a transition to Mollisols. An argillic horizon that has a sandy particle-size class or is composed entirely of thin lamellae causes a soil to be excluded from the typic subgroup and defines the psammentic subgroup.

Aquic Eutroboralfs.—These soils are wetter than Typic Eutroboralfs. Virtually all Eutroboralfs that have mottles having chroma of 2 or less within the upper 25 cm of the argillic horizon (and that are saturated with water in that zone at some time) are placed in this subgroup. This grouping is made mainly because the soils have only small extent. Soils that and Argiborolls. Where slopes are suitable, most of them are farmed.

Psammentic Eutroboralfs.—Soils in this subgroup have an argillic horizon that has a sandy texture, loamy fine sand or coarser, or that consists only of lamellae, or both. The lamellae may be present only at depths well below 50 cm, and the upper lamellae commonly are broken or discontinuous horizontally. In the United States, most Psammentic Eutroboralfs are on fans or foot slopes in the mountains of the western states. Nearly all of them are used for grazing and for forests.

Fragiboralfs

Fragiboralfs are the Boralfs that have a fragipan in or below the argillic horizon but do not have a natric horizon. The upper boundary of the argillic horizon is within 60 cm of the soil surface unless either the particle-size class is sandy or there are no albic materials that tongue or interfinger into the argillic horizon. The usual horizon sequence is an Ap, A1, or O horizon, an

within 60 cm of the mineral surface. Either the base saturation is <60 percent (by sum of cations) in some part of the argillic horizon or no subhorizon is dry in most years, or both. The name comes from the characteristic tonguing of albic materials into the argillic horizon. This is thought to indicate that the argillic horizon is being moved deeper into the soil. In the areas where the soils are transitional between Spodosols and Alfisols, many soils have a spodic horizon that overlies an argillic horizon. The two horizons commonly are separated by an albic horizon. The lower sequum is that of a Boralf. In undisturbed Glossoboralfs, very thin horizons, a few centimeters thick,

angular blocks; firm; thick coats of dark grayish brown (10YR 4/2) on blocky ped faces in upper part; strongly acid; clear smooth boundary.

IIB22 53–68 cm. Reddish brown (5YR 3/4) heavy loam; weak coarse prisms that break to moderate medium subangular blocks; firm; strongly acid; gradual smooth boundary.

IIB3 68–81 cm. Reddish brown (5YR 3/4) loam; weak coarse subangular blocky structure; friable; medium acid; clear smooth boundary.

IIC 81–100 cm. Reddish brown (5YR 4/4) loam; weak coarse platy structure, nearly massive; friable; slightly acid; glacial till. Many meters thick.

Distinctions between Typic Glossoboralfs and other subgroups

clay content of <20 percent (absolute) within a vertical distance of 7.5 cm from its upper boundary;
b. Do not have a layer in the upper 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;
c. Do not have mottles that have chroma of 2 or less within 1 m of the surface; and
d. Have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more when crushed and smoothed, or the soil to a depth of 18 cm has these colors after mixing.

Aquic Paleboralfs are like Typic Paleboralfs except for *c*.

Mollic Paleboralfs are like Typic Paleboralfs except for *d*.

The Paleboralfs have had relatively little study in the field or laboratory. It seems best at this time to consider the definitions of the great group and of its subgroups as tentative.

Udalfs

Udalfs (plates 6A and 7D) are the brownish or reddish more or less freely drained Alfisols that have udic moisture regimes and mesic, isomesic, or warmer temperature regimes. They are principally but not entirely on late-Pleistocene deposits and erosion surfaces of about the same age. The few that are on older surfaces are underlain by limestone or other calcareous sediments.

Udalfs are very extensive in the United States and in western Europe. Most of them have had a deciduous forest vegetation at some time.

Udalfs have been intensively farmed, and as a result of erosion many now have only an argillic horizon below an Ap horizon that is mostly material once part of the argillic horizon. Others are on stable surfaces and retain most of their eluvial horizons above the argillic horizon. Normally, the undisturbed soil has a thin A1 horizon darkened by humus. A few Udalfs have a natric horizon. Others have a fragipan in or below the argillic horizon.

in clay-size particles; and
3. Have chroma too high for Aqualfs or do not have either
   a. An aquic moisture regime; or
   b. Artificial drainage.

Key to great groups

HEA. Udalfs that have an agric horizon.
Agrudalfs, p. 125

HEB. Other Udalfs that have a natric horizon.
Natrudalfs, p. 133

HEC. Other Udalfs that
1. Do not have a continuous albic horizon above the argillic horizon;
2. Have a broken upper boundary of the argillic horizon; and
3. Have discrete nodules in the argillic horizon that range from 2.5 to 5 cm to about 30 cm in diameter; exteriors of nodules are enriched and weakly cemented or indurated with iron and have redder hue or stronger chroma than interiors of nodules.
Ferrudalfs, p. 126

HED. Other Udalfs that have tongues of albic materials in the argillic horizon and do not have a fragipan.
Glossudalfs, p. 128

HEE. Other Udalfs that have tongues of albic materials in the argillic horizon and have a fragipan.
Fraglossudalfs, p. 128

HEF. Other Udalfs that have a fragipan.
Fragiudalfs, p. 126

HEG. Other Udalfs that
1. Have mean summer and mean winter soil temperatures at a depth of 50 cm that differ by 5° C or more;
2. Do not have a lithic or paralithic contact within 1.5 m of the soil surface;
3. Have clay distribution such that the percentage of clay does not decrease by as much as 20 percent of the maximum within a depth of 1.5 m from the soil surface or the horizon in which the clay decreases either has >5 percent plinthite by volume or has skeletans or other evidence of clay eluviation; and
4. Have one or more of the following:
   a. Hue redder than 10YR and chroma more than 4 dominant in the matrix in at least the lower part of the argillic horizon;
   b. Hue of 2.5YR or redder and value, moist, of less than 4 and value, dry, of less than 5 throughout the major part of the argillic horizon;
   c. Many coarse mottles that have hue redder than 7.5YR or chroma more than 5, or both.
Paleudalfs, p. 133

HEH. Other Udalfs that have an argillic horizon that has throughout its thickness a hue redder than 5YR, a color value, moist of less than 4, and a color value, dry, no more than 1 unit higher than the value, moist.
< 3.5
Rhodudalfs, p. 136

the typic and anthropic subgroups are needed. The Agrudalfs of western Europe have been farmed for more than 1,000 years,[13] and the early farmers selected only the best soils for cultivation. All of them are well drained, and they seem quite similar in most properties. The Typic Agrudalfs do not have an anthropic epipedon.

Pedon 22 illustrates the physical and chemical properties of an Agrudalf formed in loess.

Ferrudalfs

Ferrudalfs are Udalfs in which the argillic horizon has been partially or largely destroyed, presumably through collection and removal of forest litter until the forest was succeeded by a heath vegetation. Under the heath, which is efficient in complexing iron and aluminum, destruction of the argillic horizon began, but no spodic horizon formed. Instead, fragments of

Fragiudalfs

Fragiudalfs (plate 6A) are the Udalfs that normally have a brown argillic or cambic horizon above a mottled fragipan that begins at a depth between about 50 cm and 1 m below the surface. Perched ground water is present seasonally above the pan, and there is usually a thin eluvial horizon, in which the peds have gray skeletans, just above the pan.

In the United States, most Fragiudalfs are on gentle slopes and formed, at least in part, in silty or loamy deposits of late-Pleistocene age, mainly in loess-mantled areas along the lower Mississippi River and its tributaries. The pan may have formed in an older buried soil if burial was to a depth of about 50 to 75 cm. Temperature regimes are mesic or thermic. In the United States, the native vegetation was primarily a broadleaf deciduous forest. Some of these soils were considered Gray-Brown Podzolic soils and others Plan-

have mottles that have chroma of 2 or less within 40 cm of the surface if the horizons that have mottles of low chroma are saturated with water at some time of year when the soil temperature is 5° C or higher in those horizons. Mottles are not the same as skeletans that may also have low chroma.

Albaquic Fragiudalfs are like Typic Fragiudalfs except for *e*, and they have, within a vertical distance of 7.5 cm at the top of the argillic horizon, a clay increase of >15 percent (absolute) in the fine-earth fraction.

Aqueptic Fragiudalfs are like Typic Fragiudalfs except for *a* and *e*.

Aquic Fragiudalfs are like Typic Fragiudalfs except for *e*.

Glossaquic Fragiudalfs are like Typic Fragiudalfs except for *b* and *e*, with or without *a*.

Glossic Fragiudalfs are like Typic Fragiudalfs except for *b*, with or without *a*.

Mollic Fragiudalfs are like Typic Fragiudalfs except for *d*, with or without *e*, and have base saturation of 50 percent or more (by NH_4OAc) in the major part of the epipedon.

Ochreptic Fragiudalfs are like Typic Fragiudalfs except for *a*.

Umbreptic Fragiudalfs are like Typic Fragiudalfs except for *a*, *b*, and *d*, and have base saturation <50 percent (by NH_4OAc) in the epipedon.

Description of subgroups

Typic Fragiudalfs.—The central concept or typic subgroup of Fragiudalfs is fixed on the most nearly freely drained soils of this great group that have an argillic horizon above the fragipan, in which the argillic horizon does not have an abrupt upper boundary and does not have evidences of degradation, and that have high color value in an Ap horizon or in comparable layers if the soil is undisturbed. In addition, they do not have a surface mantle in which there are strong evidences of amorphous clays that have high activity.

Typic Fragiudalfs are not the most extensive subgroup, but they furnish the best basis for definition of subgroups. No Fragiudalfs are freely drained because in all of them ground water is perched above the fragipan in many years. The perched ground water is a probable cause of the very common albic materials and bleached skeletans just above the fragipan. Soils that have these features and also mottles of low chroma at a shallow depth in the soil, normally along with mottles of high chroma or of reddish hue, are considered to be intergrades toward Aqualfs. An abrupt upper boundary of the argillic horizon is a characteristic of Albaqualfs and defines the albaquic subgroup.

An Ap horizon or subhorizons comparable in thickness that have the color of a mollic epipedon are considered abnormal and define the mollic and umbric subgroups.

In many Fragiudalfs the fragipan is in the argillic horizon; there is a cambic horizon above the fragipan that is separated from the pan by an eluvial horizon. part of the fragipan. These extra horizons form the basis for defining intergrades to some of the Inceptisols that have a fragipan, the Fragiaquepts and Fragiochrepts.

A similar eluvial horizon below an argillic horizon but above the fragipan is a property of the weakly developed Fraglossudalfs and defines the glossic subgroups of Fragiudalfs.

Albaquic Fragiudalfs.—Soils in this subgroup are like Typic Fragiudalfs except they have mottles that have chroma of 2 or less either in the upper 25 cm of the argillic horizon or within 40 cm of the soil surface. In addition, the percentage of clay in the fine-earth fraction increases by 15 percent (absolute, for example, the difference between 10 and 25 percent) or more at the top of the argillic horizon within a vertical distance of 7.5 cm or less. These soils are intergrades between Fragiudalfs and Albaqualfs. They are not extensive in the United States. Most of them are cultivated or are used as pasture.

Aqueptic Fragiudalfs.—These soils do not have above the fragipan an argillic horizon that has clay skins on any vertical and horizontal ped faces. They have a brownish horizon that (1) does not have clay skins and has skeletans on primary ped faces and (2) that is separated from the fragipan by an eluvial horizon that has thick skeletans and that has at least 3 percent less clay (absolute, for example, the difference between 17 and 20 percent) than the overlying and underlying horizons. Either the fragipan is in an argillic horizon or there are thick clay skins (>1 mm thick) on the bleached prisms of the fragipan. In addition, there are mottles that have chroma of 2 or less in the upper 40 cm of the soil. These soils are considered intergrades between Fragiaquepts and Fragiudalfs. They are not extensive soils in the United States.

Aquic Fragiudalfs.—These soils are like Typic Fragiudalfs except they have mottles that have chroma of 2 or less in the upper 25 cm of the argillic horizon or within 40 cm of the soil surface, and the mottled horizon is saturated with water at some time during the year when its temperature is 5° C or higher or the soil is artificially drained. They are intergrades between Fragiaqualfs and Fragiudalfs. In the United States, they are widely scattered from Pennsylvania to Illinois and from Illinois to Louisiana. They are moderately extensive locally within this area. They have gentle slopes, and most of them are farmed.

Glossaquic Fragiudalfs.—These soils have a brownish horizon that (1) does not have clay skins and has skeletans on primary ped faces and (2) is separated from the fragipan by an eluvial horizon that has thick skeletans and that has at least 3 percent less clay (absolute) than the overlying and underlying horizons. In addition, these soils have mottles that have chroma of 2 or less in the upper 40 cm. They are mostly on the coastal plain in the southeastern states, and they are not extensive. Many are cultivated.

Glossic Fragiudalfs.—Soils in this subgroup are like Typic Fragiudalfs except they have, between the argillic horizon and the fragipan, an eluvial horizon that has thick skeletans or albic materials that tongue or interfinger in the upper part of the pan. Plate 6A

upper surface of a horizontal cut across the fragipan. These soils are moderately extensive in the loess of the southern part of the Mississippi Valley. Most of them have been cultivated, but their slopes are moderate and erosion has been severe; many are now in pasture. Pedon 34 is an example of this subgroup.

Mollic Fragiudalfs.—These soils have an Ap horizon that has a color value, moist, darker than 4 and a color value, dry, darker than 6, or the soil to a depth of 18 cm, after mixing, has these color values. These soils are permitted but not required to have mottles that have chroma of 2 or less in the upper 25 cm of the argillic horizon or within 40 cm of the soil surface. Those in the United States have had grass or savanna vegetation and are not extensive except locally in Missouri and Arkansas. The epipedon is mollic or approaches the properties of a mollic epipedon.

Ochreptic Fragiudalfs.—Soils in this subgroup are like Typic Fragiudalfs except they do not have a distinct argillic horizon above the fragipan that has clay skins on some vertical and horizontal surfaces. They have, instead, a brown or strong brown unmottled horizon above the fragipan that seems more like a cambic horizon than an argillic horizon. Just above the fragipan there may be a thin eluvial horizon, in many places about 10 cm thick, that has thick gray skeletans and has at least 3 percent less clay (absolute) than the overlying and underlying horizons. The prism faces of the fragipan have thick (>1 mm) clay skins, or the fragipan itself is also an argillic horizon. These soils are not extensive in the United States. Most of them are cultivated, but some have been severely eroded and are used as pasture or are in forest.

Umbreptic Fragiudalfs.—These soils are not known to occur in the United States, but the subgroup is provided for use elsewhere.

Fraglossudalfs

Fraglossudalfs have a fragipan and an overlying argillic horizon that has evidences of destruction in the form of deep wide tongues of albic materials that normally extend through the argillic horizon. The upper boundary of the argillic horizon is usually broken, but there is little or no cementation by iron. These soils are more extensive in Europe than in the United States. The epipedon may approach an umbric epipedon. Subgroups have not been developed. No comparable class existed in the 1938 classification.

Glossudalfs

Glossudalfs (plate 7D) do not have a fragipan. They do have an argillic horizon that has evidences of destruction in the form of deep wide tongues of albic materials. The tongues commonly extend through the argillic horizon. These soils are more extensive in Europe than in the United States. No comparable class existed in the 1938 classification.

Definition

Glossudalfs are the Udalfs that

1. Have tongues of albic materials in the argillic horizon;
2. Do not have, in the argillic horizon, discrete nodules 2.5 to 30 cm in diameter whose exteriors are enriched, weakly cemented, or indurated with iron;
3. Have mean summer and mean winter soil temperatures at a depth of 50 cm or at a lithic or a paralithic contact, whichever is shallower, that differ by 5° C or more; and
4. Do not have a natric or an agric horizon and do not have a fragipan.

Description of a Glossudalf

A description of a pedon of a Glossudalf (plate 7D) in the United States follows. Colors are those of the moist soil unless otherwise noted.

Ap 0–23 cm. Very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; moderate coarse and medium granular structure; hard, friable, slightly plastic, slightly sticky; many coarse, medium, and fine pores; many roots; common coarse and medium very dark brown concretions; strongly acid (pH 5.5); abrupt smooth boundary.

A2 23–36 cm. Dark grayish brown (10YR 4/2) silt loam; light brownish gray (10YR 6/2) when dry; massive tending to weak very coarse prismatic structure; very hard, friable, slightly plastic, slightly sticky; many roots; many coarse, medium, and fine pores; few to common distinct fine mottles of yellowish brown (10YR 5/6) dry; common coarse and medium very dark brown concretions; strongly acid (pH 5.4); clear wavy boundary.

A&B 36–56 cm. The A2 part of this horizon is faintly mottled dark grayish brown and dark brown (10YR 4/2 and 4/3) silt loam, light brownish gray (10YR 6/2) when dry; the B21 part is finely and faintly mottled dark brown and dark yellowish brown (10YR 4/4) heavy silt loam, slightly darker (10YR 3/4) moist; weak very coarse prismatic structure; very hard, friable, plastic, slightly sticky; few fine roots; many coarse, medium and fine pores; moderate thick patchy clay skins on ped surfaces; common coarse and medium very dark brown and black concretions; strongly acid (pH 5.3); gradual wavy boundary.

B&A1 56–140 cm. The B21 part of the horizon is dark brown (10YR 4/3) silty clay loam, yellowish brown (10YR 5/4) when dry; strong very coarse prisms breaking to strong coarse and medium blocks; extremely hard, firm, plastic, sticky; few fine and very fine pores; common medium and fine distinct mottles of dark brown (7.5YR 3/4) and black when dry; brown mottles are clay skins; black mottles are manganese dioxide segregations; common coarse, medium and fine very dark brown and black concretions. The A2 tongues, which are 0.5 to 2.5 cm thick around prisms, are light gray (10YR 7/1) silt loam, grayish brown (10YR 5/2) when moist; hard, friable, plastic, slightly sticky; many medium and fine tubular pores; very few medium black and very dark brown concretions; few fine roots penetrate this horizon, following the gray tongues; no roots penetrate interiors of prisms; medium continuous clay skins on all surfaces and in pores of B2 part of this horizon; strongly acid (pH 5.3); gradual wavy boundary.

B&A2 140–180 cm. Dark brown (10YR 4/3) silty clay loam, brown (10YR 5/3) when dry; strong coarse and medium prismatic structure; extremely hard, firm, very plastic, very sticky; many coarse, medium and fine pores; very few, very fine roots follow gray tongues but do not penetrate the peds; common fine distinct mottles of strong brown (7.5YR 4/6) dry; surfaces of the peds and pores have thick continuous dark brown (10YR 4/3) clay skins; black manganese dioxide stains on peds; around the prisms are 0.5 to 2 cm tongues of light gray (10YR 7/1), grayish brown (10YR 5/2) moist; strongly acid (pH 5.5).

Distinctions between Typic Glossudalfs and other subgroups

Typic Glossudalfs are the Glossudalfs that

a. Do not have mottles that have chroma of 2 or less in the upper 25 cm of the argillic horizon if the mot-

teristics of Hapludalfs. They occur locally in the central part of southern United States.

Hapludalfs

Hapludalfs are brownish or reddish Udalfs of tem-

b. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Have an argillic horizon that

(1) If its upper boundary is <50 cm below the soil surface, does not have mottles that have chroma of 2 or less in the upper 25 cm if it is saturated with water within that depth at some time when the soil temperature is 5° C or higher; or

(2) If the upper boundary of the argillic horizon is deeper than 50 cm, does not have mottles that have chroma of 2 or less within a depth of 75 cm below the soil surface;

d. Have, within 50 cm of the surface, texture finer than loamy fine sand in some subhorizon;

e. Do not have interfingering of albic materials and albic materials surrounding some peds in the upper part of the argillic horizon;

f. Do not have a lithic contact within 50 cm of the soil

Albaquultic Hapludalfs are like Typic Hapludalfs except for *a*, *c*, and *i*.

Andeptic Glossoboric Hapludalfs are like Typic Hapludalfs except for *b* and *e*, and their mean annual soil temperature is lower than 10° C.

Aquic Hapludalfs are like Typic Hapludalfs except for *c*.

Aquic Arenic Hapludalfs are like Typic Hapludalfs except for *c* and *d*, with or without *g* or *i*, or both.

Aquic Lithic Hapludalfs are like Typic Hapludalfs except for *c* and *f*.

Aquollic Hapludalfs are like Typic Hapludalfs except for *c* and *g*.

Aquultic Hapludalfs are like Typic Hapludalfs except for *c* and *i*, with or without *g*.

Arenic Hapludalfs are like Typic Hapludalfs except for *d*, with or without *g* or *i*, or both.

Glossaquic Hapludalfs are like Typic Hapludalfs except for *e* and *c* or for *e*, *c*, and *g*.

Glossic Hapludalfs are like Typic Hapludalfs except for *k*, with or without *e* or *g*, or both, and the mean annual soil temperature is 10° C or higher.

Glossoboric Hapludalfs are like Typic Hapludalfs except for *e* or for *e* and *g*, and their mean annual soil temperature is lower than 10° C.

Lithic Hapludalfs are like Typic Hapludalfs except for *f*, with or without *g*.

Mollic Hapludalfs are like Typic Hapludalfs except

A thick epipedon that has a sandy particle-size class is considered abnormal and defines the arenic subgroup. Interfingering of albic materials in the upper part of the argillic horizon and a soil temperature regime that approaches frigid cause a soil to be excluded

near the Pacific Ocean in Washington state. They are not extensive soils. Their slopes are gentle to strong. Most of them are in forests.

Aquic Hapludalfs.—These soils are like Typic Hapludalfs except they have a subhorizon that is satu-

have any color value when moist. These soils are intergrades between Aquults and Hapludalfs. They are not widely scattered. Their slopes range from gentle to strong. Most of these soils are in pasture or in forest

formed from clayey parent materials. These soils are moderately extensive locally in the southeastern states. Slopes are gentle, but the soils are highly erodible. Some of the soils are farmed but most of them are under forest or grass.

Natrudalfs

Natrudalfs are the Udalfs that have a natric horizon. Commonly, the natric horizon is thin, something

25 cm of the upper boundary of the natric horizon;

b. Have an Ap horizon that has a color value, moist, of 3 or more, or the soil to a depth of 18 cm, after mixing, has that color value;

c. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend to the surface or to the base of an Ap horizon;

vegetation of mixed deciduous hardwood forests. Most of these soils were considered Red-Yellow Podzolic soils but a few were considered Planosols in the 1938 classification as modified before 1949.

Definition

Paleudalfs are the Udalfs that

1. Have mean summer and winter soil temperatures

of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness;

f. Have ≤5 percent plinthite (by volume) in all sub-

not have deep wide cracks in most years, and it does not have appreciable plinthite or a sandy texture or thick gray skeletans.

Soils that have shallow mottles of low chroma in horizons that are saturated with water at some time when the mottled horizon has a temperature of 5° C or higher are excluded from Typic Paleudalfs because those properties are shared with Aqualfs. A thick sandy epipedon that has texture of sand or loamy sand is considered abnormal and defines the arenic and grossarenic subgroups. Color of a mollic epipedon in the plow layer or, if the soil is undisturbed, in surface horizons of comparable thickness is considered abnormal and defines the mollic subgroup. Plinthite in appreciable volume is considered abnormal and defines the plinthic subgroup. An argillic horizon that has a sandy particle-size class or that is composed entirely of lamellae is the basis for defining the psammentic subgroup. Thick gray skeletans in some subhorizon within the argillic horizon (but not at the upper boundary) cause a soil to be excluded because that property is shared with Glossudalfs.

Typic Paleudalfs are moderately extensive soils in unglaciated areas where the bedrock is limestone. Their slopes are gentle or moderate, and most of the soils are farmed.

Albaquic Paleudalfs.—Soils in this subgroup are like Typic Paleudalfs except they have, within 75 cm of the soil surface, some subhorizon that has mottles that have chroma of 2 or less and that is saturated with water at some time during the year. A gray, sandy chroma of 2 or less and that is saturated with water at some time during the year. In addition, they have a subhorizon within the argillic horizon, commonly 25 cm or more below its upper boundary, that has thick skeletans of low chroma. These skeletans occupy an appreciable part of the mass of the subhorizon. These soils are of minor extent in central southern United States.

Glossic Paleudalfs.—Soils in this subgroup have a subhorizon within the argillic horizon, commonly 25 cm or more below its upper boundary, that has thick skeletans of low chroma that occupy an appreciable part of the mass of the subhorizon. These soils are otherwise like Typic Paleudalfs in defined properties and in accessory properties. They are not extensive in the United States. They occur mostly in the lower Mississippi River Valley on terraces. Slopes are very gentle, and most of the soils are farmed.

Grossarenic Paleudalfs.—These soils have an epipedon that is >1 m thick and that has texture throughout its thickness of loamy fine sand or coarser. The argillic horizon tends to have much sand. These soils are rare in the United States. They occur on the coastal plain in Texas. Slopes are gentle, and the soils are mostly cultivated or used for grazing.

Grossarenic Plinthic Paleudalfs.—These soils have an epipedon that is more than 1 m thick and that has texture of loamy fine sand or coarser throughout its thickness. The argillic horizon contains some plinthite, and ground water may be perched above the plinthite during rainy seasons. These soils are rare in the

pedon that has texture of loamy fine sand or coarser throughout its thickness and that may be either more or less than 1 m thick. They are permitted but are not required to have a color value, moist, less than 4 and a color value, dry, less than 6 in the Ap horizon or in the upper soil to a depth of 18 cm after mixing. They are intergrades between Udipsamments and Paleudalfs. They are rare in the United States and are mostly in the Mississippi Delta. Most of them are in forests.

Rhodic Paleudalfs.—These soils are like Typic Paleudalfs except all parts of the argillic horizon have a color value, moist, less than 4 and a color value, dry, no more than one unit more than the value, moist, and the hue in the argillic horizon is redder than 5YR. In addition, the Ap horizon or the upper soil to a depth of 18 cm, after mixing, normally has a color value, moist, less than 4 and a value, dry, less than 6. These soils were considered Reddish-Brown Lateritic soils in the 1938 classification. They are not extensive in the United States. They occur in Arkansas, Tennessee, and adjacent states. Their slopes are mainly gentle, and most of the soils are farmed.

Vertic Paleudalfs.—These soils have a clayey argillic horizon that contains expanding clays; they have deep wide cracks at some time in most years, but at other times the soils may be quite wet. They are not extensive in the United States. They formed mostly in materials that are rich in montmorillonite. Most of them are used for pasture or are in forest.

Rhodudalfs

Rhodudalfs are dark red Udalfs of midlatitudes that have a thinner solum than the Paleudalfs. The definition is parallel to that of other Rhodic great groups. Their parent materials are basic. These soils are rare in the United States. Definitions of subgroups have not been developed.

Tropudalfs

Tropudalfs are the Udalfs of tropical regions. Their hues range from brownish to reddish. They formed mostly on relatively recent erosion surfaces or sediments in basic parent materials. On slopes the original A horizon commonly has been lost by erosion, and the present Ap horizon is in the argillic horizon. They

subgroup follows. This soil is producing sugarcane. Its slope is about 15 percent. Precipitation is about 2,250 mm and is well distributed. The mean air temperature is about 25° C. Colors are those of the moist soil.

Ap 0–20 cm. Dark grayish brown (10YR 4/2) clay; weak coarse subangular blocky structure; firm, slightly sticky, plastic; many fine roots; medium acid; clear wavy boundary.

B21t 20–36 cm. Dark yellowish brown (10YR 4/4) clay; moderate medium subangular blocky structure; firm, slightly sticky, plastic; thin patchy clay skins; common fine roots; mildly alkaline; clear wavy boundary.

B22t 36–50 cm. Yellowish brown (10YR 5/6) clay; moderate medium subangular blocky structure; firm, slightly sticky, plastic; thin discontinuous clay skins; few fine roots; mildly alkaline; clear wavy boundary.

B23t 50–85 cm. Brownish yellow (10YR 6/6) clay, common fine distinct yellowish red (5YR 5/8) mottles; moderate medium and fine subangular blocky structure; firm, slightly sticky, plastic; few fine roots; thin patchy clay skins; few black stains; mildly alkaline; clear wavy boundary.

B24t 85–110 cm. Brownish yellow (10YR 6/6) clay, common fine prominent light greenish gray (5G 7/1) and few fine prominent red (2.5YR 5/6) mottles; moderate medium and fine subangular blocky structure; firm, slightly sticky, plastic; thin patchy clay skins; few fine roots; few black concretions; few black stains; neutral; clear wavy boundary.

B25t 110-125 cm. Yellowish brown (10YR 5/6) clay, few fine prominent light greenish gray (5G 7/1) and a few fine prominent red (2.5YR 5/6) mottles; moderate fine subangular blocky structure; firm, slightly sticky; thin patchy clay skins; very few roots; few black stains; moderately alkaline; clear wavy boundary.

C 125 cm. Brownish yellow (10YR 6/8) silty clay loam, many fine faint light gray (10YR 7/2) mottles; crushed color, yellow (10YR 7/8); massive; friable, slightly sticky, plastic; fine lime is from 25-35 percent of the horizon; strong effervescence.

Distinctions between Typic Tropudalfs and other subgroups

Typic Tropudalfs are the Tropudalfs that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizons are saturated with water at some time during the year or the soil has artificial drainage;

b. Do not have a lithic contact within 50 cm of the soil surface;

c. Do not have a layer in the upper 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine earth fraction, and that has either of the follow-

g. Have base saturation (by sum of cations) of 60 percent or more at a depth 1.25 m below the top of the argillic horizon;
h. Have CEC that is 24 or more meq per 100 g clay (by NH_4OAc) and have a cation retention from NH_4Cl that is 12 or more meq per 100 g clay in the major part of the argillic horizon; and
i. Do not have the following combination of characteristics:
(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, that extend to the surface or to the base of an Ap horizon;
(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and
(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Aquic Tropudalfs are like Typic Tropudalfs except for *a*.

Lithic Tropudalfs are like Typic Tropudalfs except for *b*.

Oxic Tropudalfs are like Typic Tropudalfs except for *h*, with or without *g*.

Ultic Tropudalfs are like Typic Tropudalfs except for *g*.

Vertic Tropudalfs are like Typic Tropudalfs except for *i*, with or without *a* or *d*, or both.

Description of subgroups

Typic Tropudalfs.—The central concept or typic subgroup of Tropudalfs was selected to be nearly parallel to the Typic Hapludalfs. Typic Tropudalfs are rare in Puerto Rico and do not occur in other parts of the United States, and the concept is provisional. In Puerto Rico, slopes of these soils may be gentle on low terraces or very strong in the uplands. Where slopes are suitable, most of these soils are farmed.

Aquic Tropudalfs.—Soils in this subgroup are like Typic Tropudalfs except they have, within 75 cm of the surface or in the upper 12.5 cm of the argillic horizon, a subhorizon that has mottles that have chroma of 2 or less and that either is saturated with water at some time during the year or has artificial drainage. They are intergrades between Ochraqualfs and Tropudalfs. They are not known to occur in Puerto Rico or the Virgin Islands, but the subgroup is provided for use if needed.

Lithic Tropudalfs.—These soils are like Typic Tropudalfs except they have a lithic contact within 50 cm of the surface. Their slopes range widely. In Puerto Rico these soils are cultivated where the slopes are suitable. The strongly sloping soils are used largely for pasture.

Ultic Tropudalfs.—These soils are like Typic Tropudalfs except their base saturation is <60 percent (by sum of cations) at a depth 1.25 m below the surface or immediately above a lithic or paralithic contact, whichever depth is shallower. They are intergrades between Tropudults and Tropudalfs. They are not known to occur in Puerto Rico or the Virgin Islands, but the subgroup is provided for use if needed.

Vertic Tropudalfs.—Soils in this subgroup have a clayey argillic horizon that contains expanding clays; they have deep wide cracks at some time in most years, but at other times the soils may be quite wet. They occur on fans and terraces in Puerto Rico. Most of them are cultivated.

Ustalfs

Ustalfs are the mostly reddish Alfisols of warm subhumid to semiarid regions. They usually have, as their name implies, an ustic moisture regime, that is, they have a warm rainy season and in most of them moisture moves through the soil to deeper layers only in occasional years. If there are carbonates in the parent materials or in the dust that settles on the surface, they tend to have a ca or a calcic horizon below or in the argillic horizon. The dry season or seasons are pronounced enough that trees are either deciduous or xerophytic. Many of these soils have or have had a savanna vegetation. Others are used for annual crops or for grazing. Sorghum and cotton are common crops. Droughts are common.

The Ustalfs (plate 2D) tend to form belts between the Aridisols of warm arid regions and the Ultisols, Oxisols, and Inceptisols of warm humid regions. The temperature regimes of Ustalfs are almost exclusively thermic, isothermic, or warmer. In the world these soils are extensive. In the United States their area is moderate, but they are extensive on the southern Great Plains.

The Ustalfs may be on erosion surfaces or deposits of late Wisconsinan age, but a great many, and characteristically those of warm regions, are on old surfaces. In the Ustalfs on old surfaces, the minerals have been strongly weathered, possibly in an environment more humid than the present one. At least, the clays in many of these older soils are kaolin. The base saturation in them at present probably reflects additions of bases in dust and rain.

Definition

Ustalfs are the Alfisols that
1. Have a mesic or isomesic or warmer temperature regime;
2. Have chroma too high for Aqualfs, or do not have either
   a. An aquic moisture regime; or
   b. Artificial drainage; and
3. Have an ustic moisture regime, or
   a. If the moisture regime is udic but marginal to ustic, have within 1.5 m of the soil surface or within 50 cm of the base of the argillic horizon either a calcic horizon or a horizon that has concentrations of soft powdery lime in spheroidal forms, as coatings on peds, or disseminated in clay-size particles,[14] or

[14] If the lime is disseminated, the horizon or horizons in which the lime is concentrated should have more lime and a higher percentage of clay-size lime than the underlying horizon.

b. If the moisture regime is aridic but marginal to ustic, have an epipedon that is both massive and hard or very hard when dry.

Key to great groups

HCA. Ustalfs that have a duripan that has its upper boundary within 1 m of the surface.

Durustalfs, p. 138

HCB. Other Ustalfs that have plinthite that forms a continuous phase or constitutes more than half the matrix within some subhorizon of the argillic horizon within 1.25 m of the surface.

Plinthustalfs, p. 145

HCC. Other Ustalfs that have a natric horizon.

Natrustalfs, p. 141

HCD. Other Ustalfs that either have a petrocalcic horizon that has its upper boundary within 1.5 m of the surface or have an argillic horizon that meets one or both of the following requirements:

1. Does not have a lithic or paralithic contact within 1.5 m of the surface; and
   a. Has a clay distribution such that the percentage of clay does not decrease by as much as 20 percent of the maximum within a depth of 1.5 m from the soil surface, or the horizon in which the clay decreases either has >5 percent plinthite by volume or has skeletans or evidences of clay eluviation; and
   b. Has one or more of the following:
      (1) Hues redder than 10YR and chroma of more than 4 in the matrix of at least the lower part of the horizon;
      (2) Hues of 7.5YR or redder and value, moist, that is less than 4 and value, dry, that is less than 5 throughout the major part of the horizon; or
      (3) Common coarse mottles that have hue of 7.5YR or redder or chroma of more than 5; or
2. Does not have a lithic or paralithic contact within 50 cm of the surface and has an argillic horizon in which the upper part has a clayey particle-size class and there is an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm, or of at least 15 percent clay (absolute) within a vertical distance of 2.5 cm at the upper boundary.

Paleustalfs, p. 142

HCE. Other Ustalfs that have an argillic horizon that has throughout its thickness a hue redder than 5YR, a color value, moist, less than 4, and a color value, dry, no more than one unit higher than the value moist.

Rhodustalfs, p. 145

HCF. Other Ustalfs

Haplustalfs, p. 138

Durustalfs

Durustalfs are the Ustalfs that have a duripan whose upper boundary is within 1 m of the surface. They are not known to occur in the United States, and subgroups have not been developed. They are provided for use in other countries.

Haplustalfs

Haplustalfs (plate 2D) are the relatively thin, reddish to brownish but not dark red or dusky red Ustalfs that do not have a petrocalcic horizon within 1.5 m and that have a gradual or clear but not abrupt upper boundary of the argillic horizon, do not have a natric horizon, do not have a duripan that has its upper boundary within 1 m of the surface, and do not have much plinthite. These are the Ustalfs on relatively recent erosion surfaces or deposits, most of them late Pleistocene in age. Some have a monsoon climate. Others have two more or less marked dry seasons during the year.

The Haplustalfs were scattered among Chestnut, Reddish Brown, Reddish Chestnut, Reddish Prairie, and Red-Yellow Podzolic soils in the 1938 classification as modified before 1949.

Definition

Haplustalfs are Ustalfs that

1. Have an argillic horizon but do not have a natric horizon;
2. Do not have a duripan whose upper boundary is within 1 m of the surface;
3. Do not have a petrocalcic horizon whose upper boundary is within 1.5 m of the surface;
4. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix within any subhorizon of the argillic horizon within 1.25 m of the soil surface;
5. Have an argillic horizon that in some part has a color hue no redder than 5YR or a value, moist, of 4 or more or a value, dry, more than one unit higher than the value, moist; and
6. Have:
   a. Clay distribution such that the content of clay decreases from the maximum by 20 percent or more of that maximum within a depth of <1.5 m from the surface if
      (1) The hue is redder than 10YR and the chroma is more than 4 in the matrix of at least the lower part;
      (2) The hue is 7.5YR or redder and the value, moist, is less than 4 and the value, dry, is less than 5 throughout the major part; or
      (3) There are common coarse mottles that have hue of 7.5YR or redder or chroma greater than 5, or both; and
   b. A sandy or loamy particle-size class in the upper part of the argillic horizon, or an increase of <20 percent clay (absolute) within a vertical distance of 7.5 cm or of <15 percent within 2.5 cm at the upper boundary, or a lithic or paralithic contact within 50 cm of the soil surface.

Description of a Typic Haplustalf

A description of a soil that represents the central concept or typic subgroup of Haplustalfs follows. This soil, in Coconino County, Ariz., has a vegetation of scattered conifers and hardwood trees along with grass. It is being used for grazing. It is on a gently sloping fan. The sediments were derived from basalt, shale, sandstone, and quartzite. The mean annual air temperature is about 10° C, and the average annual precipitation is about 400 mm, most of it coming during the growing season. Colors are those of the dry soil unless otherwise stated.

A1 0–8 cm. Brown (7.5YR 5/4) cobbly light sandy clay loam, dark brown (7.5YR 3/4) moist; weak thick plates breaking to weak fine granules; soft, friable, slightly

plastic; few fine roots; many very fine irregular pores; mildly alkaline (pH 7.5); abrupt smooth boundary.

B1 8–25 cm. Reddish brown (5YR 4/4) clay loam, dark reddish brown (5YR 3/4) moist; weak medium subangular blocky structure; slightly hard, friable, sticky, plastic; common fine roots; common very fine irregular pores, few very fine tubular pores; few thin clay films in pores; moderately alkaline (pH 8.0); clear wavy boundary.

B21t 25–43 cm. Reddish brown (2.5YR 4/4) clay, dark red (2.5YR 3/6) moist; weak medium prisms breaking to moderate fine and medium subangular blocks; hard, firm, very sticky, very plastic; few fine roots; few very fine irregular pores; common moderately thick clay

to the surface or to the base of an Ap horizon if the soil is not irrigated;

(2) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness; and

i. When neither irrigated nor fallowed to store mois-

or loamy sand is not considered normal and defines arenic subgroups, a convention used elsewhere in the taxonomy. A shallow lithic contact defines the lithic subgroup, another convention used throughout the taxonomy. Clays that have low activity suggest strong weathering and are used to define the oxic subgroup. An argillic horizon that has a loamy fine sand or coarser texture or that is composed entirely of thin lamellae is not considered normal and is excluded from the typic subgroup. It defines the psammentic subgroup.

The absence of a calcic horizon or soft powdery lime or the presence of one of them at considerable depth, depending on the particle size, reflects a higher effective precipitation than is considered normal and defines the udic subgroup. A moderately low base saturation throughout the argillic horizon is considered abnormal and defines the ultic subgroup.

Deep wide cracks in most years and a high COLE are properties shared with Vertisols and define the vertic subgroup. A soil moisture regime that approaches the aridic regime or that is aridic is considered drier than normal and defines the aridic subgroups.

Typic Haplustalfs are not extensive in the United States. They are mainly used for grazing or for drought-tolerant crops.

Aquic Haplustalfs.—These soils are like Typic Haplustalfs except they have mottles of low chroma within

rizon or a horizon that contains soft powdery lime within the depths required for the typic subgroup.

Because the epipedon is sandy, it is rare that it is hard or very hard when dry. The soils of this subgroup, therefore, generally have an ustic moisture regime and not an aridic one. If the moisture regime is ustic, an aridic subgroup of soils that have a hyperthermic temperature regime indicates that the soils are intermittently moist and dry in the moisture control section during the months that the soil temperature, at a depth of 50 cm, is above 15° C, that is, the soils are rarely continuously moist for as long as 90 days. This subgroup probably is restricted to areas where the soils have an isomesic or a hyperthermic temperature regime. Arenic Aridic Haplustalfs are not extensive in the United States, even in the southern Great Plains.

Aridic Haplustalfs.—These soils are drier than Typic Haplustalfs. A calcic horizon or soft, powdery secondary lime may be present at any depth but is not required. These soils are intergrades between Haplargids and Haplustalfs. They are moderately extensive in the southern Great Plains of the United States. Slopes in general are gentle to moderate. Many of these soils are used for grazing and others are cultivated, mostly for drought-tolerant crops.

Lithic Haplustalfs.—These soils are like Typic Haplustalfs except they have a lithic contact within 50

depths of 75 cm that are caused by periods of wetness. The soils are on nearly level positions in the landscape and may or may not have calcic horizons or relatively low base saturation. They are locally important in the central part of the southern United States. They are farmed or used for grazing.

Aquic Arenic Haplustalfs.—These soils have mottles that have chroma of 2 or less within 75 cm of the surface and the mottled horizon is saturated with water at some time during the year or is artificially drained. In addition, the epipedon is between 50 cm and 1 m thick and has texture of loamy fine sand or coarser. The presence or absence of a calcic horizon or of relatively low base saturation is not definitive of this subgroup. The soils are on gentle slopes and are of minor extent in the United States, mainly in the southern Great Plains.

Arenic Haplustalfs.—These soils are like Typic Hap-

cm of the soil surface. A calcic horizon or soft powdery lime may be present but is not required. They are rare in the United States. Their slopes are moderate to strong. Most of the soils are used for grazing.

Oxic Haplustalfs.—These soils are like Typic Haplustalfs except they have a cation-exchange capacity (by NH_4OAc) of <24 meq per 100 g clay or a cation retention from NH_4Cl of <12 meq per 100 g clay. They are also permitted but not required to have base saturation (by sum of cations) that is <75 percent in all parts of the argillic horizon and to have a calcic horizon or soft, powdery secondary lime at any depth. These soils usually have a gradual upper boundary of the argillic horizon. They are intergrades between Halplustalfs and Ustox. They are not known to occur on the United States mainland or in Puerto Rico, but the subgroup is provided for use in other countries.

Psammentic Haplustalfs.—These soils have an argil-

Udic Haplustalfs.—These soils are like Typic Haplustalfs except they do not have a calcic horizon or soft, powdery secondary lime within the following depth of the soil surface: 1.25 m if the weighted average particle-size class of the upper 50 cm of the argillic horizon or of the whole argillic horizon, if it is thinner than 50 cm, is sandy; or 90 cm if the particle-size class of the same part of the argillic horizon is loamy; or 90 cm if it is clayey. These soils are intergrades between Hapludalfs and Haplustalfs. They are extensive locally on the Great Plains in the United States. Their slopes range from gentle to strong. Where slopes are suitable, most of these soils are farmed.

Ultic Haplustalfs.—Soils in this subgroup (plate 2D) are like Typic Haplustalfs except they have base saturation (by sum of cations) that is <75 percent in all parts of the argillic horizon. Most of them do not have a calcic horizon or soft, powdery secondary lime in any horizon, but the presence of secondary lime is not prohibited. These soils are intergrades between Haplu-

between a depth of about 1 m and 1.5 m below the surface. Colors are for the dry soil unless otherwise indicated.

A2 0–20 cm. Light brownish gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; moderate medium platy structure; slightly hard, friable, slightly sticky, slightly plastic; many fine roots, and a distinct root mat between the lower boundary of the A2 horizon and the top of the B2t horizon; common fine and medium vesicular pores; moderately alkaline (pH 8.3); abrupt smooth boundary.

B2t 20–36 cm. Light brown (7.5YR 6/4) clay loam, brown (7.5YR 5/4) moist; strong medium columns breaking to strong medium subangular blocks; very hard, very firm, sticky, very plastic; few fine roots in cleavage planes; common medium pores; faint grayish caps on the tops of the columns; moderately thick continuous clay films on both vertical and horizontal ped faces; faces of peds noncalcareous, interiors of peds strongly calcareous; very strongly alkaline (pH 9.3); clear wavy boundary.

B3ca 36–48 cm. Light brown (7.5YR 6/4) fine sandy clay loam, brown (7.5YR 5/4) moist; moderate medium subangular blocky structure; very hard, firm, slightly sticky, plastic; few fine roots; common fine pores; strongly calcareous, very strongly alkaline (pH 9.7); clear smooth boundary.

and there is no salic horizon within 75 cm and no petrocalcic horizon within 1.5 m of the surface.

Shallow mottles of low chroma and ground water in the mottled horizon at a time when the temperature of the horizon is 5° C or higher cause a soil to be excluded from the typic subgroup because those properties are shared with Aqualfs. Soils that have a shallow salic horizon are excluded because such a horizon is shared with Salorthids. A petrocalcic horizon is considered abnormal and the basis of defining the petrocalcic subgroup.

Typic Natrustalfs in the United States are most

vated included a mixture of grasses and woody plants. These soils are moderately extensive on the southern Great Plains in the United States, and they probably are extensive in Africa and southern Asia.

The Paleustalfs were scattered among Reddish Brown, Reddish Chestnut, Reddish Prairie and Red-Yellow Podzolic soils in the 1938 classification as modified before 1949.

Definition

Paleustalfs are the Ustalfs that

1. Do not have a duripan within 1 m of the soil sur-

is saturated with water at some time of the year when the temperature of the horizon is 5° C or higher;

b. Have texture finer than loamy fine sand in some subhorizon within 50 cm of the soil surface;

c. Have <5 percent plinthite by volume in all subhorizons within 1.5 m of the soil surface;

d. Have a calcic horizon or soft, powdery secondary lime within a depth of 1.25 m if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy, within a depth of 90 cm if the argillic horizon is loamy, and within a depth of 70 cm if it is clayey;

e. Have an argillic horizon that has base saturation (by sum of cations) of 75 percent or more in some part;

f. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon if the soil is not irrigated;

(2) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness;

g. Do not have a petrocalcic horizon that has its upper boundary within 1.5 m of the soil surface;

h. When not irrigated and when not fallowed to store moisture:

(1) If the soil temperature regime is mesic or thermic, are dry less than six-tenths of the time in half or more years in some part of the moisture control section (not necessarily the same part) during a period when the soil temperature at a depth of 50 cm exceeds 5° C; or

(2) If the soil temperature regime is hyperthermic, isomesic, or warmer, are moist in most years in some or all parts of the moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth of 50 cm exceeds 8° C;

i. Have CEC of 24 or more meq per 100 g clay (by NH_4OAc) and have cation retention from NH_4Cl of 12 or more meq per 100 g clay in the major part of the argillic horizon;

j. Have an argillic horizon that has a color hue of 5YR or yellower in some part, or has a value, moist, of 4 or more in some part, or has a value, dry, that is more than one unit higher than the value, moist; and

k. Have an argillic horizon that is continuous horizontally, that is continuous vertically for at least the upper 20 cm, and that has a texture finer than loamy fine sand.

Aquic Paleustalfs are like Typic Paleustalfs except for *a*, with or without *d* or *e*, or both.

Aquic Arenic Paleustalfs are like Typic Paleustalfs except for *a* and *b*, with or without *d* or *e*, or both, and they have a sandy epipedon (loamy fine sand or coarser) between 50 cm and 1 m thick.

Arenic Paleustalfs are like Typic Paleustalfs except for *b* or for *b* and *d*, and they have a sandy epipedon (loamy fine sand or coarser) between 50 cm and 1 m thick.

Arenic Aridic Paleustalfs are like Typic Paleustalfs except for *b* and *h*, with or without *d*, and they have a sandy epipedon (loamy fine sand or coarser) between 50 cm and 1 m thick.

Aridic Paleustalfs are like Typic Paleustalfs except for *h*, and either they are noncalcareous in some subhorizon above the calcic horizon or they do not have a calcic horizon whose upper boundary is within a depth of 1 m below the soil surface if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy, or 60 cm if it is loamy, or 50 cm if it is clayey.

Calciorthidic Paleustalfs are like Typic Paleustalfs except for *h*, and they have a calcic horizon within a depth of 1 m if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy, 60 cm if it is loamy, or 50 cm if it is clayey, and they have carbonates in all subhorizons above the calcic horizon.

Grossarenic Paleustalfs are like Typic Paleustalfs except for *b*, with or without *a* or *d*, or both, and they have a sandy epipedon (loamy fine sand or coarser) >1 m thick.

Oxic Paleustalfs are like Typic Paleustalfs except for *i*, with or without *d* or *e*, or both, ~~they have CEC <24 meq per 100 g clay~~, and they do not have an abrupt upper boundary of the argillic horizon.

Petrocalcic Paleustalfs are like Typic Paleustalfs except for *g*, with or without *h* or *j*, or both.

Psammentic Paleustalfs are like Typic Paleustalfs except for *k*, with or without some or all of *b*, *d*, or *e*.

Rhodic Paleustalfs are like Typic Paleustalfs except for *j*, with or without *d* or *e* or both, and the hue in the argillic horizon is redder than 5YR in all parts.

Udertic Paleustalfs are like Typic Paleustalfs except for *d* and *f*, with or without *a* or *h*, or both.

Udic Paleustalfs are like Typic Paleustalfs except for *d*.

Ultic Paleustalfs are like Typic Paleustalfs except for *e* and *d*, and they have either CEC <24 meq per 100 g clay or an abrupt upper boundary of the argillic horizon.

Description of subgroups

Typic Paleustalfs.—The central concept or typic subgroup of Paleustalfs is fixed on freely drained soils that have a thin or loamy epipedon; that have an argillic horizon that contains some 2:1 lattice clays, has a loamy or clayey particle-size class and high base saturation in at least some part, and is not composed entirely of thin lamellae; that do not have deep wide cracks in most years and do not have a high COLE; that have a calcic horizon or soft powdery lime at moderate depth; and that are moist for an appreciable part of the growing season.

Soils that have shallow mottles of low chroma and ground water in the mottled horizons during a grow-

ing season are excluded from Typic Paleustalfs because those properties are shared with Aqualfs. A thick sandy epipedon, a sand or loamy sand, is not considered normal, and defines arenic and grossarenic subgroups, a convention used elsewhere in the taxonomy. Soils that have an appreciable amount of plinthite are excluded because the presence of plinthite is a property of Plinthustalfs. The absence of a calcic horizon or of soft powdery lime, or the presence of one of them only at considerable depth, depending on particle size, reflects a higher effective precipitation than is considered normal and defines the udic subgroups. A moderately low base saturation throughout the argillic horizon is considered abnormal and defines the ultic subgroup.

Deep wide cracks in most years and a high COLE are properties shared with Vertisols and define intergrades to that order. A petrocalcic horizon causes a soil to be excluded from the typic subgroup even though one is very common in Paleustalfs, and its presence defines the petrocalcic subgroup. A shallow calcic horizon also causes soils to be excluded from the typic subgroup if there are carbonates in all horizons above the calcic horizon because those properties are shared with Calciorthids.

A soil moisture regime that approaches the aridic

Plains in the United States. Their slopes are gentle to moderate.

Arenic Paleustalfs.—These soils have an epipedon between 50 cm and 1 m thick that has texture of loamy fine sand or coarser throughout its thickness. A calcic horizon or a horizon that has soft powdery lime is not required, or it may be deeper than in Typic Paleustalfs. These soils are not extensive in the United States. Their slopes are mostly gentle to moderate. Some of the soils are cultivated, but most of them are used for grazing.

Arenic Aridic Paleustalfs.—These soils have an epipedon that is between 50 cm and 1 m thick and has texture of loamy fine sand or coarser throughout its thickness, and they are drier than Typic Paleustalfs. A calcic horizon or a horizon that has soft, powdery secondary lime is not required or may be deeper than in Typic Paleustalfs because the soils are so sandy. These soils are moderately extensive on the southern Great Plains in the United States. Their slopes are gentle. These soils are mainly used for grazing.

Aridic Paleustalfs.—Soils in this subgroup are like Typic Paleustalfs, except they are drier. In addition, they do not have a calcic horizon, or they are noncalcareous in some subhorizon above the calcic horizon, or, if calcareous throughout, the calcic horizon is

parts of the argillic horizon is permitted but is not required, and a calcic horizon or a horizon that contains soft, powdery secondary lime is not required or may be deep. These soils are intergrades between Paleustalfs and Ustox. They are rare in the United States but probably are moderately extensive in some other countries.

Petrocalcic Paleustalfs.—These soils have a petrocalcic horizon, most commonly at a depth about 75 cm below the surface, and in addition they are drier than Typic Paleustalfs. The upper part of their argillic horizon is noncalcareous. In the United States, they are extensive locally in the southern Great Plains. Some of them are cultivated, and cotton, sorghum, and wheat are the major crops. A few of these soils are irrigated.

cations) that is <75 percent in all subhorizons of the argillic horizon. Most of them do not have a calcic horizon or a horizon that contains soft, powdery secondary lime. These soils are intergrades between Paleudults or Paleustults and Paleustalfs. They are extensive locally in Texas and Oklahoma in the United States. Their slopes are gentle, and most of the soils are farmed.

Plinthustalfs

Plinthustalfs are the Ustalfs that have plinthite that forms a continuous phase or that constitutes more than half the matrix of some subhorizon of the argillic horizon within 1.25 m of the soil surface.

an ustic moisture regime and a thermic temperature regime. The colors are those of the dry soil unless otherwise specified.

A1 0–12.5 cm. Reddish brown (5YR 4/4) loam, dark reddish brown (5YR 3/4) moist; weak subangular blocky structure, weak platy structure in the upper 2.5 cm; hard, friable; contains a few fine (2-5 mm) subangular to angular indurated ironstone pebbles; mildly alkaline; clear boundary.

B2t 12.5–40 cm. Reddish brown (2.5YR 4/4) light clay, dark reddish brown (2.5YR 3/4) moist; moderate medium blocks when dry, breaking to very fine wedge-shaped blocks when moist; extremely hard, very firm; contains about 15 percent subangular to fine angular indurated ironstone pebbles; mildly alkaline; abrupt boundary.

R 40–45 cm. Hard limestone bedrock; slightly fractured.

Distinctions between Typic Rhodustalfs and other subgroups

Because these soils are rare in the United States, the classification that follows probably is incomplete, and it is provisional.

Typic Rhodustalfs are the Rhodustalfs that

a. Do not have a lithic contact within 50 cm of the soil surface;

b. Have CEC of 24 or more meq per 100 g clay (by NH_4OAc) and the cation retention from NH_4Cl is 12 or more meq per 100 g clay in the major part of the argillic horizon; and

c. Have a calcic horizon or soft, powdery secondary lime within a depth of 1.25 m from the surface if the weighted average particle-size class is sandy, 90 cm if it is loamy, and 70 cm if it is clayey.

Lithic Rhodustalfs are like Typic Rhodustalfs except for *a*, with or without *c*.

Oxic Rhodustalfs are like Typic Rhodustalfs except for *b*, with or without *c*.

Udic Rhodustalfs are like Typic Rhodustalfs except for *c*.

Description of subgroups

Typic Rhodustalfs.—The central concept or typic subgroup of Rhodustalfs is fixed on soils that are deep or moderately deep to hard rock, that have some 2:1 lattice clays, and that have a calcic horizon or soft powdery lime at a moderate depth.

A shallow lithic contact defines the lithic subgroup, a convention used throughout the taxonomy. Low activity in the clay fraction is thought to indicate stronger weathering than normal and is used to define the oxic subgroup. The absence of secondary carbonates at moderate depth is thought to be abnormal and defines the udic subgroup.

Typic Rhodustalfs are rare in the United States. Their slopes range from gentle to strong. Most of them are used for grazing.

Lithic Rhodustalfs.—Soils in this subgroup have a lithic contact within 50 cm of the soil surface. They may have a calcic horizon or a ca horizon that contains soft powdery lime. These soils are rare in the United States and are known to occur only in Hawaii. Their slopes are strong, and most of the soils are used for grazing.

Udic Rhodustalfs.—Soils in this subgroup either do not have a calcic horizon or other horizon that contains soft, powdery secondary lime, or if one of these horizons is present, it is deeper than in Typic Rhodustalfs. These soils are rare in the United States. Their slopes are moderate to strong, and most of the soils are used for grazing.

Xeralfs

Xeralfs (plates 5C and 10C) are mostly reddish Alfisols of regions that have a Mediterranean climate. Most have, as their name implies, a xeric moisture regime. They are dry for extended periods in summer, but in many of them moisture moves in winter through the soil to deeper layers in at least occasional years if not in most years. Small grains, grapes, and olives are common crops where there is no irrigation. With irrigation, a wide variety of crops can be grown.

The Xeralfs formed not only in the area around the Mediterranean Sea but also in parts of South Africa, Chile, California, Western Australia, and South Australia. Most border the Mediterranean Sea or lie to the east of an ocean in midlatitudes. Their temperature regimes are mostly thermic or mesic. A very few are frigid, bordering on mesic. In the world as a whole, the Xeralfs are not extensive soils, but in the regions where they occur, they are extensive. In the United States the vegetation before the soils were farmed was a mixture of annual grasses, forbs, and woody shrubs.

Some Xeralfs formed on erosion surfaces or in deposits of late-Wisconsinan age, but some, as in Australia, are on old surfaces and have characteristics that probably reflect an environment greatly different from the present one. Except for soils in one great group that form only from basic parent materials, it is common in Xeralfs that the boundary between the A and B horizons is very abrupt, and the epipedon is hard and massive when dry unless it has texture of loamy fine sand or coarser.

Definition

Xeralfs are the Alfisols that

1. Have either
   a. A xeric moisture regime; or
   b. An aridic moisture regime bordering on xeric and also have an epipedon that is both massive and hard or very hard when dry;
2. Have a mean annual soil temperature lower than

Key to great groups

HDA. Xeralfs that have a duripan whose upper boundary is within 1 m of the soil surface but below an argillic or a natric horizon.

Durixeralfs, p. 147

HDB. Other Xeralfs that have plinthite that forms a continuous phase in or constitutes more than half the matrix of some sub-horizon of the argillic horizon within 1.25 m of the soil surface

Definition

Durixeralfs are the Xeralfs that

1. Have a duripan whose upper boundary is within 1 m of the soil surface but below an argillic or a natric horizon; and
2. Do not have plinthite that forms a continuous phase or that constitutes more than half the matrix in

5C) are like Typic Durixeralfs except the argillic horizon has a clayey or clayey-skeletal particle-size class in some subhorizon, and at the upper boundary of the argillic horizon there is a marked increase in clay. These soils are moderately extensive in California. Many of them give the impression that the argillic horizon has formed since the duripan developed. Their slopes are gentle to moderate. Most of them are used for grazing or for producing small grains.

Abruptic Haplic Durixeralfs.—These soils have an argillic horizon that has a clayey or clayey-skeletal particle-size class in some subhorizon and, at the upper boundary of the argillic horizon, there is a marked increase in clay. In addition, the duripan does not have a continuous indurated subhorizon. It is not known whether the duripan is forming, is being destroyed, or is only weakly developed. These soils are not extensive except locally in California. Their slopes are gentle, but most of the soils are used for grazing.

Haplic Durixeralfs.—These soils are like Typic Durixeralfs except the duripan does not have a continuous indurated subhorizon. It is not known whether the duripan is forming, is being destroyed, or is only weakly developed. In the United States these soils are not extensive except locally in California. Their slopes are gentle to moderate. Some of the soils are irrigated for production of citrus, some produce small grains, and some are used for pasture.

Natric Durixeralfs.—Soils in this subgroup have a natric horizon. The duripan may or may not be indurated and there may be mottles of low chroma in the natric horizon, which in some years may be saturated or may have ground water perched above it. In the United States, these soils are extensive only in the Central Valley of California. Commonly they are saline. After reclamation, they may be used for cultivated crops. Otherwise, they provide only limited grazing unless irrigated.

Haploxeralfs

These are the relatively thin, reddish to brownish but not dark red or dusky red Xeralfs that have a clear or gradual upper boundary to an argillic horizon or have a loamy particle-size class throughout the argillic horizon. They have little or no plinthite and do not have a duripan. They formed mostly in late-Pleistocene deposits or on erosional surfaces of that age. Their parent materials may be either acidic or basic, but are rarely as basic as limestone or basalt. Haploxeralfs were considered Noncalcic Brown soils in the 1938 classification. They are moderately extensive in the areas of occurrence of Xeralfs in California in the United States.

Definition

Haploxeralfs are the Xeralfs that

1. Have an argillic horizon but do not have a natric horizon or a clay distribution such that the content of clay decreases from the maximum by 20 percent or more of that maximum within a depth of <1.5 m from the soil surface if
   (1) The hue is redder than 10YR and the chroma is more than 4 in the matrix; or
   (2) There are common coarse mottles that have a hue of 7.5YR or redder or chroma greater than 5; and
   (3) There is <5 percent plinthite (by volume) in the horizon in which the percentage of clay decreases.

Pedon 12 illustrates the mollic subgroup of Haploxeralfs.

Distinctions between Typic Haploxeralfs and other subgroups

Typic Haploxeralfs are the Haploxeralfs that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizon is saturated with water at some time when the temperature of that horizon is 5° C or higher or there is artificial drainage;
b. Do not have a fragipan that has its upper boundary within 1 m of the soil surface;
c. Have an A1 horizon that throughout its upper 10 cm has a color value, moist, of 3.5 or more or has <0.7 percent organic carbon in some part, or have an Ap horizon that has a color value, moist, of 3.5 or more or contains <0.7 percent organic carbon;
d. Do not have a lithic contact within 50 cm of the soil surface;
e. Have exchangeable sodium that is <15 percent of the CEC (at pH 8.2) throughout the argillic horizon;
f. Have <5 percent plinthite (by volume) in all subhorizons within 1.5 m of the soil surface;
g. Have an argillic horizon that has base saturation (by sum of cations) of 75 percent or more throughout the upper 75 cm or to a lithic or paralithic contact, whichever is shallower;
h. Do not have the following combination of characteristics:

(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness;

i. Have an argillic horizon that is continuous vertically for at least the upper 20 cm that is not composed entirely of lamellae, and that has a texture finer than loamy fine sand;

j. Do not have a calcic horizon that has its upper boundary within the upper 1 m of soil; and

k. Have an argillic horizon that is continuous horizontally throughout the area of each pedon.

from Typic Haploxeralfs because this important property is shared with Natrixeralfs. Soils that contain plinthite are excluded because plinthite is a property of Plinthoxeralfs. Base saturation that is only moderately high is considered abnormal and defines the ultic subgroups. Soils that have deep wide cracks and a high COLE are excluded because those properties are shared with Vertisols. An argillic horizon composed entirely of thin lamellae is considered abnormal and defines the psammentic subgroup. A moderately shallow calcic horizon is also considered abnormal and defines the calcic subgroup. An argillic horizon that is discontinuous horizontally is thought to indicate weak development, and soils that contain one are excluded from the typic subgroup.

Typic Haploxeralfs are extensive in the central and

strong, and the soils are used for grazing or for forests.

Lithic Mollic Haploxeralfs.—These soils are like Typic Haploxeralfs except they have a lithic contact within 50 cm of the soil surface and, in addition, they have an A1 horizon that throughout its upper 10 cm has a color value, moist, less than 3.5 and has >0.7 percent organic carbon; rarely, they have an Ap horizon that has a color value, moist, less than 3.5 and has >0.7 percent organic carbon. These soils are rare in the United States. Their slopes are generally strong or very strong, and the soils are mainly used for grazing.

Lithic Ruptic-Xerochreptic Haploxeralfs.—Soils in

In addition, they are permitted but not required to have an A1 horizon that, throughout its upper 10 cm, has a color value, moist, less than 3.5 and has >0.7 percent organic carbon or to have an Ap horizon that has a color value, moist, less than 3.5 and has >0.7 percent organic carbon. These soils are moderately extensive in California and Oregon where the Xeralfs intergrade to Ultisols at increasing altitude and under increasing rainfall. Slopes of the Ultic Haploxeralfs range from gentle to very strong, but most are strong or very strong. Most of these soils are in forests and in places are grazed for short periods.

Vertic Haploxeralfs.—Soils in this subgroup have

Aquic Natrixeralfs.—These soils are like Typic Natrixeralfs except they have mottles that have chroma of 2 or less within 75 cm of the soil surface and they are saturated with water in the mottled horizon at some time of year. They are rare in the United States. Their slopes are mostly nearly level. These soils are used mostly for grazing.

Palexeralfs

Palexeralfs are the reddish, but not dark red or dusky red, Xeralfs that have a thick argillic horizon. Many of them have some plinthite in their lower horizons, but this is rare in the United States. These soils are in relatively stable landscape positions on gentle slopes, and their genesis began before the late Pleistocene. During the Pleistocene pluvial periods, carbonates appear to have been almost completely removed from the argillic horizon of these soils, but some of the soils appear to have been recalcified later.

These soils formed in acid or in moderately basic parent materials, but not in materials as basic as limestone or basalt. The vegetation on Palexeralfs in the United States before they were farmed was a mixture of annual grasses, forbs, and woody shrubs. These soils are not extensive in the United States, but they are moderately extensive in some parts of the world. Those in the United States were mostly considered Noncalcic Brown soils in the 1938 classfication. Almost all of them are in California.

Definition

Palexeralfs are the Xeralfs that

1. Have one or more of the following:
   a. A petrocalcic horizon that is in or below an argillic horizon but has its upper boundary within 1.5 m of the soil surface;
   b. A clay distribution such that the percentage of clay does not decrease from its maximum amount by as much as 20 percent of that maximum throughout a depth of 1.5 m from the soil surface, or the layer in which the clay decreases has either:
      (1) More than 5 percent plinthite by volume; or
      (2) Skeletans or other evidences of clay eluviation, and the soil does not have a lithic or paralithic contact within 1.5 m of the surface;
   c. One or both of the following in the lower part of the argillic horizon:
      (1) A hue redder than 10YR and chroma more than 4 in the matrix; or
      (2) Common coarse mottles that have a hue of 7.5YR or redder or chroma more than 5; or
   d. An argillic horizon that has a particle-size class that is clayey in the upper part and has an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm or of at least 15 percent clay (absolute) within 2.5 cm at the
2. Do not have a duripan whose upper boundary is within 1 m of the soil surface;
3. Do not have plinthite that forms a continuous phase or that constitutes more than half the matrix within any subhorizon of the argillic horizon within 1.25 m of the soil surface; and
4. Have an argillic horizon that in some part has a color hue of 5YR or yellower or that has either a value, moist, of 4 or more or a value, dry, more than one unit higher than value, moist.

Pedon 55 is an example of a Typic Palexeralf. Although there is a restriction on the presence of a lithic or paralithic contact only within 50 cm of the soil surface, it is very rare that either a lithic or paralithic contact occurs in these soils within a depth of 1.5 m.

Distinctions between Typic Palexeralfs and other subgroups

The list of subgroups is incomplete for the world. A few subgroups are defined that are not known to occur in the United States, but a number of others that have not yet been defined are known to exist.

Typic Palexeralfs are the Palexeralfs that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizon is saturated with water at some time of the year when its temperature is 5° C or higher or there is artificial drainage;
b. Do not have a calcic horizon within 1.5 m of the soil surface;
c. Have an A1 horizon that, throughout its upper 10 cm, has a color value, moist, of 3.5 or more or contains <0.7 percent organic carbon, or they have an Ap horizon that has a color value, moist, of 3.5 or more or contains <0.7 percent organic carbon;
d. Do not have a petrocalcic horizon whose upper boundary is within 1.5 m of the soil surface;
e. Have an argillic horizon that has at least 75 percent base saturation (by sum of cations) in some part;
f. Have an argillic horizon in which the upper part has a clayey particle-size class and there is an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm or of at least 15 percent clay (absolute) within 2.5 cm at the upper boundary;
g. Have <5 percent plinthite (by volume) in all subhorizons within 1.5 m of the soil surface;
h. Do not have the following combination of characteristics:
   (1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon if the soil is not irrigated; and
   (2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m, and
   (3) More than 35 percent clay in horizons that total >50 cm in thickness;

j. Have <15 percent saturation with sodium in all subhorizons within 1 m of the soil surface.

Aquic Palexeralfs are like Typic Palexeralfs except for *a* or for *a* and *c*.

Calcic Palexeralfs are like Typic Palexeralfs except for *b*.

Mollic Palexeralfs are like Typic Palexeralfs except for *c*.

Natric Palexeralfs are like Typic Palexeralfs except for *j*.

Petrocalcic Palexeralfs are like Typic Palexeralfs except for *d*, or for *d* and *f*.

Ultic Palexeralfs are like Typic Palexeralfs except for *e*, with or without *f* or *c*, or both.

Vertic Palexeralfs are like Typic Palexeralfs except for *h*, with or without *a* or *c*, or both.

Description of subgroups

Typic Palexeralfs.—The central concept or typic subgroup of Palexeralfs is fixed on moderately deep or deep freely drained soils that do not have a shallow calcic horizon, that do not have a petrocalcic horizon, and that have an argillic horizon that has an abrupt upper boundary, a clayey particle-size class, and high base saturation. These soils also have little or no plinthite, and they do not have deep wide cracks in most years.

Soils that have mottles of low chroma and ground water at a moderate depth are excluded from the typic subgroup because these properties are shared with Aqualfs. Soils that have a calcic or a petrocalcic horizon are excluded because these horizons are interpreted to be evidences of recalcification of the soil. Soils that have a moderately thin A1 horizon or an Ap horizon that has the color and organic-matter content of a mollic epipedon are excluded because they approach the properties of Mollisols. Moderately low base saturation is associated with relatively high precipitation, either past or present, and is used to define the ultic subgroup. A clear or gradual upper boundary of the argillic horizon is considered abnormal in Palexeralfs, and a soil that has one is excluded from the typic subgroup. Plinthite is a property shared with Plinthoxeralfs, and a soil that contains plinthite is excluded from the typic subgroup unless the amount is very small. Deep wide cracks and a high COLE are properties shared with Vertisols and define the vertic subgroup. A thick sandy epipedon is considered abnormal and causes soils to be excluded from the typic subgroup, a convention that is used elsewhere in the taxonomy.

Typic Palexeralfs are moderately extensive soils on old terraces in the foothills of the mountains of California. Slopes are gentle to steep. The soils are used for grazing or for the production of small grains.

Aquic Palexeralfs.—These soils are like Typic Palexeralfs except they have mottles that have chroma of 2 or less in some subhorizon within 75 cm of the soil surface and they are saturated with water at some time of the year in the mottled horizon unless they have artificial drainage. In addition, they are permitted to have an A1 horizon that, throughout its upper 10 cm, has a color value, moist, of less than 3.5 and contains >0.7 percent organic carbon or to have an Ap horizon that has a color value, moist, of less than 3.5 and contains >0.7 percent organic carbon. Aquic Palexeralfs are rare in the United States. Their slopes are nearly level, but the soils are mostly used for grazing.

Calcic Palexeralfs.—Soils in this subgroup are like Typic Palexeralfs except they have a calcic horizon that has its upper boundary within 1.5 m of the soil surface. They are not known to occur in the United States, but the subgroup has been suggested for use in other countries.

Mollic Palexeralfs.—These soils are like Typic Palexeralfs except they have an A1 horizon that, throughout its upper 10 cm, has a color value, moist, of less than 3.5 and contains >0.7 percent organic carbon; or they have an Ap horizon that has a color value, moist, of less than 3.5 and contains >0.7 percent organic carbon. They are rare in the United States. They are intergrades between Palexeralfs and Palexerolls. Their slopes range from gentle to moderate. Where slopes are suitable, some of these soils are farmed. Many of them are used for grazing.

Natric Palexeralfs.—These soils have 15 percent or more saturation with sodium in some subhorizon of the argillic horizon that is within 1 m of the surface of the soil. These soils commonly have columnar or prismatic structure in the argillic horizon, but the horizon that contains sodium is too deep in the soil to be a natric horizon.

Petrocalcic Palexeralfs.—These soils are like Typic Palexeralfs except they have a petrocalcic horizon whose upper boundary is within 1.5 m of the soil surface. In addition, the argillic horizon is permitted but is not required to have <35 percent clay in all subhorizons, and there may be an increase in clay content of <20 percent (absolute) at the upper boundary within a vertical distance of 7.5 cm and an increase of <15 percent clay (absolute) within a vertical distance of 2.5 cm. These soils are not known to occur in the United States, but the subgroup has been suggested for use in other countries.

Ultic Palexeralfs.—These soils are like Typic Palexeralfs except they have base saturation that is <75 percent in all parts of the argillic horizon. In addition, the argillic horizon is permitted but is not required to have <35 percent clay in all subhorizons, and there may be an increase of <20 percent (absolute) in clay content at the upper boundary within a vertical distance of 7.5 cm and an increase of <15 percent clay (absolute) within a vertical distance of 2.5 cm. These soils are also permitted to have an A1 horizon that, throughout its upper 10 cm, has a color value, moist, of less than 3.5 and contains >0.7 percent organic carbon or to have an Ap horizon that has a color value, moist, of less than 3.5 and contains >0.7 percent organic carbon. Ultic Palexeralfs are rare in the United States. Their slopes are mostly gentle. The primary use of these soils is for grazing unless they are irrigated.

Vertic Palexeralfs.—These soils have deep wide cracks in most years. They are not known to occur in

the United States, but the subgroup has been suggested for other countries.

Plinthoxeralfs

Plinthoxeralfs are the Xeralfs that have plinthite that forms a continuous phase or that constitutes more than half the matrix of some subhorizon within 1.25 m of the soil surface. Few of these soils are in the United States, but the soils are moderately extensive in some parts of the world. Subgroups have not been developed. The Plinthoxeralfs were included with Ground-Water Laterite soils in the 1938 classification.

Rhodoxeralfs

Rhodoxeralfs (plate 10C) are the more or less dark red Xeralfs that form in limestone, basalt, and other highly basic parent materials. As a group, these soils are remarkably uniform in virtually all properties except depth to rock. A few that are receiving carbonates may have a calcic or a petrocalcic horizon below the argillic horizon. Rhodoxeralfs are rare in the United States. They were considered Terra Rossa in the 1938 classification.

Definition

Rhodoxeralfs are the Xeralfs that have an argillic horizon that, in all parts, has a color hue redder than 5YR and a value, moist, of less than 4 and a value, dry, no more than one unit higher than the value, moist, and that do not have a natric horizon or a duripan.

Pedon 13 illustrates the central concept or typic subgroup of Rhodoxeralfs.

Distinctions between Typic Rhodoxeralfs and other subgroups

The list of subgroups that follows is incomplete because the soils are of such limited extent in the United States.

Typic Rhodoxeralfs are the Rhodoxeralfs that

a. Have an argillic horizon that is >15 cm thick and is continuous in each pedon;

b. Do not have a lithic contact within 50 cm of the soil surface;

c. Do not have a petrocalcic horizon whose upper boundary is within 1.5 m of the soil surface; and

d. Do not have a calcic horizon whose upper boundary is within 1.5 m of the soil surface.

Calcic Rhodoxeralfs are like Typic Rhodoxeralfs except for *d*.

Lithic Rhodoxeralfs are like Typic Rhodoxeralfs except for *b*.

Petrocalcic Rhodoxeralfs are like Typic Rhodoxeralfs except for *c*.

Description of subgroups

Typic Rhodoxeralfs.—The central concept or typic subgroup of Rhodoxeralfs is fixed on soils that are moderately deep or deep to hard rock, that have an argillic horizon that is continuous throughout each pedon, and that do not have a calcic or petrocalcic horizon shallow enough to be diagnostic.

Soils in which an argillic horizon is discontinuous laterally are excluded from the typic subgroup because such a horizon represents weak development. A shallow lithic contact is used to define lithic subgroups, a convention used throughout the taxonomy. Soils that have a calcic or a petrocalcic horizon are excluded from this subgroup because these horizons are thought to indicate recalcification through addition of carbonates that originated outside of the soil.

In the United States, most of the Typic Rhodoxeralfs are moderately to strongly sloping and are in forests or are used for grazing. A few are irrigated and farmed.

Calcic Rhodoxeralfs.—These soils are like Typic Rhodoxeralfs except they have a calcic horizon whose upper boundary is within 1.5 m of the soil surface. They are not known to occur in the United States, but the subgroup is provided for other countries.

Lithic Rhodoxeralfs.—These soils are like Typic Rhodoxeralfs except they have a lithic contact within 50 cm of the soil surface throughout each pedon. The rock is most commonly limestone. They are not known to occur in the United States, but the subgroup is provided for other countries.

Petrocalcic Rhodoxeralfs.—Soils in this subgroup are like Typic Rhodoxeralfs except they have a petrocalcic horizon whose upper boundary is within 1.5 m of the soil surface. They are not known to occur in the United States, but the subgroup is provided for other countries.

[redacted]

zon, or duripan if the depth to any of these is <1 m;

(4) 70 cm if the weighted average particle-size class is clayey between a depth of 25 cm and 1 m or between a depth of 25 cm and a lithic or paralithic contact, petrocalcic horizon, or duripan if the depth to any of these is <1 m; and

3. Meet one or more of the following requirements:
   a. Have a cryic or frigid soil temperature regime;
   b. If there are cracks at least 1 cm wide at a depth of 50 cm for some period in most years, have, within a depth of 50 cm after the upper soil to a depth of 18 cm has been mixed, either a clay content of <30 percent in some subhorizon or, if the clay content is ≥30 percent, do not have:
      (1) Gilgai; and
      (2) Between a depth of 25 cm and 1 m, either slickensides close enough to intersect or wedge-shaped structural aggregates that have their long axes tilted 10° to 60° from the horizontal.

Another important property of Aridisols is a low percentage of organic carbon. In the definitions of subgroups that follow, the percentage of organic carbon as a function of the ratio of sand to clay is used in part to distinguish typic subgroups from intergrades to Mollisols. Figure 36 shows these limits in graphic form.

Limits between Aridisols and soils of other orders

The definition of Aridisols must provide criteria to separate Aridisols from all other orders. The aggregate of these criteria defines the limits of Aridisols in relation to all other known soils.

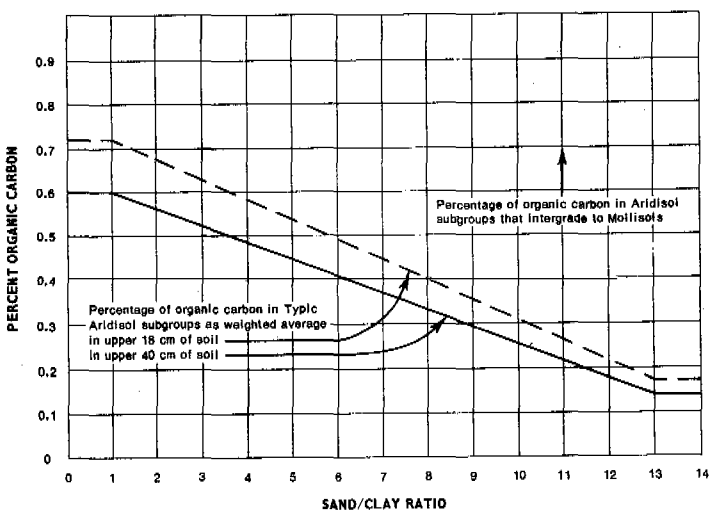


***Figure 36.*—Percentages of organic carbon as a function of the ratio of sand to clay that serve as limits between mollic subgroups of Aridisols and others.**

1. To distinguish Aridisols from Alfisols, Aridisols must either:
   a. Have no evidence of illuvial clay in the form of an argillic or natric horizon, or
   b. Have an aridic moisture regime and have an epipedon that is not both massive and hard or very hard when dry.
2. To distinguish Aridisols from Entisols, Aridisols must have one or more of the following:
   a. A cambic horizon;
   b. An argillic horizon;
   c. A salic horizon whose upper boundary is within 75 cm of the surface and ground water is within a depth of 1 m for 1 month or more in most years;
   d. A calcic or petrocalcic horizon whose upper boundary is within 1 m of the surface;
   e. A gypsic or petrogypsic horizon whose upper boundary is within 1 m of the surface;
   f. A duripan whose upper boundary is within 1 m of the surface.
3. To distinguish Aridisols from Inceptisols, if there is no argillic horizon but there is a cambic horizon, a calcic horizon, a petrocalcic horizon, or a duripan, Aridisols must have one of the following:
   a. An aridic moisture regime, or
   b. An ustic or xeric moisture regime and conductivity of the saturation extract that is 2 mmhos per centimeter or more at 25° C in some part of the soil above whichever of the following depths is least:
      (1) A lithic or paralithic contact, petrocalcic horizon, or duripan shallower than 25 cm;
      (2) 1.25 m if the weighted average particle-size class is sandy or sandy-skeletal between a depth of 25 cm and 1 m or between a depth of 25 cm and a lithic contact, paralithic contact, petrocalcic horizon, or duripan if any of these is at a depth <1 m;
      (3) 90 cm if the weighted average particle-size class is loamy between a depth of 25 cm and 1 m or between a depth of 25 cm and a lithic contact, paralithic contact, petrocalcic horizon, or duripan if any of these is at a depth <1 m.
      (4) 70 cm if the weighted average particle-size class is clayey between a depth of 25 cm and 1 m or between a depth of 25 cm and a lithic contact, paralithic contact, petrocalcic horizon, or duripan if any of these is at a depth <1 m;
4. To distinguish Aridisols from Histosols, Aridisols must meet the definition of mineral soils (ch. 3).
5. To distinguish Aridisols from Mollisols, Aridisols must not have a mollic epipedon.
6. To distinguish Aridisols from Oxisols, Aridisols must not have an oxic horizon above an argillic horizon.
7. To distinguish Aridisols from Spodosols, Aridisols must not have a spodic horizon.
8. To distinguish Aridisols from Ultisols, either there is no argillic horizon or, if there is an argillic horizon, Aridisols must have base saturation that is 35 percent

or more (by sum of cations) above the least of the following critical depths:

a. 1.25 m below the upper boundary of the argillic horizon;

b. 1.8 m below the soil surface;

c. Immediately above a lithic or paralithic contact.

9. To distinguish Aridisols from Vertisols, Aridisols must meet one or more of the following requirements:

b. Do not have cracks that open to the surface or

tional to Mollisols, are cultivated in some years. Argids are extensive soils in the western part of the United States. Plate 10D shows an Argid that has a petrocalcic horizon below the argillic horizon.

Definition

Argids are the Aridisols that have an argillic or a natric horizon.

FAA Argids that have a duripan[1] below an argillic horizon

days or more within 1 m of the surface in most years and do not have any of the following characteristics within 1 m of the soil surface if there is ground water within this depth at some time in most years:

(1) Dominant chroma of 1 or less throughout the horizons and hue as yellow or yellower than 2.5Y in some part;

(2) Dominant chroma of 2 or less and mottles that are not due to segregated lime;

(3) Both a dominant chroma of 2 or less and a greater SAR (or percentage of exchangeable sodium) in more than half the thickness of the horizons between the surface and 50 cm depth than in the saturated zone;

b. Have a platy or massive duripan that is indurated in some subhorizon;

c. Have a duripan at a depth <18 cm; or the weighted average percentage of organic carbon in the upper soil to a depth of 40 cm is <0.6 if the weighted average ratio of sand to clay in the upper soil to that depth is 1.0 or less, or is less than one-seventh percent if the ratio is 13 or more, or is intermediate between 0.6 percent and one-seventh percent if the ratio of sand to clay in the upper soil is >1.0 but <13; or the weighted average percentage of organic carbon in the upper soil to a depth of 18 cm is not as much as one-fifth more than the values just stated if a duripan is present at a depth <40 cm but >18 cm;

d. Do not have an argillic horizon that has 35 percent

differ by 5° C or more, and they have an aridic moisture regime that borders on a xeric regime.

Description of subgroups

Typic Durargids.—The central concept of the Durargids, the typic subgroup, is fixed on soils that have no evidences of current ground water, that have a strongly developed duripan, have little organic carbon or available moisture, and have only moderate contrast between the argillic horizon and the overlying epipedon. This concept does not represent the most common Durargids. Some of these features are common in Durargids, but others are relatively rare. The concept represents the driest part of the range of the Durargids. The soils that have more moisture also have greater productivity for plants and more biologic activity. The increased moisture may come from ground water, from flooding, or from precipitation. If the precipitation is effective, the soils that have more moisture not only should support more vegetation but also should have more organic carbon.

Abruptic Durargids.—Soils in this subgroup have an argillic horizon that in some part has 35 percent or more clay (in the fine-earth fraction) and that either has an increase of 15 percent or more clay (absolute) within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon or has an increase of 10 percent or more clay (absolute) if the soil has been cultivated and the lower boundary of the Ap horizon

soils have a mean annual soil temperature that is lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. The soils are not extensive in the United States. Their slopes are mostly gentle and the soils are used for grazing.

Xerollic Durargids.—Soils in this subgroup have more organic carbon than the soils of the typic subgroup but are otherwise like Typic Durargids in defined properties. The moisture regime is aridic but borders on xeric. The soils have a mean annual soil temperature that is lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. These Durargids receive most of their rain in winter.

Haplargids

These are the Argids that have an argillic horizon but do not have a duripan and do not have a natric or a petrocalcic horizon. Commonly, a calcic horizon lies below the argillic horizon. Generally, the soils are noncalcareous above the lower part of the argillic horizon, although some have been recharged with lime from calcareous dust or other sources. The Haplargids are mostly on late-Pleistocene erosion surfaces or sediments, and commonly they have gentle slopes. Most are in sediments that had only a little or no lime. They were mostly considered Desert soils, Red Desert soils, and Sierozems in the 1938 classification. Some were considered Reddish Brown soils.

Definition

Haplargids are the Argids that

1. Do not have a duripan within 1 m of the surface and do not have a natric horizon;
2. Have a lithic or paralithic contact within 50 cm of the surface or have an argillic horizon that has one or both of the following characteristics:
   a. Less than 35 percent clay in all subhorizons, or
   b. An increase of <15 percent clay (absolute) within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon or an increase of <10 percent clay (absolute) if cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon; and
3. Do not have a petrocalcic horizon whose upper boundary is within 1 m of the surface.

Pedon 57 represents the central concept or typic subgroup of Haplargids.

Distinctions between Typic Haplargids and other subgroups

Typic Haplargids are the Haplargids that

a. Are not saturated with water for 90 consecutive days or more within 1 m of the surface in most years and do not have any of the following characteristics within a depth of 1 m below the surface if there is ground water within this depth at some time in most years:
   (1) Dominant chroma of 1 or less throughout and a hue as yellow or yellower than 2.5Y in some part;
   (2) Dominant chroma of 2 or less and mottles that are not due to segregated lime; or
   (3) Both a dominant chroma of 2 or less and a greater SAR (or percentage of exchangeable Na) in more than half the thickness of the horizons between the surface and 50 cm depth than in the saturated zone;

b. Have texture finer than loamy fine sand in some subhorizon above a depth of 50 cm;

c. Do not have a horizon within 1 m of the surface that is >15 cm thick and that either contains 20 percent or more (by volume) durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

d. Do not have a lithic contact within 50 cm of the surface;

e. Have a weighted average percentage of organic carbon in the upper 40 cm that is <0.6 percent if the weighted average ratio of sand to clay in the soil above that depth is 1.0 or less, or is less than one-seventh percent if the ratio is 13 or more, or have an intermediate percentage of organic carbon if the ratio of sand to clay is between 1.0 and 13; or have a weighted average percentage of organic carbon in the soil to a depth of 18 cm that is not as much as one-fifth more than the values just stated if there is a lithic or paralithic contact at a depth <40 cm but >18 cm;

f. Have an argillic horizon that is continuous throughout the area of each pedon;

g. Do not have the following combination of characteristics:
   (1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface, to the base of an Ap horizon, or to the top of the argillic horizon;
   (2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and
   (3) More than 35 percent clay in horizons that total >50 cm in thickness; and

h. Are dry in all parts of the moisture control section more than three-fourths of the time (cumulative) that the soil temperature is 5° C or higher at a depth of 50 cm.

Aquic Haplargids are like Typic Haplargids except for *a*, with or without *e* or *h*, or both.

Arenic Haplargids are like Typic Haplargids except for *b*.

Arenic Ustalfic Haplargids are like Typic Haplargids except for *b* and *h*. They have a mean annual soil temperature of 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Arenic Ustollic Haplargids are like Typic Haplargids except for *b* and *e*, with or without *h*. They have a mean annual soil temperature of 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Borollic Haplargids are like Typic Haplargids except for *e*, with or without *h*. The mean annual soil temperature is lower than 8° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. Their aridic moisture regime borders on an ustic regime.

Borollic Lithic Haplargids are like Typic Haplargids except for *d* and *e*, with or without *h*. They have a frigid temperature regime and an aridic moisture regime that borders on an ustic regime.

Borollic Vertic Haplargids are like Typic Haplargids except for *e* and *g*, with or without *h*. The mean annual soil temperature is lower than 8° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. The cracks are not closed for as many as 60 consecutive days of the 120 days following the winter solstice in 3 or more years out of 10.

Duric Haplargids are like Typic Haplargids except for *c*.

Durixerollic Haplargids are like Typic Haplargids except for *c* and *e*, with or without *h*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. The aridic moisture regime borders on a xeric regime.

Lithic Haplargids are like Typic Haplargids except for *d*.

Lithic Ruptic-Entic Xerollic Haplargids are like Typic Haplargids except for *d*, *e*, and *f*, with or without *h*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. The aridic moisture regime borders on a xeric regime.

Lithic Ustollic Haplargids are like Typic Haplargids except for *d* and *e*, with or without *h*. They have a mean annual soil temperature of 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Lithic Xerollic Haplargids are like Typic Haplargids except for *d* and *e*, with or without *h*. They have a mean annual soil temperature that is lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Ustalfic Haplargids are like Typic Haplargids except for *h*. They have a mean annual soil temperature of 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Ustertic Haplargids are like Typic Haplargids except for *g*, with or without *e* or *h*, or both. They have cracks that remain open from 175 to 240 days, cumulative, in most years and that are not closed for as many as 60 consecutive days during the 120 days following the winter solstice in 3 or more years out of 10 if the soil temperature regime is thermic, mesic, or frigid. Other frigid soils are excluded.

Ustollic Haplargids are like Typic Haplargids except for *e*, with or without *h*. They have a mean annual soil temperature of 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Vertic Haplargids are like Typic Haplargids except for *g* or for *g* and *h* and have cracks that remain open for 8 months or more, cumulative, in most years.

Xeralfic Haplargids are like Typic Haplargids except for *h*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Xerertic Haplargids are like Typic Haplargids except for *g* or *e* and *g* and have a thermic, mesic, or frigid soil temperature regime, and they have cracks that close for 60 consecutive days or more during the 120 days following the winter solstice in more than 7 out of 10 years.

Xerollic Haplargids are like Typic Haplargids except for *e* with or without *h*, have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Description of subgroups

Typic Haplargids.—The central concept of Haplargids, the typic subgroup, is fixed on soils that do not have evidences of current ground water within a depth of 1 m, do not have appreciable cementation by silica, have little organic matter or available moisture, and have little evidence of soil movement. This concept reflects the driest part of the range of moisture content in Haplargids. Soils that receive more moisture have greater productivity for plants, more biologic activity, and more soil organic matter. The Typic Haplargids do not have a lithic contact within 50 cm of the surface. Many have a thin epipedon and argillic horizon and a ca horizon within 20 to 25 cm of the surface. The Typic Haplargids are extensive soils in the western states. Their slopes are mainly gentle. Most of them are used for grazing.

Aquic Haplargids.—Soils in this subgroup differ from Typic Haplargids in several respects. At some time of year in most years they are saturated with water for 90 consecutive days or more in some subhorizon within a depth of 1 m, or they are saturated for shorter periods and have some mottles in the saturated horizon. The soils are also permitted but are not required to have more organic matter than Typic Haplargids and to be moist in the moisture control section for longer periods. These are soils that, in some or most years, have shallow ground water that has low salt content, and they are partly moistened by capillary water from that source. They are not extensive soils in the United States. Their slopes are nearly level. Most of these soils are irrigated and cultivated.

Arenic Ustalfic Haplargids.—These soils have a thick sandy epipedon and a moisture regime that is marginal to an ustic regime. They formed in sandy sediments. Their slopes are gentle. Those in the United States are used mostly for grazing. They are not extensive soils but they occur locally in Texas and New Mexico.

Arenic Ustollic Haplargids.—These soils have an epipedon that is 50 cm or more thick and has texture of loamy fine sand or coarser throughout the upper 50 cm. They have more organic matter than soils of the typic subgroup. The moisture regime is marginal to an ustic regime. They formed in sandy sediments. These soils are nearly level. They are not extensive in the United States, and they are used mostly for grazing.

Borollic Haplargids.—Soils in this subgroup have more organic matter than Typic Haplargids, and their mean annual soil temperature is lower than 8° C. They are on the margins of arid regions where the soil temperature regime is frigid and the climate is continental rather than Mediterranean. They are moderately extensive soils on the northern Great Plains in the United States. Their slopes are gentle. Unless they are irrigated, most of them are used for grazing.

Borollic Lithic Haplargids.—Soils in this subgroup have a lithic contact within 50 cm of the surface but otherwise are like Borollic Haplargids. The soils are of moderate extent in high intermountain valleys adjacent to the Great Plains of the United States. Slopes range from gentle to strong. The soils are used mostly for grazing.

Borollic Vertic Haplargids.—These soils have a frigid temperature regime and organic matter content that is too high for the Typic Haplargids. In addition, they have fine texture and deep wide cracks when dry that close during periods of higher rainfall in the spring or summer months. These soils are moderately extensive in high intermountain valleys adjacent to the Great Plains of the United States. Slope gradients are low. Irrigated cropland or grazing is the principal use of these soils.

Duric Haplargids.—These soils have a subhorizon within 1 m of the surface that shows some cementation by silica but does not meet the requirements of a duripan. They are otherwise like Typic Haplargids. These soils are not extensive in the United States except in parts of Nevada and adjacent states. Their slopes are gentle, but the soils are used almost exclusively for grazing.

Durixerollic Haplargids.—These soils have a subhorizon within 1 m of the surface that shows some cementation by silica but does not meet the requirements of a duripan. They also have more organic matter than soils of the typic subgroup. Their moisture regime borders on xeric. These soils are not extensive in the United States. Their slopes are gentle, but the soils are used almost exclusively for grazing.

Lithic Haplargids.—These soils have a lithic contact within 50 cm of the surface but otherwise are like Typic Haplargids. They are not extensive in the United States. Their slopes range from gentle to very strong. These soils are used for grazing.

Lithic Ruptic-Entic Xerollic Haplargids.—Soils in this subgroup differ from Typic Haplargids in several respects. They have a lithic contact within 50 cm of the surface, and the argillic horizon is discontinuous in each pedon. In addition, they have more organic matter than the soils of the typic subgroup. Their moisture regime borders on xeric. These soils are not extensive in the United States. Their slopes are moderate to strong. They are used for spring or winter grazing.

Lithic Ustollic Haplargids.—These soils have a lithic contact within 50 cm of the surface and have more organic matter than Typic Haplargids. Their moisture regime is marginal to an ustic regime. They are not extensive in the United States. Their slopes are mostly gentle, and the soils are used for summer grazing.

Lithic Xerollic Haplargids.—These soils have a lithic contact within 50 cm of the surface, and they have more organic matter than the soils of the typic subgroup. Their moisture regime borders on xeric. Their slopes range from gentle to strong. These soils are not extensive in the United States. They are used for spring and winter grazing.

Ustalfic Haplargids.—These soils have a moisture regime that borders on ustic, but they are otherwise like Typic Haplargids. They are moderately extensive in parts of the southern Great Plains of the United States. Their slopes are gentle. Most of the soils are used for grazing, but where water is available they are irrigated and farmed. These soils were mostly considered Reddish Brown soils in the 1938 classification.

Ustertic Haplargids.—Except those in a frigid temperature regime, these soils have fine texture and deep wide cracks that close during periods of higher rainfall in the spring or summer months. Included are soils that have cracks that close in the winter months but have hyperthermic or iso temperature regimes. The soils may or may not contain more organic matter than those in the typic subgroup. They are moderately extensive locally in the extreme western Great Plains in the United States. Slope gradients are low. Unless the soils are irrigated, they are used mainly for grazing.

Ustollic Haplargids.—Soils in this subgroup have more organic matter than the soils of the typic subgroup. Their moisture regime is marginal to an ustic regime. They either have more summer precipitation than the typic soils or they receive additional moisture as runoff from higher soils. Most of them have an appreciable cover of perennial grasses. They are extensive soils in the United States, particularly in the Great Plains. Their slopes are mostly gentle. Some of these soils are irrigated, and the others are used mostly for summer grazing.

Vertic Haplargids.—These soils differ from Typic Haplargids by having deep wide cracks when dry. These soils may be dry in all parts of the moisture control section less than three-fourths of the time that the soil temperature is 5° C or higher at a depth of 50 cm. They are not extensive in the United States and occur mainly in the western Great Plains. They are used mostly for grazing but, where water is available, they are irrigated and farmed.

Xeralfic Haplargids.—These soils are like Typic Haplargids except they are moist in some part of the moisture control section one-fourth or more of the time (cumulative) that the soil temperature is 5° C or higher at a depth of 50 cm. Their moisture regime borders on xeric, that is, they receive winter rains. In the United States they are extensive only in California. Their slopes are mostly gentle. Some are irrigated and the others are used for winter or spring grazing.

Xerertic Haplargids.—These soils have fine texture, have deep wide cracks that close only in winter, and have a thermic, mesic, or frigid temperature regime. They are not extensive in the United States, even in the northwestern states. Some are irrigated, but most of them are used for winter or spring grazing.

Xerollic Haplargids.—These soils have more organic matter than Typic Haplargids, and their moisture regime borders on xeric. That is, the soils receive more precipitation than the soils of the typic subgroup or they receive additional water as runoff from higher soils. The precipitation comes mainly during the cool season. These soils are extensive in the northwestern states of the United States. Their slopes are mostly gentle. Some are irrigated, and the others are used mostly for winter or spring grazing.

Nadurargids

These are the Argids that have a natric horizon and an underlying duripan whose upper boundary is within 1 m of the surface. The most common depth to the pan is between 30 and 50 cm. In many places the duripan is partly cemented with lime, and the lime content of the pan may exceed 50 percent by weight. The soils commonly have gentle slopes and formed under low rainfall, generally in sediments containing pyroclastics. They are not extensive in the United States and are used mostly for grazing. They had no clear equivalent in the 1938 classification but were classified mostly as Desert and Red Desert soils.

Definition

Nadurargids are the Argids that have a natric horizon above a duripan and the upper boundary of the duripan is within 1 m of the soil surface.

Description of a Typic Nadurargid

A description of a soil that represents the central concept or typic subgroup of Nadurargids follows. This soil, in Eureka County, Nev., is on a gently sloping fan. The sediments have appreciable pyroclastic materials. The mean annual precipitation is about 150 mm, uniformly distributed throughout the seasons. The mean annual air temperature is about 9° C. The colors are those of the dry soil unless otherwise indicated.

A11 0–7.5 cm. Pale brown (10YR 6/3) very fine sandy loam, dark grayish brown (10YR 4/2) moist; massive; slightly hard (dry), very friable (moist), nonsticky and nonplastic (wet); abundant very fine and very few medium roots; many very fine and fine vesicular pores; moderately alkaline (pH 8.2); abrupt smooth boundary.

A12 7.5–18 cm. Similar to the horizon above except for moderate fine and medium platy structure; abundant fine, few medium and very few coarse roots; very few coarse and medium and very few fine and very fine tubular pores; abrupt smooth boundary.

IIB1t 18–25 cm. Light yellowish brown (10YR 6/4) clay loam, brown (10YR 4/3) moist; weak medium prisms breaking to moderate medium subangular blocks; very hard (dry), friable (moist), sticky and plastic (wet); abundant fine, few medium and very few coarse roots; few very coarse and fine tubular pores and very few medium and fine interstitial pores; common thin clay skins in pores and very few thin clay skins bridging sand grains; moderately alkaline (pH 8.4); clear wavy boundary.

IIB2t 25–32 cm. Brown (10YR 5/3) clay loam, brown (10YR 4/3) moist; weak fine prisms breaking to strong fine subangular blocks; very hard (dry), friable (moist), very sticky and very plastic (wet); common fine and few medium and very few coarse roots; very few medium and fine tubular and interstitial pores; many thin clay skins on ped faces and continuous thin clay skins in pores; mildly alkaline (pH 7.4); clear wavy boundary.

IIB3si 32–46 cm. Pale brown (10YR 6/3) fine sandy loam, brown (10YR 4/3) moist; moderate medium subangular blocky structure; very hard, brittle, slightly sticky, slightly plastic; few fine and very fine and very few coarse roots; few coarse and very few tubular and very few micro and fine interstitial pores; few thin clay skins bridging sand grains and common thin clay skins in pores; slightly effervescent in spots; mildly alkaline (pH 7.8); abrupt wavy boundary.

IIIC1sicam 46–66 cm. Light gray (10YR 7/2) dry, brown (10YR 5/3) moist; coats of opal, 2 to 3 mm thick, on cemented platelets form bands of very pale brown (10YR 7/3); massive; extremely hard (dry), extremely firm (moist), nonsticky and nonplastic (wet); very few fine roots; very few coarse tubular pores; violently effervescent; strongly alkaline (pH 8.8); clear wavy boundary.

IIIC2 66–100 cm. Light gray (10YR 7/2) gravelly sandy loam, grayish brown (10YR 5/2) moist; gravel lime coated; massive; soft (dry), very friable (moist), nonsticky and nonplastic (wet); very strongly alkaline (pH 9.6); very few fine roots; very few fine and very fine tubular pores and very few medium and fine interstitial pores.

Distinctions between Typic Nadurargids and other subgroups

Typic Nadurargids are the Nadurargids that

a. Are not saturated with water in any horizon within a depth of 1 m at any period or do not have either of the following characteristics within the horizon or horizons that are saturated:

(1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5Y in some part;

(2) Both a dominant chroma of 2 or less and mottles that are not due to segregated lime;

b. Have a platy or massive duripan that is indurated in some subhorizon; and

c. Have a duripan shallower than 18 cm; or have a weighted average percentage of organic carbon in the upper soil to a depth of 40 cm that is <0.6 if the weighted average ratio of sand to clay to that depth is 1.0 or less, or that is less than one-seventh percent if the ratio of sand to clay is 13 or more, or have an intermediate amount of organic carbon if the ratio of sand to clay is between 1.0 and 13; or have a weighted average percentage of organic carbon in the surface soil to a depth of 18 cm that is not one-fifth more than the values just stated if there is a duripan that is shallower than 40 cm but deeper than 18 cm.

Aquic Haplic Nadurargids are like Typic Nadurargids except for *a* and *b*, with or without *c*.

Haplic Nadurargids are like Typic Nadurargids except for *b*.

Haploxerollic Nadurargids are like Typic Nadurargids except for *b* and *c*. They have an aridic moisture regime that borders on a xeric regime.

Xerollic Nadurargids are like Typic Nadurargids except for *c*. They have a mean annual soil tempera-

ture lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Description of subgroups

Typic Nadurargids.—The central concept or typic subgroup of Nadurargids is fixed on soils that have a strongly cemented duripan and little organic matter or available moisture. These are some of the driest soils of the great group.

Soils that have more moisture because of ground water, flooding, or precipitation support somewhat more vegetation, tend to have more organic matter, and are considered intergrades to Mollisols. Soils in which the duripan is not indurated in any subhorizon are considered intergrades to Haplargids.

Typic Nadurargids are not extensive in the United States. They occur principally in Nevada and Arizona. Slopes are gentle. The soils are used mainly for grazing.

Aquic Haplic Nadurargids.—These soils are saturated with water in some subhorizon within 1 m of the surface at some time of year in some years or they have artificial drainage, and, in the saturated subhorizon, they have either low chroma or mottles, or both. In addition, the duripan in these soils is not platy and indurated but is massive and is very firm or extremely firm when moist and brittle when wet. The duripan also has some opal on vertical faces or some durinodes or silica pendants on coarse fragments. The percentage of organic carbon is permitted but is not required to be higher than in soils of the typic subgroup.

Haplic Nadurargids.—Soils in this subgroup are like Typic Nadurargids except the duripan is not platy and indurated but is massive and is very firm or extremely firm when moist and brittle when wet. The duripan in these soils also has some opal on vertical faces or some durinodes or silica pendants on coarse fragments.

Haploxerollic Nadurargids.—These soils are like Typic Nadurargids except the duripan is not platy and indurated but is massive and is very firm or extremely firm when moist and brittle when wet. The duripan in these soils has some coatings of opal or other forms of silica on coarse fragments or some durinodes. These soils have more organic matter than the soils of the typic subgroup and have a moisture regime that is marginal to a xeric regime. They are rare in the United States.

Xerollic Nadurargids.—These soils have more organic matter than Typic Nadurargids, and the soils have a moisture regime that is marginal to xeric. That is, they have a winter maximum of precipitation and a thermic, mesic, or frigid soil temperature regime.

Natrargids

These are the Argids that have a natric horizon but do not have a duripan or a petrocalcic horizon whose upper boundary is within 1 m of the surface. Normally the natric horizon has columnar or prismatic structure and its upper boundary lies within a few centimeters of the surface. Carbonates commonly are present throughout the soil, and soluble salts or carbonates, or both, may have accumulated below the natric horizon. Some Natrargids have a salic, gypsic, or calcic horizon. Many of these soils developed in sediments of late-Pleistocene age, in playas, or on the margins of present or Pleistocene lakes. Most of them are nearly level, and the texture of soils in the group as a whole tends to be fine where they are associated with other Aridisols. On the margins of arid regions, they are associated with the driest of the Mollisols. The slow permeability of the natric horizon and the common presence of soluble salts do not favor the development of a mollic epipedon. These soils are moderately extensive in parts of the western states and in the western part of the Great Plains. They were mostly considered Solonetz soils in the 1938 classification.

Definition

Natrargids are the Argids that

1. Have a natric horizon;
2. Do not have a petrocalcic horizon whose upper boundary is within 1 m of the soil surface;
3. Do not have a duripan whose upper boundary is within 1 m of the soil surface.

Pedon 58 represents the central concept or typic subgroup of Natrargids.

Distinctions between Typic Natrargids and other subgroups

Typic Natrargids are the Natrargids that

a. Either are not saturated with water in any horizon within 1 m of the surface at any time or do not have either of the following characteristics in the horizon or horizons that are saturated:

(1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5Y in some part; or

(2) Both a dominant chroma of 2 or less accompanied by mottles that are not due to segregated lime;

b. Do not have a horizon within 1 m of the surface that is more than 15 cm thick and that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

c. Do not have more than 10 percent of the ped surfaces deeper than 2.5 cm below the upper boundary of the natric horizon covered by skeletans;

d. Do not have a lithic contact within 50 cm of the soil surface;

e. Have a weighted average percentage of organic carbon in the upper soil to a depth of 40 cm that is <0.6 if the weighted average of sand to clay in that depth is 1.0 or less, or is not more than one-seventh percent if the ratio is 13 or more, or has an intermediate percentage of organic carbon if the ratio is between 1.0 and 13; or have a weighted average percentage of organic carbon in the surface soil to a depth of 18 cm that is not one-fifth more than the values just stated if there is a lithic or paralithic contact that is shallower than 40 cm but deeper than 18 cm; and

f. Have an SAR of ≥ 13 or have 15 percent or more saturation with sodium throughout the major part of the natric horizon.

Aquic Natrargids are like Typic Natrargids except for *a* or for *a* and *e*.

Borollic Natrargids are like Typic Natrargids except for *e* or for *e* and *f*. The mean annual soil temperature is lower than 8° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by ≥5° C, and the moisture regime is aridic bordering on ustic.

Borollic Glossic Natrargids are like Typic Natrargids except for *c* and *e*, with or without *f*. The mean annual soil temperature is lower than 8° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by ≥5° C, and the moisture regime is aridic bordering on ustic.

Duric Natrargids are like Typic Natrargids except for *b* or for *b* and *f*.

Durixerollic Natrargids are like Typic Natrargids except for *b* and *e*. They have a mean annual soil temperature lower than 22° C. The mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more, and the moisture regime is aridic bordering on xeric.

Glossic Ustollic Natrargids are like Typic Natrargids except for *c* and *e*, with or without *f*. They have a mean annual soil temperature of 8° C or higher and an aridic moisture regime that borders on ustic.

Haplic Natrargids are like Typic Natrargids except for *f*.

Haploxerollic Natrargids are like Typic Natrargids except for *e* and *f*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Haplustollic Natrargids are like Typic Natrargids except for *e* and *f*. They have a mean annual soil temperature of 8° C or higher, and the moisture regime is aridic but borders on ustic.

Lithic Natrargids are like Typic Natrargids except for *d*.

Lithic Xerollic Natrargids are like Typic Natrargids except for *d* and *e*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Ustollic Natrargids are like Typic Natrargids except for *e*. They have a mean annual soil temperature of 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Xerollic Natrargids are like Typic Natrargids except for *e*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. The moisture regime is aridic, bordering on xeric.

Description of subgroups

Typic Natrargids.—The central concept or typic subgroup of Natrargids is fixed on soils that have lit- of the natric horizon in the form of skeletans on the ped faces. This combination of characteristics is not necessarily the most extensive in the Natrargids. Rather, it describes a concept carried over from earlier classifications of an intermediate stage between the salty soils that do not have a natric horizon (Salorthids) and those in which salts and exchangeable sodium have been partially or largely removed. This was the concept of the Solonetz of arid regions.

If the SAR is <13 (or the sodium saturation is <15 percent) and there are no evidences of degradation of the natric horizon, the soil is considered an intergrade to the Haplargids. If a soil shows evidences of degradation in the form of skeletans on ped faces in a significant part of the natric horizon, it is considered a glossic extragrade. If the organic matter exceeds a low limit, the soil is considered an intergrade to Mollisols.

Typic Natrargids are widely scattered in the arid regions of the United States, but they are extensive only locally. A few are irrigated but most are used for grazing though they produce little forage.

Aquic Natrargids.—Soils in this subgroup are permitted but are not required to have more organic matter than Typic Natrargids. In addition, at some time of year in some years they are saturated with water in some subhorizon within 1 m of the surface or they have artificial drainage; in the saturated subhorizon they have either low chroma or mottles, or both. Very few of these soils are irrigated, and most are used for grazing though they produce little useful forage.

Borollic Natrargids.—These soils have more organic matter than the typic soils. They also have a mean annual soil temperature lower than 8° C, and they are intermittently moist in spring and summer. These soils are on margins of arid regions where the soil temperature regime is frigid and the climate is continental rather than Mediterranean. They also are permitted but are not required to have an SAR that is <13 (or <15 percent saturation with sodium) in all or most of the natric horizon. These soils are rare in the United States except in Montana. Many of them are cultivated because they occur as small spots in large fields. Pedon 23 is representative of this subgroup.

Borollic Glossic Natrargids.—Soils in this subgroup have more organic matter than the soils of the typic subgroup. They have a mean annual soil temperature lower than 8° C. These soils are on the margins of arid regions where the soil temperature regime is frigid and the climate is continental rather than Mediterranean. Tongues of an eluvial horizon, usually of albic materials, and skeletans cover >10 percent of the ped surfaces to a depth >2.5 cm below the upper boundary of the natric horizon. These soils are rare in the United States except in Montana. Many of them are cultivated because they occur as small spots in large fields.

Duric Natrargids.—These soils have a subhorizon

United States except in parts of Nevada. Their slopes are gentle, but most of them are used for grazing.

Durixerollic Natrargids.—These soils have a subhorizon within 1 m of the surface that does not meet the requirements of a duripan but that has some evidences of cementation by silica. In addition, they have more organic matter than the soils of the typic subgroup and their moisture regime borders on xeric. That is, the precipitation comes mainly in winter. These soils formed mostly in alluvium that contains some pyroclastic material. Their slopes are gentle, and the soils in the United States are used for winter or spring grazing. They are rare except in parts of Nevada.

Glossic Ustollic Natrargids.—These soils have more organic matter than the soils of the typic subgroup. In addition, their moisture regime is marginal to an ustic regime. That is, the precipitation comes mostly in summer or at a time when the soil is warm. They also have tongues of an eluvial horizon, usually albic materials, and skeletans cover >10 percent of the ped surfaces to a depth >2.5 cm below the upper boundary of the natric horizon; they are permitted but not required to have an SAR that is <13 (or <15 percent saturation with sodium) in all or most of the natric horizon. These soils are rare in the United States. Their slopes are gentle, and many are cultivated in association with other soils.

Haplic Natrargids.—These soils have an SAR of <13 (or <15 percent saturation with sodium) to a depth >1 or 2 cm below the upper boundary of the natric horizon. This depth may include the entire natric horizon. These soils do not have significant extent in the United States, but the subgroup is provided for use if needed.

Haploxerollic Natrargids.—These soils have an SAR of <13 (or <15 percent saturation with sodium) in the major part of the natric horizon or in all of it. In addition, they have more organic matter than the soils of the typic subgroup and their moisture regime borders on xeric. That is, the precipitation comes in winter. These soils are rare in the United States. Their slopes are gentle and most of them are used for winter or spring grazing.

Haplustollic Natrargids.—These soils have an SAR of <13 (or <15 percent saturation with sodium) in the major part of the natric horizon or in all of it. In addition, they have more organic matter than the soils of the typic subgroup and their moisture regime is marginal to an ustic regime. That is, the precipitation comes in spring and summer or during a warm season, and the soils receive more precipitation than the typic soils or receive additional water as runoff from higher soils. These soils are not extensive in the United States. Their slopes are gentle. A few are irrigated along with their adjacent soils, but most of these soils are used for summer grazing.

Lithic Natrargids.—Soils in this subgroup have a shallow lithic contact but otherwise are like the typic soils except that some are more strongly sloping. They are rare in the United States and are used almost exclusively for grazing.

Lithic Xerollic Natrargids.—These soils have a lithic contact within 50 cm of the soil surface. In addition, they have more organic matter than the soils of the typic subgroup and have a moisture regime bordering on xeric. That is, the precipitation comes in winter and is greater or more effective than that of the typic soils. These soils are rare, even in the intermountain states of the United States. Their slopes are mostly gentle. Most of them are used for winter or spring grazing.

Ustollic Natrargids.—These soils have more organic matter than Typic Natrargids and have a moisture regime bordering on ustic. That is, precipitation comes in spring or summer or during a warm season. Some receive extra moisture as runoff from higher soils. Slopes of these soils in the United States are mostly gentle. Many of the soils are cultivated because they occur as small spots in large fields of other more productive soils.

Xerollic Natrargids.—These soils have more organic matter than Typic Natrargids, and their moisture regime borders on xeric. That is, the precipitation comes in winter and is greater or more effective than that of the typic soils. These soils are moderately extensive in local areas in the intermountain states. Their slopes are gentle. Some of the soils are irrigated and cultivated along with adjacent more productive soils. Many are used for spring or winter grazing.

Paleargids

These are the reddish Argids (plate 10D) on stable land surfaces that either have a petrocalcic horizon below the argillic horizon or have an argillic horizon that has a clayey particle-size class and an abrupt or nearly abrupt upper boundary. Most formed in stable landscape positions from sediments rather than from residuum from parent rock. They are, for the most part, appreciably older than the latest Pleistocene. Some have been developing since mid or early Pleistocene or perhaps longer. Because of the Pleistocene pluvials, some of the petrocalcic horizons are complex and have evidences of successive periods of formation and solution. If calcareous dust has been present, some of these soils may have free carbonates in all horizons. In some, powdery lime coats peds that have noncalcareous interiors; in others a calcic horizon engulfs the lower part of an argillic horizon.

Slopes of these soils are gentle, and many of the soils are irrigated. The Paleargids were considered Red Desert soils and Calcisols for the most part in the 1938 classification as modified before 1960.

Definition

Paleargids are the Argids that

1. Have either a petrocalcic horizon whose upper boundary is within 1 m of the soil surface or an argillic horizon that has 35 percent or more clay in some part and that also has either
   a. An increase of 15 percent or more clay (absolute) within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon, or
   b. An increase of 10 percent or more clay (absolute) if the soil is cultivated and the lower boundary of the Ap horizon is the upper boundary of

the argillic horizon;
2. Do not have a duripan whose upper boundary is within 1 m of the soil surface;
3. Do not have a lithic or paralithic contact within 50 cm of the soil surface unless it underlies a petrocalcic horizon.

Pedon 59 illustrates the central concept. Plate 10D shows a Paleargid that has a petrocalcic horizon.

Distinctions between Typic Paleargids and other subgroups

Typic Paleargids are the Paleargids that
a. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;
b. Have a weighted average percentage of organic carbon in the upper soil to a depth of 40 cm of <0.6 percent if the weighted average ratio of sand to clay above this depth is 1.0 or less, or one-seventh percent if the ratio is 13 or more, or an intermediate percentage of organic carbon if the ratio of sand to clay is between 1.0 and 13; or a weighted average percentage of organic carbon in the surface soil to a depth of 18 cm that is not one-fifth more than the values just stated if there is a petrocalcic horizon whose upper boundary is shallower than 40 cm but deeper than 18 cm;
c. Do not have a petrocalcic horizon whose upper boundary is within 1 m of the soil surface;
d. Have either
(1) An increase of 15 percent or more clay (absolute) within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon, or
(2) An increase of 10 percent or more clay (absolute) if the soil is cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon;
e. Do not have the following combination of characteristics:
(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface, to the base of an Ap horizon, or to the top of the argillic horizon;
(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and
(3) More than 35 percent clay in horizons that total >50 cm in thickness; and
f. Are dry in all parts of the moisture control section more than three-fourths of the time (cumulative) that the soil temperature at a depth of 50 cm is 5° C or higher.

Borollic Paleargids are like Typic Paleargids except for *b* or for *b* and *f*. The mean annual soil temperature is lower than 8° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by ≥5° C. They have an aridic moisture regime that borders on an ustic regime.

Borollic Vertic Paleargids are like Typic Paleargids except for *b* and *e*, with or without *f*. The mean annual soil temperature is lower than 8° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by ≥5° C, and the cracks are not closed for as many as 60 consecutive days of the 120 days following the winter solstice in 3 or more years out of 10.

Petrocalcic Paleargids are like Typic Paleargids except for *c* or for *c* and *d*.

Petrocalcic Ustalfic Paleargids are like Typic Paleargids except for *c* and *f*, with or without *d*. They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Petrocalcic Ustollic Paleargids are like Typic Paleargids except for *b* and *c*, with or without *d* or *f*, or both. They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Petrocalcic Xerollic Paleargids are like Typic Paleargids except for *b* and *c*, with or without *d* or *f*, or both. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Ustollic Paleargids are like Typic Paleargids except for *b* or for *b* and *f*. They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Xeralfic Paleargids are like Typic Paleargids except for *f*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Xerollic Paleargids are like Typic Paleargids except for *b*, with or without *f*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Description of subgroups

Typic Paleargids.—The central concept or typic subgroup of Paleargids is fixed on soils that have an argillic horizon that has an abrupt upper boundary and that have little organic matter or available water, do not have a petrocalcic horizon, do not have distinct cementation by silica, and do not have deep wide cracks. The concept includes soils that have had appreciable clay illuviation in the argillic horizon, and the most common of these soils have an argillic horizon that has a clayey particle-size class and an abrupt upper boundary. The low amounts of organic matter and the low available moisture restrict the typic soils to those in the drier part of the range of the great group.

If the organic-matter content is relatively high, the soils are considered intergrades to Mollisols because they generally lie on a landscape between soils of the typic subgroup and Mollisols. Soils that have a petro-

calcic horizon are excluded from the typic subgroup, although they are very extensive, because they reflect a high carbonate content in the parent material, the addition of calcareous dust, or coarse texture, or all of these. A petrocalcic horizon is only an extreme development of a normal ca or calcic horizon. Silica cementation is virtually unknown in Paleargids.

Borollic Paleargids.—These soils have more organic matter than Typic Paleargids and also have a mean annual soil temperature lower than 8° C; their precipitation comes in spring and summer but not in winter. They are moderately extensive soils only in Montana in the United States. They are nearly level. Some are cultivated to produce spring wheat and are fallowed in alternate years to store moisture. Many are used for grazing.

Borollic Vertic Paleargids.—These soils have more organic matter than Typic Paleargids. They also have a mean annual soil temperature lower than 8° C, and their precipitation comes in spring and summer but not in winter. These soils are on the margins of arid regions where the soil temperature regime is frigid and the climate is continental rather than Mediterranean. In addition, they have a clayey particle-size class and deep wide cracks in summer and fall. These soils are not extensive, even in Montana. They formed in clayey alluvium on old high terraces or in residuum from mudstones. The soils in this subgroup are classified only provisionally as Aridisols because their epipedons tend to be both hard and massive when dry, but they

Petrocalcic Xerollic Paleargids.—These soils have a petrocalcic horizon that has its upper boundary within 1 m of the soil surface, they have more organic matter than Typic Paleargids, and they have a moisture regime that borders on xeric, that is, the precipitation comes in winter. In addition, the upper boundary of the argillic horizon is permitted to be clear or gradual. These soils are not known to occur in the United States but are thought to be extensive in some countries, particularly in northern Africa.

Ustollic Paleargids.—These soils have more organic matter than Typic Paleargids, and the moisture regime is marginal to an ustic regime, that is, the precipitation comes mostly in the growing season. Their slopes are mostly gentle. These soils are not extensive in the United States. They are used for summer grazing, and a few are irrigated.

Xeralfic Paleargids.—Soils in this subgroup are like Typic Paleargids except they have more moisture. Their moisture regime borders on xeric, that is, the precipitation comes mainly in winter when the soil is cold. The soils are rare in the United States. Most of them are used for winter or spring grazing.

Xerollic Paleargids.—These soils have more organic matter than Typic Paleargids, and their moisture regime borders on xeric. Precipitation comes in winter when the soils are cool or cold. Most of these soils in the United States are in the intermountain states, but they are not extensive. Their slopes are mostly gentle to moderate. The soils are used mostly for grazing.

or cambic horizon or a duripan (one or more); either have an aridic moisture regime or have a xeric or an ustic moisture regime and a conductivity of the saturation extract that is 2 mmho per centimeter or greater at 25° C in some part above whichever of the following depths is least: a lithic or paralithic contact, a depth of 1.25 m if the particle-size class is sandy from a depth of 25 cm to 1 m or to a lithic or paralithic contact, petrocalcic horizon, or duripan, whichever is shallower, a depth of 90 cm if the particle-size class is loamy, or 75 cm if it is clayey; or

3. Have a salic horizon within 75 cm of the soil surface and are saturated with water within 1 m of the surface for 1 month or more in most years or have artificial drainage.

Key to great groups

EBA. Orthids that have a salic horizon whose upper boundary is within 75 cm of the soil surface and are saturated with water within a depth of 1 m for 1 month or more in most years or have artificial drainage and lack a duripan that has an upper boundary within 1 m of the soil surface.

Salorthids, p. 177

EBB. Other Orthids that have a petrocalcic horizon whose upper boundary is within 1 m of the soil surface and is not overlain by a duripan.

Paleorthids, p. 176

EBC. Other Orthids that have a duripan whose upper boundary is within 1 m of the soil surface.

Durorthids, p. 174

EBD. Other Orthids that have a gypsic or petrogypsic horizon whose upper boundary is within 1 m of the soil surface.

Gypsiorthids, p. 175

EBE. Other Orthids that have a calcic horizon whose upper boundary is within 1 m of the surface and that are calcareous in all parts above the calcic horizon after the upper soil, to a depth of 18 cm, is mixed unless the texture is as coarse or coarser than loamy fine sand.

Calciorthids, p. 168

EBF. Other Orthids (that have a cambic horizon).

Camborthids, p. 170

Calciorthids

These are the Orthids (plate 6C) that have had much lime in the parent materials or added in dust. The scant rainfall is unable to remove the lime completely from the surface soil to a depth of 18 cm unless the texture is sandy. The only horizons normally present are the ochric epipedon and a calcic horizon whose upper boundary generally is at a depth <50 cm. A few have a cambic horizon. The soils commonly are nearly white. If the soils are irrigated and cultivated, nutrient deficiencies of trace elements are normal. These soils are extensive in the arid areas of western United States and in many other arid regions of the world. They were called Calcisols in the 1938 classification as modified prior to 1960.

Definition

Calciorthids are the Orthids that

1. Have a calcic horizon but do not have a gypsic or a petrogypsic horizon whose upper boundary is within 1 m of the soil surface;
2. Are calcareous in all parts above the calcic horizon after the upper soil to a depth of 18 cm has been mixed unless the texture is as coarse or coarser than loamy fine sand;
3. Do not have a duripan whose upper boundary is within 1 m of the soil surface;
4. Do not have a salic horizon above the calcic horizon; and
5. Do not have a petrocalcic horizon whose upper boundary is within 1 m of the soil surface.

Pedons 36 and 61 illustrate the central concept or typic subgroup of Calciorthids.

Distinctions between Typic Calciorthids and other subgroups

Typic Calciorthids are the Calciorthids that

a. Are not saturated with water for 90 consecutive days or more in most years within 1 m of the surface and do not have any of the following characteristics within a depth of 1 m below the surface if the soil above that depth is saturated with water at some period in most years or the soil is artificially drained:

(1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5Y in some part;

(2) Dominant chroma of 2 or less and mottles that are not due to segregated lime; or

(3) Both a dominant chroma of 2 or less and a greater SAR (or percentage of exchangeable Na) in more than half the thickness of the horizons between the surface and 50 cm than in the saturated zone;

b. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

c. Do not have a lithic contact within 50 cm of the surface;

d. Have a weighted average content of organic carbon in the upper soil to a depth of 40 cm that is <0.6 percent if the weighted average ratio of sand to noncarbonate clay for this depth is 1.0 or less, or is <0.15 percent if the ratio is 13 or more, or is intermediate if the ratio of sand to clay is between 1.0 and 13; or a weighted average percentage of organic carbon in the surface soil to a depth of 18 cm that is not one-fifth more than the values just stated if there is a lithic or paralithic contact that is shallower than 40 cm but deeper than 18 cm;

e. Are dry in all parts of the moisture control section more than three-fourths of the time (cumulative) that the soil temperature is 5° C or higher at a depth of 50 cm; and

f. Do not have reddish peds below the calcic horizon that are weakly calcareous or noncalcareous but that are thickly coated with lime.

Aquic Calciorthids are like Typic Calciorthids except for *a*, with or without *d* or *e*, or both.

Aquic Duric Calciorthids are like Typic Calciorthids except for *a* and *b*, with or without *d* or *e*, or both.

Argic Calciorthids are like Typic Calciorthids except for *f*.

Borollic Calciorthids are like Typic Calciorthids except for *d* or for *d* and *e*. The soil temperature regime

is frigid, and the moisture regime is aridic but borders on ustic.

Borollic Lithic Calciorthids are like Typic Calciorthids except for *c* and *d*, with or without *e*. The soil temperature regime is frigid, and the moisture regime is aridic but borders on ustic.

Durixerollic Calciorthids are like Typic Calciorthids except for *b* and *d*, with or without *e*, and have a mean annual soil temperature lower than 22° C. The mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more, and the moisture regime is aridic but borders on xeric.

Lithic Calciorthids are like Typic Calciorthids except for *c*.

Lithic Ustollic Calciorthids are like Typic Calciorthids except for *c* and *d*, with or without *e*. They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Lithic Xerollic Calciorthids are like Typic Calciorthids except for *c* and *d*, with or without *e*. They have a mean annual soil temperature lower than 22° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more, and they have an aridic moisture regime that borders on a xeric regime.

Ustochreptic Calciorthids are like Typic Calciorthids except for *e*. They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic moisture regime.

Ustollic Calciorthids are like Typic Calciorthids except for *d* or for *d* and *e*. They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Xerollic Calciorthids are like Typic Calciorthids except for *d* or for *d* and *e*. They have a mean annual soil temperature lower than 22° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more, and they have an aridic moisture regime that borders on a xeric regime.

Description of subgroups

Typic Calciorthids.—The central concept of the typic subgroup of Calciorthids is fixed on soils that show no effects of ground water within the upper 1 m, do not have appreciable cementation by silica, have little organic matter or available moisture, do not have shallow hard rock, and do not have evidence of engulfment of a former argillic horizon by the calcic horizon. Most pose another limit for this subgroup. These soils are extensive in the arid regions of the United States. Their slopes range from gentle to strong, and the soils either are irrigated or are used for grazing.

Aquic Calciorthids.—Soils in this subgroup differ from Typic Calciorthids in that they are permitted but are not required to have more organic matter and to be moist in some part of the moisture control section for one-fourth or more of the time (cumulative) that the soil temperature at a depth of 50 cm is 5° C or higher. In addition, they are saturated with water for 90 consecutive days or longer in most years in some subhorizon that is shallower than 1 m, or they are saturated for shorter periods and in addition they have in that subhorizon one or more of the following:

1. Dominant chroma of 1 or less and hue of 2.5Y or yellower;
2. Dominant chroma of 2 or less and mottles that are due to segregation of iron or manganese or both; or
3. Dominant chroma of 2 or less, and the subhorizon has a lower SAR (or percentage of saturation with sodium) than that in half the thickness of the overlying subhorizons that are in the upper 50 cm of the soil.

These are soils that, in some or most years, have shallow ground water that has low salt content and they are partially moistened by water that rises from the water table. It is thought that in many of them the calcic horizon has been formed by the rise of capillary water. They are not extensive soils in the United States. Their slopes are mainly level, and many of the soils are irrigated.

Aquic Duric Calciorthids.—These soils differ from Typic Calciorthids in that they are permitted but are not required to have more organic matter and to be moist in some part of the moisture control section for one-fourth or more of the time (cumulative) that the soil temperature at a depth of 50 cm is 5° C or higher. In addition, they are saturated with water for 90 consecutive days or more in most years in some subhorizon that is shallower than 1 m, or they are saturated for shorter periods, and in addition, in that subhorizon they have one or more of the following characteristics:

1. Dominant chroma of 1 or less and hue of 2.5Y or yellower;
2. Dominant chroma of 2 or less and mottles that are due to segregation of iron or maganese, or both; or
3. Dominant chroma of 2 or less, and the SAR or the

other bodies below the calcic horizon that are surrounded by carbonates but that have little or no carbonate in the ped interiors. These soils have been identified in the United States, but they have not yet been classified in series. They also have been reported in some parts of Africa near the Sahara Desert.

Borollic Calciorthids.—These soils have more organic matter than Typic Calciorthids. In addition, they have a mean annual soil temperature lower than 8° C, and their precipitation comes during the growing season. These soils are on the margins of arid regions where the soil temperature regime is frigid and the climate is continental rather than Mediterranean. States have moderate to very strong slopes and are used only for grazing, mostly in winter or spring. They occur only in the intermountain states and are rare there.

Ustochreptic Calciorthids.—Soils in this subgroup differ from Typic Calciorthids only in that they have more moisture and their precipitation comes during a warm season. Their moisture regime is marginal to an ustic regime. These soils in the United States have gentle to moderate slopes. They occur on the southern Great Plains, mostly in New Mexico and Texas, but they are not extensive. Most of them are used for summer grazing, but where water is available, they

the upper soil to a depth of 18 cm has been mixed, some subhorizon above the calcic horizon is free of carbonates and has texture as fine or finer than loamy very fine sand or very fine sand;
5. Do not have a petrocalcic horizon that has its upper boundary within 1 m of the surface; and
6. Do not have a gypsic or petrogypsic horizon that has an upper boundary within 1 m of the surface.

Pedons 31 and 62 illustrate the central concept or typic subgroup of Camborthids.

Distinctions between Typic Camborthids and other subgroups

Typic Camborthids are the Camborthids that
a. Are not saturated with water for 90 consecutive days or more within 1 m of the surface in most years and do not have any of the following characteristics within 1 m of the soil surface if the soil of that zone is saturated with water at some period in most years or the soil is artificially drained:
(1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5Y in some part,
(2) Dominant chroma of 2 or less and mottles that are due to segregation of iron or manganese, or
(3) Both a dominant chroma of 2 or less and a greater SAR (or percentage of exchangeable Na) in more than half the thickness of the horizons between the surface and a depth of 50 cm than in the saturated zone;
b. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;
c. Do not have a lithic contact within 50 cm of the surface;
d. Have a weighted average organic-carbon content in the upper soil to a depth of 40 cm that is <0.6 percent if the weighted average ratio of sand to noncarbonate clay to this depth is 1.0 or less, or is <0.15 percent if the ratio is 13 or more, or an intermediate weighted average percentage of organic carbon if the ratio is between 1.0 and 13; or a weighted average percentage of organic carbon in the upper soil to a depth of 18 cm that is not as much as one-fifth more than the values just stated if there is a lithic or paralithic contact shallower than 40 cm but deeper than 18 cm;
e. Are dry in all parts of the moisture control section for more than three-fourths of the time (cumulative) that the soil temperature is 5° C or more at a depth of 50 cm unless the soil is irrigated;
f. Do not have the following combination of characteristics:
(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon,
(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m, and
(3) More than 35 percent clay in horizons that total >50 cm in thickness;
g. Have a content of organic carbon that decreases regularly with depth below a depth of 25 cm and, unless a lithic or paralithic contact occurs at a shallower depth, reaches a level of <0.2 percent at a depth 1.25 m below the surface;
h. Have an SAR of 45 or less or <40 percent saturation with sodium throughout the cambic horizon if the saturated hydraulic conductivity is slow or very slow; and
i. Do not have an anthropic epipedon.

Anthropic Camborthids are like Typic Camborthids except for *d* and *i*.

Aquic Camborthids are like Typic Camborthids except for *a*, with or without *d* or *e*, or both.

Aquic Duric Camborthids are like Typic Camborthids except for *a* and *b*, with or without *d* or *e*, or both.

Borollic Camborthids are like Typic Camborthids except for *d* or for *d* and *e*. The mean annual soil temperature is lower than 8° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by ≥5° C, and the moisture regime is aridic bordering on an ustic regime.

Borollic Lithic Camborthids are like Typic Camborthids except for *c* and *d*, with or without *e*. The mean annual soil temperature is lower than 8° C, the mean summer and mean winter soil temperatures at a depth of 50 cm differ by ≥5° C, and the moisture regime is aridic bordering on ustic.

Borollic Vertic Camborthids are like Typic Camborthids except for *d* and *f*, with or without *e*. The mean annual soil temperature is lower than 8° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by ≥5° C. The cracks are not closed for as many as 60 consecutive days of the 120 days following the winter solstice in 3 or more years out of 10.

Duric Camborthids are like Typic Camborthids except for *b*.

Durixerollic Camborthids are like Typic Camborthids except for *b* and *d*, with or without *e*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Durixerollic Lithic Camborthids are like Typic Camborthids except for *b*, *c*, and *d*, with or without *e*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Fluventic Camborthids are like Typic Camborthids except for *g*.

Lithic Camborthids are like Typic Camborthids except for *c*.

Lithic Xerollic Camborthids are like Typic Camborthids except for *c* and *d*, with or without *e*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Natric Camborthids are like Typic Camborthids except for *h*, with or without any or all of *a*, *d*, *e*, *f*, and *g*, and they have slow or very slow saturated hydraulic conductivity.

Ustertic Camborthids are like Typic Camborthids

Soils that have more moisture have greater biologic activity and more organic matter and are considered intergrades to Mollisols. Weak silica cementation indicates a transition to Durorthids. Clayey texture and swelling clays indicate a transition to Vertisols.

Typic Camborthids are the driest but are not the most extensive subgroup of Camborthids in the United States. They are widely scattered over the drier parts of the southern Great Plains and the intermountain states. Their slopes range from gentle to very strong. Most of these soils are used for grazing, but where slopes are gentle and water is available, many of them

These soils are on the margins of arid regions where the soil temperature regime is frigid and the climate is continental. Their slopes are moderate or strong. They are not extensive soils in the United States, and they are used mostly for grazing.

Borollic Vertic Camborthids.—These soils have a clayey particle-size class, and they have deep wide cracks in most years. They also have more organic matter than Typic Camborthids, their mean annual soil temperature is lower than 8° C, and they are permitted but are not required to have more moisture than the typic soils. They are on the margins of arid regions where the soil temperature regime is frigid and the climate is continental rather than Mediterranean. These soils are rare in the United States.

Duric Camborthids.—These soils have a subhorizon within 1 m of the surface that has evidences of cementation by silica but does not meet the requirements of a duripan. They are considered an intergrade to Durorthids and are not common in the United States. Their slopes are mostly gentle. The soils are used mostly for grazing but they produce little forage.

Durixerollic Camborthids.—These soils have a subhorizon within 1 m of the surface that has evidences of cementation by silica but does not meet the requirements of a duripan. They also have more organic matter and may have more moisture than the soils of the typic subgroup. The moisture regime borders on xeric, that is, the precipitation comes during a cool or cold season. In the United States, these soils are moderately extensive only in Nevada and adjacent states. Their slopes are mostly gentle. Some are irrigated, but most are used for winter or spring grazing.

Durixerollic Lithic Camborthids.—Soils in this subgroup differ from Typic Camborthids in three ways:
(1) They have a lithic contact within 50 cm of the soil surface;
(2) They have a subhorizon within 50 cm of the surface that has evidences of cementation by silica but does not meet the requirements of a duripan; and
(3) They have more organic matter than Typic Camborthids and may be moist for longer periods in some part of the moisture control section. The moisture regime borders on xeric. That is, precipitation comes when the soil is cool or cold.

These soils are rare in the United States. Their slopes range from gentle to strong, and the soils are used almost exclusively for winter and spring grazing.

Fluventic Camborthids.—These soils have an organic-carbon content that decreases irregularly with depth or remains high in the deep layers. They are not extensive soils in the United States.

Lithic Camborthids.—These soils are like Typic Camborthids except they have a lithic contact within 50 cm of the soil surface. They are not extensive in the United States. Their slopes range from moderate to very strong. These soils furnish only a small amount of grazing.

Lithic Xerollic Camborthids.—Soils in this subgroup have a lithic contact within 50 cm of the soil surface, have more organic matter than Typic Camborthids, and may be moist in some part of the moisture control section for longer periods. The moisture regime borders on xeric, that is, precipitation comes when the soil is cool or cold. Slopes of these soils in the United States range from gentle to very strong. The soils are used almost exclusively for grazing.

Natric Camborthids.—These soils have slow or very slow hydraulic conductivity and high saturation with exchangeable sodium in the cambic horizon. They are not extensive in the United States.

Ustertic Camborthids.—These soils are permitted but are not required to have more organic matter than Typic Camborthids, and they have a clayey particle-size class. They have deep wide cracks that in most years are open less than 240 days, but the cracks are not closed for as many as 60 consecutive days during the 120 days following the winter solstice in 3 or more years out of 10 if the soil temperature regime is thermic, mesic, or frigid. The precipitation comes mostly when the soils are warm, not when they are cool or cold. These soils are not extensive in the United States. Their slopes are gentle, but they are used mostly for summer grazing.

Ustochreptic Camborthids.—These soils differ from Typic Camborthids in that the soil is moist in some part of the moisture control for longer periods. The moisture regime is marginal to an ustic regime, that is, the precipitation comes during a season when the soil is warm, not when it is cool or cold.

Ustollic Camborthids.—These soils have more organic matter than Typic Camborthids and may be moist in some part of the moisture control section for longer periods. The moisture regime is marginal to an ustic regime, that is, the soils receive water, either as precipitation or as runoff from higher soils, at a season when the soil is warm. Slopes of these soils in the United States are gentle, and if water is available, the soils are irrigated. A few that have a temperature regime near frigid are cultivated and are fallowed in alternate years to store moisture. Many are used for summer grazing. These soils are extensive in the drier parts of the Great Plains.

Vertic Camborthids.—These soils have a clayey particle-size class, and they have deep wide cracks that in most years remain open for more than 240 days, cumulative and in most years are not closed for as many as 60 consecutive days. These soils are rare in the United States. Their slopes are gentle. The soils are used mostly for grazing.

Xerertic Camborthids.—These soils have a clayey particle-size class, and they have deep wide cracks in summer and fall. Their moisture regime borders on xeric, that is, the precipitation comes during a season when the soil is cool or cold, and the cracks close during winter. These soils are rare in the United States. Most have a frigid soil temperature regime, which keeps them from being classified as Xererts. These soils are used mainly for winter and spring grazing.

Xerollic Camborthids.—These soils have more organic matter and are moist for longer periods than Typic Camborthids. Their moisture comes at a season when the soil is cool or cold. These soils are extensive in the intermountain states of the United States. Their slopes range from nearly level to strong. Where slopes are suitable, many of the soils are irrigated.

The others are used largely for winter and spring grazing.

Durorthids

These are the Orthids that have a duripan that has its upper boundary within 1 m of the soil surface. The common depth to the pan ranges from about 30 to 50 cm. The soils are generally gray to very pale brown, and many are calcareous throughout. They formed mostly on gentle slopes in late-Pleistocene or younger sediments that contain pyroclastics. The duripan is cemented partly with opal or chalcedony, and generally it is also partly cemented with lime. Most of these soils are used for grazing but are not productive. They are moderately extensive in a few of the western states, particularly in Nevada.

Definition

Durorthids are the Orthids that

1. Have a duripan that has its upper boundary within 1 m of the soil surface; they may have but are not required to have a cambic horizon; and
2. Do not have a petrocalcic horizon that overlies the duripan. Pedon 63 illustrates the central concept or typic subgroup of the Durorthids.

Distinctions between Typic Durorthids and other subgroups

Typic Durorthids are the Durorthids that

a. Are not saturated with water for 90 consecutive days or more in most years within 1 m of the surface and do not have a subhorizon within 1 m of the soil surface that has the following characteristics if the horizon is saturated with water at some period in most years or the soil is artificially drained:

(1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5Y in some part;

(2) Dominant chroma of 2 or less accompanied by mottles that are not due to segregated lime; or

(3) Both a dominant chroma of 2 or less and a greater SAR (or percentage of exchangeable sodium) in more than half the thickness of the horizons between the surface and 50 cm depth than in the saturated zone;

b. Have a platy or massive duripan that is indurated in some subhorizon;

c. Have a duripan whose upper boundary is shallower than 18 cm; or have a weighted average content of organic carbon in the upper soil to a depth of 40 cm that is <0.6 if the weighted average ratio of sand to non-

Aquentic Durorthids are like Typic Durorthids except for *a* and *b*, with or without *c* or *d*, or both.

Aquic Durorthids are like Typic Durorthids except for *a*, with or without *c* or *d*, or both.

Entic Durorthids are like Typic Durorthids except for *b*.

Haploxerollic Durorthids are like Typic Durorthids except for *b* and *c*, with or without *d*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Xerollic Durorthids are like Typic Durorthids except for *c* or for *c* and *d*. They have a mean annual soil temperature lower than 22° C, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more. They have an aridic moisture regime that borders on a xeric regime.

Description of subgroups

Typic Durorthids.—The central concept or typic subgroup of Durorthids is fixed on soils that have a shallow duripan that is indurated in at least some subhorizon and that have little organic matter or available water. Commonly, there are overlying horizons that meet the requirements for an ochric epipedon and a cambic horizon, but these are of much less genetic or practical significance than the duripan.

Soils that have higher than average precipitation or available moisture have greater productivity for plant growth, more organic matter, and a higher level of biologic activity. These soils that have more moisture are considered intergrades to Mollisols. But because this situation exists in the United States only in areas of winter rain, only Xerollic intergrades are now provided in the taxonomy. Elsewhere in the wor'd, ustollic subgroups probably exist. Typic Durorthids are extensive only locally in the United States. Their slopes are gentle or moderate. A few are irrigated, but most of them are used for grazing.

Aquentic Durorthids.—Soils in this subgroup differ from Typic Durorthids in several respects. At some time of year in most years they are saturated with water for 90 consecutive days or more in some subhorizon within a depth of 1 m below the surface, or they are saturated for shorter periods or have artificial drainage and in the saturated subhorizon they have low chroma. The duripan does not have a subhorizon that is indurated. It is massive, firm or very firm when moist, and brittle when wet, but it has some opal on vertical faces or some durinodes or silica por-

Aquic Durorthids.—These soils differ from Typic Durorthids in that at some time of year in most years they are saturated with water for 90 consecutive days or more in some subhorizon within a depth of 1 m below the surface, or they are saturated for shorter periods or have artificial drainage and in the satu-

The Gypsiorthids were recognized as a great group very recently, and the classification that follows must be considered provisional. Testing of the classification is impossible in the United States because the soils have such limited extent and variety. The great group is provided mainly for use in other countries.

rated subhorizon they have low chroma. In addition, the soils are permitted but are not required to have more organic matter and to be moist longer than soils of the typic subgroup. These are soils that in some or most years have shallow ground water and are partly moistened by capillary water from that source. Most of these soils in the United States are somewhat salty and sodic. They are nearly level but are used mostly for grazing and produce little forage.

Entic Durorthids.—These soils differ from Typic Durorthids in that the duripan does not have a subhorizon that is indurated. The duripan is massive, firm or very firm when moist, and brittle when wet, but it has some opal on vertical faces or some durinodes or silica pendants on coarse fragments. A few of these soils in the United States are irrigated, but most of them furnish only a small amount of grazing.

Haploxerollic Durorthids.—Soils in this subgroup

Definition

Gypsiorthids are the Orthids that have a gypsic or petrogypsic horizon that has its upper boundary within 1 m of the surface. Pedon 39 is an example of the central concept or typic subgroup of Gypsiorthids.

Distinctions between Typic Gypsiorthids and other subgroups

Typic Gypsiorthids are the Gypsiorthids that
a. Do not have a petrogypsic horizon whose upper boundary is within 1 m of the soil surface; and
b. Have a gypsic horizon in which the product of the percentage of gypsum and the thickness in centimeters above a depth of 1.5 m is 3,000 or more.

Calcic Gypsiorthids are like Typic Gypsiorthids except for *b* and have a calcic horizon above the gypsic horizon.

Petrogypsic Gypsiorthids.—These soils have a petrogypsic horizon. They have had extreme development of the gypsic horizon.

Paleorthids

These are Orthids that have a petrocalcic horizon. Ordinarily, the upper boundary of the petrocalcic horizon is close to the soil surface and is thick. Some of the soils have evidence that they formerly were Argids, but the former argillic horizon has been largely engulfed and cemented by carbonates and only a few reddish, noncemented remnants of the argillic horizon persist in or below the petrocalcic horizon. Other Paleorthids formed in parent materials rich in carbonates. Generally, these soils are on gentle slopes that have been stable for long periods, at least since the last glacial period, and a number of them probably are of mid-Pleistocene age or older. The petrocalcic horizons commonly have been shattered and recemented. Laminar horizons normally are thick, at least 10 to 20 cm or more. The soils generally are calcareous throughout, and the colors range from reddish brown to nearly white. They were called Calcisols in the 1938 classification as modified in 1957. They are moderately extensive in the southwestern states of the United States.

of 40 cm that is <0.6 percent if the weighted average ratio of sand to noncarbonate clay to this depth is 1.0 or less, or is <0.15 percent if the ratio is 13 or more, or is intermediate if the ratio of sand to clay is between 1.0 and 13; or have a weighted average percentage of organic carbon in the surface soil to a depth of 18 cm that is not one-fifth more than the values just stated if there is a petrocalcic horizon that is shallower than 40 cm but deeper than 18 cm; and

c. Are dry in all parts of the moisture control section for more than three-fourths of the time (cumulative) that the soil temperature is 5° C or higher at a depth of 50 cm.

Aquic Paleorthids are like Typic Paleorthids except for *a*, with or without *b* or *c*, or both.

Ustochreptic Paleorthids are like Typic Paleorthids except for *c*. They have a mesic, thermic, or hyperthermic soil temperature regime and an aridic moisture regime that borders on an ustic regime.

Ustollic Paleorthids are like Typic Paleorthids except for *b* or for *b* and *c*. They have a mean annual soil temperature that is 8° C or higher and an aridic moisture regime that borders on an ustic regime.

Xerollic Paleorthids are like Typic Paleorthids except for *b* or for *b* and *c*. They have a mean annual soil temperature lower than 22° C and the mean sum-

Ustochreptic Paleorthids.—These soils are moist in some part of the moisture control section for longer periods than Typic Paleorthids but otherwise are like the typic soils in most properties. They are rare in the United States. Their slopes are gentle, and the soils are used mostly for summer grazing.

Ustollic Paleorthids.—These soils have more organic matter than Typic Paleorthids and, in addition, the soil may be moist in some part of the moisture control section for longer periods than the typic soils. The moisture regime is marginal to an ustic regime, that is, the precipitation comes during a growing season. In these soils in the United States, the petrocalcic horizon is shallow, <50 cm below the surface. These soils are not extensive. Their slopes are gentle, but most of the soils are used for summer grazing.

Xerollic Paleorthids.—These soils have more organic matter than Typic Paleorthids and may be moist in some part of the moisture control section longer than the typic soils are. The moisture regime borders on xeric, that is, the precipitation comes during a season when the soil is cool or cold. Many of these soils have a

Definition

Salorthids are the Orthids that

1. Have a salic horizon within 75 cm of the soil surface and are saturated with water (i.e., within the capillary fringe) within 1 m of the surface for 1 month or more in some years or have artificial drainage;
2. Do not have a calcic or a gypsic horizon above the salic horizon; and
3. Do not have a duripan whose upper boundary is within 1 m of the surface.

Pedons 41 and 65 illustrate the central concept or typic subgroup of Salorthids.

Distinctions between Typic Salorthids and Aquollic Salorthids

Typic Salorthids are the Salorthids that

a. Have a salic horizon that has its upper boundary within 18 cm of the soil surface; and
b. Have a weighted average content of organic carbon in the upper soil to a depth of 40 cm that is <0.6 percent if the weighted average ratio of sand to noncarbonate clay to this depth is 1.0 or less, or is <0.15

their long axes tilted 10° to 60° from the horizontal; or

c. At any depth between 25 cm and 1 m, slickensides close enough to intersect.

Limits between Entisols and soils of other orders

The definition of Entisols must provide criteria to separate Entisols from all other orders. These criteria define the limits of Entisols in relation to all other known kinds of soil.

1. To distinguish Entisols from Alfisols, Entisols must not have an argillic horizon unless it is a buried soil horizon.
2. To distinguish Entisols from Aridisols, Entisols must not have
   a. A salic horizon if its upper boundary is within 75 cm of the surface and the soil is saturated with water within 1 m of the surface for 1 month or more at some time of year;
   b. A calcic or petrocalcic horizon, a gypsic or petrogypsic horizon, or a duripan, if the upper boundary of any of them is within 1 m of the surface, unless it is a buried horizon; or
   c. A cambic, argillic, or natric horizon unless it is a buried soil horizon.
3. To distinguish Entisols from Inceptisols, Entisols either
   a. Must have one of the following:
      (1) An n value of >0.7 and at least 8 percent clay in all subhorizons between a depth
4. To distinguish Entisols from Oxisols, Entisols must not have an oxic horizon and must not have plinthite that forms a continuous phase within 30 cm of the surface of the soil if the soil is saturated with water at some time of year within that depth.
7. To distinguish Entisols from Spodosols, Entisols must not have a spodic horizon that has its upper boundary within 2 m of the surface of the soil.
8. To distinguish Entisols from Ultisols, Entisols must not have an argillic horizon unless it is a buried soil horizon.
9. To distinguish Entisols from Vertisols, Entisols must have a frigid or colder temperature regime or must meet one or both of the following requirements:
   a. Must not have cracks that are as wide as 1 cm at a depth of 50 cm in most years; or
   b. Either
      (1) After the surface soil to a depth of 18 cm is mixed, have <30 percent clay in some subhorizon above a depth of 50 cm; or
      (2) Do not have gilgai, do not have slickensides close enough to intersect, and do not have wedge-shaped peds that have their long axes tilted 10° to 60° from the horizontal.

Key to suborders

JA. Entisols that
   1. Have sulfidic materials within 50 cm of the mineral soil surface; or
   2. Are permanently saturated with water and have in all horizons below 25 cm
      a. Dominant hue that is neutral or bluer than 10Y and
      b. Colors that change on exposure to the air; or

coarser in all subhorizons [1] either to a depth of 1 m or to a lithic, paralithic, or petroferric contact, whichever is shallower.

Psamments, p. 202

JD. Other Entisols that do not have a lithic or paralithic contact within 25 cm of the soil surface and that have slopes of <25 percent and organic-carbon content that decreases irregularly with depth or remains above a level of 0.2 percent to a depth of 1.25 m, and the mean annual soil temperature is higher than 0° C. (Strata of sand or loamy sand may have less organic carbon if finer sediments at a depth of 1.25 m or below have 0.2 percent organic carbon or more.)

Fluvents, p. 187

JE. Other Entisols.

Orthents, p. 194

Aquents

These are the wet Entisols. They may be in tidal marshes, in deltas on the margins of lakes where the soil is continuously saturated with water, in flood plains of streams where the soil is saturated at some time of year, or in wet, very sandy deposits. They are bluish or gray and mottled. They may have any temperature regime except pergelic. The moisture regime is aquic or peraquic, or there is artificial drainage. Most of them are in recent sediments, and they may have any vegetation that tolerates permanent or periodic wetness.

Key to great groups

JAA. Aquents that have sulfidic materials within 50 cm of the mineral soil surface.

Sulfaquents, p. 186

JAB. Other Aquents that have an *n* value of >0.7 and that have at least 8 percent clay in all subhorizons between a depth of 20 and 50 cm and that have a mean annual soil temperature higher than 0° C.

Hydraquents, p. 185

JAC. Other Aquents that have a cryic but not a pergelic [2] soil temperature regime.

Cryaquents, p. 181

JAD. Other Aquents that have an organic-carbon content [3] that decreases irregularly with depth or that remains above 0.2 percent to a depth of 1.25 m; and that have texture finer than loamy fine sand in some or all subhorizons between the Ap horizon or a depth of 25 cm, whichever is deeper, and 1 m or a lithic or paralithic contact, whichever is shallower. Thin strata of sand may have less organic carbon if the finer sediments at a depth of 1.25 m or below have 0.2 percent organic carbon or more.

Fluvaquents, p. 182

JAE. Other Aquents that have a difference of <5° C between the mean summer and mean winter soil temperatures at a depth of 50 cm.

Tropaquents, p. 187

JAF. Other Aquents that have a sandy particle-size class in all subhorizons between the Ap horizon or a depth of 25 cm, whichever is deeper, and 1 m or a lithic or paralithic contact, whichever is shallower, and that have mean summer and mean winter soil temperatures at a depth of 50 cm that differ by 5° C or more.

Psammaquents, p. 185

Haplaquents, p. 184

Aquents are the Entisols that (1) either have sulfidic materials within 50 cm of the mineral surface or are permanently saturated with water and have a dominant hue in all horizons below a depth of 25 cm that is neutral or bluer than 10Y and that changes on exposure to air; or (2) are saturated with water at some time of year or are artificially drained and have at some depth within 50 cm of the surface dominant colors (moist) in the matrix as follows:

a. In horizons that have texture finer than loamy fine sand

(1) If there is mottling, the chroma is 2 or less;

(2) If there is no mottling and the value is less than 4, the chroma is less than 1; if the value is 4 or more, the chroma is 1 or less;

b. In horizons that have texture of loamy fine sand or coarser

(1) If the hue is as red or redder than 10YR and there is mottling, the chroma is 2 or less; if there is no mottling and the value is <4, the chroma is less than 1, or if the value is 4 or more, the chroma is 1 or less;

(2) If the hue is between 10YR and 10Y and there is distinct or prominent mottling, the chroma is 3 or less; if there is no mottling, the chroma is 1 or less.

Cryaquents

These are the cold wet soils of high mountains or tundra without permafrost or of cold coastal marshes. They are wet, and they are gray to blue below a depth of a few centimeters. The Cryaquents on flood plains are gray and commonly are stratified. Those in coastal marshes commonly have green to blue hues. Because these soils are both cold and wet, they have low potential for farming and have been given low priority for study. The major areas of these soils in the United States are in the coastal marshes, outwash plains, and flood plains of Alaska. They are in recent sediments and are extensive in Alaska south of the permafrost zone. They were included in Humic Gley and Low-Humic Gley soils in the 1938 classification as modified in 1949.

Definition

Cryaquents are the Aquents that have a cryic but not a pergelic temperature regime and do not have sulfidic materials within 50 cm of the mineral soil surface or above the depth at which the soil is frozen about 2 months after the summer solstice.

[1] Lamellae that are <1 cm thick or that are too few to meet

[2] Soils that otherwise could be Aquents are grouped with Aquepts if there is permafrost.

[3] The carbon should be of Holocene age. It is not the intent

Description of a Typic Cryaquent

This soil had a cover of water-loving trees, mostly black spruce, with a ground cover of *Sphagnum* spp. and sedges. It lies on a broad outwash plain in southeastern Alaska. Colors are those of the moist soil.

O1 4–0 cm. Dark reddish brown (5YR 2/2) mat of organic materials; many roots; clear smooth boundary.

C1 0–13 cm. Dark gray (5Y 4/1) medium sand; many olive gray (5Y 4/2) sand grains; single grain; loose; mildly alkaline; few roots; water table at surface; gradual boundary.

C2g 13–45 cm. Dark gray (5Y 4/1) medium sand; few fine faint mottles of yellowish brown; single grain; loose; moderately alkaline; gradual boundary.

C3g 45–50 cm. Dark gray (5Y 4/1) layered medium sand and fine sand; few coarse prominent mottles of reddish brown; single grain; loose; moderately alkaline. Below 50 cm the soil is too wet to bring up with auger or spade, but no gravel or stones are present.

Distinctions between Typic Cryaquents and other subgroups

Typic Cryaquents are the Cryaquents that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density of the fine-earth fraction (at 1/3-bar moisture tension) of 0.95 g per cubic centimeter or less, and that has either

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or

(2) A ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum.

Andaqueptic Cryaquents are like Typic Cryaquents except for *a*.

Description of subgroups

Typic Cryaquents.—More variability in properties is permitted in this subgroup than in most typic subgroups because the soils are both cold and wet. There are no restrictions on particle size, organic carbon, and other properties that are used to distinguish taxa in many places in this taxonomy. It must be kept in mind that these soils have not been studied intensively and that changes in the subgroups may become necessary in the future. Most of the Typic Cryaquents are under their native vegetation, and an O horizon is normal but is not required.

Andaqueptic Cryaquents.—These soils have a layer in the upper 75 cm that is 18 cm or more thick and is rich in pyroclastics. The clays in this layer do not disperse well and have a high pH-dependent charge. These soils are rare in the United States and are known to occur only on wet flood plains in Alaska and in the high mountains of the northwestern states.

Fluvaquents

These are primarily the wet soils of flood plains and deltas of middle and low latitudes. Most of them have either fine or coarse stratifications that reflect deposition of sediments under changing currents and in shifting channels. The sediments are Holocene and [illegible] wet mineral soils. The materials have dried or have partially dried from time to time as they accumulated, and the *n* values are low. These soils are extensive along large rivers, particularly in humid areas. They were considered Alluvial soils or Low-Humic Gley soils in the 1938 classification as modified in 1949.

Definition

Fluvaquents are the Aquents that

1. Have a soil temperature regime warmer than cryic;
2. Have an *n* value of 0.7 or less or have <8 percent clay in some or all subhorizons between a depth of 20 and 50 cm;
3. Have textures finer than loamy fine sand in some or in all subhorizons below the Ap horizon or a depth of 25 cm, whichever is deeper, but above a depth of 1 m;
4. Have an organic-carbon content [4] that decreases irregularly with depth below 25 cm or that remains more than 0.2 percent to a depth of 1.25 m; thin strata of sand may have less organic carbon if the finer sediments at a depth of 1.25 m or below have 0.2 percent organic carbon or more; and
5. Do not have sulfidic materials within a depth of 50 cm below the mineral soil surface.

Description of a Typic Fluvaquent

A description follows of a Fluvaquent that represents the central concept or typic subgroup. This soil, on a flood plain in Alabama, floods frequently. The slope is nearly level, and some microrelief has been formed by scouring during floods. The vegetation is a forest of water-tolerant trees. Ground water is within 20 cm of the surface during 6 to 11 months in most years. Colors are those of the moist soil.

A11 0–10 cm. Brown (10YR 4/3) sandy loam; weak fine granular structure; friable (moist); strongly acid; abrupt wavy boundary.

A12g 10–30 cm. Mottled dark gray (N4/) and dark grayish brown (10YR 4/2) sandy loam; weak fine granular structure; friable (moist); fine strong brown stains around old roots; strongly acid; clear wavy boundary.

C1g 30–94 cm. Gray (5Y 5/1) sandy loam; structureless; loose; common medium strong brown (7.5YR 5/6) stains around old roots; common thin strata of silt loam and loamy sand; some strata have bits of partly decomposed forest residues; very strongly acid; clear wavy boundary.

C2g 94–150 cm. Gray (N5/) silt loam; structureless; slightly sticky (wet); common strata of sandy loam and loamy sand; common thin strata that have partly decomposed forest residues; strongly acid.

Distinctions between Typic Fluvaquents and other subgroups

Typic Fluvaquents are the Fluvaquents that

a. Have, in 60 percent or more of the matrix in all subhorizons between the Ap horizon or a depth of 25 cm, whichever is deeper, and a depth of 75 cm, one or more of the following:

(1) If mottled and

(a) If the hue is 2.5Y or redder [5] and the

[4] See footnote 3 on p. 181.

[5] If the hue of the matrix is 7.5YR or redder and if peds are present, ped exteriors have dominant chroma, moist, of 1 or less, and ped interiors have mottles that have chroma, moist, of 2 or less; if peds are absent, the chroma, moist, is 1 or less immedi-

value, moist, is more than 5, the chroma, moist, is 2 or less;

(b) If the hue is 2.5Y or redder and the value, moist, is 5 or less, the chroma, moist, is 1 or less; or

(c) If the hue is yellower than 2.5Y, the chroma, moist, is 2 or less; or

(2) The chroma, moist, is 1 or less and mottles may or may not be present;

b. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density in the fine-earth fraction (at 1/3-bar moisture tension) of 0.95 grams per cubic centimeter or less, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness;

d. Have an Ap horizon that has a color value, moist, of 4 or more or has a color value, dry, of 6 or more when crushed and smoothed, or the A1 horizon is <15 cm thick if its color value, moist, is <3.5;

e. Do not have a buried Histosol or a buried histic epipedon that has its upper boundary within 1 m of the soil surface;

f. Do not have sulfidic materials within 1 m of the mineral soil surface;

g. Have a difference of 5° C or more between the mean summer and mean winter soil temperatures at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower; and

h. Do not have a histic epipedon.

Aeric Fluvaquents are like Typic Fluvaquents except for *a* or *a* and *b*.

Aeric Tropic Fluvaquents are like Typic Fluvaquents except for *a* and *g*, with or without *d*.

Andaqueptic Fluvaquents are like Typic Fluvaquents except for *b*.

Histic Fluvaquents are like Typic Fluvaquents except for *h*, with or without all or any of *b*, *d*, and *e*.

Humaqueptic Fluvaquents are like Typic Fluvaquents except for *d*, and the base saturation (by NH_4OAc) is <50 percent in some horizon and does not increase to 50 percent or more within a depth of 1 m below the soil surface.

Mollic Fluvaquents are like Typic Fluvaquents except for *d*, and the base saturation (by NH_4OAc) is 50 percent or more throughout the soil or increases to 50 percent or more within a depth of 1 m below the soil surface.

Sulfic Fluvaquents are like Typic Fluvaquents except for *f*.

Thapto-Histic Fluvaquents are like Typic Fluvaquents except for *e* with or without *d*.

Thapto-Histic Tropic Fluvaquents are like Typic Fluvaquents except for *e* and *g*, with or without *d*.

Tropic Fluvaquents are like Typic Fluvaquents except for *g* or for *g* and *d*.

Vertic Fluvaquents are like Typic Fluvaquents except for *c*, with or without *a* or *d*, or both, and the cracks are not open permanently.

Description of subgroups

Typic Fluvaquents.—These are almost exclusively very young waterlaid deposits that are mostly in wet places on flood plains. They have fine stratifications at a shallow depth or they have too few evidences of alteration to have a cambic horizon. Mottling in them extends downward from a point very close to the surface, and the water table is at or close to the surface most of the year unless artificial drainage has been provided. The soils are wet or moist most or all of the time if they have a clayey particle-size class and expanding clays. They do not have a layer of fine pyroclastic materials that is as thick or thicker than 18 cm and that is within 75 cm of the surface. They do not have a buried Histosol or a buried histic epipedon within a depth of 1 m. They do not have a dark surface horizon, or if one is present, it is thin. These characteristics were selected for the typic subgroup, not because they are most common but because they represent the wettest and most recent Fluvaquents. As horizons begin to develop, the soils are classified in intergrade subgroups that indicate their nature.

Aeric Fluvaquents.—These soils are like Typic Fluvaquents except they are not so wet. They have some subhorizon at a depth between 25 and 75 cm in which the chroma is higher than that of soils in the typic subgroup, reflecting a level of ground water that is not as shallow for as long a period as in the typic soils.

Aeric Tropic Fluvaquents.—These soils are like Typic Fluvaquents except they have an iso temperature regime and they are not so wet. They have some subhorizon at a depth between 25 and 75 cm in which the chroma is higher than in soils of the typic subgroup. These soils in Puerto Rico are on nearly level flood plains and are used for growing sugarcane. They are not extensive soils in other parts of the United States. These soils are considered intergrades to Tropofluvents.

Andaqueptic Fluvaquents.—These soils are similar to Typic Fluvaquents except they have a layer of pyroclastic materials that is 18 cm or more thick in the upper 75 cm of the soil. In the United States, these soils occur in western Washington but are not extensive. They are used mostly for hay and pasture.

Humaqueptic Fluvaquents.—These soils have a surface horizon that has the color and other properties of an umbric epipedon except thickness. In the United States, these soils occur on nearly level flood plains in

areas where Ultisols or other soils that have low base saturation are the dominant upland soils. Most of them are forested but some are pastured, and a few

significantly. Many of them formed in Wisconsinan outwash and lacustrine deposits. They have the color of a cambic horizon at a shallow depth but do not have

Aeric Haplaquents are like Typic Haplaquents except for *a* or *a* and *b*.

Mollic Haplaquents are like Typic Haplaquents except for *b*.

Sulfic Haplaquents are like Typic Haplaquents except for *d*.

Description of subgroups

Typic Haplaquents.—The central concept or typic subgroup of Haplaquents is fixed on soils that have low chroma throughout, have a thin dark surface horizon or none, and are moderately deep or deep to hard rock. These are not the most extensive Haplaquents in the United States, but these characteristics furnish the best basis for definition of the other subgroups. These soils are rare in the United States. They are widely scattered, however, in the humid parts of the country.

Aeric Haplaquents.—These soils are like Typic Haplaquents in defined and other properties except they are not so wet. Most of them in the United States have sandy texture to a depth between 50 cm and 1 m. They are rare and are mainly in glaciated areas. Their major uses are for pasture or forests.

Mollic Haplaquents.—These soils are darker and have more organic carbon in the surface horizon than Typic Haplaquents. They tend to be the wettest Haplaquents. Most of them in the United States have sandy texture to a depth between 50 cm and 1 m. These soils are not extensive except locally in the glaciated areas. Most of them are in forests or are being used for pasture.

Sulfic Haplaquents.—Soils in this subgroup have sulfidic materials at a depth between 50 cm and 1 m below the mineral soil surface. They are not known to occur in the United States.

Hydraquents

These are for the most part the clayey soils of tidal marshes that are permanently saturated with water. Clays that were deposited under water have low bulk density, commonly about 0.6, and high water content, more than 100 percent of the dry weight. If drained, the loss of water is irreversible, and the bulk density [redacted] lantic and Gulf coasts, although a few are on the northern Pacific coast and near San Francisco Bay.

Definition

Hydraquents are the Aquents that do not have sulfidic materials within 50 cm of the mineral soil surface and

1. Have a mean annual soil temperature higher than 0° C;
2. In all subhorizons between 20 and 50 cm below the mineral surface have both an *n* value of more than 0.7 and at least 8 percent clay; and
3. Have texture that is loamy very fine sand or finer in some horizon below the Ap horizon or a depth of 25 cm, whichever is deeper, but above a depth of 1 m or a lithic or a paralithic contact, whichever is shallower.

The Hydraquents have been little used or studied in the United States, and subgroups have not been developed. The typic subgroup could be defined as having a high *n* value, 1 or more, in all subhorizons between a depth of 20 cm and 1 m. Hydraquents that have *n* values <1 in the upper 25 cm or more could be Haplic Hydraquents, which are intergrades to Haplaquents. Thapto-Histic Hydraquents, which have a buried Histosol or histic epipedon whose upper boundary is within a depth of 1 m, doubtless exist. Hydraquents that have a small amount of sulfides or none in the upper horizons can be drained and cultivated. A sulfic subgroup might be useful for those soils that, after drainage, have a pH <4.5 (1:1 water) in the upper 25 cm or more, those that have enough sulfides in the undrained soil to produce this pH on drainage, and those that have a larger amount of sulfides at a depth between 50 cm and 1 m. A large amount of sulfides at a depth below 1 m should be noted but could be shown as a phase.

Psammaquents

These Aquents have sandy texture and gray or mottled gray colors. The water table is at or near the surface for long periods unless artificial drainage has been provided. Most of these soils formed in late-Pleistocene to recent sediments. Most of them do not have distinctive features, but a few have a B horizon that

Description of a Typic Psammaquent

A description of a soil that represents the central concept or typic subgroup of Psammaquents follows.

This soil is located on the coastal plain of Texas. It lies in a shallow depression between coastal dunes and consists of sand that has been reworked by waves and wind. The water table fluctuates with the tides, but the soil is flooded after heavy rains or high storm tides. Natural vegetation is mainly grasses. The soil temperature regime is hyperthermic. Colors are those of the moist soil unless otherwise stated.

A 0–15 cm. Light brownish gray (10YR 6/2) fine sand, light gray (10YR 7/2) dry; single grain; loose; many fine roots; few shell fragments; neutral; gradual smooth boundary.

C1g 15–64 cm. Light gray (10YR 7/2) fine sand, white (10YR 8/2) dry; single grain; loose; few fine faint yellowish brown mottles along root channels; many fine roots; few shell fragments; neutral; gradual smooth boundary.

C2g 64–180 cm. Light gray (10YR 7/2) fine sand, white (10YR 8/2) dry; single grain; loose; neutral.

Distinctions between Typic Psammaquents and other subgroups

Typic Psammaquents are the Psammaquents that

a. Do not have a lithic contact within 50 cm of the soil surface;

b. Have an Ap horizon that has a color value, moist, of 4 or more or has a value, dry, of 6 or more when crushed and smoothed (smoothed with a knife to eliminate shadows), or the A1 horizon is less than 15 cm thick if its color value, moist, is lower than 3.5; and

c. Do not have an albic horizon at the surface or immediately under an A1 or Ap horizon that, in turn, is underlain by another horizon that has a color value more than one unit darker or that has chroma of 6 or more.

Humaqueptic Psammaquents are like Typic Psammaquents except for *b*, and their base saturation (by NH_4OAc) is <50 percent in more than half the thickness of the subhorizons within the upper 1 m.

Lithic Psammaquents are like Typic Psammaquents except for *a*.

Mollic Psammaquents are like Typic Psammaquents except for *b*, and their base saturation (by NH_4OAc) is 50 percent or more in more than half the thickness of the subhorizons within the upper 1 m.

Spodic Psammaquents are like Typic Psammaquents except for *c*.

Description of subgroups

Typic Psammaquents.—These soils are saturated with water part of the time. A range is permitted in length of the periods of saturation. An aeric subgroup has not been provided for those that are somewhat better drained than the wettest because there are few or no morphologic features that reflect the difference in drainage. Observations of the ground-water level over time indicate the degree of wetness, but if the soils have artificial drainage, the observations reflect only the degree of drainage that has been provided. These soils are locally extensive in the United States, particularly on the coastal plains and in areas covered by Wisconsinan outwash. Few of them are farmed. Most are used for grazing or forestry according to their natural vegetation.

Humaqueptic Psammaquents.—These soils are like Typic Psammaquents except the A1 or Ap horizon resembles an umbric epipedon but is <25 cm thick and the base saturation (by NH_4OAc) is <50 percent in more than half the thickness of the subhorizons within the upper 1 m. In the United States these soils are of local importance in Wisconsin where they are used for hay and pasture.

Lithic Psammaquents.—These soils are like Typic Psammaquents, except they have a lithic contact within 50 cm of the soil surface. In most of them the rock is sandstone. These soils are not extensive in the United States.

Mollic Psammaquents.—Soils in this subgroup are like Typic Psammaquents except the A1 or Ap horizon resembles a mollic epipedon but is <25 cm thick. These soils are moderately extensive in the United States, mostly in areas of Wisconsinan outwash. The A1 horizon usually is black or very dark gray but is too thin to meet the requirements of a mollic epipedon, which in sands must be at least 25 cm thick. Few of these soils are farmed. Most of them are used for grazing or forestry according to their natural vegetation.

Spodic Psammaquents.—These soils have an albic horizon and an underlying horizon that has a weak accumulation of amorphous materials, mostly humus. These soils are not extensive in the United States, but they are on the low coastal plains along the Atlantic Ocean and the Gulf of Mexico. Most of them still have their native vegetation.

Sulfaquents

These are the Aquents that have an appreciable amount of sulfides close to the mineral soil surface and few or no carbonates. These soils are largely restricted to coastal marshes where the water is brackish. Tidal marshes at mouths of rivers normally contain these soils unless the river sediments are rich in carbonates. Coastal marshes that are not near rivers may also contain these soils if storms periodically flood them with salt water.

The Sulfaquents are permanently saturated at or close to the surface and many are nearly neutral in reaction. The *n* value is high, usually >1 in most horizons. A histic epipedon composed of organic soil materials is common. If these soils are drained, the sulfides oxidize and the soils change rapidly to Sulfaquepts.

The Sulfaquents commonly are not used for crops. Some are used to produce rice by keeping them flooded at all times except for a very brief period while the crop is harvested.

The Sulfaquents are extensive along coasts and bays from the equator to high latitudes. They had no clear equivalent in the 1938 classification. The classification that follows is incomplete and provisional.

Definition

Sulfaquents are the Aquents that have sulfidic materials within a depth of 50 cm below the mineral soil

surface. Pedon 43 is an example of the central concept or typic subgroup of Sulfaquents.

Definition of Typic Sulfaquents

Typic Sulfaquents are the Sulfaquents that

a. Have sulfidic materials within 50 cm of the mineral soil surface if the n value is ≥ 1 or within 30 cm if the n value is <1.

Description of Typic Sulfaquents

Arents are not extensive in the United States, but with the increase in use of modern power machinery their area is increasing.

The Arents form a unique suborder in that not only are no great groups recognized, but also there is no typic subgroup. Subgroups of Arents are intergrades to suborders or great groups of Spodosols, Alfisols, or other orders, according to the nature of the fragments that can be identified and according to the soil mois-

The Fluvents can have any vegetation, any moisture regime, and any temperature regime except pergelic. Soils in recent alluvium that have a permanently frozen substratum are grouped with Aquepts if they are wet and gleyed, as most of them are in the United States, or with Orthents if they are not wet. The Fluvents were called Alluvial soils in the 1938 classification.

Definition

Fluvents are the Entisols that

1. Have texture of loamy very fine sand or finer in some subhorizon below the Ap horizon or below a depth of 25 cm, whichever is deeper, but above a depth of 1 m or a lithic or a paralithic contact that is deeper than 25 cm but shallower than 1 m;
2. Do not have fragments of diagnostic horizons that can be identified and that occur more or less without discernible order in the soil below any Ap horizon but within the series control section;
3. Have slope of <25 percent;
4. Have an organic-carbon content[9] that decreases irregularly with increasing depth or that remains >0.2 percent at a depth of 1.25 m or to a depth 25 cm below the upper boundary of any layer that remains frozen until 2 months after the summer solstice, whichever is shallower. Thin strata of sand may have less organic carbon if the finer sediments at a depth of 1.25 m or below have 0.2 percent organic carbon or more;
5. Are not permanently saturated with water and do not have the characteristics associated with wetness that are defined for Aquents;

mineral horizons and produces an irregular decrease in organic matter at increasing depth. Therefore, by the definition of Fluvents, many soils that never are flooded would need to be called Fluvents if a pergelic soil temperature regime were permitted.

Definition

Cryofluvents are the Fluvents that have a cryic temperature regime.

Description of a Typic Cryofluvent

There follows a description of a soil that represents the central concept or typic subgroup of Cryofluvents. This soil is on a flood plain in Alaska in a region of intermittent permafrost. It is well drained. The native vegetation is mostly conifers and some birch. Some frost churning appears active in the upper horizons. The low chroma reflects the color of the sediments. The colors given are those of the moist soil.

O11 12–7 cm. Mat of undecomposed moss, leaves, and twigs.

O12 7–0 cm. Dark reddish brown (5YR 2/2) mat of decomposing moss, leaves, and twigs; many fine roots; abrupt smooth boundary.

A1 0–5 cm. Very dark grayish brown (10YR 3/2) silt loam; streaked with dark brown (10YR 3/3); weak very fine granular structure; very friable (moist); many fine roots; strongly acid; clear wavy boundary.

AC 5–18 cm. Dark grayish brown (10YR 4/2) very fine sandy loam; streaks of dark yellowish brown (10YR 3/4); weak very thin platy structure; very friable (moist); common roots; micaceous; strongly acid; gradual boundary.

Aquic Cryofluvents are like Typic Cryofluvents except for *b* or for *b* and *c*.

Mollic Cryofluvents are like Typic Cryofluvents except for *c*.

Description of subgroups

Typic Cryofluvents.—These are the Cryofluvents that do not have ground water within the upper 50 cm during the growing season except for short periods following floods. When these soils thaw in spring, the soil above the layer that remains frozen may be saturated and very soft, but the water drains out rapidly when the frozen layer thaws. The soils are free of low-chroma mottles in the upper 50 cm, but the color may be variegated with streaks of brown and gray that are caused by minor frost churning. Segregations of iron in spheroidal mottles are absent or faint. An O horizon at the surface is normal, but the A1 horizon is thin or faint. Both fine and coarse stratifications are common below a depth of a few centimeters.

Typic Cryofluvents do not have a layer of fine pyroclastic materials as thick as 18 cm within the upper 75 cm of the soil.

Andeptic Cryofluvents.—These soils are like Typic Cryofluvents except they have a layer of fine pyroclastic materials that is 18 cm or more thick and that is in the upper 75 cm of the soil. These soils have very

Pedon 67 illustrates the central concept or typic subgroup of Torrifluvents.

Distinctions between Typic Torrifluvents and other subgroups

Typic Torrifluvents are the Torrifluvents that

a. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains as much as 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

b. Do not have all three of the following characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness within the upper 1 m;

c. Do not have an anthropic epipedon; and

d. Are dry in all parts of the moisture control section three-fourths or more of the time (cumulative) that

matter other than that imposed by the definition of the order (the soils must be mineral soils). The amount of organic matter is more nearly a function of the frequency of flooding and the sources of sediments than of the minor differences in climate or in vegetation on the soil.

Weak cementation by silica is excluded from the typic subgroup because it is considered to indicate initial development of a duripan. Deep wide cracks and clayey texture are properties shared with Vertisols and define the vertic subgroups.

The concept of the Typic subgroup is that of the drier part of the range of Torrifluvents. Extra moisture coming as summer rain or in summer floods is frequent flooding than the typic soils. The Ustic Torrifluvents are moist in some or all parts of the moisture control section more than one-fourth of the time (cumulative) that the soil temperature at a depth of 50 cm is 5° C or higher. These soils are extensive along the rivers of the drier parts of the Great Plains in the United States. Many of them are irrigated, and the others are used for summer grazing.

Vertic Torrifluvents.—These soils are like Typic Torrifluvents except they have fine texture and deep wide cracks that remain open for more than 8 months in most years. They have many of the properties of Vertisols but do not have evidences of soil movement in the form of gilgai, slickensides close enough to in-

in middle latitudes but not in high mountains, and they may be flooded at almost any season. Some are under forests, but many have had no vegetation except pasture or cultivated crops because the sediments that form the soil were deposited while the soils were being used. The Udifluvents are extensive in the United States. They were considered Alluvial soils in the 1938 classification.

Definition

Udifluvents are the Fluvents that
1. Have a udic moisture regime; and
2. Have a frigid to hyperthermic temperature regime but not an iso temperature regime.

Distinctions between Typic Udifluvents and other subgroups

Typic Udifluvents are the Udifluvents that
a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density in the fine-earth fraction (at 1/3-bar moisture tension) of 0.95 g per cubic centimeter or less, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;
b. Do not have mottles within 50 cm of the surface that have chroma of 2 or less or, at a depth between 50 cm and 1 m, do not have any horizons that are saturated with water at some period or that are artificially drained and have chroma less than 1 or hue bluer than 10Y and value, moist, of 4 or more; and
c. Have an Ap horizon that has a color value, moist, of 4 or more or has a color value, dry, of 6 or more when crushed and smoothed, or the A1 horizon is <15 cm thick if its color value, moist, is less than 3.5.

Aquic Udifluvents are like Typic Udifluvents except for *b* or for *b* and *c*.

Mollic Udifluvents are like Typic Udifluvents except for *c*.

Description of subgroups

Typic Udifluvents.—These are the Udifluvents that have moderately good to good drainage. They are in relatively high places on flood plains; the water table is deeper than 50 cm all the time or enough of the time that there are no mottles of low chroma (2 or less), and they are not saturated in the mottled zone within a depth of 50 cm. There are few or no evidences of alteration of the fine stratifications of the alluvium, although in some Udifluvents that have a fine-silty or fine particle-size class, the stratifications may be absent or difficult to see. Typic Udifluvents are extensive along the rivers of the humid parts of the United States and many other countries. If mottles are shallow, the soils are considered intergrades to Aquents. Most of these soils in the United States are cultivated if the polypedons are large enough.

Aquic Udifluvents.—These soils have a water table that is shallower than the one in Typic Udifluvents or persists for longer periods within a depth of 50 cm. They either have some mottles that have chroma of 2 or less within a depth of 50 cm, although chroma of >2 is dominant to this depth or deeper, or they have chroma <1 or a hue bluer than 10Y in some horizon between a depth of 50 cm or 1 m. In either situation the horizon is saturated with water at some time or the soil is artificially drained. These soils are intergrades between Udifluvents and Aquents. They are not extensive in the United States as a whole but are locally extensive on the flood plains of the larger rivers. Nearly all these soils in the United States are cultivated. Pedon 66 is a representative of the Aquic Udifluvents.

Mollic Udifluvents.—These soils differ from the Typic Udifluvents in that the Ap horizon or the upper 15 cm, after mixing, has colors as dark as those of a mollic epipedon. The sediments below this depth are finely stratified and may have dark colors. The surface horizon has not been in place long enough for mixing by roots and burrowing animals and insects, volume changes on wetting and drying, and frost action to have obliterated the fine strata below the Ap horizon or 15 cm. Otherwise, the soils would be Hapludolls. These soils are associated with Udolls in central northern United States. They are adjacent to streams and are not extensive. Most of them are farmed.

Ustifluvents

These are the Fluvents that have an ustic moisture regime and, normally, a mesic, isomesic, or warmer temperature regime. A few have a frigid but not a cryic temperature regime. These soils are on flood plains of rivers or streams in middle to low latitudes. Floods may come in any season but are most common in the rainy season. A few of the soils are flooded regularly in summer from melting snow in high mountains, even though the summer is rainless. The Ustifluvents were called Alluvial soils in the 1938 classification. Figure 37 shows a Typic Ustifluvent in Ellsworth County, Kans., that has marks of stratified materials.

Definition

Ustifluvents are the Fluvents that
1. Have an ustic moisture regime; and
2. Have a frigid to hyperthermic temperature regime or have an isomesic or warmer temperature regime.

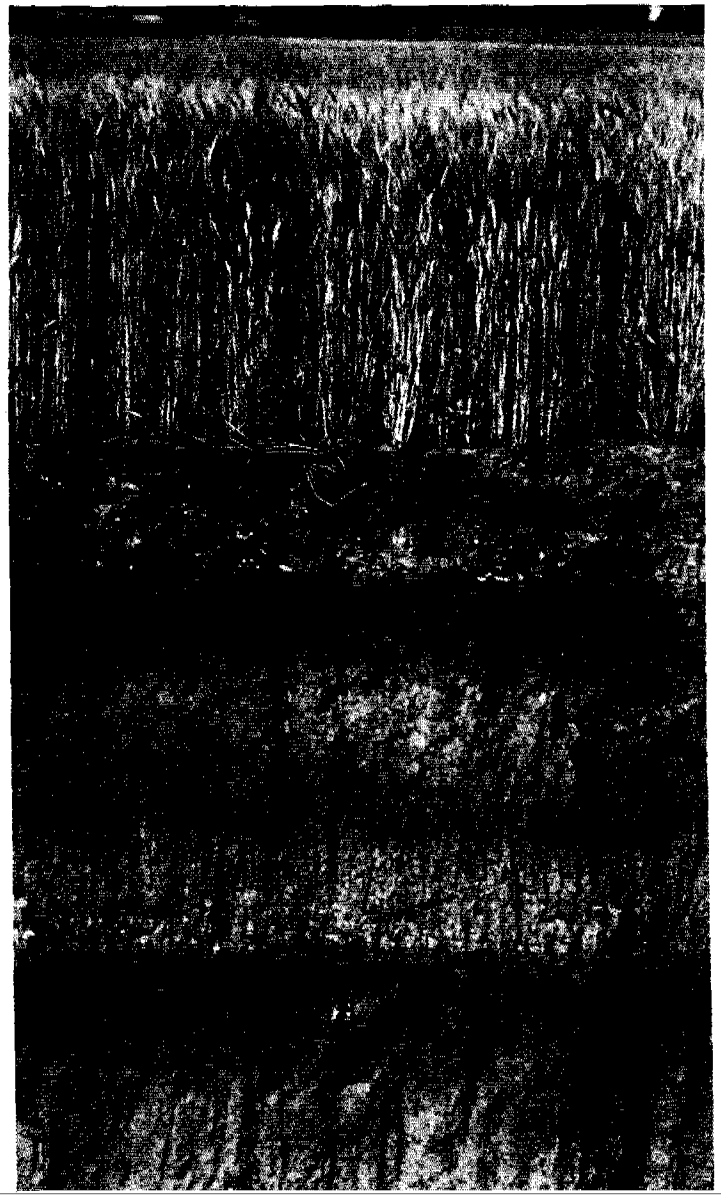
Description of a Typic Ustifluvent

A description of a soil that represents the central concept or typic subgroup of Ustifluvents follows. This soil is on a nearly level flood plain of the Rio Grande in Starr County, Tex. Precipitation is about 450 mm, and the mean annual soil temperature is about 22° C. The natural vegetation consists of mixed grasses and xerophytic shrubs, but most areas of this soil are irrigated and cultivated. The frequency of floods ranges from about one each year to about one in 10 years. Ground water is deep. The colors are those of the dry soil unless otherwise indicated.

Ap 0–18 cm. Light brownish gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; structureless; friable (moist); few roots; few mica flakes; calcareous; moderately alkaline; abrupt boundary.

C1 18–50 cm. Light brownish gray (10YR 6/2) silt loam; few strata less than 1 cm thick of silty clay loam; dark grayish brown (10YR 4/2) moist; structureless; bedding planes are evident; friable (moist); few mica flakes; few snail shell fragments; few dark yellowish brown and strong brown organic stains along bedding planes; few roots; few fine pores and wormcasts; calcareous; moderately alkaline; clear boundary.

C2 50–150 cm. Pale brown (10YR 6/3) silt loam, brown (10YR 4/3) moist; thin strata and lenses of very fine sandy loam and silty clay loam; structureless; many bedding planes; slightly hard (dry); very friable (moist); few mica flakes; few roots; few root channels and bedding planes have brownish organic stains; calcareous; moderately alkaline.



Distinctions between Typic Ustifluvents and other subgroups

Typic Ustifluvents are the Ustifluvents that

a. Do not have mottles within 50 cm of the surface that have chroma of 2 or less and do not have, at a depth within 1.5 m of the surface, a horizon that is saturated with water at some period or is artificially drained and that has chroma less than 1 or a hue bluer than 10Y; and

b. Do not have the following combination of characteristics:

(1) Cracks at some period in most years, when the soil is not irrigated, that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

c. Have an Ap horizon that has a color value, moist, of 4 or more or has a color value, dry, of 6 or more when crushed and smoothed, or the A1 horizon is <15 cm thick if its color value, moist, is less than 3.5.

Aquic Ustifluvents are like Typic Ustifluvents except for *a* or for *a* and *c*.

Mollic Ustifluvents are like Typic Ustifluvents except for *c*.

Vertic Ustifluvents are like Typic Ustifluvents except for *b* or for *b* and *a*.

Description of subgroups

Typic Ustifluvents.—These are the Ustifluvents that have good or moderately good drainage and that do not have a fine particle-size class and clay of a swelling type in a major part of the upper 1.25 m. They are in relatively high places on flood plains, and the water table is deeper than 50 cm all the time or enough of the time that there are no mottles that have low chroma (2 or less) accompanied by saturation in the mottled zone within a depth of 50 cm. In addition, the layers between a depth of 50 and 150 cm do not have periods of saturation long enough that the chroma is less than 1 or the hue is bluer than 10Y.

There are normally few or no evidences of alteration of the fine stratifications of the alluvium, although in some Ustifluvents that have a fine-silty or fine particle-size class, stratifications may be absent or difficult to see. Typic Ustifluvents are extensive along streams in the subhumid or semiarid parts of the Great Plains in the United States and are also extensive in many other countries. Many of them are farmed, with or without irrigation. Others are used

of 2 or less within a depth of 50 cm or they have chroma less than 1 or a hue bluer than 10Y at some depth between 50 cm and 1.5 m. They are intergrades between Ustifluvents and Aquents. They may or may not have an Ap horizon or upper 15 cm that would be a mollic epipedon except the layer rests on finely stratified sediment. They are not extensive in the United States. Most of them are farmed, with or without irrigation.

A1 0–7.5 cm. Light olive brown (2.5Y 5/3) silt loam, dark grayish brown (10YR 4/2) moist; massive; hard (dry), friable (moist), slightly sticky and slightly plastic (wet); abundant very fine roots; many very fine and fine tubular pores; slightly acid (pH 6.5); abrupt wavy boundary.

C1 7.5–36 cm. Pale brown (10YR 6/3) silt loam, brown (10YR 4/3) moist; massive; hard (dry), friable (moist), slightly sticky and slightly plastic (wet); common very fine roots; many very fine tubular and interstitial pores; slightly acid (pH 6.2); clear wavy boundary.

good or moderately good drainage, that have little or no evident cementation by silica, and that do not have a fine particle-size class and clay of a swelling type in the upper 1.5 m. These soils are in relatively high places on flood plains, and the water table is deeper than 1.5 m in most years.

Weak cementation by silica causes soils to be excluded from the typic subgroup because that feature is considered to indicate an intergrade to the Durorthids or Durochrepts. Soils that have both fine texture and deep wide cracks are excluded from the typic subgroup because they have most of the properties of Xererts. Presumably, the deposits are too recent to have the evidences of movement that are necessary in Vertisols.

Typic Xerofluvents are nearly level and are used for native pasture or are irrigated and used for crops. They are not extensive in the United States.

Aquic Xerofluvents.—These soils are saturated with water within 1.5 m of the surface at some time in most years. They are otherwise like Typic Xerofluvents in defined properties, but they tend to have more salts from capillary rise and evapotranspiration. These soils are on nearly level flood plains, and they are used mostly for irrigated crops and pasture. Some are used for native pasture, hay, and grazing. They are moderately extensive in parts of Nevada and Utah but not elsewhere in the United States.

Aquic Durorthidic Xerofluvents.—These soils are saturated with water within 1.5 m of the soil surface at some time in most years, and they have a horizon that is weakly cemented by silica. These soils are rich in pyroclastic materials. They occur on nearly level flood plains and are used for grazing. They are rare in the United States.

Mollic Xerofluvents.—These soils differ from the Typic Xerofluvents in that the Ap horizon or the upper 15 cm, after mixing, has colors as dark as those of the mollic epipedon. The sediments below this depth are finely stratified and may have dark colors. The surface horizon has not been in place long enough for mixing by roots and burrowing animals and insects, wetting and drying, and frost action to have obliterated the fine strata below the Ap horizon or 15 cm. Otherwise, the soils would be Haploxerolls. These soils are associated with Xerolls in western United States. They are adjacent to streams and are not extensive.

Vertic Xerofluvents.—These soils have fine texture and deep wide cracks. Churning, however, has not yet produced the properties that are diagnostic of Vertisols. There is no restriction on the presence of ground other orders are absent. An indurated diagnostic horizon, such as ironstone that once was plinthite, may be present if it is exposed at the surface and supports scattered plants. If indurated materials are present but do not support at least some plants, they are considered to be rock rather than soil. A few Orthents are in recent loamy or fine eolian deposits, in solifluction or glacial deposits, in debris from recent landslides and mudflows, and in recent sandy-skeletal alluvium.

Orthents may occur in any climate and under any vegetation. They are not present in areas that have a high water table or on shifting or stabilized sand dunes.

Definition

Orthents are the Entisols that

1. Have a lithic or paralithic contact that is shallower than 25 cm or have a particle-size class that is loamy or finer in some horizon below the Ap horizon or a depth of 25 cm, whichever is deeper, but above a depth of 1 m or a lithic or paralithic contact, whichever is shallower, or have $\geq$35 percent rock fragments (by volume) in some subhorizon within a depth of 1 m;
2. Do not have fragments of diagnostic horizons that can be identified and that occur more or less without discernible order in the soil below any Ap horizon but above a depth of 1 m or above a lithic or paralithic contact that is shallower than 1 m;
3. Have slope that is >25 percent, or have an organic-carbon content[10] that decreases regularly with increasing depth and reaches a level of 0.2 percent or less within a depth of 1.25 m or within a depth 25 cm below the upper boundary of any layer that remains frozen until 2 months after the summer solstice, whichever is shallower, or have a mean annual soil temperature of 0° C or lower, or have a lithic or paralithic contact within 25 cm of the soil surface; and
4. Are not permanently saturated with water and do not have the characteristics associated with wetness that are defined for Aquents if the moisture regime is aquic.

Key to great groups

JEA. Orthents that have a cryic or pergelic temperature regime.

Cryorthents, p. 195

JEB. Other Orthents that have a torric moisture regime or that have a conductivity of the saturation extract that is 2 mmho per centimeter or greater at 25° C in some part above whichever

gillic horizon. The particle-size class below the mantle is mostly sandy or sandy-skeletal. These soils are moderately extensive in the western mountains in the United States. Nearly all are under coniferous forests.

Andeptic Cryorthents.—These soils have a deposit of fine pyroclastic materials near the surface. Most of these deposits are of Holocene or historic age. These soils are considered intergrades to Cryandepts.

Aquic Cryorthents.—These soils are saturated with water within 50 cm of the surface at some time during most years and have mottles within that depth that have chroma of 2 or less. The dominant chroma, however, is more than 2. These soils are considered intergrades to Cryaquents.

Lithic Cryorthents.—These soils have a lithic contact within 50 cm of the soil surface and commonly at a depth appreciably less than 50 cm. These soils may be saturated with water above the lithic contact when snow melts, but because the water is cold and is moving down the slope, reducing conditions are too weak to produce mottles of low chroma. This lithic subgroup is also allowed to have permafrost. Where rock is shallow, ice wedges and lenses must be thin or absent.

tion extract that is 2 mmho per centimeter or greater at 25° C in some part above whichever of the following depths is the least: a lithic or paralithic contact, 1.25 m if the particle-size class [14] is sandy, 90 cm if loamy, and 75 cm if clayey; and that have a soil temperature regime warmer than cryic.

Description of a Typic Torriorthent

A description of a soil that represents the central concept or typic subgroup of Torriorthents follows. This soil is on a moderate slope. The annual precipitation is about 150 mm, and the mean annual soil temperature is about 9° C. The vegetation is a mixture of sagebrush and scattered grasses. The soil formed from a soft shale. The colors are those of the dry soil unless otherwise stated.

A1 0–10 cm. Light yellowish brown (2.5Y 6/3) light clay loam, olive brown (2.5Y 4/3) moist; weak medium subangular blocks parting to moderate fine granules; soft (dry), very friable (moist); <1 percent organic matter; calcareous, pH 8.0; clear smooth boundary.

AC 10–25 cm. Light yellowish brown (2.5Y 6/3) light clay loam, olive brown (2.5Y 4/3) moist; weak medium subangular blocky structure; slightly hard (dry), very friable (moist); calcareous, pH 8.2; gradual smooth boundary.

C1ca 25–70 cm. Light yellowish brown (2.5Y 6/3) light clay

Aquic Torriorthents are like Typic Torriorthents except for *e* or for *d* and *e*.

Aquic Durorthidic Torriorthents are like Typic Torriorthents except for *a* and *e*, or for *a*, *d*, and *e*.

Durorthidic Torriorthents are like Typic Torriorthents except for *a*.

Durorthidic Xeric Torriorthents are like Typic Torriorthents except for *a* and *d*. They have a thermic, mesic, or frigid soil temperature regime and have a torric moisture regime that borders on a xeric regime.

Lithic Torriorthents are like Typic Torriorthents except for *b*.

Lithic Ustic Torriorthents are like Typic Torriorthents except for *b* and *d*. They either (1) have a hyperthermic or an iso soil temperature regime or (2) have a thermic or mesic soil temperature regime and have a torric moisture regime that borders on an ustic regime.

Lithic Xeric Torriorthents are like Typic Torriorthents except for *b* and *d*. They have a thermic, mesic, or frigid soil temperature regime and an aridic moisture regime that borders on a xeric regime.

Ustertic Torriorthents are like Typic Torriorthents except for *c*, with or without *d* or *e*, or both. Unless irrigated, they have cracks that remain open from 175 to 240 days, cumulative, and are not closed for as many as 60 consecutive days during the 120 days following the winter solstice in 3 or more years out of 10 if the soil temperature regime is thermic, mesic, or frigid.

Ustic Torriorthents are like Typic Torriorthents except for *d*. They either (1) have a hyperthermic or an iso soil temperature regime or (2) have a thermic, mesic, or a frigid soil temperature regime and have an aridic moisture regime that borders on an ustic regime.

Vertic Torriorthents are like Typic Torriorthents except for *c* or for *c* and *d*. Unless the soil is irrigated, the cracks remain open in most years for more than 240 days, cumulative, and are not closed in most years for as many as 60 consecutive days at any season.

Xerertic Torriorthents are like Typic Torriorthents except for *c*, with or without *d* or *e*, or both. They have a thermic, mesic, or frigid soil temperature regime and have cracks that are closed for 60 consecutive days or more during the 120 days following the winter solstice in more than 7 years out of 10.

Xeric Torriorthents are like Typic Torriorthents except for *d*. They have a thermic, mesic, or frigid soil temperature regime and a torric moisture regime that borders on a xeric regime.

Description of subgroups

Typic Torriorthents.—The typic subgroup is fixed on the driest Torriorthents that are moderately deep or deep to hard rock.

Soils that have weak cementation by silica are excluded from the typic subgroup because that feature is considered to indicate initial development of a duripan. The Torriorthents that have clayey texture, cracks, and a swelling type of clay are also excluded because they have so many similarities to the Torrerts. No intergrades to Mollisols are recognized because the Torriorthents are highly susceptible to erosion, and if any have become stabilized enough by grasses to accumulate an appreciable amount of organic matter, the slightest disturbance or use of the vegetation is apt to initiate new erosion.

The Typic Torriorthents are extensive soils in the intermountain states of the United States. Most of them have moderate to strong slopes and are used only for grazing. Others that have gentle slopes are irrigated. The gently sloping soils are mostly on fans or piedmont slopes where the sediments are recent and had little organic carbon.

Aquic Torriorthents.—These soils are saturated with water within 1.5 m of the surface at some time of year in most years. These soils are mostly in recent alluvium, but they have too little organic matter for Fluvents. Ground water is present mostly during high-water stages of the streams. Most of these soils have conductivity well in excess of 2 mmho per centimeter as a result of salts that accumulate through capillary rise and evapotranspiration. The moisture regime depends greatly on subirrigation and is unpredictable, and there are no restrictions on it in the definition. These soils are rare in the United States. They have gentle slopes, and many of them are irrigated.

Aquic Durorthidic Torriorthents.—Soils in this subgroup differ from Typic Torriorthents in that they are saturated with water within 1.5 m of the surface at some time in most years and have a horizon at least 15 cm thick that is either weakly cemented or contains at least 20 percent durinodes. Parent materials contain some pyroclastic materials. These soils are not extensive in the United States. They are on gentle slopes and are used for grazing.

Durorthidic Torriorthents.—Soils in this subgroup have weak cementation with silica. In these soils in the United States, the cementation is in the form of durinodes. These soils are mostly in rather recent alluvium, but they have too little organic matter for Fluvents. Most of them have conductivity well in excess of 2 mmho per centimeter. Their parent materials were derived from rocks rich in pyroclastic materials. These soils are rare in the United States. They have gentle slopes, but most of them are used only for grazing.

Durorthidic Xeric Torriorthents.—These soils have within the upper meter a horizon that is weakly cemented by silica. The cemented horizon normally is within about 30 to 60 cm of the surface. It is 15 cm or more thick and has at least 20 percent durinodes, by volume, in a nonbrittle matrix, or it is massive or platy and is both brittle and firm when moist. The latter features are common in these soils in the United States. Both the durinodes and the brittle and firm or very firm consistence cause some interference with water movement and root penetration.

The soils of this subgroup also have a moisture regime that is marginal to xeric. The moisture control section is regularly moist in winter and early spring but is very dry in summer. The moisture stored in winter gives these soils a higher productivity for plant growth than the soils of the typic subgroup, which

have a less reliable supply of moisture. These soils are rare in the United States. They are used mostly for winter or spring grazing.

Lithic Torriorthents.—These soils have a lithic contact that is within 50 cm of the surface and commonly is at a depth much less than 50 cm. Soils of this lithic subgroup have low moisture-storage capacity, but they occur mostly in association with soils of other orders or subgroups that have more moisture available to plants.

Lithic Ustic Torriorthents.—These soils have more available moisture than the typic soils during summer or, if located in the Tropics, during the rainy seasons. They are moist in some or all parts of the moisture control section for more than one-fourth of the time (cumulative) that the soil temperature at a depth of 50 cm exceeds 5° C. They also have a shallow lithic contact, which limits the moisture-storage capacity. Consequently, the soils of this subgroup commonly are associated with the Ustalfs and Ustolls of more stable surfaces.

Lithic Xeric Torriorthents.—These soils have a lithic contact within 50 cm of the surface and have more available moisture than the soils of the typic subgroup. They are in regions that have enough winter precipitation that the moisture control section is moist in all parts during late winter or early spring, but they are continuously dry in all parts of the moisture control section for 60 or more days during summer in more than 7 out of 10 years. The lithic contact commonly limits the moisture-storage capacity of the moisture control section.

Ustertic Torriorthents.—These soils have clayey texture, and they have deep wide cracks that are open less than 8 months in most years. In these soils in the United States, the cracks are closed in spring and summer, and most of these soils have all the properties of Vertisols but have a frigid soil temperature regime. Most of these soils are on flood plains in the coolest and driest parts of the Great Plains. They are not extensive. Many of them are used for summer grazing and some are cultivated.

Ustic Torriorthents.—These soils have more available moisture than Typic Torriorthents during summer or during rainy seasons in the Tropics. They are moist in some or all parts of the moisture control section for more than one-fourth of the time (cumulative) that the soil temperature at a depth of 50 cm exceeds 5° C. They are capable of supporting somewhat more vegetation than the typic soils. They are commonly associated with Ustolls or Ustalfs that lie on the gentler slopes of more stable surfaces. The Orthents normally lose an appreciable part of their precipitation in runoff.

Vertic Torriorthents.—These soils have clayey texture and deep wide cracks that are open more than 240 days in most years and are never closed for as many as 60 consecutive days. These soils commonly have two short, undependable rainy seasons. Slopes of these soils in the United States range from nearly level to strong. Where slopes are suitable and water is available, most of the soils are irrigated. Others are used for grazing. These soils are moderately extensive locally in the southwestern states.

Xerertic Torriorthents.—These soils have clayey texture and deep wide cracks that regularly close during a cool or cold season. Most of them in the United States are in northern California and Nevada where the soil temperature regime is frigid. They are not extensive, and most of them are used for grazing.

Xeric Torriorthents.—Soils in this subgroup are moist in some part of the moisture control section more than one-fourth of the time while the soil temperature at a depth of 50 cm is 5° C or higher. They are in areas of winter precipitation and have a moisture regime that approaches the xeric. They can produce more vegetation than soils of the typic or ustic subgroups because the moisture stored in winter furnishes a reliable supply.

These soils are extensive in the intermountain and Pacific states of the United States. Some have moderate to strong slopes and formed mostly in soft country rock. Others have gentle slopes and formed in alluvium that had little organic matter. These gently sloping soils are mostly on fans and piedmont slopes. Where slopes are suitable and water is available, most of the Xeric Torriorthents are irrigated. Those not irrigated are used mainly for winter and spring grazing.

Troporthents

These are primarily the Orthents of intertropical regions that have a udic moisture regime. Mostly they are on moderate to strong slopes that are of recent geologic origin. The soils may have any reaction, depending on the nature of the parent material, but they are mostly acid. The vegetation may be rain forest, anthropic savanna, or cultivated crops. Most of these soils were considered Lithosols and Regosols in the 1938 classification as modified prior to 1949.

Definition

Troporthents are the Orthents that

1. Have an isomesic or warmer iso temperature regime;
2. Are not dry in some or all parts of the moisture control section for as many as 90 cumulative days in most years; and
3. Have conductivity of the saturation extract that is <2 mmho per centimeter at 25° C in all subhorizons above whichever of the following depths is least; a lithic or paralithic contact, 1.25 m if the particle-size class [15] is sandy, 90 cm if loamy, and 75 cm if clayey.

Distinctions between Typic Troporthents and other subgroups

Typic Troporthents are the Troporthents that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density in the fine-earth fraction (at 1/3-bar moisture tension) of 0.95 g per

[15] See footnote 11 on p. 194.

cubic centimeter or less, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of more than 1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum; and

b. Do not have a lithic contact within 50 cm of the soil surface.

Andeptic Troporthents are like Typic Troporthents except for *a*.

Lithic Troporthents are like Typic Troporthents except for *b*.

Description of subgroups

Typic Troporthents.—The Troporthents are so inextensive in the United States that the definition must be considered tentative. It is fixed on soils that are steep and actively eroding. If erosion is cutting into a deeply weathered regolith, the soils normally are acid and the clay fraction has moderate or low activity. The Troporthents in the United States do not provide a representative cross section of the Troporthents because the parent rocks in the United States are basic rocks.

Andeptic Troporthents.—These soils are not known to occur in the United States, but the subgroup is provided for other parts of the world.

zons above whichever of the following depths is the least: a lithic or paralithic contact, 1.25 m if the particle-size class [16] is sandy, 90 cm if loamy, and 75 cm if clayey.

Pedon 68 represents the central concept or typic subgroup of Udorthents.

Distinctions between Typic Udorthents and other subgroups

Typic Udorthents are the Udorthents that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density in the fine-earth fraction (at 1/3-bar moisture tension) of 0.95 g per cubic centimeter or less, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum.

b. Are not saturated with water for as long as 1 month within 1.5 m of the surface;

c. Do not have a lithic contact within 50 cm of the surface; and

d. Have <50 percent by volume of wormholes, wormcasts, and filled animal burrows between the bottom of the Ap horizon or a depth of 25 cm, whichever is deeper, and either a depth of 1 m or a lithic or para-

and forestry, but some that are gently sloping are used for cultivated crops.

loam, dark grayish brown (10YR 4/2) moist; strong fine granular structure; hard (dry), firm (moist); about 35 percent by volume platy fragments of chalk.

Soils that have a shallow lithic contact are excluded from the typic subgroup as is done throughout the taxonomy.

Slopes of Typic Ustorthents range from nearly level to very steep. The soils are used mostly for grazing, forestry, and catchments, but some are used for nonirrigated grain and a few that have gentle slopes are used for irrigated crops. These soils are extensive in the Great Plains of the United States.

Aquic Ustorthents.—These soils are saturated with water within 1.5 m of the surface at some time of year. These soils are on low terraces or fans in sediments that are partly sandy and partly loamy. Ground water is shallow during summer when snow is melting on adjacent mountains. The water has a very low salt content. These soils either are nearly level or they are in depressions. They commonly are drained and used for irrigated crops. They are not extensive in the United States.

Lithic Ustorthents.—These soils have a lithic contact within 50 cm of the soil surface. Generally the lithic contact is appreciably shallower than 50 cm, and a depth <25 cm is the most common. The soils are otherwise like those of the typic subgroup in defined characteristics. The slopes range from gentle to very steep. These soils are used mostly as grazing lands and watersheds, and some are in forest. They are extensive soils in parts of western United States.

Vertic Ustorthents.—These soils have a higher clay content than the typic subgroup and develop wide cracks when dry. They are extensive in Montana in the United States on rolling areas of fine-textured sedimentary rocks. They are used for grazing.

Xerorthents

These are the Orthents of Mediterranean climates that have a xeric moisture regime. Most Orthents are strongly sloping and lose water by runoff, so that not all Orthents in a Mediterranean climate have a xeric moisture regime, particularly if the regolith is thick. But the winter rains usually are gentle, summer drought is certain, and most of the Orthents in a Mediterranean climate are Xerorthents. Some, particularly those that have been cultivated for a long time, consist of what was the C horizon of other xeric great groups, chiefly Xeralfs and Xerolls. These cultivated soils commonly have gentle or moderate slopes. The Xerorthents were considered Lithosols and Regosols in the 1938 classification as modified in 1949.

Definition

Xerorthents are the Orthents that

1. Haxe a xeric moisture regime and a soil temperature regime warmer than cryic; and

2. Have conductivity of the saturation extract that is <2 mmho per centimeter at 25° C in all subhorizons above whichever of the following depths is the least: a lithic or paralithic contact, 1.25 m if the particle-size class [18] is sandy, 90 cm if loamy, and 75 cm if clayey.

[18] See footnote 11 on p. 194.

Distinctions between Typic Xerorthents and other subgroups

Typic Xerorthents are the Xerorthents that

a. Are not saturated with water within 1.5 m of the surface at any time of year in most years;

b. Do not have a horizon within 1 m of the surface that is >15 cm thick, that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

c. Do not have a lithic contact within 50 cm of the soil surface; and

d. Have base saturation (by NH_4OAc) of 60 percent or more in some part of the soil between depths of 25 cm and 75 cm below the soil surface.

Aquic Xerorthents are like Typic Xerorthents except for *a*.

Aquic Durorthidic Xerorthents are like Typic Xerorthents except for *a* and *b*.

Durorthidic Xerorthents are like Typic Xerorthents except for *b*.

Dystric Xerorthents are like Typic Xerorthents except for *d*.

Lithic Xerorthents are like Typic Xerorthents except for *c* or for *c* and *d*.

Description of subgroups

Typic Xerorthents.—The central concept or typic subgroup of Xerorthents is fixed on soils that are moderately deep or deep to hard rock, do not have ground water within a depth of 1.5 m, and do not have appreciable cementation by silica. The most common of these soils has a thin ochric epipedon that rests on soft rock or on sediment.

Soils that have a shallow lithic contact are excluded from the typic subgroup, a convention used throughout the taxonomy. Soils that have weak cementation by silica are excluded because such soils are thought to represent intergrades to Durochrepts.

Aquic Xerorthents.—These soils have a zone of saturation with water within 1.5 m of the soil surface in most years. Mottles in the lower horizons are usually present but are not required. The soils are on low terraces in the western part of the United States and are not extensive. Most areas are irrigated and farmed.

Durorthidic Xerorthents.—These soils differ from those in the typic subgroup in having a horizon that contains 20 percent or more durinodes or is weakly cemented and is more than 15 cm thick. The soils in the United States occur mainly in eastern Washington where there is appreciable volcanic ash in the loess. They are used for small grain production and grazing.

Dystric Xerorthents.—These are the Xerorthents that occur in areas of relatively high rainfall. The soils have base saturation (by NH_4OAc) of <60 percent in some part of the soil between depths of 25 and 75 cm below the surface. These soils have coarse textures but they are excluded from Psamments because of the high content of coarse fragments and from Xerochrepts because the textures are coarser than is permitted in cambic horizons. They are of moderate extent in northwestern Washington in the United States and are in forests.

Lithic Xerorthents.—These soils have a lithic contact within 50 cm of the soil surface, normally within 25 cm of the surface. The soils otherwise are like Typic Xerorthents.

Psamments

These are mainly Entisols in poorly graded (well sorted) sands of shifting or stabilized sand dunes, in cover sands, or in sandy parent materials that were sorted in an earlier geologic cycle (plate 4A). A few are in sands that were sorted by water and are on sandy natural levees or beaches. The Psamments occur under any climate or vegetation and on surfaces of virtually any age from recent historic to Pliocene or older. The Psamments of old stable surfaces consist of quartz sand, which cannot form diagnostic horizons that involve accumulation of clays or sesquioxides. Ground water is deeper than 50 cm and usually is much deeper.

The Psamments have low water-holding capacity, and when dry and bare, they are subject to blowing and drifting and support wheeled vehicles poorly. Because gravelly and very gravelly sands do not have the two qualities just described, they are excluded from Psamments and are grouped with Orthents. Thus, not all Entisols that have sandy texture are Psamments. Most of the excluded soils are in arid regions. They may be in gravelly or very gravelly materials deposited by rapidly flowing water.

Definition

Psamments are the Entisols that

1. Have below the bottom of the Ap horizon or a depth of 25 cm, whichever is deeper, a sandy particle-size class in all subhorizons, either to a depth of 1 m or to a lithic, paralithic, or petroferric contact, whichever is shallower, except for thin lamellae [19] in which clay may have accumulated but the lamellae are too few or too thin to be an argillic horizon;
2. Have <35 percent (by volume) of gravel or coarser fragments in all subhorizons;
3. Do not have fragments of diagnostic horizons that can be identified and that occur more or less without discernible order in the soil below any Ap horizon but normally insoluble crystalline minerals that do not weather to liberate iron or aluminum.

Quartzipsamments, p. 203

JCD. Other Psamments that have a udic moisture regime and mean summer and mean winter soil temperatures at a depth of 50 cm that differ by 5° C or more.

Udipsamments, p. 205

JCE. Other Psamments that have a udic moisture regime.

Tropopsamments, p. 205

JCF. Other Psamments that have a xeric moisture regime.

Xeropsamments, p. 207

JCG. Other Psamments.

Ustipsamments, p. 207

Cryopsamments

These are the Psamments of cold places. In the United States they are primarily in high mountains and in Alaska. Generally they have, or had before they were disturbed, a coniferous or tundra vegetation. Because they are both cold and sandy, they have had low priority for study. Their extent, at least in Alaska, is not known at present. Most of them are in deposits of late-Pleistocene or recent age.

Definition

Cryopsamments are the Psamments that have a cryic or a pergelic temperature regime.

Distinctions between Typic Cryopsamments and other subgroups

Typic Cryopsamments are the Cryopsamments that

a. Do not have lamellae within 1.5 m of the soil surface that meet all requirements for an argillic horizon except thickness;
b. Do not have mottles that have chroma of 2 or less within 50 cm of the soil surface;
c. Have a mean annual soil temperature that is higher than 0° C;
d. Do not have a lithic contact within 50 cm of the soil surface; and
e. Do not have an albic horizon that is 5 cm or more thick and underlain by a horizon that has a color value one unit or more darker and that meets all requirements of a spodic horizon except the index of accumulation.

Alfic Cryopsamments are like Typic Cryopsamments except for *a*.

Aquic Cryopsamments are like Typic Cryopsam-

sent a transition to Boralfs. Shallow mottles of low chroma and short periods of saturation in the mottled horizon are considered features of the intergrades to Psammaquents. A soil that has an albic horizon underlain by a darker horizon that meets all requirements of a spodic horizon except the index of accumulation is considered an intergrade to the Spodosols.

faces. They also occur on late-Pleistocene and younger surfaces. The absence of distinct horizons in the soils on very old surfaces may, in some places, be more apparent than real. A spodic horizon is known to lie beneath white sand, particularly in intertropical areas, at a depth of several meters, so deep that the determination of its presence or absence is not practical. The

a. Do not have mottles above a depth of 1 m that have chroma of 2 or less or, if the color is due to uncoated sand grains, do not have the water table within 1 m of the soil surface for as many as 60 days, cumulative, in most years;
b. Do not have an albic horizon[20] at the surface or immediately under an A1 or an Ap horizon that is underlain by another horizon that has a color value more than one unit darker or chroma of 6 or more;
c. Do not have a lithic contact within 50 cm of the soil surface;
d. Have a clay fraction that has a higher CEC than that of the clay of an oxic horizon or >25 percent of the surfaces of sand grains are uncoated;
e. Have <5 percent plinthite in all horizons above a depth of 1 m; and
f. Have a udic moisture regime.

Aquic Quartzipsamments are like Typic Quartzipsamments except for *a*.

Haplaquodic Quartzipsamments are like Typic Quartzipsamments except for *a* and *b*. They have a ground-water table that is within 1 m of the soil surface for 6 months or more in most years or are artificially drained. The mean winter and mean summer soil temperatures at a depth of 50 cm differ by 5° C or more. These soils are considered intergrades to Haplaquods. A buried A1 horizon that does not meet the requirements for a spodic horizon does not satisfy the definition of this subgroup.

Lithic Quartzipsamments.—These soils have a lithic contact, usually on quartzite, within 50 cm of the soil surface. They are otherwise like the Typic Quartzipsamments.

Orthoxic Quartzipsamments.—These soils have a clay fraction that meets all requirements for an oxic horizon, but the amount of clay is too small for an oxic horizon. These soils are not known to exist in the

coated, mottles normally are absent. These soils are considered intergrades to Psammaquents.

Haplaquodic Quartzipsamments.—These soils have an albic horizon that is underlain by horizons that have a color value at least one unit darker or have chroma of 6 or more but have too little accumulation of amorphous materials to meet the requirements for a spodic horizon. These soils also have ground water within 1 m of the surface for 6 months or more each year or have been artificially drained. The mean winter and mean summer soil temperatures at a depth of 50 cm differ by 5° C or more. These soils are considered intergrades to Haplaquods. A buried A1 horizon that does not meet the requirements for a spodic horizon does not satisfy the definition of this subgroup.

Lithic Quartzipsamments.—These soils have a lithic contact, usually on quartzite, within 50 cm of the soil surface. They are otherwise like the Typic Quartzipsamments.

Orthoxic Quartzipsamments.—These soils have a clay fraction that meets all requirements for an oxic horizon, but the amount of clay is too small for an

torric moisture regime and a soil temperature regime warmer than cryic.

Pedon 69 illustrates the central concept or typic subgroup of Torripsamments.

Distinctions between Typic Torripsamments and other subgroups

Typic Torripsamments are the Torripsamments that
a. Do not have a lithic contact within 50 cm of the soil surface;
b. Do not have a horizon within 1 m of the surface that is >15 cm thick and either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist; and
c. Are dry in all parts of the moisture control section three-fourths or more of the time (cumulative) that the soil temperature at a depth of 50 cm is 5° C or higher.

Durorthidic Xeric Torripsamments are like Typic Torripsamments except for *b* and *c*, and they have a thermic, mesic, or frigid soil temperature regime and a torric moisture regime that borders on xeric.

Lithic Torripsamments are like Typic Torripsamments except for *a* or for *a* and *c*.

Ustic Torripsamments are like Typic Torripsamments except for *c*, and they have a torric moisture regime that borders on an ustic regime.

Xeric Torripsamments are like Typic Torripsamments except for *c*, and they have a thermic, mesic, or frigid soil temperature regime and a torric moisture regime that borders on an xeric regime.

Description of subgroups

Typic Torripsamments.—The typic subgroup consists of the Torripsamments that have little available moisture, do not have evident cementation by silica, and have a moderately thick or thick regolith. The limitation on moisture restricts the subgroup to the drier part of the range of the great group. The restriction against a lithic contact is the same one that is applied in typic subgroups throughout the taxonomy.

Durorthidic Xeric Torripsamments.—These soils have a moisture regime that is not so dry as that of the typic subgroup. Much of the precipitation falls in the cool winter months. The soils have within 1 m of the surface a horizon that contains 20 percent or more durinodes or is weakly cemented and is more than 15 cm thick. Volcanic ash and pyroclastic material are present in these gently sloping soils. They occur in small areas in Nevada in the United States and are used for grazing.

Lithic Torripsamments.—These soils are less than 50 cm deep to a lithic contact. Because they are shallow, a wider range in the moisture regime is permitted than in other Torripsamments. Small areas of the soils are in mountain valleys in the western United States and are used for grazing.

Ustic Torripsamments.—These soils have a moisture regime that borders on ustic. Most of the soils in this subgroup have two short rainy seasons and two long dry seasons each year. The longer rainy season is less than 3 months, or it has only showers of erratic distribution so that the moisture control section dries between rains.

Xeric Torripsamments.—These soils have a moisture regime that borders on xeric. The rainy season is in winter and summer is very dry, but the supply of winter moisture is dependable and the soils are capable of supporting more vegetation than soils of the typic subgroup. The level of organic matter may be higher than in Typic Torripsamments but does not need to be higher in the soils of shifting dunes.

Tropopsamments

These are Psamments that have some weatherable minerals, a udic moisture regime, and an iso temperature regime. They are mostly in post-Pleistocene deposits on coastal plains and on flood plains of rivers. They have had a vegetation of evergreen forests, but many are being cultivated. These sands in the United States have sand-size fragments of basic rocks or have carbonates. The classification suggested here must be considered provisional and incomplete.

The Tropopsamments were considered Regosols in the 1938 classification. They are not extensive in the United States.

Definition

Tropopsamments are the Psamments that
1. Have a udic moisture regime;
2. Have an isomesic or warmer iso temperature regime; and
3. Have in the sand fraction <95 percent quartz, zircon, tourmaline, rutile, and other normally insoluble crystalline minerals that do not weather to liberate iron or aluminum.

Distinctions between Typic Tropopsamments and other subgroups

Typic Tropopsamments are the Psamments that
a. Do not have a lithic contact within 50 cm of the soil surface; and
b. Do not have mottles above a depth of 1 m that have chroma of 2 or less, or if the color is due to uncoated sand grains, have a ground-water table within 1 m of the soil surface for less than 60 cumulative days in most years.

Aquic Tropopsamments are like Typic Tropopsamments except for *b*.

Lithic Tropopsamments are like Typic Tropopsamments except for *a*.

Description of Typic Tropopsamments

The central concept or typic subgroup of Tropopsamments is fixed on soils that have deep ground water and a thick regolith. This concept is in line with that of the typic subgroups of other Psamments. Only Typic Tropopsamments are known to occur in the United States. The other two subgroups are provided for use in other countries.

Udipsamments

These are the Psamments (plate 4A)—of humid re-

gions in midlatitudes. They are mostly brownish and freely drained, and they have some weatherable minerals (>5 percent) in the sand fraction. They are predominantly in late-Pleistocene or more recent deposits. Most of them have had a vegetation of deciduous forests, but a few have been cultivated ever since the sands were deposited. Others have been cultivated for a very long time. These soils are extensive in the United States. They were mostly considered Regosols in the 1938 classification as modified in 1949, but a few were considered Podzols and Brown Podzolic soils and a few were considered Alluvial soils.

Definition

Udipsamments are the Psamments that

1. Have a soil temperature warmer than that of Cryopsamments and have mean summer and mean winter soil temperatures at a depth of 50 cm that differ by 5° C or more;
2. Have a udic moisture regime; and
3. Have in the sand fraction <95 percent quartz, zircon, tourmaline, rutile, and other normally insoluble minerals that do not weather to liberate iron or aluminum.

Description of a Typic Udipsamment

A description of a soil that represents the central concept or typic subgroup of Udipsamments follows. This soil, in Waushara County, Wis., formed in Late Wisconsinan outwash. It formerly had an oak forest but is now cultivated. The slope is nearly level. The mean annual precipitation is about 775 mm, and the mean annual air temperature is about 8° C. The colors are those of the moist soil.

Ap 0–20 cm. Brown (10YR 4/3) loamy sand; weak medium granular structure; very friable (moist); medium acid; abrupt smooth boundary.

[illegible]

depth of 18 cm and is underlain by a horizon that has a color value one unit or more darker and that meets all requirements for a spodic horizon except the index of accumulation; and

e. Do not have a surface horizon between 25 and 50 cm thick that meets all requirements for a plaggen epipedon except thickness.

Alfic Udipsamments are like Typic Udipsamments except for *a* and have base saturation of 35 percent or more in some horizon <1.25 m below the uppermost lamella or have a frigid temperature regime.

Aquic Udipsamments are like Typic Udipsamments except for *b* or for *a* and *b*.

Lithic Udipsamments are like Typic Udipsamments except for *c*.

Plaggeptic Udipsamments are like Typic Udipsamments except for *e*.

Spodic Udipsamments are like Typic Udipsamments except for *d*.

Ultic Udipsamments are like Typic Udipsamments except for *a*, have base saturation of <35 percent in some horizon <1.25 m below the uppermost lamella, and have a mesic or warmer temperature regime.

Description of subgroups

Typic Udipsamments.—The central concept or typic subgroup of Udipsamments is fixed on soils that have a thick regolith, have deep ground water, do not have an albic horizon that has a weak accumulation of amorphous materials below it, do not have lamellae in which silicate clays have accumulated, and do not have a thin epipedon (<50 cm) that meets all the requirements of a plaggen epipedon except thickness.

The soils that have a lithic contact within 50 cm of the soil surface are excluded from the typic subgroup as they are throughout the taxonomy. Soils that are saturated with water within a depth of 1 m and have

low chroma (2 or less) within 1 m of the soil surface. They have or may not have lamellae within 1.5 m of the surface. They are otherwise like Typic Udipsamments.

Lithic Udipsamments.—These soils have a lithic contact within 50 cm of the soil surface but are otherwise like the Typic Udipsamments.

Plaggeptic Udipsamments.—These soils are not known to occur in the United States, but the subgroup is provided for other countries.

Spodic Udipsamments.—Soils in this group have an albic horizon underlain by a horizon that is at least one unit darker in color value and that meets all requirements for a spodic horizon except the index of accumulation. The albic horizon is commonly very distinct, but the B horizon containing amorphous material is thin or faint and does not contain a significant amount of the amorphous material. These soils are considered to be developing toward Spodosols or to be more or less in equilibrium between Psamments and Spodosols, usually Orthods in the United States.

In Europe another kind of spodic subgroup of Udipsamments exists, one that consists of soils in which a former spodic horizon has been largely but not completely destroyed. These soils require a different name and definition.

Ultic Udipsamments.—These soils have lamellae in which clay has accumulated in the form of oriented coatings on the sand grains, but either the lamellae are <1 cm thick or those that are thicker are too few to meet the requirements for an argillic horizon. The

a. Do not have lamellae within 1.5 m of the soil surface that meet all requirements for an argillic horizon except thickness;[22]
b. Do not have distinct or prominent mottles above a depth of 1 m and are not saturated with water within 1 m of the surface during any time of year in most years; and
c. Do not have a lithic contact within 50 cm of the surface.

Alfic Ustipsamments are like Typic Ustipsamments except for *a*, have base saturation of 35 percent or more in some horizon <1.25 m below the uppermost lamella, and have a color value, moist, of 4 or more within 25 cm of the surface.

Aquic Ustipsamments are like Typic Ustipsamments except for *b*.

Lithic Ustipsamments are like Typic Ustipsamments except for *c*.

Description of subgroups

Typic Ustipsamments.—The central concept or typic subgroup of Ustipsamments is fixed on the sands that have deep ground water and a thick regolith and do not have lamellae in which silicate clays have accumulated. Normally the sands are a mixture of quartz and feldspars.

Lamellae in which silicate clays have accumulated are not permitted because the lamellae are considered to indicate intergrades to soils that have an argillic horizon. Soils that have a lithic contact within 50 cm

in the sand fraction. These soils are moist in winter and very dry in summer. They are freely drained. Most of them are in Late Wisconsinan or more recent deposits. Some are on terraces and glacial outwash plains. Others are in dunes, but because the supply of winter moisture is reliable, few of the dunes are shifting. Some of these soils have had a coniferous vegetation, but most have had and still have a mixture of grasses and xerophytic shrubs or trees. They are moderately extensive soils in parts of the western states of the United States. They were considered Regosols in the 1938 classification as modified in 1949.

Definition

Xeropsamments are the Psamments that

1. Have a xeric moisture regime and a soil temperature regime warmer than cryic;
2. Have in the sand fraction <95 percent quartz, zircon, tourmaline, rutile, and other normally insoluble minerals that do not weather to liberate iron or aluminum.

Description of a Typic Xeropsamment

A description of a soil that represents the central concept or typic subgroup of Xeropsamments follows. This soil, in Santa Barbara County, Calif., has a cover of small live oak, brush, and annual grasses. The mean annual air temperature is about 15° C. The annual precipitation is about 450 mm, almost all of which comes between October and April. The parent material is a very soft sandstone. Colors are those of the dry soil unless otherwise stated.

O1 Incomplete cover of twigs and leaves.

A11 0–5 cm. Light brownish gray (10YR 6/2) loamy sand, dark gray (10YR 4/1) moist; weak fine granular structure; soft (dry), very friable (moist), nonsticky and nonplastic (wet); common fine roots; many very fine and few fine interstitial pores; many fine flakes of organic matter; medium acid (pH 6.0); clear wavy boundary.

A12 5–30 cm. Light brownish gray (10YR 6/2) loamy sand, dark grayish brown (10YR 4/2) moist; massive when moist, single grain when dry; soft (dry), very friable (moist), nonsticky and nonplastic (wet); few very fine and very few medium roots; many very fine interstitial pores; medium acid (pH 6.0); diffuse smooth boundary.

A13 30–60 cm. Light brownish gray (10YR 6/2) sand, dark grayish brown (10YR 4/2) moist; massive when moist, single grain when dry; soft (dry), very friable (moist), [illegible] (wet); similar to horizon [illegible] lowish red (5YR 5/6) moist; continuous moderately thick clay skins in bridges and pores of hard fragments.

Distinctions between Typic Xeropsamments and other subgroups

Typic Xeropsamments are the Xeropsamments that

a. Do not have lamellae within 1.5 m of the soil surface that meet all requirements for an argillic horizon except thickness;[23]

b. Do not have distinct or prominent mottles above a depth of 1 m and are not saturated with water within 1 m of the surface during any time of year in most years;

c. Do not have a horizon within 1 m of the surface that is >15 cm thick and that either contains 20 percent or more durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

d. Do not have a lithic contact within 50 cm of the soil surface; and

e. Have base saturation (by NH_4OAc) of 60 percent or more in some part of the soil between depths of 25 cm and 75 cm below the soil surface.

Alfic Xeropsamments are like Typic Xeropsamments except for *a* and have base saturation of 35 percent or more in some horizon <1.25 m below the uppermost lamella.

Aquic Xeropsamments are like Typic Xeropsamments except for *b*.

Aquic Durorthidic Xeropsamments are like Typic Xeropsamments except for *b* and *c*.

Dystric Xeropsamments are like Typic Xeropsamments except for *e*.

Lithic Xeropsamments are like Typic Xeropsamments except for *d* or for *d* and *e*.

Description of subgroups

Typic Xeropsamments.—The central concept or typic subgroup of Xeropsamments is fixed on sands that have deep ground water and a thick regolith, do not have evident cementation with silica, and do not have lamellae in which silicate clay has accumulated. Normally the sands are mixtures of quartz and feldspars.

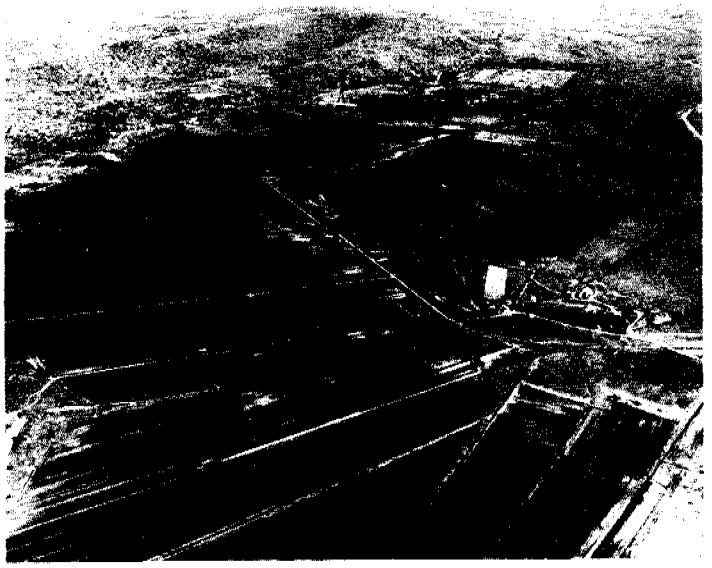
No lamellae in which silicate clay has accumulated are permitted in the typic soils because the lamellae are considered to indicate intergrades to soils that have an argillic horizon, usually Xeralfs. Soils that

Aquic Xeropsamments.—These soils are saturated with water at some time during the year and have mottles of low chroma within 1 m of the soil surface. They are otherwise like Typic Xeropsamments. They are not extensive soils in the United States.

Aquic Durorthidic Xeropsamments.—These soils have evidence of weak cementation by silica in the form of durinodes or of a horizon >15 cm thick that has firm and brittle consistence. They normally have an appreciable amount of pyroclastics in the sand fraction. In addition, they are saturated with water at some time during the year and have mottles of low chroma within 1 m of the soil surface, but the moisture regime is marginal to torric.

Dystric Xeropsamments.—These are Xeropsamments that are in areas with relatively high rainfall during the winter months. As a consequence, the base saturation is lower than for soils in the typic subgroup. These soils are not extensive. They are in the Pacific Northwest of the United States where they support forests.

Lithic Xeropsamments.—Soils in this subgroup have a lithic contact within 50 cm of the surface but are otherwise like Typic Xeropsamments.



CHAPTER 11

Histosols

Histosols are soils that are dominantly organic. They are mostly soils that are commonly called bogs, moors, or peats and mucks. A very few consist of shallow organic materials resting on rock or rubble. Histosols that are saturated with water contain at least 12 or 18 percent organic carbon by weight, depending on the clay content of the mineral fraction and kind of materials. Those that are never saturated with water other than for a few days contain 20 percent or more organic carbon by weight. Histosols are well over half organic matter by volume. More than half of the upper 80 cm of a Histosol consists of organic materials unless the depth to rock or to fragmental materials is <80 cm, a rare condition, or the bulk density is very low.

Most Histosols by far are saturated or nearly saturated with water most of the year unless they have been drained. At the extreme, the soil may be only an organic mat that floats on water. In cool, very humid climates it is common that the soil consists primarily of *Sphagnum* spp. and other plants that are kept wet by rainwater. In this situation the Histosols may blanket a dissected landscape. Water does not stand on the surface, but free water is present only a few centimeters below. These soils have been called blanket bogs, high moors, or raised peats. Figure 23 shows the landscape of a blanket bog. Plate 8D is a photograph of such a soil.

Histosols can form in virtually any climate, even in arid regions, so long as water is available. Some are underlain by permafrost and some are on the Equator. They may be in closed depressions, in coastal marshes, or on steep slopes where there is seepage, or they may blanket a dissected landscape. The common feature is water, which may come from any source. The blanket bogs are present only in cool and very humid climates but no other climatic feature is necessary for the presence or absence of Histosols. Vegetation consists of a very wide variety of water-loving or water-tolerant plants.

The classification of Histosols that follows must be considered provisional. The taxa of most other orders have been tested insofar as the soils of the United States permit. The classification of Histosols, however, has had relatively little testing. It differs significantly from the 1938 classification, and the definitions of most series of Histosols that were recognized before 1968 require revision. It is believed that most of the subgroups exist, but only a little is known about the significance of some of the differentiae used to distinguish subgroups and taxa in lower categories. In addition, laboratory methods for the study of Histosols have received relatively little attention and either do not exist or have not been generally tested and accepted.

In general, the suborders of Histosols are defined by the moisture regime and by the degree of decomposition of the organic materials. The degree of decomposition is closely related to bulk density and to the initial subsidence that takes place within 2 or 3 years after drainage. The great groups are defined in part by the soil temperature regime. Soil temperature is emphasized because it is important to the rate of decomposition and disappearance of the organic materials (and of the Histosol) if the soil is drained and used. The warmer the soil, the shorter its existence under use, even under careful management. The Histosols were called Bog soils and Lithosols in the 1938 classification.

Definition

Histosols are soils that

1. Have organic soil materials that extend from the surface to one of the following:
   a. A depth within 10 cm or less of a lithic or paralithic contact, provided the thickness of the organic soil materials is more than twice that of the mineral soil above the contact; or
   b. Any depth if the organic soil material rests on fragmental material (gravel, stones, cobbles) and interstices are filled with organic materials, or rests on a lithic or paralithic contact; or
2. Have organic materials that have an upper boundary within 40 cm of the surface and
   a. Have one of the following thicknesses:
      (1) 60 cm or more if three-fourths or more of the volume is moss fibers or the moist bulk

density is <0.1 g per cubic centimeter (6.25 lbs per cubic foot);

(2) 40 cm or more if

(a) The organic soil material is saturated with water for long periods (>6 months) or is artificially drained; and

(b) The organic material consists of sapric or hemic materials or consists of fibric materials that are less than three-fourths moss fibers by volume and have a moist bulk density of 0.1 or more; and

b. Have organic soil materials that:

(1) Do not have a mineral layer as much as 40 cm thick either at the surface or whose upper boundary is within a depth of 40 cm from the surface; and

(2) Do not have mineral layers, taken cumulatively, as thick as 40 cm within the upper 80 cm.

The general rule is that, unless the surface tier has a bulk density <0.1, a soil is classed as a Histosol if half or more of the upper 80 cm is organic, and that it is classed as a Histosol without regard to thickness of organic materials if these rest on rock or on fragmental material in which the interstices are filled or partially filled with organic materials. If the bulk density is very low, <0.1, three-fourths or more of the upper 80 cm must be organic.

Horizon designations for Histosols

The following designations are used for horizons of Histosols:

Oi for fibric material
Oe for hemic material
Oa for sapric material
Lca for marl
Lco for coprogenous earth
Ldi for diatomaceous earth
f for frozen organic materials
p for plow layer
cn for ferrihumic material

An example of a horizon sequence in a Histosol that contains mineral strata is as follows: Oi1, IIC1, Oi2, IIC2, Oe1, Oe2, IIC3, IIIC4.

Key to suborders

AA. Histosols that

1. Are never saturated with water for more than a few days following heavy rains and

a. Have a lithic or paralithic contact <1 m from the surface or have fragmental materials in which the interstices are filled or partly filled with organic materials in half or more of each pedon, or both; and

b. Less than three-fourths of the thickness of organic materials consists of *Sphagnum* fibers.

Folists, p. 217

AB. Other Histosols that

1. Are dominantly[1] fibric in the subsurface tier if that tier is wholly organic except for a thin mineral layer or layers, or the organic parts of the surface and subsurface tiers are dominantly fibric if a continuous mineral layer 40 cm or more thick begins within the depth limit of the subsurface tier; or

2. Have a surface mantle that has three-fourths or more of its volume consisting of fibers derived from *Sphagnum* and that rests on a lithic or paralithic contact, fragmental materials, or mineral soil, or on frozen[2] materials within the limits in depth of the surface or subsurface tier; and

3. Do not have a sulfuric horizon whose upper boundary is within 50 cm of the surface and do not have sulfidic materials within 1 m of the surface.

Fibrists, p. 212

AC. Other Histosols that

1. Are dominantly hemic in the subsurface tier if that tier is wholly organic except for a thin mineral layer or layers; or are dominantly hemic in the organic part of the surface and subsurface tiers if a continuous mineral layer 40 cm or more thick begins within the depth limits of the subsurface tier; or

2. Have a sulfuric horizon whose upper boundary is within 50 cm of the surface or have sulfidic materials within 1 m of the surface.

Hemists, p. 219

AD. Other Histosols.

Saprists, p. 223

Fibrists

The Fibrists consist largely of plant remains so little decomposed that they are not destroyed by rubbing and their botanic origin can be readily determined. The Fibrists may consist either of partly decomposed wood or of remains of mosses and herbaceous plants such as grasses, sedges, and papyrus, or of mixtures of these materials. The reasons why the plant remains have been preserved probably vary, but absence of oxygen is perhaps the most important. If the water level fluctuates appreciably within the soil, decomposition rapidly destroys the fibers. Some plant remains seem more resistant to decomposition than others. The wood of cypress *(Taxodium distichum)*, for example, is more resistant than many woods or most grasses and sedges.

The Fibrists (plate 8D) tend to have the lowest bulk density and the lowest ash content of the Histosols, although there are some exceptions. Fibrists may have a high ash content, particularly if they receive repeated ash falls from nearby volcanoes. If there is no source of eolian sediments, however, the ash content normally is low. The bulk density usually is <0.1. The Fibrists were called Bog soils in the 1938 classification.

Definition

Fibrists are the Histosols that either

1. Are saturated with water for 6 months or more of the year or are artificially drained and have fibric soil materials that are

a. Dominant in the organic part of the control section if there is a mineral layer (or layers) 40 cm or more thick whose upper boundary is in the subsurface tier, or if a lithic or paralithic contact

[1] Dominant, in this context, means the most abundant. If only two kinds of organic materials are present, the fibric materials occupy half or more of the volume. If there are both hemic and sapric materials as well as fibric, the fibric materials may occupy less than half of the volume but have more volume than either the hemic or sapric materials.

[2] Frozen 2 months after the summer solstice.

occurs in the subsurface tier, or if the soil is frozen about 2 months after the summer solstice at a depth of <25 cm above the base of the subsurface tier; or

b. Dominant in the subsurface tier if there is no continuous mineral layer 40 cm or more thick whose upper boundary is in that tier; or

2. Have fibric material that is three-fourths or more (by volume) derived from *Sphagnum* spp. and that either makes up the upper 90 cm or more of the soil or rests on a lithic or paralithic contact, fragmental ma-

2. Are not frozen in most years in the control section about 2 months after the summer solstice but are frozen below a depth of 5 cm within the soil at some time in most years;

3. Have less than three-fourths of their fiber volume derived from *Sphagnum* either in the upper 90 cm or more of the control section or in the soil above a lithic or paralithic contact, fragmental materials, or mineral soil materials that are shallower than 90 cm;

4. Do not have a horizon 2 cm or more thick of humilluvic materials in the control section.

Description of Typic Borofibrists

The central concept or typic subgroup of Borofibrists is fixed on soils that have thick, continuous fibric materials and only a thin surface layer or none derived from *Sphagnum*. If present, such a surface layer normally is <30 cm thick. There is therefore little or no problem with movement of water through the soil.

Layers that are more thoroughly decomposed affect the movement of water and indicate intergrades to Hemists and Saprists. Thin mineral layers normally retard the movement of water drastically. Because these layers most commonly have been deposited by floods, soils that have them are considered intergrades to Fluvaquents. Thick mineral layers, rock, limnic layers, and water layers within the control section are the bases for classifying terric, lithic, limnic, and hydric extragrades, respectively. If the surface tier is predominantly *Sphagnum*, the soil is considered an intergrade to the Sphagnofibrists.

Cryofibrists

These are cold Fibrists. The fibers may be derived from any plant, woody or herbaceous, but less than three-fourths of the fiber volume is derived from *Sphagnum*. The soils may have ice that persists within the control section more than 2 months after the summer solstice under a continental climate, or they may have a pronounced oceanic climate in which the soil does not freeze during winter in most years but is cold in summer. In either situation, the low temperatures limit the use of the soil. The definition of this group differs slightly from that of other cryic great groups because the soil temperature regimes of Histosols differ somewhat from those of mineral soils.

Definition

Cryofibrists are the Fibrists that

1. Are frozen in most years in some layer within the control section about 2 months after the summer solstice, or are not frozen in most years at any time below a depth of 5 cm but have a mean annual soil temperature lower than 8° C; and
2. Have less than three-fourths of the fiber volume derived from *Sphagnum* spp. either in the upper 90 cm or more of the control section, or in the soil above a lithic or paralithic contact, fragmental materials, or mineral soil materials shallower than 90 cm, or in the organic material that extends 10 cm or more below permafrost.

Distinctions between Typic Cryofibrists and other subgroups

Typic Cryofibrists are the Cryofibrists that

a. Have less than three-fourths of their fiber volume derived from *Sphagnum* spp. in the surface tier or more of the control section;
b. Have a mean annual soil temperature higher than 0° C;
c. Do not have a lithic contact within the control section;
d. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;
e. Do not have a mineral layer 30 cm or more thick whose upper boundary is below the surface tier in the control section; and
f. Have organic materials that are continuous laterally throughout each pedon in at least the surface tier.

Fluvaquentic Cryofibrists are like Typic Cryofibrists except for *d*.

Lithic Cryofibrists are like Typic Cryofibrists except for *c*, with or without *a* or both *a* and *b*.

Pergelic Cryofibrists are like Typic Cryofibrists except for *b*, with or without any or all of *a*, *d*, or *e*.

Sphagnic Cryofibrists are like Typic Cryofibrists except for *a*.

Terric Cryofibrists are like Typic Cryofibrists except for *e* or for *d* and *e*.

Description of Typic Cryofibrists

The central concept or typic subgroup of Cryofibrists is fixed on soils that consist of thick, continuous organic materials, that have only a thin surface layer, normally <30 cm thick, that was derived from *Sphagnum*, or none, and that do not have permafrost. Because the soils are so cold, layers of more decomposed materials are considered relatively unimportant.

Thin layers of mineral materials have a greater effect on water movement than do layers of decomposed organic material. Because mineral layers have been deposited most commonly by water, the soils that have them are considered intergrades to Fluvaquents. Thick mineral layers, rock, and permafrost within the control section are bases for classifying, respectively, the terric, lithic, and pergelic extragrades.

Luvifibrists

Luvifibrists are not known to occur in the United States, but the great group is provided tentatively for use in other countries if needed. These soils are the Fibrists that have a horizon within the control section that is 2 cm or more thick and is half or more humilluvic materials. Because these soils cannot be studied in the United States, a precise definition is not attempted here. It should be noted, however, that the soils normally are acid and that they have been cultivated for a long time.

Medifibrists

These are the Fibrists of midlatitudes. Their temperature regime is mesic, thermic, or hyperthermic. Their moisture regime is aquic unless the soils have been drained. The fibers may have been derived from wood, from grasses, sedges, and other herbaceous plants, or from mixtures of these. If these soils are drained and cultivated under the present technology, the organic materials will decompose and disappear either slowly or rapidly, depending on the management used and the temperature. Eventually, within some decades, the Medifibrists, if they are drained and cultivated, will be replaced by mineral soils.

A very few Fibrists with a mesic temperature regime that is close to frigid are grouped with Sphagnofibrists if the fibric materials are derived from *Sphagnum* spp.

Definition

Medifibrists are the Fibrists that

1. Have a mean annual soil temperature that is 8° C or higher and mean summer and mean winter soil temperatures at a depth of 30 cm or at a lithic or paralithic contact, whichever is shallower, that differ by 5° C or more:

d. Do not have a lithic contact within the control section;

e. Do not have a mineral layer between 5 cm and 30 cm thick within organic materials or do not have two or more thin continuous mineral layers in the control section below the surface tier;

f. Do not have a mineral layer 30 cm or more thick whose upper boundary in the control section is below the surface tier; and

g. Do not have a layer of water within the control section beneath the surface tier.

Fluvaquentic Medifibrists are like Typic Medifibrists

upper 90 cm of the soil or throughout the soil if there is a lithic or paralithic contact shallower than 90 cm or the soil is frozen within a depth of 1 m about 2 months after the summer solstice. Sphagnofibrists may have permafrost. A few have a mesic soil temperature regime that borders on frigid, but in general the soils are cool or cold. Most of them have a frigid or cryic temperature regime. The structure of *Sphagnum* with its water-holding cells, makes these soils unique, and for that reason they are grouped as Sphagnofibrists.

Definition

Sphagnofibrists are the Fibrists that

1. Have three-fourths or more of their fiber volume derived from *Sphagnum* in the upper 90 cm or more of the control section, or above a lithic or paralithic contact, fragmental materials, or mineral soil shallower than 90 cm, or in the organic material that extends 10 cm or more below permafrost;
2. Do not have a horizon of humilluvic materials 2 cm or more thick.

Description of a Typic Sphagnofibrist

There follows a description of a soil that represents the central concept, or typic subgroup, of Sphagnofibrists. This soil, in Beltrami County, Minn., is on the crest of a raised bog. The crest is about 2 m higher than the nearest boundary of the bog and the mineral-soil uplands. The raised portion of the bog occupies about 4.5 sq km and has a rather dense stand of black spruce *(Picea mariana)*. The understory is sparse and consists primarily of Labrador tea *(Ledum groenlandicum)*. The surface is hummocky with the crest of the hummocks as much as 0.5 m higher than the intervening depressions. The surface is covered with mosses. Species of *Sphagnum* are dominant, but the higher hummocks commonly are covered with species of *Hypnum*. The mean annual precipitation is about 555 mm, and the mean annual air temperature is about 3° C.

Oi3 41–213 cm. Reddish brown (5YR 4/4) (broken face) fibric material, brown (7.5YR 5/4) (pressed), light yellowish brown (10YR 6/4) (rubbed); about 95 percent fiber, about 90 percent after rubbing; moderate medium and coarse platy structure; nonsticky; all *Sphagnum* fiber; about 5 percent woody fragments; about 3 percent mineral material; about 4 percent thin layers of sapric material; extremely acid (pH ranges from 3.2 to 3.6 in different parts); gradual smooth boundary.

Oi4 213–345 cm. Dark reddish brown fibric material almost entirely *Sphagnum* fiber.

Distinctions between Typic Sphagnofibrists and other subgroups

Typic Sphagnofibrists are the Sphagnofibrists that

a. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin continuous mineral layers in the control section below the surface tier;

b. Have

(1) Less than 25 cm of the subsurface and bottom tiers occupied by hemic materials; and

(2) Less than 12.5 cm of the subsurface and bottom tiers occupied by sapric materials;

c. Do not have a layer of water within the control section beneath the surface tier;

d. Do not have limnic layer(s) that are 5 cm or more thick within the control section.

e. Do not have a lithic contact within the control section;

f. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;

g. Are never frozen within the control section about 2 months after the summer solstice or are never frozen below a depth of 5 cm in most years;

h. Have a mean annual soil temperature higher than 0° C.

Cryic Sphagnofibrists are like Typic Sphagnofibrists except for *g* and have a mean annual soil temperature lower than 8° C but higher than 0° C.

Fluvaquentic Sphagnofibrists are like Typic Sphag-

spp. At least three-fourths of the fibric materials, by volume, were derived from *Sphagnum*. These soils occur as raised bogs or high moors in closed depressions and as blanket bogs in more or less dissected landscapes. Figure 23 shows such a landscape.

Layers of organic material too thoroughly decomposed to be fibers affect movement of water and indicate intergrades to Hemists and Saprists. Thin mineral layers normally affect movement of water drastically. These layers normally are eolian deposits of ash or pumice, and their effect on classification of the soils is undetermined. Thick mineral layers, rock, limnic layers, water, or permafrost within the control section are used as bases for classifying terric, lithic, limnic, hydric, and pergelic extragrades, respectively.

Typic Sphagnofibrists are seldom cultivated. They serve as important sources of fuel and of mulches for gardening. They are rare in the United States but are moderately extensive in cool very humid climates.

Tropofibrists

These are the Fibrists that have an isomesic or warmer iso temperature regime. They occur in coastal mangrove swamps and other coastal swamps and in closed depressions of intertropical areas. If drained and cultivated, subsidence due to decomposition is rapid. Histosols that have a sulfuric horizon that has

b. Have less than three-fourths of their fibers, by volume, derived from *Sphagnum* in the surface tier or in more of the control section;
c. Do not have limnic layer(s) that are 5 cm or more thick within the control section;
d. Do not have a lithic contact within the control section;
e. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;
f. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier; and
g. Do not have a layer of water within the control section beneath the surface tier.

Fluvaquentic Tropofibrists are like Typic Tropofibrists except for *e*, with or without *a*.

Hemic Tropofibrists are like Typic Tropofibrists except for *a(1)*.

Hemic Terric Tropofibrists are like Typic Tropofibrists except for *a(1)* and *f*, with or without *c* or *e*, or both.

Hydric Tropofibrists are like Typic Tropofibrists except for *g*.

Limnic Tropofibrists are like Typic Tropofibrists except for *c*, with or without *a* or *e*, or both.

tudes. In the United States they are mostly in Hawaii and Alaska. There were some Folists in the northern lake states but they were destroyed almost completely

mercial timber cutting in the area.

Folists were considered Lithosols in the 1938 classification.

Definition

Folists are the Histosols that

1. Are never saturated with water[3] for more than a few days following heavy rains and have
   a. A lithic or paralithic contact <1 m from the surface or fragmental materials that have interstices filled or partially filled with organic materials, or both, in half or more of each pedon; and
   b. Have less than three-fourths of the thickness of organic materials consisting of *Sphagnum* spp. fibers; and
2. Do not have a mineral layer >10 cm thick above a lithic or paralithic contact; and the thickness of organic materials is more than twice that of the mineral layer; and
3. Have 20 percent or more organic carbon in their

Definition

Borofolists are the Folists that have a frigid tem-

Description of a Borofolist

There follows a description of a soil that illustrates the lithic subgroup of Borofolists. This soil, in Essex County, N.Y., is on a very steep mountain side 1,185 m above sea level. Vegetation is a dense scrub type of balsam-fir forest with an occasional red spruce. The annual precipitation is approximately 1,000 mm with a summer maximum, and the mean annual air temperature is approximately 1° C. Colors are those of the moist soil unless otherwise stated.

Oi 0–5 cm. Dark reddish brown (5YR 2/2) fibric material composed of loose fir needles and other litter, dark brown and brown (7.5YR 3/2 and 4/3) dry; many fibrous and fine and few medium and coarse roots in the lower part; about 92 percent organic material; extremely acid; abrupt smooth boundary.

Oe 5–13 cm. Dark reddish brown (5YR 2/2) hemic material, dark reddish brown (5YR 3/3) dry; slightly hard; many fibrous and fine, common medium, and few coarse roots; about 93 percent organic material; extremely acid; abrupt smooth boundary.

Oa1 13–28 cm. Black (5YR 2/1) sapric material, black (7.5YR 2/1) dry; moderate medium and coarse platy structure; slightly hard, friable; common fibrous and fine

tersheds, wildlife, recreation, and some forests. They are rare in the United States.

Cryofolists

These are the cold Folists. In the United States they occur in southeastern Alaska where the climate is cool, oceanic, and very humid. They are on gentle to very steep slopes. Their vegetation is primarily coniferous forests, and the only part of the soil in which there are plant roots is the O horizon. Beneath the O horizon there may be a few centimeters of mineral soil material or none on hard rock or there may be fragmental materials consisting of gravel, stones, and boulders with the interstices filled or partly filled with organic materials.

Definition

Cryofolists are the Folists that have a cryic or colder temperature regime.

Distinctions between Typic Cryofolists and other subgroups

Typic Cryofolists are the Cryofolists that
a. Have fragmental materials in which the interstices are filled or partly filled with organic materials in half or more of each pedon; and
b. Do not have a lithic contact within 1 m of the surface.

Lithic Cryofolists are like Typic Cryofolists except for *b* or for *a* and *b*.

Description of Typic Cryofolists

The central concept or typic subgroup of Cryofolists is fixed on soils that have organic materials resting on and filling or partly filling interstices in fragmental materials that consist of gravel, stones, and boulders. The soils on fragmental materials are not necessarily the most common in the great group, but they are classified as the typic subgroup because the presence of shallow hard rock is used throughout the taxonomy to define lithic subgroups.

Tropofolists

These are the Folists of intertropical regions that have isomesic or warmer temperature regimes. They occur in Hawaii, chiefly on lava flows in areas that have very high, well-distributed rainfall. The vegetation is mostly forest mixed with tree ferns.

Definition

Tropofolists are the Folists that have an isomesic or warmer iso temperature regime.

Distinctions between Typic Tropofolists and other subgroups

Typic Tropofolists are the Tropofolists that
a. Have fragmental materials in which the interstices are filled or partly filled with organic materials in half or more of each pedon; and
b. Do not have a lithic contact within 1 m of the surface.

Lithic Tropofolists are like Typic Tropofolists except for *b* or for *a* and *b*.

Description of Typic Tropofolists

The central concept or typic subgroup of Tropofolists is fixed on soils that have organic materials resting on and filling or partly filling interstices in fragmental materials that are chiefly aa lava. These soils are not necessarily the most common Tropofolists, but they are classified as the typic subgroup because the presence of shallow hard rock is used throughout the taxonomy to define lithic subgroups.

Hemists

These are primarily Histosols in which the organic materials have been decomposed enough that the botanic origin of as much as two-thirds of the materials cannot be readily determined or the fibers can be largely destroyed by rubbing between the fingers. The bulk density usually is between 0.1 and 0.2 g per cubic centimeter. The Hemists have an aquic or peraquic moisture regime, that is, ground water is at or very close to the surface nearly all the time unless artificial drainage has been provided. The level of ground water may fluctuate but seldom drops more than a few centimeters below the surface tier. Histosols that have a sulfuric horizon or sulfidic materials are included with Hemists without regard to the stage of decomposition of the organic materials.

Hemists occur from the Equator to the tundra regions in closed depressions and in broad, very poorly drained flat areas such as coastal plains. The Hemists were called Bog soils in the 1938 classification.

Definition

Hemists are the Histosols that are saturated with water for 6 months or more of the year or have artificial drainage and have one or more of the following features:
1. Hemic soil materials dominant[4] in the organic part of the control section if a mineral layer (or layers) 40 cm or more thick has an upper boundary in the subsurface tier, if a lithic or paralithic contact occurs in the subsurface tier, or if the soil is frozen about 2 months after the summer solstice at a depth of <25 cm above the base of the subsurface tier;
2. Hemic soil materials dominant in the subsurface tier if there is no continuous mineral layer 40 cm or more thick that has its upper boundary in that tier;
3. A sulfuric horizon that has its upper boundary within 50 cm of the surface or sulfidic materials within 1 m of the surface.

Key to great groups

ACA. Hemists that have a sulfuric horizon that has its upper boundary within 50 cm of the surface.

Sulfohemists, p. 222

[4] See footnote 1 on p. 212.

ACB. Other Hemists that have sulfidic materials within 1 m of the surface.

Sulfihemists, p. 222

ACC. Other Hemists that have a horizon 2 cm or more thick in which half or more of the volume is humilluvic materials.

Luvihemists, p. 221

ACD. Hemists that are frozen in some layers within the control section about 2 months after the summer solstice in most years or that are never frozen below a depth of 5 cm in most years but have a mean annual soil temperature lower than 8° C.

Cryohemists, p. 221

ACE. Other Hemists that have a mean annual soil temperature lower than 8° C.

Borohemists, p. 220

ACF. Other Hemists that have a difference of <5° C between mean summer and mean winter soil temperatures at a depth of 30 cm.

Tropohemists, p. 223

ACG. Other Hemists.

Medihemists, p. 221

Borohemists

These are the Hemists that have a frigid but not a cryic temperature regime. They do not have frost within the control section about 2 months after the summer solstice, but they have frost deeper than 5 cm in the soil in winter. The climate is continental or is borderline between continental and oceanic. Vegetation on the soil can be any woody or herbaceous plants. Experience indicates that these soils may be drained and used under careful management for long periods without great loss of the organic materials by decomposition.

Definition

Borohemists are the Hemists that

1. Have a mean annual soil temperature lower than 8° C;
2. Are not frozen in the control section about 2 months after the summer solstice in most years but are frozen below a depth of 5 cm (2 in.) within the soil at some time in most years;
3. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the surface and do not have sulfidic materials within 1 m of the surface.

Description of a Typic Borohemist

There follows a description of a soil that represents the central concept or typic subgroup of Borohemists. This soil, in Clare County, Mich., is in an undrained depression in a rather sandy Wisconsinan outwash plain. Vegetation is herbaceous acid-tolerant plants including some *Sphagnum*. The mean annual precipitation is about 750 mm, and the mean annual air temperature is about 6° C. The average air temperature in summer is about 19° C. The materials are dominantly hemic throughout. Most of the layers darken rapidly if exposed to air. The colors given are those of the freshly broken moist soil.

Oe1 0–12 cm. Dark reddish brown (5YR 3/3), dark reddish brown (5YR 3/2) when rubbed, hemic materials; about 55 percent fiber, about 25 percent after rubbing; weak thick platy structure; nonsticky; about 60 percent of the fibers are sphagnum and the remaining part is herbaceous; extremely acid; abrupt smooth boundary.

Oe2 12–48 cm. Very dark brown (10YR 2/2 on broken face and rubbed) hemic materials; about 40 percent fibers, 15 percent after rubbing; weak thick platy structure; nonsticky; 85 percent of fibers are herbaceous, and the others are wood or mosses; extremely acid; clear smooth boundary.

Oe3 48–70 cm. Dark brown (10YR 3/3 on broken face and rubbed) hemic materials; about 50 percent fibers, 25 percent after rubbing; weak thick platy structure; nonsticky; 85 percent of fibers are herbaceous and the others are wood; few woody fragments 1 to 6 inches in diameter; extremely acid; clear smooth boundary.

Oe4 70–150 cm. Dark reddish brown (5YR 3/3 on broken face and rubbed) hemic materials; about 60 percent fibers, 30 percent after rubbing; massive; nonsticky; about 90 percent of fibers are herbaceous and a few are woody fragments; very strongly acid.

Distinctions between Typic Borohemists and other subgroups

Typic Borohemists are the Borohemists that

a. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;

b. Have

(1) Less than 25 cm of the subsurface and bottom tiers consisting of fibric materials; and

(2) Less than 25 cm of the subsurface and bottom tiers consisting of sapric materials;

c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;

d. Do not have a layer of water within the control section beneath the surface tier;

e. Do not have limnic layer(s) 5 cm or more thick within the control section; and

f. Do not have a lithic contact within the control section.

Fibric Borohemists are like Typic Borohemists except for *b(1)*.

Fibric Terric Borohemists are like Typic Borohemists except for *b(1)* and *c*, with or without *a* or *e*, or both.

Fluvaquentic Borohemists are like Typic Borohemists except for *a*, with or without *b*.

Hydric Borohemists are like Typic Borohemists except for *d*.

Limnic Borohemists are like Typic Borohemists except for *e*, with or without *a* or *b*, or both.

Lithic Borohemists are like Typic Borohemists except for *f*, with or without all or any of *a*, *b*, *c*, or *e*.

Sapric Borohemists are like Typic Borohemists except for *b(2)*.

Sapric Terric Borohemists are like Typic Borohemists except for *b(2)* and *c*, with or without *a* or *e*, or both.

Terric Borohemists are like Typic Borohemists except for *c*, with or without all or any of *a*, *d*, or *e*.

Description of Typic Borohemists

The central concept or typic subgroup of Borohemists is fixed on soils that consist of thick, continuous hemic materials.

Layers of materials either more or less decomposed than hemic materials tend to interfere with movement of water and are the bases for classifying intergrades to Fibrists and Saprists. Thin mineral layers normally

restrict movement of water drastically. Because thin mineral layers most commonly have been deposited by floods, soils that have them are considered intergrades to Fluvaquents. Thick mineral layers, limnic layers, water layers, or rock within the control section are the bases for classifying terric, limnic, hydric, and lithic extragrades, respectively.

Cryohemists

These are the cold Hemists. In continental climates they have frost in the control section until about 2 months or more after the summer solstice. In oceanic climates they do not freeze deeper than 5 cm during winter, but their mean annual soil temperature is lower than 8° C. Winters are mild but summers are cold. It should be noted that isofrigid temperatures are cryic.

Definition

Cryohemists are the Hemists that
1. Are frozen in some layer within the control section about 2 months after the summer solstice in most years or are not frozen below a depth of 5 cm at any time in most years but have a mean annual soil temperature lower than 8° C; and
2. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the surface and do not have sulfidic materials within 1 m of the surface.

Distinctions between Typic Cryohemists and other subgroups

Typic Cryohemists are the Cryohemists that
a. Do not have a lithic contact within the control section;
b. Have a mean annual soil temperature higher than 0° C;
c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;
d. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;
e. Have organic materials that are continuous laterally throughout each pedon in at least the surface tier.

Fluvaquentic Cryohemists are like Typic Cryohemists except for *d*.

Lithic Cryohemists are like Typic Cryohemists except for *a* or for *a* and *b*.

Pergelic Cryohemists are like Typic Cryohemists except for *b*, with or without *d*.

Terric Cryohemists are like Typic Cryohemists except for *c*, with or without *d*.

Description of Typic Cryohemists

The central concept or typic subgroup of Cryohemists is fixed on soils that do not have a lithic contact and do not have permafrost.

A lithic contact and permafrost are used for classifying lithic and pergelic subgroups, as they are throughout the taxonomy. In addition, thick or thin mineral layers as well as intermittent mineral layers that are within the surface tier cause soils to be excluded from the typic subgroup. The presence or absence of layers of materials either more or less decomposed than hemic materials is considered less important in the very cold soils than in other great groups of Hemists.

Luvihemists

Luvihemists are not known to occur in the United States but the great group is provided tentatively for use in other countries if needed. They are the Hemists that have a horizon that is 2 cm or more thick within the control section, and half or more of the volume of that horizon is humilluvic material. Because these soils cannot be studied in the United States, a precise definition is not attempted here. It should be noted, however, that they are normally acid and that they have been cultivated for a long time.

Medihemists

These are the Hemists of midlatitudes. Their temperature regimes are mesic, thermic, or hyperthermic. Their moisture regimes are aquic unless the soils have been drained. The organic materials that form them may be derived from woody or herbaceous plants or from mixtures of the two. If these soils are drained and cultivated under the present technology, the organic materials decompose and disappear slowly or rapidly according to the management and the temperature. Eventually, within some decades, the Medihemists that are drained and cultivated will be replaced by mineral soils.

Definition

Medihemists are the Hemists that
1. Have a mean annual soil temperature that is 8° C or higher and mean summer and mean winter soil temperatures at a depth of 30 cm or at a lithic or paralithic contact, whichever is shallower, that differ by 5° C or more;
2. Do not have a layer of humilluvic materials 2 cm or more thick; and
3. Do not have a sulfuric horizon whose upper boundary is within 50 cm of the surface and do not have sulfidic materials within 1 m of the surface.

Description of a Typic Medihemist

There follows a description of a soil that represents the central concept or typic subgroup of Medihemists. This soil, which is in a drained fresh-water marsh in Orange County, Fla., is being cultivated. The vegetation before drainage was herbaceous and consisted mostly of grasses and sedges. The mean annual precipitation is about 1,400 mm, and the mean annual air temperature is about 23° C. The colors given are those of the moist soil.

Oap 0–30 cm. Black (5YR 2/1) well-decomposed sapric materials; moderate, medium granular structure; slightly sticky; less than 10 percent fiber, estimated 90 percent organic matter; sodium pyrophosphate extract color is light brown (7.5YR 6/4); mildly alkaline; abrupt smooth boundary.

Tropohemists

Sapric Terric Tropohemists are like Typic Tropohe-

Borosaprists

These are the Saprists that have a frigid but not a cryic temperature regime. The mean annual soil temperature is lower than 8° C and there is no ice in the control section about 2 months after the summer solstice, but they freeze deeper than 5 cm during winter. The surface soil to a depth of 30 cm is commonly but not necessarily sapric material. The Borosaprists have mostly continental climates with warm summers and

thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;

b. Have

(1) Less than 12.5 cm of the subsurface and bottom tiers consisting of fibric materials; and

(2) Less than 25 cm of the subsurface and bottom tiers consisting of hemic materials;

c. Do not have a mineral layer 30 cm or more thick

Definition

Cryosaprists are the Saprists that are frozen within the control section about 2 months after the summer solstice in most years or are not frozen below a depth of 5 cm at any time in most years but have a mean annual soil temperature lower than 8° C.

Distinctions between Typic Cryosaprists and other subgroups

Typic Cryosaprists are the Cryosaprists that

a. Do not have a lithic contact within the control section;

b. Have a mean annual soil temperature higher than 0° C;

c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;

d. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier; and

e. Have organic materials that are continuous laterally in at least the surface tier throughout each pedon.

Fluvaquentic Cryosaprists are like Typic Cryosaprists except for *d*.

Lithic Cryosaprists are like Typic Cryosaprists except for *a* or for *a* and *b*.

Pergelic Cryosaprists are like Typic Cryosaprists except for *b* or for *b* and *d*.

Terric Cryosaprists are like Typic Cryosaprists except for *c*.

Description of Typic Cryosaprists

The central concept or typic subgroup of Cryosaprists is fixed on soils that do not have a lithic contact or thick or thin mineral layers within the control section and do not have permafrost. These characteristics are not permitted in Typic Cryosaprists because they are used as bases for classifying lithic, terric, fluvaquentic, and pergelic subgroups. The presence or absence of layers that are not decomposed enough to be sapric is considered less important in these very cold soils than in other great groups of Saprists.

Medisaprists

These are the Saprists of midlatitudes. Their temperature regime is mesic, thermic, or hyperthermic. Under natural conditions the ground-water level tends to fluctuate within the soil, allowing periodic aerobic decomposition of the organic materials. Some of these soils that have been drained artificially have undergone aerobic decomposition as a result of the drainage. If these soils are drained and cultivated, the organic materials disappear slowly or rapidly according to the management and the temperature. Eventually the Medisaprists that are cultivated will be oxidized, and the organic materials that remain will be part of a mineral soil. This destruction of some of them already has occurred in the United States.

Definition

Medisaprists are the Saprists that

1. Have a mean annual soil temperature that is 8° C or higher and mean summer and mean winter soil temperatures at a depth of 30 cm or at a lithic or paralithic contact, whichever is shallower, that differ by 5° C or more; and

2. Do not have a layer of humilluvic materials 2 cm or more thick.

Description of a Typic Medisaprist

A description of a soil that represents the central concept or typic subgroup of Medisaprists follows. This soil has been drained and cultivated. It lies in a closed depression in an area of Wisconsinan drift in Clinton County, Mich. The mean annual precipitation is about 750 mm and the mean annual air temperature is about 9° C. The vegetation just before drainage was herbaceous, consisting of grasses, sedges, reeds, and other water-loving plants. All the layers are sapric materials. The colors given are those of the moist soil.

Oap 0–23 cm. Black (N 2/0) on broken faces and rubbed; about 5 percent fibers and a trace after rubbing; weak coarse subangular blocky structure; nonsticky; neutral (pH 7.0 in KCl); abrupt smooth boundary.

Oa2 23–33 cm. Black (N 2/0), very dark brown (7.5YR 2/2) rubbed; about 5 percent fibers and a trace after rubbing; weak medium granular structure; nonsticky; neutral (pH 7.0 in KCl); abrupt smooth boundary.

Oa3 33–60 cm. Dark reddish brown (5YR 3/2), dark reddish brown (5YR 2/2) rubbed; about 15 percent fibers, less than 5 percent after rubbing; massive, breaking to thick plates; nonsticky; neutral (pH 7.0 in KCl); abrupt smooth boundary.

Oa4 60–80 cm. Black (5YR 2/1) on broken faces and rubbed; about 10 percent fibers and a trace after rubbing; massive; nonsticky; few woody fragments; neutral (pH 7.0 in KCl); clear wavy boundary.

Oa5 80–120 cm. Dark reddish brown (5YR 2/2), black (5YR 2/1) rubbed; about 20 percent fibers, less than 10 percent after rubbing; massive, breaking to thick plates; nonsticky; neutral (pH 7.0 in KCl); abrupt smooth boundary.

Oa6 120–170 cm. Dark reddish brown (5YR 2/2) on broken faces and rubbed; about 10 percent fibers, less than 10 percent after rubbing; massive; slightly sticky; about 15 percent ash content; neutral (pH 7.0 in KCl).

Distinctions between Typic Medisaprists and other subgroups

Typic Medisaprists are the Medisaprists that

a. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;

b. Have

(1) Less than 12.5 cm of the subsurface and bottom tiers consisting of fibric materials; and

(2) Less than 25 cm of the subsurface and bottom tiers consisting of hemic materials;

c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;

d. Do not have a layer of water within the control section beneath the surface tier;

e. Do not have limnic layer(s) that are 5 cm or more thick within the control section; and

f. Do not have a lithic contact within the control section.

Fibric Medisaprists are like Typic Medisaprists except for *b(1)*.

Fibric Terric Medisaprists are like Typic Medisaprists except for *b(1)* and *c*, with or without *a* or *e*, or both.

Fluvaquentic Medisaprists are like Typic Medisaprists except for *a*, with or without *b*.

Hemic Medisaprists are like Typic Medisaprists except for *b(2)*.

Hemic Terric Medisaprists are like Typic Medisaprists except for *b(2)* and *c*, with or without *a* or *e*, or both.

Limnic Medisaprists are like Typic Medisaprists except for *e*, with or without *a* or *b*, or both.

Lithic Medisaprists are like Typic Medisaprists except for *f*, with or without all or any of *a*, *b*, *c*, or *e*.

Terric Medisaprists are like Typic Medisaprists ex-

2. Do not have a layer of humilluvic materials 2 cm or more thick.

Because the classification that follows cannot be tested adequately in the United States, it must be considered provisional.

Distinctions between Typic Troposaprists and other subgroups

Typic Troposaprists are the Troposaprists that

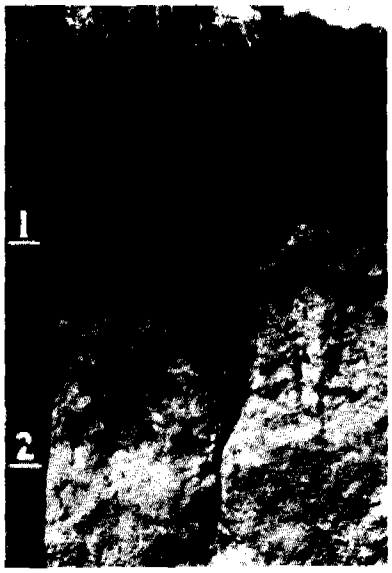
a. Do not have a mineral layer between 5 and 30 cm thick within organic materials or do not have two or more thin, continuous mineral layers in the control section below the surface tier;

b. Have

(1) Less than 12.5 cm of the subsurface and bottom tiers consisting of fibric materials; and

(2) Less than 25 cm of the subsurface and bottom tiers consisting of hemic materials;

c. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section below the surface tier;



CHAPTER 12

Inceptisols

The central concept of Inceptisols is that of soils of humid regions that have altered horizons that have lost bases or iron and aluminum but retain some weatherable minerals; they do not have an illuvial horizon enriched either with silicate clay that contains aluminum or with an amorphous mixture of aluminum and organic carbon. Horizons of accumulation of trans- umbric, histic, or plaggen epipedon is present or if there is a fragipan or duripan or a placic, calcic, petrocalcic, or sulfuric horizon.

Inceptisols may not have an aridic (torric) moisture regime. Nor may they have sandy texture throughout unless they have a plaggen or umbric epipedon or one or another of the diagnostic subsurface horizons.

and that are open to the surface or to the base of an Ap horizon, the mean annual soil temperature is <8° C, or if it is ≥8° C, either

(1) After the surface soil to a depth of 18 cm has been mixed, there is some subhorizon in the upper 50 cm that has <30 percent clay, or

(2) There is no gilgai and there are no slickensides close enough to intersect and no wedge-shaped peds that have their long axes tilted 10° to 60° from the horizontal;

f. Either have a sulfuric horizon whose upper boundary is within 50 cm of the soil surface or some subhorizon between a depth of 20 and 50 cm below the mineral soil surface has an *n* value of 0.7 or less or has <8 percent clay, or both;

2. Have an ochric epipedon, do not have an aridic soil moisture regime, and also have either

a. A conductivity of the saturation extract at 25° C that is <2 mmho per centimeter in all horizons between a depth of 25 cm and the least of the following: 1.25 m if the weighted average particle-size class is sandy, 90 cm if it is loamy, and 70 cm if it is clayey, or to a lithic, paralithic, or petroferric contact if one is shallower than the depths named; and also one or more of the following:

(1) A cambic, calcic, or a petrocalcic horizon;

(2) A fragipan that does not have any clay skins as thick as 1 mm;

(3) A duripan that has its upper boundary within 1 m of the soil surface; or

b. An SAR ≥13 (or sodium saturation of 15 percent or more) in half or more of the upper 50 cm that decreases with depth below 50 cm and ground water within a depth of 1 m at some period during the year when the soil is not frozen in any part (conductivity may exceed 2 mmho per centimeter);

3. Have

a. Either a histic epipedon that is composed of mineral soil materials and, to a depth of 35 cm or more or to a lithic or paralithic contact if one is shallower than 35 cm, either the soil has a bulk density (at 1/3-bar water retention) in the fine-earth fraction that is <0.85 g per cubic centimeter and the exchange complex is dominated by amorphous materials, or the soil is 60 percent or more (by weight) vitric[1] volcanic ash, cinders, or other vitric pyroclastic material;

b. Or a mollic epipedon and one or more of the following:

(1) To a depth of 35 cm or more or to a lithic or paralithic contact if one is shallower than 35 cm, either the soil has a bulk density (at 1/3-bar water retention) in the fine-earth fraction that is <0.85 g per cubic centimeter and the exchange complex is dominated by amorphous materials, or the soil is 60 percent or more (by weight) vitric volcanic ash, cinders, or other vitric pyroclastic material;

(2) An underlying cambic horizon that has base saturation of <50 percent (by NH_4OAc) in some part or that decreases to <50 percent at a depth of 1.8 m or less below the soil surface;

(3) An isomesic or warmer iso temperature regime and an epipedon that rests on soil materials that have <40 percent $CaCO_3$ equivalent in all subhorizons within 1 m of the surface or above a lithic or paralithic contact, whichever is shallower, and also either

(a) 35 percent or more clay that has montmorillonitic mineralogy in subhorizons that have a total thickness of 25 cm or more or a COLE ≥0.09 if the moisture regime is udic or ≥0.07 if the moisture regime is ustic, and also a lithic or paralithic contact within 50 cm of the surface; or

(b) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon; the COLE is ≥0.09 if the soil moisture regime is udic or ≥0.07 if the soil moisture regime is ustic in a horizon or horizons at least 50 cm thick, and the potential linear extensibility is 6 cm or more in the upper 1 m of the soil if the soil moisture regime is udic, in the upper 1.25 m of the soil if the soil moisture regime is ustic, or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m or 1.25 m, respectively; and the clay content is >35 percent in horizons that total 50 cm or more in thickness;

4. Have a plaggen epipedon (any diagnostic horizon below a plaggen epipedon is considered a buried horizon);

5. Have an aquic soil moisture regime and permafrost;

6. Have an umbric epipedon.

Limits between Inceptisols and other orders

The definition of Inceptisols must provide criteria to separate Inceptisols from soils of all other orders. These criteria together define the limits of Inceptisols in relation to all other known kinds of soil.

1. To distinguish Inceptisols from Alfisols, Inceptisols must not have either of the following:

a. An argillic or a natric horizon unless it is a buried soil horizon; or

b. A fragipan that has clay skins as thick as 1 mm in some part.

2. To distinguish Inceptisols from Aridisols, Inceptisols must not have a salic, gypsic, or petrogypsic hori-

[1] Included in the meaning of vitric materials in this definition are crystalline particles that are coated with glass and partially devitrified glass as well as glass.

zon, or an aridic (torric) moisture regime; and if sodium saturation is <15 percent in half or more of the soil to a depth of 50 cm or if sodium saturation is ≥15 percent but remains constant or increases with depth below 50 cm and there is no ground water within a depth of 1 m at any time of year, the conductivity of the saturation extract is <2 mmhos per centimeter in all subhorizons between a depth of 25 cm and the least of the following: 1.25 m if the weighted

(3) An isomesic or warmer iso temperature regime and an epipedon that rests on soil materials that have <40 percent $CaCO_3$ equivalent in all subhorizons within 1 m of the surface or above a lithic or paralithic contact, whichever is shallower, and also have either

(a) 35 percent or more clay that has montmorillonitic mineralogy in subhorizons that have a total thickness of 25 cm

average particle-size class is sandy, 90 cm if it is loamy, and 70 cm if it is clayey, or above a lithic, paralithic, or petroferric contact if one is shallower than those depths.

3. To distinguish Inceptisols from Entisols, Inceptisols
   a. Must have an exchange complex dominated by amorphous materials, or
   b. Must have in some subhorizon between a depth of 20 and 50 cm below the mineral soil surface an *n* value of 0.7 or less or <8 percent clay;
   c. Must not have sulfidic materials within 50 cm of the mineral soil surface; and
   d. Must have one or more of the following:
      (1) A histic epipedon composed of mineral soil materials (see item 3a, p. 228) or a mollic, umbric, or plaggen epipedon;
      (2) A calcic or petrocalcic horizon;
      (3) A fragipan or duripan;
      (4) A cambic horizon, or both an aquic moisture regime and permafrost;
      (5) A placic horizon;
      (6) Have an SAR ≥13 (or sodium saturation that is 15 percent or more) in half or more of the soil to a depth of 50 cm that decreases with depth below 50 cm and ground water within a depth of 1 m at some time of year;
      (7) A sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface.
4. To distinguish Inceptisols from Histosols, Inceptisols must meet the definition of mineral soils (ch. 3).
5. To distinguish Inceptisols from Mollisols, Inceptisols must meet one of the following requirements:
   a. Do not have a mollic epipedon;
   b. Have a mollic epipedon and also one or more of the following:
      (1) To a depth of 35 cm or more or to a lithic or paralithic contact, if one is shallower than 35 cm, either have a bulk density (at 1/3-bar water retention) in the fine-earth fraction that is <0.85 g per cubic centimeter and the exchange complex is dominated by amorphous materials; or the soil is 60 percent or more (by weight) vitric[2] volcanic ash, cinders, or other vitric pyroclastic material

or more, or a COLE ≥0.09 if the soil moisture regime is udic or ≥0.07 if the soil moisture regime is ustic, and a lithic or paralithic contact within 50 cm of the surface; or

(b) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon; the COLE is 0.09 or more if the soil moisture regime is udic, or ≥0.07 if the soil moisture regime is ustic, in a horizon or horizons at least 50 cm thick, and the potential linear extensibility is 6 cm or more in the upper 1 m of the soil if the soil moisture regime is udic, in the upper 1.25 m of the soil if the soil moisture regime is ustic, or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m or 1.25 m; and the clay content is >35 percent in horizons that total 50 cm or more in thickness.

6. To distinguish Inceptisols from Oxisols, Inceptisols must not have either of the following:
   a. An oxic horizon unless it is a buried horizon; or
   b. Plinthite that forms a continuous phase within 30 cm of the soil surface.
7. To distinguish Inceptisols from Spodosols, Inceptisols must not have either of the following:
   a. A spodic horizon unless it is a buried horizon;
   b. A placic horizon if it rests on a fragipan or on an albic horizon that rests on a fragipan.
8. To distinguish Inceptisols from Ultisols, Inceptisols must not have either of the following:
   a. An argillic horizon unless it is a buried horizon; or
   b. A fragipan that has clay skins as thick as 1 mm in some part.
9. To distinguish Inceptisols from Vertisols, Inceptisols must have a mean annual soil temperature <8° C or meet one or both of the following requirements:
   a. Must not have cracks in most years that are as

their long axes tilted 10° to 60° from the horizontal.

Key to suborders

IA. Inceptisols that
1. Have an aquic moisture regime or are artificially drained and have one or more of the following:
a. A histic epipedon;
b. A sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface;
c. An umbric or mollic epipedon that is underlain immediately or at a depth <50 cm below the soil surface by a horizon that has dominant colors, moist, on ped faces, or in the matrix if peds are absent, as follows:
(1) If there is mottling, chroma is 2 or less; [3]
(2) If there is no mottling, chroma is 1 or less;
d. An ochric epipedon that is underlain at a depth <50 cm below the soil surface by a layer that has dominant color, moist, on ped faces, or in the matrix if peds are absent. as follows:
(1) If there is mottling, chroma is 2 or less; [3]
(2) If there is no mottling, chroma is 1 or less;
2. Or have on SAR ≥13 (or sodium saturation that is 15 percent or more) in half or more of the soil to a depth of 50 cm that decreases with depth below 50 cm and ground water within 1 m of the surface at some time of year.

Aquepts, p. 236

IB. Other Inceptisols that have to a depth of 35 cm or more, or to a lithic or paralithic contact if one is shallower than 35 cm, one or both of the following:
1. Bulk density (at 1/3-bar water retention) of the fine-earth fraction that is <0.85 g per cubic centimeter and an exchange complex that is dominated by amorphous materials; or
2. Sixty percent or more of the soil (by weight) is vitric [4] volcanic ash, cinders or other pyroclastic materials.

Andepts, p. 230

IC. Other Inceptisols that have a plaggen epipedon.

Plaggepts, p. 257

ID. Other Inceptisols that have an isomesic or warmer iso temperature regime.

Tropepts, p. 257

IE. Other Inceptisols that have an ochric epipedon; or that have an umbric or mollic epipedon that is <25 cm thick and have also a mesic or warmer soil temperature regime.

Ochrepts, p. 246

IF. Other Inceptisols.

Umbrepts, p. 264

Andepts

Andepts (plates 9B and 11B) are more or less freely drained Inceptisols that have low bulk density and have an appreciable amount of allophane that has a high exchange capacity or that are mostly pyroclastic materials. Many Andepts formed in volcanic ash, but some formed from other pyroclastic rocks, sedimentary rocks, or basic extrusive igneous rocks. Most Andepts probably contain or have contained some glass, but glass weathers rapidly in a humid climate. Some Andepts on Pleistocene or early Holocene surfaces, therefore, contain only traces of glass.

[3] If the hue is redder than 10YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chroma is waived.

In climates that have pronounced dry seasons, the soils formed in basic volcanic ash may have high base saturation, a mollic epipedon, and a duripan. Those formed in humid climates where there is no dry season may have an umbric epipedon, an n value >0.7, or rarely, an ochric epipedon. Normally, except in very recent ash, the percentage of organic carbon in Andepts is high. In some it is more than 18 percent to a depth of 25 cm or more. But because the bulk density is low, the amount of organic carbon when expressed as kilograms per square meter is not excessively high.

The Andepts occur mostly in or near mountains that have active volcanoes and they occur from the equator to high latitudes. Vegetation varies according to the climate. It may be tundra, tropical rain forest, bamboo, coniferous forest, grass, or bracken ferns. Many Andepts have had repeated falls of ash, and the soils have two or more buried A1 horizons, each underlain by a B horizon, within the upper meter of the soil. It is also common that phosphorus is deficient for the growth of cultivated crops.

Definition

Andepts are the Inceptisols that
1. Have to a depth of 35 cm or more, or to a lithic or paralithic contact if one is shallower than 35 cm, one or both of the following:
a. A bulk density (at 1/3-bar water retention) in the fine-earth fraction of the soil that is <0.85 g per cubic centimeter and the exchange complex is dominated by amorphous material; or
b. Sixty percent or more of the soil (by weight) is vitric [4] volcanic ash, cinders, or other vitric pyroclastic material; and
2. Do not have an aquic moisture regime or do not have the characteristics associated with wetness that are defined for Aquepts.

Key to great groups

IBA. Andepts that have a cryic or pergelic temperature regime.

Cryandepts, p. 231

IBB. Other Andepts that have a duripan that has its upper boundary within 1 m of the soil surface.

Durandepts, p. 232

IBC. Other Andepts that have clays that dehydrate irreversibly into aggregates of sand and gravel size.

Hydrandepts, p. 234

IBD. Other Andepts that have a placic horizon within 1 m of the soil surface in half or more of each pedon.

Placandepts, p. 235

IBE. Other Andepts that are not thixotropic and in which the weighted average 15-bar water retention [5] of the fine-earth frac-

[4] See footnote 1 on p. 228.

[5] The amount of water retained at a tension of 15 bars may be reduced by drying these soils. Since 15-bar water retention is used as a measure of effective clay content, it would be unrealistic to use the extremely high value obtained on a field-moist Andept. That value reflects mostly the climatic history rather than a basic soil property. The value for 15-bar water retention that is referred to here, therefore, is that of a sample that has been dried at 40° C.

tion is $\leq$20 percent for all horizons between a depth of 25 cm NH_4OAc) is $<$50 percent in all subhorizons between

Durandepts

These are the Andepts (plate 11B) that have a frigid or warmer soil temperature regime and a duripan that has its upper boundary within 1 m of the soil surface. The pan interferes with water movement and

Plant roots do not penetrate the durinodes or the fragments of duripan but penetrate freely around and between them.

These soils are not known to occur in the United States, but the subgroup is provided for use else-

c. Are not thixotropic in any horizon between depths of 25 cm and 1 m;
d. Do not have a lithic contact within 50 cm of the soil surface;
e. Have cation-exchange capacity[8] of >30 meq per 100 g soil (by NH_4OAc) in all subhorizons above a lithic contact or a depth of 1 m, whichever is shallower, or have >10 percent weatherable minerals in the 20- to 200-micron fraction.

Aquic Dystrandepts are like Typic Dystrandepts except for *a*.

Entic Dystrandepts are like Typic Dystrandepts ex-

surface if they have been drained. These soils are not extensive in the United States. They occur in foggy, high rainfall coastal areas of the Pacific Northwest under forests.

Entic Dystrandepts.—These soils have a thin, dark epipedon or, rarely, an ochric epipedon but are otherwise like Typic Dystrandepts. These soils generally are in relatively recent ash.

Hydric Dystrandepts.—These soils have a subhorizon that is thixotropic. The materials in it commonly dehydrate irreversibly into particles of sand and silt size. In the landscape, and also in their properties,

b. Are thixotropic in some horizon between a depth of 25 cm and 1 m, or

c. Have an average 15-bar water retention [9] that is 20 percent or more in the fine-earth fraction of the whole soil between depths of 25 cm and 1 m, or between 25 cm and a lithic or paralithic contact if one is shallower than 1 m;

2. Have base saturation (by NH_4OAc) that is 50 percent or more in some subhorizon between depths of 25 and 75 cm;
3. Have a soil temperature regime warmer than cryic;
4. Do not have clays that dehydrate irreversibly into aggregates of gravel and sand size;
5. Do not have a duripan that has an upper boundary within a depth of 1 m;
6. Do not have a placic horizon within the upper 1 m of the soil.

Pedon 73 is an example of the central concept or typic subgroup of Eutrandepts.

Distinctions between Typic Eutrandepts and other subgroups

Typic Eutrandepts are the Eutrandepts that

a. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface;

b. Have an epipedon, 25 cm or more thick, that meets the color requirements of a mollic epipedon;

c. Do not have a lithic contact within 50 cm of the soil surface;

d. Do not have a subhorizon within 1.5 m of the surface that contains soft, powdery secondary lime;

e. Have an ustic moisture regime;

f. Do not have a horizon within 1 m of the surface that is >15 cm thick and that either contains 20 percent or more (by volume) durinodes or has >50 percent (by volume) fragments of a duripan in which the average horizontal repeat distance between vertical cracks is <10 cm.

Duric Eutrandepts are like Typic Eutrandepts except for *f*.

Entic Eutrandepts are like Typic Eutrandepts except for *b* or for *b* and *d*.

Lithic Eutrandepts are like Typic Eutrandepts except for c.

Udic Eutrandepts are like Typic Eutrandepts except for *e*, and they have a udic moisture regime.

horizon development and is the basis for entic subgroups. An accumulation of soft powdery lime is characteristic of the driest Eutrandepts. Because the allophane tends to form montmorillonite under conditions of high base saturation, soils that have the soft secondary lime are considered to be intergrades to Ustolls.

The restriction against mottles of low chroma may be a needless one because Andepts, even though wet, rarely have mottles of either high or low chroma. Some other differentia may be more useful to define the typic subgroup, but no suggestions for improvement have been made.

Duric Eutrandepts.—These soils may have fragments of a duripan in some horizon within a depth of 1 m, suggesting that a duripan formed but was shattered into small fragments, most of them <10 cm in horizontal dimension. Roots now can penetrate the horizon, but the volume occupied by the fragments is large. Some soils of this subgroup may have durinodes, which have the same effect as the fragments of a former duripan.

Entic Eutrandepts.—Soils in this subgroup have a thin mollic epipedon or rarely an ochric epipedon. They are permitted but are not required to have a ca horizon that contains soft powdery lime.

Lithic Eutrandepts.—These soils have a lithic contact, normally with pahoehoe lava, within 50 cm of the soil surface. They are otherwise like Typic Eutrandepts.

Udic Eutrandepts.—These soils have a udic moisture regime but otherwise are like Typic Eutrandepts. These soils appear to be in relatively recent basic ash, or they have an overlay of a recent basic ash. They are not known to occur in the United States, but the subgroup is provided for use in countries where they do occur.

Ustollic Eutrandepts.—These soils have a ca horizon that has soft, powdery secondary lime but otherwise are like Typic Eutrandepts.

Xeric Eutrandepts.—These soils have a xeric moisture regime but are otherwise like Typic Eutrandepts in defined properties. They are not known to occur in the United States, but the subgroup is provided for use in countries where they do occur.

the clays dehydrate irreversibly into aggregates of silt, sand, and gravel size. Because the water content and organic-carbon content are high, the bulk density is low and is comparable to that of many Histosols. The supply of bases is very low in many of these soils, but continuing falls of fresh basic ash seem to maintain the supply of bases in some. Natural vegetation was mostly evergreen broadleaf trees and tree ferns. These soils are known to occur only in intertropical regions. They were called Hydrol Humic Latosols in the 1938 classification as modified in 1955.

Definition

Hydrandepts are the Andepts that

1. Have clay that dehydrates irreversibly into aggregates of silt, sand, and gravel size;
2. Have a soil temperature warmer than cryic; and
3. Do not have a placic horizon within 1 m of the soil surface in half or more of each pedon.

Pedon 74 is an example of the central concept or typic subgroup of Hydrandepts.

As a group these soils are remarkably uniform.

Distinction between Typic and Lithic Hydrandepts

Typic Hydrandepts are the Hydrandepts that

a. Do not have a lithic contact within 50 cm of the soil surface.

Lithic Hydrandepts are like the Typic Hydrandepts except for *a*.

Description of subgroups

Typic Hydrandepts.—The central concept or typic subgroup of Hydrandepts is fixed on soils that do not have a lithic contact within 50 cm of the soil surface. Shallow rock is the basis for lithic subgroups. This convention has been followed throughout the taxonomy. Except for the presence of rock in some, the Hydrandepts are so similar that no other subgroups seem to be needed.

Lithic Hydrandepts.—These soils have a lithic contact, normally with pahoehoe lava, within 50 cm of the soil surface. They otherwise are like Typic Hydrandepts.

Placandepts

These are the Andepts that have a placic horizon. Like the Hydrandepts, they are mostly in very humid climates that do not have a dry season. The placic horizon is a barrier to water movement and root development. Water commonly saturates much of the soil above the pan for variable periods. This great group is represented by a very few soil series in the United States. The soils have been reported in other countries. These soils were called Hydrol Humic Latosols in the 1938 classification as modified in 1955.

Subgroups have not been developed because the soils are too poorly represented in the United States. It is thought that soils of the typic subgroup should have, within 1 m of the surface, a placic horizon that is continuous through each pedon.

Vitrandepts

These are the Andepts of mid to low latitudes that have the largest amounts of vitric[10] ash and pumice and the lowest amounts of their weathering products. The soils feel like sandy loams or loamy sands and commonly seem to be gravelly, but their moisture retention is higher than might be expected in such textural classes. Base saturation is quite variable, depending on the nature of the ash and pumice and on the precipitation. Soil temperature regimes of these soils in the United States are mostly frigid or isomesic because the soils generally are near active volcanoes at a high altitude. Few of these soils in the United States are cultivated. They were mostly considered Regosols in the 1938 classification as modified in 1949.

Definition

Vitrandepts are the Andepts that

1. Are not thixotropic and have an average 15-bar water retention[11] of <20 percent in the fine-earth fraction of the whole soil between a depth of 25 cm and either 1 m or a lithic or paralithic contact, whichever is shallower;
2. Have a soil temperature regime warmer than cryic;
3. Do not have clay that dehydrates irreversibly into aggregates of sand and gravel size;
4. Do not have a duripan within a depth of 1 m;
5. Do not have a placic horizon within 1 m of the soil surface.

Pedon 75 is an example of the central concept or typic subgroup of Vitrandepts.

Distinctions between Typic Vitrandepts and other subgroups

Typic Vitrandepts are the Vitrandepts that

a. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface if the mottled horizon is saturated with water in most years at some period when its temperature is >5° C or if the soil is artificially drained;

b. Do not have a lithic contact within 50 cm of the soil surface; and

c. Have an ochric epipedon.

Aquic Vitrandepts are like Typic Vitrandepts except for *a*.

Lithic Vitrandepts are like Typic Vitrandepts except for *b*.

Lithic Mollic Vitrandepts are like Typic Vitrandepts except for *b* and *c*, and they have a mollic epipedon.

Lithic Umbric Vitrandepts are like Typic Vitrandepts except for *b* and *c*, and they have an umbric epipedon.

Mollic Vitrandepts are like Typic Vitrandepts except for *c*, and they have a mollic epipedon.

Plaggic Vitrandepts are like Typic Vitrandepts except for *c*, and they have either a plaggen epipedon or an epipedon that meets all requirements for a plaggen epipedon except thickness and is 30 cm or more thick.

Umbric Vitrandepts are like Typic Vitrandepts except for *c*, and they have an umbric epipedon.

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[10] See footnote 1 on p. 228.
[11] See footnote 5 on p. 230.

Description of subgroups

Typic Vitrandepts.—The central concept or typic subgroup of Vitrandepts is fixed on freely drained soils that are in moderately thick or thick ash or pumice and that have an ochric epipedon and a cambic horizon. The deposits are geologically recent, and the glass is only slightly weathered.

Soils in thin deposits of <50 cm of ash or pumice over hard rock are placed in lithic subgroups as are shallow soils throughout the taxonomy. Mottles of low chroma are the basis for defining aquic subgroups, which are intergrades to Andaquepts, but a better basis seems to be needed for the distinction. A mollic or an umbric epipedon is used to define intergrades to Mollisols and Umbrepts, respectively.

Aquic Vitrandepts.—These soils have shallow ground water at some time of year, and the horizons that have the ground water have mottles of low chroma. These soils are on gentle slopes. They are considered intergrades to Andaquepts. Mostly they have appreciable amounts of crystalline minerals. Their parent materials have been moved in part by water.

Lithic Vitrandepts.—These soils have a lithic contact within 50 cm of the soil surface. The underlying hard rock may be of any kind. The soils otherwise are like Typic Vitrandepts.

Lithic Mollic Vitrandepts.—These soils have a lithic contact within 50 cm of the soil surface and have a mollic epipedon. They occur locally in the mountains of eastern California in the United States where they are used for grazing.

Lithic Umbric Vitrandepts.—Soils in this subgroup have an umbric epipedon and also a lithic contact that is within 50 cm of the soil surface. They are mostly in humid or very humid climates.

Mollic Vitrandepts.—These soils have a mollic epipedon. The base saturation may be high because the precipitation is low or because the ash or pumice is basic. Most of these soils are in areas that have relatively low precipitation for Andepts.

Plaggic Vitrandepts.—These soils have a plaggen epipedon or an epipedon that meets all requirements for a plaggen epipedon except thickness and that is 30 cm or more thick. They are mostly in humid or very humid climates. These soils are considered intergrades to Plaggepts. They are not known to occur in the United States.

Umbric Vitrandepts.—These soils have an umbric epipedon. The base saturation may be low because the precipitation and the amount of leaching are high or have a brownish surface horizon that is <50 cm thick.

Most Aquepts are in Wisconsinan or younger deposits in depressions, very flat plains, or flood plains. Some have permafrost and others are near the Equator. The common features of most of these soils are the mottled gray and rusty colors at a depth of 50 cm or less and the shallow ground water or artificial drainage. They may have almost any particle-size class except fragmental and any reaction class, any temperature regime, and almost any vegetation. Most of them have a cambic horizon, and some have a fragipan in addition. It is possible that some may have a plaggen epipedon.

Definition

Aquepts are the Inceptisols that either

1. Have an SAR that is ≥13 (or sodium saturation that is 15 percent or more) in half or more of the upper 50 cm that decreases with depth below 50 cm and the soils are saturated with water at some time of year within a depth of 1 m; or
2. Have artificial drainage or an aquic moisture regime and have one of the following:
   a. A histic epipedon composed of mineral soil materials;
   b. A mollic or umbric epipedon that is underlain immediately or at a depth <50 cm below the mineral soil surface by a horizon that has dominant color, moist, on ped faces, or in the matrix if peds are absent, as follows:
      (1) If there is mottling, chroma of 2 or less; [12]
      (2) If there is no mottling, chroma of 1 or less; [12]
   c. A histic epipedon composed of organic soil materials or an ochric epipedon that is underlain at a depth <50 cm below the mineral soil surface by a cambic horizon or a subhorizon above a fragipan that has dominant color, moist, on ped faces or in the matrix if peds are absent, that meets the requirements of 2b(1) or 2b(2);
   d. A sulfuric horizon that has its upper boundary within 50 cm of the soil surface.

Key to great groups

IAA. Aquepts that have a sulfuric horizon whose upper boundary is within 50 cm of the mineral soil surface.
Sulfaquepts, p. 245

IAB. Other Aquepts that have a placic horizon within 1 m of

ous phase or constitutes more than half the matrix within some subhorizon in the upper 1.25 m of the soil.

Plinthaquents, p. 245

1 m of the soil surface in more than half of each pedon;

7. Do not have a sulfuric horizon that has its upper

quepts. They are considered intergrades to Mollisols, specifically to the Aquolls.

Cryaquepts

These are the cold Aquepts (plate 8A), and they are extensive in arctic and subarctic regions of North America and Eurasia. Many, but not all, have permafrost at a shallow depth. They generally have an ochric or a histic epipedon over a cambic horizon, but some have an umbric epipedon. In soils that have permafrost, histic epipedons are most common. Evidences of frost churning are common, especially in the soils that have permafrost. Streaks of an O horizon that have a curved shape (plate 8B) may extend well into some of these soils. Striped patterns on steep soils and polygonal patterns on level to moderately sloping soils are normal in arctic regions but are much less common in subarctic regions. The patterns may consist of sorting of coarse fragments, variations in thickness of the O horizons, or, rarely, mineral and organic soils. Centers of the polygons may be high or low relative to the margins. In some of the polygons, the centers may be nearly barren as a result of frost boils. The soils that have permafrost were called Tundra soils in the 1938 classification. Cryaquepts that do not have permafrost were classified as Low-Humic Gley, Humic Gley, or Half-Bog soils when the 1938 classification was modified in 1949.

Definition

Cryaquepts are the Aquepts that
1. Have a cryic or pergelic soil temperature regime;
2. Do not have a fragipan;
3. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface.

Description of a Cryaquept

There follows a description of a Cryaquept that is not a Typic Cryaquept because it has permafrost. This soil is on a narrow flood plain near Manley Hot

C1 25–100 cm. Dark gray (5Y 4/1) very gravelly medium and coarse sand stratified with silt loam and fine sand; massive; loose; few roots; frozen at 92 cm; seams of clear ice; very strongly acid.

Distinctions between Typic Cryaquepts and other defined subgroups

It seems probable that a number of subgroups besides those here defined will be needed when the soils that occur in striped or polygonal patterns have been studied in more detail.

Typic Cryaquepts are the Cryaquepts that
a. Have chroma of 2 or less in 60 percent or more of the mass of all horizons between depths of 15 and 50 cm;
b. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;
c. Do not have a histic epipedon;
d. Do not have an umbric or a mollic epipedon;
e. Do not have a lithic contact within 50 cm of the soil surface;
f. Have a mean annual soil temperature that is higher than 0° C.

Aeric Cryaquepts are like Typic Cryaquepts except for *a*.

Aeric Humic Cryaquepts are like Typic Cryaquepts except for *a* and *d*, and they have an umbric epipedon.

Andic Cryaquepts are like Typic Cryaquepts except for *b* or for *b* and *d*.

Histic Cryaquepts are like Typic Cryaquepts except for *c* or for *c* and *d*.

Histic Lithic Cryaquepts are like Typic Cryaquepts except for *c* and *e*, with or without *f*.

Histic Pergelic Cryaquepts are like Typic Cryaquepts except for *c* and *f*, and the histic epipedon is

and this is done irrespective of soil temperature because ice lenses and wedges cannot be a serious problem if hard rock is present at a shallow depth. Soils that have a histic epipedon are excluded from the typic subgroup because they are considered intergrades to Histosols. Soils that have an umbric or a mollic epipedon are excluded from the typic subgroup because they are considered intergrades to the Humaquepts and Aquolls, respectively.

Aeric Cryaquepts.—These soils have chroma in some subhorizon within 50 cm of the soil surface that is higher than that permitted in soils of the typic subgroup. The chroma is higher than 2 in more than 40 percent of the subhorizon. The higher chroma is thought to reflect either deeper ground water or a shorter period of saturation. The soils are otherwise like Typic Cryaquepts.

Aeric Humic Cryaquepts.—These soils have an umbric epipedon and also have chroma in some subhorizon within 50 cm of the soil surface that is higher than that permitted in soils of the typic subgroup. The chroma is higher than 2 in more than 40 percent of the subhorizon. The higher chroma is thought to reflect either deeper ground water or a shorter period of saturation. The soils are otherwise like Typic Cryaquepts.

Andic Cryaquepts.—Soils in this subgroup have a layer of fine pyroclastic material that is more than 18 cm thick and is within the upper 75 cm of the soil. Normally in these soils in the United States it is at or very close to the surface. The epipedon commonly is umbric but this is not required. The soils are otherwise like Typic Cryaquepts.

Histic Cryaquepts.—These soils have a histic epipedon but otherwise are like Typic Cryaquepts. They tend to have ground water at a higher level than the typic soils, and very shallow water stands for some time above the mineral soil surface. They are considered intergrades to Histosols.

Histic Lithic Cryaquepts.—These soils have a histic epipedon, and they have a lithic contact within 50 cm of the surface of the mineral soil. They tend to have ground water at a higher level than the typic soils, and very shallow water stands for some time above the mineral soil surface. Because there are no ice lenses or wedges of consequence below the lithic contact, these soils are permitted but are not required to have a mean annual soil temperature of 0° C or lower.

Histic Pergelic Cryaquepts.—These soils have a histic epipedon and have permafrost at some depth. They not only are colder than Typic Cryaquepts but they also tend to have ground water at a higher level, and very shallow water stands for some time above the mineral soil surface. Lenses or wedges of ice (plate 8A) are normal below the upper boundary of the permafrost. These soils are very extensive in Alaska. A dark humus-rich horizon just above the permafrost is normal in these soils.

Humic Cryaquepts.—These soils have an umbric epipedon but otherwise are like Typic Cryaquepts [illegible] that is 0° C or lower. Dominant chroma higher than 2 may be present in seeped areas even though the water table is at or near the surface. The soils are of moderate extent in high intermountain valleys adjacent to the Great Plains of the United States. They are on concave or depressional areas and steep slopes where seepage occurs. The soils are used mostly for grazing and recreation purposes.

Pergelic Cryaquepts.—These soils have permafrost at some depth but otherwise are like Typic Cryaquepts. Lenses or wedges of ice are normal below the upper boundary of the permafrost.

Pergelic Ruptic-Histic Cryaquepts.—These soils have a histic epipedon in only part of each pedon. Intense frost churning has produced boils in the centers of the polygons. These are common soils in the colder parts of Alaska.

Fragiaquepts

These are the Aquepts that have a fragipan, commonly at a depth of 30 to 50 cm. The horizons above the pan are gray and are saturated with water for some months in most years. Most of these soils have a forest vegetation, but a few have been cleared. The trees have a shallow root system and are particularly subject to being blown down. A distinct microrelief of 50 to 60 cm or more is very common above the pan. The upper surface of the pan generally is smooth. In many areas of these soils the horizons above the fragipan have been mixed repeatedly by the uplift of the roots of falling trees. The horizons above the pan in some places consist of an O horizon, an ochric epipedon, and an intermittent cambic horizon below the mounds. In other places the cambic horizon is continuous.

The Fragiaquepts in the United States have a frigid or mesic soil temperature regime. They are moderately extensive in a few parts of the northeastern states. Aquepts that have a fragipan and that have a temperature regime marginal to cryic have been reported in other countries (Deckers 1966). The Fragiaquepts were considered Low-Humic Gley and Humic Gley soils in the 1938 classification as modified in 1949.

Definition

Fragiaquepts are the Aquepts that

1. Have a fragipan;
2. Have an SAR <13 (or <15 percent saturation with sodium) in half or more of the upper 50 cm or have an SAR (or saturation with sodium) that is constant or increases with depth below 50 cm;
3. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix within 1.25 m of the soil surface;
4. Do not have a sulfuric horizon whose upper boundary is within 50 cm of the soil surface.

Pedon 77 is an example of the central concept or typic subgroup of Fragiaquepts.

Distinctions between Typic Fragiaquepts and

b. Have, in the matrix of all subhorizons between the plow layer or, if there is no plow layer, a depth of 15 cm and a depth of 75 cm or more, moist colors as follows:

(1) If there is mottling, chroma of 2 or less;
(2) If there is no mottling, chroma of 1 or less.

Aeric Fragiaquepts are like Typic Fragiaquepts except for *b*.

Humic Fragiaquepts are like Typic Fragiaquepts except for *a*.

Description of subgroups

Typic Fragiaquepts.—The central concept or typic subgroup of Fragiaquepts is fixed on soils that have an ochric epipedon and that have dominant chroma of 2 or less if there are mottles of higher chroma, or of 1 or less if there are no mottles, in the matrix of all subhorizons between the Ap horizon or a depth of 15

2. Have a soil temperature regime warmer than that of Cryaquepts;
3. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix within 1.25 m of the soil surface;
4. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface.

Description of a Typic Halaquept

There follows a description of a soil that represents the central concept or typic subgroup of Halaquepts. This soil, in Esmeralda County, Nev., developed in alluvium that was derived from a very wide variety of rocks in a valley floor position, a playa. Vegetation is a sparse cover of sedges and grasses. The soil is occasionally flooded by runoff from adjacent mountains. The mean annual precipitation is about 100 mm, and the mean annual air temperature is about 13° C. The mean summer air temperature is about 23° C. Colors

c. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Aquic Halaquepts are like Typic Halaquepts except

Low-Humic Gley and Humic Gley soils in the 1938 classification as modified in 1949.

Definition

Haplaquepts are the Aquepts that

1. Have a soil temperature regime warmer than cryic and have mean summer and mean winter soil temperatures at a depth of 50 cm that differ by 5° C or more;
2. Have an ochric epipedon;
3. Have an exchange complex that is not dominated by amorphous materials, and are <60 percent vitric[14] volcanic ash, cinders, or other vitric pyroclastic materials;
4. Have an SAR <13 (or <15 percent saturation with sodium) in half or more of the upper 50 cm, or the SAR (or saturation with sodium) is constant or

olive brown (2.5Y 5/4) mottles; weak coarse blocky structure, tendency for vertical parting; very firm (moist); few roots; no clay skins; few pebbles; pH 7.4; gradual boundary.

B3g 85–110 cm. Olive gray (5Y 5/2) clay, many coarse prominent yellowish brown (10YR 5/6) mottles; weak coarse and very coarse blocky structure, vertical parting; very firm (moist); very few roots; depth to carbonates ranges from 100 to 107 cm, few lime concretions in lower part; few crayfish krotovinas filled with dark gray clay; pH 7.4; abrupt boundary.

C1g 110–120 cm. Yellowish brown (10YR 5/4) and dark yellowish brown (10YR 4/4) clay, many coarse distinct gray (N/6) mottles, few white calcareous splotches; weak coarse subangular blocky structure; very firm (moist); calcareous; about 5 percent coarse fragments; few shell fragments; gray color more prominent in vertical seams.

C2 120–160 cm. Yellowish brown (10YR 5/4) and dark yellowish brown (10YR 4/4) clay, many coarse distinct gray (N/5, N/6) mottles and few seams of white calcareous material; massive, few vertical cracks; very firm (moist); calcareous; about 5 percent coarse fragments of black shale and crystalline pebbles.

C3 160–180 cm. Brown (10YR 5/3, 4/3) clay; massive; calcareous; about 5 percent coarse fragments.

Distinctions between Typic Haplaquepts and other subgroups

Typic Haplaquepts are the Haplaquepts that

a. Have, in 60 percent or more of the matrix in all subhorizons between the A1 or Ap horizon and a depth of 75 cm, one or more of the following:

(1) If mottled and the mean annual soil temperature is lower than 15° C, moist chroma of 2 or less;

(2) If mottled and the mean annual soil temperature is 15° C or higher:

(a) If the hue is 2.5Y or redder[15] and the value, moist, is more than 5, the chroma, moist, is 2 or less;

(b) If the hue is 2.5Y or redder and the value, moist, is 5 or less, the chroma, moist, is 1 or less;

(c) If the hue is yellower than 2.5Y, the chroma, moist, is 2 or less;

(3) The chroma, moist, is 1 or less and mottles may or may not be present;

b. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

c. Have an Ap horizon that has a color value, moist, of 4 or more or has a value, dry, of 6 or more when crushed and smoothed, or have an A1 horizon that is <15 cm thick if its color value, moist, is lower than 3.5;

d. Have an *n* value of <0.9 between depths of 50 and 80 cm and <0.7 in all layers between 20 and 50 cm;

e. Do not have a lithic contact within 50 cm of the soil surface;

f. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon; and

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness; and

g. Do not have either of the following:

(1) Jarosite mottles and a pH between 3.5 and 4.0 (1:1 water, air dried slowly in shade) in some subhorizon within 50 cm of the soil surface, or

(2) Jarosite mottles and a pH <4.0 (1:1 water, air dried slowly in shade) in some subhorizon between depths of 50 and 150 cm.

Aeric Haplaquepts are like Typic Haplaquepts except for *a* or for *a* and *c*.

Humic Haplaquepts are like Typic Haplaquepts except for *c*, and the base saturation (by NH_4OAc) is <50 percent in some horizon and does not increase with depth to a value of 50 percent or more.

Lithic Haplaquepts are like Typic Haplaquepts except for *e* or for *a* and *e*.

Mollic Haplaquepts are like Typic Haplaquepts except for *c*, and the base saturation (by NH_4OAc) is 50 percent or more throughout or increases with depth to a value of 50 percent or more.

Sulfic Haplaquepts are like Typic Haplaquepts except for *g*, with or without all or any of *a*, *c*, *d*, or *f*.

Vertic Haplaquepts are like Typic Haplaquepts except for *f*, with or without *a* or *c*, or both.

Description of subgroups

Typic Haplaquepts.—The central concept or typic subgroup of Haplaquepts is fixed on dominantly gray soils in a thick mineral regolith without deep wide cracks at any time in most years.

High chroma in some subhorizon is the basis for definition of aeric subgroups. Soils that have thin layers of fine pyroclastic materials near the surface are excluded from the typic subgroup because such layers indicate an intergrade subgroup to Andaquepts. A dark Ap horizon or a moderately thick, dark A1 horizon are the bases for defining intergrades to Humaquepts or to Aquolls, according to the base status. Soils that have a high *n* value are excluded because that feature is evidence of some characteristics of the Hydraquents. A lithic contact within 50 cm is the basis for definition of lithic subgroups, a convention used

[15] If the hue is 7.5YR or redder in the matrix and if peds are present, the ped exteriors should have dominant chroma, moist, of 1 or less and the ped interiors should have mottles that have chroma, moist, of 2 or less; if there are no peds, the chroma, moist, should be 1 or less immediately below any surface horizon that has a value, moist, less than 5.

throughout the taxonomy. Deep wide cracks in expanding clays indicate intergrades to Vertisols. Jarosite mottles, if associated with low pH value, indicate intergrades to Sulfaquepts.

The typic subgroup probably is not the most extensive subgroup of Haplaquepts in the United States.

Aeric Haplaquepts.—These soils have a horizon within the upper 75 cm that has chroma too high for Typic Haplaquepts. The higher chroma is thought to indicate either a shorter period of saturation of the whole soil with water or somewhat deeper ground water than that in the typic soils. The correlation of color with soil drainage classes is imperfect. A dark plow layer or a relatively thick dark A1 horizon is permitted but neither is required. Many of these soils have colors that are marginal to the limits set in the definition of Typic Haplaquepts.

Humic Haplaquepts.—These soils have a darker surface horizon than Typic Haplaquepts and have relatively low base saturation. They are considered to be intermediate between Typic Haplaquepts and Humaquepts.

Lithic Haplaqu pts.—These soils have a lithic contact within 50 cm of the soil surface but otherwise are like Typic Haplaquepts.

Mollic Haplaquepts.—Soils in this subgroup have a darker surface horizon than Typic Haplaquepts and have relatively high base saturation. They are considered to be intermediate between Typic Haplaquepts and Haplaquolls.

Sulfic Haplaquepts.—These soils are mainly in drained coastal marshes. They either have jarosite mottles and have a pH (1:1 water, air dried slowly in shade) between 3.5 and 4.0 in some part within a depth of 50 cm, or they have jarosite mottles and a pH <4.0 (1:1 water, air dried slowly in shade) in some part between 50 and 150 cm of the surface. They are considered intergrades to Sulfaquepts.

Vertic Haplaquepts.—These soils have fine texture, and they shrink and swell appreciably when their moisture content changes. Most of them have a high content of montmorillonite and have a distinct dry season in which potential evapotranspiration exceeds precipitation. They are extensive soils in the Mississippi Delta.

Humaquepts

These are the nearly black or peaty, very wet, acid Aquepts of the humid midlatitudes. If not artificially drained, most of them are ponded at some time of year. They are mostly in acid late-Pleistocene or Holocene sediments. Their extent is small in the United States. They were called Humic Gley or Half-Bog soils in the 1938 classification as modified in 1949.

Definition

Humaquepts are the Aquepts that

1. Have a soil temperature regime warmer than cryic and have mean summer and mean winter soil temperatures at a depth of 50 cm that differ by 5° C (9° F) or more;
2. Have an umbric, mollic, or histic epipedon;
3. Either have a bulk density (at 1/3-bar water tension) >0.85 in all horizons or have an exchange complex that is not dominated by amorphous materials and also have <60 percent vitric[16] volcanic ash, cinders or other vitric pyroclastic materials in the silt, sand, and gravel fractions;
4. Have an SAR <13 (or sodium saturation that is <15 percent) in the upper 50 cm or have an SAR or sodium saturation that is constant or increases with depth below a depth of 50 cm;
5. Do not have a fragipan;
6. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix within 1.25 m of the soil surface;
7. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface.

Description of a Typic Humaquept

There follows a description of a soil that represents the central concept of typic subgroup of Humaquepts. This soil, in Lewis County, Wash., formed in basic alluvium in a closed upland depression. It has a cover of scattered conifers and willows and a dense understory of shrubs. The mean annual air temperature is about 7° C; the average annual precipitation is about 2,000 mm, coming mostly in fall, winter, and spring. The water table is at or near the surface most of the year. The colors are those of the moist soil.

O 2–0 cm. Decomposed litter of alder leaves, grass, and forbs.

A1 0–12 cm. Dark reddish brown (5YR 2/2) clay loam, moderate fine subangular blocky structure; very friable (moist); many fine grass and forb roots; many fine tubular pores; strongly acid; clear, smooth boundary.

A3 12–30 cm. Dark brown (7.5YR 3/2) clay loam, few medium distinct red (2.5YR 4/6) mottles; moderate medium subangular blocky structure; many fine roots; common fine tubular pores; strongly acid; clear smooth boundary.

B1g 30–55 cm. Dark brown (7.5YR 3/2) clay loam, common medium distinct red (2.5YR 5/6) mottles; moderate fine subangular blocky structure; slightly hard (dry), friable (moist), sticky and plastic (wet); few medium roots; common fine tubular pores; strongly acid; clear smooth boundary.

B2g 55–95 cm. Brown (7.5YR 4/2) clay loam, many medium distinct red (2.5YR 4/6) and gray (10YR 5/1) mottles; moderate coarse subangular blocky structure; hard (dry), firm (moist), sticky and very plastic (wet); very few medium roots; few fine tubular pores; strongly acid; gradual wavy boundary.

C1g 95–125 cm. Dark grayish brown (10YR 4/2) clay loam, many medium prominent bluish gray (5B 5/1) mottles; massive; hard (dry), firm (moist), sticky and very plastic (wet); few fine tubular pores; strongly acid; abrupt smooth boundary.

IIC2 125 cm. Grayish brown (10YR 5/2) silty clay loam, many medium prominent reddish yellow (5YR 6/6) mottles; massive; very hard (dry), firm (moist), very sticky and very plastic (wet); nonporous; medium acid.

Distinctions between Typic Humaquepts and other subgroups

Typic Humaquepts are the Humaquepts that

a. Have chroma of 2 or less, moist, and hue of 5Y or redder in 60 percent or more of the matrix in all subhorizons between depths of 15 and 75 cm;

b. Have mottles or have iron-manganese concretions within a depth 30 cm below the base of the epipedon if

[16] See footnote 1 on p. 228.

the chroma within that depth is 1 or more, the hue is redder than 5Y, and the value, moist, is 5 or more;
c. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;
d. Have an epipedon that is <60 cm thick;
e. Have a content of organic carbon that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at a shallower depth, reaches a level of 0.2 percent or less within 1.25 m of the soil surface.

quepts and are intergrades to the Histosols. The organic-carbon content may be relatively high in the deep layers.

Placaquepts

These are the Aquepts that have a placic horizon. Normally the placic horizon lies within 25 to 50 cm of the surface and a cambic horizon may be either present or absent. In many of these soils, the placic horizon is so close to the surface that there can be no cambic horizon above it. Below the placic horizon rock structure commonly is present because there is so little biologic activity.

These soils are in areas that have very high rainfall

structure but the pores are coated with strong brown (7.5YR 5/6), red (2.5YR 4/8) and yellowish red (5YR 5/8) material; fracture faces have coatings of reddish black (10R 2/1), dark red (10R 3/6), and black (N 2/); hard (dry), firm (moist), sticky and plastic and thixotrophic (wet); no roots; many fine pores; this layer consists of hard and soft material; hard material can be broken with difficulty when moist; very strongly acid (pH 4.8); gradual smooth boundary.

These are the acid sulfate soils (cat clays) that have been drained and oxidized at some time. They are extremely acid and toxic to most plants. They are mostly dark gray and have straw-colored mottles of iron sulfate (jarosite) within 50 cm of the soil surface. They are mainly in drained coastal marshes near the mouths of rivers that carry sediments that are free of

Distinctions between Typic Tropaquepts and other subgroups

Typic Tropaquepts are the Tropaquepts that

a. Have in 60 percent or more of the matrix in all subhorizons between the A1 or Ap horizon and a depth of 75 cm one or more of the following:

(1) If mottled and if the hue is 2.5Y or redder and the value, moist, is >5, the chroma, moist, is 2 or less; if the value, moist, is 5 or less, the chroma, moist, is 1 or less;

(2) If mottled and if the hue is yellower than 2.5Y, the chroma, moist, is 2 or less;

(3) The chroma, moist, is 1 or less whether mottled or not;

b. Do not have a histic epipedon that has its upper boundary at or near the surface;

c. Do not have a lithic contact within 50 cm of the soil surface;

d. Do not have the following combination of characteristics:

(1) Cracks at some time in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness;

e. Have <5 percent (by volume) of plinthite in all

Chroma that is too high in some upper subhorizon is used to define aeric subgroups. A histic epipedon indicates the wettest Tropaquepts and is used to define histic subgroups. A lithic contact within a depth of 50 cm is the basis for defining lithic subgroups, a convention used throughout the taxonomy. Deep wide cracks in clayey soils indicate intergrades to Vertisols.

Plinthite indicates intergrades to Plinthaquepts. Jarosite mottles combined with low pH value indicate intergrades to Sulfaquepts.

Aeric Tropaquepts.—These soils have chroma too high for Typic Tropaquepts. The high chroma is thought to reflect either somewhat deeper ground water or shorter periods when the entire soil is saturated. The soils are otherwise like Typic Tropaquepts.

Histic Tropaquepts.—These soils are not known to occur in the United States but the subgroup is provided for the Tropaquepts that have a histic epipedon.

Lithic Tropaquepts.—Soils in this subgroup are rare. They have a shallow lithic contact. They are otherwise like the Typic Tropaquepts.

Plinthic Tropaquepts.—These soils have plinthite in the form of disconnected red mottles that makes up between 5 and 50 percent of the volume of some subhorizon. They are rare in the United States.

Sulfic Tropaquepts.—These soils are mainly in drained coastal marshes. Either they have jarosite mottles and a pH (1:1 water, air dried slowly in shade) between 3.5 and 4.0 in some part within a depth of 50 cm, or they have jarosite mottles and a pH (1:1 water, air dried slowly in shade) <4.0 in some part between depths of 50 and 150 cm below the soil surface. They are considered intergrades to Sulfaquepts. They are not known to occur in the United

geographic accident. A calcic horizon normally is associated with an ustic or a xeric moisture regime.

Ochrepts in the United States are most extensive on the Appalachian Mountains, the Allegheny Plateau, and interior Alaska.

Definition

Ochrepts are the Inceptisols that

1. Have an ochric epipedon or, if the soil temperature regime is mesic, isomesic, or warmer, have an umbric or mollic epipedon <25 cm thick;
2. Have a difference of 5° C or more between the mean summer and mean winter soil temperatures at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower unless the mean temperature is <8° C;
3. Have bulk density (at 1/3-bar water tension) >0.85 in all horizons or have an exchange complex that is not dominated by amorphous materials; and are less than

United States these soils are moderately extensive in the high mountains of the West and Alaska. They were mostly considered Subarctic Brown Forest soils in the 1938 classification as modified in 1951 and as Sols Bruns Acides after 1957.

Definition

Cryochrepts are the Ochrepts that

1. Have a cryic or pergelic soil temperature regime;
2. Do not have a fragipan;
3. Do not have a duripan that has its upper boundary within 1 m of the soil surface.

Description of a Typic Cryochrept

There follows a description of a soil that represents the central concept or typic subgroup of Cryochrepts. This soil formed on a steep slope under fir and spruce in glacial drift at an elevation of about 3,000 m in

Distinctions between Typic Cryochrepts and other subgroups

Typic Cryochrepts are the Cryochrepts that
a. Have a mean annual soil temperature higher than 0° C;
b. Do not have a lithic contact within 50 cm of the soil surface;
c. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizon is saturated with water at some period when its temperature is $\geq 5°$ C or the soil has artificial drainage.
d. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;
e. Have base saturation (by NH_4OAc) that is 60 percent or more in some subhorizon within 75 cm of the surface; and
f. Do not have lamellae within 75 cm of the soil surface that meet all requirements for an argillic horizon except thickness.

Alfic Cryochrepts are like Typic Cryochrepts except for *f*.

Andic Cryochrepts are like Typic Cryochrepts except for *d* or for *d* and *e*.

Dystric Cryochrepts are like Typic Cryochrepts except for *e*.

Lithic Cryochrepts are like Typic Cryochrepts except for *b*, with or without *a* or *d*, or both.

Pergelic Cryochrepts are like Typic Cryochrepts except for *a* or for *a* and *c*.

Description of subgroups

Typic Cryochrepts.—The central concept of Cryochrepts, the typic subgroup, is fixed on the thick, cold soils that have moderate to high base saturation and that do not have permafrost.

Soils that have lamellae in which silicate clay has accumulated are excluded from the typic subgroup because they are considered to be intergrades to Alfisols. Shallow hard rock is used to define lithic subgroups as is done throughout the taxonomy. Permafrost is used to define pergelic subgroups if the depth to rock is >50 cm so that ice lenses or wedges may be present. Soils that have a thin mantle or layer of ash or other pyroclastic materials are excluded because they are considered to be an intergrade to Andepts.

Alfic Cryochrepts.—These soils have lamellae in which clay has accumulated and which meet all requirements for an argillic horizon except thickness. The uppermost lamella is within 75 cm of the soil surface but others may be deeper. Most of these soils have a coarse-loamy, coarse-silty, or loamy-skeletal particle-size class. They are otherwise like Typic Cryochrepts.

Andic Cryochrepts.—These soils have, in the upper 75 cm, a layer of fine pyroclastic materials that is 18 cm or more thick and that has properties similar to those of the Andepts. This layer is normally at the surface. Below it there is commonly an albic horizon that in turn is underlain at a depth >75 cm beneath the soil surface by horizons that have lamellae of clay accumulation.

Dystric Cryochrepts.—Soils in this subgroup have base saturation that is <60 percent (by NH_4OAc) in all subhorizons to a depth of 75 cm or more. They are otherwise like Typic Cryochrepts. Most of these soils are in areas of higher precipitation than the soils of the typic subgroup.

Lithic Cryochrepts.—These soils have a lithic contact within 50 cm of the soil surface and they are permitted but are not required to have a mean annual temperature below 0° C. Because the rock is shallow, the soils cannot have large ice lenses or wedges even though the soil temperature is very low.

Pergelic Cryochrepts.—These soils have permafrost unless rock is present within the depth to which the soil thaws in summer. A few that have rock at a depth between 50 cm and 1 m may not have permafrost even though the mean annual soil temperature is lower than 0° C. Most of them have permafrost, and unless the texture is very coarse, they have ice lenses or wedges in the deep layers. In some there is just above the permafrost a horizon that is relatively dark and is rich in organic carbon. Stone polygons or stripes are normal in these soils.

Durochrepts

These are the Ochrepts that have a duripan that has its upper boundary within 1 m of the soil surface. These soils in the United States occur under a Mediterranean climate that has low precipitation. Commonly there is a perched water table above the duripan for part of winter or early spring. The vegetation was a mixture of grasses and some scattered trees. They were considered Noncalcic Brown soils in the 1938 classification. They are not extensive in the United States as a whole but are very extensive locally in some places.

Definition

Durochrepts are the Ochrepts that
1. Have a duripan that has its upper boundary within 1 m of the soil surface; and
2. Do not have a fragipan.

Description of a Typic Durochrept

There follows a description of a soil that represents the central concept or typic subgroup of Durochrepts. This soil formed on a broad, nearly level terrace, presumably Pleistocene in age, in southwestern Oregon. The mean annual air temperature is about 12° C. The precipitation is about 450 mm and comes mostly in fall, winter, and spring. The vegetation was a mixture of grasses, forbs, and oak trees. The colors given are those of the moist soil unless otherwise stated.

A11 0–10 cm. Dark brown (7.5YR 3/4) loam, dark brown (7.5YR 4/4) dry; weak coarse platy structure; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); common roots; 15 percent pebbles; neutral (pH 6.6); clear smooth boundary.

A12 10–22 cm. Dark brown (7.5YR 3/4) loam, dark brown (7.5YR 4/4) dry; weak medium subangular blocky structure; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); common roots; 15 percent pebbles; many very fine and fine tubular pores; neutral (pH 6.6); clear smooth boundary.

B2 22–37 cm. Dark brown (7.5YR 3/4) clay loam, strong brown

Dystrochrepts

These are the brownish, acid Ochrepts of humid and perhumid regions in midlatitudes. They developed mostly in Holocene deposits or on steep slopes. Their parent materials generally are acid, moderately or

f. Have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more, crushed and smoothed, or the upper soil to a depth of 18 cm, after mixing, has these colors.

Andic Dystrochrepts are like Typic Dystrochrepts except for *a*.

Aquic Dystrochrepts are like Typic Dystrochrepts except for *b*.

Fluvaquentic Dystrochrepts are like Typic Dystrochrepts except for *b* and *c*.

Fluventic Dystrochrepts are like Typic Dystrochrepts except for *c*.

Fluventic Umbric Dystrochrepts are like Typic Dystrochrepts except for *c* and *f*.

Lithic Dystrochrepts are like Typic Dystrochrepts except for *d*.

Lithic Ruptic-Alfic Dystrochrepts are like Typic Dystrochrepts except for *d* and *e*, they have an argillic horizon in less than half of each pedon, and their base saturation (by sum of cations) in the subhorizon just above the lithic contact is 35 percent or more.

Lithic Ruptic-Ultic Dystrochrepts are like Typic Dystrochrepts except for *d* and *e*, and they have an argillic horizon in less than half of each pedon and have base saturation (by sum of cations) in the subhorizon just above the lithic contact that is <35 percent or more.

Ruptic-Alfic Dystrochrepts are like Typic Dystrochrepts except for *e* and they have an argillic horizon in less than half of each pedon and base saturation (by sum of cations) that is 35 percent or more at a depth 1.25 m below the upper boundary of the argillic horizon or just above a lithic or paralithic contact if ence of a thin umbric or mollic epipedon is used to define intergrades to the Umbrepts. A low bulk density accompanied by a high pH-dependent charge is considered to indicate intergrades to the Andepts.

Andic Dystrochrepts.—These soils have a layer that is influenced by pyroclastic materials, that commonly but not everywhere contains volcanic ash, and that is 18 cm or more thick. In these soils in the United States, this layer normally has many concretions cemented by iron that are commonly called shot.

Aquic Dystrochrepts.—These soils have mottles of low chroma in a brownish or a reddish matrix, depending on the hue of the parent materials. Usually there are mottles of high chroma as well. Most of these soils in the United States are in late-Pleistocene sediments and their slopes are gentle. Ground water is present in the soil in the deep layers during winter but disappears in summer.

Fluvaquentic Dystrochrepts.—These soils have mottles of low chroma in a brownish matrix and formed in Holocene deposits or even in alluvium that was deposited during the period of recorded history. They are on flood plains of rivers draining regions that have acid rocks. During winter, ground water is present in the mottled zone unless the soil has been drained. Most of these soils are subject to occasional flooding, but soils in the United States are cultivated.

Fluventic Dystrochrepts.—Soils in this subgroup are on flood plains of rivers draining regions that have acid rocks. They have formed in Holocene deposits or even in alluvium that was deposited during the period of recorded history. They are subject to occa-

Ruptic-Alfic Dystrochrepts.—These soils have an argillic horizon in a minor part of each pedon and have base saturation of 35 percent or more at a depth 1.25 m below the top of the argillic horizon or just above a lithic or paralithic contact if one is shallower than that depth. Most of these soils are strongly to steeply sloping and in most of them the depth to rock is <1.25 m. They are otherwise like Typic Dystrochrepts.

Ruptic-Ultic Dystrochrepts.—These soils are shallow over weakly consolidated sedimentary rock and have an intermittent, thin argillic horizon. Generally the argillic horizon is present where the rock is deepest. Base saturation is generally very low. These soils are mostly steeply sloping, and they are in forests or used for pasture. The forests contain mostly hardwood trees.

Umbric Dystrochrepts.—These soils have an epipedon that is darker than that of Typic Dystrochrepts but are otherwise like the soils of the typic subgroup. They are mainly under coniferous forests on steep slopes. Weakly consolidated sedimentary rock is present at a shallow depth. These soils resemble the Umbrepts but have a higher chroma in the epipedon.

Eutrochrepts

These are the brownish, base-rich Ochrepts of humid regions in the midlatitudes. They developed mostly in Holocene or late-Pleistocene deposits or on steep slopes. Their parent materials generally are calcareous sediments or basic sedimentary rocks. Their vegetation was mostly deciduous hardwoods, but the gently sloping soils are now cultivated and many of the strongly sloping soils are in pasture. The Eutrochrepts are not extensive in the United States. Many of them were considered Brown Forest soils in the 1938 classification as modified in 1949. Some were considered Regosols or Alluvial soils.

Definition

Eutrochrepts are the Ochrepts that

1. Have one or both of the following:
   a. Carbonates in the cambic horizon or in the C horizon but within the soil; or
   b. Base saturation that is 60 percent or more (by NH_4OAc) in some subhorizon that is between depths of 25 and 75 cm below the soil surface;
2. Have a udic soil moisture regime;
3. Have a temperature regime that is warmer than cryic but do not have an iso temperature regime;
4. Do not have a fragipan or a duripan.

Pedon 78 is an example of the central concept or typic subgroup of Eutrochrepts. It has no free carbonates above a depth of 81 cm, but many of these soils have carbonates at a much shallower depth.

Distinctions between Typic Eutrochrepts and other subgroups

Typic Eutrochrepts are the Eutrochrepts that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:
   (1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or
   (2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have mottles that have chroma of 2 or less within 60 cm of the soil surface if the mottled horizon is saturated with water at some period when its temperature is ≥5° C or if the soil has artificial drainage;

c. Have texture of very fine sand or finer within 50 cm of the soil surface;

d. Have carbonates within a depth of 1 m in some part of each pedon;

e. Have a content of organic carbon that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at a shallower depth, reaches a level of 0.2 percent or less within 1.25 m of the soil surface; or have slopes >25 percent;

f. Do not have a lithic contact within 50 cm of the soil surface in any part of the pedon;

g. Do not have an argillic horizon in any part of the pedon;

h. Have an ochric epipedon;

i. Do not have either of the following combinations of characteristics:
   (1) All three of the following characteristics:
      (a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend to the soil surface or to the base of an Ap horizon,
      b. A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m, and
      (c) More than 35 percent clay in horizons that total >50 cm in thickness; or
   (2) Both of the following characteristics:
      (a) A lithic or paralithic contact or altered rock that retains its rock structure within 50 cm of the soil surface, and
      (b) Horizons that total 25 cm or more in thickness and have 35 percent or more clay that has montmorillonitic mineralogy; and

j. Have <40 percent carbonates, including the coarse fragments up to 75 mm in diameter, in and below the cambic horizon but above a lithic or paralithic contact and above a depth of 1 m.

Andic Dystric Eutrochrepts are like Typic Eutrochrepts except for *a* and *d*.

Aquic Eutrochrepts are like Typic Eutrochrepts except for *b*.

Aquic Dystric Eutrochrepts are like Typic Eutrochrepts except for *b* and *d*.

Arenic Eutrochrepts are like Typic Eutrochrepts except for *c*.

Dystric Eutrochrepts are like Typic Eutrochrepts except for *d*.

Dystric Fluventic Eutrochrepts are like Typic Eutrochrepts except for *d* and *e*.

Fluvaquentic Eutrochrepts are like Typic Eutrochrepts except for *b* and *e*, with or without *d*.

Fluventic Eutrochrepts are like Typic Eutrochrepts except for *e*.

Lithic Eutrochrepts are like Typic Eutrochrepts except for *f* or for *d* and *f*.

Lithic Ruptic-Alfic Eutrochrepts are like Typic Eutrochrepts except for *f* and *g*, and they have an argillic horizon in some part but in less than half of each pedon.

Rendollic Eutrochrepts are like Typic Eutrochrepts except for *j*.

Ruptic-Alfic Eutrochrepts are like Typic Eutrochrepts except for *g* and have an argillic horizon in some part but in less than half of each pedon.

Vertic Eutrochrepts are like Typic Eutrochrepts except for *i(1)*, with or without *e* or *b*, or both.

Description of subgroups

those in the United States formed mostly in late-Pleistocene sediments. Most of them are cultivated.

Aquic Dystric Eutrochrepts.—These soils have mottles of low chroma above a depth of 60 cm and either have artificial drainage or are saturated with water in the mottled zone at some time of year, usually in winter or spring. In addition, they are free of carbonates to a depth of 1 m. These soils in the United States are in Holocene sediments. Most of them are now cultivated.

Arenic Eutrochrepts.—These soils have a surface mantle of sand or loamy sand that is >50 cm thick and is underlain by a cambic horizon. They are otherwise like Typic Eutrochrepts. These soils in the United States are in late-Pleistocene sediments and they have gentle or moderate slopes.

Dystric Eutrochrepts.—Soils in this subgroup do not have carbonates above a depth of 1 m but are otherwise like Typic Eutrochrepts. These soils in the United States formed in late-Pleistocene or Holocene sediments or on steep slopes. Nearly all the gently or moderately sloping soils are cultivated. The steep soils are used as pasture or are in forests.

measured. These soils are considered to be intergrades to Rendolls, and most of them have developed from Rendolls.

Ruptic-Alfic Eutrochrepts.—These soils have an intermittent argillic horizon. They are moderately to strongly sloping and are shallow over calcareous, weakly consolidated sedimentary rock or fractured limestone. The argillic horizon is generally in the parts of the pedon where the depth to rock is greatest.

Vertic Eutrochrepts.—These soils have fine or very fine texture, have a high COLE, and do not have a lithic or paralithic contact within 50 cm of the soil surface. Some formed from clay shale and others in residuum from marl. Only the soils derived from marl are known to be present in the United States. Most of these soils have gentle to moderate slopes. Those in the United States are used mostly for pasture.

Fragiochrepts

These are chiefly loamy soils that have a brownish cambic horizon that is underlain, usually at a depth of about 50 cm, by a fragipan (plate 9C). Usually there is perched ground water above the pan at some time of year, and few roots penetrate the pan. Consequently, plants tend to have shallow root systems. Many Fragiochrepts formed in perhumid climates on gentle or moderate slopes in late-Pleistocene or Holocene deposits. Some are strongly sloping. The soil moisture regime is udic or perudic. The temperature regime generally is frigid or warmer, but some of these soils have a cryic temperature regime bordering on frigid. Parent materials of most Fragiochrepts are loamy and either are acid or have only a small amount of carbonates. A few of the materials are sandy and have an appreciable amount of fine and very fine sand. Most of these soils in the United States are in the northeastern states, where they are extensive. A few are in the northern lake states and some others are in the humid parts of the northwestern states. They were mostly included with Sols Bruns Acides in the 1938 classification as modified in 1957.

Definition

Fragiochrepts are the Ochrepts that have a fragipan.

Description of a Typic Fragiochrept

There follows a description of a soil that represents the central concept or typic subgroup of Fragiochrepts. This soil, in Tompkins County, N.Y., developed in Wisconsinan till under a hardwood forest. The mean annual air temperature is about 8° C. The precipitation is about 800 mm and is evenly distributed throughout the year. The slope is moderate. The colors are those of the moist soil.

Ap 0–20 cm. Dark grayish brown, (10YR 4/2) channery silt loam; weak medium and fine granular structure; friable (moist); many fine roots; 20 percent coarse fragments; strongly acid; abrupt smooth boundary.

B2 20–30 cm. Yellowish brown (10YR 5/6) channery silt loam; very weak fine subangular blocks that crush to very weak, very fine granules; very friable (moist); common fine roots; 20 percent coarse fragments; strongly acid; clear wavy boundary.

A′2 30–38 cm. Light yellowish brown (10YR 6/4) channery loam; common medium faint yellowish brown mottles; massive to very weak fine platy structure; firm (moist); common fine roots; 20 percent coarse fragments; strongly acid; abrupt irregular boundary.

B′x1 38–55 cm. Brown to dark brown (10YR 4/3) channery loam; with common fine faint dark grayish brown mottles; strong very coarse prisms separated by pale brown (10YR 6/3) loam wedges 12 to 35 mm wide at the top tapering to 3 mm wide at the bottom; common distinct yellowish brown mottles within wedges; very weak fine blocky structure within prisms; very firm (moist) and brittle (wet); few fine roots between prisms; common fine pores; thin clay films in pores and on few discontinuous block faces; 30 percent coarse fragments; strongly acid; gradual wavy boundary.

B′x2 55–75 cm. Olive brown (2.5Y 4/4) channery loam; common fine and medium faint dark grayish brown mottles; strong very coarse prisms 15 to 45 cm across, separated by a film of pale brown (10YR 6/3) silt coating on an outer 3- to 6-mm rim of yellowish brown (10YR 5/6); very firm (moist) and brittle (wet); no roots; common fine pores that have clay linings; 40 percent coarse fragments; strongly acid; diffuse boundary.

B′x3 75–150 cm. Olive brown (2.5Y 4/4) channery loam; many medium fine faint dark grayish brown and few medium distinct yellowish brown mottles; moderate very coarse prisms 25 to 75 cm across; very firm (moist) and brittle (wet); no roots; few fine pores that have clay linings; 40 percent coarse fragments; medium acid; diffuse boundary.

C 150–175 cm. Olive brown (2.5Y 4/4) channery loam; common fine faint threadlike dark grayish brown mottles; massive grading with depth to weak thick lenticular plates that have dark grayish brown (2.5Y 4/2) surfaces; very firm (moist); slightly acid; 50 percent coarse fragments.

Distinctions between Typic Fragiochrepts and other subgroups

Typic Fragiochrepts are the Fragiochrepts that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less, or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have distinct or prominent mottles in the upper 30 cm of the soil; and

c. Have an ochric epipedon.

Andic Fragiochrepts are like Typic Fragiochrepts except for *a*.

Aquic Fragiochrepts are like Typic Fragiochrepts except for *b*.

Description of subgroups

Typic Fragiochrepts.—The central concept or typic subgroup of Fragiochrepts is fixed on soils that are free of distinct or prominent mottles in the upper 30 cm, that have an ochric epipedon, and that do not have a layer near the surface as thick as 18 cm that is derived largely from pyroclastic materials and has many properties of the Andepts.

Such a mantle of pyroclastic materials between 18 and 35 cm thick indicates an intergrade to the Andepts. Shallow mottling indicates intergrades to the Fragiaquepts and is the basis for defining aquic subgroups.

A thin umbric epipedon is possible within the definition of Ochrepts, but none is known to occur in Fragiochrepts. The diagnostic horizons in these soils normally are thick enough that an umbric epipedon would have to be >25 cm thick.

Andic Fragiochrepts.—These soils have a layer near the surface that is 18 cm or more thick and that has been influenced by pyroclastic materials. This layer has many of the properties of the Andepts.

Aquic Fragiochrepts.—These soils have, at a shallow depth, mottles of medium or high contrast and are somewhat wetter than Typic Fragiochrepts. Commonly they also have gentler slopes.

Ustochrepts

These are the reddish or brownish Ochrepts of subhumid to semiarid regions. They formed mostly in Holocene deposits or on steep slopes. Most of them are calcareous at a shallow depth and have a ca or a calcic horizon. The native vegetation commonly was grass, but a few that have ground water in the root zone supported trees. These soils are not extensive except locally on the Great Plains in the United States. They were mostly considered Alluvial soils and Lithosols in the 1938 classification, Regosols in the classification as modified in 1949, and Calcisols after 1957.

Definition

Ustochrepts are the Ochrepts that

Distinctions between Typic Ustochrepts and other subgroups

Typic Ustochrepts are the Ustochrepts that

a. Have a content of organic carbon[20] that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at a shallower depth, reaches a level of 0.2 percent or less within 1.25 m of the soil surface; or have slopes >25 percent;

b. Do not have a lithic contact within 50 cm of the surface;

c. Do not have either of the following combinations of characteristics:

(1) All three of the following:

(a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm and that are at least 30 cm long in some part and that extend upward to the soil surface or to the base of an Ap horizon,

(b) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m, and

(c) More than 35 percent clay in horizons that total >50 cm in thickness; or

(2) Both of the following:

(1) If the soil temperature regime is mesic or thermic, are dry less than sixth-tenths of the time in half or more years in some part of the moisture control section (not necessarily the same part) during the period when the soil temperature, at a depth 50 cm below the surface, exceeds 5° C;
(2) If the soil temperature regime is hyperthermic or isomesic or warmer, are moist in some or all parts of the soil moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth 50 cm below the soil surface is higher than 8° C.

Andic Ustochrepts are like Typic Ustochrepts except for *f* or for *f* and *e*.

Aridic Ustochrepts are like Typic Ustochrepts except for *g*.

Fluventic Ustochrepts are like Typic Ustochrepts except for *a*.

Lithic Ustochrepts are like Typic Ustochrepts except for *b*, with or without *e* or *g*, or both.

Lithic Vertic Ustochrepts are like Typic Ustochrepts except for *c(2)*, with or without *g*, and they have a lithic contact within 50 cm of the soil surface.

Paralithic Vertic Ustochrepts are like Typic Ustochrepts except for *b* and *c(2)*, with or without *g*, and they have within 50 cm of the soil surface a paralithic contact or altered rock that retains its rock structure.

Udic Ustochrepts are like Typic Ustochrepts except for *e*.

Vertic Ustochrepts are like Typic Ustochrepts except for *c(1)*, with or without *a* or *d*, or both.

Description of subgroups

Typic Ustochrepts.—The central concept or typic subgroup of Ustochrepts is fixed on thick soils that have a shallow horizon in which carbonates have accumulated. The soils are dry for extended periods in most years. Most of them are sloping or strongly sloping.

The nearly level Ustochrepts on low terraces or high flood plains are excluded from the typic subgroup if the percentage of organic carbon decreases irregularly with depth or remains relatively high in the deep layers, because they formed from and still have some properties of Fluvents. Soils that have a lithic contact shallower than 50 cm are excluded as is done throughout the taxonomy. Clayey soils that have expanding clay and deep wide cracks are excluded because they have some properties of Vertisols. Shallow clayey soils that have montmorillonitic mineralogy are excluded because they are considered to be developing toward Vertisols.

Andic Ustochrepts.—These soils have a layer 18 cm or more thick that is influenced by pyroclastic materials and has many of the properties of Andepts. In addition, it is common that a ca or a calcic horizon is deep or is absent.

Aridic Ustochrepts.—Soils in this subgroup receive less moisture than those of the typic subgroup but otherwise are like them in defined properties. In general the depth to a calcic or ca horizon is less than for soils in the typic subgroup. These soils are extensive in the western part of the southern Great Plains of the United States. The slopes range from gentle to strong. Where slopes are suitable, many of these soils are cultivated; otherwise they are used for grazing.

Fluventic Ustochrepts.—Soils in this subgroup formed in alluvium. Their slopes are gentle, and coarse stratifications are common. These soils are used both for grazing and farming.

Lithic Ustochrepts.—These soils have a lithic contact within 50 cm of the soil surface and are permitted to be free of carbonates throughout. They are otherwise like Typic Ustochrepts. Their slopes are moderate to strong, and the soils are seldom farmed.

Lithic Vertic Ustochrepts.—These soils have a lithic contact at a depth between 25 and 50 cm below the soil surface. They are clayey, and montmorillonite dominates the clay fraction. They are mostly moderately or strongly sloping soils associated in the landscape with Usterts, and they are considered to be developing toward Vertisols.

Paralithic Vertic Ustochrepts.—These soils have, at a depth between 25 and 50 cm below the soil surface, a paralithic contact or altered rock that retains its rock structure. They are otherwise like Lithic Vertic Ustochrepts.

Udic Ustochrepts.—These soils may be free of carbonates, or the carbonates in them are deep. They are otherwise like Typic Ustochrepts. These soils in the United States formed mostly from sandstone or in sandy sediments. Where slopes are suitable, the soils generally are cultivated.

Vertic Ustochrepts.—These soils are clayey and have deep wide cracks at some season in most years, a property that is shared with Usterts. They are mostly sloping or strongly sloping soils that formed from weakly consolidated shales. They are farmed in some places in the United States where the slopes are suitable, but most of them are used for grazing or to produce hay.

Xerochrepts

These are the reddish or brownish Ochrepts of Mediterranean climates. They are moist in winter or spring but are thoroughly dry in summer. Many of them have steep slopes and are shallow over rock, but others developed in Holocene sediments. The most common vegetation on these soils in the United States was coniferous forests, and commonly there was considerable grass along with the trees. These soils developed almost exclusively in the states bordering the Pacific Ocean, and they are moderately extensive there. They were considered Brown Forest soils and Noncalcic Brown soils in the 1938 classification.

Definition

Xerochrepts are the Ochrepts that

1. Have a xeric moisture regime;
2. Do not have a fragipan;
3. Do not have a duripan that has its upper boundary within 1 m of the soil surface.

Pedon 79 is an example of the central concept or typic subgroup of Xerochrepts.

Distinctions between Typic Xerochrepts and other subgroups

Typic Xerochrepts are the Xerochrepts that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface;

b. Have base saturation (by NH_4OAc) of 60 percent or more in some part of the soil between depths of 25 and 75 cm below the soil surface;

c. Have a content of organic carbon that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at a shallower depth, reaches a level of 0.2 percent or less within 1.25 m of the soil surface; or have slopes >25 percent;

d. Do not have a lithic contact within 50 cm of the soil surface;

e. Do not have either of the following combinations of characteristics:

(1) All three of the following:

(a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(b) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and

(c) More than 35 percent clay in horizons that total >50 cm in thickness; or

(2) Both the following:

(a) Have within 50 cm of the soil surface a lithic or paralithic contact or altered rock that retains its rock structure; and

(b) Have horizons totaling 25 cm or more in thickness that have 35 percent or more clay that has montmorillonitic mineralogy or a COLE ≥0.05;

f. Do not have a calcic horizon or soft powdery lime within a depth of 1.5 m if the weighted average particle-size class from depths of 25 cm to 1 m is sandy or to a lithic or paralithic contact if one is shallower than 1 m, or within a depth of 1.1 m if the weighted average particle-size class is loamy, or within a depth of 90 cm if it is clayey;

g. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum.

Andic Xerochrepts are like Typic Xerochrepts except for *g* or for *b* and *g*.

Aquic Xerochrepts are like Typic Xerochrepts except for *a*.

Aquic Dystric Xerochrepts are like Typic Xerochrepts except for *a* and *b*.

Calcixerollic Xerochrepts are like Typic Xerochrepts except for *f*.

Dystric Xerochrepts are like Typic Xerochrepts except for *b*.

Dystric Fluventic Xerochrepts are like Typic Xerochrepts except for *b* and *c*.

Dystric Lithic Xerochrepts are like Typic Xerochrepts except for *b* and *d*.

Fluventic Xerochrepts are like Typic Xerochrepts except for c.

Lithic Xerochrepts are like Typic Xerochrepts except for *d*.

Lithic Ruptic-Xerorthentic Xerochrepts are like Typic Xerochrepts except for *d*, and have an intermittent cambic horizon.

Lithic Vertic Xerochrepts are like Typic Xerochrepts except for *d* and *e(2)*, and they have a lithic contact.

Paralithic Vertic Xerochrepts are like Typic Xerochrepts except for *e(2)*, and they have a paralithic contact or altered rock that retains its rock structure.

Ruptic-Lithic Xerochrepts are like Typic Xerochrepts except for *d* and have a lithic contact in some part but less than half of each pedon.

Vertic Xerochrepts are like Typic Xerochrepts except for *e(1)*, with or without *a* or *c*, or both.

Description of subgroups

Typic Xerochrepts.—The central concept or typic subgroup of Xerochrepts is fixed on moderately thick or thick, well-drained soils that have high base saturation, that do not have a ca or a calcic horizon unless it is deep, and that do not have a surface mantle that was derived from pyroclastic materials.

Shallow mottles of low chroma and ground water in the mottled zone or artificial drainage cause soils to be excluded from the typic subgroup because those properties indicate intergrades to Aquepts and are the basis for recognition of aquic subgroups. A layer or a surface mantle, 18 to 35 cm thick, that has low bulk density and amorphous clay is excluded because it indicates a transition to Andepts and is used to define andic subgroups. A shallow lithic contact is the basis for recognition of lithic subgroups, a convention used throughout the taxonomy. Soils that have clayey texture accompanied by deep wide cracks or montmorillonitic clay and a shallow lithic or paralithic contact are excluded because these characteristics indicate intergrades to Vertisols and define the vertic subgroups. Soils that have base saturation <60 percent throughout are excluded because they are considered intergrades to Dystrochrepts. Soils formed in recent alluvium that have an organic-carbon content that decreases irregularly with depth below the surface or that remains relatively high in the deep layers are excluded because they share a number of properties with the Fluvents. Soils that have a shallow ca or calcic horizon are excluded because they share several properties with the Calcixerolls.

Andic Xerochrepts.—These soils have a layer or a surface mantle, 18 cm or more thick, that has been influenced by pyroclastic materials and that has many of the properties of Andepts. In addition, it is common that base saturation may be lower than in Typic Xerochrepts.

Aquic Xerochrepts.—These soils have mottles of low chroma (chroma less than 2) within 75 cm of the soil surface and either have artificial drainage or are saturated with water in the mottled horizons at some time of year, usually in winter or spring. They are otherwise like Typic Xerochrepts. Most of these soils have gentle slopes and are cultivated.

Aquic Dystric Xerochrepts.—These soils have mottles of low chroma (chroma less than 2) within 75 cm of the soil surface and either have artificial drainage or are saturated with water in the mottled horizons at some time of year, usually in winter or spring. Base saturation is <60 percent between depths of 25 cm and 75 cm below the surface, but otherwise the soils are like Typic Xerochrepts. Most of these soils have gentle slopes and are cultivated.

Calcixerollic Xerochrepts.—Soils in this subgroup have a calcic horizon or a ca horizon that contains soft powdery lime. These horizons normally are not present or are deep in Typic Xerochrepts. These soils formed in calcareous sediments and most but not all of them are calcareous throughout. Where slopes are suitable, most of these soils are farmed.

Dystric Xerochrepts.—These soils have lower base saturation than Typic Xerochrepts but are otherwise like them. Most of these soils formed either from acid materials or under somewhat higher precipitation than soils of the typic subgroup. Where slopes are suitable, most of the Dystric Xerochrepts are farmed, but the more strongly sloping soils are in pasture or forest. The forests are mainly coniferous.

Dystric Fluventic Xerochrepts.—These soils have lower base saturation than Typic Xerochrepts and formed in alluvium recent enough that the percentage of organic carbon decreases irregularly with depth or remains relatively high in the deep layers, or both. Most of these soils in the United States formed in noncalcareous alluvium and have gentle slopes. Some are subject to occasional flooding but receive little fresh sediment. Most of the soils are farmed.

Dystric Lithic Xerochrepts.—These soils have lower base saturation than Typic Xerochrepts and have a shallow lithic contact. They are otherwise like the typic soils. These soils in the United States mostly formed from rocks that have no carbonates and under relatively high precipitation. The soils generally are strongly to steeply sloping and are not farmed. Some are used for grazing or for forests.

Fluventic Xerochrepts.—Soils in this subgroup are formed in coarsely stratified alluvium on gentle slopes. They are not extensive but occur in western Washington in the United States. They are farmed under irrigation.

Lithic Xerochrepts.—These soils have a shallow lithic contact but are otherwise like Typic Xerochrepts. Most of them are strongly to steeply sloping and are not farmed Some are used for grazing or are in forests.

Lithic Ruptic-Xerorthentic Xerochrepts.—These soils have a shallow lithic contact and a cambic horizon that is interrupted at close intervals by irregular protrusions of the tuffaceous or extrusive bedrock. Slopes range from gentle to very steep. The soils are extensive in the foothills of the mountains in central California and are used for grazing. Annual grasses and shrubs are the principal vegetation.

Lithic Vertic Xerochrepts.—These soils are not known to occur in the United States, but the subgroup is provided for use if needed.

Paralithic Vertic Xerochrepts.—These soils are not known to occur in the United States but the subgroup is provided for use if needed.

Ruptic-Lithic Xerochrepts.—Soils in this subgroup have a lithic contact that is shallower than 50 cm in part but not all of each pedon. Most of them have a lithic contact at a depth <1 m throughout each pedon. They are otherwise like Typic Xerochrepts. Most of these soils in the United States are strongly to steeply sloping. A few that have gentle slopes are farmed, but most of them are used for grazing.

Vertic Xerochrepts.—These soils have clayey texture and have deep wide cracks in summer if they are not irrigated. They are not known to occur in the United States, but the subgroup is provided for use if needed. The Vertic Xerochrepts are associated in the landscape with Xerochrepts and Xererts.

Plaggepts

Plaggepts are the soils that have a plaggen epipedon that is composed of crystalline rather than pyroclastic materials. This suborder includes all freely drained soils that have a plaggen epipedon except a few Andepts. Because the Plaggepts are not known to occur in the United States, the classification has not been developed beyond the idea that the soils should be grouped into a single suborder. Most of these soils are in Europe and in the British Isles. Their slopes are gentle and they are either farmed or used for housing. The buried soils under the plaggen epipedon vary appreciably in morphology but few of them had high natural fertility. Plate 2C shows a Plaggept in the Netherlands.

Tropepts

The Tropepts are brownish to reddish, more or less freely drained Inceptisols that are mainly in intertropical regions and that do not have a significant amount of active amorphous clay or pyroclastic materials. Most of them have an ochric epipedon and a cambic horizon. The regolith may be thick or thin, but commonly these soils have moderate to steep slopes and a regolith that is relatively thin for the humid Tropics. Others that are on terraces have gentle slopes. These soils have an isomesic or warmer iso temperature regime. Their soil moisture regime is perudic, udic, or ustic. Where the soil moisture regime is perudic or

udic, vegetation normally was an evergreen broadleaf forest. Where the moisture regime is ustic, there were

cm and 1 m, or between 25 cm and a lithic or paralithic contact if one is shallower than 1 m.

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e. Do not have a lithic or a petroferric contact within 50 cm of the soil surface;
f. Have in all horizons above a lithic contact or above a depth of 1 m, whichever is shallower, a CEC (by NH_4OAc) of 24 or more meq per 100 g clay.[23]
g. Have a udic moisture regime; and
h. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more if the soil moisture regime is udic, or 0.07 or more if it is ustic, in a horizon or horizons at least 50 cm thick, and a potential linear extensibility of 6 cm or more in the upper 1 m or 1.25 m, respectively, of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m or 1.25 m;

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Aquic Dystropepts are like Typic Dystropepts except for *a*.

Fluventic Dystropepts are like Typic Dystropepts except for *d*.

Lithic Dystropepts are like Typic Dystropepts except for *e* and have a lithic contact within a depth of 50 cm.

Oxic Dystropepts are like Typic Dystropepts except for *f*.

Ustic Dystropepts are like Typic Dystropepts except for *g*, and they have an ustic moisture regime.

Ustoxic Dystropepts are like Typic Dystropepts except for *f* and *g*, and they have an ustic moisture regime.

Vertic Dystropepts are like Typic Dystropepts except for *h*, with or without any or all of *a*, *c*, *d*, and *g*.

Description of subgroups

Typic Dystropepts.—The central concept or typic subgroup of Dystropepts is fixed on freely drained soils that have a udic moisture regime, that are deep to hard rock, that have some 2:1 lattice clay, that do not have a surface mantle derived from or influenced by pyroclastic materials, and that were derived from a country rock or old alluvium rather than from alluvium recent enough to have a content of organic carbon that decreases irregularly with depth or remains relatively high in the deep layers. Many Typic Dystropepts are shallow soils that have a paralithic contact or saprolite shallower than 75 cm. Most that were derived from country rock have strong to steep slopes. Those derived from old alluvium commonly have gentle slopes.

Soils that have shallow mottles of low chroma (≤2) are excluded from the typic subgroup if the mottled horizon is saturated with water at some time of year or if the soil has been artificially drained, because those properties indicate intergrades to the Tropaquepts. Soils that have a layer or surface mantle ≥18 cm thick that has low bulk density and amorphous clay are excluded because that property indicates intergrades to the Andepts. A cambic horizon is required because the Tropepts must have either a cambic horizon or an umbric epipedon to be classified as Dystropepts, and the umbric epipedon is not normal. A content of organic carbon that decreases irregularly with depth or remains relatively high in the deep layers is a property of Fluvents and indicates fluventic subgroups. A shallow lithic or petroferric contact causes soils to be excluded from the typic subgroup, as is done throughout the taxonomy. A CEC that is <24 meq per 100 g clay (by NH_4OAc) indicates an advanced stage of weathering of the clay and is the basis for defining oxic subgroups. An ustic moisture regime is used to define ustic subgroups because no distinction between udic and ustic moisture regimes was made in any higher category. Clayey soils that have expanding clays, either dominated by montmorillonite or having a high COLE, are classified in vertic subgroups.

Aquic Dystropepts.—These soils have mottles of low chroma (≤2), and the mottled horizon is saturated with water at some time of year or the soil has been artificially drained. These soils are not known to occur in the United States, but the subgroup is provided for use if needed elsewhere.

Fluventic Dystropepts.—These soils formed in Holocene alluvium. They mostly have gentle slopes and are cultivated if the area has been settled.

Lithic Dystropepts.—These soils have a shallow lithic contact. Most of them have strong to steep slopes and are used for grazing or are in forests.

Oxic Dystropepts.—Soils in this subgroup have clays that have low activity. The CEC may be within the range defined for Oxisols (<16 meq per 100 g clay) or slightly higher. If the CEC is <16 meq per 100 g clay, there are weatherable minerals in the 20- to 200-micron fraction. These soils either formed in Pleistocene alluvium, or they are on strongly to steeply sloping surfaces of Pleistocene or younger age.

Ustic Dystropepts.—These soils have an ustic moisture regime but are otherwise like Typic Dystropepts. They mostly have high rainfall and commonly they have two rainy seasons, but they are dry for extended periods during the dry season or seasons.

Ustoxic Dystropepts.—These soils have an ustic moisture regime and clays that have low activity. The CEC may be within the range defined for Oxisols (<16 meq per 100 g clay) or slightly higher. If the CEC is <16 meq per 100 g clay, there are weatherable minerals in the 20- to 200-micron fraction. These soils either formed in Pleistocene alluvium or they are on strongly to steeply sloping surfaces of Pleistocene or younger age.

Vertic Dystropepts.—These soils have clayey texture and have deep wide cracks at some time of year.

[23] Some cambic horizons that have properties that approach those of an oxic horizon do not disperse well. If the ratio of the percentage of water retained at tension of 15 bars to the percentage of measured clay is 0.6 or more, the percentage of clay is determined by the higher value of (1) the measured percentage of clay or (2) 2.5 times the percentage of water retained at tension of 15 bars.

These are properties shared by the Vertisols and are the basis for defining vertic subgroups.

An ustertic subgroup may be needed where the rainfall is highly seasonal and the cracks are open for long periods. These soils should have a COLE ≥ 0.07 and 6 cm or more linear extensibility in the upper 1.25 m of the soil.

Eutropepts

These are the Tropepts that have high base saturation and that are rarely dry for long periods. The primary minerals are only slightly weathered, or the soils receive bases from higher lying soils. These soils in the United States formed from basic parent materials and have strong to steep slopes. Unweathered or slightly weathered parent materials commonly are present within 50 cm of the soil surface and rarely lie much deeper than 75 cm. These soils are extensive in Puerto Rico but are rare in Hawaii. They were mostly considered Lithosols and Gray-Brown Podzolic soils in the 1938 classification.

Definition

Eutropepts are Tropepts that

1. Have 50 percent or more base saturation (by NH_4OAc) throughout all subhorizons between depths of 25 cm and 1 m, or between 25 cm and a lithic or paralithic contact if one is shallower than 1 m;
2. Have a udic moisture regime; and
3. Do not have a horizon containing soft, powdery secondary lime within 1.5 m of the soil surface.

Pedon 81 is an example of the central concept or typic subgroup of Eutropepts.

Distinctions between Typic Eutropepts and other subgroups

Typic Eutropepts are the Eutropepts that

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface if the mottled horizon is saturated with water at some time during the year or

e. Do not have either of the following combinations of characteristics:

(1) All three of the following:

(a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the soil surface or to the base of an Ap horizon;

(b) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil, or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(c) More than 35 percent clay in horizons that total >50 cm in thickness; or

(2) Both the following:

(a) Have within 50 cm of the surface a lithic or paralithic contact or altered rock that retains its rock structure, and

(b) Have horizons totaling 25 cm or more in thickness that have 35 percent or more clay that has montmorillonitic mineralogy or that have a COLE ≥ 0.09; and

f. Have a cambic horizon.

Andic Eutropepts are like Typic Eutropepts except for *a*.

Aquic Eutropepts are like Typic Eutropepts except for *b*.

Fluvaquentic Eutropepts are like Typic Eutropepts except for *b* and *c*.

Fluventic Eutropepts are like Typic Eutropepts except for *c*.

Lithic Eutropepts are like Typic Eutropepts except for *d*.

Lithic Vertic Eutropepts are like Typic Eutropepts except for *d* and *e(2)*, with or without *f*.

Paralithic Vertic Eutropepts are like Typic Eutropepts except for *e(2)* and they have a paralithic contact or have altered rock that retains its rock structure.

Vertic Eutropepts are like Typic Eutropepts except for *e(1)*, with or without any or all of *b*, *c*, or *f*.

Description of subgroups

Typic Eutropepts.—The central concept or typic subgroup of Eutropepts is fixed on soils that do not have a surface mantle that has low bulk density influenced by pyroclastic materials; that do not have mottles of low chroma (≤ 2) and ground water in the mottled zone at some time of year or artificial drain-

An irregularly decreasing content of organic carbon from the surface downward or a relatively high organic-carbon content in the deep layers is a property of the Fluvents and defines fluventic subgroups or defines fluvaquentic subgroups if ground water is shallow. A shallow lithic contact defines lithic subgroups, a convention used throughout the taxonomy. A cambic horizon may be absent only if there is a mollic or umbric epipedon, and those epipedons are rare in the Eutropepts. Deep wide cracks and clayey texture are some of the important properties of Vertisols and define the vertic subgroup. If rock is shallow and the soils are clayey and have montmorillonite as the dominant clay mineral, the soils are considered to be developing toward the Vertisols, and those properties define the Lithic Vertic or the Paralithic Vertic Eutropepts.

Andic Eutropepts.—These soils mostly have thin surface horizons that were derived from pyroclastic materials and have an appreciable amount of amorphous clay that has a high CEC. These soils are not known to occur in the United States, but the subgroup is provided for use if needed elsewhere.

Aquic Eutropepts.—These soils have mottles of low chroma at some depth and either have ground water or artificial drainage. Most of these soils are on fans at the base of steeper slopes where they receive runoff and, in some places, seepage. Locally they are used intensively for cultivated crops.

Fluvaquentic Eutropepts.—These soils have gentle slopes and are on low terraces or high bottoms. They formed in Holocene alluvium. They are intensively cul-

ginal between mollic and ochric. These soils lie in the landscape between Eutropepts and Vertisols and have some of the properties of each.

Humitropepts

These are mainly the humus-rich Tropepts of relatively cool, humid regions of high altitudes. The soil moisture regime is mostly udic, and the temperature regime is mostly isothermic or isomesic. A very few of these soils have an isohyperthermic temperature regime that is marginal to isothermic. Base saturation is normally low or very low. The soils may have an ochric or, more commonly, an umbric epipedon, and most of them have a cambic horizon. Their vegetation was mostly an evergreen broadleaf forest, but many are used for shifting cultivation, and many in the United States are fertilized and cultivated. They are not extensive soils in the United States. Some were considered Humic Latosols in the 1938 classification as modified in 1955. The classification that follows is provisional.

Definition

Humitropepts are the Tropepts that

1. Have 12 kg or more organic carbon, exclusive of surface litter, in the soil per square meter to a depth of 1 m or to a lithic or paralithic contact if one is shallower than 1 m;
2. Have base saturation <50 percent (by NH_4OAc) in

fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Do not have mottles that have chroma of 2 or less within 1 m of the soil surface if the mottled horizon is saturated with water at some time of year or if there is artificial drainage;

c. Do not have a lithic contact within 50 cm of the soil surface;

d. Have a CEC (by NH_4OAc) of 24 or more meq per 100 g clay.[25]

e. Have a content of organic carbon that decreases regularly with depth to the base of the cambic horizon, or have slopes >25 percent; and

f. Have a udic moisture regime.

Andic Humitropepts are like Typic Humitropepts except for *a* or for *a* and *e*.

Andic Ustic Humitropepts are like Typic Humitropepts except for *a* and *f*, with or without *e*, and they have an ustic moisture regime.

Fluventic Humitropepts are like Typic Humitropepts except for *e*.

Lithic Humitropepts are like Typic Humitropepts except for *c*.

Oxic Humitropepts are like Typic Humitropepts except for *d*.

Ustic Humitropepts are like Typic Humitropepts except for *f*, and they have an ustic moisture regime.

Ustoxic Humitropepts are like Typic Humitropepts except for *d* and *f*, and they have an ustic moisture regime.

Description of subgroups

Typic Humitropepts.—The central concept or typic subgroup of Humitropepts is fixed on freely drained soils that do not have any evidence of a surface mantle influenced by pyroclastic materials, do not have a shallow lithic contact, have some 2:1 lattice clay, and formed in a humid climate from the country rock or from old alluvium.

A surface mantle that shows the influence of pyroclastic materials in its low bulk density and amorphous clay has many of the properties of Andepts and is used to define andic subgroups. Mottles of low-chroma accompanied by ground water or artificial drainage are characteristics of Aquepts and define aquic subgroups. Organic-carbon content that decreases irregularly with depth is a property of Fluvents and defines fluventic subgroups. A shallow lithic contact defines lithic subgroups, a convention used throughout the taxonomy. Clay that has low activity indicates strong weathering and is used to define oxic subgroups. An ustic soil moisture regime is used to define ustic subgroups.

Andic Humitropepts.—These soils in the United States were derived mainly from pyroclastic materials and lava and have many but not all of the properties of Dystrandepts. In regions of current vulcanism, some have only surface horizons that are influenced by ash.

Andic Ustic Humitropepts.—These soils have an ustic soil moisture regime. Those in the United States were derived mainly from pyroclastic materials and lava.

Fluventic Humitropepts.—These soils formed in Holocene alluvium that was derived from highly weathered materials. The organic-carbon content decreases irregularly with depth as it does in most Fluvents. The clays are permitted to have low activity because they are mostly inherited, and the nature of the clay is a function of the nature of the alluvium.

Lithic Humitropepts.—These soils have a shallow lithic contact but are otherwise like Typic Humitropepts. Most of them have strong to steep slopes and few are cultivated.

Oxic Humitropepts.—These soils have a udic soil moisture regime and clay that has a low CEC. Most of them in the United States have strong to steep slopes.

Ustic Humitropepts.—Soils in this subgroup have an ustic soil moisture regime but are otherwise like Typic Humitropepts.

Ustoxic Humitropepts.—These soils have an ustic soil moisture regime and clay that has low activity. Most of them in the United States have gentle slopes and are developing toward Oxisols.

Sombritropepts

These soils are the dark, humus-rich Tropepts of perhumid, cool, hilly or mountainous regions. They have a sombric horizon in or below a cambic horizon. Most of them have an umbric epipedon, a perudic soil moisture regime, and an isomesic temperature regime. They are not known to occur in the United States and their classification has not been developed.

Ustropepts

These are base-rich Tropepts that are mostly in subhumid regions. They commonly have one or two distinct dry seasons. Most of them have strong to steep slopes and are shallow over rock. Some that formed in alluvium have gentle slopes. Many have a ca or even a calcic horizon below a cambic horizon. The epipedon is mainly ochric, but a few of these soils that are clayey have a mollic epipedon. The vegetation most commonly is a savanna or a mixture of brush and grass. Few of the soils are cultivated unless they are irrigated. Most of them were considered Low Humic Latosols in the 1938 classification as modified in 1955.

Definition

Ustropepts are the Tropepts that

1. Have an ustic moisture regime or have a horizon containing soft powdery lime within 1.5 m of the surface; and

2. Have base saturation (by NH_4OAc) that is 50 percent or more in all subhorizons between depths of 25 cm and 1 m.

[25] See footnote 23 on p. 259.

Description of a Typic Ustropept

A description of a soil that represents the central concept or typic subgroup of Ustropepts follows. This soil, on the island of Vieques, is in native pasture. The mean annual precipitation is about 900 mm, and the mean annual air temperature is about 25° C. The soil is strongly sloping. The colors given are those of the

A1 0–13 cm. Dark brown (10YR 3/3) loam; weak fine granular structure; soft (dry), friable (moist), nonsticky and nonplastic (wet); common fine roots; slightly acid; clear smooth boundary.

B 13–38 cm. Brown (7.5YR 4/4) sandy clay loam; weak coarse subangular blocky structure; slightly hard (dry), friable (moist), nonsticky and slightly plastic (wet); few fine roots; krotovinas filled with material from the horizon above; common rock fragments that range from 2 to 5 m in size; neutral; gradual wavy boundary.

C 38–97 cm. Yellowish brown (10YR 5/4) very gravelly coarse sand; structureless; very friable, (moist); about 60

thickness that have 35 percent or more clay that has montmorillonitic mineralogy or have a COLE ≥ 0.07.

Fluventic Ustropepts are like Typic Ustropepts except for *b*, with or without *c* or *e*, or both, and the organic-carbon content is ≥ 0.5 percent at a depth of 1.25 m below the soil surface if the CEC is <24 meq

or of the whole soil if there is no cambic horizon.

Lithic Ustropepts are like Typic Ustropepts except for *d*.

Lithic Vertic Ustropepts are like Typic Ustropepts except for *d* and *f(2)*, with or without *c*.

Oxic Ustropepts are like Typic Ustropepts except for *e* or for *e* and *b*, and the organic-carbon content is <0.5 percent at a depth 1.25 m below the soil surface.

Paralithic Vertic Ustropepts are like Typic Ustropepts except for *f(2)*, with or without *c*, and they

meq per 100 g clay and may or may not have irregular decrease in organic carbon with increasing depth. They have gentle to steep slopes. These soils are locally important in Hawaii where pineapples are the principal crop. Some are used for grazing.

Paralithic Vertic Ustropepts.—These soils have, between depths of 25 and 50 cm below the soil surface, a shallow paralithic contact or altered rock that retains the rock structure. They are otherwise like Lithic Vertic Ustropepts. They are not known to occur in the United States, but the subgroup is provided for use if needed.

Vertic Ustropepts.—Soils in this subgroup have a clayey particle-size class, deep wide cracks, and a high COLE, but they lack one or more of the diagnostic properties of Vertisols. They are associated in the landscape with Vertisols. They may have a mollic epipedon.

Umbrepts

These are the acid, dark reddish or brownish, freely drained, organic-matter-rich Inceptisols (plate 11C) of the humid mid to high latitudes. They are mostly in hilly to mountainous regions that have high or very high precipitation, but many of them have a distinct summer dry season. In midlatitudes they have formed mostly under coniferous forests. In high latitudes and above the timberline in midlatitudes they have formed under mixed grasses and forbs or low tundra shrubs. Most of them are in late-Pleistocene or Holocene deposits or on strong to steep slopes of similar age. They are extensive in the United States only in the western states, particularly along the Pacific coast.

Definition

Umbrepts are the Inceptisols that

1. Throughout the upper 35 cm or more have an exchange complex that is not dominated by amorphous materials and are <60 percent vitric[27] volcanic ash, cinders, or other vitric pyroclastic materials;
2. Are not artificially drained and do not have an aquic moisture regime or do not have the characteristics associated with wetness that are defined for Aquepts;
3. Have 5° C or more difference between the mean summer and mean winter soil temperatures at a depth of 50 cm or at a lithic or a paralithic contact, whichever is shallower unless the mean soil temperature is <8° C;
4. Do not have a plaggen epipedon; and
5. Have one of the following characteristics:
   a. If the mean annual soil temperature is 8° C or higher, either have an umbric or anthropic epipedon that is >25 cm thick or have a mollic epipedon that is >25 cm thick if it is underlain by a cambic horizon that has base saturation of <50 percent (by NH_4OAc) in some part;
   b. If the mean annual soil temperature is lower than 8° C, either have an umbric epipedon or have a mollic epipedon that is underlain by a cambic horizon that has base saturation of <50 percent (by NH_4OAc) in some part; or
   c. Have an anthropic epipedon.

Key to great groups

IFA. Umbrepts that have a fragipan.
Fragiumbrepts, p. 265

IFB. Other Umbrepts that have a cryic or pergelic temperature regime.
Cryumbrepts, p. 264

IFC. Other Umbrepts that have a xeric moisture regime.
Xerumbrepts, p. 268

IFD. Other Umbrepts.
Haplumbrepts, p. 266

Cryumbrepts

These are the cold Umbrepts of high latitudes or high altitudes. Some have a coniferous forest. Others are above the timberline and have a mixture of forbs, grasses, and in some places woody shrubs. They are extensive in the high mountains in the western states. They are moderately extensive in Alaska, particularly in very well drained sites. Most of them have strong to steep slopes and formed from acid parent materials. They were classified as Alpine Meadow soils in the 1938 classification and as Sols Bruns Acides in the classification as modified in 1957.

Definition

Cryumbrepts are the Umbrepts that

1. Have a cryic or pergelic temperature regime; and
2. Do not have a fragipan.

Description of a Typic Cryumbrept

A description of a soil that represents the central concept or typic subgroup of Cryumbrepts follows. This soil, in Boise County, Idaho, is at an elevation of about 2,300 m on a steeply sloping ridge. The mean annual precipitation is about 1,000 mm, about half of which comes as snow. The vegetation is a mixture of forbs and grasses with scattered clumps of subalpine conifers. The base saturation is <20 percent. The colors are those of the dry soil unless otherwise stated.

A11 0–18 cm. Brown (10YR 5/3) gravelly coarse sandy loam, dark brown (10YR 3/3) moist; weak very fine granular structure; soft (dry), very friable (moist), nonsticky and nonplastic (wet); many very fine and fine roots; many micro interstitial and very fine and fine tubular pores; 20 percent angular pebbles, mostly <5 mm across; strongly acid (pH 5.3); clear smooth boundary.

A12 18–33 cm. Brown (10YR 5/3) coarse sandy loam, dark brown (10YR 3/3) moist; weak very fine granular structure; soft (dry), very friable (moist), nonsticky and nonplastic (wet); many very fine and fine roots; many micro interstitial and very fine tubular pores; 13 percent angular pebbles, mostly <5 mm across; strongly acid (pH 5.3); clear wavy boundary.

B21 33–60 cm. Yellowish brown (10YR 5/4) (light yellowish brown 10YR 6/4 crushed) gravelly coarse sandy loam, dark yellowish brown (10YR 3/4) (10YR 4/4 crushed)

and very fine tubular pores; 15 percent angular fine pebbles; strongly acid (pH 5.2.); gradual wavy boundary.

B29 60-110 cm. Light [illegible]

terials, do not have permafrost, and have both an umbric epipedon and a cambic horizon.

Low bulk density and some amorphous clay are

Definition

Fragiumbrepts are the Umbrepts that have a fragipan.

Description of a Typic Fragiumbrept

A description of a soil that represents the central concept or typic subgroup of Fragiumbrepts follows. This soil, in Clark County, Wash., formed in Pleistocene alluvium. The mean annual air temperature is about 9° C, the annual precipitation is about 1,250

have significant evidences of amorphous clay and that are free of mottles of low chroma to a depth of at least 50 cm.

A surface mantle that has amorphous clay and low bulk density has some properties of Andepts and is used to define the andic subgroup. Mottles that have low chroma at shallow depths are characteristic of Aquepts and are used to define the aquic subgroup.

Andic Fragiumbrepts.—These soils have a surface horizon that has low bulk density and some amor-

but the cause of the thickening is unknown. Some of these soils have gentle slopes.

Quartzipsammentic Haplumbrepts.—These soils have a sandy particle-size class, and the sand is virtually pure quartz or other minerals that are extremely resistant to weathering. These soils in the United States have gentle slopes and are known to occur only in Florida.

Xerumbrepts

These are the Umbrepts of Mediterranean climates that have a xeric soil moisture regime. Most of them in the United States are close to the Pacific Ocean but are far enough away to be relatively free of summer fog. Their vegetation was mostly coniferous forest, but some had a mixture of grass and ferns. They formed in Pleistocene and Holocene deposits and on slopes of comparable ages. Most of these soils in the United States are still in forests. They are not extensive except locally in western Washington and Oregon. They were considered Sols Bruns Acides in the 1938 classification as modified in 1955.

Definition

Xerumbrepts are the Umbrepts that
1. Have a xeric moisture regime; and
2. Do not have a fragipan.

Description of a Typic Xerumbrept

A description of a soil that represents the central concept or typic subgroup of Xerumbrepts follows. This soil, in Marion County, Oreg., is on a moderate slope and is being cultivated. It has formed in colluvium and residuum from fine-grained sandstone. The mean annual precipitation is about 1,500 mm, mostly in winter rain, and summers are very dry. The mean annual air temperature is about 9° C. The colors are those of the moist soil unless otherwise stated.

Ap 0–22 cm. Very dark brown (7.5YR 2/2) clay loam, dark brown (7.5YR 4/4) dry; weak coarse and medium subangular blocks parting to weak very fine subangular blocks; hard (dry), friable (moist), sticky and plastic (wet); many roots; many very fine pores; few very fine black and reddish concretions; medium acid (pH 5.8); abrupt wavy boundary.

A3 22–38 cm. Variegated dark brown (7.5YR 3/2 and 3/4) clay loam, brown (7.5YR 4/4) dry; weak coarse prisms parting to weak fine and very fine subangular blocks; hard (dry), friable (moist), sticky and plastic (wet); many roots; many fine and very fine tubular pores; common wormcasts; strongly acid (pH 5.4); clear smooth boundary.

B1 38–56 cm. Dark reddish brown (5YR 3/4) silty clay loam, reddish brown (5YR 4/4) dry; weak coarse and medium subangular blocky structure; hard (dry), friable (moist), sticky and very plastic (wet); common roots; many very fine tubular pores; few fine tubular pores; strongly acid (pH 5.4); clear smooth boundary.

B21 56–84 cm. Reddish brown (5YR 4/4) silty clay loam, reddish brown (5YR 5/4) dry; weak medium subangular blocky structure; hard (dry), friable (moist), sticky and very plastic (wet); common roots; common fine tubular pores; very strongly acid (pH 5.0); clear smooth boundary.

B22 84–120 cm. Yellowish red (5YR 4/6) silty clay loam, yellowish red (5YR 5/6) dry; weak medium and fine subangular blocky structure; very hard (dry), firm (moist), sticky and very plastic (wet); few roots; common fine and very fine tubular pores; very strongly acid (pH 5.0); gradual smooth boundary.

B3 120–140 cm. Dark brown (7.5YR 4/4) silty clay loam, strong brown (7.5YR 5/6) dry; weak coarse subangular blocky structure; hard (dry), firm (moist), sticky and very plastic (wet); few roots; common fine and very fine tubular pores; common faint medium and coarse reddish brown (5YR 4/4) mottles; few black medium stains; clear wavy boundary.

C 140 cm. Variegated strong brown (7.5YR 5/6 and 5/8) pinkish gray (7.5YR 6/2) and red (5YR 4/6) strongly weathered sandstone; clay loam texture; massive; clay films along fractures; very strongly acid (pH 4.8).

Distinctions between Typic Xerumbrepts and other subgroups

Typic Xerumbrepts are the Xerumbrepts that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface if the mottled horizon is saturated with water at some time of the year when its temperature is >5° C or if there is artificial drainage;

b. Have an umbric or mollic epipedon that is <50 cm thick;

c. Have a cambic horizon;

d. Have a content of organic carbon that decreases regularly with depth or have slopes >25 percent;

e. Do not have a lithic contact within 50 cm of the soil surface; and

f. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum.

Andic Xerumbrepts are like Typic Xerumbrepts except for *f*.

Entic Xerumbrepts are like Typic Xerumbrepts except for *c*.

Fluventic Xerumbrepts are like Typic Xerumbrepts except for *d*.

Lithic Xerumbrepts are like Typic Xerumbrepts except for *e*, with or without *c*.

Pachic Xerumbrepts are like Typic Xerumbrepts except for *b*, with or without *a* or *c*, or both.

Description of subgroups

Typic Xerumbrepts.—The central concept or typic subgroup of Xerumbrepts is fixed on freely drained soils that have an umbric epipedon <50 cm thick on a cambic horizon, that do not have a shallow lithic contact, and that were derived from country rock or old alluvium.

An umbric epipedon >50 cm thick is considered abnormal. It defines the cumulic subgroup if there is evidence that materials have been added at the surface, and it defines the pachic subgroup if there is no such evidence. The absence of a cambic horizon suggests weak horizon development and defines entic subgroups. An organic-carbon content that decreases irregularly with depth is a property shared with Flu-

vents, and it defines the fluventic subgroup. A shallow lithic contact defines lithic subgroups, a convention used throughout the taxonomy.

Andic Xerumbrepts.—These soils have a surface mantle with low bulk density; the soils have evidence of amorphous clays but are otherwise like Typic Han-

Fluventic Xerumbrepts.—These soils are on fans, high bottoms, or low terraces and are flooded at intervals. They commonly have coarse stratifications and receive some fresh sediments, but the umbric epipedon is <50 cm thick. Their slopes are gentle.

Lithic Xerumbrepts.—These soils have a shallow

ture regime is ustic in a horizon or horizons at least 50 cm thick;

(2) A potential linear extensibility of 6 cm or more in the upper 1 m of the soil if the moisture regime is udic, in the upper 1.25 m of the soil if the moisture regime is ustic, or in the whole soil if there is a lithic or paralithic contact between a depth of 50 cm and 1 m or 1.25 m as just stated; and

(3) More than 35 percent clay in horizons that total 50 cm or more in thickness;

5. If the mean soil temperature is 8° C or higher and if there are cracks open to the surface or to the base of an Ap horizon at some period in most years and the cracks are at least 1 cm wide at a depth of 50 cm, either

a. After the surface soil to a depth of 18 cm has been mixed, the soil has <30 percent clay in some horizon above a lithic or paralithic contact, a calcic horizon, or a depth of 50 cm, whichever is shallowest; or has

b. None of the following:

(1) Gilgai,

(2) Slickensides close enough to intersect at depths between 25 cm and 1 m, and

(3) Wedge-shaped natural structural aggregates that have their long axes tilted 10° to 60° from the horizontal at any depth between 25 cm and 1 m;

6. Do not have an oxic horizon; and do not have plinthite that forms a continuous phase within 30 cm of the surface if the moisture regime is aquic; and

7. Do not have a spodic horizon that has its upper boundary within 2 m of the surface.

Limits between Mollisols and soils of other orders

The definition of Mollisols must provide criteria to separate Mollisols from soils of all other orders. The aggregate of these criteria defines the limits of Mollisols in relation to all other known kinds of soil.

1. To distinguish Mollisols from Alfisols, Mollisols must have both

a. Base saturation (by NH_4OAc) that is 50 percent or more in all subhorizons of any argillic or natric horizon to a depth of 1.25 m below the upper boundary of the argillic horizon or to a depth of 1.8 m below the surface of the soil, whichever is less, and

b. Either a mollic epipedon or the combination of a surface horizon, when mixed to a depth of 18 cm, plus the upper subhorizon of an argillic or

4. To distinguish Mollisols from Histosols, Mollisols must meet the definition of mineral soils (ch. 3).

5. To distinguish Mollisols from Inceptisols, Mollisols have an argillic or a natric horizon or a mollic epipedon, but if they have a mollic epipedon and do not have an argillic or natric horizon, they must not have any of the following:

a. Either

(1) A bulk density of <0.85 g per cubic centimeter and an exchange complex dominated by amorphous materials to a depth of 35 cm or more or to a lithic or paralithic contact shallower than 35 cm; or

(2) Sixty percent or more of the soil composed of vitric volcanic ash, cinders, or other vitric pyroclastic material in silt, sand, and gravel size to a depth of 35 cm or more;

b. An underlying cambic horizon that has base saturation (by NH_4OAc) that is <50 percent in some part or that decreases to <50 percent at a depth of 1.8 m or less below the surface;

(c) An isomesic or warmer iso temperature regime and an epipedon that rests on soil materials that have <40 percent $CaCO_3$ equivalent in all subhorizons within 1 m of the surface or above a lithic or paralithic contact, whichever is shallower, and also either

(1) A lithic or paralithic contact within 50 cm of the surface and ≥35 percent clay that has montmorillonitic mineralogy in subhorizons that have a total thickness of 25 cm or more, or a COLE ≥0.09 if the soil moisture regime is udic or ≥0.07 if the soil moisture regime is ustic, or

(2) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend to the surface or to the base of an Ap horizon; COLE of 0.09 or more in a horizon or horizons at least 50 cm thick if the moisture regime is udic or 0.07 or more if the moisture regime is ustic; and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil if the moisture regime is udic, in the upper 1.25 m of the soil if the moisture regime is ustic, or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than these depths and >35 percent clay in horizons that total 50 cm or more in thickness.

6. To distinguish Mollisols from Oxisols, Mollisols must not have an oxic horizon and must not have plinthite that forms a continuous phase within 30 cm of the surface if the moisture regime is aquic.

7. To distinguish Mollisols from Spodosols, Mollisols

higher and there are cracks open to the surface or to the base of an Ap horizon at some period in most

(2) Base colors immediately below the mollic epipedon that have one or more of the follow-

3. Have in the albic horizon and in the argillic or natric horizon characteristics associated with wetness, namely, mottles or iron-manganese concretions >2 mm in diameter, or both.

Key to great groups

GAA. Albolls that have a natric horizon. **Natralbolls**, p. 274

GAB. Other Albolls. **Argialbolls**, p. 274

Argialbolls

These are the Albolls (plate 11D) that have an argillic horizon but do not have a natric horizon. Most of them have very dark gray to black coatings of humus and clay on the peds in the upper part of the argillic horizon. In the United States, these soils are most extensive in the loess-covered areas of the midwestern states where temperature regimes are mesic. A very few have a frigid or a thermic temperature regime. A distinct moisture deficit in summer and a moisture surplus in winter and spring seem to be essential to the genesis of these soils. They are associated in the landscapes with soils of all other suborders of Mollisols, possibly excepting Rendolls. Because they have gentle slopes, most of these soils in the United States are cultivated. They were considered Planosols in the 1938 classification.

Definition

Argialbolls are the Albolls that have an argillic horizon but do not have a natric horizon.

Pedon 82 is an example of the central concept or typic subgroup of Argialbolls. In this soil, the A1 and B2 horizons together meet the thickness requirements for a mollic epipedon but are separated by the albic horizon. Plate 11D shows a Typic Argialboll formed in Wisconsinan loess.

Distinctions between Typic Argialbolls and other subgroups

Typic Argialbolls are the Argialbolls that

a. Do not have a layer in the upper 75 cm that has a texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either (1) a ratio of measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

b. Have an abrupt textural change from the albic to the argillic horizon;

c. When not irrigated, are not dry in all parts of the moisture control section for as long as 45 consecutive days during the 120 days following the summer solstice in more than 6 out of 10 years.

Argiaquic Argialbolls are like Typic Argialbolls except for *b*.

Argiaquic Xeric Argialbolls are like Typic Argialbolls except for *b* and *c*.

Xeric Argialbolls are like Typic Argialbolls except for *c*.

Description of subgroups

Typic Argialbolls.—The central concept or typic subgroup of Argialbolls is fixed on soils that are saturated with water at some season long enough to have a low chroma dominant in the albic horizon and that have enough summer rain that the moisture control section is moistened, at least in some part, at frequent intervals in most years. In addition, the argillic horizon has an abrupt upper boundary, has a markedly greater percentage of clay than the albic horizon, and has the accessory property of slow or very slow hydraulic conductivity when the water content is at or above field capacity.

Prolonged dryness in the moisture control section occurs in Mediterranean climates. It is a property of the xeric suborder of Mollisols, and is used to define xeric subgroups of Argialbolls. A gradual upper boundary of the argillic horizon or a small difference in the percentage of clay between the albic and argillic horizons indicates an intergrade to Argiaquolls. A surface mantle that shows the influence of pyroclastic materials has many of the properties of Andepts and is used to define andeptic subgroups.

Argiaquic Argialbolls.—These soils are intergrades thought to be developing from Argiaquolls. They do not have the abrupt textural change of the Typic Argialbolls, and in that property they are like Argiaquolls. It is normal that the hydraulic conductivity in the argillic horizon is greater than in Typic Argialbolls.

Argiaquic Xeric Argialbolls.—The soils of this subgroup consistently have long periods in summer when the moisture control section is dry, and they also do not have the abrupt textural change that marks the typic subgroup. In these properties they resemble the Xerolls and the Argiaquolls.

Xeric Argialbolls.—These soils consistently have long periods in summer when the moisture control section is dry. Except for this property and its accessory properties, they are otherwise like Typic Argialbolls.

Natralbolls

These are the Albolls that have a natric horizon. In the United States and probably elsewhere they are rare and the polypedons are small. Very few series have been established in the United States for this group, and subgroups have not been developed. Because these soils have such limited extent and their range in properties is so small, few subgroups seem to be needed. These soils were mostly considered Soloths or transitional forms to Solonetz soils in the 1938 classification.

Definition

Natralbolls are the Albolls that have a natric horizon.

Description of a Typic Natralboll

A description of a soil that represents the central concept or typic subgroup of Natralbolls follows. This soil, in Jersey County, Ill., is on a nearly level, broad,

loess-covered Illinoian till plain. The mean annual temperature is about 13° C and the mean annual precipitation is about 950 mm with most of the rain coming in spring, summer, and fall. The soil is used for pasture and is thought not to have been plowed. Colors given are those of the moist soil unless otherwise noted.

A1 0–20 cm. Very dark gray (10YR 3/1) (10YR 5/1, dry) silt loam; weak fine and medium crumb structure; friable (moist); slightly acid; abrupt wavy boundary.

A2 20–28 cm. Dark gray (10YR 4/1) silt loam; weak thin platy structure; friable (moist); neutral; abrupt wavy boundary.

B21tg 28–64 cm. Dark grayish brown (2.5Y 4/2) heavy silty clay loam; few fine distinct mottles of light olive brown (2.5Y 5/4); weak coarse prisms breaking to weak fine angular and subangular blocks; firm (moist); common nearly continuous dark gray (10YR 4/1) organic matter and clay coatings; nearly continuous grayish brown (10YR 5/2) silt coatings on prism faces; rounded lime concretions; strongly alkaline; gradual smooth boundary.

B22tg 64–95 cm. Olive gray (5Y 5/2) heavy silty clay loam; common fine prominent mottles of dark brown (7.5YR 4/4) and light olive brown (2.5Y 5/4); weak coarse prisms breaking to weak medium angular blocks; few patchy dark grayish brown (10YR 4/2) clay skins; nearly continuous grayish brown (10YR 5/2) silt coatings on prismatic faces; plastic (wet); occasional rounded lime concretions; strongly alkaline; gradual smooth boundary.

B3g 95–125 cm. Grayish brown (2.5Y 5/2) light silty clay loam; very weak coarse angular blocky structure; plastic (wet); very few dark grayish brown (10YR 4/2)

1. A histic epipedon;
2. An SAR $\geq$13 (or sodium saturation of $\geq$15 percent) in the upper part of the mollic epipedon and decreasing SAR (or sodium saturation) at increasing depth below 50 cm;
3. One of the following combinations of color, moist:
   a. If the lower part of the mollic epipedon has chroma of 1 or less there are either:
      (1) Distinct or prominent mottles in the lower part of the mollic epipedon; or
      (2) Color immediately below the mollic epipedon, or within 75 cm of the surface if a calcic horizon intervenes, that has a value, moist, of 4 or more, and one or more of the following:
         (a) If the hue is 10YR or redder[4] and there are mottles, the chroma is less than 1.5 on ped surfaces or in the matrix; if there are no mottles, the chroma is less than 1;
         (b) If the hue is nearest to 2.5Y and there are distinct or prominent mottles, the chroma is 2 or less on ped surfaces or in the matrix; if there are no mottles, the chroma is 1 or less;
         (c) If the nearest hue is 5Y or yellower and there are distinct or prominent mottles, the chroma is 3 or less on ped surfaces or in the matrix; if there are no

GBC. Other Aquolls that have a natric horizon.

Natraquolls, p. 280

GBD. Other Aquolls that have a calcic or gypsic horizon that

Vertic Argiaquolls are like Typic Argiaquolls except for *c*.

surface downward, and problems with plant chlorosis are normal. In humid regions, potassium deficiency in plants is severe. In arid regions, salinity may be a problem. They were considered Humic Gley soils and Calcium Carbonate Solonchaks in the 1938 classification as modified in 1949 and 1959.

Petrocalcic Calciaquolls.—The soils in this subgroup have a petrocalcic horizon within 1 m of the surface and commonly within 50 cm. They are mostly on the margins of Pleistocene lakes in arid regions. The processes that produced the petrocalcic horizon are not understood.

measured clay to 15-bar water (percentages) of 1.25 or less or (2) a ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;
b. Do not have an argillic horizon;
c. Do not have a calcic horizon within or immediately underlying the mollic epipedon;
d. Have a mollic epipedon that is <50 cm thick;
e. Do not have a histic epipedon;
f. Have a mean annual soil temperature higher than 0° C; and
g. Do not have a buried Histosol that has its upper boundary within a depth of 1 m.

Argic Cryaquolls are like Typic Cryaquolls except for *b*, for *b* and *c*, or for *b*, *c*, and *d*.

Calcic Cryaquolls are like Typic Cryaquolls except for *c*.

Cumulic Cryaquolls are like Typic Cryaquolls except for *d*.

Histic Cryaquolls are like Typic Cryaquolls except for *e*.

Pergelic Cryaquolls are like Typic Cryaquolls except for *f* or for *e* and *f*.

Thapto-Histic Cryaquolls are like Typic Cryaquolls except for *g* or for *g* and *d*.

Description of subgroups

Typic Cryaquolls.—The central concept or typic subgroup of Cryaquolls is fixed on soils that have an epipedon <50 cm thick resting on a cambic horizon and that do not have a histic epipedon, a buried Histosol, or permafrost.

An argillic horizon in or below the mollic epipedon is rare and defines intergrades to the Argiaquolls. A calcic horizon at or very close to the surface also is rare and defines intergrades to the Calciaquolls. The thickness of the mollic epipedon is normally <50 cm, but in some Cryaquolls the thickness is quite variable within distances of a few centimeters because of frost action. Tongues of the mollic epipedon a few centimeters across may penetrate the cambic horizon for a distance of >25 cm (plate 8B). If such tongues are present, the average penetration is used to determine the thickness of the epipedon. An overthickened epipedon is the basis for defining the cumulic extragrade.

The wettest Cryaquolls may have a histic epipedon, and they are regarded as a transition to the Histosols. A buried Histosol at a depth of <1 m defines the thapto-histic subgroup. Permafrost is used to define pergelic subgroups, a convention followed throughout the taxonomy.

Argic Cryaquolls.—The soils in this subgroup have an argillic horizon and are considered intergrades to Argiaquolls. They are rare in the United States, even in high mountain valleys. The water table fluctuates appreciably in these soils, and most of them have enough slope that they are never ponded.

Calcic Cryaquolls.—These soils have a calcic horizon at or close to the surface and are considered intergrades to Calciaquolls. The water table usually is high during the short summer, and the presence of water leads to enrichment of the surface layer in carbonates by capillary rise and evapotranspiration. These soils are rare in the United States.

Cumulic Cryaquolls.—These soils have an overthickened mollic epipedon as a result of slow accumulation of material washed from higher ground. They are subject to occasional flooding when streams are high.

Histic Cryaquolls.—The soils in this subgroup have a histic epipedon and are considered intergrades to Histosols. They are the wettest of the Cryaquolls, and the level of ground water in them fluctuates the least. They are rare in the United States, even in high mountain valleys.

Pergelic Cryaquolls.—These soils have permafrost and also have gentle to strong slopes. The permafrost is responsible for the presence of ground water. The soils are otherwise like Typic Cryaquolls. They are rare in the United States, even in the high mountains. They are the only Cryaquolls that are not restricted to valleys or depressions.

Thapto-Histic Cryaquolls.—These soils have formed in deposits of mineral soil over a Histosol. The epipedon may extend to the buried Histosol, which is buried to a depth between 50 cm and 1 m. The soils are rare in the United States.

Duraquolls

These are the Aquolls that have a duripan. In the United States they are restricted to areas that have a Mediterranean climate or to arid regions. All the Duraquolls are near enough to volcanoes to have received ash falls. They are wet in winter but are quite dry during summer. The upper boundary of the duripan most commonly lies about 50 to 75 cm below the soil surface. Between the duripan and the mollic epipedon there may be a cambic, an argillic, or a natric horizon. Some of the soils are slightly acid, but most are strongly alkaline. They are rare and had no clear equivalent in the 1938 classification.

Definition

Duraquolls are the Aquolls that have a duripan that has its upper boundary within 1 m of the surface and have a soil temperature regime that is warmer than cryic.

Description of a Typic Duraquoll

A description of a soil that represents the central concept or typic subgroup of Duraquolls follows. This soil, in Union County, Oreg., formed in nearly level old alluvium containing appreciable ash. Mean annual precipitation is about 300 mm and comes mostly in fall, winter, and spring. The mean annual air temperature is about 8° C. During the rainy season the soil is nearly saturated above the duripan. Native vegetation consists of salt-tolerant plants. The colors given are those of the moist soil unless otherwise stated.

A11 0–7.5 cm. Very dark brown (10YR 2/2) silt loam, gray (10YR 5/1) dry; moderate medium platy and weak fine granular structure; friable (moist), slightly sticky and slightly plastic (wet); many very fine roots; many irregular pores; calcareous; moderately alkaline (pH 8.2); clear smooth boundary.

A12 7.5–15 cm. Very dark brown (10YR 2/2) silt loam, gray (10YR 5/1) dry; strong medium and coarse platy structure; friable (moist), slightly sticky and slightly plastic (wet); many very fine roots; many irregular pores;

Haplaquolls

These are mostly soils that have a black epipedon

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon; and
(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and
(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Andaqueptic Haplaquolls are like Typic Haplaquolls except for *a* or for *a* and *c*.

Cumulic Haplaquolls are like Typic Haplaquolls except for *c* or for *c* and *e*.

Duric Haplaquolls are like Typic Haplaquolls except for *d*.

Fluvaquentic Haplaquolls are like Typic Haplaquolls except for *e*.

Histic Haplaquolls are like Typic Haplaquolls except for *f*.

Lithic Haplaquolls are like Typic Haplaquolls except for *g*.

Vertic Haplaquolls are like Typic Haplaquolls except for *h*, with or without *c* or *e*, or both.

Description of subgroups

Typic Haplaquolls.—The central concept or typic subgroup of Haplaquolls is fixed on soils that have a mollic epipedon <60 cm thick, do not have a histic epipedon, are moderately deep or deep to hard rock, do not have evident silica cementation, do not have a layer or surface mantle influenced by pyroclastic materials, have a content of organic carbon that decreases regularly with increasing depth and reaches a low level at a depth of 1.25 m, and do not have wide cracks in most years.

A layer or surface mantle that has low bulk density and evidences of amorphous clays shows properties of the Andepts and is used to define the andaqueptic subgroup. An overthickened epipedon is present if new materials are slowly added at the surface and is used to define the cumulic extragrade. Weak cementation by silica indicates an intergrade to the Duraquolls. Either a relatively high organic-carbon content at a depth of 1.25 m or an irregular decrease in organic-carbon content with increasing depth is a property of Fluvaquents, and those properties define the fluvaquentic subgroup. A histic epipedon is present only in the wettest of the Haplaquolls and indicates an inter-

Cumulic Haplaquolls.—The soils in this subgroup have an overthickened mollic epipedon. They are permitted but are not required to have a buried A1 horizon. They have received occasional fresh sediments at a rate such that the accumulation of organic carbon kept pace with sedimentation. They lie on flood plains, in depressions, and along small drainageways at the base of slopes. They are widely distributed, but they are not extensive soils.

Duric Haplaquolls.—These soils show weak cementation by silica. In the United States they are rare and are present only on flood plains of streams in arid regions where they become quite dry seasonally. Their parent materials are rich in pyroclastics.

Fluvaquentic Haplaquolls.—These soils mostly have an irregular decrease in organic-carbon content with increasing depth, the effect of buried A1 horizons. In some, there are no visible buried A1 horizons, but the recent nature of the alluvium is indicated by the high level of organic carbon at a depth of 1.25 m. These soils are subject to occasional flooding and to deposition at a rate too rapid for all the fresh sediments to become incorporated in the mollic epipedon. They are common soils in back swamps on the flood plains of streams draining areas in which Mollisols are extensive. They are rare elsewhere.

Histic Haplaquolls.—In these soils a histic epipedon overlies the mollic epipedon. They mostly have water standing above the surface of the mollic epipedon for extended periods. They are rare in the United States.

Lithic Haplaquolls.—These soils have a shallow lithic contact but are otherwise like Typic Haplaquolls. Because the hard rock interferes with drainage, few of these soils are cultivated. They are rare in the United States.

Vertic Haplaquolls.—These soils (plate 1D) have deep wide cracks in most years, a high COLE, and a clayey particle-size class. To develop the cracks, their moisture content must be appreciably below field capacity at some time in most years. In the United States they are largely restricted to areas that have low summer rainfall or frequent rainless periods of at least a very few weeks. Because Vertisols may have a thick epipedon and an irregular decrease in organic-carbon content with increasing depth, these properties are permitted but are not required in the soils of this subgroup.

Natraquolls

These are the Aquolls that have a natric horizon. The natric horizon normally lies very close to the sur-

or Holocene deposits. Vegetation consists of grasses and sedges. The soils are used for range or the grasses are cut for hay. The soils are rarely cultivated. They are rare in the United States and were considered Solonetz soils in the 1938 classification.

Definition

Natraquolls are the Aquolls that
1. Have a natric horizon; and
2. Do not have a duripan that has its upper boundary within 1 m of the soil surface.

Description of a Typic Natraquoll

A description of a soil that represents the central concept or typic subgroup of Natraquolls follows. This soil, in Sully County, S. Dak., formed in alluvium on a flood plain. The mean annual air temperature is about 8° C. The precipitation is about 400 mm, and most of it comes in spring and summer. Vegetation consists mostly of grasses. The level of ground water fluctuates more than in many Natraquolls. The colors are those of the moist soil unless otherwise stated.

A2 0–7 cm. Dark gray (10YR 4/1) silt loam, gray (10YR 6/1) dry; weak medium plates parting to weak fine granules; soft (dry), friable (moist); neutral; abrupt smooth boundary.

B21t 7–20 cm. Black (10YR 2/1) clay, very dark grayish brown (10YR 3/2) crushed, dark gray (10YR 4/1) dry; moderate medium columns parting to strong fine subangular and angular blocks; very hard (dry), very firm (moist), sticky and plastic (wet); moderately alkaline; clear smooth boundary.

B22t 20–28 cm. Very dark grayish brown (10YR 3/2) silty clay, grayish brown (10YR 5/2) dry; weak coarse prisms parting to moderate medium subangular blocks; very hard (dry), very firm (moist), sticky and plastic (wet); moderately alkaline; clear smooth boundary.

B3sa 28–40 cm. Very dark grayish brown (2.5Y 3/2) silty clay, grayish brown (2.5Y 5/2) dry; moderate coarse blocky structure; very hard (dry), firm (moist), sticky and plastic (wet); few nests and fine striations of salts; calcareous; moderately alkaline; clear smooth boundary.

Ccasa 40–105 cm. Dark gray (5Y 4/1) and gray (5YR 5/1) silty clay, gray (5Y 5/1 and 5Y 6/1) dry; weak medium and coarse subangular blocky structure; very hard (dry), firm (moist), sticky and plastic (wet); common nests and fine striations of salts; few fine soft masses of segregated lime; calcareous; moderately alkaline; abrupt smooth boundary.

Ab 105–150 cm. Dark olive gray (5Y 3/2) silty clay, olive gray (5Y 5/2) dry; weak medium subangular blocky structure; hard (dry), firm (moist), sticky and plastic (wet); calcareous; moderately alkaline.

The range in properties of the Natraquolls is slight. Some have a noncalcareous surface horizon, but most

Europe and Asia. On the plains, they are mainly in late-Pleistocene or Holocene deposits. In the mountains of the western states, some may be on older surfaces, but the geomorphology of these areas has had little study.

The soil temperature regime of Borolls is frigid or cryic for the most part, but some have a pergelic temperature regime. The moisture regime is mostly udic or ustic but never xeric unless the temperature regime is cryic.

Vegetation of the Borolls on the plains was mostly grasses. A few have had a forest vegetation, but these are mostly near areas that were grassland. In the mountains they have either a forest, primarily aspen, or a grass vegetation. In Alaska, spruce, birch, and aspen trees and alpine tundra are common. Most of the Borolls on the plains are being cultivated except those that are very cold.

These soils were mostly classified as Chernozem, Chestnut, and Brown soils in the 1938 classification. A few were classified as Solonetz and Soloth soils.

Definition

Borolls are the Mollisols that
1. Have a mean annual soil temperature lower than 8° C.;
2. Do not have a xeric moisture regime unless the temperature regime is cryic;
3. Do not have an albic horizon that has characteristics associated with wetness, namely, mottles or iron-manganese concretions >2 mm in diameter, or both; or have an argillic or a natric horizon that does not have mottles or have iron-manganese concretions >2 mm in diameter;
4. Do not have the characteristics defined for Aquolls; and
5. Have an ustic moisture regime or do not have a calcareous horizon that immediately underlies the mollic epipedon at a depth of <50 cm and that has ≥40 percent $CaCO_3$ equivalent, including coarse fragments up to 7.5 cm in the largest dimension unless it is a calcic horizon or the temperature regime is cryic. (Hard limestone bedrock is neither a soil horizon nor a part of a soil.)

Key to great groups

GEA. Borolls that have an argillic horizon that has its upper

GED. Other Borolls that have an argillic horizon but do not have a cambic horizon that is above the argillic horizon and within a vertical distance of 7.5 cm from the upper boundary:

rolls except for *a* and *f(2)*, with or without *b(1)* or *h*, for *g*, with or without *d* or *f(1)*, or both.

Albic Argiborolls are like Typic Argiborolls except for *a*, *b(1)*, and *d*; or for *a* and *d*, with or without *f(2)*.

Aquic Argiborolls are like Typic Argiborolls except for *d*, with or without *f(2)*.

Aridic Argiborolls are like Typic Argiborolls except for *f(1)*.

Boralfic Argiborolls are like Typic Argiborolls except for *b(2)*.

Boralfic Udic Argiborolls are like Typic Argiborolls except for *b(2)* and *f(2)*.

Lithic Argiborolls are like Typic Argiborolls except for *e* or for *e* and *f(1)*.

Pachic Argiborolls are like Typic Argiborolls except for *g* with or without *d* or *f(1)* or both.

Pachic Udic Argiborolls are like Typic Argiborolls except for *f(2)* and *g*, with or without *d*.

Udic Argiborolls are like Typic Argiborolls except for *f(2)*.

Ustertic Argiborolls are like Typic Argiborolls except for *h* and *f(1)*, with or without *d* or *g*, or both.

Vertic Argiborolls are like Typic Argiborolls except for *h*, with or without *d* or g, or both.

Description of subgroups

Typic Argiborolls.—The central concept or typic subgroup of Argiborolls is fixed on freely drained soils that have a moderately thick brownish mollic epipedon that is appreciably darker when dry than the color required for a mollic epipedon. The content of clay increases gradually with increasing depth at the top of the argillic horizon, or the net change as a function of depth is small. There is no albic horizon above the argillic horizon and there are few or no skeletans on ped surfaces in the upper part of the argillic horizon. Hard rock and ground water are deep, and deep wide cracks are rarely or never present.

A marked increase in the content of clay within a few centimeters of vertical distance at the top of the argillic horizon causes a soil to be excluded from the shallow lithic contact defines the lithic subgroups, a convention used throughout the taxonomy.

A thick mollic epipedon, which suggests rooting deeper than normal, is used to define the pachic extragrades. The thin epipedon is by far more extensive than the thick one in North America. Deep wide cracks that open in most years and a large amount of swelling clay are properties shared with Vertisols and define intergrades to that order.

Most of the Typic Argiborolls were considered Chestnut soils in the 1938 classification.

Abruptic Argiborolls.—These soils have a marked increase in the percentage of clay within a short vertical distance at the top of the argillic horizon but are otherwise like Typic Argiborolls. Most of them in the United States have gentle slopes and appear to be on land surfaces older than late Pleistocene.

Abruptic Aridic Argiborolls.—The soils in this subgroup have a clayey argillic horizon that has markedly more clay than the epipedon, and the epipedon has higher color value, dry, than that of Typic Argiborolls. These soils in the United States have nearly level to concave slopes. They do not fit neatly into the taxonomy because, under cultivation, the epipedon becomes hard and massive when dry. If the soils are used for grazing, they have a mollic epipedon.

Abruptic Udic Argiborolls.—These soils have a clayey argillic horizon that has markedly more clay than the epipedon, and the epipedon has chroma lower than that of the typic soils. These soils receive more precipitation than Typic Argiborolls or they receive runoff from other soils.

Albic Argiborolls.—In these soils there is an albic horizon between the mollic epipedon and the argillic horizon or there is a marked increase in the percentage of clay within a short vertical distance at the top of the argillic horizon, or both. In addition, there are mottles of low chroma in the argillic horizon. These soils are considered to be developing toward the Albolls. Most of them in the United States are nearly level, and they commonly receive runoff from other soils. The chroma in the mollic epipedon commonly is

albic horizon that tongues or interfingers into the ar- but most of them are used for grazing. They are ex-

cent; moderately alkaline (pH 8.3); clear wavy boundary.

C4 75–125 cm. Light yellowish brown (10YR 6/4) very gravelly and cobbly sandy loam, yellowish brown (10YR 5/4) moist; massive; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); many very fine interstitial pores; 70 percent gravel and cobbles; violently effervescent; moderately alkaline (pH 8.2).

Distinctions between Typic Calciborolls and other subgroups

Typic Calciborolls are the Calciborolls that

a. Do not have mottles that have chroma of 2 or less within 1 m of the surface if artificially drained or if the mottled horizon is continuously saturated with water for as long as 90 days;

b. Have either or both

(1) A color value, dry, of less than 4.5 in the upper 18 cm of the mollic epipedon, after mixing, or in any Ap horizon that is >18 cm thick; or

(2) A moisture control section that is dry in some part less than six-tenths of the time in most years that the soil temperature at a depth of 50 cm is above 5° C;

c. Do not have a lithic contact within 50 cm of the surface; and

d. Do not have a petrocalcic horizon that has its upper boundary within 1 m of the surface.

Aridic Calciborolls are like Typic Calciborolls except for *b*.

Lithic Calciborolls are like Typic Calciborolls except for *c* or for *b(1)* and *c*.

Petrocalcic Calciborolls are like Typic Calciborolls

Lithic Calciborolls.—These soils have a shallow lithic contact. They are rare in the United States, and most of them are hilly and are used for grazing.

Petrocalcic Calciborolls.—The soils in this subgroup have a petrocalcic horizon. They are in older Pleistocene deposits in the United States, mostly on high terraces and fans that have an appreciable amount of limestone gravel. Their slopes are gentle. Some of these soils are irrigated and cultivated, and the rest are used for grazing.

Cryoborolls

These are the cold Borolls. Summers are cool or short. Most of them in the United States are in the mountains of the western states. A few are in Alaska. In other countries at higher latitudes they have developed on plains as well. In addition to the mollic epipedon, a variety of other horizons are present. Cambic, argillic, and calcic horizons are common; a natric horizon, a duripan, or an albic horizon is present in a few soils. These horizons are used to define the subgroups. Many of these soils that do not have a calcic horizon have a ca horizon below the cambic or the argillic horizon.

The Cryoborolls were formed mainly in late-Pleistocene or Holocene deposits or on surfaces of equivalent ages. In the United States, the vegetation on some of them at the time of settlement was either forest or grass. Many had grasses and scattered conifers. Some are now cultivated and used to produce small grains

fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the

Argic Vertic Cryoborolls are like Typic Cryoborolls except for *a* and *l*, with or without any or all of *c*, *e*, and *k*.

Boralfic Cryoborolls are like Typic Cryoborolls except for *a* and *i*, with or without *e*.

Boralfic Lithic Cryoborolls are like Typic Cryobor-

c. Do not have distinct or prominent mottles that are due to segregation of iron or manganese within 1 m of

both.

Calcic Cryoborolls are like Typic Cryoborolls except

horizon. Slopes are gentle to moderately strong. Most of these soils are used for summer grazing.

Andeptic Cryoborolls.—These soils have low bulk density, and they have some amorphous clays in at least some part of the upper 75 cm of the soil. These soils in the United States formed in tuffs and are rare.

Aquic Cryoborolls.—In these soils ground water fluctuates at some depth in the soil, and they have mottles in the horizons that are saturated part of the time. These soils are rare in the United States. Most of them are on low terraces or flood plains and are used for production of hay.

Argiaquic Cryoborolls.—These soils have an argillic horizon and ground water that fluctuates at some depth in the soil. There are mottles in the horizons that are saturated. These soils are rare in the United States. They have concave slopes and receive water from other soils. They are used mostly for summer grazing.

Argic Cryoborolls.—Soils in this subgroup have an argillic horizon but otherwise are like Typic Cryoborolls. Slopes of these soils in the United States range from gentle to strong. Some of the soils support a coniferous forest, some have a cover of grass, others have aspen trees, and still others have mixtures of these plants. Very few of these soils in the United States are cultivated, but they are used for summer grazing and production of trees. The classification as it stands does not appear to be particularly satisfactory. These soils are moderately extensive in the high mountains of the western states.

Argic Lithic Cryoborolls.—These soils have a lithic contact within 50 cm of the surface and an argillic horizon that is continuous in each pedon. Their slopes are commonly strong. Vegetation on these soils may be forest, grass, or a mixture. Most of them are used for grazing.

Argic Pachic Cryoborolls.—Soils in this subgroup have a thick mollic epipedon and an argillic horizon. The argillic horizon generally is in the lower part of the mollic epipedon. A few of these soils have moderately deep ground water at some time during the year, and the saturated zone in them is mottled. Slopes of these soils in the United States range from gentle to strong. The soils are moderately extensive in the high mountains of the western states. Most of them are used for summer grazing and some are in forests.

Argic Vertic Cryoborolls.—These soils have a fine-textured argillic horizon and deep wide cracks in most years. The thickness of the mollic epipedon, the distribution of organic carbon in the epipedon, and the presence of mottles or other evidence of wetness are not definitive of this subgroup. These soils are not extensive in the United States.

Boralfic Cryoborolls.—These soils have an albic horizon and an argillic horizon, and either they have a gradual or an irregular transition between those horizons or they have only a moderate contrast between the percentages of clay in the two horizons. Slopes of these soils in the United States range from gentle to strong. Some of the soils currently have a forest cover, but others support mostly grass. Most of them are used for summer grazing and few are cultivated. They are not extensive soils, even in the high mountains of the western states.

Boralfic Lithic Cryoborolls.—These soils have an albic horizon and an argillic horizon above a shallow lithic contact. There is an irregular boundary between the albic and the argillic horizon. These soils are not extensive in the United States, even in the high mountains of the western states. Their slopes range from gentle to strong. These soils are mostly under coniferous forests.

Calcic Cryoborolls.—These soils have a calcic horizon in or immediately below the mollic epipedon, usually just below it, but they are otherwise like Typic Cryoborolls. These soils in the United States formed mostly in calcareous alluvium, and their slopes are gentle or moderate. Vegetation is mainly grasses, but some of the soils are used to grow small grains and hay. These soils are not extensive, even in the high mountain valleys of the western states.

Calcic Pachic Cryoborolls.—These soils have a thick mollic epipedon that is directly underlain by a calcic horizon. They formed mainly in calcareous sediments. Slopes of these soils in the United States range from gentle to very strong. Where slopes are gentle, many of the soils are cultivated for short-season crops. Others are used for summer grazing.

Cumulic Cryoborolls.—Soils in this subgroup have a thick mollic epipedon, and their content of organic carbon decreases irregularly with increasing depth or remains high at depth. They formed in positions where they receive fresh sediments at a rate slow enough for the material to become incorporated in the mollic epipedon. They are on flood plains or have concave slopes. Some of them have mottles and seasonal ground water at depth. These soils are rare in the United States. They are used for summer grazing, hay, or short-season crops.

Duric Cryoborolls.—These soils have a duripan but are otherwise like Typic Cryoborolls. These soils in the United States, where they are rare, have mostly gentle slopes. They have formed in sediments rich in pryoclastic materials. They are used mostly for summer grazing.

Lithic Cryoborolls.—These soils have a shallow lithic contact. Because hard rock is present at a shallow depth, they are permitted but are not required to have a calcic horizon, a mollic epipedon that is between 40 and 50 cm thick, or a pergelic temperature regime. There may be a cambic horizon or a ca horizon between the epipedon and the rock, or the epipedon may extend to the rock. Slopes of these soils in the United States are mostly strong or very strong, and the soils are used mainly for summer grazing.

Lithic Ruptic-Argic Cryoborolls.—These soils have a lithic contact within a depth of 50 cm. In parts of each pedon the lithic contact is shallow and there is no argillic horizon. Their slopes are moderate to strong. These soils have very limited extent in the United States. They are used mostly for summer grazing.

Lithic Ruptic-Entic Cryoborolls.—These soils have a shallow lithic contact and an intermittent mollic epipedon. They may have a pergelic temperature regime, and frost boils are closely spaced. Because the shallow

rock precludes the presence of ice lenses or wedges, the pergelic temperature regime is not considered of major importance in classifying the soils. These soils in the United States are mainly in Alaska, and they are not now being used.

Natric Cryoborolls.—These soils have a natric horizon and are permitted but are not required to have an albic horizon above the natric horizon. There is normally a ca horizon below the natric horizon. These soils in the United States, where they are rare, have mostly gentle to moderate slopes. They are used mainly for summer grazing.

Pachic Cryoborolls.—These soils have a thick mollic epipedon. They are permitted but are not required to have mottles and seasonal ground water at some depth, but these properties are rare. Most of these soils in the United States have moderate to very strong slopes. Their present vegetation may be either coniferous forest or grasses. Their main use is for summer grazing.

Pergelic Cryoborolls.—These soils have a pergelic temperature regime but are otherwise like Typic Cryoborolls. They are rare in the high mountains of the western states but may be extensive in other parts of the world. In the United States, their vegetation consists mainly of alpine tundra, low-growing shrubs, forbs, sedges, and grasses. They are used for grazing in the short summer season.

the underlying horizon that has <25 percent by volume of wormholes, wormcasts, or filled animal burrows.

Pedon 86 is an example of the central concept or typic subgroup of Haploborolls.

Distinctions between Typic Haploborolls and other subgroups

a. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of the bases plus KCl-extractable aluminum;

b. Do not have mottles that have chroma of 2 or less within 1 m of the surface if artificially drained, or if undrained, are not continuously saturated with water in the mottled horizon for as long as 90 days in most years;

c. Have both the following:

(1) Either or both:

(a) A color value, dry, of less than 4.5 in the upper 18 cm of the mollic epipedon, after mixing, or in any Ap horizon that is >18 cm

i. Have a mollic epipedon <40 cm thick, or the epipedon has a sandy particle-size class in the major part, or there is a paralithic contact or a sandy contrasting layer between depths of 40 and 50 cm.

Aquic Haploborolls are like Typic Haploborolls ex-

udic subgroups, which are intergrades to the Udolls. Similarly, a high color value, dry, in the mollic epipedon suggests lower precipitation than that of the typic soils and, in part, defines aridic subgroups which are intergrades to Aridisols. The absence of a cambic horizon or of a subhorizon of the mollic epipedon that has

have a cambic horizon, and most commonly they have a mollic epipedon that is <25 cm thick. If the epipedon is >25 cm thick, the lower part does not have

there is no ca horizon. These soils are rare in the United States. Most of them have strong or very strong slopes and are used for grazing.

crack as these do. Slopes are gentle. Many of these soils in the United States are cultivated.

Natriborolls

These are the Borolls that have a natric horizon in or close below the mollic epipedon. An albic horizon may lie between the two. Below the natric horizon there is normally one horizon or more of accumulation of carbonates, sulfates, or other soluble salts. Most of the Natriborolls are in small polypedons that are scattered in polypedons of other soils. They are most common on the northern Great Plains where many of the parent materials contain salts. They were considered Solonetz soils, Soloths, and transitional forms in the 1938 classification.

Definition

Natriborolls are the Borolls that
1. Have a natric horizon;
2. Do not have a cambic horizon above the natric horizon and separated from it by an albic horizon; and
3. Have a temperature regime warmer than that of Cryoborolls.

Pedon 87 is an example of a Typic Natriboroll.

Distinctions between Typic Natriborolls and other subgroups

Typic Natriborolls are the Natriborolls that
a. Do not have tonguing or interfingering of an albic horizon more than 2.5 cm into the natric horizon;
b. Have
(1) Either or both

have an albic horizon that tongues or interfingers into the natric horizon. An albic horizon is common, however, above the natric horizon. If there is no albic horizon, there are usually some skeletans and the color of the lower part of the epipedon approaches that of an albic horizon.

Low chroma in the epipedon indicates a greater supply of moisture than that in the typic soils and defines the udic subgroups. An albic horizon that has an irregular lower boundary or thick skeletans on the peds in the upper part of the natric horizon are considered evidence of partial destruction of the natric horizon and define the glossic subgroups.

Aridic Natriborolls.—These soils have a color value, dry, that is higher than that of Typic Natriborolls and they are drier. No series of these soils have been established in the United States but the subgroup is provided for use if needed.

Glossic Natriborolls.—Soils in this subgroup have evidences of destruction of the natric horizon but are otherwise like Typic Natriborolls in defined properties. Commonly they have more exchangeable magnesium and less sodium than soils of the typic subgroup, at least in the upper part of the natric horizon. They are extensive only locally on the western Great Plains in the United States. Their slopes are gentle, and many of them are cultivated.

Glossic Udic Natriborolls.—These soils have low chroma in the epipedon and they have evidences of destruction of the natric horizon. Commonly they have more exchangeable magnesium and less sodium than Typic Natriborolls, at least in the upper part of the natric horizon. These soils receive more moisture.

albic horizon, but commonly the chroma is too high for an albic horizon. These soils do not ordinarily have a horizon of carbonate or of salt accumulation.

In the United States these soils are principally in the high mountains of the western states. Their temperature regime is frigid or cryic. Vegetation commonly includes aspen trees, conifers, and grasses.

These soils have had low priority for study. They are not extensive and they are relatively inaccessible. They are used principally for summer grazing or as water catchments. Snowfall generally is high. They were variously included with Chernozems, Brunizems, and Gray Wooded soils in the 1938 classification as modified in 1949 and 1952.

Definition

Distinctions between Typic Paleborolls and other subgroups

Typic Paleborolls are the Paleborolls that

a. Do not have an argillic horizon that has an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm below its upper boundary;

b. Do not have mottles that have chroma of 2 or less within 1 m of the surface if artificially drained or, if undrained, are not continuously saturated with water in the mottled horizon for as long as 90 days in most years;

c. Have a mean summer soil temperature at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower, of 15° C or higher if there is no O horizon and 8° C or higher if there is an O horizon; and

1. Have an argillic horizon that has its upper boundary deeper than 60 cm below the mineral soil surface;[8] and

2. Have texture finer than loamy fine sand in all subhorizons above the argillic horizon.

Description of a Typic Paleboroll

A description of a soil that represents the central concept or typic subgroup of Paleborolls follows. This soil is in Torrance County, N. Mex., on a sloping mountain ridge. It supports scattered conifers with an understory of grass and shrubs between the trees. The average annual precipitation is about 650 mm, coming mostly in summer as hard showers. The average annual air temperature is about 5° C, and the average summer air temperature is about 18° C. The col-

Abruptic Cryic Paleborolls are like Typic Paleborolls except for *a* and *c*, with or without b.

Cryic Paleborolls are like Typic Paleborolls except for *c*.

Cryic Pachic Paleborolls are like Typic Paleborolls except for *c* and *d*, with or without *b*.

Pachic Paleborolls are like Typic Paleborolls except for *d*, with or without *b*.

Description of subgroups

Typic Paleborolls.—The central concept or typic subgroup of Paleborolls is fixed on deep, freely drained soils. The content of clay increases only gradually with depth at the top of the argillic horizon, or the net change in clay content as a function of depth

Utah, Idaho, and Montana at elevations above 1,500 m, and they are used mostly for summer grazing.

Cryic Pachic Paleborolls.—Soils in this subgroup have a cryic soil temperature regime, and they have a thicker mollic epipedon than the Typic Paleborolls. They are permitted but are not required to have mottles and to have shallow ground water at some time during the year. These soils occur at elevations above 1,800 m in mountain areas of Utah and Idaho. Most of them have moderate or steep slopes and are used for summer grazing, but a few that are nearly level are used for nonirrigated grain. They are not extensive soils in the United States.

Pachic Paleborolls.—These soils have a thicker mollic epipedon than Typic Paleborolls. They are permitted but are not required to have mottles and to have shallow ground water at some time during the year. These soils occur at elevations above 1,500 m in mountain areas of Utah on very steep north or northeast slopes. They are rare, and they are used mostly for summer grazing.

Vermiborolls

These are the Borolls that have been intensively mixed by earthworms and their predators. Normally the only genetic horizon is the mollic epipedon, which rests on the parent material that has been enriched in places with lime to form a ca horizon. Wormholes, wormcasts, and krotovinas make up more than half the volume of the epipedon. The transition to the C horizon contains many holes that are more or less filled with materials from the epipedon and also many krotovinas.

The Vermiborolls are rare in North America but are extensive soils on other continents. They were considered Chernozems in the 1938 classification. Because they are so poorly represented in the United States, the classification that follows is incomplete and provisional.

Definition

Vermiborolls are the Borolls that do not have an argillic or a natric horizon but have a mollic epipedon in which 50 percent or more of the volume is wormholes, wormcasts, or filled animal burrows and that either rests on a lithic or paralithic contact or has a transition to an underlying horizon in which 25 percent or more of the volume is wormholes, wormcasts, or filled

that the soil temperature at a depth of 50 cm is above 5° C in most years; and

(2) A chroma, moist, after rubbing, of 1.5 or more in the upper part of the mollic epipedon to a depth of 18 cm, after mixing, or in any Ap horizon that is more than 18 cm thick; and

c. Do not have a lithic contact within 50 cm of the surface.

Haplic Vermiborolls are like Typic Vermiborolls except for *a*.

Hapludic Vermiborolls are like Typic Vermiborolls except for *a* and *b(2)*.

Description of a Hapludic Vermiboroll

Only the hapludic subgroup of Vermiborolls is known to occur in the United States. A description of a representative soil of this subgroup follows. This soil, in Brookings County, S. Dak., was formed in late Wisconsinan till. The slope is very gentle and the soil is being cultivated. Formerly this soil supported a tall grass prairie. The colors given are those of the moist soil unless otherwise stated.

A1p 0–18 cm. Black (N 2/0) silt loam, very dark grayish brown (1Y 3/2) dry; noncalcareous or very slightly calcareous in wormcasts and filled worm channels; weak or moderate fine blocky structure parting to weak or moderate fine granular structure; soft (dry), very friable (moist); diffuse boundary.

A12 18–28 cm. Material almost completely reworked by worms, resulting in nearly coalescent mottles of black (N 2/0) and grayish brown (2.5Y 5/2) in wormcasts and filled worm channels in a matrix of friable loam, very dark gray (N 3/0) and light gray (2.5Y 7/2) dry; mixed noncalcareous and strongly calcareous material in casts and filled worm channels; moderate fine subangular blocky structure; thin very patchy clay skins on faces of peds, diffuse boundary.

A13 28–50 cm. Material almost completely reworked by worms resulting in nearly coalescent mottles of very dark grayish brown (2.5Y 3/2) and dark grayish brown (2.5Y 4/2) of wormcasts and filled worm channels in a matrix of loam, grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2) dry; slightly hard (dry), friable or firm (moist); strongly calcareous; moderate fine subangular blocky structure; thin very patchy clay skins on faces of peds, diffuse boundary.

C1ca 50–64 cm. Material almost completely reworked by worms resulting in nearly coalescent mottles of very dark grayish brown (2.5Y 3/2) and light olive brown (2.5Y 5/3), wormcasts and filled worm channels in a matrix of clay loam, dark grayish brown (2.5Y 4/2) and light brownish gray (2.5Y 6/2) dry; friable or firm (moist); strongly calcareous; weak and moderate fine subangular blocky structure, diffuse boundary.

highly calcareous parent materials such as chalk, drift composed mainly of limestone, or shell bars. They have a mollic epipedon that rests on the calcareous parent materials or on a cambic horizon that is rich in carbonates. A few are so rich in finely divided lime, which acts as a white pigment, that the mollic epipedon has a color lighter than normal but is nevertheless rich in dark-colored humus and is within the limits of a mollic epipedon. They have developed at high altitudes and near the equator. They have a udic moisture regime.

These soils are not extensive in the United States, but they are extensive in some parts of the world. They were considered Rendzina soils in the 1938 classification.

Definition

Rendolls are the Mollisols that

1. Have a mollic epipedon that is not more than 50 cm thick;
2. Have a $CaCO_3$ equivalent of 40 percent or more on the whole soil, basis including coarse fragments up to 7.5 cm,[9] in or immediately below any mollic epipedon;
3. Do not have an argillic or a calcic horizon; and
4. Have a udic moisture regime or a cryic temperature regime.

The Rendolls are so similar that they have not been subdivided into great groups. Pedon 88 and plate 12A

Cryic Rendolls are like Typic Rendolls except for *a*.

Cryic Lithic Rendolls are like Typic Rendolls except for *a* and *c* or for *a*, *b*, and *c*.

Entic Rendolls are like Typic Rendolls except the color value, dry, of the epipedon is 6 or more after the surface soil to a depth of 18 cm has been mixed.

Eutrochreptic Rendolls are like Typic Rendolls except for *b*, and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by 5° C or more.

Eutropeptic Rendolls are like Typic Rendolls except for *b* and the mean summer and mean winter soil temperatures at a depth of 50 cm differ by <5° C.

Lithic Rendolls are like Typic Rendolls except for *c*.

Vertic Rendolls are like Typic Rendolls except for *d*.

Description of subgroups

Typic Rendolls.—The central concept or typic subgroup of Rendolls in fixed on freely drained soils that have a dark mollic epipedon when dry, do not have a cambic horizon, do not have a lithic contact within a depth of 50 cm, and have a soil temperature regime warmer than cryic.

Soils that have a cryic soil temperature regime are excluded from the typic subgroup largely for pragmatic reasons. A cambic horizon in all or part of each pedon is an extra horizon that indicates development toward another order of soils and defines intergrades to the

occur in the United States, but the subgroup is provided for use if needed elsewhere.

Udolls

Udolls (plate 2B) are the more or less freely drained Mollisols of humid continental climates in midlatitudes. In addition to the mollic epipedon, a cambic or an argillic horizon may be present. These soils formed mainly in late-Pleistocene or Holocene deposits or on surfaces of comparable ages. In the United States, their vegetation at the time of settlement was dominantly a tall grass prairie, but some of the soils on Pleistocene surfaces appear to have supported at some time a boreal forest that was supplanted by grasses some several thousands of years ago. The Udolls lie east of the Great Plains and are most extensive in Illinois, Iowa, and adjacent states. Their temperature regime is mesic or warmer and their moisture regime is udic. Where slopes are not too steep, nearly all these soils are cultivated. Maize (corn) and soybeans are the major crops.

Definition

Udolls are the Mollisols that

1. Have a mean annual soil temperature of 8° C or higher;
2. Do not have an albic horizon that has characteristics associated with wetness, namely, mottles or iron-manganese concretions, or both;
3. Are not saturated with water at any period or do not have the characteristics associated with wetness that are defined for Aquolls;
4. Do not have a calcareous horizon that lies immediately under the mollic epipedon at a depth <50 cm and that has a $CaCO_3$ equivalent of >40 percent, including coarse fragments smaller than 7.5 cm;
5. Have a udic moisture regime; and
6. Do not have a calcic or gypsic horizon and do not have a concentration of soft powdery lime in spheroidal forms, as coatings on peds, or disseminated in clay-size particles within 1.5 m of the soil surface or within 50 cm below the uppermost calcareous horizon.

Key to great groups

GGA. Udolls that have an argillic horizon and a clay distribution such that the clay content does not decrease by 20 percent of the maximum clay content within 1.5 m of the soil surface and there is no lithic or paralithic contact within that depth, and there is one or both of the following features:

casts, or filled animal burrows that contain material from the mollic epipedon and from the underlying horizon.

Vermudolls, p. 298

GGD. Other Udolls.

Hapludolls, p. 296

Argiudolls

These are the Udolls that have a relatively thin argillic horizon or one in which the percentage of clay decreases rapidly with increasing depth. The epipedon is black to very dark brown, and the argillic horizon is mostly brownish. Below the argillic horizon there may be a weakly expressed ca horizon in which secondary carbonates are concentrated in hard concretions, but many of these soils are noncalcareous to a considerable depth below the argillic horizon.

The Argiudolls are mostly in late-Wisconsinan deposits or on surfaces of that age. Many or most of them during the Pleistocene supported a boreal forest that was replaced by tall grasses during the Holocene. The Argiudolls are moderately extensive soils in Iowa, Illinois, and adjacent states. They were included with Prairie soils in the 1938 classification and with Brunizems after 1952.

Definition

Argiudolls are the Udolls that have an argillic horizon and a clay distribution such that the clay content decreases by 20 percent or more of the maximum clay content within 1.5 m of the surface if

1. The hue is redder than 10YR and a chroma of more than 4 is dominant in the matrix in at least the lower part of the argillic horizon; or
2. There are many coarse mottles that have a hue redder than 7.5YR or chroma of more than 5.

Pedon 89 and the soil shown in plate 2B are examples of the central concept or typic subgroup of Argiudolls.

Distinctions between Typic Argiudolls and other subgroups

Typic Argiudolls are the Argiudolls that

a. Do not have mottles within 40 cm of the surface if the mottled horizon is saturated with water at some period of the year when the soil temperature in the

cially drained; and have a horizon 15 cm or more thick immediately below the mollic epipedon that either

(1) Has a hue of 10YR or redder and chroma of 3 or more, and does not have mottles that have chroma of 2 or less and value of 4 or more if the mottled horizon is saturated with water at some

d. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon,

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m, and

(3) More than 35 percent clay in horizons that total >50 cm in thickness; and

e. Have CEC (by NH_4OAc) of >24 meq per 100 g clay.

Aquic Argiudolls are like Typic Argiudolls except for *a*.

Lithic Argiudolls are like Typic Argiudolls except for *b*.

Oxic Argiudolls are like Typic Argiudolls except for *e*.

Psammentic Argiudolls are like Typic Argiudolls except for *c*.

Vertic Argiudolls are like Typic Argiudolls except for *d* with or without *a*.

Description of subgroups

Typic Argiudolls.—The central concept or typic subgroup of Argiudolls is fixed on soils that have few evidences of wetness within a depth of 40 cm or more, that do not have a shallow lithic contact, that have a loamy or clayey particle-size class in at least the argillic horizon, and that do not have deep wide cracks in most years.

Shallow ground water and mottles are properties of Aquolls and are used to define the aquic subgroup. A shallow lithic contact defines the lithic subgroup, a convention used throughout the taxonomy. An argillic horizon that has a sandy particle-size class or consists entirely of thin lamellae is weakly developed and defines the psammentic subgroup. Deep wide cracks that are present in most years are characteristic of Vertisols and are used in part to define the vertic subgroup.

Aquic Argiudolls.—These soils have lower chroma than Typic Argiudolls, and there are commonly faint mottles and either shallow ground water at some time during the year or the soil is artifically drained. They are extensive soils in the glaciated region where they commonly lie between the Aquolls and the Typic Argiudolls. Their slopes are mostly nearly level, and most of the soils have been artifically drained. The epipedon usually is black.

Lithic Argiudolls.—Soils in this subgroup have a shallow lithic contact but are otherwise like Typic Argiudolls. Their slopes are commonly moderate to strong and, unless the polypedons are small, the soils are used mostly for pasture.

Psammentic Argiudolls.—These soils have formed in Pleistocene sand deposits, either dunes or glacial outwash. The argillic horizon most commonly lies below a depth of 75 cm or 1 m and consists of thin lamellae. Most of these soils are cultivated if slopes are suitable.

Vertic Argiudolls.—These soils have a clayey particle-size class and a high COLE, and they have deep wide cracks in most years. In the United States, most of these soils have a thermic temperature regime.

Hapludolls

These are the Udolls that mostly have a brownish cambic horizon below a brownish mollic epipedon. There may be a ca horizon below the cambic horizon, but the secondary carbonates are mainly concentrated in hard concretions.

The Hapludolls are mostly in Holocene deposits or on surfaces of that age. Slopes are mostly gentle, and most of the soils are cultivated. The Hapludolls are extensive soils in Iowa and adjacent States. They were mostly included with Prairie soils in the 1938 classification and with Brunizems after 1952. Some were considered Alluvial soils.

Definition

Hapludolls are the Udolls that

1. Do not have an argillic horizon; and
2. Have <50 percent by volume of wormholes, wormcasts, and filled animal burrows in the mollic epipedon below any plow layer if the epipedon rests on a lithic or paralithic contact; or have a transition between the mollic epipedon and the underlying horizon in which <25 percent by volume consists of wormholes, wormcasts, and filled animal burrows.

Pedons 30 and 90 and the major soil in plate 1A are examples of the central concept or typic subgroup of Hapludolls.

Distinctions between Typic Hapludolls and other subgroups

Typic Hapludolls are the Hapludolls that

a. Do not have mottles within 40 cm of the surface if the mottled horizon is saturated with water at some period of the year when the soil temperature in the mottled horizon is above 5° C or if the soil is artificially drained; and have a horizon 15 cm or more thick immediately below the mollic epipedon that either

(1) Has a hue of 10YR or redder and chroma of 3 or more, and does not have mottles that have chroma of 2 or less and value of 4 or more if the mottled horizon is saturated with water at some period of the year when the soil temperature in the mottled horizon is above 5° C or if the soil is artificially drained, or

(2) Has a hue of 2.5Y or redder and chroma of 4 or more;

b. Have a mollic epipedon <60 cm thick or texture that is loamy fine sand or coarser if the mollic epipedon is ≥60 cm thick;

c. Have a cambic horizon, or the lower part of the mollic epipedon meets the requirements of a cambic horizon except for color value and organic-carbon content, and either the cambic horizon or the lower part of the epipedon is free of carbonates in some part;

d. Have a regular decrease in organic-carbon content

with increasing depth to a content of 0.3 percent or less within 1.25 m of the surface, or the slope is >25 percent;

e. Do not have a lithic contact within 50 cm of the surface; and

f. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon;

(2) A coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1 m; and

(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Aquic Hapludolls are like Typic Hapludolls except for *a*.

Cumulic Hapludolls are like Typic Hapludolls except for *b* and *d*, with or without *a* or *c*, or both.

Entic Hapludolls are like Typic Hapludolls except for *c*.

Fluvaquentic Hapludolls are like Typic Hapludolls except for *a* and *d* or for *a*, *c*, and *d*.

Fluventic Hapludolls are like Typic Hapludolls except for *d* or for *c* and *d*.

Lithic Hapludolls are like Typic Hapludolls except for *e*, with or without *a* or *c*, or both.

Vermic Hapludolls are like Typic Hapludolls except for *b* and *c* and have a mollic epipedon that, below any Ap horizon, has 50 percent or more by volume of wormholes, wormcasts, or filled animal burrows.

Vertic Hapludolls are like Typic Hapludolls except for *f*, with or without all or any of *a*, *b*, and *d*.

Description of subgroups

Typic Hapludolls.—The central concept or typic subgroup of Hapludolls is fixed on soils that have few evidences of wetness within a depth of 40 cm or more, that have a thin or a moderately thick mollic epipedon, that have a cambic horizon that is free of carbonates in some part or the lower part of the mollic epipedon is free of carbonates and resembles a cambic horizon. The soils do not have a shallow lithic contact, do not have deep wide cracks in most years, and have evidence of only a small amount of animal activity.

Low chroma accompanied by mottles are properties of the Aquolls and define the aquic subgroups of Hapludolls. An irregular decrease in organic-carbon content with increasing depth or a relatively high organic-carbon content in the deep layers indicates recent allumium and defines the fluventic subgroup, or, if the soils are also saturated with water at some period, the fluvaquentic subgroup. An overthickened epipedon accompanied by a relatively high content of organic carbon in the deep layers indicates slow accumulation of materials at the surface and defines, in part, the cumulic subgroup.

The absence of a cambic horizon or the presence of carbonates throughout the cambic horizon suggests weak weathering and defines the entic subgroup. A shallow lithic contact defines the lithic subgroup, a convention used throughout the taxonomy. Intense animal activity is a property of the Vermudolls and defines the vermic subgroup. Deep wide cracks, a property of the Vertisols, are used in part to define the vertic subgroup.

Aquic Hapludolls.—These soils have lower chroma than Typic Hapludolls, commonly have faint mottles, and either have shallow ground water at some time during the year or have been artifically drained. These soils are nearly level and they commonly lie between the Aquolls and the Typic Hapludolls. Most of them have been artificially drained.

Cumulic Hapludolls.—Soils in this subgroup have an overthickened mollic epipedon. They lie at the base of slopes or on flood plains where they receive fresh sediments at a rate slow enough that the material becomes incorporated into the mollic epipedon. These soils are permitted but are not required to have a cambic horizon. They may be calcareous throughout their thickness. Their slopes are gentle and are mostly plane or concave.

Entic Hapludolls.—These soils either do not have a cambic horizon or they are calcareous in the lower part of the mollic epipedon or throughout any cambic horizon. They show relatively weak horizon development. Their slopes are moderate to strong and are convex.

Fluvaquentic Hapludolls.—These soils have lower chroma than Typic Hapludolls, and they lie in low parts of flood plains. They formed in recent alluvium in which there are buried A1 horizons or in which the content of organic carbon is relatively high in deep layers. They are otherwise like Typic Hapludolls.

Fluventic Hapludolls.—These soils are freely drained and lie in flood plains. They formed in recent alluvium in which there are buried A1 horizons or in which the content of organic carbon is relatively high in deep layers. Many of them do not have a cambic horizon. They are otherwise like Typic Hapludolls.

Lithic Hapludolls.—These soils have a shallow lithic contact. The mollic epipedon commonly extends to the rock. Some have impeded drainage because of shallow, impermeable rock.

Vermic Hapludolls.—Soils in this subgroup have evidence of intense animal activity, mainly of earthworms and their predators. These soils are thought to be developing toward the Vermudolls. They do not occur in significant areas in the United States.

Vertic Hapludolls.—These soils have deep wide cracks in most years, a high COLE, and a clayey particle-size class. In the United States most of them have a thermic temperature regime, but a few in which the moisture regime is marginal to ustic have a mesic temperature regime.

Paleudolls

These are reddish Udolls that have a thick argillic horizon in which the content of clay decreases slowly with depth. They are mainly on surfaces older than the Wisconsinan and are thought to have been form-

ing through at least one glacial and one interglacial stage. They are only on the southern Great Plains in the United States, and even there are extensive only locally. Their slopes are gentle. These soils were included with the Reddish Prairie soils in the 1938 classification.

Definition

Paleudolls are the Udolls that have an argillic horizon and the clay distribution is such that the clay content does not decrease by 20 percent of the maximum clay content within 1.5 m of the soil surface and that do not have a lithic or paralithic contact within that depth, and that also have one or both of the following:

1. A hue redder than 10YR and chroma greater than 4 dominant in the matrix in at least the lower part of the argillic horizon; or
2. Many coarse mottles that have a hue redder than 7.5YR or chroma higher than 5.

Pedon 91 is an example of the central concept or typic subgroup of Paleudolls.

Distinctions between Typic Paleudolls and

2. Have a mollic epipedon that, below any Ap horizon, has 50 percent or more by volume of wormholes, wormcasts, or filled animal burrows and that either rests on a lithic or paralithic contact or has a transition to the underlying horizon in which 25 percent or more of the material consists of discrete wormholes, wormcasts, or animal burrows filled with material from the mollic epipedon and the underlying horizon.

Distinctions between Typic Vermudolls and other subgroups

Typic Vermudolls are the Vermudolls that

a. Have a mollic epipedon that is 75 cm or more thick;
b. Do not have a cambic horizon;
c. Have a mollic epipedon that has a transition to the underlying horizon in which 50 percent or more of the material is discrete wormholes, wormcasts, or animal burrows filled with material from the mollic epipedon and the underlying horizon;
d. Do not have a lithic contact within 50 cm of the surface; and
e. Have a mollic epipedon that below any Ap horizon has granular structure formed mainly from worm-

than frigid. Moisture regimes are dominantly ustic, but a few of these soils that are marginal to Aridisols have a torric (aridic) regime, and a few may have an udic regime that is marginal to ustic.

Definition

Ustolls are the Mollisols that

1. Have a temperature regime warmer than frigid;
2. Do not have an albic horizon that has characteristics associated with wetness, namely, mottles, iron-manganese concretions >2 mm in diameter, or both;
3. Are not saturated with water at any period or lack the characteristics associated with wetness that are defined for Aquolls; and
4. Do not have a xeric moisture regime, and have one or both of the following:
   a. An ustic or aridic moisture regime; or
   b. Within 1.5 m of the soil surface or within 50 cm below the base of any cambic or argillic horizon, have either a calcic or a gypsic horizon or a horizon that has a concentration of soft powdery lime or lime disseminated in clay-size particles.[10]

Key to great groups

GFA. Ustolls that have a duripan with its upper boundary within 1 m of the soil surface.

Durustolls, p. 303

GFB. Other Ustolls that have a natric horizon.

Natrustolls, p. 306

GFC. Other Ustolls that have a petrocalcic horizon that has its upper boundary within 1.5 m of the soil surface, and that have an argillic horizon or are noncalcareous in some subhorizon above the petrocalcic horizon after the surface soil to a depth of 18 cm has been mixed, or that have an argillic horizon that has one or both of the following:

1. A vertical clay distribution such that the clay content does not decrease by 20 percent of the maximum clay content within 1.5 m of the soil surface and the soil does not have a lithic or paralithic contact within that depth, and the argillic horizon has one or both of these:
   a. A hue redder than 10YR and chroma higher than 4 in the matrix; or
   b. Common coarse mottles that have a hue of 7.5YR or redder or chroma higher than 5; or
2. A particle-size class in the upper part that is clayey and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm or of 15 percent clay (absolute) within 2.5 cm at the upper boundary, or there is a lithic or paralithic contact within 50 cm of the surface of the soil;

lithic contact or has a transition to the underlying horizon in which 25 percent or more of the material is discrete wormcasts or animal burrows filled with material from the mollic epipedon and the underlying horizon.

Vermustolls, p. 309

GFG. Other Ustolls.

Haplustolls, p. 303

Argiustolls

These are the Ustolls that have an argillic horizon in or below the mollic epipedon. Most of them have a ca horizon or a calcic horizon below the argillic horizon, and some have an sa or cs horizon below the ca horizon. They are mostly in late-Pleistocene deposits or on surfaces of comparable age in relatively stable positions. Their slopes are mostly moderate or nearly level. These soils were mostly included with the Chernozems or with Chestnut, Brown, and Reddish Chestnut soils in the 1938 classification.

Definition

Argiustolls are the Ustolls that

1. Have an argillic horizon that has both
   a. A vertical clay distribution such that the clay content decreases from the maximum by more than 20 percent of that maximum clay content within a depth of less than 1.5 m from the soil surface if
      (1) The hue in the matrix is redder than 10YR and the chroma is higher than 4, or
      (2) There are common coarse mottles that have a hue of 7.5YR or redder or chroma higher than 5; and
   b. A sandy or loamy particle-size class in the upper part or an increase of less than 20 percent clay (absolute) within a vertical distance of 7.5 cm or an increase of less than 15 percent clay (absolute) within 2.5 cm at the upper boundary, or there is a lithic or paralithic contact within 50 cm of the surface of the soil;
2. Do not have a duripan that has its upper boundary within 1 m of the surface;
3. Do not have a petrocalcic horizon that has its upper boundary within 1.5 m of the soil surface; and
4. Do not have a natric horizon.

Pedon 1 is an example of the central concept or typic subgroup of Argiustolls.

too high for a mollic epipedon and chroma too high for an albic horizon;

e. Have a mollic epipedon <50 cm thick, or the texture is loamy fine sand or coarser if the mollic epipedon is ≤50 cm thick;

f. Have a calcic horizon or soft, powdery secondary lime within a depth of 1.25 m if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy, within a depth of 90 cm if the weighted average class is loamy, and 70 cm if it is clayey, and do not have a udic moisture regime;

g. Do not have either of the following combinations of characteristics:

(1) Either

(a) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon,

(b) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m, and

(c) More than 35 percent clay in horizons that total >50 cm in thickness;

(2) Or

(a) A lithic or paralithic contact or a layer of altered rock that retains its rock structure within 50 cm of the surface, and

(b) Horizons totaling 25 cm or more in thickness that contain 35 percent or more clay that has montmorillonitic mineralogy or that have a COLE ≥0.07; and

h. When neither irrigated nor fallowed to store moisture,

(1) If the soil temperature regime is mesic or thermic, are dry less than six-tenths of the time in half or more years in some part of the moisture control section (not necessarily the same part) during a period when the soil temperature at a depth of 50 cm is higher than 5° C, or

(2) If the soil temperature regime is hyper-

Pachic Argiustolls are like Typic Argiustolls except for *e*, with or without *a* or *f*, or both.

Torrertic Argiustolls are like Typic Argiustolls except for *g(1)*, with or without *e*, *f*, or *h*, and the cracks are open 6 months or more in most years.

Udic Argiustolls are like Typic Argiustolls except for *f*.

Ustalfic Argiustolls are like Typic Argiustolls except for *d* with or without *a*, *f*, and *h*, and the mean soil temperature is 10° C or more.

Vertic Argiustolls are like Typic Argiustolls except for *g*, with or without all or any of *a*, *e*, or *f*, and the cracks are open less than 6 months in most years.

Description of subgroups

Typic Argiustolls.—The central concept or typic subgroup of Argiustolls is fixed on deep, freely drained soils that have some available moisture during most of the growing season, have carbonates at a shallow depth, have a brownish surface horizon, have a moderately thick epipedon but do not have an albic horizon above the argillic horizon, and do not have deep wide cracks in most years.

Shallow ground water or artificial drainage and mottles of low chroma are properties shared with Aquolls and are used to define aquic subgroups. A shallow lithic contact defines lithic subgroups, a convention used throughout the taxonomy. An albic horizon above the argillic horizon is characteristic of Boralfs, and if the soil temperature regime approaches frigid, is used to define the boralfic subgroup. A thick mollic epipedon is considered abnormal and defines the pachic subgroup. Deep carbonates are an indication of precipitation higher than that of Typic Argiustolls and are used to define udic subgroups. Deep wide cracks that open in most years in clayey soils are properties of Vertisols and define some vertic subgroups. Shallow soils that have clayey texture and montmorillonite clay or a high COLE are considered to be developing toward Vertisols and define other vertic subgroups. The definitions of the vertic subgroups are not entirely satisfactory and are provisional.

Alfic Lithic Argiustolls.—These soils have a lithic contact within 50 cm of the soil surface and have an albic horizon above the argillic horizon. The presence

depth to carbonates is less than in Typic Argiustolls. An sa horizon and a ca horizon are more common than in soils of the typic subgroup. These soils mostly receive less precipitation than the typic soils, or they lose more water by runoff. A few that are associated with Aridisols may receive runoff from other soils. Slopes of these soils range from nearly level to strong. In the United States, many of them that have suitable slopes are used for winter wheat or grain sorghum. If the temperature regime is mesic, many are fallowed in alternate years to store moisture. Some are irrigated, and many are used for grazing. These soils are extensive in the western part of the Great Plains.

Boralfic Argiustolls.—These soils have an albic horizon above the argillic horizon or they have an eluvial horizon that is too light in color for a mollic epipedon but has chroma too high for an albic horizon. The soil temperature regime approaches frigid, and the moisture regime is ustic but approaching udic. Vegetation on these soils is mostly scattered conifer trees and grass. These soils are rare in the United States.

Lithic Argiustolls.—Soils of this subgroup have a shallow lithic contact. They may have soft powdery lime above the rock but this feature is not common in the United States. These soils have moderate to strong slopes and are used almost entirely for grazing.

Lithic Vertic Argiustolls.—These soils have a shallow lithic contact, a clayey particle-size class, and montmorillonitic mineralogy or a high COLE. The rock under these soils in the United States commonly is limestone. Slopes are moderate to strong. These soils are used for grazing.

Pachic Argiustolls.—These soils have a thick mollic epipedon that commonly includes at least part of the argillic horizon. Ground water in the deep layers and mottles of low chroma are common. The depth to secondary lime may be great. Most of these soils receive extra water from ground water or as runoff from other soils. Slopes are mostly nearly level or concave. Nearly all these soils are cultivated. They are extensive in parts of the Great Plains of the United States. Pedon 92 is an example of this subgroup.

Torrertic Argiustolls.—These soils have deep wide cracks in most years, clayey texture, and much montmorillonite. Most of them are in alluvium or formed from montmorillonitic shales. Most of these soils in the United States are in an arid climate, but they receive additional water as runoff from other soils. Their slopes are gentle or concave. Most of them are used for grazing.

Udic Argiustolls.—Soils in this subgroup (pedon 4) receive more precipitation than Typic Argiustolls or they receive runoff from other soils. The ca horizon or the calcic horizon is deeper than in Typic Argiustolls. These soils in the United States lie between the Typic Argiustolls and the Udolls. Most of them are cultivated. They are extensive soils in the eastern parts of the Great Plains.

Vertic Argiustolls.—These soils have deep wide cracks in most years. They formed mostly from shale that is rich in montmorillonite or on limestone. They are associated in the landscapes with Usterts and with other Ustolls. Their slopes are mostly gentle, and many of the soils are cultivated. They are not extensive soils in the United States, even on the Great Plains.

Calciustolls

These are mostly Ustolls that have a calcic or petrocalcic horizon and that are calcareous in all overlying horizons. Either the parent materials had more carbonates than the limited rainfall could remove from the upper horizons or there is a continuing external source of carbonates in dust or water.

The Calciustolls formed mostly in late-Pleistocene sediments or older materials on surfaces of comparable age. In the United States, their vegetation was dominantly grass before they were cultivated. They are most extensive on the Great Plains in the United States but some are in the intermountain valleys of the western states. They were considered Chestnut and Brown soils for the most part in the 1938 classification and were regrouped as Calcisols in 1957. Some were considered to be Rendzinas.

Definition

Calciustolls are the Ustolls that

1. Have a calcic or a gypsic horizon that has its upper boundary within 1 m of the soil surface or a petrocalcic horizon that has its upper boundary within 1.5 m of the soil surface, and are calcareous in all parts of all horizons above the calcic, petrocalcic, or gypsic horizon after the upper soil to a depth of 18 cm has been mixed unless the texture is coarser than loamy very fine sand or very fine sand; and
2. Do not have an argillic horizon above the calcic, gypsic, or petrocalcic horizon, do not have a natric horizon, and do not have a duripan within 1 m of the surface.

Pedon 93 is an example of the central concept or typic subgroup of Calciustolls.

Distinctions between Typic Calciustolls and other subgroups

Typic Calciustolls are the Calciustolls that

a. Do not have mottles within 75 cm of the surface that are due to segregation of iron or manganese accompanied by seasonal ground water and, if undrained, are not continuously saturated with water for as long as 90 days within 1 m of the surface;

b. When neither irrigated nor fallowed to store moisture

(1) If the soil temperature regime is mesic or thermic, are dry less than six-tenths of the time in half or more years in some part of the moisture control section (not necessarily the same part) during a period when the soil temperature at a depth of 50 cm exceeds 5° C, or

(2) If the soil temperature regime is hyperthermic or isomesic, or warmer, are moist in some or all parts of the moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth of 50 cm exceeds 8° C;

c. Do not have a lithic contact within 50 cm of the soil surface;

d. Have a mollic epipedon that is <50 cm thick, or the texture is loamy fine sand or coarser if the mollic epipedon is ≥50 cm thick;
e. Do not have a petrocalcic horizon that has its upper boundary within 1 m of the surface;
f. Do not have a salic horizon that has its upper boundary within 75 cm of the surface; and
g. Do not have the following combination of characteristics:

(1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon,
(2) A coefficient of linear extensibility (COLE) of 0.07 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.25 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.25 m, and
(3) More than 35 percent clay in horizons that total >50 cm in thickness.

Aquic Calciustolls are like Typic Calciustolls except for *a* or for *a* and *b*.

Aridic Calciustolls are like Typic Calciustolls except for *b*.

Lithic Calciustolls are like Typic Calciustolls except for *c* or for *b* and *c*.

Pachic Caliustolls are like Typic Calciustolls except for *d*, with or without *a*.

Petrocalcic Calciustolls are like Typic Calciustolls except for *e* or for *b* and *e*.

Torrertic Calciustolls are like Typic Calciustolls except for *g*, with or without any or all of *a*, *b*, and *d*, and the cracks are open 180 days or more, cumulative, in most years.

Vertic Calciustolls are like Typic Calciustolls except for *g*, with or without any or all of *a*, *b*, and *d*, and the cracks are open less than 180 days, cumulative, in most years.

Description of subgroups

Typic Calciustolls.—The central concept or typic subgroup of Calciustolls is fixed on soils that do not have a fluctuating ground water table in their deep layers accompanied by mottles, that have an ustic moisture regime, that have a mollic epipedon of moderate thickness, that have a calcic rather than a petrocalcic horizon, and that do not have deep wide cracks in most years.

A ground water table that fluctuates within 75 cm of the surface and that stays within 1 m of the surface for 3 months or longer in each year is a characteristic of the Calciaquolls and defines the aquic subgroups. A shallow lithic contact defines lithic subgroups, a convention used throughout the taxonomy. A thick mollic epipedon usually reflects the influence of some additional moisture and is used to define a pachic subgroup rather than a udic subgroup because the movement of moisture is more commonly upward than downward. A petrocalcic horizon indicates development more intense than normal and is used to define the petrocalcic subgroup. Deep wide cracks in a clayey soil are properties of Vertisols and define the vertic subgroup.

Aquic Calciustolls.—Soils in this subgroup have shallow ground water and commonly have mottles of medium or high chroma that are due mainly to segregation of iron. These soils are not extensive in the United States. Most of them are cultivated.

Aridic Calciustolls.—These soils are drier than the Typic Calciustolls but are otherwise like Typic Calciustolls in defined properties. Other things being equal, however, the calcic horizon tends to be closer to the surface than in soils of the typic subgroup, and the mollic epipedon has less organic carbon. In the United States, most of these soils have gentle or moderate slopes. A few are irrigated, but most of them are used for grazing.

Lithic Calciustolls.—Soils in this subgroup have a shallow lithic contact but are otherwise like Typic Calciustolls in defined characteristics. In the United States, most of them have moderate slopes and are used almost exclusively for grazing.

Pachic Calciustolls.—These soils have an overthickened mollic epipedon and are permitted to have, and most of them have, ground water in the deep layers. These soils either are nearly level or they have concave shapes. Many are on terraces or very broad, flat upland ridges. The calcic horizon in many of them was formed as much by precipitation of carbonates after capillary rise of ground water rich in calcium as by precipitation of carbonates from water that moved down from the surface horizons. These soils are moderately extensive on the Great Plains in the United States. Nearly all of them are cultivated and are not summer fallowed.

Petrocalcic Calciustolls.—Soils in this subgroup have a petrocalcic horizon but are otherwise like Typic Calciustolls in defined properties. In most of them the depth to the petrocalcic horizon is <50 cm. Their slopes generally are gentle, and they are on surfaces older than late Pleistocene. These soils are extensive locally in the southern Great Plains. Most of them are used for grazing.

Torrertic Calciustolls.—These soils have deep wide cracks that are open 6 months or more, cumulative, in most years, have clayey texture, and contain considerable montmorillonite. They may have a moisture regime that borders on either aquic or aridic, and the mollic epipedon may be 50 cm or more thick. Otherwise, they resemble Typic Argiustolls. The soils are on gentle slopes in central Texas in the United States where they are extensive locally. They are farmed or are used for grazing.

Vertic Calciustolls.—These soils have deep wide cracks in most years, their texture is clayey, and they contain considerable montmorillonite. In the United States they formed mainly in alluvium, and their calcic horizon is rich in hard lime concretions as well as in soft powdery or disseminated lime. Some receive additional water as runoff from other soils. Their slopes are gentle or concave. Many of these soils are cultivated, and some are irrigated. Others are used for grazing. They are not extensive soils, even on the Great Plains.

Durustolls

These are the Ustolls that have a duripan that has its upper boundary within 1 m of the soil surface. They

c. Do not have a brittle horizon 15 cm or more thick within 1 m of the surface that contains some opal coatings or some durinodes (<20 percent by volume);
d. Have a cambic horizon, or the lower part of the mol-

consecutive days or more during a period when the soil temperature at a depth of 50 cm exceeds 8° C; and

k. Have 24 meq or more CEC per 100 g clay (by NH_4OAc) and have a cation-retention capacity from NH_4Cl of 12 or more meq per 100 g clay in the major part of the soil below a depth of 25 cm but above 1 m or a lithic or paralithic contact if one is shallower than 1 m.

Aquic Haplustolls are like Typic Haplustolls except for *a*, with or without *d* or *i*, or both.

Aridic Haplustolls are like Typic Haplustolls except for *j* or for *i(1)* and *j*.

Cumulic Haplustolls are like Typic Haplustolls except for *b* and *e*, with or without all or any of *a*, *d*, *i*, and *j*.

Entic Haplustolls are like Typic Haplustolls except for *d* and either do not have a cambic horizon or the epipedon is calcareous.

Fluvaquentic Haplustolls are like Typic Haplustolls except for *a* and *e*, with or without *d* or *i*, or both.

Fluventic Haplustolls are like Typic Haplustolls except for *e*, with or without *d* or *i*, or both.

Lithic Haplustolls are like Typic Haplustolls except for *f*, with or without any or all of *d*, *i(1)*, and *j*.

Lithic Ruptic-Entic Haplustolls are like Typic Hap-

Vertic Haplustolls are like Typic Haplustolls except for *h(1)*, with or without all or any of *a*, *b*, *d*, *e*, or *j*, and the cracks are open between 135 and 180 days in most years.

Description of subgroups

Typic Haplustolls.—The central concept or typic subgroup of Haplustolls is fixed on moderately deep or deep, freely drained soils that have a mollic epipedon <50 cm thick and either have a cambic horizon or the lower part of the epipedon resembles a cambic horizon. They are in upland positions, they do not have deep wide cracks in most years, and they have a shallow horizon of carbonate accumulation or an ustic moisture regime, or both.

Ground water in the deep layers, mottles of low chroma, or a salic horizon are bases for defining the aquic and salorthidic subgroups. A thick mollic epipedon is present in some positions where the soil receives extra water or where there is ground water in the deep layers. If the soil receives runoff but little sediment, the thick epipedon is the basis for defining the pachic subgroup. A udic moisture regime characterizes udic subgroups. If a cambic horizon is absent and the lower part of the epipedon does not resemble a cambic horizon, that feature is considered evidence of weak horizon development and defines entic sub-

than Typic Haplustolls and either are calcareous in the major part of the epipedon or do not have a cambic horizon. The epipedon commonly extends to a shallow paralithic contact. Slopes of these soils in the United States are moderate or strong. Nearly all the soils are used for grazing. They are not extensive.

Torroxic Haplustolls.—These soils have CEC too low and are drier than Typic Haplustolls. In addition they may have epipedons too thick or organic carbon too high at 1.25 m, and they basically have little or no carbonates. Slopes range from gentle to moderate. The soils are of moderate extent at the lower elevations in Hawaii. Pineapple and irrigated sugarcane are the principal crops. Many areas are used for grazing.

Udertic Haplustolls.—These soils have clayey texture and have deep wide cracks that are open less than 135 days in most years. These soils in the United States formed in clayey alluvium or in soft shales, and they are associated in the landscape with udic or pachic subgroups of Ustolls. Their slopes are mostly gentle, and the soils generally are cultivated. They are not extensive soils, even on the Great Plains.

Udic Haplustolls.—Soils in this subgroup have a greater supply of moisture than Typic Haplustolls, either as precipitation or as runoff from other soils. Secondary carbonates are deeper than in Typic Haplustolls, and the soils are moist for longer periods. These soils are otherwise like those of the typic subgroup in defined properties. These soils are extensive in the United States in the eastern third of the Great Plains. Their slopes are gentle or moderate. Most of the soils are cultivated.

Udorthentic Haplustolls.—These soils do not have a cambic horizon, and a ca horizon may be deep or absent. The surfaces on which they occur are too recent or the materials are too sandy for a cambic horizon to form. Slopes of these soils in the United States are moderate to strong if the soils are loamy, but may be gentle if the soils are sandy. These soils are widely scattered in the United States but are not extensive except locally. Most of them are used for summer grazing, but a few that are sandy and gently sloping are cultivated.

Vertic Haplustolls.—These soils have clayey texture and deep wide cracks that are open between 135 and 180 days in most years. They formed from alluvium, clayey shale, and basic rocks. They are associated in the landscape with soils of typic subgroups of Ustolls. Most of them have gentle slopes. Many of these soils in the United States are cultivated, and commonly they are irrigated.

Natrustolls

These are the Ustolls that have a natric horizon. The most common horizon sequence is either a natric horizon in the lower part of the mollic epipedon or a thin albic horizon over a columnar natric horizon in which there may or may not be skeletans on the upper few centimeters of the columns. Below the natric horizon there is usually a ca or an sa horizon. Most of the polypedons are small and nearly level or concave.

iments. They were considered Solonetz soils, Soloths, or transitional forms in the 1938 classification.

Definition

Natrustolls are the Ustolls that

1. Have a natric horizon;
2. Do not have a petrocalcic horizon that has its upper boundary within 1.5 m of the surface; and
3. Do not have a duripan that has its upper boundary within 1 m of the surface.

Pedon 95 is an example of the central concept or typic subgroup of Natrustolls.

Distinction between Typic Natrustolls and other subgroups

Typic Natrustolls are the Natrustolls that

a. Do not have any of the following characteristics within 1 m of the surface:
   (1) Dominant chroma of 1 or less throughout and hue as yellow or yellower than 2.5Y in some part;
   (2) Dominant chroma of 2 or less and mottles that are not due to segregated lime; or
   (3) Dominant chroma of 2 or less and a decrease in the percentage of exchangeable sodium from the upper 25-centimeter layer to the underlying layer;

b. Do not have a brittle horizon 15 cm or more thick that is within 1 m of the surface and that contains some opal coatings or some durinodes (<20 percent by volume);

c. Do not have tonguing or interfingering of an albic horizon more than 2.5 cm into a natric horizon;

d. When neither irrigated nor fallowed to store moisture
   (1) If the soil temperature regime is mesic or thermic or isomesic or warmer, are moist in some or all parts of the moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth of 50 cm exceeds 8° C; and
   (2) If the soil temperature regime is hyperthermic, or isomesic or warmer, are moist in some or all parts of the moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth of 50 cm exceeds 8° C; and

e. Do not have visible crystals or nests of gypsum or more soluble salts within 40 cm of the surface.

Aridic Natrustolls are like Typic Natrustolls except for *d*.

Glossic Natrustolls are like Typic Natrustolls except for *c*.

Lentic Natrustolls are like Typic Natrustolls except for *e* or for *d* and *e*.

Description of subgroups

Typic Natrustolls.—The central concept or typic subgroup of Natrustolls is fixed on soils that do not have low chroma and do not have mottles accompanied by ground water within 1 m of the surface, that have little or no evidence of destruction of the natric hori-

likely to be saturated with water above the natric horizon because it is so slowly permeable, and the chroma in the epipedon is permitted to be low.

Thick, clean skeletans in the upper part of the natric horizon or tongues of an albic horizon are considered evidences of destruction of the natric horizon and define the glossic subgroup.

Aridic Natrustolls.—Soils in this subgroup are drier than those in the typic subgroup. They are not extensive. Most of them are used for grazing.

Glossic Natrustolls.—These soils have evidence of destruction of the natric horizon in the form of thick skeletans of uncoated silt and sand on faces of columns or prisms. The skeletans extend more than 2.5 cm into the natric horizon.

Leptic Natrustolls.—These soils have visible crystals or nests of salts at least as soluble as gypsum within 40 cm of the soil surface. The moisture regime may or may not be borderline to aridic. Otherwise the soils resemble those of the typic subgroup. They are not extensive in the United States, even in the Great Plains. They are used for grazing.

Paleustolls

These are the Ustolls on old, stable surfaces. They have a thick, reddish argillic horizon or, more com-

b. A particle-size class in the upper part that is clayey and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm or of 15 percent clay (absolute) within 2.5 cm at the upper boundary; and there is no lithic or paralithic contact within 50 cm of the surface of the soil;

2. Do not have a duripan that has its upper boundary within 1 m of the soil surface; and
3. Do not have a natric horizon.

Description of a Typic Paleustoll

There follows a description of a soil that represents the central concept or typic subgroup of Paleustolls. This soil, in Cottle County, Tex., formed in old alluvium that was derived from Permian sediments. It lies on a high, nearly level plain and is used mainly to produce winter wheat. The mean annual air temperature is about 16° C and the average annual precipitation is about 600 mm, coming mainly in spring and summer. Although this soil has deep wide cracks, its COLE is <0.07. The colors are those of the dry soil unless otherwise noted.

Ap 0–15 cm. Brown (7.5YR 4/4) silty clay loam, dark brown (7.5YR 3/3) moist and crushed; weak medium subangular blocky structure; very hard (dry), firm (moist); common roots; few strongly cemented $CaCO_3$ concretions up to 6 mm in diameter; few siliceous peb-

dark pellets; few siliceous pebbles; calcareous in matrix; gradual wavy boundary.

B26tca 150–175 cm. Dark red (2.5YR 3/6) gravelly clay, light red (2.5YR 6/6) coatings 1 to 2 mm thick of calcium carbonate; moderate coarse angular blocky structure; very hard (dry), very firm (moist); few fine roots; more piping of calcium carbonates in form of powdery (5YR 4/6) bodies than in horizon above; about 15 percent of strongly cemented calcium carbonate concretions make up most of the gravel; few siliceous pebbles; few calcareous cobblestones; few dark pellets; few gypsum crystals; calcareous in matrix; abrupt wavy boundary.

B27tca 175–195 cm. Dark reddish brown (2.5YR 3/4) clay; black discontinuous coatings on faces of peds; moderate medium angular blocky structure; extremely hard (dry), very firm (moist); a layer high in coarse fragments contains carbonate pebbles up to 7.5 cm in diameter; 15 percent siliceous pebbles, and a few cobblestones of both carbonate and siliceous rocks; few gypsum crystals; calcareous in matrix; abrupt wavy boundary.

IIB3ca 195–205 cm. Dark reddish brown (2.5YR 3/4) clay, yellowish red (5YR 4/6) moist; calcareous coatings 1 to 2 mm thick; very fine and fine mottles of olive gray; moderate medium subangular blocky structure; extremely hard, very firm; few fine roots; few gypsum crystals; abrupt wavy boundary; few tongues extend into IIC horizon.

IIC 205–225 cm. Variegated grayish green (5GY 5/1) moist and reddish brown (2.5YR 3/4) moist, light clay; reddish yellow stains and thin seams of calcium carbonate; clay skins on some faces; weak platy or blocky struc-

g. When neither irrigated nor fallowed to store moisture,

(1) If the soil temperature regime is mesic or thermic, are dry less than six-tenths of the time in half or more years in some part of the moisture control section (not necessarily the same part) during a period when the soil temperature at a depth of 50 cm exceeds 5° C, or

(2) If the soil temperature regime is hyperthermic or isomesic, or warmer, are moist in some or all parts of the moisture control section for 90 consecutive days or more during a period when the soil temperature at a depth of 50 cm exceeds 15° C.

Aquic Paleustolls are like Typic Paleustolls except for *b*.

Aridic Paleustolls are like Typic Paleustolls except for *g*.

Calcic Paleustolls are like Typic Paleustolls except for *a* and have a calcic horizon within a depth of 1 m if the particle-size class of the upper 50 cm of the argillic horizon is sandy, 60 cm if it is loamy, and 50 cm if it is clayey.

Calciorthidic Paleustolls are like Typic Paleustolls except for *a* and *g* and have a calcic horizon within a depth of 1 m if the particle-size class of the upper 50

calcic horizon is considered to show more than normal development. Its presence in a soil that has an ustic moisture regime defines the petrocalcic subgroup.

Deep secondary carbonates are associated with a supply of moisture greater than normal and define udic subgroups. Deep wide cracks, clayey texture, and a high COLE are properties of Vertisols and are used to define vertic subgroups. An ustic moisture regime is considered normal in Typic Paleustolls, and a moisture regime that approaches or is aridic defines the aridic subgroups.

Typic Paleustolls are not so extensive in the United States as other subgroups of Paleustolls, but they conform with the central concept of this great group. Accidents of geography have made some of the other subgroups much more extensive.

Aquic Paleustolls.—These soils have ground water within 1 m of the surface for extended periods and have mottles of low chroma in the saturated zone. Their slopes are gentle. These soils are not extensive in the United States.

Aridic Paleustolls.—Soils in this subgroup are drier than those in the typic subgroup but are otherwise like Typic Paleustolls in defined properties. As a group, however, they have less organic carbon than the soils of the typic subgroup. They are moderately extensive in the western part of the Great Plains in the United States. Their slopes are gentle. Many of these soils are cultivated, and commonly they are irrigated.

Calcic Paleustolls.—These soils are calcareous throughout after the surface soil to a depth of 18 cm has been mixed, and they have a calcic horizon in the argillic horizon. Nearly all are reddish and have a thick, recalcified argillic horizon. They are developing toward Calciustolls, but the argillic horizon can still be identified. They are not extensive soils in the United States. Most of them are cultivated.

Calciorthidic Paleustolls.—These soils are calcareous throughout, have a calcic horizon in the argillic horizon, and are drier than those in the typic subgroup. Nearly all are reddish and have a thick, recalcified argillic horizon. They occur only in the southern Great Plains in the United States and are not extensive even there. Many of them are cultivated.

Pachic Paleustolls.—Soils in this subgroup have a thick mollic epipedon. Secondary carbonates are permitted to be deep because the depth to carbonates is partly a function of the amount being added at the surface. In the United States, all these soils have fine texture and many have deep wide cracks in most years but a COLE <0.07. These soils are nearly level and nearly all are cultivated.

Petrocalcic Paleustolls.—These soils have a petrocalcic horizon that usually is within 1 m of the surface. They may be calcareous throughout if they have an argillic horizon. They are moderately extensive in the United States only locally on the southern Great Plains and in the southwestern states. Their slopes are gentle, and most of these soils are used for grazing, or they are irrigated if water is available.

Torrertic Paleustolls.—These soils have deep wide cracks that are open 180 days or more, cumulative, in most years, have clayey texture, and contain considerable mortmorillonite. They may have a calcic horizon, a moisture regime that borders on aridic, and a mollic epipedon that is 50 cm or more thick. These soils are extensive in the southern Great Plains of the United States. Most of them are cultivated and commonly are irrigated.

Udertic Paleustolls.—These soils have deep wide cracks in most years, and carbonates are deep. They have more precipitation than Typic Paleustolls. In the United States, they formed in clayey sediments. They are extensive soils locally in the eastern part of the southern Great Plains. Their slopes are gentle and nearly all are cultivated.

Udic Paleustolls.—These soils have deeper carbonates than Typic Paleustolls, a property associated with greater precipitation. Most of them are reddish, and secondary carbonates are deep or absent. They are not extensive soils in the United States. Nearly all are cultivated.

Vertic Paleustolls.—Soils in this subgroup have deep wide cracks that are open between 135 and 180 days, cumulative, in most years, have clayey texture, and contain considerable montmorillonite. They may have a mollic epipedon that is 50 cm or more thick and either an aquic or an aridic moisture regime. These soils are not extensive in the United States. They occur in the western Great Plains where grazing is the principal use.

Vermustolls

These are the Ustolls that have been intensively and repeatedly mixed by animals, mainly by earthworms and their predators. The most common horizon sequence consists of a mollic epipedon that consists mostly of wormcasts and rests on parent materials that contain many worm channels filled with dark materials from the epipedon. There may be a horizon in which carbonates have reprecipitated, but mixing by animals may have destroyed such a horizon or prevented its formation. These soils are not known to occur in North America, but they are extensive in eastern Europe. They were mostly included with Chernozems in the 1938 classification and have been called by that name in Europe. The classification that follows is incomplete and provisional.

Definition

Vermustolls are the Ustolls that

1. Do not have an argillic or a natric horizon; and
2. Have a mollic epipedon that, below any Ap horizon, is 50 percent or more by volume wormholes and wormcasts or filled animal burrows, and that either rests on a lithic or paralithic contact or has a transition to the underlying horizon in which 25 percent or more of the material is discrete wormcasts or animal burrows filled with material from the mollic epipedon and the underlying horizon.

Distinctions between Typic Vermustolls and other subgroups

Typic Vermustolls are the Vermustolls that

a. Have a mollic epipedon that is 50 cm or more thick but is <75 cm thick;

b. Do not have a cambic horizon;

c. Have a mollic epipedon that, below any Ap horizon, has a transition to the underlying horizon in which 50 percent or more of the volume is wormholes and wormcasts or filled animal burrows;

d. Do not have a lithic contact within 50 cm of the surface;

e. Have a mollic epipedon that has granular structure and is composed almost entirely, below any Ap horizon, of wormholes, wormcasts, or filled animal burrows; and

f. Do not have mottles that have chroma of 2 or less within 1 m of the surface.

Entic Vermustolls are like Typic Vermustolls except for *a*, and the epipedon is <50 cm thick.

Haplic Vermustolls are like Typic Vermustolls except for *b* and *c*, with or without *a*, and the epipedon is <75 cm thick.

Lithic Vermustolls are like Typic Vermustolls, ex-

dominantly bunchgrass and shrubs with wheatgrass *(Agropyron)*, fescue *(Festuca)*, and bluegrass *(Poa)* species in association with sagebrush *(Artemisia)*, bitterbush *(Purshia)*, and rabbitbrush *(Chrysothamnus)* species and some scattered juniper *(Juniperus)* and pine *(Pinus)* species. In the Willamette Valley of Oregon the vegetation was a savanna of perennial grasses, oaks, and Douglas-fir, and in the areas in California that have thermic temperature regimes the vegetation was a savanna of annual grasses and oak species.

Characteristically, Xerolls have a relatively thick mollic epipedon, a cambic or an argillic horizon, and an accumulation of carbonates in the lower part of the B horizon, and they are neutral in most horizons.

Definition

Xerolls are the Mollisols that

1. Have a mean annual soil temperature lower than

GDE. Other Xerolls that have an argillic horizon.
Argixerolls, p. 311

GDF. Other Xerolls.
Haploxerolls, p. 315

Argixerolls

These are the Xerolls that have a relatively thin argillic horizon or one in which the percentage of clay decreases rapidly with depth. Mostly the epipedon is very dark brown and the argillic horizon is dark brown. Most of these soils have a ca horizon or a calcic horizon below or in the lower part of the argillic horizon. They have formed mostly in mid Pleistocene or earlier deposits or on surfaces of Tertiary age. Their slopes range from nearly level to steep. They were mostly included with the Chestnut soils in the 1938 classification and with Brunizems in the classification as modified in 1952.

Definition

Argixerolls are the Xerolls that

1. Have an argillic horizon but do not have a natric horizon;
2. Have an argillic horizon that has
   a. A vertical clay distribution such that the content of clay decreases from the maximum by >20 percent of that maximum clay content within a depth of <1.5 m from the soil surface if
      (1) The hue is redder than 10YR and the chroma is greater than 4 in the matrix, or
      (2) There are common coarse mottles that have hue of 7.5YR or redder or chroma greater than 5; and
   b. A sandy or loamy particle-size class in the upper part or an increase of <20 percent clay (absolute) within a vertical distance of 7.5 cm or of 15 percent clay (absolute) within 2.5 cm at the upper boundary, or has a lithic or paralithic contact within 50 cm of the soil surface;
3. Do not have a duripan that has its upper boundary within 1 m of the soil surface;
4. Do not have a petrocalcic horizon that has its upper boundary within 1.5 m of the soil surface; and
5. Do not have a calcic or a gypsic horizon that has its upper boundary within 1.5 m of the surface unless some part of some horizon overlying the calcic or gypsic horizon is free of carbonates and has a texture that is loamy very fine sand or finer after the upper soil to a depth of 18 cm has been mixed.

Pedon 96 is an example of the central concept or typic subgroup of Argixerolls.

Distinctions between Typic Argixerolls and other subgroups

Typic Argixerolls are the Argixerolls that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the surface if artificially drained or if undrained are not continuously saturated with water within 1 m of the soil surface for 90 days or more in most years;
b. Do not have an albic horizon above the argillic horizon;
c. Do not have a calcic horizon or soft, powdery secondary lime within a depth of 1.5 m if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy, 1.1 m if it is loamy, and 90 cm if it is clayey, or above a lithic contact that is shallower than these depths;
d. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;
e. Do not have a lithic contact within 50 cm of the soil surface;
f. Have a xeric moisture regime;
g. Have a mollic epipedon that is <50 cm thick or the texture is loamy fine sand or coarser if the mollic epipedon is ≥50 cm thick;
h. Have base saturation (by sum of cations) of >75 percent throughout the upper 75 cm or above a lithic or paralithic contact, whichever is shallower; and
i. Do not have the following combination of characteristics:
   (1) Cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm, that are at least 30 cm long in some part, and that extend upward to the surface or to the base of an Ap horizon, and
   (2) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m, and
   (3) More than 35 percent clay in horizons that have a total thickness of >50 cm.

Aquic Argixerolls are like Typic Argixerolls except for *a*, with or without *c*.

Aquultic Argixerolls are like Typic Argixerolls except for *a* and *h*.

Aridic Argixerolls are like Typic Argixerolls except for *f* and they have an aridic moisture regime that borders on xeric.

Aridic Calcic Argixerolls are like Typic Argixerolls except for *c* and *f*, and they have an aridic moisture regime that borders on xeric.

Boralfic Argixerolls are like Typic Argixerolls except for *b*, with or without all or any of *c*, *g*, or *h*, and the mean annual soil temperature is lower than 10° C.

Calcic Argixerolls are like Typic Argixerolls except for *c*.

Calcic Pachic Argixerolls are like Typic Argixerolls except for *c* and *g*, with or without *a*.

Durargidic Argixerolls are like Typic Argixerolls except for *d* and *f*.

Duric Argixerolls are like Typic Argixerolls except for *d*, with or without *c*.

Lithic Argixerolls are like Typic Argixerolls except for *e*, with or without *c* or *f*, or both.

Lithic Ultic Argixerolls are like Typic Argixerolls except for *e* and *h*.

Pachic Argixerolls are like Typic Argixerolls except for *g*, with or without *a*.

Pachic Ultic Argixerolls are like Typic Argixerolls except for *g* and *h*, with or without *a*.

Ultic Argixerolls are like Typic Argixerolls except for *h*.

Vertic Argixerolls are like Typic Argixerolls except for *i*, with or without all or any of *a*, *c*, or *g*.

Description of subgroups

Typic Argixerolls.—The central concept or typic subgroup of Argixerolls is fixed on deep, freely drained, brownish soils that do not have evidence of wetness within 75 cm of the surface, do not have an albic horizon above the argillic horizon, do not have required that the color value of these soils is higher and their content of organic carbon is less than in soils of the typic subgroup. Slopes of these soils in the United States commonly are strong or very strong and face south. These soils mostly receive less precipitation or lose more water by runoff and evapotranspiration than the soils of the typic subgroup. They are moderately extensive in parts of western United States. Most of them are used for grazing.

Aridic Calcic Argixerolls.—Soils in this subgroup have an aridic moisture regime and have a calcic hori-

not have deep wide cracks in most years, and do not have evidence of a duripan above a depth of 1 m. They

in the United States have mostly steep slopes, but their slopes range from level to steep. They are mod-

quirements of a duripan but is >15 cm thick and either has 20 percent or more by volume of durinodes in a matrix that is not brittle when wet or is brittle when wet and has firm consistence when moist. These soils are rare in the United States. They are nearly level or sloping and are used for irrigated crops or grazing.

Lithic Argixerolls.—Soils in this subgroup have a shallow lithic contact and are permitted but are not required to have a calcic horizon or free carbonates in all overlying horizons. Either the parent materials had more carbonates than the water from the scant rainfall could remove from the upper horizons or there is a continuing external source of carbonates in dust or water. Calcixerolls have formed mostly in late Pleistocene sediments or older materials on surfaces of comparable age. Their native vegetation in the United States was grass and shrubs. These soils are most extensive in the Great Basin of western continental United States. Their slopes range from nearly level to

Aquic Calcixerolls are like Typic Calcixerolls except for *a*.

Aridic Calcixerolls are like Typic Calcixerolls except for *a* and have an aridic moisture regime that borders

Lithic Calcixerolls.—Soils of this subgroup have a lithic contact within 50 cm of the surface and a xeric moisture regime or one that is aridic but borders on being xeric. These soils are moderately extensive in

Lithic Calcixerolls are like Typic Calcixerolls except for *d* or for *c* and *d*.

Pachic Calcixerolls are like Typic Calcixerolls except for *b* or for *a* and *b*, with or without *c*.

Vermic Calcixerolls are like Typic Calcixerolls except for *e*.

Vertic Calcixerolls are like Typic Calcixerolls except for *f*, with or without *a* or *b*, or both.

Description of subgroups

Typic Calcixerolls.—The central concept or typic subgroup of Calcixerolls is fixed on deep soils that do not have a fluctuating ground water table accompanied by mottles, that have a moderately thick mollic epipedon, have a regular decrease in organic-carbon content at increasing depth, and have a xeric moisture regime.

A ground water table that fluctuates within 75 cm of the surface and that stays within 1 m of the surface for 3 months or more is characteristic of Calciaquolls and defines the aquic subgroups. An aridic

They are used for grazing.

Pachic Calcixerolls.—These soils have a mollic epipedon that is 50 cm or more thick and may have an aridic moisture regime that borders on xeric. Otherwise, they resemble the soils in the typic subgroup. They occur in Utah in the United States but are not extensive. They are either irrigated and farmed or used for grazing.

Vermic Calcixerolls.—Soils in this subgroup are Calcixerolls that have been intensively and repeatedly mixed by animals, mainly earthworms and their predators. The most common horizon sequence is a mollic epipedon overlying parent material that contains many worm channels filled with dark material from the epipedon. These soils are not known to occur in the United States, but the subgroup is provided for use elsewhere.

Vertic Calcixerolls.—These soils have clayey texture and deep wide cracks in at least 7 out of 10 years. They are associated in the landscape with Xererts and other Xerolls. They are rare in the United States. They

ides or that is indurated in some subhorizon below its upper boundary;

c. Have an argillic horizon above the duripan;

d. Have a xeric moisture regime; and

e. Do not have mottles that have chroma of 2 or less above the duripan.

Abruptic Aridic Durixerolls are like Typic Durixerolls except for *a* and *d* and have an aridic moisture regime that borders on xeric.

Argic Durixerolls are like Typic Durixerolls except for *b*.

Aridic Durixerolls are like Typic Durixerolls except for *d* and have an aridic moisture regime that borders on xeric.

Entic Durixerolls are like Typic Durixerolls except for *b* and *c*.

Haplic Durixerolls are like Typic Durixerolls except for *c*.

Orthidic Durixerolls are like Typic Durixerolls except for *c* and *d* and have an aridic moisture regime that borders on xeric.

Description of subgroups

Typic Durixerolls.—The central concept or typic subgroup of Durixerolls is fixed on freely drained soils that have an argillic horizon above a strongly developed duripan, that have a relatively gradual increase

gime that borders on xeric but are otherwise like Typic Durixerolls in their defined properties. These soils are rare in the United States. They are mainly nearly level or gently sloping and are used for grazing.

Argic Durixerolls.—These soils have an argillic horizon but their duripan is weakly developed. The duripan is cemented but not indurated, and it may be absent in part of a pedon. These soils are rare in the United States. They are nearly level or gently sloping and are used for grazing, irrigated crops, and some nonirrigated wheat.

Aridic Durixerolls.—These soils have an aridic moisture regime that borders on xeric but are otherwise like Typic Durixerolls in their defined properties. In the United States they are mainly nearly level or strongly sloping. The nearly level soils are used for irrigated wheat, hay, and pasture. The sloping soils are used for grazing and some nonirrigated wheat, but yields commonly are low. These soils are not extensive in the United States, but they are moderately extensive locally in Oregon and Nevada.

Entic Durixerolls.—These soils have a duripan that is less developed than normal. It is weakly cemented and is coated with opal on less than half its surface, and it is not indurated in any part. These soils commonly have a cambic horizon but do not have an argillic horizon above the duripan. They are rare in the

Definition

Haploxerolls are the Xerolls that

1. Do not have an argillic or a natric horizon and do not have a duripan that has its upper boundary within 1 m of the surface;
2. Do not have a petrocalcic horizon that has its upper boundary within 1.5 m of the surface;
3. Do not have a calcic or a gypsic horizon that has its upper boundary within 1.5 m of the surface unless some part of some horizon overlying the calcic or gypsic horizon is free of carbonates after the soil to a depth of 18 cm has been mixed, and the texture is loamy very fine sand, very fine sand, or finer.

Pedon 99 illustrates a Haploxeroll that has a mollic epipedon too thick for the Typic subgroup.

Distinctions between Typic Haploxerolls and other subgroups

Typic Haploxerolls are the Haploxerolls that

a. Do not have mottles that have chroma of 2 or less within 75 cm of the surface if artificially drained and if undrained, are not continuously saturated with water within 1 m of the soil surface for 90 days or more in most years;

b. Do not have a calcic horizon or soft, powdery secondary lime within a depth of 1.5 m if the weighted average particle-size class of all horizons between a depth of 25 cm and 1 m, or between a depth of 25 cm and a lithic or paralithic contact that is shallower than 1 m, is sandy; within 1.1 m if the average particle-size class is loamy; or within 90 cm if it is clayey;

c. Have a mollic epipedon that is <50 cm thick or texture that is loamy fine sand or coarser if the mollic epipedon is ≥50 cm thick;

d. Do not have a horizon within 1 m of the surface that is >15 cm thick that either contains at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;

e. Have a cambic horizon, or the lower part of the epipedon meets the requirements of a cambic horizon except that extend upward to the soil surface or to the base of an Ap horizon;

(b) A coefficient of linear extensibility (COLE) of 0.05 or more in a horizon or horizons at least 50 cm thick and a potential linear extensibility of 6 cm or more in the upper 1.5 m of the soil or in the whole soil if a lithic or paralithic contact is deeper than 50 cm but shallower than 1.5 m; and

(c) More than 35 percent clay in horizons that have a total thickness of >50 cm;

(2) Or

(a) A lithic or paralithic contact or altered rock that retains its rock structure within 50 cm of the soil surface, and

(b) Horizons that have a total thickness of 25 cm or more and that have 35 percent or more clay and montmorillonitic mineralogy or that have a COLE ≥0.05; and

k. Have a xeric moisture regime.

Aquic Haploxerolls are like Typic Haploxerolls except for *a*, with or without *b* or *e*, or both.

Aquic Duric Haploxerolls are like Typic Haploxerolls except for *a* and *d*, with or without all or any of *b*, *e*, or *f*.

Aquultic Haploxerolls are like Typic Haploxerolls except for *a* and *h*, with or without *e*.

Aridic Haploxerolls are like Typic Haploxerolls except for *k* or for *h* and *k* and have an aridic moisture regime that borders on xeric.

Aridic Duric Haploxerolls are like Typic Haploxerolls except for *d* and *k*, with or without all or any of *b*, *e*, or *h*, and have an aridic moisture regime that borders on xeric.

Calcic Haploxerolls are like Typic Haploxerolls except for *b* or for *b* and *e*.

Calcic Pachic Haploxerolls are like Typic Haploxerolls except for *b* and *c*, with or without *a* or *e*, or both.

Calciorthidic Haploxerolls are like Typic Haploxe-

Pachic Ultic Haploxerolls are like Typic Haploxerolls except for *c* and *h*, with or without *a* or *e*, or both.

Torrertic Haploxerolls are like Typic Haploxerolls except for *j(1)* and *k*, with or without all or any of *a*, *b*, *c*, or *f*.

Torrifluventic Haploxerolls are like Typic Haploxerolls except for *f* and *k*, with or without all or any of *b*, *e*, or *h*.

Torriorthentic Haploxerolls are like Typic Haploxerolls except for *e* and *k*, with or without *h*, and they do not have a sandy particle-size class in all subhorizons to a depth of 1 m.

Torripsammentic Haploxerolls are like Typic Haploxerolls except for *e* and *k*, with or without *h*, and they have a sandy particle-size class in all subhorizons

An aridic moisture regime is used to define aridic and torric subgroups.

The Typic Haploxerolls make up the most extensive subgroup of Haploxerolls and are extensive in parts of western United States. These soils are mostly undulating, but in the United States their slopes range from nearly level to steep. Their native vegetation was dominantly grasses and shrubs with some pine and fir trees at higher elevations. Most of these soils that have moderate slopes are used for nonirrigated grain, legume, or hay crops. The steep soils are used mainly for grazing, and some of the nearly level and gently sloping soils are used for irrigated crops.

Aquic Haploxerolls.—Soils in this subgroup have mottles of low chroma and either have shallow ground

Calcic Haploxerolls.—These soils have a calcic horizon or free carbonates at a shallow depth but are otherwise like Typic Haploxerolls in their defined properties. Their slopes range from nearly level to very steep. The gently sloping soils are used for irrigated crops or nonirrigated winter wheat and the steep soils are used for grazing. These soils are moderately extensive in western United States.

Calcic Pachic Haploxerolls.—Soils in this subgroup have a calcic horizon or free carbonates at a shallow depth and have a mollic epipedon thicker than that of the Typic Haploxerolls. They are permitted but are not required to have a cambic horizon or to have characteristics that indicate wetness in the form of shallow ground water and mottles of low chroma. These soils are not extensive in the United States. They commonly have moderate slopes and are used mainly for grazing and some nonirrigated grain crops.

Calciorthidic Haploxerolls.—These soils receive less moisture than Typic Haploxerolls and have a calcic horizon or free carbonates at a shallow depth. They are permitted but are not required to have a cambic horizon. The nearly level soils in the United States commonly are used for irrigated crops, the moderately sloping soils are used for nonirrigated grain and hay, and the steep soils are used for grazing. These soils are extensive in parts of western United States.

Cumulic Haploxerolls.—These soils have a thick mollic epipedon and are on flood plains or in low landscape positions on stream terraces, or they have concave slopes in places where fresh sediments accumulate slowly enough to become part of the mollic epipedon. The organic-carbon content either decreases irregularly with increasing depth or remains relatively high at depth. The soils are permitted but are not required to have a cambic horizon or accumulations of secondary carbonates at a shallow depth or shallow ground water and mottles of low chroma. They are extensive in parts of western United States. Most of them are nearly level and are used for irrigated crops. Some are used for nonirrigated grain.

Cumulic Ultic Haploxerolls.—These soils have a thick mollic epipedon and base saturation of 75 percent or less in some part of the upper soil to a depth of 75 cm. Their organic-carbon content either decreases irregularly with increasing depth or remains relatively high in all the layers. They are permitted but are not required to have a cambic horizon, accumulations of secondary carbonates at a shallow depth, or shallow ground water and mottles of low chroma. Most of these soils are nearly level soils on flood plains and are used for cultivated crops. They are rare in the United States.

Entic Haploxerolls.—Soils in this subgroup do not have a cambic horizon, and either the epipedon is calcareous or the lower part of the epipedon has not been changed enough to make it a cambic horizon. Many of these soils have a high content of rock fragments in the control section, and their soil horizons are only weakly developed. These soils are not extensive in the United States. Their slopes range from nearly level to steep. These soils are used mostly for grazing but a few are used for irrigated crops.

Entic Ultic Haploxerolls.—These soils do not have a cambic horizon, and their base saturation is 75 percent or less in some part of the upper soil to a depth of 75 cm. These soils are rare in the United States. They are on nearly level or sloping terraces and are used mainly for vegetable and fruit crops.

Fluvaquentic Haploxerolls.—These soils have mottles of low chroma, they either have shallow ground water at some time of year or have artificial drainage, and their organic-carbon content either decreases irregularly with increasing depth or remains relatively high at depth. They are not required to have a cambic horizon. Secondary carbonates, if present, are shallower than in Typic Haploxerolls because of the shallow fluctuating ground water. These soils developed in nearly level alluvial terraces and flood plains, and commonly they are drained and used for irrigated crops. A few that are not drained or flooded frequently are used for pasture. They are not extensive soils, even in western United States, where they occur locally in small areas.

Fluventic Haploxerolls.—These soils have organic-carbon content that decreases irregularly with increasing depth or remains high at depth. They are permitted but are not required to have a cambic horizon or to have secondary carbonates at a depth shallower than in soils of the typic subgroup. These soils developed in nearly level flood plains, mainly from loamy alluvium, and commonly are stratified as a result of frequent flooding. They are used mainly for irrigated vegetable and fruit crops. They are not extensive soils in the United States.

Lithic Haploxerolls.—Soils in this subgroup have a shallow lithic contact. Because the epipedon may extend to the bedrock, a cambic horizon is not required but one may be present in some of the soils. These soils are moderately extensive in parts of western United States. Most of them are strongly sloping and are used only for grazing.

Lithic Ultic Haploxerolls.—These soils have a shallow lithic contact, and their base saturation is 75 percent or less in some part of the soil above the lithic contact. A cambic horizon is not required because the epipedon commonly extends to bedrock. These soils are rare in the United States. Most of them have steep slopes and are used only for grazing.

Pachic Haploxerolls.—These soils have a mollic epipedon that is thicker than the one in Typic Haploxerolls. They are permitted but are not required to have a cambic horizon or to have mottles of low chroma and shallow ground water. Most of these soils are nearly level or moderately sloping and are used for irrigated crops and some nonirrigated grain and hay. Some are steep and are used only for grazing. These soils are moderately extensive in parts of western United States.

Pachic Ultic Haploxerolls.—These soils have a mollic epipedon that is thicker than that in soils of the typic subgroup and they have base saturation of 75 percent or less in some part of the soil within 75 cm of the surface. They are permitted but are not required to have a cambic horizon or to have characteristics that indicate wetness such as shallow ground water at

some time of year and mottles of low chroma in the upper 75 cm. These soils range from nearly level to steep. They are used mostly for grazing but some have mostly small and nearly level. These soils formed mostly in late Pleistocene mixed sediments, commonly in depressions, basins, or low terrace positions. They

United States.

Torrertic Haploxerolls.—Soils in this subgroup have deep wide cracks in most years, have clayey texture, and are very sticky and very plastic when wet. They

Definition

Natrixerolls are the Xerolls that

1. Have a natric horizon:

Aquic Duric Natrixerolls.—These soils have mottles of low chroma and either are saturated with water at some time of year or have artificial drainage. In addition, they have a subhorizon within 1 m of the surface that does not meet the requirements of a duripan but is >15 cm thick and either has 20 percent or more by volume of durinodes in a matrix that is not brittle when wet or is brittle when wet and has firm consistence when moist. These soils developed in nearly level terraces and are used for pasture. They are rare in the United States.

Aridic Natrixerolls.—Soils in this subgroup receive less moisture but are otherwise like Typic Natrixerolls in defined characteristics. They are rare in the United States where they developed in alluvium on nearly level or gently sloping terraces or in residuum on moderately steep slopes. They are mostly used for grazing.

Duric Natrixerolls.—These soils have a subhorizon within 1 m of the surface that does not meet the requirements of a duripan but is >15 cm thick and either has 20 percent or more by volume of durinodes in a matrix that is not brittle when wet or is brittle when wet and has firm consistence when moist. They are nearly level or gently sloping and formed in low terraces. They are used mainly for grazing. Some are used for crops, but yields are low and variable. These soils are rare in the United States.

Palexerolls

least the lower part of the argillic horizon, or (2) Common coarse mottles that have hue of 7.5YR or redder or chroma greater than 5, or both;

b. A particle-size class in the upper part that is clayey and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm or of 15 percent clay (absolute) within a distance of 2.5 cm at the upper boundary, and do not have a lithic or paralithic contact within 50 cm of the surface of the soil;

2. Do not have a natric horizon unless it is underlain by a petrocalcic horizon that has its upper boundary within 1.5 m of the soil surface; and

3. Do not have a duripan that has its upper boundary within 1 m of the soil surface.

Pedon 101 is an example of the central concept or typic subgroup of Palexerolls.

Distinctions between Typic Palexerolls and other subgroups

Typic Palexerolls are Palexerolls that

a. Have an argillic horizon that has a clayey particle-size class in the upper part and an increase in clay content of 20 percent clay (absolute) or more within a vertical distance of 7.5 cm or of 15 percent clay (absolute) within a distance of 2.5 cm at the upper boundary;

b. Do not have mottles that have chroma of 2 or less within 75 cm of the soil surface;

c. Do not have a petrocalcic horizon that has its upper

Petrocalcic Palexerolls are like Typic Palexerolls except for *c*, with or without *a*.

Ultic Palexerolls are like Typic Palexerolls except for *f*, with or without *a*.

Description of subgroups

Typic Palexerolls.—The central concept or typic subgroup of Palexerolls is fixed on deep, freely drained soils that have a clayey argillic horizon that has an abrupt upper boundary. They have a moderately thick mollic epipedon, high base saturation, and a xeric moisture regime. They do not have a petrocalcic or a natric horizon.

A petrocalcic horizon that has its upper boundary within 1.5 m of the soil surface defines the petrocalcic subgroups. A thick mollic epipedon is considered abnormal and its presence is used to define the pachic subgroup. Base saturation that is less than normal defines the ultic subgroup.

Typic Palexerolls are the most extensive subgroup of Palexerolls, but they are not extensive soils, even where they occur locally in parts of western United States. Most of these soils in the United States are gently sloping and are used for nonirrigated grain and hay. A few that are nearly level are used for irrigated crops.

Aridic Palexerolls.—Soils in this subgroup have an aridic moisture regime that borders on xeric, but otherwise they are like Typic Palexerolls in their defined properties. They are rare in the United States. They are mainly sloping or strongly sloping and are used for grazing.

Aridic Petrocalcic Palexerolls.—These soils have an aridic moisture regime that borders on xeric, and they have a petrocalcic horizon. The petrocalcic horizon commonly is shallower than 75 cm and, in some, it is <50 cm below the surface. Most of these soils are gently sloping but some are steep. They are used mostly for grazing but some that are nearly level are used for irrigated crops. These soils are rare in the United States.

Pachic Palexerolls.—These soils have a thick mollic epipedon. In the United States where they are rare, they do not have free carbonates, are slightly acid, and are strongly sloping. They are used for grazing.

Petrocalcic Palexerolls.—These soils have a petrocalcic horizon that usually has its upper boundary within 75 cm of the soil surface. The argillic horizon that overlies the calcic horizon commonly is clayey and is calcareous in the lower part. These soils are rare in the United States. Most of them have gentle or moderate slopes and are used only for grazing.

Ultic Palexerolls.—These soils have a lower degree of base saturation than Typic Palexerolls. In the United States, where they are rare, they commonly have a thick, reddish, clayey, medium acid argillic horizon. These soils formed under a native vegetation of hardwood and conifer trees on strongly sloping surfaces and from basic rocks. They receive appreciably more moisture than the soils of the typic subgroup. Most of them are in forests but some are used for orchards.

saturated with water within this depth at some time during the year; or
2. Either are saturated with water at some time during the year or are artifically drained, have an oxic horizon, and also have one or both of the following characteristics associated with wetness:
a. A histic epipedon; or
b. If free of mottles, immediately below any epipedon that has moist color value of less than 3.5 there is dominant chroma of 2 or less; or if there are distinct or prominent mottles within 50 cm of the soil surface, the dominant chroma is 3 or less.

Aquox, p. 324

CB. Other Oxisols that have a torric moisture regime.

Torrox, p. 330

CC. Other Oxisols that:
1. Have 16 kg or more organic carbon per square meter to a depth of 1 m, exclusive of organic surface litter;
2. Have a weighted average base saturation in the oxic horizon (by NH_4OAc) of <35 percent; and
3. Have an isothermic, thermic, or cooler temperature regime.

Humox, p. 325

CD. Other Oxisols that have an ustic soil moisture regime and an isothermic, thermic, or warmer temperature regime.

Ustox, p. 330

CE. Other Oxisols.

Orthox, p. 326

Aquox

These are the wet Oxisols. They lie in shallow depressions that are commonly flooded during the rainy season or at the base of slopes where they receive seepage water. Many of these soils at the base of slopes have plinthite at the surface that is recementing transported ironstone pisolites or fragments, which are one form of what is called laterite. The Aquox as a group have been little studied, and the classification that follows is tentative.

Definition

Aquox are the Oxisols that have plinthite that forms a continuous phase within a depth of 30 cm and are saturated with water within this depth at some time during the year: or that either are saturated

CAC. Other Aquox that have an ochric epipedon.

Ochraquox, p. 324

CAD. Other Aquox.

Umbraquox, p. 325

Gibbsiaquox

These soils are not known to occur in the United States, but the great group is provided tentatively. Subgroups have not been developed.

Definition

Gibbsiaquox are the Aquox that either have cemented sheets containing 30 percent or more gibbsite or have 20 percent or more by volume gravel-size aggregates containing 30 percent or more gibbsite within 1 m of the mineral soil surface but that do not have plinthite that forms a continuous phase within 30 cm of the soil surface.

Ochraquox

These are the Aquox that have an ochric epipedon but do not have plinthite that forms a continuous phase within 1.25 m of the soil surface. They are not known to occur in the United States, but the great group is provided for other countries. Subgroups have not been developed beyond a proposed typic subgroup.

Definition

Ochraquox are the Aquox that have an ochric epipedon, do not have plinthite that forms a continuous phase within the upper 1.25 m, do not have cemented sheets of gibbsite, and have <20 percent by volume of cemented aggregates within the upper 1 m containing 30 percent or more gibbsite.

Definition of Typic Ochraquox

It is believed that Typic Ochraquox should be the Ochraquox that:
1. Have properties that are diagnostic of an oxic horizon, beginning at the surface or immediately below any thin surface horizon that has a color value, moist,

Proposed distinctions between Typic Plinthaquox and other subgroups

Typic Plinthaquox are the Plinthaquox that
a. Do not have plinthite that forms a continuous phase within a depth of 30 cm;
b. Have chroma of 2 or less in some part of the matrix of the nonplinthite materials within the horizon that contains plinthite and in all overlying horizons; and
c. Have an ochric epipedon.

A superic subgroup is proposed for the Plinthaquox that have plinthite that forms a continuous phase at the soil surface or within a depth of 30 cm.

Umbraquox

These are the Aquox that have an umbric epipedon and do not have shallow plinthite that forms a continuous phase. They are not known to occur in the United States, but the great group is provided for other countries.

Definition

Umbraquox are the Aquox that
1. Have an umbric or histic epipedon;
2. Do not have plinthite that forms a continuous phase within 1.25 m of the soil surface;
3. Have <20 percent by volume gravel-size aggregates that have 30 percent or more gibbsite and do not have cemented sheets that contain 30 percent or more gibbsite within 1 m of the soil surface.

Subgroups of Umbraquox have not been developed. It is believed that Typic Umbraquox should be the Umbraquox that
a. Have an oxic horizon that has texture of sandy clay loam or a finer class;
b. Have an oxic horizon that is 1 m or more thick;
c. Do not have plinthite that forms a continuous phase within 2 m of the soil surface.

Humox

The Humox are the Oxisols of relatively cool, humid climates at high altitudes or at relatively high latitudes for the Oxisols. Most of these soils have a reddish hue, a high content of organic matter, and a low supply of bases. As a rule, they are dark colored and have low chroma in the surface horizons. Most of them have a udic or perudic soil moisture regime and a thermic or isothermic temperature regime. They are rare in the United States, but they are extensive in Africa and South America. Their classification as yet is largely undeveloped.

Definition

Humox are the Oxisols that
1. Have 16 kg or more organic carbon per square meter to a depth of 1 m, exclusive of organic surface litter;
2. Have a weighted average base saturation (by NH_4OAc) of <35 percent in the oxic horizon;
3. Have an isothermic, thermic, or cooler temperature regime;
4. Are never saturated with water or have chroma as follows:
   a. If there are no mottles, the chroma is 3 or more immediately below any epipedon that has a color value, moist, of 3.5 or less;
   b. If there are mottles below the dark epipedon, the chroma is more than 3; and
5. Do not have plinthite that forms a continuous phase within 30 cm of the soil surface if the soil is saturated with water at this depth at some time of the year.

Key to great groups

CCA. Humox that have a sombric horizon.
Sombrihumox, p. 326

CCB. Other Humox that have, within 1 m of the soil surface, either cemented sheets that have 30 percent or more gibbsite or a subhorizon that has 20 percent or more by volume gravel-size aggregates that contain 30 percent or more gibbsite.
Gibbsihumox, p. 326

CCC. Other Humox that have in all subhorizons of the oxic horizon a cation-retention capacity (from NH_4Cl) of >1.5 meq per 100 g clay[2] or that have >1.5 meq of extractable bases plus extractable aluminum per 100 g clay.
Haplohumox, p. 326

CCD. Other Humox.
Acrohumox, p. 325

Acrohumox

This great group is provided for the most intensely weathered Humox, which have lost virtually all ability to retain bases in their mineral fraction. It is normal in these soils that the lower part of the oxic horizon, where there is the least organic matter, has a net positive charge. It is probable that these soils are rare in the world.

Definition

Acrohumox are the Humox that
1. Have a cation-retention capacity (from NH_4Cl) of 1.5 meq or less per 100 g clay[2] in some subhorizon of the oxic horizon (or have 1.5 meq or less extractable bases plus extractable aluminum per 100 g clay);
2. Do not have a sombric horizon; and
3. Do not have sheets that contain 30 percent or more gibbsite and have <20 percent by volume gravel-size aggregates containing 30 percent or more gibbsite in all subhorizons within 1 m of the surface.

The distinctions between Typic Acrohumox and other subgroups are incompletely developed because these soils are rare in the United States.

Definition and description of Typic and Petroferric Acrohumox

Typic Acrohumox are the Acrohumox that
a. Have an ochric epipedon or an umbric epipedon that is <75 cm thick;

[2] Some oxic horizons do not disperse well. The percentage of clay is determined by the higher value of (1) the measured percentage of clay or (2) 2.5 times the percentage of water retained at tension of 15 bars if the ratio of 15-bar water to measured clay is 0.6 or more.

b. Have <5 percent by volume plinthite in all subhorizons within 1.25 m of the soil surface and do not have mottles that have chroma of 2 or less within 1.25 m of the soil surface;
c. Have an oxic horizon that extends to a depth of 1.25 m or more below the soil surface;
d. Have texture that is sandy clay loam or finer in the oxic horizon; and
e. Do not have a petroferric contact within 1.25 m of the soil surface.

Petroferric Acrohumox are like Typic Acrohumox except for *e*.

Typic Acrohumox.—The central concept or typic subgroup of Acrohumox is fixed on deep, freely drained soils that have little or no plinthite and that

Typic Gibbsihumox.—The central concept or typic subgroup of Gibbsihumox is fixed on more or less freely drained soils that have at a shallow depth concretions that are cemented by gibbsite and that do not have mottles of low chroma above the uppermost gibbsite sheet or above a depth of 1 m if no sheet is that shallow. A large amount of plinthite is considered abnormal and defines plinthic subgroups. The absence of concretionary gravel in the upper horizons would be abnormal and might be used, if it occurs, to define intergrades to other great groups of Humox.

Haplohumox

These are the Humox that do not have a sombric horizon but have a small permanent cation-exchange ca-

Equator. They are yellowish to reddish. A hue of 5YR to 10YR and a high chroma are common, although most of these soils that developed from basic rocks are reddish brown to red. Many have an oxic horizon that becomes redder with depth and is strong brown in the upper part and reddish brown to yellowish red or red in the lower part. The natural vegetation is a rain forest, although anthropic savanna commonly is the present cover and may have been present for a long time. These soils are very extensive in the Amazon and Congo basins but not in Puerto Rico and Hawaii.

Definition

Orthox are the Oxisols that

1. Either:
   a. Have <16 kg organic carbon per square meter in the soil to a depth of 1 m, exclusive of organic surface litter, and either a udic moisture regime or the temperature regime is isomesic, mesic, or cooler, or both; or
   b. Have ≥16 kg organic carbon per square meter in the soil to a depth of 1 m, exclusive of organic surface litter, and either the temperature regime is isohyperthermic or hyperthermic or the

CEE. Other Orthox that have either an umbric epipedon or an ochric epipedon that has >1 percent carbon in all subhorizons to a depth of 75 cm or more below the mineral soil surface.

Umbriorthox, p. 330

CEF. Other Orthox.

Haplorthox, p. 329

Acrorthox

These are the Orthox that have lost virtually all ability to retain bases in their mineral fraction. It is normal in these soils in the United States that the lower part of the oxic horizon, where there is the least organic matter, has a net positive charge. To the eye, the soils are structureless. The productivity of these soils in Puerto Rico is so low that they have not been used for farming. Biologic activity is restricted by the virtual absence of calcium below the upper few centimeters. The amount of organic matter is large and the carbon-nitrogen ratio is wide. The extent of these soils is unknown.

Definition

Acrorthox are the Orthox that

1. Have in some subhorizon of the oxic horizon a cat-

er particle-size class and that is 60 cm or less above the horizon that has the greater percentage of clay;

f. Have a net positive charge in some subhorizon within 1.5 m of the soil surface.

Haplic Acrorthox are like Typic Acrorthox except for *f*.

Plinthic Acrorthox are like Typic Acrorthox except for *a* and *f*.

Definition

Eutrorthox are the Orthox that

1. Have in all subhorizons of the oxic horizon a cation-retention capacity (from NH_4Cl) of >1.5 meq per 100 g clay[6] (or have >1.5 meq of extractable bases plus extractable aluminum per 100 g clay);
2. Have base saturation (by NH_4OAc) of 35 percent or more in all subhorizons of the oxic horizon to a depth of at least 1.25 m; and

Definition

Gibbsiorthox are the Orthox that have, within 1.25 m of the soil surface, sheets containing 30 percent or more gibbsite or a subhorizon that has 20 percent or more by volume gravel-size aggregates containing 30 percent or more gibbsite.

Typic Gibbsiorthox are the Gibbsiorthox that

a. Have gravel-size aggregates cemented by gibbsite within the upper 50 cm; and

b. Do not have mottles that have chroma of 2 or less within the upper 1 m of the soil or above the uppermost gibbsite sheet, whichever is shallower.

Pedon 105 illustrates the Typic Gibbsiorthox. Only the typic subgroup is known to occur in the United States, in Hawaii. There the soils are of limited extent and are mostly in brush.

Haplorthox

These are Orthox of the evergreen forests of the Tropics. They may be yellow or red. They have few bases but more than the Acrorthox, and the clays have a modest cation-exchange capacity. Under the high rainfall, most of the bases are in the tissue of the growing plants and are used again and again during a year. Some in Africa appear to receive small but significant amounts of dust from the Sahara and Kala-

c. Have texture that is sandy clay loam or finer in all parts of the oxic horizon within 1.25 m of the mineral soil surface;

d. Have an oxic horizon that extends to a depth 1.25 m or more below the mineral soil surface;

e. Do not have discernible structure[9] in the major part of the oxic horizon or have only weak blockly or prismatic structure;

f. Have a hue redder than 10YR in all parts of the upper 75 cm that have a color value, moist, of 4 or more if the hue in horizons that have a color value, moist, of 4 or more becomes redder with depth by more than 2.5 Munsell units within the upper 1.5 m and if there are mottles due to segregation of iron within the upper 75 cm; and

g. Do not have a subhorizon of the oxic horizon that has as much as 40 percent more clay (relative) and as much as 15 percent more clay (absolute) than an overlying subhorizon that has a coarse-loamy or coarser particle-size class and is 60 cm or less above the horizon having the greater percentage of clay.

Aquic Haplorthox are like Typic Haplorthox except for *a*.

Epiaquic Haplorthox are like Typic Haplorthox except for *f*.

Plinthic Haplorthox are like Typic Haplorthox except for *b*.

redder hue or high chroma, and the hue becomes distinctly redder with depth. These soils become saturated in the upper horizons after heavy rains and require artificial drainage for most crops. They occur in Puerto Rico, but the areas are very small. Their slopes commonly are gentle but some are strongly sloping. Some are cultivated or produce tree crops, and others are in grass or brush.

Plinthic Haplorthox.—These soils are not known to occur in the United States, including Puerto Rico, but the subgroup is provided for use if needed.

Quartzipsammentic Haplorthox.—These soils have less clay in the oxic horizon than Typic Haplorthox. They are not known to occur in the United States, including Puerto Rico, but the subgroup is provided for use in other parts of the world.

Tropeptic Haplorthox.—These soils have a thin oxic horizon or have stronger structure in the oxic horizon than Typic Haplorthox, or both. Moderate grades of blocky or prismatic structure are normal. These are the most common Haplorthox in Puerto Rico, but they are not extensive there. Their slopes are mainly gentle. Some of the soils are cultivated but many are used for pasture. Pedon 33, is a representative of this subgroup.

Ultic Haplorthox.—Soils in this subgroup have a coarse-loamy or sandy epipedon, and the percentage of clay increases gradually but distinctly with depth and reaches a maximum. Below the depth of the maximum the percentage of clay does not decrease for several meters. These soils are not known to occur in the United States, including Puerto Rico, but are reported to be extensive in Africa.

Sombriorthox

These are the Orthox that have a sombric horizon. They are not known to occur in Puerto Rico or elsewhere in the United States but have been reported in other countries. The classification of subgroups has not been developed.

Umbriorthox

These are mostly Orthox that have an umbric epipedon or an appreciable amount of organic matter. They have extremely small extent in the United States but are known in parts of South America. Our information about them is too limited to permit many statements. By analogy with Haplorthox the following definitions are proposed.

Definition

Umbriorthox are the Orthox that

1. Have cation-retention capacity (from NH_4Cl) of >1.5 meq per 100 g clay[10] (or have >1.5 meq of extractable bases plus extractable aluminum per 100 g clay) in all subhorizons of the oxic horizon;
2. Do not have sheets of gibbsite or gravel-size aggregates cemented by gibbsite within 1.25 m of the soil surface;
3. Have either an umbric epipedon or an ochric epipedon that has ≥ 1 percent organic carbon in all subhorizons to a depth of 75 cm or more below the mineral soil surface; and
4. Have base saturation (by NH_4OAc) that is <35 percent in some subhorizon of the oxic horizon within 1.25 m of the mineral soil surface.

Distinctions between Typic Umbriorthox and other subgroups

Typic Umbriorthox are the Umbriorthox that

a. Have texture that is sandy clay loam or finer in all parts of the oxic horizon within 1.25 m of the mineral soil surface;

b. Have an oxic horizon that extends to a depth of 1.25 m or more below the mineral soil surface;

c. Have <5 percent by volume of plinthite in all subhorizons within 1.25 m of the mineral soil surface;

d. Do not have mottles that have chroma of 2 or less accompanied by red or dark red mottles within 1.25 m of the mineral soil surface;

e. Have an umbric epipedon that is <1.25 m thick and have <1 percent organic carbon in some subhorizon within 1.25 m of the mineral soil surface; and

f. In the major part of the oxic horizon, do not have discernible fine or medium granular structure or have only weak blocky or prismatic structure.

Tropeptic Umbriorthox are like Typic Umbriorthox except for any or all of *b*, *e*, and *f*.

Pedon 106 illustrates the properties of the Umbriorthox as we know them in Hawaii. This soil is considered to be tropeptic because of the structure in the oxic horizon.

Torrox

These are the Oxisols of arid climates. They are too dry to be cultivated without at least some irrigation. They are apparently relicts preserved from some former pluvial period or periods. They are dominantly red, have little organic matter, and have relatively high base saturation. If irrigated, they can be highly productive. Their extent in the world is not fully known. They have a torric soil moisture regime and, so far as is known, have an isohyperthermic temperature regime.

Definition

Torrox are the Oxisols that have a torric moisture regime.

Pedon 107 illustrates the Torrox in Hawaii. The soils we know in this suborder are so similar that no subdivisions seem justified at the great group or subgroup levels. All are considered to be typic soils of the suborder.

Ustox

The Ustox are mostly red and are dry in all parts of the moisture control section for extended periods. But

[10] See footnote 2 on p. 325.

they are also moist during at least a 90-day rainy season. They tend to be near the Tropics of Cancer and Capricorn. In Hawaii they developed on the lee sides of mountains and on islands that do not have mountains. Their vegetation is savanna, deciduous forest, or semideciduous forest. They can produce some annual crops without irrigation.

Definition

Ustox are the Oxisols that

1. Have an ustic moisture regime; and
2. Have an isothermic, thermic, or warmer temperature regime and have <16 kg organic carbon per square meter to a depth of 1 m.

Key to great groups

CDA. Ustox that have a sombric horizon.

Sombriustox, p. 332

CDB. Other Ustox that have a cation-retention capacity (from NH_4Cl) of 1.5 meq or less per 100 g clay[11] in some subhorizon of the oxic horizon (or have 1.5 meq or less of extractable bases plus extractable aluminum per 100 g clay).

Acrustox, p. 331

CDC. Other Ustox that have base saturation of 50 percent or more (by NH_4OAc) in the major part of the oxic horizon if the particle-size class is clayey or 35 percent or more if the particle-

b. Have an oxic horizon that extends to a depth 1.25 m or more below the mineral soil surface;

c. Have texture in the oxic horizon that is sandy clay loam or finer to a depth at least 1 m below the mineral soil surface;

d. Have a net positive charge in some subhorizon within 1.25 m of the soil surface.

Eutrustox

These are the Ustox that have an appreciable supply of bases and moderate to high base saturation in the oxic horizon.

Eutrustox are the Ustox that

1. Have base saturation of 50 percent or more (by NH_4OAc) in the major part of the oxic horizon if the particle-size class is clayey or of 35 percent or more if the particle-size class is loamy; and
2. Have a cation-retention capacity (from NH_4Cl) of >1.5 meq per 100 g clay[11] (or >1.5 meq of extractable bases plus extractable aluminum per 100 g clay) in all subhorizons of the oxic horizon.

Proposed distinctions between Typic Eutrustox and other subgroups

tion was developed by analogy to the other great groups.

Tropeptic Eutrustox.—These soils have moderate subangular blocky or prismatic structure in the oxic horizon. These soils occur in Hawaii but their extent is small. Their slopes are mainly gentle, and the soils are used for production of irrigated sugarcane or of pineapples.

Haplustox

These are mostly red or dark red Ustox that have some clays that have modest cation-exchange capacity but have low base saturation in some or all parts of the oxic horizon. As a rule base saturation decreases with depth and the bases are held largely in the tissue of the vegetation. These soils tend to have an extended dry season, relatively high precipitation, and a semideciduous vegetation. They are not well represented in the United States, including Puerto Rico, but are extensive in parts of South America and Africa.

Definition

Haplustox are the Ustox that

1. Have a cation-retention capacity (from NH_4Cl) of >1.5 meq per 100 g clay[13] (or >1.5 meq of extractable bases plus extractable aluminum per 100 g clay) in all subhorizons of the oxic horizon;
2. Have base saturation (by NH_4OAc) of <50 percent in the major part of the oxic horizon if the particle-

upper 75 cm that have a color value, moist, of 4 or more if the hue in horizons that have a color value, moist, of 4 or more becomes redder with depth by more than 2.5 Munsell units within the upper 1.5 m and if there are mottles due to segregation of iron within the upper 75 cm; and

g. Do not have a subhorizon of the oxic horizon that has as much as 40 percent more clay (relative) and as much as 15 percent more clay (absolute) than an overlying subhorizon that has a coarse-loamy or coarser particle-size class and is 60 cm or less above the horizon having the greater percentage of clay.

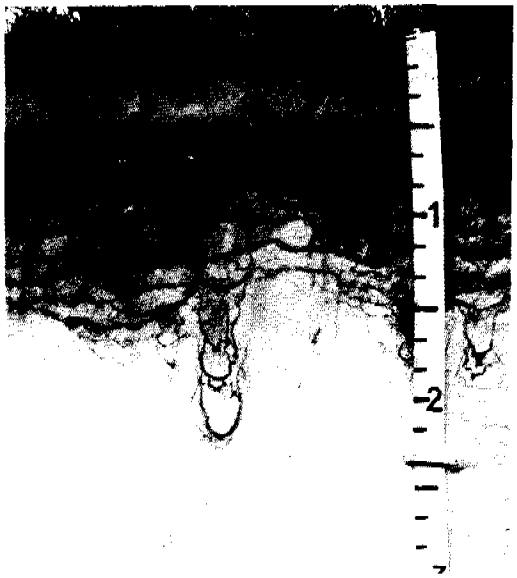
Tropeptic Haplustox are like Typic Haplustox except for *d* or *e*, or both.

Ultic Haplustox are like Typic Haplustox except for *g* or for *e* and *g*.

Description of subgroups

Typic Haplustox.—The central concept or typic subgroup of Haplustox is fixed on deep, freely drained soils that have little or no plinthite, that have an oxic horizon that has clayey texture and very weak or no macrostructure, and that do not have a horizon of distinctly coarser texture overlying the oxic horizon. Because the minerals are strongly weathered, these soils have little silt.

If the percentage of clay is low, the percentage of sand is high and the soils are considered intergrades to the Quartzipsamments. A hue that is 10YR or yellower in some part of the upper horizons that is accompanied by mottles and that becomes distinctly red-



CHAPTER 15

Spodosols

The feature that is common to most Spodosols (plates 4C, 7B, and 8C) is the presence of a spodic horizon, one in which amorphous mixtures of organic matter and aluminum, with or without iron, have accumulated. In undisturbed soils there is normally an overlying eluvial horizon, generally gray to light gray in color, that has the color of more or less uncoated quartz. In some Spodosols this horizon is or was so thin that it has been or would be largely destroyed by cultivation. In others it is very thick. Below the spodic horizon, there may be a fragipan or another sequum that has an argillic horizon. A few Spodosols have a placic horizon that rests on a spodic horizon or on a fragipan or lies in the spodic horizon. A very few others have a strongly cemented albic horizon.

Most Spodosols have little silicate clay. The particle-size class is mostly sandy, sandy-skeletal, coarse-loamy, loamy-skeletal, or coarse-silty.

Spodosols are most extensive in cool, humid, or perhumid climates. They have also formed in hot, humid, intertropical areas and other warm humid areas, for the most part in quartz-rich sands that have a fluctuating level of ground water. In many of the latter soils, the silt and sand fractions are virtually devoid of weatherable minerals and the albic horizons tend to be thick. If the albic horizon is consistently >2 m thick, the soil is excluded from Spodosols and is grouped with the Entisols. Some of the very deep spodic horizons may be buried, but it seems likely that others have formed at great depths because of the near absence of iron and aluminum in the overlying layers of soil to precipitate the organic carbon. The source of aluminum in these soils may be the ground water. Exclusion of a soil from Spodosols if the albic horizon is very thick is largely pragmatic.

Most Spodosols in the United States are in late-Pleistocene or Holocene deposits. They are for the most part in New England, New York, the northern lake states, and Alaska, in high mountains in the West, and be a rain forest, palms, or a savanna that probably is anthropic.

Moisture regimes of Spodosols are primarily aquic or udic, but a few have a xeric regime. Spodosols may have any temperature regime.

Spodosols are naturally infertile soils, but they can be highly responsive to good management. Under cultivation, particularly if lime and nitrogen are applied, the spodic horizon may be biologically destroyed.

Definition

Spodosols are mineral soils that have a spodic horizon that has its upper boundary within 2 m of the surface or they have a placic horizon that is cemented by iron, that rests on a spodic horizon, on a fragipan, or on an albic horizon that rests on a fragipan, and that meets all requirements of a spodic horizon except thickness and the index of accumulation.

Key to suborders

BA. Spodosols that either have an aquic moisture regime[1] or are artificially drained and have characteristics associated with wetness, namely one or more of the following:

1. A histic epipedon;
2. Mottling in an albic horizon or in the upper part of the spodic horizon;
3. A duripan in the albic horizon;
4. If free iron and manganese are absent or if the color value, moist, is less than 4 in the upper part of the spodic horizon, either
   a. Have any color if there are no coatings of iron oxides on the individual grains of silt and sand in or immediately below the spodic horizon wherever the value, moist, is 4 or more; or
   b. Have fine or medium mottles of iron or manganese in the materials immediately below the spodic horizon;
5. A placic horizon that rests on a fragipan or on a spodic horizon or on an albic horizon that is underlain by a spodic horizon but is not in a spodic horizon.

BB. Other Spodosols that have a spodic horizon in which the

b. Have fine or medium mottles of iron or man-

Ferrods, p. 340

BC. Other Spodosols that have a spodic horizon in which some subhorizon that is present in more than half of each pedon has a ratio of free iron to carbon of <0.2.

Humods, p. 340

BD. Other Spodosols.

Orthods, p. 343

Aquods

Aquods are the Spodosols of wet places. Either there is shallow fluctuating ground water or the climate is extremely humid. If the temperature regime is

Key to great groups

BAA. Aquods that have a fragipan below the spodic horizon but do not have a placic horizon above the fragipan.

Fragiaquods, p. 335

BAB. Other Aquods that do not have a placic horizon but have a cryic temperature regime.

Cryaquods, p. 334

BAC. Other Aquods that have a strongly cemented or indurated albic horizon that does not slake in water when a dry fragment is immersed.

Duraquods, p. 335

BAD. Other Aquods that have a placic horizon that rests on a

Distinctions between Typic Cryaquods and other subgroups

Typic Cryaquods are the Cryaquods that
a. Do not have a lithic contact within 50 cm of the surface of the mineral soil;
b. Have a mean annual soil temperature higher than 0° C;
c. Have a ratio of free iron to carbon (elemental) of <0.2 in some subhorizon;
d. Do not have mottles above the spodic horizon that are due to segregation of iron;
e. Do not have an argillic horizon underlying the spodic horizon; and
f. Have a continuous spodic horizon that is 10 cm or more thick or that is very firm when moist.

Lithic Cryaquods are like Typic Cryaquods except for *a* or for *a* and *b*.

Pergelic Cryaquods are like Typic Cryaquods except for *b*.

Pergelic Sideric Cryaquods are like Typic Cryaquods except for *b* and *c* or for *b*, *c*, and *d*.

Sideric Cryaquods are like Typic Cryaquods except for *c* or for *c* and *d*.

Description of subgroups

Typic Cryaquods.—The central concept or typic subgroup of Cryaquods is fixed on soils that have no permafrost, that are moderately deep or deep to hard rock, that have too little free iron above the spodic horizon to produce visible mottles, and that have relatively much more accumulated organic carbon than free iron in the spodic horizon. Permafrost or a shallow lithic contact causes a soil to be excluded from the typic subgroup as they do throughout the taxonomy. Because in Aquods there is most commonly little or virtually no free iron, the presence of a significant amount of iron relative to carbon is considered to represent an intergrade to the Sideraquods.

Lithic Cryaquods.—These soils are not known to occur in the United States, but the subgroup is provided for use if needed.

Pergelic Cryaquods.—Soils in this subgroup have permafrost but otherwise are like Typic Cryaquods in defined properties. They have mostly very thin albic and spodic horizons, the combined thickness is <20 cm, and the frozen ground commonly has many ice lenses or wedges. These soils are known to occur in the United States only in Alaska. They are not cultivated there and they have had low priority for study.

Pergelic Sideric Cryaquods.—These soils have permafrost and enough free iron that the albic horizon has mottles and the spodic horizon has appreciable free iron relative to carbon in all subhorizons. They are known to occur, but they are rare, in the high mountains of the western states where they may furnish some summer grazing. They also occur in Alaska but are rare there.

Sideric Cryaquods.—These soils have enough free iron that the albic horizon has mottles and the spodic horizon has appreciable free iron relative to carbon in all subhorizons. The combined thickness of the albic and spodic horizons seldom exceeds 75 cm. These soils are known but are rare in the high mountains of the western states, and they are not extensive in Alaska.

Duraquods

These are the Aquods that have a strongly cemented or indurated albic horizon. The cement is silica. The soils are saturated seasonally above the duripan but not necessarily below it. These soils are known to occur in New Zealand under the kauri pine and in some other parts of the world, but they are not known to occur in the United States. The classification at the subgroup level has not been developed. The soils are thought to be rare, but the shallow duripan restricts plant rooting severely, and their recognition is important where they do occur. They had no clear equivalent in the 1938 classification.

Definition

Duraquods are the Aquods that have a duripan in the albic horizon and have a temperature regime warmer than that of Cryaquods.

Fragiaquods

These are the Aquods that have a fragipan below the spodic horizon, usually at a depth between 40 and 75 cm. Plant roots are shallow, and soil that clings to the roots of falling trees has developed a microrelief of 20 to 50 cm in many of the soils. The soil temperature regime is mostly frigid or is cryic bordering on frigid. The soils are nearly level, but only a few of them are cultivated except for production of hay. Most of the Fragiaquods in the United States are under forests, and they are not extensive. They were considered to be Podzol soils in the 1938 classification.

Definition

Fragiaquods are the Aquods that have a fragipan below the spodic horizon, but that do not have a duripan or a placic horizon above the fragipan.

Description of a Typic Fragiaquod

There follows a description of a soil that represents the central concept or typic subgroup of Fragiaquods. This soil, in Lewis County, N.Y., is being cultivated. It formerly had a forest vegetation, chiefly of hardwood trees. It formed in a silty mantle over till, and before cultivation it probably had a microrelief that was formed by falling trees. The ratio of iron to carbon in the spodic horizon is about 2. The slope is gentle, but water cannot now stand on the soil. The mean annual air temperature is about 6° C and the mean summer temperature is about 20° C. The mean annual precipitation is about 1,000 mm and is evenly distributed throughout the year. Colors are those of the moist soil.

Ap 0–18 cm. Dark grayish brown (10YR 4/2) silt loam; friable.

B2 18–43 cm. Dark yellowish brown (10YR 4/4) silt loam; distinct medium and fine yellowish brown (10YR 5/6) mottles; very weak coarse crumb structure; friable or very friable; pH near 5.0; clear boundary.

A'2 43–53 cm. Light olive brown (2.5Y 5/3–6/2) loam; many medium or fine yellowish brown (10YR 5/6) mottles;

moderate to weak thin platy structure; firm or friable; pH near 5.0; abrupt boundary.

B'x1 53–85 cm. This horizon breaks into very coarse prisms whose interiors are olive gray (5Y 4/2 or 2.5Y 4/2) heavy silt loam or silty clay loam that has many fine and medium olive brown (2.5Y 5/3) mottles. This material is very firm and is extremely hard when dry. The prisms have very weak angular blocky structure. Clay skins are evident in the small pores and on ped faces. The outside of the prisms is coated with light brownish gray (2.5Y 6/2) loam or very fine sandy loam. These coats range from 6 mm thick at the top of the horizon to thin films near the bottom. A natural plane of parting separates the coats on adjacent prisms. The pH of the crushed soil mass is 5.0 to 5.5. The lower boundary is gradual.

B'x2 85–150 cm. This horizon has very coarse prisms whose interiors are light olive brown (2.5Y 5/3) silt loam or light silty clay loam that has many fine light olive brown (2.5Y 5/3) mottles. The prisms break into very weak coarse blocks; very firm at the top of the horizon and firm near the bottom. Clay skins are evident in small pores but not on the ped faces. The prisms have very thin dark olive gray (5Y 3/2) coats which are commonly silty clay loam; pH of the crushed material ranges from 5.2 to 6.5 and generally increases with depth; diffuse boundary.

C1 150 cm. Light olive brown (2.5Y 5/3) silt loam; weak medium angular blocky structure commonly arranged in very thick plates; firm; pH 6.0 to 7.0.

Distinctions between Typic Fragiaquods and other subgroups

Typic Fragiaquods are the Fragiaquods that

a. Have a frigid or warmer temperature regime;

b. Do not have a histic epipedon;

c. Have <5 percent by volume of iron-cemented nodules 2.5 to 30 cm in diameter in any subhorizon of

considered evidence that the Spodosol has developed from an Alfisol and defines the alfic subgroup.

Alfic Fragiaquods.—Soils in this subgroup have an argillic horizon below the spodic horizon. In the United States, the argillic horizon commonly underlies the fragipan, which developed in the eluvial horizon of an underlying sequum. These soils are rare in the United States.

Cryic Fragiaquods.—These soils have a cryic temperature regime but are otherwise much like Typic Fragiaquods. They are known to occur in the United States only in southeastern Alaska, and they are not extensive. Although the temperature regime is cryic, the climate is maritime and the soils rarely freeze.

Haplaquods

These are Aquods that are common on the plains of midlatitudes. The spodic horizon is principally an accumulation of organic matter and aluminum. Cobalt, manganese, and iron are present only in traces. The spodic horizon shows few or no mottles and is usually black to dark reddish brown. In the wettest Haplaquods there is no albic horizon, but there are normally many uncoated sand grains above the spodic horizon. Because of the reddish hue, the absence of iron in these soils was overlooked for many years.

The Haplaquods almost exclusively have sandy texture, sands or loamy sand, but because the humus content may be high, some of them feel and behave as if they were loamy soils. They are extensive soils on the coastal plain in the southern states of the United

d. Have a spodic horizon that has a weighted average of 0.6 percent or more organic carbon in the matrix of the upper 30 cm of the spodic horizon or have an upper subhorizon of the spodic horizon that

(1) Has 2.3 percent or more organic carbon in the upper 2 cm; and

(2) Is continuous or is present in more than 90 percent of each pedon;

e. Have <5 percent by volume of iron-cemented nodules 2.5 to 30 cm in diameter in any subhorizon of the spodic horizon;

The absence of an umbric epipedon indicates somewhat better drainage than that of Typic Haplaquods and defines the aeric subgroups. A lower sequum that has an argillic horizon is considered evidence that the spodic horizon formed in the eluvial horizon of an Alfisol or Ultisol and, in part, defines intergrades to those orders. A thick sandy epipedon is not uncommon in the warmer Haplaquods and is the basis for defining arenic and grossarenic subgroups, a convention used elsewhere in the taxonomy. A small amount of carbon in the spodic horizon is considered evidence of

Lithic Haplaquods.—Soils in this subgroup have a shallow lithic contact. The spodic horizon may have only a small accumulation of organic carbon and aluminum, and the epipedon is commonly ochric. These soils are rare in the United States and are known to occur only in the northern lake states.

Placic Haplaquods.—These soils have a placic horizon in or below the spodic horizon but are otherwise like Typic Haplaquods in defined properties. These soils are rare in the United States. They occur in southeastern Alaska where the soil temperature regime is cryic but the climate is maritime. The epipedon is histic, and the spodic horizon contains a large amount of organic carbon.

Ultic Haplaquods.—These soils have an argillic horizon below the spodic horizon. The argillic horizon has low base saturation throughout its thickness. Most of these soils have an ochric epipedon. They are known to occur in Florida in the United States, but they are not extensive there.

Placaquods

These are the Aquods that have an involute placic horizon that may rest on a spodic horizon, or on a fragipan, or on an albic horizon that overlies a spodic horizon. Commonly, all these features may be present in the same pedon. The horizons above the placic horizon have low-contrast mottles that probably are caused by organic matter. Placaquods are known to occur only in perhumid oceanic climates. Many have or have had *Sphagnum* spp. and heath vegetation. They are not known to occur in the United States, and the classification of subgroups has not been developed. At present, all the known Placaquods are considered to be Typic Placaquods.

Definition

Placaquods are the Aquods that have a placic horizon that rests on a spodic horizon, on a fragipan, or on an albic horizon that is underlain by a fragipan.

ter soil temperatures at a depth of 50 cm that differ by 5° C or more;

2. Have in all subhorizons of the spodic horizon a ratio of free iron (by dithionite-citrate) to carbon (both elemental) of 0.2 or more;
3. Do not have a fragipan below the spodic horizon; and
4. Do not have a duripan or a placic horizon above the spodic horizon.

Description of a Typic Sideraquod

There follows a description of a soil that represents the central concept or typic subgroup of Sideraquods. This soil, in Curry County, Oreg., formed in beach deposits under a vegetation of pine, bracken fern, grasses, and sedges. The mean annual precipitation is about 1,700 mm, coming mostly in winter. The mean annual temperature is about 11° C. The mean January temperature is about 7° C, and the mean July temperature is about 15° C. The slope of this soil is very gentle, and the soil is saturated in the winter months. Colors are those of the moist soil unless otherwise stated.

O1 7–0 cm. Very strongly acid muck with some needles, leaves, and grass litter.

A1 0–20 cm. Very dark gray (10YR 3/1) mucky fine sandy loam, dark gray (10YR 4/1) when dry; moderate fine subangular blocks breaking to moderate fine granules; soft, very friable, slightly plastic; many moderately coarse pores; many roots; very strongly acid, pH 5.0; gradual wavy boundary.

A2 20–46 cm. Gray (N 5/0 or 6/0) fine sandy loam, white (N 6/0 or 8/0) dry; massive; hard, firm, slightly plastic; few fine pores; many roots; strongly acid, pH 5.2; abrupt wavy boundary.

B21h 46–56 cm. Dark reddish brown (5YR 2/2) mucky loam, dark reddish gray (5YR 4/2) dry; weak medium subangular blocky structure or massive; some cementation but mostly soft and very friable; many fine and moderately coarse pores; common roots; very strongly acid, pH 5.0; abrupt wavy boundary.

B22ir 56–82 cm, Yellowish brown (10YR 5/4 and 5/6) and dark reddish brown (5YR 3/4) loamy sand; common medium and coarse dark reddish brown (5YR 3/4) mottles; massive; very hard, very firm; few fine pores;

some part of the argillic horizon or they have a mean annual soil temperature lower than 8° C.

Entic Sideraquods are like Typic Sideraquods except for *a*.

Description of subgroups

Typic Sideraquods.—The central concept or typic subgroup of Sideraquods is fixed on soils that have at least a moderate accumulation of iron and organic carbon in the spodic horizon and that do not have an argillic horizon underlying the spodic horizon. Because iron is present, many if not most of them have a continuous or discontinuous ortstein that is strongly cemented. The epipedon is commonly umbric. In the United States, these soils occur mostly along the Pacific Coast.

Alfic Sideraquods.—These soils have an argillic horizon below the spodic horizon, and the base saturation in the argillic horizon is moderate to high. These soils are rare in the United States and are known to occur only in Florida.

Entic Sideraquods.—These soils have only a small accumulation of organic carbon in the spodic horizon. In the United States they are known to have formed only in sands in Florida, and even there they are rare.

e. Have an umbric epipedon or one that would meet the requirements for an umbric epipedon if plowed to a depth of 25 to 30 cm;

f. Do not have a sandy epipedon (loamy fine sand or coarser throughout) that is 75 cm or more thick on the average for the thinnest half of the pedon;

g. Have a spodic horizon that has a weighted average of 0.6 percent or more organic carbon in the matrix of the upper 30 cm of the spodic horizon or have an upper subhorizon of the spodic horizon that

(1) Has 2.3 percent or more organic carbon in the upper 2 cm; and

(2) Is continuous or is present in >90 percent of each pedon; and

h. Have in 50 percent or more of each pedon a spodic horizon in which some subhorizon has a ratio of free iron (by dithionite-citrate) to carbon (both elemental) of <0.2.

Aeric Tropaquods are like Typic Tropaquods except for *e*.

Aeric Arenic Tropaquods are like Typic Tropaquods except for *e* and *f*, and the upper boundary of the spodic horizon is between 75 cm and 1.25 m below the soil surface.

Aeric Grossarenic Tropaquods are like Typic Trope

A spodic horizon that has only a small amount of organic carbon represents development weaker than normal and defines entic subgroups. An argillic horizon below the spodic horizon indicates development from an Ultisol and defines ultic subgroups.

Aeric Tropaquods.—These soils are not known to occur in the United States in significant areas, but the subgroup is provided for use elsewhere.

Aeric Arenic Tropaquods.—These soils are not known to occur in the United States in significant areas, but the subgroup is provided for use elsewhere.

Aeric Grossarenic Tropaquods.—These soils are not known to occur in the United States in significant areas, but the subgroup is provided for use elsewhere.

Entic Tropaquods.—These soils are not known to occur in the United States in significant areas, but the subgroup is provided for use elsewhere.

Histic Lithic Tropaquods.—Soils in this subgroup have a histic epipedon and a shallow lithic contact. Consequently, all horizons are relatively thin when compared to those of the typic subgroup. In the United States these soils are known to occur only in Hawaii under the rain forest at high elevations where there are clouds and fog nearly every day.

Ultic Tropaquods.—These soils are not known to occur in the United States in significant areas, but the subgroup is provided for use elsewhere.

Ferrods

This suborder is provisional. Ferrods are not known to occur in the United States, but the suborder is provided for use elsewhere. The classification has not been developed.

Ferrods are the Spodosols that

1. Have a spodic horizon that has in all subhorizons a ratio of percentage of free iron (by dithionite-citrate) to percentage of carbon (both elemental) of 6 or more; and
2. Do not have an aquic moisture regime or artificial drainage or do not have the characteristics associated with wetness as defined for Aquods.

Humods

Humods (plates 4C and 8C) are the more or less freely drained Spodosols that have a large accumulation of organic carbon relative to iron in some or all subhorizons of the spodic horizon. The undisturbed soil may have only a thin, intermittent albic horizon ical regions, most of them have supported a rain forest.

The soils of this suborder are not extensive in the United States. They are known to occur in Alaska and in the Adirondack Mountains, mostly in small areas, and in the southeastern states. Few series have been recognized. The Humods were mostly considered Podzol soils in the 1938 classification. Because the Humods are so poorly represented in the United States, the classification that follows is incomplete and provisional.

Definition

Humods are the Spodosols that

1. Do not have an aquic moisture regime or artificial drainage or do not have characteristics associated with wetness as defined for Aquods; and
2. Have one or both of the following:
   a. In 50 percent or more of each pedon, a spodic horizon that has a subhorizon in which the ratio of free iron (by dithionite-citrate) to carbon (both elemental) is <0.2;
   b. An Ap horizon that has a color value, moist, of 3 or less and a chroma, moist, of 2 or less and that rests directly on a spodic horizon that has in its upper part a subhorizon or some tongues in which the ratio of free iron to carbon is <0.2.

Key to great groups

BCA. Humods that have a placic horizon in the spodic horizon. **Placohumods,** p. 342

BCB. Other Humods that have an isomesic or warmer iso temperature regime. **Tropohumods,** p. 342

BCC. Other Humods that have a fragipan below the spodic horizon. **Fragihumods,** p. 341

BCD. Other Humods that have a cryic temperature regime. **Cryohumods,** p. 340

BCE. Other Humods. **Haplohumods,** p. 341

Cryohumods

These are the Humods of high latitudes or high elevations that do not have a placic horizon. In the United States there is commonly a thick O horizon over a very thin or intermittent albic horizon over a thick spodic horizon that has a very large amount of organic carbon. The spodic horizon may have more or-

sents the central concept of the Cryohumods of the United States.

Distinctions between Typic Cryohumods and other subgroups

Typic Cryohumods are the Humods that

a. Have 6 percent or more organic carbon (weighted average) in the matrix of the upper 30 cm of the spodic horizon or, if the spodic horizon is <30 cm thick, in the 30 cm directly below the top of the spodic horizon;

b. Do not have a lithic contact within 50 cm of the

particularly in sandy sediments, in western Europe where most of them had at some time a heather (*Calluna vulgaris*) vegetation. Most of them, if undisturbed, have an ochric epipedon and an albic horizon that rests on a spodic horizon that has a reddish hue and that has a black upper subhorizon rich in organic carbon relative to iron. They were considered Podzol soils in the 1938 classification. Because they are rare in the United States, the classification that follows is incomplete and provisional.

Definition

Orthic Haplohumods are like Typic Haplohumods except for *a(2)*, and the subhorizon is present in <90 percent of the pedon.

Plaggeptic Haplohumods are like Typic Haplohumods except for *e*.

Ultic Haplohumods are like Typic Haplohumods except for *d* or for *a* and *d*.

Xeric Haplohumods are like Typic Haplohumods except for *f*, and they have a xeric moisture regime.

Description of subgroups

Typic Haplohumods.—The central concept or typic subgroup of Haplohumods is fixed on soils that have at least a moderate amount of organic carbon in the spodic horizon, that have a spodic horizon that is close to the surface and is free of large iron-cemented nodules, that do not have an argillic horizon below the spodic horizon, and that do not have a surface mantle >30 cm thick that meets all the requirements of a plaggen epipedon except thickness.

A small amount of carbon in the spodic horizon is evidence of weak development and is the basis for defining entic subgroups. Large iron-cemented nodules in the spodic horizon are considered evidence of development from a Ferrudalf, and define the ferrudalfic subgroup. A shallow lithic contact is used to define the lithic subgroup, a convention used throughout the taxonomy. A discontinuous black upper subhorizon of the spodic horizon suggests formation from an Orthod and defines the orthic subgroup. A surface mantle between 30 and 50 cm thick that meets all requirements for a plaggen epipedon except thickness defines the plaggeptic subgroup.

Arenic Haplohumods.—These soils have a thicker albic horizon than Typic Haplohumods but are otherwise the same in defined properties. In the United States, these soils have ground water that fluctuates in depth but that saturates the spodic horizon. They are known to occur on the coastal plain in the southeastern states, but they are not extensive. Slopes are gentle, and most of the soils are in forests or are used for grazing.

Arenic Ultic Haplohumods.—These soils have a thicker albic horizon than the Typic Haplohumods and ganic carbon than Typic Haplohumods but are otherwise similar in defined properties. Because of the very thick albic horizon, the water-holding capacity is lower if the texture is the same. In the United States, these soils have ground water that fluctuates in depth but saturates the spodic horizon. They occur on the coastal plains in the southeastern states but are not extensive. Their slopes are gentle, but few of the soils are cultivated.

Lithic Haplohumods.—These soils are not known to occur in the United States in significant areas, but the subgroup is provided for use elsewhere.

Orthic Haplohumods.—These soils are not known to occur in the United States in significant areas, but the subgroup is provided for use elsewhere.

Plaggeptic Haplohumods.—These soils are not known to occur in the United States in significant areas, but the subgroup is provided for use elsewhere.

Ultic Haplohumods.—These soils have a spodic horizon that is underlain by an argillic horizon with low base saturation throughout and may have a spodic horizon with lower organic carbon content and higher chroma and value than is characteristic of the typic subgroup. The soils are on the lower coastal plain of the southwestern states but are not extensive. Slopes are gentle, and most of the soils are in forests and urban areas although some are in cropland and pasture.

Xeric Haplohumods.—These soils are not known to occur in the United States in significant areas, but the subgroup is provided for use elsewhere.

Placohumods

These are the Humods that have a placic horizon in the spodic horizon. They are probably rare in the world but are known to occur in southeastern Alaska, eastern Canada, and parts of western Europe. Their vegetation in Alaska is coniferous forest; in Europe it is or was heather. They were considered to be Podzol soils in the 1938 classification. The classification that follows is incomplete and provisional.

Definition

waii, their extent is so slight that they give no basis for developing a classification in the subgroup category. Consequently, the classification is undeveloped, but it is thought that it should parallel that of the Haplohumods.

Definition

Tropohumods are the Humods that have an isomesic or a warmer iso temperature regime.

Orthods

Orthods (plate 7B) are the more or less freely drained Spodosols that have a horizon of accumulation of aluminum, iron, and organic carbon in which no one of these elements dominates. They are the most common Spodosols in the northern parts of Europe and the United States. They formed mainly in coarse, acid, Pleistocene or Holocene deposits under a forest vegetation that consisted of either conifers or hardwood trees, but in which conifers were more common. If undisturbed, an Orthod normally has an O horizon, an albic horizon, and a spodic horizon, and it may or may not have a fragipan, depending on the texture of the materials. Some of these soils, however, have been mixed or stirred naturally by roots of falling trees or by animals and have a very thin albic horizon or none. Very commonly, under cultivation, the albic horizon is mixed with part of the spodic horizon.

In the United States, moisture regimes of Orthods are predominantly udic, but a few are xeric. Temperature regimes are mostly cryic or frigid, but a few are mesic bordering on frigid and a few are pergelic. The Orthods are extensive soils in New England, the northern lake states, the high mountains of the West, and parts of southern Alaska.

Definition

Orthods are the Spodosols that
1. Have a spodic horizon that has in some subhorizon a ratio of percentage of free iron (by dithionite-citrate) to percentage of carbon (both elemental) of <6 and that has in all subhorizons a ratio between percentages of the same two elements of 0.2 or more; and
2. Do not have an aquic moisture regime or artificial drainage or do not have the characteristics of Aquods associated with wetness.

Key to great groups

BDA. Orthods that have a placic horizon in the spodic horizon. **Placorthods**, p. 347

BDB. Other Orthods that have a fragipan below the spodic horizon. **Fragiorthods**, p. 344

BDC. Other Orthods that have a cryic or pergelic temperature regime. **Cryorthods**, p. 343

BDD. Other Orthods that have an isomesic or warmer iso temperature regime. **Troporthods**, p. 347

BDE. Other Orthods. **Haplorthods**, p. 345

Cryorthods

These are the cold Orthods of high latitudes or high elevations that do not have a fragipan or a placic horizon. The horizons are mostly thin but they may be strongly contrasting. The base of the spodic horizon is commonly 50 cm or less below the soil surface. Some have permafrost at a variable depth below the spodic horizon. Others have below the spodic horizon another sequum that has an argillic horizon.

In the United States these soils are largely in Alaska and in the high mountains of the West, New York state, and New England. They were considered Podzol soils in the 1938 classification.

Definition

Cryorthods are the Orthods that
1. Have a cryic or pergelic temperature regime;
2. Do not have a fragipan; and
3. Do not have a placic horizon.

Pedon 111 is an example of the central concept or typic subgroup of Cryorthods.

Distinctions between Typic Cryorthods and other subgroups

Typic Cryorthods are the Cryorthods that
a. Do not have an argillic horizon below the spodic horizon;
b. Have a cemented or indurated spodic horizon or have 1.2 to 6 percent organic carbon in the upper 10 cm of the spodic horizon;
c. Do not have a lithic contact within 50 cm of the soil surface;
d. Have a mean annual soil temperature higher than 0° C.

Boralfic Cryorthods are like Typic Cryorthods except for *a* or for *a* and *b*.

Entic Cryorthods are like Typic Cryorthods except for *b* in that they contain less than 1.2 percent organic carbon in the upper 10 cm of the spodic horizon.

Humic Cryorthods are like Typic Cryorthods except for *b* in that they contain >6 percent organic carbon in the upper 10 cm of the spodic horizon.

Humic Lithic Cryorthods are like Typic Cryorthods except for *c* and *b* and they contain >6 percent organic carbon in the upper 10 cm of the spodic horizon.

Lithic Cryorthods are like Typic Cryorthods except for *c* or for *c* and *d*.

Pergelic Cryorthods are like Typic Cryorthods except for *d*.

Description of subgroups

Typic Cryorthods.—The central concept or typic subgroup of Cryorthods is fixed on soils that have a single sequum, have a moderate accumulation of organic carbon in the spodic horizon, do not have a shallow lithic contact, and do not have permafrost.

A second sequum that has an argillic horizon is evidence that the Spodosol has developed from an Alfisol and defines the boralfic subgroup. A small accumulation of organic carbon in the spodic horizon is abnormal and defines the entic subgroup. A large accumulation of carbon defines intergrades to Humods. A

shallow lithic contact defines lithic subgroups, a convention used throughout the taxonomy. Permafrost defines pergelic subgroups, a convention that is used in all cryic great groups.

Boralfic Cryorthods.—These soils have a lower sequum that has an argillic horizon, and commonly they have less organic carbon in the spodic horizon than

United States, temperature regimes of these soils are mostly frigid, but some are cryic bordering on frigid and some are mesic bordering on frigid. The Fragiorthods were considered Podzol soils and Brown Podzolic soils in the 1938 classification.

Definition

Plaggeptic Fragiorthods are like Typic Fragiorthods except for *g*.

Description of subgroups

Typic Fragiorthods.—The central concept or typic subgroup of Fragiorthods is fixed on soils that do not have an argillic horizon, do not have mottles that are due to wetness, and have a spodic horizon that is at least moderately thick or has a moderate accumulation of organic carbon. Tongues of an albic horizon or an albic horizon that has been buried in a mound are not included in the meaning of mottles here. Mottles that have high chroma are implied. The soil temperature regime is frigid or warmer, and there is no intermittent black upper subhorizon of the spodic horizon that has a large amount of carbon relative to iron.

A thin mantle, 30 to 50 cm thick, that has all the properties of a plaggen epipedon except thickness causes a soil to be excluded from the typic subgroup and is used to define the plaggeptic subgroup.

An argillic horizon that usually is below the fragipan is used to define the alfic subgroup because it is evidence that the soil developed from an Alfisol. Mottles of high chroma in the spodic horizon reflect higher than normal ground water and define the aquic

Aquic Fragiorthods.—These soils have high-contrast mottles in the spodic horizon and have ground water at a depth shallower than in Typic Fragiorthods. These soils have gentle slopes and are intergrades to the Fragiaquods. They are mainly on the till plains of New York and New England in the United States and are not extensive there. They are largely used for pasture or forests.

Cryic Fragiorthods.—These soils have a cryic temperature regime but otherwise are like Typic Fragiorthods in most characteristics. In the United States, they are moderately to strongly sloping. They formed mostly in loamy till in southeastern Alaska where the climate is maritime and the precipitation is high. They are in forests.

Entic Fragiorthods.—These soils have only a small accumulation of organic carbon in the spodic horizon. In the United States, their slopes are mostly gentle and the soils have formed in loamy till. Their temperature regimes are mostly mesic. These soils were considered Brown Podzolic soils in the 1938 classification. They are moderately extensive in the southern part of New England. They are used mostly for hay, pasture, or forests.

Humic Fragiorthods.—These soils have an intermit-

pellets characteristic of the spodic horizons of these soils.

Distinctions between Typic Haplorthods and other subgroups

Typic Haplorthods are the Haplorthods that

a. Do not have an argillic horizon below the spodic horizon;

b. Have a spodic horizon that has one or more of the following:

(1) A continuous horizon at least 2.5 cm thick that is very firm or extremely firm when moist (ortstein);

(2) A texture of very fine sand or finer and is more than 10 cm thick and has a weighted average of at least 1.2 percent organic carbon in the spodic horizon and within 1 m of the surface that has a brittle matrix when wet or contains some durinodes;

f. Do not have a lithic contact within 50 cm of the surface;

g. Do not have a black intermittent upper subhorizon that has a ratio of free iron (elemental) to carbon that is <0.2;

h. Have <6 percent organic carbon in the upper 10 cm of the spodic horizon;

i. Have 1.2 percent or more organic carbon in the Ap horizon if the Ap horizon extends into the upper part of the spodic horizon.

Alfic Haplorthods are like Typic Haplorthods except for *a* or for *a* and *b*, with or without *i*, and the argillic horizon either has base saturation of 35 percent or

zon that has a large amount of carbon relative to iron indicates intergrades to Humods and defines the humic subgroup.

Alfic Haplorthods.—These soils (plate 7B) have a lower sequum in which there is an argillic horizon that has either base saturation of 35 percent or more (by sum of cations) or a frigid temperature regime. The soils normally have less organic carbon in the spodic horizon than the Typic Haplorthods. In the United States, they formed in glacial drift and have gentle slopes. A large proportion of their area is cultivated to cool-weather crops. These soils are moderately extensive in the northern lake states. Pedon 44 is an example of an Alfic Haplorthod.

Aqualfic Haplorthods.—These soils have a lower sequum in which there is an argillic horizon that has either base saturation of 35 percent or more or a frigid temperature regime, and in addition they have ground water in the soil that fluctuates in depth either in or close below the spodic horizon. These soils are considered intergrades to Aqualfs, primarily Glossaqualfs. In the United States, they formed in glacial drift and have gentle slopes. Some are cultivated, but many are used for pasture or for forests, chiefly for hardwood trees. They are not extensive even in the northern lake states.

Aquentic Haplorthods.—These soils have only a small amount of organic carbon in the spodic horizon, and they have ground water in the soil that fluctuates in depth either in or close below the spodic horizon. They are considered intergrades to Aquents. In the United States they occur in New England where soil temperature regimes are mesic. Many of them have been cleared and are cultivated or are used for hay and pasture.

Aquic Haplorthods.—These soils have ground water in the soil that fluctuates in depth either in or close below the spodic horizon. They are considered intergrades to Aquods. In the United States, they occur but are not extensive in the northern lake states, New York, and New England where soil temperature regimes are frigid. They are mostly in forests, but some are cleared and are used for hay or pasture.

Duric Haplorthods.—These soils have, below the spodic horizon, a horizon that has evidences of cementation by silica but is too weakly cemented to be a duripan. Perched ground water and root mats are common above the cemented horizon. In the United States these soils are rare. They are mainly on terraces in the far western states. Their slopes are gentle, but most of the soils are forested.

Entic Haplorthods.—These soils have a small amount of organic carbon in the spodic horizon but are otherwise like Typic Haplorthods in defined properties. In parts of the United States where soil temperature regimes are frigid, the albic horizon of these soils commonly is prominent. The water-holding capacity and the cation-exchange capacity are lower than in Typic Haplorthods, other things being equal. In parts of the United States where soil temperature regimes are mesic, the albic horizon of these soils commonly is very thin or is absent. The frigid soils are mostly in forests, but many of the mesic soils are cultivated. These soils are moderately extensive in southern New England and in the northern lake states.

Entic Lithic Haplorthods.—These soils have a shallow lithic contact and have only a small amount of organic carbon in the spodic horizon. In the United States they are mostly in New England. Their slopes are moderate to strong. Some of the soils are used for pasture, but many are in forests.

Humic Haplorthods.—These soils are not known to occur in the United States but the subgroup is provided for use elsewhere if needed.

Lithic Haplorthods.—These soils have a shallow lithic contact but otherwise are like Typic Haplorthods in most properties. However, many are stony or have common rock outcrops. In the United States they are known to occur in New England. They are mostly in forests.

Ultic Haplorthods.—These soils have a lower sequum in which there is an argillic horizon and have both low base saturation and a mesic or warmer temperature regime. They are permitted but are not required to have, and most of them have, less organic carbon in the spodic horizon than Typic Haplorthods. In the United States these soils formed only in the southeastern states, and there they are rare.

Placorthods

These are the Orthods that have a placic horizon in the spodic horizon. They are not known to occur in the United States, and they are thought to be rare elsewhere in the world. Subgroups have not been defined.

Troporthods

These are the Orthods that have an isomesic or warmer iso temperature regime. They are not known to occur in the United States, but the group is provided for use elsewhere. Subgroups have not been defined.

Limits between Ultisols and soils of other orders

The definition of Ultisols must provide criteria to separate Ultisols from soils of all other orders. The aggregate of these criteria defines the limits of Ultisols in relation to all other known kinds of soil.

1. To distinguish Ultisols from Alfisols, Ultisols must have all the following characteristics:
   a. Have a mesic, isomesic, or warmer temperature regime;
   b. Have base saturation (by sum of cations) of

3. To distinguish Ultisols from Entisols and Inceptisols, Ultisols must have one of the following:
   a. An argillic horizon that is not buried; or
   b. A fragipan that meets all the requirements of an argillic horizon, or that has clay skins >1 mm thick in some part, or that underlies an argillic horizon.
4. To distinguish Ultisols from Histosols, Ultisols must meet the definition of mineral soils (ch. 3).
5. To distinguish Ultisols from Mollisols, Ultisols must have one of the following:
   a. Have an argillic horizon but not a fragipan and have base saturation (by sum of cations) of

2. Chroma, moist, of 1 or less on surfaces of peds or in the matrix of the argillic horizon; or
3. Dominant hue of 2.5Y or 5Y in the matrix of the argillic horizon and distinct or prominent mottles and also a thermic or isothermic or warmer soil temperature regime.

Aquults, p. 351

FB. Other Ultisols that have either or both of the following characteristics:
1. Have 0.9 percent or more organic carbon in the upper 15 cm of the argillic horizon; or
2. Have 12 kg or more organic carbon in the soil per square meter to a depth of 1 m below the base of the mineral soil surface, exclusive of any O horizon that may be present.

Humults, p. 355

FC. Other Ultisols that have a udic moisture regime.

Udults, p. 360

FD. Other Ultisols that have an ustic moisture regime.

Ustults, p. 369

FE. Other Ultisols that have a xeric moisture regime.

Xerults, p. 372

Aquults

These are the gray or olive Ultisols of wet places where ground water is very close to the surface during part of each year, usually in winter and spring in middle latitudes, and is deep at another time. These soils formed mainly in alluvium and marine deposits that are of Pleistocene age or older.

These soils are extensive in the United States on the coastal plains, particularly along the Atlantic Ocean and the Gulf of Mexico. Their slopes are gentle. Most of them had and many still have a forest vegetation, but the cultivated acreage is increasing.

The Aquults have an ochric or umbric epipedon and an argillic horizon, some have a fragipan, and others have plinthite in or below the argillic horizon.

Definition

Aquults are the Ultisols that
1. Are saturated with water at some time of year or are artificially drained;
2. Have immediately below the plow layer or below any A1 horizon that has a color value, moist, less than 3.5 when rubbed, one or more of the following characteristics:
   a. Chroma, moist, of 2 or less;
   b. Mottles due to segregation of iron; or
   c. Iron-manganese concretions >2 mm in diameter; and
3. Have one or more of the following characteristics:
   a. Dominant chroma, moist, of 2 or less in coatings on the surface of peds and mottles within the peds, or dominant chroma, moist, of 2 or less in the matrix of the argillic horizon and mottles of higher chroma (if the hue is redder than 10YR because of parent materials that remain red after citrate-dithionite extraction, the requirement for low chroma is waived);
   b. Chroma, moist, of 1 or less on surfaces of peds or in the matrix of the argillic horizon; or
   c. Dominant hue of 2.5Y or 5Y in the matrix of the argillic horizon and distinct or prominent mottles and also a thermic, isothermic, or warmer soil temperature regime.

Key to great groups

FAA. Aquults that have plinthite that forms a continuous phase or constitutes more than half the matrix of some subhorizon within 1.25 m of the soil surface.

Plinthaquults, p. 354

FAB. Other Aquults that have a fragipan and, if there is 5 percent or more by volume of plinthite in some subhorizon, the upper boundary of the fragipan is within 1 m of the surface of the soil.

Fragiaquults, p. 352

FAC. Other Aquults that have an abrupt textural change between the ochric epipedon or the albic horizon and the argillic horizon and have slow hydraulic conductivity in the argillic horizon.

Albaquults, p. 351

FAD. Other Aquults that have a clay distribution such that the percentage of clay does not decrease from its maximum by as much as 20 percent of the maximum within a depth of 1.5 m from the soil surface, or the horizon in which the percentage of clay is less than the maximum has skeletans on ped faces or contains 5 percent or more plinthite by volume; and the upper 50 cm of the argillic horizon has <10 percent weatherable minerals in the 20- to 200-micron fraction.

~~Paleaquults~~, p. 353

FAE. Other Aquults that have an isomesic or warmer iso temperature regime.

~~Tropaquults~~, p. 355 delete

FAF. Other Aquults that have an ochric epipedon.

Ochraquults, p. 352

FAG. Other Aquults that have an umbric or a mollic epipedon.

Umbraquults, p. 355

Albaquults

These are the Aquults that have a marked increase in percentage of clay at an abrupt boundary at the top of the argillic horizon. The argillic horizon generally is clayey and has slow hydraulic conductivity. In most years, water is perched for a while above the argillic horizon when the soils are rewetting and later saturates the whole soil. Slopes are nearly level, and drainage of the soils is difficult. These soils in southeastern United States formed mostly in acid, late-Pleistocene sediments and lie on low marine or stream terraces. Most of them have a season when the upper horizons are dry. Some of these soils in the United States have been cleared for grazing or cropping, but many are still in forests. These soils were considered Planosols and Low-Humic Gley soils in the 1938 classification or the 1949 revision.

Definition

Albaquults are the Aquults that have an abrupt textural change between the ochric epipedon or the albic horizon and the argillic horizon, and they have low hydraulic conductivity in the argillic horizon. They do not have a fragipan, and they do not have plinthite that forms a continuous phase or constitutes half or more of the matrix of any subhorizon within 1.25 m of the soil surface.

Pedon 112 illustrates the central concept or typic subgroup of Albaquults.

Description of subgroups

Only two subgroups of Albaquults have been proposed, Typic Albaquults and Aeric Albaquults.

Typic Albaquults.—These are the Albaquults that have the colors definitive for the suborder in 60 percent or more of the matrix between the A1 or Ap horizon and a depth of 75 cm. They are moderately extensive in the United States on parts of the coastal plains in the southeastern states.

Aeric Albaquults.—These soils are not known to occur in significant areas in the United States, but the subgroup is provided for use if needed. Either they have the colors that are definitive for the suborder on ped faces but not in the ped interiors or they have an ochric epipedon that has higher chroma or a redder hue, or both.

Fragiaquults

These are the Aquults that have a fragipan. Normally the fragipan lies below the argillic horizon, but in a few it may be in the lower part of the argillic horizon. The fragipan in some Fragiaquults is virtually identical to the one in Alfisols, Inceptisols, and Spodosols. In some of these soils, however, there is one aberrant feature, a small amount of plinthite. At this stage of knowledge it is not certain that the fragipan that has plinthite is the same as the others. The behavior, however, is the same. For the present, for except for *b* and *c* and have lenticular platy structure in the fragipan.

Description of subgroups

Typic Fragiaquults.—The central concept or typic subgroup of Fragiaquults is fixed on soils that are gray and mottled in all horizons below the A1 or Ap horizon and that have little or no plinthite in the fragipan. The epipedon is ochric, and there is normally an albic horizon above the argillic horizon. The fragipan lies below at least part of the argillic horizon.

The presence of a small amount of plinthite is considered abnormal and is used to define plinthic subgroups. Chroma of 3 or more in some subhorizon above the fragipan suggests somewhat better drainage than that of Typic Fragiaquults and defines the aeric subgroup. If plinthite is also present, the combination defines the plinthudic subgroup.

Aeric Fragiaquults.—These soils have dominant chroma of 3 or more in some horizon between the A1 or Ap horizon and the fragipan. Otherwise, they resemble soils of the typic subgroup. They are on nearly level terraces in the central part of eastern United States but are not extensive. They are used mainly for cropland and pasture.

Plinthic Fragiaquults.—These soils have plinthite in the fragipan that constitutes between 5 and 50 percent of the matrix. Usually the amount of plinthite is between 5 and 15 percent. The fragipan commonly is

c. Have <5 percent plinthite (by volume) in all horizons within 1.5 m of the soil surface; and
d. Have an ochric epipedon.

Aeric Paleaquults are like Typic Paleaquults except for *a*.

Arenic Paleaquults are like Typic Paleaquults except for *b*, and they have a sandy particle-size class to a depth between 50 cm and 1 m.

Arenic Plinthic Paleaquults are like Typic Palea-

Arenic Umbric Paleaquults.—These soils have an umbric epipedon and their particle-size class is sandy to a depth between 50 cm and 1 m, although the umbric epipedon is not necessarily that thick. These soils are wetter than Typic Paleaquults and formed in somewhat sandier parent materials. Most of them in the United States are in forests. They are not extensive. They were considered Humic-Gley soils in the 1938 classification as modified in 1949.

CEC of >24 meq per 100 g clay (by NH_4OAc) and have a cation-retention capacity from unbuffered 1*N* NH_4Cl of >12 meq per 100 g clay in the major part

Umbraquults

These are the dark colored Aquults of midlatitudes.

in terms of the carbon content of the whole soil or of the argillic horizon. The vegetation of these soils in midlatitudes was mostly coniferous forest and at low latitudes, rain forest.

Definition

Humults are the Ultisols that are never saturated with water or that have a redder hue or higher chroma than Aquults and that either

1. Have 0.9 percent or more organic carbon in the upper 15 cm of the argillic horizon; or
2. Have 12 kg or more organic carbon in a unit volume of 1 square meter to a depth of 1 m exclusive of any O horizon; or both.

Key to great groups

FBA. Humults that have a sombric horizon within 1 m of the soil surface.

Sombrihumults, p. 358

FBB. Other Humults that have an argillic horizon that has <10 percent weatherable minerals in the 20- to 200-micron fraction in the upper 50 cm and has a clay distribution such that the percentage of clay does not decrease from its maximum amount by >20 percent of that maximum within 1.5 m of the soil surface, or the layer in which the percentage of clay is less than the maximum shows skeletans on ped faces or has 5 percent or

3. Have either or both of the following characteristics:
   a. Clay distribution with depth such that the percentage of clay decreases from its maximum amount by more than 20 percent of that maximum within 1.5 m of the soil surface, and the layer in which the percentage of clay is less than the maximum does not have evidences of clay eluviation in the form of skeletans on ped faces and has <5 percent plinthite by volume; or
   b. Ten percent or more weatherable minerals in the 20- to 200-micron fraction of the upper 50 cm of the argillic horizon;
4. Do not have a sombric horizon within 1 m of the soil surface; and
5. Do not have plinthite that forms a continuous phase or constitutes more than half the volume of some subhorizon within 1.25 m of the soil surface.

Pedon 115 illustrates the concept of Haplohumults but is not a Typic Haplohumult because the moisture regime is xeric. The chroma of the epipedon is higher than that of most Typic Haplohumults.

Distinctions between Typic Haplohumults and other subgroups

Typic Haplohumults are the Haplohumults that

ground water are properties shared with Aquults and define the aquic subgroup. A xeric moisture regime is considered abnormal but is highly significant to soil-plant relations and defines the xeric subgroup. A shallow lithic contact is the basis for definition of the lithic subgroup, a convention used throughout the taxonomy. A recent surface mantle that was derived from pyroclastic materials and has evidences of allophane is a property shared with Andepts and defines the andeptic subgroup.

Typic Haplohumults have gentle to strong slopes. They are moderately extensive in western Washington and Oregon in the United States. Where slopes are suitable, the soils are commonly cultivated, but most of them are in forests. Nearly all have an umbric epipedon if they are not eroded.

Andeptic Haplohumults.—Soils in this subgroup have a surface mantle that has low bulk density and have some amorphous clay in at least some part of the upper 75 cm of the soil. They formed in materials rich in pyroclastic materials. Their slopes range from gentle to steep. These soils are used for timber production, but they are rare in the United States and occur only in small areas in the western part of the state of Washington.

Aquic Haplohumults.—These soils have mottles of low chroma, and the level of ground water fluctuates in the mottled horizons or the soils have artificial drainage. They developed mostly in sediments derived largely from basic rocks. They are not extensive in the United States. Many of them are used for production of hay or are pastured.

Xeric Haplohumults.—These soils have a xeric moisture regime but are otherwise like Typic Haplohumults in defined properties. Most of them have an ochric epipedon despite the high content of organic carbon. The color of the epipedon is dark, but the chroma is too high for an umbric epipedon. Slopes of these soils in the United States are moderate to strong, and few of the soils are cultivated. They are moderately extensive in California, Oregon, and Washington.

Palehumults

These are the reddish Humults of old stable surfaces. They have a thick argillic horizon and have few weatherable minerals in the 20- to 200-micron fraction. They are known to occur in California and Puerto Rico but have only minor extent. Like other Humults of the United States, their parent materials are basic rocks or alluvium from basic rocks. All those soils have had and many still have a forest vegetation. They were considered Reddish-Brown Lateritic or Yellowish-Brown Lateritic soils in the 1938 classification.

Because there are few Palehumults in the United States, the classification that follows is incomplete and provisional.

Definition

Palehumults are the Humults that

1. Have an argillic horizon that in its upper 50 cm has <10 percent weatherable minerals in the 20- to 200-micron fraction;
2. Have clay distribution such that the percentage of clay does not decrease from its maximum amount by >20 percent of that maximum within 1.5 m of the soil surface, or the layer in which the percentage of clay is less than the maximum has skeletans on ped surfaces or has 5 percent or more plinthite by volume;
3. Do not have a sombric horizon within 1 m of the soil surface; and
4. Do not have plinthite that forms a continuous phase or that constitutes more than half the volume of any subhorizon within 1.25 m of the soil surface.

Description of a Typic Palehumult

A description of a Palehumult [illegible] rthwestern Puerto Rico [illegible] concept or typic subgrou [illegible] sed to produce sugarca [illegible] ng coastal plain below a [illegible] drock. The mean annual [illegible] n, and the mean annual [illegible] The colors are those of the [illegible]

Call Joe Nichols concerning Palehumults in Puerto Rico — Do not use this pedon

Ap 0–18 cm. D[illegible] [illegible]; moderate medium [illegible]), slightly sticky ar[illegible] many fine quartz g[illegible] pt smooth boundary.

B21t 18–38 cm. [illegible] derate fine and medi[illegible] n (moist), slightly s[illegible] fine roots; thin patch[illegible] ins; very strongly a[illegible]

B22t 38–58 cm. Y[illegible] fine and medium s[illegible] (moist), slightly st[illegible] ots; thin patchy clay[illegible] common root channe[illegible] oundary.

B23t 58–92 cm. Ye[illegible] fine subangular blo[illegible] granules; friable (moist), slightly sticky and plastic (wet); few fine roots; common fine quartz grains; common root channels; very strongly acid; clear wavy boundary.

B3 92–150 cm. Red (2.5YR 4/8) clay; weak fine subangular blocky structure, shiny ped surfaces; firm (moist), slightly sticky and plastic (wet); few fine roots; many fine quartz grains; very strongly acid.

Distinctions between Typic Palehumults and other subgroups

Typic Palehumults are the Palehumults that

a. Have >24 meq CEC per 100 g clay (by NH_4OAc) and have a cation-retention capacity from unbuffered 1*N* NH_4Cl of >12 meq per 100 g clay in the major part of the argillic horizon;

b. Do not have the following combination of characteristics in the upper 25 cm or more of the argillic horizon:

(1) Mottles that have a color value, moist, of 4 or more, and chroma, moist, of 2 or less accompanied by mottles of higher chroma that are due to segregation of iron; and

(2) Saturation with water in the mottled zone at some time of year when the soil temperature in that zone is 5° C or more or artificial drainage;

c. Have a udic moisture regime;

d. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has a bulk density (at 1/3-bar water

tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

e. Have <5 percent plinthite (by volume) in all horizons within 1.5 m of the soil surface; and

f. Have, in all parts of the soil above a depth of 75 cm, a hue redder than 10YR and a color value, moist, of 4 or more if there are mottles of high chroma within this depth and if the hue becomes redder with depth within 1 m of the soil surface.

Epiaquic Palehumults are like Typic Palehumults except for *f*.

Orthoxic Palehumults are like Typic Palehumults except for *a*.

Plinthic Palehumults are like Typic Palehumults except for *e*.

Ustic Palehumults are like Typic Palehumults except for *c* and have an ustic moisture regime.

Xeric Palehumults are like Typic Palehumults except for *c* and have a xeric moisture regime.

Description of subgroups

Typic Palehumults.—The central concept or typic subgroup of Palehumults is fixed on freely drained soils that have a udic moisture regime, have clay that has at least moderate activity, and do not have a recent surface mantle that is derived from pyroclastic materials and that has evidences of allophane. These soils are rare in Puerto Rico and are not known to occur in Hawaii.

Epiaquic Palehumults.—These soils have yellowish brown, olive brown, or gray colors in the upper horizons and have redder mottles inside the peds. The hue becomes redder with depth, but the reducing influence is too mild to produce mottles of low chroma. These soils occur in the areas of high rainfall in Puerto Rico but are not extensive there.

Orthoxic Palehumults.—These soils have clay that has low activity, but they are otherwise like Typic Palehumults in defined properties. They have short pe-

sive even locally in the United States. Their slopes are gentle to moderate.

Plinthohumults

These are the Humults that have plinthite that forms a continuous phase or that constitutes more than half the volume of some subhorizon within 1.25 m of the soil surface. They are not known to occur in the United States, but the great group has been proposed for other countries (Sys 1969). Subgroups have not been developed.

Sombrihumults

These are the Humults that have a sombric horizon whose upper boundary is within 1 m of the soil surface. They are not known to occur in the United States, but the great group is provided for use elsewhere. Humoxic and orthoxic subgroups have been proposed (Sys 1969) for the soils that have low CEC, that is, <24 meq per 100 g clay. The humoxic subgroup is proposed for soils that have an isothermic or cooler temperature regime and the orthoxic subgroup for soils that have an isohyperthermic temperature regime.

Tropohumults

These are the Humults, mainly of intertropical regions,[2] that have a thin argillic horizon. Most of them have an ochric epipedon over a reddish or red argillic horizon, but the content of organic carbon is relatively high. Their slopes commonly are strong, and in the soils that have been cultivated, the argillic horizon may be at the surface. The Tropohumults that formed from basic rocks are highly productive if the rocks are close enough to the surface to be an effective source of bases, and these soils generally are cultivated.

The native vegetation of the Tropohumults is or was mainly rain forest. Trees of a wide variety grow on these soils in one part of the world or another, and commonly there is a wide variety in one locality.

The Tropohumults are moderately extensive in Puerto Rico and Hawaii. They were mostly included with Reddish Brown Lateritic soils in the 1938 classi-

and the layer in which the percentage of clay is less than the maximum does not have evidences of clay eluviation in the form of skeletans on ped faces and has <5 percent plinthite by volume;

b. An argillic horizon that has 10 percent or more weatherable minerals in the 20- to 200-micron fraction of the soil to a depth of 50 cm;

3. Do not have a fragipan;
4. Do not have a sombric horizon within 1 m of the soil surface; and
5. Do not have plinthite that forms a continuous phase or constitutes more than half the volume of some subhorizon within 1.25 m of the soil surface.

Pedon 116 is an example of a soil that represents the central concept or typic subgroup of Tropohumults.

Distinctions between Typic Tropohumults and other subgroups

Typic Tropohumults are the Tropohumults that

a. Have CEC of >24 meq per 100 g clay (by NH_4OAc) and have a cation-retention capacity from unbuffered 1*N* NH_4Cl of >12 meq per 100 g clay in the major part of the argillic horizon;

b. Do not have the following combination of characteristics within 75 cm of the soil surface:

(1) Mottles that have a color value, moist, of 4 or more and chroma, moist, of 2 or less and also mottles of higher chroma that are due to segregation of iron; and

(2) Saturation with water in the mottled zone at some time of year when the soil temperature in that zone is 5° C or higher or there is artificial drainage;

c. Do not have a lithic contact within 50 cm of the mineral soil surface;

d. Do not have interruptions of the argillic horizon by ledges of bedrock within each pedon;

e. Do not have an epipedon as thick as 50 cm if the particle-size class is sandy throughout;

f. Have a udic moisture regime;

g. Do not have a layer in the upper 75 cm that has texture finer than loamy fine sand, that is as much as 18 cm thick, that has bulk density (at 1/3-bar water tension) of 0.95 g per cubic centimeter or less in the fine-earth fraction, and that has either of the following:

(1) A ratio of measured clay to 15-bar water (percentages) of 1.25 or less; or

(2) A ratio of CEC (at pH near 8) to 15-bar water of >1.5 and more exchange acidity than the sum of bases plus KCl-extractable aluminum;

h. Have a hue redder than 10YR in all parts of the soil above a depth of 75 cm that have a color value, moist, of 4 or more if there are mottles of high chroma above that depth and if the hue becomes redder with depth within 1 m of the soil surface; and

i. Do not have an anthropic epipedon.

Anthropic Tropohumults are like Typic Tropohumults except for *i*.

Aquic Tropohumults are like Typic Tropohumults except for *b* or for *b* and *h*.

Arenic Tropohumults are like Typic Tropohumults except for *e*. They have a sandy epipedon that is 50 cm to 1 m thick, and the upper boundary of the argillic horizon is within 1 m of the soil surface.

Epiaquic Tropohumults are like Typic Tropohumults except for *h*.

Epiaquic Orthoxic Tropohumults are like Typic Tropohumults except for *a* and *h*, and the soils are dry in some horizon in the moisture control section in most years but are not dry for 60 consecutive days or more.

Humoxic Tropohumults are like Typic Tropohumults except for *a*, and the soils are never dry in any part of the moisture control section in most years.

Orthoxic Tropohumults are like Typic Tropohumults except for *a*, and the soils are dry in some horizon in the moisture control section in most years but are not dry for 60 consecutive days or more.

Ustic Tropohumults are like Typic Tropohumults except for *f* and have an ustic moisture regime.

Ustoxic Tropohumults are like Typic Tropohumults except for *a* and *f* and have an ustic moisture regime.

Description of subgroups

Typic Tropohumults.—The central concept or typic subgroup of Tropohumults is fixed on freely drained soils that have well-distributed rainfall, that have at least a moderately active clay fraction, that are at least moderately deep to rock, and that do not have a thick, sandy epipedon or a surface mantle that is influenced by pyroclastic materials.

Mottles of low chroma within 75 cm of the soil surface and ground water in the mottled horizon at some time of year are properties shared with Aquults and are the basis for definition of the aquic subgroup. A yellowish brown or olive hue in the upper part of the soil accompanied by mottles of high chroma and by a redder hue in the deeper layers are evidences of seasonal saturation of the surface horizons with water, producing mild reducing conditions, and are used to define epiaquic subgroups.

Low activity of clay is evidence of strong mineral weathering, suggesting development toward the Oxisols, and defines the oxic subgroups. A shallow lithic contact causes soils to be excluded from the typic subgroup as is done throughout the taxonomy. Soils that have a thick sandy epipedon are also excluded as a convention of the taxonomy.

Anthropic Tropohumults.—These soils have an epipedon that resembles an anthropic epipedon. They are not known to occur in the United States, but the subgroup has been requested for use in other countries. The subgroup cannot be precisely defined with our present knowledge.

Aquic Tropohumults.—These soils are artificially drained or have ground water that fluctuates in the deep layers of the soil and have some mottles of low chroma in the saturated zone. Most of them have yellowish brown upper horizons and redder horizons at a greater depth. These soils have relatively gentle slopes or have very high rainfall. They occur in Puerto Rico but are not extensive there.

Arenic Tropohumults.—These soils have a sandy particle-size class to a depth between 50 cm and 1 m but are otherwise like Typic Tropohumults in defined properties. They are not known to occur in the United

States, but the subgroup is provided for use where needed.

Epiaquic Tropohumults.—Soils in this subgroup have some yellowish brown or olive brown colors in the upper horizons and have redder mottles inside the peds. The hue becomes redder with depth. The rainfall is seasonally high, and the upper horizons become saturated. The reducing conditions are commonly but not everywhere too mild to produce mottles of low chroma, but the hue in the upper horizons approaches that of Aquults. These soils are in the areas of high rainfall in Puerto Rico but are not extensive. Their

cropped for a very few years and then are returned to forest to allow the trees to regather in their tissues the small supply of nutrients. Most of these soils have or had a forest vegetation, but some have a savanna that probably is anthropic. The moisture regime is udic. The soil temperature regime is mesic, isomesic, or warmer.

Definition

Udults are the Ultisols that

1 Are never saturated with water or have a redder

Definition

Fragiudults are the Udults that have a fragipan in or below the argillic horizon.

Pedon 117 illustrates the central concept or Typic subgroup of Fragiudults.

Distinctions between Typic Fragiudults and other subgroups

Typic Fragiudults are the Fragiudults that

a. Meet these two requirements:

(1) Have an argillic horizon above the fragipan that has some clay skins on both vertical and horizontal surfaces of some structural aggregates; and

(2) Do not have an intervening horizon (one or more) between the argillic horizon and the fragipan that has dominant chroma of 3 or less and that has as much as 3 percent less clay (absolute) than both the overlying argillic horizon and the underlying fragipan;

b. Do not have the following combination of characteristics in the upper 25 cm of the argillic horizon and

Plinthaquic Fragiudults are like Typic Fragiudults except for *a*, *b*, and *d*, have lenticular platy structure in the fragipan, and have between the A1 or Ap horizon and the fragipan a horizon or horizons that (1) have dominant chroma of 3 or more in the matrix and (2) have mottles that have chroma of 2 or less within 40 cm of the soil surface.

Plinthic Fragiudults are like Typic Fragiudults except for *a* and *d*, have lenticular platy structure in the fragipan, and have between the soil surface and the fragipan a horizon or horizons that (1) have dominant chroma of 3 or more in the matrix and (2) do not have mottles that have chroma of 2 or less within 40 cm of the soil surface accompanied by mottles that have high chroma and reddish hue and are due to the segregation of iron.

Description of subgroups

Typic Fragiudults.—The central concept or typic subgroup of Fragiudults is fixed on soils that have an argillic horizon that has clay skins and is underlain by a fragipan without an intervening eluvial horizon,

like Typic Fragiudults in defined properties, but they tend to have more sand and less silt and clay throughout. These soils are rare in the United States, occurring only on the coastal plains in the southern states. Their slopes are gentle, and most of the soils are in forests. Because of low productivity for crops, most areas of these soils that were once cleared have been allowed to return to forest.

Glossaquic Fragiudults.—Soils in this subgroup have mottles of low chroma at shallow depth, and also have ground water in the mottled horizon at some time of year or have been artificially drained. Also there are few or no clay skins above the fragipan or there is an eluvial horizon at the top of the fragipan, or both, usually both. These soils were mostly considered Planosols in the 1938 classification. Those in the United States are mostly in forests, but some areas have been cleared and are cultivated. Most of these soils have a thermic soil temperature regime.

Glossic Fragiudults.—These soils have few or no clay skins in the horizons above the fragipan or they have an eluvial horizon at the top of the fragipan, or both. Most of them have both. They are otherwise like Typic Fragiudults in defined properties and in other properties. They are moderately extensive in the areas adjoining the lower Mississippi Valley. Many of these soils are cultivated, but large areas are used for forestry. These soils were mostly considered Red-Yellow Podzolic soils in the 1938 classification as modified in 1949.

Plinthaquic Fragiudults.—These soils have plinthite in the fragipan, have mottles of low chroma at shallow depth, and have either fluctuating ground water in the mottled zone or artificial drainage. Very few of these soils, however, have artificial drainage. These soils do not have an argillic horizon above the fragipan, but commonly they have an eluvial horizon at the top of the pan, and commonly they have many ironstone pebbles. They are otherwise like Typic Fragiudults in defined properties, but the fragipan tends to be harder and has a lenticular platy structure and there are few weatherable minerals. These soils occur in the United States only on the coastal plains in the southern states, and there they are extensive only locally. They were considered Red-Yellow Podzolic soils in the 1938 classification as modified in 1949.

Plinthic Fragiudults.—These soils have a small amount of plinthite in the fragipan and do not have an argillic horizon above it. Rather, there is an eluvial horizon above the pan, and commonly it contains many ironstone pebbles. The pan commonly is harder than in the typic soils and has a lenticular platy structure and contains fewer weatherable minerals. These soils occur in the United States only on the coastal plains in the southern states, and they are not extensive there except locally. They were considered Red-Yellow Podzolic soils in the 1938 classification as modified in 1949. Some are cultivated and some are used for forestry and pasture.

Hapludults

These are the Udults that have an ochric epipedon and a thin or moderately thick argillic horizon. They do not have a fragipan, and they have little or no plinthite, usually none. The color of the argillic horizon normally is strong brown or yellowish red. Most of these soils formed from acid rocks or sediments on surfaces that are of Pleistocene age, probably Illinoian and Wisconsinan. Where the soil is not cultivated, the vegetation is almost exclusively forest, either hardwood trees or conifers.

The Hapludults in the United States are extensive in the southeastern states, in the Middle Atlantic states, and on the coastal plains along the Gulf of Mexico in the southern states west of the Mississippi River. Their slopes generally are moderate to strong, but a few of these soils on the lowest coastal plain are nearly level.

The Hapludults were mostly considered Red-Yellow Podzolic soils in the 1938 classification as modified in 1949 where the soil temperature regime is thermic or warmer, and were considered Gray-Brown Podzolic soils where the soil temperature regime is mesic. Some were included with Lithosols, Regosols, and Planosols in the 1938 classification or the 1949 revision.

Definition

Hapludults are the Udults that

1. Do not have a fragipan;
2. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix in any subhorizon within 1.25 m of the soil surface;
3. Have a color value, moist, of 4 or more in some part of the epipedon or have an argillic horizon that has a color value, dry, of 5 or more in some subhorizon or has a color value, moist, of 4 or more;
4. Have mean summer and mean winter soil temperatures at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower, that differ by 5° C or more; and
5. Have ~~either or both of the following characteristics:~~
   a. Clay distribution with depth such that the percentage of clay decreases from its maximum amount by >20 percent of that maximum within 1.5 m of the soil surface~~, and the layer in~~ which ~~the percentage of clay is less than the maximum does not have evidences of clay eluviation in the form of skeletans on ped surfaces and has <5 percent plinthite by volume; or~~
   ~~b. Have 10 percent or more weatherable minerals in the 20- to 200-micron fraction of the upper~~ 50 ~~cm of the argillic horizon~~.

Pedon 118 illustrates the central concept or typic subgroup of Hapludults.

Distinctions between Typic Hapludults and other subgroups

Typic Hapludults are the Hapludults that

a. Do not have the following combination of characteristics in the upper 60 cm of the argillic horizon:
   (1) Mottles that have a color value, moist, of 4 or more and chroma, moist, of 2 or less, and also mottles of higher chroma that are due to segregation of iron; and
   (2) Saturation with water in the mottled zone at some time of year when the soil temperature in

that zone is 5° C or higher, or artificial drainage;

b. Do not have an epipedon as thick as 50 cm if the particle-size class is sandy throughout;

c. Have an argillic horizon >25 cm thick;

d. Have an Ap horizon that has a color value, moist, of 4 or more or has a value, dry, of 6 or more when crushed and smoothed; or the A1 horizon is <15 cm

A thick sandy epipedon defines the arenic subgroup, a convention used elsewhere in the taxonomy. A shallow lithic contact defines lithic subgroups. An umbric epipedon is considered abnormal and indicates an intergrade to Humults. A thin argillic horizon is also considered abnormal and suggests that development is at an early stage. It is used to define the ochreptic subgroup. A sandy particle-size class and lamellae in

its that are rich in quartz. Their slopes are gentle to moderate. Many of the soils are cultivated.

Puntic Lithic Entic Haplydults. Soils in this sub-

Pedon 21 illustrates the Paleudults, but it is not a Typic Paleudult because it has some plinthite below a depth of 1 m. Pedon 21 is shown in plate 9D.

Fragiaquic Paleudults are like Typic Paleudults except for *a* and *g* or for *a*, *c*, and *g*.

Fragic Paleudults are like Typic Paleudults except for *g* or for *c* and *g*.

Grossarenic Paleudults are like Typic Paleudults except for *b* or for *a* and *b*, and they have a sandy epipedon that is between 1 and 2 m thick in half or more of each pedon.

Grossarenic Plinthic Paleudults are like Typic Paleudults except for *b* and *c* or for *b*, *c*, and *g*, and they have a sandy epipedon that is between 1 and 2 m thick in half or more of each pedon.

Plinthaquic Paleudults are like Typic Paleudults except for *a* and *c*.

Plinthic Paleudults are like Typic Paleudults except for *c*.

Psammaquentic Paleudults are like Typic Paleudults except for *a* and *e*, with or without *b*.

Psammentic Paleudults are like Typic Paleudults except for *e*.

Rhodic Paleudults are like Typic Paleudults except for *d*.

Spodic Paleudults are like Typic Paleudults except for *f*, with or without *a* or *b*, or both.

Description of subgroups

Typic Paleudults.—The central concept or typic subgroup of Paleudults is fixed on freely drained soils that have an ochric epipedon that is not both sandy and thick, that have little or no plinthite, and that have an argillic horizon that is loamy or clayey and is not composed of thin lamellae.

Mottles of low chroma at a moderately shallow depth accompanied by a fluctuating ground-water level are properties shared with Aquults and are the basis for defining aquic subgroups. A thick sandy epipedon is considered abnormal and is used to define arenic and grossarenic subgroups. An appreciable amount of plinthite is also considered abnormal and is used to define plinthic subgroups. A dark epipedon and a dark red argillic horizon are properties shared with Rhodudults and define rhodic subgroups. A sandy argillic horizon or one composed mostly of lamellae is used to define psammentic subgroups, a convention used throughout the taxonomy. It is admitted that a psammentic subgroup in a pale- great group seems contradictory, but the sands are primarily quartz, and Quartzipsamments can be very old soils on surfaces that are Pliocene or even older. The epipedon of Typic Paleudults usually includes an albic horizon that has particle-size class to a depth between 50 cm and 1 m. They also have ground water that fluctuates in depth or are artificially drained, and the zone in which the water stands or stood has mottles of low chroma within 75 cm of the soil surface or in the upper 12.5 cm of the argillic horizon. They are otherwise like Typic Paleudults in defined properties, but normally the argillic horizon has more sand and less clay than it does in the typic soils. These soils in the United States are mostly in sandy deposits on the coastal plain in the southeastern states, and they are not extensive even there. The soils are nearly level. Most of them are used for forestry.

Arenic Paleudults.—These soils have an epipedon that is between 50 cm and 1 m thick and has a sandy particle-size class, that is, the texture is sand or loamy sand. They are otherwise like Typic Paleudults in defined properties, but the argillic horizon tends to have more sand and less clay than the one in the typic soils. A few of these soils that formed in stratified marine deposits have a clayey argillic horizon. These soils occur in the United States only on the coastal plain in the Middle Atlantic and southern states, where they are locally extensive. Most of them are used either for production of crops or for pasture.

Arenic Plinthaquic Paleudults.—Soils in this subgroup have an epipedon that is between 50 cm and 1 m thick and has a sandy particle-size class, that is, the texture is sand or loamy sand. They also have a small or moderate amount of plinthite in the argillic horizon, and the ground water fluctuates at some depth within the epipedon but is sometimes above the argillic horizon. The subhorizons that have plinthite normally restrict movement of water, and a perched water table may exist for short periods. These soils are known to occur only on the southern coastal plains in the United States, and they are rare. Their slopes are very gentle, and many of the soils are cultivated or in pasture.

Arenic Plinthic Paleudults.—These soils have some plinthite in the argillic horizon and have an epipedon that is between 50 cm and 1 m thick and has a sandy particle-size class, that is, the texture is sand or loamy sand. They are otherwise like Typic Paleudults in defined properties, but they differ from the typic soils in several respects. The argillic horizon has more sand and less clay than the one in the typic soils, the subhorizons that have plinthite normally slow the movement of water, and a perched water table may exist for short periods. Slopes are gentle. These soils are

ever, if other things are equal, to have a little more organic matter than the soils of other comparable subgroups.

These soils occur on the coastal plains of Puerto Rico and states of the United States. They are locally extensive in a few of the southern states. A large part of the acreage has been cleared and is being cultivated or pastured.

Fragiaquic Paleudults.—These soils have a moisture regime that borders on being aquic and a subhorizon of the argillic horizon that is within 1.25 m of the soil surface, which has the properties of a fragipan in 40 to 60 percent of the volume. The amount of plinthite in any subhorizon is not restricted. The soils are moderately extensive in southern United States. Most of them support forests, but some are cleared and are cultivated or used for grazing.

Fragic Paleudults.—These soils have a subhorizon of the argillic horizon that is within 1.25 m of the soil surface and has the properties of a fragipan in 40 to 60 percent of the volume. The amount of plinthite

Plinthic Paleudults.—Soils in this subgroup (plate 9D) have a small or moderate amount of plinthite in the argillic horizon but are otherwise like Typic Paleudults in defined properties. The subhorizons that have plinthite tend to slow the movement of water, and there may be perched ground water above the plinthite for short periods.

These soils formed on the coastal plains in the southern states of the United States. Their slopes are mostly gentle, but few of the soils are cultivated. They are used for forestry or grazing. They are moderately extensive soils locally.

Psammaquentic Paleudults.—These soils have an argillic horizon that has a sandy particle-size class, that is, the texture is sand or loamy sand. They also have ground water that fluctuates in depth unless the soil is artificially drained, and the zone in which the water stands or stood has mottles of low chroma. The mottles are within 75 cm of the surface or are in the upper 12.5 cm of the argillic horizon. These soils consist mostly of quartz sand and some kaolin. Those in

horizon. They are mainly in intertropical regions, and in some places they may be extensive. They are not known to occur in the United States, and the classification has not been developed.

Definition

Plinthudults are the Udults that have plinthite that forms a continuous phase or constitutes more than half the matrix of some subhorizon in the upper 1.25

b. Have texture finer than loamy fine sand in some part of the argillic horizon; and

c. Do not have a lithic contact within 50 cm of the soil surface.

Typic Rhodudults are the only Rhodudults that are extensive enough in the United States that series of them have been established. The Rhodudults are remarkably similar for the soils of a great group. The only features that cause exclusions from the typic

Rhodudults

These are freely drained Udults of mid to low latitudes that have dark color values throughout all horizons. Most of them have a thin or moderately thick, dark red or dusky red argillic horizon or have an appreciable amount of weatherable minerals, or both. A few have a dark brown or dark reddish brown argillic horizon. These soils formed under forests from basic rocks or sediments. As a consequence, they tend to have more total phosphorus than most other Udults.

subgroup probably reflects the nature of the underlying rock, which seems to preclude the presence of shallow ground water.

Typic Rhodudults are moderately extensive throughout the southern states wherever the rocks are basic. Most of them are cultivated.

Tropudults

These are the more or less freely drained Udults

1.5 m of the soil surface, and the layer in which the percentage of clay is less than the maximum does not have evidences of clay eluviation in the form of skeletans on ped surfaces and does not

chroma within that depth and if the hue becomes redder with depth within 1 m of the soil surface; and

k. Do not have a petroferric contact within 1 m of the soil surface.

have as much as 5 percent plinthite by volume; or

b. An argillic horizon that has 10 percent or more weatherable minerals in the 20-to 200-micron fraction of its upper 50 cm; and

5. Have an epipedon that has a color value, moist, of 4 or more in some subhorizon or have an argillic horizon that has a color value, dry, of 5 or more in some subhorizon or a color value, moist, of 4 or more.

Pedon 120 is an example of the central concept or typic subgroup of Tropudults.

Distinctions between Typic Tropudults and

Aquic Tropudults are like Typic Tropudults except for *a*.

Arenic Orthoxic Tropudults are like Typic Tropudults except for *b* and *d*, and they have a sandy epipedon that is 50 cm to 1 m thick.

Dystropeptic Tropudults are like Typic Tropudults except for *c*.

Epiaquic Tropudults are like Typic Tropudults except for *j*.

Orthoxic Tropudults are like Typic Tropudults except for *d*.

Petroferric Tropudults are like Typic Tropudults

of sand or loamy sand that is between 50 cm and 1 m thick. They are not known to occur in the United States, but the subgroup is provided for use elsewhere.

Dystropeptic Tropudults.—These soils have a thin argillic horizon but are otherwise like Typic Tropudults in defined properties. In Puerto Rico they are strongly or very strongly sloping, and the saprolite is shallow or moderately shallow, generally <75 cm below the soil surface. Many of them are cultivated despite their steep slopes.

Epiaquic Tropudults.—These soils have a yellowish brown or olive brown hue in the upper horizons, commonly on ped faces only, and have redder mottles inside the peds. The hue becomes redder with depth. Slopes of these soils range from gentle to strong, but the rainfall is seasonally high and the upper horizons become saturated. Reducing conditions in the soil are commonly too mild to produce mottles of low chroma, but the hue in the upper horizons approaches that of Aquults. These soils occur in the high-rainfall areas in Puerto Rico, but they are not extensive. Their slopes are mostly strong, and the soils are mostly cultivated.

Orthoxic Tropudults.—Soils in this subgroup have a strongly weathered clay fraction and moderately low or low CEC. These soils in Puerto Rico are mostly strongly to very strongly sloping. Many are used to produce coffee grown under shade.

Petroferric Tropudults.—These soils have a petroferric contact within 1 m of the soil surface. They are not known to occur in the United States, but the subgroup is provided for use elsewhere.

Plinthaquic Tropudults.—These soils have ground water that fluctuates in depth or are artificially drained, and the horizons that are or were saturated have mottles of low chroma. These soils also have a small or moderate amount of plinthite in or below the argillic horizon. They occupy small areas in Puerto Rico but are not known to occur in Hawaii.

Plinthic Tropudults.—These soils have a small or moderate amount of plinthite in or below the argillic horizon but are otherwise like Typic Tropudults in defined properties. It seems probable, however, that they have or have had fluctuating ground water or perched ground water present in the soil. They are not known to occur in the United States, but the subgroup is provided for use elsewhere.

Vertic Tropudults.—Soils in this subgroup have a clayey argillic horizon that has a high COLE, and there are deep wide cracks in the argillic horizon at some time of year in most years. The clay fraction tends to have higher activity than that in most of the Typic Tropudults. The fine texture and high COLE restrict the drainage of many of these soils, and there may be mottles of low chroma at shallow depth or the upper horizons may be mottled and yellowish brown and the lower horizons redder. These soils occur in Puerto Rico but are not extensive. Their slopes range from gentle to strong. Where slopes are suitable, most of the soils are cultivated.

pronounced dry season. They may have a single dry season each year, as in the areas of monsoon climate, or they may have two dry and two rainy seasons. They have little organic carbon. Most of them are reddish, but some in regions of high rainfall may be yellowish brown in the surface horizons and redder in the deeper layers.

The Ustults have mostly an ochric epipedon that rests on an argillic horizon, which may or may not contain plinthite. In some parts of the world, a shallow petroferric contact is thought to be common. The Ustults mostly have a thermic, isothermic, or warmer soil temperature regime and have an ustic soil moisture regime.

The vegetation is commonly a deciduous forest or a savanna that probably is anthropic. Because there are very few Ustults in the United States or in Puerto Rico, the classification that follows is incomplete and provisional.

Definition

Ustults are the Ultisols that

1. Are never saturated with water or have a redder hue or stronger chroma than Aquults;
2. Have an ustic moisture regime;
3. Have <0.9 percent organic carbon in the upper 15 cm of the argillic horizon exclusive of any Ap horizon; and
4. Have <12 kg organic carbon in a unit volume of 1 m^2 to a depth of 1 m below the base of any O horizon or the mineral soil surface.

Key to great groups

FDA. Ustults that have plinthite that forms a continuous phase or constitutes more than half the volume in some subhorizon within 1.25 m of the soil surface.

Plinthustults, p. 371

FDB. Other Ustults that have an argillic horizon that has <10 percent weatherable minerals in the 20- to 200-micron fraction in its upper 50 cm and have a clay distribution with depth such that the percentage of clay does not decrease from its maximum amount by >20 percent of that maximum within 1.5 m of the soil surface, or the layer in which the percentage of clay is less than the maximum has skeletans on ped faces or has 5 percent or more plinthite by volume.

Paleustults, p. 371

FDC. Other Ustults that have:
1. An epipedon that has a color value, moist, less than 4 in all parts; and
2. An argillic horizon that has a color value, dry, less than 5 and not more than 1 unit higher than the value, moist.

Rhodustults, p. 371

FDD. Other Ustults.

Haplustults, p. 369

Haplustults

These are the Ustults that have a thin or moderately thick argillic horizon. ~~or have 10 percent or more~~

gillic horizon. Probably most of these soils formed in sediments or on surfaces that are Illinoian or Wisconsinan in age. Their slopes range from gentle to very strong. Many of the soils are farmed in shifting cultivation.

The Haplustults are rare in Puerto Rico and in Hawaii, but they are extensive in some parts of the world. Many were considered Red-Yellow Podzolic soils in the 1938 classification and in the 1949 revision.

Definition

Haplustults are the Ustults that [illegible]

within 1 m of the soil surface;

f. Do not have a petroferric contact within 1 m of the soil surface;

g. Do not have a horizon within 1.5 m of the soil surface that has ≥ 5 percent plinthite by volume;

h. Have CEC >24 meq per 100 g clay (by NH_4OAc) and have a cation-retention capacity from NH_4Cl of >12 meq per 100 g clay in the major part of the argillic horizon (cation-retention capacity is defined in ch. 3 under the oxic horizon); and

i. Do not have an epipedon as thick as 50 cm if its particle-size class is sandy throughout.

Aquic Haplustults are like Typic Haplustults except [illegible]

Epiaquic Haplustults.—These soils have yellowish brown or olive brown colors in the upper horizons, commonly on ped faces only, and have redder mottles inside the peds. The hue becomes redder with depth. These soils are not known to occur in the United States or in Puerto Rico, but the subgroup is provided for use elsewhere.

Lithic Haplustults.—These soils have a shallow lithic contact. They are not known to occur in the United States or in Puerto Rico, but the subgroup is provided for use elsewhere.

Oxic Haplustults.—Soils in this subgroup have a strongly weathered clay fraction that has moderately low or low CEC. They are otherwise like Typic Haplustults in defined properties, but they tend to have less extractable aluminum and a higher pH than the typic soils. These soils are rare in Puerto Rico and are not known to occur in Hawaii.

Petroferric Haplustults.—These soils have a petroferric contact within 1 m of the soil surface but are otherwise like Typic Haplustults in defined properties. They are not known to occur in the United States or in Puerto Rico, but the subgroup is provided for use

subhorizon within 1.25 m of the soil surface; and
3. Do not have a fragipan.

Plinthustults

These are the more or less freely drained Ustults that have a large amount of plinthite. Their slopes are mostly gentle or moderate. They are not known to occur in the United States or in Puerto Rico, but the great group is provided for use elsewhere.

Definitions of subgroups cannot be tested in the United States and are not being proposed here.

Definition

Plinthustults are the Ustults that have plinthite that forms a continuous phase or constitutes more than half the matrix within some subhorizon in the upper 1.25 m of the soil.

Rhodustults

These are freely drained Ustults that have mostly a dark red or dusky red argillic horizon and a dark col-

Plinthic Haplustults.—These soils have a moderate or small amount of plinthite in or below the argillic horizon but are otherwise like Typic Haplustults in defined properties. It seems probable, however, that they have or have had a fluctuating level of ground water or perched ground water, which is or was absent or is present for shorter periods in the typic soils. These soils are rare in Puerto Rico and are not known to occur in Hawaii.

Paleustults

ately thin or there is an appreciable amount of weatherable minerals. These soils have formed mainly from basic rocks, and as a consequence they tend to have more total phosphorus than most other Ustults.

Slopes of these soils range from gentle to steep. Most of the soils formed in sediments or on slopes of the later half of the Pleistocene, either Illinoian or Wisconsinan.

The Rhodustults are rare in the United States and in Puerto Rico, and their definition cannot be tested there. The definitions that follow are incomplete and provisional.

represent the central concept or typic subgroup follows. This soil is on Molokai Island in Hawaii and is used to grow pineapples. The mean annual precipitation of about 1,000 mm falls mainly from November to April. The mean annual air temperature is about 21° C. This soil has formed from andesite on a moderate slope. The Ap horizon includes a part of the argillic horizon. The colors given are those of the moist soil unless otherwise s tated.

Ap1 0–23 cm. Dark reddish brown (2.5YR 3/4) silty clay,[3] weak red (2.5YR 4/2) dry; moderate very fine, fine and medium granular structure; hard (dry), friable (moist), sticky and plastic (wet); few roots; moderately high bulk density; common hard earthy lumps that break down when rubbed; slight effervescence with hydrogen peroxide; strongly acid (pH 5.2); abrupt smooth boundary.

Ap2 23–38 cm. Dark reddish brown (2.5YR 3/5) silty clay, weak red (2.5YR 4/2) dry; weak fine, medium, and coarse subangular blocky structure; hard (dry), friable (moist), sticky and plastic (wet), few roots; many very fine and fine and few medium tubular pores; firm in place; moderately high bulk density; slight effervescence with hydrogen peroxide; strongly acid (pH 5.5); clear wavy boundary.

B21t 38–66 cm. Dark red (2.5YR 3/6) silty clay, red (2.5YR 4/6) dry; strong very fine and fine subangular blocky structure; very hard (dry), firm (moist), sticky, and plastic (wet); few roots; few very fine tubular pores; many hard earthy lumps that break down after prolonged rubbing; thin continuous clay skins; compact in place; upper part of this horizon has pockets that are slightly smeary, very friable, and have a color of dark reddish brown (2.5YR 3/4); slight effervescence with hydrogen peroxide; strongly acid (pH 5.4); gradual wavy boundary.

B22t 66–105 cm. Dark red (2.5YR 4/6 moist and dry) silty clay; strong very fine and fine subangular blocky structure; very hard (dry), firm (moist), sticky and plastic (wet); few roots; few very fine tubular pores; thin continuous clay skins on peds; many hard earthy lumps that break down after prolonged rubbing; slight effervescence with hydrogen peroxide; compact in place;

a. Have an argillic horizon that is continuous vertically and horizontally and has a hue redder than 5YR;
b. Have texture finer than loamy fine sand in some part of the argillic horizon; and
c. Do not have a lithic contact within 50 cm of the soil surface.

Xerults

These are more or less freely drained Ultisols of Mediterranean climates. They have a moderate or small amount of organic matter. They have an ochric epipedon that rests on a brownish to reddish argillic horizon. They are not extensive in the United States except locally in the Pacific states. Their slopes are mostly strong or very strong, mainly because most Xerults in the United States are in the mountains. Their vegetation was and is mostly a coniferous forest. Their soil temperature regime is thermic or mesic, and the soil moisture regime is xeric.

Definition

Xerults are the Ultisols that
1. Have a xeric soil moisture regime;
2. Have <0.9 percent organic carbon in the upper 15 cm of the argillic horizon exclusive of any Ap horizon;
3. Have <12 kg organic carbon in a unit volume of 1 m^2 to a depth of 1 m below the base of any O horizon or the mineral soil surface; and
4. Are never saturated with water or have a redder hue or higher chroma than Aquults.

Key to great groups

FEA. Xerults that have an argillic horizon that has <10 per-

phase or constitutes more than half the matrix in any horizon within 1.25 m of the soil surface;

3. Have a color value, moist, of 4 or more in some part of the epipedon or have an argillic horizon that has a color value, dry, of 5 or more in some subhorizon or a color value, moist, of 4 or more; and

4. Have either or both of the following characteris-

f. Do not have an epipedon as thick as 50 cm if its particle-size class is sandy throughout.

Ruptic-Lithic-Xerochreptic Haploxerults are like Typic Haploxerults except for *b* and *e*.

Description of subgroups

lines can be broken. The movement also affects the thickness of soil horizons. Thickness of a horizon can vary widely within a pedon. For example, a black A1 horizon may be only a few centimeters thick or may even be absent on the microknolls but may be >1 m thick in the microdepressions. The content of organic matter and the depth to carbonates or to a ca horizon may be equally variable.

In several of the other orders, intergrades to Verti-

areas of Vertisols are now under grass, savanna, or open forests.

Most Vertisols are well suited to mechanized farming if rainfall or the supply of irrigation water is ample. Irrigation presents special problems because hydraulic conductivity of the soils is very low except in the cracks. Many Vertisols were classified as Rendzina soils in the 1938 classification and as Regosols, Grumusols, and Alluvial soils after 1951.

3. At some depth between 25 cm and 1 m, wedge-shaped (sphenoid) structural aggregates whose long axes are tilted 10° to 60° from the horizontal.

Key to suborders

DA. Vertisols that have a thermic or mesic soil temperature regime and, unless irrigated, have cracks that open and close once each year and remain open for 60 consecutive days or more in the 90 days following the summer solstice in more than 7 out of 10 years but that are closed for 60 consecutive days or more during the 90 days following the winter solstice.

Xererts, p. 381

DB. Other Vertisols that, unless irrigated, have in most years cracks that either remain open throughout the year or are closed for less than 60 consecutive days at a period when the soil temperature at a depth of 50 cm is continuously higher than 8° C.

Torrerts, p. 377

DC. Other Vertisols that have cracks that open and close one or more times during the year in most years but do not remain open for as many as 90 cumulative days in most years.

Uderts, p. 377

DD. Other Vertisols.

Usterts, p. 379

Torrerts

Torrerts are the Vertisols of arid climates. Their cracks may stay open throughout the year in most years, although they may be partially or largely filled with a soil mulch if the soil is moved by wind or animals. These soils may have a short rainy season. If the cracks close as a result of rains during a warm season, they remain closed for less than 60 consecutive days in most years. Many of these soils in the United States formed in alluvium in closed depressions that are flooded once every few years by runoff from higher areas. In this situation, the soils may be flooded in occasional years for several months. Other Torrerts formed in old fine-textured alluvium or on basic parent materials. The Torrerts are extensive only locally in a few parts of the southwestern states of the United States. Their properties are so similar that no subdivisions seem warranted at the great group level. Because there is infrequent wetting, gilgai is commonly subdued or absent in these soils in the United States. The Torrerts were considered Rogosols. Al-

upper horizon that has a color value (moist) less than 4 is <30 cm thick; and

b. Do not have prismatic or blocky structure accompanied by clay skins on ped faces that have a color value lower than that in the matrix within 1 m of the soil surface.

Mollic Torrerts are like Typic Torrerts except for *a*.

Paleustollic Torrerts are like Typic Torrerts except for *a* and *b*.

Description of subgroups

Typic Torrerts.—The central concept or typic subgroup of Torrerts (and the great group that is its equivalent) is fixed on soils that have a relatively high color value, moist, and that do not have the characteristics of an argillic horizon within at least the upper meter.

A color value that is characteristic of a mollic epipedon is a feature of soils that receive more precipitation than Typic Torrerts and is the basis for definition of the mollic subgroups. If extra moisture is received by flooding of closed depressions, the standing water normally reduces rather than increases plant growth. Evidences within the soil of an argillic horizon suggest that an ancient soil, over time, developed such fine texture that the Vertisol formed in it.

The soils are not extensive in the United States. Some are irrigated, but many furnish only a small amount of grazing.

Mollic Torrerts.—These soils are like Typic Torrerts except that, after the surface soil to a depth of 18 cm has been mixed, the color value, moist, is closer to 3 than to 4 in more than half of each pedon, and the dark color extends to a depth of 30 cm or more. They are mostly soils that do not flood but have relatively higher precipitation than Typic Torrerts. They are not extensive in the United States. Most of them are used for grazing, and a few are irrigated.

Paleustollic Torrerts.—These soils are like Typic Torrerts except they have prismatic or blocky structure within 1 m of the surface and clay skins on ped faces that have a color value lower than that in the matrix of the peds. They are thought to have been Paleustolls that, over time. developed such fine texture that the Vertisol formed. They are not extensive in the United States. Their slopes are gentle, and the soils are used for grazing.

had an open or closed hardwood forest. The forested Uderts have a gray or dark gray surface horizon.

Definition

Uderts are the Vertisols that are usually moist in some part and have cracks that open and close one or more times during the year in most years. The cracks do not remain open for as many as 90 cumulative days in most years and do not remain open for as many as 60 consecutive days in the 90 days following the summer solstice in more than 7 out of 10 years unless the mean annual soil temperature is 22° C or higher or the mean winter and mean summer soil temperatures at a depth of 50 cm differ by <5 ° C. In some years the soils may not crack.

Key to great groups

DCA. Uderts that have a chroma, moist, of 1.5 or more dominant in the matrix of some subhorizon in the upper 30 cm in more than half of each pedon.

Chromuderts, p. 378

DCB. Other Uderts.

Pelluderts, p. 378

Chromuderts

These are the Uderts that have a readily visible color (in the technical sense, that is, other than black, gray, or white) in the matrix of some subhorizon that is in the upper 30 cm and is present in more than half of each pedon. Many of these soils are dominantly brownish throughout, but the hue may range from the olives to the reds. Mottles of low chroma in the lower horizons are normal because aeration is very poor when the cracks are closed. These soils have gentle slopes where water cannot stand. They were mostly considered Rendzina soils in the 1938 classification and Grumusols after 1951.

Definition

Chromuderts are the Uderts that have matrix colors that have a chroma, moist, of 1.5 or more dominant in some subhorizon in the upper 30 cm in more than half of each pedon.

Pedon 124 is an example of a common but not a Typic Chromudert.

Distinctions between Typic Chromuderts and other subgroups

Typic Chromuderts are the Chromuderts that

a. Do not have distinct or prominent mottles within 50 cm of the soil surface in more than half of each pedon (the terms refer to contrast, not to size of the mottles); and

b. Have a color value, moist, less than 3.5 and a value, dry, less than 5.5 throughout the upper 30 cm in more than half of each pedon.

Aquentic Chromuderts are like Typic Chromuderts except for *a* and *b*.

Aquic Chromuderts are like Typic Chromuderts except for *a*.

Entic Chromuderts are like Typic Chromuderts except for *b*.

Description of subgroups

Typic Chromuderts.—The central concept or typic subgroup of Chromuderts is not fixed on the most common soils but on the best-drained soils of the great group. None of the Chromuderts is really freely drained. Mottles are very common.

Mottles are a characteristic shared with the wetter Uderts and are the basis for definition of the aquic subgroups. Because Typic Chromuderts are rarely if ever dry and the most common vegetation is grass, a thick, dark epipedon is considered normal and its absence is the basis for definition of entic subgroups. The Typic Chromuderts are not extensive in the United States. Most of them have been or are being cultivated.

Aquentic Chromuderts.—These soils are like Typic Chromuderts except they have distinct or prominent mottles within 50 cm of the soil surface in more than half of each pedon. In addition, the upper horizons that have a color value, moist, less than 3.5 and a color value, dry, less than 5.5 either are absent or are <30 cm thick in more than half of each pedon. These soils are rare in the United States. Their vegetation was dominantly forest before they were used for farming. Pedon 124 is an example of a soil in this subgroup.

Aquic Chromuderts.—Soils in this subgroup have distinct or prominent mottles within 50 cm of the soil surface in more than half of each pedon but are otherwise like Typic Chromuderts. Their vegetation was dominantly grass before they were used for farming. They are the most extensive Chromuderts in the United States.

Entic Chromuderts.—These soils are like Typic Chromuderts except their upper horizons that have a color value, moist, less than 3.5 and a color value, dry, less than 5.5 either are absent or are <30 cm thick in more than half of each pedon. They are rare in the United States. Their vegetation was dominantly forest before they were used for farming.

Pelluderts

These are the Uderts that are dominantly gray to black in all subhorizons in the upper 30 cm in more than half of each pedon. As a rule the lower chroma, except for some mottles of high chroma, extends to a considerable depth. The color of the upper horizons ranges from black to gray. Most of these soils are level or are in depressions. They were mostly considered Rendzina soils in the 1938 classification and Grumusols after 1951. Plate 10A shows a Typic Pelludert.

Definition

Pelluderts are the Uderts that have a chroma, moist, of less than 1.5 dominant in the matrix of all subhorizons in the upper 30 cm in more than half of each pedon.

Pedon 125 is a Pelludert that is like Typic Pelluderts except the color value in the upper horizons is

too high. A color value, moist, of 2 or 3 is expected in soils of the typic subgroup.

Definition of Typic Pelluderts

Typic Pelluderts are the Pelluderts that have a color value, moist, less than 3.5 and a value, dry, less than 5.5 throughout the upper 30 cm in more than half of each pedon.

Description of subgroups

Typic Pelluderts.—The central concept or typic subgroup of Pelluderts is fixed on soils that have a thick, dark epipedon. The color of the surface layer and the content of organic matter are about the only visible properties that vary in the great group. Base saturation also varies. These soils are extensive locally on the Gulf Coast in Texas. They were formerly cultivated, but most of them are now used for pasture.

Entic Pelluderts.—These soils are like Typic Pelluderts except for their color value. This is the only subgroup besides Typic Pelluderts that has been recognized in the United States. A surface horizon that has a color value, moist, less than 3.5 and a color value, dry, less than 5.5 either is absent or is <30 cm thick in more than half of each pedon. These soils are not extensive in the United States. They are used mostly for pasture.

Usterts

These are the Vertisols (plate 12C) of areas of monsoon climates, of tropical and subtropical areas that have two rainy and two dry seasons, and of temperate regions that have low summer rainfall. The cracks close once or twice during each year. The cracks are open 90 cumulative days or more in most years but are closed for 60 consecutive days or more in most years at a time when the soil temperature at a depth of 50 cm is continuously above 8° C. Usterts are extensive in Texas, Australia, Africa south of the Sahara, and India. Many have formed in gently sloping, fine-textured marine deposits or alluvium, but they have formed also from basic rocks. If irrigated, they are used intensively, but large areas in the world are used for grazing for want of heavy machinery to till them. They were mostly considered Rendzina soils in the 1938 classification and Grumusols after 1951.

Definition

Usterts are the Vertisols that have cracks that remain open for 90 cumulative days or more in most years but that are closed for at least 60 consecutive days at a time when the soil temperature at a depth of 50 cm is continuously above 8° C and have one or more of the following characteristics:

1. Cracks that open and close more than once in most years;
2. A mean annual soil temperature of 22° C or more; or
3. A mean summer and mean winter soil temperature at a depth of 50 cm that differ by <5° C.

Key to great groups

DDA. Usterts that have a chroma, moist, of 1.5 or more in some part of the matrix of the upper 30 cm in more than half of each pedon.

Chromusterts, p. 379

DDB. Other Usterts.

Pellusterts, p. 380

Chromusterts

These are the Usterts that have a readily visible color (in the technical sense, that is, other than black, gray, or white) in the matrix of some subhorizon that is in the upper 30 cm or more and is present in more than half of each pedon. They are mostly on gentle slopes on which water does not stand. A calcic horizon or a ca horizon is normal, but the depth to these horizons and the thickness of the A1 horizon may vary widely within a pedon.

The Chromusterts may have formed on late-Pleistocene surfaces or deposits, or they may be on very old surfaces. They seem to persist with relatively little net change over long periods of time. Those in the United States had at the time of settlement a vegetation of grass mixed with some forbs and woody shrubs. They were mostly considered Rendzina soils in the 1938 classification and Grumusols after 1951.

Pedon 126 is an example of a Chromustert intergrading to the Uderts.

Definition

Chromusterts are the Usterts that have a chroma, moist, of 1.5 or more dominant in the matrix in some subhorizon in the upper 30 cm in more than half of each pedon.

Distinctions between Typic Chromusterts and other subgroups

Typic Chromusterts are the Chromusterts that

a. Have a color value, moist, less than 3.5 and a value, dry, less than 5.5 throughout the upper 30 cm or more in more than half of each pedon;

b. Do not have, within 1 m of the soil surface, prismatic or blocky structure accompanied by clay skins on ped faces that have a color value lower than that in the matrix; and

c. Have cracks that remain open more than 150 cumulative days in most years and have a mean annual soil temperature that is 15° C or higher.

Entic Chromusterts are like Typic Chromusterts except for *a*.

Paleustollic Chromusterts are like Typic Chromusterts except for *b* or for *a* and *b*.

Udic Chromusterts are like Typic Chromusterts except for *c* and have cracks that remain open from 90 to 150 cumulative days in most years.

Udorthentic Chromusterts are like Typic Chromusterts except for *a* and *c* and have cracks that remain open from 90 to 150 cumulative days in most years.

Description of subgroups

Typic Chromusterts.—The central concept or typic subgroup of Chromusterts is fixed on soils that are

mostly on slopes on which water never stands. They have water continuously available to plants long enough during a growing season for crops that are somewhat tolerant of drought to mature, but their cracks are open for extended periods that come either once or twice a year. If the cracks open and close only once each year, the soil temperature regime usually is isothermic or warmer. These soils mostly supported a closed vegetation of grass or savanna, and the dark epipedon is considered normal. Evidences of an argillic horizon at some depth suggest that an ancient soil over time developed such fine texture that a Vertisol formed in it.

Cracks that are open less than 150 days a year, cumulative, in most years are considered to indicate a more humid environment than that of Typic Chromusterts and are the basis for definition of udic subgroups.

Entic Chromusterts.—These soils are like Typic Chromusterts except the upper horizons that have a color value, moist, less than 3.5 and a color value, dry, less than 5.5 either are absent or are <30 cm thick in more than half of each pedon. These soils are rare in the United States.

Paleustollic Chromusterts.—These soils are like Typic Chromusterts except they have blocky or prismatic structure within 1 m of the soil surface, and there are clay skins on ped faces that have a color value lower than that in the interiors of the peds. In addition, their surface horizons that have a color value, moist, less than 3.5 and a color value, dry, less than 5.5 either may be absent or may be <30 cm thick in more than half of each pedon. These soils are rare in the United States. Their slopes are gentle, and most of the soils are used for grazing. These soils are thought to be former Paleustolls that through time developed such fine texture that a Vertisol formed in the Paleustoll.

Udic Chromusterts.—These soils are like Typic Chromusterts except that the cracks are open from 90 to 150 days, cumulative, in most years or the mean annual soil temperature is lower than 15° C, or both. These soils are extensive in the southern Great Plains and most of them are cultivated. They are intergrades between Chromuderts and Chromusterts.

Udorthentic Chromusterts.—These soils are like Typic Chromusterts except that the cracks are open from 90 to 150 days, cumulative, during most years or the mean annual soil temperature is lower than 15° C, or both. Their upper horizons that have a color value, moist, less than 3.5 and a color value, dry, less than 5.5 either are absent or are <30 cm thick in more than half of each pedon. These soils are not extensive in the United States. Most of them are cultivated. They are intergrades between Udorthents and Chromusterts.

Pellusterts

These are the Usterts that are dominantly gray to black in all subhorizons throughout the upper 30 cm in more than half of each pedon. The low chroma, except for some mottles of high chroma, generally extends to a considerable depth. The upper horizons may range from black to gray. Most of these soils are level or in depressions. They were mostly considered Rendzina soils in the 1938 classification and Grumusols after 1951.

Definition

Pellusterts are the Usterts that have a chroma, moist, less than 1.5 dominant in the matrix of all subhorizons in the upper 30 cm in more than half of each pedon.

Pedon 127 is a Udic Pellustert because the cracks are open less than 150 cumulative days in most years. It is otherwise like the Typic Pellusterts.

Distinctions between Typic Pellusterts and other subgroups

Typic Pellusterts are the Pellusterts that

a. Have a color value, moist, less than 3.5 and a value, dry, less than 5.5 throughout the upper 30 cm in more than half of each pedon;

b. Have cracks that remain open for more than 150 cumulative days during each year and have a mean annual soil temperature that is 15° C or higher; and

c. Do not have within 1 m of the soil surface prismatic or blocky structure accompanied by clay skins on ped faces that have a color value lower than that in the matrix.

Entic Pellusterts are like Typic Pellusterts except for *a*.

Udic Pellusterts are like Typic Pellusterts except for *b*.

Udorthentic Pellusterts are like Typic Pellusterts except for *a* and *b*.

Description of subgroups

Typic Pellusterts.—The central concept or typic subgroup of Pellusterts is fixed on soils that are nearly level except for their gilgai microrelief. The polypedons are virtually flat. Water stands in the microdepressions during rainy seasons. Many of the soils are in closed depressions or on gentle concave slopes. They have water that is continuously available to plants long enough to mature the crops that are somewhat tolerant of drought, but their cracks are open for extended periods that come either once or twice each year. If the cracks open and close only once each year, the soil temperature regime usually is isothermic or warmer. These soils mostly supported a closed vegetation of grass or savanna, and the dark epipedon is considered normal. Evidences of an argillic horizon at some depth suggest that an ancient soil through time developed such fine texture that a Vertisol formed in it.

Cracks that are open less than 150 days, cumulative, in most years are considered to indicate a more humid environment than that of Typic Pellusterts and are the basis for definition of udic subgroups.

The Typic Pellusterts are not the most common Pellusterts in the United States, but they furnish a basis for the definition of other subgroups. They are moderately extensive soils in parts of Texas and Puerto Rico. Most of them are cultivated, and some are irrigated.

Entic Pellusterts.—These soils (plate 12C) are like Typic Pellusterts except the upper horizons that have a color value, moist, less than 3.5 and a color value, dry, less than 5.5 either are absent or are <30 cm thick in more than half of each pedon. They are not extensive in the United States except in parts of Texas. Some of them are cultivated and many are used for grazing.

Udic Pellusterts.—These soils are like Typic Pellusterts except that the cracks are open from 90 to 150 days, cumulative, in most years or the mean annual soil temperature is lower than 15° C, or both. These soils are intergrades between Pelluderts and Pellusterts. They are extensive in the southern Great Plains in the United States, and most of them are cultivated.

Udorthentic Pellusterts.—Soils in this subgroup are like Typic Pellusterts except that the cracks are open from 90 to 150 days, cumulative, in most years or the mean annual soil temperature is lower than 15° C, or both; the upper horizons that have a color value, moist, less than 3.5 and a color value, dry, less than

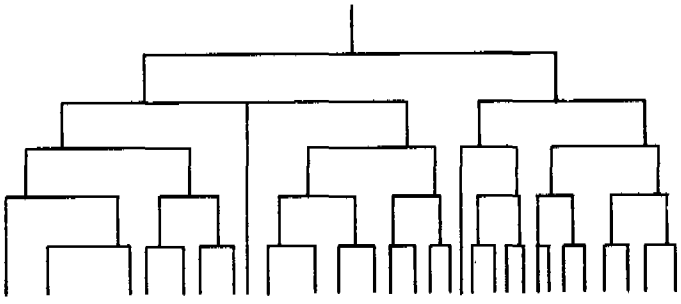
Chromoxererts

These are Xererts (plate 12D) that have a readily visible color (in the technical sense, that is, other than black, gray, or white) in the matrix of some or all subhorizons in the upper 30 cm and present in more than half of each pedon. Commonly, the horizons that have chroma of 2 or more extend to a depth >30 cm. The Chromoxererts are moderately extensive on gentle to moderate slopes in California. They are rare elsewhere in the United States. They were considered Grumusols in the 1951 modification of the 1938 classification but had no clear place in the original classification.

Definition

Chromoxererts are the Xererts that have a subhorizon in the upper 30 cm that has a dominant chroma of 1.5 or more in the matrix and is present in more than half of each pedon.

Pedon 128 is an example of the central concept or typic subgroup of Chromoxererts.



CHAPTER 18

Family and Series Differentiae and Names

It was pointed out earlier that families and series serve purposes that are largely pragmatic, that the series name is abstract, and that the technical family name is descriptive. In this chapter, the descriptive terms used in names of families are defined, the horizons or arbitrary depths to which the terms apply are given, and the taxa in which they are used are indicated. Examples of families are given to show how the family name is derived, and differences between the series in those families are pointed out as examples of series differentiae.

Family differentiae for mineral soils

The differentiae used to distinguish families of mineral soils within a subgroup are listed next in the order in which the descriptive terms appear in the family name and in which the terms are defined in this chapter.

Particle-size classes
Mineralogy classes
Calcareous and reaction classes
Soil temperature classes
Soil depth classes
Soil slope classes

based on percentages by weight in the fraction <2 mm in diameter.

The very fine sand separate (diameter between 0.05 mm and 0.1 mm) is split in engineering classifications. In defining particle-size classes, much the same split is made but in a different manner. A fine sand or loamy fine sand normally has an appreciable content of very fine sand, but the very fine sand fraction is mostly coarser than 74 microns. A silty sediment, such as loess, may also have an appreciable component of very fine sand, but most of the very fine sand is finer than 74 microns. So, in particle-size classes, the very fine sand is allowed to "float." It is treated as sand if the texture is fine sand, loamy fine sand, or a coarser class. It is treated as silt if the texture is very fine sand, loamy very fine sand, sandy loam, silt loam, or a finer class.

No single set of particle-size classes seems appropriate as family differentiae for all kinds of soils. The classes that follow provide for a choice of either 7 or 11 particle-size classes. This choice permits relatively fine distinctions in soils if the particle size is important and broader groupings if the particle size is not susceptible to precise measurement or if the use of narrowly defined classes produces undesirable groupings. Thus in some families the term "clayey" indicates that there is 35 percent or more clay in defined horizons.

enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is sandy as defined for the sandy particle-size class.

Loamy-skeletal.—Rock fragments make up 35 percent or more by volume; enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is loamy as defined for the loamy particle-size class.

Clayey-skeletal.—Rock fragments make up 35 percent or more by volume; enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is clayey as defined for the clayey particle-size class.

Sandy.—The texture of the fine earth is sand or loamy sand but not loamy very fine sand or very fine sand; rock fragments make up <35 percent by volume.

Loamy.[1]—The texture of the fine earth is loamy very fine sand, very fine sand, or finer, but the amount of clay is <35 percent; rock fragments are <35 percent by volume.

Coarse-loamy. By weight, 15 percent or more of the particles are fine sand (diameter 0.25–0.1 mm) or coarser, including fragments up to 7.5 cm in diameter; <18 percent clay in the fine-earth fraction.

Fine-loamy. By weight, 15 percent or more of the particles are fine sand (diameter 0.25–0.1 mm) or coarser, including fragments up to 7.5 cm in diameter; 18 through 34 percent clay in the fine-earth fraction (<30 percent in Vertisols).

Coarse-silty. By weight, <15 percent of the particles are fine sand (diameter 0.25–0.1 mm) or coarser, including fragments up to 7.5 cm in diameter; <18 percent clay in the fine-earth fraction.

Fine-silty. By weight, <15 percent of the particles are fine sand (diameter 0.25–0.1 mm) or coarser, including fragments up to 7.5 cm in diameter; 18 through 34 percent clay in the fine-earth fraction (<30 percent in Vertisols).

Clayey.[1]—The fine earth contains 35 percent or more clay by weight, and rock fragments are <35 percent by volume.

Fine. A clayey particle-size class that has 35 through 59 percent clay in the fine-earth fraction (30 through 59 percent in Vertisols).

Very-fine. A clayey particle-size class that has 60 percent or more clay in the fine-earth fraction.

Modifiers that replace names of particle-size classes

There are three situations in which particle-size class names are not used. In one, the name is redundant. Psamments and Psammaquents, by definition, are sandy, and no particle-size class name is needed or used in the family name.

In the second situation, particle size is a meaningless concept because, presumably, the soil consists of a mixture of discrete mineral particles and of gels. The concept of either texture or particle size is not applicable to a gel, particularly if the gel cannot be dispersed. Consequently, no particle-size class names are used if the soil is mostly glass or if the exchange complex is dominated by amorphous materials, as is the situation with Andepts by definition. In families of Andepts and Andaquepts, in most andic subgroups of Inceptisols and andaqueptic and andeptic subgroups of other orders, and in families of Entisols and Aridisols with modifiers listed below, particle-size class names, as such, are not used for the part of the soil that does not disperse.

In the third situation, the content of organic matter is high and particle size has only limited relation to the physical and chemical properties of the soils. This seems to be normal in soils that have both a cryic temperature regime and a spodic horizon. Therefore, particle-size class names are not used for the spodic horizons[2] of Cryaquods, Cryohumods, Cryorthods, or Cryic Placohumods.

The following terms are substituted for the particle-size class names in the taxa that have been listed unless the particle-size modifier is redundant. They reflect a combination of particle size and mineralogy, and they take the place of both.

Cindery.—Sixty percent or more of the whole soil (by weight)[3] volcanic ash, cinders, and pumice; 35 percent or more (by volume) is cinders that have diameter of 2 mm or more.

Ashy and ashy-skeletal.—These are mainly soils that have a fine-earth fraction that feels like a sand or a loamy sand after prolonged rubbing.

Ashy. Sixty percent or more of the whole soil (by weight) volcanic ash, cinders, and pumice; <35 percent (by volume) is 2 mm in diameter or larger.

Ashy-skeletal. Rock fragments other than cinders are 35 percent or more (by volume); the fine-earth fraction is otherwise ashy.

Medial and medial-skeletal.—These are soils that have a fine-earth fraction that feels loamy, as the term is defined earlier in this chapter, after prolonged rubbing.

Medial. Less than 60 percent of the whole soil (by weight) volcanic ash, cinders, and pumice; <35 percent (by volume) is 2 mm in diameter or larger; the fine-earth fraction is not thixotropic; the exchange complex is dominated by amorphous materials.

Medial-skeletal. Thirty-five percent (by volume) or more rock fragments other than cinders 2 mm in diameter or larger; the fine-earth fraction is otherwise medial.

Thixotropic and thixotropic-skeletal.—These are soils that have a fine-earth fraction that is thixotropic

[1] If the ratio of 15-bar water to clay is 0.6 or more in half or more of the control section, the percentage of clay is considered to be 2.5 times the percentage of 15-bar water. Carbonates of clay size are not considered to be clay but are treated as silt in all particle-size classes.

[2] Particle-size class names are applied to other spodic horizons but with reservations. Somewhat different classes probably should be used for most families of Spodosols, but data are too few to permit the testing of alternatives. Some series that would otherwise be reasonably homogeneous are split at the family level by the particle-size classes. These soils have appreciable but not very large amounts of organic matter in the spodic horizon.

[3] Percentages by weight in these definitions are estimated from grain counts; usually, a count of one or two dominant size fractions of the conventional mechanical analysis is enough for placement of the soil.

and an exchange complex dominated by amorphous clays.

Thixotropic. Less than 35 percent (by volume) has diameter of 2 mm or larger; the fine-earth fraction is thixotropic; the exchange complex is dominated by amorphous materials.

Thixotropic-skeletal. Thirty-five percent or more (by volume) rock fragments other than cinders 2 mm in diameter or larger; the fine-earth fraction is thixotropic.

Control section for particle-size classes or their substitutes

Names of particle-size classes or their substitutes as defined are not applied to a fragipan, duripan, or a petrocalcic horizon but are applied to specific horizons or to the materials between given limits of depth that are defined in terms of either the distance below the surface of the mineral soil or the upper boundary of a specified horizon. The vertical section so defined is called the control section. Definitions of the control section for determination of the particle-size classes are arranged as a key.

A. Particle-size modifiers or substitutes are used to describe material from the surface to a lithic or paralithic contact; or to a fragipan, duripan, or petrocalcic horizon if any of these come within a depth of 36 cm (14 in.) or less; or to a depth of 36 cm if the soil temperature is 0° C or lower within this depth about 2 months after the summer solstice.

B. In other soils that do not have an argillic horizon or a natric horizon and in great groups of Spodosols, Alfisols, and Ultisols that have a spodic horizon or a fragipan in or above an argillic horizon:

1. Particle-size modifiers or substitutes are used to describe material from the base of the Ap horizon or from a depth of 25 cm, whichever is greater, to a lithic or paralithic contact, fragipan, duripan, or petrocalcic horizon if the depth to any of these is <1 m; or to a depth 25 cm below the level at which the soil temperature is 0° C about 2 months after the summer solstice; whichever is shallower.

2. Otherwise, particle-size modifiers or substitutes are used to describe material from a depth of 25 cm to a depth of 1 m.

C. In other soils of the orders Alfisols and Ultisols and in great groups of Aridisols and Mollisols that have an argillic horizon that has (a) a lower boundary deeper than 25 cm (see E) and (b) an upper boundary shallower than 1 m, or the soil is in a grossarenic subgroup:

1. If there are no strongly contrasting particle-size classes, as defined later, and there is no fragipan, duripan, or petrocalcic horizon between the top of the argillic or natric horizon and a depth of 1 m, particle-size modifiers or substitutes are used to describe the whole argillic or natric horizon if it is <50 cm thick[4] or the upper 50 cm of the argillic or natric horizon if it is >50 cm thick.

2. If there are horizons or layers of strongly contrasting particle-size classes, as defined later, within or below the argillic or natric horizon and within a depth of 1 m, particle-size modifiers or substitutes are used to describe material from the top of the argillic or natric horizon to a depth of 1 m or to a lithic or paralithic contact, duripan, fragipan, or petrocalcic horizon, whichever is shallower.

3. If there is a fragipan, duripan, or petrocalcic horizon below an argillic or natric horizon, particle-size modifiers or substitutes are used to describe material from the top of the argillic horizon, excluding any part incorporated in an Ap horizon, to the top of the fragipan, duripan, or petrocalcic horizon, or are used to describe the upper 50 cm of the argillic or natric horizon whichever of these is less.

D. In other soils in the orders Alfisols and Ultisols and in great groups of Aridisols and Mollisols that have an argillic or natric horizon that has its upper boundary at a depth >1 m and that are not in a grossarenic subgroup, particle-size modifiers or substitutes are applied to describe material from a depth of 25 cm to a depth of 1 m below the mineral surface.

E. In other soils in which the lower boundary of the argillic or natric horizon is shallower than 25 cm, that is, they have a *ca* horizon in which there is soft powdery lime, or have a calcic or other named diagnostic horizon that has its upper boundary within 25 cm of the surface, or have rock structure dominant within that depth, particle-size classes are used to describe material from the top of the argillic horizon or the base of an Ap horizon, whichever is shallower, to a lithic or paralithic contact, a petrocalcic or petrogypsic horizon, duripan, or to a depth of 1 m, whichever is shallowest.

Strongly contrasting particle-size classes

In applying names of particle-size classes, the weighted average particle-size class of the control section or of the horizons listed is named unless there are strongly contrasting particle-size classes within the control section or the horizons. If there are strongly contrasting particle-size classes, both particle-size classes are named. Thus, if the weighted average of the upper part of the control section is loamy fine sand and the lower part is clay, the family differentia is sandy over clayey. If there are more than two contrasting particle-size classes within the control section, the classes differing most in median particle size are named. Sandy includes fine sand as well as coarser sands. Medial, ashy, or thixotropic substitutes are applied only if the materials extend at least 10 cm into the upper part of the control section.

The following particle-size classes are strongly contrasting if the transition between them is less than 12.5 cm thick:

1. Cindery over sandy or sandy-skeletal.
2. Cindery over loamy.
3. Sandy-skeletal over loamy if the loamy material has <50 percent fine or coarser sand.
4. Sandy over loamy if the loamy material has <50 percent fine or coarser sand.
5. Sandy over clayey.
6. Ashy over cindery.
7. Ashy over loamy-skeletal.
8. Ashy over loamy.
9. Loamy-skeletal over fragmental.
10. Loamy-skeletal over sandy.
11. Loamy-skeletal over clayey if there is an absolute difference of >25 percent in the percentages of clay in the fine earth fractions.
12. Clayey-skeletal over sandy.
13. Medial over fragmental.
14. Medial over cindery.
15. Medial over sandy or sandy-skeletal.
16. Medial over loamy-skeletal.
17. Medial over loamy.

[4] The upper boundary of the argillic horizon is not always obvious. If properties of an argillic horizon are present but the upper boundary is gradual, use the depth at which the percentage of clay exceeds that of a higher lying horizon by the appropriate amount after fitting to a smooth curve. If the boundary is irregular or broken, as in A&B or B&A horizons, use the depth at which half or more of the volume has the fabric of an argillic horizon.

18. Medial over clayey.
19. Medial over thixotropic.
20. Coarse-loamy over fragmental.
21. Coarse-loamy over sandy or sandy-skeletal if the coarse-loamy material has <50 percent fine or coarser sand.
22. Loamy over sandy or sandy-skeletal if the loamy material has <50 percent fine or coarser sand.
23. Coarse-loamy over clayey.
24. Coarse-silty over sandy or sandy-skeletal.
25. Coarse-silty over clayey.

Mineralogy classes

The control section

Mineralogy classes are based on the approximate mineralogical composition of selected size fractions of the same segment of the soil (control section) that is used for application of particle-size classes.

Contrasting mineralogy modifiers

Contrasting mineralogy modifiers are not recognized

TABLE 12.—*Key to mineralogy classes*

Class	Definition	Determinant size fraction
	CLASSES APPLIED TO SOILS OF ANY PARTICLE-SIZE CLASS	
Carbonatic	More than 40 percent by weight carbonates (expressed as $CaCO_3$) plus gypsum, and the carbonates are >65 percent of the sum of carbonates and gypsum.	Whole soil, particles <2 mm in diameter or whole soil <20 mm, whichever has higher percentage of carbonates plus gypsum.
Ferritic	More than 40 percent by weight iron oxide extractable by citrate-dithionite, reported as Fe_2O_3 (or 28 percent reported as Fe).	Whole soil, particles <2 mm in diameter.
Gibbsitic	More than 40 percent by weight hydrated aluminum oxides, reported as gibbsite and bohemite.	Whole soil, particles <2 mm in diameter.
Oxidic	Less than 90 percent quartz; <40 percent any other single mineral listed subsequently; and the ratio, percent extractable iron oxide plus percent gibbsite to percent clay,[1] is 0.2 or more. That is, $\frac{\text{extractable } Fe_2O_3\text{(pct.)} + \text{gibbsite(pct.)}}{\text{clay(pct.)}^1} \geq 0.2$	For quartz and other minerals, fraction 0.02 to 2 mm in diameter; for ratio of iron oxide and gibbsite to clay, whole soil <2 mm.
Serpentinitic	More than 40 percent by weight serpentine minerals (antigorite, chrysotile, fibrolite, and talc).	Whole soil, particles <2mm in diameter.
Gypsic	More than 40 percent by weight of carbonates (expressed as $CaCO_3$) plus gysum, and the gypsum is >35 percent of the sum of carbonates and gypsum.	Whole soil, particles <2 mm in diameter, or whole soil <20 mm, whichever has higher percentage of carbonates plus gypsum.
Glauconitic	More than 40 percent glauconite by weight.	Whole soil, particles <2 mm in diameter.
	CLASSES APPLIED TO SOILS THAT HAVE A FRAGMENTAL, SANDY, SANDY-SKELETAL, LOAMY, OR LOAMY-SKELETAL PARTICLE-SIZE CLASS	
Micaceous	More than 40 percent mica by weight.[2]	0.02 to 20 mm.
Siliceous	More than 90 percent by weight[2] of silica minerals (quartz, chalcedony, or opal) and other extremely durable minerals that are resistant to weathering. See weatherable minerals (ch. 3).	0.02 to 2 mm.
Mixed	All others that have <40 percent of any one mineral other than quartz or feldspars.	0.02 to 2 mm.
	CLASSES APPLIED TO SOILS THAT HAVE A CLAYEY OR CLAYEY-SKELETAL PARTICLE-SIZE CLASS	
Halloysitic	More than half halloysite[3] by weight and smaller amounts of allophane or kaolinite or both.	<0.002 mm.
Kaolinitic	More than half kaolinite, tabular halloysite, dickite, and nacrite by weight, smaller amounts of other 1:1 or nonexpanding 2:1 layer minerals or gibbsite, and <10 percent montmorillonite.	<0.002 mm.
Montmorillonitic	More than half montmorillonite and nontronite by weight or a mixture that has more montmorillonite than any other one clay mineral.	<0.002 mm.
Illitic	More than half illite (hydrous mica) by weight and commonly >4 percent K_2O.	<0.002 mm.
Vermiculitic	More than half vermiculite by weight or more vermiculite than any other one clay mineral.	<0.002 mm.
Chloritic	More than half chlorite by weight or more chlorite than any other clay mineral.	<0.002 mm.
Mixed	Other soils.[4]	<0.002 mm.

[1] Percentage of clay or percentage of 15-bar water times 2.5, whichever is greater, provided the ratio of 15-bar water to clay is 0.6 or more in half or more of the control section.

[2] Percentages by weight are estimated from grain counts. Usually, a count of one or two of the dominant size fractions of a conventional mechanical analysis is sufficient for placement of the soil.

[3] Halloysite as used here includes only the tubular forms. What has been called tabular halloysite is grouped here with kaolinite.

[4] Sepiolitic, defined as containing more than half by weight of sepiolite, attapulgite, and palygorskite, should be named if found.

Calcareous and reaction classes

The presence or absence of carbonates and the reaction are treated together because they are so intimately related. A calcareous horizon cannot be strongly acid. Calcareous classes are applied to the section between a depth of 25 and 50 cm or between a depth of 25 cm and a lithic or paralithic contact that

thetically. It is assumed that the temperature is that of a soil that is not being irrigated.

For soils in which the difference is 5° C (9° F) or more between mean summer (June, July, and August in the northern hemisphere) and mean winter (December, January, and February in the northern hemisphere) soil temperature at a depth of 50 cm or at a lithic or paralithic contact, whichever is shallower, the

Consistence

Some cemented horizons, for example, a duripan, are differentiae in the classification in categories above the family. Others such as a cemented spodic horizon (ortstein) are not, but no single family should include soils that have a continuous, shallow, cemented horizon and soils that do not. In Spodosols, in particular, a cemented spodic horizon needs to be used as a family differentia. The following classes of consistence are defined for Spodosols.

Ortstein.—All or part of the spodic horizon is at least weakly cemented, when moist, into a massive horizon that is present in more than half of each pedon.

Noncemented.—The spodic horizon, when moist, is not cemented into a massive horizon in as much as half of each pedon.

Cementation of a small volume into shot or concretions does not constitute cementation to form a massive horizon. The name of a family of noncemented Spodosols normally does not have a modifier to imply lack of cementation. The name of a family of cemented Spodosols contains the modifier "ortstein."

A cemented calcic or gypsic horizon is not identified in the family name. Many calcic and some gypsic horizons are weakly cemented and some are indurated. The recognition of a petrocalcic or petrogypsic horizon is expected to meet most, if not all, the needs for recognition of cementation in those horizons. Taxa of these cemented soils are not named in the family category.

Classes of coatings (on sands)

Despite the emphasis given to particle-size classes in the taxonomy, variability remains in the sandy particle-size class, which takes in sands and loamy sands

content is low, but their recognition in the field from the position of the soil in the landscape is generally easy. It is proposed, therefore, in aquic great groups, particularly in Aquolls and Aquults, to use the shape of the soil as a family differentia. Classes of level and sloping soils seem adequate, as these classes are defined in the Soil Survey Manual (Soil Survey Staff 1951). It may be necessary to use slope classes as family differentiae in other orders, but they should not be used in families of Aquods or Albaqualfs. Level is assumed in families of aquic soils if no slope modifier is used in the family name.

Classes of permanent cracks

Hydraquents consolidate[5] after drainage and become Fluvaquents. In the process, they form polyhedrons, roughly 12 to 50 cm in diameter, depending on the *n*-value and particle size. The polyhedrons are separated by cracks that range in width from 2 mm to >1 cm. The polyhedrons may shrink and swell with changes in moisture content of the soil, but the cracks are permanent and can persist for some hundreds of years even though the soils are cultivated. The cracks permit rapid movement of water through the soil either vertically or laterally. Yet the soils may have the same particle size, mineralogy, and other family properties as soils that are not cracked or that have cracks that open and close with the seasons. The soils that have permanent cracks are so rare in the United States that only a provisional definition of their characteristics can be presented.

The modifier "cracked" is used only to designate families of Fluvaquents. It means that there are continuous, permanent, lateral and vertical cracks, at least 2 mm wide, spaced at average lateral intervals of

Particle-size classes

Particle-size modifiers are used in family names of Histosols only in terric subgroups. The terms used follow.

Fragmental
Loamy-skeletal or clayey-skeletal
Sandy or sandy-skeletal
Loamy
Clayey

The meaning of each of these terms is the same as that defined for particle-size classes of mineral soils. The proper term is selected to describe the weighted average particle size of the upper 30 cm of the mineral layer or that part of the mineral layer that is within the control section, whichever is thicker.

Minerology classes

Mineralogy classes of Histosols are of three kinds, according to the nature of the subgroup or great group.

Ferrihumic.—Containing ferrihumic materials within the control section (applied to Fibrists, Hemists, and Saprists, except Sphagnofibrists and sphagnic subgroups of other great groups). Bog iron is present in some Histosols or in organic soil materials. It is called ferrihumic material. It consists of authigenic deposits (formed in place) of hydrated iron oxides mixed with varying kinds or amounts of organic materials. The iron in some places is present in large cemented aggregates. In others it may be mostly dispersed and soft. The colors normally are shades of dark reddish brown, commonly mixed with black, and the colors change little on drying. The content of iron oxide ranges from 10 percent to >20 percent.

Ferrihumic material either is saturated with water for long periods (>6 months) or is in an artificially drained soil. The content of free iron oxide should exceed 10 percent (7 percent Fe), but the horizon may be either organic or mineral provided there is at least 1 percent organic matter. The materials should have >2 percent (by weight) concretions of iron, which

Coprogenous. Limnic materials that consist of coprogenous earth are present.

Diatomaceous. Limnic materials that consist of diatomaceous earth are present.

Marly. Limnic materials that consist of marl are present.

Reaction classes

Modifiers to indicate reaction are used in all subgroups. The meanings follow.

Euic.—The pH of undried samples is 4.5 or more (0.01 M $CaCl_2$) in at least some part of the organic materials in the control section.

Dysic.—The pH is <4.5 (in 0.01 M $CaCl_2$) in all parts of the organic materials in the control section.

Soil temperature classes

Names and definitions of classes follow the rules given for soil temperature classes of mineral soils. Frigid, however, is redundant in boric and cryic great groups and is not used. No temperature modifier is used in pergelic subgroups.

Soil depth classes

Soil depth modifiers are used in all lithic subgroups of Histosols except in the suborder of Folists. It is assumed that lithic Folists have a shallow lithic contact. Other lithic Histosols have a lithic contact within the control section but it may be as much as 160 cm deep.

Shallow families.—Used in lithic subgroups to indicate a lithic contact between a depth of 18 cm and 50 cm.

Micro families.—Used to indicate a lithic contact shallower than 18 cm without regard to soil temperature. (In mineral soils, micro families are restricted to cryic great groups.)

Series differentiae within a family

The control section of the soil series is very similar

control section, attention is centered on genetic horizons if they are well expressed and not thin. If the genetic horizons are not well expressed or are thin, attention is centered on a corresponding part of the regolith. Differences in soil or regolith that are outside the control section and that are not differentiae in categories higher than the series but that are relevant to the foreseeable uses of the soils are bases for phase distinctions.

Control section in differentiation of series

Whether or not there are well-expressed genetic horizons, the part of a soil to be considered in differentiating series within a family of mineral soils is as fol-

bric epipedon. It is an ochric epipedon. The B horizon, from 48 to 89 cm, as described, lacks the rock structure of the underlying C horizon. It has more clay than the C horizon, as indicated by the particle-size distribution, the 15-bar water, and the cation-exchange capacity. We can hardly doubt that some clay has been formed, nor can we doubt from the micromorphologic descriptions that some of the clay has been moved, particularly in the C horizon. The accumulation is too slight for an argillic horizon, however, so the B horizon can only be a cambic horizon. There is no evidence of any other diagnostic horizon. The soil is an Ochrept. The moisture data show it to be a Xerochrept.

other diagnostic horizons are present, so our control section again is from a depth of 25 cm to 1 m. Within this zone rock fragments (>2 mm and <76 mm) constitute about 51 percent, by weight, of the soil, which would exceed 35 percent by volume; many cobbles larger than 76 mm are described. The fine-earth fraction is loamy, so our first modifier is *loamy-skeletal.* Measurements of mineralogy are not available, but other evidence, not presented here, indicates that <90 percent of the silt and sand are quartz and that no single group of minerals is >40 percent. The mineralogy, therefore, is *mixed.* The soil temperature regime, estimated from the air temperature, is *frigid.* No other modifiers are appropriate, so the family modifiers are *loamy-skeletal, mixed, frigid.*

Application of series differentiae

The standard descriptions of all series in the two families used as examples are given in this chapter. In the first family are the Vista and Escondido series. If we compare the descriptions of the typifying pedons of these two series, we note several differences. One is in the depth to rock. Rock is present at a depth of about 75 cm in the Escondido typifying pedon and is known to be present in other pedons of the series at depths ranging from 50 cm to 1 m. In contrast, the depth to rock is many feet in Vista soils. The rock under Escondido soils shortens the series control section, and this shortened control section is a series differentia. If the rock were deeper than 1 m, the control section would not be shortened. The depth to rock could then be a basis for phase distinctions if it were important to the use of the soil.

A second difference between the two series is the texture of the cambic horizons. The cambic horizon of the Vista soil is coarse sandy loam, and that of the Escondido is silt loam to fine sandy loam. Analyses show as much as 65 percent silt and very fine sand, 32 percent fine sand and coarser, and no gravel in the Escondido pedon. This compares with 28 percent (by weight) coarse fragments and 60 percent or more fine sand or coarser sand in the fine earth of the Vista pedon. Although the particle-size class is the same in the cambic horizons and in the control sections of the two series, there are appreciable differences in water-holding capacity.

A third difference between the two soils is in the structure of the cambic horizon, which is massive in the Vista soils and subangular blocky in the Escondido soils.

The lithic contact within the control section in the Escondido soils and the absence of one in the Vista soils require that the soils be classified in different series. The differences in texture and structure of the cambic horizons might also justify two series even in

and Mud Springs soils have rock at a depth between 50 and 100 cm and are brown throughout. The Mud Springs soil formed from materials derived from weathering of granite, and the Fuego soil from a felsite. Mud Springs has hard or very hard consistence (dry) in the B horizon, and Fuego has soft or slightly hard consistence.

Soils of the other two series in the family, Bradshaw and St. Marys, do not have a lithic or paralithic contact within 1 m of the surface. The St. Marys soils are red and slightly calcareous below the mollic epipedon, and the Bradshaw soils are brown or yellowish brown. Bradshaw soils may have some carbonates below the mollic epipedon. Bradshaw and St. Marys soils differ mainly in color and in the mineralogy that is responsible for the color differences.

Soils of all the series in this family are used mainly for grazing by domestic animals or wildlife. There are differences in the kinds of vegetation and the amount of forage produced.

These examples show the nature of series differentiae. Mostly, the series within a given family have several small differences in the nature or arrangement of horizons or, in the absence of horizons, in the nature of the control section. The differentiae are discussed under the category of series in chapter 5.

It was pointed out in chapter 5 that important differences, as shown by experience or research to condition or influence the nature of the statements that we can make about the behavior of the soil, should be considered as series differentiae. Some further examples may clarify the nature of the series differentiae within a family and partially explain why a few families have many series and many families have few series.

One very large family in the United States is the fine-loamy, mixed, mesic family of Typic Hapludalfs (the Miami family), in which there are about 50 series in 13 states ranging from the state of Washington to New Jersey. Most of the series are in a few states, and nearly half of the series in the family are in Illinois, Indiana, and southern Wisconsin. This section is in the heart of the Corn Belt of the United States. Soil temperature ranges from near frigid to near thermic, and the growing season varies accordingly. The frost-free period ranges from about 120 to 210 days, a very significant difference to the production of maize. Penetration of frost may be 1 m or more in winter in Wisconsin and only a few centimeters in severe winters in Missouri or southern Illinois. Precipitation increases with temperature, but drought is more common in the warm than in the cool parts of the area. Because the soils are fine-loamy, the clay mineralogy is not considered at the family level. Some of the soils have mostly montmorillonite and others have illite, vermiculite, or chlorite as the dominant clay mineral. Still others have mixtures of minerals.

these differences have small but significant effects on the timing of tillage operations.

Yields of maize (corn) and of other crops vary with the soil and the management. For a given phase within a family, yields of maize are not supposed to vary more than about 20 percent from the mean of the family. The mean is high under modern management practices, and the difference is very significant between a soil and management that produces 20 percent more than the mean and a soil that with similar management produces 20 percent less than the mean.

In classifying soils such as these that are highly responsive to management and that produce high yields, a large number of series may be needed in a family for quantitative statements about management practices and crop yields. It is possible that at present

In another common situation, the soils of a family have severe limitations for more than a very few uses. Considerable variability in mineralogy, depth, texture, and other properties then can be tolerated in a series without serious effects on interpretations. An example of this situation is the subgroup of Histic Pergelic Cryaquepts. This subgroup currently has 7 families and 13 series. The soils have very large acreages, but they are little used. Texture is one important difference between the series. Another is the depth of thawing in summer. The soils that thaw to a depth of 50 cm to 1 m or more have been drained in a few places and are being cultivated for cool-season vegetables. The soils that thaw only to a depth of about 20 cm in summer are not used, except for grazing by wildlife, and differences within the family lose significance to inter-

Established Series
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ESCONDIDO SERIES

The Escondido series is a member of the coarse-loamy, mixed, thermic family of Typic Xerochrepts. Typically, Escondido soils have dark brown slightly acid very fine sandy loam A horizons and neutral very fine sandy loam B2 horizons over hard metamorphic bedrock at depths of about 29 inches.

Typifying Pedon: Escondido very fine sandy loam - irrigated avocado orchard (Colors are for dry soil unless otherwise noted.)

Ap 0-6"--Dark brown (7.5YR 4/4) very fine sandy loam, dark reddish brown (5YR 3/3) moist; weak fine and medium granular structure; slightly hard, friable, nonsticky, nonplastic; common very fine and fine roots; many very fine interstitial, common very fine and fine tubular pores; slightly acid (pH 6.5); abrupt smooth boundary. (4 to 10 inches thick)

B21 6-17"--Brown (7.5YR 4/4) very fine sandy loam, dark reddish brown (5YR 3/4) moist; weak medium and coarse subangular blocky structure; slightly hard, friable, nonsticky, nonplastic; few fine and medium roots; common very fine interstitial, few medium and fine tubular pores; neutral (pH 6.7); gradual smooth boundary. (5 to 16 inches thick)

B22 17-29"--Brown (7.5YR 5/4) very fine sandy loam, dark reddish brown (5YR 3/4) moist; weak coarse subangular blocky structure; slightly hard, friable, nonsticky, nonplastic; few fine and medium roots; common very fine interstitial, few medium tubular pores; neutral (pH 6.7); abrupt irregular boundary. (5 to 16 inches thick)

R 29"--Dark grayish brown (10YR 4/2) fractured hard metasedimentary rock.

Type Location: San Diego County, California; about 0.6 mile northwest of the intersection of Richland and Borden Road, 5 miles northwest of Escondido; approximately 2,800 feet southwest of the NW corner of sec. 1, T.12S., R.3W.

Range in Characteristics: Depth to hard metamorphic rock ranges from 20 to 42 inches. The A horizon ranges from dark brown through yellowish brown (7.5YR 4/4, 10YR 5/3, 5/4), brown through dark reddish brown (5YR 3/4, 3/3, 7.5YR 4/4, 5/4, 10YR 3/3, 4/3, 5/3) moist. It is medium to slightly acid. The B2 horizon ranges from pale brown through dark reddish brown (10YR 5/3, 6/3, 6/4, 7.5YR 5/6, 6/3, 6/4, 4/4, 5YR 3/4), dark reddish brown through dark yellowish brown (5YR 3/3, 3/4, 7.5YR 4/4, 10YR 4/4, 3/3, 3/4), moist. It ranges from silt loam to fine sandy loam, and is medium acid to neutral. A horizon 1/2 to 1 1/2 inches thick of silty clay loam with redder hue occurs in some pedons immediately above the lithic contact in areas where free water may migrate for long periods during the wet season.

Competing Series and their Differentiae: These are the Coarsegold, Friant, Vallecitos and Vista series. Coarsegold soils have an argillic horizon, and have a paralithic contact. Friant soils have a lithic contact at depths of 6 to 20 inches. [illegible]

Established Series
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VISTA SERIES

The Vista series is a member of the coarse-loamy, mixed, thermic family of Typic Xerochrepts. Typically, Vista soils have dark grayish brown and brown, neutral, coarse sandy loam A horizons and brown and yellowish brown, slightly acid, coarse sandy loam B2 horizons, and C horizons in residuum weathered from acid igneous rocks.

Typifying Pedon: Vista coarse sandy loam - annual pasture
(Colors are for dry soil unless otherwise noted.)

A11 0-3" -- Dark grayish brown (10YR 4/2) coarse sandy loam, dark brown (10YR 3/3 moist; moderate fine and medium crumb structure; soft, very friable; common fine roots; many very fine and fine pores; neutral (pH 6.7); abrupt smooth boundary. (2 to 4 inches thick)

A12 3-9" -- Brown (10YR 4/3) coarse sandy loam, dark brown (10YR 3/3) moist; weak fine and

A13 9-19" -- Brown (10YR 4/3) coarse sandy loam, dark brown (10YR 3/3) moist; weak fine and

Vista Series 2

Competing Series and their Differentiae: These are the Ahwahnee, Cieneba, Crouch, Escondido, Fallbrook, Garey, Greenfield and Saugus series. Ahwahnee and Greenfield soils have argillic horizons. Cieneba soils have weathered granite at depths of less than 20 inches. Crouch soils have mollic epipedons. Escondido soils have hard bedrock at depths of less than 40 inches. Fallbrook soils have argillic horizons that contain more than 18 percent clay. Garey soils formed in deep eolian deposits and have color value of 6 or 7 in the B horizon. Saugus soils lack cambic horizons and formed in unconsolidated sediments.

400 to 3,900 feet in southern California and at less than 3,500 feet elevation in central California. The climate is subhumid mesothermal. Average annual precipitation ranges from 10 to 18 inches, average January temperature from 47° to 58°F., average July temperature from 67° to 80°F., mean annual temperature from 59° to 65°F., and the frost-free season from 210 to 300 days.

Principal Associated Soils: These are the Bonsall, Las Posas, and Ramona soils and the competing Fallbrook, Greenfield, and Vista soils. Bonsall soils have fine-textured argillic horizons that are high in exchangeable sodium. Las Posas soils have dark red, fine textured argillic horizons, formed in deeply weathered gabbro. Ramona soils have reddish brown argillic horizons formed in granitic alluvium.

Drainage and Permeability: Well to somewhat excessively drained; slow to rapid runoff; moderately rapid permeability.

Use and Vegetation: Under irrigation, avocados and citrus are grown in areas of favorable temperature. A few small areas are used for growing winter truck crops. On areas of moderate relief, grain and hay are grown without irrigation. Range is a common use in areas that are not cultivated. The natural vegetation is annual grasses and forbs, and such shrubs as California sagebrush, scrub oak, lilac, chamise, sumac, and flattop buckwheat.

Distribution and Extent: Southern California and Sierra Nevada foothills. The soil is extensive.

Series Established: San Diego County (Oceanside Area), California, 1929.

Remarks: Vista soils were formerly classified as Noncalcic Brown soils.

Established Series
Rev. JLS/TBH/JMW/AJE
2/72

BRADSHAW SERIES

The Bradshaw series is a member of the loamy-skeletal, mixed, frigid family of Typic Haploxerolls. Typically, Bradshaw soils have dark grayish brown, mildly alkaline, very cobbly very fine sandy loam A1 horizons; brown, mildly alkaline, very cobbly very fine sandy loam B2 horizons, and brown, mildly alkaline, very cobbly loam C horizons.

Typifying Pedon: Bradshaw very cobbly very fine sandy loam - native vegetation (Colors are for air dry soil unless otherwise noted.)

A11 0-3"--Dark grayish brown (10YR 4/2) very cobbly very fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft, very friable, nonsticky, nonplastic; many fine roots; 60 percent angular cobbles and gravel; mildly alkaline (pH 7.5); clear wavy boundary. (2 to 10 inches thick)

A12 3-11"--Dark grayish brown (10YR 4/2) cobbly very fine sandy loam; very dark grayish brown (10YR 3/2) moist; weak medium granular structure; slightly hard, very friable, nonsticky, nonplastic; common fine roots; 50 percent angular cobbles and gravel; mildly alkaline (pH 7.5); clear wavy boundary. (8 to 12 inches thick)

B2 11-29"--Brown (10YR 5/3) very cobbly very fine sandy loam, brown (10YR 4/3) moist; very weak fine subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; 65 percent angular cobbles and gravel; soil mass is noncalcareous with few slightly calcareous pockets and thin lime coatings on some coarse fragments; mildly alkaline (pH 7.5); clear irregular boundary. (10 to 22 inches thick)

C1 29-40"--Brown (10YR 5/3) very cobbly loam, brown (10YR 4/3) moist; massive; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; 70 percent angular cobbles and gravel; noncalcareous with thin lime coatings on some coarse fragments; mildly alkaline (pH 7.5); clear wavy boundary. (10 to 15 inches thick)

C2 40-62"--Brown (10YR 5/3) very cobbly loam, brown (10YR 4/3) moist; massive; slightly

hard, friable, nonsticky, nonplastic; few fine roots; 80 percent angular cobbles and gravel; noncalcareous with thin lime coatings on some coarse fragments; mildly alkaline (pH 7.6).

Type Location: Wasatch County, Utah; 4.75 miles south of Heber "Y" in Daniels Canyon, 1/4 mile east up side of canyon on south-facing slope, 2,320 feet south and 1,600 feet east of the northwest corner of sec. 26, T.4S., R.5E.

Range in Characteristics: The mollic epipedon is 10 to 20 inches thick. The combined thickness of the A1 and B2 horizons ranges from 24 to 32 inches. The average texture of the 10- to 40-inch control section is very cobbly very fine sandy loam or very cobbly fine sandy

Bradshaw Series 2

Setting: Bradshaw soils are on slightly convex south-and west-facing, very steep mountain slopes at elevations of 6,000 to 8,000 feet. Slope gradients are 25 to 80 percent. The soils formed in residuum and colluvium derived from sandstone, quartzite, and minor amounts of limestone. The climate is moist subhumid continental; the average annual precipitation ranges from 20 to 26 inches, falling mostly as snow. The mean annual temperature ranges from 40° to 46° F., and the mean summer temperature ranges from 60° to 65° F. The frost-free period ranges from 80 to 100 days.

Principal Associated Soils: These are the Bezzant, Daybell, Gappmayer, Harkers, Henefer, Wallsburg soils. Bezzant soils have calcic horizons and are calcareous throughout. Daybell soils have mean annual temperature of less than 59° F. Gappmayer soils have albic horizons and very cobbly sandy clay loam argillic horizons. Harkers soils have gravelly clay argillic horizons. Henefer soils have cobbly clay argillic horizons. Wallsburg soils are less than 20 inches deep over bedrock and have very stony heavy clay loam argillic horizons.

Drainage and Permeability: Well-drained; medium runoff; moderate or moderately rapid permeability.

Use and Vegetation: These soils are used for range and grazing by livestock and wildlife, and for watershed. The present vegetation is big sagebrush, serviceberry, bitterbrush, oakbrush, bluebunch wheatgrass, Great Basin wildrye, western wheatgrass, yellowbrush, and cheatgrass.

Distribution and Extent: Mountain areas in Northern Utah. The series is moderately extensive.

Series Established: Sanpete Soil Survey Area, Utah, 1971.

Remarks: The Bradshaw soils were formerly classified as Regosols.

National Cooperative Soil Survey
U. S. A.

Tentative Series
Rev. JSC-AON
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FUEGO SERIES

The Fuego series is a member of the loamy-skeletal, mixed, frigid family of Typic Haploxerolls. Fuego soils typically have grayish brown, very stony or very gravelly sandy loam A and B horizons and pale brown very gravelly sandy loam C horizons. Sola contain small amounts of volcanic ash.

Typifying Pedon: Fuego very stony loam - rangeland
(Colors are for dry soil unless otherwise noted.)

A11 0-4"--Grayish brown (10YR 5/2) very stony sandy loam, very dark grayish brown (10YR 3/2) moist; weak thin platy and weak very fine granular structure; soft, very friable, nonsticky, nonplastic; common very fine roots; many very fine pores; slightly acid (pH 6.4); clear smooth boundary. (3 to 5 inches thick)

A12 4-6"--Light brownish gray (10YR 6/2) very gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; weak thin platy and weak very fine granular structure; soft, friable, nonsticky, nonplastic; common very fine roots; many very fine pores; neutral (pH 6.7); clear smooth boundary. (0 to 3 inches thick)

B2 6-16"--Grayish brown (10YR 5/2) very gravelly sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; soft, friable, nonsticky, nonplastic; common very fine roots; many very fine irregular pores; mildly alkaline (pH 7.4); gradual smooth boundary. (10 to 12 inches thick)

C 16-21"--Pale brown (10YR 6/3) very gravelly sandy loam, dark brown (10YR 3/3) moist; massive; soft, friable, nonsticky, nonplastic; common very fine roots; many very fine irregular pores; mildly alkaline (pH 7.4); abrupt irregular boundary. (5 to 20 inches thick)

IIR 21"--Layered felsite rock.

Type location: Klamath County, Oregon; southeast slope of Council Butte between villages of Sprague River and Beatty; 2,000 feet east of southwest corner sec. 15, T.36 S., R.11E.

Range in Characteristics: The soils are dry for 60 continuous days or more in summer, but are moist in some part between 8 and 24 inches over half the time soil temperatures are warmer than 41° F. Mean annual soil temperature ranges from 43° to 47° F. Pumice ash comprises 5 to 30 percent of the whole soil volume. Depth to bedrock ranges from about 20 to 40 inches. The section between 10 inches and bedrock is sandy loam or light loam, with about 35 to 60 percent coarse fragments. The upper part of the profile is slightly acid to neutral and the lower part is neutral to mildly alkaline. The mollic epipedon is 7 to 20 inches thick. The A horizon, when the upper 7 inches is mixed, has moist chroma of 2 or 3. The C horizon has value of 3 or 4 moist and chroma of 2 or 3 dry and 3 or 4 moist.

Competing Series and their Differentiae: These are the Bradshaw, Hartig, Mud Springs (T) and St. Marys series. Bradshaw, Hartig and St. Marys soils are deeper than 40 inches to bedrock. Also, St. Marys soils have hue of 2.5YR or 5YR in the B2 horizon. Mud Springs soils have B horizons that are hard or very hard when dry and have formed in granitic residuum.

Setting: Fuego soils are on gently sloping to hilly steep plug domes, tuff rings, and other volcanic landforms at elevations of 4,300 to 4,900 feet. They formed in detrital materials from andesite, other felsite rocks, and welded tuffs. The climate is semiarid with mean annual precipitation of 15 to 18 inches. The mean annual temperature is 43° to 45° F. and the frost-free season (28° F.) is about 70 to 75 days.

Principal Associated Soils: These are the Choptie, Ferguson, and Nuss soils. Choptie soils are shallow over volcanic tuff. Ferguson soils are deeper than 40 inches to bedrock and have less than 35 percent coarse fragments. Nuss soils are underlain by diatomite or tuff 10 to 20 inches deep and have light clay loam and heavy loam B2 horizons.

Drainage and Permeability: Somewhat excessively drained; medium to slow runoff; moderately rapid permeability.

Fuego Series 2

Use and Vegetation: Range, wildlife, and recreation. Principal native plants are big sagebrush, juniper, Idaho fescue, and bluebunch wheatgrass.

Distribution and Extent: South-central Oregon along the fringe of the pumice mantled zone. The series is inextensive.

Series Proposed: Klamath County (Klamath Indian Reservation Area), Oregon, 1957.

Remarks: The Fuego soils were formerly classified as Regosols intergrading to Chestnut soils.

National Cooperative Soil Survey
U. S. A.

Tentative Series
Rev. LHS/MEO/AJE
2/72

MUD SPRINGS SERIES

The Mud Springs series is a member of the loamy-skeletal, mixed, frigid family of Typic Haploxerolls. Typically, Mud Springs soils have dark grayish brown, slightly acid, cobbly coarse sandy loam A1 horizons; yellowish brown, slightly acid, very cobbly sandy loam B21 horizons; yellowish brown, slightly acid, very cobbly coarse sandy loam B22 horizons, underlain at depth of about 25 inches by granitic bedrock.

Typifying Pedon: Mud Springs cobbly coarse sandy loam - rangeland
(Colors are for dry soils unless otherwise noted.)

A11 0-6"--Dark grayish brown (10YR 4/2) cobbly coarse sandy loam, very dark brown (10YR 2/2) moist; weak medium platy structure that breaks to weak fine granular structure; soft, very friable, nonsticky, nonplastic; common fine roots; few fine and medium tubular pores; slightly acid (pH 6.3); clear smooth boundary. (3 to 6 inches thick)

A12 6-10"--Grayish brown (10YR 5/2) cobbly coarse sandy loam, very dark brown (10YR 2/2) moist; weak fine granular structure; slightly hard, very friable, nonsticky, nonplastic; common fine and few medium roots; few fine and medium tubular pores; slightly acid (pH 6.3); clear smooth boundary. (2 to 5 inches thick)

B21 10-17"—Brown (10YR 5/3) cobbly sandy loam, dark brown (10YR 3/3) crushed moist, dark brown (7.5YR 3/3) ped surfaces moist; moderate fine subangular blocky structure; hard, friable, slightly sticky, slightly plastic; few fine, medium, and large roots; few fine and medium tubular pores; some thin clay coatings on sand grains and bridges, slightly acid (pH 6.4); gradual wavy boundary. (5 to 14 inches thick)

B22 17-25"--Yellowish brown (10YR 5/4) very cobbly coarse sandy loam, brown (10YR 4/3) crushed moist, dark brown (7.5YR 4/3) ped surfaces moist; weak medium and fine subangular blocky structure; very hard, friable, slightly sticky, slightly plastic; few fine, medium and large roots; few fine and medium tubular pores; some thin clay coatings on sand grains and bridges; slightly acid (pH 6.3); gradual wavy boundary. (8 to 15 inches thick)

R 25"--Granite bedrock (partially weathered).

Type Location: Beaver County, Utah; about 3/4 mile northwest of Mud Springs in the Mineral Mountain range, sec. 30, T.28S., R.8W.

Range in Characteristics: The solum is 20 to 40 inches thick over bedrock. These soils are moist in some parts of the moisture control section more than 50 percent of the time the soil temperature is above 41°F., but are continually dry for more than 60 consecutive days during the summer months in more than 7 out of 10 years. The mean annual soil temperature at 20 inches is 43° to 45°F, the mean summer soil temperature at 20 inches is 60° to 61°F. The A1 horizon has value of 4 or 5 dry, 2 or 3 moist, and chroma of 2 or 3. It has weak thin or medium platy to weak fine granular structure. This horizon is soft or slightly hard, friable or very friable, nonsticky or slightly sticky and nonplastic or slightly plastic. It is slightly acid or neutral. The B2 horizon has hue of 10YR or 7.5YR, value of 4 through 6 dry and 3 through 5 moist, and chroma of 2 through 4. Value darker than 3.5 moist, 5.5 dry with chroma of 3 or less extends to a depth of 12 to 18 inches. The B2 horizon is coarse sandy loam to light loam with 20 to 60 percent cobbles, averaging 40 percent. It has weak or moderate, fine or medium subangular or angular blocky structure. This horizon is hard or very hard, and friable or firm. It is slightly acid or neutral.

Competing Series and Their Differentiae: These are the Bradshaw, Fuego (T), and St. Marys series. Bradshaw and St. Marys soils are deeper than 40 inches to bedrock. Fuego soils have soft B2 horizons. St. Marys soils have hue of 2.5YR or 5YR in the B2 horizon.

[illegible]

Mud Springs Series 2

Drainage and Permeability: Well-drained; rapid runoff; moderate or moderately rapid permeability.

Use and Vegetation: Used mainly for watershed, wildlife, and summer grazing by livestock. The present vegetation is curlleaf mountain mahogany, juniper, and big sagebrush.

Distribution and Extent: These soils occur in the Mineral Mountain area of Beaver County and possibly in other granitic areas of Utah. This series is inextensive.

Series Proposed: Beaver County (East Beaver Area), Utah, 1963.

Remarks: These soils were formerly classified as Chestnut soils.

National Cooperative Soil Survey
U. S. A.

Established Series
Rev. JLH/LW/MEO/AJE
2/72

ST. MARYS SERIES

The St. Marys series is a member of the loamy-skeletal, mixed, frigid family of Typic Haploxerolls. Typically, St. Marys soils have brown neutral gravelly loam A1 horizons, red mildly alkaline very cobbly heavy fine sandy loam B2 horizons, and red mildly alkaline very cobbly heavy fine sandy loam C horizons.

Typifying Pedon: St. Marys gravelly loam - rangeland
(Colors are for dry soil unless otherwise noted.)

A11 0-9"--Brown (7.5YR 4/3) gravelly loam, dark brown (7.5YR 3/2) moist; weak very fine granular structure; soft, very friable, slightly sticky; many fine and few medium roots; neutral (pH 6.8); clear wavy boundary. (7 to 10 inches thick)

A12 9-18"--Brown (7.5YR 4/3) very cobbly fine sandy loam, dark brown (7.5YR 3/2) moist; weak very fine granular structure; soft, very friable, slightly sticky; common fine and few medium roots; neutral (pH 7.2); clear irregular boundary. (5 to 10 inches thick)

B2 18-26"--Red (2.5YR 5/6) very cobbly heavy fine sandy loam, reddish brown (2.5YR 4/4) moist; weak medium subangular blocky structure; hard, very friable, slightly sticky; common fine and few medium roots; slightly calcareous, mildly alkaline (pH 7.6); gradual irregular boundary. (8 to 14 inches thick)

C 26-50"--Red (2.5YR 5/8) very cobbly heavy fine sandy loam, red (2.5YR 4/6) moist; weak medium subangular blocky structure; hard, very friable, slightly sticky; few fine roots; calcareous; mildly alkaline (pH 7.8).

Type Location: Salt Lake County, Utah; about 550 feet northwest along an azimuth of 25° north from the top of Big Mountain, about 2,450 feet south and 750 feet east of the northwest corner of sec. 6, T.1N., R.3E.

Range in Characteristics: The mollic epipedon is 9 to 20 inches thick. Depth to bedrock ranges from 40 to more than 60 inches. Coarse fragments are cobblestones, pebbles, and rounded stones that remain after the red calcareous cementing agent of the conglomerate rock has weathered away. Mean annual soil temperature is about 45°F., and mean summer soil temperature is about 62°F. The A1 horizon has hue of 7.5YR or 5YR, value of 4 or 5 dry and 2 or 3 moist, and chroma of 2 or 3. It has weak fine or very fine granular structure in the upper part, and some pedons have moderate medium subangular blocky structure in the lower part. This horizon is soft or slightly hard, and slightly acid or neutral. The B2 horizon has hue of 2.5YR or 5YR, value of 5 or 6 dry and 3 or 4 moist, and chroma of 4 through 6. It ranges from very cobbly or very gravelly fine sandy loam to very cobbly or very gravelly loam and contains 35 to 85 percent coarse fragments. This horizon has weak, fine or medium subangular blocky structure. It is slightly acid to slightly alkaline, and noncalcareous to slightly calcareous. The C horizon has hue of 2.5YR, 5YR, or 7.5YR, value of 5 or 6 dry and 4 or 5 moist, and chroma of 4 through 7. It has the same texture range as the B2 horizon. The C horizon is slightly acid to mildly alkaline and noncalcareous to moderately calcareous.

Competing Series and Their Differentiae: These are the Bradshaw, Burgi, Fuego, Gappmayer, Kilburn, Knutsen, Mud Springs, and Poleline series. Bradshaw soils have hue of 10YR or 7.5YR in the B horizon. Burgi and Poleline soils have mollic epipedons more than 20 inches thick. Fuego and Mud Springs soils have bedrock at depths of less than 40 inches. Gappmayer soils have albic horizons and very cobbly argillic horizons. Kilburn and Knutsen soils have hue of 2.5Y, 10YR, or 7.5YR in the B horizons and mean annual temperature of 47° to 54° F. Also, Knutsen soils have less than 35 percent by volume of coarse fragments in the control section.

Setting: St. Marys soils are on south, east, and west-facing slopes of mountains at elevations of 6,000 to 8,000 feet. Slope gradients range from 30 to 70 percent. These soils formed in residuum and colluvium mainly from red conglomerate composed of quartzite, sandstone, and limestone cemented by red material that is softer than other components. The climate is moist subhumid. The mean annual temperature ranges from 39° to 45°F., the mean summer temperature from 60° to 65°F., and mean annual precipitation from 20 to 26 inches.

Principal Associated Soils: These are the Anatone, Henefer, Lucky Star, and Wallsburg soils. Anatone soils have bedrock at depths of less than 20 inches. Henefer soils have argillic horizons

St. Marys Series 2

Drainage and Permeability: Well-drained; medium to rapid runoff; moderate permeability.

Use and Vegetation: Used for summer range, wildlife, and watershed. Vegetation is big sagebrush, snowberry, ninebark, wheatgrasses, fescue, and annuals, with oakbrush and widely spaced small aspen in some places.

Distribution and Extent: Northern Utah. The series is inextensive.

Series Established: Salt Lake Area, Utah, 1941.

Remarks: These soils were formerly classified as Brunizems.

National Cooperative Soil Survey
U. S. A.

CHAPTER 19

Application of the Taxonomy to Soil Surveys

Soil surveys are made at several intensities and for many purposes. The procedures, standards, and purposes are discussed in the Soil Survey Manual (Soil

the like, on the series or other taxa to identify the significant differences.

The polypedon is a group of contiguous pedons that

include interpretations for growth of plants, including crops, forage plants, trees, and ornamental shrubs. They include uses for town and country planning, highways, pipelines and other conduits, small buildings, fills, waste disposal, recreation, power lines, and so on.

Large-scale soil maps

properties of a soil series. When making a large-scale soil map, we are most commonly concerned with locating and plotting the boundaries of polypedons. These are physical boundaries in nature, but their location is a function of our concepts of the appropriate limits of the series.

We study a polypedon by sampling some of its pedons to determine to what series, defined or potential,

uated polypedons of the same series may need to be represented as one because of the limitations of map scale, and the delineation may need to include part of the polypedon of another series that lies between them.

Third, is the problem of identification of each polypedon. Involved in the identification are several possible errors. One is determination of the size of the pedon. Ideally this requires a trench, but in practice we commonly dig with an auger or a spade at frequent intervals. Next is the inherent error of determination of properties by sampling, which includes determination of the number of pedons of each kind that must be studied to yield reliable conclusions. And finally, there is error in the accuracy of estimation or measurement of the diagnostic properties of the samples. Two separate samples of the same horizon in the same pedon commonly differ in one or more properties by more than the probable error of laboratory determinations. Even duplicate subsamples from the same sample yield different values, but confidence limits known to the laboratory workers permit reasonable interpretation of the data.

Using accessory tactile or visible properties leads to errors in field estimation of invisible properties, such as the nature and amount of clay, content of organic matter, base saturation, and so on. These errors are even greater than those of laboratory determinations and vary with the kind of soil and the skill of the mapper.

The uncertainty, however, is not unusual in science, which continually struggles with the question of "how much." The factors that control soil genesis do not change capriciously in the landscape. We have reason to believe that closely situated pedons are similar unless we see some reason why they should differ. We quickly learn, in mapping, that there is usually a pattern to the distribution of pedons of a certain kind and that the pattern is related to the soil-forming factors. Adjacent polypedons usually have many common properties that are the result of similarity in the factors that control their genesis. Usually at the boundary of a polypedon there has been or is a change in only one or two of the soil-forming factors. Because there are many similarities in the soil-forming factors in a given landscape, adjacent polypedons commonly are related in the taxonomic system.

Because series have ranges in their properties, most polypedons can be identified with reasonable accuracy even though the locations of some boundaries may be obscure. But if a polypedon has properties near the limit between two series, the errors of observation and estimation become very important to identification. One attempted solution to the problem of borderline polypedons has been to establish a third series that is transitional between the other two. This only transfers the problem to other areas and makes two even more difficult boundaries to locate where previously there was only one. The solution to the problem of borderline polypedons lies in selecting a name for the delineated area that most accurately reflects the properties and the behavior of the soil in line with the purposes of the soil survey. The name chosen for a mapping unit may be a phase of a series or of a taxon in a higher category, a complex of two or more series, an association of two or more series, or a combination of two or more undifferentiated series, depending on the nature of the soils and significance of the variability within the delineated areas for the objectives of the surveys.

We have pointed out that the taxa are conceptual, that the polypedons are real, and that at best our representations of the polypedons are imperfect. The taxa and the units shown on the map are two different things that we must not confuse even though they carry the same name. It is not unusual for a given word to have several meanings, but we must make clear which meaning is intended. The standards for naming the mapping units within a soil survey have changed in the past and can be expected to change in the future. It is not our purpose here to define these standards but rather to discuss the factors that should be considered in selecting a name.

The purpose of the survey must be considered. Surveys of soils in native range, soils used for extensive dryland farming, and soils intended for irrigation are commonly made at different scales. A narrow, steep area that would be disregarded in a survey of an area used for grazing native plants would normally be shown by spot symbols in a survey for rainfed farming if it impedes the use of machinery, and it should be delineated by some means on the map if the area is intended for irrigation.

The nature of the variability of the soil within a delineation and the importance of the variations to planning the probable uses of the soil must be considered. A variation in one or more properties in part of a delineation becomes important if it affects responses to management for growing plants, engineering manipulation, or other uses that require significant investment. Inclusions of polypedons that have obviously different properties and responses must be tolerated in some delineations that are named as phases of series.[1] If such inclusions are extensive enough to influence the foreseeable uses significantly, the presence of the contrasting soils should be indicated in the name given the mapping unit or by defined *ad hoc* symbols.

Not all differences between series are obvious. The limit between fine-loamy and fine particle-size classes is a clay content of 35 percent. The experienced mapper has little difficulty in distinguishing between a clay content of 30 percent and one of 40 percent. A distinction between 34 percent and 36 percent, however, can be made only in the laboratory. If this is the only difference, the distinction is not important for most uses of the soil map. The delineation could be named for either of the two series that have a common conceptual boundary at 35 percent clay without serious consequences. Many decisions must be made on borderline delineations if the differences are no greater than the normal errors of observation of the

[1] Present standards permit inclusions up to 10 percent of a single strongly contrasting series and an aggregate of 15 percent of strongly contrasting series in areas too small to be delineated separately, at the scale of mapping, in delineations named as a phase of a series.

erties is wrong by these normal errors, the inclusions that result do not seriously affect the use of the map if the mapping units are defined to allow for the possible errors.

Any kind of soil has many interacting properties. Near a boundary between two kinds of soil that vary only a little in one or more properties, judgment must be tempered by comparing the combination of all the properties of each soil with the expected functioning of that soil under the significant alternative uses that can be expected. An appreciable proportion of inclusions in a delineation can be tolerated if they consist of soils that have properties combining to give responses to management for growing plants and engineering manipulations similar to those of the series for which the delineation is named.[2]

The purpose of using names or symbols of series or other taxa to identify delineations on a soil map is to help the user of the map remember or ascertain the qualities and properties important to the use of that soil or to locate the interpretations that are important to his intended uses of it. If the name or symbol applied to the representation of a particular polypedon misleads a user, it is clearly wrong. If the name and interpretations do not mislead him, no harm is done by including other polypedons in the delineation. This is the basic test of the name, not simply the percentage of inclusions.

In situations where series have not been defined, polypedons or other delineations shown on large-scale maps can be named as taxa in a family or a higher category. Use of the family rather than the series category has little effect on the detail of the map or the

phases of taxa because areas large enough to delineate mainly include two or more taxa. Soil variability in nature determines this.

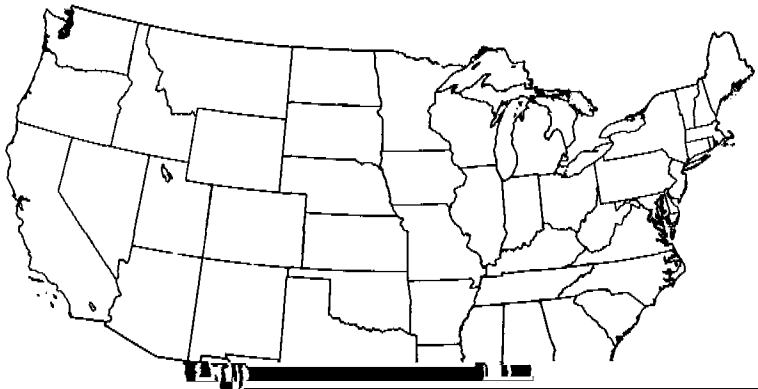
Small-scale soil maps of individul survey areas in published soil surveys in the United States have scales that range from about 1:100,000 to 1:250,000, and map units usually have been named as associations of phases of series. Soil maps of states, at a scale of about 1:1,000,000 as a rule, also have had legends in which the units are associations of series. The almost exclusive use of series names on state and county maps has been due, at least in part, to the lack of suitable taxa in higher categories in earlier classifications.

Associations of series usually have been named in terms of the two or three most extensive series. Such names may create an erroneous notion of uniformity in the minds of lay users. Typically, areas of such associations contain many other series, most of which are related to the named series through taxa of higher categories. The name of an association, like the name of a series on a large-scale map, should be chosen to convey an idea of the most important soil properties.

In making small-scale maps, there is a trend toward naming the map units as phases of soil families, subgroups, or great groups and then organizing these units in the legend into a small number of groups. The primary reason for this practice is that the number of associations of series on a state map commonly is too great for a user to comprehend. The smaller number of map units, formed by naming phases of taxa in categories higher than the series, makes the map more easily understood. Colors on the map corresponding to

ciations named as phases of great groups probably carry the maximum information possible. Phases of associations of suborders may be the most useful for soils of several orders, particularly Aridisols and Vertisols. Histosols in many parts of the country can be named at that scale only at the order level because the individual areas are small and complex. There is no reason why map units on a single map must all carry names of taxa from the same category. The general rule should be that the names should be those that relate best to the properties or interpretations of the soils of the delineated areas.

If the map scale is 1:20,000,000 or smaller, map units at mixed categoric levels probably provide the greatest potential for interpretations. At such a small scale, most of the soil properties that can be reliably represented are those that are related to major climatic differences. These properties are reflected at the order level in Aridisols, at the suborder level in Alfisols, Mollisols, Oxisols, Ultisols, and Vertisols, and at the great group level in the other four orders. Because of the construction of the system, maps at very small scale require a mixture of categoric levels to depict the few properties that are common to the soils of regions large enough to be delineated. In each map unit, at least one name in the association should establish geographic limits to the map unit that coincide roughly with broad kinds of climate and vegetation.



The general soil map (fig. 41) shows the geographic distribution of the major kinds of soil in the United States at a scale of approximately 1:20,000,000 except for Alaska and Hawaii.

This map is mainly a generalization of a map compiled in 1967 by the Soil Conservation Service at a scale of 1:7,500,000 for inclusion in the National Atlas of the United States of America. A number of modifications, however, have been introduced; these are based on data not available in 1967.

Each of 59 map units consists of phases of taxa and

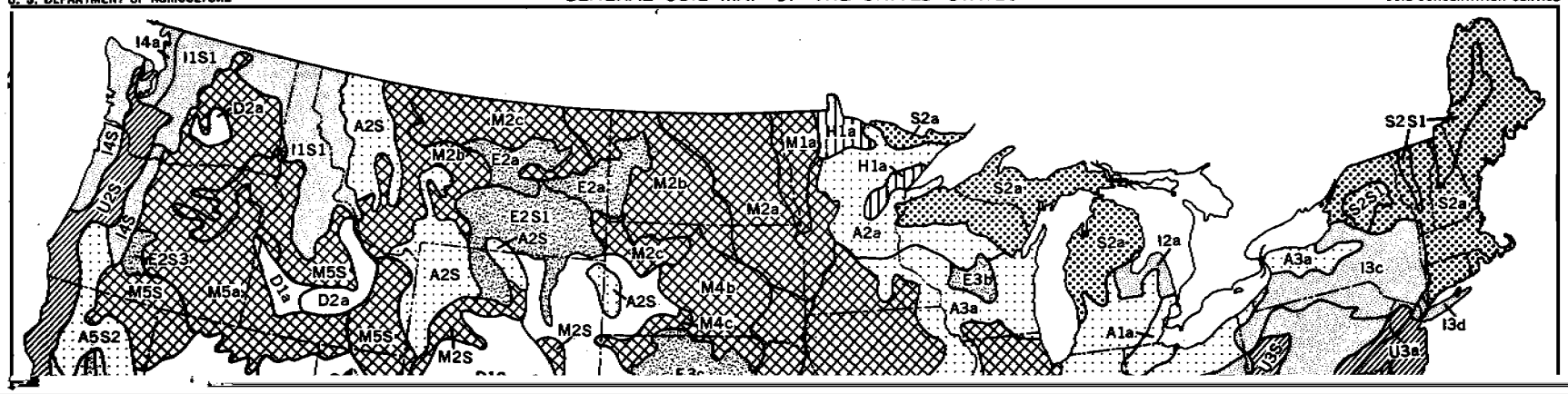
in mountainous regions, however, they developed in residuum weathered from the bedrock.

In the northern part of the country, where the soil temperature regime is frigid, Alfisols lie between Mollisols on the west and Spodosols on the north and east. South of this region, in the Midwest where the soil temperature regime is mesic, Alfisols are between Mollisols on the west and Inceptisols on the east. In the southwestern part of the country, where the soil temperature regime is thermic, Alfisols are between Aridi-

U. S. DEPARTMENT OF AGRICULTURE

GENERAL SOIL MAP OF THE UNITED STATES

SOIL CONSERVATION SERVICE



ALFISOLS

Aqualfs

A1a–Aqualfs with Udalfs, Haplaquepts, Udolls; gently sloping.

HISTOSOLS

Histosols

H1a–Hemists with Psammaquents and Udipsamments; gently sloping.

H2a–Hemists and Sapristes with Fluvaquents Ustipsamments, Ustorthents, Ustochrepts, Aquolls, and Usterts; gently or moderately sloping.

M4c–Aridic subgroups of Ustolls with Ustalfs, Orthids, Ustipsamments, Ustorthents, Usto-

on river terraces and level coastal plains. Here the Aqualfs include Albaqualfs that have a claypan, Ochraqualfs, and Glossaqualfs. Rice is the principal crop grown.

The Aqualfs in northwestern Ohio and southeastern Michigan are dominantly Ochraqualfs that developed in lacustrine sediments and till on nearly level plains. Most of these soils have a mesic soil temperature regime. Haplaquepts are the principal associated soils. This is an important farming area in which maize (corn), winter wheat, soybeans, and hay are the major crops. Sugar beets and canning crops are also important.

The Aqualfs in southern Illinois and in northeastern Missouri developed in a loess mantle of variable thickness that is underlain by glacial till. These Aqualfs also have a mesic soil temperature regime. In these areas, Udalfs are the principal associated soils. The dominant topographic features are nearly level to gently sloping plains with shallow and mostly narrow valleys and dissected plains with narrow ridgetops and steep ridge slopes and valley sides. The stream valleys in the dissected plains range to about 100 feet lower than the adjoining uplands. The Aqualfs in Illinois are mostly Albaqualfs and Natraqualfs, and those in Missouri are mostly Albaqualfs. The Aqualfs are on the nearly level to gentle slopes and on the narrow ridgetops. Udalfs are on the more sloping uplands and on the hilly valley sides. Maize (corn), winter wheat, soybeans, other feed grains, and hay for dairy cattle and other livestock are the principal crops.

The Aqualfs in southwestern Missouri developed in residuum weathered from sandstone, shale, and limestone and some added loess on gently sloping to rolling dissected plains. The soil temperature regime is mesic. Udolls are the principal associated soils in this area. The Aqualfs, most of them Albaqualfs, are on the nearly level to gentle slopes, and the Udolls are on the stronger slopes.

Boralfs

Boralfs are the more or less freely drained Alfisols of cool places. These soils in the United States have a frigid or cryic soil temperature regime and in most places a udic soil moisture regime. Although the amount of soil moisture is adequate for crops, a short, cool growing season and steep slopes in some places impose severe restrictions on farming. Boralfs are moderately extensive in the United States as dominant soils on the landscape. They are most extensive in Wisconsin, Minnesota, the Black Hills section of South Dakota and Wyoming, and in both the northern and the southern sections of the Rocky Mountains. They also occur either as associated soils or as inclusions in areas that have Udipsamments and Orthods.

The Boralfs in Minnesota and Wisconsin occupy an area north of the Udolls and Udalfs, between the Borolls on the west and the Orthods on the east (map unit A2a). Udipsamments and Histosols are the principal associated soils. The Boralfs in this area have a frigid soil temperature regime. They developed in glacial drift on level to rolling till plains that are broken in some places by outwash plains and low moraines. The northern part consists mostly of calcareous glacial till and silty and clayey lacustrine sediments on rolling plains. Here the Boralfs are mostly Eutroboralfs. Elsewhere, the drift consists mostly of noncalcareous till, and in some places there is a thin mantle of loess. The Boralfs in those parts of the area are mostly Glossoboralfs. Histosols associated with the Boralfs are in narrow to broad, low-lying, wet areas, and the Udipsamments are on nearly level outwash plains and terraces. Many of the Boralfs are in forests. In the northern part of the area, forage for livestock is the principal crop. Elsewhere, small grains and forage crops are grown.

The Boralfs in the Black Hills are mostly Eutroboralfs and Cryoboralfs. Those in the northern and southern sections of the Rocky Mountains are mostly Cryoboralfs and are on forested, steep and hilly mountain slopes (map unit A2S). The principal soils associated with Boralfs in the Black Hills are Borolls. The soils of both these suborders are on grass- and shrub-covered, hilly to steep foot slopes, and some are on gently sloping, narrow ridgetops. About half the soils on foot slopes are used for grazing by cattle and sheep.

The Cryoboralfs in the Rocky Mountains are in a belt between the Cryoborolls on the lower, grass-covered slopes and Cryorthods and Cryochrepts on the higher, forested slopes. Rock outcrops are common. Most of the Cryoboralfs are in forests. Most of the areas of grassland and much of the more open woodland is grazed. In the broader mountain valleys of the northern Rocky Mountains, potatoes, sugar beets, and peas are grown under irrigation.

Udalfs

Udalfs are the brownish or reddish, more or less freely drained Alfisols that have a udic moisture regime and a mesic or thermic soil temperature regime. They are the dominant soils on the landscape in areas of moderate extent in the United States. They are most extensive in New York, Ohio, Indiana, Kentucky, Michigan, Wisconsin, Minnesota, Missouri, Iowa, Illinois, Arkansas, Tennessee, Louisiana, and Mississippi (map unit A3a). They also occur either as associated soils or as inclusions in areas that are dominantly Aqualfs, Aquepts, Udolls, and Udults.

Most of the Udalfs in the United States developed in late-Pleistocene materials on gentle or moderate slopes.

The most extensive of the late-Pleistocene deposits, those in New York, western Ohio, Indiana, Michigan, and Wisconsin, are glacial drift on nearly level to rolling till plains. The Udalfs in these places have a mesic soil temperature regime and are mostly Hapludalfs. The principal associated soils are Aquolls and Aqualfs. Both these kinds of soil occur in flat or depressional wet areas and most of these soils have been artificially drained and are being successfully used for general farm crops. On dissected and gently rolling till plains in northeastern Ohio, most of the Udalfs have a fragipan and are Fragiudalfs; these soils have a mesic soil

temperature regime. Aqualfs in low-lying wet areas are the principal associated soils in that section.

The Udalfs in southwestern Wisconsin, southeastern Minnesota, eastern Iowa, southern and western Illinois, northeastern, central, and southeastern Missouri, southern Indiana and Ohio, northeastern Arkansas, western Kentucky, southwestern Tennessee, southeastern Louisiana, and western Mississippi developed in loess of variable thickness that is underlain by glacial drift, by limestone or sandstone and shale, or by marine sediments. These areas are dissected and have steep slopes along the edges of stream valleys. The upland divides are either narrow and rolling or broad and undulating. The Udalfs in southwestern Wisconsin, southeastern Minnesota, western Illinois, eastern Iowa, and eastern, central, and southeastern Missouri are mostly Hapludalfs, and they are on the slopes along the valleys and drainageways. They have a mesic soil temperature regime. The principal associated soils there are Udolls, which are on the narrow ridgetops and broad, level to undulating uplands. Most of these Udolls are Argiudolls. On some of the narrow ridgetops in Missouri, some of the Udalfs have a fragipan and are Fragiudalfs. Inceptisols are extensive on steep slopes in those places where the loess mantle is thin.

Most of the Udalfs in southern Indiana and Ohio, northeastern Arkansas, southwestern Tennessee, southeastern Louisiana, and western Mississippi have a fragipan and are Fragiudalfs. The principal associated soils in those sections are Aqualfs, but in Arkansas, Tennessee, and Mississippi, especially where the loess mantle is thin, there are Udults. All these soils in Indiana and Ohio have a mesic soil temperature regime. Elsewhere, the soil temperature regime is thermic.

The Udalfs in the Bluegrass Region of Kentucky and in the Nashville Basin of Tennessee developed on gentle to moderate slopes in residuum weathered from limestone. These Udalfs in Kentucky have mostly a mesic soil temperature regime, and those in Tennessee have mostly a thermic regime and include both Hapludalfs and Paleudalfs; the Paleudalfs are in areas of deeply weathered phosphatic limestone. Associated with these Udalfs are Udults and, on the steep slopes, Udolls and Rendolls.

Feed grains, mainly maize (corn) and soybeans, and hay, forage, and pasture are the principal crops on the Udalfs. Tobacco is an important cash crop in the Bluegrass Region of Kentucky.

Ustalfs

Ustalfs are the mostly reddish Alfisols of warm, subhumid to semiarid regions. Most of these soils have an ustic soil moisture regime. Their soil temperature regime in the United States is mostly thermic, but the regime in the southern part of Texas is hyperthermic. The areas in which Ustalfs are the dominant soils on [illegible] Ustalfs also occur as associated soils or as inclusions in areas of soils in ustic great groups of Entisols and Inceptisols and in ustic suborders of Mollisols and Vertisols.

The Ustalfs in east-central Texas are Haplustalfs and Paleustalfs, and most of them have nearly level or gentle slopes. In north-central Texas and in Oklahoma, the principal soils associated with the Ustalfs are Lithic Ustochrepts. In these areas peanuts, winter wheat, grain sorghum, and cotton are the main cash crops.

The soils associated with the Ustalfs in southeastern Texas are mainly Ustolls and Usterts. Here, nearly all the Ustalfs are in range of native grasses that is grazed by beef cattle.

The Ustalfs in northern and western Texas and in northeastern and southeastern New Mexico are mostly Paleustalfs. The topography consists dominantly of gently sloping plains that are bordered by very steeply sloping breaks along the major rivers. Ustolls, Ustipsamments, and Ustorthents are the principal associated soils. Ustorthents occur mostly on the steeper slopes. The more sloping parts of these areas are in range of native grasses and shrubs that is grazed by beef cattle. The smooth uplands are dry-farmed to cotton and grain sorghum.

Xeralfs

Xeralfs are the mostly reddish Alfisols that have a xeric moisture regime. These soils are dry for extended periods in summer. Xeralfs are of moderate extent as dominant soils on the landscape in the United States. They are on moderate to steep slopes of foothills and low mountains in central and southern California (map unit A5S1). Their soil temperature regime is mainly thermic. The most extensive of these Xeralfs are Haploxeralfs. The principal associated soils, also on steep slopes, are Xererts and Lithic Xerorthents. Most of these Xeralfs are in native and tame grasses or have a sparse to thick cover of shrubs. They are used mostly for grazing, but some are irrigated and produce mostly horticultural crops.

The Xeralfs of the Sierra Nevada are mostly in ultic subgroups (map unit A5S2). There are many also that are in lithic subgroups. The principal associated soils include Andepts, Xerults, Xerolls, and Xerochrepts, all steep. The soil temperature regime varies with the altitude and ranges from mesic to cryic. Practically all these soils are in forests.

Aridisols

The Aridisols are soils that do not have water available to mesophytic plants for long periods. Aridisols are extensive in the United States and are the dominant soils in areas that are mostly west of the 101st

have a moisture regime that is marginal to ustic or xeric.

Most of the Aridisols, unless they are irrigated, are used for grazing by cattle and sheep. Soils in the typic subgroups receive a small amount of precipitation that is distributed somewhat evenly throughout the year, commonly about 1.25 cm per month. They produce low yields of herbage, and grazing on them is restricted mostly to short periods. Soils in ustollic, borollic, and xerollic subgroups receive more moisture and can produce higher yields of herbage than soils in the typic subgroups. Aridisols that have a moisture regime marginal to ustic have mostly summer precipitation, commonly 2.5 cm or more per month in June, July, and August and can be grazed in summer. Aridisols that have a moisture regime marginal to xeric have precipitation mostly late in fall and in winter, commonly 2.5 cm or more per month in November, December, January, and February. They are commonly grazed in spring or winter, but in some years they can also be grazed in fall if the rains begin early and the temper-

luvial fans and terraces; Salorthids in the salt and alkali basins; and soils in torric great groups of Fluvents and Orthents on the flood plains and the younger alluvial fans.

The Argids in southern California, southern Arizona, and southwestern New Mexico are mostly in typic subgroups. They are on the older alluvial fans and terraces and in the better drained basins, and soils in some ustollic subgroups are in the low wide basins and floodways. The soil temperature regime is mostly thermic or hyperthermic. Associated soils are steep Torriorthents and also soils in typic and ustollic subgroups of Orthids, which are with the Argids on the older alluvial fans and terraces and in the better drained basins, and soils in torric great groups of Psamments, Fluvents, and Orthents on the flood plains of the large rivers. Most of these Argids have a desert shrub vegetation of species of creosotebush, cactus, mesquite, yucca, and muhly grass. These soils are used mostly for grazing, but where slopes are suitable and water is available they produce a wide variety of irri-

The Orthids are most extensive on gentle or moderate slopes of broad basins, loess-mantled lava plains, plateaus, and mesas (map unit D2a).

The Orthids in western Texas, in southeastern and south-central New Mexico, and in central and southern Arizona developed in highly calcareous materials on the floors of broad basins and on fans and terraces. Here, the Orthids are mostly those of typic or ustollic subgroups. The soil temperature regime is thermic. The principal associated soils include soils in typic subgroups of Argids and also Torriorthents on the strong slopes of fans and terraces and on the steep slopes of the mountains that have a north-south trend. The area east of the Pecos River includes extensive areas of sandy Ustalfs.

The Orthids in southern Utah and in south-central Idaho are mostly on gentle slopes and developed either on alluvial fans or in a thin to moderately thick man-

Aquents are of relatively minor extent as the dominant soils on the landscape in the United States. They are most extensive on the lower coastal plain in southern Florida (map unit Ela). They also occur either as associated soils or as inclusions in areas that are dominantly Aquepts, Aquods, or Fibrists and Saprists.

The Aquents in southern Florida developed in marine sands under the influence of a very shallow water table and are classified in the great groups of Psammaquents and Haplaquents. Their soil temperature regime is hyperthermic. The principal associated soils include Aquods on sandy flats, Aquolls, and Quartzipsamments on old beaches and dunes. Extensive areas of Aquepts are included in this area of Psammaquents. Large areas of the Psammaquents are in broad, open flats and some are in marshes or swamps. With adequate water control, the Psammaquents are used for growing truck crops, citrus fruits, and pasture

are dominantly in xerollic subgroups; many of them have a calcic horizon. Their soil temperature regime is mesic. The principal associated soils include soils in aridic subgroups of Xerolls, which also developed in loess, and Xerorthents or Xerofluvents on the lower, younger fans and on the flood plains. Extensive areas are irrigated, mainly on the plains bordering the Snake River. Potatoes, grain, sugar beets, beans, and hay are the principal crops.

The Orthids in central Washington are on the gentle slopes of terraces, alluvial fans, and flood plains. They developed mostly in loess, volcanic ash, and alluvium. Here, the Orthids are dominantly those of xerollic subgroups. Their soil temperature regime is mesic. The principal associated soils are Xerolls. These Orthids are used mostly for irrigated crops and for grazing.

Soils in lithic subgroups of Orthids and Torriorthents (map unit D2S) are the dominant soils on the

Orthents

Orthents are mainly the Entisols on recent erosional surfaces. They are the dominant soils on the landscape in areas of moderate extent in the United States. They are most extensive in North Dakota, Montana, Colorado, Arizona, Utah, New Mexico, and Texas. In these places, the soil moisture regime is either ustic or torric, and the soil temperature regime is frigid, mesic, or thermic. Although these Orthents range from gently sloping to steep, the most extensive of them have moderate or steep slopes. These soils occur also as associated soils or as inclusions in areas that are dominantly Argids, Orthids, Ustalfs, Xeralfs, Udolls, Ustolls, or Xerolls. Most of the Orthents have a cover of native grasses, shrubs, trees, or a mixture of these and are used for grazing by cattle and sheep or for forestry.

The Orthents in southwestern North Dakota, in east-

shallow to rock (map unit E2S1). The soil temperature regime is mostly mesic, although in some parts of Montana the regime is frigid, and in western Texas it is thermic. In New Mexico and western Texas, many of the Torriorthents are in highly calcareous materials on terraces and on foot slopes below escarpments. The principal associated soils, which are mostly on the more gentle upland slopes, include soils in both typic and ustollic subgroups of Argids. In Montana, the principal associated soils on the more gentle upland slopes also include soils in aridic subgroups of Borolls. Other associated soils include Torrifluvents on the flood plains, terraces, and younger alluvial fans. These associated soils are important because they are cropped intensively wherever water is available for irrigation and the soils are not affected by salts.

The Torriorthents in southwestern Texas are on gentle to moderate slopes of a dissected plateau and are shallow over limestone (map unit E2b). The principal associated soils are Torrerts on the nearly level upland surfaces. In the eastern part of the area in Texas, Ustorthents rather than Torriorthents are in the residuum weathered from limestone on the more sloping parts of a dissected plateau. These Ustorthents are shallow to rock and have a thermic soil temperature regime. Here, the principal associated soils are Usterts on nearly level uplands and in the valleys.

The Orthents in the Sacramento and San Joaquin valleys of central California have a xeric soil moisture regime and are included in the great group of Xerorthents. They are on the gentle slopes of nearly level valleys and broad basins (map unit E2c). Their soil temperature regime is thermic. The principal associated soils are Xeralfs, including both Durixeralfs and Palexeralfs, on the gentle slopes of alluvial fans and slightly dissected terraces. Extensive areas of Aridi-

associated soils are Cryopsamments and Cryandepts. Most of these soils are in forests.

Psamments

Psamments are the dominant soils on the landscape in areas of relatively minor extent in the United States. They are most extensive in Florida, Wisconsin, Nebraska, and Texas. The soil moisture regime in those places is udic, ustic, or xeric, and the soil temperature regime is mesic, thermic, or hyperthermic. Psamments also are present as associated soils or as inclusions in areas of Boralfs, Ustalfs, Aquolls, Aquods, Orthods, Aquults, and Udults. Psamments are characterized by low water-holding capacity and rapid permeability. Irrigation and added plant nutrients are commonly needed for sustained production of crops.

The Psamments in Georgia, Alabama, and Florida developed in thick to moderately thick deposits of cover sand. They have a sand fraction that is 95 percent or more quartz or other normally insoluble minerals, and they are included in the great group of Quartzipsamments (map unit E3a). These soils have a udic soil moisture regime.

The Quartzipsamments in Georgia and Alabama are on gentle and moderate slopes of the dissected coastal plain. The soil temperature regime is thermic. The principal associated soils also have characteristics that are related to the nature of the cover sands. The associated soils are in psammentic and arenic or grossarenic subgroups of Ultisols. These Quartzipsamments are mostly in woodland where the vegetation consists of pine trees and shrubs.

Some of the Quartzipsamments in Florida are on a limestone upland that has a mantle of sand. Most of them, however, are on moderate slopes in sand deposits of the coastal plain. The sand is mostly acid, and

seriously reduced. Irrigation is now widely used for high-value truck crops.

The Psamments in Nebraska and in southern Texas have an ustic soil moisture regime and a sand fraction similar to that of the Udipsamments. These Psamments are included in the Ustipsamments (map unit E3c). Those in Nebraska are on gentle or moderate slopes of stabilized old sand dunes; their soil temperature regime is mesic. Here, the principal associated soils are Aquolls in depressions among the dunes. These Ustipsamments are mostly in native grasses and are grazed by livestock in spring and summer.

The Ustipsamments in Texas are on the gentle or moderate slopes of an undulating to rolling coastal terrace. The sands have mostly been reworked by wind. The soil temperature regime is hyperthermic. Here, the principal associated soils are in arenic or grossarenic subgroups of Ustalfs. These Ustipsamments are used mainly for summer grazing.

Histosols

Histosols are dominant soils on the landscape in small sections of the United States. They are most extensive on the broad lake plain in northern Minnesota, where the soil temperature regime is frigid, and on the low coastal plain in Florida and in Louisiana, where the soil temperature regime is hyperthermic or thermic. The soil moisture regime is peraquic. Histosols also occur either as associated soils or as inclusions in areas of Psammaquents, Aquults, Cryaquepts, and Orthods.

The Histosols in northern Minnesota are on broad level areas of wet uplands, on lake plains, and in depressions (map unit H1a). These Histosols are Hemists, and they consist largely of moderately decomposed plant remains that are not completely broken down by rubbing. The mean annual soil temperature is lower than 8° C (47° F) and, although the upper layers of soil are frozen in winter, the ice melts completely during summer. These Hemists are in the great group of Borohemists. The principal associated soils are Udipsamments on the better drained and higher lying areas and Psammaquents in the low wet areas. Most of the Hemists have vegetation of sedges or water-tolerant grasses. Frost is a serious problem when cultivated crops are grown.

The Histosols in Louisiana are on the flat deltaic plain of the Mississippi River (map unit H2a). Some of them, in which the organic materials have been partly decomposed, are in the suborder of Hemists. Others, in which the organic materials are almost completely decomposed, are in the suborder of Saprists. The great groups are Medihemists and Medisaprists. The principal associated soils are Fluvaquents and Haplaquepts. Most of these Histosols are covered with either fresh-water marsh grasses or salt grasses.

The Histosols in southern Florida are on the level low coastal plain (map unit H3a). These Histosols are in the great groups of Medifibrists, Medihemists, and Medisaprists. The principal associated soils are Psammaquents and some Aquolls and Aquods. Some of these Histosols are covered with water-tolerant grasses, reeds, sedges, and other aquatic herbaceous plants. Others have been drained and are producing winter vegetable crops.

Inceptisols

Inceptisols, like the Entisols, are the dominant soils on the landscape in large areas of gentle to steep slopes in widely separated humid parts of the United States. The Inceptisols in the United States are most extensive in Alaska and on steep slopes of mountainous landscapes. The soil temperature regime is cryic, mesic, thermic, hyperthermic, isomesic, isothermic, or isohyperthermic; the soil moisture regime is aquic, udic, ustic, or xeric.

The Inceptisols present a variety of management problems to farming activities. Most of them are on slopes too steep for general farm crops, are wet, or are in cold regions and are underlain for the most part by permanently frozen ground. Some Inceptisols must be artificially drained before they can be used for farm crops; some are highly responsive to intensive fertilization and supplemental irrigation; and some have a fragipan, which limits moisture storage and restricts root development.

Andepts

Andepts are the more or less freely drained Inceptisols that formed in ash, pumice, or other pyroclastic materials, either fresh or reworked. They are rich either in glass or in allophane, which is an amorphous clay. Andepts are of relatively minor extent as the dominant soils on the landscape in the United States. They are most extensive in north-central and northeastern Washington, Idaho, northwestern Montana, southwestern Alaska including the Aleutian Islands, and the island of Hawaii. Andepts also occur either as associated soils or as inclusions in areas of Haplumbrepts, Orthods, and Humults.

The most extensive Andepts have a cryic soil temperature regime and are in the great group of Cryandepts. The Cryandepts in peninsular and coastal Alaska and on the Aleutian Islands are on gentle to steep slopes and developed in stratified volcanic ash that is underlain by extrusive rocks (map unit I1a). Here, the principal associated soils are Cryaquepts and soils in cryic great groups of Histosols on the wet lowlands. Rock outcrops are extensive. These Cryandepts have mostly vegetation of tall grass and associated forbs and shrubs used for grazing or are in forests. A few are used to produce forage and also some hardy vegetables.

The Cryandepts in Washington, Idaho, and Montana are on ash-covered, steep mountain slopes (map unit I1S1). Most of these Cryandepts are in forests. The principal associated soils are Cryumbrepts in the Cascade Mountains and Cryochrepts in the northern Rocky Mountains. Small areas of Cryorthods are present in both parts of this map unit.

The Andepts on the island of Hawaii developed from recent ash and cinder deposits on moderate to

steep mountain slopes (map unit I1S2). The soil temperature regime is isomesic, isothermic, or isohyperthermic. Most of these Andepts are Dystrandepts, but some are Eutrandepts, Vitrandepts, and Hydrandepts. The soil moisture regime is mostly udic but in the northwestern part of the island, where the Eutrandepts are extensive, it is ustic. Tropofolists are common inclusions in the most humid areas. Other inclusions in this unit of Andepts are Tropepts and Ustolls on the northwestern tip of the island and Tropohumults along the eastern coast. Many of these Andepts are used for grazing. Others produce sugarcane.

Aquepts

Aquepts are the Inceptisols that either are saturated with water at some time of year or, if artificially drained, have characteristics associated with wetness. Aquepts are the dominant soils on the landscape in extensive areas of the United States. They occur in two extremely contrasting environments. The Aquepts in the conterminous United States are on broad, nearly level alluvial and lacustrine plains in regions where the mean annual soil temperature is higher than 8° C (47° F). These Aquepts are in the great group of Haplaquepts (map unit I2a). Their soil temperature regime is mesic or thermic. The Aquepts in Alaska are on gentle to strong slopes of landscapes that have either continuous or sporadic permafrost; their topography ranges from the nearly level slopes of alluvial and coastal plains to strong mountain slopes. All the Aquepts in Alaska are in the great group of Cryaquepts, and virtually all of them have permafrost (map unit 12P). These Cryaquepts are in pergelic subgroups.

The Haplaquepts (map unit I2a) are most extensive on the broad, nearly level flood plains of the Mississippi River south of its confluence with the Ohio River and on the flood plains of the Pearl, Alabama, and Tombigbee Rivers. Most of these Haplaquepts developed in clayey alluvium and are in the vertic subgroups. Close to the main rivers and on the low terraces, however, the soils developed in stratified deposits and are Fluvaquents. The soil temperature regime is thermic. The principal associated soils are Aqualfs and Aquolls on the lower terraces and Udalfs on the higher and older terraces. The Haplaquepts are naturally poorly drained and are poorly suited to most crops other than rice; but if they are artificially drained, and most of them have been, they are highly productive of many crops. Farming on these soils is highly mechanized. Cotton, maize (corn), and soybeans are important crops throughout the area; rice is an important crop in Arkansas and Louisiana and sugarcane in Louisiana.

The Haplaquepts in eastern Michigan are on a broad, nearly level lake plain, and they developed in lacustrine deposits. Most of these Haplaquepts are in the mollic subgroups. Their soil temperature regime is mesic. The principal associated soils are Aquolls, Udalfs on the better drained areas in the southern section, and Orthods on the better drained areas in the northern section. Most of these Haplaquepts have been artificially drained and are used for crops. Even the better drained associated soils need some artificial drainage to improve the timing of tillage operations in spring and fall. Maize (corn), winter wheat, soybeans, and hay are the principal crops. Sugar beets and canning crops are also important.

Haplaquepts occur also either as associated soils or as inclusions in areas of Aquents, Haplumbrepts, Aquolls, Udolls, Orthods, and Udults.

In Alaska, Cryaquepts (map unit I2P) are extensive in coastal plains and deltas bordering the Arctic Ocean and Bering Sea, in interior lowlands, and on hills and mountain foot slopes in northern, central, and western Alaska. Slopes range from level to steep. North of the Brooks Range and in western Alaska, the permafrost is nearly continuous. In interior Alaska the permafrost is sporadic, but in both these areas virtually all the Cryaquepts are underlain by permafrost and are in pergelic subgroups. Cryaquepts also occur either as associated soils or as inclusions in areas of Cryandepts, Cryochrepts, and Spodosols. Those associated with Spodosols and most of those associated with Cryandepts do not have permafrost. The principal soils associated with the Cryaquepts are in cryic great groups of Histosols, Ochrepts, and Orthents. The Cryaquepts are mostly in forests or tundra. Hardy vegetables, small grains, and grasses are grown on some areas of the included soils.

Ochrepts

The Ochrepts in the United States range from gently sloping to steep. Some are acid and others are rich in bases. Some have a fragipan. Ochrepts are of moderate extent as the dominant soils on the landscape in the United States. They are most extensive in southern New York, northern New Jersey, Pennsylvania, western Maryland, West Virginia, eastern Ohio, western Virginia, eastern Kentucky, and central and eastern Tennessee and are less extensive in south-central Alabama and the interior part of Alaska. Their soil temperature regime is cryic, mesic, or thermic; the soil moisture regime is udic or ustic. Ochrepts also occur either as associated soils or as inclusions in areas of Andepts, Ustolls, Udults, and Uderts.

The Ochrepts in Alaska have a cryic soil temperature regime and are in the great group of Cryochrepts (map unit I3a). They occur in the region of sporadic permafrost, and a very few have a pergelic soil temperature regime. These Cryochrepts in Alaska developed in loess on the gentle or moderate slopes of terraces and hills bordering the upper and central Yukon River, the central Copper River, and their principal tributaries. On some hills where the loess mantle is thin, the Cryochrepts are members of lithic subgroups. The principal associated soils are in cryic great groups of Aquepts, Histosols, and Orthods. The gently sloping Cryochrepts are used for grain, forage crops, vegetables, and pasture; those on the upper slopes are in forests.

The Ochrepts in south-central Alabama are rich in bases and are in the great group of Eutrochrepts

(map unit I3b). They developed in residuum of weathered marl and chalk, and they are on the gentle slopes of a dissected upland. Their soil temperature regime is thermic. The principal associated soils are Uderts on the smooth parts of the upland. Much of this map unit is in pasture. Cotton, soybeans, and maize (corn) are the principal crops grown.

The Ochrepts on the gentle or moderate slopes of the tops of dissected plateaus in southern New York and northern Pennsylvania have a fragipan and are in the great group of Fragiochrepts (map unit I3c). They developed in glacial deposits. Their soil temperature regime is mesic. The principal associated soils include Fragiaquepts on the nearly level parts of the plateau tops; Dystrochrepts, in both typic and lithic subgroups, on the steep slopes of the valley sides and mountains and on glacial outwash in the valleys; and Fluventic Ochrepts on the valley floors. The Fragiochrepts are commonly wet in winter and spring. The fragipan slows percolation of water and also restricts root development. A large acreage of the Fragiochrepts is in forests of mixed hardwood trees. Hay, pasture, and some grain for dairy cattle are the principal crops grown.

The Ochrepts on Long Island, N.Y., are acid and are in the great group of Dystrochrepts. They developed

Umbrepts

Umbrepts commonly are in regions that have precipitation somewhat higher than that of the Ochrepts. Umbrepts are the dominant soils on the landscape in areas of relatively minor extent in the United States, in western Washington and Oregon. Umbrepts occur also as associated soils or as inclusions in areas of Andepts, Aquepts, and Xerults.

The Umbrepts in Washington and Oregon have a mesic soil temperature regime. They do not have a fragipan, and they have either a udic or a xeric soil moisture regime. These Umbrepts are mostly in the great group of Haplumbrepts but some are Xerumbrepts (map units I4a and I4S).

The Haplumbrepts in the Puget Sound Valley of Washington developed in glacial deposits and occur on the gentle slopes of dissected terraces (map unit 14a). The principal associated soils are Aquepts in the low-lying wet areas and Orthods on the sandier parts of the terraces. Although most of the Haplumbrepts are in forests, deciduous fruits, berries, vegetables, seed crops, and grain are grown under intensive management.

The principal soils associated with the Haplumbrepts on the steep slopes of the Olympic and Cascade

Udalfs, Psammaquents, Udipsamments, Ustipsamments, Aquepts, Borolls, Udolls, Ustolls, and Uderts. Except for those on the low coastal plains of Louisiana and Texas, most of the Aquolls have been drained and are in cultivation.

The Aquolls in eastern North Dakota and in western Minnesota are on broad, nearly level plains. They developed in lacustrine deposits that range in texture from coarse to very fine. Their soil temperature regime is frigid. The most extensive of these Aquolls are in vertic subgroups. On the wetter parts of the plain, however, there are many Calciaquolls, which have a calcic horizon at a shallow depth. The principal soils associated with the Aquolls are Borolls on the gentle slopes of slightly higher parts of the plain and Ustipsamments on gravelly old beach ridges and sand dunes. Management of water is a major problem on these Aquolls. Wide fluctuations in rainfall from year to year make the supply of moisture for crops uncertain. Drainage is required in many of the nearly level parts of the plains. Drainage systems need to be designed to remove excess water in spring so that farming operations can be started as soon as the temperature is favorable. Spring wheat, potatoes, and sugar beets are important cash crops.

The Aquolls along the Missouri, Mississippi, Ohio, and Wabash rivers developed for the most part in fine-textured alluvial deposits on broad, nearly level flood plains. The soil temperature regime is mesic. These Aquolls are most extensive in areas of fine-textured glacial water deposits that are some distance

slopes in western Minnesota, northeastern and northwestern South Dakota, North Dakota, and west-central and northern Montana (map units M2a, M2b, M2c). They are less extensive on mountainous landscapes in Wyoming (map unit M2S). Borolls also occur either as associated soils or as inclusions with Ustorthents, Cryoboralfs, and Aquolls. Low rainfall and a short growing season restrict severely the kinds of crops that can be grown on the Borolls. Spring wheat by dryfarming methods is the principal crop grown.

The Borolls in the United States formed in a cold climate that has low precipitation. The average air temperature ranges from about 6.7° C in the southern part of the area to lower than 4.7° C in the northern part and at the highest elevations. The precipitation decreases from >50 cm in western Minnesota to as little as 30 cm in the most arid areas of Montana. The thickness and the organic-matter content of the mollic epipedon are least in the sections that have the lowest supply of moisture. Soils in the udic subgroups of Borolls (map unit M2a) in western Minnesota, central and eastern North Dakota, and northeastern South Dakota have a mollic epipedon that has a chroma, moist, less than 1.5. The typic subgroups of Borolls (map unit M2b) in western North Dakota, northern South Dakota, and northeastern Montana have a mollic epipedon that has a chroma, moist, higher than 1.5 and a value, dry, less than 4.5. The aridic subgroups (map unit M2c) in northwestern South Dakota, southwestern North Dakota, and northern Montana have a mollic epipedon that has a value, dry, higher

on terraces have a natric horizon. The principal associated soils are Ustorthents and Ustipsamments, and Torriorthents on the steeper slopes. Most of the soils support a cover of native grasses and shrubs and are used as range. Some of these soils on the gentler slopes are cultivated; spring wheat is the principal crop, and it is grown with or without summer fallowing.

Typic Borolls in western Montana are on the gentle or moderate slopes of alluvial fans and terraces in the valleys of the northern Rocky Mountains. Some of these soils on the higher fans and on the terraces have an argillic horizon. The Borolls on moderate slopes of

age and are on gentle or moderate slopes. The deposits include glacial drift in northeastern Illinois, south-central Minnesota, and north-central Iowa; a moderately thick to thick deposit of loess in most of Illinois, Iowa, Nebraska, Kansas, and Missouri; and a thin mantle of either loess or loesslike material underlain by glacial drift or rock in northeastern Iowa and southeastern Minnesota. Most of the Udolls are in typic or aquic subgroups.

Where the Udolls developed in glacial drift, they are on nearly level to gently rolling plains. The principal soils associated with these Udolls are Typic and Cu-

soil moisture regime is ustic. The soil temperature regime is mesic, thermic, or hyperthermic.

Ustolls are the dominant soils on the landscape in areas of large extent in the United States. They are most extensive on gentle or moderate slopes of plains, tablelands, and dissected plateaus in a belt that trends north and south. They occur east of the Aridisols, south of the Borolls, and west of the Udolls (map units M4a, M4b, and M4c). Ustolls also occur but are less extensive on the moderate to steep slopes of the Sacramento and other mountain ranges in New Mexico and Arizona (map unit M4S).

The average annual precipitation over most of the region where Ustolls are the dominant soils on landscapes that have gentle or moderate slopes is 500 to 750 mm, but it ranges from about 350 to 900 mm and increases from north to south and from west to east. Over most of the region, more rain falls in summer than in the rest of the year; in south-central and southern Texas, however, much of the rain falls in spring and autumn. The average annual air temperature ranges from 10° to 24° C and increases from north to south. The effectiveness of the precipitation decreases from north to south and from east to west. This effectiveness is reflected not only in the crops that can be grown but also in the management practices that must be followed to have good production. Conservation of moisture is difficult because much of the summer rainfall comes as intense thunderstorms.

Although most Ustolls have an ustic soil moisture regime, this regime ranges from one that is udic or marginal to udic in the eastern areas to one that is marginal to aridic in the western areas. This variation is reflected in the length of time the soils are moist during the growing season and in the depth to a calcic horizon or to soft, powdery secondary lime. The differences in these characteristics are recognized at the subgroup level of the taxonomy.

Udic Ustolls are in the easternmost part of a belt that extends from southeastern South Dakota through the east-central parts of Nebraska and Kansas and through central Oklahoma and Texas, a region that receives about 625 to 900 mm of annual precipitation. These Ustolls (map unit M4a) have either a calcic horizon or soft, powdery secondary lime at a depth greater than 70 cm to 1.25 m. Their soil temperature regime is mostly mesic; however, those in Texas and in Oklahoma have a thermic regime. Most of the Udic Ustolls developed in moderately thick to thick loess on nearly level to rolling plains, and most of them have an argillic horizon. The principal associated soils in the area of loess are Orthents and Ustochrepts on the steeper slopes and Aquents, Fluvents, and Cumulic Udolls on the flood plains. The Udic Ustolls in parts of Kansas and in Texas and Oklahoma developed mostly in residuum weathered from sandstone, shale, or limestone on the undulating to gently rolling divides of vents, Cumulic Udolls, and Ustolls on flood plains; and in central Texas, Udic Usterts on gentle slopes. Although winter wheat and grain sorghum are the principal crops grown without summer fallowing, the more favorable moisture regime permits growing the less drought-resistant crops such as maize (corn) and soybeans. In southern Oklahoma and in Texas, cotton and some truck crops are grown.

The Ustolls in the central belt from north-central South Dakota through central Nebraska, Kansas, Oklahoma, Texas, and extending into extreme southern Texas receive about 500 to 625 mm of annual precipitation. These Ustolls are in typic subgroups (map unit M4b) and they have carbonates at a shallower depth than comparable soils in udic subgroups. Their soil temperature regime is mostly mesic. In south-central Kansas and in central Oklahoma and Texas the soil temperature regime is thermic, and in the extreme southern part of Texas, it is hyperthermic.

The Typic Ustolls (map unit M4b) in the eastern half of central South Dakota developed in glacial drift on the gentle slopes of a nearly level to gently rolling plain. The principal associated soils are other Ustolls, including those in entic subgroups on steep slopes and soils that have a natric horizon on the more level parts of the plain; and Cumulic Aquolls on the flood plains. Spring wheat is the principal crop.

The Typic Ustolls in the eastern part of the area in Nebraska and most of those in Kansas developed in moderately thick to thick loess on the gentle slopes of tablelands and on undulating to rolling ridgetops of dissected plains. Most of these Ustolls have an argillic horizon. The principal associated soils are Ustorthents on the steep slopes.

The Ustolls in south-central Kansas developed in thick windblown sands and sandy outwash materials on the gentle slopes of an undulating to rolling plain. The principal associated soils include Psammentic Ustalfs, which are also on gentle slopes; Ustipsamments in areas that have dunelike topography; and Aquic Ustolls on flood plains.

The Ustolls in most of the western half of South Dakota developed in residuum weathered from calcareous shale and clay on the gentle slopes of undulating and rolling uplands. Many of these Ustolls are in vertic subgroups. The principal associated soils on the steeper slopes are Ustorthents.

The Ustolls (map unit M4b) in most of Oklahoma and Texas developed in unconsolidated sediments or in residuum weathered from sandstone, shale and limestone. They are on gentle or moderate slopes of ridgetops and broad divides. These Ustolls are members of typic, vertic, and pachic subgroups. Some have an argillic horizon, some have a natric horizon, some have a calcic horizon, and some have a petrocalcic horizon. The principal associated soils are Typic Ustalfs, which are also on gentle or moderate slopes; Ustochrepts and

some have an argillic horizon and some have a calcic

luvial fans and terraces and Lithic Ustorthents on the

are members of cumulic subgroups. The principal soils associated with the Ustolls in this part of Texas are Usterts and, in areas of deep sand, Ustipsamments. Most of these Ustolls are under irrigation, and cotton, seed corn, sweet corn, citrus fruits, melons, and many kinds of vegetables are the principal crops.

Extensive areas of Typic Ustolls, particularly those that are strongly sloping or sandy, are in native grasses and shrubs and are used for grazing. On others, winter wheat and drought-resistant crops such as grain sorghum or cotton are grown extensively. Satisfactory yields can be obtained without irrigation although drought is common.

The Ustolls that extend from southwestern South Dakota through western Nebraska, eastern Colorado, western Oklahoma, and western Texas and those in northwestern Colorado and in northwestern Arizona

in northwestern Colorado are on the moderate lower slopes of mountains and mesas. The principal associated soils here are Borolls on the cooler upper slopes.

Extensive areas of aridic Ustolls are in native grasses and shrubs and are used for grazing. Winter wheat and drought-resistant crops such as grain sorghum are grown extensively in a system of farming that, where the soil temperature is mesic, includes summer fallowing in alternate years to store moisture.

The Ustolls on the moderate to steep slopes of mountains and plains in New Mexico and Arizona (map unit M4S) are mostly in lithic subgroups. Aridic Ustolls that have an argillic horizon are on the smoother uplands. Ustollic Argids are the principal associated soils in this area, and Torriorthents are on the steeper slopes. Most of these Ustolls are in native grasses and shrubs and are used for grazing.

receive about 280 to 500 mm of annual precipitation

In southeastern Oregon, northeastern Nevada, and southwestern Idaho, the Xerolls developed on gentle or moderate slopes either in residuum weathered from the underlying bedrock or in unconsolidated materials on the higher lying fans. Most of these Xerolls have an argillic horizon and are in typic, calcic, or lithic subgroups. The principal associated soils include Xerollic Argids and Orthids and Aridic Xerolls on the alluvial fans and the lower lying terraces and Xerorthents on the steep slopes.

Most of the Xerolls on the moderate and steep slopes of mountains and dissected plateaus (map unit M5S) are in typic and lithic subgroups and have an argillic horizon. The principal associated soils are Lithic Xerorthents on steep slopes; Xererts on some uplands and in some basins; Xeralfs on some uplands in the more acid materials; and Cryoboralfs on the forested upper mountain slopes. Most of these Xerolls support native grass and scattered trees and are used for grazing.

Spodosols

Spodosols are dominant soils on the landscape in areas of moderate extent in the United States. The two most extensive suborders are Aquods and Orthods. The Spodosols are most extensive in northern Minnesota, northeastern Wisconsin, northern Michigan, northern New York, the New England states, Alaska, and Florida. They may have any soil temperature regime but the soil moisture regime is aquic or udic.

Aquods

Aquods are the wet Spodosols. They are the dominant soils on the landscape in areas of moderate extent in the United States. They are most extensive in eastern and south-central Florida, where they are on the nearly level coastal plain and developed in sandy sediments of variable thickness that overlie clayey sediments, and in northwestern Florida, where they are on the nearly level low coastal plain and developed in sandy and clayey marine sediments (map unit S1a). The Aquods in these places are in aeric and arenic subgroups. Their soil temperature regime is thermic or hyperthermic. Aquods also occur either as associated soils or as inclusions in areas of Psammaquents, Aquepts, and Aquults. The principal soils associated with the Aquods in eastern and south-central Florida are in typic and arenic subgroups of Humods; Psammaquents and soils in typic and arenic subgroups of Aquolls and Aquults are on the wetter flats and in depressions. The principal associated soils in northwestern Florida are Aquults, of which some have an umbric epipedon and others have an ochric epipedon. Most of the Aquods are in forests, but those in south-central Florida are in the major citrus-producing area of that state.

Orthods

Orthods are the more or less freely drained Spodosols in which iron, humus, and aluminum have accumulated. Orthods are the dominant soils on the landscape in areas of moderate extent in the United States. They are most extensive on the gentle slopes of nearly level to hilly glacial plains and on the moderate slopes of till-mantled, rolling to hilly uplands and rounded mountains (map unit S2a). They are less extensive on the steeper slopes that are also thinly mantled by glacial till and on the rounded mountains in New England (map unit S2S1). Their soil temperature regime is mostly cryic or frigid, but in a few of these soils in southern New England, it is mesic. Their soil moisture regime is udic or perudic. Orthods also occur either as associated soils or as inclusions in areas of Boralfs where the parent materials are sandy. A short, cool growing season and, in many places, numerous stones impose severe restrictions on the crops that can be grown.

Orthods on gentle or moderate slopes (map unit S2a), are most extensive in northern New York, the New England states, northern Michigan, and Wisconsin. On the higher hills and the rounded mountains and in areas of sandy glacial outwash, these Orthods are in typic or lithic subgroups. Some of the Orthods on these landscapes have a fragipan. In the Aroostook area in Maine and in parts of Michigan and Wisconsin, some of the Orthods developed in thick deposits of till. These are mainly in alfic subgroups if the till was calcareous. If the till was not calcareous, many of them have a fragipan. Their soil temperature regime is frigid. In much of southern New England, where the soils developed in thick deposits of glacial drift and in lacustrine or marine sediments, the Orthods are in entic subgroups and their soil temperature regime is mesic.

The principal soils associated with the gently and moderately sloping Orthods in New England and New York are Mollic and Typic Aquepts in wet areas; Fluventic Dystrochrepts on flood plains; Lithic and Typic Dystrochrepts and some Fragiochrepts on the steeper slopes; and Histosols in wet lowlands, including some Sulfihemists in the coastal marshes. Most of these Orthods are in forests. Stoniness imposes serious restrictions on the use of many of them for farming. Forage crops for dairy cattle are the principal crops, but potatoes are an important cash crop locally, particularly in the Aroostook area in Maine. Tobacco for cigars is an important cash crop on Orthods in the Connecticut River valley of Massachusetts and Connecticut.

The Orthods on the steeper slopes of rounded mountains in New England have a frigid soil temperature regime and are in typic and lithic subgroups of Haplorthods and Fragiorthods (map unit S2S1). Where these Orthods developed in thick, acid, sandy, and gravelly deposits of outwash in glacially broadened valleys, they are in typic, aquic, and entic subgroups. The principal associated soils are Histosols, Fragiaquepts, and Psammaquents in the wet lowlands. Most of these Orthods are in forests.

The Orthods in the northern parts of Minnesota, Wisconsin, and Michigan (map unit S2a) are on the gentle slopes of nearly level to rolling plains. The Orthods in these places developed for the most part in

thick deposits of glacial drift and are in typic, entic, and alfic subgroups. Some of them have a fragipan. Their soil temperature regime is frigid. The principal soils associated with the Orthods in these areas are Boralfs in the finer textured sediments; Mollic Aquents and Aquepts on wet lowlands and in poorly drained depressions; Spodic and Typic Psamments in excessively drained sands; Histosols in basins and depressions; and, in northern Minnesota, Orthents on the moderate slopes of low hills. Most of these Orthods are in forests. Forage and some small-grain crops for livestock are the main crops. Potatoes are an important crop in some areas.

The dominant soils in southeastern Alaska (map unit S2S2) are Humic Cryorthods. These soils developed on moderate and steep slopes in glacial till or colluvium. They have a dense forest cover composed mainly of spruce and hemlock and a moderately thick understory.

tent in the United States. Their soil temperature regime is mesic or thermic. For the most part these soils are only on the nearly level lower and middle coastal plains and on river terraces extending from Delaware to Georgia and also in southwestern Louisiana and southeastern Texas (map unit U1a). They are on gentle slopes, and they developed in unconsolidated sands, silts, and clays. Their soil temperature regime is mostly mesic in Maryland and areas to the north and thermic in Virginia and areas to the south. Aquults also occur either as associated soils or as inclusions in areas of Aquepts and Udults.

The most extensive Aquults are Paleaquults and Ochraquults. Those in wettest areas, however, are mostly Umbraquults. The principal associated soils are in typic and aquic subgroups of Udults on the higher areas that have somewhat better but still restricted drainage; Hydraquents, Sulfaquents, and Histosols in

season. They have very little organic matter. Udults are the dominant soils on the landscape in areas of large extent in the United States (map units U3a and U3S). They are most extensive in the eastern, southeastern, and southern states. Their soil temperature regime is mainly mesic, thermic, or hyperthermic. These soils are present also either as associated soils or as inclusions in areas of Udalfs, Quartzipsamments, Ochrepts, and Aquults.

The Udults in the United States are most extensive on the gentle or moderate slopes of the middle and upper coastal plain, the Piedmont section, the dissected plateaus of shale, sandstone, or limestone, and

homa. Those in Indiana, Kentucky, Tennessee, Mississippi, and Alabama have a thin to moderately thick mantle of loess on the smoother parts. In these places, the Udults are mainly those of typic subgroups. Some have a fragipan. Their soil temperature regime is mesic or thermic. The principal associated soils are Udalfs, including Fragiudalfs, on the ridgetops; soils in lithic, typic, and umbric subgroups of Dystrochrepts on steep slopes; and Fluvents on narrow flood plains. Between one-third and two-thirds of the Udults are in forests. Maize (corn), feed grains, and hay for dairy cattle and other livestock are the principal crops. In some places, however, maize (corn), soybeans, cotton,

The Uderts in Texas developed in calcareous clay.

The principal associated soils there are in typic subgroups of Aquolls on areas slightly higher than the Uderts; Aqualfs on nearly level to undulating ridgelike areas; and soils in vertic subgroups of Aquolls and Ustolls on nearly level alluvial plains. Rice and cotton are the principal crops grown on the Uderts. Included in the southern part of this area of Uderts are some Usterts. The soil temperature regime there is hyperthermic.

The Uderts in Alabama and Mississippi developed in residuum weathered from marl and chalk. The principal associated soils are Eutrochrepts on the more sloping parts of the upland. Cotton, maize (corn), and soybeans are the principal crops.

Usterts

Usterts are the Vertisols of temperate regions that commonly have periods of drought during each year. They are the dominant soils on the landscape in east-central and southern Texas (map unit V2a).

The Usterts in eastern Texas developed mainly in soft, calcareous sedimentary rocks on the gently sloping to nearly level uplands of a dissected plain. The soil temperature regime there is mainly thermic. The principal associated soils are Ustolls on strong slopes; Aqualfs in the less calcareous clays; and Udifluvents and soils in vertic subgroups of Ustolls and Aquolls on nearly level alluvial plains. Cotton is the major cash crop, but small grains, grain sorghum, corn, and hay occupy a larger acreage.

The Usterts in southern Texas developed mainly in calcareous clays on nearly level to gently undulating plains. The soil temperature regime there is mainly hyperthermic. The soils in this area are predominantly Usterts, and there are inclusions of Orthids and Torrerts. Most of these Usterts are in native grasses and shrubs and are used for grazing, but some cotton and grain sorghum are grown.

Areas with little soil

There are some areas in the United States where the salt content of the soil materials is too high to permit plant growth, some where the slopes are too steep for accumulation of deep soil materials, and some where the rocks are so young that weathering is just beginning. Combinations of these three situations comprise two map units under a miscellaneous group-

TABLE 13.—*Approximate area of kinds of soil in the United States*

Soil order and suborder	Area	Extent
	Square miles	*Percent*
Alfisols	483,450	13.4
Aqualfs	36,400	1.0
Boralfs	107,500	3.0
Udalfs	211,550	5.9
Ustalfs	94,650	2.6
Xeralfs	33,350	.9
Aridisols	414,400	11.5
Argids	310,900	8.6
Orthids	103,500	2.9
Entisols	284,250	7.9
Aquents	8,200	.2
Fluvents	10,750	.3
Orthents	188,450	5.2
Histosols	18,750	.5
Fibrists	8,300	.2
Hemists	7,050	.2
Saprists	3,400	.1
Inceptisols	655,700	18.2
Andepts	66,950	1.9
Aquepts	411,100	11.4
Ochrepts	153,450	4.3
Umbrepts	24,100	.7
Mollisols	896,000	24.6
Aquolls	46,100	1.3
Borolls	176,800	4.9
Udolls	170,450	4.7
Ustolls	318,400	8.8
Xerolls	184,250	4.8
Oxisols	500	<.02
Spodosols	183,050	5.1
Aquods	25,900	.7
Orthods	157,150	4.4
Ultisols	463,050	12.9
Aquults	41,250	1.1
Humults	27,550	.8
Udults	357,650	10.0
Xerults	36,600	1.0
Vertisols	35,300	1.0
Uderts	13,500	.4
Usterts	21,500	.6

in the United States, based on a total area of 3,595,450 square miles. The figures given are based on only the principal kinds of soil that are named for each mapping unit on the soil map of the United States, scale 1:7,500,000, that was compiled in 1967 by the Soil Conservation Service and published as part of the National Atlas by the United States Geological Survey in 1969.

Inland bodies of water that are 50 square miles in size or larger are excluded from the totals given, whereas smaller bodies of water are not. The total area of excluded inland lakes, reservoirs, and other

0.02 percent of the area, a few other soils occur in very limited areas. Each of these makes up less than about 0.1 percent and most make up less than 0.02 percent of the total area. These soils are Albolls, Folists, Humods, Humox, Rendolls, Torrerts, Torrox, Tropepts, Ustults, and Xererts. Other soils that are defined in the taxonomy but that do not occur in the United States are not included in the areas given.

CHAPTER 21

Relation to Other Soil Taxonomies

Soil taxonomies have been developed largely in government ministries. Other taxonomies, in contrast, have been developed largely in universities. There are impelling reasons for this difference. Because many soil properties are not preserved in specimens, soils must be studied where they occur in nature and the study is expensive. The soils that concern government ministries are the soils that produce or can produce food, fibers, or other things useful to men.

Governments are concerned with the natural resources of the lands they govern, and the lands have geographic limits. Geography, in the sense of latitude, longitude, and elevation, is related to climate, geology, and other factors that control soil formation. Each individual government, therefore, is concerned with only a part of the kinds of soil of the world, and the views of its pedologists toward taxonomy are unavoidably affected by the kinds that have an important area in their country. Taxonomies that were developed, for example, in Canada, in the United States, and in Brazil each tend to emphasize the soil properties that occur within the respective countries and to give less attention to those that are common in other countries.

Despite such differences, the taxa of very low categories that commonly are used in large-scale mapping of soils are very similar in all taxonomies known to the authors if the soils are similar. If one could compare the units used in making large-scale maps, one

parts of the Aquods and Cryaquepts. In the Soviet taxonomy, the Alfisols and Spodosols are placed in different genera. The Spodosols are those Podzolic soils that have illuvial humus and iron. The Cryoboralfs and Cryaquepts are distinguished as subtypes. Other subtypes, genera, and species in the Soviet taxonomy make most of the distinctions that are made in this taxonomy at the subgroup, family, and series categories.

In this chapter we attempt to indicate only the nature of the taxa of this system that are included in the taxa shown on small-scale maps made according to taxonomies of a few other countries, particularly those that have a relatively wide range in kinds of soil. Some of the most detailed taxonomies, such as those of New Zealand (Taylor and Pohlen 1962) and the Netherlands (de Bakker and Schelling 1966), are not discussed here. The reason is not that they are unimportant to pedology but that they include relatively few kinds of soil.

This chapter is intended to help the reader understand how the units of the small-scale maps of the various parts of the world relate to this taxonomy. It is also intended to relate the previous system used in the United States to this one.

Because mapping units on small-scale maps are mostly taxa that have high categoric rank or that are extensive because of an accident of geography, the re-

cording to some of the taxonomies compared here, recent publications suggest that some of the citations we have used are not completely up to date but are only the most recent publications of the complete systems.

The United States system of 1938

The soil classification system introduced in the yearbook of the United States Department of Agriculture for 1938, Soils and Men (Baldwin et al. 1938), consisted of six categories: the order, suborder, great soil group, family, series, and type. Extensive use was made of three of these categories, the great soil group, series and type. The soil type is not a category in the taxonomy that is described in this book, although texture of the plow layer still appears as part of the names of many kinds of soil on soil maps. Soil type now refers to one kind of phase and to a way of naming mapping units. Soil series have been retained, but the definitions of most have been modified to some extent. The modification of series concepts, however, is not new but has been a continuing process since the category was introduced in 1903. For practical purposes, therefore, the concepts of the soil series in the two classifications are the same.

The relations of the great soil groups of the 1938 system to the taxa of this classification need to be understood in reading the literature published between 1938 and 1965. Such relations, however, are not simple. A number of the great groups were carried over from the classification of Marbut (1935) after some redefinition. The classification itself was not static. A major revision was published in 1949 (Thorp and Smith 1949) and various individual changes were made at other times. Some great soil groups were later split. For example, many of the Rendzinas of 1938 became the Grumusols of 1951 and some of the Podzol soils of 1938 became the Gray Wooded soils of 1949. Other great soil groups were combined, e.g., the Red Podzolic and Yellow Podzolic soils of 1938 became the Red-Yellow Podzolic soils of 1949. Some new great groups were added.

Names of some of the great soil groups were adopted in other countries with concepts influenced by the studies that led to the definitions of the present classification. Thus, we find Gray-Brown Podzolic soils used in the soil map of Europe (Dudal et al. 1966) as the equivalent of Udalfs.

So, to relate great soil groups of the previous classification to taxa in this classification, the time and place must be specified. The relations shown in table 14 apply to the great soil groups used for soils in the United States and Puerto Rico in about 1959, just before publication of the 7th Approximation of this system (Soil Survey Staff 1960).

The 7th Approximation and 1964 supplement

It was pointed out earlier that this taxonomy was developed over nearly two decades by a series of approximations. One of these, the 7th, was published for criticism in 1960 and included the first presentation of this system of nomenclature (Soil Survey Staff 1960). As a result of criticisms of the 7th Approximation, a number of the names were changed. Some of the names of the 7th Approximation that were later changed have appeared in the literature. To provide continuity in the taxa despite the changes in names, table 15 gives a list of the present approximate equivalents for great group names that have been changed from those given in the 7th Approximation and its 1964 supplement.

TABLE 14.—*The 1938 classification as revised to 1959 and approximate equivalents in the present system*

Revised 1938 classification	Present classification	
Great soil groups	Great groups or other taxa mostly included	Great groups or other taxa partly included
Alluvial soils [1]	Fluvaquentic and fluventic subgroups of Inceptisols and Mollisols; great groups of Fluvents.	Cryorthents; Cumulic Haploxerolls; entic subgroups of Haploxerolls and Haplustolls; Fluvaquents; great groups of Psamments; Haplaquents; Haplaquepts; Hapludolls.
Alpine Meadow soils [1]	Cryaquods	Cryaquolls and Cryumbrepts.
Ando soils [13]	Dystrandepts	Other great groups of Andepts.
Bog soils [1]	Great groups of Fibrists, Hemists, and Saprists.	
Brown soils [1]	Mesic families of aridic subgroups of Argiustolls, Argixerolls, Haploxerolls, and Haplustolls; mesic families of ustollic and xerollic subgroups of Argids and Orthids.	Frigid families of xerollic subgroups of Argids, Orthids, and Durixerolls; Aridic Haploborolls.
Brown Forest soils [1]	Eutrochrepts	Haploxerolls and Hapludolls.
Brown Podzolic soils [1]	Cryandepts; mesic families of entic Fragiorthods and Haplorthods.	Dystric Eutrochrepts; Dystrochrepts; Fragiochrepts.
Brunizems (Prairie soils) [10] [1]	Mesic families of Argiudolls and Hapludolls; mesic and thermic families of Argixerolls and Haploxerolls.	Cryoborolls; mesic families of Durixerolls, Palexerolls, and udic Argiustolls.
Calcisols [8]	Calciborolls, Calciorthids, Calciustolls, Calcixerolls, and Paleorthids.	Camborthids, Durorthids, Ustochrepts, and Xerochrepts.
Calcium Carbonate Solonchaks [8]	Calciaquolls	Aquic Calciustolls.
Chernozems [1]	Cryoborolls; mesic families of typic and udic subgroups of Argiustolls and Haplustolls; udic subgroups of Argiborolls and Haploborolls.	Mesic and frigid families of Haploxerolls.
Chestnut soils [1]	Frigid families of Argixerolls, Durixerolls, Haploxerolls, and Palexerolls; mesic fam-	Aridic subgroups of Argiborolls and Haploborolls; mesic and frigid families of calcic

TABLE 14.—*The 1938 classification as revised to 1959 and approximate equivalents in the present system*—Continued

Revised 1938 classification	Present classification	
Great soil groups	Great groups or other taxa mostly included	Great groups or other taxa partly included
Hydrol Humic Latosols [2]	Hydrandepts.	
Laterite soils [13]	Acrorthox.	
Latosolic Brown Forest soils [2]	Dystrandepts	Vitrandepts.
Latosols (great groups of) [5]	Humoxic Tropohumults; Tropepts	Great groups of Oxisols; Hydrandepts; Rhodustults.
Lithosols [1]	Lithic subgroups; shallow families of Orthents.	Lithic subgroups and shallow families of Alfisols, Aridisols, Inceptisols, Mollisols, Ultisols, and other Entisols.
Low-Humic Gley soils [13]	Great groups of Aquults; Haplaquents; Haplaquepts; and Ochraqualfs.	Cryaquents; Fluvaquents; other great groups of Aquepts and Aqualfs; Psammaquents.
Low Humic Latosols [2]	Ustropepts	Haplustox.
Noncalcic Brown soils [1]	Durixeralfs, Haploxeralfs, and Palexeralfs.	Xerochrepts.
Planosols [1]	Albaqualfs, Argialbolls, Fragiaqualfs, and Glossaqualfs.	Fragiaquults; Albaquults.
Podzol soils [1]	Cryorthods, Fragiorthods, and Haplorthods.	Haplohumods.
Prairie soils [1]	(See Brunizems)	(See Brunizems).
Red Desert soils [1]	Thermic and hyperthermic families of Camborthids, Durargids, Haplargids, and Paleargids.	Thermic and hyperthermic families of Calciorthids.
Reddish-Brown Lateritic soils [13]	Great groups of Humults; Rhodic subgroups of Paleudalfs and Paleudults; Rhodudults.	
Reddish Brown soils [1]	Haplustalfs; Paleustalfs; thermic and hyperthermic families of typic and ustollic subgroups of Calciorthids. Camborthids.	Isothermic and isohyperthermic families of Eutrandepts; thermic and hyperthermic families of aridic Argiustolls. Calciustolls.
Reddish Chestnut soils [1]	Haplustalfs; Paleustalfs; thermic and hyperthermic families of aridic and typic subgroups of Argiustolls and Paleustolls.	Thermic and hyperthermic families of Haplustolls.
Reddish Prairie soils [1]	Thermic families of udic subgroups of Argiustolls and Paleustolls.	Isothermic and isohyperthermic families of Eutrandepts; thermic families of Paleudolls.
Red-Yellow Podzolic soils [13]	Thermic families of Fragiudults, Hapludults, and Paleudults.	Mesic families of Fragiudults, Hapludults, and Paleudults; thermic families of Paleudalfs; thermic families of ultic subgroups of Haplustalfs and Paleustalfs.
Regosols [13]	Great groups of Psamments; subgroups of Orthents other than lithic; Vitrandepts.	Entic subgroups of Haploxerolls, Hapludolls, and Haplustolls; Grossarenic Paleudults; Psammaquents; Xerochrepts.
Rendzina soils [1]	Rendolls	Calciustolls, Hapludolls, and Haplustolls.

TABLE 14.—*The 1938 classification as revised to 1959 and approximate equivalents in the present system*—Continued

Revised 1938 classification	Present classification	
Great soil groups	Great groups or other taxa mostly included	Great groups or other taxa partly included
Soloth soils [1]		Natraqualfs; *natric subgroups of* Cryoborolls, Duraquolls, Durixeralfs, and Haploxeralfs.
Sols Bruns Acides [12]	Dystrochrepts, Fragiochrepts, and Haplumbrepts.	Udorthents and Xerumbrepts.
Subarctic Brown Forest soils [6]	Cryochrepts	Cryoborolls.
Tundra soils [1]	Pergelic Cryaquepts	Cryandepts, Cryochrepts, and Cryumbrepts.
Yellowish-Brown Lateritic soils [1] were combined with Reddish-Brown Lateritic soils in 1949.[13]		

[1] Baldwin, M., Charles E. Kellogg, and J. Thorp. Soil classification. *In* Soils and men, p. 979–1001. Yearbook Agri. U.S. Dep. Agr. U.S. Government Printing Office, Washington, D.C. 1938.

[2] Cline, M. G., et al. Soil survey of the Territory of Hawaii. Soil Conserv. Serv. U.S. Dep. Agr. 644 p. 1955.

[3] Harper, W. G. Morphology and genesis of Calcisols. Soil Sci. Soc. Amer. Proc. 21: 420–424. 1957.

[4] Kellogg, Charles E. Climate and soil. *In* Climate and men, p. 276–277. Yearbook Agr. U.S. Dep. Agr. U.S. Government Printing Office, Washington, D. C. 1941.

[5] Kellogg, Charles E. Tropical soils. Trans. 4th Int. Congr. Soil Sci., (Amsterdam) 1: 266–276. 1950.

[6] Kellogg, Charles E., and I. J. Nygard. The principal soil groups of Alaska. Agr. Monogr. No. 7, U.S. Dep. Agr. 138 p. 1951.

[7] Marbut, C. F. Soils of the United States. *In* Atlas of American Agriculture, part III, p. 1–98. U.S. Dep. Agr. 1935.

[8] McClelland, J. E., et al. Chernozems and associated soils of eastern North Dakota, some properties and topographic relationships. Soil Sci. Soc. Amer. Proc. 23: 51–56. 1959.

[9] Oakes, H., and J. Thorp. Dark clay soils of warm regions variously called Rendzina, black cotton soils, regur, and tirs. Soil Sci. Soc. Amer. Proc. 15: 347–354. 1951.

[10] Simonson, R. W., F. F. Riecken, and Guy D. Smith. Great soil groups in Iowa, p. 23–25. *In* Understanding Iowa soils. Wm. C. Brown Co., Dubuque, Iowa. 1952.

[11] Soil Conservation Service, U.S. Dep. Agr. Published soil surveys. Map included as sheet of the U.S. Geol. Survey National Atlas, Washington, D.C. 1968.

[12] Tavernier, R., and Guy D. Smith. The concept of Braunerde (Brown Forest soils) in Europe and the United States. Advan. Agron. 9: 217–289. 1957.

[13] Thorp, J., and Guy D. Smith. Higher categories of soil classification. Soil Sci. 67: 117–126. 1949.

TABLE 15.—*Great group names changed and approximate equivalents in present system*

7th Approximation 1960	Supplement 1964	Present soil taxonomy
Alfisols:		
Fragaqualfs		Fragiaqualfs.
Cryaltalfs		Cryoboralfs.
Fragaltalfs		Fragiboralfs.
Natraltalfs		Natriboralfs.
Typaltalfs		Eutroboralfs.
Fragudalfs		Fragiudalfs.
Typudalfs	Normudalfs	Hapludalfs.
	Normustalfs	Paleustalfs and Palexeralfs.
Typustalfs		Haplustalfs.
Ultustalfs	Vetustalfs	Palexeralfs and Paleustalfs.
Aridisols:		
	Normargids	Paleargids.
Calcorthids		Calciorthids.
Entisols:		
Orthopsamments		Cryopsamments, Tropopsamments, and Udipsamments.
Quarzopsamments		Quartzipsamments.
Agrudents	Agrorthents	Great groups of Orthents.
Cryudents		Cryorthents, Cryofluvents.
Hapludents		Tropofluvents, Udifluvents, Troporthents, and Udorthents.
Plaggudents		Plaggepts
Orthustents		Torrifluvents, Ustifluvents, Xerofluvents, Torriorthents, Ustorthents, and Xerorthents.
Psammustents		Torripsamments, Ustipsamments, and Xeropsamments.
	Haplorthents	Great groups of Fluvents and Orthents except Cryofluvents and Cryorthents.
	Aquipsamments	Psammaquents.
	Normipsamments	Great groups of Psamments except Cryopsamments and Quartzipsamments.
Inceptisols:		
Ochrandepts		Vitrandepts.
Umbrandepts		Dystrandepts and Eutrandepts.
	Mollandepts	Eutrandepts.
	Normandepts	Dystrandepts.
Fragaquepts		Fragiaquepts.
Ochraquepts	Normaquepts	Haplaquepts and Tropaquepts.
Umbraquepts		Humaquepts.
Fragochrepts		Fragiochrepts.
Mollisols:		
Argalbolls		Argialbolls.
Argaquolls		Argiaquolls.
Calcaquolls		Calciaquolls.
Argaltolls		Argiborolls.
Calcaltolls		Calciborolls.
Haplaltolls		Haploborolls.
Natraltolls		Natriborolls.
Vermaltolls		Vermiborolls.
Argudolls		Argiudolls.
Argustolls		Argiustolls.
Calcustolls		Calciustolls.
Spodosols:		
Ferraquods		Sideraquods.
Humaquods	Normaquods	Haplaquods.
Thermaquods		Tropaquods.
	Normihumods	Haplohumods.
Typorthods	Normorthods	Haplorthods.
Ultisols:		
Fragaquults		Fragiaquults.
Plintaquults		Plinthaquults.
	Ochrihumults	Great groups of Humults.

TABLE 15.—*Great group names changed and approximate equivalents in present system*—Continued

7th Approximation 1960	Supplement 1964	Present soil taxonomy
	Umbrihumults	Great groups of Humults.
Fragochrults		Fragiudults.
Plintochrults		Plinthudults.
Rhodochrults		Rhodudults.
Typochrults	Normudults	Hapludults.
	Normustults	Haplustults.
Vertisols:		
Grumaquerts		Great groups of Uderts.
Mazaquerts		Great groups of Uderts.
Grumusterts		Great groups of Torrerts, Usterts, and Xererts.
Mazusterts		Great groups of Torrerts, Usterts, and Xererts.

The French taxonomy

The taxonomy proposed by the Commission of Pedology and Soil Cartography (1967) is an outgrowth of the classification of Aubert and Duchaufour (1956). The higher categories of the French taxonomy are the class, subclass, group, and subgroup. These correspond in many ways, but not exactly, to the order, suborder, great group, and subgroup of this taxonomy. Relations between the two taxonomies are shown in table 16. Relations are shown at the French group level. The French classes in table 16 have Roman numerals, subclasses have the class numeral followed by an Arabic digit, and the groups have the subclass symbol and an additional Arabic digit.

The Canadian taxonomy

The system of soil classification for Canada (Canada Department of Agriculture 1970) was developed for Canadian soils by the Canada Soil Survey Committee. Most of the taxa are composed of soils that have a frigid, cryic, or pergelic temperature regime. A small but important part, however, have a mesic soil temperature regime. The soils that have a pergelic temperature regime are distinguished in the Canadian system as cryic subgroups. Because the Canadian system has fewer taxa and does not have a category corresponding to the suborder in this system, some Canadian subgroups relate well to the great groups but others relate better to the subgroups of this taxonomy. The correlations presented in table 17 are for Canadian great groups. They are drawn largely from the Canadian publication (op. cit.), particularly the correlations at the subgroup and great group levels given in tables 8 and 9 in that publication, and from correlation trips along the United States-Canada border that have been conducted at intervals for more than 25 years.

TABLE 16.—*The French taxonomy (1967) and approximate equivalents in this taxonomy*

French taxonomy, 1967	This taxonomy	
Class, subclass, and group	Great groups or other taxa mostly included	Great groups or other taxa partly included
I Sols Minéraux Bruts		
I–1 Sols minéraux bruts non climatiques		
I/11 Sols minéraux bruts d'érosion	Rock land	Orthents and Psamments.
I/12 Sols minéraux bruts d'apport alluvial.		Fluvents and Psamments.
I/13 Sols minéraux bruts d'apport colluvial.		Fluvents and Psamments.
I/14 Sols minéraux bruts d'apport éolien.		Psamments.
I/15 Sols minéraux bruts d'apport volcanique.		Ashy and cindery families of Orthents.
I/16 Sols minéraux bruts anthropiques		Arents.
I–2 Sols minéraux bruts climatiques des déserts froids.		
I/21 Lithosols des déserts froids		Rock land.
I/22 Cryosols bruts inorganisés		Cryorthents.
I/23 Cryosols bruts organisés		Cryorthents.
I–3 Sols minérals bruts des déserts chauds (ou xériques).		
I/31 Lithosols des déserts chauds		Rock land.
I/32 Sols bruts xériques inorganisés		Torrifluvents and Torriorthents.
I/33 Sols bruts xériques organisés d'ablation.		Torriorthents.
I/34 Sols bruts xériques inorganisés d'apport.	Torripsamments.	
I/35 Sols bruts xériques organisés d'apport.		Torrerts; level phases of clayey families of Torriorthents and Salorthids.
II Sols Peu Évolués		
II–1 Sols peu évolués à permagel		
II/11 Sols à forte ségrégation de glace non ordonnée.		Pergelic Cryaquents and Pergelic Cryaquepts.
II/12 Sols à forte ségrégation de glace ordonnée en réseau.		Pergelic Cryaquents and Pergelic Cryaquepts.
II/13 Sols sans ségrégation de glace importante à réseau organisé.		Pergelic Cryaquents and Pergelic Cryaquepts.
II/14 Sols bruns arctiques	Pergelic Cryorthents and Pergelic Cryochrepts.	
II-2 Sols peu évolués humifères		
II/21 Rankers	Lithic and entic subgroups of Haplumbrepts.	
II/22 Sols humifères lithocalciques		Lithic Hapludolls and Lithic Haplumbrepts.
II/23 Sols peu évolués à allophanes		Eutrandepts and Vitrandepts.
II–3 Sols peu évolués xériques		
II/31 Sols gris subdésertiques	Torriorthents	Ustorthents and Xerorthents.
II/32 Xerorankers [1]		Ustochrepts and Xerochrepts.
II–4 Sols peu évolués non climatiques		
II/41 Sols d'érosion	Orthents (except Torriorthents and Pergelic Cryorthents).	
II/42 Sols d'apport alluvial	Fluvents (except Torrifluvents)	Torrifluvents, Fluventic Umbrepts, and Fluventic Mollisols.
II/43 Sols d'apport colluvial	Fluvents (except Torrifluvents)	Torrifluvents, Fluventic Umbrepts, and Fluventic Mollisols.
II/44 Sols d'apport éolien	Typic subgroups of Psamments	Fine-silty and coarse-silty families of Orthents.
II/45 Sols d'apports volcaniques friables.	Ashy and cindery families of Orthents.	Vitrandepts.
II/46 Sols d'apport anthropique	Plaggepts	Arents and Orthents.
III Vertisols		
III–1 Vertisols à drainage externe nul ou réduit.		
III/11 Vertisols à drainage externe nul ou réduit à structure arrondie.		Pelluderts, Pellusterts, and Pelloxererts.
III/12 Vertisols à drainage externe nul ou réduit et à structure anguleuse sur au moins les 15 cm supérieurs.	Pelluderts, Pellusterts, and Pelloxererts.	

TABLE 16.—*The French taxonomy (1967) and approximate equivalents in this taxonomy*—Continued

French taxonomy, 1967	This taxonomy	
Class, subclass, and group	Great groups or other taxa mostly included	Great groups or other taxa partly included
III–2 Vertisols à drainage externe possible.		
III/21 Vertisols à drainage externe possible et à structure arrondie sur au moins les 15 cm supérieurs.	----------	Chromuderts, Chromusterts, and Chromoxererts.
III/22 Vertisols à drainage externe possible et à structure anguleuse sur au moins les 15 cm supérieurs.	Chromuderts, Chromusterts, and Chromoxererts.	
IV Andosols [2]		
IV–1 Andosols des pays froids		
IV/11 Andosols humifères désaturés	Cryandepts and frigid families of Dystrandepts.	Frigid families of Vitrandepts.
IV–2 Andosols des pays tropicaux		
IV/21 Sols saturés	Hyperthermic, isothermic, and warmer families of Eutrandepts.	
IV/22 Sols désaturés	Hydrandepts and hyperthermic, isothermic, and warmer families of Dystrandepts.	
V Sols Calcomagnésiques		
V-1 Sols carbonatés		
V/11 Rendzines	Typic Rendolls.	
V/12 Sols bruns calcaires	Typic Eutrochrepts	Xerochrepts.
V/13 Cryptorendzines	----------	Typic Rendolls.
V-2 Sols saturés		
V/21 Sols bruns calciques	Eutrochreptic Rendolls and Eutropeptic Rendolls.	Eutrochrepts and Typic Rendolls.
V/22 Sols humiques carbonatés	Lithic Rendolls, Cryic Rendolls, and skeletal families of Rendolls.	
V/23 Sols calciques mélanisés	Petrocalcic Palexerolls	Vertic Rendolls and Vertic Hapludolls.
V–3 Sols gypseux		
V/31 Sols gypseux rendziniformes	Gypsic families of Lithic Hapludolls and Entic Hapludolls.	
V/32 Sols bruns gypseux	Gypsiorthids.	
VI Sols Isohumiques		
VI–1 Sols isohumiques de pédo-climat relativement humide.		
VI/11 Brunizems	Udolls	Petrocalcic Palexerolls, and Natrixerolls.
VI–2 Sols isohumiques à pédo-climat très froid.		
VI/21 Chernozem	Udic subgroups of Haploborolls, Argiborolls, and Vermiborolls.	
VI/22 Sols chatains	Petrocalcic Paleustolls and typic subgroups of Borolls.	Ustrochrepts and udic and typic subgroups of Haplustolls and Argiustolls.
VI/23 Sols bruns isohumiques	Aridic subgroups of Borolls, and Ustollic Aridisols.	Aridic subgroups of Ustolls.
VI–3 Sols isohumiques à pédo-climat frais pedant les saisons pluvieuse.		
VI/31 Sols marrons	Haploxerolls, Argixerolls, and Palexerolls.	Xerochrepts.
VI/32 Sierozem	Xerollic Aridisols.	

TABLE 16.—*The French taxonomy (1967) and approximate equivalents in this taxonomy*—Continued

French taxonomy, 1967	This taxonomy	
Class, subclass, and group	Great groups or other taxa mostly included	Great groups or other taxa partly included
VII–2 Sols brunifiés des climats tempérés continentaux.		
VII/21 Sols gris forestiers	Alfic subgroups of Argiborolls and mollic subgroups of Boralfs.	
VII/22 Sols derno-podzoliques	Glossoborolls.	
VII–3 Sols brunifiés des climats boréaux		
VII/31 Sols lessivés boréaux	Typic Eutroboralfs; Cryoboralfs.	
VII–4 Sols brunifiés des pays tropicaux		
VII/41 Sols bruns eutrophes tropicaux	Eutropepts and Tropudalfs	Isohyperthermic families of Haplustalfs.
VIII Sols Podzolisés		
VIII–1 Sols podzolisés de climat tempéré		
VIII/11 Podzols and VIII/12 Sols podzoliques.	Frigid and mesic families of Typic Spodosols except Aquods and spodic subgroups of Psamments.	
VIII/13 Sols ocre-podzoliques	Frigid and mesic families of entic sub-	

TABLE 16.—*The French taxonomy (1967) and approximate equivalents in this taxonomy*—Continued

French taxonomy, 1967	This taxonomy	
Class, subclass, and group	Great groups or other taxa mostly included	Great groups or other taxa partly included
XI Sols Hydromorphes		
XI–1 Sols hydromorphes organiques		
XI/11 Sols à tourbe fibreuse	Fibrists.	
XI/12 Sols à tourbe semi-fibreuse	Hemists.	
XI/13 Sols à tourbe altérée	Saprists.	
XI–2 Sols hydromorphes moyennement organiques.		
XI/21 Sols humiques à gley		Hydraquents, Calciaquolls, and histic subgroups of Andaquepts, Cryaquepts, and Humaquepts.
XI/22 Sols humiques à stagnogley		Aqualfs and Aquepts.
XI–3 Sols hydromorphes minéraux ou peu humifères.		
XI/31 Sols hydromorphes peu humifères à gley.		Aquents, Haplaquepts, Tropaquepts, Halaquepts, Albaqualfs, Ochraqualfs, Albaquults, Ochraquults, Ochraquox, and Paleaquults.
XI/32 Sols hydromorphes peu humifères à pseudogley.		Albaqualfs, Glossaqualfs, Fragiaquepts, Haplaquepts, Fragiaqualfs, Fragiaquults, and aquic subgroups of Fragiochrepts, Fragiudalfs, and Fragiudults.
XI/33 Sols hydromorphes peu humifères à stagnogley.		Aquents, Haplaquepts, Tropaquepts, Ochraqualfs, Ochraquults, and Paleaquults.
XI/34 Sols à amphigley [1]		
XI/35 Sols hydromorphes à accumulation de fer en carapace ou cuirasse.	Petroferric subgroups of Aquox, Aquults, and Aquepts.	
XI/36 Sols hydromorphes à redistribution de calcaire ou du gypse.	Calciaquolls.	
XII Sols Sodiques		
XII–1 Sols sodiques à structure non dégradée.		
XII/11 Sols salins	Salorthids	Halaquepts, Sulfaquents, Sulfaquepts, and saline phases of torric great groups.
XII–2 Sols sodiques à structure dégradée		
XII/21 Sols salins à alcalins		Saline phases of Orthids.
XII/22 Sols sodiques à horizon B	Nadurargids, Natrargids, and natric great groups of Mollisols and Alfisols.	
XII/23 Sols sodiques à horizon blanchi	Glossic subgroups of natric great groups of Aridisols, Mollisols, and Alfisols.	Natric subgroups of Xeralfs.

[1] Xerorankers and Sols à amphigley have no equivalent in this taxonomy.
[2] This classification is provisional.

TABLE 17.—*Approximate equivalents between the system of classification for Canada and this soil taxonomy*

Canadian system	This system	
Order and great group	Great groups or other taxa mostly included	Great groups or other taxa partly included
1. Chernozemic	Borolls.	
1.1 Brown (Light Chestnut)	Aridic subgroups of Argiborolls and Haploborolls.	Aquic and vertic subgroups of Argiborolls and Haploborolls; aridic subgroups of Calciborolls; and subgroups of Cryoborolls other than natric and pergelic.
1.2 Dark Brown (Dark Chestnut)	Subgroups of Argiborolls and Haploborolls except aridic and udic.	Subgroups of Calciborolls except aridic; and subgroups of Cryoborolls other than natric and pergelic.
1.3 Black	Udic subgroups of Argiborolls and Haploborolls.	Aquic and vertic subgroups of Argiborolls and Haploborolls; subgroups of Calciborolls other than typic and aridic; subgroups of Cryoborolls other than natric and pergelic.
1.4 Dark Gray	Boralfic subgroups of Borolls.	
2. Solonetz	Natric great groups of Alfisols and Mollisols.	
2.1 Solonetz	Natriboralfs, Natriborolls, and frigid families of Natraquolls and Natralbolls.	Frigid families of Natrargids; and natric subgroups of Cryoborolls.
2.2 Solod	Glossic subgroups of Natraqualfs, Natriboralfs, and Natriborolls.	Frigid families of Natraquolls and Natralbolls.
3. Luvisolic	Boralfs and Udalfs.	
3.1 Gray Brown Luvisol	Hapludalfs	Glossudalfs.
3.2 Gray Luvisol	Cryoboralfs, Eutroboralfs, Fragiboralfs, Glossoboralfs, and Paleboralfs.	
4. Podzolic	Spodosols.	
4.1 Humic Podzol	Cryohumods, Placohumods, and frigid families of other Humods.	
4.2 Ferro-Humic Podzol	Humic Cryorthods, Placorthods, and frigid families of humic subgroups of other Orthods.	
4.3 Humo-Ferric Podzol	Cryorthods, Placorthods, and frigid families of other Orthods except humic subgroups.	
5. Brunisolic	Cryic great groups and frigid families of Inceptisols.	
5.1 Melanic Brunisol		Eutrochrepts and Hapludolls.
5.2 Eutric Brunisol	Typic and pergelic subgroups of Cryo-	

The Soviet taxonomy

The basic unit of the Soviet taxonomy is the soil type, which is roughly the equivalent of the great group in this taxonomy. By 1967, about 110 soil types had been recognized for soils of the plains in the USSR (Rozov and Ivanova 1967). Their arrangement of the soil types has been followed in this text because it is the most recent available complete list of Soviet soil types.

Also about 1967 a series of five books edited by E. N. Ivanova and N. N. Rozov was published, Classification and Determination of Soil Types (Ukazaniya po klassifikatisii i diagnostike pochv). These books have been translated and published as a single volume (Ivanova and Rozov 1967). They describe about 85 of the soil types and their subtypes and facies, but they do not describe the coldest soils. The correlations for the Arctic soils and for the soils of the tundra and frozen and others have significant parts included in more than one Soviet type. If a significant part of a taxon is not included in the Soviet type, the name from this system is followed by the abbreviation pt. (pro parta). The definitions of the Soviet soil types in the 1967 publication are specifically restricted to the soils of the plains of the USSR.

Readers in North America may not be familiar with the Soviet temperature units, which are the degree days of air temperatures in excess of 10° C. In the parts of the United States where the climate is continental, as in the subhumid to humid parts of the Great Plains, the degree days, to base 10° C, are related to the soil temperature regimes, which are defined in terms of mean annual soil temperature, approximately as follows:

Frigid	<1,500
Mesic	1,500–2,500
Thermic	2,500–4,200

Table 18.--A systematic list of USSR soils

Bio-fiziko-khimicheskie ryady
Biophysicochemical orders

[redacted]

Bickrugovorot[5] sil'no'zator' mozhennyi azotny Biological cycle[6] strongly retarded nitrogen	Gidromorfnye Hydromorphic	Bolotnye tundrovye Bog Tundra Histosols, pergelic, pt. Cryaquepts, histic pergelic, pt. Allyuvial'no-tundrovye-bolotnye Alluvial Tundra-Bog Histosols, pergelic, pt. Cryaquepts, histic pergelic, pt.				
Pochvy merzlotno-taezhnykh oblastei Soils of frozen taiga regions $\Sigma T^{\circ}>10^{\circ}$ = 600-800 $\Sigma T^{\circ}>10C$ = 600-800	Avtomorfnye Automorphic	Merzlotno-taezhnye Frozen Taiga Cryochrepts,pergelic, pt. Cryochrepts,dystric, pt. Cryumbrepts,pergelic, pt. Derno-taezhnye merzlotnye Frozen Sod Taiga Cryochrepts,pergelic, pt. Cryochrepts,dystric, pt. Cryumbrepts,pergelic, pt.	Palevye merzlotno-taezhnye Pale yellow frozen Taiga Cryochrepts,pergelic, pt. Cryoborolls,pergelic, pt. Dernovo-karbonatno-merzlotnye Frozen Sod-calcareous Cryoborolls,pergelic, pt.			
			Lugovo-lesnye-merzlotnye Frozen Meadow Forest Cryumbrepts,pergelic, pt.			
	Slabogidro-morfnye-allyu-vial'nye Weakly hydro-morphic allu-vial	Allyuvial'nye-dernovye merzlotnye Frozen Alluvial Sod Cryumbrepts,pergelic, pt. Cryoborolls,pergelic, pt. Cryorthents,pergelic, pt.				
Osadki (god) = 150-400 mm Precipitation (annual) = 150-400 mm Koef. uvlazh. >1 Moisture coef-ficient >1 Vyetri vanie-oblomochno-siallitnoe Fragmental sial-litic weathering Biokrugovorot-sil'no-zator-mozhennyi kal'tsievoazotnyi Biological cycle--strongly retarded calcium-nitrogen	Polugidromorfnye Semihydro-morphic	Merzlotno-taezhnye zabolochennye Frozen Taiga water-logged Cryaquepts,pergelic, pt.	Palevye merzlotno-taezhnye zabolochennye Waterlogged pale-yellow frozen-Taiga Cryaquepts,pergelic, pt. Peregnoino-karbonatnye merzlotnye zabolochennye Frozen waterlogged Humus-calcareous Cryaquolls,pergelic, pt. Lugovo-chernozemnovidnye merzlotnye Frozen Meadow Cher-nozemlike Cryoborolls, pergelic Cryaquolls, pergelic, pt. Solodi taezhnye merzlotnye Frozen Taiga Solods Cryaquepts, pergelic, pt.			
	Gidromorfnye zastoino-merzlotnye Hydromorphic stagnant-frozen	Bolotnye merzlotnye verkhovye Frozen Upland Bog Sphagnofibrists, pergelic	Lugovye merzlotnye Frozen Meadow Cryaquolls, pergelic Lugovo-bolotnye merzlotnye Frozen Meadow Bog Cryaquolls, histic pergelic Cryaquolls, pergelic, pt. Cryaquepts, pergelic, pt.			Solontsy lugovye merzlotnye Frozen Meadow Solonetzes Natraqualfs, pergelic, pt.[7] Natriboralfs, pergelic[7] Solonchaki merzlotnye Frozen Solonchaks

Table 18.--A systematic list of USSR soils--Continued

		Bio-fiziko-khimicheskie ryady Biophysicochemical orders				
Ekologo-geneticheskie (bio-klimaticheskie gruppy ili klassy) Ecological-genetic (bio-climatic groups or classes)	Geneticheskie ryady Genetic orders	Preimuschestvenno ful'vatnye nenasyshchennye v predelakh vsego profilya. Gumatnaya chast' svyazana s R_2O_3. Legkorastvorimye soli i karbonaty vymyty. Predominantly fulvate nonsaturated throughout the entire profile. Humate part bound with R_2O_3. Readily soluble salts and carbonates removed.	Ful'vatno-gumatnye slabo nenasyshchennye i nenasyshchennye v verknei chasti profilya, nasyshchennye v nizhnei. Gumatnaya chast' svyazana s R_2O_3 i Ca. Legkorastvorimye soli vymyty. Fulvate-humate slightly nonsaturated and nonsaturated in the upper part of the profile, saturated in the lower part. Humate part bound with R_2O_3 and Ca. Readily soluble salts removed (or leached).	Preimuschestvenno gumatnye kal'tsievye. V gumusovom gorizonte preobladaet pogloshchennye Ca'' nizhe Ca'' i Mg''. Gumatnaya chast' svyazana preimushchestvenno s Ca'' i chastichno s R_2O_3. Legkorastvorimye soli vymyty ili v nizhnei chasti profilya. Predominantly humate-calcium. Adsorbed Ca^{++} predominant in the humus horizon, further down Ca^{++} and Mg^{++}. Humate part bound primarily with Ca^{++} and, partly, with R_2O_3. Readily soluble salts leached or in the lower part of the profile.	Gumatno-ful'vatnye kal'tsievye. V gumusovom gorizonte polloshchennye Ca i chastichno Mg'' nizhe chasto vstrechaetsya Na'. Gumatnaya chast' svyazana s Ca. Legkorastvorimye soli v nizhnei i srednei chasti profilya. Humate-fulvate calcium. Adsorbed Ca^{++} and to some extent, Mg^{++} in the humus horizon, Na^{+} often found below. Humate part bound with Ca. Readily soluble salts in the lower and middle part of the profile.	Gumatno-ful'vatnye natrovye. V sostave pogloshchennykh osnovanni opredelyayushchaya rol' prinadlezhit Na' naryadu c Mg'' i Ca''. Legkorastvorimye soli mogut vstrechaet'sya vo vsekh gorizontakh profilya. Humate-fulvate-sodium. Na^{+} along with Mg^{++} and Ca^{++} plays the determining role in composition of adsorbed bases. Readily soluble salts may be found in all profile horizons.
		Bolotnye nizinnye merzlotnye Frozen Lowland Bog Histosols, pergelic, pt. Cryaquepts, histic, pergelic Allyuvial'nye bolotnye merzlotnye Frozen Alluvial Bog Histosols, pergelic, pt. Cryaquepts, histic pergelic, pt.				Cryaquepts, pergelic, (saline) Natraqualfs, pergelic7/
Pochvy taezhno-lesnykh boreal'nykh oblastei Soils of tiaga-forest boreal regions $\Sigma T°>10°$ =600-2,400 $\Sigma T°>10C$ = 600-2,400	Avtomorfnye Automorphic	Podzolistye Podzolic Cryoboralfs (except mollic) Eutroboralfs (except mollic) Glossoboralfs Orthods (except pergelic) Humods (except pergelic) Aquods, pt. Cryaquepts, pt. Lesnye peplovo-vulkanicheskie (kislye) Forest Ash-volcanic (Acid) Cryandepts Dystrandepts, frigid and mesic Vitrandepts, pt., frigid and mesic	Dernovye litogenye Sod Lithogenic Cryochrepts (except pergelic) Dystrochrepts, frigid Eutrochrepts, frigid Dernovo-karbonatnye Sod-calcareous Cryoborolls, pt. Eutrochrepts, pt. Serye lesnye Gray Forest Borolls, alfic Boralfs, mollic			
Osadka (god) = 400-800 mm Precipitation (annual) = 400-800 mm	Slabogidromorfnye Allyuvial'nye Weakly-hydromorphic Alluvial	Allyuvial'nye dernovye Alluvial Sod Cryofluvents Udifluvents, frigid Borolls, fluventic				

Koef. uvlazhn. >1 Moisture coefficient >1						
Vyvetrivanie - sialitnoe Weathering--siallitic	Polugidromorfnye Semihydromorphic	Bolotno-podzolistye Bog-Podzolic Cryaquepts, histic and typic, pt. Cryaquods Cryoboralfs, pt. Haplaquepts, frigid, pt. Haplaquods, frigid Sideraquods, frigid	Dernovo-gleevye Sod-Gley Cryaquolls, typic Haplaquolls, frigid Serye lesnye gleevye Gley Gray Forest Albolls, pt. Argiaquolls, frigid Albaqualfs, mollic, pt.			
		Allyuvial'nye dernovo-gleevye Alluvial Sod-Gley Cryaquents, pt. Fluvaquents, frigid, pt. Cryaquolls, fluvaquentic 7/ Humaquepts				
Biokrugovorto-sil'no zatormozhennyi kal'tsievo-azotnyi Biological cycle-strongly retarded calcium-nitrogen	Gidromorfnye Hydromorphic	Bolotnye verkhovye Upland Bog Cryaquepts, histic pergelic Sphagnofibrists Cryofibrists, pt., dysic Borofibrists, pt. Cryohemists, pt. Borohemists, pt.				
		Bolotnye nizinnye Lowland Bog Haplaquepts, histic, pt. 7/ Cryofibrists, euic Cryohemists, euic Borofibrists, euic Borohemists, euic Allyuvial'nye bolotnye Alluvial Bog Fluvaquents, frigid, pt. Borohemists, fluvaquentic Borosaprists, fluvaquentic				
Pochvy burozemno-lesnikh subboreal'-nykh oblastei Soils of Brown Earth-Forest $\Sigma T°>10° = 1,800-3,800$ $\Sigma T°>10C = 1,800-3,800$	Avtomorfnye Automorphic	Burye lesnye (burozemy) Brown Forest (Brown Earths) Dystrochrepts, mesic and thermic Eutrochrepts, mesic and thermic Hapludults, pt. Haploxeralfs, pt. Hapludalfs, pt. Haplustalfs, pt. Podzolisto-burozemnye Podzolic Brown Earths Albaqualfs Hapludalfs, albaquic	Rendziny burye Brown Rendzinas Hapludalfs, pt. Rendolls, eutrochreptic			
	Slabogidromorfnye allyuvial'nye Weakly-hydromorphic Alluvial	Allyuvial'nye dernovye burozemnoi zony Alluvial Sod of Brown Earth zone Udifluvents, mesic and thermic Hapludolls, fluventic, pt.				

Table 18.--A systematic list of USSR soils--Continued

Ekologo-geneticheskie (bio-klimaticheskie gruppy ili klassy Ecological-genetic (bio-climatic groups or classes)	Geneticheskie ryady Genetic orders	Bio-fiziko-khimicheskie ryady Biophysicochemical orders				
		Preimuschestvenno ful'vatnye nenasyshchennye v predelakh vsego profilya. Gumatnaya chast' svyazana s R_2O_3. Legkorastvorimye soli i karbonaty vymyty. Predominantly fulvate nonsaturated throughout the entire profile. Humate part bound with R_2O_3. Readily soluble salts and carbonates removed.	Ful'vatno-gumatnye slabo nenasyshchennye i nenasyshchennye v verknei chasti profilya, nasyshchennye v nizhnei. Gumatnaya chast' svyazana s R_2O_3 i Ca. Legkorastvorimye soli vymyty. Fulvate-humate slightly nonsaturated and nonsaturated in the upper part of the profile, saturated in the lower part. Humate part bound with R_2O_3 and Ca. Readily soluble salts removed (or leached).	Preimuschestvenno gumatnye kal'tsievye. V gumusovom gorizonte preobladaet poglosbchennye $Ca^{\cdot\cdot}$ nizhe $Ca^{\cdot\cdot}$ i $Mg^{\cdot\cdot}$. Gumatnaya chast' svyazana preimushchestvenno s $Ca^{\cdot\cdot}$ i chastichno s R_2O_3. Legkorastvorimye soli vymyty ili v nizhnei chasti profilya. Predominantly humate-calcium. Adsorbed Ca^{++} predominant in the humus horizon, further down Ca^{++} and Mg^{++}. Humate part bound primarily with Ca^{++} and, partly, with R_2O_3. Readily soluble salts leached or in the lower part of the profile.	Gumatno-ful'vatnye kal'tsievye. V gumusovom gorizonte poloshchennye Ca i chastichno $Mg^{\cdot\cdot}$ nizhe chasto vstrechaetsya $Na^{\cdot}$. Gumatnaya chast' svyazana s Ca. Legkorastvorimye soli v nizhnei i srednei chasti profilya. Humate-fulvate calcium. Adsorbed Ca^{++} and to some extent, Mg^{++} in the humus horizon, Na^{+} often found below. Humate part bound with Ca. Readily soluble salts in the lower and middle part of the profile.	Gumatno-ful'vatnye natrovye. V sostave poglosbchennykh osnovanni opredelyayushchaya rol' prinadlezhit $Na^{\cdot}$ naryadu c $Mg^{\cdot\cdot}$ i $Ca^{\cdot\cdot}$. Legkorastvorimye soli mogut vstrechaet'sya vo vsekh gorizontakh profilya. Humate-fulvate-sodium. Na^{+} along with Mg^{++} and Ca^{++} plays the determining role in composition of adsorbed bases. Readily soluble salts may be found in all profile horizons.
Osadki (god) 450-1,000 mm Precipitation (annual) 450-1,000 mm Koef. uvlazhn. >1 Moisture coefficient >1 Vyvetvivanie-sialitnoe c oglineniem Weathering siallitic with clay formation Biokrugovorot-srednezatormozhennyi Biological cycle--moderately retarded calcium-nitrogen	Polugidromorfnye Semihydromorphic	Burye lesnye gleevye (burozemy gleevye) Gley Brown Forest (Gley Brown Earths) Hapludalfs, aquic Argiaquolls, pt. Ochraqualfs, mollic, pt. Podzolisto-burozemnye gleevye Podzolic Brown Earth Gley Albaqualfs, typic Allyuvial'nye dernovo-gleevye burozemnoi zony Alluvial Sod Gley of Brown Earth zone Fluvaquents, pt. Haplaquolls, cumulic, pt. Haplaquolls, fluvaquentic, pt.	Lugovo-chernozyomo-Vidnye prerii Meadow Chernozemlike of prairies Argiborolls, aquic Argiaquolls, frigid Argialbolls, frigid			
	Gidromorfnye Hydromorphic		Lugovye tyomnye zony prerii Meadow Dark of prairie zone Ochraqualfs, histic, 2/ frigid Ochraqualfs, mollic, frigid Allyuvial'nye vlazhno-lugovye zony prerii			

			Alluvial moist-Meadow of prairie zone Fluvaquents, pt. Haplaquolls, cumulic, pt. Haplaquolls, fluvaquentic, pt.			
		Allyuvial'nye bolotnye burozemnoi zony i zony prerii Alluvial Bog of Brown Earth zone and prairie zone Medihemists, fluvaquentic Fluvaquents, mesic and thermic, pt.				
Pochvy stepnykh subboreal'nykh oblastei Soils of t steppe subboreal regions	Avtomorfnye Automorphic			Chernozyomy Chernozems Cryoborolls Vermiborolls Haploborolls, typic and udic Haplustolls, typic and udic Vermustolls, typic and udic[7] Argiustolls, typic and udic Vermudolls, pt. Pellusterts, pt. Kashtanovye Chestnut Borolls, aridic Ustolls, aridic Haplargids, ustollic, pt. Camborthids, ustollic, pt.		Solontsy stepnye (Chernozyomnye) Steppe Solonetzes (Chernozem) Natriborolls, pt. Natrustolls, typic, pt., glossic Natrargids, pt. Solontsy stepnye (Kashtanovye) Steppe Solonetzes (Chestnut) Natrustolls, aridic, pt. Natrargids, ustollic, pt.
	Slabogidromorfnye allyuvial'nye Weakly Hydromorphic Alluvial			Allyuvial'no-lugovye Alluvial Meadow Ustifluvents Ustolls, fluventic Ustolls, cumulic, pt. Allyuvial'no-lugovye slitye Compact Alluvial Meadow Haplustolls, vertic, pt		
ΣT°>10° = 1,800-3,400 ΣT°>10C = 1,800-3,400 Osadki (god) = 220-640 mm Precipitation (annual) = 220-640 mm Koef. uvlazhn. 0.3-1 Moisture coefficient 0.3-1 Vyvetrivanie-siallitno-karbonatnye Weathering sialitic carbonate	Polugidromorfnye Semihydromorphic			Lugovo-chernozyomnye Meadow Chernozem Haplustolls, udic, pt. Haplustolls, aquic, pt. Haplustolls, cumulic, pt. Lugovo-kashtanovye Meadow Chestnut Argiustolls, udic, pt. Haplustolls, udic, pt. Haplustolls, aquic, pt.		Solontsy lugovo-stepnye chernozyomnye Meadow Steppe Chernozem Solonetzes Natriborolls, pt. Natrustoll, typic, pt. Solontsy lugovo-stepnye kashtanovye Meadow Steppe Chestnut Solonetzes Natrustolls, typic, pt. (Solod)[8] Albolls, pt. Glossaqualfs, pt.

Table 18.--A systematic list of USSR soils--Continued

Ekologo-geneticheskie (bio-klimaticheskie gruppy ili klassy) Ecological-genetic (bio-climatic groups or classes)	Geneticheskie ryady Genetic orders	Bio-fiziko-khimicheskie ryady Biophysicochemical orders				
		Preimuschestvenno ful'vatnye nenasyshchennye v predelakh vsego profilya. Gumatnaya chast' svyazana s R_2O_3. Legkorastvorimye soli i karbonaty vymyty. Predominantly fulvate nonsaturated throughout the entire profile. Humate part bound with R_2O_3. Readily soluble salts and carbonates removed.	Ful'vatno-gumatnye slabo nenasyshchennye i nenasyshchennye v verknei chasti profilya, nasyshchennye v nizhnei. Gumatnaya chast' svyazana s R_2O_3 i Ca. Legkorastvorimye soli vymyty. Fulvate-humate slightly nonsaturated and nonsaturated in the upper part of the profile, saturated in the lower part. Humate part bound with R_2O_3 and Ca. Readily soluble salts removed (or leached).	Preimuschestvenno gumatnye kal'tsievye. V gumusovom gorizonte preobladaet poglosheshchennye Ca^{++} nizhe Ca^{++} i Mg^{++}. Gumatnaya chast' svyazana preimushchestvenno s Ca^{++} i chastichno s R_2O_3. Legkorastvorimye soli vymyty ili v nizhnei chasti profilya. Predominantly humate-calcium. Adsorbed Ca^{++} predominant in the humus horizon, further down Ca^{++} and Mg^{++}. Humate part bound primarily with Ca^{++} and, partly, with R_2O_3. Readily soluble salts leached or in the lower part of the profile.	Gumatno-ful'vatnye kal'tsievye. V gumusovom gorizonte polloshchennye Ca i chastichno Mg^{++} nizhe chasto vstrechaetsya Na^{+}. Gumatnaya chast' svyazana s Ca. Legkorastvorimye soli v nizhnei i srednei chasti profilya. Humate-fulvate calcium. Adsorbed Ca^{++} and to some extent, Mg^{++} in the humus horizon, Na^{+} often found below. Humate part bound with Ca. Readily soluble salts in the lower and middle part of the profile.	Gumatno-ful'vatnye natrovye. V sostave poglosheshchennykh osnovanni opredelyayushchaya rol' prinadleznit Na^{+} naryadu c Mg^{++} i Ca^{++}. Legkorastvorimye soli mogut vstrechaet'sya vo vsekh gorizontakh profilya. Humate-fulvate-sodium. Na^{+} along with Mg^{++} and Ca^{++} plays the determining role in composition of adsorbed bases. Readily soluble salts may be found in all profile horizons.
Biokrugovorot-intensivnyi azotno-dremnevyi i azotno-kremnevo kal'-tsievyi Biological cycle--intensive nitrogen-silicon and nitrogen-silicon-calcium	Gidromorfnye Hydromorphic			Lugovye Meadow Aquolls, aeric, mesic, and thermic, pt. Lugovo-bolotnye Meadow-Bog Haplaquolls, cumulic and typic, pt. Calciaquolls, pt. Natraquolls, pt. Allyuvial'nye vlazhno-lugovye Alluvial Moist Meadow Fluvaquents, pt. Haplaquolls, cumulic, pt. Haplaquolls, fluvaquentic pt. Allyuvial'nye lugovo-bolotnye Alluvial Meadow-Bog Haplaquolls, cumulic, pt. Haplaquolls, histic, pt. Histosols, fluvaquentic, pt.		Solontsy lugovye Meadow Solonetzes Natriborolls, pt. Natrustolls, pt. Natrargids, ustollic and borollic, pt. Solonchaki stepnye gidromorfnye Hydromorphic Steppe Solonchaks Salorthids, pt. Halaquepts, pt.
Pochvy polupust-ynnykh i pust-ynnykh sub-oblastei Soils of semi-desert and desert sub-boreal regions	Avtomorfnye Automorphic				Burye polupustynnye Semidesert Brown Camborthids, borollic Calciorthids, borollic Gypsiorthids, borollic 2/ Sero-burye pustynnye Desert Gray-Brown	Sonontsy polupustynnye Semidesert Sononetzes Natrargids, borollic, pt. Natrargids, ustollic, pt.

ΣT°>10° = 2,400-4,200 ΣT°>10C = 2,400-4,200 Osadki (god) = 75-300 mm Precipitation (annual) 75-300 mm Koef. uvlazhn. <0.3 Moisture coefficient <0.3 Vyvetrivanie-siallitno-karbonatno-gipsovoe oblomochno-pylevatoe Weathering-siallitic carbonate-gypsum-fragmental-silty Biokrugovorot-intensivnyi azotno-kremnevyi Biological cycle--intensive nitrogen-silicon					Camborthids, typic, pt. Torriorthents, pt. Haplargids, typic Salorthids, pt. Gypsiorthids Pustynnye takyrovidnye Desert Takyrlike Torrifluvents, typic, pt. Torriorthents, pt. Peschanye pustynnye Sandy Desert Torripsamments Takyr Soils 9/ Torriorthents, pt. Salorthids, pt. Torrerts, pt. Croshaemye pustynnye Irrigated Desert Torrifluvents, anthropic, 7/ typic Torriorthents, typic, pt.	Solonchaki pustynnye Desert Solonchaks Torriorthents, saline phase
	Slabogidromorfnye Weakly-hydromorphic Alluvial				Allyuvial'nye pustynno-lugovye Alluvial Desert-Meadow Torriorthents, aquic Torrifluvents, aquic 7/ Ustifluvents, pt. Salorthids, pt.	
	Polugidromorfnye Semihydromorphic				Lugovo-pustynnye Meadow Desert Camborthids, ustollic, pt. Torriorthents, pt. Lugovo-pustynnye takyrovidnye Meadow Desert Takyrlike 10/ Croshaemye lugovo-pustynnye Irrigated Meadow Desert Torrifluvents, pt. Camborthids, ustollic, pt.	Solontsy lugovo-polupustynnye Meadow Semidesert Solonetzes Natrargids, ustollic, pt. Natrargids, typic, pt.
	Gidromorfnye Hydromorphic				Lugovye pustynnye Desert Meadow Torrifluvents, ustollic, pt. Torriorthents, pt.	Solontsy-polupustynno-lugovye Semidesert Meadow Solonetzes Natrargids, pt.

Table 18.--A systematic list of USSR soils--Continued

Ekologo-geneticheskie (bio-klimaticheskie gruppy ili klassy) Ecological-genetic (bio-climatic groups or classes)	Geneticheskie ryady Genetic orders	Bio-fiziko-khimicheskie ryady Biophysicochemical orders				
		Preimuschestvenno ful'vatnye nenasyshchennye v predelakh vsego profilya. Gumatnaya chast' svyazana s R_2O_3. Legkorastvorimye soli i karbonaty vymyty. Predominantly fulvate nonsaturated throughout the entire profile. Humate part bound with R_2O_3. Readily soluble salts and carbonates removed.	Ful'vatno-gumatnye slabo nenasyshchennye i nenasyshchennye v verknei chasti profilya, nasyshchennye v nizhnei. Gumatnaya chast' svyazana s R_2O_3 i Ca. Legkorastvorimye soli vymyty. Fulvate-humate slightly nonsaturated and nonsaturated in the upper part of the profile, saturated in the lower part. Humate part bound with R_2O_3 and Ca. Readily soluble salts removed (or leached).	Preimuschestvenno gumatnye kal'tsievye. V gumusovom gorizonte preobladaet pogloshchennye Ca^{++} nizhe Ca^{++} i Mg^{++}. Gumatnaya chast' svyazana preimushchestvenno s Ca^{++} i chastichno s R_2O_3. Legkorastvorimye soli vymyty ili v nizhnei chasti profilya. Predominantly humate-calcium. Adsorbed Ca^{++} predominant in the humus horizon, further down with Ca^{++} and, partly, with R_2O_3. Readily soluble salts leached or in the lower part of the profile.	Gumatno-ful'vatnye kal'tsievye. V gumusovom gorizonte polloshchennye Ca i chastichno Mg^{++} nizhe chasto vstrechaetsya Na^{+}. Gumatnaya chast' svyazana s Ca. Legkorastvorimye soli v nizhnei i srednei chasti profilya. Humate-fulvate calcium. Adsorbed Ca^{++} and to some extent, Mg^{++} in the humus horizon, Na^{+} often found below. Humate part bound with Ca. Readily soluble salts in the lower and middle part of the profile.	Gumatno-ful'vatnye natrovye. V sostave pogloshchennykh osnovanii opredelyayushchaya rol' prinadleznit Na^{+} naryadu c Mg^{++} i Ca^{++}. Legkorastvorimye soli mogut vstrechaet'sya vo vsekh gorizontakh profilya. Humate-fulvate-sodium. Na^{+} along with Mg^{++} and Ca^{++} plays the determining role in composition of adsorbed bases. Readily soluble salts may be found in all profile horizons.
					Calciorthids, ustollic, pt. Oroshaemye lugovye pustynnye Desert Irrigated Meadow Torrifluvents, pt. Torriorthents, pt. Allyuvial'nye pustynno-vlazhno-lugovye Alluvial Desert moist-Meadow Torrifluvents, pt. Ustifluvents, pt. Haplustolls, fluventic, pt. Allyuvial'no-ilovato bolotnye Alluvial-Clayey-Bog Fluvaquents, pt.	Solonchaki pustynnye gidromorfnye Desert Hydromorphic Solonchaks Salorthids, pt.
Pochvy polupustynnykh umerenno-teplykh i subtropicheskikh oblastei Soils of semidesert moderately warm and subtropical regions	Avtomorfnye Automorphic				Serozyomy Sierozems Torriorthents, pt. Camborthids, xerollic, pt. Haploxerolls, aridic Haploxerolls, calcic Oroshaemye serozyomy Irrigated Sierozems	

ΣT°>10° = 3,600-5,600 ΣT°>10C = 3,600-5,600 Osadki (god) = 120-350 mm Precipitation (annual) 120-350 mm Koef. uvlazhn. <0.3 Moisture coefficient <0.3 Vyvetrivanie-sialitno-karbonatnye, so slabym oglineniem Weathering-siallitic-carbonate with weak clay formation Biokrugovorot-ves'ma intensivnyi azotno-kremnevyi i azotno-kremnevo-kal'tsievyi Biological cycle--very intensive nitrogen-silicon and nitrogen-silicon-calcium	Slabogidromorfnye allyuvial'nye Weakly-hydromorphic Alluvial				Torrifluvents, pt. Xerofluvents, pt. Allyuvial'no-logovye serozyomnoi zony Alluvial Meadow of Sierozem zone Torrifluvents, xeric	
	Polugidromorfnye Semihydromorphic				Lugovo-serozyomnye Meadow Sierozem Camborthids, xerollic, pt. Oroshaemye lugovo-serozyomnye Irrigated Meadow-Sierozem Camborthids, xerollic, pt. Xerofluvents, pt.	
	Gidromorfnye Hydromorphic				Lugovye sazovye Waterlogged Meadow Calciaquolls, pt. Haplaquolls, cumulic, pt. Oroshaemye lugovye serozyomnoi zony Irrigated Meadow of Sierozem zone Xerofluvents, aquic Haploxerolls, fluvaquentic Allyuvial'nye ilovato-bolotnye serozyomnoi zony Alluvial Clayey Bog of Sierozem zone Histosols, terric, pt. Fluvaquents, pt.	Solontsy logovye serozyomnoi zony Meadow Solonetzes of Sierozem zone Natrargids, pt. Solonchaki serozyomnoi zony gidromorfnye Hydromorphic Solonchaks of Sierozem zone Salorthids, pt.
Pochvy polusukhikh umerenno-teplykh i subtropicheskikh oblastei Soils of semidry moderately warm and subtropical regions ΣT°>10° = 3,600-4,400 ΣT°>10C = 3,600-4,400 Osadki (god) 350-600 mm Precipitation (annual) 350-600 mm Koef. uvlazhn. 0.3-1 Moisture coefficient 0.3-1	Avtomorfnye Automorphic			Korchnevye Cinnamon-Brown Ustalfs, pt. Argiustolls, pt. Calciustolls Ustochrepts, pt. Haplustolls, pt. Sero-korichnevye Gray-Cinnamon-Brown Calciustolls, pt. Haplustalfs, aridic, pt. Calciorthids, ustollic, pt. Gypsiorthids, typic. ustollic, pt.?/ Torriorthents, pt.		
	Slabogidromorfnye allyuvial'nye Weakly-hydromorphic Alluvial			Allyuvial'nye lugovye korichnevo-zemnoi zony Alluvial Meadow of Cinnamon-Brown Earth zone Torrifluvents, pt. Ustifluvents, pt.		

Table 18.--A systematic list of USSR soils--Continued

Ekologo-geneticheskie (bio-klimaticheskie gruppy ili klassy) Ecological-genetic (bio-climatic groups or classes)	Geneticheskie ryady Genetic orders	Bio-fiziko-khimicheskie ryady Biophysicochemical orders				
		Preimuschestvenno ful'vatnye nenasyshchennye v predelakh vsego profilya. Gumatnaya chast' svyazana s R_2O_3. Legkorastvorimye soli i karbonaty vymyty. Predominantly fulvate nonsaturated throughout the entire profile. Humate part bound with R_2O_3. Readily soluble salts and carbonates removed.	Ful'vatno-gumatnye slabo nenasyshchennye i nenasyshchennye v verknei chasti profilya, nasyshchennye v nizhnei. Gumatnaya chast' svyazana s R_2O_3 i Ca. Legkorastvorimye soli vymyty. Fulvate-humate slightly nonsaturated and nonsaturated in the upper part of the profile, saturated in the lower part. Humate part bound with R_2O_3 and Ca. Readily soluble salts removed (or leached).	Preimuschestvenno gumatnye kal'tsievye. V gumusovom gorizonte preobladaet poglosbchennye $Ca^{\cdot\cdot}$ nizhe $Ca^{\cdot\cdot}$ i $Mg^{\cdot\cdot}$. Gumatnaya chast' svyazana preimushchestvenno s $Ca^{\cdot\cdot}$ i chastichno s R_2O_3. Legkorastvorimye soli vymyty ili v nizhnei chasti profilya. Predominantly humate-calcium. Adsorbed Ca^{++} predominant in the humus horizon, further down Ca^{++} and Mg^{++}. Humate part bound primarily with Ca^{++} and, partly, with R_2O_3. Readily soluble salts leached or in the lower part of the profile.	Gumatno-ful'vatnye kal'tsievye. V gumusovom gorizonte poloshchennye Ca i chastichno $Mg^{\cdot\cdot}$ nizhe chasto vstrechaetsya $Na^{\cdot}$. Gumatnaya chast' svyazana s Ca. Legkorastvorimye soli v nizhnei i srednei chasti profilya. Humate-fulvate calcium. Adsorbed Ca^{++} and to some extent, Mg^{++} in the humus horizon, Na^{+} often found below. Humate part bound with Ca. Readily soluble salts in the lower and middle part of the profile.	Gumatno-ful'vatnye natrovye. V sostave poglosbchennykh osnovanni opredelyayushchaya rol' prinadlezhit $Na^{\cdot}$ naryadu c $Mg^{\cdot\cdot}$ i $Ca^{\cdot\cdot}$. Legkorastvorimye soli mogut vstrechat'sya vo vsekh horizontakh profilya. Humate-fulvate-sodium. Na^{+} along with Mg^{++} and Ca^{++} plays the determining role in composition of adsorbed bases. Readily soluble salts may be found in all profile horizons.
Vyetrivanie-siallitno-karbonatnoe, s vyrazhennym oglineniem Weathering-siallitic-carbonate with expressed clay formation Biokrugovorot-ves'ma intensivnyi azotno-kal'tsievyi Biological cycle--very intensive nitrogen-calcium	Polugidromorfnye Semihydromorphic			Lugovo-korichnevye Meadow Cinnamon-Brown Haplustolls, pt. Haplustalfs, pt. Usterts, pt. Ustochrepts, pt. Lugovo-sero-korichnevye Meadow Gray--Cinnamon-Brown Haplustolls, aquic, pt. Haplustalfs, aquic, pt.		
	Gidromorfnye Hydromorphic			Lugovye korichnevo-zemnoi zony Meadow of Cinnamon-brown Earth zone Aqualfs, pt. Aquepts, pt. Allyuvial'nye lugovo-bolotnye korichnevo-zemnoi zony. Alluvial Meadow Bog of Cinnamon-brown Earth zone Calciaquolls, pt. Pellusterts, pt.		
Pochvy vlazhnykh subtropicheskikh oblastei Soils of moist subtropical regions	Avtomorfnye Automorphic	Zheltozyomy Yellow-Earths Xerochrepts, pt. Dystrochrepts, pt. Hapludults, pt. Haploxeralfs				

ΣT°>10° = 4,000-4,300 ΣT°>10C = 4,000-4,300 Osadki (god)1,000-2,300 mm Precipitation (annual) 1,000-2,300 mm		Podzolisto-zheltozyomnye Podzolic-Yellow Earth Hapludults, pt. Haploxeralfs, pt. Krasnozyomy Red Earths Rhodudults Hapludults, pt. Dystrochrepts, pt.				
Koef. uvlazhn. >1 Moisture coefficient >1 Vyvetrivanie-ferralitnoe Weathering ferralitic Biodrugovorot-ves'ma intensivnyi kal'-tsievo-azotnyi Biological cycle--very intensive calcium nitrogen	Slabogidromorfnye allyuvial'nye Weakly-hydromorphic Alluvial	Allyuvial'nye dernovye subtropicheskie Subtropic Alluvial Sod Xerofluvents, pt. Udifluvents, pt. Hapludolls,fluventic, pt. Haploxerolls, fluventic, pt.				
	Polugidromorfnye Semihydromorphic	Zheltozyomy gleevye Gley Yellow Earths Hapludults, aquic Ochraquults, aeric Ochraqualfs, pt. Podzolisto-zheltozyomno-gleevye Gley Podzolic Yellow Earth Albaquults, pt. Albaqualfs, pt. Ochraquults, pt. Ochraqualfs, pt. Krasnozyomy gleevye Red Earths Gley Ochraqualfs, pt. Haploxeralfs, aquic, pt. Allyuvial'nye dernovo-gleevye subtropicheskie Subtropic Alluvial Sod-Gley Fluvaquents, pt. Hapludolls, cumulic, pt. Haploxerolls, cumulic, pt.				
	Gidromorfnye Hydromorphic	Allyuvial'nye bolotnye subtropicheskie Subtropical Alluvial Bog Fluvaquents, pt. Histosols, fluvaquentic, pt.				

1/ Koeffitsienty uvlazheniya po Vystokomu - Ivanovu.
2/ (Moisture coefficients after Vysolskiy - Ivanov.)
3/ Preobladayushchee napravlenie vyvetrivaniya po Polynovu.
4/ (Predominant weathering direction after Polynov.)
5/ Probladayushchii tip biologicheskogo drugovorota po Rodinu i Bazilevich.
6/ (Predominant type of biological cycle after Rodin and Bazilevich.)
7/ A subgroup provided for by conventions used elsewhere but not presently defined.
8/ The Solod is listed as a semihydromorphic type by Ivanova and Rozov (1967) but is not listed by Rozov and Ivanova (1967).
9/ The Takyr soils are listed with the automorphic type but called semihydromorphous by Ivanova and Rozov (1967). They are not listed by Rozov and Ivanova (1967), either as automorphic or semihydromorphic.
10/ The Meadow Desert Takyrlike soils are listed by Rozov and Ivanova (1967) but can not be identified in the discussions of Ivanova and Rozov (1967).

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Appendix I. Terms used to describe soils

The description of a soil profile consists mainly of descriptions of its several horizons. A *soil horizon* may be defined as a layer of soil, approximately parallel to the soil surface, with characteristics produced by soil-forming processes. One soil horizon is commonly differentiated from an adjacent one at least partly on the basis of characteristics that can be seen in the field. Yet laboratory data are sometimes required for the identification and designation of horizons as well as for their more detailed characterization. The *soil profile*, as exposed in a cut or section, includes the collection of all the genetic horizons, the natural organic layers on the surface, and the parent material or other layers beneath the solum that influence the genesis and behavior of the soil.

Besides genetic soil horizons, many soils have layers inherited from stratified parent material. In making soil examinations, all distinguishable layers, or horizons, are separately described, regardless of genesis. These descriptions need to be completely objective and clearly able "to stand on their own," regardless of presumed genesis or nomenclature. Objective descriptions are the

a symbol one must reconstruct mentally the character of the parent material, for this was done when the designation was assigned. It implies that the processes that have caused change need not be known. It also implies that specific morphology need not be consistent from profile to profile and that morphology relative to an estimated parent material is the criterion for judgment. The parent material of the horizon in question, not the material in the horizon or layer designated by the symbol C, is used as the basis of comparison. Morphology is interpreted relative to this assumed parent material, not in terms of absolute values of properties.

CONVENTIONS GOVERNING USE OF SYMBOLS

1. Capital letter symbols include O, A, B, C, and R. They indicate dominant kinds of departures from the parent material. More than one kind of departure may be indicated by a single capital letter, providing these departures are within the limits of the definitions given further along in this chapter.

2. In a description of a given profile, if a horizon designated by

in the ratios between the various sand separates, will normally suggest a difference in parent materials. One purpose in identifying lithologic discontinuities is to distinguish between those differences between horizons that are the result of pedo-genesis and those that are geologic. Consequently, a designation with a different Roman number would not normally be used for a buried soil in a thick loess deposit. The difference between the properties of the buried soil and the overlying loess are presumably the result of pedo-genesis. But a stone line usually indicates a need for another Roman number. The material above the stone line is presumed to be transported. If the transport was by wind or water, one must suspect that during the movement there was some sorting of the material according to size.

6. An illuvial or B horizon (together with its overlying eluvial or A horizon if one is present) is called a sequum. If more than one sequum is present in vertical sequence, the lower sequum is given A and B designations with a prime accent, as A′2, B′2. The prime accents are not used however for buried soils. These carry the lower case letter b.

MASTER HORIZONS AND LAYERS

Organic horizons

O—Organic horizons of mineral soils. Horizons: (1) formed or forming in the upper part of mineral soils above the mineral part; (2) dominated by fresh or partly decomposed organic material; and (3) containing more than 30 percent organic matter if the mineral fraction is more than 50 percent clay, or more than 20 percent organic matter if the mineral fraction has no clay.

surface of the soil, or deposited within the horizon without translocation of humified material through an intervening horizon that qualifies for a horizon designation other than A1.

A2—Mineral horizons in which the feature emphasized is loss of clay, iron, or aluminum, with resultant concentration of quartz or other resistant minerals in sand and silt sizes

Such horizons are commonly but not necessarily lighter in color than an underlying B. In some soils the color is determined by that of the primary sand and silt particles, but in many soils, coats of iron or other compounds, apparently released in the horizon and not translocated, mask the color of the primary particles. An A2 is most commonly differentiated from an overlying A1 by lighter color and is generally measurably lower in organic matter. An A2 is most commonly differentiated from an underlying B in the same profile by lighter color, or coarser texture, or both. A2 horizons are commonly near the surface, below an O or A1 horizon and above a B, but the symbol A2 may be used either above or below subsurface horizons; position in the profile is not diagnostic. For horizons at the surface that would qualify equally well as either A1 or A2, the designation A1 is given preference over A2.

A3—A transitional horizon between A and B, and dominated by properties characteristic of an overlying A1 or A2 but having some subordinate properties of an underlying B

No distinction is made between the different kinds of horizons that are transitional from A1 or A2 to different kinds of B; they obviously may be quite unlike one another, but the burden of characterization

B1—A transitional horizon between B and A1 or between B and A2 in which the horizon is dominated by properties of an underlying B2 but has some sub-

tions of carbonates, gypsum, or more soluble salts are permitted in C if the material is otherwise considered to be little affected by other

with wetness, especially in the presence of organic matter, wetness by itself is not a criterion of gleying. The symbol g may be applied to any of the major symbols for mineral horizons and should follow the horizon designations, as A2g, A21g, A3g, B1g, B2g, B3g, and Cg. Bg may be used where B horizons cannot be subdivided into B1, B2, and B3.

No lower case letter is used as a suffix with horizon designations to indicate reduction of iron less intense than that indicated by g. Not given a special designation but described in detail is the condition generally associated with (1) common to many, distinct to prominent mottles on base colors of chroma stronger than 2 in unaggregated material, or (2) evidenced by base chroma greater than 2 with few to common, faint to distinct mottles on ped faces and common to many distinct to prominent mottles in ped interiors in well-aggregated material.

h—Illuvial humus

Accumulations of decomposed illuvial organic matter, appearing as dark coatings on sand or silt particles, or as discrete dark pellets of silt size, are indicated by h. If used, this suffix follows the letter B or a subdivision of B, as Bh or B2h.

ir—Illuvial iron

Accumulations of illuvial iron as coatings on sand or silt particles or as pellets of silt size; in some horizons the coatings have coalesced, filled pores, and cemented the horizon.

m—Strong cementation, induration

The symbol m is applied as a suffix to horizon designations to

SUBDIVISION OF HORIZONS

In a single profile it is often necessary to subdivide the horizons for which designations are provided, for example, to subdivide Ap, A1, A2, A3, B1, B2, B3, or C so that detailed studies of morphology, sampling, and similar work can be correctly recorded. In some cases, such subdivision is arbitrary in relation to differences observable in the field; in others, it may be needed to differentiate within a horizon on bases not provided by unique horizon symbols. In all such cases, the subdivisions are numbered consecutively, with arabic numbers, from the top of the horizon downward, as B21, B22, B23. If the suffixes consisting of lower-case letters are being used, the arabic numbers precede all lower-case suffixes except p as B21t, C1g, C2g, but Ap1, Ap2.

LITHOLOGIC DISCONTINUITES

Roman numerals are prefixed to the appropriate horizon designations when it is necessary to number a series of layers of contrasting material consecutively from the surface downward. A soil that is all in one kind of material is all in material designated by the numeral I. This numeral therefore can be omitted from the symbol, as it is understood that all the material is I. Similarly, the uppermost material in a profile having two or more contrasting materials is always designated I. Consequently, for the topmost material, the numeral I can be omitted from the symbol because it is always understood. Numbering starts with the second layer of contrasting material, which is designated II, and each contrasting material below this second layer is numbered consecutively, III, IV, and so on, downward as part of each horizon

are wider than their depth; (3) *irregular*, if irregular pockets are deeper than their width; and (4) *broken*, if parts of the horizon are unconnected with other parts, as the B_2 in the limestone cracks of a truncated Terra Rossa.

HORIZONTAL VARIATIONS

The profiles of soils having well-developed microrelief cannot be satisfactorily described from pits. To describe such soils, or to understand how one soil profile merges into another at the soil boundary, a long trench is dug so that horizons may be measured, described, sketched, and sampled at appropriate horizontal intervals. Small stakes may be set on the margin of the trench at 6- or 12-inch intervals as reference points. Using one stake as a zero point, the relative elevations of the others can be measured with an ordinary surveyor's level or Y-level.

For the purpose of observing any horizontal cracking or patterns in the soil, it is often revealing to remove soil horizons, one by one from the top down, from an area of a square yard or more. One may, for example, discover gross hexagonal cracking of hardpans or claypans, unsuspected from the vertical cut alone, that suggest previous influences of freezing, moistening, or desiccation that have been interrupted by coverings now changed to a part of the solum.

SOIL COLOR

Color is the most obvious and easily determined of soil characteristics. Although it has little direct influence on the functioning of the soil, one may infer a great deal about a soil from its color, if it is considered with the other observable features. Thus the significance of soil color is almost entirely an indirect measure of other more important characteristics or qualities that are not so easily and accurately observed. Color is one of the most useful and important characteristics for soil identification, especially when combined with soil structure.

SIGNIFICANCE OF COLOR

The content of organic matter in soil, for example, is a characteristic that is commonly indicated only approximately by soil color. Generally in temperate climates dark-colored soils are relatively higher in organic matter than light-colored soils. In well-drained soils, the colors usually range from very pale brown, through the intermediate browns, to very dark brown or black, as organic matter increases. The most stable part of decomposed organic matter, humus, is darker than the raw or less well decomposed plant remains. Raw peat is brown, whereas the well-decomposed and more fertile organic soil produced from peat is black or nearly so.

As organic matter is neither all of the same color nor the only coloring matter in soils, soil color by itself is not an exact measure of this important constituent. Well-drained soils of the same relatively high content of organic matter are browner, less nearly black, under high annual temperatures than those of cool regions. Yet the dark clays of warm-temperate and tropical regions, which include some of the blackest soils in the world, seldom contain as much as 3 percent organic matter. Their color may range from medium gray to black with little or no change in the total content of organic matter. Self-mulching black clays with 2 or 3 percent of organic matter may lie side by side with reddish-brown latosolic soils having two or three times as much organic matter. Dark-colored soils low in organic matter may contain compounds of iron and humus, elemental carbon, compounds of manganese, and magnetite. Depth of color depends upon the nature and distribution of the organic matter as well as upon the total amount. In highly alkaline Solonetz soils, for example, the highly dispersed organic matter apparently coats each soil grain. Such soils are nearly black at relatively low contents of total organic matter.

The red color of soils is generally related to unhydrated iron oxide, although manganese dioxide and partially hydrated iron oxides may also contribute red colors. Since unhydrated iron oxide is relatively unstable under moist conditions, red color usually indicates good drainage and good aeration. Strongly red soils are expected on convex surfaces underlain by pervious rocks. Yet many red soils owe their color to inheritance from the parent material and not to soil-forming processes, since the redness in some rocks may persist for centuries even under moist conditions.[1]

In regions where the normal soils have red color, the well-developed red color is one indication that the soils are relatively old or at least that the soil material has been subjected to relatively intense weathering for a considerable time. Yet occasionally red colors develop very rapidly. Other things being equal, the red and yellow colors in soil generally increase both in prevalence and in intensity in going from cool regions toward the Equator. The intensity of weathering increases with temperature. Then too, many very old land surfaces may be found in warm regions, especially as contrasted with glaciated cool and temperate regions.

The yellow color in soils is also largely due to iron oxides.[2] Yellow colors in the deeper horizons usually indicate a somewhat more moist soil climate than do red colors. The general climatic differences may be in humidity and cloudiness rather than in rainfall. Where associated red and yellow soils are developed from the same kind of parent material, the yellow soils commonly occupy the less convex and more moist sites. Other things being equal, yellow colors are also more common than red colors in regions of high humidity and heavy cloud cover. Apparently, however, it takes a long time to change a yellow soil to a red one, since strongly sloping yellow soils may be found in regions of geologically recent uplift and rapid dissection.

Iron oxides occur in all colors ranging from yellow at the one extreme to red at the other. Thus many brown soils contain relatively large amounts of iron oxides in addition to organic matter.

Well-drained yellowish sands owe their colors to the fact that small amounts of organic matter and other coloring material such as iron oxide are mixed with large amounts of nearly white sand.

Gray and whitish colors of soils are caused by several substances, mainly quartz, kaolin and other clay minerals, carbonates of lime and magnesium, gypsum, various salts, and compounds of ferrous iron. The grayest colors (chromas of less than 1, values of 2.5 to 7.5) that occur in soils are those of permanently saturated G horizons. In these, the iron is in the ferrous form. Some soils are so rich in these compounds as to have nearly pure gray colors that appear bluish.[3]

Imperfectly and poorly drained soils are nearly always mottled with various shades of gray, brown, and yellow, especially within the zone of fluctuation of the water table. In the presence of organic matter, the proportion of gray generally increases with increasing wetness. Wet materials without organic matter rarely have the very light-gray color.

A light-gray color may indicate a very low content of organic matter and iron, as in the A_2 horizons of the Podzol, or in sands that consist almost wholly of quartz. Irregular layers of white clay, from which the iron has been removed, are commonly found in the lower parts of Ground-Water Laterite soils and Latosols. In arid and semiarid regions, certain soil horizons may be white or nearly white because of the very high content of calcium carbonate, gypsum, or other salts.

Nearly white colors sometimes occur as an inheritance from the parent material, as in Lithosols or Regosols on marls or other white rocks. The failure of soils to accumulate organic matter

[1] Soils owing their color to inheritance from the parent material rather than from soil-forming processes are referred to as *lithochromic*.

[2] In the past red colors have been ascribed to unhydrated and yellow colors to hydrated iron oxides. It seems clear that red colors are due to unhydrated iron oxides, but a yellow color is more difficult to explain. Recent evidence suggests that some yellow soils lack hydrated iron oxides. This raises a question about the general occurrence of such oxides in well-drained soils. Although the question may not be answered one way or another at the present time, alternative explanations for yellow colors need to be examined. It is known that the particle size of some colloidal precipitates affects the color, and this may also be true of colloidal iron oxides in soils. Moreover, there is evidence that the ferric oxide in these Red-Yellow Podzolic soils of the southeastern part of the United States that have red B horizons is reduced more easily than is the ferric oxide in the associated soils with yellow B horizons. It has been suggested that the yellow color in some profiles may be due to a solid-solution mixture of iron and aluminum oxides.

[3] The usual color of G horizons is of yellow hue, generally about 2.5Y, but of such weak chroma as to suggest the complementary hue in contrast to other stronger colors that predominate in the background against which the soils are viewed. The hue complementary to 10YR, the most usual in soil, is 10B, a blue. Before alteration from exposure to the air, the chroma of G horizons generally is less than 1; with exposure to air the color changes rapidly, sometimes within a few minutes. Few air-dry samples of G horizons have chromas of less than 1.

ordinarily indicates an environment unfavorable to plants and micro-organisms. White soils are almost invariably unproductive naturally, although a few are responsive to good management, such as some weakly developed Rendzinas.

COLOR PATTERNS

Nearly every soil profile consists of several horizons differing in color. For every soil examined and described in the field, the complete color profile should be presented. A single horizon may be uniform in color or it may be streaked, spotted, variegated, or mottled in many ways. Local accumulations of lime or organic matter may produce a spotted appearance. Streaks or tongues of color may result from the seeping downward of colloids, organic matter, or iron compounds from overlying horizons. Certain combinations of mottled colors, mainly the grays and browns, indicate impeded drainage. The word "mottled" means marked with spots of color. Some mottled colors occur unassociated with poor drainage, either past or present. A mottled or variegated pattern of colors occurs in many soil horizons and especially in parent materials that are not completely weathered.

Mottling in soils is described by noting: (1) The color of the matrix and the color, or colors, of the principal mottles, and (2) the pattern of the mottling. The color of the mottles may be defined by using the Munsell notation, as with other soil masses; but usually it is sufficient and even better to use the standard linguistic equivalents, since precise measurement of the color of the mottles is rarely significant. In fact, descriptions of soil horizons containing several Munsell notations are difficult to read rapidly.

The pattern of mottles can be conveniently described by three sets of notations: contrast, abundance, and size.[4]

Contrast.—Contrast may be described as *faint, distinct,* or *prominent* as follows:

Faint: Indistinct mottles are evident and recognizable only with close examination. Soil colors in both the matrix and mottles have closely related hues and chromas.

Distinct: Although not striking, the mottles are readily seen. The hue, value, and chroma of the matrix are easily distinguished from those of the mottles. They may vary as much as one or two hues or several units in chroma or value. The pattern may be one of a continuous matrix with mottles or one of mixtures of two or more colors.

Prominent: The conspicuous mottles are obvious and mottling is one of the outstanding features of the horizon. Hue, chroma, and value may be several units apart. The pattern may be one of a continuous matrix with contrasting mottles or one of mixtures of two or more colors.

Abundance.—Abundance of mottles can be indicated in three general classes as: *few, common,* and *many,* based upon the relative amount of mottled surface in the unit area of the exposed soil horizon, as follows:[5]

Few: Mottles occupy less than about 2 percent of the exposed surface.

Common: Mottles occupy about 2 to 20 percent of the exposed surface.

Many: Mottles occupy more than 20 percent of the exposed surface. This last class can be further subdivided according to whether (a) the mottles set in a definite matrix or (b) there is no clear matrix color.

Size.—Size refers to the approximate diameters of individual mottles. Three relative size classes can be used as follows:

Fine: Mottles less than 5 mm. in diameter along the greatest dimension.

Medium: Mottles range between 5 and 15 mm. in diameter along the greatest dimension.

Coarse: Mottles are greater than 15 mm. in diameter along the greatest dimension.

In the detailed examination of some soil horizons, it may be necessary to add still further notes on the mottling to indicate whether or not the boundaries of the mottles are sharp (knife-edge), clear (less than 2 mm. wide), or diffuse (more than 2 mm. wide). Although many mottles are roughly circular in cross-section, others are elongated and merge into streaks or tongues. Although, normally, mottling carries no inferences of differences in texture as compared to the matrix, many soils show mottling in a freshly exposed horizon because of the slicing of incipient concretions.

In soil descriptions the mottling can be most conveniently described by describing the mottles as to abundance, size, contrast, and color, such as, ". . . brown silt loam with few, fine, distinct reddish-brown and dark-gray mottles."

In verbal descriptions of soil mottling intended for the general reader, part of the detail needed in detailed soil morphology and correlation may be omitted. Thus, starting with the classes according to abundance, descriptions may be written as follows:

1. *Few:* ". . . brown silt loam, slightly mottled with red and yellow."
2. *Common:* ". . . brown silt loam, mottled with red and yellow."
3. *Many:*
   (a) If the matrix is clearly apparent: ". . . brown silt loam, highly mottled with red and yellow."
   (b) If no clear matrix exists: ". . . mottled red, yellow, and brown silt loam."

If contrast is not clearly shown by the color names, "faintly" or "prominently" may be added. Faint mottling can be implied as ". . . brown silt loam, mottled with shades."

If size is important "finely" or "coarsely" may be added, as ". . . coarsely mottled red and yellow clay", or ". . . brown silt loam finely and slightly mottled with reddish brown." Usually such distinctions are more confusing than helpful to the lay reader.

In the description of soil color, special notice should be taken of any relationships between the color pattern and structure or porosity. Structural aggregates in the soil must be broken to determine whether the color is uniform throughout. The black or dark-brown surface color of soil granules is often due to a thin coating, though the basic color of the soil material is brown or yellow. When such granules are crushed, the mass of soil is lighter in color than the original surfaces of the aggregates. Marked contrast between the color of the soil aggregates and the color of the soil when crushed is common. Coatings of red color often cover structural particles or sand grains; and a gray color may be due to a thin film of leached soil around darker aggregates.

EFFECTS OF MOISTURE

Soil color changes with the moisture content, very markedly in some soils and comparatively little in others. Between dry and moist, soil colors commonly are darker by ½ to 3 steps in value and may change from −½ to +2 steps in chroma. Seldom are they different in hue. Some of the largest differences in value between the dry and moist colors occur in gray and grayish-brown horizons having moderate to moderately low contents of organic matter.

Reproducible quantitative measurements of color are obtained at two moisture contents: (1) Air dry, and (2) field capacity. The latter may be obtained with sufficient accuracy for color measurements by moistening a sample and reading the color as soon as visible moisture films have disappeared. Both the dry and the moist colors are important. In most notes and soil descriptions, unless stated otherwise, colors are given for moist soils. Comparisons of color among widely separated soils are facilitated by using the color designation of freshly broken surfaces of air-dry samples. Official descriptions for technical use, such as series descriptions, should include the moist colors, and preferably, both dry and moist colors if significantly unlike.

DETERMINATION OF SOIL COLOR

Soil colors are most conveniently measured by comparison with a color chart. The one generally used with soil is a modification of the Munsell color chart and includes only that portion needed for soil colors, about one-fifth of the entire range of color.[6] It consists of some 175 different colored papers, or chips, systematically arranged, according to their Munsel notations, on cards carried in a loose-leaf notebook. The arrangement is by *hue, value,* and *chroma*—the three simple variables that combine to give all colors. *Hue* is the dominant spectral (rainbow) color; it is related to the dominant wavelength of the light. *Value* refers to the relative lightness of color and is a function (approximately the square root) of the total amount of light. *Chroma* (sometimes called saturation) is the relative purity or strength of the spectral color and increases with decreasing grayness.

[4] This discussion is based on a recent paper: SIMONSON, R. W. DESCRIPTION OF MOTTLING IN SOILS. Soil Science. 7: 187–192. 1951.

[5] The suggested limits are tentative only. More research is needed to establish the most useful size classes and number of classes.

[6] The appropriate color chips separately, or mounted by hues on special cards (4¼ by 7¼ inches) for a loose-leaf notebook, may be obtained from the Munsell Color Company, Inc., 10 East Franklin Street, Baltimore 2, Md.

In the soil color chart, all colors on a given card are of a constant hue, designated by the symbol in the upper right-hand corner of the card. Vertically, the colors become successively lighter by visually equal steps; their value increases. Horizontally, they increase in chroma to the right and become grayer to the left. The value and chroma of each color in the chart is printed immediately beneath the color. The first number is the value, and the second is the chroma. As arranged in the chart the colors form three scales: (1) Radial, or from one card to the next, in hue; (2) vertical in value; and (3) horizontal in chroma.

The nomenclature for soil color consists of two complementary systems: (1) Color names, and (2) the Munsell notation of color. Neither of these alone is adequate for all purposes. The color names are employed in all descriptions for publication and for general use. The Munsell notation is used to supplement the color names wherever greater precision is needed, as a convenient abbreviation in field descriptions, for expression of the specific relations between colors, and for statistical treatment of color data. The Munsell notation is especially useful for international correlation, since no translation of color names is needed. The names for soil colors are common terms now so defined as to obtain uniformity and yet accord, as nearly as possible, with past usage by soil scientists. Bizarre names like "rusty brown," "tan," "mouse gray," "lemon yellow," and "chocolate brown" should never be used.

The soil color names and their limits are given in the name-diagrams, figures 30 to 36.

The Munsell notation for color consists of separate notations for hue, value, and chroma, which are combined in that order to form the color designation. The symbol for hue is the letter abbreviation of the color of the rainbow (R for red, YR for yellow-red, or orange, Y for yellow) preceded by numbers from 0 to 10. Within each letter range, the hue becomes more yellow and less red as the numbers increase. The middle of the letter range is at 5; the zero point coincides with the 10 point of the next redder hue. Thus 5YR is in the middle of the yellow-red hue, which extends from 10R (zero YR) to 10YR (zero Y).

The notation for value consists of numbers from 0, for absolute black, to 10, for absolute white. Thus a color of value 5/ is visually midway between absolute white and absolute black. One of value 6/ is slightly less dark, 60 percent of the way from black to white, and midway between values of 5/ and 7/.

The notation for chroma consists of numbers beginning at 0 for neutral grays and increasing at equal intervals to a maximum of about 20, which is never really approached in soil. For absolute achromatic colors (pure grays, white, and black), which have zero chroma and no hue, the letter N (neutral) takes the place of a hue designation.

In writing the Munsell notation, the order is hue, value, chroma, with a space between the hue letter and the succeeding value number, and a virgule between the two numbers for value and chroma. If expression beyond the whole numbers is desired, decimals are always used, never fractions. Thus the notation for a color of hue 5YR, value 5, chroma 6, is 5YR 5/6, a yellowish-red. The notation for a color midway between the 5YR 5/6 and 5YR 6/6 chips is 5YR 5.5/6; for one midway between 2.5YR 5/6 and 5YR 6/8, it is 3.75YR 5.5/7. The notation is decimal and capable of expressing any degree of refinement desired. Since color determinations cannot be made precisely in the field—generally no closer than half the interval between colors in the chart—expression of color should ordinarily be to the nearest color chip.

In using the color chart, accurate comparison is obtained by holding the soil sample above the color chips being compared. Rarely will the color of the sample be *perfectly* matched by any color in the chart. The probability of having a perfect matching of the sample color is less than one in one hundred. It should be evident, however, which colors the sample lies between, and which is the closest match. The principal difficulties encountered in using the soil color chart are (1) in selecting the appropriate hue card, (2) in determining colors that are intermediate between the hues in the chart, and (3) in distinguishing between value and chroma

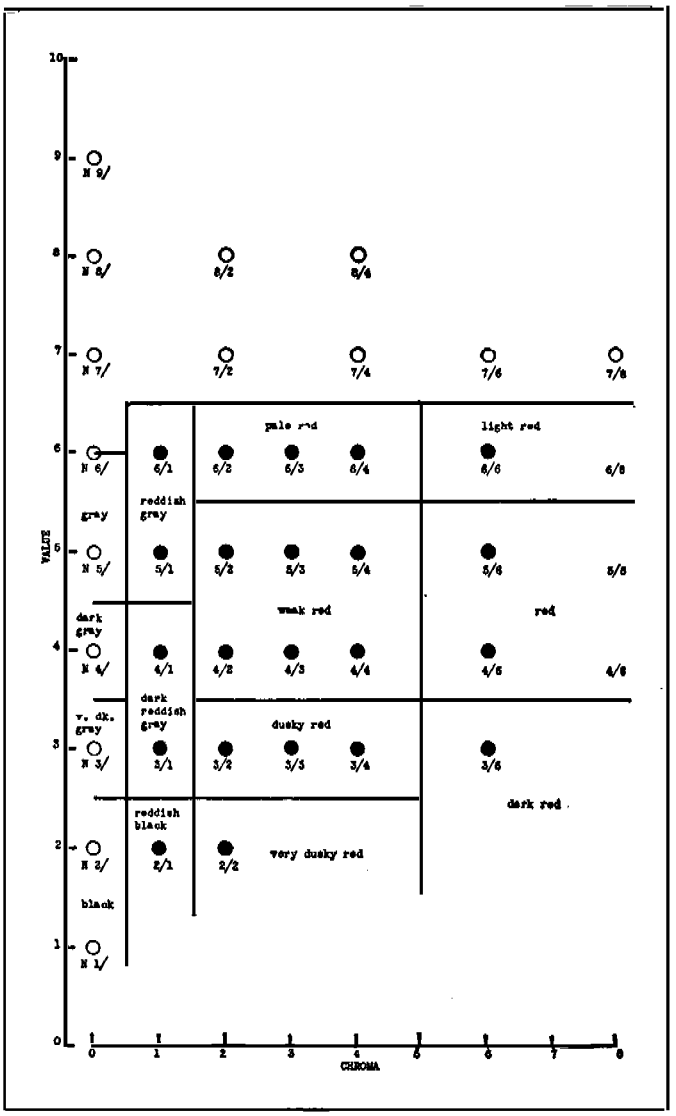


FIGURE 30.—Soil color names for several combinations of value and chroma and hue 10R.

where chromas are strong. In addition, the chart does not include some extreme dark, strong (low value, high chroma) colors occasionally encountered in moist soils. With experience, these extreme colors lying outside the range of the chart can be estimated. Then too, the ability to sense color differences varies among people, even among those not regarded as color blind.

While important details should be given, long involved designations of color should generally be avoided, especially with variegated or mottled colors. In these, only the extreme or dominant colors need be stated. Similarly, in giving the color names and Munsell notations for both the dry and moist colors, an abbreviated form, such as "reddish brown (5YR 4/4; 3/4, moist)," simplifies the statement.

By attempting detail beyond the allowable accuracy of field observations and sample selection, one may easily make poorer soil descriptions than by expressing the dominant color simply. In all descriptions, terms other than the ones given on these charts should be used only in rare instances, and then only as supplemental expressions in parentheses where some different local usage is common.

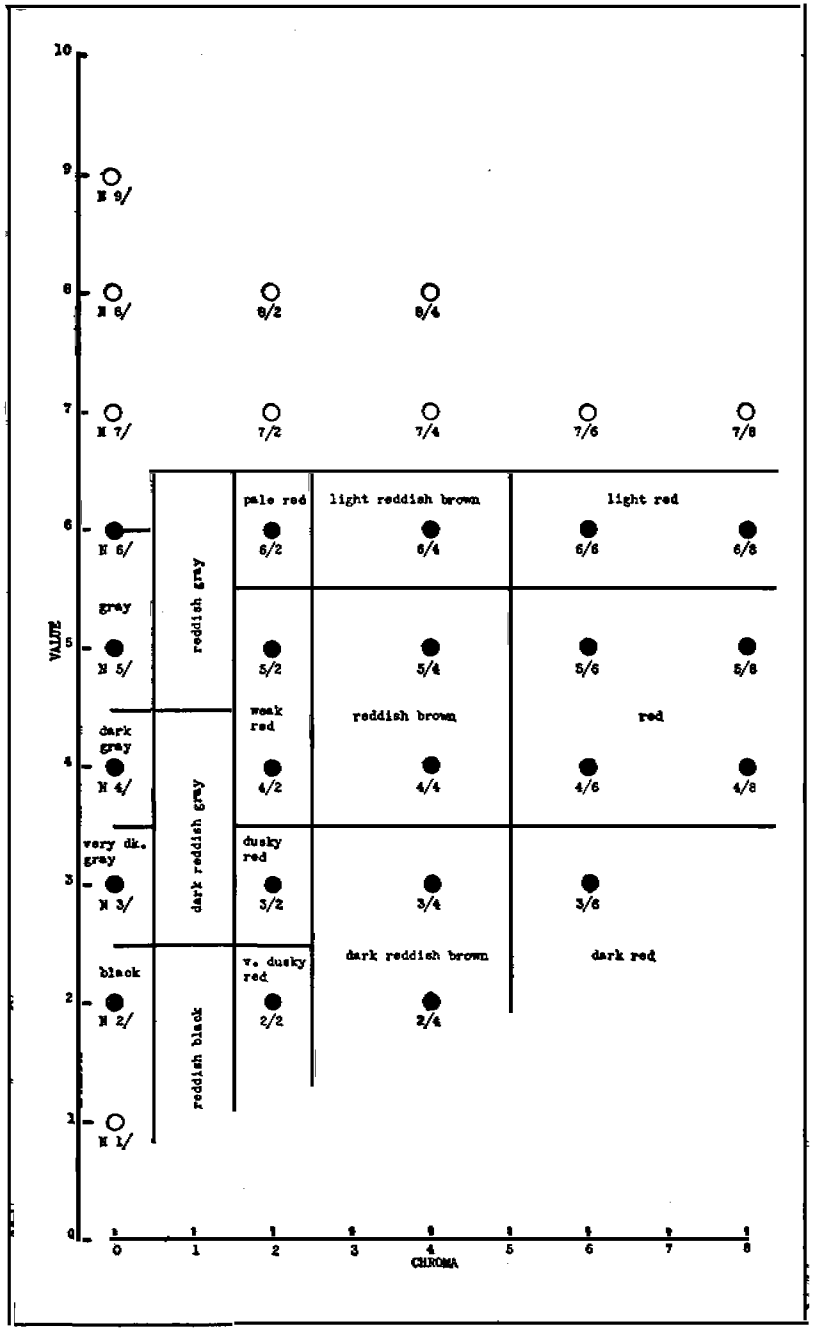


FIGURE 31.—Soil color names for several combinations of value and chroma and hue 2.5YR.

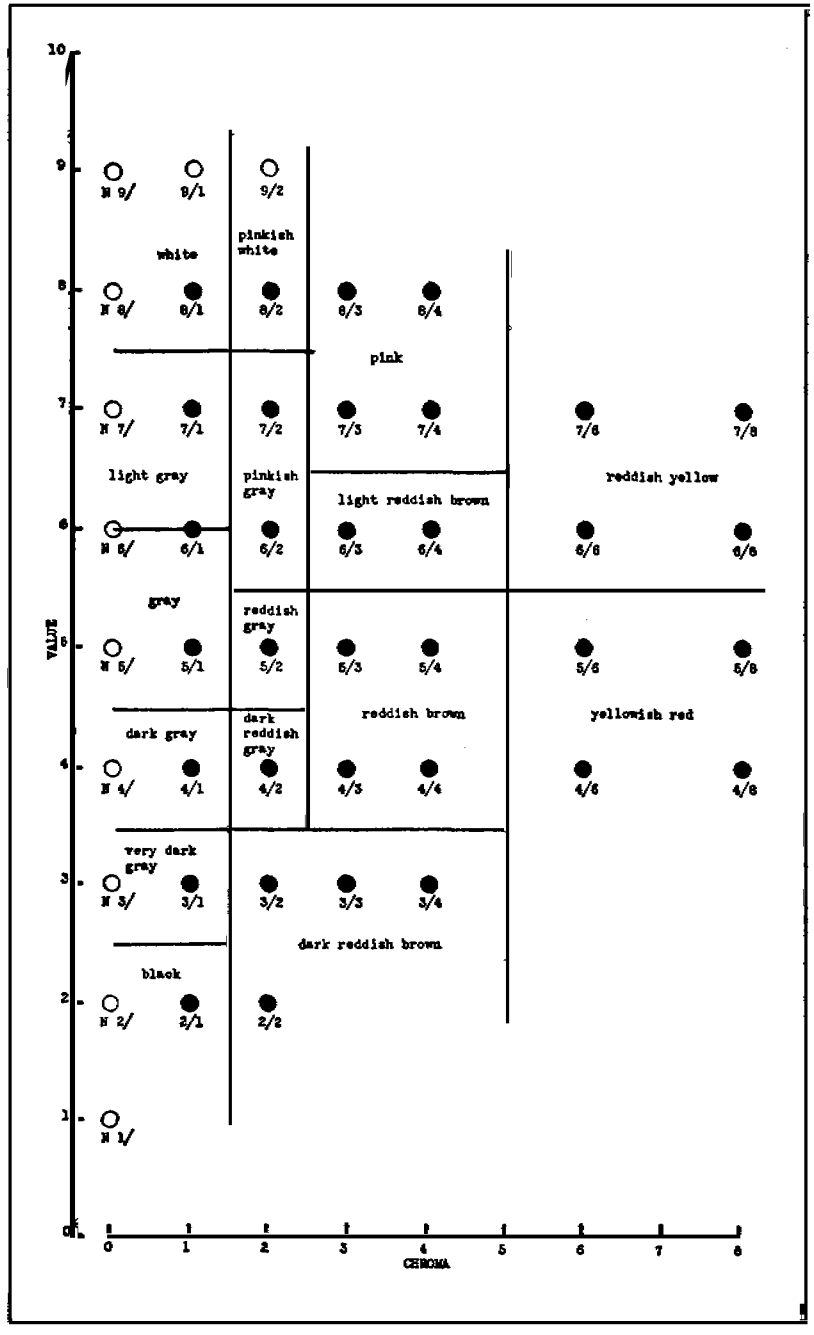


FIGURE 32.—Soil color names for several combinations of value and chroma and hue 5YR.

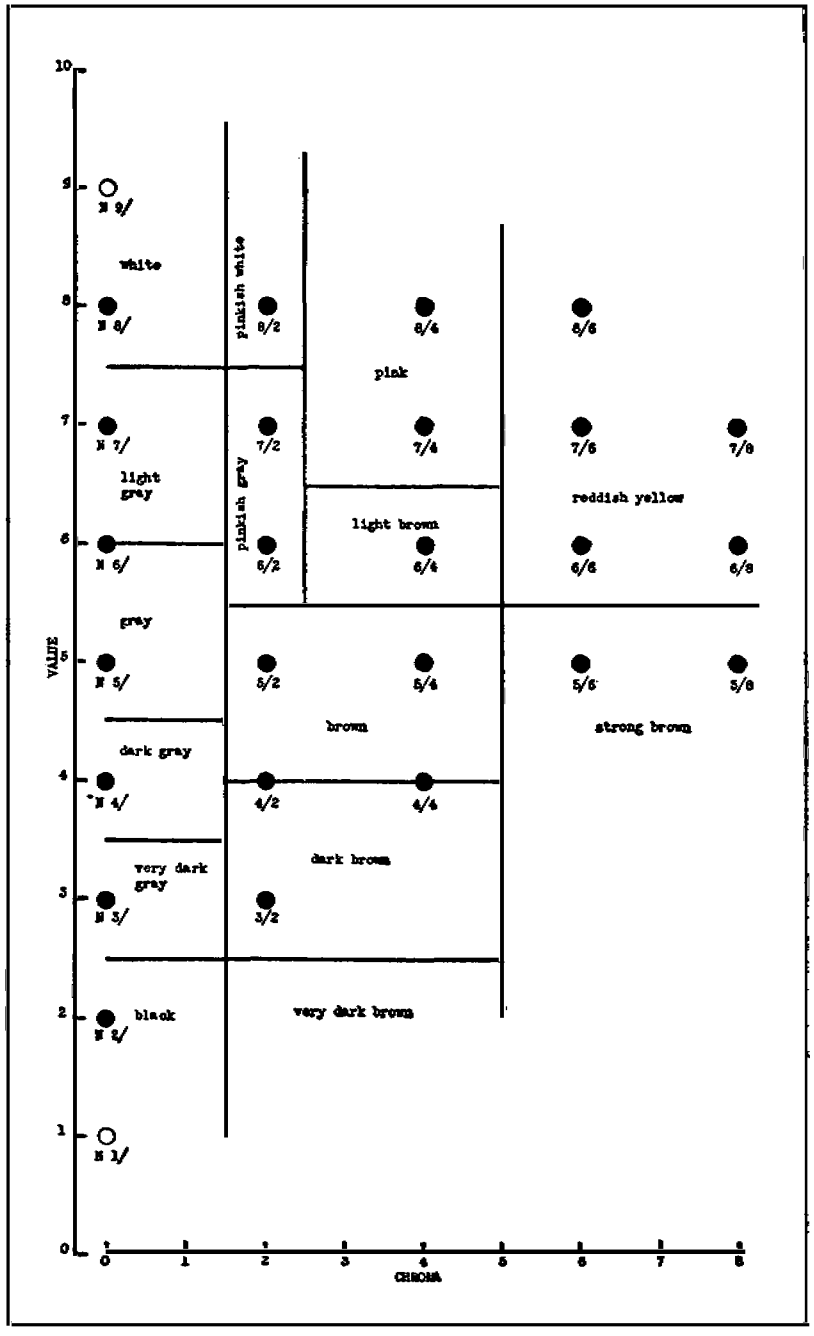


FIGURE 33.—Soil color names for several combinations of value and chroma and hue 7.5YR.

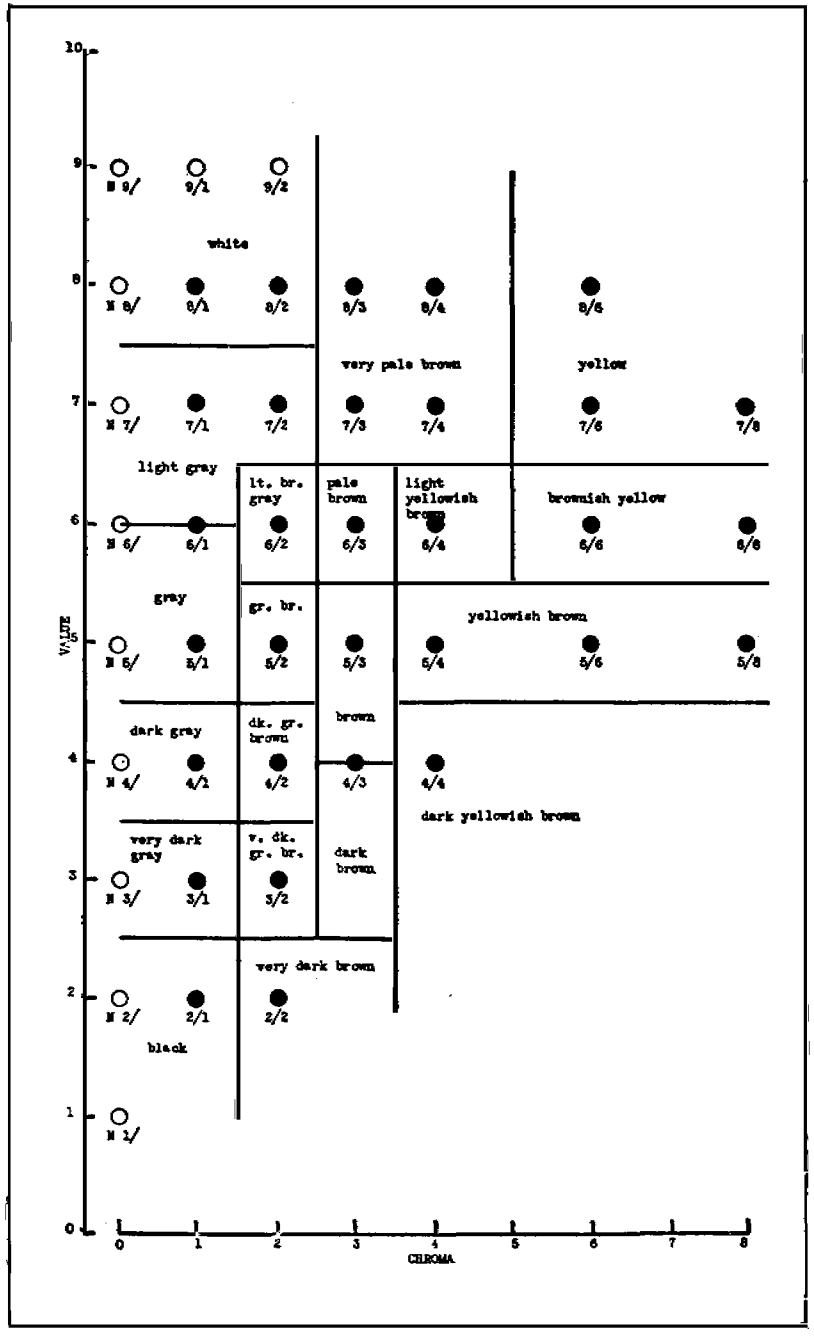


FIGURE 34.—Soil color names for several combinations of value and chroma and hue 10YR.

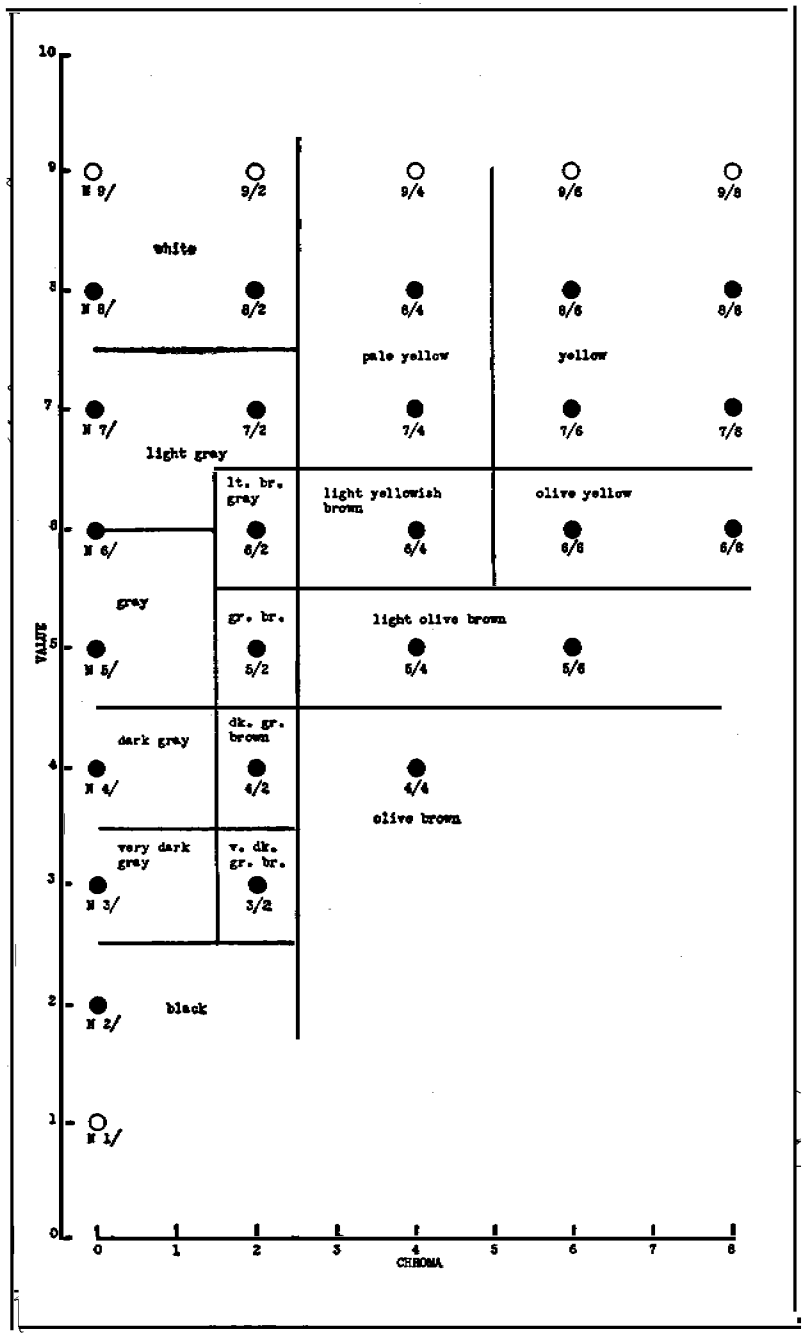


FIGURE 35.—Soil color names for several combinations of value and chroma and hue 2.5Y.

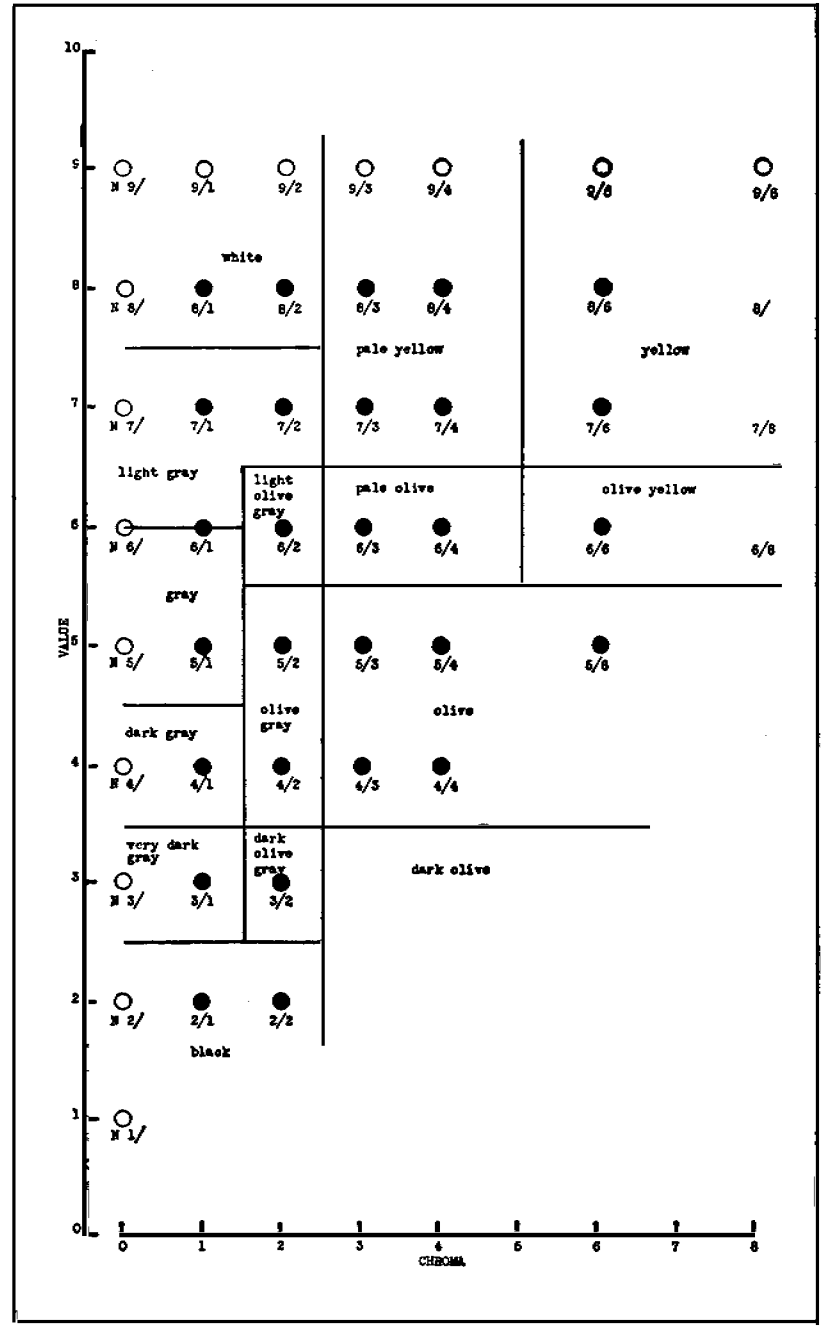


FIGURE 36.—Soil color names for several combinations of value and chroma and hue 5Y.

SOIL TEXTURE, COARSE FRAGMENTS, STONINESS, AND ROCKINESS

Soil texture refers to the relative proportions of the various size groups of individual soil grains in a mass of soil. Specifically,

and fertility, productivity, or other inferred qualities. To make such inferences we must also know the other important soil characteristics. Unfortunately, these erroneous correlations are well fixed in some textbooks and other books about soils for farmers and gardeners. Within the universe that the authors of

Survey No. ..... Field No. ..... Laboratory No. .....

Locality .....

Soil type ..... Depth .....

MECHANICAL ANALYSIS

U. S. DEPARTMENT AGRICULTURE CLASSIFICATION			INTERNATIONAL CLASSIFICATION		
Diameter	Conventional Name	Percent	Fraction	Diameter	Percent

General terms:

		Basic soil textural class names
Sandy soils.—*Coarse-textured soils*		Sands. Loamy sands.
Loamy soils.—	*Moderately coarse-textured soils*	Sandy loam. Fine sandy loam.
	Medium-textured soils	Very fine sandy loam. Loam. Silt loam. Silt.
	Moderately fine-textured soils	Clay loam. Sandy clay loam. Silty clay loam.
Clayey soils.—*Fine-textured soils*		Sandy clay. Silty clay. Clay.

COARSE FRAGMENTS

Significant proportions of fragments coarser than very coarse sand and less than 10 inches, if rounded, or 15 inches along the longer axis, if flat, are recognized by an appropriate adjective in the textural soil-class name. Such fragments are regarded as a part of the soil mass. They influence moisture storage, infil-

is classified in the appropriate miscellaneous land type.[6] If necessary to make distinctions of clear significance, another subdivision can be made of the coarse fragments at about 50 percent to give, for example, gravelly loam (20 to 50 percent gravel) and very gravelly loam (50 to 90 percent gravel). The other defined fragments may be handled similarly.

The recommended terms to apply to soil containing above 15 to 20 percent coarse fragments smaller than stones, and less than 90 percent, are defined as follows:

Channery: Soils contain fragments of thin, flat sandstone, limestone, or schist up to 6 inches along the longer axis. A single piece is a *fragment.*

Cherty: Soils have angular fragments that are less than 3 inches in diameter, more than 75 percent of which are chert; *coarse cherty* soils have fragments of 3 to 10 inches. Unless the size distinction is significant to the use capability of the soil, the *cherty* soil includes the whole range up to 10 inches. Most cherty soils are developed from weathered cherty limestone. A single piece is a *chert fragment.*

Cobbly: Soils have rounded or partially rounded fragments of rock ranging from 3 to 10 inches in diameter. *Angular cobbly,* formerly included as stony, is similar to cobbly except that fragments are

although by no means uncommon. In some sections of the country, soils containing fixed stones (rocky soils as here defined), some loose fragments 3 to 10 inches in diameter, and some stones have been called stony for many years. Where no useful purpose is served by dividing into additional types and phases, it should not be done. Thus the classes proposed for stoniness and rockiness may be grouped in the definition of any individual mapping unit.

STONINESS

Stoniness refers to the relative proportion of stones over 10 inches in diameter in or on the soil. The significance of a given

TABLE 4.—*Approximate spacings of stones and cubic yards of stones per acre-foot at selected percentages of area covered*

Diameter of stones (feet)	Spacing of stones from center to center (feet)	Area covered with stones (percent)	Stones per acre-foot (cubic yards)
2	11	3	97
	5	15	485
	2.7	50	1,616
1	5.5	3	48
	2.5	15	242

TABLE 5.—*Relation of classes of stoniness and rockiness to one another*

and to some soil classificational units

Stoniness			Rockiness		
Class	Approximate percentage of surface covered	Modification in name of classificational unit to indicate degree of stoniness	Class	Approximate percentage of rock-exposed surface[4]	Modification in name of classificational unit to indicate degree of rockiness
0	Less than 0.01	No modification. Example: Gloucester loam.	0	Less than 2	No modification. Example: Hagerstown loam.
1	0.01 to 0.1	Stony (phase).[2] Example: Gloucester stony loam.	1	2 to 10	Rocky (phase).[2] Example: Hagerstown rocky loam.
2	0.1 to 3.0	Very stony (phase). Example: Gloucester very stony loam.	2	10 to 25	Very rocky (phase). Example: Hagerstown very rocky loam.
3	3 to 15	Any one of following: Extremely stony (phase). Example: Gloucester extremely stony loam. Stony land.[3] Stony land (Gloucester soil material).	3	25 to 50	Any one of following: Extremely rocky (phase). Example: Hagerstown extremely rocky loam. Rock land.[3] Rock land (Hagerstown material).
4	15 to 90	Either of following: Stony land.[3] Very stony land.	4	50 to 90	Rock land.[3]
5	Above 90	Rubble land.	5	Above 90	Rock outcrop.

[1] This table is a general guide in detailed basic surveys where it is important to differentiate among several classes and between stoniness and rockiness. With soils having rockiness, stoniness, and some coarse fragments, and for which separation by classes serves no useful purpose, stony phases may be recognized.

[2] The word "phase" usually can be omitted; but, for example, Gloucester stony loam is simply a short way of naming the unit, Gloucester loam, stony phase. Theoretically, at least, if all areas of a soil type have one class name of stoniness, say class 2, "very stony" is a descriptive adjective of the type and there are no phases of stoniness.

[3] Commonly, the distinction between classes 3 and 4 is not necessary, and the whole range of both classes is included as *Stony land* or *Rock land*.

[4] Including soil too thin over rock for useful plant growth.

Class 1: Sufficient bedrock exposures to interfere with tillage but not to make intertilled crops impracticable. Depending upon how the pattern affects tillage, rock exposures are roughly 100 to 300 feet apart and cover about 2 to 10 percent of the surface.

Class 2: Sufficient bedrock exposures to make tillage of intertilled crops impracticable, but soil can be worked for hay crops or improved pasture if the other soil characteristics are favorable. Rock exposures are roughly 30 to 100 feet apart and cover about 10 to 25 percent of the surface, depending upon the pattern.

Class 3: Sufficient rock outcrop to make all use of machinery impracticable, except for light machinery where other soil characteristics are especially favorable for improved pasture. May have some use for wild pasture or forests, depending on the other soil characteristics. Rock exposures, or patches of soil too thin over rock for use, are roughly 10 to 30 feet apart and cover about 25 to 50 percent of the surface, depending upon the pattern.

Class 4: Sufficient rock outcrop (or of very thin soil over rock) to make all use of machinery impracticable. The land may have some value for poor pasture or for forestry. Rock outcrops are about 10 feet apart or less and cover some 50 to 90 percent of the area.

Class 5: Land for which over 90 percent of the surface is exposed bedrock (Rock outcrop).

The distinctions between classes 0, 1, and 2 are commonly the bases for phases of soil types.[6] As with stony phases, these terms are added as adjectives to the soil textural class part of the soil-type name to give names like Hagerstown rocky loam, Hagerstown very rocky loam, or Hagerstown extremely rocky loam. These are three phases, plus the unnamed nonrocky phase, within the Hagerstown loam.

The distinctions between classes 2 and 3 or between classes 3 and 4 are commonly the dividing lines between the soil series and the miscellaneous land type, Rock land. If the soil is not responsive to management for improved pasture with rockiness greater than class 2, the distinction is made there; and land with class 3 rockiness is designated as Rock land. If the soil is especially responsive to soil management practices for improved pasture and can be tilled with very light machinery, the soil is named and placed in an extremely rocky phase. If the land cannot be rockiness may be indicated as an extremely rocky phase of a soil type or as Rock land, (series name) soil material, and the term Rock land reserved for that having class 4 rockiness.

Land with class 5 rockiness is always classified as Rock outcrop even though a little soil may be found between the outcrops or the ledges.

The relationship of classes of stoniness to classes of rockiness, and of these to some soil classificational units, is shown in table 5.

Areas of rocky phases too small to enclose with boundaries are not shown on the map. Instead symbols for rock outcrops and for rock ledges are used. In each survey, the area that each represents needs to be defined.

COMBINED CLASSES OF STONINESS AND ROCKINESS

Frequently it is necessary to combine classes of rockiness and stoniness. In such instances the combined influence of the two conditions on soil use needs to be considered. Soils having class 1 stoniness and class 1 rockiness might be named as a very stony and rocky phase of a soil type, or simply as a stony phase. Land having both class 2 rockiness or higher and class 2 stoniness or higher would doubtless need to be put into a miscellaneous land type, as Stony rock land.

SOIL STRUCTURE

Soil structure refers to the aggregation of primary soil particles into compound particles, or clusters of primary particles, which are separated from adjoining aggregates by surfaces of weakness. The exteriors of some aggregates have thin, often dark-colored, surface films which perhaps help to keep them apart. Other aggregates have surfaces and interiors of like color, and the forces holding the aggregates together appear to be wholly internal.

An individual natural soil aggregate is called a *ped*, in contrast to (1) a *clod*, caused by disturbance, such as plowing or digging, that molds the soil to a transient mass that slakes with repeated

Generally, in the United States, soils with aggregates of spheroidal shape have much pore space between aggregates, have more rapid permeability, and are more productive than soils of comparable fertility that are massive or even coarsely blocky or prismatic. In other parts of the world, some soils are overgranulated. Some Latosols have such well-developed spheroidal peds that the moisture-holding capacity is low, too few contacts exist between roots and soil, and the soils are relatively unproductive.

Field descriptions of soil structure note (1) the shape and arrangement, (2) the size, and (3) the distinctness and durability of the visible aggregates or peds. Field terminology for structure consists of separate sets of terms designating each of these three qualities, which by combination form the names for structure. Shape and arrangement of peds is designated as *type* of soil structure; size of peds, as *class;* and degree of distinctness, as *grades.*[1] The structural pattern of a soil horizon also includes the shapes and sizes of pore spaces as well as those of the peds themselves.

There are four primary types of structure: (1) Platy, with particles arranged around a plane, generally horizontal; (2) prismlike, with particles arranged around a vertical line and bounded by relatively flat vertical surfaces; (3) blocklike or polyhedral, with particles arranged around a point and bounded by flat or rounded surfaces which are casts of the molds formed by the faces of surrounding peds; and (4) spheroidal or polyhedral, with particles arranged around a point and bounded by curved or very irregular surfaces that are not accommodated to the adjoining aggregates. Each of the last three have two sub-

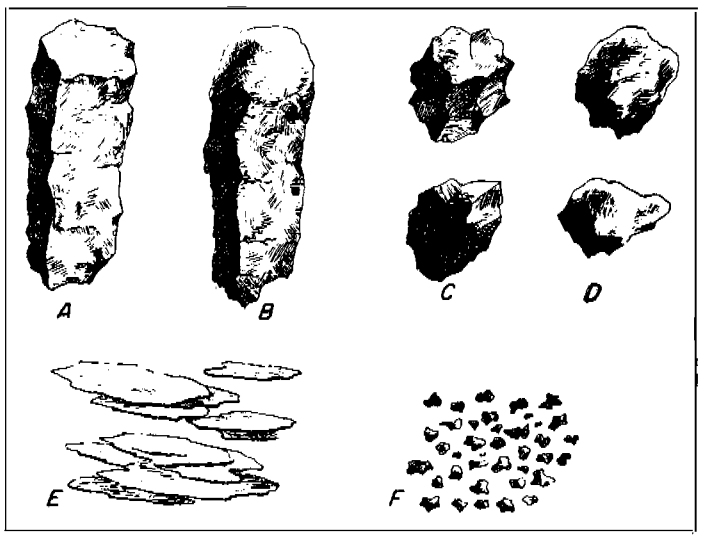


FIGURE 44.—Drawings illustrating some of the types of soil structure: *A*, prismatic; *B*, columnar; *C*, angular blocky; *D*, subangular blocky; *E*, platy; and F, granular.

angular blocky is recommended. It is difficult for many to dis-

slightly moist, which is commonly that part of the range in soil the moisture content specifies *friable when moist*; likewise, *hard*

1. *Slightly plastic:* Wire formable but soil mass easily deformable.
2. *Plastic:* Wire formable and moderate pressure required for deformation of the soil mass.
3. *Very plastic:* Wire formable and much pressure required for deformation of the soil mass.

II. CONSISTENCE WHEN MOIST

Consistence when moist is determined at a moisture content approximately midway between air dry and field capacity. At this moisture content most soil materials exhibit a form of consistence characterized by (a) tendency to break into smaller masses rather than into powder, (b) some deformation prior to rupture, (c) absence of brittleness, and (d) ability of the material after disturbance to cohere again when pressed together. The resistance decreases with moisture content, and accuracy of field descriptions of this consistence is limited by the accuracy of estimating moisture content. To evaluate this consistence, select and attempt to crush in the hand a mass that appears slightly moist.

0. *Loose:* Noncoherent.
1. *Very friable:* Soil material crushes under very gentle pressure but coheres when pressed together.
2. *Friable:* Soil material crushes easily under gentle to moderate pressure between thumb and forefinger, and coheres when pressed together.
3. *Firm:* Soil material crushes under moderate pressure between thumb and forefinger but resistance is distinctly noticeable.
4. *Very firm:* Soil material crushes under strong pressure; barely crushable between thumb and forefinger.
5. *Extremely firm:* Soil material crushes only under very strong pressure; cannot be crushed between thumb and forefinger and must be broken apart bit by bit.

The term *compact* denotes a combination of firm consistence and close packing or arrangement of particles and should be used only in this sense. It can be given degrees by use of "very" and "extremely."

III. CONSISTENCE WHEN DRY

The consistence of soil materials when dry is characterized by rigidity, brittleness, maximum resistance to pressure, more or less tendency to crush to a powder or to fragments with rather sharp edges, and inability of crushed material to cohere again when pressed together. To evaluate, select an air-dry mass and break in the hand.

0. *Loose:* Noncoherent.
1. *Soft:* Soil mass is very weakly coherent and fragile; breaks to powder or individual grains under very slight pressure.
2. *Slightly hard:* Weakly resistant to pressure; easily broken between thumb and forefinger.
3. *Hard:* Moderately resistant to pressure; can be broken in the hands without difficulty but is barely breakable between thumb and forefinger.
4. *Very hard:* Very resistant to pressure; can be broken in the hands only with difficulty; not breakable between thumb and forefinger.
5. *Extremely hard:* Extremely resistant to pressure; cannot be broken in the hands.

IV. CEMENTATION

Cementation of soil material refers to a brittle hard consistence caused by some cementing substance other than clay minerals, such as calcium carbonate, silica, or oxides or salts of iron and aluminum. Typically the cementation is altered little if any by moistening; the hardness and brittleness persist in the wet condition. Semireversible cements, which generally resist moistening but soften under prolonged wetting, occur in some soils and give rise to soil layers having a cementation that is pronounced when dry but very weak when wet. Some layers cemented with calcium carbonate soften somewhat with wetting. Unless stated to the contrary, descriptions of cementation imply that the condition is altered little if any by wetting. If the cementation is greatly altered by moistening, it should be so stated. Cementation may be either continuous or discontinuous within a given horizon.

1. *Weakly cemented:* Cemented mass is brittle and hard but can be broken in the hands.
2. *Strongly cemented:* Cemented mass is brittle and harder than can be broken in the hand but is easily broken with a hammer.
3. *Indurated:* Very strongly cemented; brittle, does not soften under prolonged wetting, and is so extremely hard that for breakage a sharp blow with a hammer is required; hammer generally rings as a result of the blow.

Appendix II. Description of pores and roots

Soil pores

Johnson et al.[1] have discussed conventions for describing soil pores. These conventions with slight modifications have been used in the descriptions of soils in this book.

Number

Pores are described by three classes defined in terms of numbers of a specified size per 1 dm^2 of an exposed surface (table 1). An area of 1 dm^2 is roughly the size of the palm of the hand.

Estimates of numbers of very fine pores have little meaning unless those pores can be recognized as discrete voids. Estimates of the continuity of such pores are more useful.

The surface for which pores are estimated should be

Continuity

Continuity of pores is a very important feature, for it indicates whether continuous spaces are available for liquid and gas to move. The terms used follow.

Discontinuous.—Most individual pores and their connecting voids are interrupted or constricted so that continuous passages larger than 0.1 mm at the smallest constriction are few or absent.

Constricted.—The individual pores and their connecting voids provide routes for movement of liquids and gases through spaces larger than 0.1 mm and common constrictions are at least two size classes smaller than the pores described. This term would be used only with medium and coarse pore sizes.

Continuous.—The individual pores and their connecting voids provide continuous passages vertically through the horizon with few constrictions more than one class smaller than the pores described.

tubes or (b) *dendritic*—the pores branch like plant roots.

Location

The location of pores is described for each horizon. The pores may be entirely within peds (imped), between peds (exped), or in material that interfingers between peds.

When describing pores in detail, a definite sequence of terms should be consistently followed. For many purposes a convenient sequence is number, size, continuity, orientation, shape, and location. For example, one might write "many, very fine, continuous, vertical, simple, tubular pores within prisms." The investigator must use judgment about the attributes important enough to include and those that would merely complicate the description without adding useful information. Some descriptions may need to emphasize only number, size, and continuity, as for "many, fine continuous pores."

Roots

A considerable body of knowledge exists about the distribution of plant roots in soils, but it is inadequate for predictions about the behavior of plants on soils of different kinds. Much more information is needed about the relation that the roots of many plants have to aeration, structure, compaction, and water- and nutrient-supplying capacities of the different kinds of soil horizons. Careful studies of plant roots in relation to detailed soil morphology are urgently needed as a basis for making better predictions about the adaptability of native, crop, and ornamental plants to the soils shown on maps. The description of each soil horizon should record at least the number, size, and distribution of roots, or the lack of roots.

Plant roots make little growth in horizons lacking available moisture or in horizons lacking nutrients, even if moisture and nutrients are available elsewhere in the soil. Plant roots fail to penetrate some soil horizons because of deficiencies of moisture, nutrients, or oxygen, or because of extremely unfavorable physical or chemical properties. Low soil temperature restricts root growth at all seasons in some soils.

Ordinarily roots cannot penetrate the cemented pans or the strongly expressed fragipans unless the pans are fractured. Unfavorable chemical properties drastically restrict root growth of many cultivated plants in some subsoils, especially in some very old soils of the Tropics. Availability of oxygen is a critical factor for root growth in many soil horizons, and deficiency of oxygen becomes increasingly likely as depth increases. Wetness as a limiting factor is usually only a visible manifestation of conditions that favor oxygen deficiency. Wetness associated with organic material that can supply energy for micro-organisms is especially conducive to oxygen deficiency.

A large part of the roots of most plants is in the upper soil horizons. For most grasses, 65 to 80 percent of the roots are in the upper 6 inches. The roots of many forest trees are concentrated in the upper soil horizons, and total root volume decreases as depth increases. The depth of penetration varies among kinds of trees and kinds of soil. If soil, moisture, and temperature are favorable, some plant roots penetrate to much greater depths than is commonly believed. Some grass roots penetrate to depths of 10 or more feet. Corn plants have been known to remove available moisture to depths of 5 or more feet. Alfalfa roots can penetrate to much greater depths and remove available moisture to depths of 25 or more feet, and roots of the oil palm may go even deeper. By recording roots or the lack of them diligently in horizon descriptions, the investigator accumulates direct evidence to substantiate appraisal of the effects of soil properties on the behavior of life in the soil.

Soil descriptions should record the number, size, and location of roots in horizons. The conventions that follow provide the minimum detail that should be recorded. The relationships of root distribution to special bodies or surfaces within horizons and any special features of the roots themselves, such as flattening, nodulation, lesions, and the like, should be recorded as special notes.

Number

The number of roots, is described by classes defined in terms of numbers per unit cross-sectional area through the horizon. The section described should be approximately at right angles to the dominant orientation of roots and large enough to intersect a representative sample for the pedon.

Size

Root size can be described by the following classes:

Very fine.—Less than 1 mm in diameter.
Fine.—From 1 to 2 mm in diameter.
Medium.—From 2 to 5 mm in diameter.
Coarse.—Larger than 5 mm in diameter.

The upper size limit for coarse roots in the table is 10 mm or 1 cm. This is for application of the classes according to numbers. Roots larger than 10 mm are counted individually and actual numbers recorded per unit cross section. Proportionate volume can also be recorded.

Location

The location of roots within horizons is described in relation to morphological features of the horizons. Relationship to horizon boundaries, to animal traces, to pores, or to other features of the horizon is described as appropriate. The description should indicate, for example, whether roots are inside peds or only follow voids between peds for soils that have them.

Descriptive terms for roots should be listed in some consistent order. Some have found number, size, and location a convenient order, as in the examples that follow:

a. Many very fine and common fine roots. This would imply that roots are uniformly distributed, as location is not given.

b. Common very fine and fine roots concentrated along vertical faces of peds.

TABLE 2.—*Abundance of roots by number and size*

Class	Very fine (1 mm)	Fine (1-2 mm)	Medium (2-5 mm)	Coarse (5-10 mm)
	Average number per square decimeter			
Few	<10	<10	<1	<1
Common	10 to 100	10 to 100	1 to 10	1 to 5
Many	≥100	≥100	≥10	≥5

c. Common very fine roots inside peds; many medium roots between peds.

d. Commom medium and coarse roots, collectively.

Example *b* is subject to two interpretations unless special conventions are established. It is not clear whether the very fine and fine roots, collectively, aggregate 10 to 100 per 100 cm^2 or whether each falls within that class. It is assumed that the term for numbers applies to each of two or more size classes listed unless the term, "collectively" is used to specify otherwise, as in example *d*.

Appendix III. Tests of organic soil materials [1]

The following tests of organic soil material can be used in field offices. Determinations include sodium pyrophosphate extract color, fiber percentages, and pH in 0.01 M $CaCl_2$.

Since it is not practicable in the field to base determinations on a dry sample weight, moist soil material is used. The specific volume of moist soil material depends on how it is packed. It is, therefore, important that packing be standardized in order to obtain com-

storage is likely, the living tissues should be removed before the sample is transferred to a cup because such identifications become more difficult as the storage time lengthens.

Preparation of sample

Place about 25 cc (rounded tbsp.) of wetted field sample on a piece of absorbent paper. Smear the soil

residue to one side of the screen and blot from underneath with absorbent tissue to withdraw water. Remove any remaining plant parts that were living at the time of sampling. If a measurable volume is removed, return it to the half-syringe, blot, and record the scale reading (cc) and subtract from the original 5-cc reading. Repack the washed fibers into the half-syringe. Blot further with absorbent tissue. The moisture content should approximate that of the 2.5-cc subsample previously measured. Record the scale reading (cc) on the repacked syringe. Unrubbed fiber percentage is equal to the reading (cc) times 20 if there is no correction for live tissues. If there is a correction, the percentage equals the reading (cc) divided by the corrected pre-wash volume times 100.

Rubbed fiber percentage

Transfer the residue from the unrubbed fiber test back to the 100 mesh sieve. Rub the sample between thumb and fingers under a stream of cold tap water running at the rate of 150 to 200 ml per 5 seconds. Continue until water passing through the sieve appears clean. Clean rubbed fibers will roll between the thumb and fingers rather than slide or smear. Measure the relative volume with the half-syringe and calculate percentage as described in the previous paragraph.

pH

Place 2.5 cc of the prepared sample in a 30-ml plastic container and add 4 ml 0.015 M $CaCl_2$ (gives final concentration of roughly 0.01 M $CaCl_2$ with most packed, moist organic materials). Mix, cover, and allow to equilibrate at least 1 hour. Uncover and measure pH with pH paper or a pH meter.

Appendix IV. Descriptions of pedons

This appendix contains descriptions of pedons and tables of laboratory data. Methods used in the laboratories are indicated in the tables by a code number at the top of each column. For quick reference the methods are identified below. Detailed descriptions of the methods are in Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples (Soil Conserv. Serv. 1972).

1. SAMPLE COLLECTION AND PREPARATION
   - A. Field sampling
     - 2. Soil sampling
       - a. Stony soils
   - B. Laboratory preparation
     - 1. Standard (airdry)
       - a. Square-hole 2-mm sieve
       - b. Round-hole 2-mm sieve
     - 2. Field moist
     - 3. Carbonate-containing material
2. CONVENTIONS
   - A. Size-fraction base for reporting
     - 1. <2-mm
     - 2. <size specified
   - B. Data sheet symbols
     - tr: trace, not measurable by quantitative procedure used or less than reportable amount
     - - : analysis run but none detected
     - blank: analysis not run
     - < : less than reported amount or none present
3. PARTICLE-SIZE ANALYSES
   - A. Particles <2-mm (pipet method)
     - 1. Airdry samples
       - a. Carbonate and noncarbonate clay
       - b. Carbonate-free clay
       - c. Water-dispersible clay
     - 2. Moist samples
   - B. Particles >2-mm
     - 1. Weight estimates
       - a. By field and laboratory weighing
       - b. From volume and weight estimates
     - 2. Volume estimates
4. FABRIC-RELATED ANALYSES
   - A. Bulk density
     - 1. Saran-coated clods
       - a. Field state
       - b. Airdry
       - c. 30-cm absorption
       - d. 1/3-bar desorption I
       - e. 1/3-bar desorption II
       - f. 1/3-bar desorption III
       - h. Ovendry
     - 3. Cores
       - a. Field moist
5. ION-EXCHANGE ANALYSES (cont.)
   - C. Base saturation
     - 1. NH_4OAc, pH 7.0
     - 2. NaOAc, pH 8.2
     - 3. Sum of cations, TEA, pH 8.2
   - D. Sodium saturation (exchangeable Na pct.)
     - 1. NaOAc, pH 8.2
     - 2. NH_4OAc, pH 7.0
   - E. Sodium-adsorption ratio
6. CHEMICAL ANALYSES
   - A. Organic carbon
     - 1. Acid-dichromate digestion
       - a. $FeSO_4$ titration
       - b. CO_2 evolution, gravimetric
   - B. Nitrogen
     - 1. Kjeldahl digestion
       - a. Ammonia distillation
     - 2. Semimicro Kjeldahl
       - a. Ammonia distillation
   - C. Iron
     - 1. Dithionite extraction
       - a. Dichromate titration
       - b. EDTA titration
     - 2. Dithionite-citrate extraction
       - a. Orthophenanthroline colorimetry
     - 3. Dithionite-citrate-bicarbonate extraction
     - 5. Sodium-pyrophosphate extraction
       - a. Atomic absorption
     - 6. Ammonium oxalate extraction
       - a. Atomic absorption
   - E. Calcium carbonate
     - 1. HCl treatment
       - a. Gas volumetric
       - b. Manometric
       - c. Weight loss
       - e. Titrimetric
     - 2. Sensitive qualitative method
       - a. Visual, gas bubbles
   - F. Gypsum
     - 1. Water extract
       - a. Precipitation in acetone
   - G. Aluminum
     - 1. KCl extraction I, 30 min.
       - a. Aluminon I
6. CHEMICAL ANALYSES (cont.)
   - N. Calcium (cont.)
     - 2. NH_4OAc extraction
       - a. EDTA-alcohol separation
       - b. Oxalate-permanganate I
       - d. Oxalate-cerate
       - e. Atomic absorption
     - 3. NH_4Cl-EtOH extraction
       - a. EDTA titration
     - 4. KCl-TEA extraction
       - b. EDTA titration
       - c. Atomic absorption
   - O. Magnesium
     - 1. Saturation extract
       - a. EDTA titration
       - b. Atomic absorption
     - 2. NH_4OAc extraction
       - a. EDTA-alcohol separation
       - b. Phosphate titration
       - c. Gravimetric, $Mg_2P_2O_7$
       - d. Atomic absorption
     - 3. NH_4Cl-EtOH extraction
       - a. EDTA titration
     - 4. KCl-TEA extraction
       - b. EDTA titration
   - P. Sodium
     - 1. Saturation extract
       - a. Flame photometry
       - b. Atomic absorption
     - 2. NH_4OAc extraction
       - a. Flame photometry
       - b. Atomic absorption
   - Q. Potassium
     - 1. Saturation extract
       - a. Flame photometry
       - b. Atomic absorption
     - 2. NH_4OAc extraction
       - a. Flame photometry
       - b. Atomic absorption
   - S. Total phosphorus
     - 1. Perchloric acid digestion
       - a. Molybdovanadophosphoric acid colorimetry
7. MINERALOGY

Pedon 1
SOIL Typic Argiustoll SOIL Nos. S63Kans-29-1 LOCATION Ford County, Kans.

SOIL SURVEY LABORATORY Lincoln, Nebraska LAB. Nos. 18450-18462

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1: Total: Sand a/ (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: 0.05–0.02	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)		3A1a Non-carbonate clay	Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-15	Ap	9.9	56.9	33.2	tr	0.1	0.2	1.4	8.2	35.3	21.6	44.6	1.7					-
15-30	B21t	5.2	48.3	46.5	-	0.1	0.2	0.8	4.1	28.4	19.9	33.1	1.1					-
30-46	B22t	4.5	52.8	42.7	tr	0.1	0.1	0.4	3.9	28.7	24.1	32.9	0.6					-
46-76	B3ca	4.7	61.2	34.1	tr	0.1	0.1	0.3	4.2	33.8	27.4	38.2	0.5					-
76-115	C1ca	5.7	65.1	29.2	tr	tr	0.1	0.4	5.2	36.2	28.9	41.7	0.5		29			-
115-145	C2ca	6.9	65.2	27.9	tr	tr	0.1	0.5	6.3	35.9	29.3	42.6	0.6		25			-
145-185	C3ca	8.9	62.9	28.2	-	tr	0.1	0.9	7.9	35.7	27.2	44.4	1.0		27			-
185-220	IIA1b	18.2	52.3	29.5	tr	0.1	0.2	3.5	14.4	29.9	22.4	47.4	3.8		30			-

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N	Carbonate as $CaCO_3$: 6E1b 6E2a < 2mm Pct.	3A1a <0.002 mm Pct.	6C2a Ext. iron as Fe Pct.	Bulk density: 4A1a Field state c/ g/cc	4A1d 1/3-bar d/ g/cc	4A1b Air-dry g/cc	4D1 COLE	Water content: 4B4 Field state e/ Pct.	4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3 to 15-bar cm/cm		pH: 8C1b Sat. paste	8C1a (1:1) H_2O	8C1a (1:10) H_2O
0-15	1.17	0.118	10			0.7	1.11				24.4		14.6				6.1	6.6
15-30	0.83	0.084	10	-		0.8	1.38	1.29	1.78	0.12	27.0	32.2	20.5	0.15			6.9	7.1
30-46	0.54	0.066	8	tr	-	0.7	1.49	1.37	1.76	0.087	21.8	29.6	19.9	0.13			7.8	8.2
46-76	0.35			3	tr	0.7	1.42	1.31	1.54	0.056	17.9	28.4	16.8	0.15			8.1	8.8
76-115	0.27			4	tr	0.7	1.24	1.17	1.28	0.032	13.2	31.5	15.6	0.19			7.9	8.6
115-145	0.24			7	3	0.6		1.2					16.0			7.5	7.9	8.4
145-185	0.28			3	1	0.8	1.31	1.20	1.34	0.036	13.7	31.6	16.2	0.18			7.9	8.6
185-220	0.23			2	tr	0.8							13.6				7.8	8.5

Depth (cm)	Extractable bases 5B1a: 6N3a Ca f/	6O3a Mg g/	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap.: 5A3a Sum cations	5A1a NH_4OAc	Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water	8E1 Resistivity ohms-cm	8B1a Elec. cond. mmhos/cm	8B Water at sat. Pct.	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-15	14.7	1.6	0.1	1.9	18.3	5.5	23.8	22.6	0.68	0.02	0.44				9.2		77	81
15-30	23.4	7.3	0.3	1.8	32.8	3.8	36.6	30.7	0.66	0.02	0.44				3.2		90	107
30-46	22.7	6.2	0.6	1.7	31.2	1.5	32.7	29.6	0.69	0.02	0.47				3.7			
46-76	20.8	5.9	1.2	1.6	29.5			25.7	0.75	0.02	0.49				3.5			
76-115	21.4	5.3	2.2	1.7	30.6			24.1	0.83	0.02	0.53				4.0			
115-145	22.6	4.2	2.7	1.7	31.2			22.4	0.80	0.02	0.57	500	4.90	51.0	5.4			
145-185	20.5	3.5	2.2	1.7	27.9			22.5	0.80	0.03	0.57				5.9			
185-220	18.5	2.7	1.6	1.4	24.2			20.1	0.68	0.03	0.46				6.9			

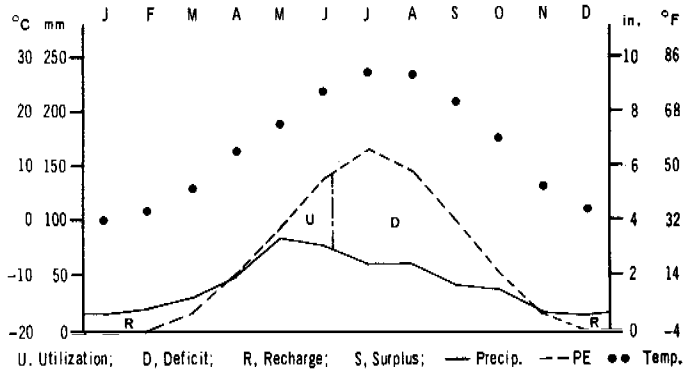
Depth (cm)	Clay fraction h/ mineralogy 7A1 / 7A2

a/ Carbonate nodules: Below 46 cm there are > 50 percent (2-0.25 mm); 5-25 percent (0.25-0.05 mm).
b/ 8.5 kg/m² to 1.5 m (method 6A).

Pedon 1

Classification: Typic Argiustoll, fine, montmorillonitic, mesic.
Location: Ford County, Kans., 265 m S & 95 m W of NE corner, sec. 23, T. 25 S., R. 26 W.
Physiographic position: Upland, High Plains tableland and elevation about 780 m.
Topography: Nearly level with gradient less than 1/2 percent.
Drainage class: Well drained.
Vegetation: Fallow.
Parent material: Loess.
Sampled by: D. A. Dodge, R. B. Grossman, G. Holmgren and C. W. McBee, June 24, 1963.
Soil No.: S63Kans-29-1.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

Ap 0-15 cm (0-6 in.). Dark grayish brown (10YR 4.5/2) light silty clay loam, very dark grayish brown (10YR 2.5/2) moist; moderate fine granular structure; hard (dry), friable (moist); clear boundary.

B21t 15-30 cm (6-12 in.). Dark grayish brown (10YR 4.5/2) silty clay, very dark grayish brown (10YR 2.5/2) moist; weak fine blocky structure; very hard (dry), very firm (moist); many fine roots; few pores; common pressure faces; gradual boundary.

B22t 30-46 cm (12-18 in.). Grayish brown (10YR 5/2) silty clay, very dark grayish brown (10YR 3/2) moist; moderate medium to coarse blocky structure; very hard (dry), very firm (moist); common pressure faces; gradual boundary.

B3ca 46-76 cm (18-30 in.). Light brownish gray (10YR 6.5/2) light silty clay loam, grayish brown (10YR 5/2) moist; moderate blocky structure changing to weak medium blocky in lower 10 cm; hard (dry), firm (moist); many fine roots; old root channels apparently open; common pressure faces; calcareous with many thin films, fine thread-like seams and small soft bodies of segregated calcium carbonate making up about 2 to 5 percent of the volume; diffuse boundary.

C1ca 76-115 cm (30-45 in.). Light gray (10YR 7/2) light silty clay loam, light brownish gray (10YR 6/2) moist; massive to weak fine subangular blocky structure; hard (dry), friable (moist); many fine roots; many fine pores; calcareous with many thin films and fine thread-like seams of calcium carbonate; diffuse boundary.

C2ca 115-145 cm (45-58 in.). Very pale brown (10YR 7/3) light silty clay loam, pale brown (10YR 6/3) moist; massive; slightly hard (dry), friable (moist); many fine pores; calcareous with many thin films and fine thread-like seams of calcium carbonate; diffuse boundary.

C3ca 145-185 cm (58-72 in.). Pale brown (10YR 6/3) light silty clay loam, brown, (10YR 5/3) moist; massive; slightly hard (dry), friable (moist); many very fine pores; calcareous with many thin films and fine threads of calcium carbonate; gradual boundary.

IIA1b 185-220 cm (72-87 in.). Brown (10YR 5/3) light silty clay loam, brown (10YR 4/3) moist; weak fine granular structure; slightly hard (dry), friable (moist); many fine pores; calcareous with few (less than 1 percent) fine soft segregations of calcium carbonate; gradual boundary.

SOIL Pedon 2 Aquic Argiudoll SOIL Nos. S66Ill-54-5 LOCATION Logan County, Ill.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 66L271-66L278

General Methods: 1A, 1B1b, 2A1, 2B

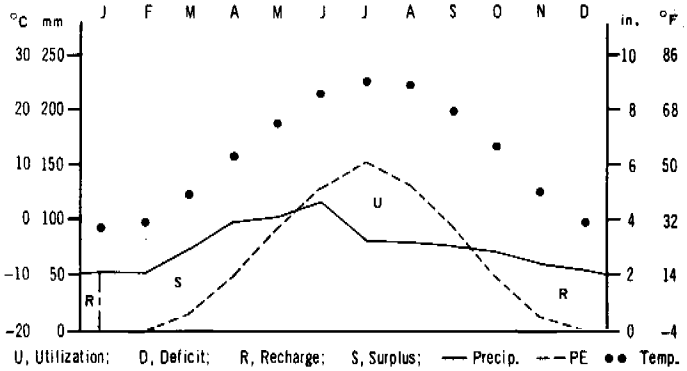
Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05) a/	Silt (0.05–0.002)	Clay (< 0.002)	Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: 0.05–0.02	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	<0.074		Coarse fragments 2A2:		3B1 2-20 Pct. ≤ 20
		Pct. of < 2 mm																
0-18	Ap	2.5	72.3	25.2	0.1	0.5	0.4	0.4	1.1	29.3	43.0	30.6	1.4	98.5				-
18-38	A3	2.8	68.7	28.5	0.3	0.7	0.5	0.5	0.8	22.6	46.1	23.6	2.0	97.9				-
38-51	B21t	2.4	61.2	36.4	0.2	0.5	0.4	0.5	0.8	19.9	41.3	21.0	1.6	98.2				-
51-66	B22t	1.6	55.9	42.5	tr	0.1	0.1	0.3	1.1	19.7	36.2	21.0	0.5	99.3				-
66-94	B23t	2.6	60.3	37.1	0.1	0.2	0.2	0.3	1.8	24.9	35.4	26.9	0.8	99.0				-
94-130	B3	2.3	72.8	24.9	tr	0.1	0.1	0.3	1.8	35.6	37.2	37.6	0.5	99.3				-
130-160	C1	5.1	80.9	14.0	-	0.1	0.1	0.2	4.7	48.9	32.0	53.7	0.4	99.3				-
160-190	C2	5.1	85.9	9.0	-	tr	tr	0.3	4.8	56.2	29.7	61.2	0.3	99.4				-

Depth (cm)	6A1a Organic carbon b/ Pct	Nitrogen Pct	C/N	Carbonate as $CaCO_3$: 6E1b 6E2a <2 mm Pct	3A1a <0.002 mm Pct	6C2a Ext. iron as Fe Pct	Bulk density: g/cm	4A1d 1/3-bar g/cm	4A1b Oven-dry g/cm	4D1 COLE	Water content: 4B1c 1/3-bar Pct	4B2 15-bar c/ Pct	4C1 1/3-to 15-bar cm/cm			pH		8C1a (1:1) H_2O

Pedon 2

Classification: Aquic Argiudoll, fine, montmorillonitic, mesic.
Location: Logan County, Ill., 260 m N. along pasture fence line from center of road and 2 m W. SE 1/4 NW 1/4 SW 1/4 SE 1/4 sec. 25, T. 21 N., R. 4 W., about 250 km (155 mi.) SW. of Chicago.
Physiographic position: Elevation about 200 m.
Topography: 1 percent slope, south aspect.
Drainage: Somewhat poor.
Vegetation: Cultivated, corn.
Parent material: Loess.
Sampled by: R. E. Bourland, L. Esworthy, J. B. Fehrenbacher, C. J. Frazee, R. B. Grossman, G. W. Hudelson, W. C. Lynn, D. R. Mapes, J. Thompson, L. E. Tyler and G. O. Walker, June 29, 1966.
Soil No.: S66Ill-54-5.

Climatic data and soil water balance



Colors are for the moist soil unless otherwise indicated.

Ap 0-18 cm (0-7 in.). Black (10YR 2/1) heavy silt loam, very dark brown (10YR 2/2) crushed, dark gray or gray (10YR 4/1-5/1) dry; moderate very fine granular structure; friable (moist); abrupt smooth boundary.

A3 18-38 cm (7-15 in.). Black (10YR 2/1) light silty clay loam, black or very dark gray (10YR 2/1-3/1) crushed, dark gray (10YR 4/1) dry; moderate fine granular structure; friable (moist); clear smooth boundary.

B21t 38-51 cm (15-20 in.). Brown or dark brown (10YR 4/3) heavy silty clay loam with black (10YR 2/1) and very dark gray (10YR 3/1) ped coatings, dark grayish brown (2.5Y 4/2) crushed; moderate fine and medium subangular blocky structure; clear smooth boundary.

B22t 51-66 cm (20-26 in.). Olive brown (2.5Y 4/4) silty clay with thin continuous very dark grayish brown (10YR 3/2) clay skins, grayish brown to light olive brown (2.5Y 5/2-5/4) crushed; few fine faint yellowish brown (10YR 5/6) mottles; few black (5YR 2/1) iron-manganese concretions; moderate medium angular blocky structure; firm (moist); clear smooth boundary.

B23t 66-94 cm (26-37 in.). Olive brown (2.5Y 4/4) heavy silty clay loam with thin continuous very dark grayish brown to very dark gray (10YR 3/2-3/1) clay skins, dark grayish brown or olive brown (2.5Y 4/2-4/4) crushed; common fine distinct yellowish brown (10YR 5/6) mottles; weak medium prisms break to moderate coarse angular blocks; firm (moist); [illegible]

B3 94-130 cm (37-51 in.). Mixed yellowish brown (10YR 5/6-5/8) and light olive gray (5Y 6/2) heavy silt loam with thin

SOIL Pedon 3 Aridic Argiboroll SOIL Nos. S62Mont-3-2 LOCATION Blaine County, Mont.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 17540-17551

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2 3B1 2–20 Pct. < 20
		Pct. of < 2 mm														
0-5	A1	48.7	29.2	22.1	2.7	5.0	7.8	20.7	12.5	12.9	16.3	37.4	36.2			5
5-13	B1	47.3	27.4	25.3	2.1	5.0	7.7	20.9	11.6	11.7	15.7	35.6	35.7			11
13-23	B21t	42.9	24.7	32.4	1.5	4.8	7.2	19.2	10.2	10.0	14.7	31.0	32.7			4
23-33	B22t	41.1	21.1	37.8	0.9	5.7	9.0	18.7	6.8	6.2	14.9	23.1	34.3			tr
33-48	B23t	35.9	27.3	36.8	1.3	3.8	6.7	16.6	7.5	8.7	18.6	25.3	28.4			tr
48-64	B3ca	31.9	34.6	33.5	0.8	2.7	4.3	13.9	10.2	11.2	23.4	29.8	21.7			2
64-95	C1ca	32.7	36.2	31.1	1.2	2.6	4.5	13.8	10.6	11.8	24.4	30.8	22.1			5
95-135	C2ca	31.0	40.1	28.9	0.9	2.0	3.1	12.6	12.4	14.0	26.1	34.7	18.6			4
135-165	C3	30.9	40.8	28.3	0.8	1.8	2.8	12.7	12.8	15.6	25.2	36.8	18.1			4

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	Carbonate as $CaCO_3$: 6E1b < 2mm b/ Pct.	3A1a <0.002 mm Pct.		Bulk density: g/cc	4A1d 1/3-bar g/cc	4A1b Air-dry g/cc	4D1 COLE	Water content: Pct.	4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm			pH: 8C1a (1:1) H_2O
0-5	2.06	0.192	11					1.17	1.28	0.032		20.0	9.4	0.12			6.6
5-13	1.29												9.8				6.4
13-23	0.97							1.36	1.56	0.047		21.9	12.4	0.13			6.5
23-33	0.74	0.074	10										14.1				6.8
33-48	0.76			1	-			1.50	1.80	0.064		23.8	13.9	0.15			7.5
48-64	0.67			8	1								12.3				8.0
64-95	0.50			8	1			1.56	1.69	0.028		22.3	11.9	0.16			8.2
95-135	0.35			8	1								11.1				8.3
135-165	0.31			7	tr								11.9				8.6

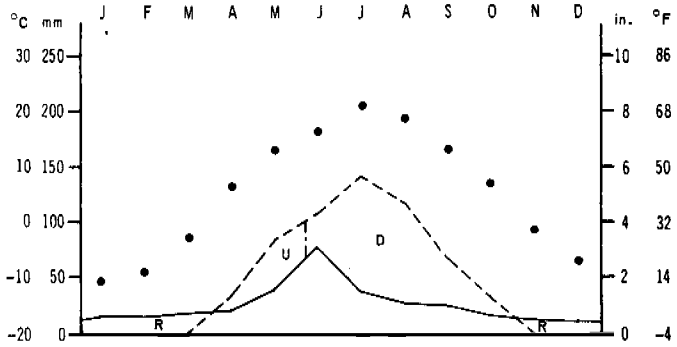
Depth (cm)	Extractable bases 6N3a Ca c/	6O3a Mg d/	6P2a Na	5B1a 6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap. 5A3a Sum cations	5A1a NH_4OAc			Ratios to clay 8D1: NH_4OAc CEC		15-bar water			Base saturation 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																
0-5	10.1	4.7	tr	1.1	15.9	6.1	22.0	16.4			0.74		0.42			72	97
5-13	7.8	5.7	tr	0.9	14.4	5.4	19.8	16.8			0.66		0.39			73	86
13-23	11.6	8.3	0.1	0.9	20.9	5.8	26.8	20.8			0.64		0.38			78	100
23-33	14.0	11.4	0.2	0.8	26.4	3.8	30.2	25.1			0.66		0.37			87	105
33-48	14.9	11.7	0.2	0.6	27.4	2.8	30.2	24.2			0.66		0.38			91	113
48-64	13.3	10.4	0.3	0.4	24.4			20.1			0.60		0.37				
64-95	10.5	11.2	0.5	0.4	22.6			17.9			0.58		0.38				
95-135	8.4	12.0	0.9	0.4	21.7			17.1			0.59		0.38				
135-165	8.0	12.4	1.5	0.4	22.3			18.0			0.64		0.42				

a/ 14 kg/m^2 to 1.5 m (method 6A). Based on interpolated bulk densities where measurements lacking.
b/ No gypsum detected in the C3 horizon.
c/ Method 6N2a used for horizons above 33 cm.
d/ Method 6O2a used for horizons above 33 cm.

Pedon 3

Classification: Aridic Argiboroll, fine, montmorillonitic.
Location: Blaine County, Mont., 200 m N. and 200 m E. of SW. corner of SW 1/4 NW 1/4 sec. 21, T. 29 S., R. 22 E.
Physiographic position: Upland glacial till plain.
Topography: Gradient of 3 percent with SW. aspect; located 30 m below the summit on a slope 150 m long.
Drainage: Well drained.
Vegetation: Western wheatgrass (Agropyron smithii), Bluebunch wheatgrass (Agropyron spicatum), Prairie junegrass (Koeleria cristata), needleandthread (Stipa comata), Idaho fescue (Festuca idahoensis), Plantain (Plantago) spp.).
Parent material: Calcareous glacial till.
Sampled by: A. Anderson, R. B. Grossman, C. A. Mogen, R. L. Moshier and J. L. Walker, August 22, 1962.
Remarks: Two percent (by volume) coarse fragments greater than 2 cm; no greater than 25 cm below field capacity and no water table within 3 m.
Soil No.: S62Mont-3-2.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

A1 0-5 cm (0-2 in.). Grayish brown (10YR 5/2) heavy loam, very dark grayish brown (10YR 3/2) moist; granular structure with granules arranged in fine plates; soft (dry), very friable (moist), slightly sticky and slightly plastic (wet); abundant roots; uncoated sand and silt grains on granules and plates give a gray (10YR 5/1) dry color before crushing; clear smooth boundary.

B1 5-13 cm (2-5 in.). Grayish brown (10YR 5/2) light sandy clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium prisms separating into medium plates; hard (dry), friable (moist), sticky and slightly plastic (wet); abundant roots; prisms are coated dark gray (10YR 4/1) and have abundant uncoated sand and silt grains; clear smooth boundary.

B21t 13-23 cm (5-9 in.). Brown (10YR 5/3) light clay loam, brown (10YR 4/3) moist; soil colors before crushing are dark grayish brown (10YR 4/2), very dark grayish brown (10YR 3/2) moist; strong medium prisms that separate easily to fine subangular blocks; very hard (dry), firm (moist), sticky and plastic (wet); abundant roots; few fine pores; thin continuous clay skins on peds; common uncoated sand and silt grains mainly on prism faces; gradual boundary.

B22t 23-33 cm (9-13 in.). Brown (10YR 5/3) heavy clay loam, dark brown (10YR 3/3) moist; strong medium prisms that separate easily to fine angular blocks; extremely hard (dry), firm (moist), sticky and plastic (wet); abundant roots; few fine pores; thin continuous clay skins on peds; very few uncoated sand grains on prism faces; gradual boundary.

B23t 33-48 cm (13-19 in.). Heavy clay loam with same colors as horizon above; strong medium prisms that separate easily to fine and medium angular blocks; extremely hard (dry), firm (moist), sticky and plastic (wet); abundant roots; few fine pores; thin continuous clay skins; clear wavy boundary.

B3ca 48-64 cm (19-25 in.). Grayish brown (2.5Y 5/2) light clay loam, very dark grayish brown (2.5Y 3/2) moist; strong medium and coarse prisms that separate to strong medium blocks; extremely hard (dry), firm (moist), sticky and plastic (wet); plentiful roots; many fine and very fine pores with common medium pores; patchy thin clay skins on prisms; nodules of calcium carbonate common; gradual boundary.

C1ca 64-95 cm (25-37 in.). Grayish brown (2.5Y 5/2) light clay loam, very dark grayish brown (2.5Y 3/2) moist; moderate coarse prismatic structure; extremely hard (dry), firm (moist), sticky and plastic (wet); plentiful roots; many fine and a few medium pores; many threads and films of calcium carbonate with a few segregations occurring as incrustations on pebbles; shale fragments present; gradual boundary.

C2ca 95-135 cm (37-53 in.). Light clay loam with same colors [illegible]

Pedon 4

SOIL Udic Argiustoll SOIL Nos. S63Kans-9-2 LOCATION Chase County, Kans.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 18431-18434

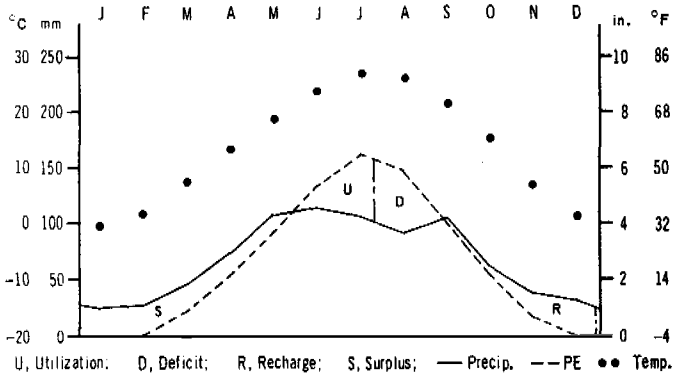
General Methods: 1A. 1B1b, 2A1, 2B

Depth	Horizon	Size class and particle diameter (mm) 3A1														Coarse fragments 2A2		
		Total			Sand					Silt								
		Sand	Silt	Clay	Very coarse	Coarse	Medium	Fine	Very fine		Int. III	Int. II				3B2 Vol.	3B1 2-20	3B1 20-75

Pedon 4

Classification: Udic Argiustoll, clayey-skeletal, montmorillonitic, mesic.
Location: Chase County, Kans. 1,100 m E. and 270 m N. of SW. corner sec. 6, T. 22 S., R. 7 E., about 75 km (50 mi.) NE. of Wichita.
Physiographic position: Erosional upland.
Topography: Fourteen percent gradient; 15 m below interfluve summit; SW. aspect.
Drainage: Rapid runoff; moderate permeability.
Vegetation: Little bluestem (Andropogon scoparius), big bluestem (Andropogon gerardi), leadplant (Amorpha canescens), prairieclover (Petalostemum spp.).
Parent material: Cherty limestone.
Sampled by: W. L. Barker, O. W. Bidwell, R. B. Grossman, G. S. Holmgren, C. W. McBee, A. P. Nelson and H. L. Penner, June 26, 1963.
Soil No.: S63Kans-9-2.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

A11 0-8 cm (0-3 in.). Very dark grayish brown (10YR 3.5/2) silt loam, very dark brown (10YR 2/1.5) moist; strong fine granular structure; upper 3 cm weak fine platy; slightly hard (dry), friable (moist); plentiful roots; 15 percent chert fragments 1 to 75 cm diameter; clear and smooth boundary.

A12 8-33 cm (3-13 in.). Very dark grayish brown (10YR 3.5/2) very cherty light silty clay loam, very dark brown (10YR 2/1.5) moist; strong fine granular structure; slightly hard (dry), friable (moist); 80 percent by volume chert coarse fragments with most less than 75 mm, but ranging to 20 cm diameter; few wormcasts; gradual and smooth boundary.

B1t 33-50 cm (13-20 in.). Dark grayish brown (10YR 3.5/2) very cherty light clay, very dark grayish brown (10YR 3/2) moist; strong fine blocky structure; hard (dry), firm (moist); coarse fragments about same as above horizon; smooth shiny ped surfaces; few wormcasts; gradual smooth boundary.

B2t 50-105 cm (20-41 in.). Dark reddish brown (2.5YR 3/4) very cherty heavy clay; dark red (2.5YR 3/5) moist; strong fine blocky structure; extremely hard (dry), very firm (moist); 80 percent chert, commonly 10 to 20 cm diameter; clear and wavy boundary.

R 105 cm (41 in.) plus. Cherty limestone with lateral and vertical seams of massive dark reddish brown (2.5YR 3/4) clay.

SOIL Pedon 5 Udic Natriboroll SOIL Nos. NDak53-P-10 LOCATION Dickey County, N. Dak.

SOIL SURVEY LABORATORY North Dakota Agricultural Experiment Station, Fargo, N. Dak. LAB. Nos.

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2: > 2	2 – 19	19 – 76
		Pct. of < 2 mm														Pct.	Pct. of < 76 mm	
0-15	Ap	55.3	30.0	14.7	0.4	6.3	10.1	30.3	8.2	12.6	17.4		47.1					
15-18	A2	55.6	33.6	10.8	0.3	5.8	9.8	27.4	12.3	14.6	19.0		43.3					
18-24	B21t	45.9	34.1	20.0	-	4.7	7.5	28.1	5.6	14.7	19.4		40.3					
24-30	B22t	46.3	27.6	26.1	-	4.1	7.6	32.7	1.9	14.5	13.1		44.4					
30-43	B3sa	49.4	25.8	24.8	-	4.0	5.8	37.5	2.1	11.8	14.0		47.3					
43-61	C1casa	26.2	37.4	36.4	-	2.0	3.1	19.7	1.4	10.0	27.4		24.8					
61-91	IIC2casa	16.0	58.1	25.9	-	2.5	1.6	11.1	0.8	3.3	54.8		15.2					
91-125	IIC3ca	6.1	70.1	23.8	-	0.9	0.8	3.6	0.8	-	70.1		5.3					
125-150	IIC4	6.5	69.9	23.6	-	-	0.8	5.0	0.7	1.7	68.2		5.8					

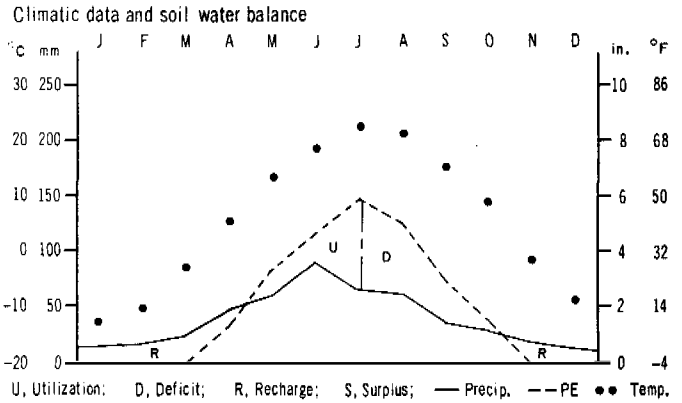
Depth (cm)	6A1a Organic carbon Pct.	6B2 Nitrogen Pct.	C/N		6E1b Carbonate as $CaCO_3$ Pct.		Bulk density g/cc	g/cc	g/cc		Water content Pct.	Pct.	Pct.				pH 8C1b Sat. paste	8C1a 1:5 H_2O
0-15	2.71	0.199	14														7.2	7.2
15-18	2.11	0.183	12														7.7	7.8
18-24	1.25	0.100	13														8.1	8.7
24-30	1.09	0.086	13														8.5	9.0
30-43	0.61	0.047	13		2												8.9	9.2
43-61	0.14				30												9.4	9.5
61-91	0.30				27												9.1	9.3
91-125	0.30				20												8.9	9.2
125-150	0.28				15												8.6	9.1

Depth (cm)	Exchangeable bases 5B1b: 6N2a Ca	6O2a Mg	6P2a Na	6Q2a K	Sum	Cat. exch. cap. 5A2a NaOAc	Water extract from saturated paste: 6N1a Ca	6O1a Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1a SO_4	8A1a Electrical conductivity
	meq/100 g						meq/liter								mmho/cm
0-15	13.7	4.8	0.6	1.0	20.1	19.3	1.1	2.0	9.6	0.9	-	6.1	0.1	7.4	0.80
15-18	9.6	4.6	1.8	0.5	16.5	15.4	-	1.6	24.4	0.2	-	0.4	-	25.9	1.31
18-24	10.0	8.1	4.9	0.7	23.7	20.5	0.3	2.6	18.2	0.2	2.0	7.7	-	71.6	2.22
24-30	11.0	10.8	10.0	0.7	32.5	23.2	-	3.2	63.0	0.2	2.6	3.9	0.1	59.9	3.6
30-43	11.6	12.5	8.1	0.7	32.9	19.7	-	3.9	108	0.2	1.6	4.7	0.1	106	4.8
43-61	-	12.9	6.0	0.5		14.7	-	3.4	91.5	0.1	2.2	4.9	tr	87.8	4.3
61-91	-	10.7	4.8	0.6		14.9	0.4	2.3	88.0	0.1	1.4	7.6	0.1	81.7	4.0
91-125	-	12.9	6.0	0.5		18.9	0.9	1.9	72.8	0.1	1.1	8.1	0.2	66.3	3.0
125-150	-	12.3	5.4	0.5		20.0			59.7	0.1	1.2	8.5	0.3		2.4

Depth (cm)	8A Water at saturation Pct.	5C2 Exchangeable Na Pct.	5E SAR	Gypsum Pct.	8D1 Ratio CEC to clay
0-15	39	3	8		1.31
15-18	42	12	27		1.4
18-24	42	24	15		1.0
24-30	72	43	50		0.89
30-43	80	41	77		0.79
43-61	89	41	70		0.40
61-91	97	32	76		0.58
91-125	107	32	62		0.79
125-150	90	27			0.85

Pedon 5

Classification: Udic Natriboroll, fine-loamy, mixed.
Location: Dickey County, N. Dak., 400 m S. and 43 m E. of NW. corner sec. 1, T. 130 N., R. 59 W.
Physiographic position: Glacial lake plain.
Topography: Nearly level with gradient less than 1/2 percent.
Drainage: Moderately well to somewhat poorly drained; moderately slow permeability.
Vegetation: Grain stubble.
Parent material: Lacustrine.
Sampled by: J. E. McClelland and C. A. Mogen, October 10, 1953.
Soil No.: NDak53-P-10.



Colors are for the dry soil unless otherwise indicated.

Ap 0-15 cm (0-6 in.). Dark gray (10YR 4.5/1) fine sandy loam, very dark gray (10YR 3/1) moist; weak fine granules; slightly hard (dry), very friable (moist); clear boundary.

A2 15-18 cm (6-7 in.). Light gray (10YR 7/1) fine sandy loam; very dark gray (10YR 3/1) moist; weak fine plates; hard (dry), very friable (moist); abrupt boundary.

B21t 18-24 cm (7-9 1/2 in.). Dark gray (10YR 4/1) heavy loam, black (10YR 2/1) moist with some gray (10YR 5/1) moist coatings; strong medium columns; extremely hard (dry), very firm (moist); clear boundary.

B22t 24-30 cm (9 1/2-12 in.). Dark gray (10YR 4/1) light sandy clay loam, black (10YR 2/1) moist with very dark brown (10YR 2/2) moist interiors; strong medium columns; extremely hard (dry), very firm (moist); clear boundary.

B3sa 30-43 cm (12-17 in.). Dark grayish brown (2.5Y 4.5/2) light sandy clay loam, black (2.5Y 2/1) moist with very dark brown (10YR 2/2) to very dark grayish brown (2.5Y 3/2) moist interiors; weak medium prisms separating to moderate fine blocks; very hard (dry), firm (moist); very slight amount of segregated lime, matrix noncalcareous; clear irregular boundary.

C1casa 43-61 cm (17-24 in.). White (2.5Y 8/2) heavy clay loam, grayish brown (2.5Y 5/2) moist mottled with olive brown (2.5Y 4/4) and light gray (N 6/0) moist; weak coarse prisms separating to weak fine blocks; friable (moist); calcareous with a moderate amount of segregated lime occurring as threads and films; gradual boundary.

IIC2casa 61-91 cm (24-36 in.). Pale yellow (2.5Y 7/3) heavy silt loam, light yellowish brown (2.5Y 6/4) moist mottled with olive yellow (2.5Y 6/6) to light brownish gray (2.5Y 6/2) moist; weak coarse prisms separating to weak fine blocks; friable (moist); calcareous; clear boundary.

IIC3ca 91-125 cm (36-49 in.). White (5Y 8/1) heavy silt loam, light gray (5Y 6/1) moist mottled with strong brown (7.5YR 5/8) moist and dark brown (7.5YR 3/2) moist; weak fine platy structure; friable (moist); calcareous; gradual boundary.

IIC4 125-150 cm (49-59 in.). Colors and texture as in horizon above; moderate fine platy structure; friable (moist); calcareous with a few soft lime segregations.

Pedon 6

SOIL Hydric Dystrandept SOIL Nos. S620reg-29-1 LOCATION Tillamook County, Oregon

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 62137 - 62146

Depth (cm)	Horizon	1B1b Total: Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Size class and particle diameter (mm) 3A1 — Sand: Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt: (0.05-0.02)	Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1			Coarse fragments 1A2a: > 2 Pct. of whole soil	2-19	19-76
		Pct. of <2 mm														Pct. of <76mm		
0-10	Ap	15.0	53.6	31.4	1.5	3.1	1.8	4.3	4.3	18.2	35.4	25.0	10.7			2		
10-30	A12	12.1	55.2	32.7	0.9	1.5	1.0	3.2	5.5	17.3	37.9	24.7	6.6			2		
30-68	A13	14.3	58.7	27.0	0.5	2.1	1.7	4.3	5.7	18.3	40.4	26.4	8.6			2		
68-96	A3	17.6	65.6	16.8	0.3	1.5	1.6	4.8	9.4	26.1	39.5	38.4	8.2			2		
96-125	B21	29.2	52.7	18.1	0.4	1.8	2.3	13.5	11.2	20.5	32.2	40.5	18.0			4		
125-145	B22	37.0	47.6	15.4	0.9	2.9	4.9	17.0	11.3	18.0	29.6	38.8	25.7			5		
145-165	B23	42.8	43.9	13.3	1.1	4.1	7.1	18.4	12.1	16.2	27.7	37.9	30.7			7		
165-190	B31	43.8	42.6	13.6	2.5	8.6	8.5	14.5	9.7	15.9	26.7	32.8	34.1			7		
190-215	B32	42.1	45.3	12.6	3.8	10.8	7.8	11.4	8.3	18.7	26.6	33.1	33.8			21		
215-255	IIC	61.2	31.6	7.2	20.3	16.0	7.2	10.5	7.2	12.3	19.3	24.7	54.0			22		

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	4A1h Oven-dry g/cc	g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3- to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1a H_2O 1:1	8C1c 1N KCl 1:1	8C1d NaF 2 min. 1:50
0-10	15.43	0.948	16	4.8			0.79	0.96			58.9	35.4		0.068		5.3	4.2	
10-30	14.77	0.927	16	4.0			0.74	0.88			63.0	35.2		0.059		5.1	4.0	
30-68	10.96	0.610	18	4.2			0.71	0.89			68.0	28.1		0.078		5.1	4.1	
68-96	6.34	0.386	16	4.1			0.94	1.06			50.6	24.4		0.040		5.3	4.2	11.0
96-125	1.56	0.193	8	4.0			1.04	1.16			45.3	23.8		0.036		5.5	4.4	10.5
125-145	1.76	0.209	8	4.5			1.03	1.14			46.1	24.0		0.036		5.5	4.5	
145-165	2.23	0.245	9	5.1			1.00	1.12			49.2	24.3		0.040		5.6	4.5	
165-190	2.38	0.239	10	4.8			0.96	1.08			56.0	23.9		0.040		5.5	4.6	
190-215	1.80	0.194	9	4.6			0.95	1.02			64.0	22.6		0.020		5.5	4.8	
215-255	1.26	0.105	12	3.4								17.7				5.7	4.9	

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2c Mg	6P2a Na	6Q2a K	Sum of bases	6H2a Ext. acidity	Cation exch. capacity: 5A6a NH_4OAc	5A3a Sum of cations		6G1d KCl ext. Al +++	Ratios to clay 8D1: CEC NH_4OAc	Ext. iron	15-bar water				Base saturation: 5C3 Sum of cations Pct.	5C1 NH_4 OAc Pct.
	meq/100g																	
0-10	6.7	1.2	0.4	0.4	8.7	94.9	78.1	103.6		4.0	2.49	0.13	1.13				8	11
10-30	2.0	1.1	0.3	0.5	3.9	99.7		103.6		5.5		0.12	1.08				4	
30-68	0.5	0.6	0.2	0.4	1.7	94.2	70.2	95.9		5.6	2.60	0.16	1.04				2	2
68-96	0.5	0.4	0.2	0.2	1.3	64.0		65.3		3.6		0.24	1.45				2	
96-125	0.6	0.3	0.2	0.1	1.2	35.2		36.4		1.3		0.22	1.31				3	
125-145	0.5	0.3	0.2	0.1	1.1	39.6	37.9	40.7		1.2	2.46	0.29	1.56				3	3
145-165	0.4	0.3	0.3	0.1	1.1	44.0		45.1		1.0		0.38	1.83				2	
165-190	0.4	0.3	0.2	0.1	1.0	42.1		43.1		1.0		0.35	1.76				2	
190-215	0.3	0.2	0.2	0.1	0.8	45.0		45.8		0.6		0.37	1.79				2	
215-255	0.8	0.4	0.2	0.1	1.5	35.4	38.0	36.9		0.4	5.28	0.47	2.46				4	4

Depth (cm)	b/ 3A1. Clay fraction mineralogy d/: 7A2 X-ray c/	7A3 DTA Pct.	Allophane Pct.
0-10			
10-30			
30-68			
68-96	VR4, KK3, QZ2	KK13	
96-125	VR4, KK3, QZ2	KK13	34
125-145			
145-165			
165-190			
190-215			
215-255		KK20	

a/ 80.1 kg of organic carbon per square meter to a depth of 1 meter.

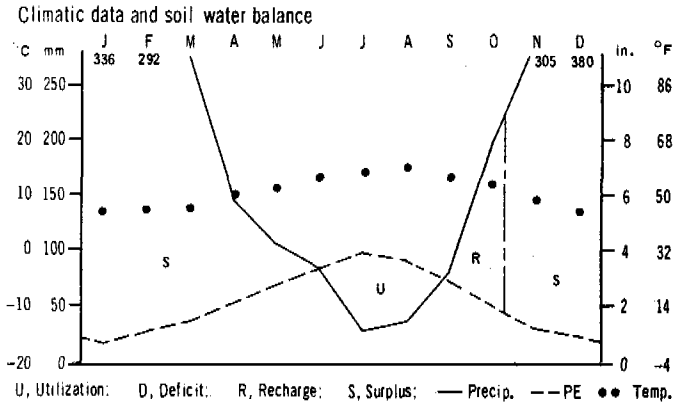
b/ Mineral code:
VR = vermiculite
KK = kaolinite
QZ = quartz

c/ Approximate weight fraction (X-ray):
4 = one-third to half
3 = one-fifth to one-third
2 = one-twentieth to one-fifth

d/ The soil was dispersed with Na_2CO_3. Allophane in the clay was determined from the sum of aluminum and silicon extracted by 0.5N KOH and the loss in weight of the clay upon heating from 105 to 900° C. The clays were given a dithionite treatment (6C2) before X-ray peaks were obtained.

Pedon 6

Classification: Hydric Dystrandept, thixotropic, mesic.
Location: Tillamook County, Oreg. SW1/4NW1/4 sec. 13, T. 1 S., R. 10 W., 30 m north of road and large fir tree.
Physiographic position: Terrace, elevation about 13 m.
Topography: Very gently undulating with slopes of 0 to 3 percent, near 1 percent at sample site.
Drainage: Well drained; surface runoff is slow; internal drainage is medium, permeability of B horizon is moderate.
Vegetation: Mostly grasses and ferns.
Parent material: Mixed terrace materials mainly of basic volcanic origin.
Sampled by: R. E. Nelson, B. R. Brasher, C. C. Bowlsby, and A. O. Ness, March 31, 1962.
Remarks: The soil was slightly above field capacity when sampled. Water seeped in through the IIC horizon and rose to about the 230 cm depth. The soil is thixotropic above 215 cm. No clay skins could be detected in the profile. The soil does not disperse well, hence the field estimates of texture are given in the profile description. Part of the gravel in the B3 and IIC horizons crushes with moderate pressure.
Soil No.: S620reg-29-1.



Colors are for the moist soil.

Ap 0-10 cm (0-4 in.). Black (10YR 1/1) silt loam; strong very fine subangular blocky and moderate fine granular structure; friable (moist), slightly sticky and slightly plastic (wet); abundant roots; many fine interstitial pores; clear smooth boundary.

A12 10-30 cm (4-12 in.). Black (10YR 1/1) silt loam; strong very fine subangular blocky and moderate fine granular structure; friable (moist), slightly sticky and slightly plastic (wet); abundant fine roots; many fine interstitial pores; clear smooth boundary.

A13 30-68 cm (12-27 in.). Black (10YR 2/1) silt loam; moderate fine and medium subangular blocky structure; friable (moist), sticky and plastic (wet); many fine roots; many fine and very fine tubular pores; clear wavy boundary.

A3 68-96 cm (27-38 in.). Very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) silty clay loam; weak to moderate fine and medium subangular blocky structure; friable (moist), sticky and plastic (wet); many fine roots; many fine and very fine tubular pores; common very fine iron cemented aggregates; abrupt wavy boundary.

B21 96-125 cm (38-50 in.). Yellowish brown (10YR 5/4) silty clay loam; weak to moderate fine and very fine subangular blocky structure; friable (moist), sticky and plastic (wet); few fine roots; many fine and very fine pores; common tongues and krotovinas (10YR 2/2 and 3/2); few pebbles; gradual wavy boundary.

B22 125-145 cm (50-57 in.). Yellowish brown (10YR 5/4) silty clay loam; weak to moderate fine and very fine subangular blocky structure; friable to firm (moist), sticky and plastic (wet); few roots; many fine and very fine pores; few pebbles; diffuse wavy boundary.

B23 145-165 cm (57-66 in.). Yellowish brown (10YR 5/4) silty clay loam; weak to moderate medium and fine subangular blocky structure; firm (moist), sticky and plastic (wet); few fine roots; common fine and very fine pores; few pebbles; gradual

B31 165-190 cm (66-75 in.). Yellowish brown (10YR 5/6) silty clay loam; weak to moderate medium and fine subangular blocky structure; firm (moist), sticky and plastic (wet); very few roots; common fine and very fine pores; few fine faint reddish brown mottles; 10 to 15 percent gravel by volume.

B32 190-215 cm (75-85 in.). Same as above; split for sampling; clear wavy boundary.

IIC 215-255 cm (85-100 in.). Yellowish brown (10YR 5/6) very gravelly silty clay loam; massive; very firm (moist); sticky and plastic (wet); no roots; few fine pores; common medium faint reddish brown mottles; 40 to 60 percent gravel by volume.

Pedon 7

SOIL Typic Umbraquult SOIL Nos. CF-1 LOCATION Craven County, North Carolina

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 55150 - 55155

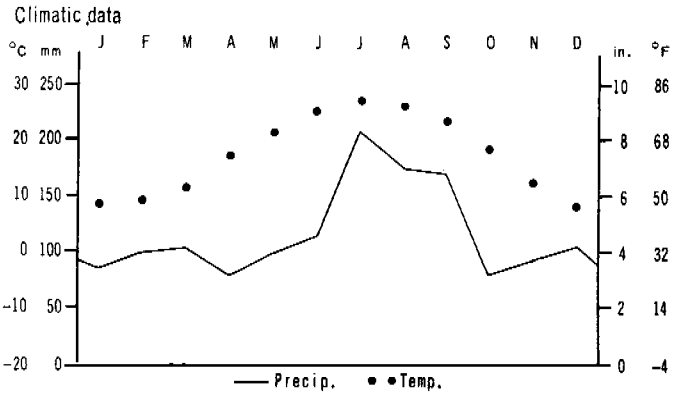
General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand (2–0.05)	Total Silt (0.05–0.002)	Total Clay (< 0.002)	Sand Very coarse (2–1)	Sand Coarse (1–0.5)	Sand Medium (0.5–0.25)	Sand Fine (0.25–0.1)	Sand Very fine (0.1–0.05)	Silt (0.05–0.02)	Silt Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)		3B2 Cm	Coarse fragments 3B1 2A2 > 2 Pct.	2 – 19 (Pct. of < 76mm)	19 – 76 (Pct. of < 76mm)
		Pct. of < 2 mm																
0–15	A11	66.6	20.1	13.3	1.3	9.6	26.4	24.8	4.5	6.9	13.2	17.4	62.1					
15–32	A12	66.6	16.1	17.3	0.2	8.3	27.4	25.9	4.8	4.7	11.4	15.8	61.8					
32–56	B21tg	58.1	16.9	25.0	0.4	7.8	23.9	21.5	4.5	4.9	12.0	15.0	53.6					
56–81	B22tg	56.9	16.4	26.7	0.4	7.4	24.0	21.1	4.0	4.8	11.6	13.9	52.9					
81–100	IIA1b	72.8	12.1	15.1	0.3	9.7	31.2	27.0	4.6	3.6	8.5	14.5	68.2					
100–125	IIC2	84.9	8.5	6.6	0.3	8.4	35.8	34.4	6.0	3.3	5.2	16.8	78.9					

Depth (cm)	6A1a Organic carbon Pct.	Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	Ext. iron as Fe Pct.	Bulk density g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD		pH 8C1c (1:1) KCl	8C1a (1:1) H_2O
0–15	5.3	0.199	27															3.9
15–32	1.61	0.062	26															4.4
32–56	0.42	0.051	8															4.2
56–81	0.30																	4.2
81–100	0.61																	4.3
100–125	0.05																	4.6

Extractable bases 5B1a | 6H1a | CEC | 6G1d | Ratios to clay | 8D3 | Base saturation

Pedon 7



Classification: Typic Umbraquult, fine-loamy, siliceous, thermic.
Location: Craven Co., N. C. In the Croatan National Forest, just east of the Jones County line. (Ref. New Bern quad. 1:24,000).
Physiographic position: Talbot terrace with elevation of about 11 meters.
Drainage: Poorly drained.
Vegetation: Pine, (Pinus); black gum, (Nyssa sylvatica); sweet gum, (Liquidambar styraciflua); bay, (Magnolia virginiana); and underbrush.
Parent material: Thick acid sandy clay deposits.
Sampled by: L. T. Alexander, Joe Kubota, and R. F. Dever.
Soil No.: CF-1.
Remarks: Colors are for the moist soil.

A11 0-15 cm (0-6 in.). Mainly black (10YR 2/1) but mixed with white, which results in a salt and pepper effect, sandy loam; granular structure; very friable (moist); many large, medium, and fine roots growing parallel to the ground surface.

A12 15-32 cm (6-12 1/2 in.). Black (10YR 2/1) sandy loam; granular structure; friable (moist); many fine roots; wavy boundary.

B21tg 32-56 cm (12 1/2-22 in.). Grayish brown (10YR 5/2) and dark grayish brown (10YR 4/2) sandy clay loam; coarse subangular blocks breaking to fine subangular blocks; sticky and plastic (wet); tongues of black (10YR 2/1) materials extending along root channels from horizon above.

B22tg 56-81 cm (22-32 in.). Gray (10YR 5/1) with many brownish yellow (10YR 6/8) mottles, sandy clay loam; coarse prisms breaking to fine subangular blocks; clay skins on both horizontal and vertical faces of peds, but more prominent on the vertical faces; sticky and plastic (wet); a number of large root channels filled with black material from the A1 horizon; many roots.

IIA1b 81-100 cm (32-40 in.). Very dark grayish brown (10YR 3/2) sandy loam; granular structure; firm (moist).

IIC2 100-125 cm (40-50 in.). Light brownish gray (10YR 6/2) and grayish brown (10YR 5/2) loamy sand; small lenses of white sand; very friable (moist).

Pedon 8

SOIL Histic Humaquept SOIL Nos. S62Maine-3-5 LOCATION Cumberland County, Maine

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 6371 - 6376

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 > 2 76 Pct.	2 - 19 (Pct. of < 76mm)	19-76 (Pct. of < 76mm)
		Size class and particle diameter (mm) 3A1 — Pct. of < 2 mm																
30-0	02	a/													1.00	tr.		
0-10	A1g	20.7	49.9	29.4	1.4	4.7	3.9	5.6	5.1	14.1	35.8	22.2	15.6		1.00	tr.		
10-25	B2	6.5	43.3	50.2	0.3	1.1	1.2	1.8	2.1	6.9	36.4	9.9	4.4		1.00	tr.		
25-58	B31	5.2	47.0	47.8	0.1	0.5	0.5	1.1	3.0	8.1	38.9	11.7	2.2		1.00	tr.		
58-84	B32	6.2	47.6	46.2	0.2	0.3	0.4	1.2	4.1	9.4	38.2	14.3	2.1		1.00	tr.		
84-120	C	9.4	58.9	31.7	0.4	0.7	0.7	1.8	5.8	29.5	29.4	36.4	3.6		1.00	tr.		

Depth (cm)	6A1a Organic carbon b/ Pct.	6B2a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density: g/cc	4A1e ⅓-bar g/cc	4A1h Oven dry g/cc	4D1 COLE	Water content: Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD cm/cm	pH:	8C1c (1:1) KCl	8C1a (1:1) H_2O
30-0	29.0	1.074	27			0.4		0.42	0.65	0.16		124.5	35.5		0.37		4.1	4.5
0-10	0.27					0.4		1.75	1.84	0.02		18.8	10.3		0.15		4.2	5.6
10-25	0.13					1.6		1.58	1.71	0.03		25.3	18.7		0.10		4.5	6.2
25-58	0.06					1.2		1.58	1.64	0.01		24.9	18.2		0.10		4.8	6.5
58-84	0.11					0.8		1.52	1.60	0.02		27.1	17.3		0.15		5.0	6.6
84-120	0.11					1.1		1.53	1.60	0.01		26.9	17.7		0.14		5.4	6.8

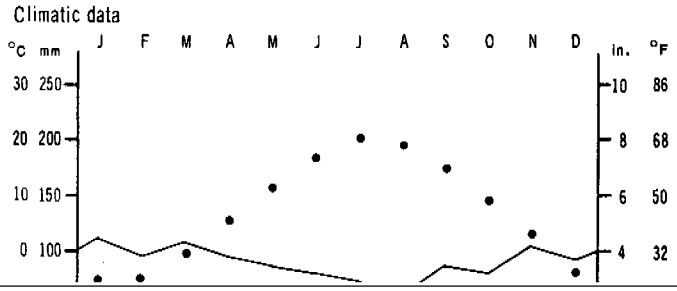
Depth (cm)	Extractable bases 5B1a: 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC: 5A3a Sum cations		6G1d Ext. Al			Ratios to clay 8D1: CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
30-0	14.5	3.4	0.5	0.4	18.8	49.0	67.8		1.5						4		28	
0-10	4.7	2.0	0.4	0.2	7.3	3.2	10.5		0.4			0.36	0.01	0.35	2		70	
10-25	8.2	3.9	0.5	0.3	12.9	3.4	16.3		0.1			0.32	0.03	0.37	2		79	
25-58	6.6	3.4	0.4	0.4	10.8	1.8	12.6		tr.			0.26	0.02	0.38	2		86	
58-84	6.6	3.3	0.4	0.5	10.8	1.2	12.0		tr.			0.26	0.02	0.37	2		90	
84-120	6.7	3.1	0.4	0.5	10.7	0.9	11.6		-			0.36	0.03	0.56	2		92	

Depth cm	Clay fraction c/ d/ mineralogy 7A1b-d: 7A2 X-ray e/	7A3 DTA
30-0	MI4,VR3,VM1,KK1,CL1	KK5
0-10	MI3,VR2,VM2,KK1	KK5
10-25	MI3,VM3,VR2,KK1	KK5
25-58		
58-84		
84-120	MI4,VR3,CL2,KK1,VM1	KK5

a/ Sample did not disperse.
b/ 38.7 kg/m2 to 1.5 m (method 6A).
c/ CEC to clay ratio indicates high component of mica.
d/ Mineral code:
MI = mica
VR = vermiculite
VM = vermiculite/mica
KK = kaolinite
CL = chlorite
e/ Approximate weight fraction (X-ray):
5 = more than half
4 = half to one-third
3 = one-third to one-fifth
2 = one-fifth to one-twentieth
1 = less than one-twentieth

Pedon 8

Classification: Histic Humaquept, fine, illitic, nonacid, mesic.
Location: Scarboro Township, Cumberland County, Maine; 0.8 km N of Oak Hill and 17 m W of center of State Route 114.
Physiographic position: Coastal lowland at elevation approximately 18 m.
Topography: Nearly level with gradient of 1 percent.
Drainage: Very poorly drained, very slowly permeable, water table occasionally below 1.5 m.
Vegetation: Reed canary grass and sedges in an opening surrounded by black alder (Alnus sp.) and other



Pedon 9

SOIL Ultic Hapludalf SOIL Nos. S62Ill-44-1 LOCATION Johnson County, Ill.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 16953-16962

General Methods: 1A, 1B1b, 2A1, 2B

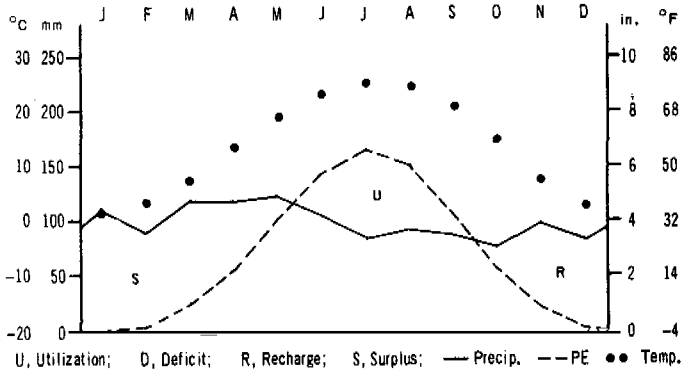
Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: a/ Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	Sand: (2–0.1)	4E1c Moved clay Pct.		Coarse fragments 2A2 3B1 2-20 Pct. < 20		
		Pct. of < 2 mm																
0-13	Ap	1.5	85.9	12.6	0.2	0.1	tr	0.2	1.0	44.5	41.4	45.6	0.5					-
13-23	A2	1.3	85.5	13.2	0.1	0.1	tr	0.1	1.0	44.3	41.2	45.4	0.3	tr				-
23-33	B1	1.0	78.4	20.6	tr	tr	tr	0.1	0.9	36.4	42.0	37.4	0.1	1.0				-
33-51	B21t	0.9	70.0	29.1	tr	tr	tr	0.1	0.8	31.8	38.2	32.7	0.1	1.6				-
51-74	B22t	1.0	69.0	30.0	0.1	tr	tr	0.1	0.8	30.5	38.5	31.4	0.2	4.0				-
74-100	B23t	1.2	71.4	27.4	0.1	tr	tr	0.2	0.9	33.1	38.3	34.1	0.3	4.7				-
100-130	B31	1.2	75.8	23.0	0.1	tr	tr	0.1	1.0	35.8	40.0	36.9	0.2	5.5				-
130-160	B32	1.0	79.0	20.0	0.1	tr	tr	tr	0.9	37.7	41.3	38.6	0.1	2.6				-
160-190	C	1.0	81.3	17.7	tr	tr	tr	0.1	0.9	38.9	42.4	39.9	0.1	1.8				-

Depth (cm)	6A1a Organic carbon b/	6B1a Nitrogen	C/N		Carbonate as $CaCO_3$	6C2a Ext. iron as Fe	Bulk density: 4A1a Field state	Bulk density: 4A1c 30-cm	Bulk density: 4A1b Air-dry	4D1 COLE	Water content: 4B4 Field state	Water content: 4B3 30-cm	Water content: 4B1b 1/3-bar	Water content: 4B2 15-bar	Water content: 4C1 1/3-to 15-bar	pH		8C1a (1:1) H_2O

Pedon 9

Classification: Ultic Hapludalf, fine-silty, mixed, mesic.
Location: Johnson County, Ill., approximately 63 m S. of sink depression, SW 1/4 SE 1/4 NE 1/4 sec. 32, T. 13 S., R. 2 E. About 220 km (135 mi.) SE. of St. Louis, Mo.
Physiographic position: Ridge top. Elevation about 200 m.
Topography: 2 percent slope.
Drainage: Well drained.
Vegetation: Grass and legume meadow.
Parent material: Deep loess.
Sampled by: R. B. Grossman and G. Holmgren, May 23, 1962.
Remarks: When samples from each subhorizon of the B horizon are dried, light gray silt ped coatings appear. These coatings seem to be continuous throughout the B horizon and into the C horizon where they blend with the distinct mottlings. When water is applied to the peds, the gray coatings disappear.
Soil No.: S62Ill-44-1.

Climatic data and soil water balance



Colors are for the moist soil unless otherwise indicated.

Ap 0-13 cm (0-5 in.). Dark grayish brown (10YR 4/2) light silt loam; weak fine granular structure; friable (moist); abundant roots; abrupt smooth boundary.

A2 13-23 cm (5-9 in.). Brown (10YR 4/3) light silt loam; very weak medium plates break to weak fine granules; friable (moist); abundant roots; abrupt smooth boundary.

B1 23-33 cm (9-13 in.). Yellowish brown (10YR 5/4) heavy silt loam; moderate fine and medium subangular blocky structure; firm (moist); many small pores; abundant roots; abrupt smooth boundary.

B21t 33-51 cm (13-20 in.). Dark brown to brown (7.5YR 4/4) light silty clay loam; strong medium subangular blocky structure;

[illegible]

firm (moist); common pores; plentiful roots; clear smooth boundary.

B22t 51-74 cm (20-29 in.). Dark brown to brown (7.5YR 4/4) with small pockets of yellowish brown (10YR 5/4) light silty clay loam; strong medium subangular blocky structure; firm (moist); peds coated with thin continuous dark reddish brown (5YR 3/4) clay skins; occasional very dark gray (10YR 3/1) iron-manganese concretions; plentiful roots; gradual smooth boundary.

B23t 74-100 cm (29-40 in.). Dark brown to brown (7.5YR 4/4) light silty clay loam; strong medium subangular blocky structure; firm (moist); peds coated with moderately thick dark reddish brown (5YR 3/4) clay skins; patches of dark yellowish brown (10YR 4/4) in the peds and wormholes filled with light brownish gray (10YR 6/2) material; common black (10YR 2/1) iron-manganese concretions and plentiful roots; gradual smooth boundary.

B31 100-130 cm (40-50 in.). Dark brown to brown (7.5YR 4/4) heavy silt loam with a few small pockets of yellowish brown (10YR 5/4); moderate medium and coarse subangular and angular blocky structure; firm (moist); peds coated with moderately thick continuous dark reddish brown (5YR 3/4) clay skins; many small pores; few iron-manganese concretions; gradual smooth boundary.

B32 130-160 cm (50-62 in.). Dark brown to brown (7.5YR 4/4) heavy silt loam with a few pockets of yellowish brown (10YR 5/4); weak coarse angular blocky structure; friable (moist); peds coated with thin continuous dark reddish brown (5YR

[illegible]

SOIL Pedon 10 Andic Dystrochrept SOIL Nos. S64Wash-14-3 LOCATION Grays Harbor County, Washington

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 64374 - 64378

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1 Total: Sand (2-0.05)	Total: Silt (0.05-0.002)	Total: Clay (<0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	Silt: 2-0.1			Coarse fragments 1A2a: > 2 Pct. of whole soil	2-19 (Pct. of <76mm)	19-76 (Pct. of <76mm)
		Pct. of <2 mm																
0-15	A1	19.2	41.2	39.6	2.1	3.8	3.3	5.4	4.6	11.2	30.0	18.6	11.8			1	1	
15-38	A3	24.2	50.3	25.5	1.2	4.3	3.9	7.6	7.2	16.6	33.7	27.9	12.9			1	1	
38-76	B21	23.7	50.4	25.9	0.9	3.9	4.1	7.6	7.2	15.6	34.8	27.0	12.3			1	1	
76-110	B22	23.4	47.4	29.2	1.1	3.9	4.1	7.5	6.8	13.8	33.6	24.8	12.4			0	0	
110-165	IIC	24.1	42.6	33.3	0.5	2.7	3.5	8.5	8.9	13.3	29.3	27.1	10.3			2	2	

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	4A1h Oven-dry g/cc	g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	8C1a H_2O 1:1	8C1d NaF (2 min)
0-15	8.05	0.358	22	6.2			0.89	1.07		1.00	54.4	29.1		0.063	0.063		4.5	9.9
15-38	2.68	0.179	15	5.8			0.93	1.05		1.00	50.1	24.9		0.041	0.041		4.9	10.7
38-76	1.53	0.100	15	5.9			1.04	1.16		1.00	43.4	23.1		0.037	0.037		5.0	10.6
76-110	1.22	0.074	16	5.6			0.92	1.01		1.00	49.1	22.3		0.032	0.032		5.0	10.5
110-165	0.46			5.0			1.27	1.41		0.99	37.5	23.6		0.036	0.036		4.9	10.0

Depth (cm)	Extractable bases: 6N2a Ca 5B3a	6O2a Mg 5B3a	6P2a Na 5B1a	6Q2a K 5B1a	Sum of bases	6H2a Ext. acidity	Cation exch. capacity: 5A6a NH_4OAc	5A3a Sum of cations		6G1e KCl ext. Al +++	Ratios to clay 8D1: CEC sum	Ext. iron	15-bar water				Base saturation: 5C3 Sum of cations Pct.	5C1 NH_4OAc Pct.
	meq/100g																	
0-15	0.6	1.1	0.3	0.2	2.2	52.6		54.8		9.1	1.38	0.16	0.73				4	
15-38	0.1	0.6	0.3	0.1	1.1	38.6		39.7		4.6	1.56	0.23	0.98				3	
38-76	tr.	0.4	0.2	0.1	0.7	34.6		35.3		5.6	1.36	0.23	0.89				2	
76-110	tr.	0.3	0.1	0.1	0.5	32.7		33.2		6.5	1.14	0.19	0.76				2	
110-165	tr.	0.5	0.2	0.1	0.8	29.1		29.9		11.6	0.90	0.15	0.71				3	

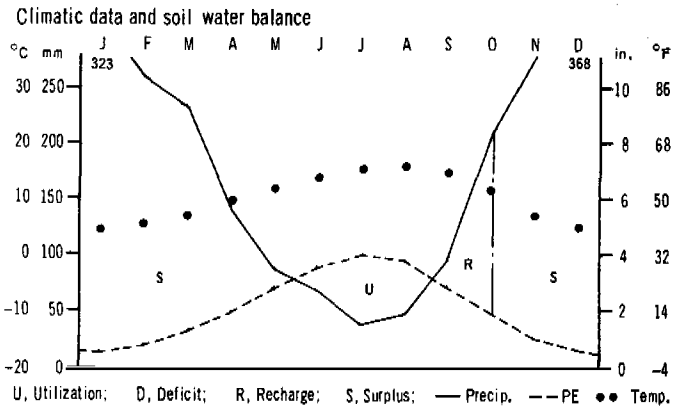
Depth (cm)	b/ Clay fraction mineralogy 3A1: 7A2 X-ray c/	7A3 DTA Pct.
0-15	VR3, KH3	
15-38	VR3, KH3	
38-76	VR3, KH3	
76-110		
110-165	VR3, KH3	

a/ 25.2 kg of organic carbon per square meter to a depth of 1 meter.

b/ Mineral code:
VR = vermiculite
KH = halloysite

c/ Approximate weight fraction (X-ray):
3 = one-fifth to one-third

Pedon 10



Classification: Andic Dystrochrept, thixotropic, mesic.
Location: Grays Harbor County, Wash. 14.5 km northwest of Hoquiam to the junction of county road 101 and Grass Creek, thence 0.3 km south to just beyond the curve on Grass Creek road and 30 m southeast into woods. Central NW1/4 NE1/4 sec. 10, T. 18 N., R. 11 W.
Physiographic position: Terrace, elevation about 9 m.
Topography: Nearly level with cradle-knoll microrelief from hemlock tipover.
Drainage: Well drained; slow surface runoff; moderately slow permeability.
Vegetation: 60-year old hemlock (Tsuga heterophylla); sparse understory of vine maple (Acer circinatum), sword fern (Nephrolepis exaltata) and moss.
Parent material: Glaciofluvial deposits of late Wisconsin age overlying older glaciofluvial deposits. Deposits consist of moderately fine textured sediments partly derived from basalt. Very deep underlying deposits of glaciofluvial compacted to cemented gravel, lacustrine and residuum of tertiary sandstone, siltstone, and shale.
Sampled by: K. W. Flach, R. W. Chapin, Carl McMurphy, August 29, 1964.
Remarks: The soil temperature was 11.5° C at 50 cm and 10.5° C at 150 cm when the soil was sampled. Five to 15 cm diameter root channels filled with surface horizon material and 5YR colored material (burned roots) extend to a depth of 110 cm in one side of the pit. They were not sampled. All horizons are thixotropic. The soil does not disperse well, hence field estimates of texture are given in the profile description.
Soil No.: S64Wash-14-3.

Colors are for the moist soil unless otherwise indicated.

O1 5-3 cm (2-1 in.). Conifer needles, twigs, bark, live moss.

O2 3-0 cm (1-0 in.). Dark reddish brown (5YR 2/2) decomposed needles, thixotropic.

A1 0-15 cm (0-6 in.). Dark brown (10YR 3/3) silt loam, brown (10YR 4/3) dry; moderate coarse granular and moderate fine subangular blocky structure; hard (dry), very friable (moist), slightly sticky, plastic and thixotropic (wet); many fine tubular and many medium vesicular pores; abundant coarse, medium and fine roots; dark brown (7.5YR 3/2) organic stained ped surfaces; few very fine unweathered pebbles, 7 percent iron cemented aggregates; clear wavy boundary.

A3 15-38 cm (6-15 in.). Dark brown (7.5YR 3/4) silt loam, yellowish brown (10YR 5/4) dry; moderate very fine subangular blocky structure; slightly hard (dry), friable (moist), sticky, plastic and thixotropic (wet); many fine tubular and many medium vesicular pores; abundant coarse, medium and fine roots; few unweathered pebbles and 5 percent iron cemented aggregates; gradual, wavy boundary.

B21 38-76 cm (15-30 in.). Dark brown (7.5YR 3/4) silty clay loam, light yellowish brown (10YR 6/4) dry; moderate very fine and weak fine subangular blocky structure; hard (dry), friable (moist), sticky, plastic and thixotropic (wet); common medium and fine tubular and common medium and fine vesicular pores; common medium and fine roots; few unweathered pebbles; diffuse wavy boundary.

B22 76-110 cm (30-44 in.). Dark brown (7.5YR 3/4) silty clay loam, yellowish brown (10YR 5/4) dry; weak very fine subangular blocky structure; hard (dry), friable (moist), very sticky, plastic and thixotropic (wet); common medium and fine tubular and many coarse vesicular pores; common medium and fine roots; smooth cutans on ped faces; few unweathered pebbles; clear, wavy boundary.

IIC 110-165 cm (44-64 in.). Yellowish brown (10YR 5/4) silty clay, light yellowish brown (10YR 6/4) dry; common medium distinct yellowish red (5YR 4/6) and light olive brown (2.5Y 5/4) mottles, strong brown (7.5YR 5/8) and light gray (2.5Y 7/2) dry; massive; very hard (dry), friable (moist), very sticky, plastic and thixotropic (wet); few medium tubular and many coarse vesicular pores; few fine roots to 165 cm; 1 percent very fine unweathered gravel by volume.

Pedon 11

SOIL Aeric Glossaqualf SOIL Nos. S60Wis-60-1 LOCATION Taylor County, Wis.

SOIL SURVEY LABORATORY Lincoln, Nebraska LAB. Nos. 13589-13598

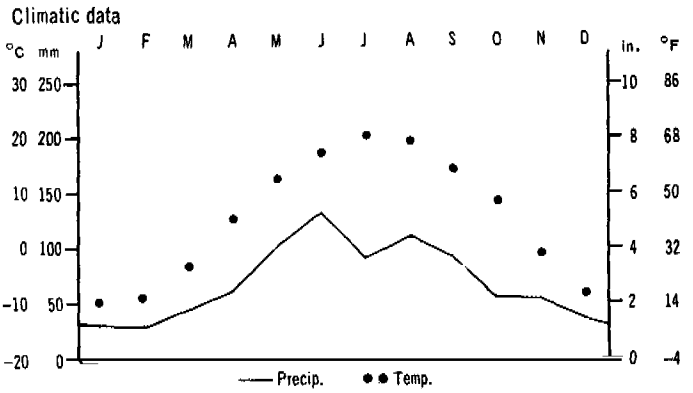
General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: a/ Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05) b/	Silt: (0.05–0.02)	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	(2–0.1)	2A2 Coarse fragments > 2 Pct.	3B2 2–20 Pct. of <75mm	3B2 20–75 Pct. of <75mm
		Pct. of < 2 mm														
0-10	A1	6.8	78.9	14.3	0.4	1.4	0.6	1.2	3.2	39.1	39.8	42.9	3.6	tr	tr	-
10-23	A21	6.7	84.8	8.5	1.2	1.3	0.4	0.5	3.3	43.1	41.7	46.6	3.4	tr	tr	-
23-36	A22	5.1	82.7	12.2	0.3	0.7	0.4	0.5	3.2	46.3	36.4	49.7	1.9	tr	tr	-
36-48	A&B	4.7	71.1	24.2	0.3	0.4	0.3	0.4	3.3	39.9	31.2	43.4	1.4	tr	tr	-
48-64	B21tg	4.7	67.7	27.6	0.2	0.3	0.3	0.5	3.4	38.2	29.5	41.8	1.3	tr	tr	-
64-81	B22tg	8.2	67.2	24.6	0.5	0.8	0.7	1.5	4.7	40.8	26.4	46.2	3.5	2	2	-
81-105	B3t	15.1	66.6	18.3	1.0	2.3	2.1	3.7	6.0	38.6	28.0	46.3	9.1	3	3	-
105-135	IIC1	50.5	37.5	12.0	6.9	8.0	8.1	16.6	10.9	16.8	20.7	35.5	39.6	35	15	20
135-165	IIC2	64.1	31.1	4.8	7.7	11.5	11.5	21.2	12.2	15.5	15.6	37.3	51.9	35	15	20

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density g/cc	4A1c 30-cm g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content 4B1b 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm	pH		8C1a (1:1) H_2O
0-10	5.54	0.354	16		1.1						14.1				4.9
10-23	0.76	0.068	11		1.0		1.30	1.33	0.007	22.7	5.4	0.22			4.9
23-36	0.13	0.019			0.9		1.61	1.63	0.003	21.1	5.7	0.25			5.0
36-48	0.16	0.026			1.0						11.0				4.8
48-64	0.13	0.020			0.9		1.52	1.68	0.036	25.2	13.3	0.18			4.8
64-81	0.12				1.0						12.6				4.8
81-105	0.06				1.0		1.48	1.60	0.028	23.0	9.6	0.19			4.9
105-135	0.05				1.3		1.91	1.95	0.005	11.8	5.3	0.09			5.5
135-165	0.03				1.0						2.4				6.5

Pedon 11

Classification: Aeric Glossaqualf, fine-silty, mixed, frigid.
Location: Taylor County, Wis., SW 1/4 SW 1/4 sec. 1, T. 33 N., R. 4 W., 45 m E & 45 m N of intersection of unnamed county road with State Highway 73.
Physiographic position: Upland, ground moraine.
Topography: Nearly level; 1 percent concave slope at site.
Drainage: Somewhat poorly drained; moderately permeable.
Vegetation: Basswood (Tilia americana), alder (Alnus rugosa), aspen (Populus grandidentata), maple (Acer); and understory of ferns (Filicales).
Parent material: Loess over loam to sandy loam glacial till of Cary age.
Sampled by: P. H. Carroll, W. DeYoung, R. B. Grossman and G. J. Post, July 22, 1960.
Soil No.: S60Wis-60-1.



Colors are for the moist soil unless otherwise indicated.

A1 0-10 cm (0-4 in.). Very dark brown (10YR 2/2) silt loam; weak very fine granular structure; very friable (moist); abundant fibrous and coarse roots; strongly acid; clear smooth boundary.

A21 10-23 cm (4-9 in.). Grayish brown (10YR 5/2) silt, light gray (10YR 7/2) dry; few medium faint brown (10YR 5/3) mottles; weak very thin platy structure; very friable (moist); many small dark reddish brown (5YR 2/2) aggregates; abundant fibrous and coarse roots; clear smooth boundary.

A22 23-36 cm (9-14 in.). Grayish brown (10YR 5/2) light silt loam, light gray (10YR 7/2) dry; many medium faint brown (10YR 5/3) mottles; weak thin platy structure; friable (moist); many dark reddish brown (5YR 2/2) aggregates; abundant fibrous and few coarse roots; clear irregular boundary.

A&B 36-48 cm (14-19 in.). Grayish brown (10YR 5/2) tongues of light silt loam 5 to 15 mm wide and with moderate thin platy structure occupy about 60 percent of the horizon; the tongues, bordered along each side by thin bands of strong brown (7.5YR 5/6), penetrate or intermingle with dark yellowish brown (10YR 4/4) heavy silt loam; many large distinct strong brown (7.5YR 5/6) and grayish brown (10YR 5/2) mottles; weak medium subangular blocky structure; very friable (moist); plentiful fibrous and few tap roots; clear irregular boundary.

B21tg 48-64 cm (19-25 in.). Grayish brown (10YR 5/2) light silty clay loam; many medium prominent mottles of dark brown (7.5YR 4/4); moderate coarse prisms parting to moderate medium angular and subangular blocks and weak medium plates; firm (moist); tongues of grayish brown (10YR 5/2) light silt loam 5 to 10 mm wide are on some faces of prominent prisms and occupy about 10 percent of the horizon; thick nearly continuous brown (7.5YR 5/2) clay skins on faces of blocky peds away from the surfaces of prominent prisms; clear smooth boundary.

B22tg 64-81 cm (25-32 in.). Grayish brown (10YR 5/2) heavy silt loam; many fine prominent mottles of dark yellowish brown (10YR 4/4); moderate medium and coarse prisms parting to weak coarse subangular blocks and weak medium plates; firm (moist); thin continuous clay skins on vertical faces of prisms and in pores, and thin and patchy on horizontal faces of blocks and plates; clear smooth boundary.

B3t 81-105 cm (32-41 in.). Brown (10YR 5/3) heavy silt loam; many medium distinct mottles of reddish brown (5YR 4/3); moderate coarse prisms parting to weak coarse subangular blocks and weak medium plates; friable (moist); thin patchy clay skins on faces of peds, in soil pores, and along vertical cleavage planes; abrupt smooth boundary.

IIC1 105-135 cm (41-53 in.). Reddish brown (5YR 4/3) and brown (7.5YR 5/2) gravelly fine sandy loam; weak thin plates; friable (moist); gradual smooth boundary.

IIC2 135-165 cm (53-65 in.). Reddish brown (5YR 4/3) gravelly sandy loam; weak thin and medium plates; friable (moist).

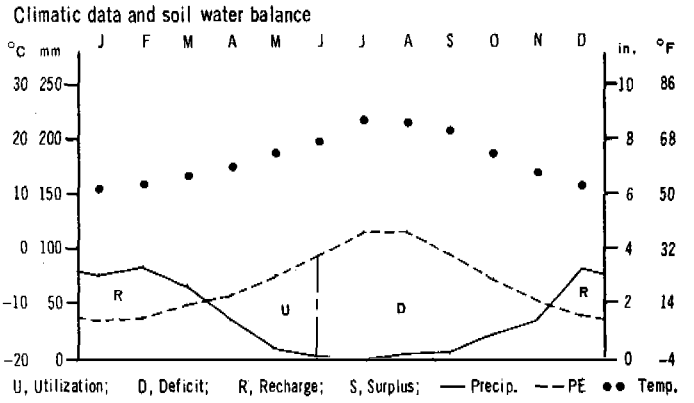
Pedon 12

SOIL Mollic Haploxeralf SOIL No. S64Calif-37-6 LOCATION San Diego County, California

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 6423 - 6429

Pedon 12

Classification: Mollic Haploxeralf, fine-loamy, mixed, thermic.
Location: San Diego County, Calif. 2.4 km south and 2.4 km east of Fallbrook in the SW1/4 of the NW1/4 of sec. 29, T. 9 S., R. 3 W.
Physiographic position: Rolling upland, elevation about 209 m.
Topography: East-facing, smooth, 9 percent middle backslope position.
Drainage: Well drained; medium runoff; moderately slow permeability.
Vegetation: Wild oats (Avena sp.) and annual weeds.
Parent material: Fragmented tonalite.
Sampled by: K. W. Flach, G. Kester, G. Borst, L. Grant, and D. Markewich, February 20, 1967.
Remarks: The Ap, C1 and C2 horizons do not disperse well, hence the field estimates of texture of these horizons are given in the profile description. The gravel content was determined from a whole soil sample after slaking overnight in a sodium hexametaphosphate solution.
Soil No.: S64Calif-37-6.



Colors are for the dry soil unless otherwise indicated.

Ap 0-8 cm (0-3 in.). Brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; weak fine crumb structure; slightly hard (dry), very friable (moist), slightly sticky and nonplastic (wet); abundant very fine and fine roots; many very fine and fine interstitial pores; 3 percent gravel by volume; abrupt smooth boundary.

A12 8-33 cm (3-13 in.). Brown (10YR 5/3) heavy sandy loam, dark brown (10YR 3/3) moist; massive; hard (dry), friable (moist), slightly sticky and nonplastic (wet); abundant very fine and fine roots; many very fine to medium tubular pores; 3 percent gravel by volume; clear smooth boundary.

B1 33-46 cm (13-18 in.). Reddish brown (5YR 5/3) heavy sandy loam, dark reddish brown (5YR 3/3) moist; weak coarse subangular blocky structure; hard (dry), firm (moist), slightly sticky and slightly plastic (wet); plentiful very fine roots; common very fine and fine tubular pores; 4 percent gravel by volume; clear smooth boundary.

B21t 46-69 cm (18-27 in.). Reddish brown (5YR 4/3) light sandy clay loam, dark reddish brown (5YR 3/3) moist; moderate coarse prismatic structure; very hard (dry), firm (moist), sticky and plastic; few very fine roots; common very fine and fine tubular pores; common moderately thick clay skins on ped faces; 3 percent gravel by volume; clear smooth boundary.

B22t 69-105 cm (27-41 in.). Reddish brown (5YR 5/4) heavy sandy clay loam, dark reddish brown (5YR 3/4) moist; weak coarse prismatic structure; very hard (dry), firm (moist), sticky and plastic (wet); few very fine roots; few very fine tubular pores; 6 percent gravel by volume; clear wavy boundary.

C1 105-155 cm (41-62 in.). Dark reddish brown (5YR 3/2) to light reddish brown (5YR 6/4) and pinkish gray (5YR 6/2) fragmented tonalite, of fine gravelly sand texture; 22 percent gravel by volume; clear wavy boundary.

C2 155-180 cm (62-70 in.). Reddish brown (5YR 5/4) to light gray (10YR 7/2) fragmented tonalite, of fine gravelly sand texture; 23 percent gravel by volume.

Pedon 13

SOIL Typic Rhodoxeralf SOIL Nos. _____ LOCATION Pola, Yugoslavia

SOIL SURVEY LABORATORY Lincoln, Nebraska LAB. Nos. 9854 - 9858

General methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand (2–0.05)	Total Silt (0.05–0.002)	Total Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt (0.05–0.02)	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 > 2 Pct.	2 - 19	19 - 76
		Pct. of < 2 mm														Pct.	Pct. of < 76mm	
0-15	Ap1	2.9	51.3	45.8	0.5	0.4	0.1	0.3	1.6	23.5	27.8	25.3	1.3					
15-23	Ap2	2.7	51.5	45.8	0.5	0.3	0.1	0.3	1.5	25.1	26.4	26.8	1.2					
23-41	B11	2.3	50.9	46.8	0.4	0.2	0.1	0.3	1.3	21.1	29.8	22.6	1.0					
41-56	B12	1.9	48.1	50.0	0.2	0.2	0.1	0.3	1.1	18.9	29.2	20.2	0.8					
56-91	B2t	1.1	23.1	75.8	tr.	0.1	tr.	0.2	0.8	9.0	14.1	9.9	0.3					
91-110	R																	

Depth (cm)	6A1a Organic carbon Pct.	6B2a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density: g/cc	4A1e ⅓ bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content: Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD	pH	8C1c (1:1) KCl	8C1a (1:1) H_2O
0-15	1.68	0.17	10		3.5		1.66											6.9
15-23	1.57	0.16	10		3.6		1.71											6.7
23-41	1.34	0.15	9		3.5		1.64											6.6
41-56	1.20	0.12	10		3.6		1.63											6.4
56-91	0.84	0.10	8		5.3		1.67											6.2
91-110																		

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	CEC: 5A3a Sum cations	5A1b NH_4OAc	6G1d Ext. Al			Ratios to clay: CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-15	15.8	1.5	0.1	0.4		6.6	24.4	14.7									73	121
15-23	13.8	1.4	0.1	0.3		7.0	22.6	17.3									69	90
23-41	12.2	1.2	0.2	0.2		9.0	22.8	17.4									60	79
41-56	11.7	1.2	0.2	0.2		9.5	22.8	18.0									58	74
56-91	18.8	2.0	0.2	0.3		13.0	34.3	27.4									62	78
91-110																		

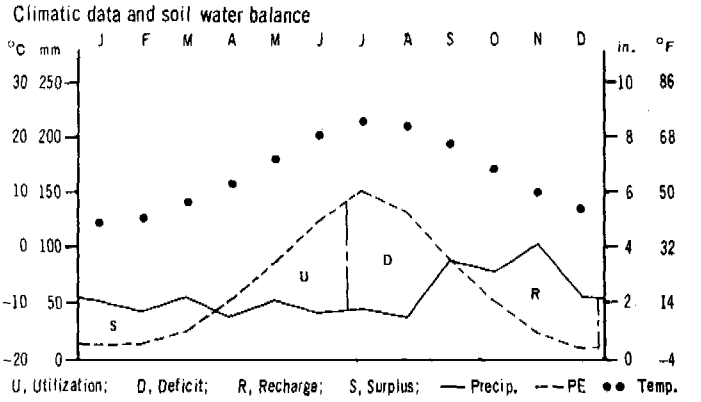
Depth (cm)	a/Clay fraction analysis 7A1b-d: 7A2 X-ray b/	7A2 DTA Pct.	7C2: K_2O Pct.	CaO Pct.	SiO_2/R_2O_3	Whole soil analysis 7C2: K_2O Pct.	CaO Pct.	SiO_2 Pct.	Fe_2O_3 Pct.	Al_2O_3 Pct.	SiO_2/R_2O_3
0-15	VR2,MT2	KK35	1.5	0.2	1.7	1.7	1.1	59.3	8.0	18.8	4.2
15-23	VR2	KK35	1.5	0.2	1.7	1.7	1.0	59.9	7.4	18.9	4.3
23-41	VR2	KK35	1.7	0.2	1.7	1.8	0.9	59.3	7.8	19.7	4.1
41-56	VR2	KK35	1.7	0.2	1.7	1.8	0.8	58.7	7.6	19.6	4.1
56-91		KK25	1.5	0.2	1.7	1.7	0.9	49.9	9.9	24.4	2.8
91-110		KK70			1.8						

a/ Mineral code:
VR = vermiculite
MT = mica
KK = kaolinite

b/ Approximate weight fractions (X-ray):
5 = more than half
4 = half to one-third
3 = one-third to one-fifth
2 = one-fifth to one-twentieth
1 = less than one-twentieth

Pedon 13

Classification: Typic Rhodoxeralf, very fine, mixed, thermic.
Location: Pola, Yugoslavia.
Topography: Gently sloping with gradient about 2 percent and with northwest aspect.
Vegetation: Small grains.
Parent material: Residuum from limestone, probably mixed with eolian or other transported materials.



Colors are for the moist soil unless otherwise indicated.

Ap1 0-15 cm (0-6 in.). Dark reddish brown (5YR 3/3) silty clay; strong fine granular structure; friable, sticky and plastic; abrupt smooth boundary.

Ap2 15-23 cm (6-9 in.). Dark reddish brown (5YR 3/3) silty clay, reddish brown (5YR 4/3) dry (a weak plow pan); coarse prisms breaking with slight pressure to fine blocks; very hard (dry), very firm (moist), sticky and plastic (wet); patchy clay skins; few 1-3 cm limestone fragments; diffuse boundary.

B11 23-41 cm (9-16 in.). Dark reddish brown (5YR 3/3) silty clay, reddish brown (5YR 4/3) dry; strong coarse prisms breaking to fine blocks; very hard (dry), very firm (moist), sticky and plastic (wet); dusky red (2.5YR 3/2) to dark reddish brown (2.5YR 2/4) dry, clay skins are moderately thick on 40 to 60 percent of ped faces and thin on the remainder; diffuse boundary.

B12 41-56 cm (16-22 in.). Dark reddish brown (4YR 3/3) silty clay, reddish brown (5YR 4/3) dry; moderate coarse subangular blocks breaking to fine blocks; very firm (moist), sticky and plastic (wet); many fine roots; many fine pores; continuous dusky red (2.5YR 3/2) to dark reddish brown (2.5YR 2/4) dry, clay skins on ped faces.

B2t 56-91 cm (22-36 in.). Dark reddish brown (4YR 3/4) moist, coated with 2.5YR 2/4 moist, 2.5YR 3/4 dry heavy clay; weak coarse prisms breaking to medium and fine subangular blocks, thick continuous clay skins; wavy boundary.

R 91-110 cm (36-44 in.). Fractured limestone in 5 to 13 cm diameter fragments having edges rounded by solution; penetrations of clay and calcite between fragments.

SOIL Pedon 14 Ultic Hapludalf SOIL Nos. S56Ind-42-1 LOCATION Knox County, Indiana

SOIL SURVEY LABORATORY Lincoln, Nebraska LAB. Nos. 5489 - 5495

General methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand 8/ Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt 0.05-0.02	Silt Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1 2A2 > 2 Pct.	2-19	19-76
		Pct. of < 2 mm															Pct. of < 76mm	
0-15	Ap	3.0	84.2	12.8	0.2	0.4	0.3	0.5	1.6	43.0	41.2	44.9	1.4			tr.		
15-23	A2	2.9	84.7	12.4	-	0.3	0.4	0.6	1.6	42.6	42.1	44.5	1.3			-		
23-33	B21t	2.2	76.1	21.7	0.1	0.4	0.2	0.4	1.1	34.0	42.1	35.3	1.1			-		
33-56	B22t	1.2	69.3	29.5	-	-	-	0.2	1.0	34.1	35.2	35.2	0.2			-		
56-81	B23t	1.5	71.3	27.2	-	-	-	0.1	1.4	38.1	33.2	39.6	0.1			-		
81-120	B3t	1.3	76.2	22.5	-	-	-	-	1.3	42.4	33.8	43.7	-			-		
120-140+	C	0.8	79.2	19.9	-	-	-	-	0.8	44.0	35.3	44.8	-			-		

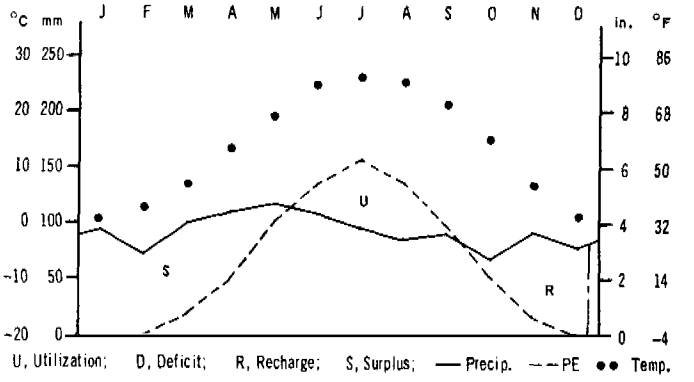
Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density 4A3a g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 CDLE	Water content Pct.		4B2 15-bar Pct.			pH 8C1c (1:1) KCl	8C1a (1:1) H_2O
0-15	0.86	0.084	10			1.0	1.49						5.2				6.7
15-23	0.85	0.084	10			0.8	1.38						5.2				6.3
23-33	0.33	0.046	7			1.3	1.45						8.2				6.5
33-56	0.17	0.034				1.8	1.46						12.1				6.5
56-81	0.12	0.027				1.7	1.48						11.1				5.6
81-120	0.10					1.8							9.3				4.8
120-140+	0.08					1.7							8.6				4.8

	Extractable bases 8B1a				6H1a	CEC	6G1d			Ratios to clay 8D1		8D3		Base saturation	

Pedon 14

Classification: Ultic Hapludalf, fine-silty montmorillonitic mesic.
Location: Knox County, Ind., T4N, R9W, Grant No. 120, NW 1/4, SE 1/4.
Topography: 2 percent slope.
Drainage: Well drained.
Vegetation: Cultivated crops.
Parent material: Loess.
Sampled by: O. C. Rogers, G. Walker, and A. Beavers, November 2, 1956.
Soil No.: S56Ind-42-1.

Climatic data and soil water balance



Colors are for the moist soil.

Ap 0-15 cm (0-6 in.). Dark grayish brown (10YR 4/2) and brown (10YR 4/3) light silt loam; weak medium granular structure; friable (moist); abrupt smooth boundary.

A2 15-23 cm (6-9 in.). Brown (10YR 5/3) and dark grayish brown (10YR 4/2) light silt loam; moderate thin platy structure; friable (moist); penetration of material from Ap horizon into top of layer along root channels and in wormholes; clear wavy boundary.

B21t 23-33 cm (9-13 in.). Brown to dark brown (7.5YR 4/4) heavy silt loam; moderate fine subangular blocky structure; slightly firm (moist); very few peds with brown (10YR 5/3) and pale brown (10YR 6/3) coatings; few very thin very dark brown (10YR 2/2) coatings; clear wavy boundary.

B22t 33-56 cm (13-22 in.). Brown (7.5YR 4/4) light silty clay loam; moderate to strong coarse subangular blocks breaking to fine subangular blocks; firm (moist); numerous thin dark reddish brown (5YR 3/4 - 3/3) clay skins; some very dark brown (10YR 2/2) coatings; gradual wavy boundary.

B23t 56-81 cm (22-32 in.). Brown (7.5YR 4/4) light silty clay loam; moderate to weak coarse and very coarse subangular blocky structure; firm (moist); clay skins of dark reddish brown (5YR 3/4) are less numerous than in the above horizon; numerous very dark brown (10YR 2/2) coatings and streaks that increase with depth; gradual wavy boundary.

B3t 81-120 cm (32-48 in.). Brown (7.5YR 4/4) heavy silt loam; weak to very weak very coarse subangular blocky structure; friable (moist); few dark reddish brown (5YR 3/3 - 3/4) clay skins; very few light brownish gray (10YR 6/2), pale brown (10YR 6/3), and very dark brown (10YR 2/2) coatings and streaks; gradual wavy boundary.

C 120-140+ cm (48-55+ in.). Brown (7.5YR 4/4) heavy silt loam; massive; friable (moist); an occasional thin crack filled with light brownish gray (10YR 6/2) material.

Pedon 15
SOIL Typic Hapludult SOIL Nos. S47-Miss-59-6 LOCATION Prentiss County, Mississippi

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 4838 - 4845

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt 0.05-0.02	Silt Int. III (0.02-0.002)	Silt Int. II (0.2-0.02)	Silt (2-0.1)		3B2 Cm	Coarse fragments 3B1 2A2 > 2 Pct.	2-19	19-76
		Pct. of < 2 mm															Pct. of < 76mm	
0-13	Ap	66.2	22.4	11.4	0.1	0.3	0.3	11.6	53.9	16.1	6.3	80.9	12.3					
13-18	A2	54.3	25.3	20.4	0.0	0.1	0.1	10.1	44.0	19.7	5.6	73.4	10.3					
18-36	B21t	35.3	14.9	49.8	0.0	0.1	0.1	3.6	31.5	9.6	5.3	44.6	3.8					
36-48	B22t	36.6	19.0	44.4	0.0	0.1	0.1	3.4	33.0	12.3	6.7	48.5	3.6					
48-79	B31t	41.5	21.1	37.4	0.0	0.1	0.1	3.8	37.5	13.7	7.4	54.8	4.0					
79-94	B32t	47.0	18.7	34.3	0.0	0.1	0.1	6.4	40.4	11.7	7.0	58.2	6.6					
94-120	C1	49.5	18.9	31.6	0.0	0.1	0.1	6.7	42.6	12.1	6.8	60.9	6.9					
120-155	C2	52.1	15.6	32.3	0.0	0.1	0.2	8.3	43.5	9.2	6.4	60.6	8.6					

Depth (cm)	Organic carbon by H_2O_2 Pct.	Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	Ext. iron as Fe Pct.	Bulk density g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD	pH	8C1c (1:1) KCl	8C1a (1:1) H_2O
0-13	2.9																	5.5
13-18	1.0																	4.7
18-36	0.4																	4.9
36-48	0.3																	4.4
48-79	0.2																	4.4
79-94	0.6																	4.3
94-120	0.2																	4.3
120-155	0.1																	4.3

Depth (cm)	Extractable bases 5B1a 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	CEC 5A3a Sum cations		6G1d Ext. Al	a/ Ext. P ppm	7C1 Total K Pct.	Ratios to clay 8D1 CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-13	4.6	0.8	0.1	0.3		6.1	11.9			6	1.00	1.04					49	
13-18	1.3	1.8	0.1	0.3		9.2	12.7			5		0.62					28	
18-36	0.7	3.6	<0.1	0.5		21.2	26.1			4		0.52					18	
36-48	0.6	3.4	<0.1	0.3		19.7	23.8			4		0.54					18	
48-79	1.8	2.9	0.1	0.3		19.9	25.0			2	1.00	0.67					20	
79-94	1.3	2.8	0.1	0.2		18.8	23.2			3		0.68					19	
94-120	1.9	2.7	0.1	0.3		17.4	22.4			1		0.71					22	
120-155	3.0	3.0	0.1	0.2		17.0	23.3			1	1.33	0.72					27	

Depth (cm)	0.05-0.10mm fraction b/mineralogy 7B1 Petrographic Pct.	Whole soil analysis Total K Pct.
0-13		1.0
13-18	c/GL5	
18-36		
36-48		
48-79		1.1
79-94		
94-120	c/GL20	
120-155		1.3

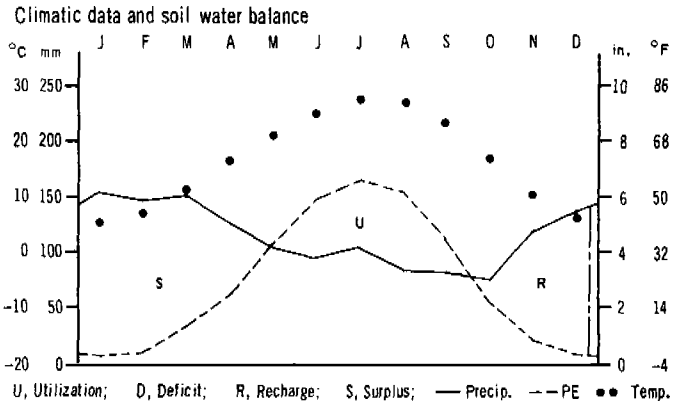
a/ Extractable phosphorous determined by modified, Truog method. Peech, Michael, et al. Methods of soil fertility investigations U. S. Department of Agriculture. Circular No. 757. 1947.

b/ Mineral code:
GL = glauconite

c/ Besides glauconite the sample has other mica and is mostly quartz.

Pedon 15

Classification: Typic Hapludult, fine, mixed, thermic.
Location: Prentiss County, Miss., east of Booneville on Route 30, 17.3 km from junction of Highways 30 and 45.
Physiographic position: Upper coastal plain.
Topography: Sloping.
Drainage: Well drained.
Vegetation: Cultivated crops.
Parent material: Clayey marine sediments containing glauconite.
Sampled by: L. T. Alexander, I. L. Martin, H. B. Vanderford, W. S. Ligon. December, 1947.
Soil No.: S47Miss-59-6.



Colors are for the moist soil unless otherwise indicated.

Ap 0-13 cm (0-5 in.). Dark grayish brown (2.5Y 4/2) very fine sandy loam coarsely splotched with yellowish brown (10YR 5/4) and very dark grayish brown (10YR 3/2) indicating uneven distribution of organic matter; very weak crumb structure; matted with fine roots.

A2 13-18 cm (5-7 in.). Brownish yellow (10YR 6/6) to yellowish brown (10YR 5/4) very fine sandy loam; very weak coarse granular structure; few fine roots.

B21t 18-36 cm (7-14 in.). Yellowish red (5YR 5/6) light clay; strong medium subangular blocky structure.

B22t 36-48 cm (14-19 in.). Yellowish red (5YR 5/8) light clay; strong medium subangular blocky structure; scattered small yellow (10YR 7/8) mottles; few mica flakes.

B31t 48-79 cm (19-31 in.). Predominantly yellowish red (5YR 5/8) heavy clay loam intricately mottled with pale yellow (2.5Y 8/4) and gray; strong medium blocky structure; hard (dry); proportions of pale yellow and gray mottles increase with depth and red decreases; at bottom, layer is highly mottled red, pale yellow, and gray; common fine mica flakes.

B32t 79-94 cm (31-37 in.). Predominantly pale olive (5Y 6/4) heavy sandy clay loam mottled with yellowish red (5YR 5/8); strong medium blocky structure; hard (dry); common fine mica flakes.

C1 94-120 cm (37-47 in.). Predominantly pale olive (5Y 6/3) with light olive gray (5Y 6/2) heavy sandy clay loam; weak prisms breaking to strong coarse blocks; hard (dry); fine to medium mottles and streaks of yellowish red (5YR 5/8); common fine mica flakes; considerable "greensand" material.

C2 120-155 cm (47-60 in.). Predominantly pale olive (5Y 6/3) with light olive gray (5Y 6/2) heavy sandy loam; slightly hard (dry); fine and medium mottles and streaks of yellowish red (5YR 5/8) mainly "greensand" material with a large mica component.

Pedon 16

SOIL Typic Hapludalf SOIL Nos. LOCATION Allen County, Ohio

LABORATORY Ohio State University LAB. Nos. 6424 - 6429

Depth (cm)	Horizon	1B1b Total: Sand (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: 0.05–0.02	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	3A1b Fine clay <0.0002	3B2 Cm	Coarse fragments 3B1: 2A2 > 2 Pct.	2 – 19	19 – 76
		Pct. of < 2 mm															Pct. of < 76mm	
0–18	Ap1	30.4	47.0	22.6	2.5	4.7	6.5	10.5	6.2				24.2	6.8				
18–25	Ap2	28.4	45.4	26.2	1.7	4.3	5.7	9.8	6.9				21.5	7.4				
25–36	B21t	20.4	34.3	45.3	1.7	3.4	3.9	6.3	5.1				15.3	20.2				
36–58	B22t	19.9	37.3	42.8	1.5	3.0	3.3	6.2	5.9				14.0	16.2				
58–74	C1	23.5	41.8	34.7	2.4	3.7	3.5	6.5	7.4				16.1	9.5				
74–89	C2	22.9	44.2	32.9	1.8	4.1	3.8	6.1	7.1				15.8	8.9				

Depth (cm)	6A1a Organic carbon Pct.	Nitrogen Pct.	C/N		a/ Carbonate as $CaCO_3$ Pct.	Ext. iron as Fe Pct.	Bulk density: g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content: Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD	pH:	8C1c (1:1) KCl	8C1a (1:1) H_2O
0–18	1.25																	6.2
18–25	1.08																	5.9
25–36	0.45																	5.3
36–58	0.45																	6.9
58–74					15.4													7.6
74–89					19.2													7.7

Depth (cm)	Extractable bases 5B1a: 6N2d Ca	6Q2b Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC: 5A3a Sum cations		6G1d Ext. Al			Ratios to clay: CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	

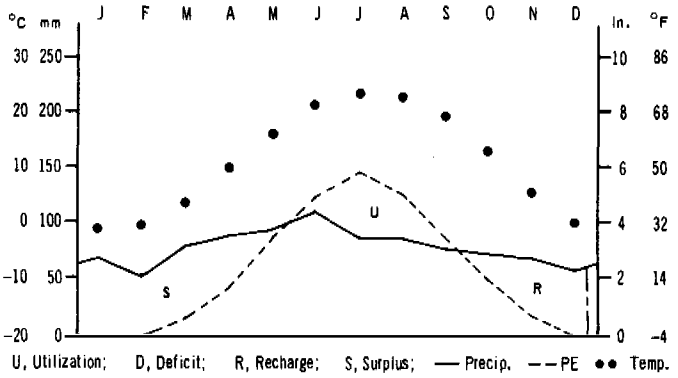
Depth (cm)					

a/ Sample treated with HCl and CO_2 collected in NaOH. Carbonate precipitated with $BaCO_3$ and excess NaOH back titrated with standard HCl. Piper, C. S. 1944. Soil and plant analysis. Interscience Publishers, Inc., New York. p. 130.

Pedon 16

Classification: Typic Hapludalf, fine, mixed, mesic.
Location: Allen County, Ohio. NW¼NW¼ sec. 24, T. 2 S., R. 7 E. of the first principal meridian.
Physiographic position: Smooth till plain of Wisconsin glaciation at elevation of 250 m.
Topography: 3 percent slope.
Drainage: Moderately well drained, slow permeability.
Vegetation: Meadow (cultivated).
Parent material: Calcareous glacial till deposited approximately 15,000 years before present.
Sampled by: A. R. Brock, R. L. Christman, and Welch. August 30, 1957.
Remarks: Colors are for moist soil unless otherwise indicated.

Climatic data and soil water balance



Ap1 0-18 cm (0-7 in.). Dark grayish brown (10YR 4/2), light brownish gray (10YR 6/2) when dry; heavy loam; weak fine granular structure; slightly hard (dry), slightly sticky (wet); abundant roots.

Ap2 18-25 cm (7-10 in.). Dark brown (10YR 4/3), pale brown (10YR 6/3) dry heavy loam; moderate fine subangular blocky structure; slightly hard (dry), slightly sticky (wet); abundant roots.

B21t 25-36 cm (10-14 in.). Dark yellowish brown (10YR 4/4) to yellowish brown (10YR 5/6) light clay; strong medium and coarse blocks breaking to strong fine blocks; hard (dry), firm (moist); many fine and medium yellowish brown (10YR 5/8) mottles; dark grayish brown (10YR 4/2) clay skins on ped surfaces; few less than 1 cm fragments of sandstone, shale, limestone, chert, and granite; plentiful roots.

B22t 36-58 cm (14-23 in.). Dark grayish brown (10YR 4/2) light clay; strong medium to coarse angular blocky structure; plastic (wet) and very hard (dry); faint to distinct fine to medium yellowish brown (10YR 5/8) mottles; common roots and numerous small stones.

C1 58-74 cm (23-29 in.). Mottled dark brown (10YR 4/3) and yellowish brown (10YR 5/6) light clay loam; weak medium to coarse angular blocky structure; slightly plastic (wet) and very hard (dry); very compact; few roots; small chips and pebbles of limestone shale and chert.

C2 74-89 cm (29-35 in.). Calcareous light clay loam till.

Pedon 17

SOIL Typic Argiaquoll SOIL Nos. _____ LOCATION Van Wert County, Ohio

LABORATORY Ohio State University LAB. Nos. 4578 - 4586

Depth (cm)	Horizon	1B1b Total Sand (2–0.05)	Total Silt (0.05–0.002)	Total Clay (< 0.002)	Sand Very coarse (2–1)	Sand Coarse (1–0.5)	Sand Medium (0.5–0.25)	Sand Fine (0.25–0.1)	Sand Very fine (0.1–0.05)	Silt 0.05–0.02	Silt Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	3A1b Fine clay <0.0002	3B2 Cm	Coarse fragments 3B1 2A2 ≥ 2 Pct.	2 - 19	19 - 76
		Pct. of < 2 mm															Pct. of < 76mm	
0-18	Ap	15.3	51.6	33.1	1.1	1.3	1.9	4.7	6.3				9.0	8.5				
18-25	A12	14.5	53.1	32.4	0.9	1.1	1.6	4.2	6.7				7.8	9.2				
25-41	B21tg	11.7	47.9	40.4	0.7	1.0	1.3	3.1	5.6				6.1	15.8				
41-53	B22tg	9.8	45.2	45.0	0.6	1.0	1.3	2.8	4.1				5.7	20.0				
53-71	B23tg	10.1	48.5	41.4	0.3	1.0	1.1	2.8	4.9				5.2	18.1				
71-120	B24tg	11.3	50.7	38.0	0.5	1.3	1.6	3.2	4.7				6.6	14.7				
120-140	IIC1	25.5	54.0	20.5	1.7	3.5	3.8	7.9	8.6				16.9	4.9				
140-205	IIC2	22.3	57.4	20.3	2.0	3.1	3.3	6.1	7.8				14.5	5.0				
205-255	IIIC3	57.6	30.1	12.3	26.7	14.6	6.2	6.3	3.8				53.8	2.8				

Depth (cm)	6A1a Organic carbon Pct.	Nitrogen Pct.	C/N		a/ Carbonate as $CaCO_3$ Pct.	Ext. iron as Fe Pct.	Bulk density g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD		pH 8C1c (1:1) KCl	8C1a (1:1) H_2O
0-18	2.09																	6.3
18-25	2.04																	6.2
25-41	1.08																	6.5
41-53	0.57																	6.8
53-71																		7.0
71-120																		7.3
120-140					18.2													8.0
140-205					19.8													8.0
205-255					14.9													8.0

Depth (cm)	Extractable bases 5B1a 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC 5A3a Sum cations		6G1d Ext. Al			Ratios to clay CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	

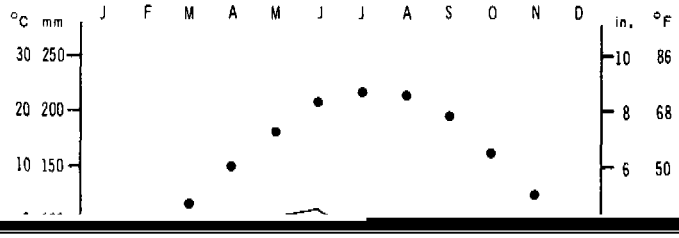
Depth

a/ Sample treated with HCl and CO_2 collected in NaOH. Carbonate precipitated with $BaCO_3$ and excess NaOH back titrated with standard HCl. Piper, C. S. 1944. Soil and plant analysis. Interscience Publishers, Inc., New York. p. 130.

Pedon 17

Classification: Typic Argiaquoll, fine, mixed, mesic.
Location: Van Wert County, Ohio. NE¼SE¼ sec. 21, T. 3 S., R. 3 E., of first principal meridian.
Physiographic position: Outwash on Late Wisconsin till plain at elevation of 270 m.
Topography: Level to gently undulating. Less than 1 percent slope.
Drainage: Very poorly drained.
Vegetation: Oats stubble plowed for wheat.
Parent material: [illegible]

Climatic data



SOIL Pedon 18 Typic Argiboroll SOIL Nos. S54NDak-53-1 LOCATION Williams County, N. Dak.

SOIL SURVEY LABORATORY Mandan, N. Dak. LAB. Nos. 2315-2321

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	Fine clay <0.0001 a/		Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-4	A11	34.8	43.5	21.7	3.6	4.1	4.9	11.6	10.6	20.8	22.7	38.0	24.2	5.3				-
4-8	A12	36.5	39.2	24.3	2.2	4.1	5.2	13.1	11.9	19.0	20.2	38.6	24.6	7.6				2
8-20	B21t	38.4	32.3	29.3	2.3	4.7	6.0	13.9	11.5	15.5	16.8	35.0	26.9	12.9				2
20-28	B22t	38.7	33.0	28.3	3.7	4.5	5.8	13.8	10.9	15.0	18.0	33.6	27.8	7.0				1
28-58	B3ca	34.0	34.5	31.5	3.1	4.2	4.7	11.3	10.7	13.3	21.2	30.6	23.3	4.7				3
58-99	C1ca	35.6	36.6	27.8	3.8	3.8	4.3	11.7	12.0	14.5	22.1	33.7	23.6	2.7				2
99-150	C2	32.3	37.7	30.0	3.3	3.9	4.0	10.5	10.6	14.2	23.5	30.9	21.7	3.8				3

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N		6E1a Carbonate as $CaCO_3$ Pct.		Bulk density g/cc	g/cc	g/cc		Water content Pct.	Pct.	4B2 15-bar Pct.			pH 8C1b Sat. paste	8C1a (1:5) H_2O	8C1a (1:10) H_2O
0-4	4.68	0.335	14		-								12.8			6.6	6.9	7.2
4-8	2.60	0.227	11		-								11.3			6.2	6.5	6.7
8-20	1.26	0.116	11		-								11.6			6.3	6.7	7.2
20-28	1.20	0.115	10		3								11.5			7.3	8.1	8.4
28-58	0.77				19								10.0			7.9	8.8	9.0
58-99	0.44				15								9.4			8.1	9.1	9.3
99-150	0.35				12								11.0			8.5	9.4	9.6

Depth (cm)	Extractable bases 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	5B1a Sum		Cat. exch. cap. 5A1a NH_4OAc	Ca	Mg	Water extract from saturated paste 8A 6P1a Na	6Q1a K		CO_3	HCO_3	Cl	SO_4	8A1a Electrical conductivity
	meq/100 g							meq/liter									mmho/cm
0-4	18.7	5.4	0.1	1.3	25.5		27.9			0.3	0.8						0.8
4-8	12.0	4.1	0.1	0.9	17.1		20.8			0.3	0.3						0.6
8-20	14.5	5.7	0.1	0.5	20.8		22.6			0.4	0.1						0.6
20-28			0.1	0.3			21.8			0.3	-						0.7
28-58			0.1	0.2			16.0			0.4	-						0.6
58-99			0.2	0.2			14.8			1.2	-						0.7
99-150			1.2	0.3			17.2			4.2	-						0.7

Depth (cm)	8A Water at saturation Pct.	5D2 Exchangeable Na Pct.		Gypsum Pct.	Ratios to clay 8D1 NH_4OAc CEC		15-bar water
0-4	72.0	tr			1.29		0.59
4-8	59.3	tr			0.86		0.47
8-20	50.2	tr			0.77		0.40
20-28	57.0	tr			0.77		0.41
28-58	50.1	1			0.51		0.32
58-99	48.0	1			0.53		0.34
99-150	59.0	6			0.57		0.33

a/ The fine clay data are from: Chestnut, chernozem and associated soils of western North Dakota. C. A. Mogen, J. E. McClelland, J. S. Allen, and F. W. Schroer, Soil Sci. Soc. Amer. Proc. v. 23, pp. 56-61, 1959.

Pedon 18

Classification: Typic Argiboroll, fine-loamy, mixed.

Climatic data and soil water balance

°C mm J F M A M J J A S O N D in. °F

Pedon 19

SOIL Psammentic Hapludalf SOIL Nos. S61NY-37-1 LOCATION Orleans County, New York

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 61562 - 61573

General methods: 1A. 1B1b. 2A1. 2B

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1 Total: Sand (2-0.05)	Total: Silt (0.05-0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: 0.05-0.02	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 ≥ 2 <76 Pct.	2-19	19-76
		Pct. of < 2 mm														Pct. of < 76mm		
0-23	Ap	49.2	46.2	4.6	-	0.1	0.4	11.3	37.4	26.0	20.2	73.6	11.8			2		
23-38	B21	72.0	25.6	2.4	0.3	0.6	2.3	22.4	46.4	18.6	7.0	81.7	25.6			4		
38-71	B22	72.8	25.7	1.5	-	0.2	1.6	18.4	52.6	20.1	5.6	87.2	20.2			tr.		
71-76	B23	70.4	27.7	1.9	-	tr.	0.2	11.4	58.8	21.4	6.3	91.1	11.6			-		
76-105	B24	69.1	30.4	0.5	-	0.1	0.4	11.9	56.7	24.1	6.3	91.5	12.4			-		
105-115	B25	74.8	21.4	3.8	tr.	0.7	4.2	30.0	39.9	14.9	6.5	75.0	34.9			-		
115-150	B26	79.1	19.9	1.0	0.1	0.6	4.1	33.4	40.9	14.5	5.4	77.9	38.2			-		
150-200	B31	83.2	16.2	0.6	-	0.5	6.2	39.9	36.6	12.4	3.8	74.2	46.6			-		
200-205	B27	79.3	11.4	9.3	tr.	2.1	10.6	42.2	24.4	7.2	4.2	54.9	54.9			-		
205-230	B32	83.2	16.4	0.4	-	1.4	6.9	38.7	36.2	12.3	4.1	71.7	47.0			-		
230-235	B28	75.7	14.5	9.8	0.8	6.8	14.2	31.0	22.9	9.1	5.4	47.8	52.8			tr.		
235-270	B33	83.0	15.1	1.9	0.4	3.5	8.6	35.0	35.5	12.0	3.1	68.5	47.5			-		

Depth (cm)	6A1a Organic carbon a/ Pct.	6B2a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density: 4A1b Air-dry g/cc	4A1e ⅓ bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content: 4B1c 1/10-bar Pct.	4B1c ⅓ bar Pct.	4B2 15-bar Pct.		4C1 WRD cm/cm		pH: 8C1c (1:1) KCl	8C1a (1:1) H_2O
0-23	1.42	0.122	12			0.6	1.37				23.7	12.7	5.9				5.4	6.0
23-38	0.31	0.029	11			0.4	1.51				15.6	7.0	3.0				4.7	5.7
38-71	0.09					0.4	1.45				14.0	4.9	1.7				4.5	5.5
71-76	0.10					0.6	1.59				16.7	6.3	2.4				4.4	5.5
76-105	0.04					0.4	1.54				17.4	5.1	1.2				4.4	5.5
105-115	0.05					0.6	1.63				13.9	7.1	2.5				4.4	5.6
115-150	0.04					0.5	1.53				12.6	5.3	1.5				4.4	5.6
150-200	0.04					0.4	1.53				10.4	4.1	1.5				4.3	5.5
200-205	0.06					0.8	1.70				15.1	9.0	4.8				4.4	5.7
205-230	0.02					0.5					11.2	4.2	1.3				4.5	5.6
230-235	0.02					0.9	1.67				14.0	9.1	5.0				4.2	5.4
235-270	0.02					0.6	1.64				11.6	4.1	1.6				4.5	5.4

Depth (cm)	Extractable bases 5B1a: 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC: 5A3a Sum cations		6G1d Ext. Al			Ratios to clay 8D1: CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-23	6.9	1.4	0.1	0.3	8.7	6.6	15.3		tr.			3.33	0.13	1.28			57	
23-38	1.2	0.7	0.1	tr.	2.0	4.2	6.2		0.2			2.58	0.17	1.25			32	
38-71	0.7	0.2	tr.	tr.	0.9	2.1	3.0		0.3			2.00	0.27	1.13			30	
71-76	0.9	0.3	tr.	tr.	1.2	3.0	4.2		0.3			2.21	0.32	1.26			28	
76-105	0.7	0.1	tr.	tr.	0.8	1.3	2.1		0.2			4.20	0.80	2.40			38	
105-115	1.6	0.2	tr.	tr.	1.8	2.1	3.9		0.2			1.03	0.16	0.66			46	
115-150	1.2	0.2	tr.	tr.	1.4	1.3	2.7		0.1			2.70	0.50	1.50			52	
150-200	1.0	0.3	tr.	tr.	1.3	1.1	2.4		0.1			4.00	0.67	2.50			54	
200-205	3.0	0.3	tr.	0.1	3.4	2.1	5.5		0.1			0.59	0.09	0.52			62	
205-230	1.2	0.2	0.1	0.1	1.6	0.8	2.3		0.1			5.75	1.25	3.25			65	
230-235	3.0	0.3	0.1	0.1	3.5	2.5	6.0		0.2			0.61	0.09	0.51			58	
235-270	1.4	0.3	tr.	tr.	1.7	1.3	3.0		0.1			1.58	0.32	0.84			57	

Depth

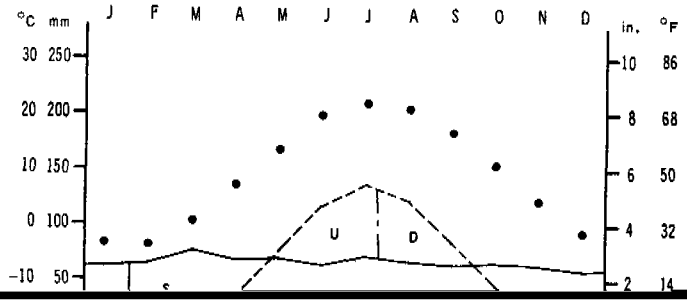
a/ 6.2 kg/m² to 1.5 m (method 6A).

Pedon 19

Classification: Psammentic Hapludalf, coarse-loamy, mixed, mesic.
Location: Orleans County, N. Y., approximately 0.4 km south of intersection with N. Y. Highway 31 about 3.2 km east of Albion.
Physiographic position: Glacial outwash delta.
Topography: Nearly level.
Drainage: Well drained.
Vegetation: Abandoned cherry orchard.
Parent material: Sandy deltaic deposits.
Sampled by: M. G. Cline, B. Brasher, and D. Bohrer, October 9, 1961.
Soil No.: 561NY-37-1

Colors are for the moist soil.

Climatic data and soil water balance



SOIL Pedon 20 Typic Albaqualf SOIL Nos. _____ LOCATION Union County, Ohio

LABORATORY Ohio State University LAB. Nos. E5248 - E5257

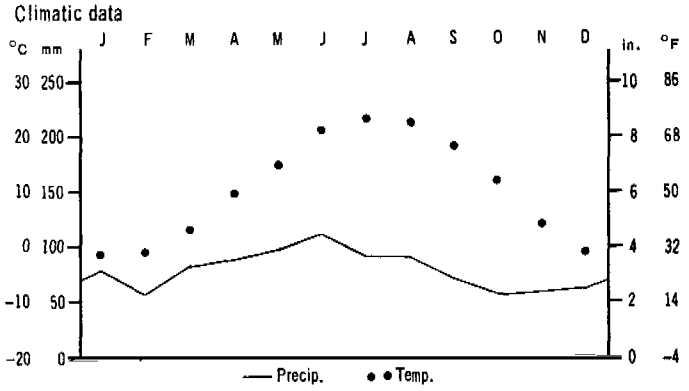
Depth (cm)	Horizon	1B1b Total Sand (2–0.05)	Total Silt (0.05–0.002)	Total Clay (< 0.002)	Sand Very coarse (2–1)	Sand Coarse (1–0.5)	Sand Medium (0.5–0.25)	Sand Fine (0.25–0.1)	Sand Very fine (0.1–0.05)	Silt (0.05–0.02)	Silt Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	3A1b Fine clay <0.0002	3B2 Cm	Coarse fragments 3B1: 2A2 > 2 Pct.	2–19 (Pct. of < 76mm)	19–76 (Pct. of < 76mm)
		Pct. of < 2 mm																
0–8	A1	18.8	52.3	28.9	4.4	5.0	3.4	3.2	2.8				16.7	7.6		0.0		
8–19	A2	30.5	39.1	30.4	13.9	9.4	3.5	3.0	0.7				29.8	6.6		3.1		
19–28	B21tg	10.1	38.0	51.9	2.9	2.2	1.2	1.9	1.9				8.2	20.4		0.8		
28–43	B22tg	5.9	32.7	61.4	0.9	1.3	0.8	1.4	1.5				4.4	29.8		0.7		
43–58	a/ B23tg	6.1	32.9	61.0	0.5	1.2	1.0	1.7	1.7				4.4	30.0		0.0		
58–76	B23tg	6.3	34.9	58.8	0.7	1.1	1.0	1.8	1.7				4.6	26.6		1.9		
76–100	B3	6.0	39.0	55.0	1.5	1.3	0.8	1.1	1.3				4.7	19.3		2.3		
100–145	C1	3.7	38.4	57.9	0.5	0.6	0.6	0.1	1.9				1.8	19.4		1.3		
145–210	C2	0.8	39.2	60.0	0.2	0.2	0.1	0.2	0.1				0.7	17.0		0.0		

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N		b/ Carbonate as $CaCO_3$ Pct.	Ext. iron as Fe Pct.	Bulk density: 4A1e ⅓-bar g/cc	Bulk density: 4A1h Oven-dry g/cc	4D1 COLE	Water content: Pct.	Water content: 4B1c ⅓-bar Pct.	Water content: 4B2 15-bar Pct.		4C1 WRD		pH: 8C1c (1:1) KCl	pH: 8C1a (1:1) H_2O
0–8	6.5	0.48	14														5.4
8–19	1.11	0.09	12														4.8
19–28	0.63	0.08	8														4.6
28–43	0.69	0.07	9														4.6
43–58	0.64	0.06	10														4.8
58–76	0.69	0.06	11														6.4
76–100					10.9												7.5
100–145					12.7												7.6
145–210					19.8												7.8

Depth (cm)	Extractable bases 5B1a: c/ Ca	c/ Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC: 5A3a Sum cations		6G1d Ext. Al			Ratios to clay: CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0–8	8.6	4.3	0.0	0.62	13.5	24.3	37.8										35.7	
8–19	1.3	1.1	0.1	0.21	2.7	17.1	19.8										13.6	
19–28	2.0	3.9	0.1	0.35	6.4	20.8	27.2										23.5	

Pedon 20

Classification: Typic Albaqualf, fine, mixed, mesic.
Location: Union County, Ohio, 1.6 km south of Marysville.
Physiographic position: Lowland in undulating morainic area of Wisconsin age at elevation of 314 m.
Topography: Nearly level, less than 1 percent slope.
Drainage: Poorly drained.
Vegetation: Forested area with white oak (Quercus alba), swamp white oak (Quercus bicolor), pin oak (Quercus palustris), shag bark hickory (Carya ovata).
Parent material: Calcareous clay till.
Sampled by: N. Holowaychuk, G. Post, F. Matanza, W. Shumate. December 11, 1956.
Remarks: Soil moist to 43 cm and moderately dry below this depth. Soil material below 145 cm is free of coarse fragments and appears to be water laid.



Colors are for moist soil unless otherwise indicated. Samples from 100 to 245 cm taken with an auger.

O1 5-0 cm (2-0 in.). Leaf litter.

A1 0-8 cm (0-3 in.). Very dark grayish brown (10YR 3/2) light silty clay loam, gray (N 5/) dry; strong medium and coarse granular structure; friable (moist), nonsticky and nonplastic (wet), hard (dry); abundant roots; clear smooth boundary.

A2 8-19 cm (3-7½ in.). Light brownish gray (2.5Y 6/2) light silty clay loam, light gray (2.5Y 7/2 to 8/2) dry; weak plates breaking to weak very fine subangular blocks or medium granules; friable (moist), slightly sticky slightly plastic (wet) and hard (dry); numerous black very fine rounded moderately hard concretions (shot); clear boundary.

B21tg 19-28 cm (7½-11 in.). Light brownish gray (2.5Y 6/2) light clay with many distinct medium brownish yellow (10YR 6/6) reddish yellow (7.5YR 6/6) mottles; light gray (2.5Y 7/2), brownish yellow (10YR 6/6) and gray (N 6/) dry; moderate fine subangular blocky structure; moderately firm (moist), plastic and moderately sticky (wet), very hard (dry); common fine rounded black moderately hard concretions; some thin clay skins on yellowish parts of peds; common roots; gradual boundary.

B22tg 28-43 cm (11-17 in.). Light brownish gray (2.5Y 6/2) heavy clay with large, distinct mottles of yellowish brown (10YR 5/6); light gray (N 7/) and light yellowish brown (10YR 6/4 to 6/6) dry; weak medium and large subangular blocky structure; very firm (moist), sticky and plastic (wet), very hard (dry); common light brownish gray clay skins; few roots; gradual boundary.

B23tg 43-76 cm (17-30 in.). Dark grayish brown (2.5Y 4/2) heavy clay with faint olive brown (2.5Y 4/3) mottles decreasing in lower part of horizon; gray (10YR 6/1), (N 6/) and yellowish brown (10YR 5/6) dry; massive breaking to coarse prisms; extremely firm (moist), sticky and plastic (wet), extremely hard (dry); cracks up to 2 cm wide; thin clay skins along root channels; some very fine black concretions, few roots; clear wavy boundary.

B3 76-100 cm (30-40 in.). Olive brown (2.5Y 4/3) heavy clay with dark grayish brown (2.5Y 4/2) coatings on peds; gray (N 6/), light olive brown (2.5Y 5/6) and white (N 8/) dry; moderate medium and coarse subangular blocky structure; very firm (moist), sticky and plastic (wet), extremely hard (dry); matrix is calcareous, with some gray splotches of carbonates; common limestone fragments and igneous rock cobbles; limestone fragments have yellowish brown coatings or stains; few roots.

C1 100-145 cm (40-57 in.). Olive brown (2.5Y 4/3) heavy clay with dark grayish brown coatings; gray (N 6/) light olive brown (2.5Y 5/6) and white (N 8/) dry; weak prisms breaking to medium coarse angular blocks; sticky and plastic (wet), extremely hard (dry); numerous splotches of white calcareous material on vertical and horizontal faces; some fragments of limestone and igneous rocks; auger sample.

C2 145-210 cm (57-82 in.). Light olive brown (2.5Y 5/6) heavy clay with gray (N 5/) coatings; angular blocky structure; sticky and plastic (wet), very hard to extremely hard (dry); some white calcareous splotches.

C3 210-245 cm (82-96 in.). Light olive brown (2.5Y 5/6) heavy clay with grayish brown (2.5Y 5/2) coating that decreases with depth; pale brown (10YR 6/3) and gray (10YR 6/1) dry; sticky and moderately plastic (wet), very hard to extremely

SOIL Pedon 21 Plinthic Paleudult SOIL Nos. S65NC-51-3 LOCATION Johnston County, North Carolina

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 65746 - 65751

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total: Sand (2-0.05)	Silt (0.05-0.002)	Clay (< 0.002)	Size class and particle diameter (mm) 3A1 Sand: Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt: (0.05-0.02)	Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 > 2 <76 Pct.	2 - 19	19 - 76
		Pct. of < 2 mm														Pct. of < 76mm		
0-13	Ap	64.1	27.2	8.7	4.4	16.1	12.8	17.7	13.1	9.8	17.4	31.7	51.0			2	2	0
13-23	a/A2	65.8	26.8	7.4	6.1	16.9	13.3	10.7	18.8	10.0	16.8	30.7	47.0			2	2	0
30-51	B21t	47.1	19.0	33.9	5.6	12.5	8.9	12.2	7.9	6.4	12.6	20.7	39.2			4	4	0
51-69	B22t	45.8	19.8	34.4	4.8	12.0	8.8	10.5	9.7	6.8	13.0	21.1	36.1			2	2	0
69-89	B23t	55.0	14.8	30.2	7.9	17.0	10.0	7.1	13.0	6.1	8.7	19.5	42.0			2	2	0
89-110	B24t	52.8	15.7	31.5	7.3	14.7	10.3	12.5	8.0	6.7	9.0	20.9	44.8			2	2	0
110-135	B25t	53.7	18.7	27.6	3.2	18.9	11.0	12.6	8.0	11.0	7.7	25.2	45.7			2	2	0
135-165	b/B26t	62.9	12.7	24.4	7.8	20.6	12.1	8.0	14.4	7.0	5.7	22.2	48.5			2	2	0
135-165	c/B26t	65.3	14.0	20.7	9.9	22.1	13.0	13.7	6.6	7.6	6.4	21.1	58.7			0	0	0
165-230	b/B3	69.6	8.6	21.8	7.8	22.3	14.4	15.4	9.7	5.5	3.1	21.5	59.9			2	2	0
165-230	c/B3	76.7	8.1	15.2	11.2	27.8	15.5	15.7	6.5	4.9	3.2	18.9	70.2			0	0	0
230-275	C	74.7	7.4	17.9	6.8	24.7	16.3	17.5	9.4	4.7	2.7	21.7	65.3			1	1	0

Depth (cm)	6A1a Organic carbon d/ Pct.	Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C2a Ext. iron as Fe Pct.	Bulk density: g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content: Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD cm/cm	pH: 8C1c (1:1) KCl	8C1a (1:1) H_2O
0-13	0.89					0.42							4.2			4.3	4.9
13-23	0.38					0.33							2.7			4.5	4.9
30-51	0.24					2.6		1.54	1.58	0.008		18.3	11.5		0.10	3.8	4.7
51-69	0.19					2.8		1.44	1.49	0.010		18.8	12.3		0.09	4.0	4.6
69-89	0.10					2.5		1.56	1.59	0.005		16.8	10.6		0.10	4.2	4.7
89-110	0.08					2.8		1.68	1.70	0.004		16.4	12.1		0.07	4.1	5.1
110-135						3.3		1.70	1.72	0.004		16.7	11.8		0.08	4.1	4.9
135-165						2.1		1.72	1.73	0.002		16.1	10.0		0.10	4.1	4.9
135-165						5.2											4.9
165-230						1.4		1.81	1.83	0.003		11.7	8.4		0.06	3.9	4.9
165-230						2.1											5.0
230-275	-					0.59		1.75	1.76	0.003		11.9	6.8		0.09	4.0	4.7

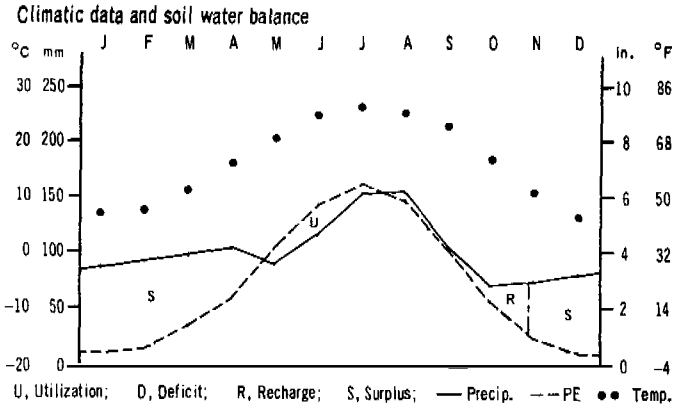
Depth (cm)	Extractable bases 5B1a 5A6: 6N2e Ca	6O2d Mg	6P2b Na	6Q2b K	Sum	6H2a Ext. acidity	CEC: 5A3a Sum cations	5A5a Ba	6G1d Ext. Al			Ratios to clay 8D1: CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-13	1.40	0.24	0.01	0.22	1.87	5.5	7.4	6.5	0.6			0.85	0.05	0.48			25	
13-23	0.72	0.07	-	0.11	0.90	2.5	3.4	2.8	0.4			0.46	0.04	0.36			26	
23-51	1.34	0.38	0.01	0.19	1.92	7.7	9.6	7.7	1.2			0.28	0.08	0.34			20	
51-69	1.34	0.64	0.03	0.08	2.09	6.9	9.0	6.8	1.0			0.26	0.08	0.36			23	
69-89	0.57	0.55	0.03	0.06	1.21	5.9	7.1	5.9	1.0			0.24	0.08	0.35			17	
89-110	0.26	0.34	0.04	0.05	0.69	6.0	6.7	5.6	1.2			0.21	0.09	0.38			10	
110-135	0.04	0.30	0.04	0.03	0.41	5.6	6.0	5.3	1.3			0.22	0.12	0.43			7	
135-165	0.04	0.18	0.02	0.02	0.26	4.0	4.3	3.8	1.2			0.18	0.09	0.41			6	
135-165	0.04	0.17	0.04	0.03	0.28	3.7	4.0	3.4	0.8			0.19	0.25				7	
165-230	0.03	0.15	0.02	0.02	0.22	3.2	3.4	3.1	1.1			0.16	0.06	0.38			6	
165-230	0.03	0.14	0.03	0.02	0.22	2.4	2.6	2.2	0.9			0.17	0.14				8	
230-275	0.03	0.07	0.02	0.03	0.15	2.6	2.8	2.6	1.2			0.16	0.03	0.38			5	

Depth (cm)	Clay fraction e/ mineralogy 7A1b-d: X-ray 7A2 f/	DTA 7A3 Pct.
0-13	VC4	KK35,GI9,QZ4
13-23	VC4,VR1	KK26,GI9,QZ8
30-51	VC3,VR1	KK35,GI12,QZ7
51-69	VC3	KK32,GI10,QZ2
69-89	VC3	KK40,GI13,QZ1
89-110	VC3	KK40,GI10
110-135	VC3	KK50,GI5
135-165	VC3	KK56,GI<2
135-165	VC3	KK56
165-230	VC3	KK58,GI<2
165-230	VC3	KK58
230-275	VC3	KK58

a/ 23-30 cm depth not sampled.
b/ Bulk sample.
c/ Red subsample.
d/ 4.4 kg/m² to 1.5 m (method 6A) (bulk density of Ap and A2 horizon estimated).
e/ Mineral code:
VC = vermiculite/chlorite intergrade
KK = kaolinite
GI = gibbsite
f/ Approximate weight fraction (X-ray):
5 = more than half
4 = half to one-third
3 = one-third to one-fifth
2 = one-fifth to one-twentieth
1 = less than one-twentieth

Pedon 21

Classification: Plinthic Paleudult, fine-loamy, siliceous, thermic.
Location: Johnston County, N. C. 13 meters northeast of center line of county road 1101 at a point 0.5 kilometers northwest from the junction of county roads 1101 and 1102. This location is about 1.6 kilometers south of the town of Benson.
Physiographic position: Slightly elevated area on depositional Brandywine surface.
Topography: Level to nearly level with 0 to 1 percent gradient.
Drainage: Well drained.
Vegetation: Cultivated land in fescue.
Sampled by: R. B. Daniels, E. E. Gamble, J. G. Cady, and C. H. Simonson. October 21, 1965.
Soil No.: S65NC-51-3.



Colors are for the moist soil.

Ap 0-13 cm (0-5 in.). Dark grayish brown (10YR 4/2) sandy loam; massive; friable (moist); abrupt smooth boundary.

A2 13-23 cm (5-9 in.). Pale brown (10YR 6/3) sandy loam; massive; friable (moist); abrupt irregular boundary.

B1 Not sampled 23-30 cm (9-12 in.). Yellowish brown (10YR 5/6) sandy clay loam; massive; friable (moist); coatings in common root channels are apparently not clay skins; common fescue roots; clear boundary.

B21t 30-51 cm (12-20 in.). Yellowish brown (10YR 5/6) heavy sandy clay loam; weak subangular blocky structure; friable (moist); common thin clay skins in common root channels; common fescue roots; few individual clean sand grains on nearly all broken surfaces; clear smooth boundary.

B22t 51-69 cm (20-27 in.). Yellowish brown (10YR 5/6) heavy sandy clay loam; weak medium subangular blocky structure; few faint medium strong brown (7.5YR 5/6) mottles; friable (moist); thin clay skins in common root channels; common fescue roots; few small vertically oriented pipe-like bodies of a less clayey texture than the matrix that contain a few clean sand grains; clear boundary.

B23t 69-89 cm (27-35 in.). Yellowish brown (10YR 5/8) heavy sandy clay loam; weak medium subangular blocky structure; friable (moist); common soft yellowish red (5YR 4/8) mottles; few to common thin clay skins on some ped faces; few areas of clean sand grains; clear boundary.

B24t 89-110 cm (35-43 in.). Yellowish brown (10YR 5/6) to brownish yellow (10YR 6/6) heavy sandy clay loam; massive; friable (moist); many fine to coarse light gray (10YR 7/2) and very pale brown (10YR 7/3) mottles, and many fine to medium yellowish red (5YR 4/8) to red (2.5YR 5/8) mottles less than 5 mm wide, frequently less than 1 mm thick, up to 3 cm long and about 50 percent flecked with other colors; red mottles increase in quantity with depth, grade from soft in the upper parts to firm[1/] and very firm at the bottom of the horizon, and do not stain the fingers; few 6 mm diameter areas of coarser texture with many clean sand grains in upper part of horizon; smooth coatings of uncertain composition on red and strong brown material; common medium to coarse pores; clear smooth boundary.

B25t 110-135 cm (43-54 in.). Variegated yellowish brown (10YR 5/6) to brownish yellow (10YR 6/6) and light gray (10YR 7/2) heavy sandy clay loam; massive; friable (moist); light gray areas are 1 to 2 cm wide with horizontal orientation of long axis; common to many yellowish red (5YR 4/8) to red (2.5YR 4/8) firm[1/] and very firm mottles 8 to 10 cm long, generally less than 1 cm wide, with preferred horizontal orientation of long axis, and surrounded by yellowish brown material; browns next to the reds are seemingly partly cemented, becoming firmer toward the red center away from the gray; point counts indicate average plinthite is 15 percent of volume; thin to thick discontinuous mostly yellowish brown clay skins; few pores; clear smooth boundary.

B26t 135-165 cm (54-64 in.). Brownish yellow (10YR 6/6) light sandy clay loam; massive; friable (moist) but with brittle failure in the upper parts of the horizon; many white (10YR 8/2) and red (2.5YR 4/8) mottles; red mottles appear to be mostly iron stained clay; red mottles are 1/3 firm (moist), 2/3 friable (moist); common coarse pores; few to common brown clay skins in pores; clear boundary.

B3 165-230 cm (64-90 in.). Yellowish brown (10YR 5/6) and red (2.5YR 4/8) light sandy clay loam in a reticulate pattern; massive; friable (moist); common medium to coarse white (10YR 8/2) mottles; reds tend to be vertically oriented in bodies 1 to 5 cm across and tend to be surrounded by browns in the upper parts of the horizon, and intermixed with them in the lower parts; reds are soft and tend to stain the fingers; common thin nearly continuous brown clay skins in vertically oriented pores, few thin discontinuous clay skins on gray areas; diffuse smooth boundary.

C 230-275 cm (90-108 in.). Brownish yellow (10YR 6/6) and light gray (10YR 7/2) sandy loam; massive; friable (moist)

SOIL Pedon 22 Typic Agrudalf SOIL Nos. _____ LOCATION Hamme-Mille, Vicinity of Lourain, Belgium

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 60808 - 60814

General methods: 1A, 1B1b, 2A1, 2B

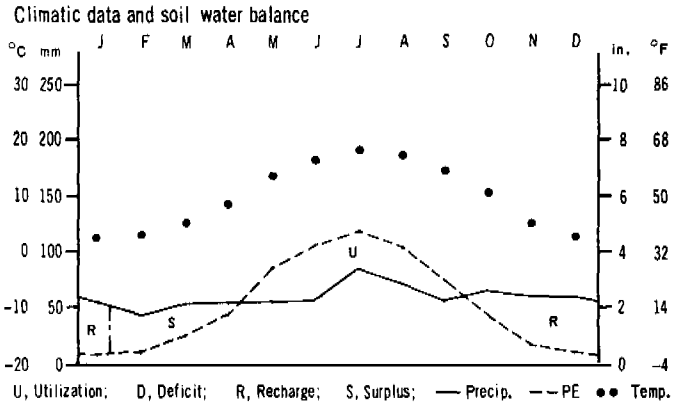
Depth (cm)	Horizon	1B1b Total Sand (2–0.05)	Total Silt (0.05–0.002)	Total Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 > 2 Pct.	2 – 19 (Pct. of < 75mm)	19 – 76 (Pct. of < 75mm)
		Pct. of < 2 mm																
0–23	Ap	10.5	72.7	16.8	tr.	0.2	0.6	2.0	7.7	54.1	18.6	62.8	2.8			tr.		
23–43	B21t	7.8	69.5	22.7	tr.	tr.	0.1	0.6	7.1	50.9	18.6	58.3	0.7			tr.		
43–86	B22t	7.3	70.4	22.3	0.0	0.0	0.1	0.6	6.6	48.9	21.5	55.9	0.7			0		
86–130	B23t	5.6	72.6	21.8	0.0	0.0	0.1	0.3	5.2	48.9	23.7	54.4	0.4			0		
130–155	B3	11.0	70.8	18.2	0.0	0.0	0.1	1.2	9.7	52.4	18.4	63.1	1.3			0		
155–175	C1	12.4	70.8	16.8	0.0	0.0	0.1	0.9	11.4	54.9	15.9	66.9	1.0			0		
175	C2	9.1	77.9	13.0	0.2	0.2	0.1	0.4	8.2	60.8	17.1	69.3	0.9			tr.		

Depth (cm)	6A1a Organic carbon (Pct.)	6B2a Nitrogen (Pct.)	C/N		Carbonate as $CaCO_3$ (Pct.)	6C1a Ext. iron as Fe (Pct.)	Bulk density: (g/cc)	Bulk density: 4A1e ⅓-bar (g/cc)	Bulk density: 4A1h Oven-dry (g/cc)	4D1 COLE	Water content: (Pct.)	Water content: 4B1c ⅓-bar (Pct.)	Water content: 4B2 15-bar (Pct.)		4C1 WRD	pH:	pH: 8C1c (1:1) KCl	pH: 8C1a (1:1) H_2O
0–23	1.02	0.116	9			0.9							6.6					6.3
23–43	0.37	0.057	6			1.1							8.4					6.3
43–86	0.21	0.038				1.1							7.8					6.0
86–130	0.15	0.030				1.0							7.3					6.3
130–155	0.11	0.020				0.8							6.4					6.3
155–175	0.07	0.020				0.8							5.7					6.5
175	0.11	0.017			13	0.8							4.6					7.7

Depth (cm)	Extractable bases 5B1a: 6N2d Ca (meq/100g)	6O2b Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC: 5A3a Sum cations	CEC: 5A1a NH_4OAc	6G1d Ext. Al	a/ Exch. Mn. meq/100g	Exch. Mn. ppm	Ratios to clay 8D1: CEC sum	Ext. iron	15-bar water	Ext. b/ P_2O_5 ppm	Citric acid ext. c/ P_2O_5 ppm	Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
0–23	9.8	1.0	0.4	0.4	11.7	3.1	14.8	11.2	0	0.13	36	0.88	0.05	0.39	128	310	79	
23–43	11.2	1.6	0.4	0.3	13.5	3.4	16.9	13.4	0	0.03	9	0.74	0.05	0.37	28	175	80	

Pedon 22

Classification: Typic Agrudalf, fine-silty, mixed, mesic.
Location: Hamme-Mille in vicinity of Louvain, Belgium.
Physiographic position: Undulating plateau (maximum relief 20 to 40 m); loamy region of Middle Belgium. Elevation is 85 m.
Topography: Short 3 to 4 percent north-facing slope.
Drainage: Runoff medium to rapid; permeability rapid to very rapid due to many holes in the soil; internal drainage medium to rapid; well drained.
Vegetation: Cultivated.
Parent material: Niveo-Eolian loess (Würm III).
Sampled by: L. Baeyens, R. Tavernier, J. B. Ameryckx, F. DeConinck, R. Leys, and A. Louis, December 19, 1959.
Remarks: Profile moist throughout with permanent ground water table at approximately 30 m. Biological activity is very high and characteristic for this soil.



Ap 0-23 cm (0-9 in.). Brown (10YR 4/3) light silt loam; strong fine crumb structure; in places at the base of the horizon there is a nearly massive compact layer about 4 cm thick with weak compound blocky structure; very friable (moist); in this horizon some subangular blocky pieces of the B21t have been incorporated by plowing; undecomposed wheat stubble and farm stable manure, brick fragments, charcoal remnants, pieces of lime, and coal fragments are throughout; many irregular large holes resulting from plowing and small holes from animals, chiefly earthworms; abrupt irregular lower boundary.

B21t 23-43 cm (9-17 in.). Strong brown (7.5YR 4/6) (crushed) heavy silt loam with brown (7.5YR 4/4 ped faces; coarse and very coarse prisms rounded on sides, subdivided horizontally into medium plates that break to very fine subangular blocks; very friable (moist); humiferous in spots though animal mixing; 2.5 cm holes, becoming narrower (1.5 cm) with depth partially filled with fine crumbs of very humus rich material; approximately 4 to 6 holes in 10 linear cm on profile face; these holes in places are filled with organic remnants and silt loam washed in by water coming from the larger holes in the Ap left by plowing; holes are lined with a very shiny dark brown (7.5YR 4/2) humus rich layer 6 mm thick; numerous small roots of wheat and traces of very fine roots on ped faces; diffuse smooth lower boundary.

B22t 43-86 cm (17-34 in.). Dark yellowish brown (10YR 4/4) heavy silt loam with brown (7.5YR 4/3 ped faces; very coarse moderate prisms (over 10 cm) increasing in size with depth, breaking to very coarse subangular blocks (5 cm average); few large spots of yellowish brown (10YR 5/4) circumscribed with a strong brown (7.5YR 5/6) ring with a diffuse outer boundary; about two 1 cm diameter wormholes per 10 cm of profile face, filled mainly with dark brown humic crumbly material; the larger roots are mainly in wormholes, fine roots less apparent than in the horizon above; diffuse smooth lower boundary.

B23t 86-130 cm (34-50 in.). Yellowish brown (10YR 5/4) heavy silt loam (crushed) with brown (7.5YR 4/3) ped faces; coarse prisms, less well defined than in B22t and increasing in size with depth, breaking to weak subangular blocks; wormholes present, 1 to 1.5 per 10 cm, but with less filling than above; roots are mainly in wormholes; diffuse smooth lower boundary.

B3 130-155 cm (50-61 in.). Yellowish brown (10YR 5/4) silt loam; very weak coarse blocks discernible; very friable (moist); wormholes 1 or less per 10 cm mainly filled with bleached coarse silt; clay skins discontinuous (about 50 percent of surfaces) and thin; some original stratification observable.

C1 155-175 cm (61-68 in.). Yellowish brown (10YR 5/4) light silt loam; very weak coarse blocky structure; very friable (moist); soft (dry); few wormholes (1-2 in 90 cm of the profile face) filled with nonmineralized organic material; original weak stratification evident; some root holes; abrupt smooth lower boundary.

C2 175 cm (68 in.). Similar to C1 but calcareous.

SOIL Pedon 23 Borollic Natrargid SOIL Nos. S62Mont-3-11 LOCATION Blaine County, Mont.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 17579-17588

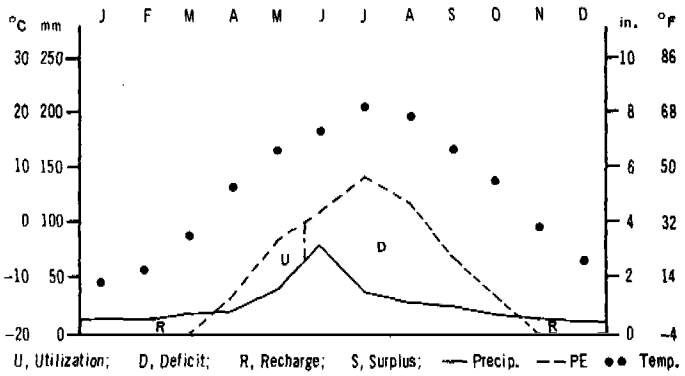
General Methods: 1A, 1B1b, 2A1, 2B

Depth	Horizon	Size class and particle diameter (mm) 3A1														Coarse fragments 2A2 3B1
		Total			Sand					Silt						
		a/ Sand	Silt	Clay	Very	Coarse	Medium	Fine	Very fine		Int. III	Int. II (0.2–0.02)	(2–0.1)			

Pedon 23

Classification: Borollic Natrargid, fine, montmorillonitic.
Location: Blaine County, Mont., 135 m N. and 45 m E. of SW. corner sec. 36, T. 36 N., R. 19 E.
Physiographic position: Nearly level glacial till plain.
Topography: Slope gradient of 1 percent. Pedon in the very edge or upper slope of a small depression. Microrelief is less than 30 cm.
Drainage: Well drained; slow runoff with ponding in small depressions; slow permeability.
Vegetation: Western wheatgrass (Agropyron smithii), blue grama (Bouteloua gracilis), fringed sagewort (Artemisia frigida), cactus (Opuntia spp.).
Parent material: Calcareous clay loam glacial till.
Sampled by: A. Anderson, R. B. Grossman, C. A. Mogen, R. L. Moshier, E. C. Nielson and J. L. Walker, August 29, 1962.
Remarks: Dry; no water table within 2 m.
Soil No.: S62Mont-3-11.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

A2 0-8 cm (0-3 in.). Grayish brown grading to light brownish gray (10YR 5/2 to 6/2) loam, very dark grayish brown grading to dark grayish brown (10YR 3/2 to 4/2) moist; moderate very fine platy structure; soft (dry), very friable (moist), nonsticky and nonplastic (wet); uppermost 3 cm a root mat with plentiful roots below; concentrations of uncoated sand and silt grains on upper surfaces of plates; noncalcareous; abrupt boundary.

B21t 8-13 cm (3-5 in.). Light brownish gray (10YR 6/2) heavy clay loam, dark grayish brown (10YR 4/2) moist; strong medium [illegible] and fine columns that separate easily to medium and fine angular blocks; extremely hard (dry), firm (moist), very sticky and very plastic (wet); plentiful roots; many medium and fine pores; caps of columns are light gray (10YR 7/2) and covered by uncoated sand and silt grains; thin continuous clay skins on surfaces of columns below gray caps; vertical faces of columns have a sprinkling of uncoated sand and silt grains; [illegible]

B22t 13-18 cm (5-7 in.). Grayish brown (10YR 5/2) heavy clay loam, dark grayish brown (10YR 4/2) moist; moderate medium prisms that separate very easily to fine blocks; extremely hard (dry), friable (moist), very sticky and very plastic (wet); plentiful roots; many medium and fine pores; thin continuous clay skins on ped surfaces; vertical faces of prisms have a sprinkling of uncoated sand and silt grains; noncalcareous; clear boundary.

B3 18-23 cm (7-9 in.). Brown (10YR 5/3) light sandy clay loam, brown (10YR 4/3) moist; moderate coarse prisms that separate to coarse and medium blocks; extremely hard (dry), firm (moist), sticky and plastic (wet); plentiful roots; surfaces of peds grayish brown (10YR 5/2) and dark grayish brown (10YR 4/2) moist; common thin clay skins on ped surfaces; slightly calcareous but no segregated carbonate; clear boundary.

C1 23-43 cm (9-17 in.). Grayish brown (2.5Y 5/2) light sandy clay loam, dark grayish brown (2.5Y 4/2) moist; moderate coarse prisms that separate with difficulty to coarse and medium blocks; very hard (dry), friable (moist), slightly sticky and slightly plastic (wet); plentiful roots; common medium and fine pores; few nodules of carbonate; clear wavy boundary.

C2ca 43-71 cm (17-28 in.). Light gray (5Y 6/1) heavy loam, dark gray (5Y 4/1) moist; moderate coarse prisms that separate to coarse and medium blocks; extremely hard (dry), firm (moist), sticky and plastic (wet); few roots; common fine and few medium pores; pieces of lignite common; many nodules, seams, and pebble casts of carbonate; gradual boundary.

SOIL Pedon 24 Typic Natraqualf SOIL Nos. S64Tenn-79-3 LOCATION Shelby County, Tennessee

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 64355 - 64361

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt 0.05-0.02	Silt Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1 2A2 > 2 <76 Pct.	2-19	19-76
		Pct. of < 2 mm															Pct. of < 76mm	
0-25	Ap	0.8	84.0	15.2	0.1	0.1	0.1	0.1	0.4	25.9	58.1	26.3	0.4		1.00	0		
25-36	A2	1.7	82.2	16.1	0.1	0.2	0.3	0.5	0.6	29.3	52.9	30.1	1.1		1.00	0		
36-56	B21tg	1.0	70.3	28.7	0.1	0.2	0.2	0.1	0.4	23.3	47.0	23.7	0.6		1.00	0		
56-99	B22tg	1.1	70.5	28.4	0.1	0.2	0.2	0.2	0.4	22.8	47.7	23.2	0.7		1.00	0		
99-140	B23tg	3.1	69.1	27.8	0.5	0.8	0.4	0.5	0.9	30.0	39.1	31.1	2.2		1.00	0		
140-190	B3g	4.0	71.1	24.9	0.6	1.1	0.6	0.6	1.1	34.4	36.7	35.8	2.9		1.00	0		
190-305	Cg	1.9	75.7	21.3	0.4	0.6	0.4	0.5	1.1	40.9	34.8	42.3	3.0		1.00	0		

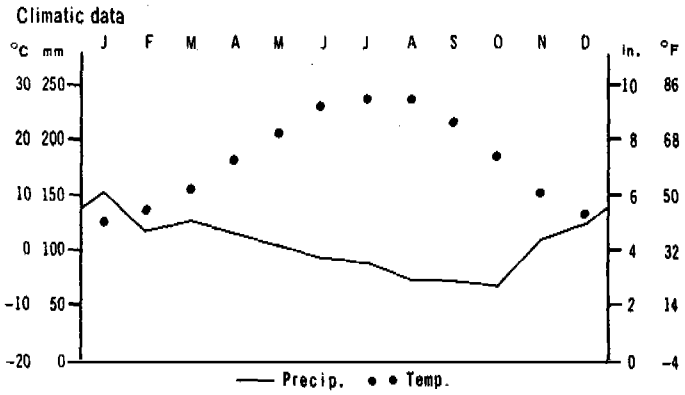
Depth (cm)	6A1a Organic carbon a/ Pct.	6B2 Nitrogen Pct.	C/N		6E1e Carbonate as $CaCO_3$ Pct.	6C2a Ext. iron as Fe Pct.	Bulk density g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD cm/cm	pH 8C1b Sat. paste	8C1c (1:1) KCl	8C1a (1:1) H_2O
0-25	0.51	0.07	7			0.7		1.38	1.42	0.010		25.4	6.6		0.26	8.4	5.0	6.2
25-36	0.57	0.05	11			0.3										6.8	3.3	4.9
36-56	0.38	0.04	10			0.6		1.47	1.59	0.027		22.4	12.4		0.15	4.8	3.2	4.5
56-99	0.16					0.5		1.52	1.60	0.018		21.4	12.4		0.14	5.8	4.5	5.8
99-140	0.05					0.7		1.50	1.57	0.016		23.4	13.4		0.15	7.4	5.5	7.0
140-190	0.10				tr.	0.8		1.41	1.54	0.031		25.6	13.0		0.18	7.5	5.9	7.4
190-305	-				1	0.6		1.48	1.55	0.016		25.2	10.6		0.22	7.5	6.3	7.6

Depth (cm)	Extractable bases 5B1a 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC 5A3a Sum cations	5A2a NaOAc	6G1d Ext. Al	b/ 5D1 Exch. Na	Ratios to clay 8D1 CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg	Base saturation 5C3 Sum cations	5C2 NaOAc
	meq/100 g									Pct.					Pct.	Pct.
0-25	7.1	1.2	0.2	0.1	8.6	3.4	12.0	11.8	tr.	2	0.79	0.05	0.43	5.9	72	73
25-36	2.6	1.0	0.3	0.1	4.0	5.1	9.1	10.0	1.3	3	0.57	0.02		2.6	44	40
36-56	4.4	3.2	1.3	0.2	9.1	8.4	17.5	20.2	2.5	6	0.61	0.02	0.43	1.4	52	45
56-99	5.2	5.4	3.0	0.2	13.8	2.3	16.1	17.9	tr.	17	0.57	0.02	0.44	1.0	86	77
99-140	6.4	7.4	5.8	0.2	19.8	1.1	20.9	23.2	tr.	25	0.75	0.03	0.48	0.9	95	85
140-190	7.0	7.8	5.8	0.3	20.9	0.9	21.8	24.0	tr.	24	0.88	0.03	0.52	0.9	96	87
190-305	9.4	7.1	4.9	0.2	21.6	0.2	21.8	21.0	tr.	23	1.02	0.03	0.50	1.3	99	

Depth

a/ 5.2 kg/m² to 1.5 m (method 6A) (bulk density of A2 horizon estimated).
b/ Based on NaOAc CEC.

Pedon 24



Classification: Typic Natraqualf, fine-silty, mixed, thermic.
Location: Shelby County, Tenn. Penal Farm.
Physiographic position: Undulating loessial uplands.
Topography: Nearly level - about 1 percent slope.
Drainage: Poorly drained.
Vegetation: Mostly dog fennel and a few vines.
Parent Material: Loess.
Sampled by: D. P. Franzmeier, E. J. Pedersen, D. K. Springer, E. C. Sease, C. L. Mangrum, and W. C. Moore.
Soil No.: S64Tenn-79-3
Colors are for the moist soil.

Ap 0-25 cm (0-10 in.). Brown (10YR 5/3) with common light brownish gray (10YR 6/2) mottles; light silt loam; weak fine granular structure; friable (moist); many roots; clear smooth boundary.

A2 25-36 cm (10-14 in.). Gray (10YR 6/1) with a few fine and medium yellowish brown (10YR 5/4) and light yellowish brown (10YR 6/4) mottles; light silt loam; angular blocky structure, some evidence of platy structure; friable (moist); common fine roots; abrupt wavy boundary.

B21tg 36-56 cm (14-22 in.). Gray (10YR 6/1) silt or silt loam commonly thickly coated with grayish brown (2.5Y 5/2) weak coarse columnar structure; yellowish brown (10YR 5/4) and reddish brown (5YR 5/4) stains follow old root channels; common streaks and pockets of clay in the gray silt loam matrix, light silty clay loam when mixed; few pin holes; few fine roots; gradual wavy boundary.

B22tg 56-99 cm (22-39 in.). Mixture of grayish brown (2.5Y 5/2) seams, coatings, and pockets of silty clay loam in the gray (10YR 6/1) silt loam matrix; weak coarse columnar structure; firm (moist); yellowish brown (10YR 5/4) and black (10YR 2/1) stains along old root channels; light silty clay loam when mixed; many pin holes; few fine roots; gradual irregular boundary.

B23tg 99-140 cm (39-55 in.). Mottled grayish brown (2.5Y 5/2), light brownish gray (10YR 6/2) and gray (10YR 6/1) light silty clay loam; weak coarse columnar structure; firm (moist); few faint fine black (10YR 2/1) and very dark grayish brown (10YR 3/2) stains; few small iron and manganese concretions; few fine roots; gradual irregular boundary.

B3g 140-190 cm (55-74 in.). Grayish brown (2.5Y 5/2) with common fine and medium mottles of gray (10YR 6/1), yellowish brown (10YR 5/4), light yellowish brown (10YR 6/4), and brownish yellow (10YR 6/6); heavy silt loam; massive; firm (moist); few fine calcium carbonate concretions; gradual irregular boundary.

Cg 190-305 cm (74-120 in.). Grayish brown (2.5Y 5/2) with common yellowish brown (10YR 5/4) and gray (10YR 6/1) mottles; heavy silt loam; massive; friable (moist).

SOIL Pedon 25 Typic Haplorthod SOIL Nos. S60NH-5-4 LOCATION Grafton County, New Hampshire

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 60567 - 60574

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Silt (0.05-0.002)	Clay (< 0.002)	Size class and particle diameter (mm) 3A1 Sand: Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt: 0.05-0.02	Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 > 2 Pct.	2-19	19-76
		Pct. of < 2 mm															Pct. of < 76mm	
0-20	Ap1	55.7	41.1	3.2	4.7	7.9	7.3	14.0	21.8	21.9	19.2	51.5	33.9		0.96	11		
20-25	Ap2	55.1	41.8	3.1	5.8	7.2	7.2	12.8	22.1	22.8	19.0	52.3	33.0		0.96	10		
25-36	A2	57.3	39.4	3.3	4.8	8.1	7.9	13.2	23.3	24.8	14.6	55.9	34.0		0.97	5		
36-43	B21h	52.6	44.7	2.7	6.0	7.4	5.9	9.6	23.7	28.5	16.2	57.9	28.9		0.96	13		
43-53	B221r	49.6	48.1	2.3	5.5	6.4	5.5	9.8	22.4	29.0	19.1	57.1	27.2		0.96	5		
53-84	B3	55.5	42.8	1.7	5.0	7.0	6.1	11.8	25.6	26.9	15.9	59.9	29.9		0.88	22		
84-105	C1	64.7	34.0	1.3	5.2	8.4	8.6	17.4	25.1	22.5	11.5	57.7	39.6		0.71	39		
105-120	C2	76.7	22.0	1.1	8.7	13.2	12.6	21.3	20.9	14.1	8.1	46.5	55.8			36		

Depth (cm)	6A1a Organic carbon a/ Pct.	6B2a Nitrogen Pct.	C/N	Fe/C	Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density: g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content: Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD cm/cm	pH: 8C1c (1:1) KCl	8C1a (1:1) H_2O
0-20	3.54	0.264	13	0.28		0.94		0.91	1.00	0.03		28.9	9.3		0.17	4.8	4.9
20-25	3.34	0.210	16	0.30		1.00		1.08	1.12	0.01		24.7	8.6		0.17	4.7	5.1
25-36	0.76	0.053	14	0.26		0.20		1.36	1.34	0.000		11.4	2.6		0.12	4.1	5.1
36-43	3.86	0.181	21	0.52		1.90		0.78	0.87	0.037		44.6	10.1		0.26	4.3	5.0
43-53	2.90	0.136	21	0.59		1.60		1.13	1.23	0.03		33.5	9.6		0.26	4.2	4.9
53-84	1.23	0.065	19	0.32		0.30		1.32	1.36	0.01		20.4	3.9		0.19	4.6	4.9
84-105	0.27			1.11		0.30		1.69	1.68	0.000		8.2	1.5		0.08	4.7	4.9
105-120	0.06			1.67		0.20							0.8			4.5	4.9

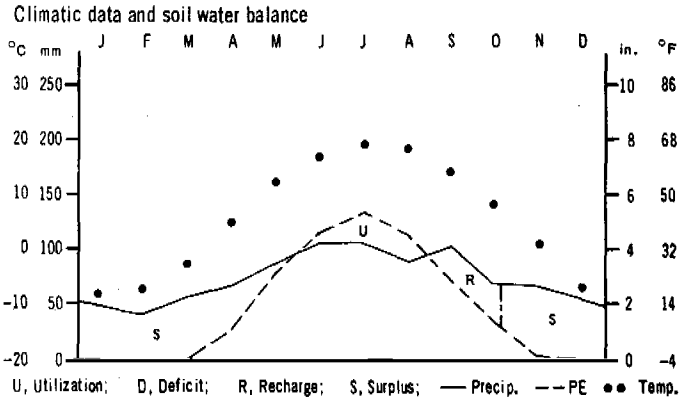
Depth (cm)	Extractable bases 5B1a: 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC: 5A3a Sum cations		6G1d KCl Ext. Al	6G7a Ext. Al D.C.		Ratios to clay 8D1: CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-20	2.9	0.2	tr.	tr.	3.1	22.6	25.7		1.3	0.59		8.03	0.31	2.91			12	
20-25	3.6	0.2	0.1	tr.	3.9	22.4	26.3		1.0	0.61		8.48	0.32	2.77			11	
25-36	1.9	0.2	tr.	tr.	2.1	5.1	7.2		1.0	0.07		2.18	0.06	0.79			29	
36-43	2.4	0.3	tr.	tr.	2.7	42.0	44.7		2.4	1.09		16.6	0.74	3.74			6	
43-53	1.7	0.1	tr.	tr.	1.8	43.0	44.8		3.3	0.98		19.5	0.74	4.17			4	
53-84	0.5	0.1	tr.	tr.	0.6	17.8	18.3		1.7	0.61		10.8	0.24	2.29			3	
84-105	0.5	0.1	tr.	tr.	0.6	5.5	6.0		0.7	0.21		4.62	0.23	1.15			8	
105-120	0.1	0.1	tr.	tr.	0.2	2.1	2.2		0.3	0.09		2.00	0.09	0.73			4	

Depth (cm)	Pyrophosphate extractable: 6C5a Iron Pct.	6G5a Al Pct.	Ratio of Fe+Al to clay	Ratio Pyro Fe+Al to D.C. Fe+Al
0-20	1.9	0.9	0.9	1.9
20-25	2.0	0.9	1.0	1.8
25-36	0.2	tr.	0.1	0.7
36-43	5.7	1.6	2.7	2.4
43-53	5.8	1.7	3.2	2.9
53-84	0.4	0.7	0.6	1.2
84-105				
105-120				
	Accumulation index = 1280			

a/ 19.0 kg/m^2 to 1.2 m (method 6A) (bulk density of C2 horizon estimated).

Pedon 25

Classification: Typic Haplorthod, coarse-loamy, mixed, frigid.
Location: Grafton County, N. H. (Moosilauke Quadrangle) Plot located on photo No. DXV-IN-180.
Physiographic position: Lower slope of rolling glacial uplands.
Topography: Gently sloping, 3 percent.
Drainage: Well drained.
Vegetation: Idle field, timothy, red top and quackgrass (Agropyron repens).
Parent material: Glacial till primarily from granitic material and some schist.
Sampled by: B. Brasher, G. Schmidt, A. Prince, D. van der Voet, F. Vieira, T. Kelsey, and S. Pilgrim. June 21, 1960.
Soil No.: S60NH-5-4.



Colors are for the moist soil.

Ap1 0-20 cm (0-8 in.). Very dark grayish brown (10YR 3/2), fine sandy loam with 3 percent coarse fragments; weak fine granular structure; very friable (moist); many roots.

Ap2 20-25 cm (8-10 in.). Very dark grayish brown (10YR 3/2); fine sandy loam with 3 percent coarse fragments; weak fine granular structure; very friable (moist); many roots; thickness A horizon 20-28 cm; an arbitrary break for laboratory purposes; abrupt smooth boundary.

A2 25-36 cm (10-14 in.). Grayish brown (2.5Y 5/2); fine sandy loam with 2 percent coarse fragments; weak fine granular structure; very friable (moist); roots common; clear broken boundary.

B21h 36-43 cm (14-17 in.). Black (5YR 2/1); fine sandy loam with 5 percent coarse fragments; weak fine granular structure; very friable (moist); roots common; 0-13 cm thick; clear broken boundary.

B22ir 43-53 cm (17-21 in.). Very dusky red (2.5YR 2/2); fine sandy loam with one percent coarse fragments; moderate medium granular structure; friable (moist); roots common; 0-18 cm thick; clear broken boundary.

B3 53-85 cm (21-33 in.). Light olive brown (2.5Y 5/4); fine sandy loam with 8 percent coarse fragments; moderate medium granular structure; friable; few roots; 18-30 cm thick; clear wavy boundary.

C1 85-105 cm (33-42 in.). Olive gray (5Y 5/2); gravelly fine sandy loam massive in place, single grain removed; friable; few roots; iron staining appears to be derived from inherent coarse fraction; 20-25 cm thick; clear wavy boundary.

C2 105-120 cm (42-48 in.). Gray (5Y 5/1); loamy sand with 12 percent coarse fragments; massive in place, single grain removed; friable; no roots.

SOIL Pedon 26 Typic Fragiorthod SOIL Nos. S63NY-45-1 LOCATION St. Lawrence County, N. Y.

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 63495 - 63501

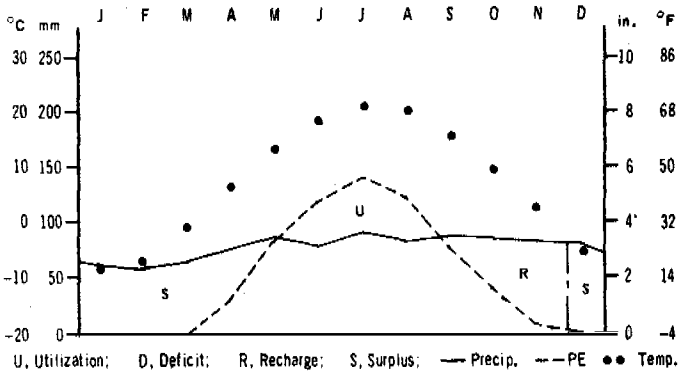
General methods: 1A, 1B1b, 2A1, 2B

Depth	Horizon	1B1b Total Sand	Total Silt	Total Clay	Sand Very	Sand Coarse	Sand Medium	Sand Fine	Sand Very fine	Silt	Silt Int. III	Silt Int. II			3B2	Coarse fragments 3B1 2A2		
4-0	02															1.00	tr.	
0-4	A2	59.2	32.3	8.5	1.9	8.4	12.6	21.9	14.4	13.3	19.0	39.0	44.8			0.97	7	
4-18	B21	57.4	30.2	12.4	3.0	7.5	11.2	20.8	14.9	12.7	17.5	38.7	42.5			0.95	11	
18-33	B22	57.9	32.3	9.8	2.9	7.1	11.1	20.4	16.4	12.8	19.5	40.5	41.5			0.92	16	

Pedon 26

Classification: Typic Fragiorthod, coarse-loamy, mixed, frigid.
Location: St. Lawrence County, N. Y., 8 km southeast of Canton on the Canton Agricultural and Technical Institute Farm.
Physiographic position: Near crest of glacial till ridge.
Topography: 8 percent southward slope with cradle knolls.
Vegetation: Cutover woodland with sugar maple (Acer saccharum), beech (Fagus grandifolia), black ash (Fraxinus nigra), hophornbeam (Ostrya virginiana), paper birch (Betula papyrifera), and hemlock (Tsuga canadensis).
Parent material: Glacial till, with low lying lacustrine deposits nearby.
Sampled by: J. G. Cady, M. G. Cline, D. F. Flora, D. P. Franzmeier, F. Z. Hutton, R. C. Marshall, and E. J. Pedersen. July 17, 1963.
Soil No.: S63NY-45-1.

Climatic data and soil water balance



Colors are for the moist soil.

O2 4-0 cm (1½-0 in.). Black (10YR 2/1) organic material with many white (10YR 8/1) fine and very fine sand grains; moderate medium and coarse granules and weak fine subangular blocks dangle from a network of fine roots when the material is removed; filled with roots and permeated by rodent burrows 3 cm in diameter. Laterally, mixing with inorganic material varies greatly in the pedon, and the characteristics of the horizon approach those of an A1.

A2 0-4 cm (0-1½ in.). Brown (7.5YR 5/2) fine sandy loam; very weak very fine granular structure; very friable (moist); many fine and medium roots; includes pockets of material from O22 horizon; no evidence of small animal burrows, although material from the A2 has been brought to the surface in places; no stones; 0 to 8 cm thick; abrupt wavy boundary.

B21 4-18 cm (1½-7 in.). Dark brown to brown (7.5YR 4/4) fine sandy loam; colors grade from dark brown (7.5YR 3/3) in upper part to dark yellowish brown (10YR 4/4) in lower part; very weak very fine granular structure; very friable (moist); few fragments coarser than 8 cm; 13 to 23 cm thick; gradual wavy boundary.

B22 18-33 cm (7-13 in.). Dark yellowish brown (10YR 4/4) fine sandy loam; material breaks out in fragile medium and fine fragments which crush to very weak very fine granules; very friable (moist); many medium and fine roots; few fragments coarser than 8 cm; 10 to 23 cm thick; diffuse wavy boundary.

B3 33-51 cm (13-20 in.). Dark yellowish brown (10YR 4/4) fine sandy loam; breaks out in irregular fine to medium fragments, some of which appear to be incipient peds; these crush to very weak very fine granules; slightly firm in spots to friable (moist) in others; common fine roots; few fragments coarser than 8 cm, but more than in horizons above; common tubular voids less than 1 mm in diameter; 13 to 28 cm thick; abrupt wavy boundary.

IIA'2x 51-71 cm (20-28 in.). Brown to dark brown (10YR 4/3) when crushed; fine sandy loam; surfaces of broken peds have a background color of grayish brown (10YR 5/2) from which light brownish gray (10YR 6/2) and light gray (10YR 7/2) sand grains protrude; massive; very firm in place, very firm and brittle to crush (moist); discontinuous 2 to 6 mm wavy horizontal bands of brown (10YR 4/3) material are spaced 3 to 8 cm apart; horizontal and vertical tubular cavities spaced 6 to 25 mm apart have light gray (10YR 7/2) silt-like linings; locally the horizon contains few discontinuous 1 cm layers of yellowish brown (10YR 5/4) fine sandy loam like B3; a very few roots extend into the horizon; 13 to 28 cm thick; clear wavy boundary.

IIB'2x 71-105 cm (28-42 in.). Brown and dark brown (7.5YR 4/2) when crushed; fine sandy loam; surfaces of broken peds range from brown (7.5YR 5/2) to dark grayish brown (10YR 4/2) and have irregular 6 mm bands of dark brown and brown material spaced 6 to 25 mm apart. The material breaks crudely into fine angular block-like fragments with fewer pressure faces and distinctly more cohesive than the horizon above; the 7.5 YR portions are the more cohesive: firm in place, firm and moderately brittle to crush (moist); in the dark grayish brown (10YR 4/2) portions, surfaces of broken peds have a coating of clean sand grains, but these are absent in the dark brown and brown (7.5YR 4/2) material. No clay coats on faces; common ½ mm tubular pores have smooth linings that may be clay; common dark brown fragments of weathered sandy limestone; a few fine roots are present and are more conspicuous than in horizon above.

Pedon 27

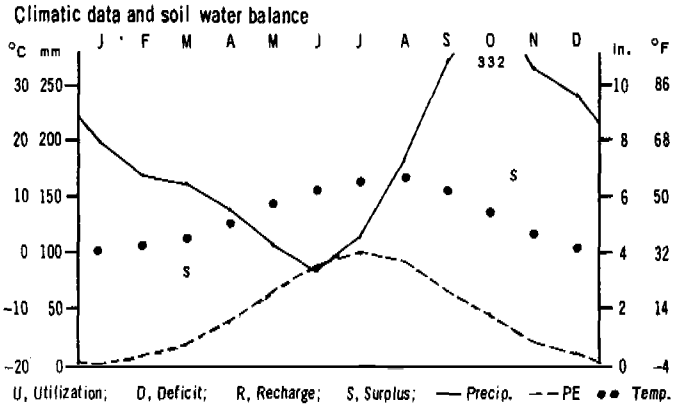
SOIL Cryic Placohumod SOIL Nos. S67Ak-51-2 LOCATION Kruzof Island, Alaska

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 67133 - 67143

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1														Coarse fragments 1A2a		
		Total			Sand					Silt								
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1			> 2 Pct. of whole soil	2-19	19-76
		Pct. of <2 mm															Pct. of <76mm	

Pedon 27

Classification: Cryic Placohumod, thixotropic.
Location: Kruzof Island, Alaska. NW1/4NW1/4 sec. 22, T. 54 S., R. 61 E. Approximate longitude 135°40' W., latitude 57°11' N.
Physiographic position: Hilly uplands, elevation about 137 m.
Topography: Southeast-facing, smooth 10 percent slope.
Drainage: Well drained.
Vegetation: Hemlock (Tsuga heterophylla) - Sitka spruce (Picea sitchensis) forest, logged.
Parent material: Volcanic cinders, deposited about 8,000 years B.P.
Sampled by: K. W. Flach, W. M. Johnson, F. R. Stephens, S. Rieger, July 22, 1967.
Remarks: The soil is highly thixotropic below the A2 horizon and has a positive reaction to the Fieldes test for allophane. The soil does not disperse well, hence the field estimates of texture are given in the profile description.
Soil No.: S67Ak-51-2.



Colors are for moist soil.

O1 25-8 cm (10-3 in.). Reddish black (10R 2/1) partially decomposed forest litter; thin ash lenses; many roots; abrupt wavy boundary.

O2 8-0 cm (3-0 in.). Reddish black (10R 2/1) and very dusky red (10R 2/2) muck; many roots; abrupt wavy boundary.

A2 0-5 cm (0-2 in.). Gray (10YR 5/1) very fine sandy loam; very weak thin plates breaking to very fine subangular blocks; very friable (moist), nonsticky and nonplastic (wet); few roots; very thin layer of reddish yellow (7.5YR 6/6) silty volcanic ash at top of horizon; 4 percent porous gravel by volume; abrupt irregular boundary.

A3 5-8 cm (2-3 in.). Very dark gray (10YR 3/1) and dark grayish brown (10YR 4/2) silt loam; weak fine subangular blocky structure; friable (moist), thixotropic (wet); few roots; 3 percent porous gravel by volume; abrupt broken boundary.

B21h 8-20 cm (3-8 in.). Black (5YR 2/1) mucky silt loam; weak coarse prismatic structure with thin shiny coatings on peds; thixotropic (wet); few roots; 5 percent porous gravel by volume; abrupt irregular boundary, with some narrow tongues extending to 81 cm.

B22h 20-30 cm (8-12 in.). Yellowish red (5YR 5/6) sandy loam; weak coarse prismatic structure, with dark reddish brown (5YR 3/4) coatings on peds; few vertical cracks coated with dark reddish brown (2.5YR 2/4) and black (N 2/); thixotropic (wet); no roots; few firm (moist) gray patches at base of horizon; 1 percent gravel by volume; abrupt broken boundary.

B23irm 30-33 cm (12-13 in.). Dark reddish brown (2.5YR 3/4) silt loam; moderate fine to medium angular blocky structure; interiors of peds, which are weathered pumice fragments, are red (2.5YR 4/6); irregular seams of dark reddish brown (2.5YR 2/4); firm to very firm (moist), thixotropic (wet); no roots; horizon is roughly horizontal, but is involute.

B31 33-56 cm (13-22 in.). Strong brown (7.5YR 5/6) and yellowish red (5YR 4/6) silt loam; massive, but the soil consists of highly weathered pumice particles with yellow (10YR 7/8) interiors that make up about 30 percent of the volume of the horizon; irregular dark reddish brown (2.5YR 3/4) streaks; thixotropic (wet); no roots; gradual boundary.

B32 56-91 cm (22-36 in.). Same as horizon above, except that yellow pumice interiors make up about 50 percent of the volume of the horizon.

B33 91-190 cm (36-75 in.). Same as above, but sampled separately.

C 190-230 cm (75-90 in.). Yellow (10YR 7/8) slightly weathered pumice of fine gravel size.

Pedon 28

SOIL Typic Haplaquoll SOIL Nos. S63Ill-12-1 LOCATION Clark County, Ill.

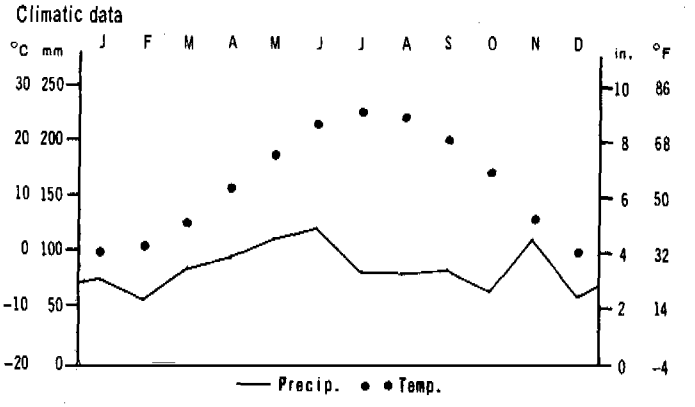
SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 19297-19303

General Methods: 1A, 1B1b, 2A1, 2B

Depth	Horizon	Size class and particle diameter (mm) a/ 3A1															
		Total			Sand					Silt						Coarse fragments 2A2	
		Sand	Silt	Clay	Very coarse	Coarse	Medium	Fine	Very fine		Int. III	Int. II					3B1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2-20

Pedon 28

Classification: Typic Haplaquoll, fine-loamy, mixed, mesic.
Location: Clark County, Ill. 87 m E. and 27 m N. of road center at SW. corner of NW 1/4 sec. 15, T. 9 N., R. 11 W. About 250 km (155 mi.) S. of Chicago.
Physiographic position: Wabash River valley floor. Elevation about 200 m.
Topography: Nearly level.
Drainage: Poorly drained; slow runoff; moderate permeability.
Vegetation: Cultivated.
Parent material: Alluvium.
Sampled by: G. Holhubner, I. Jorgensen, L. E. Tyler and G. O. Walker, October 17, 1963.
Remarks: Some recent overwash appears to be incorporated in Ap and A12 horizons.
Soil No.: S63Ill-12-1.



Colors are for the moist soil unless otherwise indicated.

Ap 0-15 cm (0-6 in.). Very dark grayish brown (10YR 3/2) light silty clay loam; weak medium granular structure; friable (moist); sand grains evident in matrix; abundant roots; slightly acid; abrupt smooth boundary.

A12 15-30 cm (6-12 in.). Very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2) light clay loam; weak coarse subangular blocky structure; firm (moist); sand grains evident in matrix; abundant roots; slightly acid; abrupt smooth boundary.

B1g 30-41 cm (12-16 in.). Dark gray (10YR 4/1) light clay loam; common fine distinct dark brown (10YR 4/3 and 3/3) mottles; gray (10YR 6/1 and 6/2) dry; dark grayish brown (2.5Y 4/2) crushed; weak to moderate fine and medium subangular blocky structure; firm (moist); sand grains evident in matrix and sparse gray silt coats on peds (dry); abundant roots; strongly acid; clear smooth boundary.

B21g 41-64 cm (16-25 in.). Dark gray (10YR 4/1) light clay loam with common fine distinct dark brown (7.5YR 3/2 and 4/4) mottles in ped interiors only; moderate fine and medium prisms break to weak to moderate medium subangular blocks; firm (moist); discontinuous very dark gray (10YR 3/1) dull films on peds; sand grains evident in matrix; plentiful roots and many iron-manganese concretions; strongly acid; gradual smooth boundary.

B22g 64-89 cm (25-35 in.). Dark gray (2.5Y 4/1) light clay loam with common fine to medium distinct brown (10YR 5/3), yellowish brown (10YR 5/6), and strong brown (7.5YR 5/8) mottles principally in ped interiors; moderate fine and medium prisms break to weak medium subangular blocks; firm (moist); discontinuous, very dark gray (10YR 3/1) dull films on peds; sand grains evident in matrix; few roots; medium acid; gradual smooth boundary.

B3g 89-115 cm (35-45 in.). Dark gray (2.5Y 4/1) sandy clay loam with many medium distinct dark brown (7.5YR 3/2) and strong brown (7.5YR 4/6) mottles; weak vertical cleavage grades to massive; friable to firm (moist); few iron-manganese concretions; occasional pebbles; medium acid; gradual wavy boundary.

Cg 115-155 cm (45-62 in.). Dark gray (2.5Y 4/1) with many medium distinct dark yellowish brown (10YR 3/4) to dark brown (7.5YR 4/4) and few fine distinct strong brown (7.5YR 4/6 to 4/8)mottles; pockets and layers of sandy clay loam, clay loam and silty clay loam; massive; friable (moist); occasional pebbles; common iron-manganese concretions; medium acid; crayfish activity evident in this horizon.

Pedon 29

SOIL Typic Dystrochrept SOIL Nos. S58WVa-13-3 LOCATION Greenbrier County, West Virginia

SOIL SURVEY LABORATORY Beltsville, Maryland and Lincoln, Nebraska LAB. Nos. 10496 - 10499

General methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Silt (0.05-0.002)	Clay (< 0.002)	Sand b/ Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt 0.05-0.02	Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1 2A2 > 2 a/ Pct.	2-19	19-76
		Pct. of < 2 mm															Pct. of < 76mm	
0-5	A11	23.6	60.4	16.0	0.6	1.5	1.1	6.0	14.4	24.7	35.7	41.7	9.2			tr.		
5-18	A12	19.7	62.1	18.2	0.2	1.0	0.9	4.8	12.8	22.8	39.3	39.2	6.9			tr.		
18-33	B2	12.4	64.4	23.2	0.1	0.8	0.7	3.2	7.6	20.9	43.5	30.7	4.8			tr.		
33-58	C	10.3	69.5	20.2	0.1	0.5	0.8	2.6	6.4	27.6	41.9	35.7	3.9			tr.		
58+	R																	

Depth (cm)	6A1a Organic carbon c/ Pct.	6B1a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density 4A1a Field moist g/cc	4A1e 1/3-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content 4B1c 1/10-bar Pct.	4B1c 1/3-bar Pct.	4B2 15-bar Pct.		4C1 WRD	pH 8C1c (1:1) KCl	8C1a (1:1) H_2O
0-5	5.48	0.247	22			1.6					45.3	34.5	9.8				5.1
5-18	1.13	0.071	16			1.8	1.41				32.8	27.9	6.5				4.9
18-33	0.33	0.045	7			2.2	1.72				29.0	25.7	8.5				4.7
33-58	0.14	0.040				2.8	1.85				24.6	23.1	8.4				4.7
58+																	

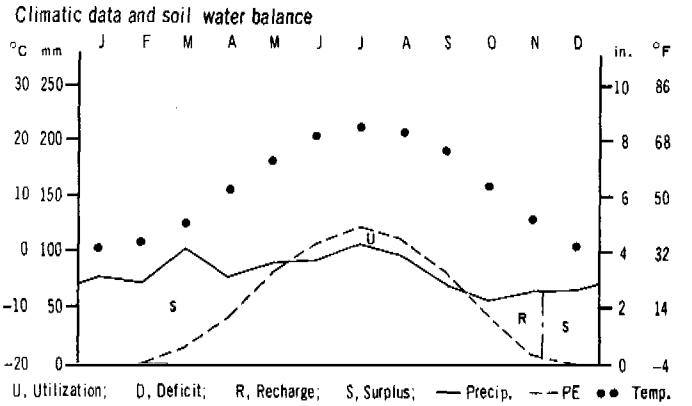
Depth (cm)	Extractable bases 5B1a 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity H	CEC 5A3a Sum cations	5A1a NH_4OAc	6G1d Ext. Al			Ratios to clay 8D1 CEC sum	Ext. iron	15-bar water	8O3 Ca/Mg		Base saturation 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-5	6.5	1.6	<0.1	0.6	8.7	14.7	23.4	16.2				1.46	0.10	0.61	4.1		37	54
5-18	1.0	0.6	<0.1	0.3	1.9	9.5	11.4	8.4				0.63	0.10	0.36			17	23
18-33	0.7	1.0	<0.1	0.2	1.9	9.7	11.6	8.7				0.50	0.09	0.37			16	22
33-58	0.7	1.4	<0.1	0.2	2.3	10.0	12.3	9.7				0.61	0.14	0.42			19	24
58+																		

Depth cm	Clay fraction d/ analysis 7A2 X-ray e/	7A3 DTA Pct.	7C2 Ratio SiO_2/R_2O_3	7C2 Whole soil analysis Al_2O_3 Pct.	Fe_2O_3 Pct.	SiO_2 Pct.	Ratio SiO_2/R_2O_3
0-5	VR3,MI1	KK10	2.1	9.6	4.3	69.2	9.5
5-18	VR3,MI1	KK15	2.1	11.4	4.3	73.6	8.8
18-33	VR2,MI2	KK10	2.2	15.5	5.8	68.3	6.0
33-58	MI3,VR2	KK20	2.2	16.1	7.1	64.5	5.3
58+							

a/ Coarse fragments slaked in water and dispersant.
b/ Many ferruginous concretions.
c/ 5.6 kg/m² to 0.58 m (method 6A) (bulk density of A1 horizon estimated).
d/ Mineral code:
VR = vermiculite
MI = mica
KK = kaolinite
e/ Approximate weight fraction (X-ray):
5 = more than half
4 = half to one-third
3 = one-third to one-fifth
2 = one-fifth to one-twentieth
1 = less than one-twentieth

Pedon 29

Classification: Typic Dystrochrept, fine-silty, mixed, mesic.
Location: Greenbrier County, W. Va., 5 km SW of Smoot.
Physiographic position: Rolling and hilly uplands. Elevation 732 m.
Topography: Dissected, somewhat rounded low hills, strongly to steeply sloping; slope 25 percent.
Drainage: Well drained.
Vegetation: Mixed oak (Quercus), hickory (Carya), yellow poplar (Liriodendron tulipifera), cucumber tree (Magnolia acuminata).
Parent material: Red siltstone shales and sandstone from the Mauch Chunk formation which may effervesce with hydrochloric acid in places in deep cuts.
Sampled by: Klaus Flach, Daniel Bohrer, Boyd J. Patton, Leonard Newman, and John L. Gorman.
Soil No.: S58WVa-13-3.



Colors are for the dry soil unless otherwise indicated.

O1 8-1 cm (3-1/2 in.). Continuous hardwood leaf litter.

O2 1-0 cm (1/2-0 in.). Compacted hardwood leaf mull.

A11 0-5 cm (0-2 in.). Dark reddish brown (5YR 3/3) light silt loam with moderate fine granular structure; very friable (moist); clear wavy boundary.

A12 5-18 cm (2-7 in.). Reddish brown (5YR 3/3 heavy silt loam with weak fine subangular and very weak fine platy structure; very friable (moist); clear wavy boundary.

B2 18-33 cm (7-13 in.). Dark reddish brown (5YR 3/4) heavy silt loam with moderate fine and medium subangular blocky structure; friable (moist); discontinuous pressure faces on some peds; clear wavy boundary.

C 33-58 cm (13-23 in.). Dark reddish brown (5YR 3/4) heavy silt loam with 75 percent channery siltstone; massive breaking to weak medium subangular blocks; clear wavy boundary.

R 58+ cm (23+ in.). Red siltstone.

Pedon 30

SOIL Typic Hapludoll SOIL Nos. S58Iowa-43-8 LOCATION Harrison County, Iowa

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 9606-9610

General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: a/ Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-20	A1	3.6	73.8	22.6	-	-	-	0.1	3.5	49.7	24.1	53.3	0.1					-
20-41	A3	4.6	72.7	22.7	-	-	-	0.2	4.4	49.4	23.3	53.9	0.2					-
41-64	B21	4.8	73.1	22.1	-	0.1	0.1	0.2	4.4	49.5	23.6	54.0	0.4					-
64-91	B22	5.5	75.4	19.1	0.1	0.1	0.1	0.3	4.9	51.0	24.4	56.1	0.6					-
91-125	C1	6.0	78.2	15.8	-	0.1	0.1	0.5	5.3	52.2	26.0	57.8	0.7					-

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N		6E1a Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density g/cc	Bulk density g/cc	Bulk density g/cc		Water content Pct.	Water content Pct.	4B2 15-bar Pct.			pH		8C1a (1:1) H_2O
0-20	2.86	0.247	12		tr	1.0							12.3					7.1
20-41	0.85	0.089	10		tr	1.1							10.2					7.3
41-64	0.49	0.057	8		tr	1.1							10.1					7.4
64-91	0.41				tr	1.1							9.5					7.6
91-125	0.19				6	0.8							8.7					7.9

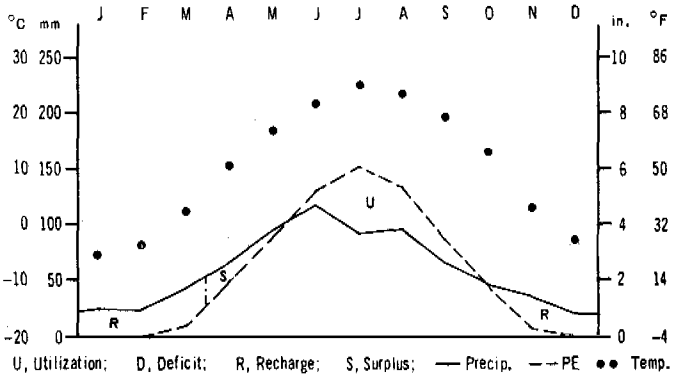
Depth (cm)	Extractable bases 5B1a: Ca	6O2b Mg	6P2a Na	6Q2a K		6H1a Ext. acidity	Cat. exch. cap.	5A1a NH_4PAc			Ratios to clay 8D1: NH_4OAc CEC		15-bar water			Base saturation Pct.	Pct.
	meq/100 g																
0-20		3.5	tr	1.0		3.3		16.9			0.75		0.54				
20-41		3.5	tr	0.7		2.0		13.0			0.57		0.45				
41-64		4.0	tr	0.7		1.6		11.2			0.51		0.46				
64-91		5.6	tr	0.7		1.2		14.1			0.74		0.50				
91-125		5.5	tr	0.8		-		14.1			0.89		0.55				

a/ Iron-manganese nodules comprise much of the sand coarser than 0.1 mm.

Pedon 30

Classification: Typic Hapludoll, fine-silty, mixed, mesic.
Location: Harrison County, Iowa, 113 m E. of NW. corner NE 1/4 SE 1/4 sec. 8, T. 79 N., R. 43 W., about 45 km (30 mi.) N. of Omaha, Nebr.
Physiographic position: Rolling to hilly upland.
Topography: Strongly sloping, 15 percent NE.
Drainage: Well drained, moderately permeable.
Vegetation: Partly timbered bluegrass (Poa arida) pasture, about 25 percent stand of oak (Quercus spp.), walnut (Juglans spp.), elm (Ulmus spp.) and ash (Fraxinus spp.).
Parent material: Wisconsinan age loess (post-Farmdale).
Sampled by: R. B. Daniels and G. H. Simonson, October 8, 1958.
Soil No.: S58Iowa-43-8.

Climatic data and soil water balance



Colors are for the moist soil unless otherwise indicated.

A1 0-20 cm (0-8 in.). Black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry, very dark gray (10YR 3/1) crushed; moderate fine to medium granular structure; friable (moist); gradual boundary.

A3 20-41 cm (8-16 in.). Very dark grayish brown (10YR 3/2) heavy silt loam, dark grayish brown (10YR 4/2) dry, abundant mixing of black (10YR 2/1) and dark brown (10YR 3/3), very dark grayish brown (10YR 3/2) crushed; weak fine subangular blocky structure; friable (moist); abundant wormcasts; gradual boundary.

B21 41-64 cm (16-25 in.). Dark brown (10YR 3/3) and brown to dark brown (10YR 4/3) heavy silt loam, brown (10YR 5/3) to pale brown (10YR 6/3) dry, brown to dark brown (10YR 4/3) crushed; weak fine to medium subangular blocky structure; friable (moist); abundant wormcasts; gradual boundary.

B22 64-91 cm (25-36 in.). Brown to dark brown (10YR 4/3) heavy silt loam, brown (10YR 5/3) crushed; massive to very weak medium subangular blocky structure; friable (moist); common wormcasts; abrupt boundary.

C 91-125 cm (36-49 in.). Brown (10YR 5/3) light silt loam, few fine faint mottles grayer and browner than 10YR 5/3; structureless, massive; friable (moist); few to common wormcasts; calcareous.

SOIL Pedon 31 Typic Camborthid SOIL Nos. S60NMex-7-4 LOCATION Dona Ana County, N. Mex.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 13136-13141

General Methods: 1A1, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2 Vol. c/ 250–2 %	Wt. 3B1 75–2 %	20–2 %
		Pct. of < 2 mm a/, b/ Carbonate removed																
0–8	A1	63.0	27.7	9.3	11.3	9.0	4.2	14.7	23.8	19.2	8.5	52.6	39.2			50	65	46
8–25	B21	62.4	25.6	12.0	16.1	10.3	3.7	11.8	20.5	17.4	8.2	45.2	41.9			40	57	39
25–43	B22	59.9	26.6	13.5	19.2	10.7	3.3	9.8	16.9	17.7	8.9	40.7	43.0			50	68	44
43–74	C1ca	60.0	28.2	11.8	18.0	10.5	3.8	10.5	17.2	18.8	9.4	42.2	42.8			50	68	36
74–110	C1ca	60.7	27.4	11.9	15.5	11.5	5.0	12.2	16.5	17.8	9.6	41.1	44.2			80	89	16
110–130	C2ca	54.7	32.7	12.6	12.1	11.1	5.1	11.2	15.2	19.3	13.4	40.6	39.5			70	84	18

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe a/ Pct.	Carbonate as $CaCO_3$ <2 mm c/, d/ Pct.	<0.002 mm Pct.	Bulk density g/cc	g/cc	4B5 Air-dry g/cc	5A1a CEC NH_4OAc a/ meq/100 g	Water content Pct.	Pct.	Pct.			pH (1:1)	
0–8	0.33	0.038	9		tr					7.5							
8–25	0.35	0.041	8	0.6	-				1.35	8.4							
25–43	0.38				tr					9.6							
43–74	0.26				2					9.3							
74–110	0.18				4					8.7							
110–130	0.18				3					10.2							

Depth (cm)	Clay fraction e/ mineralogy 7A1: 7A2 f/ X-ray	7A3 DTA Pct.	0.05-0.02 mm fraction e/ mineralogy: 7B1 Petrographic g/ Pct.	Base saturation Pct.	Pct.
0–8					
8–25					
25–43	MV3,MT2,MI2	KK15			
43–74			FD65,QZ20,MI15		
74–110					
110–130					

a/ Carbonate removed by method 1B3 and the determination reported for the sample so treated.
b/ In contact overnight with 0.1N NaOH in addition to regular treatments to aid disaggregation.
c/ Bulk density of 1.3 g/cc assumed for fine-earth fabric; less than 5 percent greater than 75 mm.
d/ Determination on whole material by method 6E1a, 6E1c and 6E2a and calculated as a percentage of the < 2 mm.
e/ Mineral code:
- MV = interstratified montmorillonite-vermiculite
- MT = montmorillonite
- MI = mica
- KK = kaolinite
- FD = feldspar
- QZ = quartz

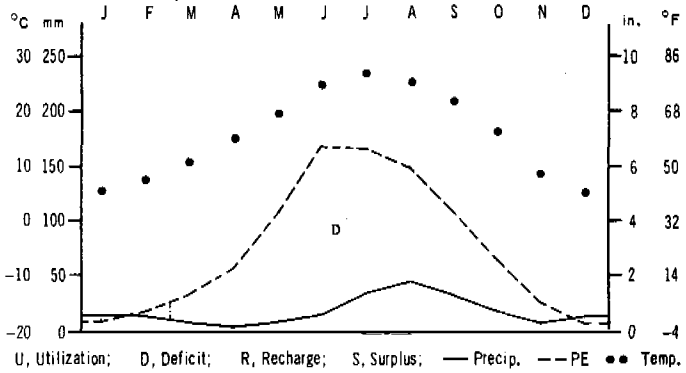
f/ Approximate weight fractions:
- 3 = one-fifth to one-third
- 2 = one-twentieth to one-fifth

g/ Hornblende and epidote were identified; about 80 percent of feldspar and mica is altered.

Pedon 31

Classification: Typic Camborthid, loamy-skeletal, mixed, thermic.
Location: Dona Ana County, N. Mex. SW 1/4 NW 1/4 sec. 23, T. 23 S., R. 3 E. 14 km (9 mi.) E. of center of Las Cruces.
Physiographic position: Alluvial fan; elevation 1,500 m.
Topography: 7 percent slope to W.
Vegetation: Scattered bunches of black grama (Bouteloua eripoda), numerous bunches of fluffgrass (Tridens pulchellus), snakeweed (Gutierrezia sarothrae), mesquite (Prosopis julijeora), Mormon tea (Ephredra spp.).
Parent material: Fan alluvium derived from rhyolite.
Sampled by: L. H. Gile, R. B. Grossman, J. L. Millet and F. F. Peterson, April 12, 1960.
Remarks: Site on the Organ geomorphic surface of Holocene age. Measurements in the general area indicate that the current dust fall contains carbonate.
Soil No.: S60NMex-7-4.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

Soil surface. Angular pebbles of rhyolite cover 80 to 90 percent of the soil surface.

A1 0-8 cm (0-3 in.). Brown (7.5YR 5.5/4) very gravelly fine sandy loam, dark brown (7.5YR 3.5/2) moist; weak medium plates; soft (dry); abundant fine roots; noncalcareous; clear smooth boundary.

B21 8-25 cm (3-10 in.). Reddish brown (6YR 5/4) very gravelly coarse sandy loam, dark reddish brown (5YR 3/3) moist; partly massive, partly weak very fine granules, and partly fine to very fine subangular blocks controlled by pebble surfaces; soft (dry) and slightly hard (dry); plentiful roots; pebbles have thin discontinuous coatings of loamy material; noncalcareous; clear wavy boundary.

B22 25-43 cm (10-17 in.). Reddish brown (6YR 5/4) very gravelly coarse sandy loam, dark reddish brown (5YR 3/3) moist; massive and weak very fine granules; soft (dry); plentiful roots; loamy material adheres discontinuously to pebbles; noncalcareous; clear wavy boundary.

C1ca 43-110 cm (17-43 in.). Brown (7.5YR 5/4) very gravelly coarse sandy loam, dark brown (7.5YR 3.5/4) moist; massive and single grain; loose (dry) and slightly hard (dry); plentiful roots; carbonate occurs on pebbles as continuous coatings and as filaments; strongly effervescent; horizon split at 74 cm for sampling; clear wavy boundary.

C2ca 110-130 cm (43-51 in.). Light brown (7.5YR 5.5/4) very gravelly fine sandy loam, dark brown (7.5YR 3.5/4) moist; single grain; loose (dry); few roots; carbonate occurs on pebbles as discontinuous thin coatings and as occasional filaments; strongly effervescent.

SOIL Pedon 32 Typic Acrustox SOIL Nos. DPFS 83 GO LOCATION Brazil, Federal District

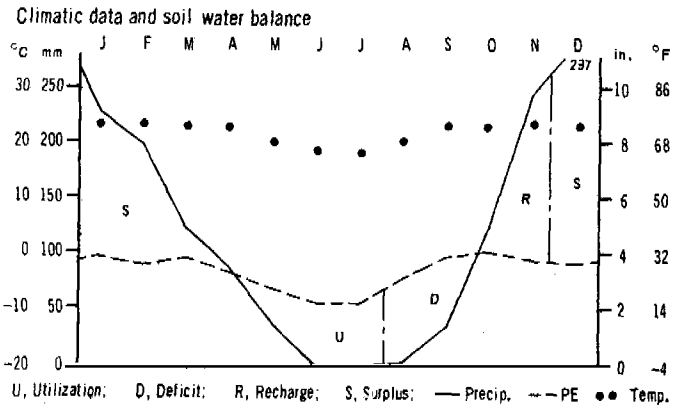
SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 67B286 - 67B291

General methods: 1A, 1B1b, 2A1, 2B

Depth	Horizon	1B1b Total Sand	Total Silt	Total Clay	Size class and particle diameter (mm) 3A1 a/ Sand Very coarse	Coarse	Medium	Fine	Very fine	Silt	Int. III	Int. II	a/	Water dis-per.	3B2	Coarse fragments 3B1 2A2 ≥ 2	2 - 19	19 - 76

Pedon 32

Classification: Typic Acrustox, clayey, oxidic, isohyperthermic.
Location: 7.1 km toward Planaltina from Estadio de Brasilia, Federal District, Brazil.
Physiographic position: Top of the Brasilia Plateau, elevation of 1,100 m.
Topography: Nearly level with gradient 1 to 3 percent, and slope lengths of several km.
Drainage: Well drained.
Vegetation: Small trees and shrubs, formerly subjected to annual or biennial fires (cerrado).
Parent material: Derived from slates of Bambui series, referred to Silurian; seemingly weathered in place but probably transported.
Sampled by: Collected under the direction of Marcello Nunes Carmargo, Brazilian Ministry of Agriculture, D.P.E.A., D.P.F.S. (Division of Pedology and Soil Fertility).
Soil No.: DPFS 83 GO.
Remarks: Many pores throughout the pedon with diameters less than 1 mm predominant.



Colors are for the moist soil unless otherwise indicated.

A1 0-10 cm (0-4 in.). Dark reddish brown (2.5YR 3/4) heavy clay with dark reddish brown (2.5YR 3/3) ped surfaces, red (2.5YR 5/6) with red (2.5YR 4/6) ped surfaces dry; weak very fine to medium granular structure; very friable (moist); sticky and plastic (wet); many roots; clear smooth boundary.

A3 10-30 cm (4-12 in.). Red (2.5YR 3.5/6) heavy clay with dark red (2.5YR 3.5/5) ped surfaces, yellowish red (5YR 4.5/6) with reddish brown (2.5YR 4/4) ped surfaces dry; some parts are weak very fine to medium granular and other parts appear massive, porous and slightly coherent in place, breaking with slight pressure to very fine granules; firm (moist), sticky and plastic (wet); many roots; gradual smooth boundary.

B1 30-65 cm (12-25 in.). Red (10R 4/6) heavy clay; appears massive, porous, and slightly coherent in place, breaking with slight pressure to very fine granules; sticky and plastic (wet); common roots; diffuse smooth boundary.

B21 65-140 cm (25-55 in.). Red (10R 4/7) heavy clay; appears massive, porous and slightly coherent in place, breaking with very slight pressure to very fine granules; sticky and plastic (wet); common roots; diffuse smooth boundary.

B22 140-235 cm (55-93 in.). Red (10R 4/7) clay; appears massive, porous and slightly coherent in place, breaking with very slight pressure to very fine granules; sticky and plastic (wet); common roots; diffuse boundary.

B23 235-310 cm (93-122 in.). Red (10R 4.5/6) clay; appears massive, porous and slightly coherent in place; breaking with very slight pressure to very fine granules; sticky and plastic (wet); few roots.

SOIL Pedon 33 Tropeptic Haplorthox SOIL Nos. S59PR-10-8 LOCATION Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 12846-12856

General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: a/ Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	3A1c Water-disp. clay <0.002		Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-15	Ap	5.3	17.6	77.1	0.3	0.5	0.6	1.7	2.2	3.3	14.3	6.5	3.1	47				tr
15-33	B21	6.0	17.2	76.8	0.1	0.6	0.7	2.0	2.6	3.6	13.6	7.4	3.4	tr				tr
33-51	B22	3.1	13.0	83.9	0.1	0.2	0.3	1.0	1.5	1.4	11.6	3.5	1.6					-
51-86	B23	1.9	14.9	83.2	tr	0.2	0.2	0.6	0.9	2.3	12.6	3.6	1.0					-
86-115	B24	5.7	23.9	70.4	0.2	0.6	0.6	1.9	2.4	4.7	19.2	8.3	3.3					tr
115-150	B25	11.6	35.7	52.7	0.3	1.2	1.3	4.3	4.5	7.4	28.3	14.4	7.1					tr
150-185	B26	15.0	36.6	48.4	0.4	1.5	1.7	5.4	6.0	8.6	28.0	17.8	9.0					tr
185-215	C1	17.7	36.2	46.1	0.7	2.3	2.5	6.2	6.0	8.0	28.2	17.6	11.7					-
215-305	C2	9.6	46.2	44.2	0.1	0.6	0.8	3.3	4.8	7.8	38.4	14.7	4.8					tr
305-335	C3	13.5	44.3	42.2	1.0	1.6	1.2	3.9	5.8	9.9	34.4	18.1	7.7					tr

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ Pct.		Bulk density: 4A1a Field state g/cc		4A1h Oven-dry g/cc	4D1 COLE	Water content: 4B4 Field state Pct.	4B1b 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm		pH: 8C1c (1:1) N KCl	8C1a (1:1) H_2O
0-15	4.30	0.370	12	9.4			0.96		1.23	0.087	51.8	41.8	31.9	0.10		5.0	5.6
15-33	c/1.75	0.179	10	9.8			1.07		1.34	0.078	49.3	40.3	33.6	0.07		4.6	4.7
33-51	0.70	0.109	6	10.1			1.06		1.31	0.073	48.9	43.7	35.7	0.08		4.8	4.8
51-86	0.50	0.080	6	11.5			1.11		1.33	0.064	47.2	42.1	34.2	0.09		4.3	5.0
86-115	0.25	0.039	6	14.8			1.42		1.52	0.024	31.6	35.1	30.0	0.07		4.2	5.1
115-150	0.16			14.3			1.40		1.52	0.028	31.4	32.6	27.4	0.07		3.9	5.1
150-185	0.12			14.0			1.41		1.52	0.024	32.0	34.9	26.2	0.12		3.8	4.9
185-215	0.13			13.2									26.7			3.8	4.7
215-305	0.06			12.8									27.3			3.8	4.9
305-335	0.05			14.3									27.8			3.8	4.8

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap: 5A3a Sum cations	5A1a NH_4OAc	6G1d KCl-ext. Al		5A3b Bases plus Al me/100g clay	Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																
0-15	8.3	1.5	0.1	0.9	10.8	19.7	30.5	20.5				0.26	0.12	0.41		35	53
15-33	1.8	0.2	tr	0.5	2.5	18.8	21.3	10.6	0.3		3.6	0.14	0.13	0.44		12	24
33-51	1.4	0.2	tr	0.1	1.7	15.2	16.9	7.5	0.1		2.1	0.09	0.12	0.43		10	23
51-86	0.5	0.6	tr	tr	1.1	13.4	14.5	7.7	0.6		2.0	0.09	0.14	0.41		8	14
86-115	0.1	0.1	tr	tr	0.2	13.4	13.6	7.6	1.2		2.0	0.11	0.21	0.43		1	3
115-150	tr	0.2	tr	tr	0.2	14.1	14.3	8.4	2.3		4.7	0.16	0.27	0.52		1	2
150-185	0.1	0.1	0.1	tr	0.3	14.1	14.4	8.9	3.3		7.4	0.18	0.29	0.54		2	3
185-215	0.1	0.1	0.1	tr	0.3	14.1	14.4	8.7	3.5		8.2	0.19	0.29	0.58		2	3
215-305	0.1	0.2	0.1	tr	0.4	12.8	13.2	8.8	4.2		d/7	0.20	0.29	0.62		3	4
305-335	0.1	0.1	0.1	tr	0.3	13.4	13.7	7.9	3.6		d/6	0.19	0.34	0.66		2	4

Depth (cm)	Clay fraction e/ mineralogy 7A1: 7A2 X-ray f/	7A3 DTA Pct.	Silt fraction e/ mineralogy 7A1: 7A2 X-ray f/	7A3 DTA Pct.
0-15	VR2	KK30,GI15	QZ2	GI5
15-33				
33-51	GE2,VR2	KK35,GI25		
51-86				
86-115				
115-150				
150-185		KK40	QZ3	KK40
185-215				
215-305				
305-335				

Underlined if 15-bar to clay ratio exceeds 0.6, indicating that the non-clay probably has strong clay-like properties.

Temperatures were taken September 21, 1963, when the site was revisited:

Depth	Temperature	Depth	Temperature
40 in. 100 cm	24.2° C.	13 ft. 4 m	23.4° C.
5 ft. 150 cm	24.0° C.	18 ft. 5.5 m	23.0° C.
9 ft. 275 cm	23.7° C.		

a/ Earthy nodules: > 50 percent.

b/ 15 kg/m² to 1.5 m (Method 6A).

c/ Radiocarbon age is 1,780 ± 100 years before present (analysis by Isotopes, Inc., No. I-1908).

d/ Clay percentage estimated as 15-bar water percentage x 2.5.

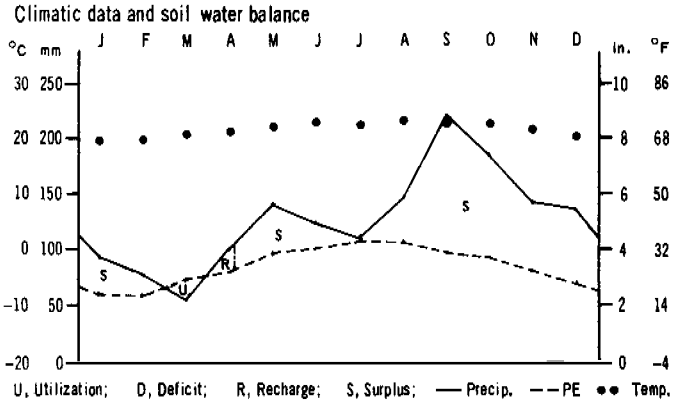
e/ Mineral code:
VR = vermiculite
KK = kaolinite
GI = gibbsite
QZ = quartz
GE = goethite

f/ Approximate weight fractions:
3 = one-fifth to one-third
2 = one-twentieth to one-fifth

Pedon 33

Classification: Tropeptic Haplorthox, clayey, oxidic, isohyperthermic.
Location: Puerto Rico. Barranquitas Soil Study Area; 14 m E. of field road and 142 m S. of house at kilometer marker 8.8, Highway 152. 40 km (25 mi.) SW. of San Juan.
Physiographic position: Elevation 585 m.
Topography: 8 percent south slope, 90 m above where the slope levels out.
Vegetation: Native pasture.
Parent material: Chloritized basaltic andesite flow breccia.
Sampled by: R. A. Boccheciamp, K. W. Flach, R. N. Gierbolini, R. B. Grossman and T. U. Yager, December 16, 1959.
Remarks: A few pieces of charcoal occur in the Ap. Nearly all pores appear tubular. Few sand-size quartz crystals or angular grains, some up to 3 mm across occur in the C2, C3 and C4 horizons. Apparently the auger cut a quartz vein. Two terms are used to describe the rate of failure of natural fabric. Fails abruptly and fails semiplastically. To fail abruptly means that no plasticity is observed prior to failure. Stress builds up

Climatic data and soil water balance



as the piece of soil is squeezed and dissipates quickly as the piece of soil breaks apart into numerous fragments or peds due to failure along natural planes of weakness. In semiplastic failure, deformation is readily observed prior to rupture.
Soil No.: S59PR-10-8.

Colors are for the moist soil.

Ap 0-15 cm (0-6 in.). Dark reddish brown (5YR 3/3) clay with 10 percent reddish brown (2.5YR 4/4); massive in the upper part to weak fine granules in the lower part; friable (moist), slightly sticky and plastic (wet); abundant roots; many sand-size aggregates; abrupt smooth boundary.

B21 15-33 cm (6-13 in.). Dark reddish brown (2.5YR 3/4) clay; moderate medium to fine angular to subangular blocky structure; firm (moist), slightly sticky and plastic (wet); fails semiplastically to abruptly; plentiful roots; few fine and common

very fine pores; many soft black sand-size aggregates; clear boundary.

B22 33-51 cm (13-20 in.). Dark reddish brown (2.5YR 3/4) clay with some ped surfaces having slightly lower chroma; moderate to weak medium to fine subangular to angular blocky structure; firm (moist), slightly sticky and plastic (wet); fails abruptly to semiplastically; plentiful roots; few fine and common very fine pores; no pressure faces; few sand-size aggregates; clear wavy boundary.

B23 51-86 cm (20-34 in.). Reddish brown (2.5YR 4/5) clay with a few reddish brown (2.5YR 4/4) ped surfaces; weak fine angular and subangular blocky structure; firm (moist), slightly sticky and plastic (wet); fails abruptly; very few roots; few fine and common very fine pores; pressure faces common with a few surfaces striated; possibly a few thin patchy clay skins; very few sand-size aggregates; clear smooth boundary.

B24 86-115 cm (34-46 in.). Dark reddish brown (2.5YR 3/4 to 4/4) clay; weak fine angular blocky structure; firm (moist), slightly sticky and plastic (wet); fails abruptly; few roots; few fine and many very fine pores; pressure faces common with a few surfaces striated and possibly some thin patchy clay skins; very few sand-size aggregates; gradual boundary.

B25 115-150 cm (46-60 in.). Dark reddish brown (2.5YR 3/4) clay; weak fine angular blocky structure; firm (moist), nonsticky and plastic (wet); fails abruptly; very few roots; few fine and common very fine pores; pressure faces common with a few surfaces striated; possibly some thin patchy clay skins; very few sand-size aggregates; clear smooth boundary.

B26 150-185 cm (60-72 in.). Dark reddish brown (2.5YR 3/4) clay; weak fine angular blocky structure; firm (moist), nonsticky and plastic (wet); fails abruptly; many fine and common very fine pores; pressure faces common; possibly some thin patchy clay skins; very few sand-size quartz grains; 2 percent saprolite; arbitrary boundary.

C1 185-215 cm (72-84 in.). Dark reddish brown to dark red (2.5YR 3/4 to 3/6) clay; firm (moist), nonsticky and plastic (wet); 25 percent saprolite; arbitrary boundary.

C2 215-305 cm (84-120 in.). Dusky red (10R 3/4) and dark reddish brown (2.5YR 3/4) silty clay loam matrix with strong brown (7.5YR 5/8) and gray (N 5/0) splotches; firm (moist), nonsticky and plastic (wet); 75 percent saprolite; arbitrary boundary.

SOIL Pedon 34 Glossic Fragiudalf SOIL Nos. S59Ky-56-3 LOCATION Jefferson County, Kentucky

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 59450 - 59458

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1 Total: Sand (2-0.05)	Silt (0.05-0.002)	Clay (< 0.002)	Sand: Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt: 0.05-0.02	Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 > 2 Pct.	2-19	19-76
		Pct. of < 2 mm															Pct. of < 76mm	
0-15	Ap	3.3	83.5	13.1	0.1	0.2	0.2	0.3	2.6	44.2	39.3	46.9	0.8		1.0	tr.		
15-33	B1t	2.7	72.7	24.6	-	-	0.1	0.2	2.4	31.9	40.8	34.4	0.3		1.0	tr.		
33-61	B21t	3.3	74.6	22.1	-	-	-	0.2	3.1	41.4	33.2	44.5	0.2		1.0	tr.		
61-81	B22t	4.2	78.3	17.5	-	0.1	0.1	0.3	3.7	45.3	33.0	49.1	0.5		1.0	tr.		
81-94	A'2	8.7	76.7	14.6	0.1	0.1	0.3	0.6	7.6	43.2	33.5	51.2	1.1		1.0	tr.		
94-120	B'21x	4.2	77.6	18.2	-	0.2	0.2	0.4	3.4	45.0	32.6	48.6	0.8		1.0	tr.		
120-135	B'22x	2.9	77.9	19.2	-	0.1	0.1	0.3	2.4	44.8	33.1	47.4	0.5		1.0	tr.		
135-150	B'23x	1.9	70.9	27.2	-	0.1	0.1	0.2	1.5	30.1	40.8	31.7	0.4		1.0	tr.		
150-200	C	2.1	79.1	18.8	-	0.1	0.1	0.2	1.7	36.4	42.7	38.1	0.4		1.0	tr.		

Depth (cm)	6A1a Organic carbon a/ Pct.	6B2a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density: g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content: Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD cm/cm	pH: 8C1c (1:1) KCl	8C1a (1:1) H_2O
0-15	0.96	0.126	8			1.0		1.48	1.48	0.00		17.2	5.7		0.17		6.6
15-33	0.27					2.0		1.46	1.50	0.01		20.2	10.5		0.14		5.5
33-61	0.14					2.4		1.40	1.45	0.01		24.2	10.5		0.19		4.5
61-81	0.10					2.2		1.50	1.52	0.00		24.0	8.8		0.23		4.4
81-94	0.06					2.0		1.44	1.46	0.00		21.1	7.5		0.20		4.4
94-120	0.04					1.8		1.60	1.66	0.01		20.0	9.4		0.17		4.5
120-135	0.04					1.8		1.53	1.59	0.01		23.4	9.9		0.21		4.8
135-150	0.06					1.6		1.60	1.68	0.02		21.1	12.3		0.14		5.1
150-200	0.04					1.5		1.54	1.58	0.01		22.5	9.4		0.20		5.6

Depth (cm)	Extractable bases: 6N2a Ca	602b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	CEC: 5A3a Sum cations		6G1d Ext. Al			Ratios to clay: CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-15	6.1	1.4	tr.	0.2		3.1	10.9					0.83	0.08	0.44			72	
15-33	5.6	2.3	0.1	0.2		5.4	13.6					0.55	0.08	0.43			60	
33-61	2.4	3.2	0.1	0.2		9.6	15.5					0.70	0.11	0.48			38	
61-81	1.1	2.9	0.1	0.2		9.6	13.9					0.79	0.13	0.50			31	
81-94	1.0	1.1	0.1	0.2		9.2	11.6					0.79	0.14	0.51			21	
94-120	2.1	4.4	0.3	0.2		8.7	15.7					0.86	0.10	0.52			44	
120-135	3.4	6.6	0.5	0.2		5.8	16.5					0.86	0.09	0.52			65	
135-150	5.4	8.7	0.7	0.2		4.8	19.9					0.73	0.06	0.45			76	
150-200	4.6	6.8	0.7	0.2		3.8	16.1					0.86	0.08	0.50			76	

8

Depth (in.)					

a/ 4.2 kg/m^2 to 1.5 m (method 6A).

Pedon 34

Classification: Glossic Fragiudalf, fine-silty, mixed, thermic.
Location: Jefferson County, Ky., about 1.6 km NW of Junction

Climatic data and soil water balance

°C mm | J F M A M J J A S O N D | in. °F

Pedon 35

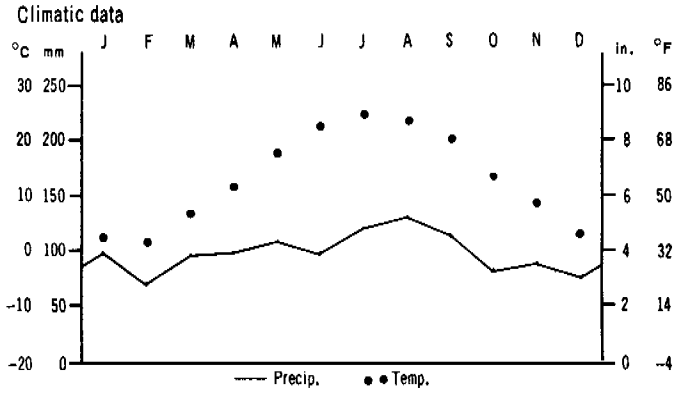
SOIL Aeric Fragiaquult SOIL Nos. S58Md-16-1 LOCATION Prince Georges County, Maryland

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 58652 - 58662

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1													3B2	Coarse fragments 3B1		
		Total			Sand					Silt								
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (< 0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	0.05-0.02	Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)		Cm	2A2 > 2 Pct.	2 - 19	19 - 76
		Pct. of < 2 mm															Pct. of < 76mm	
0-2	A1	14.3	71.4	14.3	0.6	2.0	2.2	3.2	6.3	22.5	48.9	30.5	8.0			0		
2-13	A2	10.1	70.2	19.7	0.3	1.6	1.8	1.7	4.7	19.6	50.6	25.2	5.4			tr.		
13-23	B1t	8.7	65.2	26.1	0.3	1.0	1.4	1.6	4.4	18.6	46.6	23.9	4.3			tr.		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]		

Pedon 35



Classification: Aeric Fragiaquult, fine-silty, mixed, mesic.
Location: Prince Georges County, Md.
Topography: Less than 1 percent slope.
Vegetation: Second-growth forest consisting of white oak (Quercus alba), red oak (Quercus borealis), redgum, (Liquidambar styracifolia), blackgum (Nyssa sylvatica), maple (Acer), and Virginia pine (Pinus virginiana); understory mostly blueberry (Vaccinium), and azalea (Rhododendron).
Parent material: Alluvium from coastal plain material.
Soil No.: S58Md-16-1.

Colors are for the moist soil.

O1 5-2 cm (2-1 in.). Undecomposed forest litter.

O2 2-0 cm (1-0 in.). Black (10YR 2/1) decomposed forest litter; many roots.

A1 0-2 cm (0-1 in.). Dark gray (5Y 4/1) light silt loam; weak medium granular structure; friable (moist); many roots; abrupt wavy boundary.

A2 2-13 cm (1-5 in.). Light brownish gray (2.5Y 6/2) to light yellowish brown (2.5Y 6/4) silt loam; weak fine platy structure; friable (moist); common medium light gray (N 7/) and light olive brown (2.5Y 5/4) mottles; many roots; clear smooth boundary.

B1t 13-23 cm (5-9 in.). Light olive brown (2.5Y 5/4) to grayish brown (2.5Y 5/2) heavy silt loam; weak coarse subangular blocky structure; firm (moist); many medium light brownish gray (2.5Y 6/2) and olive yellow (2.5Y 6/6) mottles; common roots; clear smooth boundary.

B21t 23-30 cm (9-12 in.). Light olive brown (2.5Y 5/4) to grayish brown (2.5Y 5/2) silty clay loam; moderate medium subangular blocky structure; firm (moist); surfaces of peds are grayish brown (2.5Y 5/2); many medium yellowish brown (10YR 5/4) and light brownish gray (2.5Y 6/2) mottles; common roots; clear smooth boundary.

B22tg 30-43 (12-17 in.). Grayish brown (2.5Y 5/2) silty clay; strong, medium and coarse subangular blocks breaking to very coarse plates; firm (moist); continuous thin dull clay skins on faces of peds; many medium strong brown (7.5YR 5/6) and gray (N 6/) mottles; common roots; clear smooth boundary.

A'21g 43-53 cm (17-21 in.). Discontinuous bands of strong brown (7.5YR 5/6) and gray (N 5/) silty clay loam; moderate coarse platy structure; friable (moist), compact in place; peds generally have gray exteriors and strong brown interiors; few roots; abrupt smooth boundary.

IIA'22xg 53-79 cm (21-31 in.). Gray (2.5Y 5/1) heavy loam; massive breaking to plates in the upper 6 inches; very compact in place, brittle when moist; many yellowish brown (10YR 5/4) and gray (N 5/) mottles; wedges of clay that have peripheries of strong brown

Pedon 36

SOIL Typic Calciorthid SOIL Nos. S60NMex-7-2 LOCATION Dona Ana County, N. Mex.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 13126-13131, 68L234-68L235

General Methods: 1A1, 1B1a, 1B1b, 2A1, 2B 67L036 for radiocarbon date only

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2 > 2 Pct.	Wt. 3B1 75-2 %< 75	Wt. 3B1 20-2 %< 20
		Pct. of < 2 mm a/, b/ Carbonate removed																
0-5	A1	61.9	18.6	19.5	1.7	6.2	7.8	27.8	18.4	11.2	7.4	43.9	43.5				42	22
5-10	Bca	54.1	18.5	27.4	2.0	6.1	7.5	21.4	17.1	12.0	6.5	41.7	37.0				6	6
10-23	C1ca	52.6	17.0	30.4	2.4	6.1	6.5	19.4	18.2	12.4	4.6	42.4	34.4				9	9
23-36	C1ca	63.0	15.0	22.0	3.1	7.9	7.9	24.3	19.8	11.2	3.8	45.6	43.2				10	10
36-58	C2ca	58.3	14.3	27.4	5.2	12.5	6.8	17.8	16.0	10.9	3.4	37.4	42.3				8	8
58-89	C3ca	70.9	15.4	9.9	4.8	14.9	15.3	23.0	16.7	9.9	5.5	39.7	58.0				15	15
89-120	IIC4ca	86.3	6.3	7.4	14.7	14.8	14.8	30.0	12.0	3.9	2.4	30.8	74.3					63
120-135	IIIC5ca	82.2	10.2	7.6	10.0	15.4	14.4	27.7	14.7	7.5	2.7	36.0	67.5				39	32

Depth (cm)	6A1a Organic carbon c/, d/ Pct.	6B1a Nitrogen c/ Pct.	C/N	5A1a CEC NH_4OAc a/ meq/100 g	Carbonate as $CaCO_3$ e/ 3A1a < 2mm Pct.	Carbonate as $CaCO_3$ e/ 3A1a <0.002 mm Pct.	Bulk density g/cc	Bulk density g/cc	4A1b Air-dry g/cc		Water content Pct.	Water content Pct.	Water content Pct.			pH	pH (1:1)
0-5	0.19	0.027	7	15.8	5												
5-10	0.23			19.6	10	2											
10-23	0.23			19.3	16	4											
23-36	0.20			15.8	23	8			1.40								
36-58	0.20			17.1	21	15											
58-89	0.24			8.5	10	6											
89-120					16												
120-135					5												

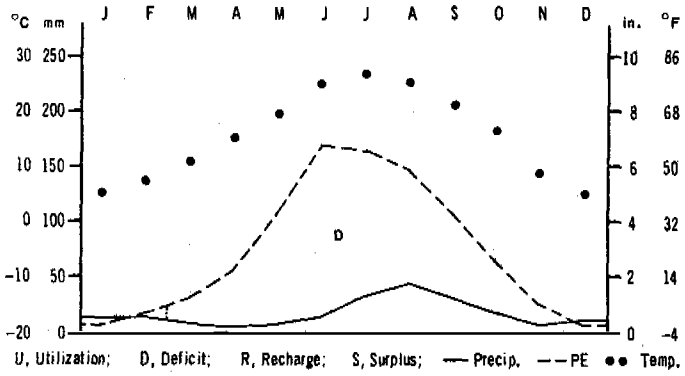
Depth (cm)	Extractable bases 5B1a: Ca	602b Mg	6P2a Na	6Q2a K	5A1a CEC NH_4OAc	Clay fraction f/, g/ mineralogy 7A1: 7A2 X-ray h/	7A3 DTA Pct.	0.10-0.05 mm fraction mineralogy 1B3: 7B1 Petrographic Pct.
	meq/100 g							
0-5		2.5	0.2	0.9	14.1			
5-10		3.0	0.1	0.8	16.7			QZ50,FD25,MA25,OP3,FM2
10-23		3.0	0.1	0.8	16.6			
23-36		3.8	0.6	0.4	14.5	MV4,MI1	KK10	
36-58		5.1	3.4	0.3	10.8			
58-89		4.9	3.6	0.4	8.3			QZ35,FD40,MA25,OP2,FM<1
89-120								
120-135								

a/ Carbonate removed by method 1B3 and the determination reported for the sample so treated.
b/ In contact overnight with 0.1N NaOH in addition to regular treatment to aid disaggregation.
c/ Determination on sample treated by method 1B3 to remove carbonate; values expressed on a carbonate-containing basis.
d/ 2.5 kg/m² to 80 cm (method 6A). A bulk density of 1.4 g/cc was assumed for the fine-earth fabric.

Pedon 36

Classification: Typic Calciorthid, fine-loamy, mixed, thermic.
Location: Dona Ana County, N. Mex., 0.8 km ($\frac{1}{2}$ mi.) E. of Interstate Highway 25 and 30 m S. of Dripping Springs Road. About 5 km (3 mi.) SE. of the center of Las Cruces.
Physiographic position: Alluvial fan; 1,260 m elevation.
Topography: Crest of slight ridge; nearly level transversely, with subdued drainageways about 30 cm deep on either side of pit; longitudinal slope along the ridge crest is 2 percent to the west.
Vegetation: Creosotebush (Larrea divaricata or Larrea tridentata) about $\frac{1}{2}$ m high and $\frac{1}{2}$ to 3 m apart.
Parent material: Fan alluvium derived from rhyolite, andesite, and from sand and rounded gravel of mixed composition.
Sampled by: L. H. Gile, R. B. Grossman, J. L. Millet and F. F. Peterson, April 12, 1960.
Remarks: The site occurs on the Picacho geomorphic surface which is of mid-Wisconsinan age. Measurements in the general area indicate that the current dust fall contains carbonate.
Soil No.: S60NMex-7-2.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

Soil surface. Desert pavement covers 70 to 80 percent of the surface and is composed of angular rhyolite pebbles less than about 5 cm in diameter with some angular andesite and a few rounded pebbles of mixed lithology. Most pebbles have thin discontinuous desert varnish. A thin layer of loose pale brown sand occurs between the pebbles.

A1 0-5 cm (0-2 in.). Pinkish gray (7.5YR 6/2) gravelly fine sandy loam, brown (7.5YR 4/2) moist; weak coarse plates; soft (dry); no roots; moderately vesicular; lenses 0.5 mm thick of reddish brown sand occur throughout; effervesces strongly; abrupt smooth boundary; sample includes desert pavement.

Bca 5-10 cm (2-4 in.). Light reddish brown (6YR 6/4) sandy clay loam, reddish brown (6YR 4/4) moist; moderate fine to very fine granular with few weak very fine subangular blocks; soft (dry) and loose(dry); very few roots; few carbonate filaments on ped surfaces; few pebbles with discontinuous carbonate coatings less than 1 mm thick on undersides; effervesces strongly; abrupt wavy boundary.

C1ca 10-36 cm (4-14 in.). Dominantly pinkish white (7.5YR 8/2) sandy clay loam, pink (7.5YR 7/4) moist; with lesser amounts of light brown (7.5YR 6.5/4, 5.5/4) moist; weak and very weak medium to fine subangular blocks; material digs out as a mixture of peds and loose soil; loose parts soft (dry) and peds hard (dry); few roots; few reddish brown (5YR 4/4) bodies 1 to 3 mm in diameter; common carbonate nodules; carbonate filaments on stronger peds and thin discontinuous carbonate coatings on pebbles; effervesces strongly; horizon split for sampling at 23 cm; clear wavy boundary.

C2ca 36-58 cm (14-23 in.). Dominantly light brown (7.5YR 6.5/4) sandy clay loam, brown (7.5YR 5.5/4) moist; weak to moderate coarse to medium subangular blocks; most parts very hard (dry); few roots; some brown (7.5YR 4.5/4) parts; many weakly to moderately defined aggregates of cylindroidal shape, 1 to 3 cm in diameter and light brown in color; effervesces strongly; clear wavy boundary.

C3ca 58-89 cm (23-35 in). Light brown (7.5YR 5.5/4) sandy loam, brown (7.5YR 4/4) moist; massive and weak coarse subangular blocks; soft (dry) and slightly hard (dry); few roots; few light brown aggregates of cylindroidal shape which are not well differentiated from matrix; thin discontinuous carbonate coatings on pebbles; effervesces strongly; clear wavy boundary.

IIC4ca 89-120 cm (35-47 in.). White (10YR 9/2) very gravelly sandy loam, very pale brown (10YR 7/3) moist; massive; dominantly hard (dry) and very hard (dry) with parts soft (dry); very few roots; most pebbles and sand grains continuously coated with carbonate; carbonate-cemented clusters of pebbles common; effervesces strongly; the very gravelly material discontinuous and laterally grades into low-gravel material in which carbonate occurs as scattered nodules; abrupt smooth boundary.

IIIC5ca 120-135 cm (47-53 in.). Light brown (7.5YR 6.5/4) gravelly sandy loam, brown (7.5YR 5/4) moist; massive; slightly hard (dry); no roots; thin discontinuous carbonate coatings on sand grains and pebbles; effervesces strongly.

Micromorphology, method 4E1b. Thin sections of the upper half of the Bca horizon were examined. Fine-grain carbonate forms a continuous open network with the interstices partly filled by sand grains and small volumes of clay. In parts low in carbonate, silicate clay occurs as coatings around sand grains and as small volumes, a millimeter or less across. The sand grains are mostly discrete quartz and feldspar. Some rock fragments and a few grains of ferromagnesian minerals are present. The minerals appear little weathered; alteration is restricted to the surface of the grains.

SOIL Pedon 37 Aridic Calcixeroll SOIL Nos. S67Utah-20-1 LOCATION Sanpete County, Utah

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 67409 - 67416

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Silt Int. II (0.2-0.02)	Silt 2-0.1	Carbonate as $CaCO_3$ 6E1b <2 mm Pct.	Carbonate as $CaCO_3$ 3A1a <0.002 mm Pct.	Coarse fragments 1A2a > 2 Pct. of whole soil	Coarse fragments 1A2a 2-19 Pct. of <76mm	Coarse fragments 1A2a 19-76 Pct. of <76mm
		Size class and particle diameter (mm) 3A1 — Pct. of <2 mm																
0-10	A11	28.4	47.2	24.4	3.0	2.7	1.6	6.4	14.7	18.9	28.3	38.0	13.7		6	41	26	14
10-18	A12	25.2	49.2	25.6	4.8	3.2	1.5	5.2	10.5	22.5	26.7	36.4	14.7		7	57	19	36
18-38	A13	25.3	45.7	29.0	5.5	4.2	2.0	4.5	9.0	18.2	27.5	30.0	16.3		10	76	11	63
38-53	C1ca	28.7	43.2	28.1	5.1	4.8	2.5	6.0	10.4	15.5	27.7	29.7	18.3		15	70	22	47
53-74	C2ca	31.6	40.6	27.8	7.4	5.8	2.7	5.9	9.8	14.6	26.0	28.1	21.8		17	71	26	43
74-110	C3ca	42.3	37.6	20.1	12.0	7.9	3.8	7.4	11.2	15.7	21.9	31.4	31.1		11	73	35	36
110-145	C4ca	45.8	42.8	11.4	11.8	8.2	3.9	8.8	13.1	20.0	22.8	38.5	32.7		7	75	29	45
145-170	C5	40.7	50.7	8.6	8.8	6.3	2.9	7.2	15.6	26.7	24.0	46.9	25.1		3	80	34	45

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C2b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ 6E1b <2 mm Pct.	Carbonate as $CaCO_3$ 6E1b 2-19 fmm Pct.	Bulk density 4A1f 1/3-bar g/cc	Bulk density 4A1h Oven-dry g/cc	Bulk density Est. 1/3-bar g/cc	3B2 Cm	Water content 4B1c 1/3-bar Pct.	Water content 4B2 15-bar Pct.	Water content 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH 8C1b Saturated paste	pH 8C1c 1N KCl 1:1	pH 8C1a H_2O 1:10
0-10	3.69	0.291	13	0.4	30	96			0.90	0.80		16.4				7.7		8.5
10-18	3.46	0.280	12		31	95	0.90	0.98		0.69	42.7	15.9		0.029	0.020	7.6		8.4
18-38	3.31	0.276	12	0.3	35	95	0.82	0.90		0.51	51.3	18.3		0.032	0.016	7.6		8.4
38-53	2.07	0.177	12		53	89			0.97	0.54		19.0				7.6		8.6
53-74	1.11			0.2	65	90	0.97	0.99		0.50	34.4	16.5		0.007	0.004	7.7		8.8
74-110	1.05				64	98			0.97	0.51		12.1				8.1		9.0
110-145	0.79				61	94	0.96	0.99		0.47	41.0	12.0		0.010	0.005	8.4		9.2
145-170	0.49			0.2	39	92	0.98	1.03		0.41	31.3	12.8		0.017	0.007	8.3		9.2

Depth (cm)	Extractable bases 6N4c Ca 5B3a	6O4c Mg 5B3a	6P2a Na 5B1a	6Q2a K 5B1a	6H2a Ext. acidity	5A6a CEC NH_4OAc	5D2 Exchangeable Sodium Pct.	5E Sodium adsorption ratio	8A Water at saturation Pct.	Water extract from saturated paste 8A1 6N1b Ca	6O1b Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1b SO_4	8A1a Electrical conductivity mmho/cm
	meq/100 g									meq/liter								
0-10	21.8	2.1	0.1	0.9		24.1		<1	65.6	5.5	0.8	0.2	0.3	-	6.4	0.7		0.62
10-18	21.6	1.6	0.1	0.8		24.2		<1	65.0	5.0	0.7	0.2	0.2	-	5.3	0.4		0.55
18-38	21.6	2.2	0.1	0.6		24.8		<1	71.6	5.5	0.8	0.2	0.1	-	5.4	0.4		0.57
38-53	18.1	2.3	0.1	0.3		16.0	1	<1	67.9	5.7	1.6	0.2	0.1	-	6.5	0.4		0.59
53-74	10.7	1.9	0.1	0.2		11.7	1	<1	58.0	3.4	1.0	0.3	0.1	-	4.6	0.3		0.48
74-110	8.8	5.8	0.1	0.2		11.2	1	<1	52.9	2.3	2.7	0.4	0.1	-	4.5	0.6		0.48
110-145	6.9	7.8	0.2	0.2		10.2	1	<1	51.0	1.3	3.0	0.6	0.1	-	4.4	0.4		0.47
145-170	5.2	8.4	0.2	0.4		14.2	1	<1	51.3	0.8	2.0	0.6	0.1	-	4.7	0.4		0.53

Depth (cm)	Ratios to clay 8D2 CEC NH_4OAc	Ext. iron	15 bar water	b/ 3A1 Clay fraction mineralogy 7A2 X-ray c/
0-10	1.34	0.02	0.91	MI3, MT2, KK2
10-18	1.27		0.84	
18-38	1.31	0.02	0.96	MI3, MT2, KK2
38-53	1.23		1.46	
53-74	1.06	0.02	1.50	MT3, KK2
74-110	1.24		1.34	
110-145	2.55		3.00	
145-170	2.37	0.03	2.13	

a/ 12.3 kg of organic carbon per square meter to a depth of 1 meter.

b/ Mineral code:
MT = montmorillonite
MI = mica
KK = kaolinite

c/ Approximate weight fraction (X-ray):
3 = one-fifth to one-third
2 = one-twentieth to one-fifth

Micromorphology

A12 Crystic fabric; many interstitial and few tubular pores; many carbonate nodules.

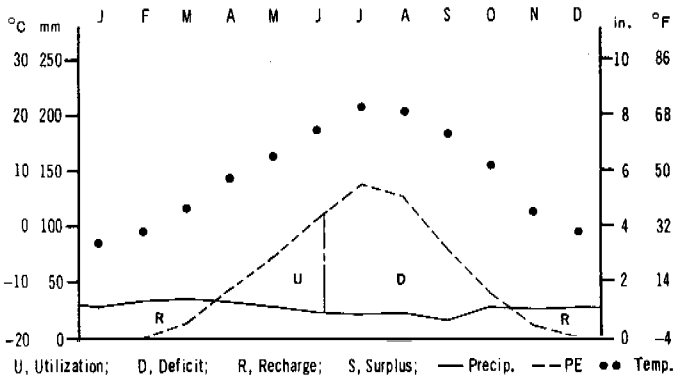
C2ca Crystic fabric; many pores; carbonate thickly coats limestone fragments.

Morphology of coarse fragments (all are limestone): The oolitic limestone fragments are coated by carbonate and small amounts of silica. Coatings have a hardness of 2 to 4 and are thickest in the C1ca horizon. The nodules are limestone relics.

Pedon 37

Classification: Aridic Calcixeroll, loamy skeletal, carbonatic, frigid.
Location: Sanpete County, Utah. 4.8 km east of Sterling, south fork of Six Mile Canyon, Funks Cove. Sec. 36, T. 18 S., R. 2 E.
Physiographic position: Steep hillside, 1830 m elevation.
Topography: North-facing, concave 50 percent slope.
Drainage: Well drained; medium runoff; rapid permeability.
Vegetation: Bluebunch wheatgrass (Agropyron spicatum), big sagebrush (Artemisia tridentata), slender wheatgrass (Agropyron trachycaulum), serviceberry (Amelanchier sp.), and scattered juniper (genus Juniperus).
Parent material: Local alluvium and colluvium from limestone.
Sampled by: B. R. Brasher, A. Erickson, J. Swenson, and W. D. Nettleton, August 28, 1967.
Remarks: The soil does not disperse well, hence the field estimates of texture are given in the profile description. There is a thin discontinuous accumulation of gravel on the surface of the pedon.
Soil No.: S67Utah-20-1.

Climatic data and soil water balance



Colors are for the dry soil unless indicated otherwise.

A11 0-10 cm (0-4 in.). Dark grayish brown (10YR 4/2) gravelly loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft (dry), friable (moist), slightly sticky and plastic (wet); many very fine and fine roots; gravel occurs mainly as a surface mantle; strongly effervescent, carbonates are disseminated; 19 percent gravel and 1 percent cobbles by volume; clear smooth boundary.

A12 10-18 cm (4-7 in.). Dark grayish brown (10YR 4/2) gravelly loam; very dark grayish brown (10YR 3/2) moist; weak thick plates breaking to weak fine granules; slightly hard (dry), friable (moist), slightly sticky and plastic (wet); many very fine and many fine roots; few fine pores; strongly effervescent, carbonates are disseminated and some soft powdery carbonate is segregated on the bottom of coarse fragments; 29 percent gravel and 1 percent cobbles by volume; gradual wavy boundary.

A13 18-38 cm (7-15 in.). Dark grayish brown (10YR 4/2) gravelly loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard (dry), friable (moist), slightly sticky and plastic (wet); many very fine and common fine roots; few fine pores; strongly effervescent; carbonates are disseminated and segregated on bottom of coarse fragments; 45 percent gravel and 4 percent cobbles by volume; clear smooth boundary.

C1ca 38-53 cm (15-21 in.). Pale brown (10YR 6/3) gravelly loam, brown (10YR 5/3) moist; massive; slightly hard (dry), friable (moist), sticky and plastic (wet); many very fine roots; few very fine pores; violently effervescent, carbonates are disseminated and segregated on coarse fragments and in soft nodules, flakes and veins; 45 percent gravel and 2 percent cobbles by volume; gradual wavy boundary.

C2ca 53-74 cm (21-29 in.). Very pale brown (10YR 7/3) gravelly loam, pale brown (10YR 6/3) moist; massive, hard (dry), friable (moist), slightly sticky and plastic (wet); few very fine and few fine roots; few fine pores; violently effervescent, carbonates are disseminated and segregated on coarse fragments and in flakes, veins and soft nodules; 45 percent gravel and 5 percent cobbles by volume; clear wavy boundary.

C3ca 74-110 cm (29-44 in.). Pinkish gray (7.5YR 7/2) gravelly loam, pinkish gray (7.5YR 6/2) moist; massive; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); few very fine roots; few fine pores; violently effervescent, carbonates are disseminated and segregated on coarse fragments and in flakes and nodules; 45 percent gravel and 4 percent cobbles by volume; gradual smooth boundary.

C4ca 110-145 cm (44-58 in.). Pink (7.5YR 7/3) very gravelly light loam, light brown (7.5YR 6/3) moist; massive; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); few very fine and fine roots; few very fine pores; violently effervescent, carbonates are disseminated and segregated on the coarse fragments, also some cementation into nodules; 50 percent gravel and 4 percent cobbles by volume; gradual wavy boundary.

C5 145-170 cm (58-66 in.). Pink (7.5YR 7/3) very gravelly light loam; light brown (7.5YR 6/3) moist; massive; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); common fine and very fine roots; violently effervescent, carbonates are disseminated; 55 percent gravel and 3 percent cobbles by volume.

SOIL Pedon 38 Typic Calciaquoll SOIL Nos. S64Ill-27-1 LOCATION Ford County, Ill.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 20397-20403

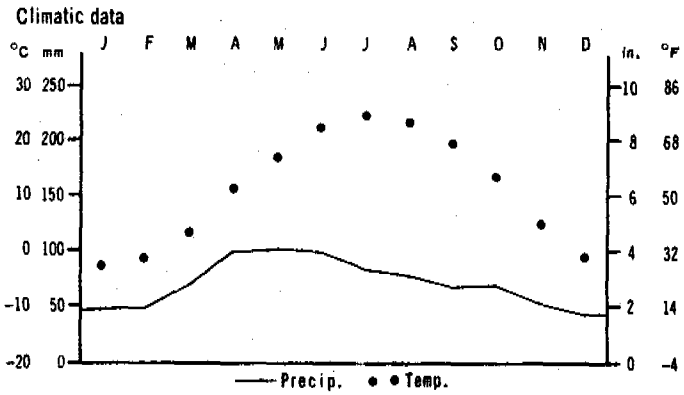
General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-23	Apca	6.1	61.8	32.1	0.4	0.9	1.2	1.9	1.7	18.0	43.8	20.6	4.4					tr
23-46	A12ca																	tr
46-64	B1g	14.7	56.5	28.8	1.2	2.4	3.5	4.8	2.8	22.2	34.3	27.2	11.9					tr
64-79	B21g																	tr
79-91	B22g	11.1	57.1	31.8	1.4	2.0	2.7	3.3	1.7	21.1	36.0	24.3	9.4					tr
91-105	B3g																	tr
105-140	Cgca	14.8	66.8	18.4	1.1	1.9	3.1	5.0	3.7	32.5	34.3	38.6	11.1					2

Depth (cm)	Horizon	Nitrogen Pct	C/N	Carbonate as $CaCO_3$ 6E1b <2mm Pct.	Carbonate as $CaCO_3$ 3A1a <0.002 mm Pct.	Bulk density g/cc	Bulk density g/cc	Bulk density g/cc	Water content Pct	Water content Pct	Water content Pct	pH (1:1)

Pedon 38

Classification: Typic Calciaquoll, fine-silty, mixed, mesic.
Location: Ford County, Ill., 285 m S. and 23 m W. of crossroads center at NE. corner sec. 20, T. 23 N., R. 7 E. About 150 km (95 mi.) SW. of Chicago.
Physiographic position: Elevation about 200 m.
Topography: Slight depression, 1/2 percent slope.
Drainage: Poorly drained.
Sampled by: J. B. Fehrenbacher and G. O. Walker, November 17, 1964.
Soil No.: S64Ill-27-1.



Colors are for the moist soil.

Apca 0-23 cm (0-9 in.). Black (10YR 2/1) silty clay loam; weak to moderate fine granular structure; firm (moist); many snail shells and few pebbles; strong effervescence; abrupt smooth boundary.

A12ca 23-46 cm (9-18 in.). Very dark brown (10YR 2/2) silty clay loam; weak to moderate; fine to medium granular structure; firm (moist); many snail shells and few pebbles; strong effervescence; clear smooth boundary.

B1g 46-64 cm (18-25 in.). Dark grayish brown (2.5Y 4/2) silty clay loam with common fine faint light olive brown (2.5Y 5/4) mottles; moderate to weak fine to medium angular blocky structure; continuous very dark gray (10YR 3/1) coatings; firm (moist); few snail shells and pebbles; weak effervescence; gradual smooth boundary.

B21g 64-79 cm (25-31 in.). Dark gray (5Y 4/1) silty clay loam with few fine faint olive (5Y 4/4) and dark yellowish brown (10YR 4/4) mottles; moderate medium prisms break to moderate fine to medium angular blocks; continuous very dark gray (10YR 3/1) coatings; firm (moist); few snail shells and pebbles; weak effervescence; gradual smooth boundary.

B22g 79-91 cm (31-36 in.). Dark gray (5Y 4/1) silty clay loam with common medium distinct olive brown (2.5Y 4/4) and few fine prominent yellowish brown (10YR 5/6) mottles; weak coarse prisms break to weak medium angular blocks; thin discontinuous very dark gray (10YR 3/1) coatings; few pebbles; very weak effervescence; gradual smooth boundary.

B3g 91-105 cm (36-41 in.). Mixed olive brown (2.5Y 4/4), olive yellow (2.5Y 6/6) and gray (5Y 5/1) light silty clay loam; weak coarse angular blocky structure; very thin patches of gray (10YR 5/1) coatings; firm (moist); few pebbles; weak effervescence; gradual smooth boundary.

Cgca 105-140 cm (41-56 in.). Mixed gray (5Y 5/1) and light olive brown (2.5Y 5/6) silt loam with few coarse prominent dark yellowish brown (10YR 4/4) mottles; massive; firm (moist); few pebbles; strong effervescence; clear smooth boundary.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 16535-16543

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05) b/	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	Silt: (2–0.1)	3A1a Non-carbonate clay <0.002		Coarse fragments		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-1/2	A11	31.0	43.4	25.6	tr	0.4	2.3	7.8	20.5	20.4	23.0	46.0	10.5	24				tr
1/2-5	A12	28.3	41.8	29.9	-	0.8	2.5	7.5	17.5	16.7	25.1	39.0	10.8	27				tr
5-13	A13	28.6	42.2	29.2	-	0.7	2.6	7.5	17.8	16.6	25.6	39.2	10.8	26				-
13-33	B21ca	25.5	39.8	34.7	-	0.4	2.0	6.7	16.4	14.2	25.6	35.0	9.1	31				-
33-56	B22ca	21.6	40.1	38.3	-	0.4	1.5	5.2	14.5	14.2	25.9	32.2	7.1	30				-
33-56	a/ B22ca	24.6	34.3	41.1	tr	0.5	1.8	5.5	16.8	14.2	20.1	34.7	7.8					
56-84	a/ C1cs	20.0	30.2	49.8	-	tr	0.2	2.7	17.1	15.5	14.7	34.9	2.9					-
84-115	a/ C2cs	10.3	50.4	39.3	-	tr	tr	0.3	10.0	29.0	21.4	39.3	0.3					-
115-140	a/ C3cs	15.3	40.5	44.2	-	0.2	0.6	2.6	11.9	17.6	22.9	31.3	3.4					-
140-180	a/ C4cs	14.4	42.8	42.8	-	0.1	0.4	2.2	11.7	18.9	23.9	32.2	2.7					-

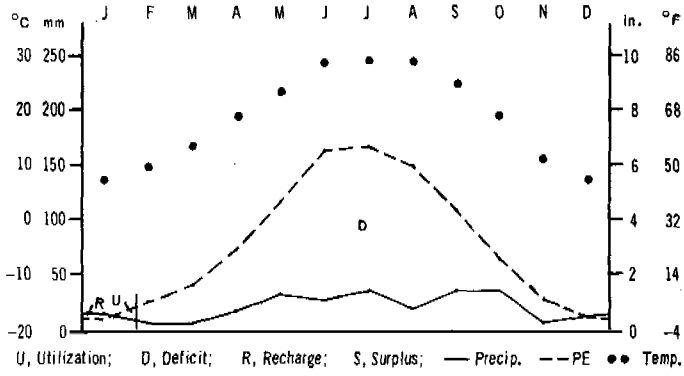
Depth (cm)	6A1a Organic carbon	6B1a Nitrogen	C/N	Carbonate as $CaCO_3$: 6E1b < 2 mm	3A1a <0.002 mm	6C1a Ext. iron as Fe	Bulk density: 4A1c 30-cm	4A1b Air-dry	4D1 COLE	Water content: 4B3 30-cm c/	4B1b 1/3-bar c/	4B2 15-bar c/	4C1 1/3-to 15-bar		pH: 8C1b Sat. paste	8C1a (1:1) H_2O	8C1a (1:10) H_2O
	Pct.	Pct.		Pct.	Pct.	Pct.	g/cc	g/cc	g/cc				cm/cm				
0-1/2	1.27	0.112	11	12	2	0.4						11.3			7.3	7.9	8.3
1/2-5	0.96	0.094	10	12	3	0.4						12.2			7.6	7.9	8.3
5-13	0.93	0.088	10	12	3	0.5		1.37	1.45	0.020	25.5	19.8	12.8	0.10	7.5	7.9	8.4
13-33	0.63	0.066	10	19	4	0.5							13.4		7.4	7.8	8.3
33-56	0.63	0.068	9	26	8	0.4		1.22	1.33	0.028	30.7	23.1	13.6	0.12	7.3	7.4	7.9
56-84	0.26	0.025	10	10				1.30	1.36	0.014	18	18	5	0.17	7.2	7.6	8.0
84-115	0.14			8									6		7.5	7.7	8.0
115-140	0.16			14									10		7.6	7.8	8.1
140-180	0.18			11									10		7.7	7.9	8.2

Depth (cm)	Extractable bases 5B1a: 6N4b Ca	6O4b Mg	6P2a Na	6Q2a K	Sum	Cat. exch. cap: 5A2a NaOAc	5A1a NH_4OAc	Ca	Mg	Water extract from saturated paste 8A1: 6P1a Na	6Q1a K		6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1a SO_4	8A1a Electrical conductivity
	meq/100 g							meq/liter									mmho/cm
0-1/2	17.7	2.1	0.1	2.2	22.1	20.0	18.8			1.0	1.7						2.50
1/2-5	20.0	2.8	0.9	3.5	27.2	21.8	20.4			9.0	3.3						3.81
5-13	18.2	3.2	1.1	3.2	25.7	21.6	20.0			10.6	3.2		-	3.3	5.4	36.0	4.00
13-33	18.1	3.0	3.6	3.2	27.9	21.0	19.2			41.8	4.4		-	2.5	62.5	37.4	9.2
33-56		3.5	5.1	3.1		21.7	18.3			77.0	13.0		-	1.5	256	22.5	29.1
56-84			1.7	0.7		6.8	5.7			49.2	5.0		-	2.0	198	22.3	21.3
84-115			2.7	0.5		6.0	4.8			68.2	3.6		-	1.5	153	33.7	17.4
115-140			3.8	0.8		9.6	8.4			76.4	2.8		-	2.0	135	46.1	16.6
140-180			5.3	0.6		9.3	8.1			104	2.0		-	1.5	186	52.6	21.3

Pedon 39

Classification: Typic Gypsiorthid, fine-loamy, gypsic, thermic.
Location: Reeves County, Tex., 0.4 km (0.25 mi.) E. of Texas Highway 17, 2.6 km (1.6 mi.) S. of U.S. Highway 80. About 160 km (100 mi.) SE. of El Paso.
Physiographic position: Probably terrace of Pecos River, elevation about 1,000 m.
Topography: Level plain with gradient less than $\frac{1}{8}$ percent.
Drainage: Poorly drained.
Vegetation: Fourwing saltbush (Atriplex canescens), tarbush (Flourensia cernua), occasional mesquite (Prosopsis juliflora) with traces of plains bristlegrass (Setaria macrostachya) and alkali sacaton (Sporobolus airoides).
Parent material: Calcareous, gypsiferous alluvium--mostly from limestone but some from igneous sources.
Sampled by: J. R. Coover, R. E. Daniell, R. H. Jordan and E. D. Rivers, October 26, 1961.
Remarks: Gypsic horizon is moist.
Soil No.: S61Tex-195-3.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

A11 0-1/2 cm (0-1/4 in.). Light gray (10YR 6.5/2) loam, brown (10YR 4.5/3) moist; platy crust; slightly hard (dry), very friable (moist); strongly effervescent; vesicular peds; evaporite specks; abrupt boundary.

A12 1/2-5 cm (1/4-2 in.). Light gray (10YR 6.5/2) loam, brown (10YR 4.5/3) moist; weak to moderate medium platy structure; slightly hard (dry), very friable (moist); strongly effervescent; clear boundary.

A13 5-13 cm (2-5 in.). Light brownish gray (10YR 6.5/2) loam, brown (10YR 4.5/3) moist; weak to moderate fine subangular blocky structure; hard (dry), friable (moist); strongly effervescent; gradual boundary.

B21ca 13-33 cm (5-13 in.). Pink (7.5YR 7/3) clay loam, light brown (7.5YR 5/4) moist; weak to moderate and medium fine subangular blocky structure; hard (dry), friable (moist); strongly effervescent with few films and threads of calcium carbonate; few to common wormcasts; insect cavities, root channels; diffuse boundary.

B22ca 33-56 cm (13-22 in.). Pink (7.5YR 7/4) clay loam, light brown (7.5YR 5.5/4) moist; weak fine subangular blocky structure; consistence, reaction, wormcasts, insect cavities, root channels and calcium carbonate as above; abrupt wavy boundary varying from 46 to 66 cm below the surface.

C1cs 56-84 cm (22-33 in.). Very pale brown (10YR 8/3) weakly cemented gypsiferous calcareous loam, very pale brown (10YR 7/3) moist; very hard (dry); friable (moist) and somewhat brittle; few roots; few old root channels filled with grayish brown or brown clay; few fine seams coated with gypsum and darker material.

C2cs 84-115 cm (33-46 in.). Similar to the horizon above; split for sampling; gradual boundary.

C3cs 115-140 cm (46-55 in.). Light gray (10YR 7/2), grayish brown (10YR 5/2) moist; similar to above but contains less calcium carbonate and probably more fine earth; gradual boundary.

C4cs 140-180 cm (55-70 in.) plus. Very pale brown (10YR 7/3), brown (10YR 5/3) moist; similar to horizon above.

SOIL Pedon 40 Petrocalcic Paleargid SOIL Nos. S59NMex-7-16 LOCATION Dona Ana County, N. Mex.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 11341-11347, 15029-15031

General Methods: 1A1, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2 b/ Vol. 250–2 %< 250	Wt. 3B1 75–2 %< 75	20–2 %< 20
		Pct. of < 2 mm																
		a/Carbonate removed																
0-1	A11	57.1	30.1	12.8	4.0	2.8	2.4	17.1	30.8	19.7	10.4	62.7	26.3			15	25	25
1-5	A12	58.1	29.8	13.6	5.9	3.6	2.6	18.4	27.6	18.9	10.9	59.4	30.5			25	39	26
5-15	B21t	61.9	23.4	17.8	12.2	4.2	3.0	18.6	23.9	15.7	7.7	52.2	38.0			40	53	39
15-28	B22tca	53.8	23.8	22.4	16.7	3.9	2.4	13.5	17.3	13.4	10.4	39.9	36.5			45	63	46
28-30	C1cam	58.0	18.5	23.5	25.3	8.7	3.3	9.9	10.8	14.9	3.6	31.6	47.2				80	57
30-64	C2cam	62.3	15.7	20.0	27.8	7.3	3.4	11.8	14.0	10.4	5.3	31.9	48.3				87	26
64-125	C3ca	73.8	12.9	13.3	27.2	9.5	4.6	17.1	15.4	9.3	3.6	35.5	58.4				71	30
Lab. No.																		
15029	C1cam	20.1	26.6	53.3	9.2	2.7	0.8	1.2	6.2	13.1	13.5	19.6	13.9				-	-
15030	C1cam	46.9	22.0	31.1	16.7	6.4	2.9	9.0	11.9	11.4	10.6	29.0	35.0				22	23
15031	C1cam	66.3	13.8	20.4	11.6	5.8	10.1	20.8	18.0	8.9	4.9	38.5	48.3				45	36

Depth (cm)	6A1a Organic carbon c/ Pct.	Nitrogen Pct.	C/N	d/Carbonate as $CaCO_3$ < 2 mm Pct.	Whole soil Pct.	5A1a CEC NH_4OAc a/	6C1a Ext. iron as Fe a/ Pct.	a/,e/Total analysis SiO_2 Pct.	Al_2O_3 Pct.	Fe_2O_3 Pct.	TiO_2 Pct.	CaO Pct.	K_2O Pct.	MgO Pct.	Ign. loss Pct.	Total Pct.	0.05-0.02 mm fraction f/mineralogy Pct.
0-1	0.44			-	-	13.0											
1-5	0.29			-	-	12.6											
5-15	0.37			tr	tr	13.6	0.8	72.3	11.3	3.64	0.63	0.79	3.26	0.93	2.70	95.6	
15-28	0.74			10	4	17.1	0.8	70.1	11.4	3.38	0.55	0.77	3.38	0.84	3.02	93.4	
28-30	0.15			80	44	16.3	0.9	58.8	16.5	4.72	0.68	1.06	3.08	1.81	9.44	96.1	FD75,QZ15,MI10
30-64	0.14			58	15	16.4	0.8	66.3	12.9	3.36	0.54	0.89	3.72	1.92	6.04	95.7	
64-125	0.11			23	8	10.1	0.9										
Lab. No.																	
15029	0.49			74	74	35.9	1.4	74.2	10.2	3.34	0.55	0.76	2.66	1.30	3.64	96.7	
15030	0.15			83	80	21.8	0.9	69.5	11.9	3.15	0.50	0.59	3.86	0.93	3.00	93.4	
15031	0.25			46	32	16.8	0.7	70.6	10.7	2.37	0.41	0.45	4.05	0.80	1.90	91.3	

Radiocarbon dates: Yrs. B. P.

B22tca
- Carbonate in whole material. Isotopes Inc. No. 374. 5,725 ± 200
- Carbonate associated with > 2 mm. Isotopes Inc. No. 1039. g/10,226 ± 400
- Carbonate in < 2 mm. h/1,300 (computed)
- Organic carbon in < 2 mm. Isotopes Inc. No. 2222. 565 ± 95
- Organic carbon in water-dispersed < 0.002 mm. Method 3A1c. Isotopes Inc. No. 2223. 910 ± 100

C1cam
- Carbonate in soft laminar part. Isotopes Inc. No. 375. 4,575 ± 170
- Carbonate in hard laminar part. Isotopes Inc. No. 392. i/13,850 ± 600
- Organic carbon in hard laminar part. Isotopes Inc. No. 616. 9,550 ± 300
- Carbonate in non-laminar part. Isotopes Inc. No. 391. 18,300 ± 600

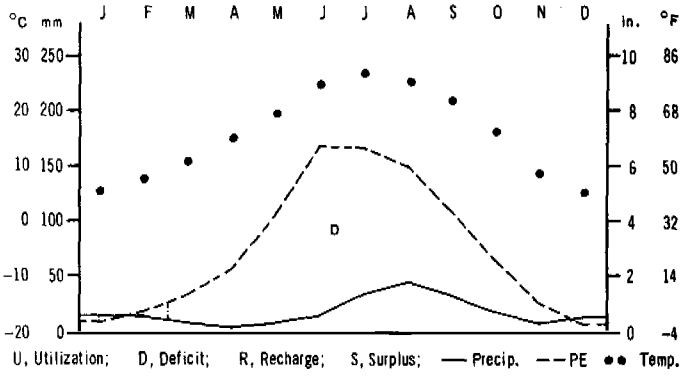
C2cam
- Carbonate in whole material. Isotopes Inc. No. 376. 15,300 ± 400
- Carbonate associated with > 20 mm. Isotopes Inc. No. 2128. j/27,900 + 1,100 − 1,000

a/Carbonate removed by method 1B3 and the determination reported for the sample so treated.
b/Carbonate-containing basis. Assumed bulk density of 1.4 g/cc for fine-earth fabric.
c/Determination on sample treated by method 1B3 to remove carbonate; values expressed on a carbonate-containing basis.
d/Carbonate measured on whole soil by method 6E1a and calculated to < 2 mm basis.
e/Borate glass disks used for all elements except magnesium, which was determined on a soil powder.
f/Mineral code:
FD = feldspar, mostly microcrystalline aggregates
QZ = quartz
MI = mica, mostly altered
g/> 2 mm washed, dried, and ground to form the sample.
h/From dates on whole material and > 2 mm plus carbonate percentages.
i/The $_c$ (C^{13}) / is + 2.0.
j/> 20 mm washed in water, dried, and loosely adhering carbonate removed with an electric buffing wheel. Pebbles were then ground to form the sample.

Pedon 40

Classification: Petrocalcic Paleargid, loamy-skeletal, mixed, thermic, shallow.
Location: Dona Ana County, N. Mex., SE 1/4 SE 1/4 sec. 19, T. 23 S., R. 3 E., about 11 km (7 mi.) E. of Las Cruces.
Physiographic position: Alluvial terrace on the outer edge of an alluvial fan piedmont; elevation 1,380 m.
Topography: Slope 2 percent to the W.
Vegetation: Creosotebush (Larrea divaricata or Larrea tridentata), whitethorn (Acacia constricta), ratan (Krameria parvifolia).
Parent material: Terrace alluvium derived from rhyolite.
Sampled by: J. S. Allen, L. H. Gile, R. B. Grossman and R. V. Ruhe, May 21, 1959.
Remarks: The site occurs on the Picacho geomorphic surface, which is of mid-Wisconsinan age. Measurements in the general area indicate that the current dust fall contains carbonate.
Soil No.: S59NMex-7-16.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

Soil surface. Desert pavement of pitted and varnished fine rhyolite pebbles; discontinuous layer of loose reddish sand occurs between pebbles. Included : A21 sample.

A11 0-1 cm (0-$\frac{1}{2}$ in.). Brown (7.5YR 4.5/2) gravelly loam, dark brown (7.5YR 3/2) moist; moderate medium platy structure; soft (dry); no roots; vesicular; noncalcareous; abrupt wavy boundary.

A12 1-5 cm ($\frac{1}{2}$-2 in.). Brown (7.5YR 5/4) gravelly fine sandy loam, dark brown (7.5YR 3.5/3) moist; weak fine to very fine platy structure; soft (dry); few roots; noncalcareous; abrupt smooth boundary.

B21t 5-15 cm (2-6 in.). Reddish brown (5YR 5/4, 4/4 moist) very gravelly fine sandy loam; weak very fine crumb structure; slightly hard (dry); plentiful roots; thin discontinuous coatings of silicate clay on pebbles and sand grains and some clay bridging between sand grains; dominantly noncalcareous; abrupt to clear wavy boundary.

B22tca 15-28 cm (6-11 in.). Reddish brown (5YR 5/4) very gravelly fine sandy clay loam, dark reddish brown (5YR 3.5/4) moist; slightly hard (dry); plentiful roots; interstice fillings have fine crumb structure and adhere weakly to pebble surfaces; powdery carbonate coatings on the pebbles intermingled with reddish brown clayey coatings; effervesces strongly; abrupt smooth boundary.

C1cam 28-30 cm (11-12 in.). The laminar subhorizon occurs in the upper $\frac{1}{2}$ to 1 cm; uppermost laminae (Lab. No. 15029) are pink (7.5YR 7/4), light brown (7.5YR 6/4) moist, and score easily with a knife; remaining laminae (Lab. No. 15030) score difficultly with a knife and range from white (10YR 9/2) to very pale brown (10YR 7/4); underlying the laminar subhorizon (Lab. No. 15031) is pink (7.5YR 7/4) massive material; laminar part indurated; massive part very hard and extremely hard (dry); powdery white carbonate coatings on most pebbles; flaky brittle olive-colored coatings occur on some pebbles; no roots; effervesces strongly; clear wavy boundary.

C2cam 30-64 cm (12-25 in.). Pink (5YR 8/3) and white (10YR 9/1); respectively, pink (5YR 7/4) and very pale brown (10YR 8/3) moist; some interstice fillings are pinkish gray (5YR 7/2) and light brown (7.5YR 6/4) moist; very hard and weakly cemented (dry); upper part contains cracks filled with reddish brown loamy material in which roots are concentrated; effervesces strongly; clear wavy boundary.

C3ca 64-125 cm (25-49 in.). Mostly lenses of loose fine gravel and weakly cemented fine gravel with pockets of light brown (7.5YR 6/4) loamy material, dark brown (7.5YR 4/4) moist; loamy material massive, very hard (dry); few roots; pebbles in loose gravel lenses have hard flaky carbonate coatings on undersides; many carbonate nodules in loamy material; loamy material effervesces strongly.

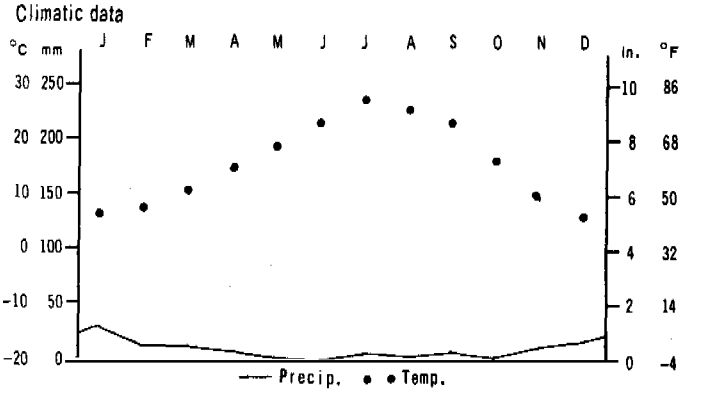
SOIL Pedon 41 Typic Salorthid SOIL Nos. S55Calif-36-3 LOCATION San Bernardino County, California

SOIL SURVEY LABORATORY **Riverside, California** LAB. Nos. 5517 - 5523

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1															
		Total			Sand					Silt					Coarse fragments 1A2a		
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05 -0.02)	Int. III (0.02-0.002)	Int. II (0.2 -0.02)	2-01		> 2 Pct. of whole soil	2-19	19-76
																Pct. of <76mm	

Pedon 41

Classification: Typic Salorthid, very-fine, montmorillonitic, thermic.
Location: San Bernardino County, Calif. About 8 km northeast of Lucerne Valley. 122 m west and 61 m south of center of sec. 24, T. 5 N., R. 1 W.
Physiographic position: Playa, elevation about 915 m.
Topography: Nearly level.
Drainage: Well drained.
Vegetation: A few clumps of shad scale (Atriplex canescens), about 60 cm high.
Parent material: Alluvium, mainly from granitic rocks.
Sampled by: Fred Eggers, W. G. Harper, and R. E. Nelson, January, 1955.
Remarks: Weakly defined very coarse prisms are present in the C2sa and C3sa horizons.
Soil No. S55Calif-36-3.



Colors are for the dry soil unless indicated otherwise.

C1 0-5 cm (0-2 in.). Pale brown (10YR 6/3) clay, yellowish brown (10YR 5/4) moist; weak coarse prisms breaking to strong very fine subangular blocks; very hard (dry), firm (moist); violently effervescent; few pebbles; abrupt smooth boundary.

C2sa 5-15 cm (2-6 in.). Light yellowish brown (10YR 6/4) clay, yellowish brown (10YR 5/4) moist; strong very fine granules; soft (dry), very friable (moist); very few roots; 5 to 10 percent by volume of salt crystals up to 3 mm in diameter; abrupt wavy boundary.

C3sa 15-25 cm (6-10 in.). Yellowish brown (10YR 5/4) silty clay, dark yellowish brown (10YR 4/4) moist; weak very coarse prisms breaking to moderate very fine to medium granules; slightly hard (dry), friable (moist); violently effervescent; few shad scale roots; abrupt smooth boundary.

C4sa 25-58 cm (10-23 in.). Brown (10YR 5/3) clay, brown (10YR 5/3) moist; very weak medium to coarse prisms breaking to weak fine subangular blocks; very hard (dry), firm (moist); violently effervescent; few shad scale roots; clear smooth boundary.

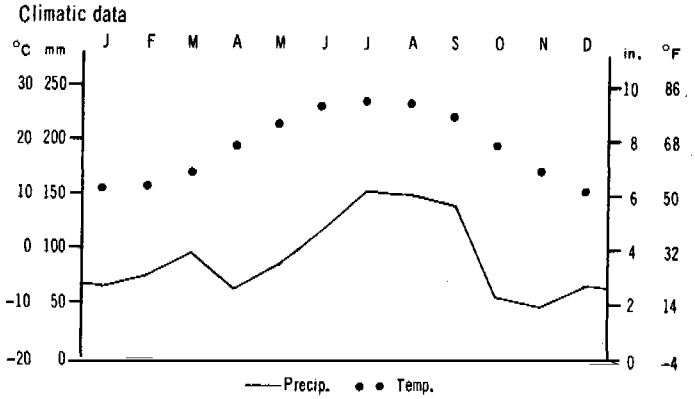
C5sa 58-86 cm (23-34 in.). Brown (10YR 5/3) clay moist; weak medium subangular blocks; hard (dry), firm (moist); violently effervescent; very few fine shad scale roots; abrupt smooth boundary.

C6sa 86-105 cm (34-41 in.). Brown (10YR 5/3) clay moist; massive; very hard (dry), firm (moist); violently effervescent, common fine to medium white (10YR 8/1) carbonate mottles; very few roots; abrupt smooth boundary.

C7 105-135 cm (41-53 in.). Pale brown (10YR 6/3) clay moist; massive; very hard (dry), firm (moist); violently effervescent, many white (10YR 8/2) carbonate mottles.

Pedon 42

Classification: Typic Sulfaquept, fine, mixed, thermic.
Location: Colleton County, S. C., 9.6 km south of Green Pond.
Physiographic position: Tidal marshland.
Topography: Level inside a diked area.
Drainage: Very poorly drained.
Vegetation: Needle marshgrass, 45 cm high, and giant cordgrass in a formerly cultivated area.
Parent material: Marine sediments and organic materials.
Sampled by: L. T. Alexander, C. M. Ellerbe, J. F. Fleming et al., July, 1957.
Soil No.: S57SC-15-2.
Remarks: Dikes and drainage established 1947.



Colors are for the moist soil.

A11 0-8 cm (0-3 in.). Dark reddish brown (5YR 3/2) highly organic silty clay or clay; nonsticky and nonplastic (wet).

A12 8-23 cm (3-9 in.). Very dark grayish brown (10YR 3/2) highly organic silty clay loam or silty clay; slightly sticky and slightly plastic (wet).

Bg1 23-41 cm (9-16 in.). Dark grayish brown (2.5Y 4/2) silty clay; sticky and slightly plastic (wet); many yellow (2.5Y 7/6) jarosite mottles.

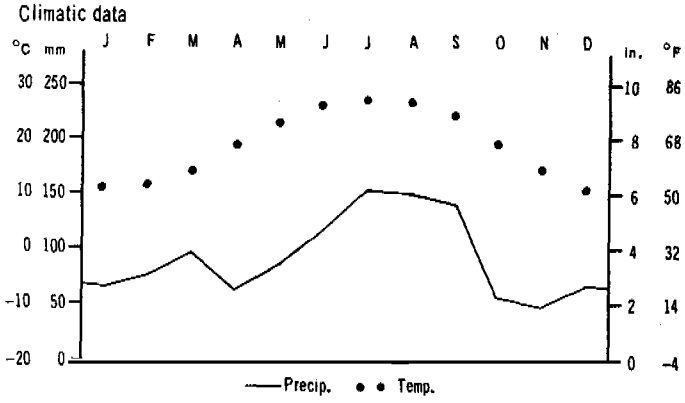
Bg2 41-63 cm (16-25 in.). Very dark brown (10YR 2/2) highly organic silty clay loam or silty clay; sticky and slightly plastic (wet); under field moisture condition offers no resistance to pressure, and the material escapes readily between the fingers when gentle hand pressure is applied; common yellow (2.5Y 7/6) jarosite mottles.

Bg3 63-94 cm (25-37 in.). Very dark brown (10YR 2/2) highly organic clay; sticky and slightly plastic (wet); under field moisture condition offers no resistance to pressure, and the material escapes readily between the fingers when gentle hand pressure is applied; common yellow (10YR 7/6) jarosite mottles.

Depth (cm)	Field water content	8C1 Initial field moist	8C1b Dried 1 week	8C1b Dried 1 month	8A2 Electrical resistance in ohms at 16°C			7C1 Total sulfur	Loss on ignition at 700°C
					Initial	Dried 1 week	Dried 1 month		
	Pct.	pH	pH	pH				Pct.	Pct.
0-8	105	3.6	3.3	3.4	271	279	257	0.4	18
8-23	106	2.9	2.9	3.2	224	210	60	0.2	12
23-41	149	2.3	2.6	2.8	122	111	97	1.7	15
41-63	187	2.5	1.8	1.7	70	29	19	5.1	22
63-94	209	2.3	1.7	1.6	54	25	19	5.5	24

Pedon 43

Classification: Typic Sulfaquent, fine, mixed, thermic.
Location: Colleton County, S. C., 9.6 km south of Green Pond.
Physiographic position: Tidal marshland.
Topography: Level.
Drainage: Very poorly drained.
Vegetation: Needle marshgrass.
Parent material: Marine sediments and organic materials.
Sampled by: L. T. Alexander, C. M. Ellerbe, J. F. Fleming et al., July, 1957.
Soil No.: S57SC-15-1.
Remarks: Undisturbed area with daily tides 15 cm deep.



Colors are for the moist soil.

0-18 cm (0-7 in.). Very dark grayish brown (10YR 3/2) highly organic silty clay loam or silty clay; slightly sticky and nonplastic (wet); under field moisture condition offers no resistance to pressure, and when gentle hand pressure is applied, the material escapes readily between the fingers.

18-38 cm (7-15 in.). Very dark brown (10YR 2/2) highly organic silty clay loam or silty clay; slightly sticky and slightly plastic (wet); under field moisture condition offers no resistance to pressure, and when gentle hand pressure is applied, the material escapes readily between the fingers.

38-56 cm (15-22 in.). Very dark brown (10YR 2/2) highly organic silty clay; sticky and slightly plastic (wet); under field moisture condition offers no resistance to pressure, and when gentle hand pressure is applied, the material escapes readily between the fingers.

56-69 cm (22-27 in.). Very dark brown (10YR 2/2) highly organic silty clay; sticky and slightly plastic (wet); under field moisture condition offers no resistance to pressure, and when gentle hand pressure is applied, the material escapes readily between the fingers.

69-84 cm (27-33 in.). Black (10YR 2/1) highly organic silty clay; sticky and slightly plastic (wet).

Depth (cm)	Field water content	8C1 Initial field moist	8C1b Dried 1 week	8C1b Dried 1 month	8A2 Electrical resistance in ohms at 16°C			7C1 Total sulfur	$CaCO_3$ equivalent
					Initial	Dried 1 week	Dried 1 month		
	Pct.	pH	pH	pH				Pct.	Pct.
0-18	295	4.9	2.6	2.4	44	30	14	3.5	-
18-38	213	5.7	4.7	3.9	28	22	17	2.1	-
38-56	181	5.2	3.8	3.1	22	17	13	3.2	-
56-69	172	5.2	3.6	3.0	20	15	12	3.5	-
69-84	105	5.6	3.8	3.2	21	14	11	2.2	-

SOIL Pedon 44 Alfic Haplorthod SOIL Nos. S56Maine-2-4 LOCATION Aroostook County, Maine

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 561223 - 561229

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1 2A2 > 2 Pct.	2-19 (Pct. of < 76mm)	19-76 (Pct. of < 76mm)
		Pct. of < 2 mm																
0-20	Ap	35.2	49.6	15.2	8.8	6.2	4.0	7.6	8.6	19.6	30.0	32.6	26.6			26		
20-36	B21	37.3	47.9	14.8	6.3	7.3	4.8	9.2	9.7	26.3	21.6	41.2	27.6			24		
36-64	A'2	46.2	41.3	12.5	8.9	9.3	6.0	11.0	11.0	16.5	24.8	33.8	35.2			28		
64-81	B'21	33.3	42.0	24.7	6.7	6.5	4.0	7.6	8.5	13.9	28.1	26.8	24.8			32		
81-102	B'22	36.5	42.3	21.2	7.0	6.8	4.7	8.9	9.1	15.2	27.1	29.7	27.4			19		
102-125	B'23	36.9	42.5	20.6	6.4	7.4	4.7	9.2	9.2	14.5	28.0	29.2	27.7			22		
125-150	C1	36.2	41.6	22.2	9.4	7.7	4.2	7.1	7.8	14.0	27.6	25.8	28.4			25		

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N		6E1e Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density 4A3a Field moist core g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD	pH	8C1c (1:1) KCl	8C1a (1:1) H_2O
0-20	2.08	0.202	10			1.5	1.09						8.2					4.8
20-36	1.55	0.127	12			1.5							8.5					4.6
36-64	0.16					1.0							5.1					4.8
64-81	0.14					1.5							9.2					5.1
81-102	0.08					1.3							8.2					6.0
102-125	0.10					1.3							7.5					6.2
125-150	0.08				10	1.4							9.0					7.7

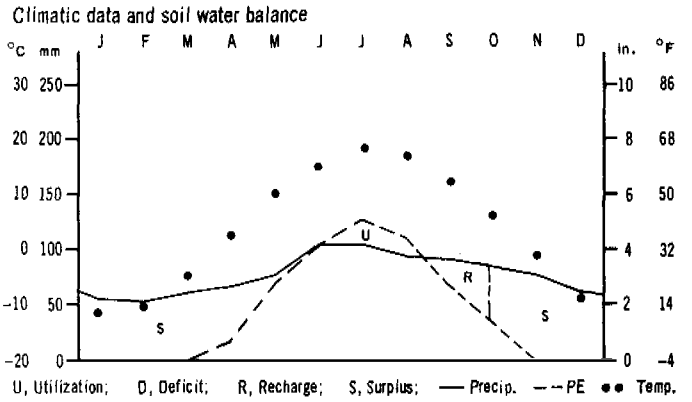
Depth (cm)	Extractable bases 5B1a 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	CEC 5A3a Sum cations		6G1d Ext. Al			Ratios to clay 8D1 CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-20	3.0	0.7	0.1	0.7	4.5	18.2	22.7					1.49	0.10	0.54			20	
20-36	1.0	0.1	tr.	0.4	1.5	22.3	23.8					1.61	0.10	0.57			6	
36-64	2.0	0.3	tr.	0.2	2.5	4.6	7.1					0.57	0.08	0.41			35	
64-81	5.1	0.8	tr.	0.2	6.1	4.6	10.8					0.44	0.06	0.37			57	
81-102	6.1	0.8	tr.	0.1	7.0	2.7	9.7					0.46	0.06	0.39			72	
102-125	6.1	0.9	tr.	0.1	7.1	2.5	9.7					0.47	0.06	0.36			74	
125-150	a/												0.06	0.40				

Depth

a/ Calcareous.

Pedon 44

Classification: Alfic Haplorthod, coarse-loamy, skeletal, mixed frigid.
Location: Aroostook County, Maine. Myron Gartley Farm, approximately 7.2 km south of Presque Isle on U. S. Route 1.
Topography: Nearly level.
Drainage: Well drained.
Vegetation: spruce, (Picea); fir, (Abies); red maple, (Acer rubrum); aspen, (Populus); white birch (Betula papyrifera); black birch, (Betula nigra); pussy willow, (Salix discolor); dogwood, (Cornus); witchhazel, (Hamamelis virginiana); and some grasses.
Parent material: Late Wisconsin glacial till largely from the underlying gray calcareous shale, which has some interbeds of nearly pure limestone.
Sampled by: W. Farley, E. J. Pedersen, and W. H. Lyford. July 13, 1956.
Soil No.: S56Maine-2-4.
Remarks: Colors are for the moist soil unless indicated otherwise.



Ap 0-20 cm (0-8 in.). Brown (10YR 4/3), light brownish gray (2.5YR 6/2) to light yellowish brown (2.5Y 6/3) dry; gravelly light loam, 20-30 percent by volume of 0.5-75 cm diameter subrounded and angular dark gray shale siltstone and fine grained quartzite; weak coarse and fine granular structure; very friable (moist); gravel is not calcareous but some pebbles are brown inside as a result of leaching of previously calcareous shales; abrupt smooth boundary.

A2 Not sampled 20-24 cm (8-10 in.). Pale brown (10YR 6/3) broken, light gray in place; light loam; weak thin platy or very weak fine granular structure, very friable (moist); horizon occurs as spots 20-30 cm wide and 3-5 cm thick at horizontal distances of 2-2.5 meters; abrupt smooth boundary.

B2ir 20-36 cm (8-14 in.). Brown (7.5YR 4/4) gravelly light loam; 20-30 percent by volume of 0.5-1 cm subrounded and angular shale fragments; compound very weak subangular blocky and weak very fine granular structure; very friable (moist); roots numerous; horizon discontinuous but present over 80-90 percent of the area; broken wavy boundary.

A'2 36-64 cm (14-25 in.). Yellowish brown (10YR 5/4) crushing to a slightly browner color; gravelly light loam, 10-20 percent by volume of 0.5-3 cm angular and subangular shale fragments; compound weak to moderate coarse platy and weak fine subangular structure; firm in place (moist); friable when removed, slightly brittle; horizontal ped faces have a few clay skins in pores and openings and many fine vertical cylindrical pores in plates many of which extend continuously from top to bottom and upper openings with clay skins; abrupt smooth boundary.

B'21t 64-81 cm (25-32 in.). Olive brown (2.5Y 4/4) very gravelly heavy loam, 60-80 percent by volume of 5-10 cm diameter angular and subangular pebbles; moderate medium subangular blocky structure; firm in place, friable when removed (moist); slightly sticky and plastic (wet); ped faces have clay skins, pore channels are evident on ped faces, many fine pores in ped interiors with clay skins; position of gravel resembles a "stone line" or solifluction unconformity, about 20 percent of the fragments are very friable leached brown "ghosts" from calcareous shale, horizon appears to have maximum concentration of clay and of ghosts; fine faint gray mottling occurs in a few places; gradual smooth boundary.

B'22t 81-102 cm (32-40 in.). Olive brown (2.5Y 4/4) gravelly heavy loam, 30-40 percent by volume of 0.5-8 cm subrounded shale and fine grained quartzite pebbles; very weak very coarse angular blocky structure, firm in place (moist); ped faces have a surface network of pore channels with light olive brown (2.5Y 5/4) clay skins, pores are mostly between peds and appear as channels when peds are separated; 2 percent by volume very friable moist brown ghosts; gradual smooth boundary.

B3 102-125 cm (40-49 in.). Much like the above but with compound very weak very coarse subangular blocky and moderate medium platy structure, blocky peds have clay skins but platy peds have none; abrupt smooth boundary.

C1 125-150 cm (49-58 in.). Olive brown (2.5Y 4/4) gravelly heavy loam, 30-40 percent by volume of 0.5-8 cm diameter subrounded dark gray calcareous shale or siltstone and a few fine grained quartzite pebbles; moderate medium platy structure, peds are 0.5-1 cm thick and 5-8 cm across, feathered at the edges and have no clay skins; firm to very firm in place (moist), not brittle, nonplastic and nonsticky (wet); digs out with difficulty using a tiling spade; no visible pores; a few 0.5-1 ghosts occur; moderately calcareous.

SOIL Pedon 45 Aeric Glossaqualf SOIL Nos. S61Wis-60-4 LOCATION Taylor County, Wis.

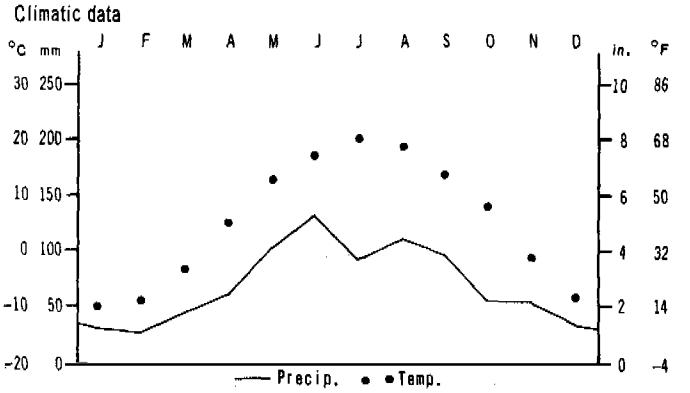
SOIL SURVEY LABORATORY Lincoln, Nebraska LAB. Nos. 15987-15994

General Methods: 1A, 1B1a, 2A1, 2B

Depth	Horizon	Size class and particle diameter (mm) 3A1													2A2 Coarse fragments 3B1
		Total			Sand					Silt					
		a/ Sand	Silt	Clay	Very coarse	Coarse	Medium	Fine	Very fine		Int. III	Int. II			
															2-20

Pedon 45

Classification: Aeric Glossaqualf, fine-silty, mixed, frigid.
Location: Taylor County, Wis., NW 1/4 SW 1/4 sec. 5, T. 31 N., R. 3 W., 66 m E. of State Highway 73.
Physiographic position: Upland, ground moraine.
Topography: Nearly level, 1 percent slope to west.
Drainage: Poorly drained, slow permeability, slow runoff.
Vegetation: Sedges (Carex spp.), redtop (Agrostis alba), annual bluegrass (Poa annua), willow (Salix spp.), raspberries (Rubus spp.), dogwood (Cornus spp.); abandoned pasture.
Parent material: Moderately deep silt mantle overlying acid sandy loam to loam glacial till.
Sampled by: R. B. Grossman, A. J. Klingelhoets, G. B. Lee, G. J. Post and G. Wing, September 22, 1961.
Soil No.: S61Wis-60-4.



Colors are for the moist soil unless otherwise indicated.

A1 — 0-8 cm (0-3 in.). Black (10YR 2/1) and very dark brown (10YR 2/2) silt loam; very fine subangular blocks separated to moderate fine granules; friable (moist); plentiful roots; strongly acid; abrupt smooth boundary.

A21 — 8-15 cm (3-6 in.). Grayish brown (2.5Y 5/2) to light brownish gray (2.5Y 6/2) silt, few fine distinct mottles of strong brown (7.5YR 5/6 to 5/8); moderate thin plates; slightly vesicular; plentiful roots; strongly acid; clear wavy boundary.

A22 — 15-25 cm (6-10 in.). Light brownish gray (10YR 6/2) silt, many medium distinct mottles of yellowish brown (10YR 5/6), strong brown (7.5YR 5/6 to 5/8), and dark brown (7.5YR 4/4); moderate thin and medium plates; friable (moist); slightly vesicular; plentiful roots; strongly acid; gradual irregular boundary.

B&A — 25-36 cm (10-14 in.). Grayish brown (10YR 5/2) light silt loam, tongues of light brownish gray (10YR 6/2) extending from horizon above, many large distinct mottles of yellowish brown (10YR 5/8) and strong brown (7.5YR 5/6 to 5/8); moderate thick plates; friable (moist); slightly vesicular; plentiful roots; very strongly acid; gradual wavy boundary.

B21tg — 36-53 cm (14-21 in.). Brown (10YR 5/3) heavy silt loam, few tongues of gray (10YR 6/1) extending from A22 horizon, many large prominent mottles of strong brown (7.5YR 5/6 to 5/8) and dark brown (7.5YR 4/4); moderate thick plates; firm (moist), slightly hard (dry); slightly vesicular; few sedge (Carex spp.) roots; very strongly acid; gradual wavy boundary.

B22tg — 53-74 cm (21-29 in.). Brown (7.5YR 5/2) heavy silt loam, many large distinct mottles of strong brown (7.5YR 5/6 to 5/8), gray (N 5/0), reddish brown (5YR 4/4), and yellowish red (5YR 5/6); moderate thick plates; few sedge (Carex spp.) roots and old root channels; few fine black manganese nodules; strongly acid; clear wavy boundary.

IIB3g — 74-110 cm (29-43 in.). Brown (7.5YR 5/2) light loam, many large distinct mottles of strong brown (7.5YR 5/6 to 5/8), light gray (N 6/0), reddish brown (5YR 4/4), and yellowish red (5YR 5/6); weak to moderate thick plates; firm (moist), slightly hard (dry); clay skins line old root and wormholes; medium acid; gradual wavy boundary.

IIC1 — 110-135 cm (43-53 in.). Dark brown (7.5YR 4/2 and 4/4) sandy loam, few distinct medium mottles of strong brown (7.5YR 5/6 to 5/8); massive; friable (moist), slightly hard (dry); slightly acid; clear wavy boundary.

Pedon 46

SOIL Typic Ochraqualf SOIL Nos. S61-Ill-50-4 LOCATION LaSalle County, Ill.

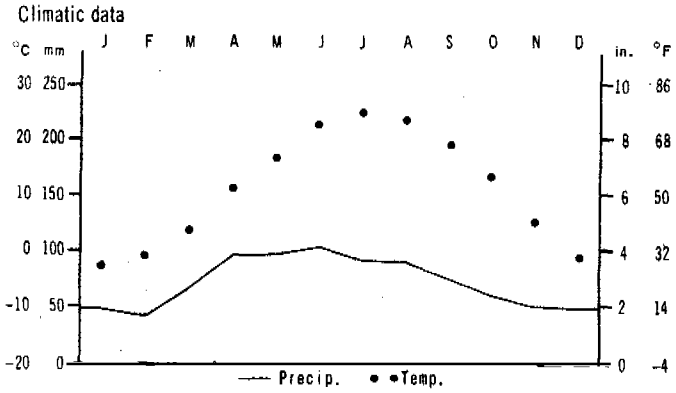
SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 16577-16585

General Methods: 1A, 1B1a, 2A1, 2B

Size classes and particle diameter (mm) 2A1

Pedon 46

Classification: Typic Ochraqualf, fine-silty, mixed, mesic.
Location: LaSalle County, Ill. 185 m S. of gravel road along fence and 129 m W. and 7 m WSW. NW 1/4 NE 1/4 SW 1/4 sec. 11, T. 34 N., R. 1 E. About 100 km (60 mi.) SW. of Chicago.
Physiographic position: Elevation about 200 m.
Topography: Slight depression, 0 percent slope.
Drainage: Poorly drained.
Vegetation: Bluegrass (Poa spp.).
Parent material: Loess > 1.5 m thick.
Sampled by: J. E. Paschke and L. E. Tyler, October 26, 1961.
Soil No.: S61Ill-50-4.



Colors are for the moist soil.

A1 0-10 cm (0-4 in.). Very dark gray (10YR 3/1) light silt loam, very dark gray (10YR 3/1 to 3/2) crushed; moderate medium

A2 10-28 cm (4-11 in.). Grayish brown (10YR 5/2) to light brownish gray (10YR 6/2) heavy silt loam with common fine faint yellowish brown (10YR 5/4) mottles mainly in root channels; moderate medium platy and moderate fine and very fine subangular blocky structure; friable (moist); plentiful roots; worm channels filled with A1 material; common iron-manganese concretions, few in upper portion; clear smooth boundary.

B1t 28-38 cm (11-15 in.). Grayish brown (2.5Y 5/2) heavy silt loam with common fine faint dark yellowish brown (10YR 4/4) mottles; moderate fine and very fine subangular blocky structure; friable (moist); plentiful roots; common iron-manganese concretions; clear smooth boundary.

B21t 38-61 cm (15-24 in.). Dark gray (10YR 4/1) crushing to 10YR 4/2 heavy silty clay loam with common medium distinct

SOIL Pedon 47 Aeric Tropaqualf SOIL Nos. S61PR-9-1 LOCATION Rio Piedras Experiment Station, Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 16892-16898

General Methods: 1A, 1B1a, 2A1, 2B

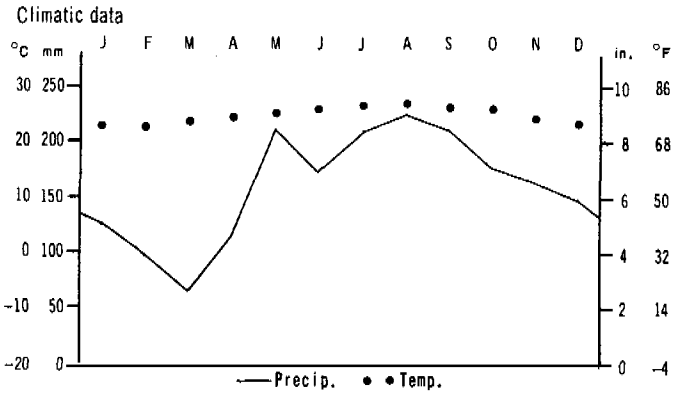
Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05) a/	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05) b/	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	Silt: (2–0.1)			Coarse fragments 2A2: 3B1 2-20 Pct. < 20
		Pct. of < 2 mm														
0-18	Ap	15.7	43.8	40.5	1.6	3.5	2.1	3.8	4.7	11.7	32.1	18.7	11.0			tr
18-30	A1	14.8	43.2	42.0	1.8	3.3	1.9	3.3	4.5	10.7	32.5	17.2	10.3			tr
30-43	B21t	11.0	40.6	48.4	1.0	2.6	1.6	2.4	3.4	11.6	29.0	16.5	7.6			tr
43-81	B22t	7.1	39.7	53.2	0.4	0.6	0.5	1.6	4.0	10.0	29.7	15.2	3.1			tr
81-125	B3	19.1	42.9	38.0	0.4	1.1	1.8	6.5	9.3	13.5	29.4	27.2	9.8			tr
125-140	C1	5.9	44.9	49.2	-	0.4	0.5	1.3	3.7	10.1	34.8	14.7	2.2			tr
140-150	C2	6.6	52.4	41.0	-	0.1	0.3	1.4	4.8	12.7	39.7	18.5	1.8			tr

Depth (cm)	6A1a Organic carbon c/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ Pct.	Bulk density: 4A1a Field state g/cc	4A1c 30-cm d/ g/cc	4A1b Air-dry g/cc	4D1 COLE e/	Water content: 4B4 Field state Pct.	4C1 1/3-to 15-bar cm/cm	4B3 30-cm Pct.	4B1b 1/3-bar	4B2 15-bar	pH: 8C1c (1:1) N KCl	8C1a (1:1) H_2O
0-18	1.48	0.156	9	5.9		1.20	1.32	1.48	0.073	40.7	0.12	30.3	32.1	21.7	4.0	4.6
18-30	1.19	0.135	9	6.5		1.26	1.32	1.46	0.052	34.7	0.12	29.2	31.2	21.5	4.1	5.1
30-43	0.54	0.061	9	4.9		1.29	1.32	1.45	0.040	33.6	0.10	29.9	30.6	22.9	3.5	4.8
43-81	0.32	0.039	8	5.2		1.28	1.3	1.58	0.073	35.2	0.13		34.9	25.0	3.4	4.8
81-125	0.10			5.7		1.36	1.36	1.52	0.040	30.8	0.11	30.4	30.2	22.2	3.7	5.1
125-140	0.09			4.8										23.2	4.1	5.6
140-150	0.06			5.2										22.9	4.3	5.8

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap.: 5A3a Sum cations	5A1a NH_4OAc	6G1d KCl-ext. Al	5A3b Bases plus Al me/100g clay	Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water	Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g														
0-18	9.4	3.0	0.3	0.1	12.8	16.2	29.0	20.7	0.5	32.8	0.51	0.14	0.54	44	62
18-30	9.0	3.6	0.4	0.1	13.1	15.9	29.0	19.9	0.4	32.1	0.47	0.15	0.51	45	66
30-43	5.1	4.4	0.6	0.2	10.3	16.3	26.6	18.5	3.5	28.5	0.38	0.10	0.47	39	56
43-81	4.1	7.8	1.1	0.3	13.3	15.5	28.8	21.7	5.1	34.6	0.41	0.10	0.47	46	61
81-125	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Pedon 47

Classification: Aeric Tropaqualf, fine, mixed, isohyperthermic.
Location: Puerto Rico. Rio Piedras Experiment Station, 60 m NW. on road to Foods Laboratory and 60 m NE. of the entrance to the Experiment Station. 7 km (4 mi.) SSE. of San Juan.
Physiographic position: Coastal plain.
Topography: Nearly level (1 percent).
Drainage: Somewhat poorly drained, surface runoff slow, permeability slow.
Vegetation: Merker grass (Pennisetum purpureum) pasture.
Parent material: Old coastal alluvium.
Sampled by: R. B. Grossman, J. Juarez, I. L. Martin and W. E. McKinzie, October 11, 1961.
Soil No.: S61PR-9-1.



Colors are for the moist soil.

Ap 0-18 cm (0-7 in.). Dark brown (10YR 4/3) silty clay; weak fine granular structure; firm (moist), slightly sticky and slightly plastic (wet); abundant roots; few fine nodules of iron-manganese oxides; gradual wavy boundary.

A1 18-30 cm (7-12 in.). Yellowish brown (10YR 5/8) and dark grayish brown (10YR 4/2) silty clay; weak fine granular structure; firm (moist), slightly sticky and plastic (wet); abundant roots; few nodules of iron-manganese oxides; abrupt wavy boundary.

B21t 30-43 cm (12-17 in.). Dark grayish brown (10YR 4/2) and yellowish brown (10YR 5/8) silty clay; weak coarse subangular blocky structure; common fine distinct yellowish brown mottles; firm (moist), slightly sticky and slightly plastic (wet); black coatings on soil peds and in root channels; few fine manganese concretions; abrupt wavy boundary.

B22t 43-81 cm (17-32 in.). Strong brown (7.5YR 5/8) and gray (5Y 6/1) light clay; weak medium subangular blocky structure; firm (moist), slightly sticky and plastic (wet); seams between peds and root channels filled with gray clay; few fine nodules of iron-manganese oxides; gradual wavy boundary.

B3 81-125 cm (32-50 in.). Brownish yellow (10YR 6/8) and light gray (N 7/0) heavy silty clay loam with pockets of yellowish brown clay loam materials; weak coarse subangular blocks; slightly sticky and slightly plastic (wet); few peds and fracture planes coated with black iron-manganese oxides; root channels and worm burrows filled with clay; abrupt wavy boundary.

C1 125-140 cm (50-55 in.). Light gray (N 7/0) mottled with strong brown (7.5YR 5/8) silty clay; massive; sticky and plastic (wet); few roots; abrupt wavy boundary.

C2 140-150 cm (55-60 in.). Light gray (N 7/0) and strong brown (7.5YR 5/8) silty clay; massive; sticky and plastic (wet).

Micromorphology, method 4E1. The B22t shows some clay skins and strong orientation of the clayey matrix.

SOIL Pedon 48 Typic Cryoboralf SOIL Nos. S55Colo-25-6 LOCATION Grand County, Colo.

SOIL SURVEY LABORATORY Lincoln, Nebraska LAB. Nos. 2893-2898

General Methods: 1A, 1B1b, 2A1, 2B

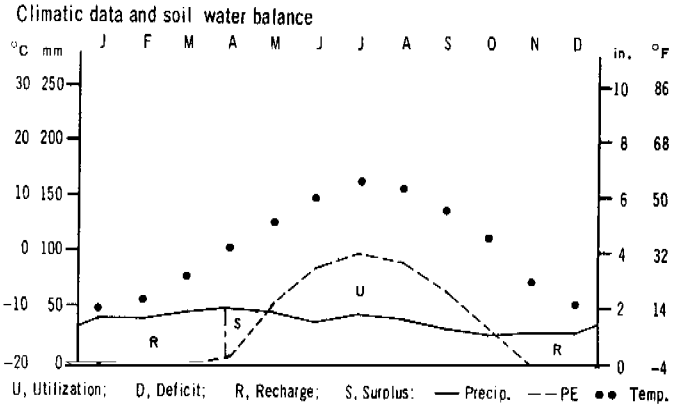
Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-18	A2	42.3	45.3	12.4	16.9	15.0	2.8	5.3	2.3	21.7	23.6	27.0	40.0					8
18-30	B1t	33.1	39.1	27.8	6.7	5.4	3.9	7.8	9.3	18.9	20.2	32.8	23.8					4
30-56	B21t	29.7	34.2	36.1	3.6	4.5	4.0	8.3	9.3	16.0	18.2	30.3	20.4					2
56-81	B22t	30.2	35.3	34.5	3.7	4.5	4.0	8.6	9.4	17.1	18.2	31.7	20.8					1
81-97	B3t	34.6	32.9	32.5	5.0	6.1	4.8	9.4	9.3	16.1	16.8	30.8	25.3					2
97-120	C	39.0	30.5	30.5	10.1	7.6	4.6	8.4	8.3	15.0	15.5	28.1	30.7					4

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6A1a Ext. iron as Fe Pct.	Bulk density g/cc	g/cc	g/cc		Water content Pct.	4B2 15-bar Pct.	Pct.			pH		8C1a (1:1) H_2O
0-18	0.84	0.042	20			0.8						5.6						5.9
18-30	0.35	0.025	14			1.0						10.4						5.4
30-56	0.26	0.018	14			1.1						14.8						5.2
56-81	0.20	0.020				1.0						14.9						5.1
81-97	0.22	0.015				1.0						13.7						5.5
97-120	0.17	0.015				1.1						12.8						5.9

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap.: 5A3a Sum cations	5A1a NH_4OAc				Ratios to clay 8D1: Ext. iron	15-bar water	NH_4OAc CEC		8D3 Ca/Mg	Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-18	6.1	1.8	-	0.6	8.5	4.8	13.3	11.0				0.06	0.45	0.89		3.4	64	77
18-30	12.6	4.2	0.1	0.6	17.5	4.2	21.7	19.7				0.04	0.37	0.71		3.0	81	89
30-56	19.4	5.9	0.1	0.7	26.1	5.4	31.5	27.7				0.03	0.41	0.77		3.3	83	94
56-81	19.1	6.1	0.2	0.5	25.9	4.3	30.2	27.6				0.03	0.43	0.80		3.1	86	94
81-97	19.4	6.1	0.2	0.4	26.1	3.9	30.0	26.8				0.03	0.42	0.82		3.2	87	97
97-120	18.6	5.6	0.2	0.3	24.7	3.7	28.4	26.1				0.04	0.42	0.85		3.3	87	95

Pedon 48

Classification: Typic Cryoboralf, fine-loamy, mixed.
Location: Grand County, Colo., Frazier Experimental Forest, 1.8 km N & 58 m W of Forest Service headquarters bldg., SW 1/4 NE 1/4 sec. 34, T. 1 S., R. 76 W.
Physiographic position: Outwash terrace, elev. 3,100 m.
Topography: Gently sloping, 4 percent convex, east facing.
Drainage: Well drained.
Vegetation: Lodgepole pine (Pinus contorta), thin understory of blueberry (Vaccinium spp.) and grasses.
Parent material: Alluvium.
Sampled by: J. S. Allen and A. J. Cline, August 1955.
Soil No.: S55Colo-25-6.



Colors are for dry soil unless otherwise indicated.

O2 3-0 cm (1-0 in.). Gray (10YR 5/1) partially decomposed organic material, very dark gray (10YR 3/1) moist; abrupt boundary.

A2 0-18 cm (0-7 in.). Light gray (10YR 7/2) light loam, grayish brown (10YR 5/2) moist; weak coarse and medium plates break to weak and moderate fine crumbs; soft (dry), friable (moist); medium acid; gradual wavy boundary.

B1t 18-30 cm (7-12 in.). Pale brown (10YR 6/3) light clay loam, dark brown (10YR 4/3) moist, light gray (10YR 7/2) coatings; moderate fine angular and subangular blocky structure; slightly hard (dry), friable (moist); thin continuous clay skins; strongly acid; gradual wavy boundary.

B21t 30-56 cm (12-22 in.). Light brown (7.5YR 6/4) heavy clay loam, brown (7.5YR 5/4) moist, light gray (10YR 7/2) coatings; weak to moderate very coarse prisms separate to strong medium angular blocks; extremely hard (dry), very firm (moist); thick continuous clay skins; strongly acid; gradual smooth boundary.

B22t 56-81 cm (22-32 in.). Brown (7.5YR 5/4) light clay loam, dark brown (7.5YR 4/4) moist, light gray (10YR 7/2) coatings with some dark organic staining; weak to moderate very coarse prisms separate to moderate and strong coarse and medium angular blocks; extremely hard (dry), very firm (moist); thick clay skins; strongly acid; gradual smooth boundary.

B3t 81-97 cm (32-38 in.). Brown (7.5YR 5/4) light clay loam, dark brown (7.5YR 4/4) moist, light gray (10YR 7/2) indistinct coatings; weak coarse subangular blocky structure; hard (dry), friable (moist); thin nearly continuous clay skins; strongly acid; gradual smooth boundary.

C 97-120 cm (38-47 in.). Yellowish brown (10YR 5/4) gravelly light clay loam, dark yellowish brown (10YR 4/4) moist; massive; hard (dry), friable (moist); medium acid; grades into waterwashed cobbles and pebbles.

Pedon 49

SOIL Typic Eutroboralf SOIL Nos. S48Minn-56-4 LOCATION Otter Trail County, Minnesota

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 49651 - 49658

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1 Total: Sand (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: 0.05–0.02	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 > 2 Pct.	2 – 19	19 – 76
		Pct. of < 2 mm															Pct. of < 76mm	
5–0	O1																	
0–13	A2	38.2	52.8	9.0	1.3	5.4	6.5	12.9	12.1	25.0	27.8		26.1					
13–25	B21t	16.8	54.0	29.2	0.5	1.8	2.1	4.8	7.6	23.9	30.1		9.2					
25–38	B22t	35.0	35.5	29.5	2.0	6.2	6.7	12.2	7.9	15.4	20.1		27.1					
38–58	B3	70.2	16.4	13.4	7.3	14.8	13.4	23.7	11.0	8.6	7.8		59.2					
58–74	C1ca	73.1	18.1	8.8	6.5	14.5	14.1	25.5	12.5	10.1	8.0		60.6					
74–115	C2ca	70.4	20.2	9.4	5.1	13.7	13.9	25.1	12.6	11.0	9.2		57.8					
115–140	C3	68.3	20.4	11.3	5.1	13.1	13.5	24.5	12.1	10.3	10.1		56.2					

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density: g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content: Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD	pH:	8C1c (1:1) KCl	8C1a (1:1) H_2O
5–0																		6.6
0–13	0.47	0.039	12			0.4												7.4
13–25	0.38	0.048	8			0.7												7.1
25–38	0.30	0.050	6			0.7												7.0
38–58	0.23	0.023	10			0.6												7.0
58–74	0.10	0.012				0.4												7.8
74–115	0.14	0.011				0.4												8.2
115–140	0.08	0.008				0.3												8.1

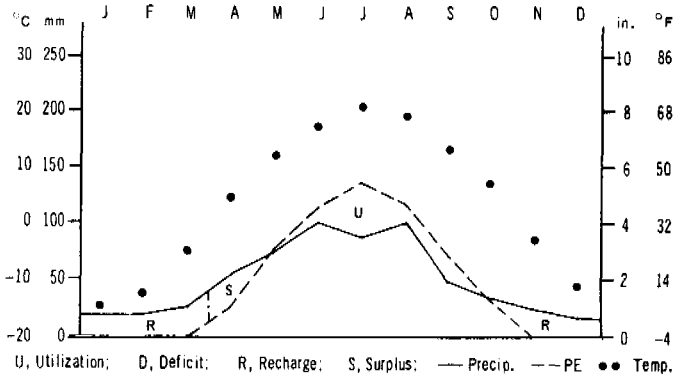
Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	CEC: 5A3a Sum cations		6G1d Ext. Al			Ratios to clay: CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
5–0																		
0–13	6.2	1.4	0.0	0.2	7.8	1.1	8.9		0.99	0.04							88	
13–25	13.8	3.6	tr.	0.5	17.9	2.6	20.5		0.70	0.02							87	
25–38	13.5	4.2	tr.	0.4	18.1	2.6	20.7		0.70	0.02							87	
38–58										0.04								
58–74										0.04								
74–115										0.04								
115–140										0.03								

Depth

Pedon 49

Classification: Typic Eutroboralf, fine-loamy, mixed.
Location: Otter Tail Co., Minn., north of Pelican Rapids, NE 1/4 NE 1/4 Sec. 15, Twp. 137 N, R. 42 W.
Physiographic position: Till plain.
Topography: Slopes between 2 and 10 percent.
Vegetation: Mixed deciduous trees consisting of mainly red oak, (Quercus borealis), poplar, (Populas), a few box elders, (Acer negundo), and basswood, (Tilia americana), with an undercover of hazel brush, (Corylus americana).
Parent material: Calcareous till.
Sampled by: Prof. P. R. McMiller and I. J. Nygard on October 5, 1948.
Soil No.: S48Minn-56-4.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

O1 5-0 cm (2-0 in.). Very dark brown (10YR 2/2) mat of leaves and roots.

A2 0-13 cm (0-5 in.). White (10YR 8/2) light silt loam, light gray (10YR 7/2) moist; well developed fine platy structure; very friable (moist); slightly vesicular; abundant stones; clear boundary.

B21t 13-25 cm (5-10 in.). Dark grayish brown (10YR 4/2) light silty clay loam, light yellowish brown (10YR 6/4) when crushed; moderate medium subangular blocky structure; hard (dry), firm (moist), plastic (wet); peds coated with light gray

(10YR 7/2) silt; abundant roots.

B22t 25-38 cm (10-15 in.). Dark grayish brown (10YR 4/2) to very dark grayish brown (10YR 3/2) light clay loam, light yellowish brown (10YR 6/4) when crushed; very coarse subangular blocky structure; hard (dry), firm (moist), plastic (wet); peds partially coated with light gray (10YR 7/2) silt; discontinuous thick clay skins; plentiful roots; few pebbles.

B3 38-58 cm (15-23 in.). Light yellowish brown (10YR 6/4) light sandy loam, pale yellow (2.5Y 7/4) when crushed; weak very coarse subangular blocky

C1ca 58-74 cm (23-29 in.). Pale yellow (2.5Y 7/4) streaked with white (N 8/0) carbonates light sandy loam; single grain; few reddish brown (2.5YR 5/4) mottles; few roots; few largely dolomitic pebbles; highly calcareous.

C2ca 74-115 cm (29-45 in.). Pale yellow (2.5Y 7/4) streaked with white (N 8/0) carbonates light sandy loam; single grain; few strong brown (7.5YR 5/6) mottles, few reddish brown (2.5YR 5/4) stains; few roots; many largely dolomitic pebbles; common lime segregations; highly calcareous.

C3 115-140 cm (45-55 in.). Pale yellow (2.5Y 7/4) heavy sandy loam; single grain; friable (moist); lime segregations in streaks; highly calcareous.

Pedon 50

SOIL Typic Hapludalf SOIL Nos. S56Ill-30-1 LOCATION Gallatin County, Ill.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 5506-5514

General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 Total: a/ Sand (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: (0.05–0.02)	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	Coarse fragments 2A2 3B1 2–20 Pct. < 20
		Pct. of < 2 mm												
0-10	Ap	1.2	86.6	12.2	0.1	0.1	0.1	0.2	0.7	40.8	45.8	41.6	0.5	-
10-28	A2	0.8	85.4	13.8	-	0.1	0.1	0.2	0.4	38.8	46.6	39.3	0.4	-
28-36	B1t	0.4	81.2	18.4	-	-	-	-	0.4	33.9	47.3	34.3	-	-
36-48	B21t	0.4	74.5	25.1	-	-	-	-	0.4	31.7	42.8	32.1	-	-
48-81	B22t	0.6	69.2	30.2	-	-	-	0.1	0.5	31.1	38.1	31.7	0.1	-
81-120	B31t	0.8	73.0	26.2	-	-	-	0.1	0.7	34.4	38.6	35.2	0.1	-
120-155	B32t	0.5	77.2	22.3	-	-	-	0.1	0.4	41.6	35.6	42.1	0.1	-
155-190	C	0.3	86.0	13.7	-	-	-	-	0.3	47.3	38.7	47.6	-	-

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	Carbonate as $CaCO_3$ Pct.	Bulk density 4A3a Field state b/ g/cc	g/cc	g/cc	Water content 4B4 Field state Pct.	Pct.	4B2 15-bar Pct.	pH 8C1a (1:1) H_2O
0-10	1.74	0.163	11		1.12			19.2		6.3	7.2
10-28	0.74	0.073	10		1.23			15.7		5.5	5.8
28-36	0.31	0.036	9							6.9	5.2
36-48	0.35	0.041	8		1.40			10.3		9.4	5.2
48-81	0.22	0.033			1.43			18.2		12.4	5.1
81-120	0.10				1.45			22.1		11.3	5.0
120-155	0.09				1.47			23.5		10.6	5.6
155-190	0.08				1.49			24.5		6.8	6.8

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap. 5A3a Sum cat-ions	5A1a NH_4OAc	Ratios to clay 8D1: NH_4OAc CEC	15-bar water	8D3 Ca/Mg	Base saturation 5C3 Sum cat-ions Pct.	5C1 NH_4OAc Pct.
	meq/100 g												
0-10	8.4	2.8	-	0.7	11.9	1.6	13.5	10.8	0.88	0.52	3.0	88	110
10-28	3.4	1.2	-	0.4	5.0	3.6	8.6	7.1	0.51	0.40	2.8	58	70
28-36	3.3	1.6	0.1	0.3	5.3	4.5	9.8	7.9	0.43	0.38	2.1	54	67
36-48	4.7	2.8	-	0.4	7.9	5.3	13.2	11.4	0.45	0.37	1.7	60	69
48-81	5.6	5.4	-	0.5	11.5	7.9	19.4	16.1	0.53	0.41	1.0	59	71
81-120	4.2	5.1	0.1	0.4	9.8	7.4	17.2	14.6	0.56	0.43	0.8	57	67
120-155	6.2	6.0	0.2	0.3	12.7	3.7	16.4	15.0	0.67	0.48	1.0	77	85
155-190	5.2	3.9	0.1	0.2	9.4	2.4	11.8	10.0	0.73	0.50	1.3	80	94

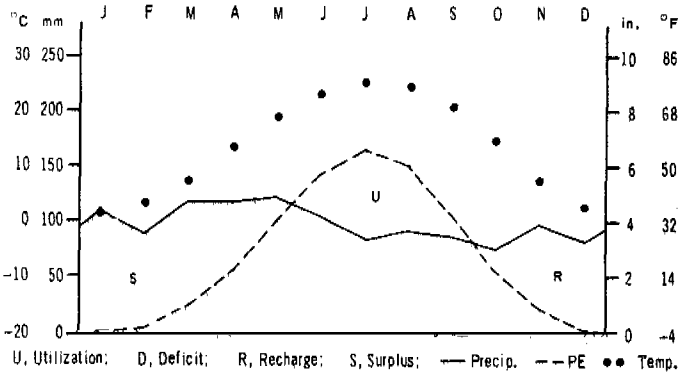
Depth (cm)	Clay fraction c/ mineralogy 7A1: 7A2 X-ray d
0-10	
10-28	
28-36	
36-48	MT5,MI2,KK1
48-81	
81-120	
120-155	
155-190	

a/ Few iron-manganese nodules.
b/ Determined by University of Illinois.
c/ Mineral code:
MT = montmorillonite
MI = mica
KK = kaolinite
d/ Approximate weight fractions:
5 = more than one-half
2 = one-twentieth to one-fifth
1 = less than one-twentieth

Pedon 50

Classification: Typic Hapludalf, fine-silty, mixed, mesic.
Location: Gallatin County, Ill., 150 m N. of half section line, E. side of road, SW 1/4 SE 1/4 NE 1/4 sec. 22, T. 7 S., R. 9 E.
Topography: 2 to 3 percent slope gradient.
Drainage: Well drained.
Vegetation: Bluegrass (Poa spp.).
Sampled by: J. K. Ableiter, A. H. Beavers, R. T. Odell and O. C. Rogers, October 31, 1956.
Soil No.: S56Ill-30-1.

Climatic data and soil water balance



Colors are for the moist soil.

Ap 0-10 cm (0-4 in.). Dark grayish brown (10YR 4/2) silt loam; weak fine granular structure; friable (moist); abundant roots; abrupt smooth boundary.

A2 10-28 cm (4-11 in.). Brown (10YR 4/3 to 5/3) light silt loam; very weak thin platy structure; friable (moist); plentiful fine roots and common wormcasts; abrupt wavy boundary.

B1t 28-36 cm (11-14 in.). Yellowish brown (10YR 5/6) to strong brown (7.5YR 5/6) heavy silt loam; weak to moderate fine and medium subangular blocky structure; firm (moist); abrupt wavy boundary.

B21t 36-48 cm (14-19 in.). Dark brown (7.5YR 4/4) heavy silt loam; moderate medium subangular blocky structure; firm (moist); few thin dark brown (7.5YR 4/2) clay skins; clear smooth boundary.

B22t 48-81 cm (19-32 in.). Dark brown (7.5YR 4/4) light silty clay loam; moderate to strong medium to coarse subangular blocky structure; firm (moist); numerous distinct dark brown (7.5YR 4/2) clay skins on peds; occasional streaks and coatings of light yellowish brown (10YR 6/4) and very dark brown (10YR 2/2) material; clear smooth boundary.

B31t 81-120 cm (32-47 in.). Brown (7.5YR 5/4) heavy silt loam; weak coarse subangular blocky structure; firm (moist); few prominent reddish brown (5YR 4/4) clay skins; occasional streaks and coatings of very dark brown (10YR 2/2) material; light yellowish brown (10YR 6/4) material coats numerous peds and fills root channels and cracks; gradual wavy boundary.

B32t 120-155 cm (47-62 in.). Yellowish brown (10YR 5/6) to brown (7.5YR 5/4) heavy silt loam; massive to very weak very coarse subangular blocky structure; friable (moist); a few dark brown (7.5YR 4/4) and reddish brown (5YR 4/4) clay skins; light brownish gray to pale brown (10YR 6/2 to 6/3) material as thin coatings on peds and as crack fillings; gradual wavy boundary.

C 155-190 cm (62-75 in.). Brown (7.5YR 4/4) light silt loam; massive; friable (moist); very thin coating of light yellowish brown (10YR 6/4) material on some peds; diffuse wavy boundary.

SOIL Pedon 51 Typic Paleudalf SOIL Nos. S65Tenn-94-1 LOCATION Williamson County, Tennessee

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 65520 - 65526

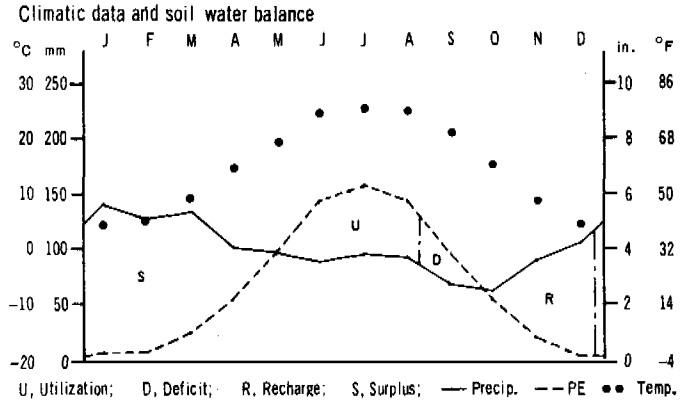
General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total: Sand (2-0.05)	Silt (0.05-0.002)	Clay (< 0.002)	Size class and particle diameter (mm) 3A1 — Sand a/: Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt: 0.05-0.02	Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 > 2 <240 mm Pct.	2-19	19-76
		Pct. of < 2 mm															Pct. of < 76mm	
0-13	Ap	20.0	55.5	24.5	3.0	3.5	2.2	5.1	6.2	19.7	35.8	29.5	13.8		0.70	44	13	7
13-36	B21t	12.4	22.6	65.0	1.2	1.9	1.8	3.4	4.1	6.3	16.3	12.4	8.3		0.80	34	8	4
36-64	B22t	11.2	22.5	66.3	1.3	1.8	1.3	2.9	3.9	6.9	15.6	12.6	7.3		0.84	28	6	7
64-91	B23t	12.7	19.3	68.0	1.2	2.0	1.8	3.8	3.9	4.3	15.0	10.4	8.8		0.97	6	4	2
91-125	B24t	14.7	20.9	64.4	0.8	2.2	2.0	4.1	5.6	4.9	16.0	12.4	9.1		0.98	4	4	0
125-165	B31	14.0	22.7	63.3	0.9	2.3	2.1	3.8	4.9	4.9	17.8	11.8	9.1		0.99	1	1	0
165-205	B32	11.0	27.3	61.7	0.4	1.1	1.8	4.2	3.5	3.9	23.4	9.8	7.5		1.00	0	tr.	tr.
205+	Ra/																	

Depth (cm)	6A1a Organic carbon b/ Pct.	Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD cm/cm	pH 8C1c (1:1) KCl	8C1a (1:1) H_2O
0-13	1.79					2.0		1.44	1.48	0.01		21.6	11.2		0.10		4.3	5.0
13-36	0.61					4.3		1.29	1.53	0.05		34.0	26.4		0.08		4.2	5.5
36-64	0.24					4.5		1.27	1.51	0.05		36.4	27.3		0.10		3.5	5.0

Pedon 51

Classification: Typic Paleudalf, very-fine, vermiculitic, thermic.
Location: Williamson County, Tenn., 3.2 km east of Arrington, Tennessee.
Physiographic position: Rolling uplands.
Topography: 7 percent slope with 280° aspect.
Drainage: Well drained.
Vegetation: Hay and pasture.
Parent material: Phosphatic limestone.
Sampled by: R. F. Dever, S. J. Ross, J. F. Campbell, E. P. Davis, O. G. Sprouse, and J. F. Brasfield. June 10, 1965.
Soil No.: S65Tenn-94-1.



Colors are for the moist soil unless otherwise indicated.

Ap 0-13 cm (0-5 in.). Dark brown (7.5YR 3/2) brown (10YR 5/3 dry) cherty silt loam; moderate medium granular structure; friable (moist); 20 percent chert fragments; many roots; abrupt smooth boundary.

B21t 13-36 cm (5-14 in.). Reddish brown (5YR 4/4) brown (7.5YR 5/4 dry) clay with a few streaks and coatings of dark brown (7.5YR 3/2); moderate medium subangular blocky structure; firm (moist); thin discontinuous clay skins; 15 percent chert fragments; many fine roots; gradual smooth boundary.

B22t 36-64 cm (14-25 in.). Yellowish red (5YR 4/6) clay with a few streaks of brown (10YR 4/3) along old root channels; moderate medium subangular blocky structure; firm (moist); 10 percent chert fragments; thin continuous clay skins; gradual wavy boundary.

B23t 64-91 cm (25-36 in.). Strong brown (7.5YR 5/6) clay; moderate medium subangular blocky structure; very firm (moist), plastic (wet); thin continuous clay skins; few small soft black concretions; few chert fragments; gradual smooth boundary.

B24t 91-125 cm (36-50 in.). Strong brown (7.5YR 5/6) clay with a few fine pale brown (10YR 6/3) mottles; weak fine angular blocky structure; very firm (moist), plastic (wet); thin discontinuous clay skins; common fine soft and hard black concretions; few chert fragments; gradual smooth boundary.

B31 125-165 cm (50-65 in.). Strong brown (7.5YR 5/6) clay with common medium pale brown (10YR 6/3) mottles; weak fine angular blocky structure; very firm (moist), plastic (wet); common fine soft and hard concretions; gradual smooth boundary.

B32 165-205 cm (65-80 in.). Brown (7.5YR 4/4) clay; massive; very firm (moist), plastic (wet); many fine concretions.

R 205+ cm (80+ in.). Phosphatic limestone bedrock.

Pedon 52

SOIL SURVEY LABORATORY Beltsville, Md. LAB. Nos. 531009-531015

General Methods: 1A, 1B1b, 2A1, 2B

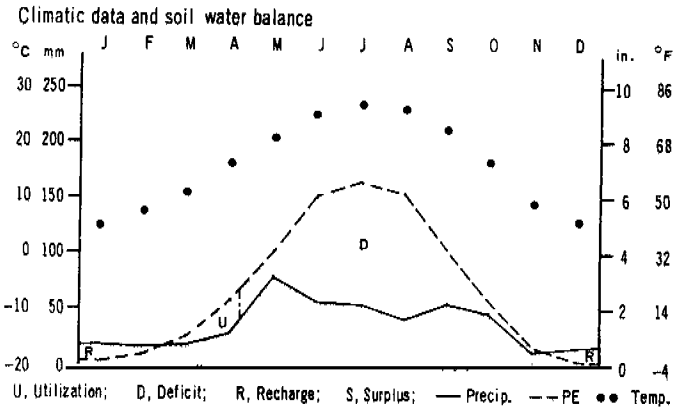
Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2 3B1 2–20 Pct.		
		Pct. of < 2 mm																
0–18	Ap	56.7	21.9	21.4	0.0	1.4	3.1	25.5	26.7	13.8	8.1	58.5	30.0					-
18–41	B21t	48.1	22.1	29.8	0.1	1.8	2.9	21.1	22.2	12.9	9.2	50.3	25.9					-
41–66	B22t	38.7	26.9	34.4	0.1	1.4	2.0	15.5	19.7	14.5	12.4	45.3	19.0					-
66–100	B23t	42.2	25.2	32.6	0.6	2.2	2.4	16.1	20.9	14.5	10.7	47.0	21.3					-
100–150	B3ca	42.2	27.5	30.3	1.6	3.1	2.7	15.4	19.4	12.4	15.1	42.8	22.8					< 1
150–180	C1ca	37.0	30.7	32.3	2.0	3.0	2.5	13.2	16.3	10.4	20.3	36.0	20.7					< 1
180–215	C2ca	37.4	30.9	31.7	0.4	1.6	2.0	14.3	19.1	11.4	19.5	40.7	18.3					< 1

Depth (cm)	6A1a Organic carbon	Nitrogen	C/N		Carbonate as $CaCO_3$		Bulk density				Water content					pH	
	Pct.	Pct.			Pct.		g/cc	g/cc	g/cc		Pct.	Pct.	Pct.				8C1a (1:1) H_2O
0–18	0.87																7.6
18–41	0.75																7.1
41–66	0.50																7.6
66–100	0.25																7.8
100–150	0.15																8.0
150–180	0.04																8.2
180–215	0.02																8.2

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P1a Na	6Q1a K	Sum	6H1a Ext. acidity	Cat. exch. cap 5A3a Sum cations								Base saturation 5C3 Sum cations Pct.	Pct.
	meq/100 g															
0–18	14.9	1.9	0.4	1.1	18.3	0.4	18.7								98	
18–41	15.8	3.0	0.4	0.6	19.8	1.3	21.1								94	
41–66																
66–100																
100–150																
150–180																
180–215																

Pedon 52

Classification: Typic Paleustalf, fine-loamy, mixed, thermic.
Location: Lynn County, Tex., 6.4 km (4 mi.) SE. of Wilson along Farm Road 211. About 30 km (20 mi.) S. of Lubbock.
Physiographic position: Upland plain. Elevation about 1,200 m.
Topography: Nearly level, gradient less than 1/2 percent.
Sampled by: I. C. Mowery and F. H. Templin, July 1, 1953.
Soil No.: S53Tex-153-63.



Colors are for the dry soil unless otherwise indicated.

Ap 0-18 cm (0-7 in.). Brown (10YR 4.5/2.5) light sandy clay loam, dark brown (10YR 3/3) moist; compound moderate medium granular and medium prismatic structure; slightly hard (dry); friable (moist); noncalcareous; gradual lower boundary.

B21t 18-41 cm (7-16 in.). Brown (7.5YR 4/4) heavy sandy clay loam, dark brown (7.5YR 3/4) moist; compound moderate medium granular and medium prismatic structure; moderately hard (dry); friable (moist); noncalcareous; gradual lower boundary.

B22t 41-66 cm (16-26 in.). Reddish brown (6YR 4/3) light clay loam, dark reddish brown (6YR 3/3) moist; compound moderate medium granular and medium prismatic structure; moderately hard (moist); moderately firm; slightly effervescent; clear lower boundary.

B23t 66-100 cm (26-40 in.). Yellowish red (5YR 5/6) light clay loam, yellowish red (5YR 4/6) moist; weak medium granular structure; moderately hard (dry); friable (moist); moderately effervescent films and threads and few small hard nodules of calcium carbonate; abrupt lower boundary.

B3ca 100-150 cm (40-60 in.). Reddish yellow (5YR 6/6) clay loam, yellowish red (5YR 5/6) moist; weak medium granular structure; moderately hard (dry); friable (moist); calcium carbonate masses; gradual lower boundary.

C1ca 150-180 cm (60-70 in.). Soft caliche consisting of whitish friable masses of impure calcium carbonate intermingled with pink (7.5YR 8/4) clay loam, pink (7.5YR 7/4) moist; friable (moist); violently effervescent; diffuse lower boundary.

C2ca 180-215 cm (70-84 in.) plus. Reddish yellow (5YR 6/6) clay loam, yellowish red (5YR 5/6) moist; friable (moist); about 20 percent soft white calcium carbonate nodules.

Pedon 53

SOIL Typic Durixeralf SOIL Nos. S69Calif-31-20 LOCATION Placer County, California

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 69115 - 69122

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Silt Int. II (0.2-0.02)	Silt 2-0.1	Fine clay 0.002-0.0002		Coarse fragments 1A2a a/ > 2 Pct. of whole soil	2-19 (Pct. of <76mm)	19-76 (Pct. of <76mm)
		Size class and particle diameter (mm) 3A1 — Pct. of <2 mm																
0-28	Ap	52.4	38.2	9.4	6.3	10.8	6.8	15.6	12.9	19.9	18.3	42.2	39.5	2.9				
28-38	B11t	48.9	37.4	13.7	6.1	9.8	6.5	14.5	12.0	19.8	17.6	40.5	36.9	4.8				
38-51	B12t	45.6	37.3	17.1	4.5	8.4	5.9	14.5	12.3	19.0	18.3	40.1	33.3	9.0				
51-79	IIB2t	24.7	32.3	43.0	0.7	2.7	2.5	9.8	9.0	12.8	19.5	28.2	15.7	25.8				
79-94	IIB31tsim	66.2	26.1	7.7	10.9	16.3	9.6	19.1	10.3	12.1	14.0	33.3	55.9			G		
94-115	IIB32tsim	49.0	40.8	10.2	2.6	9.6	7.9	17.6	11.3	17.0	23.8	38.4	37.7			G		
115-155	IIB33tsim	31.2	51.6	17.2	1.9	4.9	4.4	10.7	9.3	16.5	35.1	31.9	21.9			G		
155-190	IICsi	31.9	50.4	17.7	2.0	5.2	4.7	10.9	9.1	16.5	33.9	32.0	22.8					

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	6C2b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	Carbonate as $CaCO_3$: 3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	Bulk density: 4A1h Oven-dry g/cc	Bulk density: g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	Water content: 4B2 15-bar Pct.	Water content: 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	pH: 8C1a H_2O 1:1	pH: 8C1e $CaCl_2$
0-28	0.30	0.032	9	1.0			1.79	1.81		1.00	12.7	4.4		0.004	0.004			5.0
28-38	0.16			1.4			1.70	1.75		1.00	13.3	5.5		0.010	0.010			5.2
38-51	0.13			1.6			1.73	1.81		1.00	14.3	6.9		0.015	0.015			5.5
51-79				2.0			1.62	1.97		1.00	20.4	17.4		0.067	0.067			6.3
79-94				1.4			1.74	1.81		1.00	18.0	12.1		0.013	0.013			6.6
94-115				1.0			1.72	1.82		1.00	19.2	11.0		0.019	0.019			6.6
115-155				0.9			1.80	1.91		1.00	15.9	12.6		0.020	0.020			7.3
155-190				1.0			1.80	1.91		1.00	15.8	14.0		0.020	0.020			7.2

Depth (cm)	Extractable bases: 6N4c Ca 5B3a	Extractable bases: 6O4c Mg 5B3a	Extractable bases: 6P2a Na 5B1a	Extractable bases: 6Q2a K 5B1a	Sum of bases	6H2a Ext. acidity	Cation exch. capacity: 5A6a NH_4OAc	Cation exch. capacity: 5A3a Sum of cations		6G1e KCl ext. Al +++	Ratios to clay 8D1: CEC NH_4OAc	Ratios to clay 8D1: Ext. iron	Ratios to clay 8D1: 15-bar water				Base saturation: 5C3 Sum of cations Pct.	Base saturation: 5C1 NH_4OAc Pct.
	meq/100g																	
0-28	2.9	1.1	0.1	0.1	4.2		5.7				0.61	0.11	0.48					74
28-38	4.0	2.0	0.1	0.1	6.2		6.8				0.50	0.10	0.40					91
38-51	4.6	3.1	0.1	0.1	7.9		8.6				0.50	0.09	0.40					92
51-79	16.5	13.4	0.5	0.3	30.7		31.1				0.72	0.05	0.40					99
79-94	17.9	14.4	0.6	0.2	33.1		31.3				4.06	0.18	1.57					100
94-115	18.1	13.0	0.5	0.2	31.8		27.6				2.71	0.11	1.08					100
115-155	19.3	14.3	0.5	0.3	34.4		30.0				1.74	0.05	0.73					100
155-190	21.2	14.8	0.6	0.3	36.9		29.9				1.69	0.06	0.79					100

Depth (cm)	b/ Clay fraction mineralogy 3A1: 7A2 X-ray c/	7A3 DTA Pct.
0-28		
28-38		
38-51	MI3, KK3, MT1	
51-79		
79-94		
94-115		
115-155		
155-190	MM3, MT2, MI2, KK2	

a/ G = ground whole. Horizon indurated, contained no gravel.

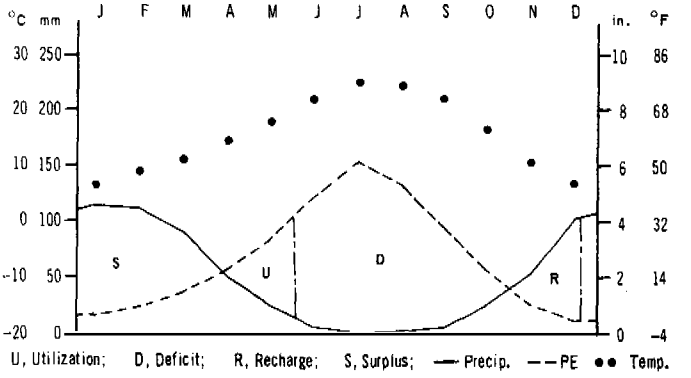
b/ Mineral code:
- MI = mica
- KK = kaolinite
- MT = montmorillonite
- MM = montmorillonite-mica

c/ Approximate weight fraction (X-ray):
- 3 = one-fifth to one-third
- 2 = one-twentieth to one-fifth
- 1 = less than one-twentieth

Pedon 53

Classification: Typic Durixeralf, coarse-loamy over clayey, mixed, thermic.
Location: Placer County, Calif., 380 m west of the intersection of Fiddyment and Moore Roads, 20 m north of Moore Road, 20 m north of SW corner of sec. 19, T. 12 N., R. 6 E.
Physiographic position: River terrace, elevation about 30 m.
Topography: Gentle, west-facing, 2 percent slope.
Drainage: Well drained.
Vegetation: Ripgut brome (Bromus rigidus), rose clover (Trifolium hirtum), soft chess (Bromus mollis), bur clover (genus Medicago), foxtail fescue (Festuca megalura).
Parent material: Sediments from granitic textured rocks deposited over the Laguna Formation.
Sampled by: K. W. Flach, W. D. Nettleton, G. M. Kennedy, T. M. Ryan, L. A. Brittan, May 8, 1969.
Remarks: The duripan fractures into medium angular blocks. The blocks are coated with clay skins in the upper part of the pan but clay skins decrease in number with increasing depth. There are black manganese stains in the IIB33tsim and IICsi horizons.
Soil No.: S69Calif-31-20.

Climatic data and soil water balance



Colors are for dry soil unless otherwise indicated.

Ap 0-28 cm (0-11 in.). Variegated brown (7.5YR 5/4) and strong brown (7.5YR 5/6) heavy sandy loam, dark reddish brown (7.5YR 3/4) moist; massive; hard (dry), friable (moist), nonsticky and slightly plastic (wet); many very fine and common fine roots; common very fine tubular and interstitial pores; clear smooth boundary.

B11t 28-38 cm (11-15 in.). Strong brown (7.5YR 5/6) light loam, reddish brown (5YR 4/4) moist; massive; hard (dry), friable (moist), slightly sticky and slightly plastic (wet); common very fine roots; common very fine, fine and medium tubular pores; many thin clay skins lining pores and bridging and coating mineral grains; clear smooth boundary.

B12t 38-51 cm (15-20 in.). Reddish brown (5YR 4/4) loam, dark red (2.5YR 3/6) moist; massive; slightly hard (dry), friable (moist), sticky and slightly plastic (wet); few very fine roots; common very fine, fine and medium pores; many thin clay skins lining pores and bridging and coating mineral grains; abrupt smooth boundary.

IIB2t 51-79 cm (20-31 in.). Reddish brown (5YR 4/4 dry and moist) light clay; strong medium and coarse prismatic structure; very hard (dry), firm (moist), very sticky and very plastic (wet); very few very fine roots; few very fine tubular pores; many slickensides on ped faces; abrupt slightly wavy boundary.

IIB31tsim 79-94 cm (31-37 in.). Variegated light yellowish brown (10YR 6/4), light brown (7.5YR 6/4) and yellowish red (5YR 5/6) duripan; dark red (2.5YR 3/6), dark reddish brown (5YR 3/4), reddish brown (5YR 4/4) moist; massive; extremely hard (dry), extremely firm (moist), nonsticky and nonplastic (wet); gradual wavy boundary.

IIB32tsim 94-115 cm (37-46 in.). Variegated light yellowish brown (10YR 6/4), yellowish red (5YR 5/6), and light brown (7.5YR 6/4) duripan, dark reddish brown (5YR 3/4) moist; massive; very hard (dry), extremely firm (moist), nonsticky and nonplastic (wet); gradual wavy boundary.

IIB33tsim 115-155 cm (46-61 in.). Variegated light yellowish brown (10YR 6/4), yellowish red (5YR 5/6), and light brown (7.5YR 6/4) duripan, dark reddish brown (5YR 3/4) and reddish brown (5YR 4/4) moist; massive; very hard (dry), extremely firm (moist), nonsticky and nonplastic (wet); gradual wavy boundary.

IICsi 155-190 cm (61-75 in.). Variegated pale brown (10YR 6/3) and yellowish red (5YR 5/6 and 5/8) duripan, brown (7.5YR 4/4), dark reddish brown (5YR 3/4) and dark red (2.5YR 3/6) moist; massive; very hard (dry), very firm (moist), nonsticky and nonplastic (wet).

Pedon 54

SOIL Typic Natrixeralf SOIL Nos. S64Calif-48-4 LOCATION Solano County, California

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 64511 - 64519

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	Silt: 2-0.1			Coarse fragments 1A2a: > 2 Pct. of whole soil	2-19 (Pct. of <76mm)	19-76 (Pct. of <76mm)
		Size class and particle diameter (mm) 3A1 — Pct. of <2 mm																
0-15	A2	41.6	45.9	12.5	tr.	0.8	2.6	18.4	19.8	25.0	20.9	56.4	21.8			0		
15-36	B21t	36.9	41.8	21.3	tr.	0.6	2.6	17.3	16.4	21.2	20.6	48.9	20.5			0		
36-66	B22t	35.4	40.6	24.0	tr.	0.7	2.4	16.3	16.0	20.2	20.4	47.1	19.4			0		
66-100	B23t	23.8	41.5	34.7	0.2	0.7	1.5	9.8	11.6	14.6	26.9	32.7	12.2			0		
100-125	B24t	13.3	44.5	42.2	1.0	1.4	1.1	4.5	5.3	11.8	32.7	20.0	8.0			0		
125-165	B3ca	32.8	37.7	29.5	5.4	5.3	3.1	9.3	9.7	14.2	23.5	30.7	23.1			0		
165-195	C1	36.5	33.0	30.5	0.8	1.7	2.5	17.5	14.0	14.7	18.3	40.1	22.5			0		
195-230	C2	39.4	32.9	27.7	tr.	0.1	0.9	19.9	18.5	16.8	16.1	61.0	20.9			0		
230-270	C3	39.3	36.9	23.8	tr.	0.1	0.8	18.1	20.8	20.8	16.1	54.3	19.0			0		

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	6E1c Clay size Pct.	Bulk density: 4A1f 1/3-bar g/cc	4A1h Oven-dry g/cc	g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15 bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	8C1a H_2O 1:1	8C1a H_2O 1:10
0-15	1.13	0.105	11	0.8	-		1.62	1.66		1.00	14.3	4.8		0.008	0.008		5.5	6.0
15-36	0.41	0.054	8	0.9	-		1.71	1.80		1.00	14.4	10.4		0.018	0.018		7.4	8.0
36-66	0.15	0.026	6	0.9	-		1.60	1.79		1.00	18.0	11.7		0.037	0.037		8.4	9.1
66-100	0.11			1.2	3		1.41	1.68		1.00	26.0	16.4		0.061	0.061		8.4	9.4
100-125	0.10			1.4	8	tr.	1.44	1.71		1.00	25.6	18.5		0.060	0.060		8.4	9.5
125-165	0.06			1.0	22	1	1.70	1.80		1.00	18.2	13.9		0.019	0.019		8.7	9.8
165-195	0.05			1.0	8	tr.	1.66	1.81		1.00	19.9	13.8		0.028	0.028		8.7	9.7
195-230	0.02			1.1	tr.		1.75	1.85		1.00	18.5	12.7		0.019	0.019		8.5	9.4
230-270	0.02			1.0	tr.							11.1					8.4	9.0

Depth (cm)	Extractable bases 5B1a: 6N2a Ca	6O2a Mg	6P2a Na	6Q2a K	6H2a Ext. acidity	5A2a CEC NaOAc	5D2 Exchangeable Sodium Pct.	5E Sodium adsorption ratio	8A Water at saturation Pct.	Water extract from saturated paste 8A1: 6N1b Ca	6O1b Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1a SO_4	8A1a Electrical conductivity mmho/cm
	meq/100g									meq/liter								
0-15	3.6	4.6	0.8	0.2		12.6	6	5	33.7	0.6	0.6	3.5	0.2	-	tr.	2.6	1.1	0.52
15-36	1.6	9.4	0.5	0.2		17.5	2	2	48.2	0.5	1.0	18.6	0.1	-	0.9	16.9	3.3	2.33
36-66	1.6	10.4	11.8	0.2		17.3	43	35	71.7	0.5	5.4	60.4	0.6	-	2.0	34.3	37.0	7.0
66-100	4.3	17.4	17.7	0.3		24.7	42	35	89.2	0.9	10.1	82.7	0.1	-	2.7	47.5	52.6	9.4
100-125	4.5	18.5	17.6	0.3		28.1	40	35	101.5	0.5	5.8	63.5	0.3	-	2.6	36.1	36.3	7.1
125-165	8.5	15.2	10.6	0.3		23.6	32	33	85.0	0.6	1.5	34.2	0.2	-	3.1	20.7	11.6	3.62
165-195	15.3	15.2	6.4	0.3		25.6	20	18	67.9	0.3	1.6	16.9	0.2	-	3.5	12.4	3.1	2.10
195-230	8.0	14.2	3.4	0.3		24.3	12	10	56.9	0.6	1.2	9.7	0.1	-	3.0	7.8	1.0	1.32
230-270	6.7	13.5	1.7	0.3		21.9	7	6	48.0	0.5	1.0	5.0	tr.	-	2.6	2.2	1.3	0.69

Depth (cm)	Ratios to clay 8D1: CEC NaOAc	Ext. iron	15-bar water	Salt Pct.	6F1a Gypsum Pct.	b/ Clay fraction mineralogy 3A1: 7A2 X-ray c/	7A3 DTA Pct.
0-15	1.01	0.06	0.38			MT3, KK3	
15-36	0.82	0.04	0.49				
36-66	0.72	0.04	0.49		-	MT5, KK2	
66-100	0.71	0.03	0.47		-		
100-125	0.67	0.03	0.44		-		
125-165	0.80	0.03	0.49			MT4, KK2	
165-195	0.84	0.03	0.45			MT5, KK2	
195-230	0.88	0.04	0.46				
230-270	0.92	0.04	0.47				

a/ 5.5 kg of organic carbon per square meter to a depth of 1 meter.

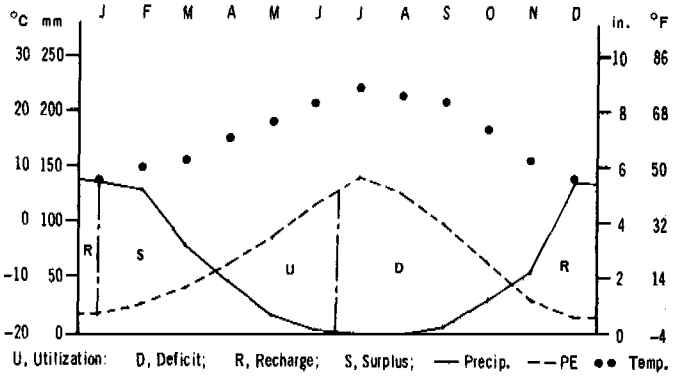
b/ Mineral code:
MT = montmorillonite
KK = kaolinite

c/ Approximate weight fraction (X-ray):
5 = more than half
4 = one-third to half
3 = one-fifth to one-third
2 = one-twentieth to one-fifth

Pedon 54

Classification: Typic Natrixeralf, fine-loamy, mixed, thermic.
Location: Solano County, Calif. 13 km south of Dixon on the Art Brown Ranch. NW corner of SW1/4NW1/4 sec. 36, T. 6 N., R. 1 E.
Physiographic position: Basin rim or low terrace, elevation about 7 m.
Topography: Nearly level with hummocks up to 38 cm high and 5 to 6 m in diameter.
Drainage: Somewhat poorly drained; very slow runoff; very slow permeability.
Vegetation: Annual weeds and grasses dominantly salt grass (Distichlis spicata), soft chess (Bromus mollis), and tarweed.
Parent material: Alluvium from sedimentary rocks.
Sampled by: R. E. Nelson, B. R. Brasher, L. Bates, S. Johnson, G. Kennedy, and W. Andrews, October 6, 1964.
Remarks: The soil is moist below 30 cm. The hummocks consist of A horizon material. The A horizon between the hummocks is very thin. This profile is on the side of a hummock.
Soil No.: S64Calif-48-4

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

A2 0-15 cm (0-6 in.). Pale brown (10YR 6/3) light loam with common fine faint mottles of yellowish brown (10YR 5/4), dark grayish brown (10YR 4/2) with common fine faint mottles of brown (10YR 4/3) moist; weak coarse prismatic with capping of weak coarse platy structure; hard (dry), friable (moist), slightly sticky and slightly plastic (wet); plentiful micro and very fine random roots; common tubular micro pores; abrupt smooth boundary.

B21t 15-36 cm (6-14 in.). Brown (10YR 5/3) heavy loam, brown (10YR 4/3) moist; strong coarse columnar structure; extremely hard (dry), firm (moist), sticky and very plastic (wet); plentiful micro horizontal roots; common micro pores; common thin clay skins on ped faces and in pores; clear smooth boundary.

B22t [illegible]

Pedon 55

SOIL Typic Palexeralf SOIL Nos. S64Calif-48-1 LOCATION Solano County, California

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 64528 - 64535

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1 Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Silt Int. II (0.2-0.02)	Silt 2-0.1			Coarse fragments 1A2a > 2 Pct. of whole soil	2-19 Pct. of <76mm	19-76 Pct. of <76mm
		Pct. of <2 mm																
0-18	Ap	55.8	33.8	10.4	0.6	3.7	8.5	26.1	16.9	18.6	15.2	50.6	38.9			0		
18-36	A12	56.1	32.4	11.5	0.4	3.3	8.6	26.0	17.8	17.5	14.9	50.5	38.3			0		
36-71	B21t	38.6	24.2	37.2	0.3	1.5	5.2	19.3	12.3	13.0	11.2	37.0	26.3			0		
71-100	B22t	47.1	22.3	30.6	tr.	0.8	3.9	27.0	15.4	12.4	9.9	45.0	31.7			0		
100-135	B23t	55.1	21.5	23.4	0.2	1.3	5.2	30.0	18.4	12.4	9.1	49.8	36.7			0		
135-175	IIB24t	28.7	43.2	28.1	tr.	0.5	1.9	10.6	15.7	19.5	23.7	42.6	13.0			0		
175-200	IIB3t	61.8	19.6	18.6	0.1	6.3	17.8	26.9	10.7	10.0	9.6	32.8	51.1			0		
200-215	IIIB2tb	23.5	44.9	31.6	tr.	0.7	1.9	8.5	12.4	18.4	26.5	36.6	11.1			0		

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ 6E1b <2 mm Pct.	Carbonate as $CaCO_3$ 3A1a <0.002 mm Pct.	Bulk density 4A1f 1/3-bar g/cc	Bulk density 4A1h Oven-dry g/cc	Bulk density g/cc	3B2 Cm	Water content 4B1c 1/3-bar Pct.	Water content 4B2 15-bar Pct.	Water content 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH 8C1b Saturated paste	pH 8C1a H_2O 1:1	pH 8C1a H_2O 1:10
0-18	0.69	0.064	11	0.6	-		1.59	1.70		1.00	13.6	4.3		0.022	0.022		6.4	6.6
18-36	0.36	0.045	8	0.6	-		1.66	1.71		1.00	12.3	4.6		0.010	0.010		5.7	6.3
36-71	0.32	0.052	6	1.2	-		1.54	1.88		1.00	22.8	15.2		0.064	0.064		6.6	7.2
71-100	0.14			1.3	-		1.62	1.90		1.00	21.0	13.9		0.053	0.053		7.0	7.7
100-135	0.07			1.1	-		1.69	1.83		1.00	17.7	10.9		0.027	0.027		7.2	7.8
135-175	0.07			1.3	-		1.65	1.83		1.00	20.1	14.8		0.036	0.036		7.4	8.1
175-200	0.03			0.8	-		1.79	1.88		1.00	13.2	8.9		0.016	0.016		7.7	8.1
200-215	0.03			1.2	-		1.69	1.89		1.00	18.7	15.1		0.038	0.038		7.8	8.3

Depth (cm)	Extractable bases 6N2a Ca	6O2a Mg	6P2a Na	6Q2a K	5B1a	6H2a Ext. acidity	5A2a CEC Na OAc	5D2 Exchangeable sodium Pct.	5E Sodium adsorption ratio	8A Water at saturation Pct.	Water extract from saturated paste 8A1 6N1b Ca	6O1b Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1a SO_4	8A1a Electrical conductivity mmho/cm
	meq/100g										meq/liter								
0-18	4.0	2.5	0.2	0.5		1.9	9.8	1	1	32.6	1.0	0.8	1.3	0.3	-	0.4	1.2		0.35
18-36	4.7	1.8	0.2	0.2		3.0	9.5	-	2	29.5	0.3	0.4	9.5	tr.	-	0.2	0.8		1.52
36-71	13.9	9.5	1.0	0.4		2.4	25.3	-	6	49.8	11.4	12.4	21.9	1.1	-	0.5	10.1	36.9	4.02
71-100	12.8	8.8	1.4	0.3			23.8	5	5	50.5	0.7	0.6	3.9	0.1	-	0.6	3.0		0.59
100-135	10.6	7.9	1.8	0.2			26.7	7	6	48.3	0.5	0.5	4.3	tr.	-	0.5	3.1		0.59
135-175	16.5	11.8	2.9	0.2			32.4	9	7	55.1	2.0	1.6	8.8	0.1	-	0.6	10.5		1.41
175-200	10.2	6.9	1.6	0.2			19.5	7	5	40.1	1.0	1.6	6.1	0.1	-	0.6	7.9		1.00
200-215	16.9	11.8	2.2	0.4			31.4	6	5	55.4	2.7	2.3	8.2	0.1	-	1.1	11.0		1.46

Depth (cm)	Ratios to clay 8D1 CEC Na OAc	Ext. iron	15-bar water	Salt Pct.	6F1a Gypsum Pct.	b/ Clay fraction mineralogy 3A1 7A2 X-ray c/	7A3 DTA Pct.
0-18	0.94	0.06	0.41				
18-36	0.83	0.05	0.40			VR3, MI3, KK2	
36-71	0.68	0.03	0.41		-		
71-100	0.78	0.04	0.45			MT5, KK2	
100-135	1.14	0.05	0.47				
135-175	[illegible]	[illegible]	[illegible]		-	MT5, KK2	

a/ 5.4 kg of organic carbon per square meter to a depth of 1 meter.

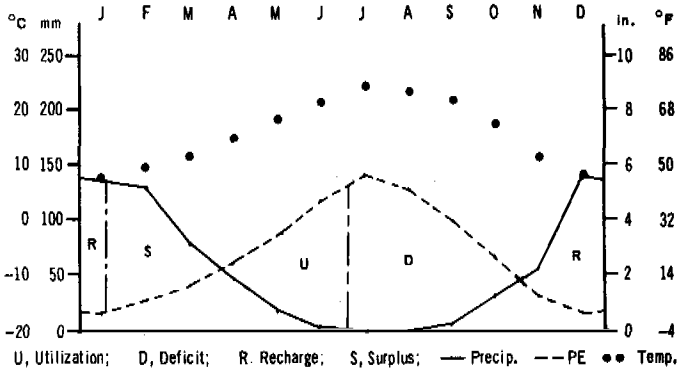
b/ Mineral code:
MT = montmorillonite
VR = vermiculite
MI = mica
KK = kaolinite

c/ Approximate weight fraction (X-ray):
5 = more than half
3 = one-fifth to one-third

Pedon 55

Classification: Typic Palexeralf, fine, montmorillonitic, thermic.
Location: Solano County, Calif. 6 km west and 1 km south of Dixon on Forsgren Ranch, 300 m south, 100 m west of NE corner of NW1/4 sec. 29, T. 7 N., R. 1 E.
Physiographic position: Terrace, elevation about 24 m.
Topography: Level.
Drainage: Moderately well drained; slow runoff; very slow permeability.
Vegetation: Fallow.
Parent material: Alluvium from sedimentary rocks.
Sampled by: R. E. Nelson, B. R. Brasher, L. Bates, S. Johnson, G. Kennedy, W. Andrews, October 5, 1964.
Remarks: An A2 horizon rests on the B21t horizon and varies in thickness from zero to 8 cm. The soil was moist below 36 cm.
Soil No.: S64Calif-48-1.

Climatic data and soil water balance



Colors are for dry soil unless otherwise indicated.

Ap 0-18 cm (0-7 in.). Light brownish gray (10YR 6/2) fine sandy loam with few fine distinct mottles of brownish yellow (10YR 6/6), dark brown (10YR 3/3) moist; massive; hard (dry), friable (moist), nonsticky and slightly plastic (wet); abundant micro, plentiful fine and medium random roots; common very fine tubular and interstitial pores; clear smooth boundary.

A12 18-36 cm (7-14 in.). Light brownish gray (10YR 6/2) fine sandy loam with few fine distinct mottles of brownish yellow (10YR 6/6), dark brown (10YR 3/3) moist; massive; hard (dry), friable (moist), nonsticky and slightly plastic (wet); abundant micro, plentiful fine and medium random roots; common micro, few very fine tubular pores; abrupt smooth boundary.

B21t 36-71 cm (14-28 in.). Dark yellowish brown (10YR 4/4) heavy clay loam, dark brown (7.5YR 4/4) moist; strong coarse prismatic structure; extremely hard (dry), very firm (moist), sticky and plastic (wet); few very fine and fine roots; common micro tubular pores; many stress cutans are on ped faces; iron and manganese concretions; gradual smooth boundary.

B22t 71-100 cm (28-40 in.). Yellowish brown (10YR 5/6) heavy sandy clay loam, dark yellowish brown (10YR 4/4) with dark brown (7.5YR 4/4) coatings moist; strong medium prismatic structure; extremely hard (dry), very firm (moist), sticky and plastic (wet); few very fine and fine exped roots; common micro tubular pores; many stress cutans are on ped faces; iron and manganese concretions; gradual smooth boundary.

B23t 100-135 cm (40-54 in.). Yellowish brown (10YR 5/4) light sandy clay loam, dark yellowish brown (10YR 4/4) moist; [illegible]

exped roots; common micro tubular pores; many stress cutans are on ped faces; iron and manganese concretions; gradual wavy boundary.

SOIL Typic Durargid SOIL Nos. S64Ariz-2-18 LOCATION Cochise County, Arizona

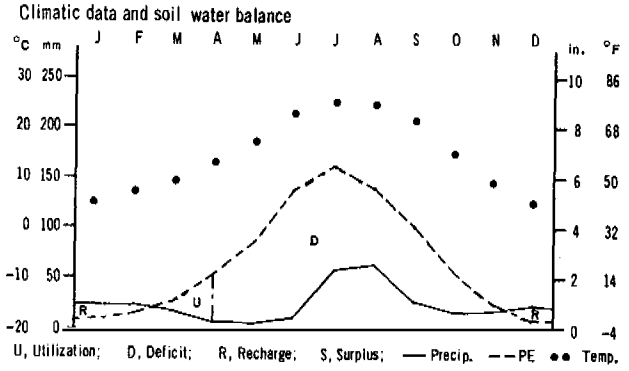
SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 64583 - 64594

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	Silt: 2-0.1			Coarse fragments 1A2a: > 2 Pct. of whole soil	2-19 (Pct. of <76mm)	19-76 (Pct. of <76mm)
		Size class and particle diameter (mm) 3A1 — Pct. of <2 mm																
0-5	A11	75.7	18.7	5.6	3.9	15.0	14.4	27.4	15.0	11.9	6.8	41.6	60.7			1	1	
5-15	A12	66.1	23.6	10.3	3.7	12.4	12.6	24.8	12.6	11.2	12.4	36.6	53.5			2	2	
15-23	A3	58.3	28.7	13.0	5.1	11.7	11.0	19.5	11.0	14.5	14.2	35.4	47.3			3	3	
23-30	B1	50.3	32.5	17.2	4.9	9.0	8.6	17.4	10.4	16.0	16.5	36.0	39.9			4	4	
30-43	B21t	27.1	22.5	50.4	1.7	4.7	4.4	9.2	7.1	10.7	11.8	22.8	20.0			2	2	
43-58	B22t	27.3	25.0	47.7	1.8	4.6	4.2	9.6	7.1	11.9	13.1	24.2	20.2			2	2	
58-66	B23tsica	36.2	37.9	25.9	1.8	5.3	5.1	13.0	11.0	18.2	19.7	37.2	25.2			10	10	
66-84	C1sicam															10	10	
84-97	C2sicam															10	10	
97-140	C3sica	37.2	48.3	14.5	3.8	4.3	3.1	9.6	16.4	28.2	20.1	51.0	20.8					
140-205	C4	48.2	36.9	14.9	0.2	1.6	5.3	21.6	19.5	23.9	13.0	57.2	28.7					
205-235	C5	70.7	17.5	11.8	0.5	5.0	17.8	34.6	12.8	10.8	6.7	41.2	57.9					

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm b/ Pct.	Carbonate: 3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	Bulk density: 4A1h Oven-dry g/cc	Bulk density: Est. 1/3-bar g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	Water content: 4B2 15-bar Pct.	Water content: 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	pH: 8C1a H_2O 1:1	pH: 8C1a H_2O 1:10
0-5	0.35	0.032	11	0.5								2.7					6.3	6.6
5-15	0.29	0.030	10	0.6			1.67	1.68		0.99	8.4	3.8		0.002	0.002		6.0	6.5
15-23	0.26	0.031	8	0.7			1.62	1.66		0.98	9.6	4.4		0.008	0.008		6.6	6.8
23-30	0.26	0.031	8	0.8			1.60	1.67		0.98	11.7	5.5		0.016	0.016		7.1	7.2
30-43	0.20			1.2			1.43	1.71		0.99	25.7	15.4		0.060	0.059		7.4	7.9
43-58	0.28			1.1			1.44	1.73		0.99	27.4	15.7		0.062	0.061		7.9	8.5
58-66	0.36			0.8	12				1.55	0.94		17.4					7.9	8.6
66-84	0.17			0.4	17				1.55	0.94		14.0					8.2	8.9
84-97	0.14			0.4	26		1.55	1.56		0.94	18.1	11.4		0.003	0.003		8.4	9.1
97-140	0.04			0.6	16	1	1.52	1.58		1.00	18.2	8.2		0.014	0.014		8.4	9.2
140-205	0.01			0.7	1		1.53	1.62		1.00	18.5	7.7		0.018	0.018		8.3	9.1
205-235	0.01			0.6	tr.		1.66	1.72		1.00	11.2	6.2		0.011	0.011		8.3	8.6

Depth (cm)	Extractable bases: 6N2b	6O2c	6P2a	6Q2a	5R1a	6H2a Ext. acid-	5A1a CEC	5D2 Exchangeable	5E Sodium adsorp-	8A Water at satu-	Water extract from saturated paste 8A1: 6N1a Ca	6O1a Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO	6K1a Cl	6L1b SO_4	8A1a Electrical

Pedon 56



Classification: Typic Durargid, fine, mixed, thermic.
Location: Cochise County, Ariz. 11.3 km west and 14.5 km north of Willcox on the Ft. Grant Road. 204 m north and 38 m west of the SE corner sec. 11, T. 12 S., R. 23 E.
Physiographic position: Valley plain, elevation about 1,300 m.
Topography: Nearly level with slightly concave slopes of 0.2 percent.
Drainage: Well drained; slow runoff; slowly permeable.
Vegetation: Rangeland -- sparse cover of blue grama (Bouteloua gracilis), annual gramas (Bouteloua sp.) and burro-weed (Suaeda moquini).
Parent material: Alluvium from granitic textured rocks, rhyolite, andesite, and possibly some volcanic ash.
Sampled by: K. W. Flach, B. R. Brasher, J. E. Jay, M. L. Richardson and R. K. Preece, October 19, 1964.
Remarks: The water table is at 30 to 45 m depth. The adjacent horizons above and below the duripan do not disperse well, hence the field estimates of the texture are given in the profile description for these two horizons. Rodents have burrowed through the duripan horizons and tunneled vertically and horizontally at intervals of about 2 to 6 m. The tunnels are backfilled with a mixture of materials from all horizons. Roots and water enter the softer, lower horizons through the tunnels.
Soil No.: S64Ariz-2-18.

Colors are for the dry soil unless otherwise indicated.

A11 0-5 cm (0-2 in.). Brown (7.5YR 5/4) loamy coarse sand, brown to dark brown (7.5YR 4/4) moist; moderate medium platy structure; slightly hard (dry), very friable (moist), nonsticky and nonplastic (wet); abundant fine and very fine roots; many fine interstitial pores; noneffervescent; 1 percent gravel by volume; abrupt smooth boundary.

A12 5-15 cm (2-6 in.). Brown (7.5YR 5/4) fine sandy loam, dark reddish brown (5YR 3/4) when moist; massive breaking to weak very fine and fine subangular blocks; slightly hard (dry), very friable (moist), slightly sticky and slightly plastic (wet); abundant very fine, fine, and medium roots; many fine interstitial pores; noneffervescent; 1 percent gravel by volume; clear smooth boundary.

A3 15-23 cm (6-9 in.). Brown (7.5YR 5/4) fine sandy loam, dark reddish brown (5YR 3/4) moist; massive breaking to moderate very fine and fine subangular blocks; slightly hard (dry), friable (moist), slightly sticky and plastic (wet); plentiful fine and very fine roots; many fine interstitial and common fine tubular pores; noneffervescent; 2 percent gravel by volume; abrupt smooth boundary.

B1 23-30 cm (9-12 in.). Brown (7.5YR 5/4) loam, dark reddish brown (5YR 3/4) moist; massive breaking to moderate fine and medium subangular blocks; slightly hard (dry), friable (moist), slightly sticky and plastic (wet); plentiful very fine and fine roots; common fine and very fine tubular and interstitial pores; few thin patchy clay skins; noneffervescent; 2 percent gravel by volume; clear smooth boundary.

B21t 30-43 cm (12-17 in.). Reddish brown (5YR 4/4) light clay, reddish brown (5YR 4/4) crushed, reddish brown (5YR 4/4) moist; moderate medium and coarse prisms breaking to moderate medium and coarse angular blocks; hard (dry), firm (moist), sticky and plastic (wet); abundant compressed fine and very fine roots on ped faces; few fine tubular and common exped pores; noneffervescent; 1 percent gravel by volume; diffuse smooth boundary.

B22t 43-58 cm (17-23 in.). Reddish brown (5YR 4/4) light clay, reddish brown (5YR 4/4) crushed, reddish brown (5YR 4/4) moist; moderate medium and coarse prisms breaking to moderate medium and coarse angular blocks; hard (dry), firm (moist), sticky and plastic (wet); abundant compressed fine and very fine roots on ped faces; few fine tubular and common exped pores; noneffervescent; 1 percent gravel by volume; clear smooth boundary.

B23tsica 58-66 cm (23-26 in.). Reddish yellow (7.5YR 6/6 and 6/8) clay, yellowish red (5YR 4/6) with common fine distinct mottles of pinkish white (7.5YR 8/2) and pink (7.5YR 6/4) moist; massive breaking to moderate fine and medium subangular blocks; hard (dry), firm (moist), sticky and very plastic (wet); plentiful fine roots that are massed and abundant in lower part; common fine and very fine tubular and interstitial pores; few thin clay bridges; weakly to strongly effervescent; 6 percent gravel by volume; abrupt smooth boundary.

C1sicam 66-84 cm (26-33 in.). Pinkish gray (7.5YR 6/2) with surface coatings of reddish yellow (7.5YR 6/8) carbonate and pink mottles (7.5YR 7/4), duripan indurated by silica and carbonates, reddish brown (5YR 5/3), yellowish red (5YR 5/8) and light brown (7.5YR 6/4) when moist; massive to weak coarse platy structure; extremely hard (dry), extremely firm (moist); no roots except in fractures; very few fine tubular pores; rodent burrows; silica (?) coatings on plate faces; strongly effervescent; 6 percent gravel by volume; clear smooth boundary.

C2sicam 84-97 cm (33-38 in.). Pale brown (10YR 6/3) matrix with many veins and laminae of white (N 8/) indurated pan materials; brown to dark brown (10YR 4/3) and pink (7.5YR 7/4) when moist; massive to weak coarse platy structure; extremely hard (dry), extremely firm (moist); no roots; few fine tubular pores; rodent burrows; violently effervescent; 6 percent gravel by volume; clear wavy boundary.

C3sica 97-140 cm (38-56 in.). Very pale brown and pale brown (10YR 7/3 and 6/3) and white coatings in pores (N 8/) clay loam, brown to dark brown (7.5YR 4/4) when moist; massive; slightly hard (dry), friable (moist), slightly sticky and plastic (wet); no roots; many fine and very fine and a few coarse tubular pores; rodent burrows; violently effervescent; clear smooth boundary.

C4 140-205 cm (56-80 in.). Mottled pale brown, brown and very pale brown (10YR 6/3, 5/3 and 8/4) light loam, brown (7.5YR 5/4) and brown to dark brown (10YR 4/3) when moist; massive; slightly hard (dry), very friable (moist), nonsticky and slightly plastic (wet); no roots; many fine and very fine and a few coarse tubular pores; strongly effervescent; clear smooth boundary.

C5 205-235 cm (80-93 in.). Pale brown and brown (10YR 6/3 and 5/3) fine sandy loam; brown to dark brown (10YR 4/3) moist; massive; slightly hard (dry), friable (moist), nonsticky and slightly plastic (wet); no roots; many fine and very fine and a few coarse tubular pores; noneffervescent.

Pedon 57

SOIL Typic Haplargid SOIL Nos. S67Ariz-11-1 LOCATION Pinal County, Arizona

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 67658 - 67668

Depth (cm)	Horizon	1B1b Total: Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Sand: Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt: (0.05-0.02)	Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1	Fine clay 0.002-0.0002		Coarse fragments 1A2a: > 2 Pct. of whole soil	2-19	19-76
		Size class and particle diameter (mm) 3A1 — Pct. of <2 mm														Pct. of <76mm		
0-3	A11	58.2	28.0	13.8	2.3	6.6	8.1	25.1	16.1	14.9	13.1	45.6	42.1	4.7		-	-	-
3-12	A12	60.4	23.0	16.6	3.3	8.7	9.0	23.7	15.7	13.2	9.8	41.9	44.7	5.5		1	1	-
12-23	B1t	57.5	21.8	20.7	2.5	7.2	8.7	23.2	15.9	13.1	8.7	42.6	41.6	8.5		1	1	-
23-46	B21t	45.9	24.5	29.6	1.6	4.0	5.3	18.4	16.6	15.0	9.5	42.8	29.3	15.5		1	1	-
46-66	B22tca	39.4	31.3	29.3	1.4	3.2	4.2	14.7	15.9	18.7	12.6	44.0	23.5	12.9		3	3	-
66-84	B23tca	32.4	31.3	36.3	1.5	3.2	3.8	11.6	12.3	15.2	16.1	34.5	20.1	12.4		2	2	-
84-110	B24tca	31.2	39.4	29.4	1.4	2.4	2.9	10.7	13.8	15.5	23.9	36.0	17.4			4	4	-
110-130	B31tca	33.9	40.1	26.0	1.2	2.4	3.4	12.3	14.6	16.0	24.1	38.6	19.3			2	2	-
130-160	B32tca	33.4	43.5	23.1	1.1	2.3	3.3	12.1	14.6	16.9	26.6	39.4	18.8			1	1	-
160-180	B33tca	27.4	48.9	23.7	0.5	1.2	2.1	9.6	14.0	17.4	31.5	37.8	13.4			1	1	-
180-230	C	31.5	49.2	19.3	0.2	0.8	2.4	13.0	15.1	20.5	28.7	44.2	16.4			-	-	-

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	6C2b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	4A1h Oven-dry g/cc	g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	8C1a H_2O 1:1	8C1a H_2O 1:10
0-3	0.98	0.095	10	0.7	-		1.49	1.51		1.00	14.7	6.3		0.004	0.004	6.9		7.8
3-12	0.26	0.038	7	0.7	-		1.50	1.60		0.99	16.3	5.6		0.022	0.022	6.6		7.5
12-23				0.7	-		1.63	1.65		0.99	12.1	6.9		0.004	0.004	6.9		7.5
23-46				0.7	-		1.47	1.65		0.99	20.4	10.2		0.039	0.039	7.5		8.4
46-66				0.7	3		1.39	1.56		0.98	22.5	11.7		0.039	0.039	7.9		8.9
66-84				0.7	8		1.41	1.61		0.99	24.6	14.4		0.045	0.045	8.0		9.1
84-110				0.6	15		1.34	1.55		0.98	24.0	13.5		0.050	0.049	8.1		9.2
110-130				0.6	16		1.45	1.66		0.99	22.9	13.7		0.046	0.046	8.1		9.4
130-160				0.3	18		1.60	1.76		0.99	21.6	10.0		0.032	0.032	8.3		9.5
160-180				0.6	12		1.42	1.57		0.99	22.3	10.5		0.034	0.034	8.1		9.4
180-230				0.7	9		1.37	1.49		1.00	24.1	8.3		0.028	0.028	7.9		9.1

Depth (cm)	Extractable bases (meq/100 g): 6N4c Ca 5B3a	6O4c Mg 5B3a	6P2a Na 5B1a	6Q2a K 5B1a	6H2a Ext. acidity	5A1a CEC NH_4OAc	5D2 Exchangeable sodium Pct.	5E Sodium adsorption ratio	8A Water at saturation Pct.	Water extract from saturated paste 8A1 (meq/liter): 6N1b Ca	6O1b Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1b SO_4	8A1a Electrical conductivity mmho/cm
0-3			0.1	2.0		13.7	1											0.50
3-12			0.1	1.4		12.9	1											0.47
12-23			0.1	1.6		16.9	1											0.25
23-46			0.1	1.8		18.7	1											0.20
46-66			0.2	1.3		17.8	1											0.20
66-84			0.4	1.2		22.5	2											0.20
84-110			0.5	0.6		19.1	3											0.30
110-130			1.8	0.3		17.1	11											0.23
130-160			2.8	0.3		15.5	15	7	58.2	1.1	0.6	6.7	0.6		2.3	2.0		0.96
160-180			4.0	0.2		18.9	15	11	63.8	3.3	2.4	17.8	0.2		1.6	8.5		2.70
180-230			6.3	0.3		19.6	21	10	53.3	19.4	14.2	39.2	0.2		1.0	18.4		6.8

Depth (cm)	Ratios to clay 8D1: CEC NH_4OAc	Ext. iron	15-bar water	Salt Pct.	6F1a Gypsum Pct.	Clay fraction mineralogy 3A1: 7A2 X-ray [a/] [b/]	7A3 DTA Pct.
0-3	0.99	0.05	0.46			MT3, MI3	
3-12	0.78	0.04	0.34			MI3, MT2, KK1	
12-23	0.82	0.03	0.33			MT3, MI3, KK2	
23-46	0.63	0.02	0.34			MT4, MI4, KK2	
46-66	0.61	0.02	0.40				
66-84	0.62	0.02	0.40			MT4, MI2, KK2	
84-110	0.65	0.02	0.46				
110-130	0.66	0.02	0.52				
130-160	0.67	0.01	0.43				
160-180	0.80	0.03	0.44				
180-230	1.02	0.04	0.43			MT5, MI2, KK2	

[a/] Mineral code:
MT = montmorillonite
MI = mica
KK = kaolinite

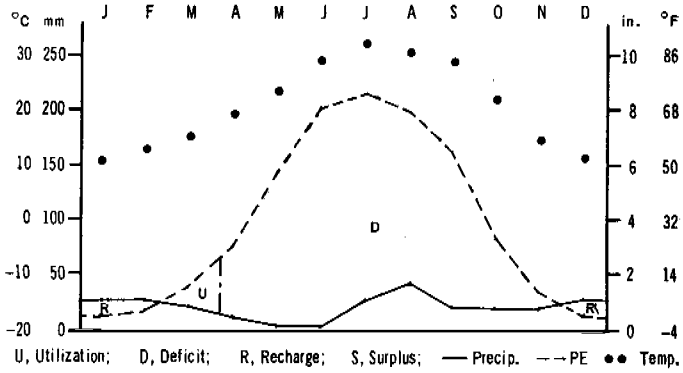
[b/] Approximate weight fraction (X-ray):
5 = more than half
4 = one-third to half
3 = one-fifth to one-third
2 = one-twentieth to one-fifth
1 = less than one-twentieth

Pedon 57

Classification: Typic Haplargid, fine-loamy, mixed, thermic.
Location: Pinal County, Ariz. 46 m north and 76 m east of the center of sec. 11, T. 3 S., R. 8 E.
Physiographic position: Valley plain, elevation about 396 m.
Topography: Nearly level, southwest-facing slope of less than 0.5 percent.
Drainage: Well drained; moderately slow permeability.
Vegetation: Desert shrub--dominantly creosote (Larrea tridentata) with some brittlebush (Encelia sp.) and cacti.
Parent material: Valley fill material from acid and basic igneous and metasedimentary rocks.
Sampled by: K. W. Flach, W. D. Nettleton, D. Hendricks, E. Adams, and J. E. Jay, October 13, 1967.
Soil No.: S67Ariz-11-1.

Colors are for the dry soil unless otherwise indicated.

Climatic data and soil water balance



A11 0-3 cm (0-1 in.). Light brown (7.5Y R 6/4) heavy fine sandy loam, brown (7.5YR 4/4) when moist; weak medium platy structure; slightly hard (dry), friable (moist), slightly sticky and plastic (wet); many fine and medium roots; few fine vesicular pores; noneffervescent; abrupt smooth boundary.

A12 3-12 cm (1-5 in.). Light brown (7.5YR 6/4) heavy fine sandy loam, brown (7.5YR 4/4) when moist; weak coarse plates breaking to weak fine subangular blocks; hard (dry), friable (moist), slightly sticky and slightly plastic (wet), many fine and medium roots; common fine tubular and interstitial pores; noneffervescent; 1 percent gravel by volume; abrupt smooth boundary.

B1t 12-23 cm (5-9 in.). Brown (7.5YR 5/4) light sandy clay loam, dark reddish gray (5YR 4/2) when moist; weak medium prisms breaking to weak medium subangular blocks; hard (dry), friable (moist), slightly sticky and plastic (wet); common fine and medium roots; few fine tubular and common fine interstitial pores; few thin clay skins in pores; noneffervescent; 1 percent gravel by volume; clear smooth boundary.

B21t 23-46 cm (9-18 in.). Brown (7.5YR 5/4) heavy sandy clay loam, dark brown (7.5YR 4/4) when moist; weak medium prisms breaking to moderate medium subangular blocks; hard (dry), friable (moist), sticky and plastic (wet); few fine and very fine roots; common fine tubular and few fine interstitial pores; few thin clay skins in pores; noneffervescent; 1 percent

Pedon 58

SOIL Typic Natrargid SOIL Nos. S64Ariz-2-20 LOCATION Cochise County, Arizona

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 64605 - 64611

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Silt Int. II (0.2-0.02)	Silt 2-0.1			Coarse fragments 1A2a > 2 Pct. of whole soil	2-19	19-76
		Size class and particle diameter (mm) 3A1															Pct. of <76mm	
		Pct. of <2 mm																
0-5	A21	68.7	23.0	8.3	0.3	3.5	7.3	34.7	22.9	13.6	9.4	58.5	45.8				tr.	
5-13	A22	56.0	34.4	9.6	0.6	3.2	5.2	25.7	21.3	17.0	17.4	55.1	34.7				tr.	
13-28	B2t	41.4	29.3	29.3	0.5	2.6	4.0	19.3	15.0	12.8	16.5	40.2	26.4				tr.	
28-61	Cca	39.2	36.5	24.3	1.2	2.3	3.2	16.3	16.2	13.0	23.5	40.3	23.0				1	
61-105	IIB2tcab	41.6	30.1	28.3	0.7	2.8	5.4	18.0	14.7	10.9	19.2	37.1	26.9				5	
105-130	IIC1cab	69.8	14.0	16.2	9.6	18.1	16.1	19.1	6.9	6.3	7.7	22.2	62.9				12	
130-205	IIIC2casib C	75.7	14.1	10.2	1.9	6.3	17.4	39.4	10.7	8.2	5.9	40.4	65.0				7	

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C1a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ 6E1b <2 mm Pct.	Carbonate as $CaCO_3$ 3A1a <0.002 mm Pct.	Bulk density 4A1f 1/3-bar g/cc	Bulk density 4A1h Oven-dry g/cc	Bulk density g/cc	3B2 Cm	Water content 4B1c 1/3-bar Pct.	Water content 4B2 15-bar Pct.	Water content 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH 8C1b Saturated paste	pH 8C1a H_2O 1:1	pH 8C1a H_2O 1:10
0-5	0.40	0.042	10	0.28	3		1.57	1.57		1.00	11.5	4.3		0.001	0.001		8.7	9.2
5-13	0.29	0.032	9	0.35	tr.		1.66	1.68		1.00	13.1	4.9		0.005	0.005		9.2	9.7
13-28	0.38	0.041	9	0.40	6	1	1.27	1.56		1.00	32.9	15.1		0.072	0.072		9.0	9.9
28-61	0.13			0.22	15	5	1.58	1.72		0.99	19.0	11.0		0.030	0.030		9.9	10.2
61-105	0.07			0.14	25	12	1.71	1.93		0.97	18.9	9.5		0.041	0.040		10.0	10.2
105-130	0.03			0.23	2		1.51	1.74		0.93	23.8	10.0		0.048	0.044		9.9	10.2
130-205	0.01			0.34	1		1.40	1.60		0.96	26.3	7.2		0.044	0.042		9.7	10.0

Depth (cm)	Extractable bases 6N2b Ca	6O1c Mg	6P2a Na	6Q2a K	5B1a	6H2a Ext. acidity	5A1a CEC NH_4OAc	5D2 Exchangeable sodium	5E Sodium adsorption ratio	8A Water at saturation	Water extract from saturated paste 8A1 6N1a Ca	6O1a Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1a SO_4	8A1a Electrical conductivity
	meq/100g							Pct.		Pct.	meq/liter								mmho/cm
0-5	16.8	1.6	2.0	1.0			8.2	21	9	29.9	2.7	0.6	11.5	0.4	-	3.9	3.4		1.60
5-13	13.0	1.3	4.1	0.8			9.5	40	18	27.7	0.5	0.3	11.2	0.2	-	5.0	3.0		1.25
13-28	16.3	2.0	17.2	0.9			20.8	72	49	59.8	1.1	0.3	41.3	0.1	-	8.5	8.3	25.5	4.35
28-61	11.2	0.5	27.9	0.9			20.3	100	197	47.0	1.0	0.3	159	0.3	10.0	12.4	10.9	138	13.2
61-105	10.8	0.6	21.7	0.6			13.0	104	312	41.4	0.5	0.3	198	0.5	15.6	12.2	11.9	161	16.7
105-130	8.4	0.8	19.8	0.5			14.7	88	155	63.1	0.5	0.5	110	0.2	5.4	13.9	7.3	85.2	10.0
130-205	3.6	0.4	12.4	0.2			11.3	84	98	57.6	0.3	0.2	50.5	0.1	1.1	8.5	4.9	35.7	5.16

Depth (cm)	Ratios to clay 8D1 CEC NH_4OAc	Ext. iron	15-bar water	Salt Pct.	6F1a Gypsum Pct.	b/ Clay fraction mineralogy 3A1 7A2 X-ray c/	7A3 DTA Pct.
0-5	0.99	0.03	0.52			MT2, MI2	

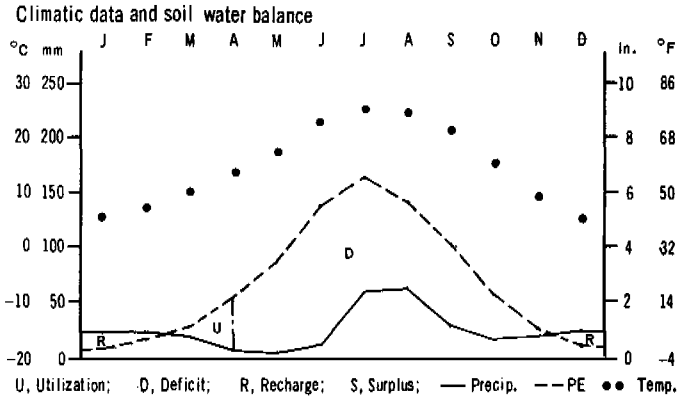
a/ 2.5 kg of organic carbon per square meter to a depth of 1 meter.

b/ Mineral code:
MT = montmorillonite
MI = mica
KK = kaolinite

c/ Approximate weight fraction (X-ray).

Pedon 58

Classification: Typic Natrargid, fine-loamy, mixed, thermic.
Location: Cochise County, Ariz. 27 km south and 4.4 km east of Willcox via Kansas Settlement Road. 0.4 km west and 30 m north of E1/4 corner of sec. 27, T. 16 S., R. 25 E.
Physiographic position: Valley plain adjacent to Willcox Playa, elevation about 1,280 m.
Topography: Slightly concave slope of less than 0.2 percent.
Drainage: Moderately well drained; very slow runoff; very slow permeability.
Vegetation: Grassland. Mainly alkali sacaton (Sporobolus airoides) with minor amounts of tobosa grass (Hilaria mutica), mesquite bushes (Prosopis sp.) and annual grasses.
Parent material: Mixed alluvium from rhyolite, rhyolite tuff, and andesite.
Sampled by: K. W. Flach, B. R. Brasher, J. E. Jay, M. L. Richardson, and R. K. Preece, October 20, 1964.
Remarks: Ground water table is 15 to 30 m. The soil was slightly moist when sampled. Two horizons, the IIClcab and the IIIC2casib do not disperse well, hence, the field estimates of texture are given in the description of these two horizons.
Soil No.: S64Ariz-2-20.



Colors are for the dry soil unless indicated otherwise.

A21 0-5 cm (0-2 in.). Light brownish gray (10YR 6/2) light fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak medium and fine platy structure; slightly hard (dry), very friable (moist), nonsticky and nonplastic (wet); plentiful fine and medium roots; common fine discontinuous and a few fine and medium continuous tubular pores; slightly effervescent; abrupt smooth boundary.

A22 5-13 cm (2-5 in.). Light gray to gray (10YR 6/1) sandy loam, dark grayish brown (10YR 4/2) moist; massive; hard (dry), friable (moist), nonsticky and nonplastic (wet); plentiful fine and medium roots; many fine discontinuous and a few fine continuous tubular pores; strongly effervescent, carbonate is disseminated; abrupt smooth boundary.

B2t 13-28 cm (5-11 in.). Grayish brown (10YR 5/2) light clay loam, dark grayish brown (10YR 4/2) when moist; moderate fine and medium prisms breaking to moderate fine and medium angular and subangular blocks; hard (dry), firm (moist), sticky and plastic (wet); common fine and medium roots; many exped interstitial and common fine and very fine tubular pores; common thin clay skins on ped faces and in pores; slightly effervescent; clear smooth boundary.

Cca 28-61 cm (11-24 in.). Pale brown (10YR 6/3) heavy loam with many fine faint light gray (10YR 7/2) mottles, brown to dark brown (10YR 4/3) and light brownish gray (10YR 6/2) when moist; massive, breaking to strong fine subangular blocks; slightly hard (dry), friable (moist), sticky and plastic (wet); abundant fine

SOIL Pedon 59 Typic Paleargid SOIL Nos. S64Ariz-2-28 LOCATION Cochise County, Arizona

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 64655 - 64661

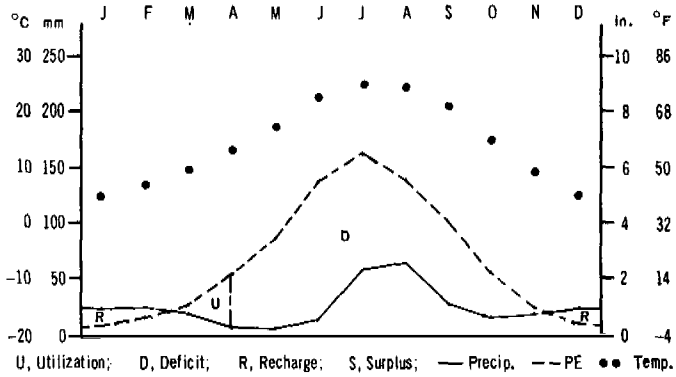
Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1			Coarse fragments 1A2a > 2 Pct. of whole soil	2-19 Pct. of <76mm	19-76 Pct. of <76mm
		Size class and particle diameter (mm) 3A1 — Pct. of <2 mm																
0-5	A11	65.9	28.7	5.4	6.1	12.6	11.1	23.0	13.1	19.1	9.6	44.6	52.8			19	17	2
5-15	A12	62.3	28.5	9.2	7.0	11.7	9.9	20.7	13.0	17.3	11.2	41.7	49.3			34	29	5
15-28	A3	56.1	27.2	16.7	12.7	12.7	7.6	13.7	9.4	16.3	10.9	33.2	46.7			44	38	6
28-53	B21t	26.3	15.0	58.7	7.5	7.1	2.8	5.2	3.7	6.5	8.5	13.1	22.6			31	24	7
53-89	B22tca	41.5	10.4	48.1	14.1	12.7	5.6	6.0	3.1	4.6	5.8	10.7	38.4			65	36	29
89-110	B3tca	61.1	15.2	23.7	17.0	19.1	9.6	10.4	5.0	7.1	8.1	17.3	56.1			56	34	16
110-180	C	83.0	6.1	10.9	28.1	32.0	13.2	8.0	1.7	2.4	3.7	7.2	81.3			54	49	5

Depth (cm)	6A1a Organic carbon	6B1a Nitrogen	C/N	6C2b Ext. iron	Carbonate as $CaCO_3$ 6E1b	Carbonate as $CaCO_3$ 3A1a	Bulk density 4A1f 1/3-bar	Bulk density 4A1h Oven-dry		3B2 Cm	Water content 4B1c 1/3-bar	Water content 4B2 15-bar	Water content 4C1 1/3-to 15-bar	4D1 Extensibility	4D1 Extensibility	pH 8C1b Saturated	8C1a	8C1a

Pedon 59

Classification: Typic Paleargid, fine, mixed, thermic.
Location: Cochise County, Ariz. 14.5 km north and 1.2 east of Willcox. 250 m west and 114 m north of the E1/4 corner of sec. 18, T. 11 S., R. 25 E.
Physiographic position: Lower end of coalescent fan, elevation about 1,360 m.
Topography: Slightly convex, southeast-facing slope of 2 percent.
Drainage: Well drained; moderate runoff; slow permeability.
Vegetation: Grassland. Fair cover of blue and black grama (Bouteloua gracilis and Bouteloua eriopoda), rothrock grama (Bouteloua rothrockii), and annual gramas.
Parent material: Alluvium from andesite, rhyolite, rhyolitic tuff, quartzite and granite.
Sampled by: K. W. Flach, B. R. Brasher, J. E. Jay, M. L. Richardson, and R. K. Preece, October 23, 1964.
Remarks: The water table ranges from 30 to 45 m. A very thin intermittent, pinkish gray (5YR 6/2) layer, dark reddish gray (5YR 4/2) moist, occurs between the A3 and B21t horizons.
Soil No.: S64Ariz-2-28.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

A11 0-5 cm (0-2 in.). Light brown (7.5YR 6/4) light fine sandy loam, brown (7.5YR 4/4) when moist; weak medium and coarse platy structure; slightly hard (dry), very friable (moist); slightly sticky and slightly plastic (wet); plentiful fine and medium roots; few fine tubular and many fine interstitial pores; 10 percent fine gravel by volume; abrupt smooth

SOIL Pedon 60 Petrocalcic Paleargid SOIL Nos. S61NMex-7-7 LOCATION Dona Ana County, N. Mex.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 14979-14990

General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: 0.05-0.02	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)			Coarse fragments 2A2 3B1 2-20 Pct.	< 20
		Pct. of < 2 mm															
		a/,b/ Carbonate removed - 3A1															
0-5	A	85.0	5.3	9.7	3.3	10.8	13.1	42.8	15.0	3.6	1.7	41.3	70.0				tr
5-18	B1t	86.9	3.8	9.3	1.6	8.9	16.6	47.1	12.7	2.5	1.3	38.7	74.2				tr
18-25	B1t	81.8	5.6	12.6	1.6	9.4	15.3	43.2	12.3	4.1	1.5	37.8	69.5				1
25-36	B21t	80.0	5.2	14.8	3.4	11.9	16.4	38.7	9.6	3.1	2.1	30.6	70.4				1
36-48	B22tca	77.4	5.9	16.7	4.6	10.8	14.6	36.7	10.7	3.6	2.3	31.8	66.7				2
48-74	C1cam	68.2	8.7	23.1	2.8	5.1	9.1	35.4	15.8	4.8	3.9	40.5	52.4				1
74-100	C2cam	71.4	10.8	17.8	1.2	7.3	15.0	32.1	15.8	5.9	4.9	38.5	55.6				1
100-150	C3cam	75.0	6.1	18.9	2.6	9.2	14.2	35.4	13.6	3.2	2.9	35.0	61.4				1
150-185	C4ca																2
185-235	C5ca																2
235-270	C6ca	88.6	6.1	5.3	1.5	11.1	19.1	46.1	10.8	2.7	3.4	34.8	77.8				1
270-355	C7	91.4	4.1	4.5	4.8	20.3	24.6	36.0	5.7	2.2	1.9	22.1	85.7				1

Depth (cm)	6A1a Organic carbon c/ Pct.	Nitrogen Pct.	C/N		6E1b Carbonate as $CaCO_3$ Pct.	5A1a CEC NH_4OAc a/ meq/100g	Bulk density g/cc	Bulk density g/cc	4A1b Air-dry g/cc	Clay fraction d/,e/ mineralogy 7A2 f/ X-ray	0.25-0.10 mm fraction e/ mineralogy 1B3 7B1 Petrographic Pct.
0-5	0.25					7.6				MT3,MI3,KK2	
5-18	0.13					6.5			1.86	MT3,MI3,KK2	
18-25	0.17					8.8			1.78		
25-36	0.14				1	10.4			1.70	MT3,MI3,KK2	QZ40,TW60
36-48	0.24				16	11.5			1.53	MT3,MI3,KK2	
48-74	0.15				75	14.5				AT4,MT3,KK2	
74-100	0.05				65	12.6			1.68	AT5,MT2,KK2	
100-150	0.06				51	8.1			1.66	SE4,AT3,MT2,KK2	
150-185					52					SE5,AT2,MT2,KK1	
185-235					41				1.73	SE5,AT2,MT2,KK1	
235-270					13	4.4				MT3,AT3,KK2	QZ40,TW60
270-355					2	4.7			1.66	MT4,KK3,AT2	

a/ Carbonate removed by method 1B3 and the determination reported for the sample so treated. The C4ca and C5ca horizons contain dominantly sepiolite in the clay fraction. This mineral is partially dissolved by the treatment to remove carbonate. Hence, textural and exchange capacity data are not reported.

b/ In contact overnight with 0.1N NaOH in addition to regular treatments to aid disaggregation.

c/ Determination on sample treated by method 1B3 to remove carbonate; values expressed on a carbonate-containing basis.

d/ Clay extracted without prior carbonate removal and then treated for 1 hour with pH 5 NH_4OAc at room temperature.

e/ Mineral code:

MT = montmorillonite [illegible]

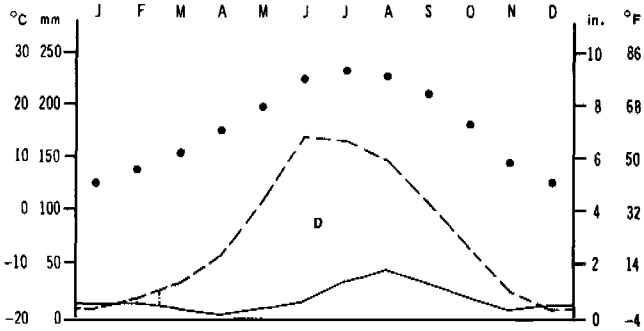
SE = sepiolite
QZ = quartz
TW = total weatherable, mostly feldspar and fragments of rhyolite groundmass

f/ Approximate weight fractions:
5 = more than one-half
4 = one-third to one-half
3 = one-fifth to one-third
2 = one-twentieth to one-fifth
1 = less than one-twentieth

Pedon 60

Classification: Petrocalcic Paleargid, loamy, mixed, thermic, shallow.
Location: Dona Ana County, N. Mex., NE 1/4 sec. 23, T. 23 S., R. 1 W., 13 km (8 mi.) WSW. from center of Las Cruces.
Physiographic position: Relict basin floor; elevation, 1,355 m.
Topography: Nearly level.
Vegetation: Snakeweed (Gutierrezia sarothrae), mesquite (Prosopis juliflora) and yucca (Yucca elata).
Parent material: Fluvial facies of a basin fill consisting of noncalcareous sand and a few rounded pebbles of mixed composition; part of the Upper Santa Fe Group.
Sampled by: R. B. Grossman, J. L. Millet and F. F. Peterson, May 6, 1961.
Remarks: The site is on the La Mesa geomorphic surface of mid-Pleistocene age. The A horizon was sampled several meters away where undisturbed. Measurements in the general area indicate that the current dust fall is sol

Climatic data and soil water balance



Soil No.: S61NMex-7-7.

Colors are for the dry soil unless otherwise indicated.

Soil surface. A discontinuous layer of loose reddish sand 3 to 10 cm thick is present. Scattered pebbles of mixed lithology are present.

A — 0-5 cm (0-2 in.). Reddish brown (5YR 5/4, 5YR 3.5/4 moist) loamy sand; weak medium plates with 1 to 2 mm loose reddish brown sand between plates; soft (dry) and loose; few roots; noncalcareous; abrupt boundary.

B1t — 5-25 cm (2-10 in.). Reddish brown (5YR 3.5/4) loamy sand, dark reddish brown (5YR 3/4) moist; hard (dry), friable (moist); weak very coarse prisms; noncalcareous; horizon split for sampling at 18 cm; clear smooth boundary.

B21t — 25-36 cm (10-14 in.). Reddish brown (5YR 4/4) heavy fine sandy loam, dark reddish brown (5YR 3/4) moist; weak very coarse prisms; noncalcareous with weak and moderate effervescence in lower part; few carbonate filaments in lower part; clear wavy boundary.

B22tca — 36-48 cm (14-19 in.). Brown (7.5YR 5/2) heavy sandy loam, dark brown (7.5YR 4/4) moist; weak very coarse prisms break to weakly expressed medium and coarse subangular blocks; slightly hard and hard (dry); few roots except for a concentration on top of underlying horizon; common dark brown (moist) insect burrow fillings less than 1 cm across; common carbonate nodules, some of cylindroidal form; scattered fragments of the C1cam in the lower part; effervesces strongly; abrupt wavy to irregular boundary.

C1cam — 48-74 cm (19-29 in.). Several platy units, each of which consists of an uppermost laminar zone, 1 cm thick, underlain by and cemented to strongly cemented massive material; the top lamina ranges from white (7.5YR 8/1) to pink (7.5YR 8/4); subjacent laminae range from white (7.5YR 8/1) to brown (7.5YR 5/4); the attached massive material, which ranges from about 5 to 15 cm in thickness, consists of a pinkish white (7.5YR 8/2) to light brown (7.5YR 6/4) matrix and white (7.5YR 8/1) to brown (7.5YR 5/4) coatings along cleavage planes; horizon as a whole has weak very coarse prismatic structure; prisms range up to a meter across and extend through C2am horizon; some prism faces coated with laminae; no roots; sand grains separated by carbonate; effervesces strongly; clear to abrupt wavy boundary.

C2cam — 74-100 cm (29-39 in.). White (10YR 8/2) and light gray (10YR 7/2) moist to pinkish white (7.5YR 8/2) and pinkish gray (7.5YR 7/2) moist; very coarse prisms that are massive or very coarse plates; strongly cemented; no roots; discontinuous carbonate coatings on blocks; sand grains are separated by carbonate; effervesces strongly; gradual wavy to irregular boundary.

C3cam — 100-150 cm (39-59 in.). Eighty percent strongly cemented white (10YR 8/2) and very pale brown (10YR 7/3) carbonate nodules; 20 percent pinkish white (7.5YR 8/2) fine sandy loam, light brown (7.5YR 6/3) moist; horizon as a whole has coarse and very coarse subangular blocky structure; very hard and extremely hard (dry); fine sandy loam material is massive and single grain; soft (dry) and loose; very few roots; nodules have irregular surfaces and many are nearly discrete; sand grains in nodules are separated by carbonate; horizon effervesces strongly; clear wavy boundary.

C4ca — 150-185 cm (59-73 in.). Sixty percent strongly cemented white (10YR 8/2), very pale brown (10YR 7/3) moist carbonate nodules 1 to 10 cm across; 40 percent pinkish gray (7.5YR 7/2) loamy fine sand or fine sandy loam, brown (7.5YR 5/3) moist; nodules similar to those in horizon above but with a smooth coating of carbonate; loamy material massive and single grain; very few roots; horizon effervesces strongly; gradual wavy boundary.

C5ca — 185-235 cm (73-93 in.). Fifty percent strongly cemented white (10YR 8/2), light gray (10YR 7/2) moist carbonate nodules similar to those in the horizon above; 50 percent white (10YR 8/2), pale brown (10YR 6/3) moist loamy fine sand or fine sandy loam; horizon effervesces strongly; clear wavy boundary.

C6ca — 235-270 cm (93-106 in.). Light gray (10YR 7/2) sand, yellowish brown (10YR 5/4) moist; massive; firm (moist); no roots; few indurated carbonate nodules, 1 to 5 cm across, that lack the noticeable carbonate coatings found in horizons above; horizon effervesces slightly to strongly; gradual boundary.

C7 — 270-355 cm (106-140 in.). Light gray (10YR 6.5/2) sand, brown (10YR 4.5/3) moist; massive and single grain; soft (dry) and loose; no roots; effervesces weakly.

Micromorphology, method 4E1b. Thin sections of the B22tca show prominent coatings of oriented clay on sand grains in reddish brown volumes; no clay skins on ped faces.

SOIL Pedon 61 Typic Calciorthid SOIL Nos. S59Nev-2-9 LOCATION Clark County, Nevada

SOIL SURVEY LABORATORY **Riverside, California** LAB. Nos. 5946 - 5951

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Sand: Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt: (0.05-0.02)	Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1			Coarse fragments 1A2a: > 2 Pct. of whole soil	2-19	19-76
		Pct. of <2 mm															Pct. of <76mm	
0-15	C1	96.4	1.3	2.3	0.1	3.7	28.2	58.1	6.3	1.3	0.0	34.8	90.1			1		
15-41	C2	91.1	2.2	6.7	1.0	4.5	18.0	59.0	8.6	2.2	0.0	41.3	82.5			2		
41-69	IIC3	87.5	5.7	6.8	0.7	5.5	17.5	52.9	10.9	3.9	1.8	43.8	76.6			4		
69-94	IIC4ca	88.4	4.8	6.8	1.6	9.5	22.7	47.0	7.6	3.3	1.5	35.3	80.8			9		
94-110	IIIC5ca	72.1	15.7	12.2	9.6	12.6	12.9	28.8	8.2	6.7	9.0	30.3	63.9			76		
110+	IVC6ca	77.8	12.5	9.7	15.7	23.8	14.5	19.3	4.5	3.9	8.6	17.6	73.3			81		

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C2b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	4A1h Oven-dry g/cc	4A3a Field moist g/cc	3B2 Cm	Water content: Pct.	4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	8C1a H_2O 1:10	8C1c IN KCl 1:1
0-15	0.02	0.005			3				1.70				1.1			8.5	9.0	
15-41	0.06	0.004			4				1.61				2.7			8.4	9.1	
41-69	0.05				4				1.52				3.5			8.4	9.1	
69-94	0.03				7								3.5			8.3	9.0	
94-110	0.13				26								7.1			8.3	8.9	
110+	0.10				19								5.8			8.3	9.1	

Depth (cm)	Extractable bases (meq/100 g): 6N4c Ca 5B3a	6O4c Mg 5B3a	6P2a Exch. Na 5B1b	6Q2a Exch. K 5B1b	6H2a Ext. acidity	5A2a CEC NaOAc	5D1 Exchangeable sodium Pct.	5E Sodium adsorption ratio	8A Water at saturation Pct.	Water extract from saturated paste 8A1 (meq/liter): 6N1a Ca	6O1a Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1b SO_4	8A1a Electrical conductivity mmho/cm
0-15			tr.	0.2		3.0	tr.	<1	24.0	1.6	0.2	0.2	0.5	-	1.8	0.1		0.2
15-41			0.1	0.4		5.0	2	<1	23.0	1.8	0.2	0.4	0.4	-	2.2	0.3		0.3
41-69			tr.	0.5		4.2	tr.	<1	27.9	1.7	0.3	0.4	0.3	-	2.0	0.4		0.3
69-94			0.1	0.5		4.1	2	<1	28.1	1.8	0.2	0.4	0.3	-	1.8	0.1		0.3
94-110			0.1	0.6		5.4	2	<1	40.4	2.5	0.4	1.0	0.3	-	1.8	0.4		0.4
110+			0.6	0.7		7.6	8	4	32.3	2.0	0.5	3.8	0.3	-	2.6	2.0		0.7

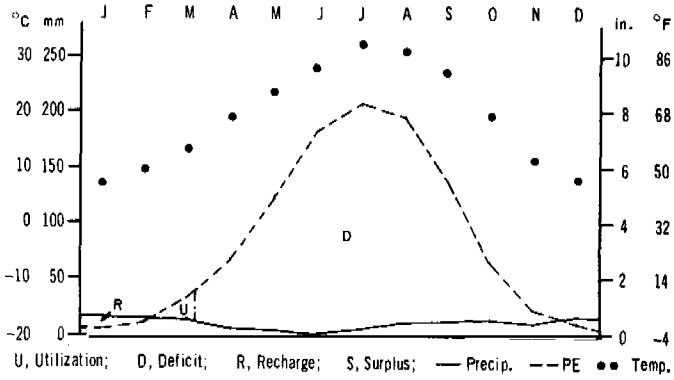
Depth (cm)	Ratios to clay 8D1: CEC NaOAc	Ext. iron	15-bar water	Salt Pct.	6F1a Gypsum Pct.
0-15	1.30		0.48		
15-41	0.75		0.40		
41-69	0.62		0.51		
69-94	0.60		0.51		
94-110	0.44		0.58		
110+	0.78		0.60		

a/ 0.8 kg of organic carbon per square meter to a depth of 1 meter.

Pedon 61

Classification: Typic Calciorthid, sandy, mixed, thermic.
Location: Clark County, Nev. 305 m south and 107 m east of northwest corner of sec. 26, T. 15 S., R. 67 E.
Physiographic position: Low dunes superimposed upon old terrace, elevation about 424 m.
Drainage: Excessively drained; very slow runoff; very rapid internal drainage; very rapid permeability.
Vegetation: White bur-sage (Franseria dumosa), creosotebush (Larrea tridentata), Indian ricegrass (Oryzopsis hymenoides), big galleta grass (Hilaria sp.), desert primrose and assorted annual weeds; plant density is 5 percent.
Parent material: Aeolian sands derived from mixed sedimentary rock sources.
Sampled by: L. N. Langan, V. D. Leavitt, L. Grant, and R. E. Nelson, March, 1959.
Remarks: The water table is below 15 m.
Soil No.: S59Nev-2-9.

Climatic data and soil water balance



Colors are for the moist soil.

C1 0-15 cm (0-6 in.). Yellowish red (5YR 5/6) fine sand; single grain; loose (moist), nonsticky and nonplastic (wet); common very fine fibrous roots; many very fine interstitial pores; strongly effervescent; 1 percent fine gravel by volume; clear smooth boundary.

C2 15-41 cm (6-16 in.). Yellowish red (5YR 5/6) fine sand; single grain; loose (moist), nonsticky and nonplastic (wet); common very fine and few fine fibrous roots; many very fine interstitial pores; strongly effervescent; 1 percent fine gravel by volume; clear smooth boundary.

IIC3 41-69 cm (16-27 in.). Brown (7.5YR 5/4) fine sand with few medium faint light brown (7.5YR 6/4) lime mottles; single

SOIL Pedon 62 Typic Camborthid SOIL Nos. S67NMex-7-3 LOCATION Dona Ana County, N. Mex.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 67L905-67L911

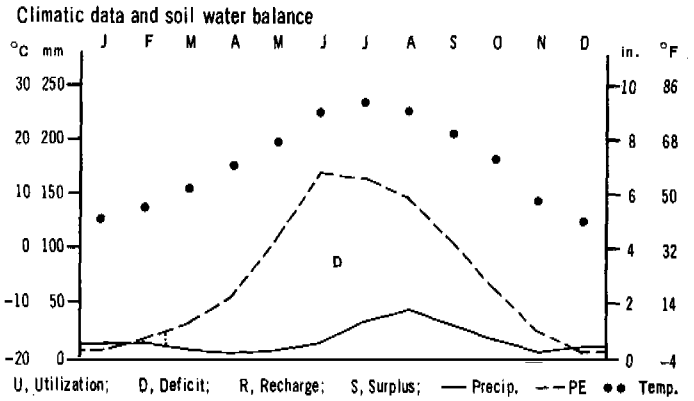
General Methods: 1A1, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2-0.05)	Total: Silt (0.05-0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: 0.05-0.02	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)			3B1 Coarse fragments > 2 Pct.	20-5	5-2
		Pct. of < 2 mm															Pct. of < 20 mm	
0-3	A11	77.9	15.1	7.0	7.2	11.4	8.7	22.8	27.8	11.6	3.5	54.3	50.0	37.6			5	12
3-10	A12	73.1	18.3	8.6	6.9	11.0	8.3	20.9	26.1	14.4	3.9	53.7	47.0	42.8			1	9
10-20	B21	74.5	16.4	9.1	12.1	14.2	8.2	18.6	21.3	12.9	3.5	45.9	53.1	38.2			2	10
20-28	B22	73.6	17.5	8.9	13.8	13.7	7.6	17.0	21.5	13.9	3.6	46.1	52.0	39.4			2	14
28-58	C1ca	73.9	17.9	8.2	13.3	13.6	8.6	17.5	20.8	13.0	4.9	44.7	53.0	38.8			4	21
58-91	C2ca	74.2	17.0	8.8	11.4	13.4	9.8	20.2	19.3	12.5	4.5	44.0	54.9	36.8			4	14
91-125	C3	90.9	4.8	4.3	33.0	31.3	11.7	10.5	4.5	2.6	2.2	12.2	86.4	11.4			5	26

Depth (cm)	6A1a Organic carbon Pct.	Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ 6E1b 6F2a <2 mm Pct.	3A1a <0.002 mm Pct.	Bulk density g/cc	g/cc	g/cc		Water content Pct.	Pct.	4B2 15-bar Pct.			pH	(1:1)
0-3	0.18				tr								2.7				
3-10	0.30				tr								3.2				
10-20	0.26				tr								3.6				
20-28	0.22				tr	-							3.5				
28-58	0.19				2	tr							3.7				
58-91	0.13				3	tr							3.8				
91-125	0.04				1	tr							1.6				

Pedon 62

Classification: Typic Camborthid, coarse-loamy, mixed, thermic.
Location: Dona Ana County, N. Mex., SE 1/4 sec. 32, T. 21 S., R. 3 E., 18 km (11 mi.) NE. of center of Las Cruces.
Physiographic position: Alluvial fan; elevation, 1,400 m.
Topography: Slope 2 percent to W.
Vegetation: Scattered clumps of black grama (Bouteloua eripoda) and three-awn (Aristida spp.); a few Mormon tea (Ephredra spp.), yucca (Yucca elata), mesquite (Prosopis juliflora).
Parent material: Fan alluvium derived from monzonite.
Sampled by: L. H. Gile, R. B. Grossman and J. W. Hawley, October 16, 1967.
Remarks: The pedon occurs on the Organ geomorphic surface of Holocene age. Charcoal from the C horizon has a C-14 age of 4,200 + 100 yrs. B. P. Isotopes, Inc. No. I-4282. Measurements in the general area indicate that the current dust fall is calcareous.
Soil No.: S67NMex-7-3.



Colors are for the dry soil unless otherwise indicated.

Soil surface. Between grass clumps, the surface is about 25 percent covered with fine monzonite pebbles and coarse sands.

A11 0-3 cm (0-1 in.). Brown (7.5YR 5/4) loamy sand, dark brown (7.5YR 4/3) moist; weak medium platy and weak fine crumb structure; loose (dry) and soft (dry), very friable (moist); no roots; light brownish gray (10YR 6/2) crust at the surface; noncalcareous; abrupt smooth boundary.

A12 3-10 cm (1-4 in.). Brown (7.5YR 5/4) light fine sandy loam, dark brown (7.5YR 4/3) moist; massive; slightly hard (dry), friable (moist); plentiful roots; noncalcareous; abrupt smooth boundary.

B21 10-20 cm (4-8 in.). Reddish brown (6YR 5/4) light coarse sandy loam, reddish brown (6YR 3.5/4) moist; massive; slightly hard (dry), friable (moist); few roots; faint reddish stainings on sand grains; noncalcareous; clear wavy boundary.

B22 20-28 cm (8-11 in.). Reddish brown (6YR 5/4) light coarse sandy loam, reddish brown (6YR 3.5/4) moist; massive; slightly hard (dry), friable (moist); few roots; faint reddish stainings on sand grains; krotovina, 4 cm diameter, extends through the horizon and is filled with darker fine earth; noncalcareous; clear smooth boundary.

C1ca 28-58 cm (11-23 in.). Brown (7.5YR 5.5/4) fine gravelly light coarse sandy loam, dark brown (7.5YR 4/4) moist; massive; slightly hard (dry), friable (moist); few roots; pebbles and sand grains thinly coated with carbonate; effervesces strongly; lower 5 cm coarse sand; abrupt smooth boundary.

C2ca 58-91 cm (23-36 in.). Brown (7.5YR 5.5/4) light sandy loam, dark brown (7.5YR 4/4) moist; massive; slightly hard (dry), friable (moist); few roots; pebbles and sand grains thinly coated with carbonate; effervesces strongly; abrupt wavy boundary.

C3 91-125 cm (36-49 in.). Brown (7.5YR 5/4) stratified fine gravelly coarse sand, dark brown (7.5YR 4/4) moist; massive; slightly hard (dry); no roots; effervesces weakly, with occasional small volumes noncalcareous.

SOIL Pedon 63 Typic Durorthid SOIL Nos. S59Nev-9-33 LOCATION Lincoln County, Nevada

SOIL SURVEY LABORATORY **Riverside, California** LAB. Nos. 59794 - 59801

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	2-0.1			Coarse fragments 1A2a: 2-10 mm a/	2-19	19-76
		Pct. of <2 mm														Pct. of <76mm		
0-3	A11	85.8	11.9	2.3	9.8	35.5	17.0	17.1	6.4	7.6	4.3	21.8	79.4			11		
3-10	A12	80.6	14.5	4.9	9.1	32.7	16.6	16.3	5.9	7.2	7.3	20.6	74.7			11		
10-41	A13	75.2	14.0	10.8	9.9	28.8	14.6	15.9	6.0	7.1	6.9	20.7	69.2			7		
41-58	C1sicam	87.0	6.5	6.5	27.8	34.6	10.3	10.6	3.7	2.6	3.9	11.3	83.3			16		
58-76	C2sicam	80.7	12.8	6.5	11.3	22.8	13.4	23.0	10.2	6.9	5.9	30.1	70.5			10		
76-94	C3	86.9	9.4	3.7	14.1	24.7	15.9	23.0	9.2	5.1	4.3	26.9	77.5			10		
94-140	C4sicam	84.2	11.7	4.1	23.2	23.6	11.0	17.9	8.5	5.6	6.1	24.5	75.7			11		
140-175	IIC5	90.1	7.7	2.2	16.7	28.8	15.4	19.2	10.0	4.4	3.3	26.0	80.1			10		

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N	6C1b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	Carbonate: 3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	Bulk density: 4A1h Oven-dry g/cc	Bulk density: g/cc	3B2 Cm	Water content: Pct.	Water content: 4B1c 1/3-bar Pct.	Water content: 4B2 15-bar Pct.	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	pH: 8C1a H_2O 1:10	pH: 8C1c IN KCl 1:1
0-3	0.11	0.013		0.7	3								3.0			8.2	8.8	
3-10	0.08	0.015		0.7	5								3.7			8.3	8.9	
10-41	0.15	0.021		0.6	7								6.1			8.3	8.9	
41-58	0.20	0.019		0.1	14								7.9			8.1	8.8	
58-76	0.03			0.3	9								6.5			8.4	9.0	
76-94	0.01			0.3	3								6.0			8.5	9.1	
94-140	0.01			0.3	14								8.1			8.3	9.2	
140-175	-			0.3	4								3.9			8.4	9.1	

Depth (cm)	Extractable bases: 6N2b Ca 5B1a	6C2c Mg 5B1a	6P2a Exch. Na 5B1b	6Q2a Exch. K 5B1b	6H2a Ext. acidity	5A2a CEC Na OAc	5D1 Exchangeable sodium Pct.	5E Sodium adsorption ratio	8A Water at saturation Pct.	Water extract from saturated paste 8A1: 6N1a Ca	6O1a Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1a SO_4	8A1a Electrical conductivity mmho/cm
	meq/100 g									meq/liter								
0-3	11.7	1.2	0.2	0.5		5.6	4		20.4	3.0	0.2	1.3	0.7	-	3.1	0.5	0.3	0.4
3-10	15.5	1.6	0.2	0.7		7.3	3		17.2	3.1	0.1	1.4	0.7	-	2.4	0.4	0.4	0.4
10-41	18.9	2.9	0.2	1.1		11.6	2		19.7	2.5	0.3	0.8	0.7	-	2.7	0.2	0.1	0.3
41-58	15.6	3.6	0.5	0.9		12.1	4		33.7	1.9	0.1	4.0	0.6	-	3.1	0.1	0.2	0.4
58-76	20.9	3.2	1.1	1.7		14.3	8		30.7	0.7	0.1	6.3	0.6	-	3.2	0.1	0.3	0.4
76-94	16.9	3.1	1.1	1.3		12.2	9		30.4	0.6	0.1	8.7	0.5	-	3.1	0.7	0.7	0.5
94-140	19.0	4.5	1.0	0.8		16.3	6		34.3	1.3	0.7	7.4	0.3	-	2.8	2.7	3.2	1.0
140-175	11.8	2.8	1.2	3.2		7.9	15		26.1	1.8	0.6	6.6	0.3	-	1.8	2.8		0.9

Depth (cm)	Ratios to clay 8D1: CEC Na OAc	Ext. iron	15-bar water	Salt Pct.	6F1a Gypsum Pct.
0-3	2.43	0.30	1.30		
3-10	1.49	0.14	0.76		
10-41	1.07	0.06	0.56		
41-58	1.86	0.02	1.21		
58-76	2.20	0.05	1.00		
76-94	3.30	0.19	1.62		
94-140	3.98	0.07	1.98		
140-175	3.59	0.14	1.77		

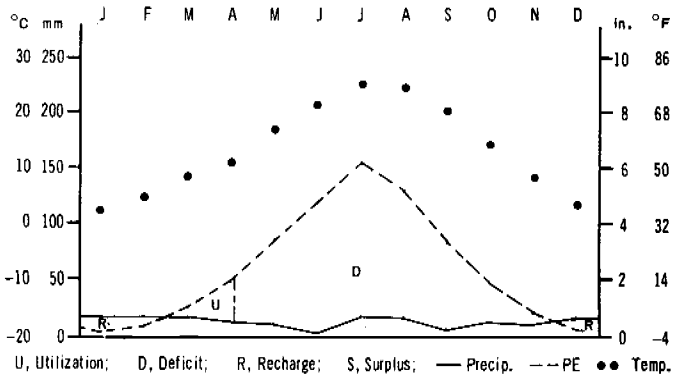
a/ Percent by weight of the <10 mm soil fraction.

b/ 1.7 kg of organic carbon per square meter to a depth of 1 meter.

Pedon 63

Classification: Typic Durorthid, loamy, mixed, thermic, shallow.
Location: Pahranagat Valley, Lincoln County, Nev. 2.4 km west and 0.4 km south of Alamo High School and 41 m west of the south end of the airport runway. 244 m north of the southwest corner of sec. 7, T. 7 S., R. 61 E.
Physiographic position: Alluvial fan pediment, elevation about 1,150 m.
Topography: East-facing, 3 percent slope.
Drainage: Well drained; slow runoff; rapid permeability above the duripan, very slow permeability through the pan.
Vegetation: Density of vegetation is 8 percent of which blackbrush (Coleogyne ramosissima) is 30 percent, creosotebush (Larrea tridentata) is 20 percent, desert pearl is 30 percent, shad scale (Atriplex confertifolia) is 10 percent, bud sage (Artemisia spinescens) is 4 percent, fourwing saltbush (Atriplex canescens) is 6 percent, and dalea (Dalea sp.), Joshua trees (Yucca brevifolia) and Mormon tea (Ephedra sp.) make up the remainder.
Parent material: Alluvium, mostly from welded tuffs with some granodiorite and basalt.
Sampled by: R. E. Nelson, C. D. Henry, W. G. Harper, D. G. Bagley, and L. Rooke, November, 1959.
Remarks: The soil does not disperse well, hence the field estimates of texture are given in the profile description.
Soil No.: S59Nev-9-33.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

A11 0-3 cm (0-1 in.). Light gray (10YR 7/2) loamy coarse sand or coarse sand, grayish brown (10YR 5/2) moist; single grained; soft (dry), loose (moist), nonsticky and nonplastic (wet); very few roots; many very fine, fine and medium interstitial pores; 5 percent gravel by field volume estimate; slightly effervescent; abrupt smooth boundary.

A12 3-10 cm (1-4 in.). Light brownish gray (10YR 6/2) loamy coarse sand, dark grayish brown (10YR 4/2) moist; weak medium to thick platy structure; slightly hard (dry), very friable (moist), nonsticky and nonplastic (wet); few very fine and fine roots; many very fine, fine and medium vesicles; strongly effervescent; 5 percent gravel by field volume estimate; abrupt smooth boundary.

A13 10-41 cm (4-16 in.). Light gray (10YR 7/2) fine gravelly coarse sandy loam, brown (10YR 5/3) moist; massive; slightly hard (dry), very friable (moist), nonsticky and nonplastic (wet); plentiful very fine, fine and medium roots; many very fine, fine and medium vesicles; violently effervescent with carbonates on most of the pebbles; 25 percent fine gravel by field volume estimate; abrupt wavy boundary.

C1sicam 41-58 cm (16-23 in.). White (10YR 8/1) indurated duripan, pale brown (10YR 6/3) moist; platy; extremely hard (dry), extremely firm (moist), nonsticky and nonplastic (wet); few very fine and fine roots between cemented plates; many micro pores below the immediate surface which is more strongly cemented by silica and calcium carbonate; violently effervescent; 40 percent gravel by field volume estimate; abrupt wavy boundary.

C2sicam 58-76 cm (23-30 in.). White (10YR 8/2) indurated duripan, pale brown (10YR 6/3) moist; massive; hard to extremely hard (dry), very friable with some extremely firm silica and lime-cemented fragments (moist), nonsticky and nonplastic (wet); plentiful very fine, fine and a few medium roots; many very fine and fine interstitial pores; 40 to 50 percent gravel by field volume estimate; violently effervescent; carbonates on practically all of the pebbles; clear wavy boundary.

C3 76-94 cm (30-37 in.). Very pale brown (10YR 7/3) gravelly (mainly fine gravel) loamy coarse sand, brown (10YR 5/3) moist; massive; soft (dry), loose (moist), nonsticky and nonplastic (wet); abundant very fine roots; many very fine and fine interstitial pores; 65 percent gravel by field volume estimate; violently effervescent; abrupt wavy boundary.

C4sicam 94-140 cm (37-55 in.). Light gray (10YR 7/2) very gravelly loamy coarse sand in lenses and pockets between plates of silica and carbonate-cemented gravelly sand. The cemented material is white (10YR 8/2), light brownish gray (10YR 6/2) moist; massive; extremely hard (dry), extremely firm (moist) where cemented; soft (dry) in the lenses and pockets of sandy material; nonsticky and nonplastic (wet); very few fine roots; many very fine cavities or pores in the cemented material and elsewhere, many very fine, fine and medium interstitial pores; violently effervescent; 65 to 70 percent gravel by field volume estimate; clear wavy boundary.

IIC5 140-175 cm (55-68 in.). Light gray (10YR 7/2) very gravelly coarse sand, grayish brown (10YR 5/2) moist; massive; soft (dry), loose (moist), nonsticky and nonplastic (wet); devoid of plant roots; many very fine, fine and medium interstitial pores; 70 to 75 percent fine gravel by field volume estimate; strongly effervescent.

Pedon 64

SOIL Typic Paleorthid SOIL Nos. S56Nev-2-2 LOCATION Clark County, Nevada

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 5640 - 5644

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Silt Int. II (0.2-0.02)	Silt 2-0.1			Coarse fragments 1A2a 2-25 mm a/	2-19	19-76
		Size class and particle diameter (mm) 3A1 — Pct. of <2 mm														Pct. of <76mm		
0-3	A1	68.1	17.5	14.4	1.0	1.4	5.6	40.0	20.1	4.9	12.6	49.8	48.0			28		
3-10	B2	71.5	11.1	17.4	1.3	1.9	6.6	43.8	17.9	4.3	6.8	48.6	53.6			13		
10-23	B3ca	69.1	16.0	14.9	2.6	2.8	7.0	39.5	17.2	7.6	8.4	47.5	51.9			33		
23-36	IIC1ca	69.9	16.4	13.7	5.3	4.3	8.4	38.0	13.9	7.2	9.2	42.3	56.0			58		
36+	IIC2cam	80.4	10.7	8.9	14.3	7.5	9.8	39.7	9.1	5.1	5.6	35.5	71.3			82		

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N	6C2b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ 6E1b <2 mm Pct.	Carbonate as $CaCO_3$ 3A1a <0.002 mm Pct.	Bulk density 4A1f 1/3-bar g/cc	Bulk density 4A1h Oven-dry g/cc	Bulk density g/cc	3B2 Cm	Water content 4B1a 1/3-bar Pct.	Water content 4B2 15-bar Pct.	Water content 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH 8C1b Saturated paste	pH 8C1c IN KCl 1:1	pH 8C1a H_2O 1:10
0-3	0.12	0.016			15						10.7	4.6				7.5		9.0
3-10	0.09	0.012			11						10.7	5.5				8.4		9.1
10-23	0.10	0.013			16						17.7	5.6				8.5		9.1
23-36	0.12				20						17.0	6.0				8.5		9.0
36+	0.09				35						9.4	3.7				8.5		9.2

Depth (cm)	Extractable bases 6N4c Ca 5B3a	6O4c Mg 5B3a	6P2a Exch. Na 5B1b	6Q2a Exch. K 5B1b	6H2a Ext. acidity	5A2a CEC Na OAc	5D1 Exchangeable sodium Pct.	5E Sodium adsorption ratio	8A Water at saturation Pct.	Water extract from saturated paste 8A1	6N1a 6O1a Ca + Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1b SO_4	8A1a Electrical conductivity mmho/cm
	meq/100 g									meq/liter								
0-3			0.1	0.8		7.5	1	1	17.3		4.3	0.9	0.4					0.58
3-10			0.1	0.9		11.0	1	1	21.1		3.6	0.8	0.3					0.50
10-23			0.1	0.8		8.1	1	<1	37.1		2.4	0.4	0.3					0.34
23-36			0.1	0.6		3.7	3	<1	35.8		3.0	0.6	0.3					0.44
36+			0.1	0.3		3.6	3											

Depth (cm)	Ratios to clay 8D1 CEC Na OAc	Ext. iron	15-bar water	Salt Pct.	6F1a Gypsum Pct.		
0-3	0.52		0.31		-		
3-10	0.63		0.31		-		
10-23	0.54		0.38		-		
23-36	0.27		0.44		-		
36+	0.40		0.42		-		

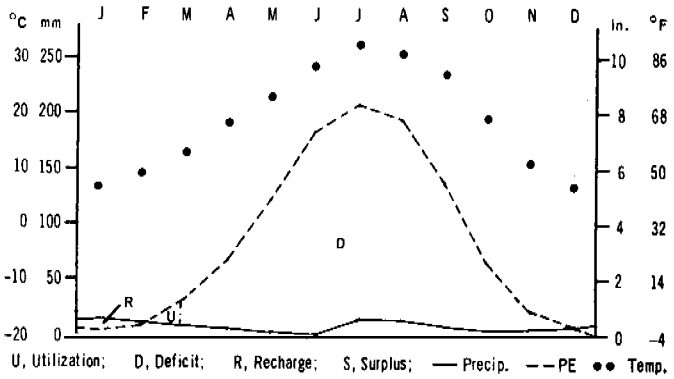
a/ Percent of the <25 mm soil fraction.

b/ 1.8 kg of organic carbon per square meter to a depth of 1 meter.

Pedon 64

Classification: Typic Paleorthid, loamy, mixed, thermic, shallow.
Location: Clark County, Nev. 9.7 km southwest of McCarran Air Field and 1 km south of Blue Diamond Road. 91 m north and 9 m west of 1/4 corner of sec. 24, T. 22 S., R. 60 E., and sec. 19, T. 22 S., R. 61 E., located in the SE1/4 NE1/4 of sec. 24, T. 22 S., R. 60 E.
Physiographic position: Alluvial fan, elevation about 700 m.
Topography: East-facing, 3 percent slope.
Drainage: Well drained; medium runoff; internal drainage is medium above the petrocalcic horizon and very slow below it.
Vegetation: About 1 percent covered by shrubs of which 64 percent is bur-sage (Franseria dumosa), 35 percent is creosotebush (Larrea tridentata), 1 percent is Mormon tea (Ephedra sp.) and yucca and cactus make up the remainder.
Parent material: Alluvium from limestone, sandstone, quartzite, conglomerate, shale, and a little basalt and rhyolite.
Sampled by: R. E. Nelson, L. Dunn, and L. N. Langan, February, 1956.
Remarks: This soil has a desert pavement. Fine sand hummocks 5 to 10 cm high have built up under the shrubs.
Soil No.: S56Nev-2-2.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

A1 0-3 cm (0-1 in.). Pink (7.5YR 7/4) gravelly fine sandy loam, brown (7.5YR 5/4) moist; moderately vesicular; weak medium platy structure; slightly hard (dry), friable (moist); few roots; strongly effervescent; abrupt smooth boundary.

B2 3-10 cm (1-4 in.). Pink (5YR 7/4) gravelly fine sandy loam, yellowish red (5YR 5/6) moist; weak coarse prismatic structure; slightly hard (dry), friable (moist); few roots; strongly effervescent; abrupt wavy boundary.

B3ca 10-23 cm (4-9 in.). Reddish yellow (7.5YR 7/6) gravelly fine sandy loam with common, fine, distinct white (10YR 8/2) mottles, strong brown (7.5YR 5/6) moist; weak medium to fine subangular blocky structure; slightly hard (dry), friable (moist); plentiful roots; violently effervescent; clear wavy boundary.

IIC1ca 23-36 cm (9-14 in.). Pink (7.5YR 7/4) gravelly fine sandy loam, strong brown (7.5YR 5/6) moist; massive; hard (dry), firm (moist); few roots; weakly cemented with lime; violently effervescent; clear wavy boundary.

IIC2cam 36 cm+(14 in.+). Pink (7.5YR 8/4) petrocalcic horizon, reddish yellow (7.5YR 7/6) moist; massive; extremely hard (dry), extremely firm (moist); violently effervescent.

Pedon 65

SOIL Typic Salorthid SOIL Nos. S60Nev-2-1 LOCATION Clark County, Nevada

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 606 - 6013

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	2-0.1			Coarse fragments 1A2a: > 2 Pct. of whole soil	2-19 (Pct. of <76mm)	19-76 (Pct. of <76mm)
		Pct. of <2 mm																
0-11	A1	1.5	49.6	48.9	0.1	0.1	0.1	0.8	0.4	6.6	43.0	7.6	1.1			0		
11-15	C1sa	0.9	44.4	54.7	0.0	0.1	0.1	0.4	0.3	5.3	39.1	5.9	0.6			0		
15-20	C2sa	1.6	55.1	43.3	0.0	0.1	0.1	0.7	0.7	11.8	43.3	13.0	0.9			0		
20-36	C3sa	10.2	52.8	37.0	0.0	0.1	0.2	4.2	5.7	18.9	33.9	28.0	4.5			0		
36-56	IIC4	16.9	54.4	28.7	0.1	0.2	0.4	7.1	9.1	21.9	32.5	36.8	7.8			0		
56-76	IIIC5	2.0	57.9	40.1	0.0	0.1	0.1	0.6	1.2	11.1	46.8	12.7	0.8			0		
76-105	IVC6	3.4	78.4	18.2	0.1	0.1	0.1	0.6	2.5	35.2	43.2	38.1	0.9			0		
105-150	VC7	3.9	53.1	43.0	0.0	0.3	0.6	1.4	1.6	6.1	47.0	7.5	2.3			0		

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C2b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	Carbonate: 3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	Bulk density: 4A1h Oven-dry g/cc	Bulk density: g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	Water content: 4B2 15-bar Pct.	Water content: 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	pH: 8C1c 1N KCl 1:1	pH: 8C1a H_2O 1:10
0-11	0.69	0.064	11		4											8.4		8.6
11-15	0.38	0.039	10		2											8.7		9.1
15-20	0.60	0.063	10		3											8.8		9.0
20-36	0.44	0.046	10		4											8.4		8.8
36-56	0.27	0.030	9		6											8.4		8.8
56-76	0.26	0.033	8		13											8.6		9.0
76-105	0.18	0.019			11											8.6		9.1
105-150	0.21	0.028			13											8.6		8.9

Depth (cm)	Extractable bases: 6N4c Ca 5B3a	6O4c Mg 5B3a	6P2a Na 5B1a	6Q2a K 5B1a	6H2a Ext. acidity	5A2a CEC Na OAc	5D2 Exchangeable sodium Pct.	5E Sodium adsorption ratio	8A Water at saturation Pct.	Water extract from saturated paste 8A1: 6N1a Ca	6O1a Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1b SO_4	8A1a Electrical conductivity mmho/cm
	meq/100 g									meq/liter								
0-11			20.6	3.0		38.6		67	79.4	25.0	3.6	255	2.2	-	1.4	1.4		22.5
11-15			149.8	3.0		16.7		281	69.3	56.7	12.4	1650	63.8	19.7	56.8	56.8		116.7
15-20			483.4	2.4		24.9		553	61.6	56.7	9.3	3175	62.5	-	337.3	337		122.5
20-36			9.2	2.9		23.2		201	56.0	36.1	52.5	1320	24.8	2.0	443.5	444		83.8
36-56			21.0	2.5		21.6		110	54.9	36.1	92.7	885	19.5	2.2	360.4	360		66.7
56-76			21.6	4.4		32.3		110	71.0	51.5	61.8	825	18.4	0.5	337.3	337		63.0
76-105			19.9	4.8		25.6		74	53.1	42.2	20.6	413	10.0	-	175.6	176		37.7
105-150			16.8	5.2		36.8		34	80.7	164.8	154.5	430	11.6	-	212.5	213		38.3

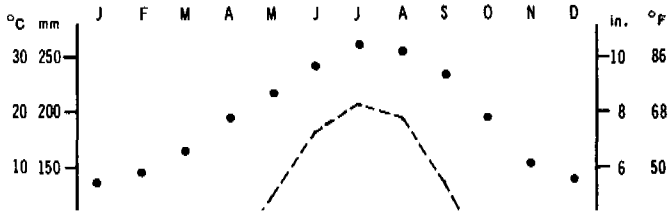
Ratios to clay 8D1 6F1a

a/ 3.7 kg of organic carbon per square meter to a depth

Pedon 65

Classification: Typic Salorthid, fine-silty, mixed, thermic.
Location: Moapa Valley, Clark County, Nev. On U. S. Highway 93 about 0.8 km northwest of the junction of U. S. 93 and U. S. 91 near Glendale, Nevada. 46 m north of 93, or 91 m north and 91 m east of the SW corner of sec. 35, T. 14 S., R. 66 E.
Physiographic position: Flood plain of Meadow Valley Wash, elevation about 468 m.
Topography: Smooth, southeast-facing, 1 percent slope.

Climatic data and soil water balance



SOIL Pedon 66 Typic Udifluvent SOIL Nos. S70Iowa-67-3 LOCATION Monona County, Iowa

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 70L1143-70L1151

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	<0.074	0.005–0.002	3A1b <0.002	Coarse fragments 2A2	3B1 2-20 Pct. <20
		Pct. of < 2 mm																
0-14	Ap	5.1	78.4	16.5	-	tr	0.1	0.5	4.5	47.9	30.5	52.7	0.6	98.8	2.6	9.9		-
14-31	C1	6.9	78.6	14.5	-	-	tr	0.3	6.6	41.9	36.7	48.7	0.3	98.9	3.2	7.6		-
31-42	C2	4.1	81.0	14.9	-	tr	0.1	0.4	3.6	40.2	40.8	44.1	0.5	99.1	3.5	8.7		-
42-56	C3	16.5	73.0	10.5	-	-	0.2	0.8	15.5	56.7	16.3	72.7	1.0	98.2	1.6			-
56-66	C4	8.2	75.3	16.5	-	-	0.1	1.1	7.0	35.8	39.5	43.8	1.2	96.8	4.1			-
66-98	C5	34.1	55.3	10.6	-	tr	0.3	2.1	31.7	43.8	11.5	77.3	2.4	90.9	1.2			-
98-125	C6	13.0	71.6	15.4	tr	0.1	0.2	0.8	11.9	49.8	21.8	62.2	1.1	97.9	2.5			-
125-135	C7	1.3	65.4	33.3	-	tr	0.1	0.3	0.9	25.9	39.5	26.9	0.4	99.4	8.1			-
135-185	C8	1.9	76.5	21.6	-	0.1	tr	0.3	1.5	34.6	41.9	36.3	0.4	99.4	5.6			-

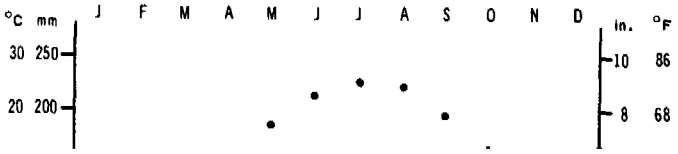
Depth (cm)	6A1a Organic carbon Pct.	Nitrogen Pct.	C/N		6E1b Carbonate as $CaCO_3$ Pct.		Bulk density g/cc	g/cc	g/cc		Water content Pct.	Pct.	4B2 15-bar Pct.	8D1 Ratio 15-bar to clay		pH	8C1e (1:2) $CaCl_2$	8C1a (1:1) H_2O
0-14	1.28				5								8.4	0.51			7.4	7.6
14-31	0.57				7								7.3	0.50			7.6	8.0
31-42	0.60				7								7.6	0.51			7.6	8.0
42-56	0.45				7								5.6	0.53			7.6	8.0
56-66	0.57				7								7.9	0.48			7.6	7.9
66-98	0.42				6								5.5	0.52			7.7	8.1
98-125	0.52				7								7.6	0.49			7.6	7.9
125-135	0.65				5								14.5	0.44			7.7	7.8
135-185	0.58				6								10.4	0.48			7.7	7.8

Depth	Extractable bases: Ca	Mg	Na	K													Base saturation	
	meq/100 g																Pct.	Pct.

Pedon 66

Classification: Typic Udifluvent, coarse-silty, mixed (calcareous), mesic.
Location: Monona County, Iowa, 200 m E. and 60 m N. of SW. corner of NE 1/4 NW 1/4 sec. 34, T. 85 N., R. 46 W. 105 km (65 mi.) N. of Omaha, Nebr.
Physiographic position: Missouri River bottomland.
Topography: Nearly level, less than ½ percent slope gradient

Climatic data and soil water balance



Pedon 67

SOIL Typic Torrifluvent SOIL Nos. S67Tex-71-3 LOCATION El Paso County, Tex.

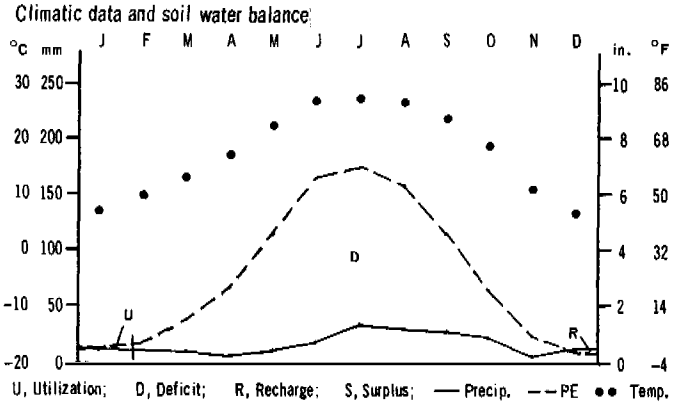
SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 67L074-67L080

General Methods: 1B1b, 2A1, 2B

Depth	Horizon	Size class and particle diameter (mm) 3A1													3A1a	Coarse fragments 2A2		
		Total			Sand					Silt					Carbon-ate as			3B1
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	Int. III (0.02-0.005)	Int. II (0.005-0.002)						2-20
0-30	Ap	39.6	43.1	17.3	0.2	0.6	0.8	9.0	29.0	23.1	20.0	59.8	10.6	79.1	-			tr
30-48	C1	42.7	41.6	15.7	0.1	0.4	0.7	10.7	30.8	21.7	19.9	61.9	11.9	76.0	-			tr
48-76	C2	74.1	21.5	4.4	-	0.1	0.2	20.9	52.9	17.9	3.6	91.0	21.2	53.0	tr			-
76-91	C3	31.7	47.9	20.4	-	0.1	0.5	20.3	10.8	14.7	33.2	40.9	20.9	73.6	tr			-
91-115	C4	43.8	46.4	9.8	-	0.1	0.1	6.7	36.9	34.0	12.4	76.7	6.9	83.6	-			-
115-125	C5																	-
125-150	C6																	-
	6A1a						Bulk density				Water content					pH		

Pedon 67

Classification: Typic Torrifluvent, coarse-loamy, mixed, (calcareous), thermic.
Location: El Paso County, Tex., 4.4 km (2.7 mi.) NW. of Farm Road 258 (Fabens, Tex.) on U.S. Highway 80, 60 m NE. on Webb Road and 15 m NW. of the road. About 50 km (30 mi.) SW. of El Paso.
Physiographic position: Rio Grande floodplain. Elevation about 1,100 m.
Topography: Nearly level.
Vegetation: Cultivated.
Parent material: Alluvium.
Sampled by: L. J. Bartelli, H. C. Dean, V. Link, G. S. McKee and party, March 2, 1967.
Remarks: The C3 horizon is at about field capacity. Moisture content in horizons above the C3 is below field capacity.
Soil No.: S67Tex-71-3.



Colors are for the dry soil unless otherwise indicated.

Ap 0-30 cm (0-12 in.). Pink (7.5YR 7/4) light loam; dark brown (7.5YR 4/2) moist, crushed; structureless; very hard fragments; friable; plentiful roots; calcareous; abrupt smooth boundary.

C1 30-48 cm (12-19 in.). Dark brown (7.5YR 4/2) moist, light loam, light brown (7.5YR 6/3) crushed; discontinuous zones with weak to medium coarse subangular blocky structure; friable (moist); no bedding planes evident; plentiful roots; calcareous; abrupt wavy boundary.

C2 48-76 cm (19-30 in.) Brown (7.5YR 5/3) moist, very fine sandy loam, pinkish gray (7.5YR 7/3) crushed; structureless; weak bedding planes; few roots; calcareous; abrupt wavy boundary.

C3 76-91 cm (30-36 in.). Dark brown (7.5YR 4/2) moist, heavy loam, light brown (7.5YR 6/3) crushed; bedding planes; calcareous; abrupt wavy boundary.

C4 91-115 cm (36-46 in.). Dark brown (7.5YR 4/3) moist, light loam, light brown (7.5YR 6/3) crushed; structureless; calcareous; abrupt wavy boundary.

C5 115-125 cm (46-50 in.). Dark brown (7.5YR 4/3) moist, silty clay loam, light brown (7.5YR 6/3) crushed; structureless; calcareous.

C6 125-150 cm (50-60 in.) plus. Pale brown (10YR 6/3) stratified layers of very fine sand; loamy fine sand and silt loam; calcareous.

Pedon 68

SOIL Typic Udorthent SOIL Nos. S61Iowa-36-1 LOCATION Fremont County, Iowa

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 15658-15662

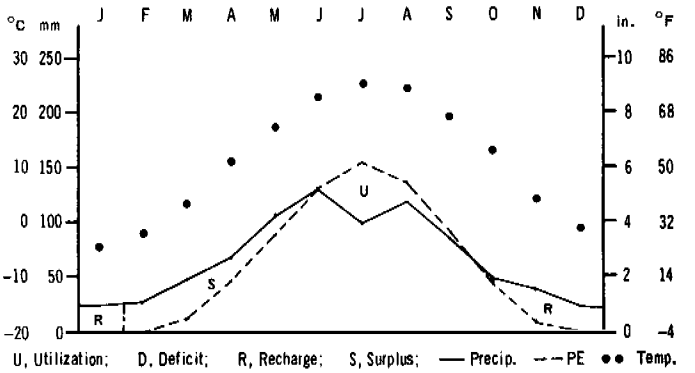
General Methods: 1A, 1B1b, 2A1, 2B

Depth	Horizon	Size class and particle diameter (mm) 3A1															
		Total			Sand					Silt						Coarse fragments 2A2	
		Sand	Silt	Clay	Very coarse	Coarse	Medium	Fine	Very fine		Int. III	Int. II					3B1 >20

Pedon 68

Classification: Typic Udorthent, coarse-silty, mixed (calcareous), mesic.
Location: Fremont County, Iowa, 18 m N. and 37 m E. of the SW. corner sec. 30, T. 68 N., R. 42 W.; approximately 9 km NW. of Hamburg. About 70 km (45 mi.) S. of Omaha, Nebr.
Physiographic position: Dissected upland.
Topography: Very steep, 70 percent, SW. facing side slope of interfluve extending W. from uplands.
Drainage: Somewhat excessively drained; moderate permeability; rapid runoff.
Vegetation: Little bluestem (Andropogan scoparius), other grasses, scattered scrub oak (Quercus spp.), few scattered cedar (Juniperus spp.).
Parent material: Calcareous coarse loess, Wisconsinan age.
Sampled by: R. I. Dideriksen and J. R. Nixon, March 23, 1961.
Soil No.: S61Iowa-36-1.

Climatic data and soil water balance



Colors are for the moist soil unless otherwise indicated.

A1 0-5 cm (0-2in.). Dark grayish brown (10YR 4/2) light silt loam; weak very fine granular structure; soft (dry), very friable (moist); abundant fine roots; very porous; numerous wormcasts; calcareous; gradual boundary.

AC 5-25 cm (2-10 in.). Dark brown (10YR 4/3) light silt loam, yellowish brown (10YR 5/4) dry; weak very fine granular structure to massive; soft (dry), very friable (moist); abundant very fine roots; common fine and medium pores; common wormcasts; calcareous; diffuse boundary.

C1 25-61 cm (10-24 in.). Yellowish brown (10YR 5/4) light silt loam, pale brown (10YR 6/3) dry; weak fine granular structure to massive; soft (dry), very friable (moist); few very fine roots; common fine and medium pores; few brown (10YR 5/3) wormcasts; calcareous; diffuse boundary.

C2 61-97 cm (24-38 in.). Yellowish brown (10YR 5/4) light silt loam, pale brown (10YR 6/3) dry, few fine faint light brownish gray (2.5Y 6/2) mottles; weak very fine granular structure to massive; soft (dry), very friable (moist); very few fine roots; common very fine pores; calcareous; few light-colored filamentous lime; diffuse boundary.

C3 97-135 cm (38-53 in.). Yellowish brown (10YR 5/4) light silt loam, pale brown (10YR 6/3) dry, few fine faint light brownish gray (2.5YR 6/2) mottles; weak very fine granular structure to massive; soft (dry), very friable (moist); very few fine roots; common very fine pores; few very fine soft nodules of dark oxide; calcareous, few light-colored filamentous lime.

SOIL Pedon 69 Typic Torripsamment SOIL Nos. S66NMex-7-11 LOCATION Dona Ana County, N. Mex.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 66L753-66L759

General Methods: 1A1, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	(2-0.1)	<0.074		Coarse fragments 2A2 Wt. 3B1 75-2	5-2	20-2
		Size class and particle diameter (mm) 3A1 — Pct. of < 2 mm														% < 75		% < 20
0-28	C1	93.7	3.0	3.3	0.2	13.2	32.7	41.4	6.2	1.9	1.1	23.6	87.5	8.9		tr	tr	tr
28-58	C2	92.7	3.5	3.8	1.0	15.1	31.0	39.2	6.4	2.3	1.2	23.3	86.3	10.1		tr	tr	tr
58-84	B2b	89.2	6.0	4.8	1.8	15.8	27.4	35.3	8.9	4.6	1.4	28.4	80.3	15.2		tr	tr	tr
84-110	B3cab	89.2	5.9	4.9	1.8	15.4	26.9	36.5	8.6	4.0	1.9	27.4	80.6	15.1		2	2	2
110-135	C1cab	88.8	5.8	5.4	3.2	14.6	25.5	37.9	7.6	3.1	2.7	26.0	81.2	14.7		1	1	1
135-165	C2cab	94.0	2.7	3.3	3.7	21.4	30.4	35.1	3.4	1.1	1.6	16.3	90.6	7.3		1	1	1
165-190	C3b	94.8	2.5	2.7	2.9	20.7	29.8	37.0	4.4	1.2	1.3	18.3	90.4	6.9		tr	tr	tr

Depth (cm)	6A1a Organic carbon a/ Pct.	Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ 6E1b 6E2a < 2 mm Pct.	3A1a <0.002 mm Pct.	Bulk density g/cc	4A1d 1/3-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content 4B1a 0.06-bar Pct.	4B1a 0.1-bar Pct.	4B2 15-bar Pct.		0.25-0.10 mm fraction b/ mineralogy 7B1 Petrographic Pct.
0-28	0.15				-						7.3	4.9	1.9		
28-58	0.15				tr						7.1	5.9	2.0		
58-84	0.13				tr			1.57	1.60	0.007	9.4	6.7	2.4		
84-110	0.10				1	-		1.58	1.60	0.003	11.1	6.7	3.4		
110-135	0.10				2	-		1.62	1.64	0.003			3.2		
135-165	0.06				1	-					8.0	7.2	2.8		
165-190	0.06				tr						6.6	5.9	2.2		QZ45,FD35,MA20,RE tr WE tr

a/ 2.1 kg/m² to 110 cm.

b/ Mineral code:

QZ = quartz

FD = feldspar, 30 percent with index of refraction below 1.550 and 5 percent with index of refraction at or above 1.550

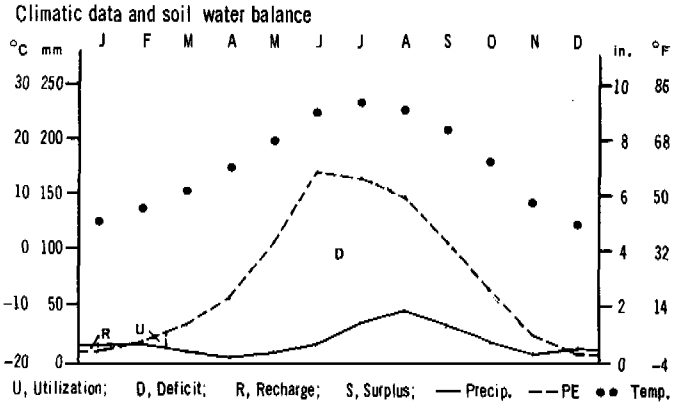
MA = Microcrystalline aggregates, appear to be fragments of rhyolite ground-mass

RE = Other resistant, mostly opaques

WE = Other weatherable, mostly hornblende

Pedon 69

Classification: Typic Torripsamment, mixed, thermic.
Location: Dona Ana County, N. Mex., 1.5 km W. of Tortugas Mountain. 5.5 km (3.5 mi.) E. of center of Las Cruces.
Physiographic position: Dissected outer edge of alluvial fan Piedmont along edge of Rio Grande Valley. Elevation 1,260 m.
Topography: Shoulder of ridge with slope of 6 percent to the SE. Coppice dune.
Vegetation: Mesquite (Prosopis juliflora), few creosotebush (Larrea divaricata or Larrea tridentata).
Parent material: Eolian sand from local source; underlying soil developed in alluvial or colluvial material.
Sampled by: L. H. Gile, R. B. Grossman, J. W. Hawley and W. C. Lynn, November 8, 1966.
Remarks: The coppice dune rests on the Fort Selden, valley-slope surface, considered to range in age from late Wisconsinan to Holocene. The buried soil is formed in material of this geomorphic surface. Measurements in the general area indicate that the current dust fall is calcareous.
Soil No.: S66NMex-7-11.



Colors are for the dry soil unless otherwise indicated.

Soil surface. Surface of dune weakly crusted; in places there is a thin discontinuous layer of loose sand on the crust.

C1 0-28 cm (0-11 in.). Brown (10YR 5.5/3) sand, dark brown (10YR 4/3) moist; massive and single grain; soft (dry) and loose (dry); few to plentiful roots; stratification more apparent than in horizon below; noncalcareous; clear wavy boundary.

C2 28-58 cm (11-23 in.). Brown (10YR 5.5/3) sand, dark brown (10YR 4/3) moist; massive or single grain with a tendency to part along boundaries of strata to form plates; strata 1 to 4 mm thick; soft (dry) and loose (dry); few to plentiful roots; generally noncalcareous, but in places effervesces weakly; abrupt smooth boundary.

B2b 58-84 cm (23-33 in.). Brown (10YR 5/3) sand, dark grayish brown (10YR 3.5/2) moist; massive; soft (dry); few roots; generally effervesces weakly but in places noncalcareous; clear wavy boundary.

B3cab 84-110 cm (33-43 in.). Light brownish gray (10YR 6/2) sand, dark grayish brown (10YR 4/2) moist; massive; soft (dry); few roots; few patchy carbonate coatings on sand grains; effervesces weakly; clear wavy boundary.

C1cab 110-135 cm (43-54 in.). Light gray (10YR 7/2) sand, grayish brown (10YR 5.5/2) moist; massive; soft (dry); few roots; few carbonate filaments; sand grains have patchy carbonate coatings and a few pebbles have thin discontinuous carbonate coatings; few krotovinas, 2 to 10 cm diameter, with colors of the B2b horizon; effervesces strongly; clear wavy boundary.

C2cab 135-165 cm (54-64 in.). Light brownish gray (10YR 6.5/2) coarse sand, grayish brown (10YR 4.5/2) moist; massive; soft (dry); few roots; few faint patchy carbonate coatings on sand grains; a few pebbles with thin patchy carbonate coatings; effervesces strongly; clear wavy boundary.

C3b 165-190 cm (64-74 in.). Light brownish gray (10YR 6.5/2) sand, grayish brown (10YR 4.5/2) moist; massive; soft (dry); no roots; effervesces weakly.

Pedon 70

SOIL Typic Ustipsamment SOIL Nos. S63Kans-29-3 LOCATION Ford County, Kans.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 18471-18475

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	Silt: (2–0.1)			Coarse fragments 2A2: 3B1 2-20 Pct. < 20
		Pct. of < 2 mm														
0-13	A1	91.5	5.9	2.6	0.9	14.2	32.5	40.1	3.8	4.0	1.9	24.5	87.7			tr
13-25	AC	96.0	1.6	2.4	1.1	13.5	35.7	42.8	2.9	0.4	1.2	20.3	93.1			tr
25-61	C1	96.8	0.8	2.4	0.6	12.2	33.3	46.9	3.8	0.1	0.7	23.5	93.0			tr
61-105	C2	97.3	0.6	2.1	2.6	21.3	34.0	36.4	3.0	-	0.6	17.4	94.3			tr
105-150	C3	97.0	0.7	2.3	0.8	16.7	35.2	41.1	3.2	0.1	0.6	20.0	93.8			tr

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C2a Ext. iron as Fe Pct.	Bulk density: 4A3a Field state b/ g/cc	g/cc	g/cc		Water content: 4B1d Field state Pct.	Pct.	4B2 15-bar Pct.			pH: 8C1b Sat. paste	8C1a (1:1) H_2O
0-13	0.30	0.030	10			0.3	1.44				2.2		1.9				6.6
13-25	0.11					0.2	1.53				1.5		1.6				6.3
25-61	0.07					0.2	1.54				2.5		1.1				6.3
61-105	0.04					0.3	1.58				2.8		1.1			6.4	6.2
105-150	0.03					0.3	1.6						1.0				6.4

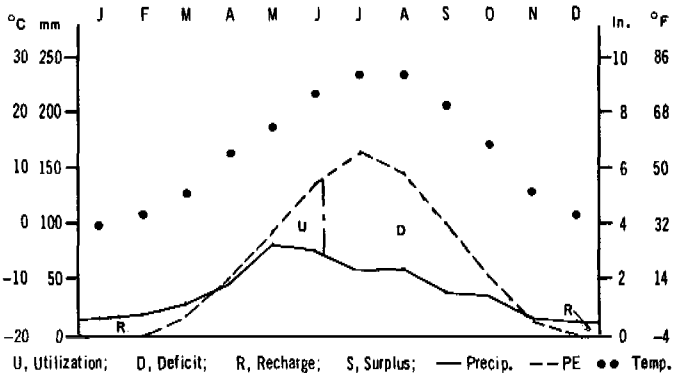
Depth (cm)	Extractable bases 5B1a: 6N2a Ca	6O2a Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap: 5A3a Sum cations	5A1a NH_4OAc			8E1 Resistivity ohms-cm	8B1a Elec. cond. mmhos/cm	8B Water at sat. Pct.			Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																
0-13	1.9	1.2	tr	0.3	3.4	1.8	5.2	2.9								65	117
13-25	1.7	0.6	tr	0.1	2.4	1.0	3.4	2.4			22,000					71	100
25-61	1.4	0.4	tr	0.1	1.9	1.0	2.9	2.1								66	90
61-105	1.3	0.5	tr	0.1	1.9	0.9	2.8	2.0			18,200	0.23	22.5			68	95
105-150	1.2	0.5	tr	0.1	1.8	0.9	2.7	1.8								67	100

a/ 1.7 kg/m² to 1.5 m (method 6A).
b/ Value for C3 horizon is estimated.

Pedon 70

Classification: Typic Ustipsamment, mixed, mesic.
Location: Ford County, Kans., 1,000 m N. and 79 m E. of SW. corner of sec. 2, T. 28 S., R. 21 W., about 40 km (25 mi.) ESE. of Dodge City.
Physiographic position: Upland sandhills. Elevation about 750 m.
Topography: Convex slope with 10 percent gradient to E.
Drainage: Rapid permeability; very slow runoff.
Vegetation: Sand bluestem (Andropogen hallii), sand paspalum (Paspalum stramineum), scattered pricklypear cactus (Opuntia spp.).
Sampled by: D. A. Dodge, R. B. Grossman, G. S. Holmgren and C. W. McBee, June 25, 1963.
Remarks: Soil temperature at 6 m, 13.8° C.
Soil No.: S63Kans-29-3.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

A1 0-13 cm (0-5 in.). Grayish brown (10YR 5/2) sand, dark grayish brown (10YR 4/2) moist; single grain; loose (moist or dry); mass somewhat held together by grass roots; noncalcareous; gradual boundary.

AC 13-25 cm (5-10 in.). Brown (10YR 5/3) sand, brown (10YR 4/3) moist; single grain; loose (moist or dry); plentiful roots; noncalcareous; diffuse boundary.

C1 25-61 cm (10-24 in.). Light yellowish brown (10YR 6/4) sand, yellowish brown (10YR 5/3.5) moist; single grain; loose (moist or dry); plentiful fine roots becoming less common with depth; lenses of fine sand and of medium sand; noncalcareous.

C2 61-105 cm (24-41 in.). Same as C1; subdivided for sampling.

C3 105-150 cm (41-59 in.). Same as C1; subdivided for sampling.

Pedon 71

SOIL Typic Cryandept SOIL Nos. S67Ak-56-2 LOCATION Alaskan Peninsula

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 67154 - 67158

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1 Total: Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Sand: Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt: (0.05-0.02)	Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1			Coarse fragments 1A2a: > 2 Pct. of whole soil	2-19 Pct. of <76mm	19-76 Pct. of <76mm
		Pct. of <2 mm																
0-12	A11	65.7	30.4	3.9	2.7	7.4	6.7	28.1	20.8	17.6	12.8	56.0	44.9			-	-	-
12-23	A12															-	-	-
23-32	A11b	61.1	31.5	7.4	3.6	12.1	10.5	18.9	16.0	17.4	14.1	44.2	45.1			-	-	-
32-43	A12b															-	-	-
43-55	IICb	87.4	9.4	3.2	15.6	33.9	10.9	19.0	8.0	5.3	4.1	23.2	79.4			-	-	-

Depth (cm)	6A1b Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	Ratios to clay 8D1: CEC NH_4OAc	Ext. iron	15-bar water	Bulk density: 4A1f 1/3-bar g/cc	4A1h Oven-dry g/cc	g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4B2a 15-bar Pct.	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	8C1d NaF 1:50	8C1c IN KCl 1:1
0-12	3.56	0.292	12	3.33	0.23	3.23	0.76	0.88		1.00	43.0	12.6	12.2	0.050	0.050	4.6	9.5	4.4
12-23	3.68	0.326	11				0.69	0.79		1.00	55.5	15.1	19.3	0.047	0.047	4.9	10.6	4.6
23-32	3.28	0.252	13	2.12	0.24	1.68	0.79	0.86		1.00	47.3	12.4	20.2	0.029	0.029	5.3	10.7	5.1
32-43	2.24	0.194	12				0.76	0.83		1.00	44.0	10.7	20.7	0.026	0.026	5.7	10.6	5.3
43-55	0.80	0.073	11	2.09	0.41	1.75						5.6	7.9			6.6	9.3	5.6

Depth (cm)	Extractable bases 5B4a: 6N2e Ca	6O2d Mg	6P2a Na	6Q2a K	Sum of bases	6H2a Ext. acidity	Cation exch. capacity: 5A6a NH_4OAc moist	5A6a NH_4OAc AD	5A3a Sum of cations	Bases + KCl ext. Al +++	6G1d KCl ext. Al +++	Base saturation: 5C3 Sum of cations Pct.	5C1 NH_4OAc Pct.	b/ 3A1 Clay fraction mineralogy: 7A2 X-ray c/	d/ Mineralogy <2 mm soil Pct.
	meq/100g														
0-12	1.4	0.8	0.1	0.3	2.6	18.6	34.7	13.0	21.2	3.7	1.1	12	20		Am3
12-23	1.2	0.5	0.1	0.3	2.1	31.9	51.8	18.8	34.0	2.9	0.8	6	11		
23-32	0.5	0.3	0.1	0.2	1.1	25.7	14.3	15.7	26.8	1.4	0.3	4	7	MI1	Am9
32-43	1.4	0.4	0.2	0.2	2.2	23.1	11.4	13.5	25.3	2.4	0.2	9	16		
43-55	1.5	0.4	0.1	0.1	2.1	11.2	6.1	6.7	13.3	2.2	0.1	16	31	MI1	Am7

Depth (cm)	D.-C. 6C2b Fe	ext. 6G7a Al	Na-pyroph. extractable: 6C5a Fe	6G5a Al	$(NH_4)_2$-Ox. extractable: 6C6a Fe	6G6a Al	NaPyr. Fe+Al / D.-C. Fe+Al	NaPyr. Fe+Al / clay
	Pct.							
0-12	0.9	0.4	0.4	0.3	0.6	0.4	0.54	0.18
12-23	1.7							
23-32	1.8	0.9	0.6	0.5	1.7	1.8	0.41	0.15
32-43	1.8							
43-55	1.3	0.4	0.2	0.2	1.2	1.0	0.24	0.13

a/ 11.3 kg of organic carbon per square meter to a depth of 1 meter.

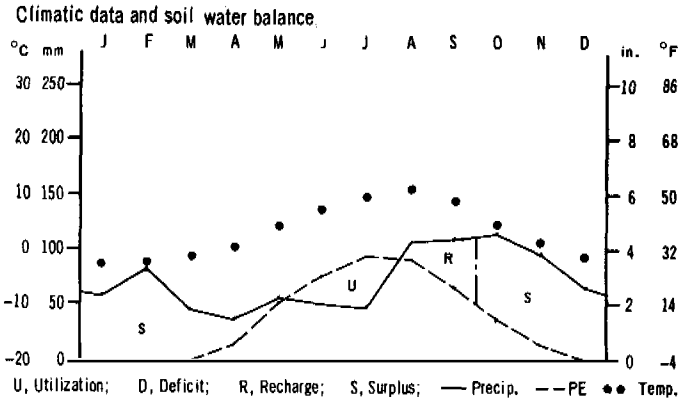
b/ Mineral code:
MI = mica
Am = allophane

c/ Approximate weight fraction (X-ray):
1 = less than one-twentieth

d/ Rehydration after heating to 300° C. (Birrell, K. W. and M. Fieldes, Amorphous Constituents. In Soils of New Zealand Part 2).

Pedon 71

Classification: Typic Cryandept, thixotropic.
Location: Alaska Peninsula. About 457 m east of Meshik Lake. Approximate longitude 157°54' W., latitude 56°48' N.
Physiographic position: Upland, glacial moraine.
Topography: 46 percent southwest-facing slope.
Drainage: Well drained.
Vegetation: Grasses, forbs, shrubs, alder.
Parent material: Volcanic ash over basaltic till.
Sampled by: K. W. Flach and Sam Rieger, August 1, 1967.
Remarks: The soil does not disperse well, hence the field estimates of texture are given in the profile description.
Soil No.: S67Ak-56-2.



Colors are for the dry soil unless otherwise indicated.

O1 8-0 cm (3-0 in.). Very dark brown (10YR 2/2) moist partially decomposed organic materials; silt admixture; many roots; abrupt smooth boundary.

A11 0-12 cm (0-5 in.). Dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak very fine granular structure; very friable (moist); many roots; abrupt wavy boundary.

A12 12-23 cm (5-9 in.). Dark brown (10YR 4/3) silt loam, dark brown (7.5YR 3/2) moist; discontinuous thin lenses of very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) fine sandy loam; very friable (moist), thixotropic (wet); roots common; abrupt wavy boundary.

A11b 23-32 cm (9-13 in.). Dark yellowish brown (10YR 4/4) very fine sandy loam, dark reddish brown (5YR 2/2) moist; thin lenses of cinders; weak very thin platy structure; thixotropic (wet); few roots; abrupt wavy boundary.

A12b 32-43 cm (13-17 in.). Yellowish brown (10YR 5/4) fine sandy loam, dark brown (7.5YR 3/2) moist; weak very fine granular structure; thixotropic (wet); few roots; abrupt wavy boundary.

IICb 43-55 cm (17-22 in.). Dark brown (10YR 4/3) cinders of coarse sand size, black (10YR 2/1) moist; pockets of material like that in A12b horizon; single grain; loose (dry); no roots.

Pedon 72

SOIL FAMILY Oxic Dystrandept, medial, isothermic

SOIL SURVEY LABORATORY - Riverside, Calif. SOIL Nos. S65Ha-4-23 LOCATION Maui County, Hawaii

Depth (cm)	Horizon	Total chemical analysis SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO_2	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.	Total	Extractable iron 6C2a Fe	Fe_2O_3	Carbonate as $CaCO_3$ 6E1b	0.5N NaOH soluble SiO_2	Al_2O_3
		Percent of whole soil																
0-20	Ap	20.1	4.5	23.5	20.7	0.63	1.35	0.73	0.09	0.69	1.11	27.0	100.4	11.4	16.3		8.52	6.71
20-41	B21	20.7	4.5	30.3	19.6	0.50	1.15	0.39	0.07	0.56	0.90	21.8	100.5	10.0	14.3		11.51	10.29
41-74	B22	21.4	3.8	31.5	20.0	0.50	1.20	0.18	0.07	0.48	0.93	20.2	100.3	9.9	14.2		11.44	10.55
74-99	B23	24.1	3.8	31.7	19.6	0.40	1.09	0.24	0.26	0.34	0.72	18.1	100.4	7.5	10.7		13.31	22.35
99-145	B3	28.0	3.7	32.8	17.2	0.34	1.31	0.05	0.15	0.28	0.55	16.1	100.5	6.0	8.6		15.71	22.88
145-165	IIC													3.6	5.1			

Depth (cm)	6A1a b/ Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	Extractable bases 5B1a 6N2a Ca	602a Mg	6P2a Na	6Q2a K	Sum of bases	Ext. acidity 6H2a	Cation exch. capacity 5A1a NH_4OAc	5a3a Sum	NH_4OAc 6L2a extr. SO_4	KCl ext. Al^{+++} 6G1D	Base saturation 5C1 NH_4OAc	5C3	pH 8C1a H_2O 1:5	8C1c KCl 1:5
				Meq./100 g.										Percent			
0-20	8.87	0.69	13	17.5	6.3	0.3	1.7	25.8		53.7		-		48		6.2	5.4
20-41	3.51	0.30	12	11.8	5.4	0.4	1.8	19.4		40.6		-		23		6.6	5.8
41-74	2.57	0.21	12	7.8	4.7	0.7	0.9	14.1		36.6		-		38		7.1	5.8
74-99	1.59	0.13	12	6.1	2.4	1.5	0.5	10.5		25.6		-		41		6.1	5.4
99-145	0.86	0.07	12	3.0	3.6	2.2	1.6	10.4		29.8		0.2		35		6.2	5.2
145-165	0.29			0.2	4.3	1.4	4.0	9.9		20.3		0.4		49		6.2	5.2

Depth (cm)	Size class and particle diameter (mm) 3A1 Sand (2-0.05)	Silt (0.5-0.002)	Clay (<.002)	Coarse fragments >2mm pct. of whole soil	Atterberg limits Plastic limit Pct.	Liquid limit Pct.	Plastic index Pct.	c/ Bulk density 1/3-bar	Oven-dry	Field moist	Particle density	c/ Water content 1/3-bar	15-bar	Extensibility 4D1 COLEf	COLE
	Pct. of 2mm.							g/cc				Pct. of whole soil		cm/cm	
0-20					67	85	18			0.70	2.69	64.6	41.0		
20-41										0.70	2.79	67.1	49.1		
41-74					67	74	7			0.84	2.88	50.6	40.6		
74-99										0.94	2.87	51.5	38.6		
99-145											2.85	41.2	34.9		
145-165					41	51	10				2.90	38.6	28.7		

Depth (cm)	a/Mineralogical analysis, whole soil DTA 7A3	Ext. iron 6C2	Total analysis d/	Diff. solubility e/	0.5N NaOH soluble f/ Amt.
	Percent				
0-20	KK15,GI1	GE20	MI10,FE5,RE5	QZ5	Am4
20-41	KK15,GI2	GE15	MI10,FE10,RE5	QZ5	Am4
41-74	KK15,GI5	GE15	MI5,FE10,RE5	QZ3	Am4
74-99	KK20,GI5	GE10	MI5,FE15,RE5	QZ3	Am4
99-145	KK35,GI5	GE10	MI5,FE10,RE5	QZ3	Am3
145-165					

a/Analyses by the University of Hawaii.

Mineral code:

KK = kaolinites GI = gibbsite
GE = goethite MI = mica
QZ = quartz FE = magnetite
RE = anatase Am = allophane

Numbers following mineral code are percent by weight except for the code Am.

b/28.4 kg of organic carbon per square meter to a depth of 1 meter.

c/Analyses by the Hawaii Sugar Planters Association.

d/All extractable Fe was allocated to goethite, remaining total iron to magnetite. Ti was allocated to anatase, K to mica.

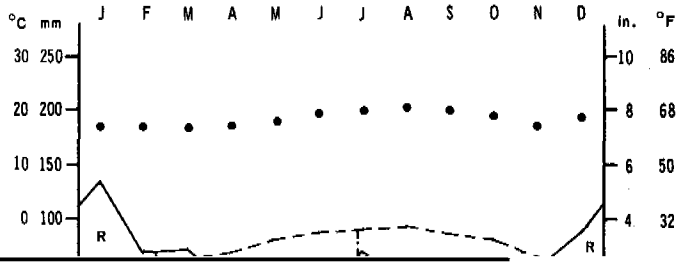
e/Differential solubility (Jackson, M. L., 1956), Soil chemical analysis, Advanced course, published by author, University of Wisconsin, Madison.

f/Approximate weight fraction:
{Al_2O_3 extracted by 0.5N NaOH less Al_2O_3 in halloysite and gibbsite}
{SiO_2 extracted by 0.5N NaOH less SiO_2 in halloysite} · $2H_2O$.
4 = one-third to half
3 = one-fifth to one-third

Pedon 72

Classification: Oxic Dystrandept, medial, isothermic.
Location: Island of Maui, Maui County, Hawaii. Kilohana Quadrangle - 20°49'30" north latitude and 156°18'40" west longitude, 45 m north of Upper Kula Road, State Highway 377, in hospital pasture on the Haleakala Ranch 4 km southeast of Pukalani Post Office.
Physiographic position: Mountainous uplands, elevation about 705 m.
Topography: West-facing, smooth 10 percent midslope.
Drainage: Well drained; medium runoff; moderately rapid permeability.
Vegetation: Noncultivated improved pasture consisting

Climatic data and soil water balance



Pedon 73

SOIL FAMILY Typic Eutrandept, medial over cindery, isothermic

SOIL SURVEY LABORATORY - Riverside, Calif. SOIL Nos. S65Ha-4-22 LOCATION Maui County, Hawaii

Depth (cm)	Horizon	a/ Total chemical analysis												Extractable iron 6C2a		Carbonate as $CaCO_3$ 6E1b	0.5N NaOH soluble	
		SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO_2	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.	Total	Fe	Fe_2O_3		SiO_2	Al_2O_3
		Percent of whole soil																
0-23	Ap	29.3	4.1	20.9	17.9	0.32	4.68	2.53	0.47	0.06	0.75	19.1	100.1	8.7	12.4		11.54	8.05
23-41	A12	29.8	4.3	21.6	19.3	0.33	4.77	2.48	0.46	0.40	0.71	16.9	101.0	10.6	15.2		12.71	8.64
41-63	B2	29.6	4.6	22.5	19.9	0.28	4.29	2.03	0.46	0.23	0.61	15.9	100.4	9.6	13.7		12.94	9.10
63-76	IIC1	41.2	4.1	16.0	15.4	0.23	7.90	7.86	1.84	0.64	0.51	5.2	100.9	2.2	3.1		11.76	4.69
76-99	IIIC2	32.0	4.7	23.0	21.0	0.23	4.94	1.47	0.33	0.13	0.27	12.6	100.7	10.6	15.2		17.01	10.19

Depth (cm)	6A1a b/ Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	Extractable bases 5B1a 6N2a Ca	602a Mg	6P2a Na	6Q2a K	Sum of bases	Ext. acidity 6H2a	Cation exch. capacity 5A1a NH_4OAc	5a3a Sum	NH_4OAc 6G2a extr. SO_4	KCl ext. Al^{+++} 6G1D	Base saturation 5C1 NH_4OAc	5C3	pH 8C1a H_2O 1:1	8C1c KCl 1:1
				Meq./100 g.										Percent			
0-23	5.81	0.46	13	35.8	11.7	0.4	6.1	54.0		61.1		-		88		6.7	5.8
23-41	2.55	0.21	12	55.5	22.3	1.7	4.2	83.7		65.5		-		100		7.4	6.5
41-63	2.58	0.20	13	42.7	12.3	6.0	0.3	61.3		63.1		-		97		7.4	6.4
63-76	0.42			34.9	11.7	2.2	0.9	49.7		54.3		-		92		7.8	6.4
76-99	0.79			39.9	13.7	6.0	0.2	59.8		56.7		-		100		7.5	6.5

Depth (cm)	Size class and particle diameter (mm) 3A1 Sand (2-0.05)	Silt (0.5-0.002)	Clay (<.002)	Coarse fragments >2mm pct. of whole soil	Ratios to clay 8D1 CEC NH_4OAc	Ext. iron	15-bar water	c/ Bulk density 1/3-bar	Oven-dry	Field moist	Particle density	c/ Water content 1/3-bar	15-bar	Extensibility 4D1 COLEf	COLE
	Pct. of 2mm.							g/cc				Pct. of whole soil		cm/cm	
0-23	27.3	49.0	23.7		2.58	0.37	1.49			0.874	2.773	49.9	35.2		
23-41	21.6	62.2	16.2		4.04	0.65	2.35			0.834	2.875	50.0	38.1		
41-63	24.2	61.9	13.9		4.54	0.69	3.11			0.756	3.045	55.7	43.2		
63-76	88.1	10.2	1.7		31.94	1.29	8.29			0.778	2.540	17.7	14.1		
76-99	27.2	54.1	18.7		3.03	0.57	2.74			0.764	2.974	58.0	51.3		

Depth (cm)	a/ Mineralogical analysis, whole soil DTA 7A3	Ext. iron 6C2	Total analysis d/	0.5 N NaOH soluble Amt e/
	Percent			
0-23	KK20	GE15	MI10,FE10,RE5	Am4
23-41	KK20	GE15	MI 5,FE 5,RE5	Am4
41-63	KK20	GE15	MI 5,FE10,RE5	Am4
63-76	KK 5, GI1	GE 5	MI10,FE20,RE5	Am5
76-99	KK20	GE15	MI 2,FE10,RE5	Am4

a/ Analyses by the University of Hawaii.

Mineral code: KK = kaolinites, GI = gibbsite, GE = goethite, MI = mica, FE = magnetite, RE = anatase, Am = allophane

Numbers following mineral code are percent by weight except for the code Am.

b/ 21.6 kg of organic carbon per square meter to a depth of 1 meter.

c/ Analyses by the Hawaii Sugar Planters Association.

d/ All extractable Fe was allocated to goethite, remaining total iron to magnetite. Ti was allocated to anatase, K to mica.

e/ Approximate weight fraction:

{Al_2O_3 extracted by 0.5N NaOH less Al_2O_3 in halloysite and gibbsite}·{SiO_2 extracted by 0.5N NaOH less SiO_2 in halloysite} · $2H_2O$

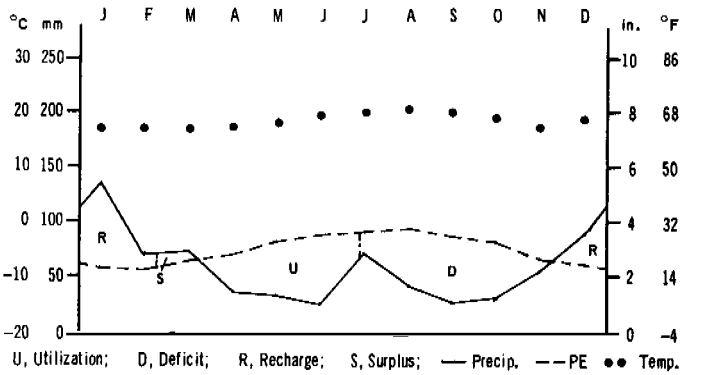
5 = more than half

4 = one-third to half

Pedon 73

Classification: Typic Eutrandept, medial over cindery, isothermic.
Location: Island of Maui, Maui County, Hawaii. Makena Quadrangle, 20°40'00" north latitude and 156°24'10" west longitude. 15 m east of State Highway 37 and 165 m south of Makena Road and State Highway 37 intersection in the northwest corner of pasture number 5 on the Ulupalakua Ranch 7.4 km from Kula.
Physiographic position: Midslope of mountainous upland, 550 m elevation.
Topography: 12 percent west-facing slope.
Drainage: Well drained; medium runoff; moderate permeability.
Vegetation: Burclover (Medicago hispida), kikuyugrass (Pennisetum clandestinum), plantain (Plantago lanceolata), rattailgrass (Sporobolus capensis), and white clover (Trifolium repens).
Parent material: Volcanic ash over cinders.
Sampled by: K. Flach, L. Swindale, L. Giese, F. Stephens, and G. Yamamoto, April 13, 1965.
Remarks: The soil does not disperse well, hence the field estimates of texture are given in the profile description.
Soil No.: S65Ha-4-22.

Climatic data and soil water balance



Colors are for moist soil.

Ap 0-23 cm (0-9 in.). Dark brown (7.5YR 3/2) silt loam; moderate fine and very fine granular structure; slightly hard (dry), very friable (moist), slightly sticky and slightly plastic (wet); abundant roots; many pores; clear smooth boundary.

A12 23-41 cm (9-16 in.). Dark brown (7.5YR 3/2) loam; moderate fine and very fine subangular blocky structure; slightly hard (dry), very friable (moist), slightly sticky and slightly plastic (wet); abundant roots; many fine and very fine pores; gradual wavy boundary.

B2 41-63 cm (16-25 in.). Dark reddish brown (5YR 3/4) silty clay loam; weak medium and coarse prismatic structure; slightly hard (dry), very friable (moist), sticky and plastic (wet); abundant roots; many pores, worm casts and channels; abrupt wavy boundary.

IIC1 63-76 cm (25-30 in.). Black cinders (1 to 10 mm); single grain; extremely hard and loose (dry); few roots; cinder layers occur intermittently; abrupt smooth boundary.

IIIC2 76-99 cm (30-39 in.). Dark brown (7.5YR 3/2) loam; massive; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); few roots; many hard earthy lumps; abrupt wavy boundary.

IIIC3 99 cm (39 in.). Black cinders (1 to 10 mm); single grain; extremely hard and loose (dry); 10 to 20 percent cobble and stone-sized Aa lava by volume.

Pedon 74

SOIL FAMILY Typic Hydrandept, thixotropic, isothermic

SOIL SURVEY LABORATORY - Riverside, Calif. SOIL Nos. S62Ha-1-1 LOCATION Hawaii County, Hawaii

Depth (cm)	Horizon	a/ Total chemical analysis SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO_2	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.	Total	Extractable iron 6C1a Fe	Fe_2O_3	Carbonate as $CaCO_3$ 6E1b	0.5N NaOH soluble SiO_2	Al_2O_3
		Percent of whole soil																
0-18	Ap	13.1	4.6	17.5	23.1	0.22	0.20	0.17	1.11	0.71	0.90	39.0	100.6	14.0	20.0		1.33	2.47
18-36	B21	12.2	4.6	20.6	24.3	0.20	0.24	0.08	0.05	0.70	0.64	36.1	99.7	14.4	20.6		1.11	3.14
36-51	B22	11.9	4.4	24.6	19.5	0.16	0.29	-	0.03	0.46	0.86	37.3	99.5	11.5	16.4		3.61	7.52
51-63	B23	10.5	4.8	24.0	21.4	0.18	0.27	-	tr.	0.38	0.96	36.8	99.3	12.3	17.6		3.93	7.83
63-71	B24	10.9	4.4	24.4	20.6	0.21	0.09	-	-	0.35	0.96	37.1	99.0	11.6	16.6		4.33	8.50
71-81	B25	12.2	3.9	30.7	16.6	0.19	0.19	-	-	0.26	0.10	36.7	100.8	9.0	12.9		7.74	13.17
81-86	IIB26	11.0	4.5	31.2	19.6	0.19	0.22	-	-	0.14	0.08	33.5	100.4	12.2	17.4		8.65	13.95
99-115	IVB28	10.2	5.4	23.9	26.9	0.10	0.20	-	-	0.41	0.07	32.7	99.9	16.6	23.7		2.27	5.42
150-165	VIIB211	13.1	4.6	22.8	29.7	0.05	tr.	-	0.10	0.72	0.05	30.2	101.3	18.8	26.9		1.22	2.77

Depth (cm)	6A1a b/ Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	Extractable bases 5B1a 6N2a Ca	6O2a Mg	6P2a Na	6Q2a K	Sum of bases	Ext. acidity 6H2a	Cation exch. capacity 5A1a NH_4OAc	5a3a Sum	NH_4OAc 6L1a extr. SO_4	KCl ext. Al^{+++} 6G1D	Base saturation 5C1 NH_4OAc	5C3	pH 8C1a H_2O 1:5	8C1c KCl 1:5
				Meq./100 g.										Percent			
0-18	[illegible]0	0.90	13	9.4	2.6	0.3	0.5	12.8		53.1		1.1	0.5	24		5.4	4.5
18-36	[illegible].55	0.45	15	0.8	0.3	0.2	0.2	1.5		33.7		3.1	0.6	4		5.2	4.5
36-51	9.36	0.44	21	0.5	0.3	0.2	0.1	1.1		39.3		3.2	0.3	3		5.4	4.7
51-63	8.49	0.43	20	-	0.1	0.2	0.1	0.4		29.9		6.8	0.2	1		5.4	5.0
63-71	7.80	0.39	20	-	1.2	0.1	0.2	1.5		25.3		10.2	0.1	6		5.5	5.2
71-81	7.01	0.35	20	-	0.6	0.1	0.1	0.8		24.3		13.5	tr.	3		5.6	5.4
81-86	5.14	0.21	24	-	0.4	0.2	0.1	0.7		23.0		21.0		3		5.7	5.6
99-115	4.92	0.29	17	-	0.7	0.1	0.2	1.0		21.2		24.2	tr.	5		5.5	5.3
150-165	3.33	0.31	11	-	0.6	0.2	0.2	1.0		14.4		32.6	tr.	7		5.2	5.1

Depth (cm)	Size class and particle diameter (mm) 3A1 Sand (2-0.05)	Silt (0.5-0.002)	Clay (<.002)	Coarse fragments >2mm pct. of whole soil	Atterberg limits Plastic limit	Liquid limit	Plastic index	c/ Bulk density 1/3-bar	Oven-dry	Field moist	Particle density	c/ Water content Field moist	1/3-bar	15-bar	Extensibility 4D1 COLEf	COLE
	Pct. of 2mm.							g/cc				Pct. of whole soil			cm/cm	
0-18				-						0.51	2.506	122.9	133.4	101.9		
18-36				-						0.33	2.676	209.1	191.6	154.5		
36-51				-						0.30	2.614	220.1	212.0	166.9		
51-63				-						0.30	2.707	226.9	229.3	196.0		
63-71				-						0.27	2.693	253.7	244.8	193.9		
71-81				-						0.30	2.603	237.1	232.0	187.5		
81-86				-						0.27	2.727	262.4	200.3	165.8		
99-115				-						0.24	2.771	304.1	267.5	211.1		
150-165				-							2.874		263.8	199.6		

Depth (cm)	a/Mineralogical analysis, whole soil DTA 7A3	Extr. iron 6C2	Total analysis d/	0.5 N NaOH soluble Amt. e/
	Percent			
0-18	KK5, GI2	GE20	MI10,FE5,RE5	Am4
18-36	KK3, GI3	GE20	MI10,FE5,RE5	Am4
36-51	KK2, GI2	GE20	MI 5,FE5,RE5	Am5
51-63	KK2, GI1	GE20	MI 5,FE5,RE5	Am5
63-71	KK2, GI2	GE20	MI 5,FE5,RE5	Am5
71-81	GI1	GE15	MI 4,FE5,RE5	Am5
81-86	GI1	GE20	MI 2,FE3,RE5	Am5
99-115	KK2, GI5	GE25	MI 1,FE5,RE5	Am5
150-165	KK1, GI5	GE30	MI10,FE5,RE5	Am4

a/ Analyses by the University of Hawaii.

Mineral code: KK = kaolinites, GI = gibbsite, GE = goethite, MI = mica, FE = magnetite, RE = anatase, Am = allophane

Numbers following mineral code are percent by weight except for the code Am.

b/ 26.5 kg of organic carbon per square meter to a depth of 1 meter.

c/ Analyses by the Hawaii Sugar Planters Association.

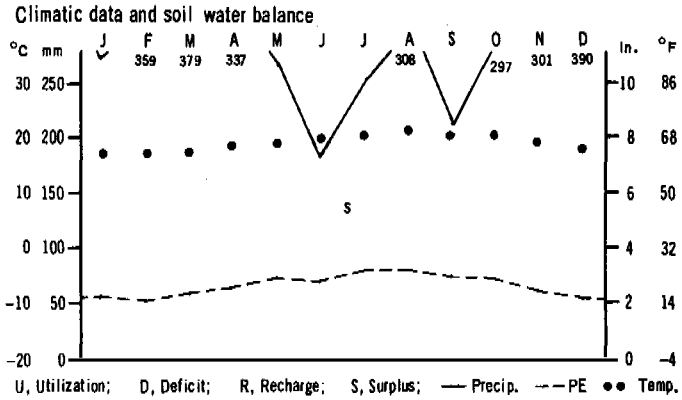
d/ All extractable Fe was allocated to goethite, remaining total iron to magnetite. Ti was allocated to anatase, K to mica.

e/ Approximate weight fraction:
{Al_2O_3 extracted by 0.5N NaOH less Al_2O_3 in halloysite and gibbsite}·
{SiO_2 extracted by 0.5N NaOH less SiO_2 in halloysite} · $2H_2O$

5 = more than half
4 = one-third to half

Pedon 74

Classification: Typic Hydrandept, thixotropic, isothermic.
Location: Island of Hawaii, Hawaii County, Hawaii. Southeast 3.2 km on Highway 19 from junction of Highway 19 and Highway 240 to Paauhau Sugar Plantation road, then south to airstrip, then right for 0.16 km, then left (uphill) to cane field boundary, and then 45 m south from cane field boundary into the pasture.
Physiographic position: Mauna Kea Mountain, 660 m elevation.
Topography: Rolling to hilly, windward slope.
Drainage: Well drained; slow runoff; moderately rapid permeability.
Vegetation: Pangola (Digitaria decumbens), glenwoodgrass (Sacciolepsis contracta), kikuyu (Pennisetum clandestinum), joee (Stachytarpheta cayannensis), hilograss (Paspalum conjugatum), guava (Psidium guayava), ohia (Metrosideros collina), amaumau fern (Sadleria cyatheoides), and tree fern (Cibotium sp.).
Parent material: Volcanic ash.
Sampled by: W. Ikeda and H. Sato, 1962.
Remarks: All horizons harden irreversibly upon drying into silt, sand and gravel size aggregates.
Soil No. S62-Ha-1-1.



Colors are for moist soil.

Ap 0-18 cm (0-7 in.). Dark brown (7.5YR 3/2) silty clay loam; strong medium and fine granular structure; friable (moist), sticky and plastic (wet); many roots; many pores; abrupt wavy boundary.

B21 18-36 cm (7-14 in.). Dark brown (7.5YR 3/4) silty clay loam; moderate medium fine and very fine subangular blocky structure; friable (moist), sticky and thixotropic (wet); many roots; common medium and many fine and very fine pores; few patches of dull smooth coatings on ped surfaces; abrupt smooth boundary.

B22 36-51 cm (14-20 in.). Dark brown (10YR 3/3) silty clay loam; moderate medium, fine and very fine subangular blocky structure; friable (moist), sticky and thixotropic (wet); many roots; common medium and many fine and very fine pores; few patches of dull smooth coatings on ped surfaces; abrupt smooth boundary.

B23 51-63 cm (20-25 in.). Dark brown (10YR 3/3) silty clay loam; strong coarse and medium breaking to strong fine and very fine subangular blocks; friable (moist), sticky and thixotropic (wet); many roots; many fine and very fine pores; few to common patches of dull smooth coatings on ped surfaces; abrupt smooth boundary.

B24 63-71 cm (25-28 in.). Dark brown (7.5YR 3/3) silty clay loam; strong coarse and medium breaking to strong fine and very fine subangular blocks; friable (moist), sticky and thixotropic (wet); many roots; few coarse and medium and many fine and very fine pores; few to common patches of dull smooth coatings on ped surfaces; abrupt wavy boundary.

B25 71-81 cm (28-32 in.). Very dark grayish brown (10YR 3/2) silty clay loam; strong coarse and medium breaking to strong fine and very fine subangular blocks; friable (moist) (some peds are firm), sticky and thixotropic (wet); many roots; few coarse and medium and many fine and very fine pores; common patches of dull smooth coatings on ped surfaces; abrupt wavy boundary.

IIB26 81-86 cm (32-34 in.). Dark reddish brown (2.5YR 3/4) silty clay loam; strong medium, fine and very fine subangular blocky structure; slightly sticky and thixotropic (wet); many roots; common coarse and medium and many fine and very fine pores; common firm and very firm rock-like volcanic ash fragments; ped surfaces have translucent gelatinous appearance; abrupt smooth boundary.

IIIB27 86-99 cm (34-39 in.). Dark brown (10YR 3/3) silty clay loam; moderate medium and fine prisms breaking to strong (few pockets of moderate) fine and very fine subangular blocks; friable (moist), sticky and thixotropic (wet); many fine roots; many fine and very fine pores; common patches of dull smooth coatings on ped surfaces; abrupt smooth boundary.

IVB28 99-115 cm (39-45 in.). Dark brown (7.5YR 3/4) and yellowish red (5YR 3/6) silty clay loam; moderate medium and fine prisms breaking to strong fine and very fine subangular blocks; friable (moist), sticky and thixotropic (wet), many roots; common medium and many fine and very fine pores; ped surfaces have translucent gelatinous appearance; abrupt smooth boundary.

VB29 115-140 cm (45-56 in.). Dark brown (10YR 3/3) silty clay loam; moderate medium and fine prisms breaking to strong and very fine subangular blocks; friable (moist) (some peds are firm), sticky and thixotropic (wet); common fine roots; common medium and many fine and very fine pores; common patches of dull smooth coatings on ped surfaces; abrupt wavy boundary.

VIB210 140-150 cm (56-59 in.). Dark brown (7.5YR 3/4) silty clay loam; moderate medium and fine prisms breaking to strong fine and very fine subangular blocks; friable (moist), sticky and thixotropic (wet); common fine roots; ped surfaces have translucent gelatinous appearance; abrupt smooth boundary.

VIIB211 150-165 cm (59-65 in.). Yellowish red (5YR 4/6) silty clay loam; a thin 2.5-5 cm (1-2 in.) thick dark yellowish brown (10YR 4/4) layer with few to common, fine prominent white mottles occurs at the upper boundary; strong medium and fine prisms breaking to strong fine and very fine subangular blocks; friable (moist) (some peds are firm), sticky and thixotropic (wet); common fine roots; common very fine pores; ped surfaces have translucent gelatinous appearance.

Pedon 75

SOIL FAMILY Typic Vitrandept, medial, isomesic

SOIL SURVEY LABORATORY - Riverside, Calif. SOIL Nos. S65Ha-1-13 LOCATION Hawaii County, Hawaii

Depth (cm)	Horizon	Mineralogical analysis: Allophane	Montmorillonite	Illite	Halloysite	Gibbsite	Boehmite	Goethite	Amorphous SiO_2	Amorphous Al_2O_3	Magnetite etc.	Anatase	Quartz	Volcanic glass	Feldspar	Olivine	Pyroxene	Pyrite
		Percent of whole soil																
0-10	A1																	
10-20	B2																	
20-41	IIC																	
41-66	IIIAb																	
66-88	IIIB2b																	

Depth (cm)	Horizon	a/ Total chemical analysis: SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO_2	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.	Total	Extractable iron 6C2a: Fe	Fe_2O_3	Carbonate as $CaCO_3$ 6E1b	0.5N NaOH soluble: SiO_2	Al_2O_3
		Percent of Whole Soil																
0-10	A1													4.6	6.6			
10-20	B2													6.9	9.9			
20-41	IIC													2.3	3.3			
41-66	IIIAb													6.0	8.6			
66-88	IIIB2b													5.7	8.2			

Depth (cm)	6A1a b/ Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	Extractable bases 5B1a: 6N2a Ca	602a Mg	6P2a Na	6Q2a K	Sum of bases	Ext. acidity 6H2a	Cation exch. capacity: 5A1a NH_4OAc	5a3a Sum	NH_4OAc 6L2a extr. SO_4	KCl ext. Al^{+++} 6G1D	Base saturation: 5C1 NH_4OAc	5C3	pH: 8C1a H_2O 1:5	8C1c KCl 1:5
				Meq./100 g.										Percent			
0-10	5.27	0.410	13	7.5	1.9	0.2	1.3	10.9		27.5		-		40		6.6	5.5
10-20	2.12	0.212	10	1.7	0.3	0.1	0.3	2.4		18.6		-		13		6.5	5.6
20-41	0.46	0.070	7	10.4	1.6	0.4	1.8	14.2		15.8		-		90		6.9	6.2
41-66	3.52	0.436	8	15.7	2.0	0.3	0.8	18.8		25.7		-		73		6.9	6.0
66-88	3.12	0.360	9	12.9	1.5	0.2	0.5	15.1		24.4		-		62		6.8	5.9

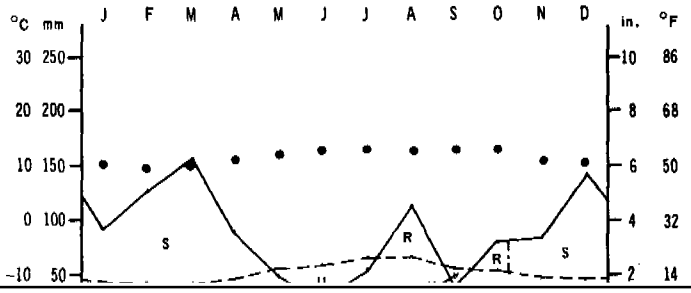
Depth (cm)	Size class and particle diameter (mm) 3A1: Sand (2-0.05)	Silt (0.5-0.002)	Clay (<.002)	Coarse fragments >2mm pct. of whole soil	c/ Atterberg limits: Plastic limit Pct.	Liquid limit Pct.	Plastic index Pct.	d/ Bulk density: 1/3-bar	Oven-dry	Field moist	Particle density d/	d/ Water content: 1/3-bar clod	1/3-bar	15-bar	Extensibility 4D1: COLEf	COLE
	Pct. of 2mm.							g/cc				Pct. of whole soil			cm/cm	
0-10					N.P.	N.P.	N.P.	0.78	0.86		2.718	62.0	40.9	19.4	0.030	0.030
10-20								0.75	0.74		2.896	54.3	47.0	23.7	0.006	0.006
20-41											2.634		14.5	7.8		
41-66					N.P.	N.P.	N.P.	0.71	0.66		2.763	58.2	48.6	19.8	0.024	0.024
66-88								0.81	0.77		2.773	47.6	49.9	22.3	0.016	0.016

a/ Analyses by the University of Hawaii.
b/ 18.4 kg of organic carbon per square meter to a depth of 1 meter.
c/ These samples were not allowed to dry prior to analysis.
d/ Analyses by the Hawaii Sugar Planters Association.

Pedon 75

Classification: Typic Vitrandept, medial, isomesic.
Location: Island of Hawaii, Hawaii County, Hawaii. Umikoa Quadrangle, 19°54'30" N. latitude and 155°23'30" E. longitude. 50 m below Puu Kihe on Kukaiau Ranch.
Physiographic position: Windward slopes of Mauna Kea, 2,190 m elevation.
Topography: Convex slope, gradient 12 percent.
Drainage: Well drained; slow runoff; rapid permeability.
Vegetation: Mamani (Sophora chrysophylla), sweet vernal (Anthoxanthum odoratum), heu pueo (Trisetum glomeratum), and plantain (Plantago lanceolata).
Parent material: Volcanic ash and cinders.
Sampled by: H. Sato, K. Flach, and R. Smythe, April 9, 1965.

Climatic data and soil water balance



U, Utilization; D, Deficit; R, Recharge; S, Surplus; — Precip. - - PE •• Temp.

analysis was not made. Only field estimates of texture are given in the profile description.
Soil No.: S65Ha-1-13.

Colors are for the moist soil.

A1 0-10 cm (0-4 in.). Dark brown (7.5YR 3/3) very fine sandy loam; weak fine granular structure; loose (dry), friable (moist), nonsticky and nonplastic (wet); abundant roots; many fine pores; abrupt smooth boundary.

B2 10-20 cm (4-8 in.). Yellowish red (5YR 4/6) very fine sandy loam; massive; friable (moist), nonsticky and nonplastic (wet); few roots; many fine pores; 5 to 10 percent by volume of gravel 20 mm diameter or larger; abrupt smooth boundary.

IIC 20-41 cm (8-16 in.). Black (5YR 2/1) cinders; single grain; loose (moist), nonsticky and nonplastic (wet); few roots; abrupt wavy boundary.

IIIAb 41-66 cm (16-26 in.). Dark reddish brown (5YR 2/2) very fine sandy loam; massive; friable (moist), nonsticky and nonplastic (wet); few roots; about 50 percent by volume of gravel, cobbles, and stones larger than 20 mm diameter; abrupt smooth boundary.

IIIB2b 66-88 cm (26-35 in.). Dark brown (7.5YR 3/2) very fine sandy loam; massive; friable (moist), nonsticky and nonplastic

Pedon 76

SOIL Mollic Andaquept SOIL Nos. S67Oreg-18-13 LOCATION Klamath County, Oregon

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 67514 - 67518

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	Silt: 2-0.1			a/ Coarse fragments 1A2a > 2 Pct. of whole soil	2-19 (Pct. of <76mm)	19-76 (Pct. of <76mm)
		Pct. of <2 mm																
0-4	A11	55.5	28.5	16.0	3.5	15.6	12.3	17.7	6.4	6.6	21.9	21.1	49.1			-	-	-
4-13	A12	57.9	28.0	14.1	4.9	14.7	12.8	18.8	6.7	6.4	21.6	22.2	51.2			9	9	-
13-23	A13	65.5	23.8	10.7	3.9	15.1	15.3	23.4	7.8	6.5	17.3	25.6	57.7			9	9	-
23-38	AC	72.9	19.6	7.5	6.3	18.6	16.8	24.1	7.1	6.2	13.4	24.4	65.8			11	11	-
38-64	C	86.2	10.3	3.5	7.2	23.7	21.5	28.1	5.7	4.3	6.0	20.7	80.5			34	11	23

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N	6C2b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	Carbonate: 3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	Bulk density: 4A1h Oven-dry g/cc	Bulk density: g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	Water content: 4B2 15-bar Pct.	Water content: 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	pH: 8C1a H_2O 1:1	pH: 8C1c 1N KCl 1:1
0-4	7.71	0.520	15	0.4	-		0.59	0.76		1.00	90.9	27.0		0.086	0.086	7.2		6.5
4-13	2.60	0.208	13	0.4	-		1.13	1.19		1.00	39.7	13.0		0.019	0.019	6.8		6.1
13-23	0.88	0.072	12	0.5	-		1.20	1.24		1.00	34.5	8.8		0.013	0.013	6.5		5.6
23-38	0.34			0.5	-		1.32	1.35		1.00	23.5	6.6		0.006	0.006	6.5		5.4
38-64	0.16			0.4	-		1.33	1.34		1.00	22.7	3.3		0.003	0.003	6.7		5.4

Depth (cm)	Extractable bases: 6N4a Ca 5B3a	Extractable bases: 6O2c Mg 5B3a	Extractable bases: 6P2a Na 5B4a	Extractable bases: 6Q2a K 5B4a	6H2a Ext. acidity	5A6a CEC NH_4OAc	5D2 Exchangeable sodium	5E Sodium adsorption ratio	8A Water at saturation	Water extract from saturated paste 8A1: 6N1b Ca	6O1b Mg	6P1a Na	6Q1a K	6H1a CO_3	6J1a HCO_3	6K1a Cl	6L1b SO_4	8A1a Electrical conductivity
	meq/100 g						Pct.		Pct.	meq/liter								mmho/cm
0-4	9.7	6.1	3.1	0.4	4.1	29.4	4	9	104.7	4.3	4.3	19.0	0.6	-	24.4	4.3	0.9	2.34
4-13	6.8	5.0	2.0	0.2	2.9	19.1	8	6	64.7	1.8	1.8	8.4	tr.	-	5.2	1.9	0.6	1.26
13-23	4.9	4.4	0.7	0.1	2.6	13.1												
23-38	3.9	2.9	0.5	0.1	1.8	10.8												
38-64	1.8	1.3	0.2	0.1	1.4	5.2												

Depth (cm)	Ratios to clay 8D1: CEC NH_4OAc	Ratios to clay: Ext. iron	Ratios to clay: 15 bar water	Clay fraction mineralogy 3A1 c/ 7A2 X-ray d/	Very fine sand fraction mineralogy c/ Pct. of grains
0-4	1.84	0.03	1.69		GS50, OW50
4-13	1.35	0.03	0.92	MT2	GS24, GW45, OW31
13-23	1.22	0.05	0.82		GS40, GW14, OW46
23-38	1.44	0.07	0.88		GS39, GW18, OW43
38-64	1.49	0.11	0.94		

a/ Porous gravel. 1/3 bar H_2O, Db, COLEf, and Cm not corrected for gravel.

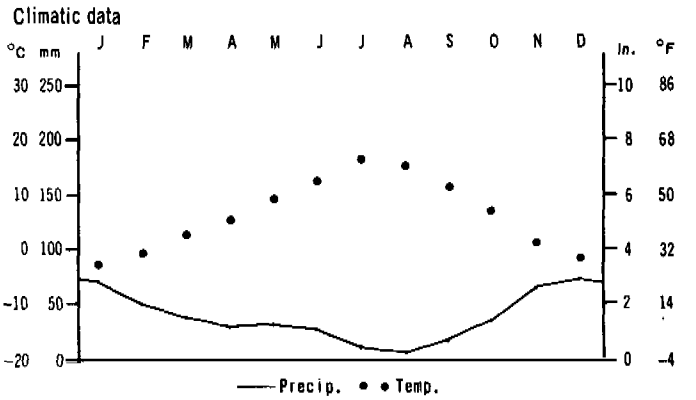
b/ 6.7 kg of organic carbon per square meter to a depth of 1 meter.

c/ Mineral code:
MT = montmorillonite
GS = volcanic glass
GW = weathered glass
OW = among others: plagioclase, orthoclase, hypersthene, augite, hornblende

d/ Approximate weight fraction (X-ray):
2 = one-twentieth to one-fifth

Pedon 76

Classification: Mollic Andaquept, cindery, nonacid, frigid.
Location: Klamath County, Oreg. About 0.4 km west of Fort Klamath. 533 m west and 61 m south of the NE corner of sec. 21, T. 33 S., R. 7½ E.
Physiographic position: Bottomland, 638 m elevation.
Topography: Nearly level with less than 1 percent slope.
Drainage: Poorly drained; slow to very slow runoff and internal drainage; rapid to very rapid permeability.
Vegetation: Irrigated alsike clover (Trifolium hybridum) and bluegrass (Poa sp.)
Parent material: Water redeposited pumice, ash and gravel.
Sampled by: K. W. Flach, J. P. Tribe, D. R. Taylor, G. L. Simonson, J. S. Cahoon, A. O. Ness, September 15, 1967.
Remarks: A water table occurs at 30 to 60 cm most of the year. It was at 63.5 cm when the soil was sampled. The soil does not disperse well, hence field estimates of texture are given in the profile description.
Soil No.: S67Oreg-18-13.



Colors are for the moist soil unless otherwise indicated.

A11 0-4 cm (0-1½ in.). Very dark gray and dark brown (10YR 3/1, 3/3) root mat mixed with loamy mineral material, gray (N 5/) dry; massive; soft (dry), firm (moist), nonsticky and nonplastic (wet); abrupt smooth boundary.

A12 4-13 cm (1½-5 in.). Black (10YR 2/1) loam, gray (N 5/) dry; weak thin plates breaking to weak very fine granules; friable (moist), slightly sticky and slightly plastic (wet); plentiful very fine roots; common very fine tubular pores; 4 percent pumice pebbles by volume; clear smooth boundary.

A13 13-23 cm (5-9 in.). Black (10YR 2/1) loam, gray (2.5Y 5/1) dry; weak medium subangular blocks breaking to weak very fine granules; friable (moist), slightly sticky and slightly plastic (wet); plentiful very fine roots; common very fine tubular pores; 4 percent pumice pebbles by volume; gradual smooth boundary.

AC 23-38 cm (9-15 in.). Very dark gray (10YR 3/1) sandy loam, dark gray (10YR 4/1) dry; massive; very friable (moist), slightly sticky and nonplastic (wet); many very fine interstitial pores; plentiful very fine roots; 6 percent pumice pebbles by volume; gradual smooth boundary.

C 38-64 cm (15-25 in.). Very dark gray (10YR 3/1) and dark grayish brown (10YR 4/2) gravelly loamy sand; massive; very friable (moist), nonsticky and nonplastic (wet); very few very fine roots; 21 percent porous gravel by volume.

SOIL Pedon 77 Typic Fragiaquept SOIL Nos. S62NH-1-1 LOCATION Belknap County, New Hampshire

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos.

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 > 2 <76 Pct.	2-19 (Pct. of < 76mm)	19-76 (Pct. of < 76mm)
		Pct. of < 2 mm																
0-15	Ap	54.7	34.9	10.4	3.3	10.4	9.8	17.2	14.0	18.1	16.8	41.9	40.7		0.89	4		
15-36	A21g	65.2	27.1	7.7	6.6	13.0	11.3	19.4	14.9	15.5	11.6	41.3	50.3		0.72	28		
36-79	A22g	68.9	24.8	6.3	8.8	13.9	11.1	20.4	14.7	12.1	12.7	37.8	54.2		0.82	12		
36-56	B21	63.2	24.3	12.5	5.3	11.4	10.8	20.7	15.0	11.4	12.9	38.1	48.2		0.84	9		
56-99	B22x	58.4	27.9	13.7	4.3	9.9	9.1	20.2	14.9	12.7	15.2	38.8	43.5		0.85	8		
99-125	B3x	51.6	34.5	13.9	4.8	8.7	7.5	16.2	14.4	15.1	19.4	38.5	37.2		0.85	7		
125-165	Cx	47.9	39.1	13.0	3.8	7.2	6.7	15.4	14.8	17.9	21.2	42.0	33.1		0.87	5		

Depth (cm)	6A1a Organic carbon a/ Pct.	6B2a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density: g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content: Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD cm/cm	pH:	8C1c (1:1) KCl	8C1a (1:1) H_2O
0-15	3.50	0.232	15			0.7		0.96	1.14	0.05		43.2	9.6		0.29		4.0	4.7
15-36	0.10					0.6		1.74	1.74	0.00		11.0	2.3		0.11		4.0	5.1
36-79	0.06					0.6		1.92	1.91	0.00		8.8	2.4		0.10		4.2	5.3
36-56	0.11					1.3		1.87	1.88	0.00		11.5	5.1		0.10		4.1	5.2
56-99	0.02					1.2		1.90	1.92	0.00		12.5	5.8		0.11		4.2	5.3
99-125	0.07					1.0		1.90	1.92	0.00		13.7	6.2		0.12		4.2	5.4
125-165	0.07					1.1		1.88	1.90	0.00		14.3	6.4		0.13		4.2	5.5

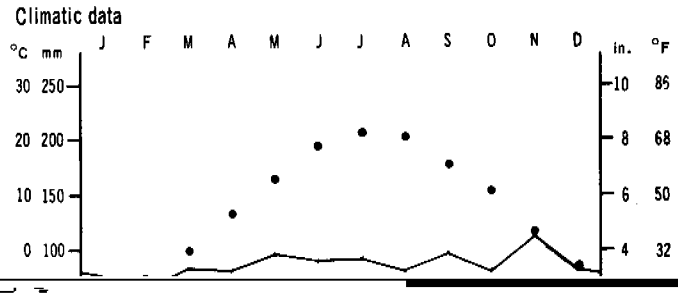
Depth (cm)	Extractable bases 5B1a: 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC: 5A3a Sum cations		6G1d Ext. Al			Ratios to clay 8D1: CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-15	2.8	0.7	0.1	0.2		13.7	17.5		1.2			1.68	0.07	0.92			22	
15-36	0.7	0.1	tr.	tr.		2.9	3.7		0.6			0.48	0.08	0.30			22	
36-79	0.5	0.2	tr.	tr.		2.1	2.8		0.2			0.44	0.09	0.38			25	
36-56	[illegible]	0.2	0.1	0.1		4.1	5.4		0.3			0.43	0.10	0.40			24	
56-99	[illegible]	0.5	0.1	0.2		4.0	6.0		0.2			0.44	0.09	0.42			33	
99-125	1.5	0.7	0.1	0.2		4.8	7.3		0.4			0.52	0.07	0.45			34	
125-165	1.7	0.8	0.1	0.2		4.7	7.5		0.3			0.58	0.08	0.49			37	

Depth				

a/ 6.2 kg/m^2 to a depth of 1.5 m (method 6A).

Pedon 77

Classification: Typic Fragiaquept, coarse-loamy, mixed, mesic.
Location: Belknap County, N. H., 2.4 km SE of Loon Pond along Route 107, and 90 m NE of Route 107.
Physiographic position: Depression in lower slope of drumlin.
Topography: 4 percent, concave single slope.
Drainage: Poorly drained.
Vegetation: Red top, (Agrostis alba); bluegrass, (Poa pratensis).
Parent material: Compact gracial till derived from schistose and granitic rock.
Sampled by: E. Pedersen, S. Ross, R. Bond, D. van der Voet, and



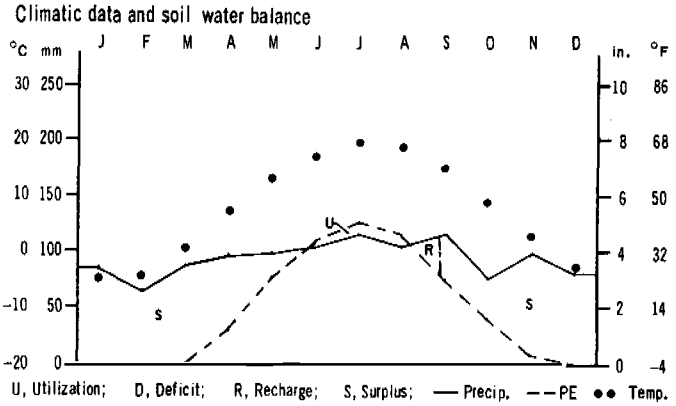
Pedon 78

SOIL Typic Eutrochrept SOIL Nos. S60Mass-2-7 LOCATION Berkshire County, Massachusetts

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 60497 - 60502

Pedon 78

Classification: Typic Eutrochrept, coarse-loamy, mixed, mesic.
Location: Berkshire County, Mass., 202 m S of Cross (Seekonk) Road, 503 m E of Old Great Barrington Road, aerial photo DPM-3K-91.
Physiographic position: Rolling uplands of the limestone valley.
Topography: 7 percent slope.
Drainage: Well drained.
Vegetation: Hay, red, clover, brome grass, and Kentucky bluegrass.
Parent material: Glacial till derived principally from Stockbridge limestone of Ordovician age and some phyllite schist.
Sampled by: E. J. Pedersen, D. D. Bohrer, F. A. Filios, S. J. Zayach, and D. C. Fuller. June 9, 1960.
Soil No.: S60Mass-2-7.



Colors are for the moist soil.

Ap 0-23 cm (0-9 in.). Very dark grayish brown (10YR 3/2) loam; moderate fine and medium granular structure; very friable (moist); many fine and medium roots; less than 5 percent coarse fragments, mainly flat schist, a few weathered limestone remnants; abrupt smooth boundary.

B21 23-38 cm (9-15 in.). Dark yellowish brown (10YR 4/4) loam; breaks out in clods that crush to weak fine and medium granules; very friable (moist); common fine roots; 5 to 10 percent coarse fragments consisting mainly of flat schist; clear wavy boundary.

B22 38-64 cm (15-25 in.). Brown to dark brown (10YR 4/3) sandy loam; breaks out in clods that crush to weak fine and medium granules; very friable (moist); common fine roots; 10 to 15 percent coarse fragments consisting mainly of flat schist; common earthworm casts and burrows; clear smooth boundary.

B3 64-81 cm (25-32 in.). Olive brown (2.5Y 4/4) sandy loam; massive or very weak thick platy structure; friable and very friable (moist); common fine roots; 10 to 15 percent coarse fragments consisting of fine gravel, flat schists, and quartzite; a few weathered limestone remnants; common earthworms and earthworm burrows and casts; clear smooth boundary.

C1 81-109 cm (32-43 in.). Olive brown (2.5Y 4/4) gravelly sandy loam with strong brown (7.5YR 5/6) limestone fragments; massive; friable and firm (moist); very few fine roots; 25 percent coarse skeleton of fine gravel, channers of schist, quartzite, and some weathered limestone remnants; very weak effervescence with cold dilute hydrochloric acid; clear smooth boundary.

C2 109-152 cm (43-60 in.). Olive gray (5Y 4/2) fine sandy loam; massive; friable (moist); 10 to 15 percent coarse fragments consisting of fine gravel and flat schist and limestone that are unweathered or only partially weathered. Weak effervescence with cold dilute hydrochloric acid, reaction occurs with individual particles.

C3 152-178 cm (60-70 in.). (Auger sample). Same as above except matrix is weakly calcareous.

Pedon 79

SOIL Typic Xerochrept SOIL Nos. S64Calif-37-1 LOCATION San Diego County, California

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 641 - 647

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	2-0.1	a/ Clay <.002	b/ Clay <.002	c/ Coarse fragments 1A2a > 2 Pct. of whole soil	2-19 (Pct. of <76mm)	19-76 (Pct. of <76mm)
		Pct. of <2 mm																
0-8	A11	72.7	17.1	10.2	19.5	21.2	9.0	14.8	8.2	8.4	8.7	24.2	64.5	11.5	9.3	19	19	0
8-23	A12	70.9	18.5	10.6	17.8	18.0	9.0	17.2	8.9	9.0	9.5	26.8	62.0	10.9	8.5	22	22	0
23-48	A13	70.3	18.2	11.5	18.2	18.4	8.9	16.0	8.8	8.4	9.8	25.8	61.5	12.2	9.3	23	23	0
48-71	B21	68.7	19.4	11.9	16.2	17.0	8.6	16.3	10.6	9.5	9.9	28.2	58.1	12.5	9.5	24	24	0
71-89	B22	70.6	18.5	10.9	19.5	18.0	8.5	16.1	8.5	8.7	9.8	26.0	62.1	12.4	8.9	28	28	0
89-110	C1	82.3	12.5	5.2	35.3	23.2	6.9	11.8	5.1	6.0	6.5	17.0	77.2	4.1	2.4	41	41	0
110-155	C2	82.9	12.5	4.6	32.5	23.9	7.8	12.9	5.8	6.0	6.5	18.1	77.1	4.5	2.7	40	40	0

Depth (cm)	6A1a Organic carbon a/ d/ Pct.	6B1a Nitrogen a/ Pct.	C/N	6C2a a/ Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	Carbonate: 3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	Bulk density: 4A1h Oven-dry g/cc	Bulk density: Est. 1/3-bar g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	Water content: 4B2 15-bar a/ Pct.	Water content: 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	pH: 8C1a H_2O 1:1	pH: 8C1c IN KCl 1:1
0-8	0.96	0.080	12	1.0			1.55	1.89		0.88	8.7	5.4		0.066	0.059	6.7	6.9	
8-23	0.56	0.055	10	0.9			1.51	1.86		0.86	9.8	4.0		0.072	0.061	6.5	6.6	
23-48	0.34			1.0			1.46	1.51		0.86	12.0	3.1		0.010	0.010	6.6	6.8	
48-71	0.28			0.9			1.43	1.52		0.85	10.1	3.7		0.021	0.017	6.6	6.7	
71-89	0.10			1.1			1.46	1.52		0.82	10.9	6.4		0.014	0.011	6.7	6.9	
89-110	0.03			0.7			1.92	1.97		0.67	6.7	4.6		0.008	0.006	7.2	7.1	
110-155	0.03			0.8					1.92			4.2				7.3	7.4	

Depth (cm)	Extractable bases a/ 5B1a: 6N2a Ca	6O2a Mg	6P2a Na	6Q2a K	6H2a a/ Ext. acidity	5A2a a/ CEC NaOAc	5D2 Exchangeable Sodium Pct.		8A Water at saturation a/ Pct.	Water extract from saturated paste 8A1: 6N1b Ca	6O1b Mg	6P1a Na b/	6Q1a K b/	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1b SO_4	8A1a Electrical conductivity mmho/cm
	meq/100g									meq/liter								
0-8	10.5	3.4	1.4	0.2	1.7	16.9	8											
8-23	10.5	2.8	0.4	0.1	2.3	18.6	2											
23-48	13.0	4.0	0.4	0.1	2.2	19.8	2											
48-71	11.1	4.0	0.4	0.1	1.8	19.1	2											
71-89	13.5	5.1	0.4	0.1	2.1	22.8	2											
89-110	9.1	3.7	0.5	tr.	1.2	14.9	3		44.4			0.7	tr.					0.08
110-155	9.0	3.7	0.7	0.2	0.8	16.2	4											

Depth (cm)	Ratios to clay 8D1: CEC NaOAc	Ext. iron	15-bar water	e/ Clay fraction mineralogy 3A1: 7A2 X-ray f/	7A3 DTA Pct.
0-8	1.47	0.10	0.47	MI5, KK3, VM1	KK 7
8-23	1.71	0.08	0.37	VR4, KK3, VM2	
23-48	1.62	0.09	0.25	VR4, KK3, VM2	
48-71	1.53	0.08	0.30	VR4, KK3, VM2	
71-89	1.84	0.10	0.52	KK4, VR3, VM2, MI1	KK12
89-110	3.63	0.13	1.12	VR5, KK3, VM1	KK 6
110-155	3.60	0.17	0.93	VR5, KK3, VM1	KK16

a/ Analysis of ground whole soil; results expressed on <2 mm basis.

b/ Analysis of ground whole soil; results expressed on whole soil basis.

c/ From characterization sample; determined by shaking overnight in a hexametaphosphate solution.

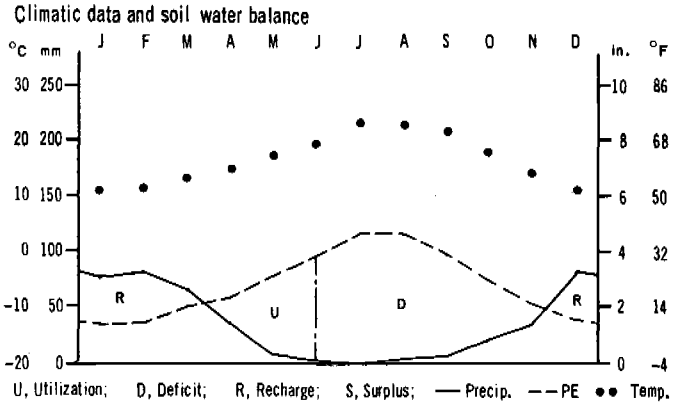
d/ 4.9 kg of organic carbon per square meter to a depth of 1 meter.

e/ Mineral code:
VR = vermiculite MI = mica
VM = vermiculite-mica KK = kaolinite

f/ Approximate weight fraction (X-ray):
5 = more than half
4 = one-third to half
3 = one-fifth to one-third
2 = one-twentieth to one-fifth
1 = less than one-twentieth

Pedon 79

Classification: Typic Xerochrept, coarse-loamy, mixed, thermic.
Location: San Diego County, Calif. 3.6 km south and 1.2 km east of Fallbrook in the NE1/4 of the SW1/4 of sec. 31, T. 9 S., R. 3 W.
Physiographic position: Rolling upland, 180 m elevation.
Topography: Southwest-facing, smooth, 8 percent upper backslope position.
Drainage: Well drained; medium runoff; moderately rapid permeability.
Vegetation: Annual weeds and grasses.
Parent material: Fragmented tonalite.
Sampled by: K. W. Flach, G. Kester, G. Borst, C. Henry, R. Bowman, and G. Anderson, February 17, 1964.
Remarks: There has been much burrowing by ground squirrels. The irregular boundary between the B22 and C1 horizons may be a result of this activity. In a nearby pit burrow holes occur in the C1 horizon. Isolated bodies of the C horizon occur within, or surrounded by, material of the B horizon. The C1 and C2 horizons do not disperse well, hence the field estimates of texture are given for these horizons.
Soil No.: S64Calif-37-1.



Colors are for the dry soil unless otherwise indicated.

A11 0-8 cm (0-3 in.). Dark grayish brown (10YR 4/2) coarse sandy loam, dark brown (10YR 3/3) moist; moderate, fine to medium crumb structure; soft (dry), very friable (moist), nonsticky and nonplastic (wet); plentiful very fine and fine roots; many very fine and fine random pores; 12 percent fine gravel by volume; abrupt smooth boundary.

A12 8-23 cm (3-9 in.). Dark brown (10YR 4/3) coarse sandy loam, dark brown (10YR 3/3) moist; weak fine to medium granular structure; slightly hard (dry), very friable (moist), nonsticky and nonplastic (wet); plentiful very fine and fine roots; common very fine and fine tubular and interstitial pores; 14 percent fine gravel by volume; diffuse to clear irregular boundary. Krotovinas filled with this material, 8 to 10 cm wide, extend into the underlying horizons, in places extending into the upper part of the C horizon.

A13 23-48 cm (9-19 in.). Dark brown (10YR 4/3) coarse sandy loam, dark brown (10YR 3/3) moist; weak fine to medium granular structure; slightly hard (dry), very friable (moist), nonsticky and nonplastic (wet); few very fine and fine roots; common very fine and fine tubular and interstitial pores; 14 percent fine gravel by volume; clear, wavy boundary.

B21 48-71 cm (19-28 in.). Dark brown (10YR 4/3) finely gravelly coarse sandy loam, dark brown (10YR 3/3) moist; massive; hard (dry), friable (moist), nonsticky and nonplastic (wet); few very fine and fine roots; common very fine and fine tubular and interstitial pores; 15 percent fine gravel by volume; clear smooth boundary.

B22 71-89 cm (28-35 in.). Yellowish brown (10YR 5/4) finely gravelly coarse sandy loam, dark yellowish brown (10YR 3/4) moist; massive; hard (dry), friable (moist), nonsticky and nonplastic (wet); very few very fine and fine roots; common very fine and fine interstitial, few fine tubular pores; 18 percent fine gravel by volume; abrupt, irregular to broken boundary.

C1 89-110 cm (35-44 in.). Yellowish brown (10YR 5/4) and very pale brown (10YR 7/4) fragmented tonalite, finely gravelly sand in texture, composed mostly of quartz, feldspar, hornblende, and accessory dark colored minerals; 33 percent fine gravel (tonalite) by volume; clear, irregular boundary.

C2 110-155 cm (44-61 in.). Brown (10YR 5/3) and very pale brown (10YR 7/3) fragmented tonalite, finely gravelly sand in texture, composed mostly of quartz, feldspar, hornblende, and other dark colored minerals, mostly unweathered; 33 percent fine gravel (tonalite) by volume.

SOIL Pedon 80 Typic Dystropept SOIL Nos. S61PR-8-5 LOCATION Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos.

General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) Total: Sand a/ (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: 0.05–0.02	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	3A1c Water-disp. clay <0.002		2A2 Coarse fragments		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-15	Ap	19.7	40.1	40.2	2.8	2.5	1.7	4.8	7.9	13.1	27.0	24.2	11.8					tr
15-33	B	21.9	40.1	38.0	3.2	2.4	1.5	5.2	9.6	13.5	26.6	26.8	12.3	19				tr
33-69	C1	43.8	41.9	14.3	0.4	2.3	3.6	18.6	18.9	17.3	24.6	49.4	24.9					tr
69-100	C2	52.8	39.6	7.6	1.3	4.8	5.8	22.3	18.6	18.6	21.0	52.0	34.2					tr

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ Pct.		Bulk density: 4A1a Field state g/cc	4A1c 30-cm g/cc	4A1b Air-dry g/cc	4D1 COLE b	Water content: 4B4 Field state Pct.	4B3 30-cm Pct.	4B1b 1/3-bar Pct.	4B2 15-bar	4C1 1/3-to 15-bar cm/cm		pH: 8C1c (1:1) N KCl	8C1a (1:1) H_2O
0-15	2.28	0.194	12	10.2			1.20	1.27	1.39	0.052	32.4	27.9	32.3	22.7	0.12		3.5	4.2
15-33	1.35	0.119	11	9.7			1.11		1.30	0.056	35.0		30.0	22.9	0.08		3.7	4.6
33-69	0.26	0.028	9	7.2										18.5			3.7	4.5
69-100	0.05			7.9										17.3			3.7	4.6

Depth (cm)	Extractable bases: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap.: 5A3a Sum cations	5A1a NH_4OAc	6G1d KCl-ext. Al		5A3b Bases plus Al me/100g clay	Ratios to clay: 8D1 NH_4OAc CEC	Ext. iron	15-bar water		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																
0-15	1.6	0.7	tr	0.3	2.6	23.8	26.4	18.7	8.6		27.9	0.46	0.25	0.56		10	14
15-33	3.0	0.7	tr	0.1	3.8	19.0	22.8	16.6	6.9		28.2	0.44	0.26	0.60		17	23
33-69	1.9	1.4	tr	0.2	3.5	19.8	23.3	16.9	10.9		c/31	1.18	0.50	1.29		15	21
69-100	tr	0.8	0.1	0.2	1.1	20.4	21.5	17.0	12.6		c/32	2.24	1.04	2.28		5	6

Underlined if 15-bar to clay ratio exceeds 0.6, indicating that the nonclay probably has strong clay-like properties.

a/Coarse and very coarse sands of the solum (method 7B1) consist largely of reddish brown iron-bearing nodules (25-50 percent), finer sand largely whitish soapy-looking grains with low interference colors and may be feldspar altered to kaolinite; quartz is rare; a trace of identifiable ferromagnesian minerals is present.

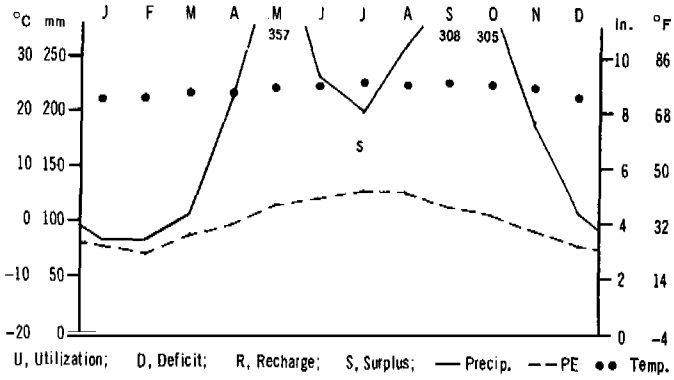
b/Field state.

c/Clay percentage estimated as 15-bar water percentage x 2.5.

Pedon 80

Classification: Typic Dystropept, fine, oxidic, isohyperthermic.
Location: Puerto Rico. 3.0 km from kilometer marker 19.4, Highway 105, on dirt road, 15 m W. of road. About 20 km (12 mi.) E. of Mayaguez.
Topography: Steep (50 percent) east-facing sideslope leading to a stream, about 15 m from interfluve summit.
Drainage: Well drained, rapid runoff, medium internal drainage, moderate permeability.
Vegetation: Merker (Elephant) grass (Pennisetum purpurem).
Parent material: Residuum or very local colluvium from volcanic rocks, supposedly high in manganese.
Sampled by: O. R. Carter, R. B. Grossman, W. E. McKinzie and L. H. Rivera, December 19, 1961.
Remarks: Soil was near field capacity when sampled. Family texture based on clay percentage estimated as 2.5 times the 15-bar water content. Two terms are used to describe the rate of failure of natural fabric: fails abruptly and fails semiplastically. To fail abruptly means that no plasticity is observed prior to failure. Stress builds up as the piece of soil is squeezed and dissipates quickly as the piece of soil breaks apart into numerous fragments or peds due to failure along natural planes of weakness. In semiplastic failure, deformation is readily observed prior to rupture.
Soil No.: S61PR-8-5.

Climatic data and soil water balance



Pedon 81

SOIL Typic Eutropept SOIL Nos. S61PR-4-2 LOCATION Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 14885-14892

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	3A1c Water-disp. clay < 0.002		Coarse fragments 2A2		3B1 2-20 Pct. ≤ 20
		Pct. of ≤ 2 mm																
0-3	Ap1	22.6	33.4	44.0	1.1	3.9	3.4	7.7	6.5	9.8	23.6	20.5	16.1					tr
3-15	Ap2	32.5	35.5	32.0	2.3	5.7	5.0	10.9	8.6	11.1	24.4	25.6	23.9					tr
15-33	B	44.8	33.9	21.3	4.3	7.3	6.8	15.3	11.1	11.4	22.5	30.8	33.7	14				tr
33-56	C1	56.9	29.9	13.2	7.2	12.4	8.5	17.0	11.8	11.2	18.7	32.3	45.1					tr
56-86	C2																	
86-135	R																	

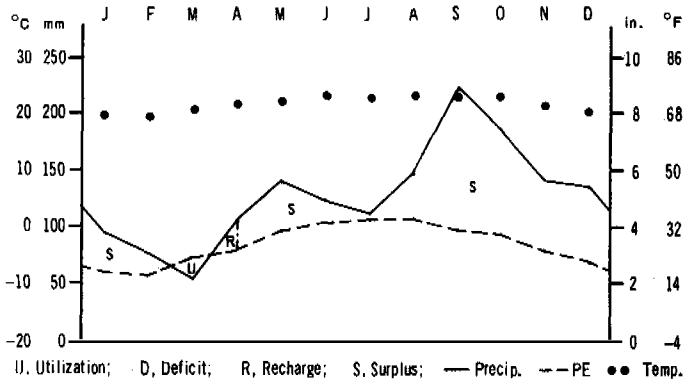
Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N		6E2a Carbonate as $CaCO_3$ Pct.	6C2a Ext. iron as Fe Pct.	Bulk density: 4A1a Field state g/cc	Bulk density: g/cc	4A1b Air-dry g/cc	4D1 COLE	Water content: 4B4 Field state Pct.	Water content: Pct.	4B2 15-bar Pct.			pH: 8C1c (1:1) N KCl	pH: 8C1a (1:1) H_2O
0-3	2.26	0.186	12			5.5							24.4			3.9	4.9
3-15	1.77	0.158	11			4.5	1.26		1.33	0.017	24.9		22.5			3.7	5.0
15-33	0.73	0.072	10			3.9	1.17		1.26	0.024	32.1		19.8			3.6	5.0
33-56	0.15					2.9	1.62		1.70		14.6		17.2			3.6	5.5
56-86							1.96		2.04	0.014	9.0						
86-135							1.96		2.08	0.020	9.6						

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap: 5A3a Sum cations	5A1a NH_4OAc	6G1d KCl-ext. Al	5A3b Bases + Al me/100g clay a/	Ratios to clay: NH_4OAc CEC	Ext. iron	8D1 15-bar water	8D3 Ca/Mg	Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g															
0-3	14.1	10.6	0.2	1.0	25.9	22.7	48.6	34.0	1.9	63.2	0.77	0.13	0.55	1.3	53	76
3-15	13.2	9.4	0.2	0.4	23.2	24.8	48.0	35.0	4.6	50	1.09	0.14	0.70	1.4	48	66
15-33	14.6	13.2	0.4	0.2	28.4	23.6	52.0	38.2	4.9	67	1.79	0.18	0.93	1.1	55	74
33-56	24.8	20.6	0.5	0.2	46.1	10.8	56.9	45.8	1.5	111	3.47	0.22	1.30	1.2	81	101

Pedon 81

Classification: Typic Eutropept, fine, mixed, isohyperthermic.
Location: Puerto Rico. Barranquitas Soil Study Area. 24 m W. of marker K8 H9, Highway 152. 40 km (25 mi.) SW. of San Juan.
Topography: Slope is 20 percent to north and 10 to 15 percent to west.
Vegetation: Brushy road bank; previously cultivated.
Parent material: "Basaltic-andesite flow breccia". (Briggs, R. P. Laterization in East-Central Puerto Rico. Trans. Second Caribbean Geol. Cong. 103-109. 1959.).
Sampled by: R. B. Grossman, March 12, 1961.
Remarks: Family texture based on clay percentage estimated as 2.5 times the 15-bar water content. Two terms are used to describe the rate of failure of natural fabric: fails abruptly and fails semiplastically. To fail abruptly means that no plasticity is observed prior to failure. Stress builds up as the piece of soil is squeezed and dissipates quickly as the piece of soil breaks apart into numerous fragments or peds due to failure along natural planes of weakness. In semiplastic failure deformation is readily observed prior to rupture.
Soil No.: S61PR-4-2.

Climatic data and soil water balance



Colors are for the moist soil.

Ap1 0-3 cm (0-1 in.). Dark reddish brown (5YR 3.5/4) clay; moderate medium and coarse granular; friable (moist); sticky and plastic (wet); overlay of slope wash plus some Ap2.

Ap2 3-15 cm (1-6 in.). Brown (10YR 4/3) clay loam with many ped surfaces dark grayish brown (10YR 4/2); moderate medium subangular blocks that crush to medium granules; firm (moist), slightly sticky and plastic (wet); fails abruptly; plentiful roots; many medium and coarse pores; possible weak broken clay skins on pore walls; common pebble and sand-size saprolite that crushes easily between fingers; clear to abrupt boundary.

B 15-33 cm (6-13 in.). Brown (10YR 5/3) loam with strong brown (7.5YR 5/6) ped surfaces; weak coarse subangular blocks; firm to friable (moist); few roots; distinct broken clay skins mainly along pore walls and on surfaces of saprolite; reddish brown (5YR 4/4) clayey surfaces are quite general and predominate in several isolated parts; soft saprolite common; wavy clear to abrupt boundary.

C1 33-56 cm (13-22 in.). Saprolite. Breaks down easily between fingers after saturation with water; about 60 percent reddish brown (5YR 4/3), 30 percent white (10YR 8/2) and 10 percent yellowish green, the latter two colors occurring as disconnected parts less than 5 mm across; fracture surfaces have black coatings suggesting iron-manganese oxides; gradual boundary.

C2 56-86 cm (22-34 in.). Similar to above; cannot be easily broken in hands after saturation; principal color strong brown (7.5YR 5/6).

R 86-135 cm (34-54 in.). Saprolite; numerous clay-rich seams, reddish brown (5YR 4/3) clay common on surfaces of saprolite fragments.

Pedon 82

SOIL Typic Argialboll SOIL Nos. S59Iowa-93-1 LOCATION Wayne County, Iowa

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 11538-11549

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Total Sand (a/) (2-0.05)	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: 0.05-0.02	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)			Coarse fragments 2A2 3B1 2-20 Pct. < 20
		Size class and particle diameter (mm) 3A1 — Pct. of < 2 mm														
0-18	A1	1.2	77.5	21.3	0.2	0.3	0.2	0.2	0.3	32.8	44.7	33.2	0.9			-
18-30	A21	1.5	78.2	20.3	0.1	0.5	0.3	0.3	0.3	32.1	46.1	32.5	1.2			-
30-46	A22	3.1	76.5	20.4	0.6	1.1	0.5	0.4	0.5	30.7	45.8	31.4	2.6			-
46-53	A&B	3.0	69.2	27.8	0.3	1.0	0.6	0.6	0.5	27.2	42.0	28.0	2.5			-
53-66	B21t	3.8	54.2	42.0	1.3	1.1	0.5	0.5	0.4	20.3	33.9	20.9	3.4			-
66-76	B22t	1.7	44.4	53.9	0.1	0.4	0.3	0.4	0.5	16.7	27.7	17.4	1.2			-
76-81	B23t	1.5	44.0	54.5	-	0.2	0.2	0.4	0.7	16.4	27.6	17.3	0.8			-
81-97	B24t	1.8	45.4	52.8	0.1	0.3	0.3	0.5	0.6	16.7	28.7	17.6	1.2			-
97-120	B3t	1.2	50.9	47.9	-	0.2	0.2	0.4	0.4	18.4	32.5	19.0	0.8			-
120-135	C1	1.2	57.9	40.9	0.1	0.2	0.2	0.3	0.4	21.1	36.8	21.7	0.8			-
135-155	C21	0.8	60.1	39.1	-	0.1	0.1	0.2	0.4	22.7	37.4	23.2	0.4			-
155-175	C22	0.6	63.6	35.8	-	0.1	0.1	0.2	0.2	24.2	39.4	24.5	0.4			-

Depth (cm)	6A1a Organic carbon (Pct.)	6B1a Nitrogen (Pct.)	C/N		Carbonate as $CaCO_3$ (Pct.)	6C1a Ext. iron as Fe (Pct.)	Bulk density (g/cc)	Bulk density (g/cc)	Bulk density (g/cc)		Water content (Pct.)	4B2 15-bar (Pct.)	Water content (Pct.)			pH		pH 8C1a (1:1) H_2O
0-18	2.69	0.227	12			0.6						10.3						5.6
18-30	1.62	0.129	13			0.6						8.7						5.7
30-46	0.83	0.067	12			0.8						7.7						6.0
46-53	0.64	0.059	11			0.8						11.5						5.9
53-66	0.76	0.069	11			1.3						17.7						5.8
66-76	0.74	0.064	12			1.1						22.9						5.6
76-81	0.64	0.062				1.1						24.0						5.7
81-97	0.52	0.051				1.1						23.4						5.7
97-120	0.28	0.037				0.8						21.7						6.2
120-135	0.16	0.029				1.2						20.0						6.4
135-155	0.16	0.024				1.3						19.6						6.6
155-175	0.10	0.022				0.9						17.8						6.6

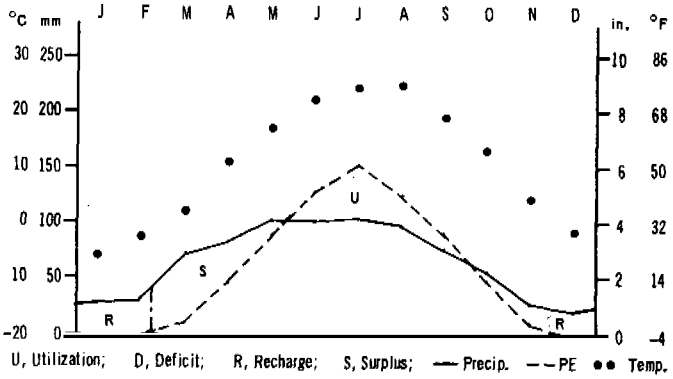
Depth (cm)	Extractable bases 6N2b Ca (meq/100 g)	6O2b Mg	6P2a Na	6Q2a K	5B1a Sum	6H1a Ext. acidity	Cat. exch. cap. 5A3a Sum cations	5A1a NH_4OAc		8A1a Elec. cond. mmhos/cm	8A H_2O at saturation Pct.	Ratios to clay 8D1 NH_4OAc CEC	Ext. iron	15-bar water		8D3 Ca/Mg	Base saturation 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
0-18	11.8	3.3	0.1	0.2	15.4	9.9	25.3	18.4		0.4	59.0	0.86	0.03	0.48		3.6	61	84
18-30	9.8	2.5	0.2	0.2	12.7	7.9	20.6	15.5		0.4	49.5	0.76	0.03	0.43		3.9	62	82
30-46	8.0	2.8	0.4	0.1	11.3	6.0	17.3	13.5		0.4	45.0	0.66	0.04	0.38		2.8	65	84
46-53	10.6	4.7	0.7	0.2	16.2	7.2	23.4	19.0		0.4	51.4	0.68	0.03	0.41		2.2	69	85
53-66	16.3	8.1	1.4	0.4	26.2	10.4	36.6	28.5		0.4	72.5	0.68	0.03	0.42		2.0	72	92
66-76	22.0	11.5	2.0	0.5	36.0	12.4	48.4	35.6		0.4	101	0.66	0.02	0.42		1.9	74	101
76-81	23.2	12.2	2.1	0.6	38.1	10.7	48.8	38.4		0.4	104	0.70	0.02	0.44		1.9	78	99
81-97	22.8	12.2	2.1	0.5	37.6	10.0	47.6	37.7		0.3	99.2	0.71	0.02	0.44		1.9	79	100
97-120	21.8	11.5	2.0	0.5	35.8	6.7	42.5	33.5		0.3	88.4	0.70	0.02	0.45		1.9	84	107
120-135	20.0	10.6	1.7	0.4	32.7	5.2	37.9	30.8		0.3	84.7	0.75	0.03	0.49		1.9	86	106
135-155	19.8	10.6	1.7	0.4	32.5	6.4	38.9	29.6		0.3	75.5	0.76	0.03	0.50		1.9	84	110
155-175	18.3	9.5	1.6	0.4	29.8	3.7	33.5	28.6		0.4	70.2	0.80	0.03	0.50		1.9	89	104

a/ Iron-manganese nodules comprise an appreciable amount of the sand.

Pedon 82

Classification: Typic Argialboll, fine, montmorillonitic, mesic.
Location: Wayne County, Iowa, 207 m E. and 46 m N. of SW. corner NW 1/4 sec. 15, T. 68 N., R. 21 W. About 95 km (60 mi.) S. of Des Moines.
Physiographic position: Broad level uplands of the undissected Kansan till plain.
Topography: Level, less than 1 percent.
Drainage: Poorly drained.
Vegetation: Annual bluegrass (Poa annua), horsenettle (Solanum carolinense).
Parent material: Loess of Wisconsinan age, approximately 2.5 m thick over Kansan till.
Sampled by: W. P. Dietz, F. F. Riecken and E. C. A. Runge, July 17, 1959.
Soil No.: S59Iowa-93-1.

Climatic data and soil water balance



Colors are for the moist soil unless otherwise indicated.

A1 0-18 cm (0-7 in.). Very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry, some light gray (10YR 7/1) dry ped coatings; moderate medium granular to weak fine platy structure; friable (moist); clear boundary.

A21 18-30 cm (7-12 in.). Gray and very dark gray (10YR 6/1 and 3/1) heavy silt loam, light gray (10YR 7/1) dry, light gray (10YR 7/1) dry ped coatings more distinct than in above horizon; moderate fine plates break to very fine subangular blocks; friable (moist); gradual boundary.

A22 30-46 cm (12-18 in.). Gray and very dark gray (10YR 5/1 and 3/1) heavy silt loam, gray and light gray (10YR 5/1 and 7/1) dry, upper ped surfaces (top) covered with gray and dark gray (10YR 5/1 and 4/1) coatings, lower ped surfaces are very dark gray (10YR 3/1), few fine faint yellowish brown (10YR 5/6 to 5/8) mottles; moderate to strong medium platy structure; friable (moist); clear boundary.

A&B 46-53 cm (18-21 in.). Gray and very dark gray (10YR 5/1 and 2.5/1) light silty clay loam, dark gray and light gray (10YR 4/1 and 7/1) dry, gray (10YR 5/1) silt and sand on peds; moderate fine subangular blocky structure; friable to slightly firm (moist); some thick discontinuous clay skins on peds; abrupt boundary.

B21t 53-66 cm (21-26 in.). Very dark gray and black (10YR 3/1 and 2/1) silty clay, common medium distinct yellowish brown (10YR 5/6 and 5/8) mottles mostly within peds; weak medium subangular blocky structure; very firm (moist); thick continuous clay skins; many small cemented black iron-manganese nodules; gradual boundary.

B22t 66-76 cm (26-30 in.). Same as above horizon except there is more clay and a clear boundary.

B23t 76-81 cm (30-32 in.). Dark gray to gray (10YR 4/1 and 2.5Y 5/1) silty clay, common medium distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; firm to very firm (moist); few fine [illegible]

SOIL Pedon 83 Typic Argiaquoll SOIL Nos. S61Iowa-61-3 LOCATION Madison County, Iowa

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 16368-16378

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: (0.05–0.02)	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	Silt: (2–0.1)			Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-18	Ap	2.4	69.7	27.9	0.2	0.4	0.4	0.6	0.8	30.2	39.5	31.3	1.6					-
18-33	A12	2.7	65.7	31.6	0.2	0.4	0.6	0.7	0.8	27.3	38.4	28.4	1.9					-
33-48	A13	2.7	62.1	35.2	0.1	0.5	0.5	0.7	0.9	26.1	36.0	27.3	1.8					-
48-64	A3	4.0	55.6	40.4	0.9	0.9	0.6	0.8	0.8	23.9	31.7	25.1	3.2					-
64-81	B21t	2.3	55.1	42.6	0.4	0.4	0.2	0.4	0.9	23.0	32.1	24.1	1.4					-
81-99	B22t	2.4	60.0	37.6	0.3	0.6	0.3	0.4	0.8	26.4	33.6	27.4	1.6					-
99-120	B31t	1.6	60.8	37.6	0.1	0.2	0.2	0.4	0.7	27.3	33.5	28.2	0.9					-
120-145	B32t	1.7	63.5	34.8	0.1	0.2	0.2	0.4	0.8	29.7	33.8	30.7	0.9					-
145-175	C1	1.3	64.8	33.9	-	0.1	0.1	0.2	0.9	31.1	33.7	32.1	1.4					-
175-200	C2	1.1	67.3	31.6	0.1	0.1	tr	0.1	0.8	31.4	35.9	32.3	0.3					-
200-225	C3	1.1	68.8	30.1	-	0.1	0.1	0.1	0.8	33.0	35.8	33.9	0.3					-

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N		6E1b Carbonate as $CaCO_3$ Pct.		Bulk density: g/cc	4A1c 30-cm g/cc	4A1b Air-dry g/cc	4D1 COLE	Water content: 4B1b 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3- to 15-bar cm/cm			pH		8C1a (1:1) H_2O
0-18	2.78	0.188	15					1.40	1.56	0.036	27.8	12.9	0.21					6.9
18-33	1.88	0.132	14					1.26	1.40	0.036	29.8	14.2	0.20					6.1
33-48	1.32	0.107	12					1.31	1.50	0.047	28.1	15.6	0.16					6.0
48-64	0.92	0.078	12									18.6						6.0
64-81	0.48											19.9						6.2
81-99	0.25							1.38	1.66	0.064	31.1	18.3	0.18					5.8
99-120	0.18											17.6						6.2
120-145	0.12											16.9						6.3
145-175	0.12				-			1.33	1.61	0.064	32.4	16.5	0.21					6.7
175-200	0.08				-							15.5						7.1
200-225	0.09				1							15.3						7.3

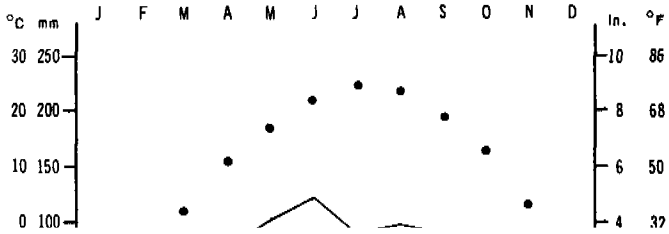
Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap.: 5A3a Sum cations	5A1a NH_4OAc			Ratios to clay 8D1: NH_4OAc CEC		15-bar water		8D3 Ca/Mg	Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																
0-18	21.4	4.1	tr	0.4	31.3	5.4	36.7	25.3			0.91		0.46		5.2	83	102
18-33	15.8	5.1	0.1	0.5	30.2	8.7	38.9	24.5			0.78		0.45		3.1	71	88
33-48	15.8	6.3	0.1	0.6	30.9	8.1	39.0	25.3			0.72		0.44		2.5	74	90
48-64	18.0	8.1	0.2	0.7	35.8	8.8	44.6	30.4			0.75		0.46		2.2	75	89
64-81	19.5	8.5	0.3	0.8	36.9	7.8	44.7	33.4			0.78		0.47		2.3	79	87
81-99	18.4	8.4	0.3	0.7	34.1	6.3	40.4	30.4			0.81		0.49		2.2	82	91
99-120	18.2	8.8	0.3	0.7	33.3	5.3	38.6	29.8			0.79		0.47		2.1	84	94
120-145	17.8	8.0	0.3	0.6	31.0	4.3	35.3	28.2			0.81		0.49		2.2	86	95
145-175	17.6	7.1	0.3	0.6	28.6	3.0	31.6	27.2			0.80		0.49		2.5	90	94
175-200	16.6	8.0	0.3	0.6	27.9	2.4	30.3	25.1			0.79		0.49		2.1	91	102
200-225			0.2	0.6		1.4		24.0			0.80		0.51				

need new set here

Pedon 83

Classification: Typic Argiaquoll, fine, montmorillonitic, mesic.
Location: Madison County, Iowa, 147 m W. and 102 m S. of NE. corner sec. 6, T. 75 N., R. 28 W. About 18 km (5 mi.) W. of Winterset. About 30 km (20 mi.) SW. of Des Moines.
Physiographic position: Broad upland divide.
Topography: Nearly level, less than 1 percent.
Drainage: Poorly drained, slow to moderately slow permeability.
Vegetation: Clover (Trifolium spp.).
Parent material: Wisconsinan age loess.

Climatic data



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Colors are for the moist soil unless otherwise indicated.

Ap 0-18 cm (0-7 in.). Black (10YR 2/1) light silty clay loam, dark gray (10YR 4/1) dry; weak medium subangular blocky structure; firm (moist); plentiful roots; very few fine dark spherical cemented iron-manganese nodules; clear smooth boundary.

A12 18-33 cm (7-13 in.). Black (10YR 2/1) light silty clay loam, dark gray (10YR 4/1) dry; moderate fine granular struc-

SOIL Pedon 84 Typic Haplaquoll SOIL Nos. S57Ill-38-2 LOCATION Iroquois County, Ill.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 7331-7338

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: a/ Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: (0.05–0.02)	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	Coarse fragments 2A2 3B1 2-20 Pct. < 20
		Pct. of < 2 mm												
0-15	Ap	26.4	44.4	29.2	0.2	0.3	1.4	10.9	13.6	19.9	24.5	39.8	12.8	tr
15-33	A12	25.2	43.5	31.3	0.1	0.4	1.3	10.2	13.2	19.2	24.3	38.4	12.0	tr
33-43	B1	24.3	44.3	31.4	0.1	0.3	1.2	9.6	13.1	19.8	24.5	38.7	11.2	tr
43-64	B21g	24.6	46.4	29.0	0.1	0.3	1.3	9.9	13.0	20.1	26.3	38.9	11.6	-
64-79	B22g	15.1	53.3	31.6	0.2	0.3	0.9	6.2	7.5	19.1	34.2	30.2	7.6	-
79-97	B3g	33.5	42.7	23.8	0.1	0.4	1.9	14.6	16.5	18.1	24.6	43.0	17.0	-
97-130	C1g	25.2	50.9	23.9	0.1	0.3	0.9	7.2	16.7	27.4	23.5	48.4	8.5	-
130-140	C2g	28.6	49.8	21.6	0.1	0.4	0.8	10.1	17.2	25.8	24.0	50.1	11.4	-

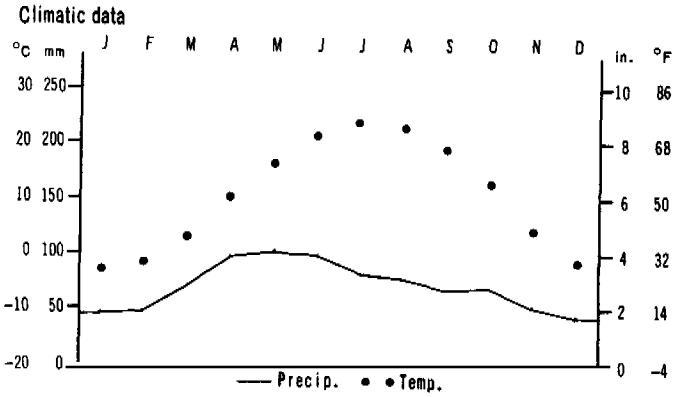
Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	6E1a Carbonate as $CaCO_3$ Pct.	Bulk density: 4A1a Field state b/ g/cc	Bulk density: g/cc	Bulk density: g/cc	Water content: 4B4 Field state b/ Pct.	Water content: Pct.	Water content: 4B2 15-bar c/ Pct.	pH: 8C1a (1:1) H_2O
0-15	4.20	0.325	13	-	1.26			17.0		16.8	7.2
15-33	2.44	0.204	12	-						16.5	6.9
33-43	0.99	0.086	12	-	1.62			13.9		13.8	7.2
43-64	0.41	0.046	9	-						12.0	7.5
64-79	0.30			-	1.48			13.0		13.4	7.6
79-97	0.18			-						8.0	7.9
97-130	0.19			12						7.1	8.0
130-140	0.17			24	1.56			22.5		3.4	8.1

Depth (cm)	Extractable bases 6N2a Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap. 5A3a Sum cations	5A1a NH_4OAc	Base saturation 5C3 Sum cat-ions Pct.	5C1 NH_4OAc Pct.
	meq/100 g									
0-15	28.3	10.1	-	0.4	38.8	4.6	43.4	35.9	89	108
15-33	24.5	8.7	0.1	0.4	33.7	4.1	37.8	32.8	89	102
33-43	19.1	7.7	0.1	0.4	27.3	3.3	30.6	25.8	89	106
43-64	14.7	6.9	0.1	0.3	22.0	2.1	24.1	20.5	91	107
64-79	16.4	8.1	0.1	0.4	25.0	1.2	26.2	22.8	95	112
79-97	10.9	5.8	0.1	0.3	17.1	1.2	18.3	13.9	93	-
97-130		5.3	-	0.3		-		10.7		
130-140		4.2	-	0.2		-		7.9		

a/ Few irregular smooth light brown to black concretions occur in all sand fractions; few calcium-carbonate concretions in C1 and C2 horizons.
b/ Uhland core method (SSSAP 14:361, 1950). Determined by University of Illinois.
c/ Determined by University of Illinois.

Pedon 84

Classification: Typic Haplaquoll, fine-silty, mixed, mesic.
Location: Iroquois County, Ill., 33 m S. and 15 m W. of E. 1/4 corner, NE 1/4 NE 1/4 NE 1/4 SE 1/4 sec. 16, T. 26 N., R. 10 E. About 150 km (90 mi.) S. of Chicago.
Physiographic position: Elevation about 200 m.
Topography: Level.
Drainage: Poorly drained.
Vegetation: Soybeans.
Parent material: Wisconsinan glacial outwash.
Sampled by: J. D. Alexander, J. B. Fehrenbacher and P. R. Johnson, October 29, 1957.
Remarks: Krotovinas start in B1 (33 cm) and extend to sampling depth; they are mostly 1 to 6 cm in diameter and there are about 35 per square meter in horizontal cross section; their color is mostly black (10YR 2/1) moist. No pebbles were observed.
Soil No.: S57Ill-38-2.



Colors are for the moist soil.

Ap 0-15 cm (0-6 in.). Black (10YR 2/1) clay loam; moderate medium angular blocky structure; firm (moist); sand grains visible; plentiful roots; abrupt smooth boundary.

A12 15-33 cm (6-13 in.). Black (10YR 2/1) light clay loam; medium to strong granular structure; friable to firm (moist); sand grains visible; plentiful roots; few small iron-manganese concretions; clear smooth boundary.

B1 33-43 cm (13-17 in.). Very dark gray (10YR 3/1.5) light clay loam; moderate to strong medium to coarse granular structure; firm (moist); plentiful roots; sand grains visible; few small iron-manganese concretions; clear smooth boundary.

B21g 43-64 cm (17-25 in.). Olive gray (5Y 4.5/2) light clay loam; few fine distinct yellowish brown (10YR 5/8) mottles; moderate medium prisms break to moderate medium angular to subangular blocks; firm (moist); sand grains visible; occasional small iron-manganese concretions; thin discontinuous olive gray (5Y 5/2) clay skins; clear smooth boundary.

B22g 64-79 cm (25-31 in.). Olive gray (5Y 5/2) light silty clay loam; common fine prominent yellowish brown (10YR 5/8) mottles; moderate to strong medium prisms break to strong medium angular blocks; firm (moist); sand grains visible; plentiful roots; occasional iron-manganese concretions; clear smooth boundary.

B3g 79-97 cm (31-38 in.). Gray (5Y 5.5/1) silty clay loam with pockets of clay loam; many medium distinct yellowish brown (10YR 5/6 to 5/8) mottles; weak medium prisms break to weak [illegible]

Pedon 85

SOIL Typic Cryoboroll SOIL Nos. S58Mont-23-1 LOCATION Judith Basin County, Mont.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 8367-8372

General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2-0.05)	Total: Silt (0.05-0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: (0.05-0.02)	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)			Coarse fragments 2A2 3B1 2-20 Pct.		
		Pct. of < 2 mm																
0-13	A11	32.3	36.1	31.6	2.0	2.4	3.8	9.7	14.4	17.5	18.6	35.5	17.9					6
13-23	A12	33.3	36.2	30.5	1.5	2.4	4.2	14.3	10.9	17.3	18.9	35.8	22.4					16
23-38	B1	36.4	34.2	29.4	2.9	3.4	5.8	15.9	8.4	17.1	17.1	33.6	28.0					24
38-56	B21	35.2	32.6	32.2	1.6	3.1	5.1	14.1	11.3	15.8	16.8	33.6	23.9					18
56-79	B22	39.9	29.8	30.3	0.9	2.7	5.8	19.2	11.3	14.0	15.8	35.6	28.6					17
79-120	B3	44.9	23.8	31.3	1.1	3.3	7.7	20.8	12.0	4.3	19.5	25.7	32.9					31
120+																		

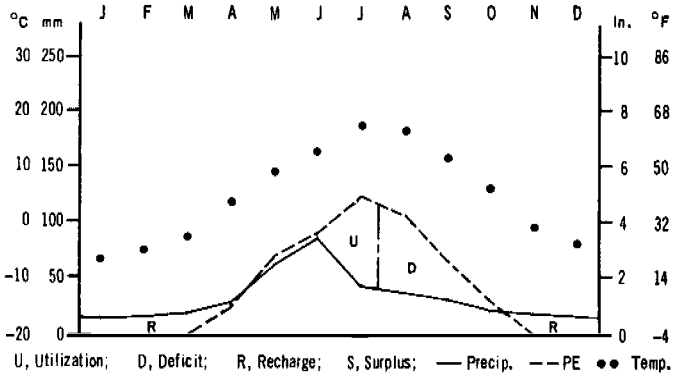
Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N		6E1a Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density g/cc	g/cc	g/cc		Water content Pct.	Pct.	4B2 15-bar Pct.			pH (1:5)	8C1a (1:1) H_2O
0-13	10.0	0.711	14			1.5							23.0			6.3	
13-23	4.93	0.365	14			1.7							14.8				5.7
23-38	2.18	0.197	11			1.7							12.1				5.8
38-56	0.89	0.079	11			1.8							12.7				6.0
56-79	0.64	0.055	12			1.8							12.1				6.2
79-120	0.34				-	1.8							12.4				6.6
120+																	

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap. 5A3a Sum cations	5A1a NH_4OAc			Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water		8D3 Ca/Mg	Base saturation 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																
0-13	28.5	6.0	-	2.1	36.6	15.8	52.4	41.2			1.30	0.05	0.73		4.8	70	89
13-23	16.7	3.4	-	0.8	20.9	16.0	36.9	30.4			1.00	0.06	0.49		4.9	57	69
23-38	14.5	4.0	-	0.7	19.2	11.2	30.4	24.4			0.83	0.06	0.41		3.6	63	79
38-56	18.7	7.1	-	0.3	26.1	7.1	33.2	28.8			0.89	0.06	0.39		2.6	79	91
56-79	20.1	8.4	0.1	0.2	28.8	5.6	34.4	29.6			0.98	0.06	0.40		2.4	84	97
79-120	21.8	8.1	0.1	0.2	30.2	3.8	34.0	29.9			0.96	0.06	0.40		2.7	89	101
120+																	

Pedon 85

Classification: Typic Cryoboroll, fine-loamy, mixed.
Location: Judith Basin County, Mont., 430 m N. and 65 m W. of SE. corner of SE 1/4 SW 1/4 sec. 9, T. 16 N., R. 9 E.
Physiographic position: Rolling upland, 1,600 m elevation.
Topography: 15 m relief; site on 7 percent slope gradient with N. aspect.
Drainage: Well drained; moderately rapid permeability.
Vegetation: Rough fescue (Festuca scabrella), Idaho fescue (Festuca idahoensis), mountain brome (Bromus carinatus), shrubby cinquefoil (Potentilla fruticosa), lupine (Lupinus spp.) and annuals.
Parent material: Sandstone.
Sampled by: J. S. Allen, D. R. Cawlfield, C. A. Mogen and J. L. Parker, June 23, 1958.
Remarks: Moist throughout, 15 percent by volume coarse fragments, 20 to 250 mm in the A12 through B22 horizons and 50 percent in the B3 horizon.
Soil No.: S58Mont-23-1.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

A11 0-13 cm (0-5 in.). Black (10YR 2/1) clay loam, black (10YR 2/1) moist; moderate fine granular structure; soft (dry), very friable (moist), nonsticky and slightly plastic (wet); mat of fine roots; clear boundary.

A12 13-23 cm (5-9 in.). Very dark brown (10YR 2/2) gravelly clay loam, black (10YR 2/1) moist; weak medium and fine subangular blocky structure; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); abundant roots; clear boundary.

B1 23-38 cm (9-15 in.). Very dark grayish brown (10YR 3/2) gravelly light clay loam, very dark brown (10YR 2/2) moist; moderate fine to medium subangular blocky structure; slightly hard (dry), friable (moist), sticky and plastic (wet); patches of clay skins on vertical faces; abundant roots; clear wavy boundary.

B21 38-56 cm (15-22 in.). Brown (10YR 5/3) gravelly light clay loam, brown (10YR 4/3) moist; strong fine angular blocky structure; hard (dry), firm (moist), very sticky and very plastic (wet); continuous clay skins on ped faces; plentiful roots; gradual boundary.

B22 56-79 cm (22-31 in.). Brown (10YR 5/3) gravelly light clay loam, brown (10YR 4/3) moist; strong medium and fine angular

Pedon 86

SOIL Typic Haploboroll SOIL Nos. S58NDak-45-1 LOCATION Stark County, N. Dak.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 8469-8476

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2: 3B1 2–20 Pct.		
		Pct. of < 2 mm																
0-10	Ap	60.1	23.9	16.0	1.0	4.8	10.9	32.1	11.3	15.1	8.8	43.0	48.8					tr
10-30	B21	63.7	20.3	16.0	1.4	4.3	10.7	35.2	12.1	13.4	6.9	43.8	51.6					2
30-48	B22	54.0	31.9	14.1	1.2	3.0	7.7	25.9	16.2	21.0	10.9	50.8	37.8					3
48-64	C1ca	58.0	21.0	21.0	7.4	6.6	11.8	24.2	8.0	8.8	12.2	26.6	50.0					20
64-79	IIC2	78.7	10.8	10.5	15.5	9.7	15.4	31.9	6.2	4.5	6.3	22.5	72.5					45
79-91	IIC3	89.4	4.9	5.7	37.0	19.8	15.5	15.1	2.0	1.5	3.4	7.8	87.4					59
91-99	IIC4	86.3	8.2	5.5	7.8	13.2	19.9	35.7	9.7	4.3	3.9	32.5	76.6					34
99-130	IIIC5	83.4	8.5	8.2	-	0.4	2.6	64.9	15.4	3.7	4.8	68.8	67.9					tr

Depth (cm)	6A1a Organic carbon (Pct.)	6B1a Nitrogen (Pct.)	C/N		6E1a Carbonate as $CaCO_3$ (Pct.)		Bulk density (g/cc)				Water content (Pct.)		4B2 15-bar (Pct.)			pH 8C1a (1:1) H_2O	(1:5) H_2O	(1:10) H_2O
0-10	1.24	0.118	11		-								6.6			6.6	6.9	7.0
10-30	0.75	0.070	11		-								6.7			6.8	7.2	7.2
30-48	0.88	0.081	11		-								6.5			7.3	7.6	7.6
48-64	0.93	0.081	11		15								7.9			8.3	8.7	8.9
64-79	0.51				5								5.8			8.4	8.9	9.1
79-91	0.46				2								5.1			8.5	9.0	9.2
91-99	0.16				6								3.7			8.6	9.1	9.3
99-130	0.04				2								5.2			8.6	9.2	9.3

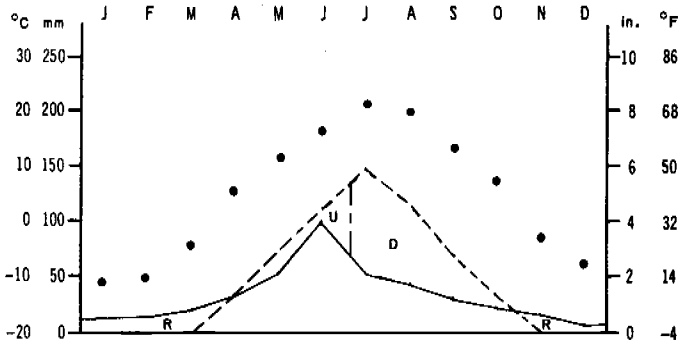
Depth (cm)	Extractable bases 6N2b Ca (meq/100 g)	6O2b Mg	6P2a Na	6Q2a K	5B1a Sum	6H1a Ext. acidity	Cat. exch. cap. 5A3a Sum cations	5A1a NH_4OAc	Water extract from saturated paste 8A1 — Ca (meq/liter)	Mg	6P1a Na	6Q1a K		CO_3	HCO_3	Cl	SO_4	8A1a Electrical conductivity (mmho/cm)
0-10	9.3	2.6	tr	0.6	12.5	3.2	15.7	13.2			0.4	0.4						0.6
10-30	9.5	3.0	tr	0.2	12.7	2.8	15.5	13.1			0.3	0.1						0.4
30-48	10.6	3.3	tr	0.1	14.0	1.8	15.8	13.4			0.4	tr						0.4
48-64			tr	0.1				11.2			0.5	0.1						0.5
64-79			0.1	0.1				8.6			0.7	0.1						0.6
79-91			0.1	0.1				8.1			1.2	0.1						0.6
91-99			0.1	0.1				5.8			1.3	0.1						0.6
99-130			0.1	0.1				10.4			1.0	0.1						0.5

Depth (cm)	8A Water at saturation (Pct.)	Exchangeable Na (Pct.)		Gypsum (Pct.)	Ratios to clay 8B1: NH_4OAc CEC		15-bar Water
0-10	37.0	tr			0.83		0.41
10-30	34.9	tr			0.82		0.42
30-48	42.0	tr			0.95		0.46
48-64	40.5	tr			0.53		0.38
64-79	31.7	1			0.82		0.55
79-91	23.7	1			1.4		0.89
91-99	29.5	1			1.1		0.67
99-130	40.1	1			1.3		0.63

Pedon 86

Classification: Typic Haploboroll, coarse-loamy, mixed.
Location: Stark County, N. Dak., 183 m E. and 30 m N. of the SW. corner SE 1/4 sec. 10, T. 139 N., R. 97 W.
Physiographic position: Broad flat high terrace.
Drainage: Well drained, moderate to rapid permeability.
Vegetation: Crested wheatgrass (Agropyron desertorum).
Parent material: Alluvium.
Sampled by: R. H. Jordan, K. E. Larson and L. Shoesmith, July 14, 1958.
Soil No.: S58NDak-45-1.

Climatic data and soil water balance



U, Utilization; D, Deficit; R, Recharge; S, Surplus; —— Precip. – – PE •• Temp.

SOIL Pedon 87 Typic Natriboroll SOIL Nos. S64NDak-6-6 LOCATION Bowman County, N. Dak.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 20107-20117

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1: Total: Sand (2–0.05) a/	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	<0.074	0.005–0.002	3A1b <0.0002	Coarse fragments 2A2 3B1 2–20 % <20
		Pct. of < 2 mm															
0–8	A11	61.0	29.9	9.1	0.1	0.5	3.2	30.1	27.1	17.9	12.0	63.6	33.9	54.8			-
8–18	A12	61.9	27.6	10.5	tr	0.4	3.1	30.3	28.1	18.3	9.3	65.5	33.8	54.5	3.2		-
18–25	A13	66.4	24.1	9.5	0.1	0.4	3.5	34.7	27.7	16.1	8.0	64.7	38.7	49.1	2.8		-
25–30	A2	72.5	21.4	6.1	0.2	0.4	4.2	40.3	27.4	13.9	7.5	65.4	45.1	42.1	2.5		tr
30–38	B21t	68.9	17.1	14.0	0.7	0.5	4.0	39.6	24.1	10.9	6.2	58.6	44.8	43.2	1.9	10.2	tr
38–53	B22t	66.2	14.3	19.5	0.4	0.4	3.7	40.5	21.2	7.4	6.9	52.9	45.0	43.9			tr
53–71	B31	82.4	8.3	9.3	-	0.4	6.0	55.6	20.4	4.3	4.0	56.7	62.0	25.9			tr
71–97	B32ca	81.9	9.2	8.9	0.3	1.6	11.9	47.9	20.2	5.6	3.6	51.5	61.7	26.6			tr
97–110	IIC1ca	59.0	22.1	18.9	0.3	1.4	6.9	22.6	27.8	11.4	10.7	51.3	31.2	56.0			tr
110–135	IIC2	61.4	19.7	18.9	-	0.5	1.1	14.1	45.7	9.4	10.3	68.0	15.7	59.2			-
135–170	IIC3	76.1	9.8	14.1	-	0.1	0.6	56.3	19.1	4.0	5.8	70.3	57.0	30.2			-

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N	Carbonate as $CaCO_3$: 6E1b 6E2a < 2mm Pct.	3A1a <0.002 mm Pct.	6C2a Ext. iron as Fe Pct.	Bulk density: g/cc	4A1d 1/3-bar g/cc	4A1h Air-dry g/cc	4D1 COLE	Water content: 4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm			pH: 8C1b Sat. paste	8C1a (1:1) H_2O	8C1a (1:10) H_2O
0–8	1.82	0.154	12			0.7		1.24	1.26	0.007	31.4	5.6	0.32				6.4	
8–18	0.93	0.102	9			0.9		1.40	1.43	0.007	25.2	4.8	0.29				6.9	
18–25	0.68	0.073	9			0.8		1.39	1.42	0.007	19.2	4.4	0.21				7.7	
25–30	0.47	0.052	9	-		0.9		1.39	1.41	0.003	17.1	3.4	0.19				8.4	
30–38	0.41	0.049	8	tr	-	1.3		1.60	1.75	0.032	18.0	7.7	0.16			8.1	9.0	9.1
38–53	0.48	0.055	9	1	-	1.2		1.48	1.66	0.040	22.4	8.6	0.20			8.1	8.6	9.1
53–71	0.21			1	-	0.9		1.52	1.56	0.010	17.9	4.0	0.21				8.5	
71–97	0.09			4	tr	1.7		1.61	1.69	0.017	16.8	4.8	0.19			8.5	9.3	9.6
97–110	0.19			7	tr	1.8		1.51	1.84	0.068	25.8	9.9	0.24				8.9	
110–135	0.32			5	-	1.2		1.25	1.44	0.047	32.4	11.8	0.26			7.8	8.1	8.9
135–170	0.07			2	-	0.4		1.33	1.54	0.052	29.3	9.0	0.27				8.6	

Depth (cm)	Extractable bases: 6N2a Ca c/	6O2a Mg d/	6P2a Na	6Q2a K	5B1a Sum	6H1a Ext. acidity	Cat. exch. cap.: 5A3a Sum cations	5A1a NH_4OAc	Water extract from saturated paste 8B1: 6N1a Ca	6O1a Mg	6P1a Na	6Q1a K		6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1a SO_4	8B1a Electrical conductivity mmho/cm
	meq/100 g								meq/liter									
0–8	7.2	2.8	0.1	0.8	10.9	4.1	15.0	11.6										
8–18	6.5	3.5	0.4	0.6	11.0	2.6	13.6	10.7										
18–25	5.6	3.1	1.2	0.4	10.3	2.3	12.6	9.7										
25–30	3.5	2.4	2.0	0.3	8.2	1.3	9.5	7.2										
30–38	3.7	4.5	5.9	0.5	14.6			11.8	1.6	1.2	38.6	0.3		-	10.0	6.7	22.8	3.4
38–53	8.2	6.9	10.4	0.6	26.1			15.6	18.9	21.5	132	0.6		-	9.0	5.7	152	11.7
53–71	5.2	3.2	5.9	0.3	14.6			8.4										
71–97	4.1	2.6	5.5	0.3	12.5			7.1	1.0	1.5	51.0	0.3		-	5.8	3.8	45.2	5.1
97–110	5.4	5.0	10.3	0.5	21.2			13.7										
110–135		7.3	13.9	0.6				20.3	25.9	20.4	135	1.0		-	3.0	8.1	176	13.0
135–170	4.6	4.7	10.8	0.4	20.5			15.2										

Depth (cm)	8B Water at saturation Pct.	5D2 Exchangeable Na Pct.	5E SAR	6F1a 8B1 Gypsum Pct.	Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water	Clay fraction mineralogy 7A1: 7A2 X-ray e/, f/
0–8					1.27	0.08	0.62	MI2,KK2,VR2
8–18					1.02	0.09	0.46	
18–25					1.02	0.08	0.46	
25–30					1.18	0.15	0.56	
30–38	35.1	38		-	0.84	0.09	0.55	MI2,KK2,VR2
38–53	43.2	30	29	-	0.80	0.06	0.44	
53–71					0.90	0.10	0.43	
71–97	39.2	49	46	-	0.80	0.19	0.54	
97–110					0.72	0.10	0.52	
110–135	60.6	28	28	1	1.07	0.06	0.62	
135–170					1.08	0.03	0.64	

a/ Carbonate comprises 1 to 5 percent of the sand below 38 cm.

b/ 8 kg/m² to 1.5 m (method 6A).

c/ KCl-TEA extraction (method 6N4b) used below 38 cm.

d/ KCl-TEA extraction (method 6O4b) used below 38 cm.

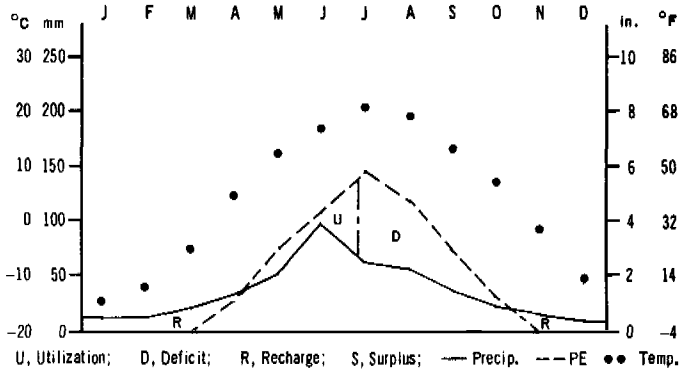
e/ Mineral code:
MI = mica
KK = kaolinite
VR = vermiculite, contains some chlorite interlayers

f/ Approximate weight fractions:
2 = one-twentieth to one-fifth

Pedon 87

Classification: Typic Natriboroll, coarse-loamy, mixed.
Location: Bowman County, N. Dak. 201 m S. and 302 m E. of NW. corner sec. 36, T. 130 N., R. 105 W.
Physiographic position: Upland, long sloping fan, elevation about 915 m.
Topography: Nearly level, 1 percent slope toward the SW.
Drainage: Well drained; moderately permeable.
Vegetation: Native grassland--blue grama (Bouteloua gracilis) and needleandthread (Stipa comata).
Parent material: Sediments from Hell Creek formation, Upper Cretaceous.
Sampled by: A. F. Bahr, R. B. Grossman, R. L. Juve and D. D. Opdahl, October 8, 1964.
Remarks: Dry to 1.2 m, slightly moist 1.2 to 1.8 m; 10.0° C. at 0.5 m, 12.2° C. at 1.5 m, 11.5 C. at 3 m, 10.1° C. at 4.6 m, 9.0° C. at 6.1 m, and 8.6° C. at 7.6 m.
Soil No.: S64NDak-6-6.

Climatic data and soil water balance



Colors are for the moist soil unless otherwise indicated.

A11 0-8 cm (0-3 in.). Very dark grayish brown (10YR 3/2) fine sandy loam, dark grayish brown (10YR 4/2) dry; medium and fine crumb structure; slightly hard (dry), very friable (moist), nonsticky and nonplastic (wet); abundant roots; clear smooth boundary.

A12 8-18 cm (3-7 in.). Very dark grayish brown (10YR 2.5/2) heavy fine sandy loam, dark gray (10YR 4/2) dry; weak medium subangular blocks break to fine subangular blocks; slightly hard (dry), very friable (moist), nonsticky and nonplastic (wet); abundant roots; clear smooth boundary.

A13 18-25 cm (7-10 in.). Very dark grayish brown (10YR 3/2) light fine sandy loam, dark grayish brown (10YR 4/2) dry; weak coarse prisms break to weak coarse blocks; slightly hard (dry), very friable (moist), nonsticky and nonplastic (wet); abundant roots; many pores; clear smooth boundary.

A2 25-30 cm (10-12 in.). Dark grayish brown (2.5Y 4/2) light fine sandy loam, light brownish gray (2.5Y 6/2) dry; weak coarse and medium plates; very friable (moist), nonsticky and nonplastic (wet); plentiful roots; plates stained very dark grayish brown (10YR 3.5/2) and grayish brown (10YR 5/2) dry; abrupt smooth boundary.

B21t 30-38 cm (12-15 in.). Olive brown (2.5Y 4/3) heavy fine sandy loam, light olive brown (2.5Y 5/3) dry; strong coarse columns break to strong medium angular blocks; extremely hard (dry), very firm (moist), slightly sticky and slightly plastic (wet); plentiful roots restricted largely to ped surfaces, ped surfaces very dark grayish brown (2.5Y 3/2), dark grayish brown (2.5Y 4/2) dry; clear smooth boundary.

B22t 38-53 cm (15-21 in.). Olive brown (2.5Y 4/4) heavy fine sandy loam, light olive brown (2.5Y 5/3) dry; strong coarse prisms break to strong medium angular blocks; extremely hard (dry), very firm (moist), slightly sticky and slightly plastic (wet); many coarse calcium carbonate nodules; calcium carbonate coats ped faces; parts noncalcareous; plentiful roots restricted largely to ped surfaces; gradual wavy boundary.

B31 53-71 cm (21-28 in.). Olive brown (2.5Y 4/4) loamy fine sand, light olive brown (2.5Y 5/3) dry; weak coarse prisms break to weak coarse subangular blocks; extremely hard (dry), very friable (moist), nonsticky and nonplastic (wet); few roots; noncalcareous except for nodular and fine thread-like segregations of calcium carbonate; gradual wavy boundary.

B32ca 71-97 cm (28-38 in.). Olive (5Y 4/3) loamy fine sand, olive gray (5Y 5/2) dry; weak coarse and medium subangular blocks; very hard (dry), very friable (moist), nonsticky and nonplastic (wet); few roots; strongly calcareous with many fine nodular segregations of calcium carbonate; gradual wavy boundary.

IIC1ca 97-110 cm (38-43 in.). Olive (5Y 4/3) heavy fine sandy loam, olive (5Y 5/3) dry; moderate medium angular blocks; hard (dry), very friable (moist), sticky and plastic (wet); calcareous with common nodular segregations of calcium carbonate; gradual wavy boundary.

IIC2 110-135 cm (43-53 in.). Olive (5Y 4/3) heavy fine sandy loam, light olive gray (5Y 6/2) dry; massive (stratified); hard (dry), friable (moist), slightly sticky and nonplastic (wet); noncalcareous with few bands of calcium carbonate.

IIC3 135-170 cm (53-67 in.). Olive (5Y 4/3) heavy fine sandy loam; olive (5Y 5/3) dry; massive (stratified); slightly hard (dry), friable (moist), slightly sticky and nonplastic (wet).

SOIL Pedon 88 Typic Rendoll SOIL Nos. S58PR-4-6 LOCATION Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 9811-9813

General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand a/ (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2 3B1 2-20 Pct. < 20
		Pct. of < 2 mm														
0-15	Ap	48.3	24.4	27.3	3.5	11.6	9.4	16.8	7.0	8.1	16.3	23.8	41.3			tr
15-23	B	29.4	53.2	17.4	1.8	6.0	5.4	10.6	5.6	14.2	39.0	25.4	23.8			tr
23-58	C	28.6	60.9	10.5	2.2	6.3	4.9	9.3	5.9	8.9	52.0	20.0	22.7			tr

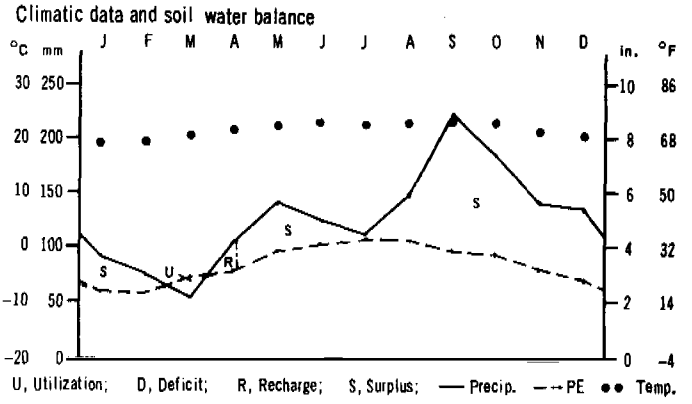
Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ 6E1a < 2 mm Pct.	6E1c <0.002 mm Pct.	Bulk density g/cc	g/cc	4A1h Oven-dry g/cc	Water content Pct.	Pct.	4B2 15-bar Pct.	pH 8C1a (1:1) H_2O
0-15	2.16	0.214	10	1.0	22				1.48			13.0	7.6
15-23	0.90	0.102	9	0.6	61	1			1.36			8.5	7.7
23-58	0.022	0.020		0.4	78	1			1.40			5.0	8.0

Depth (cm)	Extractable bases 5B1a Ca	Mg	6P2a Na	6Q2a K	Sum	Cat.exch.cap. 5A1a NH_4OAc	Ratios to clay 8D1 NH_4OAc CEC	Ext. iron	15-bar water	Base saturation Pct.	Pct.
	meq/100 g										
0-15			0.3	0.2		21.6	0.79	0.04	0.48		
15-23			tr	0.1		11.7	0.67	0.03	0.49		
23-58			0.1	0.1		5.6	0.52	0.04	0.48		

a/Carbonate grains < 5 percent in the Ap horizon and 25-50 percent in the B and C horizons.

Pedon 88

Classification: Typic Rendoll, coarse-loamy, carbonatic, isohyperthermic.
Location: Puerto Rico. Approximately 100 m N. of a road 0.8 km W. of kilometer marker 1.3 on Highway No. 165. About 20 km (12 mi.) WSW. of San Juan.
Physiographic position: Footslope below a limestone hill.
Topography: Slope is 20 percent with S. aspect.
Drainage: Well drained. Moderate permeability.
Vegetation: Unimproved pasture; brush.
Parent material: Residuum or local colluvium from limestone.
Sampled by: L. T. Alexander, F. Llavat-Cristy, K. W. Flach, R. E. Gierbolini, J. Juarez, L. H. Rivera and T. U. Yager, November 6, 1958.
Remarks: Sampled at 1/2-field capacity.
Soil No.: S58PR-4-6.



Colors are for moist soil.

Ap 0-15 cm (0-6 in.). Very dark grayish brown (10YR 3/2) sandy clay loam; weak fine subangular blocks breaking to fine granules; friable (moist), slightly sticky and plastic (wet); common fine and medium very pale brown (10YR 7/4) soft nodules of lime; violent effervescence; thin zone of highly contrasting colors of dark red and grayish brown between this and the subjacent horizon; clear smooth boundary.

B 15-23 cm (6-9 in.). Very pale brown (10YR 7/4) silt loam; massive; friable (moist), slightly sticky and slightly plastic (wet); white soft fragments of lime common; semihardened lime-cemented lenses make up 10 percent of the horizon; tongues of the Ap comprise about 15 percent of the soil mass; violent effervescence; clear smooth boundary.

C 23-58 cm (9-23 in.). Very pale brown (10YR 7/4) silt loam; massive; friable (moist), slightly sticky (wet); many white soft fragments of lime; violent effervescence.

Pedon 89

SOIL Typic Argiudoll SOIL Nos. S59Iowa-86-1 LOCATION Tama County, Iowa

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 11528-11537

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand[a] (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: (0.05–0.02)	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2 3B1 2-20 Pct. < 20
		Pct. of < 2 mm														
0-18	Ap	2.2	69.2	28.6	0.1	0.2	0.3	0.4	1.2	36.2	33.0	37.6	1.0			-
18-28	A12	1.8	66.0	32.2	-	0.2	0.2	0.3	1.1	33.2	32.8	34.4	0.7			-
28-43	A3	1.8	64.0	34.2	-	0.2	0.2	0.3	1.1	31.2	32.8	32.4	0.7			-
43-51	B1t	1.6	62.8	35.6	-	0.1	0.1	0.2	1.2	32.3	30.5	33.6	0.4			-
51-64	B21t	1.6	63.0	35.4	-	0.1	0.1	0.2	1.2	34.4	28.6	35.7	0.4			-
64-74	B22t	1.6	65.2	33.2	-	-	-	0.2	1.4	34.7	30.5	36.2	0.2			-
74-89	B23t	1.6	67.9	30.5	-	-	-	0.1	1.5	37.5	30.4	39.1	0.1			-
89-115	B31	1.8	70.0	28.2	-	-	-	0.1	1.7	38.6	31.4	40.4	0.1			-
115-130	B32	2.3	69.2	28.5	-	-	-	0.1	2.2	41.1	28.1	43.4	0.1			-
130-155	C1	3.4	69.0	27.6	0.2	0.4	0.3	0.5	2.0	41.9	27.1	44.1	1.4			-

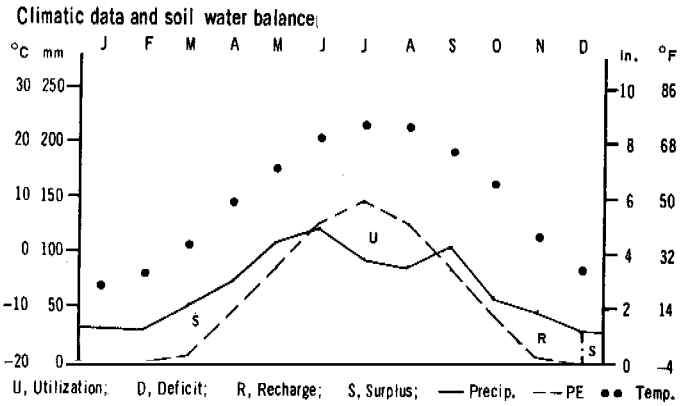
Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N		6E1a Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density g/cc	g/cc	g/cc		Water content Pct.	Pct.	4B2 15-bar Pct.			pH 8C1a 1:1 H_2O
0-18	2.35	0.210	11			0.6							12.7			5.7
18-28	1.95	0.174	11			1.1							13.6			5.8
28-43	1.42	0.131	11			1.1							14.4			5.7
43-51	0.97	0.095	10			1.1							15.0			5.5
51-64	0.68	0.072	9			1.2							14.2			5.7
64-74	0.45	0.054	8			1.2							13.8			5.7
74-89	0.34	0.041				1.2							13.3			5.7
89-115	0.21	0.032				1.2							12.6			5.8
115-130	0.15	0.026				1.1							12.4			6.1
130-155	0.12	0.025			-	1.1							12.2			6.5

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap: 5A3a Sum cations	5A1a NH_4OAc	8A Water at saturation Pct.	8A1a Elec. cond. mmhos/cm.	Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water	8D3 Ca/Mg	Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g															
0-18	13.9	3.4	0.1	0.5	17.9	9.3	27.2	20.6	50.9	0.4	0.72	0.02	0.44	4.1	66	87
18-28	13.8	4.2	0.1	0.4	18.5	11.4	29.9	21.4	57.1	0.4	0.66	0.03	0.42	3.3	62	86
28-43	14.3	5.8	0.1	0.4	20.6	9.6	30.2	23.8	60.9	0.4	0.70	0.03	0.42	2.5	68	86
43-51	14.6	6.4	0.1	0.4	21.5	8.5	30.0	24.0	60.5	0.3	0.67	0.03	0.42	2.3	72	90
51-64	15.0	6.8	0.1	0.4	22.3	8.1	30.4	23.6	61.0	0.3	0.67	0.03	0.40	2.2	73	94
64-74	14.7	6.6	0.1	0.3	21.7	7.6	29.3	22.8	59.3	0.3	0.69	0.04	0.42	2.2	74	95
74-89	14.3	6.6	0.1	0.3	21.3	6.8	28.1	21.7	59.7	0.2	0.71	0.04	0.44	2.2	76	98
89-115	14.4	5.8	0.1	0.3	20.6	6.1	26.7	20.9	60.0	0.3	0.74	0.04	0.45	2.5	77	98
115-130	15.2	5.7	0.1	0.3	21.3	5.1	26.4	20.3	55.9	0.5	0.71	0.04	0.44	2.7	81	105
130-155	16.1	5.6	0.2	0.4	22.3	4.1	26.4	20.1	56.5	0.6	0.73	0.04	0.44	2.9	84	111

[a] Iron-manganese nodules comprise a major portion of the sand.

Pedon 89

Classification: Typic Argiudoll, fine-silty, mixed, mesic.
Location: Tama County, Iowa, 360 m N. and 13 m W. of SE. corner of NW 1/4 NW 1/4 sec. 14, T. 85 N., R. 13 W. About 120 km (75 mi.) NE. of Des Moines.
Physiographic position: Upland.
Topography: Undulating, 2 to 3 percent slightly convex at site.
Drainage: Well drained.
Vegetation: Alfalfa.
Parent material: Wisconsinan age loess, glacial till occurs at depth.
Sampled by: F. F. Riecken, E. C. A. Runge, W. D. Shrader and R. I. Turner, July 23, 1959.
Soil No.: S59Iowa-86-1.



Colors are for the moist soil unless otherwise indicated.

Ap 0-18 cm (0-7 in.). Black to very dark brown (10YR 2/1.5) light silty clay loam, very dark brown (10YR 2/2) crushed; weak fine to medium subangular blocky structure; friable to slightly firm (moist); abundant roots; many earthworms and earthworm holes; gradual boundary.

A12 18-28 cm (7-11 in.). Black to very dark brown (10YR 2/1.5) light silty clay loam, very dark brown (10YR 2/2) crushed; moderate fine to medium granular structure; friable (moist); abundant roots; many earthworms and earthworm holes; gradual boundary.

A3 28-43 cm (11-17 in.). Black to very dark brown (10YR 2/1.5) and very dark grayish brown (10YR 3/2) light silty clay loam, darker color on peds; moderate fine subangular blocky structure; friable (moist); abundant roots; many earthworms and earthworm holes; gradual boundary.

B1t 43-51 cm (17-20 in.). Very dark grayish brown (10YR 3/2) and dark brown (10YR 4/3) heavy silty clay loam, darker color on peds, very dark brown to brown (10YR 4/3) crushed; moderate fine subangular blocky structure; friable (moist); abundant roots; dry ped surfaces exhibit very thin gray coatings of silt; common earthworm holes; gradual boundary.

B21t 51-64 cm (20-25 in.). Very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) heavy silty clay loam, darker color on peds; brown to dark yellowish brown (10YR 4/3.5) crushed; moderate fine to medium subangular blocky structure; slightly firm (moist); abundant roots; very thin gray coatings of silt on ped surfaces; common earthworm holes and small pores; gradual boundary.

B22t 64-74 cm (25-29 in.). Brown to dark brown (10YR 4/3) light silty clay loam, brown to dark brown (10YR 4/3.5) crushed, some dark yellowish brown (10YR 3/4) ped coatings; moderate medium subangular blocky structure; friable to slightly firm (moist); very thin gray ped coatings of silt more patchy than in above horizons; abundant roots; common earthworm holes and small pores; gradual boundary.

B23t 74-89 cm (29-35 in.). Brown to dark brown (10YR 4/3.5) light silty clay loam, dark yellowish brown (10YR 4/4) crushed; weak fine prisms separate to moderate medium subangular blocks, friable to slightly firm (moist); very thin gray ped coatings of silt; abundant roots; common earthworm holes and pores; gradual boundary.

B31 89-115 cm (35-45 in.). Dark yellowish brown to yellowish brown (10YR 4.5/4) light silty clay loam, few fine faint brown (10YR 5/3) to yellowish brown (10YR 5/6) mottles; weak medium prisms separate to moderate to weak medium subangular blocks; thin patchy gray ped coatings of silt; abundant roots; many pores; few to common earthworm holes; gradual boundary.

B32 115-130 cm (45-51 in.). Yellowish brown (10YR 5/4) light silty clay loam, brown (10YR 5/3) coatings on prisms, common fine distinct yellowish brown (10YR 5/6) and light brownish gray (10YR 6/2) mottles; weak coarse prisms; friable (moist); gray to light gray (10YR 6/1) dry grainy coatings of silt on prisms; plentiful roots; common pores; few fine uncemented dark iron-manganese nodules; gradual boundary.

C1 130-155 cm (51-61 in.). Yellowish brown (10YR 5/4) light silty clay loam, brown (10YR 5/3) coatings on prisms, few fine faint yellowish brown (10YR 5/6) and light brownish gray (10YR 6/2) mottles; weak coarse prisms; friable (moist); gray to light gray (10YR 6/1) dry coatings of silt on prisms; plentiful roots; common pores; few fine soft dark uncemented iron-manganese aggregates.

SOIL Pedon 90 Typic Hapludoll SOIL Nos. S63Iowa-83-2 LOCATION Shelby County, Iowa

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 18365-18374

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2-0.05) a/	Total: Silt (0.05-0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: (0.05-0.02)	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)			Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-18	Ap	3.0	66.6	30.4	0.1	0.1	0.1	0.2	2.5	38.7	27.9	41.3	0.5					-
18-33	A12	2.6	63.9	33.5	tr	0.1	0.1	0.2	2.2	35.7	28.2	38.0	0.4					-
33-46	A3	2.8	64.4	32.8	tr	0.1	0.1	0.2	2.4	36.1	28.3	38.6	0.4					-
46-69	B21	3.2	66.4	30.4	tr	0.1	0.1	0.2	2.8	38.9	27.5	41.8	0.4					-
69-86	B22	4.1	67.7	28.2	-	tr	0.1	0.3	3.7	39.7	28.0	43.6	0.4					-
86-110	B31	4.1	69.0	26.9	-	0.1	0.1	0.3	3.6	41.6	27.4	45.4	0.5					-
110-125	B32	3.8	68.2	28.0	-	tr	tr	0.2	3.6	39.4	28.8	43.1	0.2					-
125-145	C1	3.7	69.4	26.9	-	tr	tr	0.2	3.5	40.5	28.9	44.1	0.2					-
145-175	C2	4.7	69.6	25.7	-	tr	0.1	0.2	4.4	41.9	27.7	46.4	0.3					-
175-195	C3	4.1	70.5	25.4	-	tr	0.1	0.3	3.7	40.2	30.3	44.1	0.4					-

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N		6E2a Carbonate as $CaCO_3$ Pct.	6C2a Ext. iron as Fe Pct.	Bulk density: g/cc	4A1d 1/3-bar c/ g/cc	4A1b Air-dry g/cc	4D1 COLE	Water content: 4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm			pH		8C1a (1:1) H_2O
0-18	2.20	0.195	11			1.3		1.31	1.41	0.024	24.4	13.0	0.15					5.6
18-33	1.87	0.156	12			1.3		1.25	1.37	0.032	27.4	14.1	0.17					5.7
33-46	1.11	0.106	10			1.3		1.24	1.36	0.032	26.4	14.5	0.15					5.8
46-69	0.58	0.062	9			1.3		1.23	1.34	0.028	26.1	14.0	0.15					5.8
69-86	0.33					1.4		1.24	1.36	0.032	25.5	13.4	0.15					5.9
86-110	0.21					1.3		1.3				12.8						5.9
110-125	0.17					1.3		1.31	1.44	0.032	27.0	13.7	0.17					6.0
125-145	0.11					1.4		1.34	1.46	0.028	26.7	13.6	0.18					6.0
145-175	0.10					1.2		1.3				12.6						6.2
175-195	0.10				-	1.5						12.6						6.3

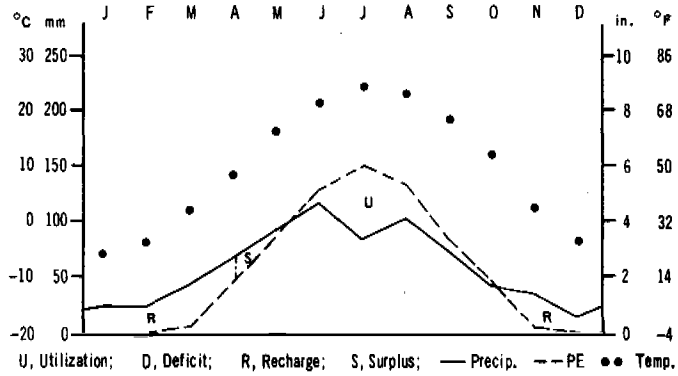
Depth (cm)	Extractable bases 5B1a: 6N2a Ca	6O2a Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap.: 5A3a Sum cations	5A1a NH_4OAc			Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water		8D3 Ca/Mg		Base saturation: 5C3 Sum cations	5C1 NH_4OAc
	meq/100 g																Pct.	Pct.
0-18	13.9	4.3	0.1	0.8	19.1	11.0	30.1	22.0			0.72	0.043	0.43		3.2		63	87
18-33	14.7	5.5	0.1	0.6	20.9	9.8	30.7	22.9			0.68	0.039	0.42		2.7		68	91
33-46	14.8	6.3	0.1	0.6	21.8	8.2	30.0	21.6			0.66	0.040	0.44		2.3		73	101
46-69	14.8	6.6	0.1	0.6	22.1	6.6	28.7	20.0			0.66	0.043	0.46		2.2		77	111
69-86	14.7	6.6	0.1	0.5	21.9	5.1	27.0	20.7			0.73	0.050	0.48		2.2		81	106
86-110	14.6	6.8	0.2	0.6	22.2	4.9	27.1	20.4			0.76	0.049	0.48		2.1		82	109
110-125	15.2	6.9	0.2	0.6	22.9	4.6	27.5	20.7			0.74	0.046	0.49		2.2		83	111
125-145	14.6	6.9	0.2	0.6	22.3	4.2	26.5	20.8			0.77	0.052	0.51		2.1		84	107
145-175	13.8	6.7	0.2	0.6	21.3	3.8	25.1	19.7			0.77	0.047	0.49		2.1		85	108
175-195	13.7	7.0	0.2	0.6	21.5	3.8	25.3	18.3			0.72	0.059	0.50		2.0		85	117

a/ Over 50 percent iron-manganese nodules in 2-0.1 mm.
b/ 14 kg/m² to 1.5 m (method 6A).
c/ Values for the B31 and C2 horizons are estimated.

Pedon 90

Classification: Typic Hapludoll, fine-silty, mixed, mesic.
Location: Shelby County, Iowa, 132 m S. and 373 m W. of center of road corner NE 1/4 NW 1/4 sec. 28, T. 78 N., R. 38 W., approximately 5 km (3 mi.) N. of Walnut, Iowa, about 135 km (85 mi.) W. of Des Moines.
Physiographic position: Gently rolling, upland.
Topography: Site on axis of a poorly defined short interfluve, slope 3 percent W.
Drainage: Well drained, moderately permeable.
Vegetation: Alfalfa.
Parent material: Wisconsinan age loess.
Sampled by: R. I. Dideriksen, C. S. Fisher, R. H. Jordan and E. D. Rivers, May 14, 1963.
Remarks: Moist. No water table within 2 m. Rodent burrows at 25, 50 and 140 cm.
Soil No.: S63Iowa-83-2.

Climatic data and soil water balance



Colors are for the moist soil unless otherwise indicated.

Ap 0-18 cm (0-7 in.). Very dark brown (10YR 2/2) light silty clay loam, dark gray (10YR 4/1) to grayish brown (10YR 5/2) dry; weak medium subangular blocks break to weak fine granules; friable (moist); common fine and medium root channels; abundant roots; weak plow pan at 15 to 20 cm; clear smooth boundary.

A12 18-33 cm (7-13 in.). Very dark brown (10YR 2/2) light silty clay loam, grayish brown (10YR 5/2) dry, weak fine subangular blocky and fine granular structure; friable (moist); abundant roots; few wormcasts; clear smooth boundary.

A3 33-46 cm (13-18 in.). Very dark grayish brown (10YR 3/2) light silty clay loam, dark brown to brown (10YR 4/3) crushed grayish brown (10YR 5/2) and pale brown (10YR 6/3) dry; weak fine subangular blocky structure; friable (moist); common fine and very fine pores; few dark wormcasts and fillings in root channels; clear smooth boundary.

B21 46-69 cm (18-27 in.). Dark brown to brown (10YR 4/3) light silty clay loam, yellowish brown (10YR 5/4) crushed; pale brown (10YR 6/3) dry; weak fine subangular blocky structure; friable (moist); pores as above; thin discontinuous clay skins on some peds; very few dark fillings in root channels; gradual smooth boundary.

B22 69-86 cm (27-34 in.). Dark brown to brown (10YR 4/3) light silty clay loam, common fine grayish brown (2.5Y 5/2) and a few fine dark yellowish brown (10YR 4/4) mottles; weak medium prisms break to weak medium subangular blocks; friable (moist); pores as above; a few very thin discontinuous clay skins on some vertical ped faces; few very fine uncemented dark brown to black iron-manganese nodules; gradual smooth boundary.

B31 86-110 cm (34-43 in.). Yellowish brown (10YR 5/4) heavy silt loam, many medium grayish brown (2.5Y 5/2) and common fine dark brown to brown (7.5YR to 10YR 4/4) mottles; structure and consistence as above; many fine and very fine pores; less clay skins than above; common fine uncemented dark brown to black iron-manganese nodules; gradual smooth boundary.

B32 110-125 cm (43-49 in.). Mottled yellowish brown (10YR 5/4) and olive gray (5Y 5/2) light silty clay loam, common fine dark brown to brown (7.5YR 4/4) mottles; weak medium prisms break to very weak medium subangular blocks; friable (moist); pores as above; some darker fillings in vertical channels; very few indistinct silt coats on some vertical ped faces; common fine uncemented dark brown to black iron-manganese nodules; diffuse smooth boundary.

C1 125-145 cm (50-57 in.). Mottled dark brown to brown (10YR to 7.5YR 4/4) and olive gray (5Y 5/2) heavy silt loam; massive with some vertical cleavage; friable (moist); common fine and very fine pores; silt coats on some vertical ped faces; slight increase in iron-manganese aggregates; diffuse smooth boundary.

C2 145-175 cm (57-69 in.). Mottled yellowish brown (10YR 5/6) and olive gray (5Y 5/2) heavy silt loam; massive with some vertical cleavage; friable (moist); pores as above; some indistinct silt coats on cleavage faces; iron-manganese aggregates same as above horizon; diffuse smooth boundary.

C3 175-195 cm (68-77 in.). Same as above horizon but no cleavage noted.

SOIL: Pedon 91 Typic Paleudoll — SOIL Nos. S60-Okla-58-1 — LOCATION: Ottawa County, Okla.

SOIL SURVEY LABORATORY: Lincoln, Nebr. — LAB. Nos. 13393-13399

General Methods: 1A, 1B1a, 2A1, 2B

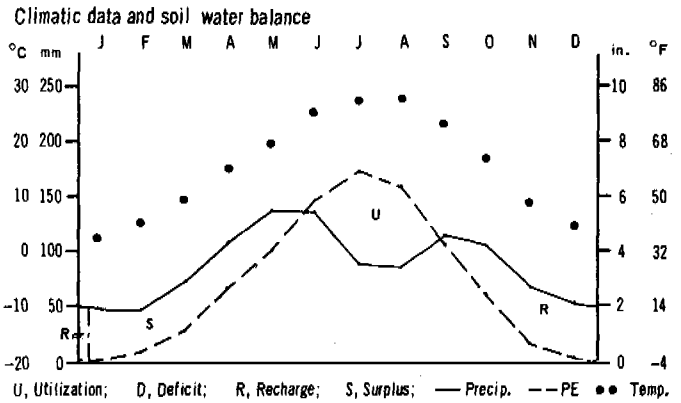
Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1) a/	Sand: Coarse (1–0.5) a/	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2: 3B1 2–20 Pct. < 20
		Pct. of < 2 mm														
0-15	Ap	17.5	67.1	15.4	-	0.3	1.2	7.0	9.0	35.2	31.9	49.1	8.5			-
15-23	A12	17.6	66.0	16.4	0.1	0.3	1.2	7.3	8.7	34.1	31.9	47.8	8.9			-
23-46	B1	14.6	61.1	24.3	-	0.4	1.1	5.8	7.3	30.2	30.9	41.6	7.3			-
46-66	B21t	13.7	54.4	31.9	0.2	0.4	1.0	5.4	6.7	25.0	29.4	35.5	7.0			tr
66-100	B22t	16.0	41.8	42.2	0.3	0.5	1.1	6.1	8.0	23.2	18.6	35.4	8.0			tr
100-130	B31t	17.8	40.5	41.7	0.5	0.8	1.2	6.7	8.6	22.5	18.0	35.6	9.2			tr
130-155	B32t	19.6	38.8	41.6	4.2	1.3	1.0	5.6	7.5	21.3	17.5	32.6	12.1			7

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N	6C1a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ Pct.		Bulk density: 4A1a Field state g/cc	4A1c 30-cm g/cc	4A1h Oven-dry g/cc		Water content: 4B4 Field state Pct.	4B1b 1/3-bar Pct.	4B3 30-cm Pct.	4B2 15-bar	4C1 30 cm to 15-bar cm/cm		pH: 8C1b (1:1) H_2O
0-15	0.87	0.088	10	1.0			1.50	1.49	1.54		20.8		21.3	5.7	0.23		6.5
15-23	0.82	0.087	9	1.0			1.49	1.48	1.51		18.0		21.4	5.5	0.24		6.4
23-46	0.70	0.089	8	1.3			1.50	1.47	1.54		16.6	18.8	21.5	8.3	0.19		6.2
46-66	0.60	0.083	7	1.7			1.57	1.52	1.64		15.4	19.9	21.3	11.0	0.16		5.5
66-100	0.40			2.4			1.64	1.59	1.70		18.0	21.8	21.4	15.1	0.10		5.4
100-130	0.24			2.4			1.62	1.56	1.70		18.8	22.9	22.0	15.4	0.10		5.4
130-155	0.21			3.3										16.1			5.2

Depth (cm)	Extractable bases 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	5B1a Sum	6H2a Ext. acidity	Cat. exch. cap. 5A3a Sum cations	5A1a NH_4OAc		Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water		8D3 Ca/Mg		Base saturation 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																
0-15	5.6	0.6	-	0.5	6.2	9.9	7.3	6.7		0.47	0.06	0.37		9.3		68	92
15-23	5.8	0.7	-	0.3	6.8	10.0	7.3	6.8		0.44	0.06	0.34		8.3		68	93
23-46	4.8	1.3	-	0.3	6.4	11.2	8.0	6.4		0.33	0.05	0.34		3.7		57	80
46-66	4.8	2.4	-	0.3	7.5	14.1	9.8	7.5		0.31	0.05	0.34		2.0		53	76
66-100	5.7	3.9	-	0.3	9.9	17.8	12.4	9.9		0.29	0.06	0.36		1.5		56	80
100-130	5.4	4.3	-	0.3	10.0	17.6	13.4	10.0		0.32	0.06	0.37		1.2		57	75
130-155	5.7	4.6	-	0.4	10.7	18.9	14.1	10.7		0.34	0.08	0.39		1.2		57	76

Pedon 91

Classification: Typic Paleudoll, fine-silty, siliceous, thermic.
Location: Ottawa County, Okla., 100 m N. and 30 m E. of W. 1/4 corner sec. 21, T. 27 N., R. 23 E. About 120 km (75 mi.) NW. of Tulsa.
Physiographic position: Upland. Elevation about 250 m.
Topography: 1-2 percent slope WNW.
Drainage: Well drained.
Vegetation: Rye, wheat, barley.
Parent material: Presumed residuum weathered from limestone.
Sampled by: J. S. Allen, R. Bain, J. M. Downs, F. J. Dries, C. Newland and D. J. Polone, June 6, 1960.
Soil No.: S60-Okla-58-1.



Colors are for the dry soil unless otherwise indicated.

Ap 0-15 cm (0-6 in.). Dark brown (7.5YR 4/4) light silt loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; friable (moist); abundant roots; clear boundary.

A12 15-23 cm (6-9 in.). Brown (7.5YR 4/4) light silt loam, dark brown (7.5YR 3/2) moist; moderate medium granular structure; friable (moist); clear boundary.

B1 23-46 cm (9-18 in.). Reddish brown (5YR 5/4) heavy silt loam, reddish brown (5YR 4/3) moist; weak medium subangular blocky to coarse granular structure; friable (moist); numerous wormcasts; abundant roots; diffuse boundary.

B21t 46-66 cm (18-26 in.). Yellowish red (5YR 5/6) light silty clay loam, yellowish red (5YR 4/6) moist; weak fine subangular blocky structure; friable (moist); diffuse boundary.

B22t 66-100 cm (26-40 in.). Red (2.5YR 4/6) silty clay, dark red (2.5YR 3/6) moist; prisms break to subangular blocks; few roots; few thin clay skins on ped surfaces; diffuse boundary.

B31t 100-130 cm (40-51 in.). Red (2.5YR 4/6), dark red (2.5YR 3/6) moist silty clay; weak subangular blocky structure; clay skins on ped surfaces; some small chert pebbles at the lower depth; diffuse boundary.

B32t 130-155 cm (51-61 in.). Red (2.5YR 5/6) light clay, red (2.5YR 4/6) moist; weak subangular blocky structure; numerous concretions and small chert pebbles.

Pedon 92

SOIL Pachic Argiustoll SOIL Nos. S65Nebr-91-1 LOCATION Webster County, Nebr.

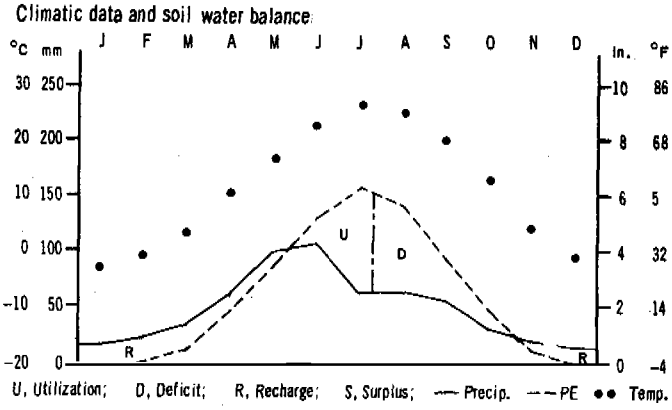
SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 20449-20456

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1														Coarse fragments 2A2		
		Total			Sand					Silt								
		b/ Sand (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	0.05–0.02	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	0.005–0.002	<0.0002			3B1 2-20 Pct. < 20
		← Pct. of < 2 mm →																
0-13	A11	9.5	67.4	23.1	-	0.1	0.1	0.3	9.0	50.6	16.8	59.9	0.5	3.2	16.7			-
13-25	A12	7.5	59.3	33.2	-	-	0.1	0.1	7.3	41.5	17.8	48.9	0.2	3.5	25.9			-
25-41	B1	5.6	51.8	42.6	-	-	-	-	5.6	34.1	17.7	39.7	-	4.2	33.7			-
41-58	B2t	5.1	50.2	44.7	-	-	-	-	5.1	31.0	19.2	36.1	-	5.3	34.5			-
58-79	B3	6.4	56.8	36.8	-	-	-	0.1	6.3	35.6	21.2	42.0	0.1	4.5	23.4			-
79-100	C1ca	7.3	69.5	23.2	0.1	0.1	0.1	0.2	6.8	41.1	28.4	48.1	0.5	7.6	7.2			-
100-130	C2	7.8	67.2	25.0	-	-	-	0.1	7.7	41.6	25.6	49.4	0.1	5.8	9.4			-
130-150	C3	7.0	68.0	25.0	-	-	0.1	0.2	6.7	40.0	28.0	46.9	0.3	6.7	9.6			-
58-79	a/	6.8	55.4	37.8	-	-	0.1	0.3	6.4	33.8	21.6	40.4	0.4	4.1	22.5			
79-100	a/	7.3	60.2	32.5	-	-	0.1	0.3	6.9	37.1	23.1	44.2	0.4	4.3	17.3			
100-130	a/	7.6	61.4	31.0	-	-	0.1	0.4	7.1	37.8	23.6	45.2	0.5	4.7	16.2			
130-150	a/	7.1	64.1	28.8	-	-	0.1	0.4	6.6	37.8	26.3	44.7	0.5	4.9	15.4			

Pedon 92

Classification: Pachic Argiustoll; fine, montmorillonitic, mesic.
Location: Webster County, Nebr. 250 m W. and 55 m S. of NE. corner sec. 1, T. 3 N., R. 10 W. 80 km (50 mi.) S. of Grand Island.
Physiographic position: Stable upper interfluve, dissected upland; elevation 605 m.
Topography: 1 to 2 percent with east aspect.
Drainage: Moderately well drained; moderately slow permeability.
Vegetation: Native grasses, principally big bluestem (Andropogon gerardi), sideoats grama (Bouteloua curtipendula), western wheatgrass (Agropyron smithii), blue grama (Bouteloua gracilis), Scribner panicum (Panicum scribnerianum), Kentucky bluegrass (Poa pratensis) and June-grass (Koeleria cristata).
Parent material: Wisconsinan loess (Peorian).
Sampled by: J. V. Drew and R. H. Jordan, April 21, 1965.
Remarks: Good root distribution, no restrictive zones.
Soil No.: S65Nebr-91-1.



Colors are for the dry soil unless otherwise indicated.

A11 0-13 cm (0-5 in.). Dark gray (10YR 4/1) to black (10YR 2/1) moist silt loam; moderate fine granular structure; soft (dry), friable (moist); abundant roots; noncalcareous; clear smooth boundary.

A12 13-25 cm (5-10 in.). Dark grayish brown (10YR 4/2) to very dark brown (10YR 2/2) moist light silty clay loam; moderate fine to medium granular structure; soft (dry), friable (moist); abundant roots; occasional pea-size nests of insect and/or wormcasts about 1 mm in diameter; noncalcareous; clear smooth boundary.

B1 25-41 cm (10-16 in.). Dark grayish brown (10YR 4/2) to very dark grayish brown (10YR 3/2) moist silty clay; weak fine subangular blocks break to moderate medium granular; soft (dry), friable (moist); [illegible]

SOIL Pedon 93 Typic Calciustoll SOIL Nos. S60Tex-33-3 LOCATION Carson County, Tex.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 12711-12714

General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 Total: Sand[a] (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: (0.05–0.02)	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	Clay 3A1a Carbonate Pct.	Clay 3A1a Non-carbonate Pct.	Coarse fragments 2A2		3B1 2-20 Pct. < 20
		← Pct. of < 2 mm →																
0-20	A1	30.7	49.6	19.7	< 0.1	0.5	0.7	4.9	24.6	37.8	11.8	66.1	6.1	6	14			-
20-56	B2ca	20.1	48.7	31.2	< 0.1	0.4	0.7	2.9	16.1	30.5	18.2	48.7	4.0	13	18			tr
56-120	C1ca	14.6	55.4	30.0	< 0.1	0.2	0.4	1.7	12.3	33.7	21.7	47.2	2.3	9	21			tr
120-205	C2	26.7	48.9	24.4	< 0.1	0.3	0.5	3.2	22.7	33.5	15.4	58.9	4.0	6	18			tr

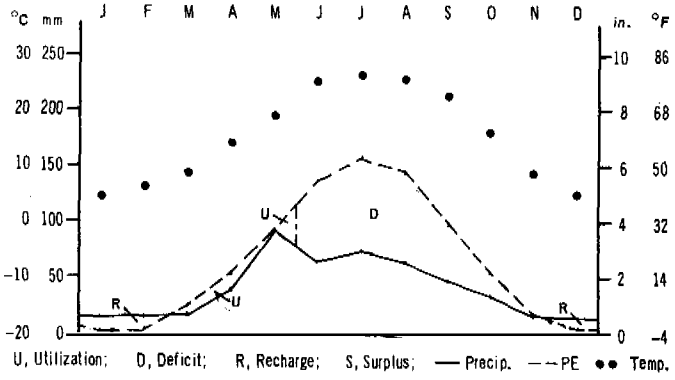
Depth (cm)	6A1a Organic carbon Pct.	Nitrogen Pct.	C/N		6E1a Carbonate as $CaCO_3$ Pct.		Bulk density g/cc	g/cc	g/cc		Water content Pct.	Pct.	Pct.			ph		8C1a (1:1) H_2O
0-20	1.56				12													7.7
20-56	1.05				24													7.8
56-120	0.24				22													8.0
120-205	0.06				14													8.3

[a] Few to common carbonate nodules.

Pedon 93

Classification: Typic Calciustoll, fine-silty, mixed, thermic.
Location: Carson County, Tex., 7.2 km (4.5 mi.) N. and 1.6 km (1 mi.) W. of White Deer, Tex. 290 m N. and 35 m W. of SE. corner sec. 40, Block 4. About 50 km (30 mi.) NE. of Amarillo.
Physiographic position: Rolling upland draining toward Canadian River. About 10 m below and 0.5 km NW. of high plains rim. Elevation about 1,200 m.
Topography: Smooth convex slope with 4 percent gradient NE. towards draw.
Vegetation: Rangeland in good condition. Blue grama (Bouteloua gracilis), buffalograss (Buchloe dactyloides) with scattered patches of side-oats grama (Bouteloua curtipendula).
Sampled by: L. Geiger, January 13, 1960.
Soil No.: S60Tex-33-3.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

A1 0-20 cm (0-8 in.). Dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak subangular blocky and granular structure; friable (moist), slightly sticky (wet); strongly effervescent; few very fine hard calcium carbonate nodules; common wormcasts; gradual boundary.

B2ca 20-56 cm (8-22 in.). Brown (7.5YR 5/2) silt loam, dark grayish brown (7.5YR 4/2) moist; mostly granular structure with some weak subangular blocks; strongly effervescent with common very fine calcium carbonate nodules; common medium and fine pores; clear boundary.

C1ca 56-120 cm (22-48 in.). Brown (7.5YR 5/4) silt loam, dark brown (7.5YR 4/4) moist; weak subangular blocks to structureless; friable (moist), slightly sticky (wet); violently effervescent, 10 to 20 percent calcium carbonate by volume; common fine pores; gradual boundary.

C2 120-205 cm (48-80 in.). Light brown (7.5YR 6/4) silt loam, brown (7.5YR 5/4) moist; massive; hard (dry), friable (moist), slightly sticky (wet); strongly effervescent; few fine soft masses of calcium carbonate; many very fine pores.

Pedon 94

SOIL Entic Haplustoll SOIL Nos. S63Tex-254-2 LOCATION Zavala County, Tex.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 18258-18266

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand a/ (2-0.05)	Total: Silt (0.05-0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: 0.05-0.02	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)	3A1a Non-carbonate <0.002		Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-15	Ap	36.2	37.4	26.4	0.1	0.8	2.7	11.5	21.1	16.3	21.1	45.4	15.1	22				tr
15-38	A12	32.7	35.7	31.6	0.1	0.9	2.3	10.2	19.2	15.0	20.7	41.2	13.5	25				tr
38-61	B21ca	27.6	36.1	36.3	0.2	0.7	1.8	8.6	16.3	14.3	21.8	36.6	11.3	26				tr
61-84	B22ca	24.7	37.3	38.0	0.3	0.7	1.5	7.1	15.1	13.5	23.8	33.5	9.6	26				tr
84-115	B31ca	22.4	40.1	37.5	1.1	1.1	1.2	6.0	13.0	12.4	27.7	29.6	9.4	21				tr
115-145	B32ca	18.2	44.0	37.8	0.8	0.9	1.1	4.9	10.5	10.9	33.1	24.8	7.7	20				tr
145-175	C1ca	16.8	45.2	38.0	1.8	1.1	1.0	4.2	8.7	9.7	35.5	21.3	8.1	22				tr

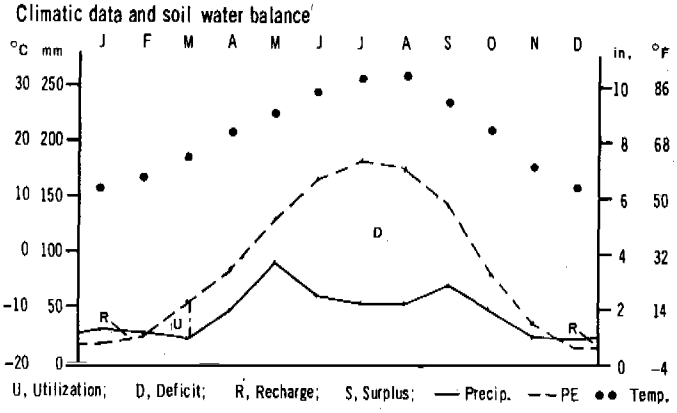
Depth (cm)	6A1a Organic carbon b/ Pct.	Nitrogen Pct.	C/N	Carbonate as $CaCO_3$: 6E1b < 2mm Pct.	3A1a <0.002 mm Pct.		Bulk density: g/cc	4A1d 1/3-bar c/ g/cc	4A1b Air-dry g/cc	4D1 COLE	Water content: Pct.	4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm		pH		8C1a (1:1) H_2O
0-15	1.43			17	4			1.09	1.16	0.020		26.8	11.0	0.17				7.8
15-38	1.02			21	7			1.11	1.17	0.017		24.1	12.0	0.13				7.7
38-61	0.69			27	10			1.22	1.31	0.024		25.3	12.5	0.16				7.8
61-84	0.48			30	12			1.3					12.2					7.8
84-115	0.29			41	17			1.30	1.38	0.020		26.4	10.9	0.20				7.6
115-145	0.18			49	18			1.4					10.7					7.6
145-175	0.13			53	16			1.44	1.51	0.017		23.1	11.4	0.17				7.7

Depth (cm)	Extractable bases 5B1a: 6N4b Ca	6O4b Mg	6P2a Na	6Q2a K			Cat. exch. cap. 5A1a NH_4OAc				Ratios to clay 8D2: NH_4OAc CEC	Ext. iron	15-bar water	8D3 Ca/Mg	Base saturation: Pct.	Pct.
	meq/100 g															
0-15	15.4	2.0	0.1	1.9				16.2			0.74		0.50	7.7		
15-38	16.3	1.8	0.1	1.4				15.9			0.64		0.48	9.1		
38-61	15.8	1.5	0.1	0.6				15.4			0.59		0.48	11		
61-84	15.3	1.7	0.3	0.5				14.8			0.57		0.47	9.0		
84-115	13.6	2.2	0.3	0.5				12.1			0.58		0.52	6.2		
115-145	10.8	2.1	0.3	0.4				9.2			0.46		0.54	5.1		
145-175	8.2	2.6	0.3	0.4				8.0			0.36		0.52	3.2		

a/ Carbonate comprises 10 to 20 percent of the sand.
b/ 10 kg/m^2 to 1.5 m (method 6A).
c/ Values for B22ca and B32ca are estimated.

Pedon 94

Classification: Entic Haplustoll, fine-silty, mixed, hyperthermic.
Location: Zavala County, Tex. 1.9 km (1.2 mi.) W. of La Pryor on U.S. Highway 83 and 140 m S. on field road and 33 m E. About 145 km (90 mi.) WSW. of San Antonio.
Physiographic position: Terrace. Elevation about 300 m.
Topography: Smooth surface with less than 1 percent slope.
Drainage: Well drained with slow runoff.
Vegetation: Seeded Texas bristlegrass (Setaria texana).
Parent material: Loamy alluvium.
Sampled by: J. A. DeMent, W. R. Elder, R. B. Grossman and M. Stout, April 22, 1963.
Remarks: Calcium carbonate nodules are slightly hard. Many are vertically oriented and seem to be filled worm or termite channels.
Soil No.: S63Tex-254-2.



Colors are for the dry soil unless otherwise indicated.

Ap 0-15 cm (0-6 in.). Light brownish gray (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine granular and subangular blocky structure, cloddy when dry; hard (dry), friable (moist); many fine wormcasts; lighter colored crust 5 cm thick and sealed in the upper 1 mm, porous and somewhat platy below; mildly alkaline, calcareous; abrupt boundary.

A12 15-38 cm (6-15 in.). Grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocks with some fine granules; hard (dry), friable (moist); common streaks of light brownish gray; few fine to medium calcium carbonate nodules and common very fine lime threads; many wormcasts and filled channels, few termite runs; mildly alkaline, calcareous; clear boundary.

B21ca 38-61 cm (15-24 in.). Brown (10YR 5/3) loam; dark brown (10YR 4/3) moist; weak prisms break to weak subangular blocks;

SOIL Pedon 95 Typic Natrustoll SOIL Nos. S59Kans-8-3 LOCATION Butler County, Kans.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 10949-10954

General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1: Total: Sand[a] (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2: 3B1 2-20 Pct. < 20
		Pct. of < 2 mm														
0-13	A1	3.6	73.7	22.7	0.1	0.1	0.1	0.5	2.8	44.8	28.9	47.9	0.8			-
13-36	B21t	1.5	48.9	49.6	tr	0.1	0.1	0.2	1.1	25.7	23.2	26.9	0.4			-
36-46	B22t	1.1	50.5	48.4	tr	tr	tr	0.1	1.0	25.4	25.1	26.5	0.1			tr
46-71	B3	3.4	49.5	47.1	0.7	0.6	0.4	0.5	1.2	23.0	26.5	24.5	2.2			tr
71-89	C1ca	3.1	46.1	50.8	0.4	0.4	0.3	0.5	1.5	21.8	24.3	23.6	1.6			tr
89-110	C2	1.8	44.5	53.7	0.1	0.1	0.1	0.3	1.2	19.9	24.6	21.3	0.6			-
110+	R															

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N		6E1a Carbonate as $CaCO_3$ Pct.	6C1a Ext. iron as Fe Pct.	Bulk density: g/cc	4A1c 30-cm g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content: Pct.	4B3 30-cm Pct.	4B2 15-bar Pct.			pH 8C1a (1:10) H_2O	(1:1) H_2O
0-13	3.27	0.218	15		-	0.6		1.19	1.27	0.020		28	10.7			6.4	6.0
13-36	1.43	0.113	13		tr	0.9			1.75				21.9			7.5	6.7
36-46	1.04	0.081	13		tr	0.8							21.1			8.8	7.7
46-71	0.69	0.056	12		4	0.8		1.34	1.82	0.106		31	20.4			9.3	8.2
71-89	0.53				2	0.9		1.34	1.73	0.092		32	22.1			9.0	8.0
89-110	0.43				tr	1.0							23.9			8.7	7.8
110+																	

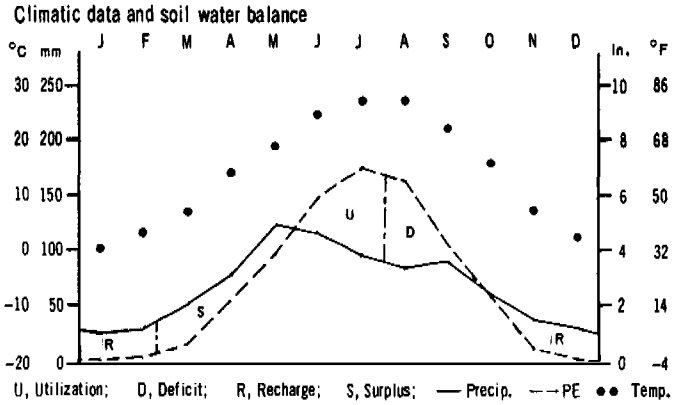
Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Cat. exch. cap.: Ext. acidity	5A3a Sum cations	5A1a NH_4OAc	Water extract from saturated paste 8A1: Ca	Mg	6P1a Na	6Q1a K		CO_3	HCO_3	Cl	SO_4	8A1a Electrical conductivity
	meq/100 g								meq/liter									mmho/cm
0-13	10.5	5.0	0.4	0.5	16.4	8.7	25.1	19.2			1.8	0.2						0.4
13-36	15.2	16.6	4.3	0.5	36.6	5.6	42.2	34.8			5.2	tr						0.6
36-46	17.1	17.7	5.4	0.5	40.7	2.0	42.7	34.1			9.4	0.1						1.1
46-71		18.1	7.5	0.5		< 0.1		31.0			14.4	tr						1.7
71-89		19.9	10.7	0.5		< 0.1		34.5			31.2	0.1						4.2
89-110	15.8	20.4	12.2	0.6	49.0	1.2	50.2	34.6			46.1	0.1						6.0
110+																		

Depth (cm)	8A Water at saturation Pct.	5D2 Exchangeable Na Pct.		6F1a Gypsum Pct.	Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar Water
0-13	61.6	2		-	0.85	0.03	0.47
13-36	97.5	11		-	0.70	0.02	0.44
36-46	97.3	13		-	0.70	0.02	0.44
46-71	108.6	19		-	0.66	0.02	0.43
71-89	106.2	21		-	0.68	0.02	0.44
89-110	105.1	21		-	0.64	0.02	0.45
110+							

[a] Appreciable portion of sand consists of nodules of iron-manganese oxides; some nodules of carbonate in B3 and C1ca horizons.

Pedon 95

Classification: Typic Natrustoll, fine, montmorillonitic, mesic.
Location: Butler County, Kans. 110 m S. and 45 m E. of NW. corner sec. 20, T. 26 S., R. 6 E., about 50 km (30 mi.) E. of Wichita.
Physiographic position: Erosional upland.
Topography: Nearly level to gently undulating area; site on a slightly convex slope with less than 1 percent gradient.
Drainage: Slow runoff; very slow permeability.
Vegetation: Native meadow.
Sampled by: R. H. Jordan, H. L. Penner, G. J. Post and M. Stout, Jr., May 12, 1959.
Remarks: Moist throughout.
Soil No.: S59Kans-8-3.



Colors are for the moist soil.

A1 0-13 cm (0-5 in.). Very dark gray (10YR 2.5/1) silt loam; moderate fine and medium granular structure; upper 3 cm weakly platy; very friable (moist); noncalcareous; abrupt smooth boundary.

B21t 13-36 cm (5-14 in.). Very dark grayish brown and very dark brown (10YR 3/2 and 10YR 2/2) silty clay; weak coarse prisms break with difficulty to coarse blocks; very firm (moist); continuous pressure surfaces; uncoated silt grains form a thin coating on prism surfaces in uppermost 3 cm of horizon; noncalcareous; clear wavy boundary.

B22t 36-46 cm (14-18 in.). Very dark grayish brown (10YR 3/2) silty clay; moderate fine and medium blocky structure; very firm (moist); continuous pressure surfaces; effervesces discontinuously; few fine soft nodules of carbonate; clear wavy boundary.

B3 46-71 cm (18-28 in.). Dark brown (10YR 3/2.5) silty clay; moderate medium blocky structure; very firm (moist); continuous pressure surfaces; many slickensides; few soft nodules of carbonate; clear smooth boundary.

C1ca 71-89 cm (28-35 in.). Dark brown (10YR 3/2.5) silty clay; weak medium blocky structure; very firm (moist); few large slickensides; common soft nodules and masses of carbonate; clear smooth boundary.

C2 89-110 cm (35-43 in.). Very dark grayish brown (10YR 3/2) silty clay; weak medium blocky structure; very firm (moist); occasional large slickenside 20 cm across; abrupt wavy boundary.

R 110 cm (43 in.) plus. Limestone.

SOIL Pedon 96 Typic Argixeroll SOIL Nos. S65Calif-27-13 LOCATION Monterey County, California

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 65427 - 65433

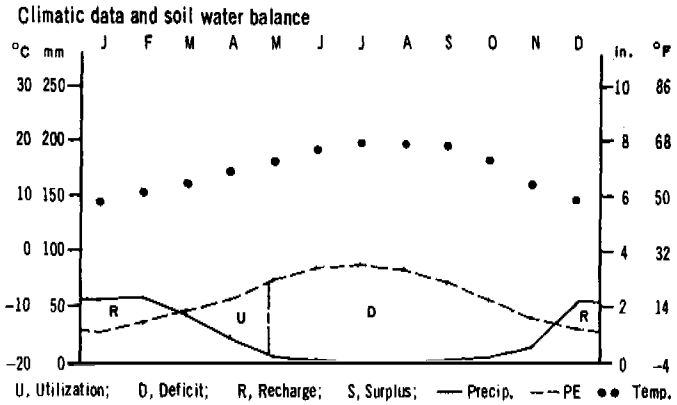
Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Sand: Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt (0.05-0.02)	Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1			Coarse fragments 1A2a > 2 Pct. of whole soil	2-19	19-76
		Size class and particle diameter (mm) 3A1 — Pct. of <2 mm															Pct. of <76mm	
0-18	Ap	62.1	27.7	10.2	15.4	16.7	8.7	13.1	8.2	16.2	11.5	31.4	53.9			11	11	0
18-53	A12	62.0	27.0	11.0	13.0	16.9	9.0	13.7	9.4	15.8	11.2	32.6	52.6			14	14	0
53-76	B1t	57.3	28.5	14.2	12.2	15.2	7.8	13.1	9.0	16.3	12.2	32.7	48.3			10	10	0
76-110	B21t	49.2	28.4	22.4	9.1	11.0	5.3	12.8	11.0	14.7	13.7	33.9	38.2			16	16	0
110-140	B22t	57.9	24.3	17.8	17.5	14.8	6.2	10.8	8.6	12.6	11.7	27.6	49.3			21	21	0
140-150	B3	79.8	11.5	8.7	25.7	24.0	10.8	13.7	5.6	6.3	5.2	18.7	74.2			32	29	3
150-205	IIC	91.1	4.4	4.5	20.6	31.1	17.8	17.8	3.8	2.6	1.8	14.1	87.3			35	32	3

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	4A1h Oven-dry g/cc	Est. 1/3-bar g/cc	3B2 Cm	Water content	4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4D1 Extensibility COLE cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	8C1a H_2O 1:1	8C1c IN KCl 1:1
0-18	0.89	0.080	11	0.6	-				1.60	0.93			4.6				7.6	
18-53	0.70	0.063	11	0.7	-		1.61	1.64		0.91		10.7	5.0	0.006	0.005		8.1	
53-76	0.32			0.9	-		1.79	1.82		0.93		12.0	5.8	0.006	0.005		8.0	
76-110	0.21			1.4	-		1.81	1.89		0.88		15.1	10.0	0.015	0.013		7.3	
110-140	0.16			1.1	-		1.85	1.91		0.84		13.3	8.0	0.011	0.009		7.2	
140-150	0.07			0.6	-		1.65	1.68		0.77		8.4	4.2	0.006	0.004		6.9	
150-205	0.06			0.4	-				1.65	0.75			2.6				7.0	

Depth (cm)	Extractable bases: 6N2a Ca	6O2a Mg	6P2a Na	5B1a 6Q2a K	Sum of bases	6H2a Ext. acidity	Cation exch. capacity: 5A1a NH_4OAc	5A3a Sum of cations	6G1e KCl ext. Al +++	Ratios to clay 8D1: CEC NH_4OAc	Ext. iron	15-bar water	Base saturation: 5C3 Sum of cations Pct.	5C1 NH_4OAc Pct.
	meq/100g													
0-18	7.3	2.0	0.3	0.6	10.2		8.0			0.78	0.06	0.45		100+

Pedon 96

Classification: Typic Argixeroll, fine-loamy, mixed, thermic.
Location: Monterey County, Calif. 0.7 km southwest on Chualar Road from Old Stage Road to pumphouse on north side of road, 253 m northwest on dirt road, 6 m northeast into field.
Physiographic position: Alluvial fan, elevation about 55 m.
Topography: Smooth, west-facing slope of 1.5 percent.
Drainage: Well drained; medium runoff; moderately slow permeability.
Vegetation: Irrigated cropland, beans.
Parent material: Alluvium from phaneritic, intermediate igneous rocks.
Sampled by: W. D. Nettleton, B. R. Brasher, C. J. Weisel, R. D. Waggoner, F. J. Pecarich, T. D. Cook, and L. C. Leifer, May 20, 1965.
Soil No.: S65Calif-27-13.



Colors are for the dry soil unless otherwise indicated.

Ap 0-18 cm (0-7 in.). Dark grayish brown (10YR 4/2) coarse sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium granular and weak medium subangular blocky structure; hard (dry), friable (moist), slightly sticky and slightly plastic (wet); plentiful very fine roots; many very fine interstitial pores; 7 percent gravel by volume; clear smooth boundary.

A12 18-53 cm (7-21 in.). Dark grayish brown (10YR 4/2) coarse sandy loam, very dark grayish brown (10YR 3/2) moist; moderate medium and coarse granular structure; hard (dry), friable (moist), slightly sticky and slightly plastic (wet); few very fine roots; many very fine interstitial pores; 9 percent gravel by volume; clear wavy boundary.

B1t 53-76 cm (21-30 in.). Yellowish brown (10YR 5/4) heavy coarse sandy loam, dark brown (10YR 3/3) moist; massive; hard (dry), friable (moist), sticky and plastic (wet); few very fine roots; many very fine interstitial, common very fine and few fine tubular pores; common thin clay skins in bridges and pores; considerable rodent activity; 7 percent gravel by volume; clear smooth boundary.

B21t 76-110 cm (30-44 in.). Brown (7.5YR 5/4) heavy loam, dark brown (7.5YR 3/2) moist; brown to dark brown (7.5YR 4/4) crushed; massive, distinct vertical joints suggest some structure with continuous thin clay skins on major joints; very hard (dry), firm (moist), very sticky and plastic (wet); no roots; common very fine interstitial pores; continuous thin clay skins in bridges and pores; 12 percent gravel by volume; diffuse smooth boundary.

B22t 110-140 cm (44-55 in.). Brown (7.5YR 5/4) heavy finely gravelly coarse sandy loam, dark brown (7.5YR 3/2) moist, brown to dark brown (7.5YR 4/4) rubbed; massive; very hard (dry), firm (moist), very sticky and plastic (wet); common very fine interstitial and few very fine tubular pores; continuous thin clay skins in bridges and pores and a few moderately thick

B3 140-150 cm (55-59 in.). Brown (7.5YR 5/4) finely gravelly loamy coarse sand, brown to dark brown (7.5YR 4/4) moist; massive; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); many very fine interstitial pores; few thin clay skins in bridges; 23 percent gravel by volume; abrupt smooth boundary.

IIC 150-205 cm (59-80 in.). Brown (7.5YR 5/4) finely gravelly coarse sand, brown to dark brown (7.5YR 4/4) moist; single grain; soft (dry), loose, nonsticky and nonplastic (wet); many fine interstitial pores.

Pedon 97

SOIL Pachic Calcixeroll SOIL Nos. S65Calif-27-4 LOCATION Monterey County, California

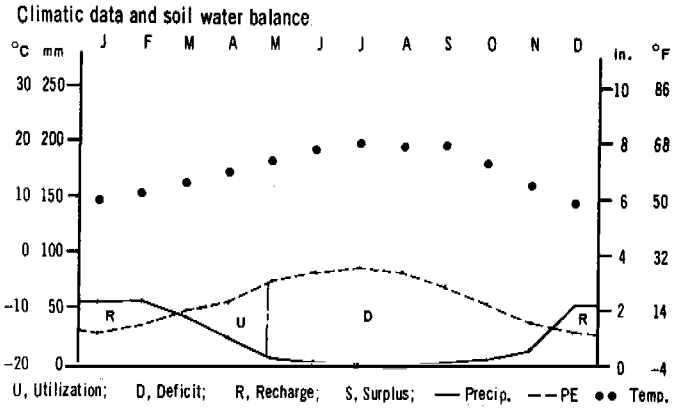
SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 65468 - 65474

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	Silt: 2-0.1			Coarse fragments 1A2a: [b] > 2 Pct. of whole soil	2-19 (Pct. of <76mm)	19-76 (Pct. of <76mm)
		Pct. of <2 mm																
0-10	A11	19.0	50.5	30.5	0.7	0.9	1.3	5.9	10.2	30.6	19.9	44.6	8.8			G		
10-41	A12	18.8	48.0	33.2	0.8	0.9	1.3	5.5	10.3	28.0	20.0	42.0	8.5			G		
41-81	A13	19.5	46.2	34.3	1.4	0.9	1.1	5.5	10.6	26.4	19.8	40.7	8.9			G		
81-91	A14ca	18.2	46.9	34.9	0.4	1.1	1.2	5.2	10.3	25.6	21.3	39.3	7.9			G		
91-115	C1ca	31.7	46.2	22.1	3.8	5.2	4.9	7.7	10.1	16.2	30.0	30.6	21.6			G		
115-150	C2	38.1	46.1	15.8	2.8	5.7	4.8	9.9	14.9	20.2	25.9	41.4	23.2			G		
115-150	[a] shale	34.0	46.8	19.2	0.7	3.1	3.2	11.8	15.2	21.0	25.8	44.3	18.8			G		

Depth (cm)	6A1a Organic carbon	6B1a Nitrogen	C/N	6C2b Ext. iron	Carbonate as $CaCO_3$: 6E1b	Carbonate as $CaCO_3$: 3A1a	Bulk density: 4A1f 1/3-	Bulk density: 4A1h Oven-	3B2 Cm	Water content: 4B1c 1/3-	Water content: 4B2 15-	Water content: 4C1 1/3-to	4D1 Extensibility	4D1 Extensibility	pH: 8C1b Satu-	pH: 8C1a	pH: 8C1c

Pedon 97

Classification: Pachic Calcixeroll, fine-silty, mixed, thermic.
Location: Monterey County, Calif. About 9.7 km north of King City on Montgomery Ranch, 1,160 m northeast from reservoir, 1.6 km northeast from main buildings, about 21 m uphill from dirt road and 122 m down from the ridgetop.
Physiographic position: Hilly upland, elevation about 183 m.
Topography: Slightly convex, north northeast-facing slope of 26 percent.
Drainage: Well drained; medium runoff; moderately slow permeability.
Vegetation: Range, grass, ripgut brome (Bromus rigidus), soft chess (Bromus mollis), burclover (Medicago sp.), fiddle-neck (Phacelia tanacetifolia), all dry.
Parent material: Soft, calcareous shale and sandstone, Plio-Pleistocene, nonmarine.
Sampled by: B. R. Brasher, W. D. Nettleton, C. J. Weisel, R. D. Waggoner, F. J. Pecarich, T. D. Cook, and L. C. Leifer, May 18, 1965.



Remarks: The gravel is soft and porous. Hence it was ground to less than 2 mm and included with the fine earth. The A horizon is much broken and interrupted by krotovinas. The krotovinas are filled with dark gray (10YR 4/1) light silty clay loam material, very dark gray (10YR 3/1) moist, that has strong granular structure. The krotovinas were not sampled.
Soil No. S65Calif-27-4.

Colors are for the dry soil unless otherwise indicated.

A11 0-10 cm (0-4 in.). Dark gray (10YR 4/1) light silty clay loam, very dark gray (10YR 3/1) moist; weak medium plates readily breaking to moderate medium angular blocks; very hard (dry), firm (moist), sticky and plastic (wet); abundant very fine roots; common very fine tubular pores; weakly effervescent with disseminated carbonate; platy structure at surface due to cattle trampling; gradual smooth boundary.

A12 10-41 cm (4-16 in.). Dark gray (10YR 4/1) light silty clay loam, very dark gray (10YR 3/1) moist; strong moderate and coarse subangular blocky structure; hard (dry), friable (moist), sticky and plastic (wet); plentiful very fine roots; many very fine interstitial and many very fine and few fine tubular pores; strongly effervescent with disseminated carbonate; clear irregular boundary.

A13 41-81 cm (16-32 in.). Dark gray (10YR 4/1) light silty clay loam, very dark gray (10YR 3/1) moist; moderate coarse subangular blocky structure; hard (dry), friable (moist), sticky and plastic (wet); plentiful very fine roots; many very fine interstitial, common very fine and few fine tubular pores; strongly effervescent with disseminated carbonate and many fine filaments of carbonate toward bottom of horizon; gradual irregular boundary.

A14ca 81-91 cm (32-36 in.). Dark grayish brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) moist; weak medium angular blocky structure; hard (dry), friable (moist), sticky and plastic (wet); few very fine roots; common very fine interstitial and few very fine tubular pores; violently effervescent with disseminated carbonate, fine carbonate filaments cover 65 percent of ped faces; abrupt wavy boundary.

C1ca 91-115 cm (36-45 in.). Very pale brown (10YR 7/3) calcareous shale and sandstone with many white, thick to thin coats of carbonate on rock joints; soft (dry); carbonate appears to have accumulated from above; gradual wavy boundary.

C2 115-150 cm (45-60 in.). Similar to above but with few thin carbonate coats on rock joints.

Pedon 98

SOIL Aridic Durixeroll SOIL Nos. S66Nev-4-4 LOCATION Elko County, Nevada

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 66750 - 66759

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	Silt: 2-0.1			Coarse fragments 1A2a: > 2 Pct. of whole soil	2-19 Pct. of <76mm	19-76 Pct. of <76mm
		Size class and particle diameter (mm) 3A1 — Pct. of <2 mm																
0-5	A11	19.3	65.0	15.7	3.7	3.3	1.8	3.5	7.0	33.2	31.8	42.3	12.3			15	12	3
5-10	A12	16.6	61.3	22.1	2.7	2.5	1.5	2.7	7.2	29.4	31.9	38.3	9.4			14	11	3
10-20	A13	17.8	57.4	24.8	2.9	2.1	1.4	2.7	8.7	28.1	29.3	38.5	9.1			11	8	3
20-30	B1t	18.5	53.5	28.0	2.9	2.6	1.6	2.7	8.7	26.6	26.9	37.0	9.8			30	5	25
30-53	B2t	13.6	26.1	60.3	2.6	2.5	1.7	2.5	4.3	12.7	13.4	18.4	9.3			7	7	-
53-63	IIB3t	34.5	24.3	41.2	9.3	9.1	4.8	6.3	5.0	9.3	15.0	17.6	29.5			47	22	25
a/63-69	IIC1sicam	81.8	14.3	3.9	30.8	21.8	9.4	12.7	7.1	6.8	7.5	20.1	74.7			G		
69-105	IIC2sicam	84.9	10.7	4.4	34.0	25.2	10.3	10.3	5.1	4.7	6.0	14.7	79.8			81	38	43
105-125	IIC3sica	71.8	18.9	9.3	24.8	22.1	12.1	9.4	3.4	5.5	13.4	12.4	68.4			69	52	17
Composite A																15	12	3

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N	Field water content May 1966 Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	4A1h Oven-dry g/cc	g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	8C1a H_2O 1:1	8C1a H_2O 1:10
0-5	2.24	0.186	12	-	-		1.30	1.34		0.92	24.8	9.9		0.010	0.009		6.6	6.9
5-10	1.05	0.110	10	4	-		1.24	1.33		0.93	24.4	10.7		0.023	0.021		6.6	7.0
10-20	0.75			8	-		1.29	1.37		0.94	22.6	12.2		0.020	0.019		6.4	7.0
20-30	0.58			10	-		1.19	1.32		0.84	24.7	12.7		0.034	0.029		6.5	7.0
30-53	0.53			22	-		1.23	1.70		0.97	39.4	30.2		0.116	0.111		6.6	7.3
53-63	0.47			17	-		1.10	1.43		0.73	42.2	25.4		0.091	0.064		6.9	7.3
a/63-69	0.29			7	4		1.54	1.55			17.9	10.7		0.001			8.1	8.7
69-105	0.15			10	2		1.44	1.44		0.30	22.0	10.2		0.000	0.000		7.9	8.7
105-125	0.12			11	1		1.43	1.45		0.45	20.0	10.4		0.003	0.001		8.0	8.7
Comp. A	1.09	0.109	10	6	-							10.7					6.7	7.1

Depth (cm)	Extractable bases: 6N4c Ca 5B3a	6O4c Mg 5B3a	6P2a Na 5B1a	6Q2a K 5B1a	Sum of bases	6H2a Ext. acidity	Cation exch. capacity: 5A1a NH_4OAc	5A3a Sum of cations		6G1e KCl ext. Al +++	Ratios to clay 8D1: CEC NH_4OAc	Ext. iron	15-bar water				Base saturation: 5C3 Sum of cations Pct.	5C1 NH_4OAc Pct.
	meq/100g																	
0-5	8.9	2.5	0.1	2.0	13.5		18.6				1.18		0.63					73
5-10	10.2	3.2	0.1	1.8	15.3		19.7				0.89		0.48					78
10-20	11.1	3.3	0.2	1.8	16.4		20.3				0.82		0.49					81
20-30	12.6	3.9	0.2	1.3	18.0		22.3				0.80		0.45					81
30-53	29.4	9.0	0.5	1.0	39.9		49.3				0.82		0.50					81
53-63	27.5	8.6	0.5	1.0	37.6		47.3				1.15		0.62					79
a/63-69	15.3	3.6	0.3	0.4	19.6		20.0				5.13		2.74					98
69-105	14.0	3.2	0.3	0.4	17.9		22.1				5.02		2.32					81
105-125	13.8	3.1	0.2	0.4	17.5		19.1				2.05		1.12					92
Comp. A	10.5	3.1	0.2	3.7	17.5		20.8											84

Depth (cm)	c/ Clay fraction mineralogy 3A1: 7A2 X-ray d/	7A3 DTA Pct.
0-5	MI3, MT1, KK1	
5-10		
10-20		
20-30		
30-53	MT5, MI1, KK1	
53-63		
a/63-69	MT3, MI2	
69-105		
105-125	MT4, MI1, KK1	

a/ The <19 mm soil was ground whole. Horizon indurated, contains 70 percent gravel by volume.

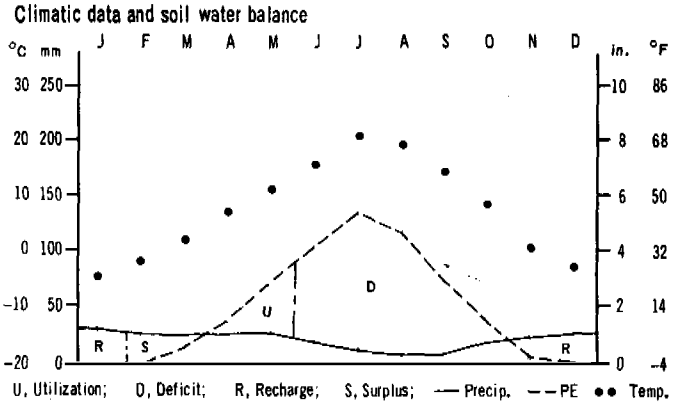
b/ 5.7 kg of organic carbon per square meter to a depth of 1 meter.

c/ Mineral code:
- MT = montmorillonite
- MI = mica
- KK = kaolinite

d/ Approximate weight fraction (X-ray):
- 5 = more than half
- 4 = one-third to half
- 3 = one-fifth to one-third
- 2 = one-twentieth to one-fifth
- 1 = less than one-twentieth

Pedon 98

Classification: Aridic Durixeroll, fine-loamy over clayey, mixed, frigid.
Location: Elko County, Nev. 482 m west and 317 m south of the northeast corner of sec. 16, T. 37 N., R. 52 E.
Physiographic position: Alluvial fan, elevation about 1,800 m.
Topography: Smooth to gently convex slope of 2 to 16 percent.
Drainage: Well drained.
Vegetation: Big sagebrush (Artemesia tridentata) with some Douglas rabbitbrush (Chrysothamnus sp.) and an understory of Great Basin wildrye (Elymus sp.), Sandberg bluegrass (Poa secunda), Nevada bluegrass (Poa nevadensis), squirreltail (Sitanion hystrix), phlox (Phlox sp.), and lupine (Lupinus sp.).
Parent material: Alluvium derived from mixed sources but primarily from tuffs with some admixture from loess high in volcanic ash.
Sampled by: B. R. Brasher, W. D. Nettleton, L. N. Langan, and E. Spencer, May 6, 1966.



Remarks: The IIB3t, IIClsicam, IIC2sicam, and IIC3sica horizons do not disperse well, hence the field estimates of texture are given for these horizons.
Soil No.: S66Nev-4-4.

Colors are for the dry soil unless indicated otherwise.

A11 0-5 cm (0-2 in.). Light brownish gray (10YR 6/2) light silt loam, very dark grayish brown (10YR 3/2) moist; massive; slightly hard (dry), very friable (moist), slightly sticky and slightly plastic (wet); abundant micro and few very fine and fine roots; few very fine vesicular and many very fine tubular pores; 8 percent gravel by volume; abrupt smooth boundary.

A12 5-10 cm (2-4 in.). Brown (10YR 5/3) heavy silt loam, dark brown (10YR 3/3) moist; weak very thin platy and moderate very fine granular structure; soft (dry), very friable (moist), slightly sticky and slightly plastic (wet); abundant micro and few very fine and fine roots; many very fine interstitial pores; 7 percent gravel by volume; clear smooth boundary.

A13 10-20 cm (4-8 in.). Brown (10YR 5/3) heavy silt loam, dark brown (10YR 3/3) moist; moderate medium and fine subangular blocky structure; slightly hard (dry), very friable (moist), sticky and plastic (wet); plentiful very fine and fine roots; many very fine interstitial and few very fine tubular pores; 6 percent gravel by volume; clear smooth boundary.

B1t 20-30 cm (8-12 in.). Pale brown (10YR 6/3) gravelly light silty clay loam with many coarse faint brown (10YR 5/3) stains, brown and dark brown (10YR 4/3 and 3/3) moist; moderate medium subangular blocky structure; hard (dry), friable (moist), very sticky and very plastic (wet); plentiful very fine and fine roots; common very fine and few fine and medium tubular pores; 16 percent gravel by volume; abrupt wavy boundary.

B2t 30-53 cm (12-21 in.). Yellowish brown (10YR 5/4) heavy clay, dark yellowish brown (10YR 4/4) moist and yellowish brown (10YR 5/4) crushed moist; moderate medium prismatic and strong coarse subangular blocky structure; very hard (dry), very firm (moist), very sticky and very plastic (wet); plentiful micro and few very fine and fine roots; common very fine and few fine tubular pores; many slickensides and stress cutans on ped faces; 3 percent gravel by volume; abrupt wavy boundary.

IIB3t 53-63 cm (21-25 in.). Variegated very pale brown (10YR 7/4) and light yellowish brown (10YR 6/4) gravelly light clay with yellowish brown (10YR 5/4) clay skins and many very thin, unoriented white (10YR 8/1) silica laminae with pale brown (10YR 6/3) interiors, strong brown (7.5YR 5/6) and dark brown (10YR 3/3) moist and brown (7.5YR 5/4) crushed moist; massive; very hard (dry), very firm (moist), very sticky and very plastic (wet); many very fine and micro roots matted on the horizon surface; common very fine and few fine tubular pores; horizon appears to be developing into a duripan; common moderately thick clay bridges between sand grains and common thick and moderately thick clay skins in pores; 27 percent gravel by volume; abrupt wavy boundary.

IIClsicam 63-69 cm (25-27 in.). Very pale brown (10YR 7/3) indurated very gravelly duripan with very thin (2 mm or less) continuous and discontinuous white (10YR 8/1) laminae of silica and carbonate, and continuous pale brown and brown (10YR 6/3 and 5/3) moderately thick clay skins coating upper laminae, stratified brown and pale brown (10YR 5/3 and 6/3) moist with dark yellowish brown (10YR 4/4) and dark brown (10YR 3/3) coatings moist; massive; extremely hard (dry), extremely firm (moist); no roots; few very fine and fine tubular and interstitial pores; noneffervescent matrix but violently effervescent in spots; 70 percent gravel by field volume estimate; clear wavy boundary.

IIC2sicam 69-105 cm (27-42 in.). Variegated pale brown (10YR 6/3) and very pale brown (10YR 7/4) strongly cemented very gravelly duripan, with many randomly oriented, thin and very thin (less than 5 mm) discontinuous silica and carbonate laminae and coatings on gravel that are white (10YR 8/1 and 8/2), brown and yellowish brown (10YR 4/3 and 5/4) moist; massive; extremely hard (dry), extremely firm (moist); no roots; few very fine interstitial and tubular pores; noneffervescent matrix but violently effervescent in spots; 70 percent gravel by volume; clear wavy boundary.

IIC3sica 105-125 cm (42-49 in.). Very pale brown (10YR 7/4) very gravelly coarse sandy loam that is weakly silica cemented with occasional 1 mm thick, diagonally oriented, white (10YR 8/1) silica and carbonate laminae, dark yellowish brown (10YR 4/4) moist; massive; very hard (dry), firm (moist), nonsticky and nonplastic (wet); no roots; few very fine and fine interstitial and tubular pores; few moderately thick silica bridges between sand grains and continuous films in pores; matrix noneffervescent but violently effervescent in spots; 55 percent gravel by volume.

Pedon 99

SOIL Pachic Haploxeroll SOIL Nos. S69Wash-24-10 LOCATION Okanogan County, Washington

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 69267 - 69272

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	Silt: 2-0.1			Coarse fragments 1A2a: > 2 Pct. of whole soil	2-19 (Pct. of <76mm)	19-76 (Pct. of <76mm)
		Pct. of <2 mm																
0-10	Ap	54.5	38.6	6.9	7.4	6.9	5.9	20.2	14.1	16.9	21.7	44.0	40.4			6	6	
10-25	A12	51.8	40.9	7.3	2.7	5.3	6.0	21.9	15.9	17.6	23.3	47.8	35.9			6	6	
25-61	B2	56.1	37.8	6.1	6.2	8.4	7.2	19.5	14.8	17.9	19.9	44.3	41.3			9	9	
61-105	IIC1	65.4	26.8	7.8	4.5	8.9	9.8	26.7	15.5	14.5	12.3	45.7	49.9			24	20	4
105-130	IIC2	67.6	22.1	10.3	5.7	9.5	10.5	28.9	13.0	12.0	10.1	41.3	54.6			28	22	6
130-165	IIC3	71.5	20.1	8.4	6.6	10.4	10.9	29.5	14.1	11.9	8.2	42.0	57.4			41	34	7

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C2b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	Carbonate: 3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	Bulk density: 4A1h Oven-dry g/cc	Bulk density: g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	Water content: 4B2 15-bar Pct.	Water content: 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1d NaF 2 min.	pH: 8C1a H_2O 1:1	pH: 8C1e $CaCl_2$
0-10	1.55	0.132	12	0.8			1.27	1.30		0.97	21.3	6.5		0.008		9.2	6.2	5.8
10-25	1.37	0.102	13	0.7			1.19	1.20		0.97	20.5	5.0		0.003		9.1	6.0	5.4
25-61	0.92	0.078	12	0.7			1.20	1.21		0.96	18.2	5.1		0.003		9.3	6.3	5.6
61-105	0.20	0.021	10	0.9			1.74	1.77		0.83	9.6	3.5		0.006		9.	6.8	5.9
105-130	0.12			1.0			1.59	1.64		0.81	9.9	4.7		0.010		9.	7.4	6.2
130-165				0.9			1.60	1.64		0.70	8.2	3.9		0.008		9.	7.6	6.2

Depth (cm)	Extractable bases: 6N2e Ca	6O2d Mg	6P2a Na	5B1c 6Q2a K	Sum of bases	6H2a Ext. acidity	Cation exch. capacity: 5A6a NH_4OAc	5A3a Sum of cations		6G1e KCl ext. Al +++	Ratios to clay 8D1: CEC NH_4OAc	Ext. iron	15-bar water				Base saturation: 5C3 Sum of cations Pct.	5C1 NH_4OAc Pct.
	meq/100g																	
0-10	7.9	1.4	0.1	1.1	10.5		12.5				1.81	0.12	0.94					83
10-25	6.3	1.0	0.1	0.8	8.2		10.7				1.47	0.10	0.68					76
25-61	6.0	1.3	0.1	0.6	8.0		10.0				1.64	0.11	0.84					79
61-105	3.6	1.3	0.1	0.3	5.3		5.7				0.73	0.12	0.45					92
105-130	4.2	1.8	0.4	0.3	6.7		7.0				0.68	0.10	0.46					95
130-165	3.8	1.6	0.5	0.2	6.1		6.3				0.75	0.11	0.46					96

Depth (cm)	b/ 3A1 Clay fraction mineralogy: 7A2 X-ray c/	Di.-Ci. ext.: 6C2b Fe Pct.	6G7a Al Pct.
0-10	MI2, KK1	0.8	0.1
10-25		0.7	0.1
25-61	MI3, KK1	0.7	0.1
61-105		0.9	0.1
105-130	MI5, KK2	1.0	-
130-165		0.9	0.1

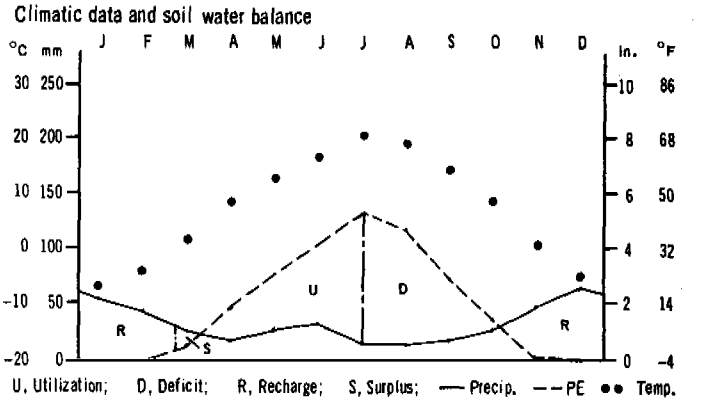
a/ 9.8 kg of organic carbon per square meter to a depth of 1 meter.

b/ Mineral code:
MI = mica
KK = kaolinite

c/ Approximate weight fraction (X-ray):
5 = more than half
3 = one-fifth to one-third
2 = one-twentieth to one-fifth
1 = less than one-twentieth

Pedon 99

Classification: Pachic Haploxeroll, coarse-loamy, mixed, mesic.
Location: Okanogan County, Wash. 732 m east and 866 m south of the SW corner of sec. 27, T. 32 N., R. 22 E.
Physiographic position: Upland, elevation about 610 m.
Topography: Convex, southwest-facing slope of 12 percent.
Drainage: Well drained; moderate permeability.
Vegetation: Weeds.
Parent material: Glacial till of mixed mineralogy.
Sampled by: C. Lenfesty and N. Donaldson, June 8, 1969.
Remarks: The A and B horizons do not disperse well, hence the field estimates of texture are given for these horizons.
Soil No.: S69Wash-24-10.



Colors are for the dry soil unless otherwise indicated.

Ap 0-10 cm (0-4 in.). Dark grayish brown (10YR 4/2) fine sandy loam, very dark brown (10YR 2/2) moist; weak fine granular structure; soft (dry), very friable (moist), slightly sticky and slightly plastic (wet); many fine roots; 3 percent gravel by volume; abrupt smooth boundary.

A12 10-25 cm (4-10 in.). Dark grayish brown (10YR 4/2) fine sandy loam, very dark brown (10YR 2/2) moist; weak fine subangular blocky structure; soft (dry), very friable (moist), slightly sticky and slightly plastic (wet); many fine roots; 3 percent gravel by volume; clear wavy boundary.

B2 25-61 cm (10-24 in.). Brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) moist; weak fine and medium subangular blocky structure; slightly hard (dry), friable (moist); slightly sticky and slightly plastic (wet); many fine roots; 4 percent gravel by volume; clear wavy boundary.

IIC1 61-105 cm (24-41 in.). Light brownish gray (10YR 6/2) gravelly fine sandy loam, dark grayish brown (10YR 4/2) moist; massive; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); common fine roots; 17 percent gravel by volume and occasional cobbles; clear wavy boundary.

IIC2 105-130 cm (41-52 in.). Light gray (10YR 6/1) gravelly fine sandy loam, dark gray (10YR 4/1) moist; massive; slightly hard (dry), very friable (moist), slightly sticky and slightly plastic (wet); common fine roots; 19 percent gravel by volume and occasional cobbles; clear wavy boundary.

IIC3 130-165 cm (52-64 in.). Light gray (10YR 6/1) gravelly light fine sandy loam, dark gray (10YR 4/1) moist; massive; slightly hard (dry), very friable (moist), nonsticky and nonplastic (wet); few fine roots; 30 percent gravel by volume and occasional cobbles and stones.

Pedon 100

SOIL Aquic Natrixeroll SOIL Nos. S60Nev-3-5 LOCATION Douglas County, Nevada

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 6073 - 6080

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1 Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1			Coarse fragments 1A2a > 2 Pct. of whole soil	2-19 Pct. of <76mm	19-76 Pct. of <76mm
		Pct. of <2 mm																
0-8	A1	58.3	38.4	3.3	0.3	3.7	3.1	24.0	27.2	24.4	14.0	70.1	31.1			0		
8-20	IIB2t	29.1	30.8	40.1	0.1	2.2	2.4	13.5	10.9	12.3	18.5	32.9	18.2			0		
20-43	IIB3t	24.6	49.9	25.5	0.8	2.1	1.4	8.5	11.8	18.3	31.6	36.9	12.8			0		
43-58	IIIC1	54.1	31.0	14.9	0.3	3.0	1.9	21.5	27.4	19.3	11.7	65.0	26.7			5	5	
58-79	IIIC2	66.0	22.3	11.7	0.2	2.4	2.2	35.4	25.8	14.6	7.7	69.8	40.2			0		
79-105	IVC3	90.8	4.7	4.5	0.4	8.5	11.4	59.7	10.8	3.7	1.0	51.0	80.0			0		
105-115	VC4	76.4	16.2	7.4	0.2	3.0	2.7	42.5	28.0	11.0	5.2	74.3	48.4			0		
115-130	VIC5	88.9	6.7	4.4	0.6	7.1	10.0	59.2	12.0	4.5	2.2	54.7	76.9			0		

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C1a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ 6E1b <2 mm Pct.	Carbonate as $CaCO_3$ 3A1a <0.002 mm Pct.	Bulk density 4A1f 1/3-bar g/cc	Bulk density 4A1h Oven-dry g/cc	Bulk density g/cc	3B2 Cm	Water content 4B1c 1/3-bar Pct.	Water content 4B2 15-bar Pct.	Water content 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH 8C1b Saturated paste		pH 8C1a H_2O 1:10
0-8	0.77	0.053	15	0.8	-							3.8				7.3		7.9
8-20	0.98	0.074	13	2.0	1							22.9				8.6		9.8
20-43	0.29	0.022		1.0	5							20.5				8.9		9.9
43-58	0.16			1.0	tr.							11.3				8.6		9.8
58-79	0.11			1.1	tr.							9.4				8.3		9.3
79-105	0.01			1.1								4.1				8.4		8.5
105-115	0.06											6.9				8.1		8.9
115-130	0.02											5.0				8.0		8.1

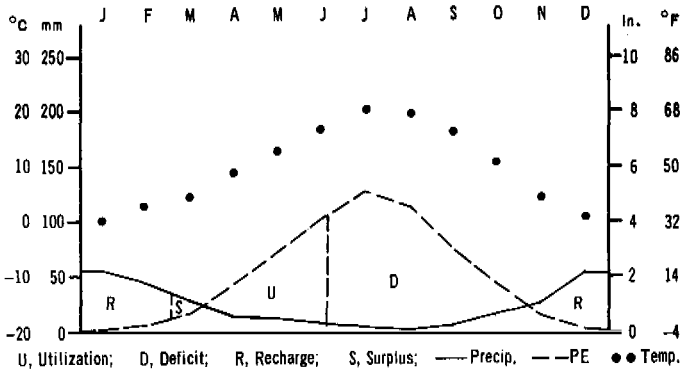
Depth (cm)	Extractable bases 6N2b Ca 5B1a	Extractable bases 6O2a Mg 5B1a	Extractable bases 6P2a Na 5B1b	Extractable bases 6Q2a K 5B1b	6H2a Ext. acidity	5A2a CEC NaOAc	5D1 Exchangeable sodium Pct.	5E Sodium adsorption ratio	8A Water at saturation Pct.	Water extract from saturated paste 8A1 6N1a Ca	6O1a Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1b SO_4	8A1a Electrical conductivity mmho/cm
	meq/100 g									meq/liter								
0-8	2.9	1.3	2.7	1.6	1.7	9.6	28	29	30.9	1.5	0.6	29.5	1.4	-	5.7	20.0		3.1
8-20	10.1	3.0	24.3	3.1	-	40.0	61	89	74.6	1.2	-	69.0	0.6	-	9.8	30.0		7.1
20-43	14.7	2.9	26.8	1.6	-	36.6	58	126	79.9	1.4	0.8	132.0	0.7	-	4.6	37.5		13.1
43-58	7.8	1.8	19.3	1.1	-	25.1	77	119	51.4	2.5	0.6	148.0	0.6	-	4.1	53.6		11.6
58-79	4.4	1.7	14.1	0.6	-	22.5	63	89	40.6	3.4	0.7	128.5	0.3	-	3.0	54.3		14.0
79-105	5.3	1.5	4.3	0.2	1.5	12.8	34	57	33.2	0.4	0.2	31.5	0.1	-	1.2	7.7		1.9
105-115	10.4	3.7	3.5	0.1	2.4	19.5	18	31	37.2	1.4	0.4	29.5	<0.1	-	4.2	12.8		1.9
115-130	7.8	2.6	2.4	0.1	2.5	8.2	29	11	37.6	0.5	0.3	6.8	<0.1	-	1.0	2.3		0.8

Ratios to clay 8D1 CEC	Ext.	Extra-	6F1a

a/ 3.0 kg of organic carbon per square meter to a depth

Pedon 100

Climatic data and soil water balance



Classification: Aquic Natrixeroll, fine-silty, mixed, mesic.
Location: Carson Valley, Douglas County, Nev. 46 m south and 427 m east of the W1/4 corner of sec. 19, T. 14 N., R. 20 E.
Physiographic position: Terrace of Carson River, elevation about 2,030 m.
Topography: Smooth, nearly level with many moderately deep broad drainage channels.
Drainage: Somewhat poorly drained; very slow internal drainage and runoff; slow permeability.
Vegetation: Plant density of about 7 percent consisting of big sagebrush (Artemesia tridentata) 35 percent, greasewood (Sarcobatus sp.) 55 percent, saltgrass (Distichlis sp.) 9 percent, and blue-jointed ryegrass (Lolium sp.) 1 percent.
Parent material: Loamy alluvium derived from mixed rock sources, consisting primarily of granite with admixtures of basalt, rhyolite, and assorted sedimentary and metamorphic rocks.
Sampled by: L. N. Langan, R. E. Nelson, R. Malchow, and L. H. Grant, April 23, 1960.
Remarks: The water table was at 2 m when sampled. It fluctuates between 1 and 1.5 m during runoff periods of most years. The horizons, except for the IIB2t, do not disperse well, hence the field estimates of texture are given.
Soil No.: S60Nev-3-5.

Colors are for the dry soil unless indicated otherwise.

A1 0-8 cm (0-3 in.). Gray (10YR 5/1) very fine sandy loam, between very dark gray and dark gray (10YR 3/1) when moist; moderate coarse platy structure; slightly hard (dry), very friable (moist), nonsticky and nonplastic (wet); plentiful fine and abundant very fine roots; many fine and few very fine and medium vesicular pores; abrupt slightly wavy boundary.

IIB2t 8-20 cm (3-8 in.). Grayish brown (10YR 5/2) clay, very dark grayish brown (10YR 3/2) when moist; strong fine columnar structure; very hard (dry), firm (moist), very sticky and very plastic (wet); plentiful fine and abundant very fine roots; common very fine tubular pores; few bleached sand grains on columnar caps; slightly calcareous and strongly effervescent in spots; abrupt smooth boundary.

Pedon 101

SOIL Typic Palexeroll SOIL Nos. S64Oreg-32-6 LOCATION Wallowa County, Oregon

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 64201 - 64207

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Silt Int. II (0.2-0.02)	Silt 2-0.1			Coarse fragments 1A2a > 2 Pct. of whole soil	2-19 Pct. of <76mm	19-76 Pct. of <76mm
		Pct. of <2 mm																
0-18	Ap	17.0	60.8	22.2	0.6	1.0	0.7	5.7	9.0	19.5	41.3	32.9	8.0			1	1	
18-33	A21	16.0	64.3	19.7	0.8	1.1	0.7	4.3	9.1	20.9	43.4	33.4	6.9			1	1	
33-41	IIA22	13.8	60.7	25.5	1.6	2.3	1.1	2.5	6.3	22.7	38.0	30.6	7.5			26	4	22
41-51	IIIB21t	7.4	32.7	59.9	1.1	1.5	0.7	1.2	2.9	7.7	25.0	11.3	4.5			1	1	
51-63	IIIB22t	7.6	35.1	57.3	0.9	1.7	0.8	1.4	2.8	11.5	23.6	15.1	4.8			1	1	
63-94	IIIB3ca	8.5	38.4	53.1	1.1	1.4	0.7	1.6	3.7	14.7	23.7	19.4	4.8			tr.	tr.	
94+	IVR																	

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ 6E1b <2 mm Pct.	Carbonate as $CaCO_3$ 3A1a <0.002 mm Pct.	Bulk density 4A1f 1/3-bar g/cc	Bulk density 4A1h Oven-dry g/cc	Bulk density Est. 1/3-bar g/cc	3B2 Cm	Water content 4B1c 1/3-bar Pct.	Water content 4B2 15-bar Pct.	Water content 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH 8C1b Saturated paste	pH 8C1a H_2O 1:1	pH 8C1a H_2O 1:10
0-18	4.35	0.333	13	1.2			1.03	1.10		1.00	49.1	17.1		0.020			6.3	
18-33	1.41	0.141	10	1.4			0.91	0.95		1.00	50.0	15.7		0.014			6.2	
33-41	0.61	0.073	8	2.2					1.00	0.88		12.9					6.5	
41-51	0.66	0.079	8	2.2			1.32	1.82		0.99	34.8	32.8		0.110			6.7	
51-63	0.51			2.2	1		1.27	1.69		1.00	39.1	28.4		0.100			7.7	8.7
63-94	0.37			2.2	1		1.28	1.70		1.00	38.1	32.3		0.100			7.9	9.0
94+	0.16			2.2	7							37.3					7.9	9.0

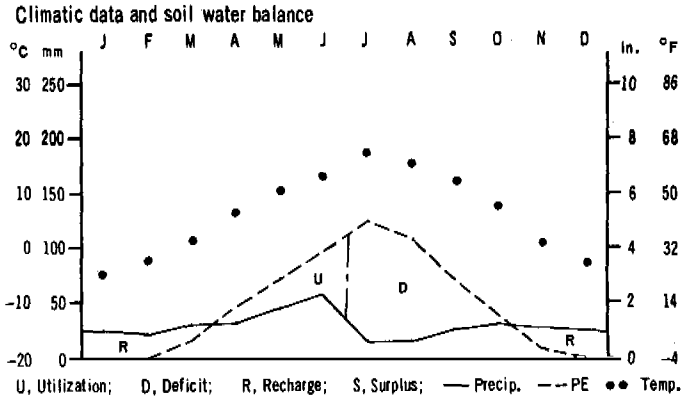
Depth (cm)	Extractable bases 6N2b Ca	6O2c Mg	6P2a Na	5B1a 6Q2a K	6H2a Ext. acidity	5A2a CEC NaOAc	5D1 Exchangeable sodium Pct.	5E Sodium adsorption ratio	8A Water at saturation Pct.	Water extract from saturated paste 8A1 6N1a Ca	6O1a Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1b SO_4	8A1a Electrical conductivity mmho/cm
	meq/100g									meq/liter								
0-18	19.7	5.7	0.2	1.0	10.4	39.4	0	1	81.5	0.6	0.2	0.6	0.3	-	0.9	0.2		0.14
18-33	15.7	6.5	0.8	0.5	8.0	31.9	2	2	71.5	0.3	0.2	1.0	0.2	-	0.5	0.2		0.14
33-41	13.5	5.9	1.2	0.5	5.6	27.7	4	3	51.0	0.3	0.2	1.6	0.1	-	0.9	0.4		0.20
41-51	33.6	16.0	3.1	1.0	5.0	62.4	5	4	81.1	0.4	0.3	2.5	0.1	-	1.2	0.7		0.28
51-63	40.3	17.8	3.5	0.9	1.3	60.4	5	5	79.2	0.8	0.4	3.7	0.3	-	2.8	0.4		0.45
63-94	44.2	17.5	4.2	0.8	tr.	61.0	6	5	78.3	0.8	0.5	4.0	0.1	-	3.4	0.4		0.47
94+	62.8	24.2	5.8	0.7	-	87.5												

Depth (cm)	Ratios to clay 8D1 CEC Na OAc	Ext. iron	15-bar water	Salt Pct.		Base saturation 5C3 Sum of cations Pct.	5C2 NaOAc Pct.
0-18	1.77	0.05	0.77			72	68
18-33	1.62	0.07	0.80			74	73
33-41	1.09	0.09	0.51			79	76
41-51	1.04	0.04	0.55			91	86
51-63	1.05	0.04	0.50			98	
63-94	1.15	0.04	0.61			100	
94+						100	

a/ 13.6 kg of organic carbon per square meter to a depth of 1 meter.

Pedon 101

Classification: Typic Palexeroll, fine, montmorillonitic, frigid.
Location: Wallowa County, Oreg. About 17 km northeast of Joseph near headwaters of Pine Creek (3 km east of Crow Creek Road). 43 m east and 18 m south of center of sec. 28, NW1/4, SE1/4, T. 1 N., R. 46 E.
Physiographic position: Upland plateau, with many intermittent lakes and ponds, elevation about 1,460 m.
Topography: Slope is 1 percent. The site is about 20 m below the highest point in the area.
Drainage: Moderately well drained; slow internal drainage; slow permeability.
Vegetation: Kentucky bluegrass (Poa pratensis) about 50 percent, dryland sedge (Carex sp.) 15 percent, crested wheatgrass (Agropyron cristatum) 10 percent, forbs 25 percent.
Parent material: Loess over mixed alluvium or colluvium and residual volcanic tuff.
Sampled by: D. Baldwin, K. W. Flach, R. C. Harriman, M. G. Lindsay, R. W. Mayko, G. H. Simonson, and H. M. Vance, July 22, 1964.
Soil No.: S64Oreg-32-6.



Colors are for the moist soil unless otherwise indicated.

Ap 0-18 cm (0-7 in.). Black (10YR 2/1.4) heavy silt loam, dark gray (10YR 4/1) when dry; weak medium plates breaking to moderate fine granules; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); abundant roots; pores mainly interstitial; few pebbles; clear wavy boundary.

A21 18-33 cm (7-13 in.). Dark brown (10YR 3/3) heavy silt loam, brown (10YR 5/3) when dry; weak medium and coarse prisms breaking to weak fine subangular blocks; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); plentiful roots; many very fine tubular pores; few pebbles; abrupt wavy boundary.

IIA22 33-41 cm (13-16 in.). Brown (10YR 4/3) heavy silt loam, pale brown (10YR 6/3) when dry; moderate fine subangular blocky structure; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); plentiful roots; many very fine tubular pores; stone line with about 10 percent gravel by volume coarser than 20 mm; horizon ranges from 0 to 8 cm thick in pit; abrupt wavy boundary.

IIIB21t 41-51 cm (16-20 in.). Dark yellowish brown (10YR 3/4) clay peds with dark brown (10YR 3/3) clay coatings; moderate fine and medium columns breaking to moderate, medium and fine subangular blocks; very firm (moist), very sticky and very plastic (wet); few roots; many very fine tubular pores; common slickensides up to 5 cm long; A2 horizon material capping prisms; few basaltic fragments 2 to 10 mm in diameter; few black concretions 2 to 5 mm in diameter that effervesce with hydrogen peroxide; clear smooth boundary.

IIIB22t 51-63 cm (20-25 in.). Brown (7.5YR 4/4) light clay; weak coarse columns breaking to moderate medium and fine subangular blocks; very firm (moist), very sticky and very plastic (wet); few roots; few very fine tubular pores; common slickensides up to 5 cm long; few basaltic fragments 2 to 10 mm in diameter; few black concretions 2 to 5 mm in diameter that effervesce with hydrogen peroxide; clear wavy boundary.

IIIB3ca 63-94 cm (25-37 in.). Brown (7.5YR 4/4) light clay; moderate medium subangular blocky structure; very firm (moist), sticky and plastic (wet); few roots; few very fine tubular pores; few basaltic fragments 2 to 10 mm in diameter; few black concretions 2 to 5 mm in diameter that effervesce with hydrogen peroxide; common light gray lime segregations 2 to 20 mm in diameter; abrupt smooth boundary.

IVR 94 cm+ (37 in.+). Volcanic tuff.

Pedon 102

SOIL Typic Acrorthox SOIL Nos. S57PR-8-1 LOCATION Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 7442-7448 (16867-16873) a/

General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A2 — Total: Sand (2–0.05) b/	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	Silt: (2–0.1)	3A1c Water-disp. clay <0.002		Coarse fragments 2A2		3B1 2–20 Pct. < 20
		Pct. of < 2 mm																
0-28	A1	9.2	36.3	54.5	1.5	2.0	0.9	2.3	2.5	6.7	29.6	10.6	6.7	c/22				tr
28-46	B1	7.4	34.9	57.7	2.9	1.5	0.6	1.1	1.3	7.1	27.8	9.0	6.1	33				tr
46-71	B21	9.8	30.6	59.6	2.3	0.9	0.4	1.4	4.8	13.4	17.2	19.2	5.0	37				tr
71-97	B22	23.3	21.0	55.7	2.5	1.8	1.1	6.0	11.9	9.4	11.6	25.9	11.4	2				tr
97-120	B23	17.0	23.3	59.7	1.7	1.8	1.1	4.3	8.1	9.2	14.1	20.3	8.9	42				tr
120-155	B24	19.2	27.2	53.6	4.0	3.3	1.4	3.5	7.0	10.2	17.0	19.5	12.2	d/32				17
155-180	C1	17.1	45.3	37.6	8.8	4.0	1.0	1.4	1.9	10.1	35.2	12.8	15.2	34				tr

Depth (cm)	6A1a Organic carbon e/, f/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ Pct.		Bulk density: 4A1a Field state g/cc	4A1c 30-cm g/cc	4A1b Air-dry g/cc	4D1 COLE g/	Water content: 4B4 Field state Pct.	4C1 30-to 15-bar cm/cm	4B3 30-cm Pct.	4B1b 1/3-bar	4B2 15-bar		pH: 8C1c (1:1) KCl	8C1a (1:1) H_2O
0-28	6.04	0.390	15	13.0			1.08	1.21	1.30	0.064	43.2	0.04	29.9	35.4	26.5		4.3	5.1
28-46	2.04	0.131	16	12.9			1.18	1.27	1.32	0.040	36.8	0.13	32.9	26.7	22.8		4.4	5.0
46-71	1.33			16.5			1.08	1.18	1.23	0.044	41.5	0.15	37.7	34.4	24.8		4.7	5.0
71-97	0.86			19.2			1.30	1.34	1.38	0.010	38.6	0.15	37.4	35.7	25.9		5.7	5.2
97-120	0.72	0.048	15	23.1			1.36	1.38	1.42	0.010	37.1	0.14	36.6	31.6	26.4		6.1	5.5
120-155	0.56			25.7			1.33	1.36	1.38	0.003	38.0	0.18	37.8	29.8	24.5		6.4	5.7
155-180	0.19			27.3			1.72	1.70	1.72	0.003	24.4	0.13	25.4	22.7	18.0		6.7	5.8

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap: 5A3a Sum cations	5A1a NH_4OAc	6G1d KCl-ext. Al		5A3b Bases plus Al me/100g clay	Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water			Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-28	1.3	1.4	0.1	0.1	2.9	31.9	34.8	25.4	1.4		7.9	0.47	0.24	0.49			8	11
28-46	0.1	-	-	-	0.1	21.4	21.5	12.1	0.9		1.7	0.21	0.22	0.40			tr	1
46-71	-	-	-	-	-	15.7	15.7	8.2	-			0.14	0.28	0.42			-	-
71-97	-	-	-	-	-	12.8	12.8	6.4				0.11	0.34	0.46			-	-
97-120	-	0.1	-	-	0.1	12.0	12.1	5.3	tr		0.2	0.09	0.39	0.44			1	2
120-155	-	-	-	-	-	12.8	12.8	3.8	tr		tr	0.07	0.48	0.46			-	-
155-180	-	-	-	-	-	9.4	9.4	1.4	tr		tr	0.04	0.73	0.48			-	-

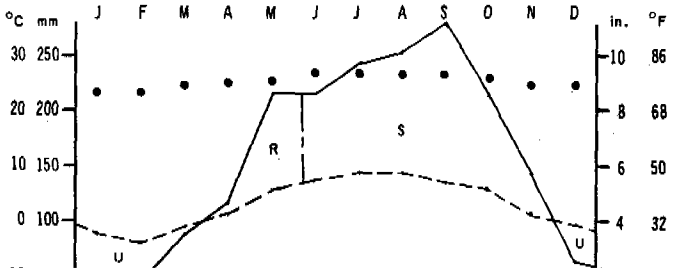
Depth (cm)	< 2 mm fraction h/ mineralogy: 7A2 X-ray i/	7A3 DTA Pct.
0-28	QZ4,GE2	GI25,KK5
28-46	QZ4,GE2	GI25,KK10
46-71	QZ3,GE3	GI30,KK20
71-97	GE3,QZ2	GI30,KK20
97-120	GE3,QZ2	GI30,KK12
120-155	GE3	GI40,KK10
150-180	GE4	GI60,KK3

a/ Site resampled in 1961 for bulk density and moisture determinations.
b/ Earthy nodules: > 50 percent.
c/ 18 percent after sodium-sulfate pretreatment; 25 percent after potassium-sulfate pretreatment. (Stand overnight in one normal salt solution, wash free of excess salts.)
d/ A trace after sodium-sulfate pretreatment; none after potassium-sulfate pretreatment.
e/ 38 kg/m² to 1.5 m (method 6A).
f/ Radiocarbon age of the B1-horizon material is 4,130 ± 110 years before present (analysis by Isotopes, Inc., No. I-4164).
g/ Data for the upper three horizons are based on field-state bulk density.
h/ Mineral code:
QZ = quartz
GE = goethite
GI = gibbsite
KK = kaolinite
i/ Approximate weight fractions:
4 = one-third to one-half
3 = one-fifth to one-third
2 = one-twentieth to one-fifth

Pedon 102

Classification: Typic Acrorthox, clayey, oxidic, isohyperthermic.
Location: Puerto Rico. Site is 0.8 km W. of kilometer marker 5.5 on Highway No. 349. On crest of hill under mango trees. About 1.5 km (1 mi.) E. of Mayague.
Physiographic position: Mesa-like hilltops.
Topography: Planar, 2-3 percent slope.
Drainage: Well drained.
Vegetation: Native grasses and trees.
Parent material: Serpentinite.
Sampled by: L. T. Alexander, Juan Juarez, Jr., C. J. Koch and J. E. Trigo, September 11, 1957.
Remarks: Site resampled in 1961 for bulk density and moisture

Climatic data and soil water balance



U, Utilization; D, Deficit; R, Recharge; S, Surplus; — Precip. – – PE •• Temp.

Colors are for the moist soil.

A1 0–28 cm (0–11 in.) Dark reddish brown (2.5YR 2/4) clay; strong fine granular structure; friable (moist); [illegible]

Pedon 103
Soil Haplic Acrorthox Soil No. Location Belém Brazil (Amazonas State)

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 69B8 - 69B12
General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1 Total: Sand (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	a/ Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: 0.05–0.02	Int. III (0.02–0.002)	Int. II (0.2–0.02)	3A1b Fine clay <0.0002	3A1c Water disper. clay	Fine clay / total clay	Coarse fragments 3B1: b/2A2 > 2 Pct.	2 – 19	19 – 76
		Pct. of < 2 mm															Pct. of < 76mm	
0–4	A1	60.3	5.0	34.7	4.7	17.7	15.1	18.6	4.2	1.8	3.2	15.6	31.2	20.7	0.90	-		
4–19	A3	38.1	5.7	56.2	2.0	8.9	9.7	13.7	3.8	1.5	4.2	12.6	42.3	26.4	0.75	-		
19–87	B21	30.9	4.9	64.2	1.9	6.9	7.5	11.1	3.5	1.3	3.6	10.8	42.1	0.6	0.66	-		
87–130	B22	19.8	2.8	77.4	2.0	4.4	4.6	6.8	2.0	0.8	2.0	6.5	43.1	0.3	0.56	-		
130–180+	B23	14.9	4.3	80.8	1.7	3.7	3.2	4.8	1.5	0.9	3.4	5.0	41.2	0.2	0.51	-		

Depth (cm)	6A1a Organic carbon Pct.	Nitrogen Pct.	C/N	6G7a Ext. Al D.C. Pct.	Carbonate as $CaCO_3$ Pct.	6C2b Ext. iron as Fe D.C. Pct.	Bulk density: g/cc	4A1e ⅓-bar g/cc	4A1h Oven dry g/cc	4D1 COLE	Water content: Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.	8E1 Resistivity at 16°C Ohms	4C1 WRD cm/cm	pH: 8C1c $CaCl_2$	8C1c (1:1) KCl	8C1a (1:1) H_2O
0–4	2.76	0.20		0.41		1.76							13.1			3.5	3.5	4.1
4–19	1.13	0.12		0.62		2.72							19.0			4.0	4.0	4.4
19–87	0.58	0.07		0.64		2.72							20.8			4.1	4.2	4.7
87–130	0.29	0.05		0.62		2.77							27.0			4.4	4.5	5.4
130–180+	0.22	0.05		0.64		2.93							29.9	35340		4.5	4.8	5.6

Depth (cm)	Extractable bases 5B1c: 6N2e Ca	6O2d Mg	6P2b Na	6Q2b K	Sum	6H2a Ext. acidity	CEC: 5A3a Sum cations	5A1a NH_4OAc pH7	6G1e Ext. Al	5A1a c/CEC NH_4Cl	Ratios to clay: CEC NH_4Cl	CEC NH_4OAc	Ext. iron	8D1 15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0–4	0.07	0.09	0.03	0.08	0.27	12.7	13.0	6.7	2.3	3.2	0.09	0.19	0.05	0.38			2	4
4–19	0.04	0.05	0.04	0.04	0.17	8.0	8.2	3.4	1.1	2.3	0.04	0.06	0.05	0.34			2	5
19–87	0.01	0.01	0.02	0.01	0.05	6.0	6.0	2.8	0.6	1.7	0.03	0.04	0.04	0.32			1	2
87–130	0.01	0.01	0.02	0.01	0.05	5.1	5.1	2.4	0.2	1.1	0.01	0.03	0.04	0.35			1	2
130–180+	0.01	<0.01	0.01	0.01	0.03	4.8	4.8	2.1	0.0	1.2	0.01	0.03	0.04	0.37			1	1

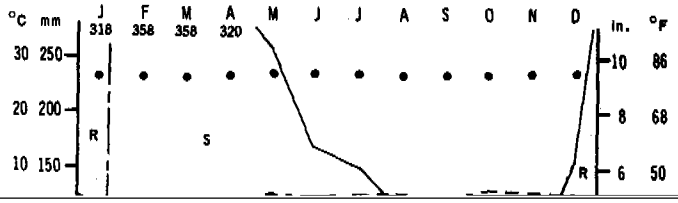
Depth	Clay fraction d/mineralogy 7A1b-d

a/ Fine and very fine sand mainly reddish brown aggregates.
b/ Few easily crushed concretions.

Pedon 103

Classification: Haplic Acrorthox, clayey, kaolinitic, isohyperthermic.
Location: Amazonas State, along Highway Am-070, 10.5 km from Cacau-Pirêra toward Manacapurú, on the right side 100 m from the road.
Physiographic position: Top of low, gently undulating plateau.
Topography: Level with gradient, 0 to 2 percent.
Drainage: Well drained.
Vegetation: Evergreen tropical forest.

Climatic data and soil water balance



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Pedon 104

SOIL Tropeptic Eutrorthox SOIL Nos. S63PR-7-1 LOCATION Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 18930-18935

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand a/ (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: (0.05–0.02)	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	<0.0002	<0.074	Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-20	Ap	19.2	7.7	73.1	-	1.4	6.2	9.8	1.8	1.6	6.1	7.3	17.4		81.8			-
20-46	B21	12.3	6.5	81.2	0.1	1.0	3.5	6.3	1.4	1.1	5.4	5.2	10.9		88.3			-
46-69	B22	9.3	5.2	85.5	0.3	0.7	2.7	4.7	0.9	1.7	3.5	4.5	8.4	42.3	91.1			-
69-99	B23	5.8	4.7	89.5	0.1	0.3	1.8	3.1	0.5	0.1	4.6	1.9	5.3		94.4			-
99-130	B3	3.1	6.3	90.6	-	0.2	0.9	1.6	0.4	-	6.3	1.1	2.7		97.1			-
130+	R																	

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	6E1b 6E2a Carbonate as $CaCO_3$ Pct.		Bulk density: 4A1a Field state g/cc	4A1d 1/3-bar c/ g/cc	4A1b Air-dry g/cc	4D1 COLE	Water content: 4B4 Field state Pct.	4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm		pH: 8C1c (1:1) N KCl	8C1a (1:1) H_2O
0-20	2.73	0.227	12	7.2			1.22	1.2	1.42		35.1		26.7			4.9	5.6
20-46	0.94	0.145	6	8.3			1.25	1.3	1.41		34.7		30.1			4.7	5.4
46-69	0.55	0.110	5	7.8			1.23	1.26	1.37	0.028	36.1	34.2	32.5	0.02		5.4	5.9
69-99	0.35			8.3			1.25	1.26	1.40	0.036	35.0	33.9	30.1	0.05		5.2	5.6
99-130	0.25			8.8			1.29	1.28	1.46	0.044	34.9	34.9	29.8	0.07		5.7	5.7
130+					98												

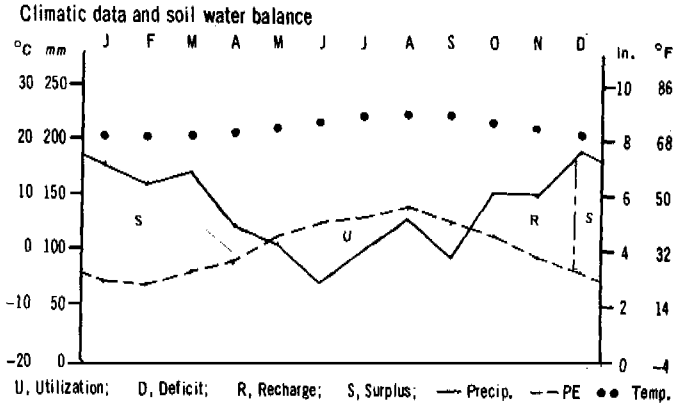
Depth (cm)	Extractable bases 5B1a: 6N2a Ca	6O2a Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap.: 5A3a Sum cat-ions	5A1a NH_4OAc	6G1d KCl-ext. Al	6L2a NH_4OAc ext. SO_4	5A3b Bases plus Al me/100g clay	Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water	Base saturation: 5C3 Sum cat-ions Pct.	5C1 NH_4OAc Pct.
	meq/100 g															
0-20	8.1	2.1	0.1	0.6	10.9	15.6	26.5	15.1		1.1	14.9	0.21	0.10	0.37	41	72
20-46	4.2	1.6	0.1	0.6	6.5	13.2	19.7	9.5	0.3	2.8	8.4	0.12	0.10	0.37	33	68
46-69	5.0	1.5	0.2	0.4	7.1	12.0	19.1	8.6	-	2.4	8.3	0.10	0.09	0.38	37	83
69-99	5.9	1.9	0.2	0.1	8.1	11.0	19.1	9.8		3.0	9.1	0.11	0.09	0.34	42	83
99-130	10.2	1.9	0.3	0.1	12.5	8.8	21.3	14.1		1.3	13.8	0.16	0.10	0.33	59	89
130+																

Depth (cm)	Clay fraction d/ mineralogy 7A1: 7A2 X-ray e/	7A3 DTA Pct.
0-20		
20-46		
46-69	MI1,CL1	KK45,GI5,GE5
69-99		
99-130		
130+		

a/ Earthy nodules: > 50 percent 2-0.5 mm; 5-25 percent 0.5-0.05 mm.
b/ 14 kg/m² to 1.5 m (method 6A).
c/ Values estimated for upper two horizons.
d/ Mineral code:
MI = mica
CL = chlorite
KK = kaolinite
GI = gibbsite
GE = goethite
e/ Approximate weight fractions:
1 = less than one-twentieth

Pedon 104

Classification: Tropeptic Eutrorthox, clayey, mixed, isohyperthermic.
Location: Puerto Rico. 2 km NE. of Vega Alta; 1.7 km N. on Highway No. 694 (from kilometer 28.5 on Highway 2), left 0.8 km by dairy barn 0.2 km. 25 km (15 mi.) W. of San Juan.
Physiographic position: Terrace or alluvial fan immediately north of limestone hills.
Topography: 3 percent slope.
Drainage: Well drained; medium runoff; moderate permeability.
Vegetation: Pangolagrass pasture (Digitaria decumbens).
Parent material: Transported sediments derived from weathered limestone and quartzitic sand deposits.
Sampled by: R. B. Grossman, J. Juarez, W. E. McKinzie and L. H. Rivera, September 30, 1963.
Remarks: Soil was about field capacity when sampled.
Soil No.: S63PR-7-1.



Colors are for the moist soil unless otherwise indicated.

Ap 0-20 cm (0-8 in.). Dark reddish brown (5YR 3/4) clay; weak fine subangular blocky structure; slightly hard (dry), firm (moist), slightly sticky and slightly plastic (wet); common fine roots; common sand size subrounded quartz grains; common fine sand size black grains; clear smooth boundary.

B21 20-46 cm (8-18 in.). Dark red (2.5YR 3/6) clay, red (2.5YR 4/6) dry; weak fine and medium subangular blocks breaking to medium granules; friable (moist), slightly sticky and slightly plastic (wet); small pieces fail abruptly upon slight pressure between fingers; plentiful fine roots; common fine pores; common pressure surfaces; common fine black sand-size grains; common fine quartz grains; gradual smooth boundary.

B22 46-69 cm (18-27 in.). Dark red (2.5YR 3/6) clay, red (2.5YR 4/6) dry; weak fine subangular blocky structure; friable (moist), slightly sticky and slightly plastic (wet); small pieces fail abruptly upon slight pressure between fingers; few fine roots; common fine pores; common pressure surfaces; few fine black sand-size grains; common fine subrounded sand-size quartz grains; gradual smooth boundary.

B23 69-99 cm (27-39 in.). Red (2.5YR 4/6) clay; weak fine and medium subangular blocks breaking to medium granules; friable (moist), slightly sticky and slightly plastic (wet); small pieces fail abruptly upon slight pressure between fingers; few fine roots; common fine pores; common pressure surfaces; common fine sand-size black grains; common sand-size subrounded quartz grains; gradual smooth boundary.

B3 99-130 cm (39-51 in.). Red (2.5YR 4/6) clay; weak fine and medium subangular blocky structure; friable (moist), slightly sticky and slightly plastic (wet); small pieces fail semiplastically upon slight pressure between fingers; common sand-size quartz grains; few fine sand-size black grains; abrupt wavy boundary.

R 130 cm (51 in.) plus. White hard limestone.

Pedon 105

SOIL FAMILY Typic Gibbsiorthox, clayev. oxidic. isohyperthermic

SOIL SURVEY LABORATORY - Riverside, Calif. SOIL Nos. S62Ha-2-5 LOCATION Kauai County, Hawaii

Depth (cm)	Horizon	a/ Total chemical analysis												Extractable iron 6C1a		Carbonate as $CaCO_3$ 6E1b	0.5N NaOH soluble	
		SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO_2	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.	Total	Fe	Fe_2O_3		SiO_2	Al_2O_3
		Percent of whole soil																
0-38	Ap1	8.5	8.7	31.3	45.5	0.07	-	-	0.06	0.23	0.70	5.0	100.1	24.5	35.0		0.29	5.26
38-48	Ap2	2.9	8.0	20.6	48.2	0.07	-	-	0.07	0.23	0.63	19.7	100.4	32.5	46.5		0.22	5.04
48-76	B21	1.0	8.3	20.8	46.4	0.04	-	-	0.07	0.10	0.60	20.5	97.8	26.2	37.5		0.06	10.16
76-100	B22	0.4	7.3	28.5	42.3	0.09	-	-	0.07	-	0.61	20.7	100.0	26.1	37.3		-	15.57
100-155	C1	0.4	6.8	30.1	41.3	0.08	tr.	-	tr.	-	0.64	20.2	99.5	23.5	33.6		-	18.89
155-230	C2	0.6	7.1	31.1	40.9	0.16	tr.	-	tr.	-	1.18	19.4	100.4	20.5	29.3		-	20.99

Depth (cm)	6A1a b/ Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	Extractable bases 5B1a 6N2a Ca	602a Mg	6P2a Na	6Q2a K	Sum of bases	Extr. acidity 6H2a	Cation exch. capacity 5A1a NH_4OAc	5a3a Sum	NH_4OAc 6L2a extr. SO_4	KCl ext. Al^{3+++} 6G1D	Base saturation 5C1 NH_4OAc	5C3	pH 8C1a H_2O 1:5	8C1c KCl 1:5
				Meq./100 g.										Percent			
0-38	3.88	0.27	14	0.5	0.6	0.1	0.1	1.3		14.6		1.6	0.3	9		5.2	4.2
38-48	2.43	0.14	17	-	-	0.1	0.1	0.2		9.6		5.0	0.1	2		4.7	4.4
48-76	1.58	0.07	23	-	0.6	tr.	tr.	0.6		4.8		6.5	0.1	12		5.0	5.1
76-100	1.10	0.05	22	-	-	tr.	tr.	-		2.6		11.3	0.1	tr.		4.8	5.3
100-155	0.66	0.23	3	0.2	0.1	0.1	0.1	0.5		1.9		14.5	0.1	26		4.8	5.4
155-230	0.16	0.11	1	-	-	0.1	tr.	0.1		0.5		14.4	0.1	20		4.9	5.3

Depth (cm)	Size class and particle diameter (mm) 3A1 Sand (2-0.05)	Silt (0.5-0.002)	Clay (<.002)	Coarse fragments >2mm pct. of whole soil	Atterberg limits Plastic limit	Liquid limit	Plastic index	c/ Bulk density 1/3-bar	Oven-dry	Field moist	Particle density	c/ Water content	1/3-bar	15-bar	Extensibility 4D1 COLEf	COLE
	Pct. of 2mm.							g/cc				Pct. of whole soil			cm/cm	
0-38										1.12	3.17		41.2	30.9		
38-48										1.10	3.38		40.9	33.8		
48-76										1.12	3.29		41.1	33.4		
76-100										1.26	3.22		42.8	29.3		
100-155										1.19	3.23		41.6	26.6		
155-230											3.24		37.6	18.8		

Depth (cm)	a/Mineralogical analysis, whole soil DTA 7A3	Extr. iron 6C2	Total analysis d/	Diff. solubility e/
	Percent			
0-38	KK5, GI40	GE40	MI3,FE15,RE10	QZ5
38-48	KK2, GI35	GE50	MI3,FE 2,RE10	QZ2
48-76	GI25	GE40	MI1,FE15,RE10	QZ1
76-100	GI35	GE40	FE10,RE10	
100-155	GI45	GE40	FE10,RE10	
155-230	GI45	GE30	FE15,RE10	

a/Analyses by the University of Hawaii.
Mineral code: Numbers following mineral code are percent by weight.
KK = kaolinites
GI = gibbsite
GE = goethite
MI = mica
FE = magnetite
RE = anatase
QZ = quartz

b/27.5 kg of organic carbon per square meter to a depth of 1 meter.

c/Analyses by the Hawaii Sugar Planters Association.

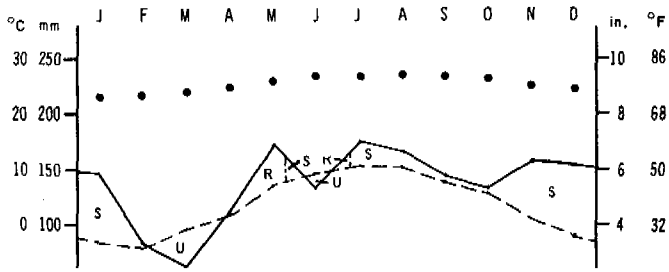
d/All extractable Fe was allocated to goethite, remaining total iron to magnetite. Ti was allocated to anatase, K to mica.

e/Differential Solubility (Jackson, M. L., 1956), Soil chemical analysis, advanced course, published by author, University of Wisconsin, Madison.

Pedon 105

Classification: Typic Gibbsiorthox, clayey, oxidic, isohyperthermic.
Location: Island of Kauai, Kauai County, Hawaii. 75 m south of highway at a point 1.7 km southwest of Bailey bridge at Kalihiwai, approximately 6.4 km west of Kilauea. Approximately 22 km northwest of Lihue.
Physiographic position: Upland, elevation about 96 m.
Topography: Slightly convex, southwest-facing 1 to 2 percent slope.
Drainage: Well drained; medium runoff; moderately rapid permeability.
Vegetation: Pangola (Digitaria decumbens) pasture.

Climatic data and soil water balance



Pedon 106

SOIL FAMILY Tropeptic Umbriorthox, clayey, oxidic, isohyperthermic

SOIL SURVEY LABORATORY - Riverside, Calif. SOIL Nos. S63Ha-2-2 LOCATION Kauai County, Hawaii

Depth (cm)	Horizon	a/ Total chemical analysis SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO_2	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.	Total	Extractable iron 6C1a Fe	Fe_2O_3	Carbonate as $CaCO_3$ 6E1b	0.5N NaOH soluble SiO_2	Al_2O_3
		Percent of whole soil																
0-23	Ap	17.4	4.5	33.1	29.8	0.18	2.04	tr.	0.11	0.75	0.64	13.1	101.6	16.5	23.6		14.14	5.03
23-53	B21	17.8	4.8	32.7	32.8	0.08	1.56	tr.	0.08	0.51	0.50	8.3	99.1	19.6	28.0		13.86	5.82
53-76	B22	22.1	5.7	22.3	34.5	0.10	1.40	-	0.11	0.33	0.57	12.1	99.2	20.6	29.5		15.64	8.85
76-99	B23	22.0	5.4	21.1	33.8	0.11	0.49	-	0.11	0.15	0.48	15.8	99.4	18.4	26.3		16.02	9.07
99-120	B24	16.1	5.1	29.0	32.1	0.10	0.59	-	0.13	0.11	0.51	16.7	100.4	18.3	26.2		17.05	8.85
120-150	B3	18.5	4.8	27.1	32.8	0.14	0.50	-	0.09	0.09	0.62	15.6	100.2	17.4	24.9		16.99	11.44

Depth (cm)	6A1a b/ Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	Extractable bases 5B1a 6N2a Ca	602a Mg	6P2a Na	6Q2a K	Sum of bases	Extr. acidity 6H2a	Cation exch. capacity 5A1a NH_4OAc	5a3a Sum	NH_4OAc 6L2a extr. SO_4	KCl extr. Al^{+++} 6G1D	Base saturation 5C1 NH_4OAc	5C3	pH 8C1a H_2O 1:5	8C1c KCl 1:5
				Meq./100 g.										Percent			
0-23	4.39	0.37	12	2.2	2.0	0.2	0.8	5.2		19.8		0.8	0.2	26		5.9	4.9
23-53	1.72	0.14	12	1.0	0.6	0.2	0.2	2.0		9.4		2.8	0.1	21		5.4	5.4
53-76	1.27	0.08	16	1.1	0.6	0.6	0.1	2.4		10.8		1.6		22		5.8	5.8
76-99	0.62			0.9	0.8	0.9	0.1	2.7		7.2		3.4		38		6.0	5.9
99-120	0.52			0.9	0.9	1.0	0.1	2.9		5.9		5.6		49		5.8	5.7
120-150	0.41			1.0	0.8	1.3	0.1	3.2		6.8		7.6		47		5.6	5.3

Depth (cm)	Size class and particle diameter (mm) 3A1 Sand (2-0.05)	Silt (0.5-0.002)	Clay (<.002)	Coarse fragments >2mm pct. of whole soil	Atterberg limits Plastic limit	Liquid limit	Plastic index	c/ Bulk density 1/3-bar	Oven-dry	Field moist	Particle density	c/ Water content Field moist	1/3-bar	15-bar	Extensibility 4D1 COLEf	COLE
	Pct. of 2mm.							g/cc				Pct. of whole soil			cm/cm	
0-23				-						0.91	2.87	71.0	46.3	34.2		
23-53				-						0.92	3.06	57.2	50.5	40.3		
53-76				-						0.98	3.05	55.1	49.2	42.3		
76-99				-						1.10	3.04	48.4	44.1	38.8		
99-120				-						1.14	3.08	47.1	41.1	34.5		
120-150				-						1.15	3.13	51.1	44.1	33.2		

Depth (cm)	a/ Mineralogical analysis, whole soil DTA 7A3	Extr. iron 6C2	Total analysis d/
	Percent		
0-23	KK20, GI20	GE25	MI10, FE10, RE5
23-53	KK25, GI15	GE30	MI 5, FE 5, RE5
53-76	KK25, GI20	GE30	MI 5, FE 5, RE5
76-99	KK30, GI15	GE30	MI 2, FE10, RE5
99-120	KK30, GI20	GE30	MI 2, FE10, RE5
120-150	KK35, GI10	GE30	MI 1, FE10, RE5

a/ Analyses by the University of Hawaii.

Mineral code:
KK = kaolinites
GI = gibbsite
GE = goethite
MI = mica
FE = magnetite
RE = anatase

Numbers following mineral code are percent by weight.

b/ 18.4 kg of organic carbon per square meter to a depth of 1 meter.

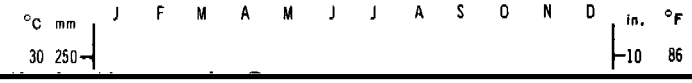
c/ Analyses by the Hawaii Sugar Planters Association.

Pedon 106

Classification: Tropeptic Umbriorthox, clayey, oxidic, isohyperthermic.

Location: Island of Kauai, Kauai County, Hawaii. 3.7 km west

Climatic data and soil water balance



Pedon 10?

SOIL FAMILY Typic Torrox, clayey, kaolinitic, isohyperthermic

SOIL SURVEY LABORATORY - Riverside, Calif. SOIL Nos. S61Ha-7-5 LOCATION Honolulu County, Hawaii

Depth (cm)	Horizon	Total chemical analysis SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO_2	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.	Total	Extractable iron 6C1a Fe	Fe_2O_3	Carbonate as $CaCO_3$ 6E1b	0.5N NaOH soluble SiO_2	Al_2O_3
		Percent of whole soil																
0-15	Ap1													9.9	14.1			
15-38	Ap2													9.7	13.8			
38-66	B21													9.1	13.0			
66-100	B22													7.8	11.2			
100-150	C													7.6	10.9			

Depth (cm)	6A1a Organic carbon Pct.	6B2a Nitrogen Pct.	C/N	Extractable bases 5B1a 6N2a Ca	6O2b Mg	6P2a Na	6Q2a K	Sum of bases	Extr. acidity 6H2a	Cation exch. capacity 5A1a NH_4OAc	5a3a Sum	NH_4OAc extr. SO_4	KCl extr. Al^{+++} 6G1D	Base saturation 5C1 NH_4OAc	5C3 Sum	pH 8C1a H_2O 1:1	8C1c KCl 1:1
				Meq./100 g.										Percent			
0-15	1.92	0.200	10	6.0	3.0	0.3	0.4	9.7	13.8		23.5		tr.		41	5.7	5.0
15-38	1.97	0.187	10	5.3	3.1	0.3	0.1	8.8	12.1		20.9		tr.		42	6.0	5.3
38-66	0.50	0.066	8	3.0	2.2	0.6	-	5.8	5.7		11.6				51	6.4	5.8
66-100	0.50	0.050	10	3.2	2.5	1.4	-	7.1	7.3		14.4				49	6.6	5.9
100-150	0.24			2.0	1.8	0.9	0.1	4.8	5.4		10.2				47	6.9	6.1

Depth (cm)	Size class and particle diameter (mm) 3A1 Sand (2-0.05)	Silt (0.5-0.002)	Clay (<.002)	Coarse fragments >2mm pct. of whole soil	Atterberg limits Plastic limit	Liquid limit	Plastic index	Bulk density 1/3-bar	Oven-dry	Field moist	Particle density	Water content 1/3-bar	4B2 15-bar	Extensibility, 4D1 COLEf	COLE
	Pct. of 2mm.							g/cc				Pct. of whole soil		cm/cm	
0-15													22.3		
15-38													22.5		
38-66													22.1		
66-100													23.1		
100-150													21.2		

Depth (In.)	a/ Mineralogy, whole soil 7A2 X-ray b/	7A3 DTA Pct.
0-15	MG3, HM3, MI2, QZ2, IL2	KK40, GI12
15-38		KK40, GI10
38-66		KK52, GI10
66-100		KK54, GI 2
100-150	MG4, HM3, IL3	KK52

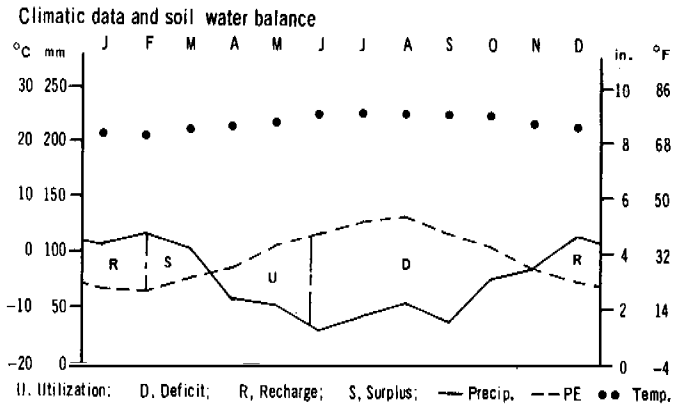
a/ Mineral code:
MG = magnetite
HM = hematite
MI = mica
QZ = quartz
IL = ilmenite
KK = kaolinite
GI = gibbsite

b/ Approximate weight fraction (X-ray):
4 = one-third to half
3 = one-fifth to one-third
2 = one-twentieth to one-fifth

Pedon 107

Classification: Typic Torrox, clayey, kaolinitic, isohyperthermic.
Location: Island of Oahu, Honolulu County, Hawaii. 0.5 km from Diamond Head side of Wahiawa end of the island of Oahu. Block 2, Field 4115-16, Dole Pineapple.
Physiographic position: 96 m.
Drainage: Well drained.
Vegetation: Pineapple (Ananas comosus).
Parent material: Basic igneous rock or alluvium.
Sampled by: D. Womack and J. M. Williams.
Remarks: The soil does not disperse well, hence particle size analysis was not made. Only field estimates of texture are given in the profile description.
Soil No. S61Ha-7-5.

Colors are for moist soil unless otherwise indicated.



Ap1 0-15 cm (0-6 in.). Dark reddish brown (2.5YR 2/4) silty clay, dark reddish brown (2.5YR 3/4) dry; moderate coarse medium and fine granular structure; very hard (dry), friable (moist), sticky and plastic (wet); many roots; many fine and very fine interstitial pores; strong effervescence with hydrogen peroxide; few fine black manganese dioxide shot; strongly magnetic; clear wavy boundary.

Ap2 15-38 cm (6-15 in.). Dark reddish brown (2.5YR 2/4) silty clay, dark red (2.5YR 3/6) dry; weak medium and fine subangular blocky structure; very hard (dry), friable (moist), sticky and plastic (wet); many roots; many medium fine and very fine tubular pores; common very fine black manganese dioxide shot; strongly magnetic; strong effervescence with hydrogen peroxide; abrupt wavy boundary.

B21 38-66 cm (15-26 in.). Dark reddish brown (2.5YR 2/4) silty clay; moderate fine and very fine subangular blocky structure; friable (moist), sticky and plastic (wet); very few fine roots; many fine and very fine tubular pores; somewhat brittle; many small patches of stress cutans; common very fine black manganese dioxide shot; strongly magnetic; clear wavy boundary.

B22 66-100 cm (26-40 in.). Dark reddish brown (5YR 3/3) light silty clay; weak and moderate fine and very fine subangular blocky structure; friable (moist), sticky and plastic (wet); few roots; many very fine and fine tubular pores; few medium pores; many small patches of stress cutans; gradual wavy boundary.

C 100-150 cm (40-60 in.). Dark reddish brown (5YR 3/4) silty clay loam; weak medium and fine subangular blocky structure; friable (moist), sticky and plastic (wet); common coarse medium and fine dark red and strong brown weathered rock fragments; many medium fine and very fine tubular pores; many patches of stress cutans.

SOIL Pedon 108 Aeric Haplaquod SOIL Nos. S53Ga-13-10 LOCATION Brantley County, Georgia

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 53320 - 53328

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Silt Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1 2A2 > 2 Pct.	2-19 (Pct. of < 76mm)	19-76 (Pct. of < 76mm)
		Pct. of < 2 mm																
0-8	A1	94.5	5.0	0.5	0.4	21.2	36.2	31.4	5.3		3.1	20.4				0		
8-41	A2	94.3	5.3	0.4	0.6	23.1	34.3	31.7	4.6		3.3	20.4				0		
41-43	A3	88.4	8.9	2.7	0.6	21.9	32.9	28.8	4.2		7.0	18.3				0		
43-46	B21h	88.7	9.6	1.7	0.5	20.7	33.2	29.8	4.5		4.4	19.4				0		
46-51	B22h	89.9	7.9	2.2	0.6	21.9	33.9	29.1	4.4		3.9	18.2				0		
51-69	B3	93.0	5.3	1.7	0.6	20.8	35.5	31.6	4.5		3.4	19.5				0		
69-99	C1	94.6	4.7	0.7	0.6	23.3	34.0	31.5	5.2		2.4	20.7				0		
99-110	IIC2	79.3	16.0	4.7	0.5	18.6	29.6	26.7	3.9		12.3	18.8				0		

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	Fe/C	6C2b Ext. Al D.C. Pct.	6C1a Ext. iron as Fe D.C. Pct.	Na Pyrophosphate (2-200, pH 10) extractable 6G5a Al Pct.	6C5a Fe Pct.	6A1b Ext. C	Pyr. ext. Fe+Al / %clay	Pyr. ext. Fe+Al / C-D Fe+Al Pct.	Pyr. ext. Al+C / Clay Pct.			4C1 WRD	pH 8C1c (1:1) KCl	8C1a (1:1) H_2O
0-8	1.12	0.039	29	-	0	tr.	tr.	tr.		-							4.8
8-41	0.03	0.006	5	-	0	tr.	tr.	tr.		-							5.6
41-43	1.05	0.035	30	0.1	0.06	0.1	tr.	tr.		-							4.5
43-46	2.54	0.037	69	-	0.54	0.1	0.91	tr.	2.20	0.54	1.42	1.83					4.7
46-51	1.10	0.029	38	-	0.34	tr.	0.51	tr.	0.93	0.23	1.50	0.65					5.1
51-69	0.10	0.008	12	-	0.05	tr.	tr.	tr.		-							5.3
69-99	0.02	0.005	4	-	0.02	tr.	tr.	tr.		-							5.7
99-110	0.07	0.009	8	1.4	0.07	0.1	0.10	tr.		0.02							5.2

Accumulation Index = 144

Depth (cm)	Extractable bases 5B1a 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC 5A3a Sum cations	5A1a NH_4OAc	6G1d Ext. Al			Ratios to clay 8D1 CEC Sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-8	1.5	0	<0.1	<0.1	1.5	4.3	5.8	3.2				11.6	-				26	
8-41	0.4	0	<0.1	<0.1	0.4	0.6	1.0	0.4				2.5	-				40	
41-43	0.4	0	<0.1	<0.1	0.4	6.2	6.6	3.4				2.4	0.04				6	
43-46	0.2	0.2	<0.1	<0.1	0.4	27.1	27.5	11.7				16.2	0.06				1	
46-51	0.2	0.1	<0.1	<0.1	0.3	13.5	13.8	4.5				6.3	-				3	
51-69	0.4	0	<0.1	<0.1	0.4	2.2	2.6	0.8				1.5	-				15	
69-99	0.4	0.1	<0.1	<0.1	0.5	0.9	1.4	0.7				2.0	-				36	
99-110	0	0	<0.1	<0.1	-	1.8	1.8	1.1				0.4	0.02				0	

Depth (cm)	Sand fraction mineralogy 7B1 Petrographic
0-8	
8-41	
41-43	
43-46	Siliceous minerals 99 Pct.
46-51	
51-69	
69-99	
99-110	

Pedon 108

Climatic data

°C mm J F M A M J J A S O N D °C

Pedon 109

SOIL Typic Cryohumod SOIL Nos. S67Ak-58-2 LOCATION Nondalton, Alaska

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 67167 - 67172

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Silt Int. II (0.2-0.02)	Silt 2-0.1			Coarse fragments 1A2a > 2 Pct. of whole soil	2-19 Pct. of <76mm	19-76 Pct. of <76mm
		Pct. of <2 mm																
10-0	01															-	-	-
0-5	A2	36.4	57.5	6.1	1.8	5.0	5.4	11.8	12.4	21.1	36.4	39.9	24.0			-	-	-
5-13	B21h	51.4	41.2	7.4	3.6	6.6	7.3	20.0	13.9	17.2	24.0	41.5	37.5			20	20	-
13-23	B22															27	21	6
23-33	B3															21	20	1
33-76	IIC	66.8	31.1	2.1	12.3	16.4	9.8	17.4	10.9	14.8	16.3	35.3	55.9			57	41	16

Depth (cm)	6A1b Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	Ratios to clay 8D1 CEC NH_4OAc	Ratios to clay 8D1 Ext. iron	Ratios to clay 8D1 15-bar water	Bulk density 4A1f 1/3-bar g/cc	Bulk density 4A1h Oven-dry g/cc	Bulk density Est. 1/3-bar g/cc	3B2 Cm	Water content 4B1c 1/3-bar Pct.	Water content 4B2 15-bar Pct.	Water content 4B2a 15-bar Pct.	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH 8C1b Saturated paste	pH 8C1d NaF 1:50	pH 8C1c IN KCl 1:1
10-0	42.52	0.997	43									123.	117.			3.6	6.3	3.1
0-5	9.98	0.282	35	3.95	0.07	3.11	0.65	0.73		1.00	64.8	19.0	15.2	0.038	0.038	3.7	7.0	3.5
5-13	11.77	0.379	31	8.35	0.19	3.18	0.56	0.68		0.95	72.0	23.5	13.6	0.068	0.065	4.6	11.0	4.2
13-23	6.66	0.223	30				0.76	0.88		0.90	49.0	16.5	25.4	0.050	0.045	4.9	11.0	4.4
23-33	1.31	0.055	24				1.31	1.33		0.88	19.3	6.5	8.7	0.005	0.005	5.5	10.6	4.6
33-76	0.17			2.00	0.29	1.19			1.30	0.60		2.5	2.7			5.8	9.7	4.5

Depth (cm)	Extractable bases 6N2e Ca	6O2d Mg	6P2a Na	5B4a 6Q2a K	Sum of bases	6H2a Ext. acidity	Cation exch. capacity 5A6a NH_4OAc moist	5A6a NH_4OAc AD	5A3a Sum of cations	Bases + KCl ext. Al +++	6G1d KCl ext. Al +++	Base saturation 5C1 NH_4OAc Pct.	5C3 Sum of cations Pct.	b/ 3A1 Clay fraction mineralogy 7A2 X-ray c/	d/ miner. alogy <2 mm soil Pct.
	meq/100g														
10-0	8.5	3.1	0.3	1.8	13.7	89.2		95.6	102.9	17.0	3.3	14	13		
0-5	0.1	0.2	0.2	0.2	0.7	34.1	23.9	24.1	34.8	5.5	4.8	3	2	VR3, KK1	Am 2
5-13	0.1	0.1	0.1	0.1	0.4	75.9		61.8	76.3	5.0	4.6	1	1	VR1	Am10
13-23	0.3	0.1	0.1	0.1	0.6	60.0	37.1	43.6	60.6	2.3	1.7	1	1		Am12
23-33	0.7	0.1	0.2	0.1	1.1	20.4	10.6	11.5	21.5	1.6	0.5	10	5		Am 8
33-76	0.6	0.1	0.2	0.1	1.0	4.6		4.2	5.6	1.2	0.2	24	18	VR3, KK3, MI1	Am 3

Depth (cm)	D.-C. 6C2a Fe	ext. 6G7a Al	Na-pyroph. extractable 6C5a Fe	Na-pyroph. extractable 6G5a Al	$(NH_4)_2$-Ox. extractable 6C6a Fe	$(NH_4)_2$-Ox. extractable 6G6a Al	Na Pyr. Fe+Al Di.-Ci. Fe+Al	Na Pyr. Fe+Al clay
	Pct.							
10-5	0.3							
0-5	0.4		0.2	0.2	0.5	0.3		0.07
5-13	1.4	2.5	1.1	2.5	1.2	2.8	0.92	0.49
13-23	1.4	2.4	0.7	1.5	1.1	3.0	0.58	
23-33	1.0		0.1	0.4	0.7	1.5		
33-76	0.6		tr.	0.1	0.4	0.4		0.05

a/ 14.9 kg of organic carbon per square meter to a depth of 1 meter.

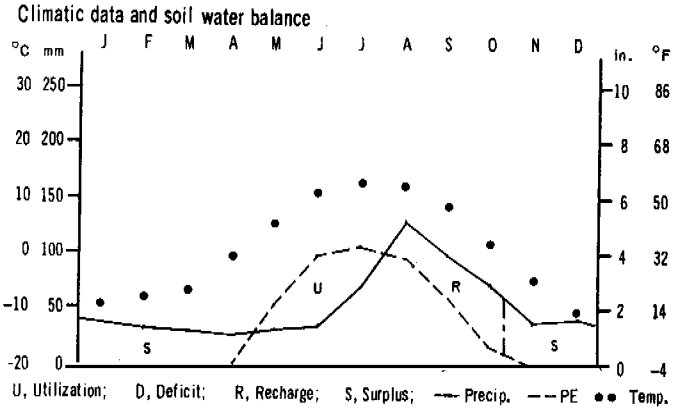
b/ Mineral code:
VR = vermiculite
MI = mica
KK = kaolinite
Am = allophane

c/ Approximate weight fraction (X-ray):
3 = one-fifth to one-third
1 = less than one-twentieth

d/ Rehydration after heating to 300° C. (Birrell, K. W. and M. Fieldes, Amorphous Constituents. In Soils of New Zealand Part 2).

Pedon 109

Classification: Typic Cryohumod, coarse-loamy over sandy or sandy-skeletal, mixed.
Location: 152 m east of south end of airstrip at Nondalton, Alaska. Approximate longitude 154°51',W; latitude 59°59',N.
Physiographic position: Glacial moraine, elevation about 107 m.
Topography: Southeast-facing, 15 percent slope.
Drainage: Well drained.
Vegetation: Black spruce (Picea mariana), birch (Betula sp.), willows (Salix sp.), low-growing shrubs; burned over.
Parent material: Volcanic ash over till.
Sampled by: K. W. Flach and S. Rieger, August 2, 1967.
Remarks: The soil did not disperse well, hence field estimates of texture are given in the profile description.
Soil No.: S67Ak-58-2.



Colors are for moist soil.

O1 10-0 cm (4-0 in.). Very dusky red (2.5YR 2/2) partially decomposed organic materials; many roots; charcoal; abrupt smooth boundary.

A2 0-5 cm (0-2 in.). Dark gray (10YR 4/1) silt loam; pockets of dark brown (10YR 4/3) fine sand, probably ash, and irregular streaks of very dusky red (2.5YR 2/2) mucky silt loam; weak very thin platy structure; friable (moist), thixotropic (wet); many roots; charcoal; mycelia; abrupt irregular boundary.

B21h 5-13 cm (2-5 in.). Reddish black (10YR 2/1) silt loam; moderate very fine granular structure; crusted at upper surface of horizon; fine concretions throughout, but generally friable (moist); roots common; mycelia; 5 percent gravel by volume; clear irregular boundary.

B22 13-23 cm (5-9 in.). Dark reddish brown (2.5YR 3/4) coarse silt loam; weak very fine granular structure; friable (moist), thixotropic (wet); roots common; mycelia; 10 percent gravel by volume; clear wavy boundary.

B3 23-33 cm (9-13 in.). Dark brown (7.5 YR 4/4) coarse silt loam; weak very thin platy structure; friable (moist); slightly thixotropic (wet); roots common; 12 percent gravel by volume; abrupt wavy boundary.

IIC1 33-76 cm (13-30 in.). Olive (5Y 4/3) gravelly sandy loam; lenses of dark brown (10YR 4/3) gravelly sandy loam and yellowish brown (10YR 5/6) silt loam near upper surface of horizon; weak fine platy structure; loose; no roots; about 40 percent gravel by volume.

Pedon 110

SOIL Typic Placohumod SOIL Nos. LOCATION Antwerp, Belgium

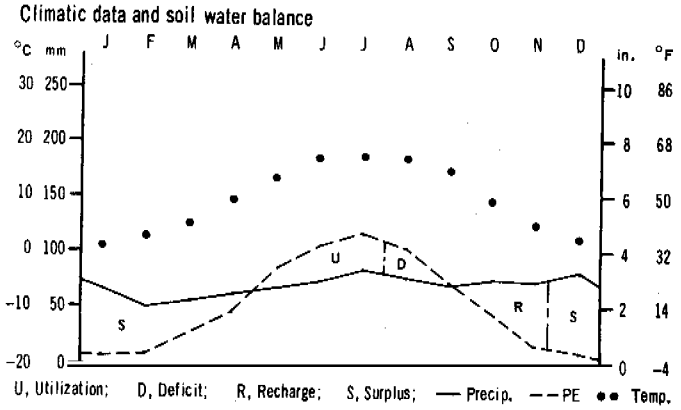
SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 65716 - 65718

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total: Sand (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	Size class and particle diameter (mm) 3A1 Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: (0.05–0.02)	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 > 2 < 76	2 – 19	19 – 76 Pct. of

Pedon 110

Classification: Typic Placohumod, sandy, siliceous, mesic.
Location: Near Herentals, province of Antwerp, Belgium.
Physiographic position: Old sand dune, 6 to 8 m above the plain.
Vegetation: Scattered pine (planted) and Calluna vulgaris.
Parent material: Windblown sands.
Sampled by: Guy D. Smith.



8-0 cm (3-0 in.). Windblown sand from pit.

A2 — 0-23 cm (0-9 in.). Gray (10YR 5/1 dry) and dark gray (10YR 4/1 moist) loose sand; few roots; abrupt irregular lower boundary with tongues of A2 penetrating to 90 cm or more at intervals of a meter or so.

B21h — 23-28 cm (9-11 in.). Black (10YR 2/1 dry, or N 2/0 moist) sand coated with humus; friable (moist); few roots; this horizon completely surrounds the tongues of A2, but is thinner where vertically oriented than where horizontal; sample taken from 24 to 26 cm between tongues of A2; abrupt irregular lower boundary to a thin iron pan.

B22irm Not sampled — A thin iron pan, about 1 mm thick; firm (moist), brittle; continuous between tongues of A2, but does not extend along sides of tongues or below them.

B22h — 28-33 cm (11-13 in.). Dark brown (7.5YR 2.5/2 dry) or black (5YR 2/1 moist) fine sand coated with humus; single grain; very friable (moist); surrounds all tongues of A2; few roots; abrupt irregular lower boundary.

B23 — 33-61 cm (13-24 in.). Strong brown sand, very friable to loose (moist), with about 8 interlaced lamellae or fibers of dark brown sand, 2 mm to 10 mm thick, spaced at 2 to 10 cm vertical intervals; few roots; clear irregular lower boundary.

B3 — 61-91+ cm (24-36+ in.). Yellowish brown sand; single grain; loose (moist); with a few dozen fibers or lamellae as above.

Stereoscopic Microscope Examination

B21h — 23-28 cm (9-11 in.). In a broken clod face sand grains are surrounded by a continuous phase of black material. Sand grains are easily dislodged from the matrix and most of them are clean. The mass breaks down readily to individual sand grains, mostly clear quartz, and to black aggregates somewhat smaller than the sand particles.

When a clod is broken lightly with fingers and sieved, the >0.1 mm fraction consisted of mostly quartz grains with 10 percent or less of surface coated, some grains are nearly entirely coated and a few aggregates.

The 0.1 - 0.05 mm fraction consists of irregular shaped black aggregates, coated grains and mostly-clean sand grains.

The <0.05 mm fraction consists of irregularly-shaped, black aggregates.

B22h — 28-33 cm (11-13 in.). In a broken clod face individual sand grains are coated by a jell-like material that causes sand grains to stick together. When it dries, the jell-like material looks lighter brown and more powdery.

When clod is broken lightly with fingers and sieved, the <0.1 mm material contains a very few reddish brown aggregates. Over half of the grains have more than half of their surface over half coated. Few really clean grains. Most sand grains with about 20 to 80 percent of surface coated.

The 0.05 - 0.1 mm fraction is about the same as above; a few more aggregates.

The <0.05 mm fraction consists of very irregularly shaped reddish brown aggregates.

Pedon 111

SOIL Typic Cryorthod SOIL Nos. S68Wash-10-3 LOCATION Ferry County, Washington

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 68810 - 68815

Depth (cm)	Horizon	1B1b Total: Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Sand: Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt: (0.05-0.02)	Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1			Coarse fragments 1A2a: > 2 Pct. of whole soil	2-19	19-76
		Pct. of <2 mm															Pct. of <76mm	
0-1	A2	62.9	31.4	5.7	13.2	14.0	8.7	16.1	10.9	11.7	19.7	31.9	52.0					
1-20	B21ir	61.1	34.9	4.0	10.6	14.1	9.2	15.1	12.1	14.8	20.1	35.3	49.0			10	10	
20-43	B22ir	63.5	33.2	3.3	19.0	14.5	8.0	12.7	9.3	14.4	18.8	30.9	54.2			17	17	
43-56	B3ir	71.0	24.9	4.1	25.5	15.1	8.3	13.3	8.8	11.4	13.5	27.4	62.2			14	14	
56-76	IIC1	74.8	22.6	2.6	12.2	17.0	12.6	20.9	12.1	11.8	10.8	35.4	62.7			14	14	
76-94	IIC2	84.4	13.9	1.7	20.2	20.9	11.5	21.5	10.3	8.7	5.2	30.3	74.1			8	8	

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C2b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	4A1h Oven-dry g/cc	Est. 1/3-bar g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	8C1a H_2O 1:1	8C1e $CaCl_2$
0-1	5.31	0.161	33	0.8					0.90								5.1	
1-20	1.22	0.066	18	0.8					0.85	0.97		6.1					5.8	5.3
20-43	0.44	0.035	13	0.7					0.90	0.94		4.9					6.3	5.6
43-56	0.21			0.6					0.90	0.95		3.4					6.5	5.6
56-76	0.09			0.4					1.66	0.91		1.8					6.5	5.6
76-94	0.05			0.6					1.66	0.95		1.6					6.7	6.0

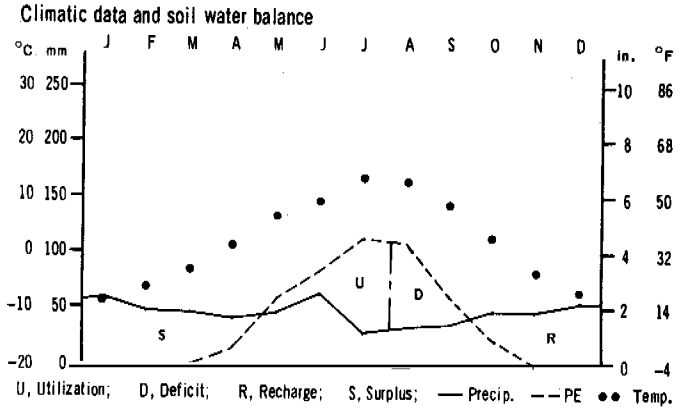
Depth (cm)	Extractable bases: 6N2e Ca	6O2d Mg	6P2a Na	5B1c 6Q2a K	Sum of bases	6H2a Ext. acidity	Cation exch. capacity: 5A6a NH_4OAc	5A3a Sum of cations		6G1e KCl ext. Al +++	Ratios to clay 8D1: CEC NH_4OAc	Ext. iron	15-bar water				Base saturation: 5C3 Sum of cations Pct.	5C1 NH_4 OAc Pct.
	meq/100g																	
0-1	7.1	1.3	0.2	1.1	9.7		23.1			-	4.05	0.14						41
1-20	4.7	1.1	0.1	0.6	6.5	10.1	13.2	16.6		0.2	3.30	0.20	1.53					49
20-43	3.9	0.5	0.1	0.8	5.3	5.8	6.5	11.1		0.3	1.97	0.21	1.48					81
43-56	4.6	0.7	0.1	0.5	5.9		6.4			0.3	1.56	0.15	0.83					92
56-76	3.2	0.9	0.1	0.2	4.4		4.6			0.1	1.77	0.15	0.69					95
76-94	2.7	1.1	0.1	0.1	4.0		4.3			0.1	2.53	0.35	0.94					93

Depth (cm)	D.-C. ext. 6C2b Fe	6G7a Al	Na-pyroph. extractable 6C5a Fe	6C5a Al	Na Py. Fe+Al / D.-C. Fe+Al	Na Py. Fe+Al / clay
	Pct.					
0-1	0.8	0.3				
1-20	0.8	0.3	0.2	0.3	0.45	0.13
20-43	0.7	0.2	0.1	0.1	0.22	0.06
43-56	0.6	0.1	0.1	0.1	0.29	0.05
56-76	0.4	-	-	-		
76-94	0.6	0.1				

a/ 1.2 kg of organic carbon per square meter to a depth of 1 meter.

Pedon 111

Classification: Typic Cryorthod, coarse-loamy, mixed.
Location: Ferry County, Wash. 2.7 km west of Sherman Pass elevation sign on Sherman Pass Highway, 30 m south of center of highway, in sec. 23, T. 36 N., R. 34 E.
Physiographic position: Mountainous upland, elevation about 1,550 m.
Topography: North northwest-facing, 30 percent slope.
Drainage: Well drained; moderate permeability.
Vegetation: Douglas-fir (Pseudotsuga menziesii), subalpine pine (Pinus sp.), fir (Abies sp.), larch (Larix sp.), alder (Alnus sp.), lodgepole pine (Pinus contorta), pine grass (Calamagrostis rubescens), and wild huckleberry (Vaccinium ovatum).
Parent material: Volcanic ash--glacial till over granite.
Sampled by: R. E. Nelson, A. Zulauf, R. W. Chapin, C. Lenfesty, and N. Donaldson, September 12, 1968.
Remarks: The soil did not disperse well, hence field estimates of texture are given in the profile description.
Soil No.: S68Wash-10-3.



Colors are for the dry soil unless otherwise indicated.

O1 5-2 cm (2-3/4 in.). Needles and twigs--leaves partially decomposed.

O2 2-0 cm (3/4-0 in.). Decomposing needles, leaves, and twigs.

A2 0-1 cm (0-1/4 in.). Light brownish gray (10YR 6/2) light sandy loam, very dark grayish brown (10YR 3/2) moist; single grain; soft (dry), very friable (moist), nonsticky and nonplastic (wet); many fine roots; abrupt wavy boundary.

B21ir 1-20 cm (1/4-8 in.). Brown (10YR 5/3) light sandy loam, dark yellowish brown (10YR 4/4) moist; weak fine granular structure; soft (dry), very friable (moist), nonsticky and slightly plastic (wet); many fine roots; about 3 percent gravel by volume; abrupt smooth boundary.

B22ir 20-43 cm (8-17 in.). Pale brown (10YR 6/3) light sandy loam, dark brown (7.5YR 3/4) moist; massive breaking to weak blocks; slightly hard (dry), very friable (moist), nonsticky and slightly plastic (wet); many fine and medium roots; common fine pores; about 6 percent gravel by volume; clear wavy boundary.

B3ir 43-56 cm (17-22 in.). Pale brown (10YR 6/3) light sandy loam, brown (10YR 4/3) moist; massive, breaking to weak blocks; slightly hard (dry), very friable (moist), nonsticky and slightly plastic (wet); many fine and medium roots; many fine pores; about 5 percent gravel by volume; clear wavy boundary.

IIC1 56-76 cm (22-30 in.). Light yellowish brown (2.5Y 6/4) loamy sand, grayish brown (2.5Y 5/2) or olive brown (2.5Y 4/4) moist; massive; slightly hard (dry), very friable (moist), nonsticky and slightly plastic (wet); few fine roots; few fine pores; about 9 percent gravel by volume; clear wavy boundary.

IIC2 76-94 cm (30-37 in.). Multicolored loamy sand; grayish brown (2.5Y 5/2) or olive brown (2.5Y 4/4) moist; massive; slightly hard (dry), very friable (moist); nonsticky and slightly plastic (wet); few fine roots; few fine pores; about 9 percent gravel by volume; clear wavy boundary to granite rock.

SOIL Pedon 112 Typic Albaquult SOIL Nos. S55Ga-89-2 LOCATION Liberty County, Georgia

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 5670 - 5676

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total: Sand (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	Size class and particle diameter (mm) 3A1 Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: 0.05–0.02	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 > 2 Pct.	2 – 19	19 – 76
		Pct. of < 2 mm															Pct. of < 76mm	
0-10	A11	55.6	37.5	6.9	0.3	2.7	4.1	24.2	24.3	20.1	17.4	60.5	31.3			tr.		
10-18	A12	57.4	35.6	7.0	1.5	3.8	4.4	29.8	17.9	17.4	18.2	53.1	39.5			-		
18-25	A3	54.8	36.0	9.2	0.7	9.8	1.9	26.8	15.6	18.6	17.4	52.2	39.2			-		
25-38	B1t	45.3	37.0	17.7	0.8	13.4	1.9	20.1	9.1	20.1	16.9	36.0	36.2			-		
38-86	B21tg	32.1	24.8	43.1	0.6	1.4	1.5	18.8	9.8	10.7	14.1	27.5	22.3			-		
86-150	B22tg	29.5	27.4	43.1	0.3	6.7	0.6	12.3	9.6	13.3	14.1	30.6	19.9			-		
150-170	B23tg	35.4	27.2	37.4	0.4	11.0	0.5	11.0	12.5	11.6	15.6	31.4	22.9			-		

Depth (cm)	6A1a Organic carbon	6B1a Nitrogen	C/N		Carbonate as $CaCO_3$	Ext. iron as Fe	Bulk density:	4A1e ⅓-bar	4A1h Oven-dry	4D1 COLE	Water content:	4B1c ⅓-bar	4B2 15-bar		4C1 WRD	pH:	8C1c (1:1) KCl	8C1a (1:1) H_2O
	Pct.	Pct.			Pct.	Pct.	g/cc	g/cc	g/cc		Pct.	Pct.	Pct.					
0-10	2.20	0.095	23															4.1
10-18	1.17	0.059	20															4.4
18-25	0.54	0.060	9															4.5
25-38	0.22																	4.4
38-86	0.09																	4.1
86-150	0.10																	4.0
150-170	0.12																	3.8

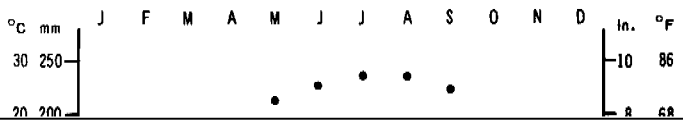
Depth (cm)	Extractable bases 5B1a: 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	CEC: 5A3a Sum cations		6G1d Ext. Al			Ratios to clay 8D1: CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-10	1.8	0.9	0.1	0.1		11.7	14.6					2.12					20	
10-18	1.0	0.6	0.1	tr.		9.1	10.8					1.54					16	
18-25	0.8	0.8	0.1	tr.		6.6	8.3					0.90					20	
25-38	0.7	1.1	0.1	0.1		8.7	10.7					0.60					19	
38-86	2.7	3.5	0.4	0.2		19.0	25.8					0.60					26	
86-150	3.3	3.9	0.5	0.2		18.6	26.5					0.61					30	
150-170	3.2	3.7	0.6	0.3		16.2	24.0					0.64					32	

Depth				

Pedon 112

Classification: Typic Albaquult, clayey, mixed, thermic.
Location: Liberty County, Ga. Southwest corner of Fleming, Georgia Experiment Station.
Topography: Level.
Vegetation: Forest stand composed of slash pine (Pinus

Climatic data



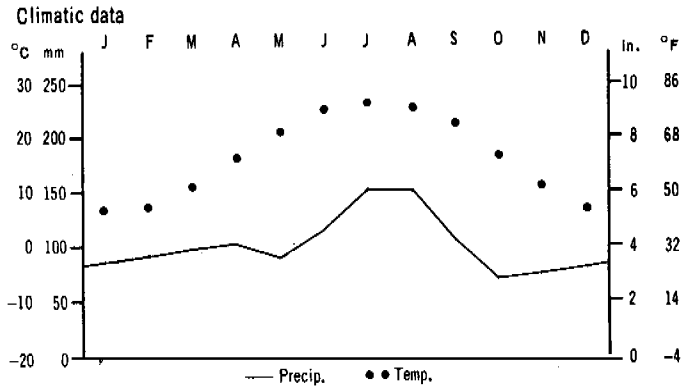
SOIL Pedon 113 Typic Paleaquult SOIL Nos. S65NC-51-2 LOCATION Johnston County, North Carolina

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 65734 - 65745

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total: Sand (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	Size class and particle diameter (mm) 3A1 — Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: 0.05–0.02	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	Fine clay <.0002 mm	3B2 Cm	Coarse fragments 3B1: 2A2 > 2 Pct.	2 - 19	19 - 76
		Pct. of < 2 mm														Pct. of < 76mm		
0-10	A1	62.3	29.3	8.4	3.8	15.0	12.1	19.6	11.8	11.1	18.2	32.6	50.5			1	1	0
10-23	A2	56.2	27.5	16.3	4.4	13.9	10.5	15.7	11.7	10.6	16.9	29.9	44.5	8.2		1	1	0
23-41	B21tg	53.1	28.7	18.2	5.0	14.8	10.5	13.1	9.7	10.5	18.2	26.4	43.4		0.99	2	2	0
41-74	B22tg	47.3	29.2	23.5	4.8	13.6	9.1	11.0	8.8	10.0	19.2	24.2	38.5		0.99	1	1	0
74-120	a/B23tg	47.7	22.6	29.7	4.0	14.4	10.1	11.8	7.4	7.9	14.7	21.0	40.3	19.2	0.99	1	1	0
74-120	b/	43.4	23.8	32.8	4.4	13.9	9.0	10.1	6.0	8.6	15.2	19.9	37.4			tr.	tr.	0
74-120	c/	54.4	27.3	18.3	4.7	15.2	11.2	15.0	8.3	10.7	16.6	27.0	46.1			0	0	0
120-160	B24tg	53.8	20.0	26.2	4.8	17.4	11.8	12.6	7.2	7.3	12.7	20.2	46.6	19.3	1.00	tr.	tr.	0
160-225	d/B3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			1	1	0

Pedon 113



Classification: Typic Paleaquult, fine-loamy, siliceous, thermic.
Location: Johnston County, N. C., 1.6 km south of the town of Benson.
Physiographic position: Depressional area on depositional Brandywine surface.
Topography: 0 to 1 percent slope.
Drainage: Poorly drained.
Vegetation: Cleared woodland, now partly grown up in briars and grass.
Parent material: Coastal Plain sediments.
Sampled by: R. B. Daniels, E. E. Gamble, J. G. Cady, and G. H. Simonson. October 20, 1965.
Soil No.: S65NC-51-2.

Colors are for the moist soil.

A1 0-10 cm (0-4 in.). Black (5YR 2/1) light sandy loam; massive; friable (moist); few medium gray (10YR 5/1) mottles. At places around the pit a gray (10YR 5/1) sandy loam to loamy sand, as much as five cm thick, occurs over lengths of 30 to 60 cm; abrupt smooth boundary.

A2 10-23 cm (4-9 in.). Gray (10YR 6/1) heavy sandy loam; massive; friable (moist); many roots and pores; clear boundary.

B21tg 23-41 cm (9-16 in.). Light gray (10YR 7/1) heavy sandy loam; weak fine and medium subangular blocky structure; friable (moist); few brownish yellow (10YR 6/6) mottles ranging from tiny flecks to 5 mm diameter bodies; peds have grainy, irregular faces and they look the same as the interior material; structural aggregates may be broken fragments, interior matrix looks grainy with mixtures of coarse and fine sand in a ball-like arrangment; local accumulations of fine sand and silt and possible clay; clear irregular boundary.

B22tg 41-74 cm (16-29 in.). Gray (10YR 6/1) heavy loam; massive; firm to friable (moist); many medium yellowish red (5YR 5/6) and yellowish brown (10YR 5/6) mottles in a pattern that ranges from vertically oriented to unoriented bodies 1 to 25 mm across; brown areas have weak medium subangular blocky structure; few thin discontinuous clay skins in the brown areas and on some cleavage faces; many pores and roots; clear wavy boundary.

B23tg 74-120 cm (29-48 in.). Gray (10YR 6/1) heavy sandy clay loam; weak fine and medium subangular blocky structure grading down to weak medium irregular angular to subangular blocky structure; many fine to coarse strong brown (7.5YR 5/8) and yellowish brown (10YR 5/8) mottles or bodies; few fine red (10R 4/8) flecks in the upper 15 cm; firm (moist); gray (N 6/) clay skins on vertical cleavages gradual smooth boundary.

B24tg 120-160 cm (48-63 in.). Gray (10YR 6/1) sandy clay loam; weak prisms breaking to weak medium irregular angular to subangular blocks; firm (moist); many fine to coarse strong brown (7.5YR 5/8) mottles; few dark sandy loam root channels; vertical cleavages have gray (N 6/) clay skins that are the best developed of the profile; clear wavy boundary.

B3g 160-225 cm (63-88 in.). This horizon is composed of gray tongues and yellow and red tongues. Gray tongue - Gray (10YR 6/1) and light gray (N 7/) light sandy clay loam few fine yellowish brown (10YR 5/6)mottles; massive; firm (moist); few areas up to 7 cm wide of brown (7.5YR 5/2) sandy loam that appear to be root fillings; thick discontinuous clay skins in some pores; gradual wavy boundary. Yellow and red tongue - Brownish yellow (10YR 6/6) and red (2.5YR 4/8) light sandy clay loam; many fine to medium gray (10YR 6/1) mottles; massive; slightly firm (moist); clear wavy boundary.

C 225-265 cm (88-104 in.). Light gray (2.5YR 7/2) and light brownish gray (10YR 6/2) sandy loam; common pale yellow (2.5Y 7/4) mottles; some brown (7.5YR 5/2) sandy loam that looks like the downward extension of tongues or root fillings from above.

Pedon 114

SOIL Oxic Plinthaquult SOIL Nos. S58PR-9-1 LOCATION Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 9831-9837

General Methods: 1A, 1B1a, 2A1, 2B

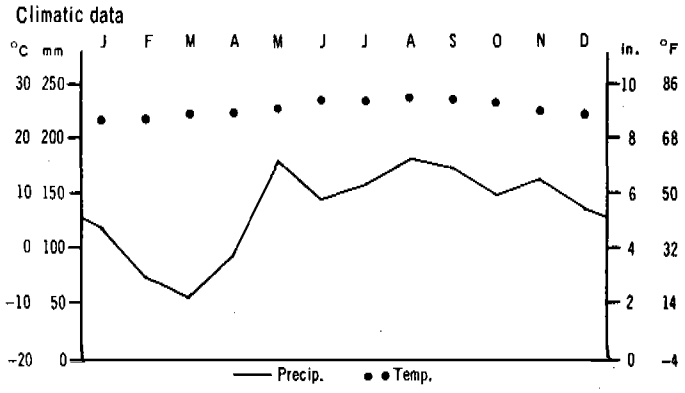
Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand[a] (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	3A1c Water-disp. clay <0.002		Coarse fragments 2A2		3B1 2–20 Pct. < 20
		Pct. of < 2 mm																
0-25	Ap	16.3	28.0	55.7	0.8	3.1	2.6	5.8	4.0	8.7	19.3	15.8	12.3					tr
25-33	B1t	8.1	15.5	76.4	0.4	1.4	1.3	2.9	2.1	5.0	10.5	8.6	6.0					-
33-58	B21tg	7.9	15.9	76.2	0.5	1.5	1.1	2.7	2.1	4.9	11.0	8.4	5.8	2				-
58-91	B22tg	10.6	19.7	69.7	0.4	1.7	1.5	3.7	3.3	5.9	13.8	11.3	7.3					tr
91-120	B23tg	13.1	21.8	65.1	1.2	2.4	1.9	4.2	3.4	6.1	15.7	11.9	9.7					tr
120-140	B24tg	14.4	22.9	62.7	1.2	2.7	2.1	4.9	3.5	5.4	17.5	11.5	10.9					-
140-180	B25tg	10.0	24.9	65.1	0.4	1.7	1.5	3.6	2.8	5.2	19.7	10.0	7.2					-

Depth (cm)	6A1a Organic carbon	6B1a Nitrogen	C/N	6C2a Ext. iron as Fe	Carbonate as $CaCO_3$		Bulk density		4A1h Oven-dry		Water content		4B2 15-bar			pH	
	Pct.	Pct.		Pct.	Pct.		g/cc	g/cc	g/cc		Pct.	Pct.	Pct.			8C1c (1:1) KCl	8C1a (1:1) H_2O
0-25	3.25	0.250	13	2.9					1.19				25.6			3.5	4.2
25-33	1.18	0.115	10	3.7					1.29				32.2			3.2	4.2
33-58	0.74	0.070	10	4.5					1.28				31.8			3.3	4.4
58-91	0.31	0.045	7	4.1					1.49				28.2			3.4	4.3
91-120	0.21			4.1					1.46				25.5			3.3	4.3
120-140	0.20			4.7					1.60				24.2			3.3	4.2
140-180	0.11			2.3									23.6			3.3	4.1

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acid-ity	Cat. exch. cap.: 5A3a Sum cat.	5A1a NH4OAc	6G1d KCl-ext. Al	5A3b Bases plus Al	Ratios to Clay 8D1: NH4OAc CEC	Ext. iron	15-bar water	Base saturation: 5C3 Sum cat.	5C1 NH4OAc

Pedon 114

Classification: Oxic Plinthaquult, clayey, mixed, isohyperthermic.
Location: Puerto Rico. Municipio De Toa Baja, Barrio of Sabana Seca. Longitude 60°10'26" W., latitude 18°26'0" N. 400 m E. of kilometer marker 8.5, Highway No. 866 or approximately 1.5 km E. by NE. of Sabana Seca schools. About 2.3 km from the Atlantic Ocean. About 20 km (12 mi.) W. of San Juan.
Physiographic position: Coastal Plain, elevation 3 m.
Topography: Slope less than 1 percent, smooth to slightly undulating. The field of 6 to 9 hectares has overall elevation differences of less than 1 m.
Drainage: Poorly drained; very slow permeability.
Vegetation: Sugarcane recently plowed under.
Parent material: Coastal Plain clays.
Sampled by: L. T. Alexander, K. W. Flach, L. H. Rivera and T. U. Yager, November 8, 1958.
Remarks: Sampled at 1/2 to 3/4 field capacity. Roots extend into the B22tg, but few are found in lower horizons. Plinthite nodules reach maximum hardness and abundance in the B24tg. They are generally soft and appear dry even though below the water table; some offer moderate resistance to crushing. Free water collected in the lower few inches of the pit within 2 hours.
Soil No.: S58PR-9-1.



Colors are for the moist soil.

Ap 0-25 cm (0-10 in.). Very dark grayish brown (10YR 3/2) clay; weak fine subangular blocks break to fine granules; firm

Blt 25-33 cm (10-13 in.). Dark grayish brown (2.5Y 4/2) clay with many medium and coarse prominent yellowish brown (10YR 5/6 mottles) (1:1 ratio of matrix to mottles); moderate fine subangular and angular blocky structure; firm (moist)

SOIL Pedon 115 Xeric Haplohumult SOIL Nos. S68Calif-29-32 LOCATION Nevada County, California

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 68892 - 68898

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Sand: Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt: (0.05-0.02)	Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1	Fine clay 0.002-0.0002		Coarse fragments 1A2a > 2 Pct. of whole soil	2-19	19-76
		Size class and particle diameter (mm) 3A1 — Pct. of <2 mm														Pct. of <76mm		
0-18	A1	23.2	39.4	37.4	1.6	4.2	3.3	7.4	6.7	13.7	25.7	24.9	16.5	7.2		13	13	
18-36	B1t	19.3	35.3	45.4	0.9	2.8	2.9	6.6	6.1	11.4	23.9	21.5	13.2			5	5	
36-46	B21t	17.8	31.1	51.1	1.3	2.8	2.6	5.9	5.2	9.6	21.5	18.4	12.6			5	5	
46-84	B22t	18.6	30.8	50.6	0.9	2.8	2.8	6.2	5.9	10.1	20.7	19.8	12.7	14.3		6	1	
84-120	B31t	22.1	28.2	49.7	0.5	2.7	3.9	8.6	6.4	9.0	19.2	20.3	15.7			7		
120-155	B32t	26.8	32.8	40.4	0.6	3.4	4.5	10.2	8.1	10.2	22.6	24.0	18.7			6		
155-185	C	26.7	34.7	38.6	0.4	2.4	4.3	11.3	8.3	10.7	24.0	25.4	18.4			a/G		

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N	6C2b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	4A1h Oven-dry g/cc	g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH: 8C1b Saturated paste	8C1a H_2O 1:1	8C1e $CaCl_2$
0-18	6.69	0.260	26	8.3			0.94	0.97		0.95	37.9	23.9		0.011	0.010		5.8	5.3
18-36	2.16	0.103	21	9.7			1.00	1.07		0.98	40.2	24.1		0.023	0.022		5.4	4.8
36-46	1.39			11.1			1.06	1.14		0.98	40.6	25.5		0.025	0.024		5.2	4.8
46-84	0.84			10.5			1.11	1.20		0.98	42.1	26.7		0.026	0.026		5.3	4.8
84-120	0.85			13.2			1.08	1.15		0.97	49.1	28.7		0.021	0.020		5.2	4.6
120-155	0.42			12.6			1.18	1.25		0.97	42.4	27.7		0.019	0.019		5.2	4.5
155-185	0.37			12.9			1.01	1.05		1.00	54.2	27.4		0.013	0.013		5.2	4.4

Depth (cm)	Extractable bases: 6N2e Ca	6O2d Mg	6P2a Na	5B1c 6Q2a K	Sum of bases	6H2a Ext. acidity	Cation exch. capacity: 5A6a NH_4OAc	5A3a Sum of cations		6G1e KCl ext. Al +++	Ratios to clay 8D1: CEC NH_4OAc	Ext. iron	15-bar water	5C1 Base saturation NH_4OAc Pct.	c/ 3A1 Clay fraction mineralogy: 7A2 X-ray d/
	meq/100g														
0-18	12.1	3.6	-	1.1	16.8		33.9				0.91	0.22	0.64	49	KK3
18-36	3.4	3.2	-	0.7	7.3		20.2			0.3	0.44	0.21	0.53	36	
36-46	3.1	3.7	-	1.0	7.8		17.9			0.2	0.35	0.22	0.50	43	KK3
46-84	2.7	3.2	-	1.0	6.9		20.6			0.2	0.41	0.21	0.53	33	
84-120	2.4	2.0	-	0.8	5.2	16.7	17.2	21.9		0.5	0.35	0.27	0.58	30	
120-155	1.3	1.3	-	0.6	3.2	17.7	14.6	20.9		1.4	0.36	0.31	0.69	22	
155-185	1.0	1.0	0.1	0.5	2.6	17.5	14.8	20.1		2.9	0.38	0.33	0.71	17	KK3

Depth (in.)	Di.-Ci. ext. 6C2b Fe	6G7a Al	Na-pyroph. extractable 6C5a Fe	6G5a Al	Na Py. Fe+Al / Di.-Ci Fe+Al	Na Py. Fe+Al / clay
	Pct.					

a/G = ground whole to <2 mm, gravel too soft to be separated.

b/20.9 kg of organic carbon per square meter to a depth of 1 meter.

c/Mineral code:

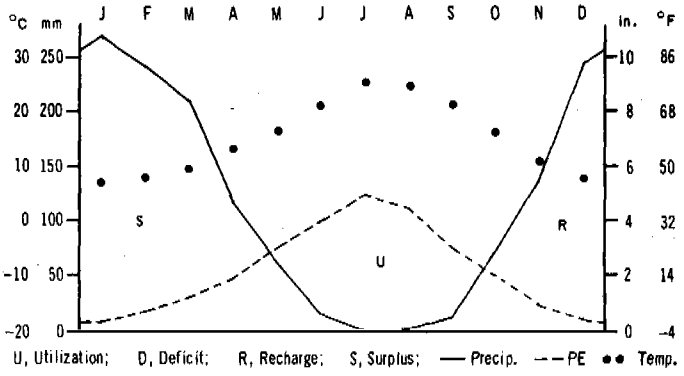
KK = kaolinite

d/Approximate weight fraction (X-ray):

Pedon 115

Classification: Xeric Haplohumult, clayey, kaolinitic, mesic.
Location: Nevada County, Calif. 8 km east-southeast of Grass Valley, 412 m north of the junction of You Bet and Red Dog Road, 701 m south and 305 m west of the NE corner of sec. 4, T. 15 N., R. 9 E.
Physiographic position: Mountainous upland, elevation about 829 m.
Topography: Concave, northeast-facing 14 percent slope.
Drainage: Well drained; medium runoff; moderately slow permeability.
Vegetation: Mixed coniferous forest, ponderosa pine (Pinus ponderosa), incense-cedar (Libocedrus decurrens), black oak (Quercus velutina), and bear clover (Chamaebatia foliolosa).
Parent material: Diabase and metabasic rock.
Sampled by: L. A. Brittan, G. Staidl, C. B. Goudey, T. M. Ryan, G. M. Kennedy, September 5, 1968.
Remarks: The B32 and C horizons did not disperse well, hence the field estimates of texture are given for these horizons.
Soil No.: S68Calif-29-32.

Climatic data and soil water balance



Colors are for dry soil unless otherwise indicated.

O1 5-0 cm (2-0 in.). Undecomposed oak leaves and pine needles.

A1 0-18 cm (0-7 in.). Reddish brown (5YR 4/4) heavy clay loam, dark reddish brown (5YR 3/4) moist; moderate medium subangular blocks breaking to strong fine and medium crumbs; slightly hard (dry), friable (moist), slightly sticky and plastic (wet); many very fine and fine random and many medium and coarse horizontal and oblique roots; many very fine interstitial, few very fine tubular pores; 5 percent gravel by volume; clear wavy boundary.

B1t 18-36 cm (7-14 in.). Yellowish red (5YR 4/6) light clay, dark red (2.5YR 3/6) moist; weak medium subangular blocks breaking to weak fine crumbs; slightly hard (dry), friable (moist), sticky and plastic (wet); common very fine and fine random and many medium and coarse horizontal and oblique roots; many very fine interstitial and common very fine tubular pores; 2 percent gravel by volume; clear wavy boundary.

B21t 36-46 cm (14-18 in.). Red (2.5YR 4/6) light clay, dark red (2.5YR 3/6) moist; weak medium subangular blocks breaking to weak fine crumbs; slightly hard (dry), friable (moist), sticky and very plastic (wet); common very fine and fine random and many medium and coarse horizontal roots; many very fine interstitial and common very fine tubular pores; many thin clay skins line pores; 2 percent gravel by volume; clear wavy boundary.

B22t 46-84 cm (18-33 in.). Red (2.5YR 4/6) light clay, dark red (2.5YR 3/6) moist; weak medium and coarse angular blocky structure; hard (dry), friable (moist), sticky and plastic (wet); few very fine and fine vertical and common medium and coarse horizontal and oblique roots; common very fine interstitial and few very fine and fine tubular pores; many thin clay skins on faces of peds and continuous moderately thick clay skins line pores; less than 1 percent gravel, 2 percent weathered cobbles by volume; gradual wavy boundary.

B31t 84-120 cm (33-48 in.). Yellowish red (5YR 5/8) light clay, red (2.5YR 4/6) moist; weak medium and coarse angular blocky structure; hard (dry), friable (moist), sticky and plastic (wet); few very fine and fine vertical and common medium horizontal and oblique roots; common very fine interstitial and few very fine and fine tubular pores; many thin clay skins on faces of peds and continuous moderately thick clay skins line pores; 3 percent cobbles by volume; gradual wavy boundary.

B32t 120-155 cm (48-61 in.). Yellowish red (5YR 5/8) clay loam, red (2.5YR 5/8) moist; weak medium and coarse angular blocky structure; hard (dry), friable (moist), sticky and plastic (wet); few very fine and fine vertical and common medium horizontal and oblique roots; few very fine tubular and interstitial pores; many thin clay skins on faces of peds and continuous moderately thick clay skins line pores; 3 percent cobbles by volume; clear wavy boundary.

C 155-185 cm (61-72 in.). Yellowish red (5YR 5/8) loam, red (2.5YR 4/6) moist; massive; slightly hard (dry), friable (moist), slightly sticky and plastic (wet); few very fine, fine and medium vertical roots; few very fine tubular pores; continuous moderately thick red (2.5YR 4/6 dry, 4/8 moist) clay skins line pores; 20 percent by volume of soft weathered rock fragments 1 to 8 cm in diameter.

SOIL Pedon 116 Typic Tropohumult SOIL Nos. S61PR-10-1 LOCATION Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 16810-16815

General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05) a/	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05) b/	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	3A1b Water-disp. clay <0.002		Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-15	Ap	9.2	23.6	67.2	0.3	1.3	1.2	2.9	3.5	8.0	15.6	13.2	5.7					tr
15-28	B21t	4.3	13.9	81.8	0.1	0.4	0.5	1.5	1.8	3.7	10.2	6.5	2.5	38				tr
28-48	B22t	4.7	17.3	78.0	0.2	0.3	0.4	1.5	2.3	4.6	12.7	7.9	2.4					tr
48-69	B23t	8.5	24.1	67.4	0.4	0.7	1.0	2.8	3.6	5.9	18.2	11.3	4.9	4				tr
69-94	B3	10.0	33.2	56.8	0.3	0.5	0.7	3.5	5.0	8.4	24.8	15.8	5.0					tr
94-125	C	20.6	39.8	39.6	0.3	1.3	2.0	7.8	9.2	10.8	29.0	25.2	11.4					tr

Depth (cm)	6A1a Organic carbon c/, d/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ Pct.		Bulk density: 4A1a Field state e/ g/cc	4A1c 30-cm g/cc	4A1b Air-dry g/cc	4D1 COLE f/	Water content: 4B4 Field state Pct.	4B3 30-cm Pct.	4B1b 1/3-bar Pct.	4B2 15-bar Pct.		pH: 8C1c (1:1) N KCl	8C1a (1:1) H_2O
0-15	5.20	0.409	13	10.4			0.90		1.38	0.16	63.1		41.7	29.8		3.6	4.6
15-28	2.01	0.168	12	13.1			1.02		1.44	0.12	52.7		43.3	34.1		3.5	4.5
28-48	1.34	0.135	10	14.0			1.0						43.6	35.0		3.6	4.6
48-69	0.87	0.087	10	14.0			1.04	1.22	1.42	0.11	54.7	39.1	43.0	34.0		3.6	4.7
69-94	0.59	0.062	10	12.6			1.0						40.4	32.1		3.6	4.8
94-125	0.47			11.3			1.04	1.14	1.29	0.073	55.0	44.2	43.4	30.2		3.5	4.6

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap.: 5A3a Sum cations	5A1a NH_4OAc g/	6G1d KCl-ext. Al		5A3b Bases + Al me/100g clay h/	Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																
0-15	2.4	3.1	tr	0.5	6.0	29.1	35.1	23.6	3.5		14.1	0.35	0.15	0.44		17	25
15-28	0.1	1.9	tr	0.1	2.1	28.4	30.5	19.9	8.0		12.3	0.24	0.16	0.42		7	10
28-48	0.1	1.3	0.1	0.1	1.6	28.6	30.2	20.2	10.0		14.9	0.26	0.18	0.45		5	8
48-69	0.2	1.4	0.1	0.1	1.8	28.5	30.3	21.8	12.2		20.8	0.32	0.21	0.50		6	8
69-94	0.2	1.5	0.1	0.1	1.9	29.9	31.8	24.3	14.6		29.0	0.43	0.22	0.56		6	8
94-125	0.2	2.4	0.1	0.1	2.8	34.5	37.3	29.2	19.4		29	0.73	0.28	0.76		8	10

Depth (cm)	Clay fraction i/ mineralogy 7A1: 7A2 X-ray j/	7A3 DTA Pct.	< 2 mm fraction i/ mineralogy: 7A2 X-ray j/	7A3 DTA Pct.
0-15	VR3	KK30	QZ3,GE2	KK28
15-28	VR3	KK41	QZ3,GE3	KK30
28-48	VR2	KK40	GE3,QZ2	KK35
48-69	VR2,MT1	KK42	GE2,QZ2 FD1	KK35
69-94	MT2,VR1	KK30	GE2,QZ2	KK36
94-125	MT3,VR1	KK35	GE2,QZ2,FD1	KK32

Underlined if 15-bar to clay ratio exceeds 0.6, indicating that the non-clay probably has strong clay-like properties.

a/ Earthy nodules: 5-25 percent.

b/ Largely grains of an alteration product (method 7B1). Some quartz is present and possibly a few kaolinite books. No ferromagnesian minerals observed.

c/ 18 kg/m² to 1.25 m (method 6A).

d/ Radiocarbon age of sample from B21t horizon is 1,810 ± 100 years before present (analysis by Isotopes, Inc., No. I-1930).

e/ Values for the B22t and B3 horizons are estimated.

f/ Field state.

g/ CEC by 1N NH_4Cl unbuffered, for the B21t horizon, is 13.0 me/100 g.

h/ Clay percentage for the C horizon is estimated as 15-bar water percentage x 2.5.

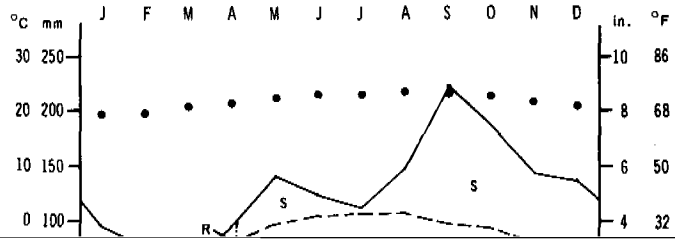
i/ Mineral code:
VR = vermiculite
MT = montmorillonite
KK = kaolinite
QZ = quartz
GE = goethite
FD = feldspar

j/ Approximate weight fractions:
3 = one-fifth to one-third
2 = one-twentieth to one-fifth
1 = less than one-twentieth

Pedon 116

Classification: Typic Tropohumult, clayey, oxidic, isohyperthermic.
Location: Puerto Rico. Barranquitas Soil Study Area, approximately 150 m east of field road and 145 m south of house at kilometer marker 8.8, Highway 152, 40 km (25 mi.) SW. of San Juan.
Physiographic position: Highly dissected upland.
Topography: Slope of 30 percent to the E. On the backslope leading to a drainageway. The youngest extensive surface of the area. Site is 15 m below the slope break to a higher surface, near the tip of a small triangular

Climatic data and soil water balance



SOIL Pedon 117 Typic Fragiudult SOIL Nos. S61Miss-12-2 LOCATION Clarke County, Miss.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 15136-15143

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: a/ Sand (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: 0.05–0.02	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-15	Ap	57.1	39.5	3.4	0.6	1.6	3.7	32.9	18.3	24.5	15.0	65.1	38.8					tr
15-28	A2	43.8	50.6	5.6	0.1	0.7	1.9	24.3	16.8	21.2	29.4	55.4	27.0					-
28-56	B1t	37.8	42.9	19.3	0.2	0.5	1.4	20.9	14.8	17.9	25.0	47.8	23.0					-
56-71	B21t	43.3	39.1	17.6	< 0.1	0.4	1.4	23.7	17.8	17.5	21.6	52.8	25.5					-
71-89	B22t	45.2	32.3	22.5	< 0.1	0.4	1.5	25.1	18.2	15.2	17.1	52.0	27.0					-
89-110	Bx1	47.2	28.2	24.6	< 0.1	0.3	1.5	25.5	19.9	13.3	14.9	52.5	27.3					-
110-140	Bx2	47.9	25.1	27.0	< 0.1	0.3	1.6	26.4	19.6	12.1	13.0	51.5	28.3					-
140-175	Bx3	48.9	23.5	27.6	< 0.1	0.3	1.6	27.2	19.8	11.8	11.7	51.9	29.1					-

Depth (cm)	6A1a Organic carbon (Pct.)	6B1a Nitrogen (Pct.)	C/N		Carbonate as $CaCO_3$ (Pct.)	6C1a Ext. iron as Fe (Pct.)	Bulk density: 4A1a Field state (g/cc)	4A1c 30-cm (g/cc)	4A1b Air-dry (g/cc)	4D1 COLE	Water content: 4B4 Field state (Pct.)	4B3 30-cm (Pct.)	4B1b 1/3-bar (Pct.)	4B2 15-bar (Pct.)	4C1 1/3-to 15-bar (cm/cm)		pH: 8C1c (1:1) KCL	8C1a (1:1) H_2O
0-15	0.55	0.038	14			0.4	1.57	1.57	1.57	-	17.1	19.2	9.0	1.7	0.11		3.8	5.1
15-28	0.12	0.010				0.4								2.0			3.7	5.0
28-56	0.10	0.023				1.3	1.62	1.57	1.64	0.014	14.8	20.2	16.5	7.6	0.14		3.4	4.8
56-71	0.05	0.013				1.1								6.8			3.4	4.6
71-89	0.04					1.1								9.0			3.2	4.5
89-110	0.03					0.9	1.80	1.71	1.82	0.020	14.0	18.2	16.1	9.7	0.11		3.2	4.5
110-140	0.03					1.7	1.75	1.67	1.78	0.020	16.3	20.3	17.6	10.4	0.12		3.2	4.5
140-175	0.03					1.3								10.4			3.1	4.4

Depth (cm)	Extractable bases 5B1a: 6N2b Ca (meq/100 g)	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap.: 5A3a Sum cations	5A1a NH_4OAc	6G2a Al KCl-ext.	5A3b Bases plus Al me/100 g clay	Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water	Base saturation: 5C3 Sum cations (Pct.)	5C1 NH_4OAc (Pct.)
0-15	0.5	0.6	< 0.1	0.1	1.2	3.4	4.6	2.8	0.2	41	0.82	0.12	0.50	26	43
15-28	0.4	0.3	< 0.1	0.1	0.8	2.3	3.1	2.0	0.4	21	0.36	0.07	0.36	26	40
28-56	1.2	0.4	< 0.1	0.3	1.9	6.7	8.6	6.5	2.4	22	0.34	0.07	0.39	22	29
56-71	1.2	0.8	< 0.1	0.2	2.2	6.7	8.9	6.2	2.9	29	0.35	0.06	0.39	25	35
71-89	1.1	1.2	< 0.1	0.2	2.5	9.8	12.3	9.5	5.0	33	0.42	0.05	0.40	20	26
89-110	0.1	1.9	0.1	0.2	2.3	11.7	14.0	10.6	6.3	35	0.43	0.04	0.39	16	22
110-140	<0.1	2.4	0.1	0.2	2.7	12.6	15.3	11.4	7.5	38	0.42	0.06	0.39	18	24
140-175	<0.1	2.8	0.1	0.2	3.1	11.5	14.6	12.2	7.7	39	0.44	0.05	0.38	21	25

Depth (cm)	0.1-0.05 mm fraction b/ mineralogy: 7B1 Petrographic Pct.
0-15	

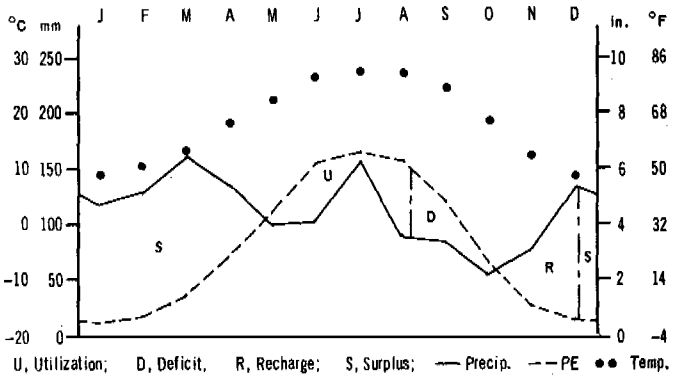
a/ Iron-manganese bearing aggregates comprise most of the coarse and very coarse sands in the Ap horizon.

b/ Mineral code:
QZ = quartz
RE = other resistant including opaques, epidote
TW = total weatherable including feldspar, muscovite, biotite

Pedon 117

Classification: Typic Fragiudult, fine-loamy, siliceous, thermic.
Location: Clarke County, Miss., 1 km (1/2 mi.) S. of Stonewall. 120 m W. and 90 m S. of NE. corner of SW 1/4 SE 1/4 sec. 5, T. 3 N., R. 15 E. 270 km (160 mi.) ENE. of New Orleans, La.
Topography: Nearly level (1 percent slope).
Drainage: Moderately well drained with medium runoff and internal drainage. Permeability is moderate in the upper part of the solum and slow in the lower part.
Vegetation: Bahiagrass pasture (Paspalum notatum flügge).
Parent material: Coastal Plain terrace.
Sampled by: J. S. Allen, R. C. Carter, Dean C. McMurtry, Jr. and H. L. Neal, May 15, 1961.
Soil No.: S61Miss-12-2.

Climatic data and soil water balance



Colors are for the moist soil.

Ap 0-15 cm (0-6 in.). Dark grayish brown (10YR 4/2) light fine sandy loam; weak fine and medium granular structure; very friable (moist); few fine roots; root and wormholes filled with material from A2; few fine soft black nodules; clear smooth boundary.

A2 15-28 cm (6-11 in.). Very pale brown (10YR 7/3) light fine sandy loam; weak fine and medium granular and medium subangular blocky structure; friable (moist); few fine roots; some mixing of Ap material in root and wormholes; few fine soft brown and black nodules; clear smooth boundary.

B1t 28-56 cm (11-22 in.). Yellowish brown (10YR 5/6) heavy loam; moderate fine and medium subangular blocky structure; friable (moist); few fine roots; some material from A horizon in root and wormholes in upper part of horizon; few fine black and brown nodules; clear smooth boundary.

B21t 56-71 cm (22-28 in.). Yellowish brown (10YR 5/6) light loam; common fine faint pale brown (10YR 6/3) mottles; moderate fine and medium subangular blocky structure; friable (moist); few fine roots; common fine voids; few fine soft brown nodules; clear smooth boundary.

B22t 71-89 cm (28-35 in.). Mottled yellowish brown (10YR 5/6) and light brownish gray (10YR 6/2) heavy loam; many fine and medium distinct mottles; moderate medium and coarse subangular and angular blocky structure; friable (moist); few fine roots; common fine voids; patchy clay skins on ped faces and in cracks; few fine vertical cracks filled with light gray (10YR 6/1) clay loam; common fine soft brown concretions; gradual smooth boundary.

Bx1 89-110 cm (35-44 in.). Mottled yellowish brown (10YR 5/6) light brownish gray (10YR 6/2) and yellowish red (5YR 4/8) heavy loam; many fine and medium distinct and prominent mottles; moderate fine and medium subangular and angular blocky structure; friable to firm (moist), slightly plastic (wet); few fine roots; few fine voids; few vertical cracks less than 3 cm wide filled with light gray (10YR 6/1) heavy clay loam; gradual smooth boundary.

Bx2 110-140 cm (44-56 in.). Mottled yellowish brown (10YR 5/6) gray (10YR 5/1) and yellowish red (5YR 4/8) heavy sandy clay loam; mottles are many fine distinct and prominent; moderate medium and coarse subangular and angular blocky structure; firm (moist), slightly plastic (wet); clay skins in cracks and on ped faces; few vertical streaks of light gray (10YR 6/1) clay loam; gradual smooth boundary.

Bx3 140-175 cm (56-68 in.). Mottled yellowish red (5YR 4/8) light gray to gray (10YR 6/1) and yellowish brown (10YR 5/6) heavy sandy clay loam; mottles are many fine and medium distinct and prominent; moderate medium and coarse subangular blocky and angular blocky structure; firm (moist), slightly plastic (wet); few vertical cracks of light gray to gray (10YR 6/1) clay loam; clay skins on ped faces and in cracks.

SOIL Pedon 118 Typic Hapludult SOIL Nos. S60Va-18-1 LOCATION Carroll County, Virginia

SOIL SURVEY LABORATORY Beltsville, Maryland and Lincoln, Nebraska LAB. Nos. 6084 - 6091

General methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt 0.05-0.02	Silt Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)		3B2 Cm	Coarse fragments 3B1 2A2 > 2 <76 Pct.	2-19	19-76
		Pct. of < 2 mm														Pct. of < 76mm		
0-4	A1	59.7	20.4	19.9	4.7	8.2	8.8	27.1	10.9	5.7	14.7	30.8	48.8		0.92	18		
4-18	A2	50.5	19.3	30.2	2.9	6.7	8.2	23.4	9.3	5.3	14.0	27.1	41.2		0.97	5		
18-24	B1t	44.4	18.1	37.5	2.2	5.3	6.8	21.4	8.7	5.1	13.0	25.3	35.7		0.98	4		
24-46	B21t	35.3	17.1	47.6	2.9	5.0	5.0	15.6	6.8	4.5	12.6	19.5	28.5		0.98	3		
46-71	B22t	42.0	15.4	42.6	3.4	5.1	5.4	18.5	9.6	3.1	12.3	22.6	32.4		0.99	1		
71-97	B3	56.3	18.0	25.7	2.5	4.6	7.0	27.4	14.8	6.4	11.6	36.4	41.5		0.99	2		
97-180	C11	67.2	19.0	13.8	3.7	7.9	8.6	31.2	15.8	6.8	12.2	39.5	51.4		0.96	6		
180-210+	C12	68.2	25.2	6.6	4.2	6.6	7.2	31.4	18.8	9.3	15.9	46.5	49.4		0.98	3		

Depth (cm)	6A1a Organic carbon c/ Pct.	6B2a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C3 Ext. iron a/ as Fe Pct.	Bulk density 4A1a Field moist g/cc	4A1e ⅓-bar g/cc	4A1h Oven-dry g/cc	4D1 COLE	Water content Pct.	4B1c ⅓-bar Pct.	4B2 15-bar Pct.		4C1 WRD cm/cm	pH b/ 8C1c (1:1) KCl	b/ 8C1a (1:1) H_2O
0-4	3.40	0.127	27			1.8							9.8			3.8	4.3
4-18	0.98	0.074	13			2.8		1.48	1.53	0.011		20.6	12.8		0.11	4.0	4.6
18-24	0.71	0.056	13			3.4		1.46	1.52	0.013		23.0	16.9		0.09	4.0	4.6
24-46	0.38	0.056	7			5.7		1.40	1.48	0.018		29.2	22.4		0.09	4.3	5.1
46-71	0.11					5.1		1.40	1.46	0.014		30.0	22.3		0.11	4.5	5.4
71-97	0.04					4.7		1.42	1.46	0.009		25.5	15.5		0.14	4.5	5.3
97-180	0.04					4.1	1.58		1.60	0.00			10.0			4.4	5.3
180-210+	0.02					1.3	1.44		1.48	0.01			7.8			4.2	5.2

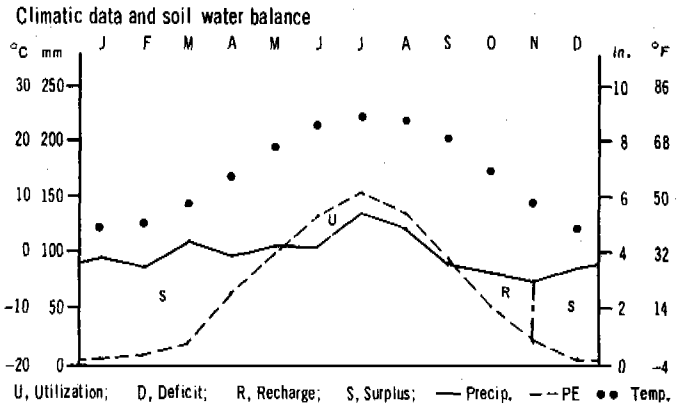
Depth (cm)	Extractable bases 5B1a 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC 5A3a Sum cations	5A3b Sum bases + Al	5G1d Ext. Al		7C2 Total K_2O Pct.	Ratios to clay 8D1 CEC sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-4	tr.	0.2	tr.	0.2	0.4	12.7	13.1	4.0				0.66	0.09	0.49	-		3	
4-18	tr.	tr.	tr.	0.1	0.1	8.2	8.3	2.0			1.2	0.27	0.09	0.42	-		1	
18-24	tr.	tr.	tr.	0.1	0.1	8.2	8.3	2.3				0.22	0.09	0.45	-		1	
24-46	tr.	0.1	tr.	0.1	0.2	8.7	8.9	2.0			1.2	0.19	0.12	0.47	-		2	
46-71	tr.	tr.	tr.	0.1	0.1	7.3	7.4	1.3			1.0	0.17	0.12	0.52	-		1	
71-97	tr.	tr.	tr.	0.1	0.1	5.9	6.0	1.3				0.23	0.18	0.60	-		2	
97-180	tr.	tr.	tr.	tr.	-	4.9	4.9	1.4			2.1	0.36	0.30	0.72	-		-	
180-210+	tr.	0.1	tr.	tr.	0.1	4.9	5.0	2.1			1.0	0.76	0.19	1.18	-		2	

Depth (cm)	Clay fraction d/ mineralogy 7A1b-d 7A2 X-ray e/	7A3 DTA Pct.
0-4	VR2,VM2,QZ1	KK41,GI12
4-18	VR2,VM2,QZ1	KK46,GI12
18-24	VR2,VM2,QZ1	KK47,GI12
24-46	VR2,VM2,QZ1	KK47,GI13
46-71	VR2,VM2,QZ1	KK47,GI13
71-97	VR2,VM2,QZ1	KK50,GI10
97-180	VR2,VM2,QZ1	KK32,GI4
180-210+	VR2,VM2,QZ1	KK39,GI1

a/ Determined at Virginia Polytechnical Institute.
b/ Determined at North Carolina State University at Raleigh.
c/ 5.9 kg/m² to depth of 1.5 m (method 6A).
d/ Mineral code:
VR = Al interlayered vermiculite
VM = vermiculite/mica
KK = kaolinite
GI = gibbsite
QZ = quartz
e/ Approximate weight fractions (X-ray):
2 = one-fifth to one-twentieth
1 = less than one-twentieth

Pedon 118

Classification: Typic Hapludult, clayey, mixed, mesic.
Location: Carroll County, Va., near the town of Cana.
Physiographic position: Smooth upland, Blue Ridge Province, elevation approximately 366 m.
Topography: Gently sloping (3 percent) toward the west.
Drainage: Well drained, with medium surface runoff and medium internal drainage.
Vegetation: Second growth forest including scarlet oak (Quercus coccinea), black oak (Quercus velutina), short leaf pine (Pinus echinata), mountain laurel (Kalmia latifolia), and huckleberry (Vaccinium).
Parent material: Residuum from weathered mica schist that has quartz veins and a moderate mica content.
Sampled by: E. J. Pedersen, J. Fleming, C. I. Rich, W. E. Thomas, R. L. Williams, N. B. Pfeiffer, and G. H. Robinson. January 15, 1960.
Soil No.: S60Va-18-1.



Colors are for moist soil.

O1 — 1-0 cm (1/2-0 in.). Very dark brown to nearly black partially decomposed leaves and twigs mixed with some soil material.

A1 — 0-4 cm (0-1½ in.). Dark grayish brown (10YR 4/2) heavy fine sandy loam; weak fine granular structure; very friable (moist); few shiny quartz sand grains; few fine mica flakes; some mixing of A2 horizon due to animal activity; many fine and medium roots; 15 percent by volume of gravel-size fragments; clear smooth boundary.

A2 — 4-18 cm (1½-7 in.). Brown (7.5YR 5/4) heavy sandy clay loam; color grades to dark brown (7.5YR 4/4) with depth; weak fine granular structure; very friable (moist); some penetration of A1 material; many fine and common medium pores; occasional quartz pebbles; common fine and medium roots; clear smooth boundary.

B1t — 18-24 cm (7-9½ in.). Yellowish red (5YR 4/6) heavy clay loam; weak fine subangular blocky structure; friable (moist); thin discontinuous clay skins; common fine pores; few fine mica flakes; occasional quartz pebbles; few medium and fine roots; gradual smooth boundary.

B21t — 24-46 cm (9½-18 in.). Red (2.5YR 5/6) light clay; ped faces coated red (2.5YR 4/6); moderate medium and fine subangular blocky structure; friable (moist); thin continuous clay skins; occasional quartz pebbles; few fine pores; few fine mica flakes; few medium and fine roots; gradual smooth boundary.

B22t — 46-71 cm (18-28 in.). Red (2.5YR 5/8) light clay; ped faces coated red (2.5YR 4/8); moderate medium and fine subangular blocky structure; firm to friable (moist); thin continuous clay skins; common fine mica flakes; occasional quartz pebbles; mica content increases with depth; few fine and medium roots; gradual wavy boundary.

B3 — 71-97 cm (28-38 in.). Red (2.5YR 4/6) sandy clay loam; weak medium angular blocky structure which is probably influenced by rock structure; very friable (moist); common to many mica flakes averaging larger than horizons above; soil feels slick when rubbed between the fingers; thin and patchy clay skins are most distinct on vertical faces; few roots; few gravel-size veins of C12 material extend through the horizon to the upper boundary; gradual irregular boundary.

C11 — 97-180 cm (38-70 in.). Strong brown, pale brown, and weak red weathered quartz mica schist; some penetration of red loamy soil material in cracks; mica content causes the soil material to feel slick when rubbed between the fingers; veins of C12 material extend through this horizon into the B3; gradual irregular boundary.

C12 — 180-210+ cm (70-82 in.). Weak red, strong brown, and pale brown mica schist that is highly weathered and soft, containing some quartz veins and some penetration of soil material. This horizon contains black streaks and spots of organic matter and/or manganese oxides.

Pedon 119

SOIL Typic Rhodudult SOIL Nos. S58Tenn-53-4 LOCATION Loudoun County, Tennessee

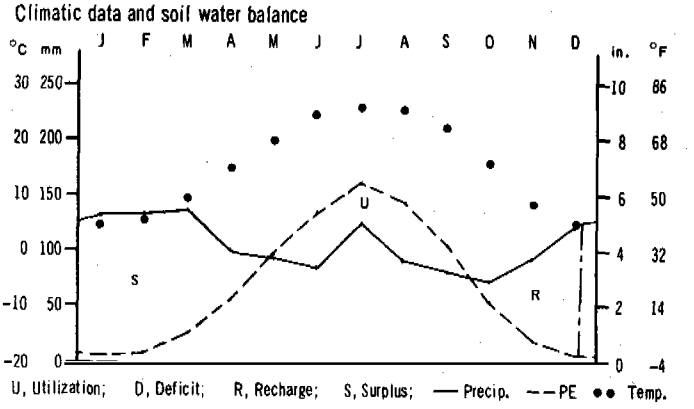
SOIL SURVEY LABORATORY Lincoln, Nebraska LAB. Nos. 7829 - 7836.

General methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	1B1b Total Sand	Total Silt	Total Clay	Size class and particle diameter (mm) 3A1 Sand[a] Very coarse	Coarse	Medium	Fine	Very fine	Silt Int. III	Int. II			3B2	Coarse fragments 3B1 2A2 ≥ 2	2 - 19	19 - 76

Pedon 119

Classification: Typic Rhodudult, clayey, oxidic, thermic.
Location: 5 km north of Greenback, Loudon County, Tenn.
Physiographic position: In the upper quarter of a long, slightly convex north slope at an elevation of about 320 m.
Topography: Steep, with gradient of 30 percent becoming 50 percent about 6 m below the sampling site.
Vegetation: Predominantly red oak (Quercus rubra) in second growth forest with some trees 80 to 100 years old.
Parent material: Residuum from calcareous sandstone.
Sampled by: L. T. Alexander, J. A. Elder, R. H. Jordon, K. W. Flach. April 9, 1958.
Soil No.: S58Tenn-53-4.



Colors are for the moist soil.

O1 Not sampled — 3-0 cm (1-0 in.). Black (5YR 2/1) soil material having strong very fine granular structure, mixed with partly decomposed leaves, twigs, and seeds; numerous distinct wormcasts in the lower part of the horizon.

A1 — 0-13 cm (0-5 in.). Dark reddish brown (2.5YR 3/4) heavy loam; weak fine subangular blocks breaking readily to moderate medium and fine granules; very friable (moist); many roots; gradual smooth boundary.

B1 — 13-23 cm (5-9 in.). Dark reddish brown (2.5YR 3/4) light clay loam; very weak fine subangular blocks breaking readily to moderate fine granules; friable (moist); gradual smooth boundary.

B21t — 23-41 cm (9-16 in.). Dusky red to dark red (10R 3/4 to 2.5YR 3/6) heavy clay loam; very weak fine subangular blocks breaking readily to fine granules; friable (moist); gradual smooth boundary.

B22t — 41-56 cm (16-22 in.). Dusky red to dark red (10R 3/4 to 2.5YR 3/6) light clay; weak fine subangular blocks breaking readily to moderate fine and very fine granules; friable (moist); gradual wavy boundary.

B23t — 56-76 cm (22-30 in.). Dusky red to dark red (10R 3/4 to 2.5YR 3/6) light clay; weak and moderate fine subangular blocks breaking readily to weak fine granules; friable (moist); faint discontinuous clay skins; gradual smooth boundary.

B24t — 76-100 cm (30-40 in.). Dark red (10R 3/6 to 2.5YR 3/6) light clay; weak to moderate medium and fine subangular blocks breaking to weak fine granules; friable (moist); faint nearly continuous clay skins; shale fragments in portions of the lower parts of this horizon; gradual smooth boundary.

B3 — 100-130 cm (40-52 in.). Dark red (2.5YR 3/6) light clay; very weak fine prisms breaking to weak and moderate fine and medium subangular blocks; friable (moist); faint discontinuous clay skins; few highly weathered magnetic sandstone fragments; gradual smooth boundary.

C — 130-170 cm (52-67 in.). Dark red (2.5YR 3/6) heavy clay loam; weak fine prisms breaking to weak medium subangular blocks; friable to firm (moist); thin distinct clay skins on some ped faces; few fine reddish yellow (7.5YR 6/6) 2 mm by ½ mm shale fragments; sandstone fragments as in B3.

Pedon 120
SOIL Typic Tropudult SOIL Nos. S58PR-4-4 LOCATION Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 9800-9807

General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05) a/	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	3A1c Water-disp. clay < 0.002			Coarse fragments 2A2 3B1 2–20 Pct. < 20
		Pct. of < 2 mm															
0–15	Ap	25.1	27.0	47.9	0.3	2.9	4.8	10.8	6.3	7.2	19.8	19.1	18.8				-
15–41	B21t	19.5	25.4	55.1	0.2	3.1	3.6	7.8	4.8	4.8	20.6	14.7	14.7	39			tr
41–56	B22t	12.0	30.4	57.6	0.3	1.2	1.8	4.6	4.1	6.0	24.4	12.8	7.9				-
56–76	B23t	15.0	33.4	51.6	0.1	1.1	1.9	6.2	5.7	6.7	26.7	16.1	9.3				-
76–89	B24t	18.2	35.7	46.1	-	0.9	2.0	7.7	7.6	8.3	27.4	20.8	10.6				-
89–115	B3	24.9	35.7	39.4	0.2	3.8	6.5	8.7	5.7	8.0	27.7	17.7	19.2				-
115–135	C1	21.8	45.3	32.9	0.4	1.8	2.4	8.1	9.1	11.9	33.4	25.8	12.7				-
135–180	C2	28.0	46.8	25.2	0.3	2.8	5.1	11.5	8.3	10.5	36.3	24.7	19.7				-

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ Pct.	Bulk density g/cc	g/cc	4A1h Oven-dry g/cc	Water content Pct.	Pct.	4B2 15-bar Pct.	pH 8C1c (1:1) KCl	8C1a (1:1) H_2O
0–15	2.40	0.205	12	4.3				1.43			20.7	3.7	4.7
15–41	0.67	0.088	8	5.6				1.50			23.7	3.4	4.6
41–56	0.50	0.060	8	7.6				1.54			26.7	3.5	4.5
56–76	0.38	0.044	9	7.1				1.51			25.4	3.5	4.5
76–89	0.32			6.8				1.48			24.4	3.5	4.4
89–115	0.25			5.1				1.41			21.6	3.5	4.4
115–135	0.34			8.3				1.24			22.3	3.6	4.4
135–180	0.25			5.3				1.10			17.4	3.5	4.4

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap.: 5A3a Sum cations	5A1a NH_4OAc	6G1d KCl-ext. Al	5A3b Bases + Al me/100g clay b/	Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water	Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g														
0–15	2.1	0.9	0.1	1.6	4.7	14.2	18.9	14.1	2.6	15.2	0.29	0.09	0.43	25	33
15–41	0.1	0.5	tr	0.5	1.1	17.5	18.6	12.8	7.0	14.7	0.23	0.10	0.43	6	8
41–56	-	0.5	tr	0.3	0.8	19.2	20.0	16.3	7.9	15.1	0.28	0.13	0.46	4	5
56–76	-	0.4	tr	0.2	0.6	18.0	18.6	16.9	8.5	17.6	0.33	0.14	0.49	3	4
76–89	-	0.2	0.1	0.2	0.5	18.8	19.3	16.4	8.7	20.0	0.36	0.15	0.53	2	3
89–115	-	0.3	0.1	0.1	0.5	16.7	17.2	12.7	7.8	21.1	0.32	0.13	0.55	3	4
115–135	-	0.6	0.1	0.2	0.9	20.9	21.8	15.6	9.1	18	0.47	0.25	0.68	4	6
135–180	-	0.4	0.1	0.2	0.7	17.1	17.8	11.8	8.0	20	0.47	0.21	0.69	4	6

Depth (cm)	Clay fraction c/ mineralogy 7A1: 7A2 X-ray d/	7A3 DTA Pct.
0–15, 15–41, 41–56	VR3	KK40
56–76, 76–89, 89–115	VR2	KK40
115–135, 135–180		

Underlined if 15-bar to clay ratio exceeds 0.6, indicating that the nonclay probably has strong clay-like properties.

a/ Earthy nodules: 5-25 percent above 115 cm, > 50 percent below 115 cm.

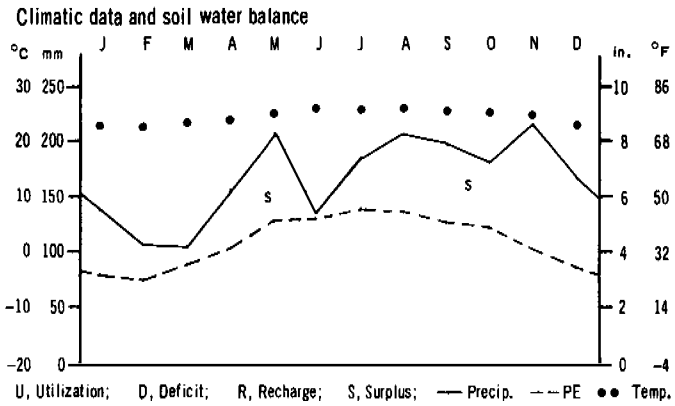
b/ Clay percentage estimated as 15-bar water percentage x 2.5.

c/ Mineral code:
VR = vermiculite, 14 Å peak not apparent at room temperature, but 10 Å peak present after heating
KK = kaolinite

d/ Approximate weight fractions:
3 = one-fifth to one-third
2 = one-twentieth to one-fifth

Pedon 120

Classification: Typic Tropudult, clayey, mixed, isohyperthermic.
Location: Puerto Rico. Point of land 12 m S. of Highway No. 159 at kilometer marker 20.83. About 30 km (20 mi.) SW. of San Juan.
Physiographic position: Extremely dissected uplands.
Topography: 20 percent north-facing convex slope.
Drainage: Well drained, moderate permeability.
Vegetation: Unimproved pasture for the past 7 or 8 years, in plantains (Musa paradisiaca) previously.
Parent material: Residuum or local colluvium from Tertiary volcanic conglomerate.
Sampled by: L. T. Alexander, K. W. Flach, R. E. Gierbolini, J. Juarez, F. Llavat-Cristy, L. H. Rivera and T. U. Yager, November 5, 1958.
Remarks: Soil at 1/2 field capacity.
Soil No.: S58PR-4-4.



Colors are for the moist soil.

Ap 0-15 cm (0-6 in.). Brown to dark brown (7.5YR 4/4) clay; moderate fine subangular blocky structure; firm (moist), slightly sticky and slightly plastic (wet); common medium red (2.5YR 4/6) inclusions of possible B horizon which has occasional thin clay skins; abrupt wavy boundary.

B21t 15-41 cm (6-16 in.). Reddish brown (5YR 4/4) clay with fine yellowish brown (10YR 5/4) specks, interior of peds yellowish red (5YR 4/6); strong medium and fine subangular blocky structure; continuous clay skins around peds; firm (moist), slightly sticky and slightly plastic (wet); clear smooth boundary.

B22t 41-56 cm (16-22 in.). Yellowish red (5YR 4/6) clay similar to B21t except structure tends to become fine angular blocky and the interior of the peds slightly more red; clear smooth boundary.

B23t 56-76 cm (22-30 in.). Red to yellowish red (2.5YR 4/6 to 5YR 4/6) clay with few fine yellowish brown (10YR 5/4) specks; moderate medium subangular and fine angular blocky structure; firm (moist), slightly sticky and slightly plastic (wet); thin continuous and thick patchy clay skins around peds; gradual smooth boundary.

B24t 76-89 cm (30-35 in.). Red (2.5YR 4/6) clay with few fine yellowish brown (10YR 5/4 to 5/6) specks; moderate medium and

Pedon 121

SOIL Typic Haplustult SOIL Nos. S57PR-14-2 LOCATION Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 7387-7391

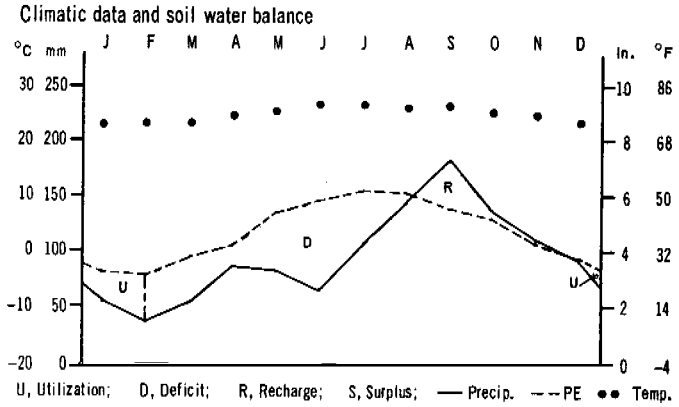
General Methods: 1A, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 Total: Sand a/ (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	3A1c Water-disp. clay <0.002		Coarse fragments 2A2:		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-23	Ap	41.2	37.6	21.2	3.1	7.3	6.3	13.4	11.1	16.4	21.2	34.9	30.1					2
23-46	B21t	27.9	16.2	55.9	1.2	7.2	5.3	8.4	5.8	6.1	10.1	16.2	22.1					1
46-76	B22t	31.2	22.3	46.5	3.0	7.1	5.0	9.1	7.0	7.0	15.3	18.8	24.2	33				2
76-105	C1	40.3	27.7	32.0	6.4	10.9	6.0	9.8	7.2	5.5	22.2	17.9	33.1					8
105-130	C2	53.0	25.5	21.5	12.8	16.6	6.7	9.7	7.2	5.7	19.8	17.8	45.8					tr

Depth (cm)	6A1a Organic carbon Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ Pct.		Bulk density g/cc	g/cc	g/cc		Water content Pct.	Pct.	4B2 15-bar Pct.		Base Sat. 5C3 Sum cations	5C1 NH_4OAc	pH 8C1c (1:1) KCl	8C1a (1:1) H_2O
0-23	1.64	0.149	11	2.3									11.7		20	29	3.4	4.5
23-46	0.80	0.093	9	4.7									26.3		18	26	3.1	4.6
46-76	0.49	0.053	9	5.1									21.9		15	22	3.1	4.7

Pedon 121

Classification: Typic Haplustult, clayey, mixed, isohyperthermic.
Location: Puerto Rico. 45 m S. of bridge No. 960+85 along main irrigation canal. Lajas Valley, 60 km (35 mi.) W. of Ponce.
Physiographic position: Gently sloping alluvial fans derived principally from volcanic rocks in the surrounding hills.
Topography: Smooth surface with 1 to 2 percent slope.
Drainage: Moderately well drained.
Vegetation: Sugarcane.
Sampled by: L. T. Alexander, J. A. Bonnet, R. E. Gierbolini, J. Juarez, Jr., C. J. Koch, and J. E. Trigo, September 5, 1957.
Remarks: Abundant roots in Ap; old root channels evident down to B22t.
Soil No.: S57PR-14-2.



Colors are for the moist soil.

Ap 0-23 cm (0-9 in.). Dark brown (7.5YR 3/2) loam with weak medium granular structure; friable (moist); few small iron-impregnated volcanic fragments; smooth abrupt boundary.

B21t 23-46 cm (9-18 in.). Yellowish brown (10YR 5/6) clay with distinct spots of dark brown (7.5YR 3/2) from Ap; moderate medium subangular blocky structure with tendency toward prismatic structure; slightly sticky (wet); few small iron-impregnated volcanic fragments; clay skins on peds; clear smooth boundary.

B22t 46-76 cm (18-30 in.). Yellowish brown (10YR 5/8) clay with common medium distinct mottles of red (10R 4/8); moderate medium subangular blocky structure with tendency toward prismatic structure; clay skins present; sticky and plastic (wet); clear smooth boundary.

C1 76-105 cm (30-41 in.). Mixed yellowish brown (10YR 5/8) and white (N 8/0) clay loam; massive; sticky and plastic (wet); many iron-impregnated volcanic rock fragments, some may be ironstone; clear smooth boundary.

C2 105-130 cm (41-52 in.) plus. Mixed white (N 8/0) and red (10R 4/8) sandy clay loam; massive; sticky and plastic (wet); many iron-impregnated volcanic rock fragments, some may be ironstone.

SOIL Pedon 122 Typic Haploxerult SOIL Nos. S60Calif-3-24 LOCATION Amador County, California

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 60128 - 60133

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1 Total: Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Sand: Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	Silt: (0.05-0.02)	Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1			Coarse fragments 1A2a: > 2 Pct. of whole soil	2-19	19-76
		Pct. of <2 mm															Pct. of <76mm	
0-5	A1	38.8	47.5	13.7	4.8	6.9	3.2	11.2	12.7	19.0	28.5	39.7	16.1			33		
5-23	A3	36.8	47.6	15.6	3.6	6.0	2.8	10.8	13.6	19.4	28.2	40.8	23.2			11		
23-56	B1t	26.4	43.7	29.9	1.2	3.9	2.3	8.2	10.8	15.3	28.4	32.1	15.6			16		
56-94	B2t	19.5	42.1	38.4	1.2	4.0	2.3	5.9	6.1	12.1	30.0	22.1	13.4			8		
94-120	B3t	19.5	45.7	34.8	1.8	4.0	2.0	5.5	6.2	11.6	34.1	21.5	13.3			6		
120-175	C1	a/44.2	47.6	8.2	a/4.0	a/4.2	a/5.5	a/11.3	a/9.2	15.2	32.4	31.3	35.0			2		

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N	6C1b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b <2 mm Pct.	3A1a <0.002 mm Pct.	Bulk density: 4A1f 1/3-bar g/cc	4A1h Oven-dry g/cc	g/cc	3B2 Cm	Water content: 4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15 bar cm/cm			pH: 8C1b Saturated paste	8C1a H_2O 1:1	8C1c IN KCl 1:1
0-5	4.22	0.140	30	5.3								10.5					6.0	4.9
5-23	1.71	0.068	25	5.8								9.1					5.7	4.5
23-56	0.75	0.041	18	7.5								13.7					5.1	4.1
56-94	0.48	0.028	17	10.4								18.0					5.0	4.1
94-120	0.31	0.024		10.4								17.0					5.0	3.9
120-175	0.22			8.3								8.6					4.8	3.9

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O1c Mg	6P2a Na	6Q2a K	Sum of bases	6H2a Ext. acidity	Cation exch. capacity: 5A2a NaOAc	5A3a Sum of cations		6G1e KCl ext. Al +++	Ratios to clay 8D1: CEC NaOAc	Ext. iron	15-bar water			Base saturation: 5C3 Sum of cations Pct.	Pct.
	meq/100g																
0-5	9.1	2.9	0.1	0.5	12.6	14.7		23.9			1.74	0.39	0.77			46	
5-23	2.6	2.2	0.1	0.4	5.3	8.7		16.9			1.08	0.37	0.58			38	
23-56	0.6	2.8	0.1	0.4	3.9	7.4		11.7			0.39	0.25	0.46			35	
56-94	0.4	2.7	0.1	0.3	3.5	8.2		11.7			0.30	0.27	0.47			30	
94-120	0.5	2.1	<0.1	0.2	2.8	8.4		11.4			0.33	0.30	0.49			25	
120-175	0.3	1.5	0.1	<0.1	1.9	6.1		9.1			1.11	1.00	1.05			24	

Depth (cm)	c/ Clay fraction mineralogy 3A1: 7A2 X-ray d/	7A3 DTA Pct.
0-5		
5-23	MT3, VR3	KK52, GI1
23-56		
56-94	VR2	KK40, GI1
94-120	VR2	KK40, GI1
120-175		

a/ Sand consists of partially decomposed rock that breaks down quite easily to smaller aggregates under slight to moderate pressure.

b/ 14.6 kg of organic carbon per square meter to a depth of 1 meter.

c/ Mineral code:
- MT = montmorillonite
- VR = vermiculite
- KK = kaolinite
- GI = gibbsite

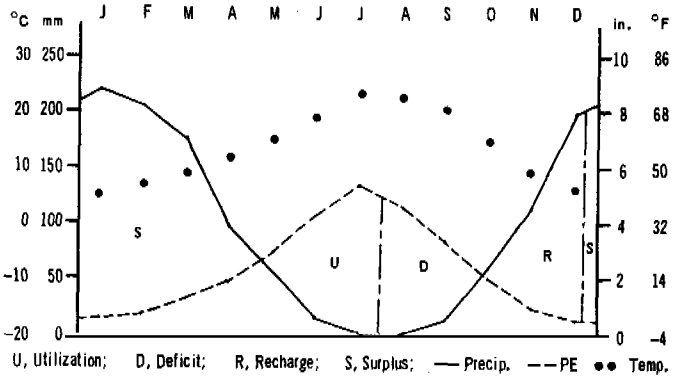
d/ Approximate weight fraction (X-ray):
- 3 = one-fifth to one-third
- 2 = one-twentieth to one-fifth

wrong

Pedon 122

Classification: Typic Haploxerult, fine-loamy, mixed, mesic.
Location: Amador County, Calif. 0.8 km west of Shake Ridge Road, crossing over Rancheria Creek, 46 m north of Shake Ridge Road, 6.1 km west of junction of Charleston-Volcano Road and Shake Ridge Road. 0.6 km north of the SE corner of sec. 24, T. 7 N., R. 11 E.
Physiographic position: Steep uplands, elevation about 625 m.
Topography: North-facing, 25 percent slope.
Drainage: Well drained; moderate runoff; moderate permeability.
Vegetation: Ponderosa pine (Pinus ponderosa), sugar pine (Pinus lambertiana), black oak (Quercus velutina), mountain misery (Chamaebatia foliolosa), manzanita (Arctostaphylos sp.), toyon (Photinia arbutifolia).
Parent material: Metasedimentary rocks of the Calaveras formation (schists with vertical cleavage).
Sampled by: G. Kennedy, R. E. Nelson, R. Sketchley, C. Henry, P. Nazar, and J. McClelland, May 4, 1960.
Remarks: Field estimates of the volume of gravel for the B2t, B3t and C1 horizons are given in the profile description.
Soil No.: S60Calif-3-24.

Climatic data and soil water balance



Colors are for the dry soil unless otherwise indicated.

O1 3-0 cm (1-0 in.). Organic layer consisting of fresh needles, litter, and decomposing litter.

A1 0-5 cm (0-2 in.). Brown (10YR 4/3) gravelly loam, dark brown (7.5YR 3/2) when moist; weak fine subangular blocky structure; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); abundant very fine, few fine and medium roots; many very fine, few fine interstitial and tubular pores; abrupt smooth boundary.

A3 5-23 cm (2-9 in.). Brown (7.5YR 5/4) gravelly light loam, dark brown (7.5YR 4/4) when moist; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); abundant very fine, few fine and medium roots; many very fine tubular and interstitial pores; few fine and medium tubular pores; clear smooth boundary.

B1t 23-56 cm (9-22 in.). Brown (7.5YR 5/5) light clay loam, reddish brown (5YR 4/5) when moist; moderate medium subangular blocky structure; hard (dry), friable (moist), sticky and plastic (wet); abundant very fine, few fine to very coarse roots; pores as above; thin, nearly continuous clay skins in pores; gradual irregular boundary because of presence of a few partially disintegrated stones and bedrock.

B2t 56-94 cm (22-37 in.). Brown (7.5YR 5/5) heavy silty clay loam, strong brown (7.5YR 4/6) when moist; moderate medium subangular blocky structure; very hard (dry), firm (moist), sticky and plastic (wet); few fine to coarse roots; many very fine interstitial and tubular pores, few fine and medium tubular pores; moderately thick continuous clay skins on ped faces and in many pores; about 25 percent by volume of weathered soft rocks; gradual irregular boundary.

B3t 94-120 cm (37-47 in.). Yellowish brown (10YR 5/6) silty clay loam, dark yellowish brown (10YR 4/6) when moist; moderate medium subangular blocky structure; very hard (dry), firm (moist), slightly sticky and slightly plastic (wet); few very fine to large roots; many very fine interstitial pores, few very fine, common fine tubular pores; clay skins as above but thin; about 35 percent by volume of weathered soft rocks; clear irregular boundary.

C1 120-175 cm (47-68 in.). Brownish yellow, yellowish red, and gray (10YR 6/6, 5YR 5/6, and N 6/) decomposing rock, brownish yellow, red, and dark gray (10YR 6/6, 2.5YR 4/6, and N 4/) when moist; massive; extremely hard (dry), very firm (moist); very few roots; few very fine tubular, common fine interstitial pores; moderately thick, continuous clay skins along fracture faces.

SOIL Pedon 123 Typic Torrert SOIL Nos. S60NMex-7-16 LOCATION Dona Ana County, N. Mex.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 13218-13222

General Methods: 1A1, 1B1a, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1: Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)	3A1b <0.0002		Coarse fragments 2A2:	Wt.	3B1 20–2
		Pct. of < 2 mm																
		Carbonate removed a/, b/																
0-5	A	5.9	30.5	63.6	0.1	0.2	0.1	1.0	4.5	5.4	25.1	10.7	1.4					tr
5-23	AC	6.0	28.4	65.6	0.3	0.4	0.2	1.3	3.8	5.8	22.6	10.5	2.2	22.7				tr
23-48	C1	5.6	31.9	62.5	0.2	0.2	0.2	1.4	3.6	5.8	26.1	10.4	2.0					tr
48-81	C2	5.6	28.7	65.7	0.1	0.2	0.2	1.4	3.7	6.2	22.5	10.9	1.9	20.0				tr
81-115	C2	5.8	28.3	65.9	0.2	0.4	0.2	1.4	3.6	6.4	21.9	11.0	2.2	26.0				tr

Depth (cm)	6A1a Organic carbon c/ Pct.	Nitrogen Pct.	C/N	6C1a Ext. iron as Fe a/ Pct.	6E1a Carbonate as $CaCO_3$ Pct.		Bulk density: g/cc	4A1c 30-cm g/cc	4A1b Air-dry g/cc	4D1 COLE	Water content: 4B1 30-cm Pct.	4B2 15-bar Pct.	Pct.			pH 8C1a: (1:10) H_2O	(1:1) H_2O
0-5	0.58			1.3	4											8.2	7.6
5-23	0.45			1.2	4			1.28	1.50	0.056	32.8	18.8				8.4	7.9
23-48	0.26			1.2	3			1.36	1.56	0.047	30.8					8.4	7.9
48-81	0.24			1.2	3											8.4	7.9
81-115	0.29			1.2	3			1.42	1.69	0.059	29.0	20.0				8.4	7.8

Depth (cm)	Extractable bases 5B1a: Ca	6O2a Mg	6P2a Na	6Q2a K		5A1a CEC NH_4OAc			Water extract from saturated paste 8A1: 6N1a Ca	6O1a Mg	6P1a Na	6Q1a K	8A1a Electrical conductivity			Ratios to clay: NH_4OAc CEC	Ext. iron	15-bar water
	meq/100 g								meq/liter				mmho/cm					
0-5		4.6	tr	tr		33.1			8.9	0.9	0.5	0.7	1.1			0.52	0.02	
5-23		4.4	tr	tr		32.2			3.8	0.2	0.2	0.4	0.5			0.49	0.02	0.29
23-48		4.4	tr	tr		31.1			3.3	0.8	0.3	0.3	0.4			0.50	0.02	
48-81		4.4	0.1	0.1		30.4			3.3	0.8	0.3	0.3	0.5			0.46	0.02	
81-115		4.8	0.1	0.1		29.2			3.4	0.4	0.2	0.3	0.4			0.44	0.02	0.30

Depth (cm)	8A Water at saturation Pct.	Clay fraction d/ mineralogy 7A1: 7A2 x-ray e/	7A3 DTA Pct.
0-5	59.9		
5-23	61.6		
23-48	63.6	MV3,MI1	KK1Q
48-81	66.9		
81-115	66.9		

a/ Carbonate removed by method 1B3 and the determination reported for the sample so treated.

b/ The < 2 mm in contact overnight with 0.1N NaOH in addition to regular treatments designed to aid disaggregation.

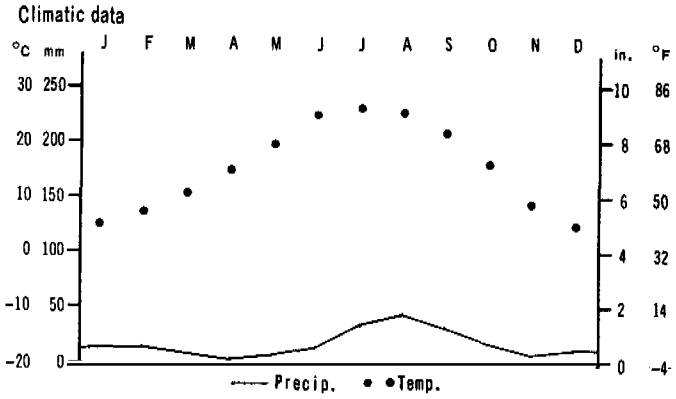
c/ Determination on sample treated by method 1B3 to remove carbonate; values expressed on a carbonate-containing basis.

d/ Mineral code:
MV = interstratified montmorillonite-vermiculite, poorly ordered
MI = mica
KK = kaolinite

e/ Approximate weight fractions:
3 = one-fifth to one-third
1 = less than one-twentieth

Pedon 123

Classification: Typic Torrert, very fine, mixed, thermic.
Location: Dona Ana County, N. Mex., NE 1/4 NE 1/4 sec. 27, T. 21 S., R. 2 E., 16 km (10 mi.) N. of Las Cruces.
Physiographic position: Central part of a closed basin, elevation 1,308 m.
Topography: Near the center and at the lowest point of Isaack's Lake, a playa. Site is level. Microrelief of 3 to 8 cm.
Vegetation: Annual weeds, 30 to 150 cm high.
Parent material: Calcareous sediments from acid and intermediate igneous rocks, limestone, and calcareous sandstone and siltstone of the surrounding mountain areas, plus older basin-fill deposits, including fan sediments of local derivation and fluvial sand and rounded gravel of mixed composition.
Sampled by: L. H. Gile, R. B. Grossman, J. L. Millet and F. F. Peterson, April 20, 1960.
Remarks: Measurements in the general area indicate that the current dust fall is calcareous.
Soil No.: S60NMex-7-16.



Colors are for the dry soil unless otherwise indicated.

Soil surface. The surface is prominently cracked into polyhedrons about 30 cm in diameter. Some cracks are 3 cm or more wide. The surface 1 cm of the polyhedrons is formed by smaller units.

A 0-5 cm (0-2 in.). Brown (7.5YR 5/2) heavy clay, dark brown (7.5YR 4/2) moist; strong fine platy structure with very coarsely spaced vertical cracks; slightly hard (dry); few roots; effervesces strongly; abrupt smooth boundary.

AC 5-23 cm (2-9 in.). Reddish brown (5YR 5/3.5, 4/4 moist) heavy clay; very coarse prismatic and weak fine platy structure; firm (moist); few roots; large vertical cracks terminate in the lower part of this horizon; few carbonate nodules less than 1 mm across; effervesces strongly; abrupt smooth boundary.

C1 23-48 cm (9-19 in.). Variegated reddish brown (5YR 4.5/4) and reddish gray (5YR 5/2) heavy clay; respectively, reddish gray (5YR 5/2) and dark reddish gray (5YR 4/2) moist; massive with many slickensides; firm (moist); no roots; few carbonate nodules less than 1 mm across; effervesces strongly; gradual boundary.

C2 48-115 cm (19-45 in.). Color and texture as for horizon above; slickensides more strongly developed than in overlying horizon; firm (moist); no roots; few carbonate nodules less than 1 mm across; effervesces strongly; horizon split for sampling at 81 cm.

Pedon 124
SOIL Aquentic Chromudert SOIL Nos. S63PR-16-2 LOCATION Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 19059-19066

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2-0.05) a/,b/	Total: Silt (0.05-0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: (0.05-0.02)	Silt: Int. III (0.02-0.002)	Silt: Int. II (0.2-0.02)	(2-0.1)	<0.002	<0.074	Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-18	Ap	14.5	37.8	47.7	1.3	2.5	1.8	3.5	5.4	11.8	26.0	19.3	9.1		89.4			2
18-38	A12	9.1	29.5	61.4	0.6	1.2	1.1	2.3	3.9	9.1	20.4	14.4	5.2		93.6			tr
38-61	C1	6.9	29.4	63.7	0.4	0.7	0.5	1.6	3.7	8.9	20.5	13.7	3.2		95.8			tr
61-97	C2	7.1	33.7	59.2	0.5	0.8	0.4	1.5	3.9	9.8	23.9	14.7	3.2	41.2	95.7			tr
97-135	C3	7.4	34.6	58.0	0.4	0.4	0.4	1.7	4.5	10.1	24.5	15.8	2.9		95.9			tr
135-170	C4	9.4	32.5	58.1	1.1	1.2	0.8	2.3	4.0	8.8	23.7	14.3	5.4		93.4			tr
170-230	C5	2.9	37.9	59.2	0.7	0.5	0.3	0.5	0.9	5.5	32.4	6.7	2.0		97.7			4
230-285	C6	5.3	39.9	54.8	0.2	0.7	0.7	1.9	1.8	5.1	34.8	8.1	3.5		95.8			tr

Depth (cm)	6A1a Organic carbon c/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ 6E2a < 2 mm Pct.	6E1b <0.002 mm Pct.	Bulk density 4A1a Field state g/cc	4A1d 1/3-bar g/cc	4A1b Air-dry g/cc	4D1 COLE	Water content 4B4 Field State Pct.	4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm		pH 8C1c (1:1) N KCl	8C1a (1:1) H_2O
0-18	1.96	0.200	10	5.5			1.20	1.28	1.61	0.078	39.8	31.3	22.4	0.11		4.0	4.8
18-38	1.17	0.121	10	4.1			1.15	1.17	1.81	0.16	44.8	39.7	26.1	0.16		4.4	5.3
38-61	0.44	0.053	8	4.1			1.29	1.23	1.88	0.16	36.0	37.2	26.2	0.14		5.0	5.9
61-97	0.13			3.3	tr		1.35	1.28	1.91	0.14	33.2	35.4	23.6	0.15		5.8	6.8
97-135	0.10			2.9	1	-	1.46	1.34	1.96	0.14	28.6	32.7	22.6	0.14		6.5	7.5
135-170	0.06			2.6	2	-	1.49	1.33	1.96	0.14	27.1	33.5	24.2	0.12		6.6	7.6
170-230				3.4	1	-							25.6			6.6	7.8
230-285				5.8	tr								23.1			6.6	7.7

Depth (cm)	Extractable bases 5B1a 6N2a Ca d/	6O2a Mg e/	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap. 5A3a Sum cations	5A1a NH_4OAc	6G1d KCl-ext. Al	6L2a NH_4OAc ext. SO_4		Ratios to clay 8D1 NH_4OAc CEC	Ext. iron	15-bar water		Base saturation 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																
0-18	5.8	11.0	0.4	0.4	17.6	16.9	34.5	25.5	0.5	0.6		0.53	0.12	0.47		51	69
18-38	9.9	17.1	1.0	0.2	28.2	13.6	41.8	26.9	0.4	0.5		0.44	0.07	0.43		67	105
38-61	10.8	22.1	1.9	0.4	35.2	7.6	42.8	32.2		0.3		0.51	0.06	0.41		82	109
61-97	10.2	23.8	2.5	0.4	36.9	3.8	40.7	32.0		0.2		0.54	0.06	0.40		91	115
97-135	9.5	22.9	3.3	0.5	36.2	3.2	39.4	29.4		0.1		0.51	0.05	0.39			
135-170	9.5	24.7	3.8	0.5	38.5	1.8	40.3	31.9		0.1		0.55	0.04	0.42			
170-230	9.1	24.8	3.8	0.4	38.1	1.9	40.0	32.5		tr		0.55	0.06	0.43			
230-285	6.7	17.8	2.6	0.3	27.4	2.6	30.0	24.1		0.1		0.55	0.11	0.42			

Depth (cm)	Clay fraction f/ mineralogy 7A1 — 7A2 X-ray	7A3 DTA	0.10-0.02 mm fraction f/ mineralogy 7B2 Petrographic

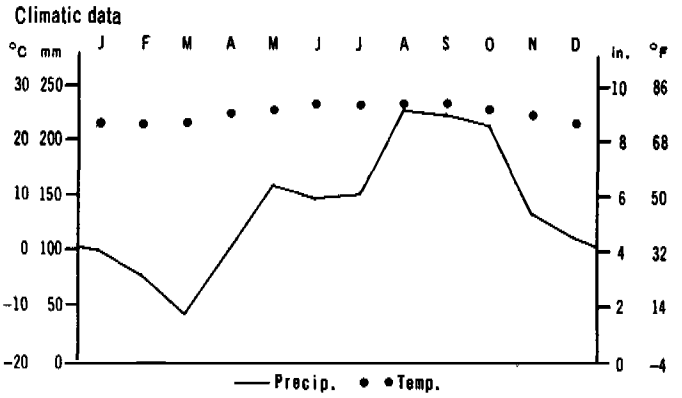
a/ Earthy nodules in the upper four horizons comprise > 50 percent of 2.0-0.25 mm and 5-25 percent of 0.25-0.05 mm sands; earthy nodules > 50 percent of sands in C6 horizon.

b/ Carbonate grains in the C3, C4 and C5 horizons comprise 25-50 percent of 2.0-0.25 mm and 5-10 percent of 0.25-0.05 mm sands.

c/ 9.7 kg/m² to 1.5 m (method 6A).

Pedon 124

Classification: Aquentic Chromudert, very fine, montmorillonitic, isohyperthermic.
Location: Puerto Rico. 1.2 km W. of town of Gurabo, 245 m N. and 185 m W. of Gurabo Experiment Station headquarters. 25 km (15 mi.) SE. of San Juan.
Physiographic position: Alluvial fan with 2 percent slope.
Drainage. Somewhat poorly drained, slow runoff, slow permeability.
Vegetation: Guava (Psidium guajava L.) orchard with native pasture undergrowth.
Parent material: Alluvial fan sediments derived from volcanic rocks.
Sampled by: R. B. Grossman, W. E. McKinzie and L. H. Rivera, October 1, 1965.
Remarks: Soil was above field capacity in the upper four horizons and at field capacity below. Free water at 3.0 m. Area has been in guava for the last 5 years and before that in native grasses. No fertilizer or lime has been applied in at least 5 years.
Soil No.: S63PR-16-2.



Colors are for the moist soil.

Ap 0-18 cm (0-7 in.). Very dark grayish brown (10YR 3/2) light clay with few fine faint yellowish brown mottles and red (2.5YR 4/6) coatings along root channels; weak fine granular structure; hard (dry), very firm (moist), slightly sticky and plastic (wet); plentiful fine roots; common fine black nodules; few fine fragments of volcanic rock; very strongly acid; clear smooth boundary.

A12 18-38 cm (7-15 in.). Dark yellowish brown (10YR 4/4) heavy clay with few fine distinct gray (10YR 5/1), common medium distinct yellowish brown (10YR 5/6) mottles; brown (10YR 4/3) rubbed color; weak fine and medium angular blocky structure with many pressure faces; very firm (moist), slightly sticky and plastic (wet); plentiful fine roots; few fine black nodules; few fine fragments of volcanic rock; strongly acid; clear wavy boundary.

C1 38-61 cm (15-24 in.). Yellowish brown (10YR 5/6) heavy clay with many medium distinct gray (10YR 5/1) mottles; brown (10YR 4/3) rubbed color; weak fine and medium angular blocky structure with many pressure faces and some slickensides; very firm (moist), slightly sticky and plastic (wet); few fine roots; few fine black nodules; few fine fragments of volcanic rock; coatings along root channels; medium acid; clear wavy boundary.

C2 61-97 cm (24-38 in.). Yellowish brown (10YR 5/4) light clay with few fine distinct gray (10YR 5/1) and few fine distinct greenish gray (5GY 6/1) mottles; weak medium and coarse angular blocky structure with many pressure faces and some slickensides; very firm (moist), slightly sticky and plastic (wet); common fine black nodules; few fine fragments of volcanic rock; neutral; abrupt wavy boundary.

C3 97-135 cm (38-53 in.). Yellowish brown (10YR 5/4) light clay with common fine distinct gray (10YR 5/1) and few fine distinct greenish gray (5GY 6/1) mottles; weak medium angular blocky structure with common pressure faces and some slickensides; very firm (moist), slightly sticky and plastic (wet); few fine black nodules; few fine fragments of volcanic rocks; few fine and medium carbonate nodules; mildly alkaline; gradual smooth boundary.

C4 135-170 cm (53-67 in.). Yellowish brown (10YR 5/4) light clay with common fine distinct gray (10YR 5/1) and few fine distinct greenish gray (5GY 6/1) mottles; weak medium angular blocky structure with few pressure faces and slickensides; very firm (moist), slightly sticky and plastic (wet); few fine black nodules; few fine and medium volcanic fragments; few fine carbonate nodules; mildly alkaline.

C5 170-230 cm (67-90 in.). Mixed yellowish brown (10YR 5/4) and greenish gray (5GY 6/1) light clay; massive; very firm (moist), slightly sticky and plastic (wet); few fine black nodules; weak effervescence; mildly alkaline.

C6 230-285 cm (90-113 in.). Yellowish brown (10YR 5/6) light clay with few medium distinct greenish gray (5GY 6/1); massive; very firm (moist), slightly sticky and plastic (wet); weak effervescence; mildly alkaline.

SOIL Pedon 125 Entic Pelludert SOIL Nos. S59Tex-123-1 LOCATION Jefferson County, Tex.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 11592-11597

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-18	Ap	10.5	38.7	50.8	< 0.1	< 0.1	< 0.1	0.5	10.0	14.6	24.1	25.0	0.5					-
18-33	A12	8.9	38.0	53.1	< 0.1	< 0.1	< 0.1	0.7	8.2	12.9	25.1	21.6	0.7					-
33-61	A13	7.8	35.0	57.2	< 0.1	< 0.1	< 0.1	0.4	7.4	11.0	24.0	18.7	0.4					-
61-81	A14	8.3	33.0	58.7	< 0.1	< 0.1	< 0.1	0.4	7.9	10.9	22.1	19.1	0.4					-
81-110	AC	8.2	32.4	59.4	< 0.1	< 0.1	< 0.1	0.4	7.8	11.1	21.3	19.2	0.4					-
110-150	C	7.3	27.3	65.4	< 0.1	< 0.1	< 0.1	0.2	7.1	9.2	18.1	16.5	0.2					-

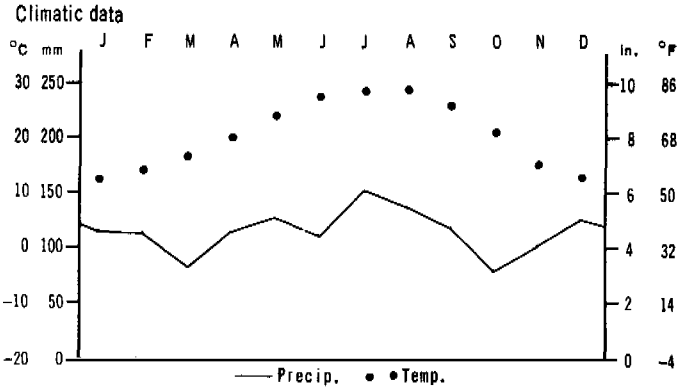
Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C2a Ext. iron as Fe Pct.	Bulk density: 4A1a Field state g/cc	4A1c 30-cm g/cc	4A1h Oven-dry g/cc	4D1 COLE b/	Water content: 4B4 Field state Pct.	4B3 30-cm Pct.	4B1b 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar b/ cm/cm		pH: 8C1a (1:1) H_2O
0-18	1.44	0.123	12			0.9	1.33	1.43	1.76	0.098	31.6	25.0	30.8	20.1	0.14		5.0
18-33	0.91	0.075	12			0.8	1.33	1.40	1.83	0.112	32.6	28.2	32.5	20.5	0.16		4.6
33-61	0.69	0.062	11			1.0	1.30	1.41	1.89	0.133	35.8	28.8	36.0	23.0	0.17		4.8
61-81	0.53					1.0								22.9			4.9
81-110	0.45					1.0	1.33	1.35	1.94	0.134	34.0	32.5	36.0	22.8	0.18		5.2
110-150	0.18				-	1.6	1.37	1.39	1.96	0.127	33.2	31.3	36.3	24.9	0.16		6.5

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap: 5A3a Sum cat-ions	5A1a NH_4OAc	6G2 Ext. Al			Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water		8D3 Ca/Mg	Base saturation: 5C3 Sum cat-ions Pct.	5C1 NH_4OAc Pct.
	meq/100 g																	
0-18	15.7	6.0	1.2	0.4	23.3	13.6	36.9	26.4	2			0.52	0.02	0.40		2.6	63	88
18-33	14.6	5.5	1.5	0.4	22.0	14.8	36.8	29.4	4			0.55	0.02	0.39		2.6	60	75
33-61	17.8	6.6	1.6	0.4	26.4	12.6	39.0	30.1	2			0.53	0.02	0.40		2.7	68	88
61-81	19.4	6.8	1.7	0.4	28.3	10.9	39.2	30.1	2			0.51	0.02	0.39		2.8	72	94
81-110	21.8	7.4	1.8	0.4	31.4	7.7	39.1	30.3	tr			0.51	0.02	0.38		2.9	80	104
110-150	26.7	8.8	2.1	0.5	38.1	4.5	42.6	33.4	tr			0.51	0.02	0.38		3.0	89	114

a/ 13 kg/m² to 1.5 m (method 6A).
b/ Field-state bulk densities used for calculations.

Pedon 125

Classification: Entic Pelludert, fine, montmorillonitic, thermic.
Location: Jefferson County, Tex. Texas Riceland Farm, 1.3 km (0.8 mi.) W. of County Courthouse and 3.5 km (2.2 mi.) SW. on A Avenue and 3.8 km (2.4 mi.) S. on West Port Arthur Road and 6.1 km (3.8 mi.) W. and S. on Hillebrandt Road and 120 m E. and 66 m S. About 130 km (80 mi.) E. of Houston.
Physiographic position: Coastal Plain. Elevation about 10 m.
Topography: Nearly level with gradient less than 1/2 percent.
Vegetation: Pasture; vaseygrass (Paspalum urvillei), carpetgrass (Axonopus affinis), longtom (Paspalum lividum).
Sampled by: J. R. Coover, L. L. Gordon, R. B. Grossman, and G. J. Post, August 1959.
Remarks: All horizons at field capacity when sampled.
Soil No.: S59Tex-123-1.



Colors are for the moist soil.

Ap 0-18 cm (0-7 in.). Dark gray (10YR 4.5/1) light clay with common fine and medium faint brownish yellow and common distinct fine and medium dark brown mottles; weak blocks to massive structure; sticky and plastic (wet) but stiff; plentiful fine fibrous roots; dark reddish brown coatings on many root channels and ped surfaces; abrupt boundary.

A12 18-33 cm (7-13 in.). Dark gray (10YR 4/1) light clay with common faint fine brownish yellow and distinct fine strong brown predominantly intrapedal mottles; moderate medium blocky structure with few coarse blocks; same consistence as above; few to plentiful fine roots; few fine pores, some with dark reddish brown coatings; clear boundary.

A13 33-61 cm (13-24 in.). Dark gray (10YR 4/1) light clay with common to many faint fine and medium brownish yellow (10YR 6/8) and few distinct strong brown (7.5YR 5/8) mottles; weak medium blocky structure with tendency to compound wedge-shaped medium blocks formed by intersection of primary slickensides showing striations and secondary shear planes; sticky and very plastic (wet); few fine fibrous roots; few to common fine pores; few fine root channels, some with dark reddish brown coatings of iron; gradual wavy boundary.

AC1 61-81 cm (24-32 in.). Dark gray (10YR 4/1) light clay with common to many faint fine and medium brownish yellow and few distinct strong brown mottles; fine to medium moderately expressed wedge-shaped blocks formed by intersection of primary slickensides and secondary shear planes; sticky and plastic (wet), slightly more sticky than horizon above; few very fine roots; occasional very fine pores; roots penetrate structural units; gray (N 4.5/0) krotovinas at about 25 cm intervals; gradual wavy boundary.

AC2 81-110 cm (32-44 in.). Gray (10YR 5/1) light clay with many fine and medium yellowish brown (10YR 5/6) and few medium distinct strong brown (7.5YR 5/6) mottles; distinct primary slickensides striated at 5 cm intervals; medium fine blocks formed from intersection of secondary shear planes; very plastic and sticky (wet); few fine roots; few to common fine pores; 2.5 cm diameter gray (N 4.5/0) clay krotovinas at about 25 cm intervals; gradual wavy boundary.

C 110-150 cm (44-60 in.). Coarsely mottled yellowish brown (10YR 5/5) and light gray (2.5Y 6/1) heavy clay; diagonal primary slickensides every 5 to 7 cm; irregular or wedge-shaped medium blocks formed by intersection with horizontal shear planes at about 2 cm intervals; very little yellowish brown mottling on the light gray slickensides; sticky and very plastic (wet); krotovinas as in above horizon; very few fine roots; few very fine pores, mostly inside the peds.

Micromorphology, method 4E1. Hydrous iron oxides are strongly segregated throughout the pedon. Many of the hydrous iron oxide accumulations show faint extinction on rotation of the stage, suggestive of oriented silicate clay partially masked by iron oxides. Silicate clay segregation is strongest in the A12 and A13 horizons. The clay-rich segregations occur within the fabric formed by the sand and silt rather than as coatings on macro-void walls, and, judging from the reddish brown color, are apparently rich in hydrous iron oxides. The clay concentrations are probably a result of reorientation along shear planes, not illuviation. At most, only a very few clay skins occur.

SOIL Pedon 126 Udic Chromustert SOIL Nos. S61PR-14-9 LOCATION Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 14856-14861

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2-0.05)	Total: Silt (0.05-0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: (0.05-0.02)	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)			Coarse fragments 2A2		3B1 2-20 pct. < 20
		Pct. of < 2 mm																
0-18	Ap	17.7	30.7	51.6	1.8	2.4	1.9	5.1	6.5	11.5	19.2	21.0	11.2					tr
18-36	A12	16.7	28.3	55.0	2.0	2.3	1.7	4.5	6.2	10.7	17.6	19.5	10.5					tr
36-58	A13	13.6	24.8	61.6	1.7	1.8	1.3	3.7	5.1	8.9	15.9	16.2	8.5					tr
58-86	C1	12.4	24.6	63.0	1.0	1.6	1.2	3.5	5.1	9.3	15.3	16.5	7.3					tr
86-130	C2	13.3	28.5	58.2	1.0	1.5	1.2	3.8	5.8	10.8	17.7	19.0	7.5					tr
130-150	C3	15.1	27.6	57.3	1.5	1.5	1.4	4.5	6.2	10.6	17.0	19.6	8.9					tr

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N		6E2a 6E1c Carbonate as $CaCO_3$ Pct.	6C2a Ext. iron as Fe Pct.	Bulk density: 4A1a Field state g/cc	4A1c 30-cm g/cc	4A1b Air-dry g/cc	4D1 COLE	Water content: 4B4 Field state Pct.	4B3 30-cm Pct.	4B1b 1/3-bar Pct.	4B2 15-bar	4C1 1/3-to 15-bar cm/cm		pH: 8C1a (1:1) H_2O
0-18	1.64	0.138	12			3.4	1.36		1.60		22.3		32.4	20.4			5.8
18-36	1.29	0.118	11			3.4	1.41	1.22	1.79	0.14	28.7	39.9	40.6	23.5	0.21		5.9
36-58	0.63	0.063	10			3.1	1.36	1.18	1.78	0.15	30.5	42.0	40.8	27.1	0.16		6.3
58-86	0.37	0.040	9		-	2.7	1.41		1.84		29.1		38.6	26.2			6.8
86-130	0.12				1	2.5	1.48	1.25	1.79	0.13	27.0	37.6	36.9	24.6	0.15		7.8
130-150	0.07				tr	2.7								24.2			7.8

Depth (cm)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat.exch.cap: 5A3a Sum cations	5A1a NH_4OAc			Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water		8D3 Ca/Mg	Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																
0-18	23.3	16.4	0.3	0.5	40.5	10.2	50.7	41.7			0.81	0.07	0.40		1.4	80	97
18-36	23.6	17.5	0.5	0.5	42.1	10.0	52.1	41.2			0.75	0.06	0.43		1.3	81	102
36-58		22.8	1.0	0.7				43.5			0.71	0.05	0.44				
58-86		24.0	1.6	0.7				43.3			0.69	0.04	0.42				
86-130		24.4	2.1	0.7				39.5			0.68	0.04	0.42				
130-150		23.5	2.6	0.8				38.2			0.67	0.05	0.42				

Depth (cm)	Clay fraction b/ mineralogy 7A1 — 7A2 X-ray c/
0-18	
18-36	
36-58	
58-86	MT5, KK2
86-130	
130-150	

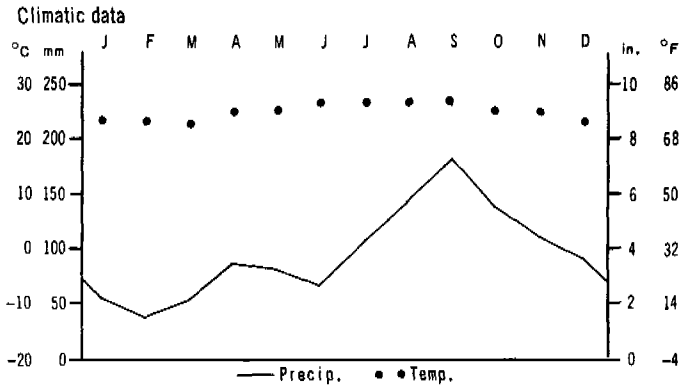
a/ 11 kg/m² to 1.5 m (method 6A).

b/ Mineral code:
MT = montmorillonite
KK = kaolinite

c/ Approximate weight fractions:
5 = more than one-half
2 = one-twentieth to one-fifth

Pedon 126

Classification: Udic Chromustert, very fine, montmorillonitic, isohyperthermic
Location: Puerto Rico. On Lajas Experiment Station, 210 m N. and 45 m E. of junction of roads to poultry barns and to Lajas railroad station, E. of Experiment Station headquarters. Lajas Valley, 60 km (35 mi.) W. of Ponce.
Physiographic position: Top of low convex alluvial fan above valley floor, nearly level (1 percent slope).
Drainage: Moderately well drained, moderately slow permeability, slow to medium runoff.
Vegetation: Idle, weeds on old cultivated field.
Parent material: Alluvial or valley-fill sediments derived from volcanic and limestone rocks.
Sampled by: O. R. Carter, R. B. Grossman, W. E. McKinzie, and L. H. Rivera, March 21, 1961.
Remarks: The A horizons were below field capacity and the C horizons at field capacity when sampled. Prominent cracks to 58 cm.
Soil No.: S61PR-14-9.



Colors are for the moist soil.

Ap 0-18 cm (0-7 in.). Very dark grayish brown (10YR 3/2) light clay; weak medium granular structure; firm (moist), slightly sticky and plastic (wet); abundant fine roots; common fine volcanic fragments; medium acid; clear smooth boundary.

A12 18-36 cm (7-14 in.). Very dark grayish brown (10YR 3/2) and 20 percent dark brown (10YR 3/3) light clay; massive when wet; upon drying breaks to weak medium and coarse angular blocks with pressure faces; slickensides 3 cm across; firm (moist), sticky and plastic (wet); few fine roots; some desiccation cracks; common fine brown fragments of volcanic rock up to 3 cm across; medium acid; clear wavy boundary.

A13 36-58 cm (14-23 in.). Dark brown (10YR 3/3) heavy clay with tongues and pockets of very dark grayish brown (10YR 3/2) clay; massive when wet; upon drying breaks to weak medium and coarse angular blocks with pressure faces and slickensides up to 15 cm in width; firm (moist), sticky and plastic (wet); some desiccation cracks; common fine volcanic pebbles; common fine black aggregates; slightly acid; gradual wavy boundary.

C1 58-86 cm (23-34 in.). Dark yellowish brown (10YR 4/4) heavy clay with tongues and pockets of very dark grayish brown (10YR 3/2) clay; massive when wet; upon drying breaks to weak medium and coarse angular blocks with pressure faces; slickensides up to 15 cm in width; firm (moist), sticky and plastic (wet); common fine black aggregates; neutral; clear wavy boundary.

C2 86-130 cm (34-51 in.). Dark yellowish brown (10YR 4/4) light clay; massive when wet; upon drying breaks to weak coarse subangular blocks with tendency to a wedge shape that have very dark brown (10YR 2/2) pressure faces; slickensides from 3 to 30 cm across, 30 degrees to horizontal; very firm (moist), sticky and plastic (wet); common fine black nodules; mildly alkaline and noncalcareous except for calcareous seams; clear wavy boundary.

C3 130-150 cm (51-60 in.). Dark yellowish brown (10YR 4/4) light clay; massive when wet; upon drying breaks to weak fine angular blocks that have very dark brown (10YR 2/2) pressure faces; many slickensides less than 3 cm across; friable (moist), sticky and plastic (wet); slightly calcareous.

Pedon 127

SOIL Udic Pellustert SOIL Nos. S62Tex-43-3 LOCATION Collin County, Tex.

SOIL SURVEY LABORATORY Lincoln, Nebr. LAB. Nos. 17746-17752

General Methods: 1A, 1B1b, 2A1, 2B

Depth (cm)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand a/ (2–0.05)	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: (0.05–0.02)	Silt: Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2		3B1 2-20 Pct. < 20
		Pct. of < 2 mm																
0-15	Ap	23.1	40.7	36.2	tr	0.1	0.2	7.9	14.9	21.3	19.4	43.5	8.2					-
15-56	A12	16.9	39.0	44.1	tr	tr	0.2	5.9	10.8	17.3	21.7	33.5	6.1					-
56-84	A13	16.1	39.3	44.6	tr	tr	0.2	5.7	10.2	16.5	22.8	31.9	5.9					-
84-125	A14	15.6	38.7	45.7	tr	tr	0.2	5.4	10.0	16.3	22.4	31.3	5.6					-
125-165	AC1	14.1	37.6	48.3	tr	0.1	0.1	5.0	8.9	17.9	19.7	31.4	5.2					tr
165-200	AC2	14.8	35.5	49.7	0.3	0.3	0.2	4.8	9.2	15.4	20.1	29.0	5.6					2
200-245	C	17.1	33.5	49.4	0.6	0.5	0.3	5.7	10.0	18.9	14.6	34.0	7.1					7

Depth (cm)	6A1a Organic carbon b/ Pct.	6B1a Nitrogen Pct.	C/N	6C2a Ext. iron as Fe Pct.	Carbonate as $CaCO_3$: 6E1b 6E2a < 2mm Pct.	3A1a <0.002 mm Pct.	Bulk density: 4A1a Field state g/cc	4A1d 1/3-bar c/ g/cc	4A1b Air-dry g/cc	4D1 COLE	Water content: 4B4 Field state Pct.	4B1c 1/3-bar Pct.	4B2 15-bar Pct.	4C1 1/3-to 15-bar cm/cm		pH: 8C1b Sat. paste	8C1a (1:1) H_2O	8C1a (1:10) H_2O
0-15	1.05	0.079	13	0.5			1.56	1.46	1.79	0.068	16.6	23.3	14.0	0.14		6.0	6.4	6.4
15-56	0.87	0.059	15	0.4			1.56	1.43	1.91	0.101	20.8	26.9	17.8	0.13		5.8	6.3	6.7
56-84	0.83	0.053	16	0.4	tr			1.4					18.4			6.6	6.6	7.4
84-125	0.61	0.036	17	0.4	tr		1.71	1.42	1.92	0.106	15.8	28.7	18.9	0.14		7.5	7.7	7.8
125-165	0.34	0.020	17	0.5	1	-		1.4					19.6			7.5	7.6	8.3
165-200	0.18	0.014	13	0.6	1	-		1.4					19.8			7.6	7.7	8.4
200-245	0.10			1.0	4	-	1.63	1.42	1.92	0.106	19.6	29.5	19.6	0.14		7.7	7.8	8.5

Depth (cm)	Extractable bases 5B1a: 6N2a Ca d/	6O2a Mg e/	6P2a Na	6Q2a K	Sum	6H1a Ext. acidity	Cat. exch. cap.: 5A2a NaOAc	5A1a NH_4OAc	Water extract from saturated paste 8A1: 6N1a Ca	6O1a Mg	6P1a Na	6Q1a K		6T1a CO_3	6J1a HCO_3	6K1a Cl	6L1a SO_4	8A1a Electrical conductivity
	meq/100 g								meq/liter									mmho/cm
0-15	23.0	4.3	0.3	0.8	28.4	4.5	28.6	27.4	1.6	0.3	1.0	0.1		-	1.5	0.2	0.3	0.34
15-56	27.0	4.6	1.4	0.6	33.6	4.7	34.8	31.7	1.1	0.1	2.9	tr		-	2.8	-	0.3	0.44
56-84	28.4	4.7	2.6	0.6	36.3	3.6	35.3	32.6	1.2	0.1	4.5	tr		-	2.5	0.7	1.6	0.65
84-125	25.2	4.3	3.7	0.7	33.9	1.4	35.3	32.4	3.9	0.5	10.6	0.1		-	3.0	1.5	9.8	1.59
125-165	26.4	4.2	4.2	0.8	35.6		35.4	32.5	5.0	0.6	13.7	0.1		-	2.8	2.5	14.9	2.00
165-200	26.2	4.1	4.5	0.8	35.6		34.6	31.3	6.1	0.6	15.8	0.1		-	3.0	3.2	18.0	2.23
200-245	24.9	3.6	4.5	0.7	33.7		31.2	28.2	6.4	0.7	16.4	0.1		-	2.0	3.7	18.8	2.34

Depth (cm)	8A Water at saturation Pct.	5D1 Exchangeable Na Pct.	5E SAR	6F1a Gypsum Pct.	Ratios to clay 8D1: NH_4OAc CEC	Ext. iron	15-bar water
0-15	47.6	1			0.76	0.01	0.39
15-56	54.6	3			0.72	0.01	0.40
56-84	57.0	6			0.73	0.01	0.41
84-125	62.6	8	7		0.71	0.01	0.41
125-165	67.5	9	8		0.67	0.01	0.40
165-200	67.6	10	9		0.63	0.01	0.40
200-245	64.3	11	9	tr	0.57	0.02	0.40

a/ Iron-manganese nodules comprise more than 50 percent of the very coarse and coarse sand above 165 cm. Below 165 cm carbonate comprises more than 50 percent of the very coarse and coarse sand and 1 to 5 percent of the finer than coarse sand.

b/ 16 kg/m^2 to 1.5 m (method 6A).

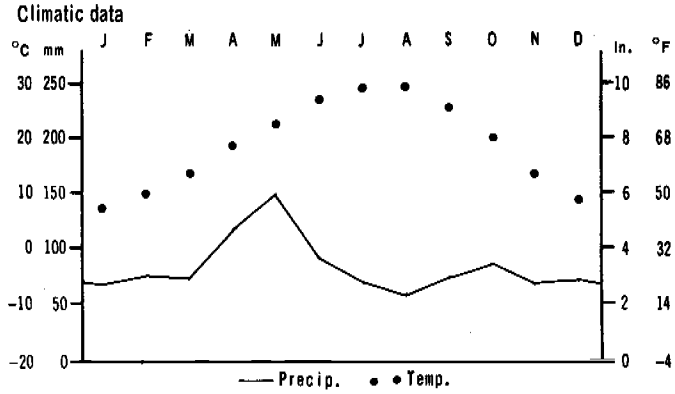
c/ Values for A13, AC1 and AC2 horizons are estimated.

d/ KCl-TEA extraction (method 6N4b) below 84 cm.

e/ KCl-TEA extraction (method 6O4b) below 84 cm.

Pedon 127

Classification: Udic Pellustert, fine, montmorillonitic, thermic.
Location: Collin County, Tex., 2.1 km (1.3 mi.) S. of NE. corner of county and 2.7 km (1.7 mi.) E. and 100 m S. of road. About 70 km (45 mi.) NE. of the center of Dallas.
Physiographic position: Old undissected alluvial plain with adjacent upland slopes. Elevation about 140 m.
Topography: Broad level plain with less than 1 percent slope.
Vegetation: Cultivated, cotton.
Parent material: Alluvial clays.
Sampled by: J. A. DeMent, W. R. Elder, R. L. Juve and M. Stout, September 18, 1962.
Remarks: Sample is from the center of microdepression obliterated by cultivation; hence, the thick A horizon. Moisture at sampling estimated at 75 percent of field capacity in upper pedon, drier with depth.
Soil No.: S62Tex-43-3.



Colors are for the dry soil unless otherwise specified.

Ap 0-15 cm (0-6 in.). Dark gray (10YR 4/1) heavy clay loam, very dark gray (10YR 3/1) moist; 3 to 6 mm platy crust of light gray (10YR 6/1) light silty clay loam, gray (10YR 5/1) moist with about 1 cm porous material appended below; weak blocky structure; mostly cloddy; very hard (dry); very firm (moist); abrupt smooth boundary.

A12 15-56 cm (6-22 in.). Gray (1Y 5/1) light clay, black (10YR 2.5/1) moist; weak fine and very fine angular blocky structure with shiny ped surfaces; extremely hard (dry), extremely firm (moist); common to few fine pores; slightly acid; diffuse boundary.

A13 56-84 cm (22-33 in.). Gray (1Y 5/1) light clay, black (10YR 2.5/1) moist; moderate fine and medium angular blocky structure with strong intersecting slickensides; shiny ped surfaces; extremely hard (dry), extremely firm (moist); neutral; diffuse boundary.

A14 84-125 cm (33-49 in.). Gray (10YR 5/1) light clay, dark gray (10YR 4/1) moist; common faint fine yellowish brown mottles; weak to moderate medium and fine angular blocky structure; dull ped surfaces with strong large intersecting slickensides; extremely hard (dry), extremely firm (moist); few filled wormholes; about 4 to 8 percent hard grayish calcium carbonate nodules 1 to 5 cm in diameter; mildly alkaline, noncalcareous soil matrix; diffuse boundary.

AC1 125-165 cm (49-64 in.). Grayish brown (2.5Y 5/2) light clay, dark grayish brown (2.5Y 4/2) moist; common fine faint olive brown mottles; moderate fine and medium angular blocky structure with moderate intersecting slickensides; extremely hard (dry), extremely firm (moist); common fine and medium calcium carbonate nodules and many calcareous grains less than 1 mm; mildly alkaline, noncalcareous soil matrix; diffuse boundary.

AC2 165-200 cm (64-78 in.). Light olive brown (2.5Y 5/4) light clay, same color dry; common faint fine dark grayish brown and brighter light olive brown mottles; moderate medium blocky structure with many shiny ped faces and many moderate to strong intersecting coarse slickensides; extremely hard (dry), extremely firm (moist); few gray wormcasts and filled cracks of gray (10YR 5/1); common fine calcium carbonate nodules; mildly alkaline, mostly noncalcareous; diffuse boundary.

C 200-245 cm (78-96 in.). Dark grayish brown (2.5Y 4/2) light clay with many brownish yellow (10YR 6/6) mottles. Also grays, browns, and yellows; strong medium and fine blocky structure with shiny ped surfaces and occasional coarse slickensides; extremely hard (dry), extremely firm (moist); few to common gray wormcasts, filled wormholes and cracks; common calcium carbonate nodules and soft masses with many calcareous particles of very fine sand size; mildly alkaline, mass mostly noncalcareous; diffuse boundary.

SOIL Pedon 128 Typic Chromoxerert SOIL Nos. S67Calif-33-2 LOCATION Riverside County, California

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 6725 - 6735

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Silt Int. II (0.2-0.02)	Silt 2-0.1			Coarse fragments 1A2a > 2 Pct. of whole soil	2-19 Pct. of <76mm	19-76 Pct. of <76mm
		Size class and particle diameter (mm) 3A1 — Pct. of <2 mm																
0-10	A11	22.9	50.0	27.1	2.4	3.4	2.4	5.2	9.5	32.9	17.1	45.2	13.4			23	11	12
10-25	A12	19.2	43.5	37.3	1.9	3.2	2.1	4.0	8.0	27.2	16.3	37.3	11.2			31	7	24
25-36	A13	20.1	39.7	40.2	2.2	3.5	2.0	4.1	8.3	23.4	16.3	33.9	11.8			10	9	1
36-61	A14	18.4	41.4	40.2	2.2	2.9	1.8	4.0	7.5	23.8	17.6	33.5	10.9			5	5	-
61-84	C1ca	19.4	39.1	41.5	2.6	2.8	1.9	4.1	8.0	21.3	17.8	31.7	11.4			6	6	-
84-135	C2	15.0	40.6	44.4	1.4	2.0	1.4	3.1	7.1	19.5	21.1	28.5	7.9			2	2	-
135-150	C3	8.4	44.3	47.3	0.9	1.6	0.8	1.9	3.2	18.9	25.4	23.3	5.2			-	-	-
150-170	C4	7.6	45.0	47.4	0.5	0.9	0.6	1.9	3.7	14.2	30.8	19.1	3.9			-	-	-
170-185	C5	20.8	44.3	34.9	0.7	1.7	2.6	8.7	7.1	12.3	32.0	24.7	13.7			1	1	-
185-225	IIC6	66.1	23.2	10.7	4.0	8.2	13.9	29.9	10.1	8.8	14.4	33.6	56.0			4	4	-
225-260	IIIC7	2.1	57.4	40.5	0.1	0.3	0.3	0.7	0.7	4.1	53.3	5.3	1.4			-	-	-

Depth (cm)	6A1a Organic carbon a/ Pct.	6B1a Nitrogen Pct.	C/N	6C2b Ext. iron as Fe Pct.	Carbonate as $CaCO_3$ 6E1b <2 mm Pct.	Carbonate 3A1a <0.002 mm Pct.	Bulk density 4A1f 1/3-bar g/cc	Bulk density 4A1h Oven-dry g/cc	Bulk density g/cc	3B2 Cm	Water content 4B1c 1/3-bar Pct.	Water content 4B2 15-bar Pct.	Water content 4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH 8C1b Saturated paste	pH 8C1c 1N KCl 1:1	pH 8C1a H_2O 1:16
0-10	1.85	0.171	11		-		1.32	1.55		0.87	22.1	12.2		0.055	0.047	7.1		7.8
10-25	0.78	0.080	10		-		1.46	1.85		0.80	26.2	15.3		0.082	0.064	6.8		7.8
25-36	0.59	0.052	11		tr.		1.55	1.91		0.94	23.3	16.7		0.072	0.067	7.5		8.9
36-61	0.59	0.036	16		4		1.54	1.93		0.97	24.2	16.2		0.078	0.077	7.9		9.3
61-84	0.40	0.028	14		5		1.56	1.91		0.96	24.0	17.4		0.070	0.067	8.0		9.3
84-135	0.32				4		1.52	1.87		0.99	25.3	19.9		0.072	0.071	7.8		9.0
135-150	0.23				2		1.44	1.82		1.00	28.8	23.5		0.081	0.081	7.6		8.7
150-170	0.22				1		1.28	1.76		1.00	38.7	29.3		0.112	0.112	7.6		8.7
170-185	0.13				tr.		1.22	1.64		1.00	39.7	26.3		0.104	0.104	7.4		8.7
185-225	0.10				-		1.53	1.69		0.98	20.6	13.9		0.034	0.033	7.2		8.2
225-260	0.13				-		1.26	1.82		1.00	40.9	37.1		0.130	0.130	7.1		8.1

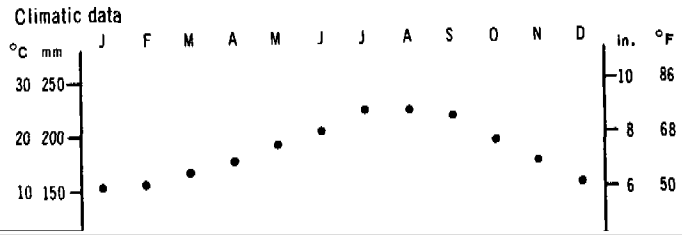
Depth (cm)	Extractable bases 6N2e Ca	6O2d Mg	6P2a Na	6Q2a K	5B1a	6H2a Ext. acidity	5A1a CEC NH_4OAc	5D2 Exchangeable sodium Pct.	5E Sodium adsorption ratio	8A Water at saturation Pct.	Water extract from saturated paste 8A1 6N1b Ca	6O1b Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1b SO_4	8A1a Electrical conductivity mmho/cm
	meq/100 g										meq/liter								
0-10	16.8	5.6	0.4	1.9			24.6												
10-25	20.2	8.6	0.8	1.2			30.8												
25-36	28.6	8.4	1.6	0.8			32.2												
36-61	29.8	7.8	2.8	0.6			30.6		6	63.6	1.0	0.4	4.6	0.1	-	3.8	1.4	1.7	0.68
61-84	31.5	7.8	4.0	0.6			30.7		8	70.9	1.3	0.4	6.9	0.1	-	3.1	3.3	3.9	1.01
84-135	34.2	9.1	5.9	0.6			36.7		9	80.2	6.0	2.1	17.4	0.2	-	2.0	20.4	10.3	3.17
135-150	42.1	12.8	8.1	0.8			47.9		7	88.9	23.5	8.8	27.2	0.5	-	1.8	23.9	44.2	5.51
150-170	51.2	14.1	8.6	0.8			53.0		7	93.3	26.2	9.6	30.8	0.3	-	1.9	23.6	48.8	5.65
170-185	47.5	15.2	8.8	0.9			58.8		7	85.4	26.2	9.7	30.8	0.3	-	1.7	21.6	52.9	5.77
185-225	22.3	9.1	5.0	0.3			35.7		9	51.2	4.1	1.7	16.1	0.1	-	1.3	13.0	11.3	2.53
225-260	42.2	17.0	10.8	1.1			66.2		9	110.7	7.0	3.4	19.9	0.2	-	0.9	16.8	15.3 b/	3.17

Ratios to clay 8D1 | 6F1a | c/ Clay fraction mineralogy 3A1

a/ 8 B 1/8 of organic carbon per gram

Pedon 128

Classification: Typic Chromoxerert, fine, montmorillonitic, thermic.
Location: Riverside County, Calif. Sec. 19, T. 4 S., R. 5 W.,
Physiographic position: Rolling uplands, 540 m elevation.
Topography: East northeast-facing, 5 percent slope.
Drainage: Well drained.
Vegetation: Red brome (Bromus rubens), soft chess (Bromus mollis), sawtooth goldenbush (Haplopappus squarossus), goldenbush (Haplopappus sp.), bunchgrass (Stipa sp.), wild mustard (Cruciferae sp.), needlegrass (Aristida sp.), and



Parent material: Soft marine sandstone and shale.
Sampled by: R. B. Brasher, E. E. Peterson, K. W. Flach

Soil No. S67Calif-33-2.

U, Utilization; D, Deficit; R, Recharge; S, Surplus; — Precip. - - - PE •• Temp.

Pedon 129

SOIL Chromic Pelloxerert SOIL Nos. S64Calif-37-8 LOCATION San Diego County, California

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 6450 - 6455

Depth (cm)	Horizon	1B1b Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (<0.002)	Sand Very coarse (2-1)	Sand Coarse (1-0.5)	Sand Medium (0.5-0.25)	Sand Fine (0.25-0.1)	Sand Very fine (0.1-0.05)	Silt (0.05-0.02)	Silt Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1	a/ Clay <.002	b/ Clay <.002	c/ Coarse fragments 1A2a > 2 Pct. of whole soil	2-19 Pct. of <76mm	19-76 Pct. of <76mm
		Size class and particle diameter (mm) 3A1																
		Pct. of <2 mm																
0-10	Ap	38.5	25.5	36.0	2.4	6.6	6.4	13.9	9.1	11.7	13.8	28.9	29.4	35.4	35.2	1	1	0
10-46	A11	33.3	28.8	37.9	2.4	6.2	5.9	11.5	7.3	15.7	13.1	29.6	26.0	39.1	38.4	2	2	0
46-56	A12	35.1	26.6	38.3	2.5	6.2	5.3	12.5	8.6	15.9	10.7	32.0	26.5	34.4	34.2	1	1	0
56-71	ACca	50.7	22.9	26.4	1.6	6.6	8.1	20.4	14.0	11.2	11.7	36.9	36.7	24.5	24.3	1	1	0
71-115	C1	79.6	11.1	9.3	7.0	19.6	14.3	29.3	9.4	6.6	4.5	25.8	70.2	6.7	5.9	12	12	0
115-145	C2	81.5	11.3	7.2	5.3	19.3	14.2	32.0	10.7	6.8	4.5	29.0	70.8	5.4	4.5	17	17	0

Depth (cm)	6A1a Organic carbon a/ d/ Pct.	6B1a Nitrogen a/ Pct.	C/N	6C2a a/ Ext. iron as Fe Pct.	b/ Carbonate as $CaCO_3$ 6E1b <2 mm Pct.	3A1a <0.002 mm Pct.	Bulk density 4A1f 1/3-bar g/cc	4A1h Oven-dry g/cc	Est. 1/3-bar g/cc	3B2 Cm	Water content 4B1c 1/3-bar Pct.	4B2 15-bar a/ Pct.	4C1 1/3-to 15-bar cm/cm	4D1 Extensibility COLEf cm/cm	4D1 Extensibility COLE cm/cm	pH 8C1b Saturated paste	8C1a H_2O 1:1	8C1c IN KCl 1:1
0-10	1.59	0.131	12	0.6	-				1.50	0.99		15.6				5.5	5.9	
10-46	0.54	0.057	9	0.6	-		1.50	1.75		0.99	25.0	17.0		0.053	0.052	6.7	7.1	
46-56	0.44	0.045	10	0.5	1		1.50	1.81		0.99	25.7	17.3		0.065	0.064	7.8	8.2	
56-71	0.28			0.5	1		1.53	1.71		0.99	23.7	17.2		0.038	0.037	7.8	8.4	
71-115	0.01			0.5	-		1.59	1.74		0.92	19.4	15.4		0.031	0.028	8.0	8.7	
115-145	-			0.5	-		1.73	1.86		0.88	15.5	14.3		0.025	0.022	8.2	8.7	

Depth (cm)	Extractable bases a/ 6N2a Ca	6O2a Mg	6P2a Na	6Q2a K	5B1a	6H2a a/ Ext. acidity	5A2a a/ CEC NaOAc	5D2 Exchangeable sodium Pct.	5E Sodium adsorption ratio	8A Water at saturation Pct.	b/ Water extract from saturated paste 8A1 6N1a Ca	6O1a Mg	6P1a Na	6Q1a K	6I1a CO_3	6J1a HCO_3	6K1a Cl	6L1b SO_4	8A1a Electrical conductivity mmho/cm
	meq/100 g										meq/liter								
0-10	17.2	12.5	0.6	1.0		4.5	34.7	2	2	54.5	2.1	2.1	2.3	0.3	-	3.6	2.4		0.65
10-46	23.2	14.6	1.4	0.3		1.5	41.7	3	3	61.0	1.2	0.7	3.0	tr.	-	3.4	1.4		0.52
46-56	31.9	14.7	2.5	0.3		-	44.7	4	5	58.0	0.7	0.8	4.7	tr.	-	4.5	0.4		0.55
56-71	36.4	17.2	3.9	0.2		-	53.3	7	7	51.9	0.6	0.8	5.5	tr.	-	4.8	0.5		0.62
71-115	38.9	23.3	7.6	0.1		1.4	65.7	11	9	49.0	0.4	0.4	5.8	tr.	-	3.5	0.7		0.63
115-145	42.1	20.3	6.6	0.1		0.2	64.0	10	9	48.7	0.7	0.3	6.1	0.1	-	3.8	0.8		0.70

Depth (cm)	Ratios to clay 8D1 CEC NaOAc	Ext. iron	15-bar water	e/ 3A1 Clay fraction mineralogy 7A2 X-ray f/	g/ Mont. and Verm.
0-10	0.98	0.02	0.44		
10-46	1.07	0.02	0.43	MT5, KK2, MV1	25
46-56	1.30	0.01	0.50		
56-71	2.18	0.02	0.70		
71-115	9.81	0.05	2.30		
115-145	11.85	0.07	2.65	MT5, VR2, MV1	34

a/ Analysis of ground whole soil; results expressed on <2 mm basis.

b/ Analysis of ground whole soil; results expressed on whole soil basis.

c/ From characterization sample; determined by shaking overnight in a hexametaphosphate solution.

d/ 6.6 kg of organic carbon per square meter to a depth of 1 meter.

e/ Mineral code:

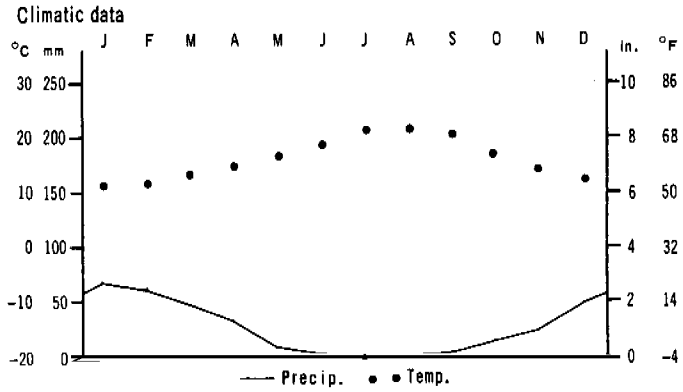
MT = montmorillonite VR = vermiculite

MV = montmorillonite-vermiculite KK = kaolinite

f/ [illegible]

Pedon 129

Classification: Chromic Pelloxerert, fine, montmorillonitic, thermic.
Location: San Diego County, Calif. 37 m east of the center line of Camp Pendleton Road and 46 m north, 61 m west of the SE1/4 corner of the NE1/4 of sec. 33, T. 10 S., R. 4 W.
Physiographic position: Rolling upland, elevation about 44 m.
Topography: Smooth, west-facing slope of 4 percent.
Drainage: Well drained; medium to rapid runoff; slowly permeable.
Vegetation: Wild oats (Avena sp.), mustard (Cruciferae sp.).
Parent material: Fragmented tonalite.
Sampled by: R. E. Nelson, G. Borst, G. Kester, L. Grant, R. Bowman, and D. Markewich, March 11, 1964.
Remarks: The ACca, C1 and C2 horizons do not disperse well, hence field estimates of texture are given in the profile description for these horizons.
Soil No.: S64Calif-37-8.



Colors are for the dry soil unless indicated otherwise.

Ap 0-10 cm (0-4 in.). Dark gray (10YR 4/1) heavy clay loam, very dark gray (10YR 3/1) moist; moderate coarse to fine granular structure; very hard (dry), firm (moist), sticky and plastic (wet); abundant very fine and fine roots; many fine tubular and many fine to medium interstitial pores; 1 percent fine gravel by volume; abrupt smooth boundary.

A11 10-46 cm (4-18 in.). Dark gray (10YR 4/1) heavy clay loam, very dark gray (10YR 3/1) moist; moderate medium angular blocky structure; extremely hard (dry), very firm (moist), sticky and plastic (wet); few very fine and fine roots; common very fine and fine tubular pores; few slickensides; 1 percent fine gravel by volume; abrupt wavy boundary.

A12 46-56 cm (18-22 in.). Grayish brown (10YR 5/2) heavy clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium angular blocky structure; extremely hard (dry), very firm (moist), sticky and plastic (wet); very few, very fine roots; few very fine to fine tubular pores; few intersecting slickensides; few fine soft masses of lime; slightly effervescent; 1 percent fine gravel by volume; clear wavy boundary.

ACca 56-71 cm (22-28 in.). Grayish brown (10YR 5/2) clay, very dark grayish brown (10YR 3/2) moist; moderate medium angular blocky structure; very hard (dry), very firm (moist), sticky and plastic (wet); very few very fine roots; very few very fine tubular pores; slightly to strongly effervescent; many medium to fine soft masses of carbonate; contains features of rock structure of the underlying material; 1 percent fine gravel by volume; clear wavy boundary.

C1 71-115 cm (28-45 in.). Pale brown tonalite, loamy sand in texture; massive; very hard (dry), firm (moist), nonsticky and nonplastic (wet); seams of carbonate about 1 cm thick, 15 to 30 cm apart, extending obliquely into the underlying horizon; strongly effervescent; 8 percent fine gravel by volume; clear smooth boundary.

C2 115-145 cm (45-57 in.). Pale yellow tonalite, loamy sand in texture; massive; very hard (dry), firm (moist), nonsticky and nonplastic (wet); oblique seams of carbonate about 1 cm thick, 15 to 30 cm apart, occur to the depth of sampling; 12 percent fine gravel by volume; strongly effervescent.

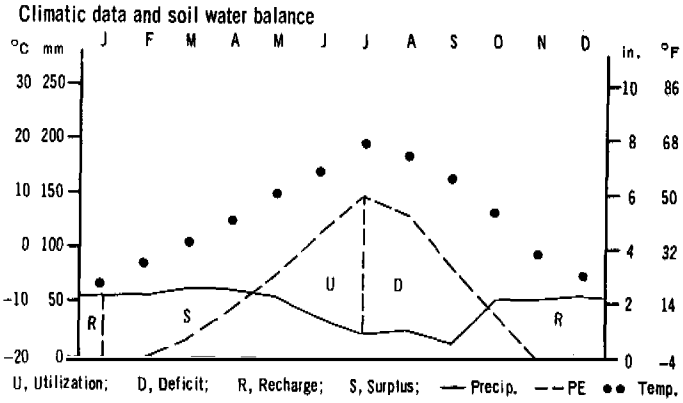
SOIL Pedon 130 Typic Haploxeroll SOIL Nos. S67Utah-18-1 LOCATION Salt Lake County, Utah

SOIL SURVEY LABORATORY Riverside, California LAB. Nos. 67230-67235

Depth (cm)	Horizon	1B1b Size class and particle diameter (mm) 3A1													Coarse fragments 1A2a		
		Total			Sand					Silt							
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	Int. III (0.02-0.002)	Int. II (0.2-0.02)	2-0.1			> 2 Pct. of whole soil	2-19 / 19-76 Pct. of <76mm
		Pct. of <2 mm															

Pedon 130

Classification: Typic Haploxeroll, fine-loamy, mixed, frigid.
Location: Salt Lake County, Utah. 6.5 km northwest of Copperton, 61 m east and 366 m south of the northwest corner of sec. 35, T. 2 S., R. 3 W.
Physiographic position: Mountainous, 2,350 m elevation.
Topography: South-facing, steep 55 percent slope.
Drainage: Well drained; medium to slow runoff; moderate permeability.
Vegetation: Bluebunch wheatgrass (Agropyron spicatum), big sagebrush (Artemesia tridentata), scattered oak (Quercus sp.), snowberry (Symphoricarpas sp.), and cheatgrass (Bromus tectorum).
Parent material: Limestone and calcareous quartzite.
Sampled by: B. R. Brasher and W. D. Nettleton.
Soil No.: S67Utah-18-1.



Colors are for the dry soil unless otherwise indicated.

A11 0-8 cm (0-3 in.). Brown (10YR 4/3) gravelly loam, very dark grayish brown (10YR 2/3) moist; moderate fine crumb structure; soft (dry), loose (moist), slightly sticky and slightly plastic (wet); many fine and few medium roots; many fine pores; 11 percent gravel and 7 percent cobbles and stones by volume; noncalcareous; clear wavy boundary.

A12 8-23 cm (3-9 in.). Brown (10YR 4/3) gravelly heavy loam, very dark grayish brown (10YR 2/3) moist; moderate fine granular structure; soft (dry), very friable (moist), slightly sticky and slightly plastic (wet); many fine and few medium roots; many fine pores; 17 percent gravel and 7 percent cobbles and stones by volume; noncalcareous; clear wavy boundary.

A13 23-41 cm (9-16 in.). Brown (10YR 4/3) gravelly heavy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); many fine pores; few medium and fine roots; 26 percent gravel and 7 percent cobbles and stones by volume; noncalcareous; clear wavy boundary.

B1 41-84 cm (16-33 in.). Brown (10YR 5/3) very cobbly heavy loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; slightly hard (dry), friable (moist), slightly sticky and slightly plastic (wet); few medium and fine roots;

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