Rationale for a Plinthic Horizon in *Soil Taxonomy*

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INTRODUCTION

Plinthite is one of only a few soil features that are defined by change of physical characteristics through exposure to the atmosphere. Consistent identification and quantification is the central issue for classifying and correlating plinthic soils. A definition for plinthite was proposed by Dr. Ray Daniels and colleagues (Daniel et al., 1978). The following proposed definition incorporates concepts from the current definition from *Soil Taxonomy* (Soil Survey Staff, 1999), additional concepts proposed by Daniels, and terminology expressed in the "World Reference Base for Soil Resources" **(**IUSS Working Group RB, 2006). It also takes into consideration observations made during the Dense Soil Properties Study of Selected Soils in the Southern Coastal Plain, Sumter and Lee Counties, SC, 2006, as well as other field observations made of soils containing plinthite in the Southeast U.S. The major difference in the proposed description is the addition of a cementation requirement to the definition of plinthite. The cementation criteria will allow for consistent measurement and quantification of plinthic materials. The intent is not to radically change previous concepts but to refine and build on established principles and recorded field observations.

Plinthite

Plinthite (Gr. *plinthos*, brick) is an iron-rich, humus-poor mixture of clay with quartz and other highly weathered minerals. It commonly occurs as reddish redox concentrations in a layer that has a polygonal (irregular), platy (lenticular), or reticulate (blocky) pattern. Plinthite irreversibly hardens upon exposure to repeated wetting and drying, especially if exposed to heat from the sun. Other morphologically similar iron-rich materials that do not progressively harden upon repeated wetting and drying are not considered plinthite. The horizon in which plinthite occurs commonly has 2.5 percent (by mass) or more citrate-dithionite extractable iron in the fine-earth fraction and a ratio between acid oxalate extractable Fe and citrate-dithionite extractable Fe of less than 0.10.

Individual plinthite nodules commonly have 3 to more than 10 percent citrate-dithionite extractable Fe. Plinthite normally forms in a horizon below the surface, but it may form at the surface in a seepy area at the base of a slope. From a genetic viewpoint, plinthite forms by the segregation, transport, and concentration of iron. In many places iron may have been transported vertically or horizontally from other horizons or from higher adjacent soils. Plinthite may occur as a constituent of a number of horizons, such as an epipedon, a cambic horizon, an argillic horizon, a kandic horizon, an oxic horizon, or a C horizon. Generally, plinthite forms in a horizon that is (or has been) periodically saturated with water. Initially, the segregated iron forms more or less clayey, reddish, or brownish redox concentrations.

These concentrations are not considered plinthite unless there has been enough segregation of iron in an environment sufficient to permit irreversible hardening, cementation, and removal as a discrete body. Plinthite does not harden irreversibly as the result of a single cycle of drying and rewetting. After a single drying, it will remoisten but does not slake (disaggregate) when immersed in water, even with periodic gentle agitation. However, it can be dispersed in large part if shaken in water containing a dispersing agent. Cemented nodules or aggregates of plinthite are pararock fragments.

Plinthite is firm or very firm and brittle when the soil moisture content is near field capacity and hard when the moisture content is below the wilting point. Moist plinthite nodules will withstand moderate to strong rolling between the thumb and forefinger prior to rupture. In place, plinthite in a moist soil is soft enough to be cut with a spade or knife. After irreversible hardening to the point of being strongly or more cemented, the aggregates are no longer considered plinthite and are regarded as ironstone. The strongly cemented to indurated ironstone materials can be broken or shattered with a spade but cannot be dispersed even with strong agitation in water with a dispersing agent.

In the Southeastern United States, plinthite forms as either nodular or platy aggregates on level to gently sloping landscapes that have a fluctuating zone of saturation. Nodular plinthite most commonly forms above soil layers that restrict vertical water movement. Platy plinthite forms in a zone that acts as an aquatard, which perches water for short to moderate periods. Roots do not penetrate either nodular or platy plinthite but follow the less rupture-resistant zones surrounding the plinthite.

A small amount of plinthite in the soil does not form a continuous phase; that is, the individual redox concentrations or aggregates are not connected with each other. If a large amount of plinthite is present, it may form a continuous phase. If a continuous layer becomes indurated, it is a massive ironstone layer that has irregular, somewhat tubular inclusions of yellowish, grayish, or white, clayey material. If the layer is exposed, these inclusions may be washed out; leaving an ironstone that has many coarse, tubular pores.

Much that has been called laterite is included in the meaning of plinthite. Doughy and concretionary laterite that has not hardened is an example. Hardened (strongly or more cemented) laterite, whether it is vesicular or pisolitic, is not included in the definition of plinthite.

Proposed Plinthic Horizon Description for *Soil Taxonomy*

Five factors are important in identifying a plinthic horizon.

First, a plinthic horizon must have a minimum thickness. A thickness of 15 cm or more is thought to be thick enough to impart the interpretations for plant growth and for many engineering uses. A plinthic horizon commonly is 50 to more than 200 cm thick.

Second, a plinthic horizon has appreciable amounts of iron. Iron may be measured within concentrated areas (10 percent or more citrate-dithionite extractable Fe in nodules or masses) or as a weighted average for the horizon (2.5 percent or more citrate-dithionite extractable Fe in the fine-earth fraction).

Third, a plinthic horizon contains a significant amount of plinthite. This property separates the plinthic horizon from fragipans, duripans, and other cemented horizons. In the U.S., some of these horizons meet the requirements for a fragipan or fragic soil properties. Where plinthic horizons are at depths comparable to those of fragipans, the effects on plants and on engineering uses of the soils are very similar. For pragmatic reasons, therefore, such horizons that have an upper boundary that meets the depth requirement for *Fragi* great groups or *Fragic* subgroups are considered plinthic horizons if they contain 15 percent or more (by volume) plinthite.

Fourth, a plinthic horizon shows <u>evidence of pedogenesis</u>, in addition to density and brittleness. This evidence, in the matrix, on faces of peds, or in seams, is in the form of oriented clay films, clay bridging of sand grains, and both redoximorphic features or soil structure. The evidence of pedogenesis is needed to separate the plinthic horizon from dense parent materials (densic materials).

Fifth, a plinthic horizon has a combination of properties that <u>restrict water movement and the penetration of roots</u>. Saturated hydraulic conductivity for the plinthic horizon is significantly lower than indicated by particle-size, structure, and/or clay mineralogy alone. Generally, roots are restricted, except in zones along structural faces or along the boundary between plinthite nodules. Commonly, structural units are platy, blocky, or polygonal. In most plinthic horizons, the average horizontal spacing that roots can enter is 10 cm or more. Material within the structural units may be massive or have a secondary structure. The plinthic materials have a firm or firmer rupture-resistance class and a brittle manner of failure at or near field capacity. Some plinthic horizons are massive and are restrictive throughout the horizon.

Required Characteristics

To be identified as a plinthic horizon, a layer must have *all* of the following characteristics:

1. The layer is 15 cm or more thick; *and*

2. The layer has <u>both</u> of the following;
   a. 2.5 percent (by mass) or more citrate-dithionite extractable Fe in the fine-earth fraction *or* 10 percent or more citrate-dithionite extractable Fe in the plinthite nodules; *and*
   b. A ratio between acid oxalate extractable Fe and citrate-dithionite extractable Fe of less than 0.10.

3. The layer has 15 percent or more (by volume) plinthite, consisting of discrete cemented nodules or concretions that are less than strongly cemented, have a redder hue or stronger chroma than the surrounding material, and change irreversibly upon exposure to repeated wetting and drying with free access of oxygen; commonly in combination with masses of oxidized iron or iron depletions (relic or contemporary redoximorphic features) in a irregular, platy, or reticulate pattern; *and*

4. The layer shows evidence of pedogenesis within the horizon or, at a minimum, on the faces of structural units; *and*

5. The layer has either moderately low or lower saturated hydraulic conductivity or more than a 5-fold difference in Ksat from the overlying subsurface horizon if it has moderately high saturated hydraulic conductivity.

Impact to Existing Soil Series

There are 58 soil series presently classified in plinthic subgroups. Where plinthite content range straddles the proposed 15 percent (by volume) break for the plinthic horizon, some series will require additional evaluation. However, it is anticipated that soils with moderately low or low saturated hydraulic conductivity (slow or very slow permeability) will become Plinthudults and those with moderately high saturated hydraulic conductivity (moderate or moderately slow permeability) will remain in a plinthic subgroup. Many of the soils in plinthic subgroups presently have an upper limit of plinthite set at 15 percent (by volume).

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