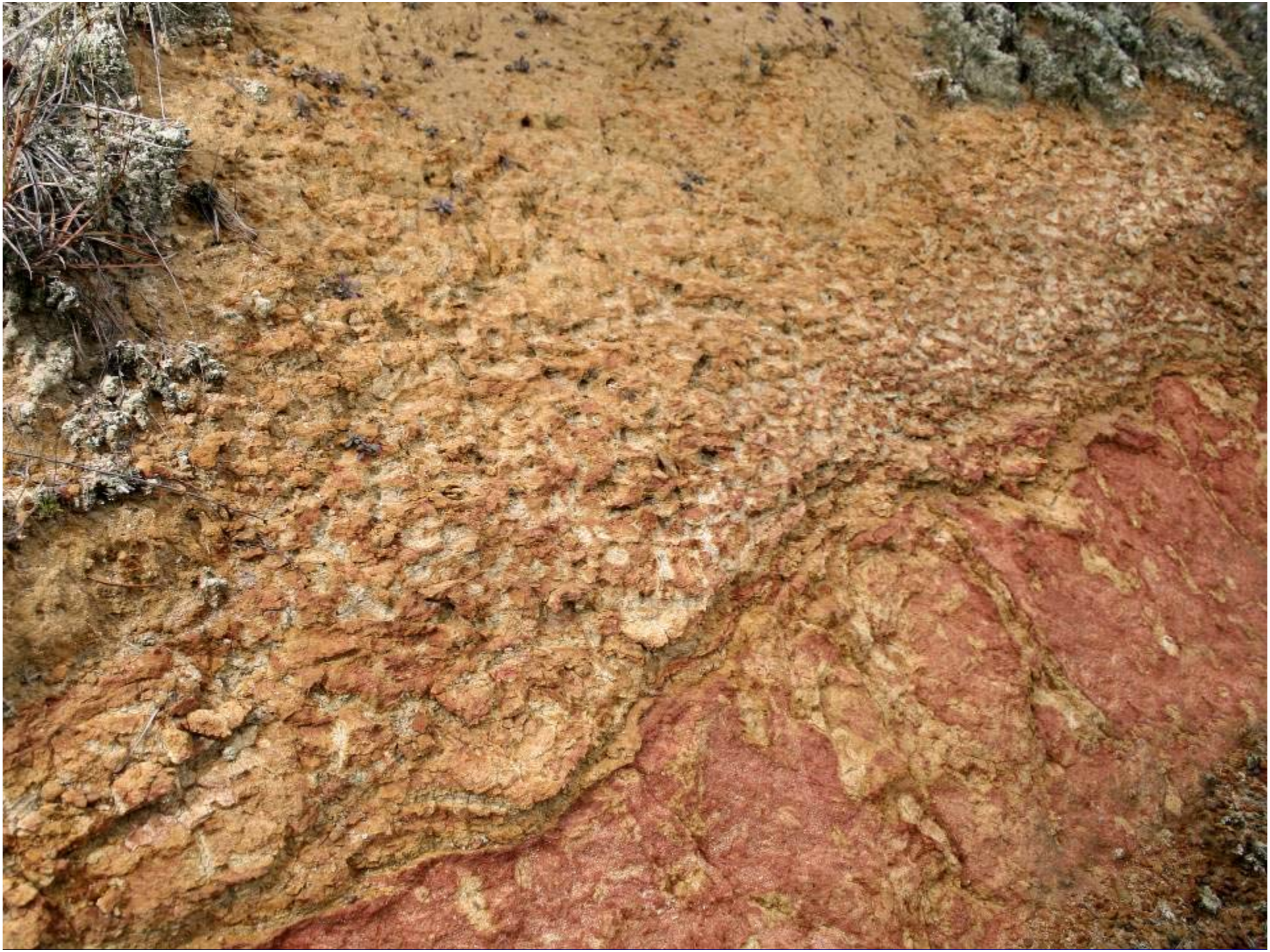
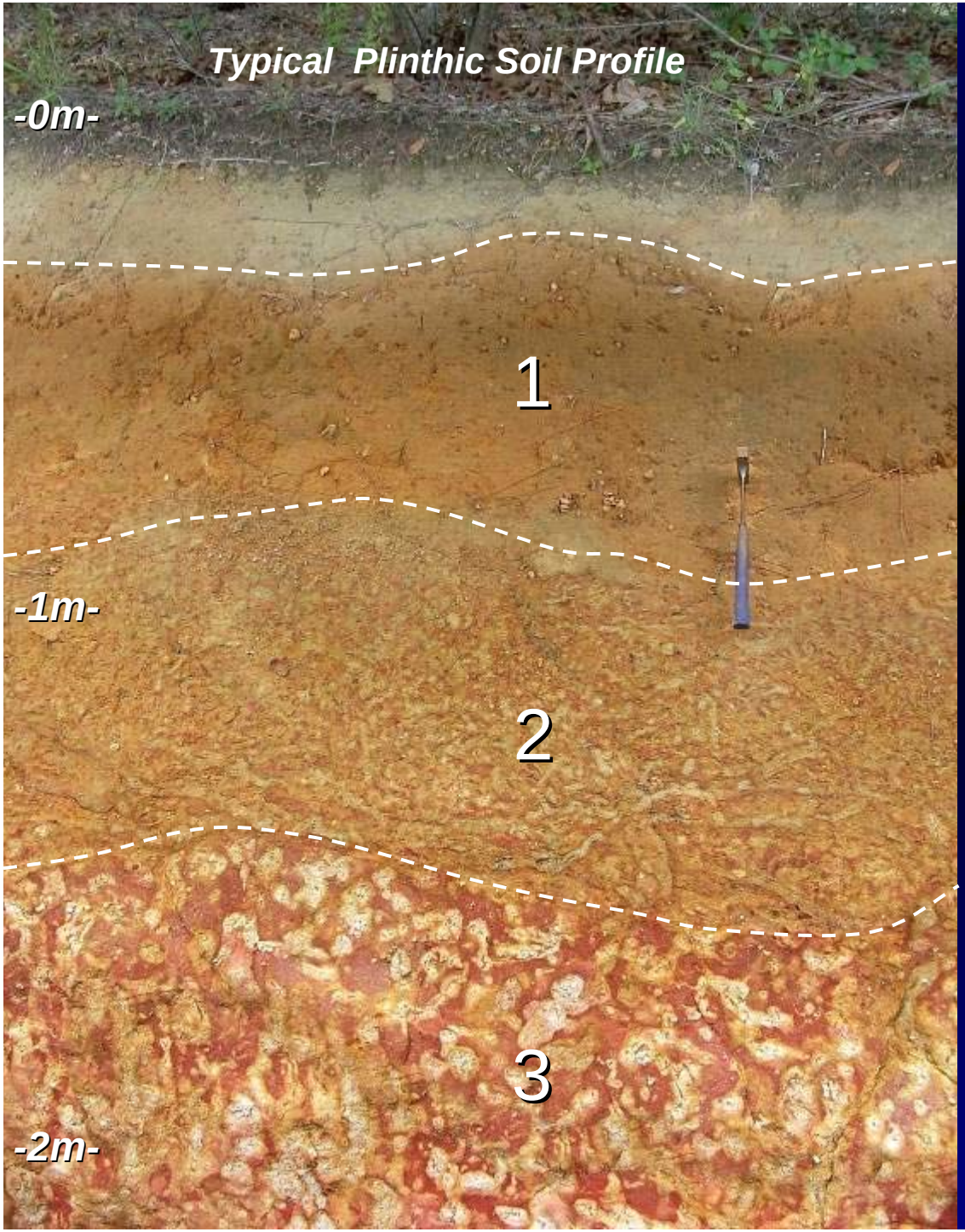
Rationale for a Plinthic Horizon in *Soil Taxonomy*

2008 South Regional Cooperative Soil Survey Conference

Gainesville, Florida

July 13-17, 2008



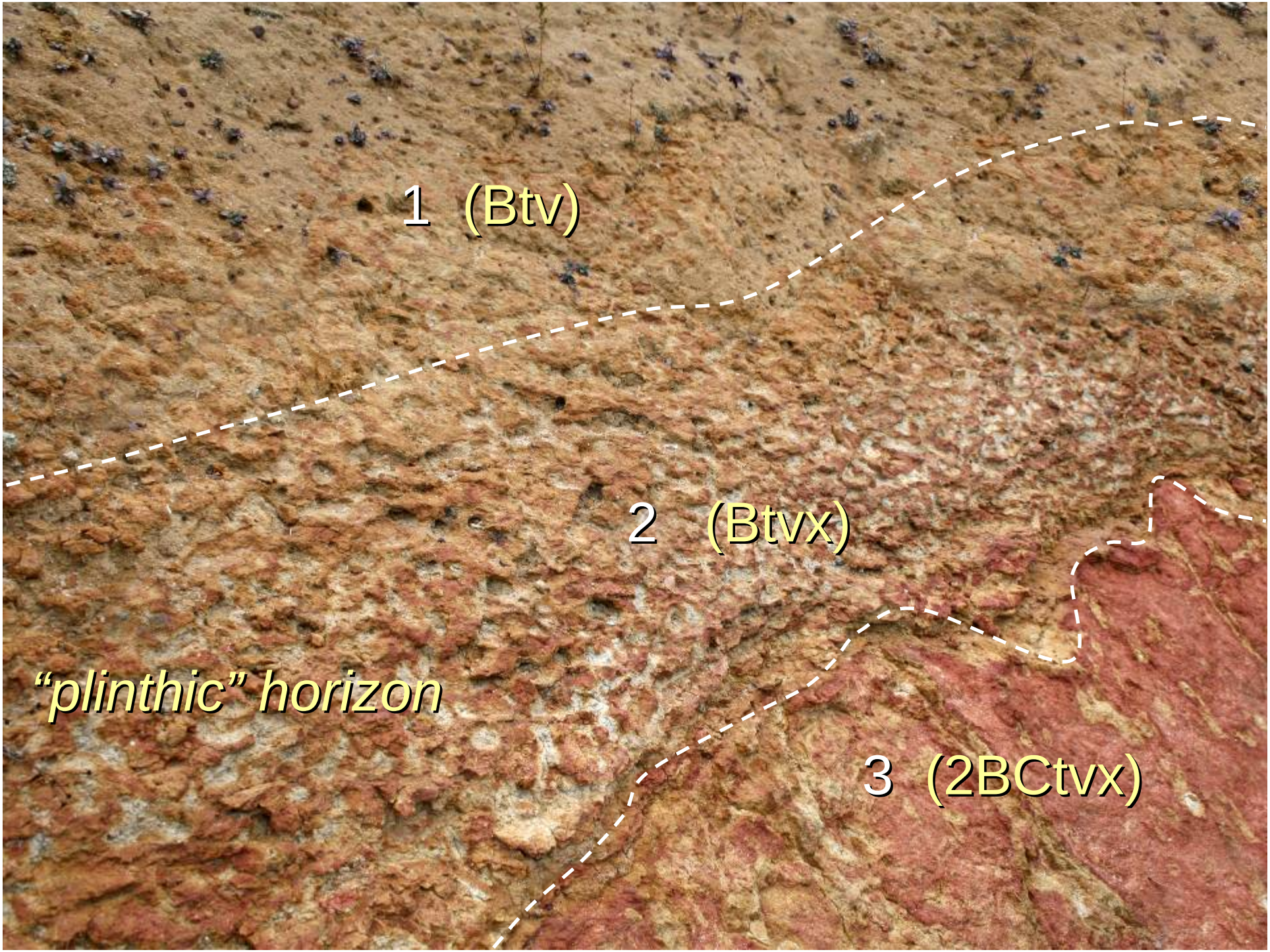


Percent Plinthite?

Bt (upper)
(5 to 15 percent cemented materials)

Bt (middle)
(15 to 50 percent cemented materials)
"plinthic horizon"

Bt (lower)
(2 to 15 percent cemented materials)
"the brick"

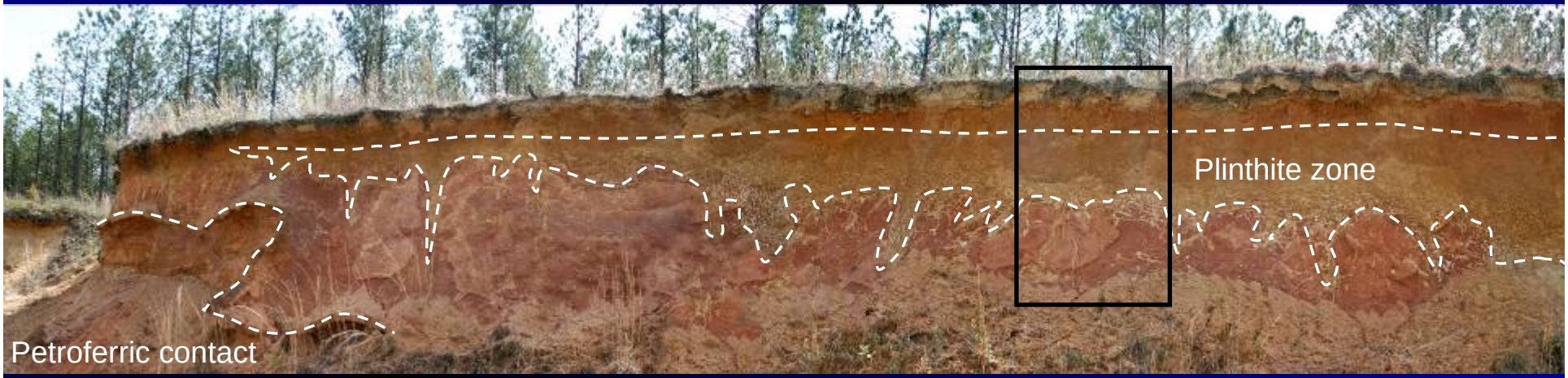

1 (Btv)
2 (Btvx)
"plinthic" horizon
3 (2BCtvx)


1 (Btv)
2 (Btvx)


Btvx

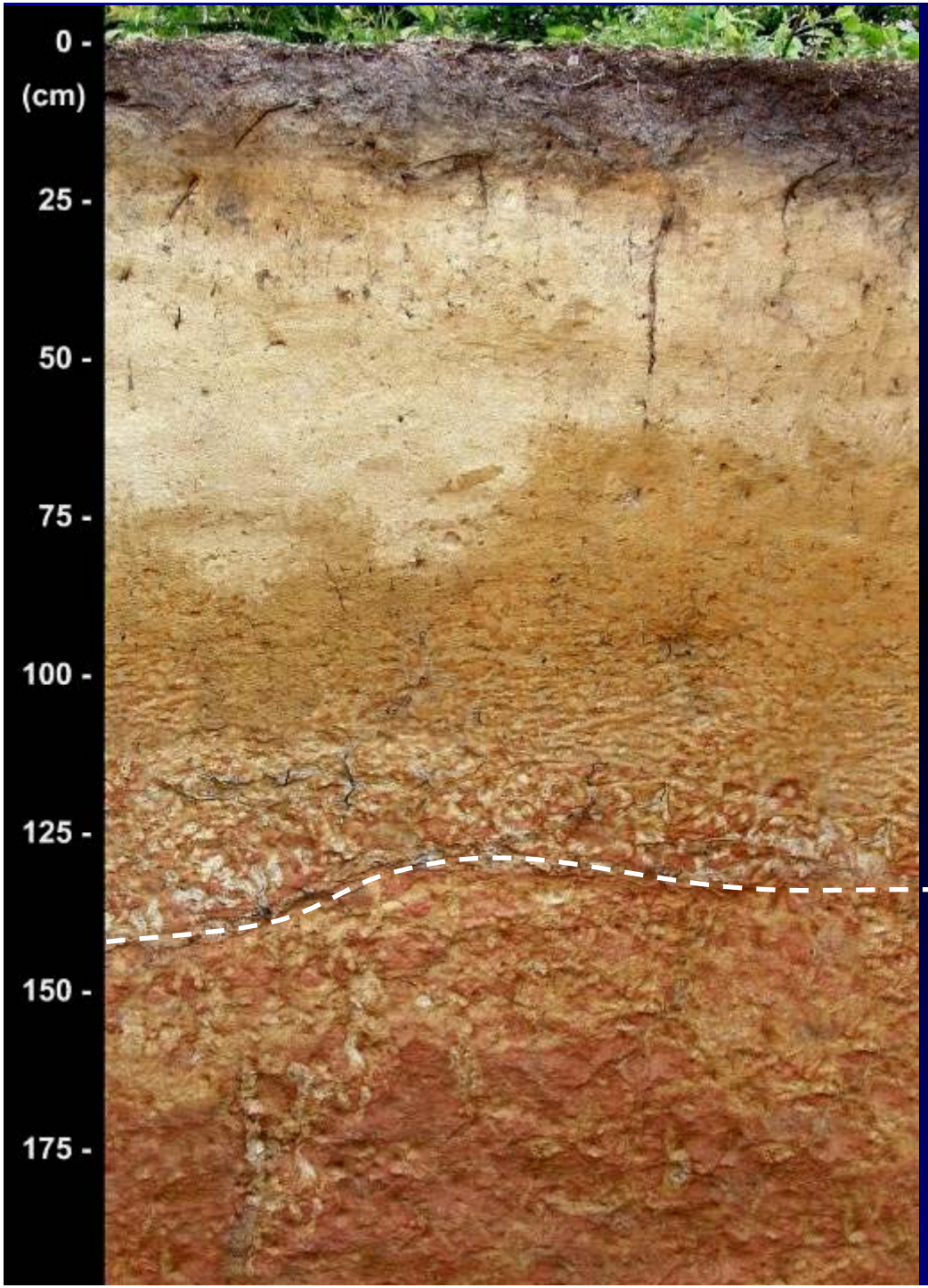

Btvx
2BCtvx


NRCS


Plinthite zone
Petroferric contact


-0-
in
-5-
-10-
-15-
-20-
-25-
-30-
-35-
-40-
-45-
-50-
-55-
-60-
-65-
-70-
Ap
E
Bt
Btvx1
Btvx2
2BCtvx


37 percent (volume)
“weakly cemented”
materials (plinthite)



FUQUAY

Arenic Plinthic Kandiudult
(fresh exposure)

A

E

Less than strongly cemented materials

	(Vol.)	***(Wt.)***
Bt	***------***	***------***
Btv	***13%***	***15%***
Btvx1	***21%***	***24%***
Btvx2	***24%***	***26%***
Btvx3	***32%***	***37%***
2BCtvx	***7%***	***8%***
2BCtvx	***5%***	***5%***

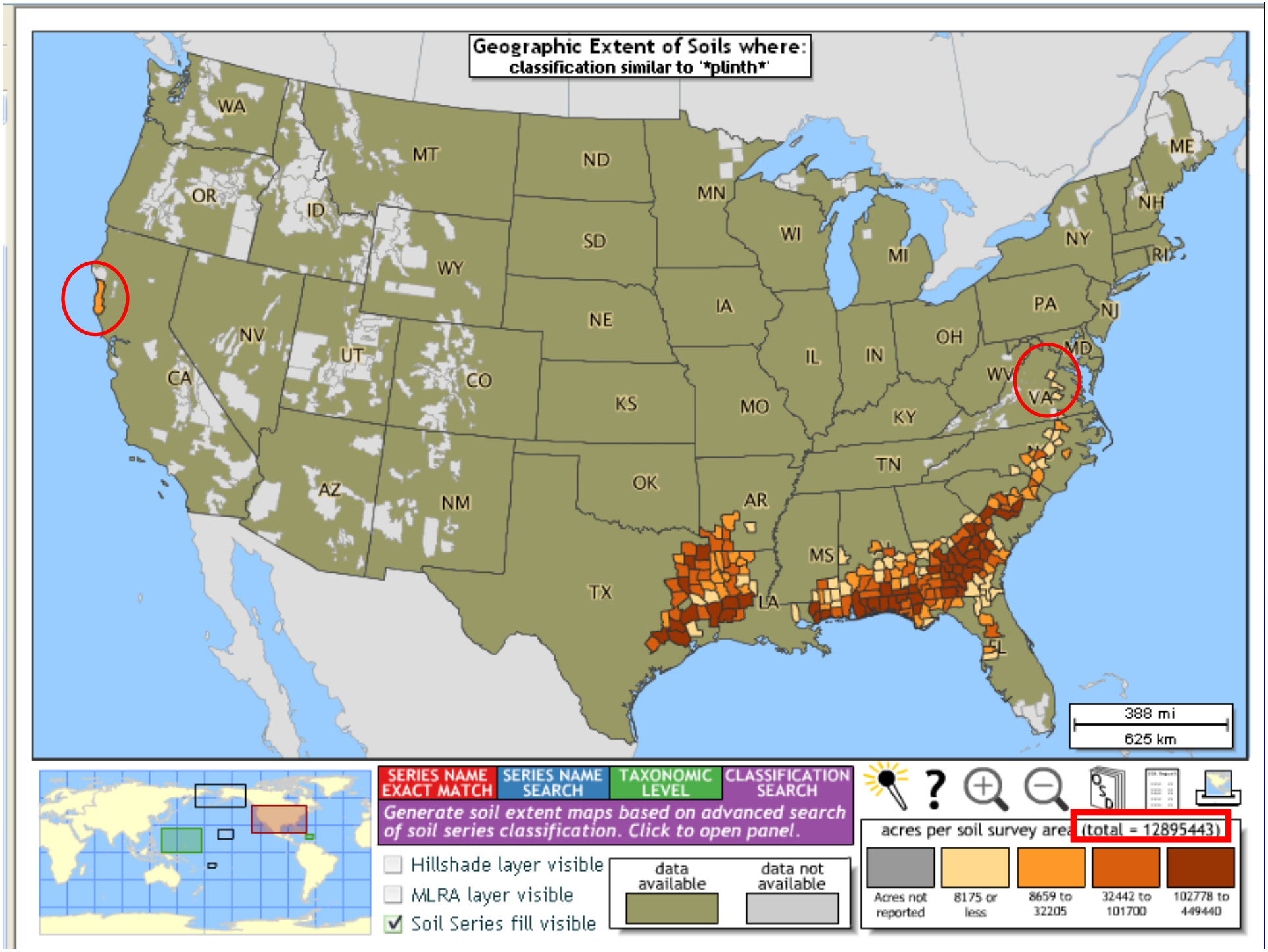
Dense Soil Properties Study Group

- Bob Dobos (NSSC-Interps)
- Charlie Ogg (MLRA-SSL)
- Ellis Benham (SSL)
- Greg Brannon (MO15)
- Joey Shaw (AU)
- John Kelley (MO14)
- Larry West (UGA/NL-Investigations)
- Mike Wilson (SSL)
- Steve Lawrence (GA SO)
- Tom Reedy (NSSC-Standards)

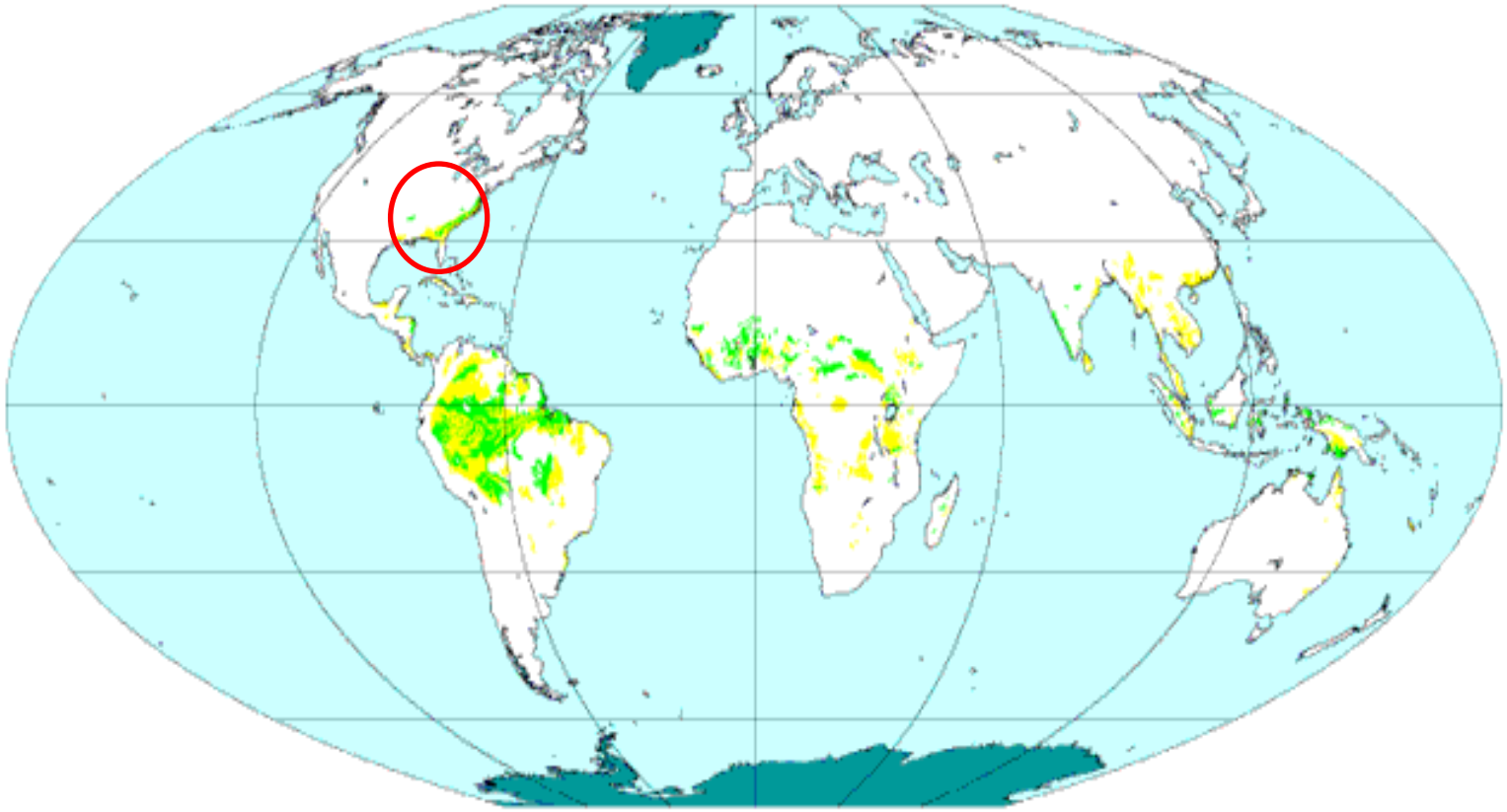
Dense Soil Properties Study

Objectives…

- *What are the restrictive layers that limit soil performance?*
- *How to identify and quantify the associated soil features & diagnostic properties (horizonation)?*
- *Interpretations-related soil properties, criteria & NASIS population.*
- *Principals of application for consistent correlation.*
- *Slake Test Procedures (Field v. Lab).*
- *Evaluation of previous research/studies.*


Geographic Extent of Soils where:
classification similar to '*plinth*'
WA
OR
CA
ID
NV
MT
WY
UT
AZ
CO
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MS
MI
IN
KY
TN
OH
WV
VA
NC
SC
GA
FL
PA
NY
MD
NJ
RI
NH
ME
388 mi
625 km
SERIES NAME EXACT MATCH
SERIES NAME SEARCH
TAXONOMIC LEVEL
CLASSIFICATION SEARCH
Generate soil extent maps based on advanced search of soil series classification. Click to open panel.
Hillshade layer visible
MLRA layer visible
Soil Series fill visible
data available
data not available
acres per soil survey area
(total = 12895443)
Acres not reported
8175 or less
8659 to 32205
32442 to 101700
102778 to 449440

Distribution of PLINTHOSOLS
Based on WRB and the FAO/Unesco Soil Map of the World



Dominant
Associated
Inclusions
Miscelanneous lands
(Inland waterbodies, Glaciers, No data)

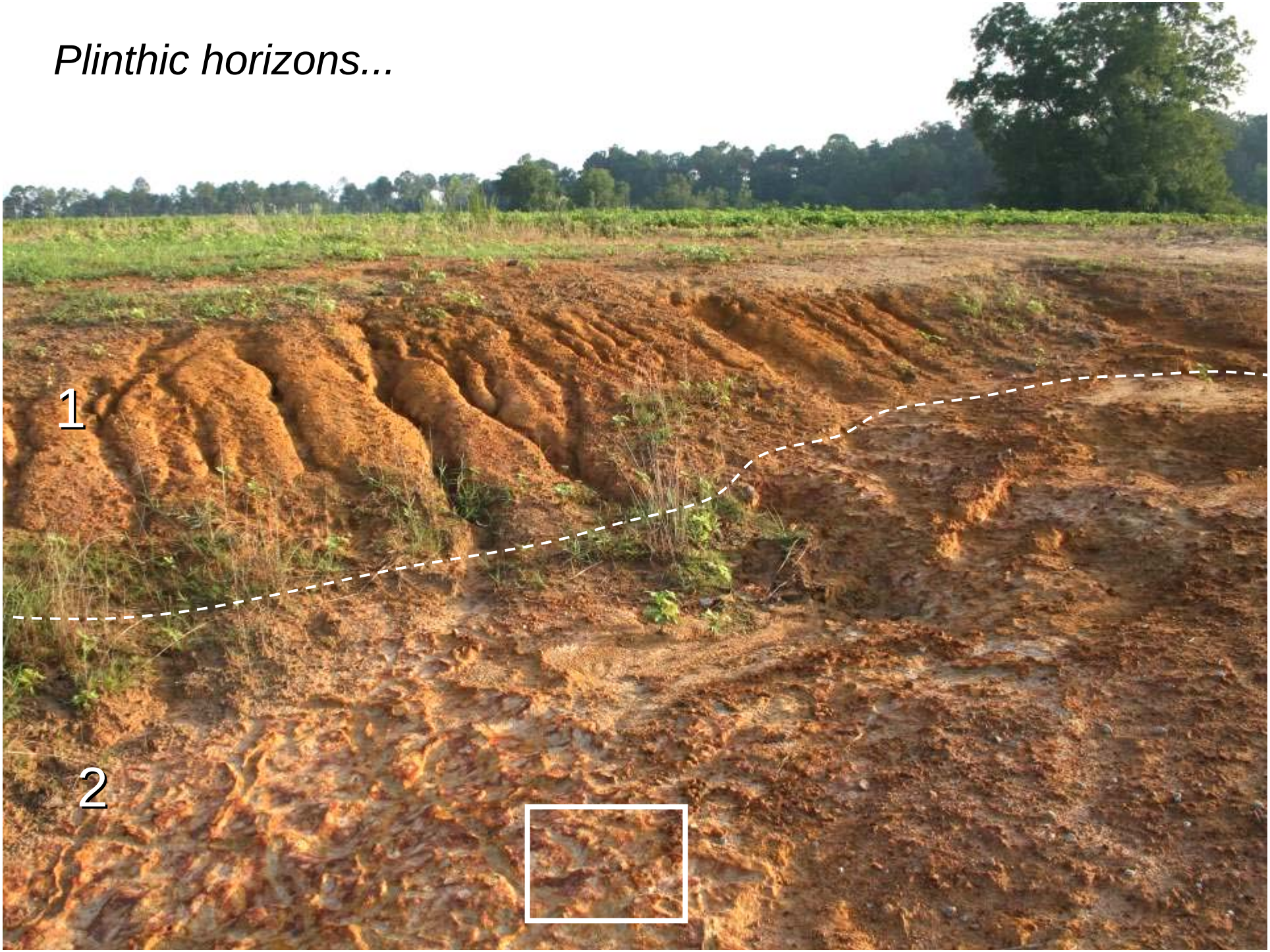
Flat Polar Quartic Projection

FAO-GIS, February 1998

Individual aggregates have…

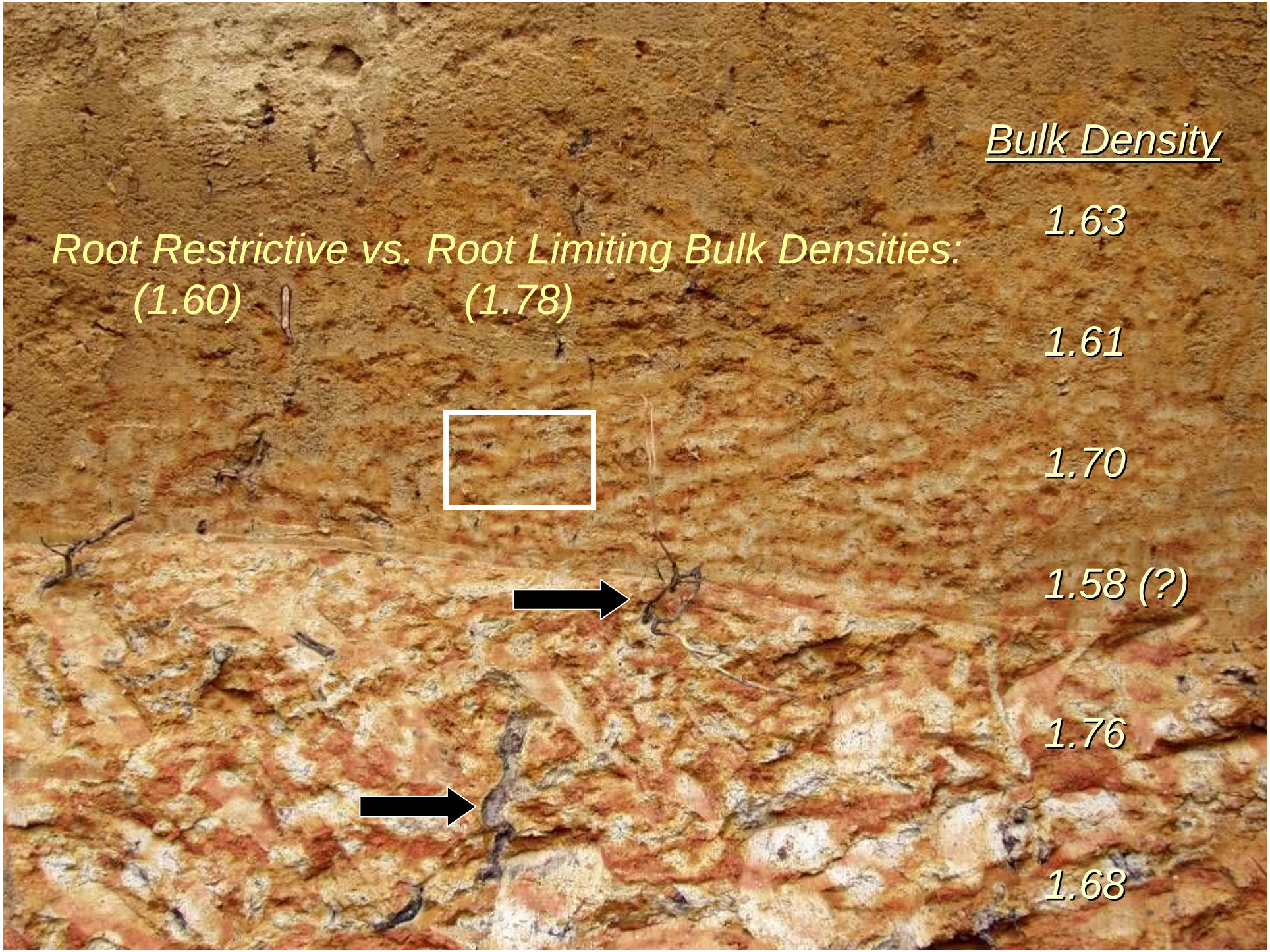
- Firm or very firm rupture resistance, and
- *(brittle manner of failure)*
- *(removable as discrete body)*

Plinthic horizons...



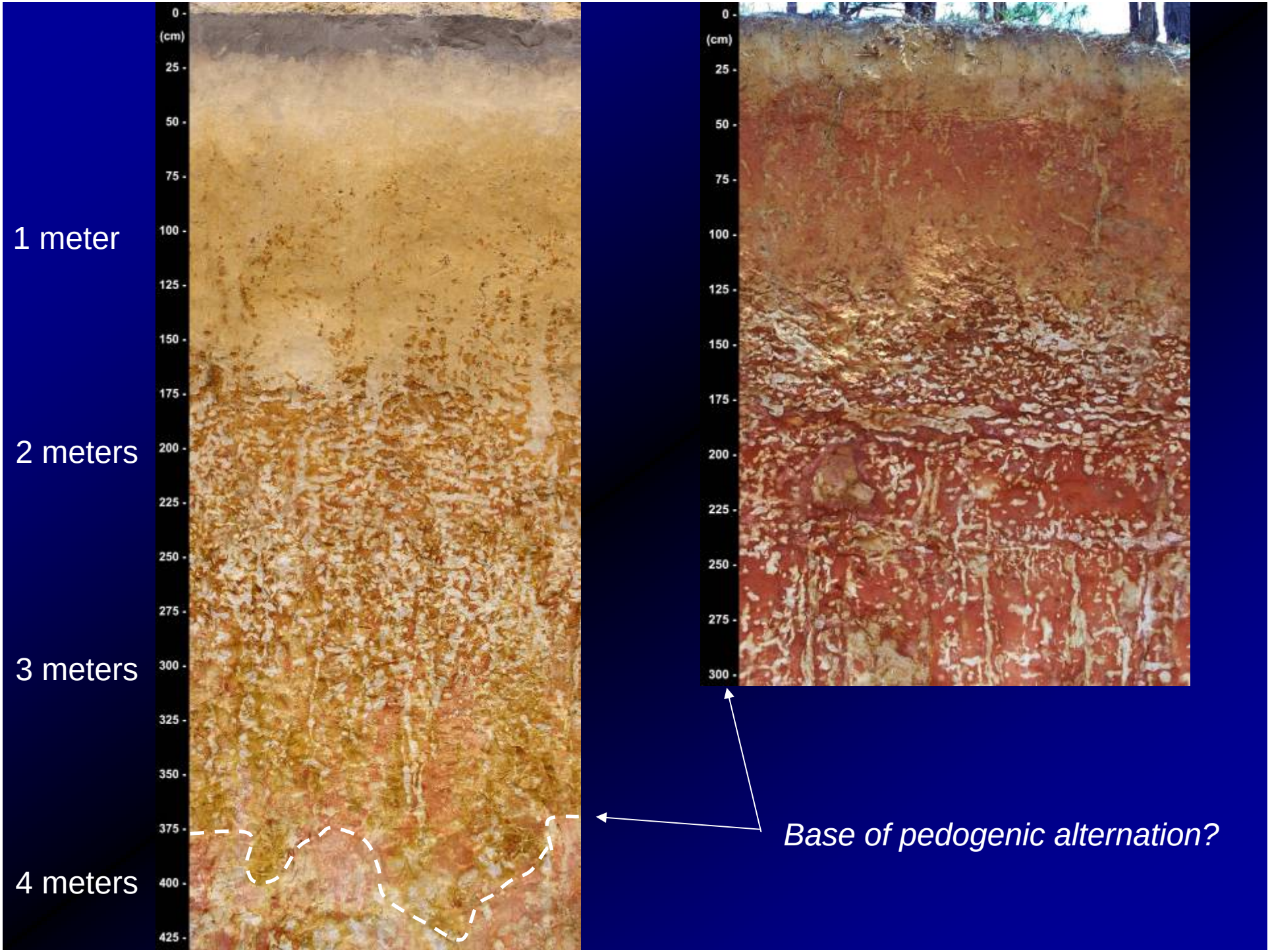
- Materials within the layer harden, when exposed to air and repeated wetting and drying


fresh exposure

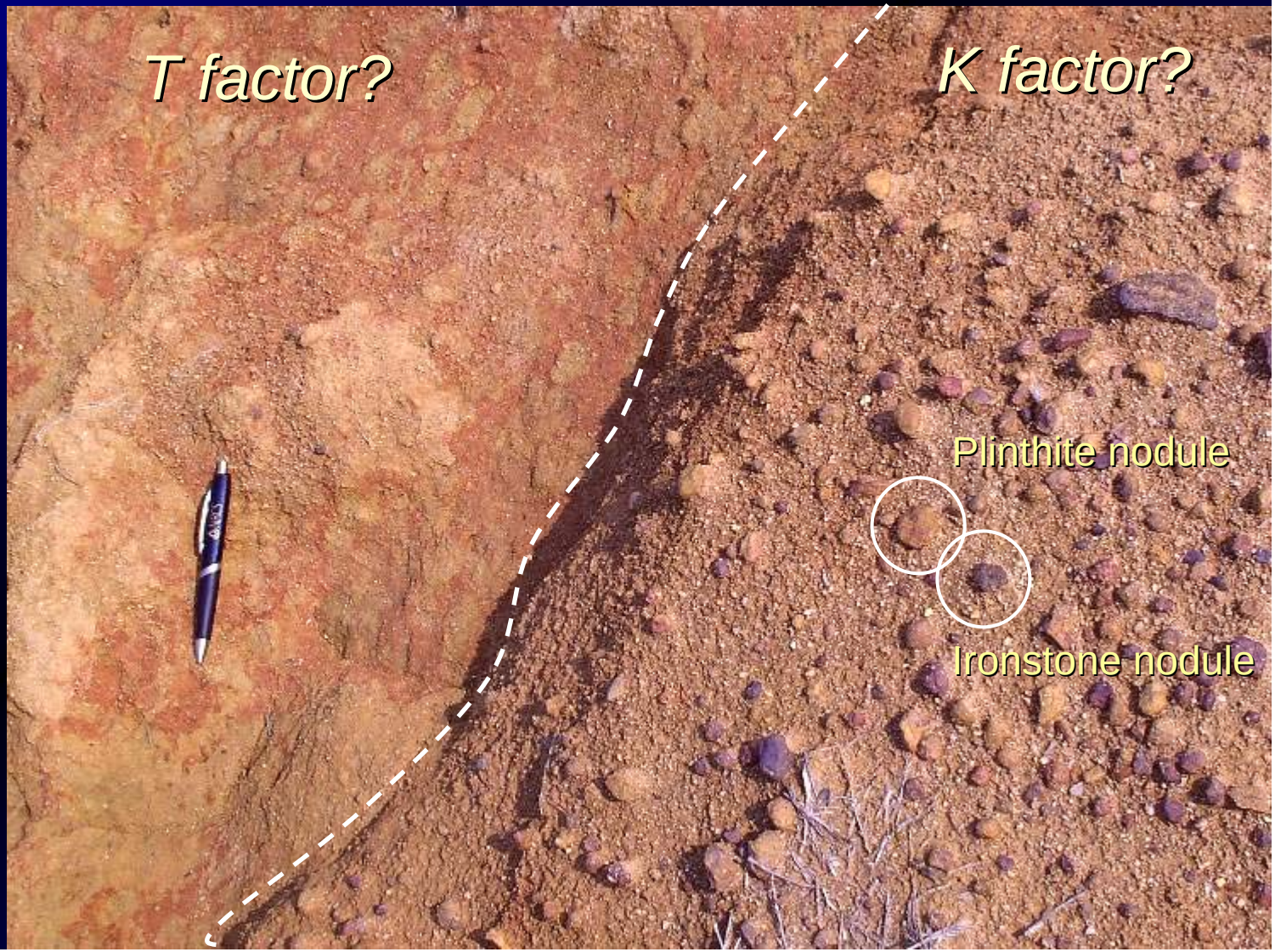

Root Restrictive vs. Root Limiting Bulk Densities:
(1.60) (1.78)
Bulk Density
1.63
1.61
1.70
1.58 (?)
1.76
1.68

- *Very high excavation difficulty (difficult with over-the-head swing of pick)*

- Dense, compact materials are pedogenic...
  ...have clay films or clay bridging, or...


1 meter
2 meters
3 meters
4 meters
0 -
(cm)
25 -
50 -
75 -
100 -
125 -
150 -
175 -
200 -
225 -
250 -
275 -
300 -
325 -
350 -
375 -
400 -
425 -
Base of pedogenic alternation?

Interpretations

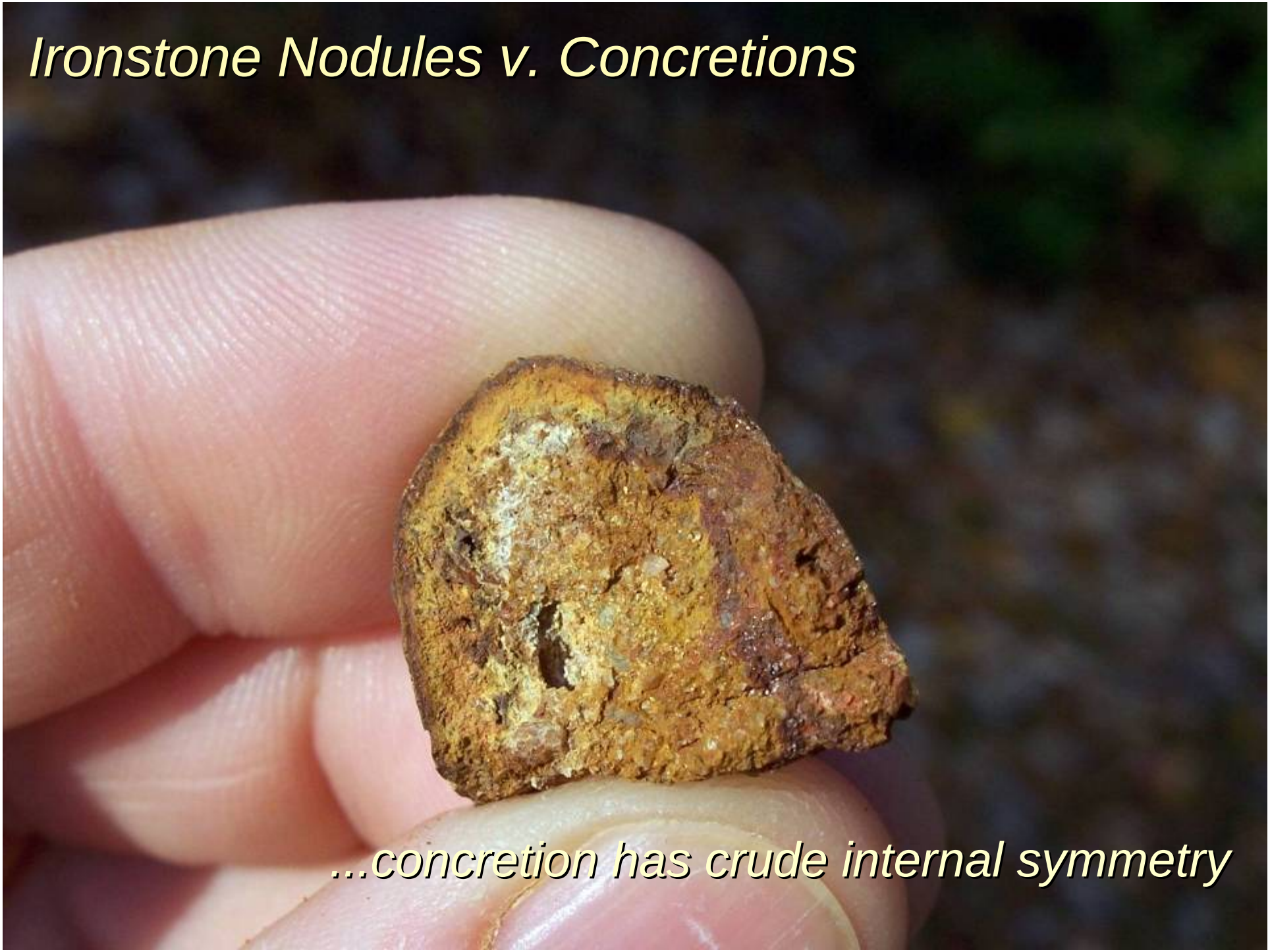


8. Dense Layer	A. Soils having a layer whose upper boundary begins at the depths indicated and has the following average bulk density for layer soil textural class(s); and with permeability difference of 2 classes between dense layer and upper adjacent layer. (excluding Vertisols, and Vertic subgroups) (not used in Land Resource Regions R, W, X, and Y and MLRA's 100 and 101):			
	Layer Soil Textural Class[2]	Moist Avg. BD	Layer Depth	T Value
	COS, S, LCOS, LS, FS,LFS	>1.80	<20 20-60 >60	3 4 5
	VFS, LVFS, FSL, COSL VFSL, SL, with average <18 percent clay.	>1.75	<20 20-60 >60	3 4 5
	COSL, VFSL, FSL, SL, or CL and average 18 to 35 percent clay or L or SCL	>1.7	<20 20-60 >60	3 4 5
	SI, SIL, or SICL and average <35 percent clay.	>1.6	<20 20-60 >60	3 4 5
	CL, SC, C, SICL, SIC and clay average within 35 to 60 percent clay.	>1.55	<20 20-60 >60	3 4 5
	C with average clay value 60 percent or more clay (exclude Soil Orders of Andisols and Oxisols).	>1.35	<20 20-60 >60	3 4 5

Field Identification

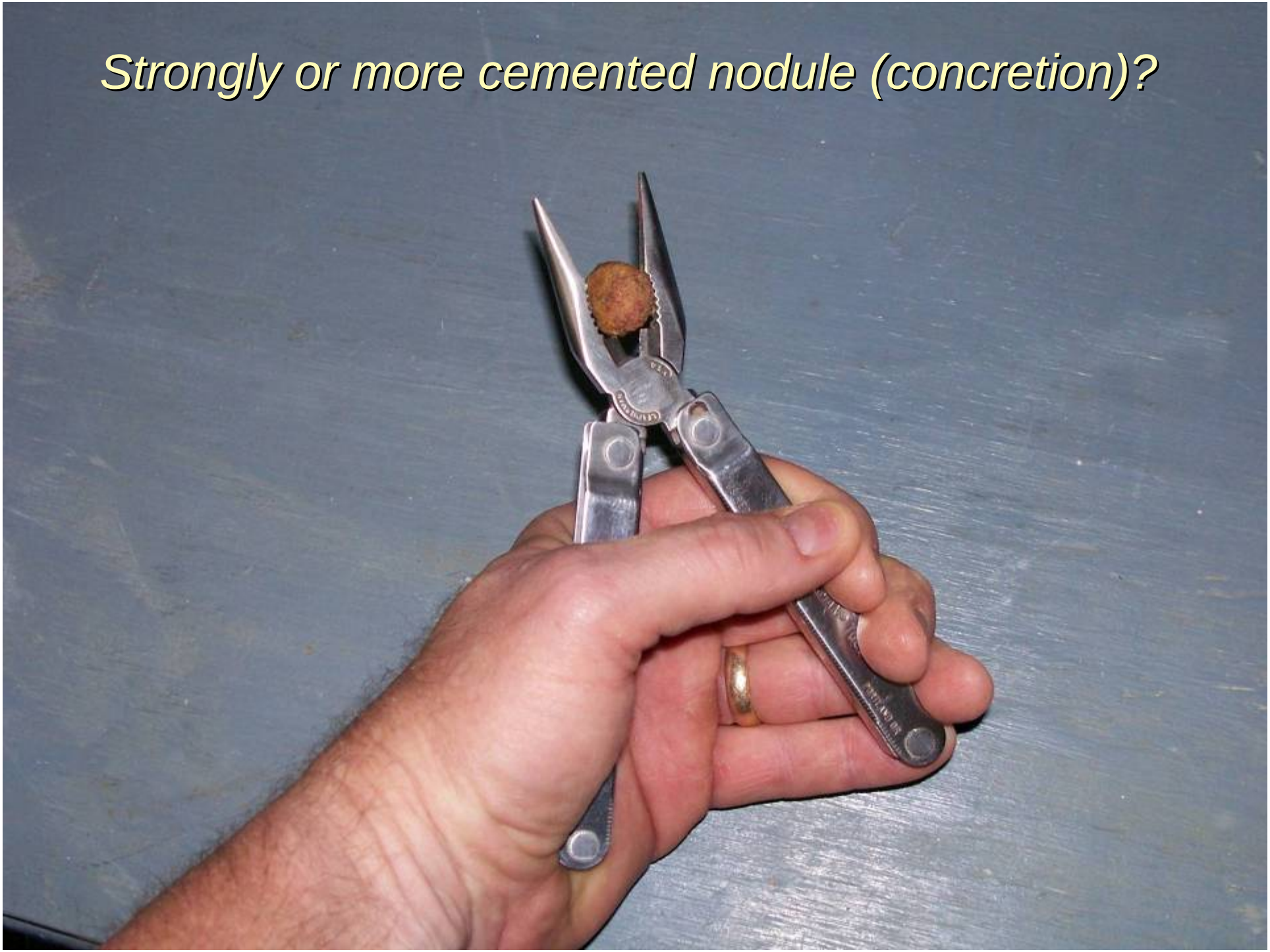
- Plinthite aggregate *(mass v. nodule)*
  (removable as a discrete body)

Ironstone Nodules v. Concretions



...concretion has crude internal symmetry

Strongly or more cemented nodule (concretion)?



Taxonomic considerations

c *Concretions or nodules*

This symbol indicates a "*significant*" accumulation of concretions or nodules. *Cementation is required*. The cementing agent commonly is iron, aluminum, manganese, or titanium. It cannot be *(plinthite),* silica, dolomite, calcite, or more soluble salts.

...degree of cementation not indicated

Btc/vx?

Taxonomic considerations...

... terminology

- Septaria
- Iron glaebules
- Plinthite
- Petroplinthite
- Pisoplinthite
- Litho-plinthite
- Ironstone nodule
- Ironstone concretion


Taxonomic considerations....
... Relic v. Contemporary redox

Plinthite (plinthic horizon) v. Fragipan

In the United States, soils that have a small amount of plinthite normally are brittle in at least some parts of the horizons that contain the plinthite. Some of these horizons meet the requirements for a fragipan. At this stage of knowledge, it is not clear that such horizons should be considered fragipans. Where they are at depths comparable to those of fragipans the effects on plants and on engineering uses of the soils are the same.

For pragmatic reasons, therefore, such horizons that have an upper boundary within 100 cm of the mineral soil surface are considered fragipans. (>60 percent firm and brittle)

Soil Taxonomy

Taxonomic considerations

These concentrations are not considered plinthite unless there has been enough segregation of iron to permit their irreversible hardening on exposure to repeated wetting and drying.

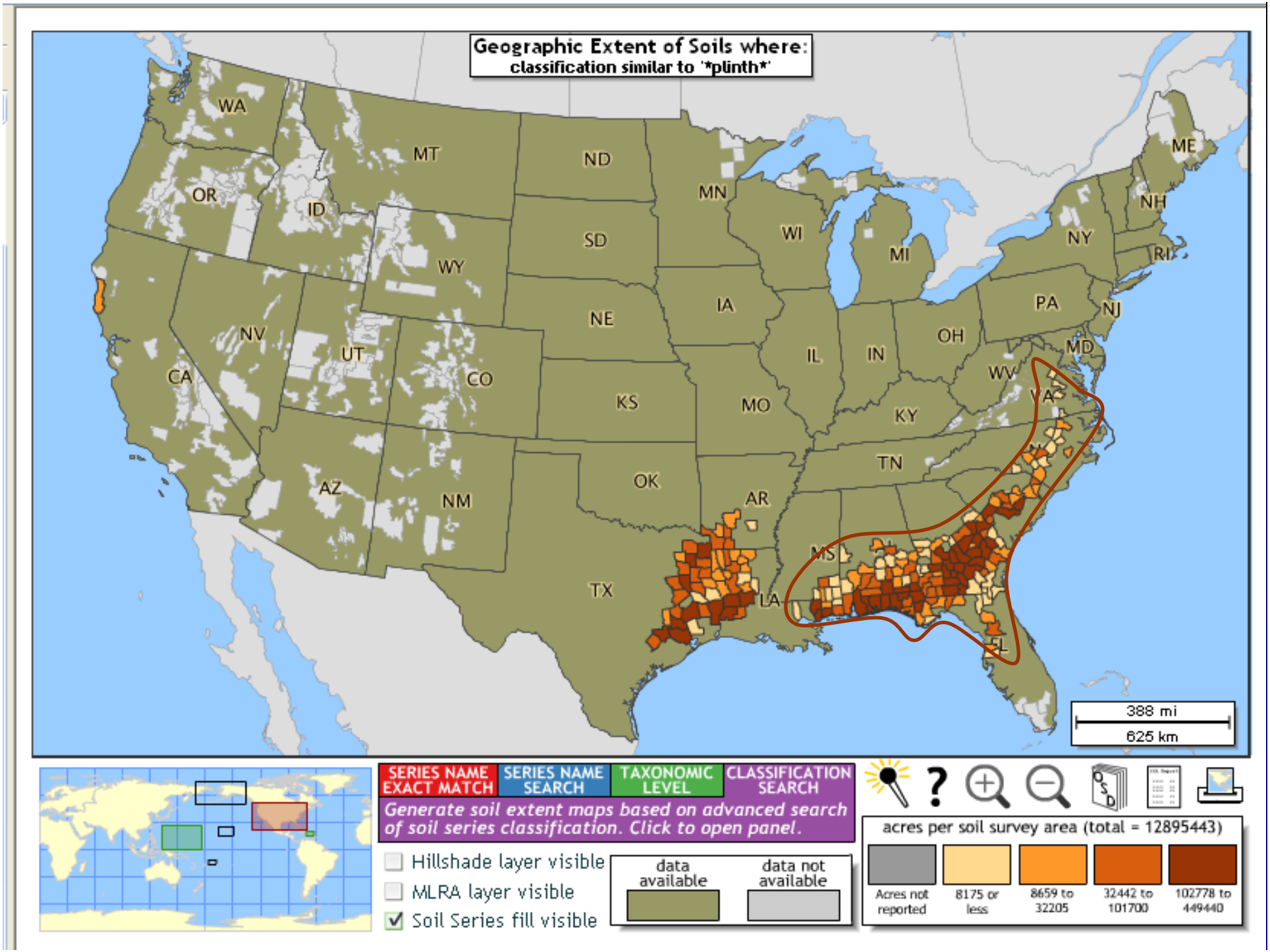
(cementation required?)

mass v. nodule

It commonly occurs as dark red redox concentrations that usually form platy, polygonal, or "reticulate" patterns.

Soil Taxonomy


Reticulate (western plinthite)


Geographic Extent of Soils where:
classification similar to '*plinth*'
WA
OR
CA
ID
NV
MT
WY
UT
AZ
CO
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MS
MI
IN
KY
TN
OH
WV
VA
NY
PA
MD
NJ
ME
NH
RI
FL
388 mi
625 km
SERIES NAME EXACT MATCH
SERIES NAME SEARCH
TAXONOMIC LEVEL
CLASSIFICATION SEARCH
Generate soil extent maps based on advanced search of soil series classification. Click to open panel.
Hillshade layer visible
MLRA layer visible
Soil Series fill visible
data available
data not available
acres per soil survey area (total = 12895443)
Acres not reported
8175 or less
8659 to 32205
32442 to 101700
102778 to 449440

Reticulate (eastern plinthite)

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.

1975 Soil Taxonomy

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. (litho-plinthite)

Soil Taxonomy


Continuous phase plinthite…
USDA
NRCS
Btvx

Soil Survey Manual, Chapter 3

Masses are noncemented concentrations of substances that commonly cannot be removed from the soil as a discrete unit.

Plinthite consists of reddish, iron-enriched bodies that are low in organic matter and are coherent enough to be separated readily from the surrounding soil. Plinthite has higher penetration resistance than adjacent brown or gray bodies or than red bodies that do not harden.

The bodies are commonly about 5 to 20 mm (2 to 75 mm) across their smallest dimension. Plinthite bodies are firm or very firm when moist, hard or very hard when air dry, and become moderately cemented on repetitive wetting and drying.

Soil Survey Manual, Chapter 3

Nodules and concretions are cemented bodies that can be removed from the soil intact.

Ironstone is an in-place concentration of iron oxides that is at least weakly(?) cemented. Ironstone nodules are commonly found in layers above plinthite. These ironstone nodules are apparently plinthite that has cemented irreversibly as a result of repeated wetting and drying. Commonly, the center of iron-rich bodies cements upon repeated wetting and drying but the periphery does not.

Morphology of Plinthite and Criteria for its Field Identification[1]

R.B. Daniels, H.F. Perkins, B.F. Hajek and E.E. Gamble

ABSTRACT

Plinthite is an iron-rich material that has the ability to harden upon repeated wetting and drying, especially when exposed to the sun. Many morphologically similar iron-rich materials do not harden upon repeated wetting and drying. This has lead to a wide variety of materials in the southeastern United States being called plinthite. We proposed that plinthite be restricted to those iron-rich materials that have the following characteristics. Plinthite has a color range from 10R to the 7.5YR hues. It occurs as discrete bodies larger than 2 mm that can be separated from the matrix. It is firm to very firm moist and hard to very hard dry, yet it can be broken in the hands. A moist body of plinthite will withstand moderate rolling between the thumb and forefinger and moist or air dry it will not slake when submerged in water even with periodic gentle agitation. These criteria have been field tested and they separate plinthite from similar materials that will not harden and from material has already irreversibly hardened.

Plinthite has platy and nodular forms. Platy plinthite is red to yellowish red bodies 1 cm thick and 2 to 4 cm long that commonly have a horizontal orientation. Nodular plinthite has a similar color range and has an irregular to spherical shape. Platy plinthite perches water within and above the plinthite horizon in most soils with a udic moisture regime. In soils with nodular plinthite, a perched zone of water saturation is produced by the underlying reticulately mottled horizons that restrict vertical water movement. It is suggested that platy plinthite forms largely on level landscapes under a freely fluctuating water table. Nodular plinthite apparently forms on more sloping landscapes where lateral movement of water above a restrictive horizon is important.

... Coordination with International Systems (WRB)

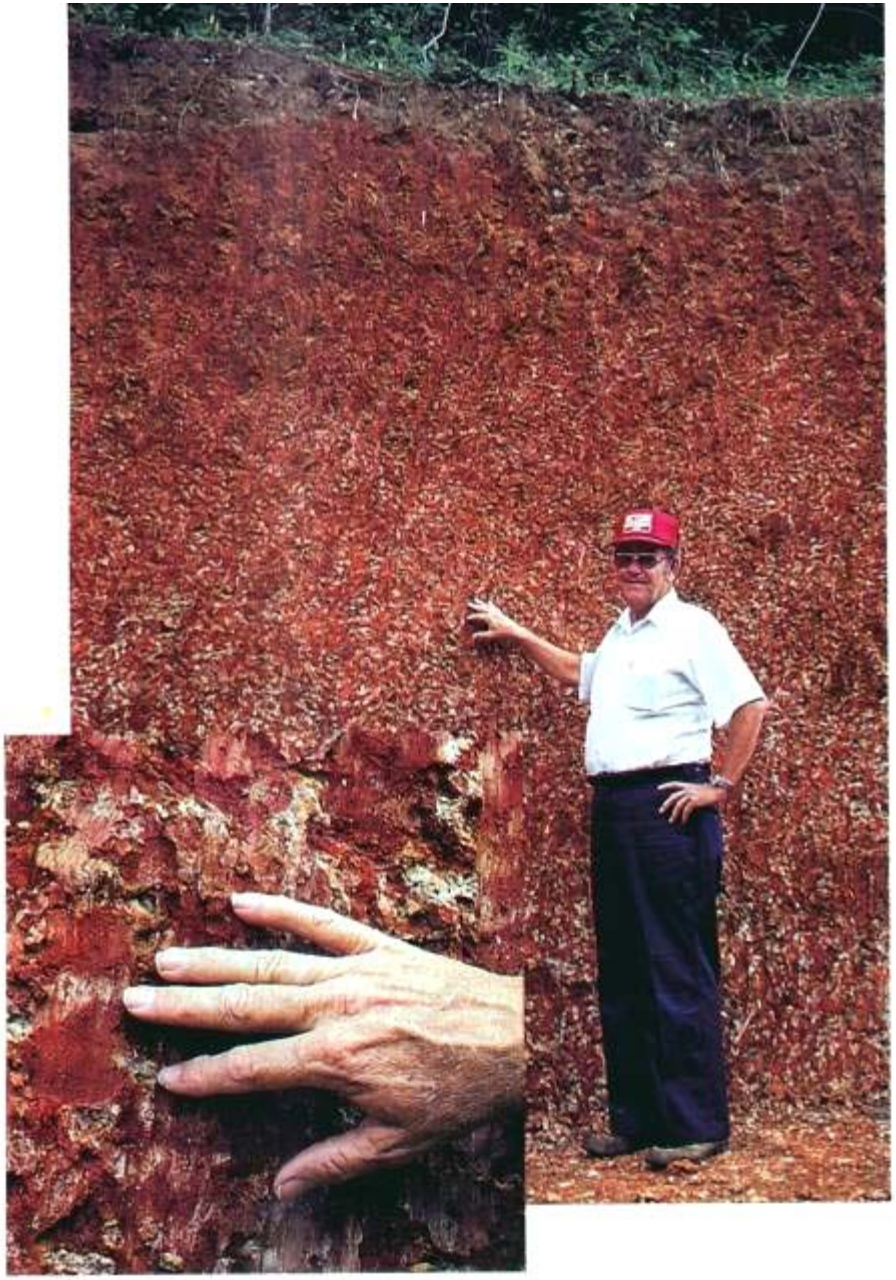


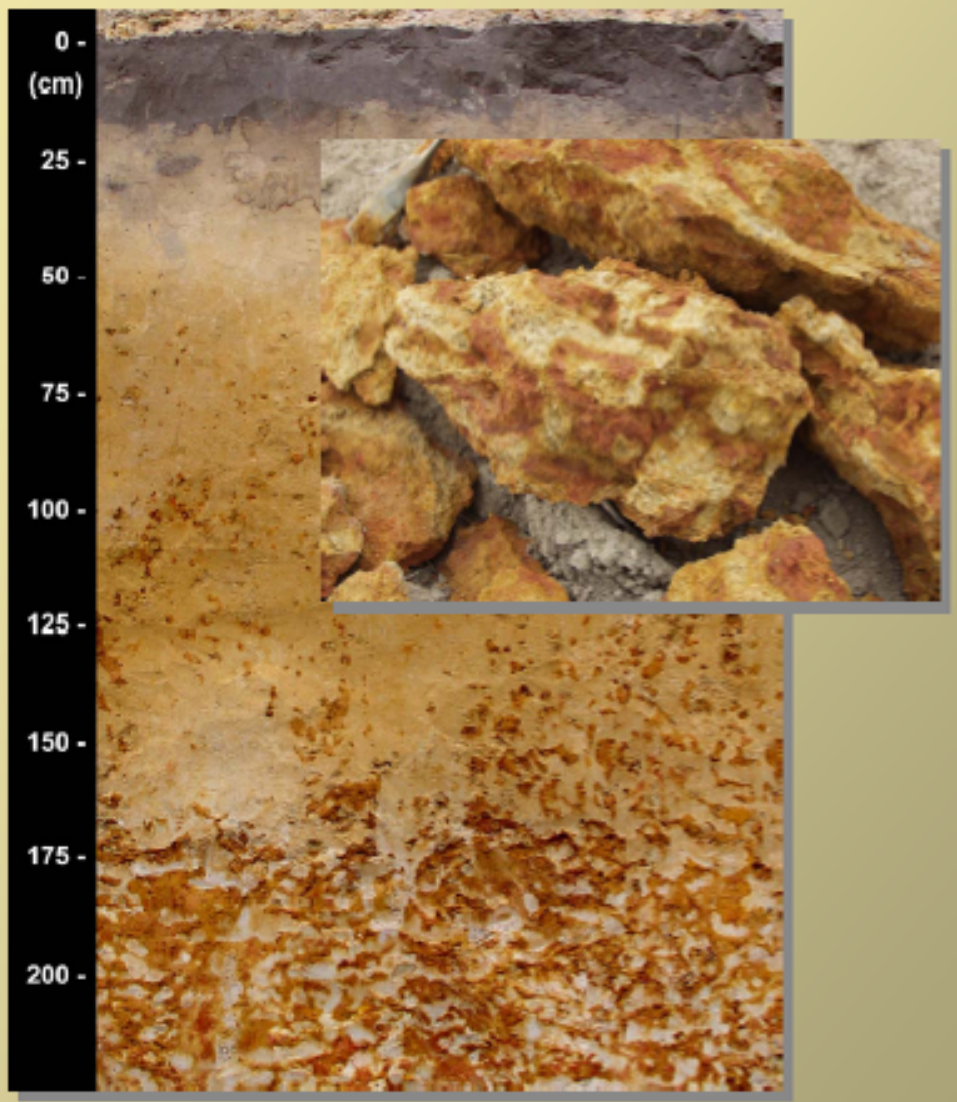
PLATE 15 A Typic Plinthudult in central Sri Lanka. Mottled zone is plinthite, in which ferric iron concentrations will harden irreversibly if allowed to dry.

Morphological Properties *(Lecture Notes):*

Plinthite is red mottled clay but not all red mottled clay is plinthite. It is not always easy to distinguish between `normal' mottled clay, plinthite and ironstone gravel because they grade into each other.

Field criteria for identification of plinthite are:
- red mottles are firm or very firm when moist and hard or very hard when dry
- they *can be cut with a knife* but only with difficulty
- they *have sharp boundaries*
- they *hardly stain the fingers* when rubbed, and
- they *do not slake in water*.

The most obvious distinguishing feature of plinthite is of course, that it hardens irreversibly to petroplinthite upon repeated wetting and drying but this cannot always be ascertained in the field.



Guide for Determining Plinthite Content

Slake Tests

Need to coordinate with other tests... especially, pararock and rock fragment determinations.

Slake Tests Questions?

- *How much sample is needed?*
- *How to prepare (air dry) the sample?*
- *How long to soak?*
- *How much agitation of the sample is appropriate? (swirling, rinsing, brushing, spraying, etc.)*
- *Method: weight to volume, water displacement, others?*

DRAFT_Jan. 10, 2007

Laboratory Sample Collection and Preparation (1B)
Soils (1B1)
Soil Sample Preparation (1B1b)
Air-Dry Preparation (1B1b2)
Particles >2-mm (1B1b2f)
Particle-Size Analysis (1B1b2f1)
Particle-Size Analysis Recorded (1B1b2f1a)
Dissaggregation (Slaking) for Identification and Semiquantification of Cemented Materials (1B1b2f1a4)

1. Application:

Slaking is defined as a process that results in breakdown of soil aggregates (aggregate disintegration) to a finer aggregate size > 2μm. Dispersion is the subsequent process of disintegration of the fine aggregates and release of clay-sized (<2μm) particles (Abu-sharar et al., 1987). These two processes (slaking and dispersion) have been studied to examine the factors affecting soil structure, aggregate stability, porosity, and surface crusting that effect infiltration, hydraulic conductivity, water availability, and erosion susceptibility (Six et al., 2000; Ruiz-Vera and Wu, 2006; Zaher et al., 2005; Abu-sharar et al., 1987; Lado et al., 2004a, Lado et al., 2004b;

TECHNICAL NOTE

USDA NRCS
Natural Resources Conservation Service

NATIONAL SOIL SURVEY CENTER
Federal Building, Room 152
100 Centennial Mall North
Lincoln, Nebraska 68508-3866

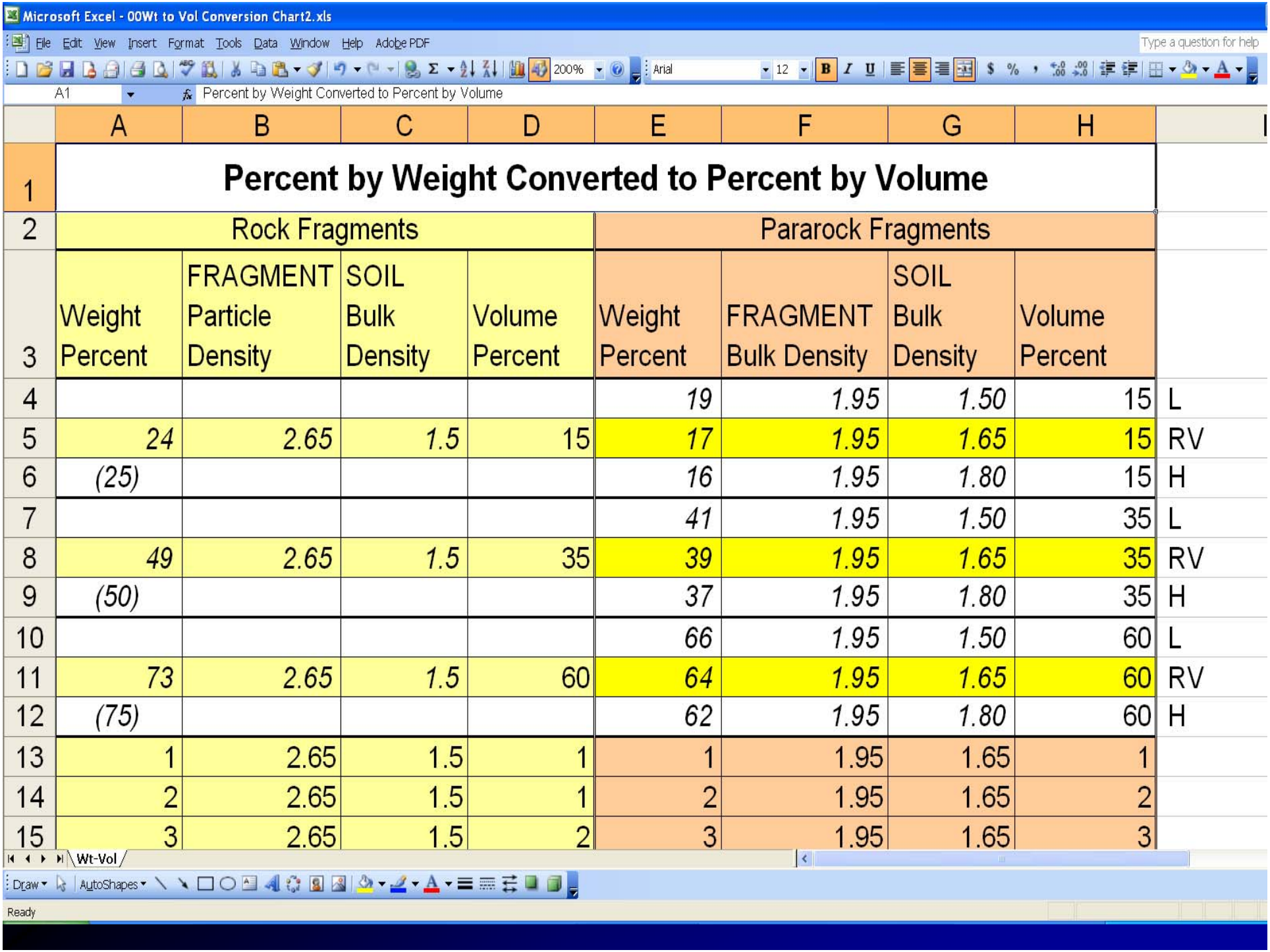
Soil Survey Technical Note No. 10

Dissaggregation (Slaking) for Identification and Semiquantification of Cemented Materials

---Example---

Purpose

This procedure is intended primarily for field office application, but can also be performed in a laboratory setting. Mixtures of lithologies or materials of different degrees of cementation must be evaluated separately following slaking in water as this procedure separates cemented from non-cemented materials. Slaking (disaggregation) has been used for many years in soil survey (Soil Survey Staff, 2006; Wood and Perkins, 1976; Daniels et al., 1978; Flach et al, 1992). It is a critical test for processing soil material for laboratory analysis (Burt, 2004) and proper classification of soil materials for genesis, and use and management. Slaking has commonly been used to qualify presence or absence of



Percent by Weight Converted to Percent by Volume

	Rock Fragments				Pararock Fragments				
	Weight Percent	FRAGMENT Particle Density	SOIL Bulk Density	Volume Percent	Weight Percent	FRAGMENT Bulk Density	SOIL Bulk Density	Volume Percent	
4					19	1.95	1.50	15	L
5	24	2.65	1.5	15	17	1.95	1.65	15	RV
6	(25)				16	1.95	1.80	15	H
7					41	1.95	1.50	35	L
8	49	2.65	1.5	35	39	1.95	1.65	35	RV
9	(50)				37	1.95	1.80	35	H
10					66	1.95	1.50	60	L
11	73	2.65	1.5	60	64	1.95	1.65	60	RV
12	(75)				62	1.95	1.80	60	H
13	1	2.65	1.5	1	1	1.95	1.65	1	
14	2	2.65	1.5	1	2	1.95	1.65	2	
15	3	2.65	1.5	2	3	1.95	1.65	3	

Proposal: Diagnostic horizon

A plinthic horizon has:

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

2. The layer has both 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, *and*

Proposal: Diagnostic horizon

A plinthic horizon has:

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) in a irregular, platy, or reticulate pattern; *and*

Proposal: Diagnostic horizon

A plinthic horizon has:

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.

Proposal: Diagnostic horizon

A Plinth Great Group:

a plinthic horizon with an upper boundary within 150 cm of the mineral soil surface.

A Plinthic Subgroup:

5 to less than 15 percent, by volume cemented plinthite nodules in one or more horizons within 150 cm of the mineral soil surface; or

a plinthic horizon with an upper boundary 150 to 200 cm below the mineral soil surface.

Taxonomic considerations

- *plinthic horizon (>15 percent, by vol. plinthite)*

  15% = Present WRB break point *(texture modifier)*
  25% = Old WRB break point
  35% = Texture modifier
  50% = ST (10th edition) or *continuous phase*

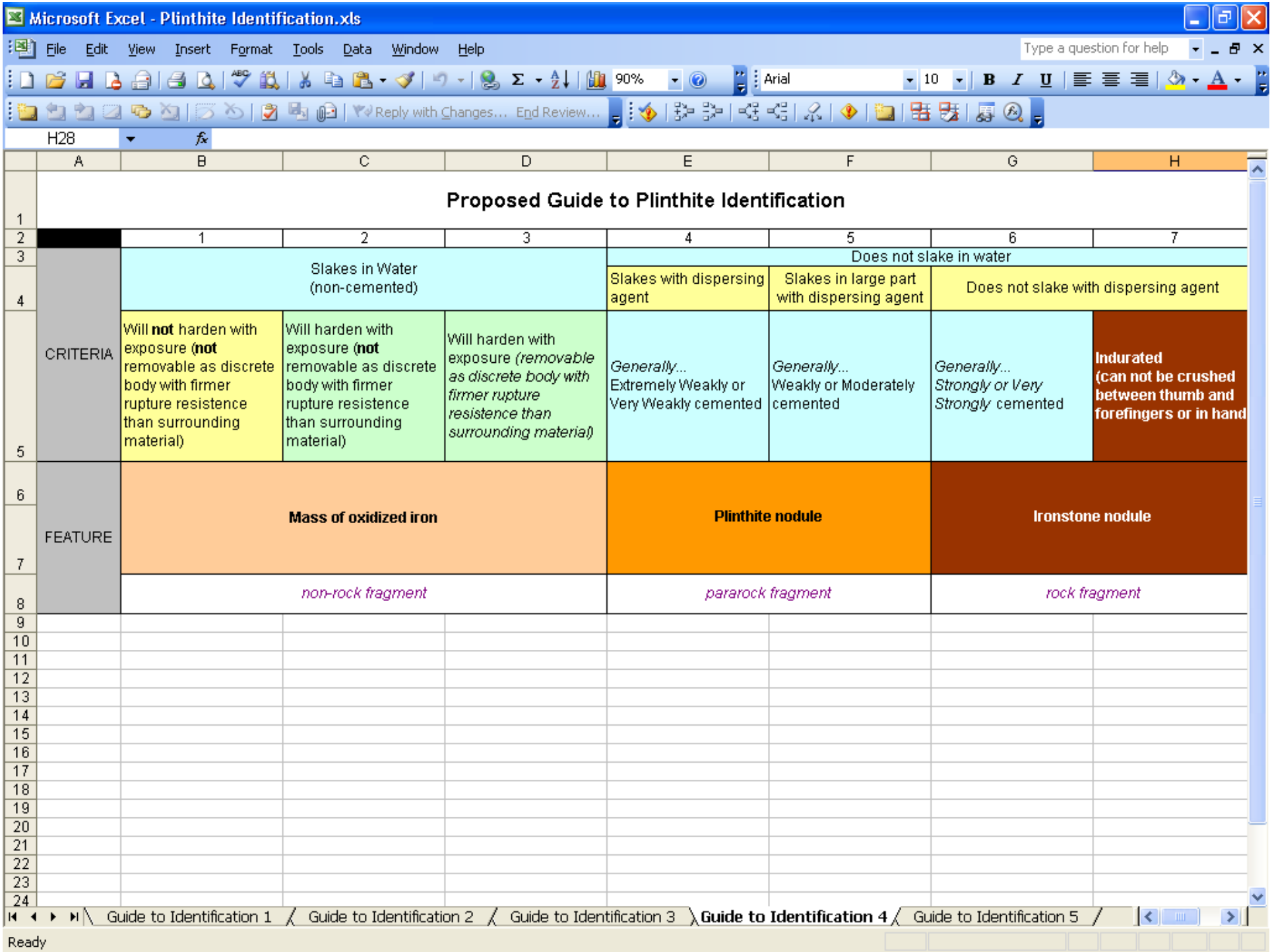
With present slake test procedures, at...

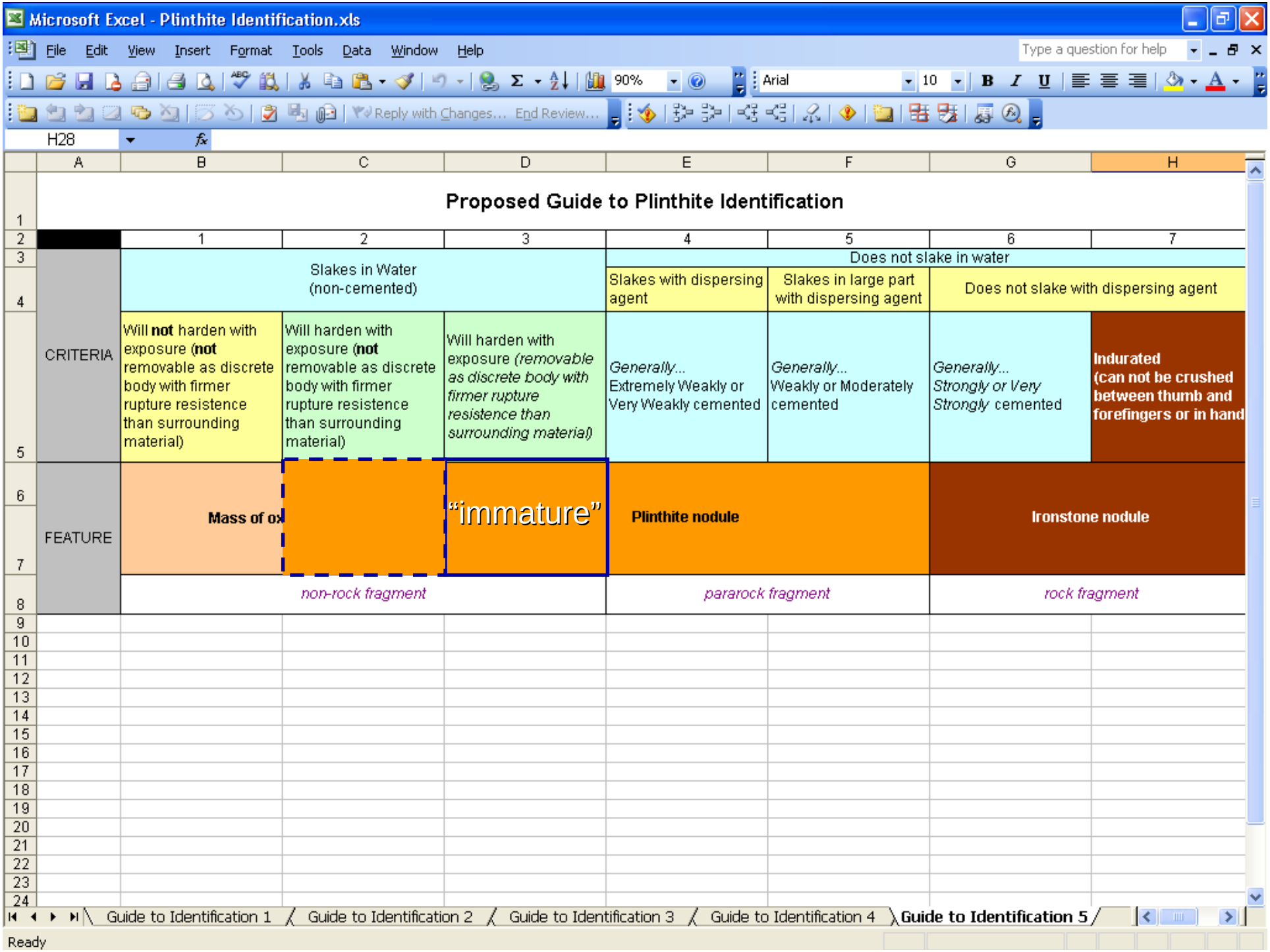
15 percent; most plinthic soils will be Plinthudults

25 or 35 percent; most SE series will be split

>50 percent; most series will remain Plinthic subgroups

What level is interpretively important?


Microsoft Excel - Plinthite Identification.xls
File Edit View Insert Format Tools Data Window Help
Type a question for help
Arial 10
Reply with Changes... End Review...
H28
Proposed Guide to Plinthite Identification
1 2 3 4 5 6 7
Does not slake in water
Slakes in Water (non-cemented)
Slakes with dispersing agent
Slakes in large part with dispersing agent
Does not slake with dispersing agent
CRITERIA
Will not harden with exposure (not removable as discrete body with firmer rupture resistence than surrounding material)
Will harden with exposure (not removable as discrete body with firmer rupture resistence than surrounding material)
Will harden with exposure (removable as discrete body with firmer rupture resistence than surrounding material)
Generally... Extremely Weakly or Very Weakly cemented
Generally... Weakly or Moderately cemented
Generally... Strongly or Very Strongly cemented
Indurated (can not be crushed between thumb and forefingers or in hand
FEATURE
Mass of oxidized iron
Plinthite nodule
Ironstone nodule
non-rock fragment
pararock fragment
rock fragment
Guide to Identification 1
Guide to Identification 2
Guide to Identification 3
Guide to Identification 4
Guide to Identification 5
Ready


Microsoft Excel - Plinthite Identification.xls
File Edit View Insert Format Tools Data Window Help
Type a question for help
Arial 10
Reply with Changes... End Review...
H28
Proposed Guide to Plinthite Identification
1 2 3 4 5 6 7
Slakes in Water (non-cemented)
Does not slake in water
Slakes with dispersing agent
Slakes in large part with dispersing agent
Does not slake with dispersing agent
CRITERIA
Will not harden with exposure (not removable as discrete body with firmer rupture resistence than surrounding material)
Will harden with exposure (not removable as discrete body with firmer rupture resistence than surrounding material)
Will harden with exposure (removable as discrete body with firmer rupture resistence than surrounding material)
Generally... Extremely Weakly or Very Weakly cemented
Generally... Weakly or Moderately cemented
Generally... Strongly or Very Strongly cemented
Indurated (can not be crushed between thumb and forefingers or in hand
FEATURE
Mass of ox
"immature"
Plinthite nodule
Ironstone nodule
non-rock fragment
pararock fragment
rock fragment
Guide to Identification 1
Guide to Identification 2
Guide to Identification 3
Guide to Identification 4
Guide to Identification 5
Ready

Breakout Group discussion…

- Require plinthite to be cemented?
  -establish slake test procedure
  -guidelines for NASIS property population
- Establish “plinthic” diagnostic horizon
- Redefine subgroup/great group criteria

United States Department of Agriculture

Natural resources Conservation Service

National Soil Survey Center

June 2008

Dense Soils Properties Study of Selected Soils in the Southern Coastal Plain

Soil Survey Investigations Report No. 50

- Concepts
- Historical perspective (Joe Nichols, Dick Arnold, Hari Eswaran, others?)
- Proposals
- Representative pedons with associated data sets (soil moisture, chemical, physical, slake tests, etc.)


Questions or comments ?
Presented by
John Kelley, MO14
Raleigh, NC