

SUPPLEMENT
to
SOIL CLASSIFICATION SYSTEM
(7th Approximation)

SOIL SURVEY STAFF
SOIL CONSERVATION SERVICE
U. S. DEPARTMENT OF AGRICULTURE
March 1967

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UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
Washington, D.C. 20250

March 24, 1967

TO: Soil Survey Staff and Collaborators
FROM: Charles E. Kellogg, Deputy Administrator for Soil Survey
RE: Soil Survey - Classification and Correlation - Soil Classification System

Attached is a new supplement to the publication, "Soil Classification, A Comprehensive System, 7th Approximation," which replaces the one issued October 20, 1966. Since 1951 we have been developing a system of soil classification that incorporates the knowledge gained since 1938 and that overcomes some of the shortcomings of the system published that year. In 1960 we published a draft of the classification to permit wide review and criticism. Many constructive suggestions for improvement were received, and in 1964 we summarized the changes that we had made as a result of the suggestions.

In 1965 we began to use the classification. With its use the soils were studied in more detail and also the taxa and definitions in the system.

No useful classification can remain static while knowledge increases and demands for interpretation change. Changes must continue to be made, but the entire staff must be kept advised of the changes in an orderly manner.

We propose to publish the classification in the near future, including the placement of the soil series in families and higher categories. For the final review of the series placement, a third summary of all changes since 1960 seems essential. We cannot otherwise be sure that everyone has been advised of every change.

This text includes all changes in definitions of diagnostic horizons and features as well as in definitions of taxa at the subgroup and higher categories. It also includes the changes in family differentiae, but does not list the families we recognize. Lists of families are being developed in the offices of the principal soil correlators and in State offices.

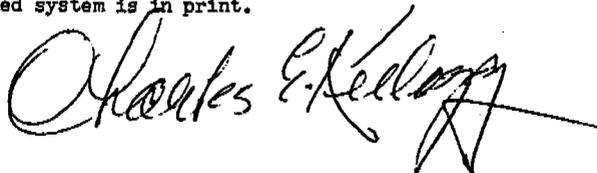
We hope that relatively few changes will be required in the materials in this text prior to publication, but some of the developing concepts have not yet been tested as thoroughly as we should like prior to publication. Among these are the suborders and great groups defined partially on moisture regimes, and the great groups carrying names with the prior formative element "pale-".

The decimal numbering system used formerly has been dropped. If names of taxa have been changed without significant changes in the concepts, the earlier names are indicated in the text. The arrangement of the definitions of taxa other than orders is alphabetical for convenience in location.

The metric system of linear measurements is used throughout the text, but because we are not all thoroughly familiar with metric units, the approximate equivalents in terms of inches are given parenthetically.

The classification of Oxisols and Histosols still lags. A draft classification of Oxisols is presented here but we cannot test it thoroughly in the United States because only a few of the taxa can be found here. A draft of a classification of Histosols that can be added to this material will be distributed at a later date.

We are distributing this text to all staff members and to our collaborators. We plan to have copies available upon request until the published system is in print.



Errata, March 1967 Supplement
to Soil Classification System (7th Approximation)

- p. 9 Umbric epipedon; third word is "have," not "havw"
- p. 46 A.2. should read: At some period in most years, cracks at least 1 cm wide at a depth of 50 cm (20 inches) unless irrigated;
(The same correction is needed on p. 86, line 4 after (20 inches))
- p. 50 C.1.b. should read: Artificial drainage or saturation with water at some period of the year when not frozen and either:
(1) a histic or umbric epipedon, and at depths of less than 50 cm or immediately underlying the epipedon a horizon with dominant moist colors on ped faces, or in the matrix if peds are absent, that meet one or both of the following:
(a) if there is mottling, chromas are 2 or less;
(b) if there is no mottling, chromas are 1 or less;*or
(2) an ochric epipedon underlain at depths of less than 50 cm by a cambic horizon with dominant moist colors that meet the requirements of (1) above;
(The same correction is needed on p. 89, Inceptisols, item 1.b., and p. 92, Aquepts, item 2.)
- C.2. line 1: after "plaggen epipedon", change comma to semicolon; same change p. 89, line 1, item 2.
- C.2.b. change "A cambic" to "An underlying cambic"; same change, pp. 52, 89, and 103.
- C.2.c.(2) should read: "moist and dry values of the mollic epipedon are no darker than those of the underlying horizon."; same change p. 89, item 2. c.(2).
- p. 52 Tropepts. Add an item c. to 2. as follows: "moist and dry values are no darker than those of underlying horizons:"
(The same addition should be made on p. 103.)
- p. 64 Item H. (Alfisols): first line should read "Other mineral soils that lack an oxic horizon unless it underlies an argillic horizon, and that lack plinthite that forms a continuous phase within 30 cm (12 inches) of the soil surface, and that"

Item H.1. (Alfisols): third line should read "dry; and either the mean annual soil temperature is 8°C (47°F) or less, or base saturation (by sum of cations) is 35 percent or more at a depth of 1.25 m"
- p. 68 IAA. add the word "cemented" before "sheets"; same change on page 198, Gibbsiaquox.
IC.2. should read "A mean annual soil temperature of 15°C (59°F) or more;"
- p. 69 IEA. add the word "cemented" before "sheets"; same change on page 201, Gibbsiorthox.
- p. 100 Typic Entrochrepts, item d should read: "have carbonates in the cambic horizon in some part of each pedon;". An item "j" should be added to read: "have less than 40 percent carbonates in and below the cambic horizon to a depth of 1 m (40 inches)."
- p. 101 Lithic-Vertic Entrochrepts should read "Entrochrepts like the Typic except for f and i (2)."
Rendollic Entrochrepts should read "Entrochrepts like the Typic except for j."
Vertic Entrochrepts should read "Entrochrepts like the Typic except for i(1) with or without e."
- p. 102 Lithic-Vertic Ustochrepts should read "Ustochrepts like the Typic except for b and d (2)."
- p. 103 Lithic-Vertic Xerochrepts should read "Xerochrepts like the Typic except for d and e(2)."
Vertic Xerochrepts should read "Xerochrepts like the Typic except for e(1) with or without c."
- p. 105 Lithic-Vertic Entropepts should read "Entropepts like the Typic except for e and f(2) with or without g."
Vertic Entropepts should read "Entropepts like the Typic except for f(1) with or without c or g, or both."
- p. 107 Lithic-Vertic Ustropepts should read "Ustropepts like the Typic except for d and f(2), with or without c."
Vertic Ustropepts should read "Ustropepts like the Typic except for f(1), with or without b or c or both."

- p. 137 Haplic Vermudolls: at end of sentence, add "a".
- p. 141 Lithic-Vertic Haplustolls should read "Haplustolls like the Typic except for f and h(2) with or without d or i or both."
- p. 142 Vertic Haplustolls should read "Haplustolls like the Typic except for h(1) with or without all or any of b, d, or e."
- p. 149 Typic Natrixerolls, item c, line 3, change 2.5 m to 2.5 cm.
- p. 160 (Alfisols) First line should read "Alfisols are mineral soils that have no spodic or oxic horizon overlying an argillic horizon; that have no plinthite that forms a continuous phase within 30 cm (12 inches) of the soil surface; that"
Item 1, line 4, change "cm" to "m".
- p. 165 Typic Cryoboralfs, change item a to read like item a of Typic Umbraqualfs, p. 164.
- p. 169 Mollic Fraquilalfs: change b to d.
- p. 171 Andic Glossoboric Hapludalfs: change c to e.
- p. 180 Typic Durixeralfs, item a, line 3 change 2.5 m to 2.5 cm.
- p. 181 Aquultic Haploxeralfs: change f to g.
- p. 46 Footnote, line 1, delete the two words "the Key".
- p. 173 Aquultic Paleudalfs: change e to c
Mollic Paleudalfs: change c to e
Ultic Paleudalfs: change e to c

add p. 137 agric Fluvitic Hapludolls. d with or without c.

NOMENCLATURE

NAMES OF SUBORDERS AND GREAT GROUPS

The current names of the taxa in the orders, suborders, and great groups are shown in the table of names at the end of this chapter. The names initially proposed used the same prior formative elements in more than one category of some orders. This led to difficulty in naming subgroups. We have subsequently restricted the use of a given prior formative element to a single category in any one order. Spelling has been altered in the names of great groups having calcic horizons and fragipans by inserting the letter *i* to soften the final *c* of "calc" and the *g* for "frag" and "arg." These have become "calci," "Fragi," and "argi."

The formative elements used for suborder and great group names and their derivations follow.

Formative Elements in Names of Suborders

Formative elements	Derivation of formative element	Mnemonic	Connotation of formative element
alb	L. <u>albus</u> , white.	albino	Presence of albic horizon (a bleached eluvial horizon).
and	Modified from Ando.	Ando	Ando-like.
aqu	L. <u>aqua</u> , water.	aquarium	Characteristics associated with wetness.
ar	L. <u>arare</u> , to plow	arable	Mixed horizons.
arg	Modified from argillic horizon; L. <u>argilla</u> , white clay.	argillite	Presence of argillic horizon (a horizon with illuvial clay).
bor	Gr. <u>boreas</u> , northern.	boreal	Cool.
ferr	L. <u>ferrum</u> , iron.	ferruginous	Presence of iron.
fibr	L. <u>fibra</u> , fiber.	fibrous	Least decomposed stage.
fluv	L. <u>Fluvius</u> , river.	fluvial	Flood plains.
hem	Gr. <u>hemi</u> , half.	hemisphere	Intermediate stage of decomposition.
hum	L. <u>humus</u> , earth.	humus	Presence of organic matter.
lept.	Gr. <u>leptos</u> , thin.	leptometer	Thin horizon.
ochr	Gr. base of <u>ochros</u> , pale.	ocher	Presence of ochric epipedon (a light-colored surface).
orth	Gr. <u>orthos</u> , true.	orthophonic	The common ones.
plag	Modified from Ger. <u>plaggen</u> , sod.		Presence of plaggen epipedon.
psamm	Gr. <u>psammos</u> , sand.	psammite	Sand textures.
rend	Modified from Rendzina.	Rendzina	Rendzina-like.
sapr	Gr. <u>sapros</u> , rotten.	saprophyte	Most decomposed stage.
torr	L. <u>torridus</u> , hot and dry.	torrid	Usually dry.
trop	Modified from Gr. <u>tropikos</u> , of the solstice.	tropical	Continually warm.
ud	L. <u>udus</u> , humid.	udometer	Of humid climates.
umbr	L. <u>umbra</u> , shade.	umbrella	Presence of umbric epipedon (a dark-colored surface).
ust	L. <u>ustus</u> , burnt.	combustion	Of dry climates, usually hot in summer.
xer	Gr. <u>xeros</u> , dry.	xerophyte	Annual dry season.

Formative Elements for Names of Great Groups

Formative element	Derivation of formative element	Mnemonic	Connotation of formative element
acr	Modified from Gr. <u>akros</u> , at the end.	acrolith	Extreme weathering.
agr	L. <u>ager</u> , field.	agriculture	An agric horizon.
alb	L. <u>albus</u> , white.	albino	An albic horizon.
and	Modified from Ando.	Ando	Ando-like.
anthr	Gr. <u>anthropos</u> , man,	anthropology	An anthropic epipedon.

Formative Elements for Names of Great Groups (Continued)

Formative element	Derivation of formative element	Mnemonic	Connotation of formative element
aqu arg	L. <u>aqua</u> , water. Modified from argillic horizon; L. <u>argilla</u> , white clay.	aquarium argillite	Characteristic associated with wetness. An argillic horizon.
calc camb	L. <u>calcis</u> , lime. L. L. <u>cambiare</u> , to exchange.	calcium change	A calcic horizon. A cambic horizon.
chrom cry dur dystr, dys	Gr. <u>chroma</u> , color. Gr. <u>kryos</u> , coldness. L. <u>durus</u> , hard. Modified from Gr. <u>dys</u> , ill; <u>dystrophic</u> , infertile.	chroma crystal durable dystrophic	High chroma. Cold. A duripan. Low base saturation.
eutr, eu	Modified from Gr. <u>eu</u> , good; <u>eutrophic</u> fertile.	eutrophic	High base saturation.
ferr frag	L. <u>ferrum</u> , iron. Modified from L. <u>fragilis</u> , brittle.	ferric fragile	Presence of iron. Presence of fragipan.
fragloss	Compound of <u>fra(g)</u> and <u>gloss</u> .		See the formative elements <u>frag</u> and <u>gloss</u> .
gibbs gloss	Modified from <u>gibbsite</u> . Gr. <u>glossa</u> , tongue.	gibbsite glossary	Presence of gibbsite. Tongued.
hal	Gr. <u>hals</u> , salt.	halophyte	Salty.
hapl	Gr. <u>haplous</u> , simple.	haploid	Minimum horizon.
hum	L. <u>humus</u> , earth.		Presence of humus.
hydr	Gr. <u>hydōr</u> , water.	hydrophobia	Presence of water.
hyp	Gr. <u>hypnon</u> , moss.	hypnum	Presence of hypnum moss.
luo, lu	Gr. <u>louo</u> , to wash.	ablution	Illuvial.
moll	L. <u>mollis</u> , soft.	mollify	Presence of mollic epipedon.
nadur	Compound of <u>na(tr)</u> , and <u>dur</u> .		
natr	Modified from <u>natrium</u> , sodium.		Presence of natric horizon.
ochr	Gr. base of <u>ochros</u> , pale.	ocher	Presence of ochric epipedon (a light-colored surface).
pale	Gr. <u>paleos</u> , old.	paleosol	Old development.
pell	Gr. <u>pellos</u> , dusky.		Low chroma.
plac	Gr. base of <u>plax</u> , flat stone.		Presence of a thin pan.
plag	Modified from Ger. <u>plaggen</u> , sod.		Presence of plaggen horizon.
plinth	Gr. <u>plinthos</u> , brick.		Presence of plinthite.
quartz	Ger. <u>quarz</u> , quartz.	quartz	High quartz content.
rend	Modified from Rendzina	Rendzina	Rendzina-like.
rhod	Gr. base of <u>rhodon</u> , rose.	rhododendron	Dark-red colors.
sal	L. base of <u>sal</u> , salt.	saline	Presence of salic horizon.
sider	Gr. <u>sideros</u> , iron.	siderite	Presence of free iron oxides.
sphagno	Gr. <u>sphagnos</u> , bog.	sphagnum-moss	Presence of sphagnum-moss.
torr	L. <u>torridus</u> , hot and dry.	torrid	Usually dry.
trop	Modified from Gr. <u>tropikos</u> , of the solstice.	tropical	Continually warm.
ud	L. <u>udus</u> , humid.	udometer	Of humid climates.
umbr	L. base of <u>umbra</u> , shade.	umbrella	Presence of umbric epipedon.
ust	L. base of <u>ustus</u> , burnt.	combustion	Dry climate, usually hot in summer.
verm	L. base of <u>vermes</u> , worm.	vermiform	Wormy, or mixed by animals.
vitr	L. <u>vitrum</u> , glass.	vitreous	Presence of glass.
xer	Gr. <u>xeros</u> , dry.	xerophyte	Annual dry season.
sombr	F. <u>sombre</u> , dark	somber	A dark horizon.

NAMES OF SUBGROUPS

Subgroup names consist of the name of the appropriate great group modified by one or more adjectives. The adjective typic is used for the subgroup that is thought to typify the central concept of the great group.

Intergrade subgroups that have, in addition to the properties of their great group, some properties of another class carry the name of the other class in an adjective form. For example, assume a Cryorthent that has a B horizon too weakly developed to allow placing the soil in any order other than Entisol, but strongly enough developed to be recognizable. We shall assume that the aberrant properties in this soil are those that have been used to define a suborder in another order. The name of the subgroup therefore would be formed by modifying the great group name, Cryorthent, with the adjective form of the name of the appropriate suborder. If the very weakly developed B horizon were one in which illuvial humus had accumulated (as defined later for a spodic horizon and diagnostic for the suborder of Humods), the name of the subgroup would be Humodic Cryorthent. In this manner, the names of orders, suborders, or great groups, or any of the prior formative elements of these names, may be used in adjectival form for subgroup names. A few soils may have aberrant properties of two great groups belonging in different orders or suborders. For these, it is necessary to use two adjectival forms of class names in the subgroup name.

Naming of Intergrades Toward Other Great Groups in the Same Suborder

If the aberrant property of a soil is one which is characteristic of another great group in the same suborder, only the distinctive formative element of the great group name is used to indicate the aberrant properties. Thus, Typic Durargid is defined as having a platy or massive duripan that does not soften appreciably on wetting. If the only aberrant feature of a Durargid is that the duripan is brittle and has only about a third of its volume cemented into nodules called durinodes, it is considered to intergrade toward the Haplargids--the Argids that do not have duripans. The name, however, is Haplic Durargid, not Haplargidic Durargid. Only the prior formative element is used in adjectival form if the two great groups are in the same suborder.

Naming of Intergrades Toward a Great Group in the Same Order, but in a Different Suborder

Two kinds of names may be used to indicate intergrades toward a great group in the same order, but in a different suborder. If the only aberrant feature is one of color, with chromas that are too high or too low for typic subgroups, the adjectives aquic and aeric are used. These are shorter and in some instances more descriptive than the formative elements of the suborder or great group names.

Thus, if the only aberrant feature of a Hapludult is mottling that is too shallow for the Typic Hapludult, the adjective aquic is used in subgroup names. If mottling with low chromas appears within the upper 25 cm (10 inches) of the argillic horizon, the soil is called an Aquic Hapludult.

If an Aquult has chromas that are too high for the typic subgroups but no other aberrant feature, it is placed in an aeric subgroup. The use of an adjective taken from the suborder, udic, would not suggest that the difference was one of aeration alone.

In other instances the adjective in the subgroup name is made from the prior formative element of the appropriate great group name in that suborder. For example, if a Dystrochrept has an epipedon that approaches an umbric epipedon it may be considered to intergrade to the Umbrepts. It is called an Umbric Dystrochrept rather than an Umbreptic Dystrochrept.

Naming of Intergrades Toward Great Groups in Other Orders

If a Hapludalf has an epipedon that is too dark for a typic subgroup and approaches the properties of a mollic epipedon, the soil is considered to intergrade to one of the great groups of Mollisols. If the only aberrant feature is the nature of the epipedon, the soil is placed in the subgroup of Mollic Hapludalfs. This feature is the feature common to all Mollisols, and the prior formative element of the order name is used. If, in addition the soil should show mottles with gray colors in the upper part of the argillic horizon, it would be considered an intergrade toward the Aquolls and would be called an Aquollic Hapludalf. Note that this is simpler than Aquic Mollic Hapludalf. The general rule is that the simplest possible name is used.

Naming of Subgroups not Intergrading Toward any known Kind of Soil

Some soils have aberrant properties that are not characteristic of a class in any order, suborder, or great group. One example might be taken from the soils found at the base of slopes, in depressions or other places where new soil material slowly accumulates at the surface. The rate of accumulation of new material may be slower than the accumulation of organic matter, so that in time a very thick, dark surface develops. In these soils the A horizon could be considered the parent material of the C. The presence of such over-thickened A horizons is not used to define any great group, for the genetic considerations lead us to believe that they are more appropriately recognized as a subgroup. The soils lie outside the range of the Typic subgroup and there is no class toward which they intergrade. Hence, a descriptive adjective is required. For this particular situation, the adjective Cumulic (L. cumulus, heap, plus ic, from Gk. ikos) is used to form the 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 to not-soil, and are called lithic subgroups.

The names of subgroups of this sort that we might call extragrades together with their derivations are as follows:

Formative element	Derivation of formative element	Mnemonic	Connotation of formative element
abruptic	L. <u>abruptum</u> , torn off.	abrupt	Abrupt textural change.
allic	Modified from <u>aluminum</u> .		Presence of extractable aluminum.
arenic	L. <u>arena</u> , sand.	arenose	Sandy texture.
clastic	Gr. <u>klastos</u> , broken.	clastic	High mineral content.
cumulic	L. <u>cumulus</u> , heap.	accumulation	Thickened epipedon.
glossic	Gr. <u>glossa</u> , tongue.	glossary	Tongued.
gross-arenic	L. <u>grossus</u> , thick, and L. <u>arena</u> , sand.		Thick sandy layer.
limnic	Modified from Gr. <u>limn</u> , lake.	limnology	Presence of a limnic layer.
lithic	Gr. <u>lithos</u> , stone.	lithosphere	Presence of a lithic contact.
leptic	Gr. <u>leptos</u> , thin		A thin solum.
pergelic	L. <u>per</u> , throughout in time and space, and L. <u>gelare</u> , to freeze.		Permanently frozen or having permafrost.
petrocalcic	Gr. <u>petra</u> , rock and <u>calcic</u> from calcium.		Petrocalcic horizon.
plinthic	Modified from Gr. <u>plinthos</u> , brick.	plinthite	Presence of plinthite.
ruptic	L. <u>ruptum</u> , broken.	rupture	Intermittent or broken horizons.
stratic	L. <u>stratum</u> , a covering.	stratified	Stratified layers.
superic	L. <u>superare</u> , to overtop.	superimpose	Presence of plinthite in the surface.
pachic	Gr. <u>pachys</u> thick	pachyderm	A thick epipedon

Nomenclature for Multiple Subgroups Intergrading Between Two Given Great Groups

More than one subgroup sometimes occurs in a given great group intergrading to the same class of soil, or even to "not-soil." In one place the horizons may be continuous, in another discontinuous, and in a third buried. Or in one, properties of two classes are mixed in a single horizon but exist in separate horizons in the other. Soil of class X may be developing from or toward class Y producing subgroups with different properties.

Nomenclature for handling all multiple subgroups is incomplete. It can be expanded only when knowledge of the kinds of soils is at hand.

If the intergrade is one with intermittent horizons, the adjective Ruptic (L. ruptum, broken) is used in the subgroup name. The substantive in the name is that used for the kind of soil having the greatest area; the adjectives are formed from the names of the classes with the lesser area, preceded by the adjective Ruptic and connected by hyphens. Thus, if X is dominant in area and Y minor, the soil is named Ruptic-Yic X. If the adjectives that name the minor component are multiple, as in Lithic Dystrachreptic, hyphens are used to connect all such adjectives. For example, a subgroup of Hapludults that includes in each pedon a minor component of Lithic Dystrachrepts would be named Ruptic-Lithic-Dystrachreptic Hapludults. Note that this name implies

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that only the minor part of each pedon is lithic. If the entire pedon were lithic and only the argillic horizon of the Hapludult intermittent, the name would be Ruptic-Dystrochreptic Lithic Hapludult. If only the lithic portion of each pedon fitted the definition of Hapludult, the name would be Ruptic-Dystrochreptic Lithic-Hapludult. The general rule is to hyphenate modifiers in the portion of the name that they modify. No hyphens are used if the modifier applies to the entire pedon.

If the subgroup is one with a buried soil that is an important part of the present soil, the name includes Thapto (or. 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.

Arrangement of Modifiers

Modifiers are arranged alphabetically insofar as possible, but Ruptic and Thapto are placed without reference to alphabetic order since they must immediately precede the terms they modify.

Table 9. Names of Orders, Suborders, and Great Groups

Order	Suborder	Great Group	Order	Suborder	Great Group		
Entisols (1)	Aquents	Cryaquents	Inceptisols (3)	Plaggepts	Trovepts	Dystrovepts	
		Haplaquents				Eutrovepts	
		Hydraquents				Humitrovepts	
		Psammaquents				Ustrovepts	
	Tropaquents	Umbrepts				Anthrombrepts	
	Arents				Cryofluvents	Cryumbrepts	
					Torrifluvents	Fragiumbrepts	
					Tropofluvents	Haplumbrepts	
					Udifluvents	Xerumbrepts	
		Ustifluvents			Aridisols (4)	Argids	Durargids
	Xerofluvents	Haplargids					
	Orthents	Cryorthents					Nadurargids
		Torriorthents					Natrargids
		Troporthents				Paleargids	
		Udorthents			Orthids	Calciorthids	
Ustorthents		Camborthids					
Xerorthents	Durorthids						
Psamments	Cryopsamments	Paleorthids					
	Quartzipsamments	Salorthids					
	Torripsamments	Mollisols (5)	Albolls	Argialbolls			
	Udipsamments			Natralbolls			
	Ustipsamments			Aquolls	Argiaquolls		
Xeropsamments	Calciaquolls						
Vertisols (2)	Torrerts				Uderts	Chromuderts	Cryaquolls
		Pelluderts	Duraquolls				
	Usterts	Chromusterts	Haplaquolls				
		Pellusterts	Natraquolls				
	Xererts	Chromoxererts	Borolls	Argiborolls			
Pelloxererts		Calciborolls					
Inceptisols (3)	Andepts	Cryandeps		Cryoborolls			
		Durandeps		Haploborolls			
		Dystrandeps		Natriborolls			
		Eutrandeps	Paleborolls				
		Hydrandeps	Vermiborolls				
	Aquepts	Andaquepts	Rendolls	Udolls	Argiudolls		
		Cryaquepts			Hapludolls		
		Fragiaquepts			Paleudolls		
		Halaquepts			Vermudolls		
		Haplaquepts			Ustolls	Argiustolls	
	Humaquepts	Calciustolls					
	Plinthaquepts	Durustolls					
	Tropaquepts	Haplustolls					
	Ochrepts	Cryochrepts	Natrustolls				
		Durochrepts	Paleustolls				
Dystrochrepts		Vermustolls					
Eutrochrepts							
Fragiochrepts							
Ustochrepts							
Xerochrepts							

New diagnostic horizons and features.

1. **Lithic contact:** A lithic contact is a boundary between soil and continuous, coherent, underlying material. The underlying material must be continuous within the limits of a pedon except for cracks produced in place without significant differential displacement of the pieces relative to each other. The underlying material must be sufficiently coherent when moist to make hand-digging with a spade impractical, although it may be chipped or scraped with a spade. If a mineral, it must have a hardness of 3 or more (Mohs scale) or, if not a single mineral, chunks of gravel size that can be broken out must not disperse with 15 hours shaking in water or in sodium hexametaphosphate (Calgon) solution. The underlying material considered here does not include diagnostic soil horizons such as duripans or petrocalcic horizons.

2. **Paralithic contact (lithic-like):** A paralithic contact is also a boundary between soil and continuous coherent underlying material. It differs from the lithic contact in that the underlying material, if a mineral, has a hardness of less than 3 (Mohs scale). Or, if not a single mineral, chunks of gravel size that can be broken out disperse more or less completely with 15 hours end-over-end shaking in water or in sodium hexametaphosphate solution and, when moist, the material may be dug with difficulty with a spade. The material underlying a paralithic contact is normally a partially consolidated sedimentary rock, such as sandstone, siltstone, or shale, with a dry bulk density of more than 2.

3. **Petrocalcic horizon:** (Note that a laminar horizon is not required.) The petrocalcic horizon is a continuous indurated calcic horizon, cemented by carbonates of calcium, and in places with some magnesium. Accessory silica may be present. The petrocalcic horizon is continuously cemented throughout the pedon to the point that dry fragments do not slake in water. It cannot be penetrated by spade or auger when dry. It is massive or platy, extremely hard when dry, and very firm to extremely firm when moist. Non-capillary pores are filled and the petrocalcic horizon is impermeable to roots. Permeability to water is moderately slow to very slow. It is usually much thicker than 10 cm (4 inches). A laminar capping is commonly present but is not required. If present, the carbonates constitute half or more of the weight of the laminar horizon, and the hardness is 3 or more (Mohs scale). Gravel, sand, and silt grains have been separated by the crystallization of carbonates in at least parts of the laminar subhorizon.

4. **Durinodes:** (*L. durus*, hard; nodus, knot) Durinodes are weakly cemented to indurated nodules that break down in concentrated KOH after treatment with HCl to remove carbonates, but that do not break down on treatment with concentrated HCl alone. The cement is SiO₂, presumably opal and microcrystalline forms of silica. Dry durinodes do not slake in water. They are firm to extremely firm, and brittle when wet, both before and after acid treatment; they are disconnected and range upward in size from about 1 cm. Most durinodes are roughly concentric when viewed in cross-section, and concentric stringers of opal may be visible with a hand lens.

5. **Placic horizon:** The placic horizon is a thin black to dark reddish cemented pan, presumably cemented by iron. Its thickness generally ranges from about 2 mm up to about 10 mm. Rarely, it may be as thin as 1 mm or as thick as 20 to 25 mm in spots. It is not associated with stratifications in parent materials, but is in the solum roughly parallel to the soil surface and usually within the upper 50 cm of the mineral soil. It has a pronounced wavy or even involute form. It occurs as a single pan, not as multiple sheets, one underlying another. It is slowly permeable or impermeable to water and roots.

The genesis of the placic horizon, often called a thin iron pan, is not understood. It may or may not be associated with water saturated conditions in the soil above. It may be found in tropical regions or in Alaska, in sands or clays, but always in a very humid or perhumid climate. The base saturation of overlying horizons is very low in virgin soils. The native vegetation may be a tropical rain forest, sphagnum, or other rain loving plants.

Identification is rarely difficult. The hard brittle pan differs so much from the materials in which it occurs and is so close to the surface that it is obvious unless it is minimal in thickness. A few analyses of placic horizons show that the content of organic carbon is appreciable, up to 3 percent or more. The presence of organic carbon as well as shape and position distinguish the placic horizon from the ironstone sheets that often occur where water hangs or moves laterally at lithologic discontinuities. Fig 26, p 195, 7th Approximation illustrates the thin wavy appearance of the placic horizon.

Modification of definitions of diagnostic horizons and features proposed in the 7th Approximation:

Mollic epipedon, p. 33. The second column should read as follows (note that the major change is a restriction on chroma): A mollic epipedon is a surface mineral layer. It may underlie an organic layer in wet soils, but it is normally the surface layer. It has, after the surface 18 cm (7 inches) are mixed, as by plowing, the following properties:

1. Soil structure is sufficiently strong that the horizon is not both massive and hard or very hard, when dry. (The name of the order and of the epipedon are both derived from the Latin word, *mollis*, meaning soft).
2. Colors of both broken and crushed samples have values darker than 3.5 when moist and 5.5 when dry, and chromas of less than 3.5 when moist*; the color value is normally at least 1 Munsell unit darker than the IC or the chroma is at least 2 units less (both moist and dry) if a IC horizon is

Mollic epipedon, cont.

present. If only a IIC horizon or R is present, comparison should be made with the next horizon underlying the epipedon. Some parent materials such as loess, cinders, alluvium, or carbonaceous shales also have dark colors and low chromas. Soils formed in such materials may accumulate appreciable amounts of organic matter with no visible darkening in the epipedon. The requirement that the mollic epipedon have lower values or chromas than the IC, or the next underlying horizon if there is no IC, must be waived if (a) the surface horizon or horizons meet all other requirements for a mollic epipedon and, in addition, have at least 1 percent more organic matter than the IC or IIC horizon, or (b) if the epipedon extends to a lithic contact (R horizon).

The mollic epipedon is expected to have dark colors and low chromas throughout the major part of the matrix. If the structure is fine granular or fine blocky, the broken colors may reflect only the colors of coatings. The color of the matrix in such instances can only be determined by crushing or briefly rubbing the sample. Prolonged rubbing should be avoided because it may cause darkening of a sample if soft iron-manganese concretions are present, but crushing should be enough to break and mix coatings.

3. The base saturation is over 50 percent by the NH_4OAc method.

4. The organic carbon content is at least 0.58 percent (1 percent organic matter) throughout. If the dark surface horizon is less than 18 cm (7 inches) thick in a virgin soil with a solum of less than 46 cm (18 inches), the organic carbon content must be sufficient to give an average of 0.58 percent to an Ap that is 18 cm (7 inches) thick. Otherwise, if plowed the Ap would have too little organic matter for a mollic epipedon. The mollic epipedon is a mineral rather than an organic horizon. Its content of organic matter therefore has an upper as well as a lower limit. The upper limit of organic matter in a mollic epipedon is the lower limit for the histic epipedon. Because organic horizons can form above a mollic epipedon in wet soils, the mollic epipedon is not necessarily the surface horizon. It is, however, the surface mineral horizon.

5. The thickness is (a) more than 10 cm (4 inches) if underlain directly by a lithic contact (R horizon), or (b) if the soil contains an argillic, natric, spodic, cambic, or oxic horizon, or a fragipan or duripan, as defined later, the thickness of the epipedon must be more than one-third of the thickness of the solum where the solum is less than 75 cm (30 inches) thick and must be more than 25 cm (10 inches) where the solum is more than 75 cm (30 inches) thick, or (c) 18 cm (7 inches) or more if there is no solum other than an Ap or Al (a IC or IIC directly underlies the epipedon), and (d) more than 25 cm (10 inches) if the epipedon has a texture coarser than loamy very fine sand throughout.

6. The epipedon has less than 250 parts per million of P_2O_5 soluble in citric acid, or has increasing amounts of P_2O_5 soluble in citric acid below the epipedon. This restriction is used to eliminate a number of plow layers of very old arable soils and kitchen middens that have acquired, under use, the other properties of the mollic epipedon.

Umbric epipedon. Many soils have dark surface horizons that cannot be distinguished by the eye from mollic epipedons, but laboratory studies may show that the dominant exchangeable cation is hydrogen. Such epipedons are called umbric. The content of organic carbon may be even higher in umbric than in mollic epipedons. Examples of soils with umbric epipedons would include the Ando soils, Rubrozems, a number of extremely acid Humic Gley soils, and some Tundra soils.

Color is a poor general guide to the content of organic carbon, yet the dark colors of some umbric epipedons are caused by organic carbon, for these epipedons become light colored when the organic matter is destroyed. And, in some kinds of soil, the darkness is roughly proportional to the amounts of organic carbon.

Perhaps it is prejudice or resistance to change, but for some kinds of soil, particularly those in which the content of organic matter is roughly proportional to darkness, the most satisfactory groupings are still those that place soils with a dark-colored surface horizon in different groups from those with a light-colored surface horizon. In those kinds of soil where darkness is not related to the content of organic matter, the soils with light-colored epipedons probably should be separated from those with dark-colored epipedons only at very low categoric levels, perhaps the family or the series.

The umbric epipedon is comparable to the mollic epipedon in its color, organic carbon, consistence, structure, and thickness requirements. It includes those thick, dark surface horizons that have base saturation of less than 50 percent (by NH_4OAc). It should be noted that the restriction against a hard or very hard and massive epipedon when dry is applied only to those epipedons that become dry. If the epipedon is always moist, there is no restriction on dry consistence or structure.

Soil 5, page 70, illustrates the umbric epipedon. A study of the description and the other data show that the umbric epipedon is about 32 inches thick. The horizons below 32 inches are too light in color to be included. The carbon-nitrogen ratios are too wide and base saturation is too low for a mollic epipedon. The content of organic carbon is high enough for a histic epipedon, but the soil has neither a high water table nor artificial drainage.

Soil 6, page 71, is an example of an umbric epipedon in a soil with a B horizon of illuvial clay (argillic horizon). In this soil the umbric epipedon is about 12 inches thick and includes only the A horizon. While this is a common situation, there is nothing that prevents the umbric epipedon from including all or part of a B horizon.

Chapter 5

Histic Epipedon

The histic (Gk. *histos*, tissue) epipedon normally occurs at the surface, though it may be buried at a shallow depth. It is a thin organic horizon if virgin; if plowed it has the very high content of organic matter that results from mixing of peat with some mineral material. And, since peat deposits are associated with free water, the histic epipedon is either saturated with water for more than 30 consecutive days at some season of the year or has been artificially drained.

The histic epipedon therefore can be defined as a horizon or horizons at or near the surface, saturated with water at some season unless artificially drained, and meeting one of the following requirements:

1. A surface horizon less than 30 cm (12 inches) thick if drained, and less than 45 cm (18 inches) thick if undrained*, with more than 17.4 percent organic carbon (30 percent or more organic matter) if the mineral portion is half or more clay; with more than 11.6 percent organic carbon (20 percent or more organic matter) if the mineral portion has no clay; or with intermediate proportional contents of clay and organic carbon. If the epipedon is less than 20 cm (8 inches) thick, it is still thick enough to satisfy 2- below if the horizons are mixed to a depth of 20 cm (8 inches).
2. A plow layer having more than 8.12 percent organic carbon (14 percent or more organic matter) if there is no clay; or more than 16.24 percent organic carbon (28 percent or more organic matter) if the mineral fraction is half or more clay; or intermediate proportional contents of clay and organic carbon.
3. A mineral surface layer less than 50 cm (20 inches) thick with an underlying organic layer that has enough organic carbon to satisfy 1. above, and a thickness of 10 to 30 cm (4 to 12 inches). In this situation, the histic epipedon is considered to be buried and to start at the top of the organic layer. The surface mineral layer burying the histic epipedon is considered too thin to be diagnostic in the classification.

Ochric Epipedon

Ochric (Gk. *ochros*, pale, light colored) epipedons are those that are too light in color, too high in chroma, too low in organic carbon, or too thick to be mollic, umbric, anthropic, or histic. Or, they are both hard and massive when they are dry. If they are never dry, either the rubbed color values are 5.5 or higher when dry or 3.5 or higher when moist, the chromas are 4 or more, or the A1 or Ap horizons that have both low values and chromas are too thin to be mollic or umbric epipedons, that is, less than one-third of the solum or 25 cm (10 inches) or less in a solum that is more than 75 cm (30 inches) thick. Ochric epipedons may have rubbed color values lower than 5.5 when dry or lower than 3.5 when moist, provided they are virtually no darker than the C horizon. The ochric epipedon includes eluvial horizons at or near the surface (A2 and albic horizons) and extends to the first underlying diagnostic argillic, natric, spodic, or oxic horizon. If the underlying horizon is a cambic horizon and there is no surface horizon that is appreciably darkened by humus, the most convenient lower limit of the ochric epipedon is the base of the plow layer, or an equivalent depth in soils that have not been plowed. Actually, the same subhorizon in an unplowed soil may be both a part of the epipedon and a part of the cambic horizon. The epipedons and the subsurface diagnostic horizons are not mutually exclusive. The ochric epipedon does not have rock structure; it does not include fresh sediments with fine stratifications.

Soil 8, p. 73, describes a soil with an epipedon that is too light in color to qualify as either mollic or umbric.

Soil 27, p. 92, and soil 99, p. 243, illustrate soils having surface horizons too high in chroma to be umbric epipedons.

Soil 9, p. 74, illustrates a soil having a surface horizon that has been darkened by organic matter but is too thin to be either mollic or umbric. Only the surface 3 inches are dark enough and have enough organic carbon to meet the requirements of a mollic epipedon. If this profile were plowed to a depth of 6 inches, the resulting mixture would be too light colored and would contain too little organic carbon to meet the requirements of a mollic epipedon. It is therefore ochric.

Soil 87, p. 223, illustrates a soil with an epipedon that is ochric because it is both hard and massive when dry.

* The variable limits for thickness with and without drainage are to allow for the subsidence that follows drainage.

Chapter 5

ARGILLIC HORIZON

The Genesis

An argillic horizon is an illuvial horizon in which layer-lattice silicate clays have accumulated by illuviation to a significant extent. It therefore must be formed below the surface of the mineral soil, though it may later be exposed at the surface by erosion.

If clay moves from one horizon to another, or from one point to another within a horizon, something must start the movement and something must stop it. These forces are poorly understood or at least are not a subject of general agreement.

We assume the clay is carried by water. Because there is a strong similarity between the clay in the eluvial and illuvial horizons, we assume that the clay in argillic horizons migrated dominantly as clay rather than as decomposition products that have subsequently been synthesized into clay. Because we find few or no evidences of clay movement in the soils on the youngest landscapes, we conclude that argillic horizons require thousands of years to form. Because, on some landscapes, we may find evidences of clay movement in soils under forest, but not under grass, we assume vegetation has an influence. And we assume that climate is a factor because we find few or no evidences of clay illuviation in soils of regions with wet climates, such as the Appalachian Plateau, the Ardennes, or the British highlands where water percolates through the soils at all seasons, but we do find the evidences commonly in the adjacent lowlands in climates where the soils become thoroughly or partially dried at some season.

In the light of our present knowledge the most reasonable picture of the clay movement is as follows: First, the parent material must contain very fine clays or weathering must produce them. The very fine clays, carrying the same negative charge as the soil matrix, tend to disperse unless something is present to keep them flocculated. Salts, including carbonates, and free oxides tend to keep the clays flocculated. The sodium ion, between critical limits, increases dispersion. And organic matter seems to play an important but possibly indirect role in dispersion.

Wetting of a dry soil seems to lead to disruption of the fabric and to dispersion of clay. Once dispersed, the clay moves with the percolating water and stops where the percolating water stops. Water percolating in noncapillary voids commonly is stopped by capillary withdrawal into the soil fabric. During this withdrawal the clay is filtered out and deposited on the walls of the noncapillary voids. This explains why illuvial clays are so commonly plastered on the ped faces and on the walls of pores. Such a mechanism for clay movement and deposition is favored in several ways by a seasonal moisture deficit: First, as mentioned above, wetting a dry soil favors the dispersion of the clay; secondly, on drying, cracks form in which percolation of gravitational water or water held with low tension can take place; thirdly, the halting of percolating water by capillary withdrawal is favored by the strong tendency for dry soil to take up moisture.

Water ordinarily does not remain in the noncapillary voids; rather, it will move into and be transported through material having pores of capillary size. Movement of water in noncapillary voids occurs only if the rate of water addition exceeds the capillary conductivity of the soil. As conditions for water percolation in large voids do not usually prevail, clay movement and deposition is likely to be infrequent and sporadic. Thus, a long period of time usually is necessary before the cumulative effect of clay movement becomes readily discernible.

Capillarity can have still more to do with the downward movement of water (as well as into the peds). If a lower soil horizon is considerably coarser in texture, capillaries are broken and the water tends to hang in the fine capillaries above. As the water evaporates or is withdrawn by roots, suspended or dissolved materials are left. This action even accentuates the original differences in fineness of capillaries.

Carbonates sometimes seem to play an effective role in stopping the moving clay. The evidence of this lies in common accumulation of clay in or just above a horizon that has limestone gravel in a non-calcareous matrix. Other factors are undoubtedly important, but these seem to be the most common.

Finally, not only is time required for an argillic horizon to form, but also mixing of horizons by animals, by frost, and by shrinking or swelling must be slow or absent.

Significance of Argillic Horizons to Soil Classification

The argillic horizon by itself has little importance to soil classification. A taxon that included all soils with argillic horizons would have almost no other common property. Yet the horizon is a mark of the dominance of silicate clay translocation over processes that destroy or remove clay from the soil, and over processes that mix horizons. Because its formation is relatively slow, its presence indicates stability of the surface when undisturbed by man. Time has been ample on this stable surface to develop an apparent equilibrium between formation and decomposition of organic matter. Its presence indicates that a substantial amount of water has moved through overlying horizons, enough that soluble materials have been removed, though they may subsequently have been replaced. One might say that its presence is evidence that climate and vegetation have had opportunity to show their effects, though one may not say that this is true for the present climate and vegetation.

Taken in combination with other diagnostic features, the argillic horizon has much more meaning. In the desert environment it indicates a soil and surface of great age, for in the present environment rainfall is often 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 the surfaces of recent or very late Pleistocene age from the older surfaces. Its presence also correlates well with many other properties affected by leaching. In these relatively dry areas, 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 textured, and develops an abrupt upper boundary. Soils with fine textured B horizons and abrupt A-B horizon boundaries were the orthotypes of the soils called Planosols.

In cool humid regions the argillic horizon seems to be transient. It forms slowly, but with time it is moved deep into the soil and finally destroyed. In its place one finds the cambic or spodic horizons that are discussed later.

In humid temperate and tropical regions, the presence of the argillic horizon has still other meanings. In the humid temperate forested regions, the argillic horizon is mainly a mark of surface stability and of a seasonal moisture deficit. Its use helps distinguish the stable and unstable surfaces, as well as the soils with seasonal moisture deficits.

In humid tropics the argillic horizon appears to be useful in distinguishing many of the soils with some weatherable minerals from those formed in the old, completely weathered sediments. However, we have much to learn yet about these soils.

It needs to be 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 with the largest number of common properties.

Appearance of the Argillic Horizon

The horizons of accumulation of illuvial clay that constitute argillic horizons have a variety of forms, and though positive identification is sometimes difficult, several features may be used for recognition in most soils. No one feature is common to all argillic horizons and lacking in 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, the texture change between the eluvial and illuvial horizons is generally clear or abrupt. Sometimes it is gradual, and often it is irregular.

The argillic horizon is generally distinctly finer in texture than the overlying eluvial horizon or the underlying parent material. The ratio of the clay content of the eluvial and illuvial horizon is 1.2 or larger, and usually larger. The increase of 20 percent or more in the clay content usually occurs within a vertical distance of less than 6 inches (15 cm.). In a few soils the transition may take up to 12 inches (30 cm.). The lower boundary of the argillic horizon is often gradual, and irregular.

Second, there are usually coatings of oriented clay on the surfaces of pores and of pedis somewhere within the horizon.

Third, the ratio of fine clay (less than 0.0002 mm.) to coarse clay is larger in the argillic horizon than it is in the eluvial horizons or in the horizons that underlie the argillic horizon.

Fourth, rock structure is not evident or is evident in less than half of the volume. Rock structure, in this context, refers to weathered rock in which the original shape and relative position of the altered minerals are still evident. Material is often called saprolite by soil scientists if it retains rock structure.

Fifth, the minerals resistant to weathering, such as quartz and zircon, are commonly less abundant in the argillic horizon than in the overlying or underlying horizons. This reflects dilution by illuvial clay. If the soil contains quartz the silica-sesquioxide ratio of the argillic horizon is lower than that of adjacent horizons.

Evidences of Clay Translocation

It is important to recognize that the clay that has moved from one horizon to another is usually only a small part of the total clay. The bulk of the clay in most argillic horizons either has formed in the horizon or has been inherited from the parent material.

It is also important to recognize that a subsurface horizon may be finer in texture than the overlying horizons without being an argillic horizon. The finer texture may be the result of stratification in the parent material, or of the loss of clay from the surface horizons without significant illuviation. Differential clay formation has also been postulated.

Soils 10 to 15, pages 75 to 80, (numbers for soil profiles, tables, figures, and pages are those in the text of Soil Classification, A Comprehensive System, 7th Approximation) have horizons with the more or less typical features of argillic horizons. Chemical and mineralogical data for the first three soils are given in table 10, page 36.

In mineralogy, the clay that has moved does not usually differ from the clay that has not moved except that in mixtures that contain montmorillonite it does seem that montmorillonite is more completely removed from the A horizon than the other kinds of clay. Elemental and mineralogical analyses of the clay fraction of soils with argillic horizons normally show little or no difference between the clay of the various horizons. Analyses of the fine earth (less than 2 millimeters) and of the clay fraction (less than 2 microns) are shown for three soils in table 10. Soil 10 has been considered a Terra Rossa; soil 11, a Gray-Brown Podzolic soil; and soil 12, a Red-Yellow Podzolic soil. The constancy of the SiO_2/R_2O_3 ratios of the clay fraction and the uniformity in the clay mineralogy in the various horizons of each soil attest to the lack of large differences between the clays of the horizons. In contrast to the constancy of the SiO_2/R_2O_3 ratios of the clay fraction, the ratios for the fine earth differ among horizons. These differences are attributable to differences in clay percentages. As the clays have a lower SiO_2/R_2O_3 ratio than the silt and sand, the SiO_2/R_2O_3 ratio for the fine earth decreases as the proportion of clay rises. If the ratios for soils 11 and 12 are recalculated to what they would be if clay of the composition of that in the C were added or subtracted to bring the horizons to the same clay percentage as the C horizon, the differences among horizons tend to disappear. For a given profile, the dependence of the SiO_2/R_2O_3 ratios on the clay percentage lends support to a hypothesis that the differences in clay between the A and B are due largely to clay movement. The amount of clay is a function of parent material, climate, relief, vegetation and time.

Soil 10, in which the argillic horizon directly underlies an Ap, shows the greatest accumulation in the horizon just above the limestone. In this soil it is probable that the plow layer itself consists largely of material from the argillic horizon.

Soils 13, 14 and 15 are included to show the concentration of the fine clay in the argillic horizon. The data for these soils are summarized in table 11, page 38.

Recognition of Translocated Clay

Since translocated clay is basic to the concept of argillic horizons, its identification in the soil can help identify the horizons. Translocated clay can often be distinguished in the field from other clay and can be distinguished more often in the laboratory by observing its orientation. The layer-lattice clays are generally platy in shape, and if they have been moved and deposited, tend to be oriented with their long axes parallel to the surfaces on which they were deposited. Halloysite is the principal exception. The movement of clay may be from one horizon to another, or it may be within a horizon. Since water is the agent that moves the clay, the translocated clay tends to form coatings of oriented clay particles on the channels through or into which water moves or in which it stands. These channels are principally crevices bounded by the cleavage faces of peds, and the pores left by roots or animals.

Clays deposited in sediments such as shale or till may be oriented with the depositional or stress surface. Clays that formed in place within the soil may be oriented according to the crystal structure of the original mineral grain from which they formed, i.e. micas and feldspars. However, neither the mineral grains nor the planes in the shale or till are normally oriented with respect to any soil features. Consequently, in thin sections, the layers of oriented clays in peds, on the surfaces of pores, and on the surfaces of peds often can be distinguished from the rest of the clay. Usually the boundary between coating and matrix is sharp and the coating is nearly free of sand and silt inclusions. Figures 6, 7, and 8, pages 39 to 41, show the appearance of the layers of oriented clays in thin sections. Figure 6 shows the layering on a ped surface; figure 7 shows a pore that has been filled with clay; figure 8 shows how clay

accumulates in a sand as coatings on the grains of sand and as bridges between the grains. The layered appearance of the clay coatings in these figures suggest cyclical illuviation. Each figure includes two photographs: A was taken with ordinary light, and B under crossed polarizers. The brightness under crossed polarizers of the interference color of the clay bodies (sometimes called birefringence) is evidence of orientation of the clay particles. Extinction of transmitted light through the clay occurs in certain planes when the thin section is rotated. The pattern of light transmission or extinction and the layering indicate that the orientation is parallel to the surfaces on which the clay has been deposited.

Figure 9, page 42, is included for contrast. It shows a ped surface in the cambic horizon of a Dystrochrept (Sol Brun Acide). The layered clays are absent on the ped surfaces. Instead, one finds weak orientation of the silts and clay, and no distinct difference in texture between the ped coat and the ped interior is evident.

The peds in an argillic horizon have varying stabilities, and the fragmentation and consolidation of peds may be relatively rapid or slow. Particularly under forests, woody roots can disrupt peds and on decomposition leave new planes of weakness. Thus, clay skins that formed on the surface of a ped may now be found in the interiors of many peds as streaks of oriented clay. Shrinking and swelling of peds may have the same effects. Another mechanism is the collapse of pores. Consequently, in many soils, clay skins may be few and thin or even absent on the peds in the upper part of the argillic horizon. Deeper horizons, subject to less disturbance by roots and volume changes, should have more stable peds, and often they show the thickest and most abundant clay skins on ped surfaces.

To have thick continuous clay skins on the ped surfaces, the peds must be stable in relation to the rate of illuviation. Thus, one does not expect many or thick clay skins in the upper part of an argillic horizon if the eluvial horizon is thoroughly depleted of clay. In fact, in soils on very old stable surfaces of humid forested climates there may 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, the clay skins on and in the peds are found only in the lower parts.

If the clay mineral is halloysite, optical evidence of orientation of the clay cannot be expected. However, the evidences of translocation may be present in the form of layered coatings of clay on peds or in pores.

In the field, the oriented clays on the ped surfaces and in pores, variously called clay skins, clay films, clay flows, illuviation cutans and tomhäutchen, can be recognized with high precision if they are well developed and in medium textured or moderately coarse textured materials. Uncertainty of recognition increases if the layers are thin, or if the matrix material has a clay texture. Figure 10, page 43, shows under magnification, a thick clay skin in a pore and very thin clay skins on the ped surfaces of an argillic horizon. Figure 11, page 43, shows clay skins and clay bridges in a sand. Examination of ped surfaces and pores with a 10- to 20-power hand lens usually discloses one or more of the features common to most clay skins. The skins may differ from the ped interiors in color as well as in texture. Pores emerging on the lower side of a ped often have irregular lips where the clay protrudes. Often the surfaces have an irregular shape and show channels and apparent flow lines formed by running water.

Structureless or massive soils obviously cannot have clay skins on ped surfaces, since they have no peds. The clays in the illuvial horizons of these soils are usually found as coatings on the individual sand grains, and these coatings often are oriented with the surfaces of the grains (see figure 8). Occasional pores in these horizons persist long enough to have patchy or continuous clay skins, with flow lines. These appear in figure 8 in both upper and lower center.

The clay skins are important in the field identification of most argillic horizons because they indicate translocated clay. Yet clay skins alone are at times not adequate to identify an argillic horizon. Because of the turbulent flow of water down wide cracks, clay skins might be formed by a single rain in a soil having no significant illuviation. For this reason, clay skins in an argillic horizon should occur on all sides of the peds, not just on the vertical faces, and they should be more than an occasional spot.

Special Problems in Identification

Identification in Soils Formed In Isotropic Medium-Textured Parent Material

The Formative Stage: If we start with the simplest situation--a medium textured soil developed from a single parent material having no lithologic discontinuities--the loss of about 10 percent of the clay in the eluvial horizon and its accumulation in an illuvial horizon normally produce a textural change that can be recognized consistently by trained soil morphologists. At this point the ratio of the clay in the illuvial horizon to the clay in the eluvial horizon is about 1.2 (e.g., 25 percent in the surface horizon, and 30 percent in the argillic horizon), if the two horizons are of about equal thickness. There are common or frequent 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 the recognition of an argillic horizon.

In addition to the increased clay content and clay skins, we can expect the argillic horizon to have at least two other properties in this situation. The first property is thickness. Significant illuviation requires that the illuvial horizon have a reasonable thickness. An illuvial horizon 1 cm. thick underlying an eluvial horizon 50 cm. thick would not indicate a great deal of translocation. The illuvial horizon's thickness should be at least one-tenth that of the overlying horizons to indicate significant illuviation.

The second property is related to the transition from the eluvial horizon to the argillic horizon. The boundary may be abrupt or even gradual, but the clay content increases sharply enough that the limits for an argillic horizon are exceeded within a 12-inch vertical distance. To have an argillic horizon, the minimum increase in clay should occur within a 12-inch or thinner transition. It should be stressed that an increase in clay content with depth is not in itself evidence of an argillic horizon.

Stages of Degradation: Detailed studies of the micromorphology of some soils with argillic horizons (e. g., Glossoboralfs) show evidences that an argillic horizon may be formed and later destroyed. The clay skins are absent from the ped surfaces, and bleached coatings of silt or sand are left. Oriented clays within the peds persist for a time. It is possible, therefore, to have an argillic horizon undergoing degradation. Such a horizon has few or no clay skins on ped surfaces but has few or many oriented clay bodies within the peds. It is common in degrading horizons that the clay skins on ped surfaces or in pores are most abundant in the lower part of the argillic horizon and in the transition to the next underlying horizon. In advanced stages of degradation there may be no clay skins in or on the peds in the upper part of the argillic horizon.

The degrading argillic horizon shows evidence of degradation in addition to that indicated by absence of clay skins. It has an irregular upper boundary marked by narrow or broad penetrations of the eluvial horizon. Small nodular remnants of the argillic horizon are often found in the lower part of the eluvial horizon.

To summarize, if a horizon has an irregular or broken upper boundary it is considered an argillic horizon so long as it (1) retains a clay ratio of 1.2 or more with the overlying horizon; (2) has oriented clays in or on peds in the lower part; and (3) has an upper subhorizon with an irregular upper boundary that is not separated from the subhorizon with clay skins by an eluvial horizon (the albic horizon which is discussed later).

Identification in Sandy Soils

In sands and loamy sands, the argillic horizon often forms as a series of "fibers", or lamellae (fig. 12, p. 44). These are spaced at intervals ranging from a very few inches up to a foot or more. Only the lamellae are used for comparing textures and determining the thickness of the illuvial horizon. Obviously, a single lamella with a thickness of 2 mm. should not constitute an argillic horizon. It is too thin to indicate significant illuviation. Lamellae 1 cm. or more thick, and totaling something like 15 cm. or more in thickness, should be present for the recognition of an argillic horizon in sands and loamy sands.

Whether the argillic horizon is continuous or in lamellae, an arbitrary and somewhat higher ratio of the clay in the illuvial and eluvial horizons seems necessary in sandy soils. If the clay content of the parent material is only 1 percent, the movement of 10 percent of the clay from the surface horizon to an illuvial horizon would give clay contents of 0.9 and 1.1, respectively, if the two horizons had the same mass. Such a difference is too small to be detected in the field, or even in the laboratory by ordinary procedures. For this reason, an arbitrary difference of at least 3 percent of the total soil, the difference between 3 percent clay and 6 percent clay, has been selected as a division point for those soils having less than 15 percent clay in their surface horizons. With a difference of less than 3 percent clay between the eluvial and illuvial horizons, an argillic horizon is not recognized, although a B horizon may be readily discernible.

Identification in Fine-Textured Kaolinitic Soils

A ratio of the clay in the illuvial and eluvial horizons of 1.2 would require an unreasonable amount of translocation in parent materials rich in clay. A difference of 8 percent of the total fine earth fraction ordinarily should be detectable in clayey soils in the field and is easily measured in the laboratory. Consequently, if the surface horizon contains more than 40 percent clay, an increase of 8 percent or more in a subsurface horizon seems adequate for the recognition of an argillic horizon if the other characteristics of the horizon are present.

If the surface horizons are clayey, an argillic horizon is rarely obvious. Normally there is little or no color difference between the illuvial horizon and other horizons. Clay skins are difficult to see in the field because they have little contrast in texture with the matrix. They are also most susceptible to destruction in fine-textured horizons by pressure and by changes resulting from consolidation or fragmentation of peds that make for instability of ped surfaces. Even in the laboratory, uncertainty is great because pressures and stresses can produce clay orientation.

Consequently, in fine-textured kaolinitic soils evidences of illuviation are usually at a minimum. We can expect to find a clay increase of 8 percent within a vertical distance of less than 12 inches (30 cm.) if the soil has not been truncated. We can usually expect to find moderate to strong blocky or prismatic structure. And we can expect to find weak to strong orientation of clays throughout the peds of the argillic horizon and clay skins on the peds and pores in the lower part of the argillic horizon where peds should be most stable. If these features are present, we should consider the horizon an argillic horizon.

Identification of fine-textured horizons that contain expanding 2:1 lattice clays

Argillic horizons have some unique properties if their textures are clayey with marked swelling and if there is a strong textural contrast with the eluvial horizon. Clay skins under such conditions are difficult or impossible to identify. When the horizons swell pressures are generated that produce irregular but smooth ped surfaces with clay textures. It seems probable that the pressure can destroy any clay skins that may form on the ped surfaces. Therefore, if the illuvial horizon is rich in clay and shrinks and swells appreciably, clay skins are not apt to be useful as marks of illuviation. In soils that do not have a lithologic discontinuity between the eluvial and illuvial horizons, the difference in clay content may be used as one evidence. Others that may also be used in soils having lithologic discontinuities are abrupt, tongued, boundaries; irregular or wavy boundaries; and evidences of eluviation in the transitional horizons in the form of uncoated silt and sand grains, particularly where the uncoated grains are most prominent on ped faces. These evidences should be accompanied by evidences of shrinking and swelling of the finer textured horizon in the form of occasional slickensides, or pronounced wavy horizon boundaries with an amplitude of at least 2 inches in a pedon. In thin sections, pressure orientation may be deduced from the birefringent prism faces and from the interiors of peds that show large quantities of optically oriented clay but no clearly identifiable clay skins.

The argillic horizon may have more clay than the C, but this is not necessarily so in soils from stratified or very fine textured parent materials. The argillic horizon should, however, have relatively more fine clay than the parent material in which it developed. In soils from fine-textured materials the C horizon can have as much or more total clay than the argillic horizon. Data on the amount of fine clay are relatively scarce, but for soils developed in clayey parent materials we might expect that either the content of fine clay will be maximum in the argillic horizon, or that the ratio of fine to coarse clay will be a maximum in that horizon.

Soil 16, page 81, illustrates a soil developed in such material. There is as much or more clay in the C than in the argillic horizon, which starts at 11 inches and extends to 30 inches. In the argillic horizon the fine clay constitutes half of the total. In the A it is about one-quarter of the total, and in the C it is about one-third. The clay in the C is dominantly illite.

Another common situation is that in soils developed from limestone, where the argillic horizon apparently has less clay or no more clay than the C. At this time, data are not adequate to predict whether the ratio of fine clay to coarse clay will permit a clear distinction between the argillic horizon and the C horizon.

Identification in 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 recognition of argillic horizons. If the eluvial and illuvial horizons have not developed from the same material, or if no eluvial horizon remains for comparison, the difference in clay content between the horizons cannot be used to define the limits of the argillic horizon. It is common on flood plains to find recent deposits of sand lying on clay. The ratio of clay in the lower layer to the clay in the surface layer may exceed 3, even though none of the clay is illuvial. On the other hand, in old stratified deposits, the horizon of illuvial clay accumulation may coincide with an originally finer textured stratum, but one does not want to assert that illuvial horizons cannot form in stratified materials.

Some soils that have been cultivated for many years have lost their original eluvial horizons. In these soils the plow layer may be in the argillic horizon. If cultivation is stopped and the soil remains undisturbed under grass or forest for a few generations, a new A1 horizon may form in the old plow layer. In time, evidence of the plowing disappears and a profile is formed that has a thin A1 horizon containing as much clay as the B.

It is desirable to recognize the argillic horizon at about the same stage of development in all soils. The development of clay skins in the soils formed from stratified parent materials should be equal to the development in the most weakly expressed but recognizable argillic horizons of soils that developed in uniform parent materials. It is, therefore, necessary to look in stratified materials or in truncated soils where only an Ap overlies the horizon in question for the evidences of illuviation and eluviation, the clay skins, the ratios of fine clay to coarse clay, and ped coatings of bleached silt and sand. If most of the peds have coatings that cover some 10 to 15 percent

of their surfaces with clay skins thick enough to obscure fine sand grains, and have some pores with nearly continuous clay skins, or if thin sections show something like 1 percent of some part of the horizon to be oriented clays, the horizon is considered to be an argillic horizon.

In summary, we can say that an argillic horizon is one that contains illuvial layer-lattice clays. This horizon forms below an eluvial horizon, but it may be at the surface if a soil has been partially truncated, and it has the following properties that may be used for identification in the field:

1. If an eluvial horizon remains, and there is no lithologic discontinuity between it and the argillic horizon, the argillic horizon contains more total and more fine clay than the eluvial horizon, as follows:
 - a. If any part of the eluvial horizon has less than 15 percent total clay in the fine earth (less than 2 mm.) fraction, the argillic horizon must contain at least 3 percent more clay. (13 percent versus 10 percent, for example.)
 - b. If the eluvial horizon has more than 15 percent and less than 40 percent total clay in the fine earth fraction, the ratio of the clay in the argillic horizon to that in the eluvial horizon must be 1.2 or more.
 - c. If the eluvial horizon has more than 40 percent total clay in the fine earth fraction, the argillic horizon must contain at least 8 percent more clay. (50 percent versus 42 percent, for example.)
2. An argillic horizon should be at least one-tenth the thickness of the sum of all overlying horizons, or more than 15 cm. (6 inches) thick if the eluvial and illuvial horizons are thicker than 1.5 (60 inches). The clay increases required under item 1 are reached within a vertical distance of 30 cm. (12 inches) or less.
3. In massive soils the argillic horizon should have oriented clays bridging the sand grains and in some pores.
4. If peds are present, an argillic horizon either (1) shows clay skins on some of both the vertical and horizontal ped surfaces and in the fine pores, or shows oriented clays in 1 percent or more of the cross section; or (2) meets requirements 1 and 2 above and has a broken or irregular upper boundary accompanied by some clay skins in the lowest part of the horizon; or (3) if the horizon is clayey with kaolinitic clay and the surface horizon has more than 40 percent clay, there are some clay skins on peds and in pores in the lower part of that horizon having blocky or prismatic structure; or (4) if the illuvial horizon is clayey with 2 to 1 lattice clays, clay skins may be lacking, provided there are evidences of pressure caused by swelling; the evidences of pressure may be occasional slickensides or wavy horizon boundaries in the illuvial horizon, accompanied by uncoated sand or silt grains in the overlying horizon.
5. If a soil shows a lithologic discontinuity between the eluvial horizon and the argillic horizon, or if only a plow layer overlies the argillic horizon, the argillic horizon need show only clay skins in some part, either in some fine pores, or if peds exist, on some vertical and horizontal ped surfaces. Thin sections should show that some part of the horizon has about 1 percent or more of oriented clay bodies.

NATRIC HORIZON

The natric horizon is a special kind of argillic horizon. It has, in addition to the properties of the argillic horizon, (1) prismatic, or more commonly, columnar structure, or rarely a blocky structure with tongues of an albic horizon extending more than 2.5 cm. (1 inch) into the horizon; and (2) in some subhorizon more than 15 percent saturation with exchangeable sodium. Or, if an underlying C horizon has more than 15 percent saturation with sodium in some part, the natric horizon may have more exchangeable magnesium plus sodium than calcium plus hydrogen in some subhorizon.

It should be noted that some subhorizons of the natric horizon may have hydrogen or calcium as the dominant exchangeable cation if other subhorizons have the necessary sodium. Or, some subhorizons may have hydrogen or calcium as the dominant cations if other subhorizons have a dominance of magnesium, and the C horizon has more than 15 percent saturation with sodium in some part.

The natric horizon is common to most soils that have been called solodized-Solonetz and Solonetz. Figure 13, p. 45, shows the typical appearance of a natric horizon in a soil profile.

The effect of the sodium on dispersion of clays and the formation of argillic horizons has been long recognized. The importance of special recognition of argillic horizons that have large amounts of exchangeable sodium has not been seriously questioned.

The effect of the magnesium ion on the dispersion of clays is still disputed. Laboratory studies seem to show but slight difference between the effects of magnesium and calcium. Yet it is common to find a poor physical condition in clays with large amounts of exchangeable magnesium, and the reasons for this relation are unknown. In the absence of more definite data, the authors cannot accept the idea that the effects of magnesium ions are similar to those of sodium ions. Magnesium has been included in the definition of the natric horizon because, as the sodium is being removed, magnesium seems to follow in the leaching sequence. If leaching continues, the magnesium is eventually replaced by hydrogen. When replacement reaches the point that saturation by magnesium and sodium is less than 50 percent of the exchange capacity in all subhorizons, the horizon is no longer considered natric. One sees relicts of such horizons, with their form clearly evident but with all other properties altered because of great changes in the environment.

Some examples may help clarify the criteria for the natric horizon. Data for three soils from North Dakota and South Dakota are given in table 12, p. 46. All were developed under grass, have distinct prismatic or columnar argillic horizons, and have been considered by some soil scientists as solodized-Solonetz.

The first soil, (17), has a natric horizon because the exchangeable sodium exceeds 15 percent of the exchange capacity. The second soil, (18), from Sargent County, North Dakota, has a natric horizon because the magnesium and sodium exceed calcium (exchangeable hydrogen is very small in the montmorillonite clay of this soil) and because exchangeable sodium exceeds 15 percent of exchange capacity in the two lowest horizons. The third soil, (19), has an argillic horizon, but not a natric horizon, because exchangeable sodium is less than 15 percent, and exchangeable calcium exceeds the sum of magnesium and sodium. In this last soil it is impossible to be sure that there was ever any significant amount of sodium.

Chapter 5

THE SPODIC HORIZON

The spodic horizon is one in which active amorphous materials composed of organic matter and aluminum, with or without iron, have precipitated. The term "active" is used here to describe material having high exchange capacity, large surface area, and high water retention. In virgin soils the horizon usually lies below an eluvial mineral horizon, normally an albic horizon, it may less commonly be at the surface of the mineral soil but below an O horizon, or in cultivated soils it commonly is immediately below the Ap horizon.

Genesis of the Spodic Horizon

Spodic horizons occur only in humid environments. They are most common in cold and temperate climates but they also occur in hot climates. They are not found in arid environments though they occur in Mediterranean climates having long dry summers.

In cool climates, spodic horizons occur in soils that have had a heath (*Erica* and *Calluna*) or forest vegetation, either broadleaf or coniferous. Heath is associated with spodic horizons that have subhorizons containing little or no free iron. In a mixed forest the spodic horizon is often more strongly expressed under some species, such as hemlock (*Tsuga canadensis*), than under others. The type of vegetation and type of litter are important, but we lack a generally accepted theory. In warm climates spodic horizons occur under savanna, palms, and mixed forests. Spodic horizons under some conifers, such as the kauri pine (*Agathis australis*), may have subhorizons containing little iron.

Spodic horizons form mostly in coarse-textured (sandy, coarse-loamy, or coarse-silty) acid parent materials. Some have formed in finer textured material. Because there may be no albic (A2) horizon, some may have been overlooked in the past. Also, aggregation of fine material causes such horizons to appear coarser than they are. If a parent material is rich in clay, however, the formation of a spodic horizon is usually delayed until eluviation or weathering has reduced the clay content below a critical level. A spodic horizon then forms in the eluvial horizon, and the underlying argillic horizon is either destroyed or moved to greater depth as the spodic horizon thickens. Spodic and argillic horizons are usually separated by an albic horizon, but under heath vegetation a spodic horizon may rest directly on and tongue into an argillic horizon. Similarly, in calcareous parent materials formation of a spodic horizon does not commence until carbonates have been leached from the upper part of the profile. Spodic horizons form on relatively fresh parent materials containing unweathered primary minerals or on nearly pure quartz sand.

Spodic horizons can form in well-drained soils or in soils having a shallow fluctuating ground-water level. If the ground-water level is within the spodic horizon for long times, the spodic horizon may lack iron. Spodic horizons do not seem to develop in soils that are permanently saturated with water.

Under optimum conditions, spodic horizons can form in a few hundred years. Their biological destruction can be equally rapid in cultivated soils.

Most spodic horizons are horizons in which organic matter, iron, and aluminum have accumulated. As far as we know, aluminum is always present and is probably essential. Almost all spodic horizons have an organic matter, iron, and aluminum maximum in the upper few centimeters of the horizon, although in some iron may be absent or the iron and aluminum maxima may be below the organic-matter maximum. Most spodic horizons have hues of 10YR or redder. The presence of such hues in spodic horizons lacking iron, the persistence of the hues after reduction if iron is present, and their destruction by ignition if iron is absent all suggest that organic compounds are important dyes.

The mobile sesquioxide^{1/} can come from dissolution of primary minerals and from cycling by plants. In albic horizons that overlie spodic horizons, the aluminosilicates appear fresh but many are pitted as by solution. This is particularly true of ferromagnesian minerals. Yet a well-developed spodic horizon may be the surface mineral horizon, overlain only by an O horizon. While mixing of horizons by animals or falling trees can usually be demonstrated in such soils, more than one source of the precipitated sesquioxides is possible.

In some older theories of the formation of spodic (or Podzol B) horizons, mutual flocculation of positively charged sesquioxide colloids and negatively charged organic colloids has been postulated. In others, flocculation of sesquioxides or organic matter by changes in redox potentials or in pH with depth has been proposed.

^{1/} As used here, sesquioxide refers to compounds of iron and aluminum.

Spodic horizon--Cont.

According to newer theories an association is formed between organic matter and iron and aluminum by chelation and electrostatic bonding. Such compounds are soluble if the sesquioxide concentration is low and are precipitated when the sesquioxide concentration reaches a critical level. Hence, if soluble compounds moving through the soil pick up sesquioxides from primary minerals and from parts of the spodic horizon, they eventually precipitate somewhere in the spodic horizon. Such movement can be downward due to gravity or lateral or even upward due to capillary forces. Immobilization of the 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 spodic horizons can be used as one of the means of identification. These properties are high concentration of carboxyl and hydroxyl sites that are destroyed on heating and solubilization of organic matter and sesquioxide compounds on treatment with a strong complexing agent (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 from the eluvial to the illuvial horizon and within the illuvial horizon to form argillic horizons. Hence, in soils with argillic horizons, the clays in the eluvial and illuvial horizons are similar except when some one clay mineral moves preferentially to others. The silica-sesquioxide ratio for the whole soil is at a minimum in the argillic horizon but that of the clay fraction remains virtually constant throughout the profile. In soils with spodic horizons the dominant processes are dissolution of primary minerals in any eluvial horizon, movement of iron, aluminum, and organic matter, and precipitation of amorphous organic matter-metal complexes. Typically, the mineralogy of eluvial and illuvial horizons differs greatly and the silica-sesquioxide ratio in the spodic horizon is at a minimum both in the whole soil and in the clay fraction.

In mechanical analysis at least some of the illuviated iron and aluminum disperses and becomes part of the measured clay fraction^{2/}. Hence, data commonly show a clay maximum in the spodic horizon. Both spodic and argillic horizons may be horizons of free iron accumulation. But in well-drained soils having argillic horizons the ratio of free iron to clay tends to be constant in all horizons, whereas in soils having spodic horizons this ratio tends to be variable.

In table 13, page 60, 7th Approximation, two soils with spodic horizons are compared to two soils with argillic horizons. All four soils have an albic horizon and have been considered Podzols by some. Descriptions of the soils and additional data are on pages 85 to 88. Although the silica-sesquioxide ratio of the whole soil has a minimum in both groups of soils, this ratio for the <0.002-mm fraction is approximately constant throughout in the soils with argillic horizons and highly variable in the soils with spodic horizons.

Micromorphology also shows that there are large differences. The birefringent crystalline clay coatings of the argillic horizon (fig. 6, page 39, 7th Approximation) differ sharply from the isotropic amorphous coatings of the spodic horizons (fig. 15, page 48). Most spodic horizons, however, contain some illuviated crystalline clay.

Distinctions between Spodic and Cambic Horizons

The cambic horizon is formed by alteration of parent material in place, causing release of iron and structure formation, or by solution and removal of carbonates; it is never an illuvial horizon but it may contain large amounts of precipitated active amorphous materials that are very similar to those of the spodic horizon. There are two situations where spodic and cambic horizons may be confused in the field. A cambic horizon may grade by imperceptible stages into a spodic horizon as a result of varying amounts of accumulation of amorphous materials. A very weakly developed spodic horizon, however, contains more active amorphous material than many cambic horizons, and the two kinds of horizon can be separated either on the basis of their micromorphology or by the chemical techniques described later. It may also be difficult to distinguish spodic horizons from the cambic horizons of soils developed in pyroclastic materials such as volcanic ash. Both horizons contain amorphous materials that do not differ significantly in the kinds of measurements we can make now. Both kinds of amorphous material may lose similar proportions of their cation-exchange capacity upon heating or extraction with dithionite-citrate.

The distinction between the spodic horizon and the cambic horizon with an amorphous active fraction (in soils formed in vitric materials such as volcanic ash) is based first on evidences of illuviation. Assume there is an overlying eluvial (albic) horizon that extends below plow depth as a continuous horizon or even as an intermittent horizon. In this situation we may safely infer that the underlying horizon is illuvial provided it meets the minimum requirements for extractable carbon, iron and aluminum relative to clay. The eluvial (albic) horizon should have chromas of 2 or less, or sand and silt grains that are dominantly clean, and it should be thick enough to insure that some part of the eluvial horizon extends below plow depth. A very thin eluvial horizon, only 1 to 3 cm thick, is apt to be accompanied by an illuvial horizon of comparable thickness and would not by itself indicate sufficient illuviation for a spodic horizon. It is apt to indicate only the beginning formation of a spodic horizon.

^{2/} The illuvial material of some spodic horizons disperses readily in one and not in another dispersing agent. Hence, different methods may give different results. In some spodic horizons the apparent silt accumulation is more pronounced than the clay accumulation.

Chapter 5

Spodic horizon--Cont.

If the soil has an amorphous active fraction and there is no albic horizon or only a thin albic horizon that will not persist after plowing, the distinction is based on the nature and amounts of the non-clay fraction. If the horizon is clayey with mostly amorphous clays, it is considered to be a cambic horizon. Because the amorphous clays do not disperse well, the 15-bar water retention is a more valid measure of the clay content. An upper limit of 20 percent 15-bar water is used for the spodic horizon. If the 15-bar water is less than 20 percent the horizon is considered spodic only if the silt and sand are mostly (more than 40 percent of the 20 to 200 micron fraction) crystalline minerals such as quartz, feldspars and micas. If the 15-bar water is less than 20 percent and 60 percent or more of the 20 to 200 micron fraction is vitric pyroclastic material such as ash and pumice, or if the 15-bar water exceeds 20 percent the horizon is considered cambic.

Recognition of the Spodic Horizon

In the field

If an albic horizon overlies a spodic horizon, there is seldom any difficulty in recognizing the illuvial origin of the spodic horizon. In virgin soils that lack albic horizons there is commonly a thin dark eluvial horizon in which many sand grains are free of humus and sesquioxide coatings. This overlies the spodic horizon in which the sand grains are completely coated, and indicates the illuvial origin of the spodic horizon.

Many spodic horizons are so close to the mineral surface of the soil that the overlying horizons are easily destroyed by plowing or even by the disturbances that accompany the cutting of a forest. In some the albic or other overlying horizons seem to have been mixed with the spodic horizon by falling trees, by animals, or may never have existed. In a disturbed soil it may be difficult or impossible to establish the illuvial nature of the spodic horizon, even though it has all the chemical and physical properties of spodic horizons that are clearly illuvial. To keep like soils together in the classification, coatings on crystalline sand grains of an isotropic amorphous mixture of organic matter, iron, and aluminum with the specific properties discussed later, are considered adequate for recognition of spodic horizons.

If a bleached eluvial (albic) horizon is distinct, there is commonly a second maximum of organic carbon in the spodic horizon. The presence of organic carbon and the characteristics of the exchange complex, such as high cation-exchange capacity, distinguish cemented spodic horizons (ortsteins) from ironstone layers at lithologic discontinuities below many soils. It should be pointed out that spodic horizons may occur at depths of more than two meters in some tropical and subtropical areas. Buried spodic horizons may be found at even greater depths. Figure 16, page 49, 7th Approximation, shows a profile having a spodic horizon underlying an eluvial A2 horizon (albic horizon).

The typical spodic horizon is easily recognized in the field by its color and structure. The texture is most often sandy, coarse loamy, or coarse silty. Hues, values, and chromas change markedly with depth within a few centimeters. The lowest values, reddest hues, or highest chromas are in the upper part of the horizon. Colors are mostly 10YR or redder in hue with moist values and chromas of 5/6, 4/4, 3/2, and 2/1, or with these values in higher chromas. The horizon below the spodic horizon has lower chromas or yellower hues, or some combination of these. Structure, in the conventional meaning (visible to the naked eye), is absent or there is crumb, granular, or platy structure or weak blocky or prismatic structure. Subrounded to subangular black or dark brown pellets of silt size (20- to 50-micron diameter) and coatings on sand grains can be detected in sandy spodic horizons by using a 40- to 60-power hand lens. Figure 14, page 47, 7th Approximation, shows the pellets in thin section. 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 cemented. In a dry soil the coatings may be cracked and may flake off to form pellets. Figure 15, page 48, 7th Approximation, shows a cemented spodic horizon in thin section. Clay skins, discussed with the argillic horizon, are not found on peds or in pores in spodic horizons although coatings on sand grains in a spodic horizon may not be distinguishable with a hand lens from thin clay coatings in an argillic horizon.

If textures are silty or fine loamy, pellets and coatings may not be visible. Color changes with depth may be more diffuse than if textures are sandy. If textures appear to be moderately fine and the bulk density is low enough that the finger can be pushed into the soil in the side of a moist fresh pit, one must suspect a cambic horizon with an amorphous active fraction. Similarly, one must suspect a cambic horizon if the textures appear to be coarse loamy or coarse silty and ash or pumice are abundant in the silt and coarse fraction.

If textures are silty or fine loamy and the bulk density is 1 or more, the pellets, coatings, cementation, and colors discussed above furnish the best clues for field distinction between spodic and cambic horizons.

Spodic horizon--Cont.

In the laboratoryOptical identification of amorphous material

Many spodic horizons can be identified with certainty by the presence of well-defined isotropic coatings (fig. 15, page 48, 7th Approximation) or of well-defined isotropic pellets (fig. 14, page 47). Some may be confused with argillic horizons if the coatings are weakly anisotropic in the part closest to an underlying sand grain or if there are significant inclusions of mica or other anisotropic clay minerals. Optical methods also may not be reliable if only diffuse pellets are present or if volcanic glass or other evidence of pyroclastic material leads one to suspect a cambic horizon that contains amorphous clay. In such cases the positive identification of spodic horizons may have to be based on chemical and physical methods.

Chemical identification

Some of the properties of the active amorphous material of spodic horizons such as high cation-exchange capacity, loss of exchange capacity on heating,^{3/} and the presence of specific functional groups have been mentioned before. It would be desirable to define the spodic horizon by such properties. Some forms of organic matter and amorphous (allophane-like) material in some cambic horizons, particularly those developed in pyroclastic materials, have such similar properties that an exclusive definition of spodic horizon in these terms is impossible at this stage of our knowledge.

The spodic horizon is therefore defined here in terms of (1) 15-bar water retention, (2) percentage of pyroclastic material in the silt and coarser fractions and (3) solubility of its active components--organic matter, hydrated iron oxides, and hydrated aluminum oxides--in hot dithionite-sodium pyrophosphate relative to the clay content of the horizon:

1. The 15-bar water retention is <20 percent
2. Less than 60 percent of the 20 to 200 micron fraction (by weight) consists of vitric ash, pumice or other pyroclastic materials
3. $\frac{\text{percent extractable carbon} + \text{iron} + \text{aluminum}}{\text{percent clay}} \geq 0.15$

These conditions must be satisfied in any one subhorizon having enough extractable Fe, Al, or organic matter to satisfy the "other limits" discussed later. Carbon, iron, and aluminum (elemental concentration) are extracted by hot pyrophosphate-dithionite solution at pH 7.3; percentage of clay and silt are determined by the hexametaphosphate-pipette method.

Representative data for spodic horizons and selected cambic, argillic, and oxic horizons, as well as mollic and umbric epipedons, are given in Table A. Pyrophosphate-dithionite is used as the extractant to permit the carbon determination. Pyrophosphate-dithionite solution seems to be somewhat specific for the kinds of carbon, iron, and aluminum in the amorphous material. In spodic horizons usually more than half of the total carbon is extracted, whereas in the absence of amorphous (allophane-like) materials, less of the total carbon is extracted. In spodic horizons pyrophosphate-dithionite removes about as much iron as the dithionite-citrate method, but it removes only a small fraction of the dithionite-citrate-extractable iron from argillic, oxic, and some cambic horizons. The organic matter dissolved by pyrophosphate-dithionite may help to hold aluminum in solution. If solutions of aluminum salts are added to the extracting solution, aluminum pyrophosphate precipitates and no aluminum in solution is detected. Very little aluminum is extracted from gibbsite.

The amount of pyrophosphate-dithionite soluble carbon, iron, and aluminum and its ratio to clay permits the distinction between most spodic and other horizons that lack significant amounts of amorphous materials

Other limits of the spodic horizon

The amount of amorphous material in spodic horizons varies widely. It seems essential to set some lower limit for thickness of the horizon and its content of precipitated material. Spodic horizons below the plow layer should contain a subhorizon that is at least 1 cm thick and that contains at least 1 percent extractable organic carbon, iron, and aluminum (expressed on an elemental basis, not as oxides).

^{3/} Usually, the loss of CEC upon heating to 240° C. for 16 hours exceeds 25 percent for spodic horizons and is less than 25 percent for many other kinds of soil horizons (see Table A). This criterion would yield a satisfactory separation except for some very weakly developed horizons that have only traces of amorphous material, and cambic horizons with amorphous clays.

Chapter 5

Spodic horizon--Cont.

The limit of 1 percent for extractable carbon, iron, and aluminum is waived, however if the moist value of the spodic horizon is 3 or less, the moist hue is 7.5YR or redder and is as red or redder than the underlying horizon. These colors indicate that coatings of humus and other amorphous materials on the sand and silt are more or less continuous.

A horizon is not a spodic horizon if it is so thin, so near the surface, and so weakly expressed that plowing a few times to a depth of 6 or 7 inches obliterates all traces. A horizon that could be or has been incorporated in a 6- or 7-inch plow layer may be considered spodic if there are no underlying diagnostic horizons other than a fragipan with or without an intervening albic horizon and the following limits are satisfied:

- a. at least 3 percent organic matter (1.7 percent carbon) in the plow layer;
- b. a moist color value of less than 3 and a hue redder than 10YR, or a chroma of 3 or more;
- c. fragments of amorphous coatings or pellets;
- d. no underlying diagnostic horizon other than a fragipan or an albic horizon, or both.

The fact that a spodic horizon is continuous on one side of a fence or property line is not evidence that the Ap horizon on the other side of the fence includes a spodic horizon. If the land use pattern has been stable for some scores of years, a spodic horizon may have formed in the noncultivated soil under its present vegetation or, due to liming or other management practices, the Ap horizon may have lost most of the properties of a spodic horizon.

Summary of the Limits of the Spodic Horizon

1. If there is an albic horizon thicker than 18 cm (7 inches) or there is an intermittent albic horizon below an Ap a spodic horizon has:
 - a. Enough amorphous material that

$$\frac{1/4 \text{ percent extractable C + Fe + Al}}{\text{percent clay}} \geq 0.15$$
 - b. A thickness of 1 cm or more, either as a continuous horizon or as a sum of lamellae within 1 m (40 inches);
 - c. Extractable $\frac{1}{4}$ carbon + iron + aluminum \geq 1.0 percent, or moist color hues are 7.5YR or redder and moist values of 3 or less in some continuous part of the horizon or in any one subhorizon that is at least 1 cm thick and hues are as red or redder than the underlying horizon.
2. If an O, an Ap, or an Al rests on the spodic horizon, the spodic horizon has the requirements of 1. above, and in addition has:
 - a. A 15-bar water content of less than 20 percent;
 - b. Less than 60 percent of vitric volcanic ash, pumice and other pyroclastic materials in the 20 to 200 micron fraction;
 - c. Enough depth that the horizon is not obliterated by plowing to 18 cm (7 inches) or enough degree of expression that the horizon after mixing to 18 cm (7 inches) meets the criteria listed under 3.
3. If an Ap is present and is not underlain by a diagnostic subsurface horizon other than a fragipan, with or without an albic horizon, the Ap is considered a spodic horizon if it has the following properties:
 - a. Contains more than 3 percent organic matter (1.7 percent organic carbon);
 - b. $\frac{1/4 \text{ percent extractable C + Fe + Al}}{\text{percent clay}} \geq 0.20$;
 - c. Fragments of amorphous coatings or pellets can be clearly identified;
 - d. The hue is redder than 10YR and the moist color value less than 3, or the chroma is 3 or more in hues of 10YR or redder;
 - e. A 15-bar water content of less than 20 percent;
 - f. Less than 60 percent of vitric volcanic ash, pumice and other pyroclastic materials in the 20 to 200 micron fraction.

$\frac{1}{4}$ Elemental weight percent by pyrophosphate-dithionite extraction.

TABLE A. Change in cation exchange capacity and loss of C, Fe, and Al on various treatments of selected diagnostic horizons

Soil series ^{1/} and suborder	Horizon	15- bar H ₂ O Pct.	Clay ^{2/} percent	Org. carbon ^{3/}	Dry ^{4/} CEC meq/100 g ^{5/}	240°C CEC	CEC Change on Heat- ing Pct.	C Extracted Pct.	Fe Extracted Pct.	Al Extracted Pct.	C + Fe + Al ^{7/} Pct. Clay
Camroden Orthod	Spodic	19.2	22.2	6.65	76.2a	25.2	-67	4.00	2.67	1.00	0.35
Faxton Orthod	Spodic	12.9	6.9	5.79	48.1a	9.8	-80	4.38	1.48	1.42	1.06
Potsdam Orthod	Spodic	7.8	14.7	0.79	12.9a	9.4	-27	.51	1.09	.69	.16
Windsor Orthod	Spodic	3.9	2.8	.54	6.5a	4.7	-28	.27	.46	.37	.39
Leon Aquod	Spodic	1.9	1.7	1.13	10.9	6.9	-37	.92	.02	.12	.62
"Antwerp" Humod	Spodic	8.3	1.1	3.46	19.4a	3.5	-82	2.51	.30	.24	2.77
"Kanto" Andept	Umbric epipedon	50.0		7.5	57.9a	41.5	-28	2.16	2.13	1.55	
Waimea Andept	Mollic	59.2		3.21	104.7a	94.9b	-9	1.57	2.49	.93	
Nipe Oxisol	Oxic	24.8	59.6	1.33	17.1	16.1	-6	.74	4.76	.95	.11
Hayesville Udult	Argillic	19.4	42.8	.38	6.8	8.7	+28	.22	2.12	.45	.07
Diablo Kerert	Mollic epipedon		47.4	.92	40.9	38.2	-7	.63	.37	.10	.02
Stockbridge Ochrept	Cambic	8.0	23.0	.27	8.9	8.2	-8	.17	.98	.20	.06
Brinkerton Aqualf	Argillic	17.2	35.6	.62	25.0	21.0	-16	.39	2.18	.30	.08

^{1/} Soil series names are uncorrelated field names subject to change. "Antwerp" and "Kanto" indicate neighborhood of samples.

^{2/} Hexametaphosphate-pipette determination.

^{3/} Walkley-Black or Allison (SSSAP 24:36, 1960).

^{4/} Air dry unless otherwise noted.

a. Field Moist

b. 200° C.

^{5/} Based on weight of untreated sample dried at 110° C.

^{6/} Pct. pyrophosphate-dithionite extracted (one treatment), pH 7.3.

^{7/} Percent C + Fe + Al (elemental weight percent by pyrophosphate-dithionite extraction).

The Genesis

The cambic horizon is an altered horizon having texture finer than loamy fine sand. The alteration of the cambic horizon is produced by movement of the soil particles by frost, roots, and animals to such extent as to destroy most of the original rock structure including fine stratification of silt, clay, and very fine sand in alluvial or lacustrine deposits, by aggregation of the soil particles into peds, and in addition by (1) hydrolysis of some of the primary minerals to form clays and liberate sesquioxides, or (2) solution and redistribution or removal of some carbonates, or (3) oxidation, reduction and segregation, or removal of free oxides.

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.

The cambic horizon may be at the surface if there is no A1 horizon. Otherwise, it is immediately below one of the diagnostic epipedons. It is considered a part of the solum and occurs within the zone normally reached by the roots of native plants. Thus, it normally lies in the position of a B horizon, and by many it is considered to be a B horizon. Its base must be at least 25 cm (10 inches) below the surface.

Below many argillic and spodic horizons there is a transition to the C in which there has been weathering and alteration. The alteration of this transitional horizon may be comparable to that of a cambic horizon. Yet, because there is an overlying argillic or spodic horizon, a transitional horizon of this kind is not considered a cambic horizon. Rather, it is considered a transition to the C horizon. This distinction, which may seem very fine, is primarily one of position in the profile; the cambic horizon occupies the position of a B horizon, between the A and C, and not the position of a transition between a spodic or argillic horizon and the C.

Similarly, there may be transitional horizons (A3 and B1), between the A and an argillic horizon, that have properties of a cambic horizon. Such horizons are not considered part of a cambic horizon if they rest directly on the argillic horizon, but they are considered transitional horizons. Nevertheless, a cambic horizon may be recognized in the same profile as an argillic horizon or a spodic horizon if the two are separated by another diagnostic horizon discussed later, the albic horizon, or if the argillic horizon is a buried horizon. Thus we see that position and alteration without illuviation are important characteristics of the cambic horizon.

Identification of the cambic horizon

The cambic horizon may have one of several somewhat contrasting forms, but each of these grades at times imperceptibly into the others. The genetic significance of the cambic horizon varies somewhat with the kind of soil. It consistently carries the implication of a subsurface horizon that has been altered without mineral accumulation. The degree of alteration may vary, but some weatherable minerals* are present. One could define the several kinds of cambic horizons and give them distinctive names, but the limits of the transitional forms would be difficult to understand. The possible benefits do not seem to justify the complication that would have to be introduced if one tried to distinguish clearly between the transitional forms. Nevertheless, it is important to understand that cambic horizons vary in appearance and in genetic significance. We should look at the typical forms that the cambic horizon may have under varying combinations of the soil-forming factors.

1. Cambic horizons may form in the presence of fluctuating ground water. If ground water is present in the horizon at all times, the colors will usually be neutral, or will be shades of green or blue. These colors are excluded from the cambic horizon on the assumption that losses are negligible in the presence of a permanent ground water. If ground water fluctuates, the free iron is generally removed from the individual particles of sand, silt, and clay. This iron is either lost from the horizon or concentrated in the form of concretions or mottles. Gray or grayish and brownish mottled horizons are produced by fluctuating ground water. However, mottling alone is not an 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 chromas. The horizon must have an upper boundary that is shallower than 50 cm (20 inches), or it must immediately underlie an umbric or mollic epipedon. It must have dominant moist colors on ped faces, if peds are present, or in the matrix if peds are absent, as follows:

- a. If there is mottling, chromas are 2 or less.
- b. If there is no mottling and values are less than 4, chromas are less than 1; if values are 4 or more, chromas are 1 or less.
- c. Hues no bluer than 10Y if the hue changes on exposure to air. ** (Hues that do not change on exposure are not diagnostic).

*Weathering may be either chemical or physical. Kaolinite books of silt or sand size can be reduced to clay size and in this sense are weatherable. Feldspars can be altered chemically and are therefore weatherable.

** Color changes on exposure are ordinarily visible within a few minutes. Simply expose a moist clod briefly and then break the clod to compare the interior and exterior colors.

Weathering may have affected the easily weatherable minerals. The weathering may have removed lattice iron or have formed secondary clay minerals, but weathering has not progressed to the point where virtually the only minerals present are clay-sized kaolin minerals, free sesquioxides, and quartz and other forms of SiO_2 . Soil 37, p. 119, does not have a cambic horizon because it has the green and blue hues that indicate a permanent ground water. But soil 38, p. 120, has a cambic horizon formed with a fluctuating ground water.

2. In the absence of ground water and of carbonates, cambic horizons in soils of humid regions normally have brownish colors; the chroma, because of liberation of free iron oxides, commonly is stronger or the hue redder in the cambic horizon than in the C. Feldspar minerals, and such easily weatherable minerals as glass, biotite, some pyroxenes, and some amphiboles, are commonly partly weathered. Mica, if it is present, is usually at least partly weathered to 2:1 lattice clay. These minerals and kaolin books of silt size have not been completely destroyed in the cambic horizon. The hydrated oxide of iron removed from primary minerals may have formed coatings on individual soil particles and is considered to be responsible for the color of the horizon if it is brown or red. The free iron/clay ratio is virtually constant among subhorizons of these cambic horizons, in contrast to those formed in the presence of ground water.

Because considerable time is required for the partial destruction of iron-bearing minerals or the formation of clay, the cambic horizon has had time to develop blocklike or prismatic structure, but such structure may be lacking if the clay content is so low that there is no volume change with changes in soil moisture.

Since illuviation is negligible, the peds lack distinctive coatings and generally are weakly developed. Preferred alignment of plate-shaped particles parallel to the ped face can be demonstrated in thin sections (fig. 9, p. 42) on many smooth ped faces.

The microfabric (fig. 9) of this form of the cambic horizon often resembles that of the argillic horizon in having random orientation of individual particles and little pore space in the matrix. It differs from an argillic horizon in lacking, in all subhorizons, clay skins that are of distinctly finer material than the matrix. Under crossed polarizers, the brightness of the interference color (birefringence) on the faces of peds in a cambic horizon indicates a preferred orientation of particles. Although the ped faces show evidence of preferred alignment of plate-shaped particles, they differ from clay skins in that the particles are less perfectly arranged and are similar or identical to the ped interiors in particle-size distribution. The cambic horizon may have an occasional clay skin, but evidences of clay illuviation are not adequate for recognition of an argillic horizon.

Table 14 contains selected data on three profiles that have cambic horizons. In profile 24, the cambic horizon overlies a lower sequum containing an eluvial horizon and a fragipan. The profile description, profile No. 24, is on page 89. It will be noted that the cambic horizon, from 2 to 16 inches, contains more free iron but less total iron and less "lattice" iron than the underlying horizons. Lattice iron is not an entirely correct name, for it includes magnetite. Clay mineral analyses show some weathering of micas and chlorite to vermiculite. The cambic horizon in this profile has appreciably more clay than the overlying A2 or the underlying eluvial horizon, A'2. It could therefore be confused with an argillic horizon. This is an extreme example. More commonly the cambic horizon either has less clay or has at the most 2 or 3 percent more clay than the A. There are, however, no evidences of significant clay illuviation in profile 24. Clay skins are so few and so thin that they are not seen by field examination. Thin sections show the presence of a very few very small clay skins in pores. The total analyses indicate the clay has been largely formed in place, for the B is intermediate in its silica-sesquioxide ratio between the A and C. Both spodic and argillic horizons (table 13) have the minimum silica-sesquioxide ratio, on the basis of the fraction less than 2 mm. for the profiles in which they occur. Distinctions between spodic and cambic horizons that contain active amorphous materials are discussed under the spodic horizon.

Profile 33 is a soil with a mollic epipedon above the cambic horizon. The data suggest the beginning of an argillic horizon, from 9 to 15 inches, in the mollic epipedon. The cambic horizon, from 15 to 34 inches, shows no evidence of being an illuvial horizon, but does show evidences of formation of clay, as the clay content decreases steadily with depth.

Profile 34 is a soil with an ochric epipedon and a cambic horizon. The cambic horizon, from 2 to 13 inches, shows loss of both iron and aluminum, but no evidence of illuviation.

All these profiles, 24, 33, and 34, have significant amounts of weatherable minerals in the silt and sand fractions. Evidence may be seen in the appreciable contents of K_2O in all profiles, and the CaO in profiles 24 and 33.

3. The cambic horizon that forms in humid climates from highly calcareous materials may show a granular or crumb structure produced by soil fauna. Earthworms, in particular, are often active in temperate and warm climates in mixing material from different horizons. Consequently, the soil is often calcareous throughout, even though there has been a considerable loss of carbonates. In calcareous materials, evidences of weathering of feldspars and other silicate minerals may be slight or absent. There is evidence of the loss of carbonates either in the form of limestone ghosts or solution pitting of limestone pebbles, or the carbonate content gradually increases with depth. In addition, the clay content usually shows a gradual decrease with depth.

Chapter 5

Cambic horizon

4. In arid and semiarid climates the cambic horizon commonly has still another form. Carbonates are usually but not always present, but the activities of soil fauna, except in areas with Cicadidae, are of less significance to soil structure. Volume changes accompanying seasonal changes in moisture usually produce a prismatic structure, sometimes with very coarse prisms. In the deserts, the tops of the prisms may lie only a very few centimeters below a platy surface horizon. Other things being equal, it appears that the drier the soil, the closer to the surface one finds the prisms. Rock structure, including fine stratifications of sediments, is lacking, primarily because the materials have been moved by roots and animals. The cambic horizon normally has additional evidences of alteration. Carbonates have been re-distributed and partly or completely removed, as evidenced by solution pitting of limestone pebbles, and by the presence of an underlying horizon containing much larger amounts of carbonates that the soil morphology shows have been reprecipitated in the soil. Carbonates that are in transit through the cambic horizon may be reprecipitated there, particularly on the undersides of stones, in pores, on ped faces, and in other places as well. The horizon is not necessarily free of carbonates that the soil morphology shows have been precipitated in place. However, the tops of pebbles in the cambic horizon should not be completely coated with lime.

If carbonates are absent in the parent material and in the dust that falls on the soil, there may be no secondary carbonates in the soil. In this situation the cambic horizon must often be identified by the soil structure, combined with the absence of rock structure evidenced by fine stratifications. The clay content should decrease with depth in the cambic horizon, but the parent materials are so commonly stratified that one cannot be sure that clay has been formed in the soil.

Features common to cambic horizons

In spite of the diversity in appearance of cambic horizons, there are some common features.

Coarse-textured materials, sands, and loamy sands coarser than loamy very fine sand, are excluded from cambic horizons. This is admittedly arbitrary, since sands can be altered by weathering. Nevertheless, recognition of alteration in sands is much more difficult. Normally, structure cannot form. Decisions that a given sand does or does not show alteration are also apt to be arbitrary and inconsistent among different soil scientists. The mollic, umbric, and plaggen epipedons, and the argillic and spodic horizons, all may occur in sands, and are used to place soils into appropriate groups. Cambic horizons are not recognized in sands, or in loamy sands as coarse or coarser than loamy fine sand.

The degree of alteration of primary minerals may be slight to very strong, but some weatherable minerals are present. These include the clay minerals having 2:1 lattices and amorphous clays, as well as the various alterable minerals that yield bases or iron to the soil solution. Clay minerals having 1:1 lattices are considered weatherable if the crystals are of silt or sand size.

Soil structure rather than rock structure is present in more than half of the volume of all subhorizons.

The position of all cambic horizons is comparable; they lie immediately below an epipedon, or at the surface if the soil has no A1 horizon.

The cambic horizons may not have the dark colors combined with the organic-matter contents that are definitive for mollic or umbric epipedons. The cambic horizons are not illuvial horizons, and may not have the properties diagnostic for argillic or spodic horizons; nor may they have the cemented or brittle properties definitive of the duripans or fragipans.

In summary, the cambic horizon is an altered horizon that lacks the dark colors and organic matter that are definitive of mollic and umbric epipedons, and it has--

1. Textures of loamy very fine sand or finer in the fine earth (less than 2mm.) fraction.
2. Soil structure rather than rock structure.
3. Some weatherable minerals.
4. Evidence of alteration in one of the following forms:
 - a. Gray colors as defined on page 25.
 - b. Stronger chromas or redder hues than the underlying horizons.
 - c. Evidences of removal of carbonates. Particularly, the cambic horizon shows less carbonate than the underlying ca horizon. If all coarse fragments in the ca horizon are completely coated with lime, some in the cambic horizon are partially free of coatings. If coarse fragments in the ca horizon are coated only on the under side, those in the cambic horizon should be free of coatings.
5. Too few evidences of illuviation to meet the requirements of argillic or spodic horizons.
6. No cementation or induration and lacks a brittle consistence when moist.
7. No overlying albic horizon thicker than 18 cm (7 inches) in any part if the clay fraction is amorphous, and there is either:
 - a. 60 percent or more vitric volcanic ash, pumice and other pyroclastic materials in the 20 - 200 micron fraction, or
 - b. 20 percent or more 15-bar water.
8. Enough thickness that its base is at least 25 cm (10 inches) below the soil surface.

Chapter 5

OXIC HORIZON

The oxic horizon is an altered subsurface horizon at least 30 cm (12 inches) thick consisting of a mixture of hydrated oxides of iron or aluminum, or both, often amorphous, and variable amounts of 1:1 lattice clays and accessory highly insoluble minerals such as quartz sand. Its fine-earth fraction has little or no 2:1 lattice clay or 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 1N NH_4Cl solution and has a cation-exchange capacity by NH_4OAc of 16 meq or less. The oxic horizon has a lower exchange capacity or smaller amounts of minerals that can weather physically or chemically than the cambic horizon. It differs from the argillic horizon in having few or no clay skins and in having either a gradual or diffuse increase in clay content with depth, or no increase. Its upper boundary is set at the least depth at which there is no water-dispersible clay. For diagnostic purposes, its lower boundary is usually set at a depth of 2 meters. These properties and limits are discussed later in more detail.

Genesis

Geomorphologic evidence shows that oxic horizons are generally in soils of very old stable geomorphic surfaces, old in the sense that they are more apt to be mid-Pleistocene or earlier than late- or post-Pleistocene. They are not in soils of recent surfaces with thin regolith.

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 transported sediments. Quartz veins can be traced from deep layers through cambic or argillic horizons, but the authors have not yet seen them in oxic horizons. It should be noted, however, that quartz veins are very rare in Hawaii and Puerto Rico where we have studied oxic horizons most.

Whatever the materials, the great age of the oxic horizon has allowed time for mixing by animals and plant roots so that it retains almost no vestige of the original rock structure either as fine stratifications or saprolite. One exception only is found to this; If iron oxides or gibbsite coat and cement fragments of weathered rock, the original rock structure may be retained in the interior of the cemented parts but not in the fine earth. Pseudomorphs of olivine tend to persist but are not considered indicators of lack of weathering.

The age of the oxic horizons is such that minerals weatherable in warm humid climates are absent or are present only in traces. There is, therefore, no reserve of bases beyond those in the exchange fraction and in plant tissue.

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

Most of the soils with oxic horizons are nearly level or have relatively gentle slopes; relief is commonly 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

The oxic horizon is considered important to soil classification. Although much remains to be learned about its genetic significance, it is important that weathering has been so extreme that virtually the only remaining minerals are quartz, zircon, and similar highly insoluble primary minerals, hydrated iron and aluminum oxides, and 1:1 lattice clay minerals. Yet there is little or no evidence that clay is moving in the soil. This suggests a high order of stability or immobility of the clay fraction. Stability is further suggested by the absence of water-dispersible clay in all oxic horizons that have a net negative charge as well as by the great resistance to erosion.

There are few or no primary minerals that release bases on weathering. The low activity of the clay limits the supply of bases held at exchange sites. Other nutrients, such as phosphorus, are often in forms not available to plants. In humid regions, the nutrients essential for plant growth often are largely in the living and dead tissue of plants and can be lost if the plant cover is burned and not allowed to regenerate. Calcium can be so low as to be a barrier to root growth, particularly of annual plants. Thus, soils with oxic horizons have unique management requirements that stem from the low activity of the clay, high permeability, low erodibility, extreme weathering, and low reserve of bases in the oxic horizon.

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In general, if other kinds of soils are available, soils with oxic horizons are not cultivated or are in plantations. In the humid parts of Africa and South America, shifting cultivation and grazing are very common types of agriculture on soils with oxic horizons. Where the climate is subhumid, leaching and hazards of base exhaustion are reduced but lack of water limits agriculture. Classification that does not reflect these properties has very limited value.

IdentificationPosition

The oxic horizon normally underlies one of the epipedons or has been exposed by truncation. Rarely, it underlies a spodic horizon. Some have considered it a B horizon; others have called it a C horizon.

The boundary between the epipedon and the oxic horizon is normally diffuse unless the soil has been cultivated and eroded. It is often difficult to locate because the epipedon may not be visibly darkened even though it has 5 to 10 percent organic matter. Rough field tests for the presence of water-dispersible clay can help locate the upper boundary if location is important. Clays of the epipedon can be partly dispersed by shaking in distilled water, but those of the upper part of the oxic horizon cannot.

Materials similar to those in the oxic horizon can continue to depths of many meters without apparent change. The lower boundary of the oxic horizon in such a situation must ordinarily be either arbitrary or unknown. For practical reasons, we have set an arbitrary lower boundary at 2 meters if the soil materials between 1.7 and 2 meters depth meet the requirements of the oxic horizon.

A very few soils have an epipedon that approaches or is thicker than 2 meters. They are mostly soils that have been mixed intensively and deeply by animals. We would set the lower boundary of the oxic horizon in these soils at a depth that permits sampling a horizon at least 30 cm thick. In this situation the epipedon has all the diagnostic properties of an oxic horizon discussed later except that the NH_4OAc cation-exchange capacity may be above the limit and that water-dispersible clay may be present.

Positive identification of oxic horizons usually requires both field examination and laboratory analyses, but field identification can be highly accurate if analyses of a few soils are available.

In the field

Oxic horizons resemble cambic horizons in many respects, particularly cambic horizons that approach the oxic horizon in degree of alteration of primary minerals. There are nevertheless several properties that can be used in the field for identification of oxic horizons.

First is structure and consistence. Most oxic horizons appear massive in fresh pits. But many have very weak, very coarse prismatic structure, so weak that it is visible only in old road cuts. A few have weak coarse or medium blocky structure. A fragment of a few cubic centimeters of an oxic horizon, either moist or dry, crushes easily between the fingers to very fine granules. Most of these granules are very stable and very fine, much less than 1 mm in diameter. Commonly, they can be seen only under a hand lens. A fragment, if moist, crushes before there is any visible deformation of the fragment as a whole, indicating low plasticity and high friability.

Subhorizon boundaries within the oxic horizon are normally diffuse except boundaries of subhorizons that contain stone lines, plinthite, or sheets of gibbsite. Changes in color and texture with depth may be considerable but are so gradual that the boundaries are difficult to locate, and subhorizon boundaries are apt to be more or less arbitrary. Unless a stone line is present, boundaries with the underlying materials are equally gradual or diffuse as a rule.

Pores visible to the eye or under a hand lens are common to abundant in oxic horizons. The stability of these pores presumably reflects the aggregate stability of the horizon. Linings of the pores by clay skins are seldom found, even though water can move rapidly through some of the larger pores.

Weathered rock fragments that retain the original rock structure (saproelite) 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 often be recognized readily by varicolored spots of white, red, and strong brown with boundaries that are abrupt even under the microscope in material virtually free of pores. Spots of individual colors are commonly 0.1 to 2 mm in long dimension and have no regular pattern. In thin sections the spots are seen to be pseudomorphs of crystals of primary minerals such as feldspars and

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micaceous. Colors may be rather uniform in some saprolites from acidic rocks, but the materials have obviously been altered in place without appreciable disruption of the fabric. Saprolite may underlie an oxic horizon but should constitute no more than about 5 percent by volume of the oxic horizon. The presence of more than 5 percent by volume of saprolite within 2 meters commonly marks the lower boundary of the oxic horizon. Similarly, sand-size kaolin crystals or "books" that smear between the fingers into micalike flakes of sand size should be rare or absent in any subhorizon of the oxic horizon because they too are remnants of original rock structure. Pseudomorphs of olivines, mentioned earlier, may be present.

Color is not diagnostic. Oxic horizons may have varying shades of gray, brown, and red, or there may be mixtures of these colors in medium or coarse patterns of mottles.

The percentage of clay in an oxic horizon can increase, decrease, or remain constant with depth. Horizons of different texture can have clear boundaries if separated by a stone line. Otherwise, changes in the percentage of clay with depth are gradual. If there are clay skins in pores and on ped surfaces somewhere within the soil, the relative clay¹ increase within a vertical distance of 12 inches (30 cm) is less than that required for the argillic horizon. Particularly, the oxic horizon has no clear boundary with an overlying horizon that contains distinctly less clay throughout. Such a boundary is one of the marks of argillic horizons, and if it is present, one should look carefully for clay skins. Clay skins may be present only at depths of more than a meter where roots are scarce, but if they occupy more than 1 percent of the volume of any subhorizon, they indicate the presence of an argillic horizon². Clay skins may be present in oxic horizons, but they should be very few and be restricted mainly to pores. Pressures from swelling may produce peds with smooth reflective faces in oxic horizons. If the texture is fine, these faces resemble clay skins. Laboratory study of such faces and of clay skins can help one learn to distinguish between them in the field (see Argillic Horizon).

In the laboratory

Identification of an oxic horizon in the laboratory usually requires one or more of the following measurements: (1) percentage of weatherable minerals in the sand fraction, (2) particle-size distribution or water held at 15-bars tension, or both, (3) base retention from 1N 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, (6) percentage of clay dispersible in water, and (7) identification of clay minerals.

Petrographic examination. Feldspar, glass, and ferromagnesian minerals should constitute less than 3 percent of the fraction between 20 and 200 microns. Mica (muscovite) may constitute as much as 6 percent of this fraction.

Particle-size distribution. A reliable estimate of the amount of clay in an oxic horizon is essential for estimating the cation-exchange capacity of the clay. Particle-size distribution is usually determined by the pipette method using sodium hexametaphosphate as a dispersing agent and reciprocal or end-over-end shaking. But some oxic horizons have silt- and sand-size aggregates of clay that do not disperse but contribute to the exchange capacity. An independent measure of clay content is therefore necessary, and the water retained at 15 bars affords such an estimate. The ratio, $\frac{\text{percent 15-bar water}}{\text{percent clay}}$, does not exceed 0.5 if the clay disperses. Ratios of 0.4 are most common in oxic horizons. If there is appreciable cementation, removal of free sesquioxides by citrate-dithionite permits reasonably complete dispersion. In limited trials using samples that had ratios of 15-bar water to clay of 0.7 and 0.9 respectively, the ratio was reduced to 0.5 by treating as total clay the sum of the material extracted by citrate-dithionite and the clay that dispersed after the citrate-dithionite treatment. In general, the value of 2.5 x 15-bar water seems to give the best estimate of the clay percentage in horizons having a pH-dependent cation-exchange capacity low enough to exclude the possibility of an appreciable amorphous component (allophane) in the clay fraction. We use the higher of the two methods, either 2.5 x 15-bar water or the clay percentage measured by pipette.³

¹Clay by the pipette method.

²We should note that clay skins are commonly abundant in saprolite below an oxic horizon, but their presence in the saprolite is not a mark of an argillic horizon.

³Pipette method without citrate-dithionite extraction. Data on particle-size distribution after citrate-dithionite extraction are too few at present to make the method useful for classifying soils. When and if more data are accumulated, the limits on cation-exchange capacity per 100 grams clay may need to be re-examined.

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It would be unreasonable to consider a horizon as oxic if it contains less than 1 percent silt and clay and more than 99 percent quartz sand. Somewhere, there must be a more or less arbitrary upper limit for the percentage of sand. The limit between loamy sands and sandy loams is the coarsest texture permitted for an oxic horizon. Because silt percentages are low, the oxic horizons should have more than 15 percent clay. These limits apply only to the fine-earth fraction (less than 2mm). Oxic horizons may be very gravelly. Ironstones and quartz pebbles are the most common kinds of gravel.

Cation retention. The clay in the oxic horizon has low activity. It retains a relatively small amount of base per 100 grams of clay from a salt solution. Retention, after being saturated with ammonium in a 1N chloride solution and washed free of excess salt, is 10 meq or less per 100 grams of clay, or there are less than 10 meq of extractable bases and KCl-extractable aluminum. These values include any retention by the organic matter or by the silt and sand fractions. For acid soils lacking allophane, cation retention is similar to some concepts of the "permanent exchange capacity." Its numerical value in oxic horizons 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 C according to their exchange capacities by NH_4OAc at pH 7, sum of cations including exchange acidity measured at pH 8.1, and base retention. Quillayute, Honakaa, and Haiku soils are all believed to contain amorphous clays with high exchange capacities (allophane or allophanelike materials) and have significant differences between the "permanent charge," the retention of ammonium ions from NH_4Cl , the retention of ammonium ions at pH 7, and the sum of cations. The 15-bar water content and percentage of clay measured by the pipette method indicate that each horizon has more than 50 percent clay. The clay, silt, and sand fractions in each of the horizons listed except the argillic horizon of Limones seem to be very similar mineralogically, though there are wide differences between the horizons.

Cation-exchange capacity. The exchange capacity of the oxic horizon by NH_4OAc including the contribution of organic matter, silt, and sand is 16 meq or less per 100 grams clay estimated by the methods discussed earlier. This limit is introduced to exclude soils with appreciable amounts of amorphous clays that have high "pH-dependent exchange capacities" (allophane). These soils often have a low "permanent charge" but have moderate to high exchange capacity at pH 7 and 8.1 (Haiku, Honakaa, and Quillayute, table C).

The silt and sand fractions of some oxic horizons are mixtures of large kaolin crystals and iron-cemented aggregates. In particular, oxic horizons and cambic horizons that are near their common boundary tend to have a silt and sand fraction rich in kaolin. The large kaolin "books" or "worms" have a cation-exchange capacity about half that of the clay that disperses, but their 15-bar water retention is low. Hence, as kaolin increases in the silt and sand fractions, the ratio of cation retention and of exchange capacity to the clay increases. When these ratios exceed either 10 or 16 by the methods given earlier, the limit between the oxic and cambic horizons is passed. Thus, soils with appreciable amounts of silt- and sand-size kaolin are excluded from the oxic horizon. These kaolin "books" or "worms," as pointed out in the discussion of the cambic horizon, are considered weatherable minerals. The weathering, of course, would have to be physical rather than chemical.

Thin sections. Seldom will there be any need to determine the volume of clay skins. It may be needed to distinguish between argillic horizons and oxic horizons in a few soils. The limits are discussed under the argillic horizon. Oxic horizons should not have any subhorizon with as much as 1 percent of clay skins if the other features of an argillic horizon are present. Thin sections of oxic horizons show either no preferred orientation of the clay or 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.

Water-dispersible clay. Reciprocal or end-over-end shaking in water for 16 hours without a dispersing agent does not disperse a significant part (more than 3 percent) of the clay fraction unless the horizon has a net positive charge. Positively charged horizons can be identified readily by comparing the pH in water and that in KCl. If the charge is positive, the pH in KCl is higher than the pH in water. Or, if the soil is pretreated with a neutral salt such as KCl and washed free of salt, horizons with a net positive charge seem to lose their water-dispersible clay.

It should be noted that surface horizons rich in organic matter usually have water-dispersible clay, particularly if there is more than 1 percent organic matter. The upper boundary of the oxic horizon and the lower boundary of the epipedon comes at the least depth at which water-dispersible clay is absent. A horizon that is just below the epipedon and that lacks water-dispersible clay is present even in oxic horizons with net positive charges.

Hydrated oxides of iron and aluminum generally constitute more than 12 percent of the fraction finer than 2 microns, but this is not a universal feature nor is the high oxide content restricted to oxic horizons. Nevertheless the high metallic-oxide content is certainly an important if not the primary factor responsible for the high aggregate stability of most oxic horizons. Most 1:1 lattice clays seem capable of adsorbing about 12 percent of iron oxide expressed as Fe_2O_3 . At higher percentages there seem to be surplus oxides that can cement the clays or form concretions. Failure of the clay to disperse in water probably is due largely to (a) the content of iron oxides, and (b) the very low electrostatic repulsion due to the low activity of the clay.

Clay mineralogy. We think quantitative identification of the clay minerals should not be necessary to identify oxic horizons. The quantitative accuracy of present methods is still subject to debate. If 2:1 lattice clays or allophane are present in significant amounts, the "permanent charge" and cation retention by the clay fraction or the NH_4OAc cation-exchange capacity, or both, is too high for an oxic horizon. The diagnostic horizons of Cialitos, Waihuna, and Astoria soils (table C) contain identifiable 2:1 lattice clays. Haiku, Honakas, and Quillayute soils seem to contain amorphous clays. All are clearly excluded from the oxic horizon by their cation-exchange properties except Haiku, which has a marginal NH_4OAc exchange capacity of 16.3 meq per 100 grams of 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.

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

1. Is at least 30 cm thick.
2. Has a fine-earth fraction that retains 10 meq or less of ammonium ions per 100 grams of clay from a 1N NH_4Cl solution:

$$\frac{\text{meq bases retained} \times 100}{\text{percent clay}^1} \leq 10$$
 or has less than 10 meq of bases extractable with NH_4OAc and aluminum extractable with 1N KCl per 100 grams of clay.
3. Has an apparent cation-exchange capacity of the fine-earth of 16 meq or less per 100 grams of clay by NH_4OAc :

$$\frac{\text{meq cec} \times 100}{\text{percent clay}^1} \leq 16$$
4. Has no more than traces of primary aluminosilicates such as feldspars, micas, glass, and ferromagnesian minerals, as discussed earlier.
5. Has no more than traces of water-dispersible clay in some subhorizons.
6. Has texture of sandy loam or finer in the fine-earth fraction and more than 15 percent clay.
7. Has mostly gradual or diffuse boundaries between its subhorizons.
8. Has less than 5 percent by volume that shows rock structure.

¹Percent clay as measured by the pipette method or 2.5 x 15-bar water, whichever value is the higher.

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Table C. Selected characterization data for oxic, argillic, and cambic horizons
(Nd, no data; - none detected)

Soil	Horizon	Organic carbon	Clay Percent	15-bar water	Extractable cations		Cation-exchange capacity of clay				
					Al+++ ¹	Total bases ²	NH ₄ Cl ³ pH 7	NH ₄ Cl ⁴ unadj.	Perm. ⁵ charge	NH ₄ OAc	Sum ⁶
					meq/100 g soil		meq/100 g clay or 2.5 x 15-bar H ₂ O 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	42.2 ⁸	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.
Cielitos- 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
Limonas (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 (Oregon)	Cambic ¹⁰	.5	41.6 ⁸	29.7	32.8	1.4	54.8	45.4	46.1	nd.	64.5
Honakas (Hawaii)	Cambic ⁹	5.1	nd.	135	-	0.7	nd.	7.7	0.7	23.0	-
Quillayute (Oregon)	Cambic ⁹	1.6	18.1 ⁸	23.8	1.3	1.2	38.5	13.4	4.2	nd.	54.4

¹1N KCl-extractable.²NH₄OAc-extractable bases.³pH adjusted with NH₄OH; 1N NH₄Cl.⁴1N NH₄Cl; unbuffered.⁵NH₄OAc-extractable bases plus 1N KCl-extractable aluminum.⁶Extractable bases plus extractable acidity.⁷Whichever of these values is higher but not to exceed 100.⁸Dispersion quite incomplete.⁹Contains some allophane.¹⁰Contains some 2:1 lattice clay.

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CALCIC HORIZON

The letter designation ca is used to indicate accumulations of calcium carbonate or of calcium and magnesium carbonates. The accumulations may be in the C horizon, but they may also be found in a variety of the horizons such as mollic epipedons, argillic and natric horizons, and duripans.

The calcic horizon includes horizons of secondary carbonate enrichment that are more than 15 cm (6 inches) thick, have a calcium carbonate equivalent content of more than 15 percent, and have at least 5 percent more calcium carbonate equivalent than the C. If no C is present, and a calcic horizon is not indurated, it is more than 15 cm (6 inches) thick, has a calcium carbonate equivalent content of more than 15 percent, and contains more than 5 percent, by volume, of identifiable secondary carbonates in concretions or soft powdery forms. If a calcic horizon is indurated and rests on hard rock, or in more precise words has a lithic contact, the calcic horizon may be as thin as 2.5 cm (1 inch) if the product of the thickness in cm, multiplied by the percentage of calcium carbonate equivalent, is 200 or more (if thickness in inches is used, the product is 80 or more).

It is difficult to distinguish calcic horizons in soils from highly calcareous parent materials. Limestones are formed by precipitation of calcium carbonate or calcium and magnesium carbonates just as are ca horizons. A modern ca horizon formed on limestone is difficult to identify at present, for the only tool we can use is the measurement of the radioactive carbon (C^{14}). The measurement is expensive and can be used on relatively few soils. The most useful diagnostic feature for recognition of the calcic horizon in such situations is the presence of a surface layer that consists of fine laminae, or powdery or laminar pendants below limestone fragments. If the percentage, by volume, of powdery redeposited lime exceeds 5 percent in a layer more than 6 inches thick, or there is a laminar coating that is 2.5 cm (1 inch) or more thick, the horizon should be considered a calcic horizon.

Commonly, calcic horizons have developed in unconsolidated materials of more or less mixed mineralogic composition. In these the secondary lime is generally easy to recognize, for it occurs as a white powdery filling, as concretions, as pseudo mycelia, as pendants or crusts below pebbles and stones, or as thin sheets at lithologic discontinuities where there are breaks in the sizes of the pores. If, in such situations, the carbonate content of a layer 6 inches or more thick exceeds 15 percent by weight, and the layer has at least 5 percent more calcium carbonate equivalent than the next underlying layer, the horizon is considered a calcic horizon. Such horizons are generally thickest in gravels, other things being equal.

The genetic implications of a calcic horizon are variable. In desert regions, if the parent materials contain considerable amounts of calcium, the very limited rainfall seems unable to remove lime completely from even the surface few inches of the soil. About the only significant horizon that can develop in such a soil is a calcic horizon. Soil 59, page 162, illustrates such a situation. In areas transitional from the desert to the steppes, an Al horizon, or mollic epipedon, may develop in addition to the calcic horizon. Apparently, no other horizons ordinarily develop. Such soils are the arid and semiarid equivalents of the Rendolls (Rendzinas) of humid regions. Given a parent material that is rich in carbonates or given regular additions of carbonates in dust, the calcic horizon tends in time to become plugged with carbonates and cemented into a hard, massive, continuous horizon that we call the petrocalcic horizon. Such horizons seem to be restricted to surfaces older than the late Pleistocene. The younger soils seem to have calcic horizons in which the lime is soft and disseminated, or has accumulated in hard concretions or both. The petrocalcic horizon is a mark of advanced soil evolution. The non-cemented calcic horizon is a mark of relatively recent development (Soil 59, page 102) or a scarcity of carbonates.

In soils that have, near the surface, ground waters that contain appreciable amounts of calcium bicarbonate, the capillary rise and evaporation, plus transpiration, cause precipitation of large amounts of lime. Depending on the height of the capillary fringe, the deposition of lime may take place in the very surface, or in the soil at depths of a foot or two. In such soils, the accumulation of lime is comparable to the accumulation of more soluble salts in the desert playas. One might think of such soils as the humid equivalents of the Salorthids (Solonchaks). Soil 1, page 66, is a soil with such a calcic horizon.

In the situation just discussed, one might attach a high genetic significance to a calcic horizon. In some other circumstances, however, one can attach no genetic significance to a calcic horizon. Deposition from ground water at depths of 10 feet or more is more nearly a geologic than a pedologic process. In soils formed from calcareous materials on the steppes, the amount of accumulation of lime may be extremely erratic, and, in fact, may vary from one foot to the next. 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 of accumulation that makes the distinction between a ca and a calcic horizon. Soil 3, page 68, is typical of a soil in which there is a calcic horizon of no apparent genetic or other significance. The mollic epipedon and the argillic horizon are significant to the classification of this soil. The presence of a ca horizon is also significant, but the absolute amount of lime in the ca horizon has no known significance.

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THE DURIPAN

The duripan is a subsurface horizon that is cemented by silica, usually opal or microcrystalline forms of silica, to the point that fragments from the air-dry horizon will not slake in water or acid. The duripans vary in the degree of cementation by silica, and in addition, often contain accessory cements, chiefly iron oxides and calcium carbonates. As a consequence, the duripans vary in appearance. They grade into the petrocalcic horizons of semiarid and arid climates, into the fragipans of humid climates, and into noncemented earthy materials.

The Genesis

Duripans occur primarily in soils of subhumid Mediterranean or arid climates--soils that are usually dry or that are seasonally dry. They have an environment in which soluble silica might be expected to be washed down into but not out of the soil.

The parent materials normally contain small amounts of calcium. Where calcium is abundant, calcic horizons tend to supplant the duripans. The most strongly expressed cementation is commonly in soils that contain appreciable amounts of glass in the overlying horizons, which suggests the importance of soluble silica to the genesis.

If glass is lacking in the overlying horizons, there is reason to suspect that it was once in the soil. Geographically, the duripans are restricted to areas of vulcanism. Ash showers may be continuing, or the soils may be in sediments worked from regions rich in pyroclastic materials such as tuffs and ignimbrites. Glass tends to weather rapidly, and if it is rich in bases, can liberate soluble silicates at a rapid rate.

Appearance of the Duripan in Arid Climates

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 some birefringent material that is probably a microcrystalline form of silica. Carbonates are often present in small to large amounts. Roots can often be found between the plates. The cementation can be destroyed by first soaking in acid to remove any carbonates, and then by soaking in 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 it is completely destroyed by concentrated alkali either as a single treatment or by alternating treatments with acid. Usually the presence of a continuous thin opal capping that is insoluble in acid on the laminar layer indicates enough silica cementation to satisfy this requirement. If no laminar layer is present and the horizon is cemented and satisfies criteria of the calcic horizon, it is a duripan if at least a continuous subhorizon within the horizon does not slake in acid. Usually, a nearly continuous layer of secondary silica occurs in this part of the horizon.

The forms transitional to regolith in arid climates are massive and brittle when wet. Silica laminar caps and silica coatings on plates may not be present. In order for the horizon to be a duripan there must be at least a few vertical opal coatings, or durinodes must make up at least 20 percent (by volume) of the horizon. In addition opal or other forms of silica partly fills interstices, and bridges sand-sized mineral grains. Moistened specimen of this form of the duripan usually show a dull glassy luster when viewed under a hand lens. These forms of the duripan are very firm or extremely firm when moist, but can be penetrated with some difficulty with an auger. Under irrigation such horizons are slowly permeable to water and virtually impenetrable to roots of many plants.

Appearance of the Duripan in Mediterranean Climates

In the forms transitional to regolith, the duripans are only weakly cemented. When the pan is moist, brittleness is pronounced, but with some difficulty, it can be penetrated by an auger. When dry, the pan is very hard. Permeability is slow. In Mediterranean climates, the pan has an abrupt upper boundary and is usually broken into very coarse prisms, or polygons, roughly 1/3 to 3 or more meters in diameter. Coatings of opal partially line the faces of the prisms and many of the pores. Roots are scarce or absent in the prisms but may be matted on the surface of the pan and on the sides of the prisms. The prisms may have been formed by volume changes that result from wetting and drying. This is suggested by the absence of prisms in the duripans of arid regions.

The more strongly cemented pans of Mediterranean climates have opal coatings over the tops of the polygons as well as the sides, and the coatings are thicker. Water often stands temporarily on top of the pans during the rainy season. Coatings of iron, manganese, and oriented clay often may be observed on these pans. Subsequent deposits of opal could engulf such coatings, and give rise to a cementation that can be broken down only by repeated alternate use of solutions of concentrated acid and alkali. Figure 37, p. 212, shows a thin section of the upper 2.5 cm of such a pan. Carbonates may be found above or in any part of the pan, or they may be completely absent, all of which indicates that carbonates are not an essential part of the pans. Figure 18, p. 55, shows a fragment of a duripan that is partially cemented with lime, but the dark surface crust is probably opal, iron, and manganese.

Appearance of the Duripan in Mediterranean Climates--Cont.

In more humid climates, carbonates and salts are absent in the pan. The opal coatings in pores and on the sides of the polygons are lacking, and in their place are mottles of gray and strong brown. Strength of cementation decreases in the pan until the dry pan slakes when placed in water, and we must consider the horizon a fragipan rather than a duripan.

A third kind of duripan is sometimes found in albic horizons that overlie spodic horizons. We know little about them, but so far as is known now, these duripans are restricted to soils with spodic horizons in which humus or humus and aluminum have accumulated (Humaquods, or Humus Podzols). The albic horizon (A2) may become indurated but remains nearly white. The one sample examined appears to contain fine chalcedony.

In summary, the duripan is a subsurface horizon with the following properties:

1. Cementation is strong enough that dry fragments from some subhorizon do not slake in water;
2. Coatings of silica, insoluble in acid but soluble in concentrated alkali or alternating acid and alkali, are present in some pores and on some structural faces, or durinodes constitute more than 20 percent of the volume of some subhorizon;
3. Cementation is not destroyed by soaking in acid in more than half of any laminar capping that may be present, or in some other continuous subhorizon of the horizon. Cementation, in such layers, is completely destroyed by concentrated sodium hydroxide either as a single treatment or by alternating with acid.

Other soil characteristics.

Domination by Amorphous Material

The colloidal material that comes within the meaning of amorphous in this phase includes allophane and has all or most of the properties of allophane. But the term, as used here, is more inclusive than allophane as defined by some. Amorphous material, as used here, is amorphous to X-rays. It is associated with organic matter but contains aluminum, and never has more than traces of Al that can be extracted with KCl. Consequently, if the base saturation is low, less than 35 percent, the amorphous material has less than 10 meq./100 g. permanent charge. But it has high exchange capacity in systems buffered at pH 7 and very high exchange capacity at pH 8.2. The exchange capacity is clearly pH induced. The amorphous material also has high anion exchange capacity. It has an enormous surface area and retains much water against 15-bar tension, commonly 50 to 100 percent or more. It cannot be dispersed readily in hexametaphosphate.

If the amorphous material dominates an exchange complex, we find the following conditions are satisfied:

1. The exchange capacity of the measured clay (at pH 8.2) is very high, more than 150 meq/100 grams measured clay, and commonly more than 500 meq. This is in part the result of the poor dispersion.
2. If there is enough clay to have a 15-bar water content of 20 percent or more, the pH of 1 gram of soil in 50 ml. of 1 N NaF is > 9.4 after 2 minutes.
3. The $\frac{\text{15-bar water retention}}{\text{measured clay}}$ ratio is more than 1.0.
4. Organic matter exceeds 1 percent.
5. Differential thermal analysis shows a low temperature endotherm.

Amorphous material is usually an early weathering product of vitric volcanic ash and other pyroclastic materials in humid climates, but other readily weatherable materials such as basalt and sedimentary rocks containing pyroclastics may also weather to amorphous material. And under the environments that produce spodic horizons, similar amorphous materials appear to be formed in the absence of pyroclastics.

Interfingering of an albic horizon: Interfingering consists of penetrations of the albic horizon into the underlying argillic or natric horizon along ped faces, primarily vertical faces. The penetrations are not wide enough to constitute tonguing, but form continuous skeletans, ped coatings of clean silt or sand, more than 1 mm thick on the vertical ped faces. (Note that this requires a total thickness of more than 2 mm. if each ped has a coating of more than 1 mm.) Because quartz is such a common constituent of soils, the skeletans are usually white when dry, and light gray when moist, but their color is determined by the color of the sand or silt fraction. The skeletans constitute more than 15 percent of the volume of any subhorizon in which interfingering is recognized.

Chapter 5

Plinthite: (Gr. plinthos, brick), p. 36. Substitute the following for the text of the 7th Approximation. (Note that it restricts the meaning of plinthite to nonindurated materials).

Plinthite is the sesquioxide rich, humus poor, highly weathered mixture of clay with quartz and other diluents, which commonly occurs as red mottles, usually in platy, polygonal, or reticulate patterns; plinthite changes irreversibly to ironstone hardpans or irregular aggregates on exposure to repeated wetting and drying. The lower boundaries of plinthite occurrence are usually diffuse or gradual, but they may be abrupt at a lithologic discontinuity.

Plinthite may occur as a constituent of a number of horizons, such as epipedons, cambic horizons, argillic horizons, oxic horizons, and C horizons. It is one form of the material that has been called laterite. It normally forms in horizons below the surface, but it may, under some conditions, form at the surface.

From a genetic viewpoint, plinthite represents segregation of iron; there have been, in many places, probable additions of iron from other horizons or from higher lying adjacent areas.

Generally, plinthite forms in horizons that are saturated with water at some season. The original segregation of the iron is normally in the form of soft, more or less clayey, red or dark red mottles. The mottles are not considered plinthite unless there has been enough iron segregation to permit irreversible hardening on exposure to wetting and drying. Plinthite in the soil is usually firm when the soil moisture is near field capacity and hard when near the wilting point. Plinthite does not harden irreversibly as a result of a single cycle of drying. After a single drying, it will remoisten and can be dispersed in large part by shaking in water with a dispersing agent.

In a moist soil, plinthite is soft enough that it can be cut with a spade. Indurated ironstone materials can be broken or shattered with a spade but cannot be cut, and cannot be dispersed by shaking in water with a dispersing agent.

If present in small amounts, plinthite does not form a continuous phase in the soil; that is, the individual mottles or aggregates are not connected with each other. If present in large amounts, the plinthite may form a continuous phase, and when followed by induration, produces a massive ironstone layer that has irregular somewhat tubular inclusions of yellowish, grayish or white, clayey material. If exposed, these inclusions may be washed out, and thus an ironstone with many coarse tubular pores is left. Figure 25 shows such an exposure of ironstone that probably once was plinthite.

Soil Moisture: References to soil moisture apply when soils are not frozen, artificially drained, or irrigated.

Organic Soils: Organic soils are those which, to a depth of at least 30 cm or to a lithic contact, whichever is shallower, have more than 17.4 percent organic carbon (30 percent or more organic matter) if the mineral fraction is more than 50 percent clay, or more than 11.6 percent organic carbon (20 percent or more organic matter) if the mineral fraction has no clay. Intermediate clay content requires a proportional content of organic carbon.

COLE Coefficient of linear extensibility: This is the ratio of the difference between the moist and dry lengths of a clod to its dry length. It is $\frac{L_m - L_d}{L_d}$, where L_m is the length at 1/3 bar moisture, and L_d is the length when dry. It is usually calculated from the difference in bulk density of the clod when moist and dry.

Potential Linear Extensibility: The sum of the products for each horizon of the horizon thickness and the COLE of the horizon.

Saturated with water at some period of the year: This is a phrase that occurs frequently in the definitions of taxa and questions have been raised about its meaning. A soil that is saturated with water is essentially a two phase system--soil and water, though there may be some trapped air within the soil. This situation exists if water stands in a deep bore hole at such a shallow depth that the capillary fringe reaches the soil surface. In sandy soils the capillary fringe may be only 10 to 15 cm (4 to 6 inches) thick. In clayey soils the thickness may be 30 cm (12 inches) or more depending on the size distribution of the pores. Thus, the soil is saturated with water when the water table is from 10 to 30 cm (4 to 12 inches) below the surface, depending on texture and on pore size distribution.

We do not know what duration is important. It must be at least a few days because it is implicit in the definition that dissolved oxygen is virtually absent. Because the dissolved oxygen is removed from the soil water by the respiration of microorganisms, it is also implicit in the phrase that the soil temperature in some horizons is above the biologic zero or more than about 5°C (41°F) at the time that the soil is saturated. There is no doubt but that soil temperature affects the duration of saturation required to produce reducing conditions. A horizon of a soil may be saturated with water when the soil is not saturated. In this situation water will stand in a bore hole that ends in the saturated horizon although it may not stand in a deep bore hole.

Mottles with Chromas of 2 or less: This phrase appears in the definitions of many taxa. It includes the meaning 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, about 5°C (41°F), during at least a part of the time that the horizon is saturated.

Chapter 6. CRITERIA OF CLASSIFICATION IN THE LOWER CATEGORIES

Family Differentiae

1. Texture: No single set of textural classes seems appropriate as a family grouping for all kinds of soil. The classification tabulated below provides for a choice of either 7 or 11 particle size classes. This choice permits relatively fine distinctions in soils if texture is important, and broader groupings in soils if texture 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 more than 35 percent clay in defined horizons; but in other families the term "fine" indicates that the clay portion constitutes 35 to 60 percent of the horizons, and the term "very fine" indicates more than 60 percent clay.

Particle-Size Classes for Family Groupings

1. **FRAGMENTAL**: Stones, cobbles, gravel, and coarse sand, with fines too few to fill interstices larger than 1 mm.
2. **SANDY SKELETAL**: More than 35 percent, by volume, coarser than 2mm., with enough fines to fill interstices larger than 1 mm.; fraction less than 2mm. is as defined for particle size class 5.
3. **LOAMY SKELETAL**: More than 35 percent, by volume, coarser than 2mm., with enough fines to fill interstices larger than 1 mm.; fraction less than 2mm. is as defined for particle size class 6.
4. **CLAYEY SKELETAL**: More than 35 percent, by volume, coarser than 2mm., with enough fines to fill interstices larger than 1 mm.; fraction less than 2mm. is as defined for particle size class 7.
5. **SANDY¹**: Sands and loamy sands coarser than loamy very fine sand.
6. **LOAMY¹**:

6a. Coarse-loamy:

With less than 18 percent clay:

Coarse sandy loam
Sandy loam
Fine sandy loam
Loam

With less than 18 percent clay and more than 15 percent coarser than very fine sand (including coarse fragments up to 7.5 cm):

Very fine sandy loam
Loamy very fine sand
Silt loam

6b. Fine-loamy:

With more than 18 percent clay:

Coarse sandy loam
Sandy loam
Fine sandy loam
Loam

With more than 18 percent clay but less than 35 percent clay, and more than 15 percent coarser than very fine sand (including coarse fragments up to 7.5 cm):

Very fine sandy loam
Silt loam
Sandy clay loam
Clay loam
Silty clay loam

6c. Coarse-silty:

With less than 18 percent clay, and less than 15 percent coarser than very fine sand (including coarse fragments up to 7.5 cm):

¹ These terms refer to texture of fine earth fraction (less than 2mm) in applicable horizons that have less than 35 percent coarse fragments, by volume. Some soils do not disperse well. The clay content used should be the higher of the measured clay value, or 2.5 times the 15-bar water percentage if one-half or more of the control section has a 15-bar H₂O ratio of 0.6 or more. If the ratio of coarse to clay exceeds 0.7, the 15 bar H₂O determination should be made on H₂O₂ treated samples.

Loamy very fine sand
 Very fine sandy loam
 Silt loam
 Loam
 Silt

6d. Fine-silty:

With more than 18 percent clay but less than 35 percent clay, and less than 15 percent coarser than very fine sand (including coarse fragments up to 7.5 cm):

Very fine sandy loam
 Silt loam
 Silty clay loam
 Loam
 Clay loam

7. CLAYEY¹:

7a. Fine:

With more than 35 percent clay but less than 60 percent clay:

Clay loam
 Silty clay loam
 Clay
 Silty clay
 Sandy clay

7b. Very fine:

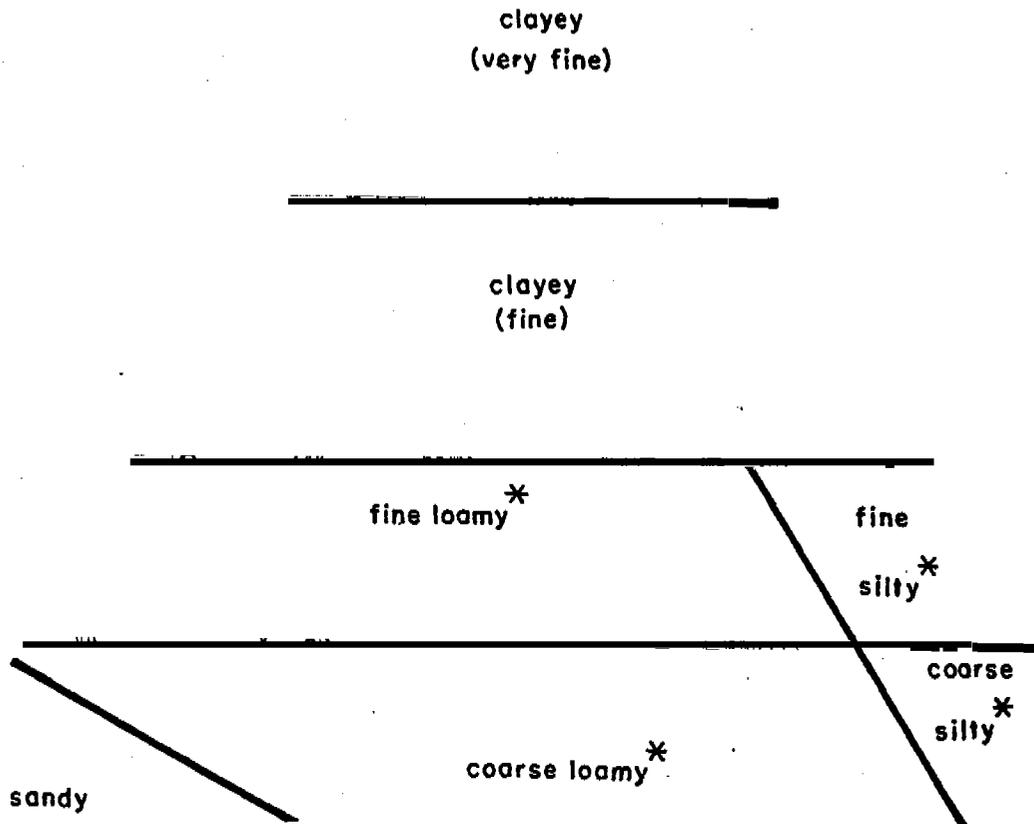
With more than 60 percent clay.

¹ These terms refer to texture of fine earth fraction (less than 2mm) in applicable horizons that have less than 35 percent coarse fragments, by volume.

Particle-size classes, as defined, are not applied to fragipans, duripans, or petrocalcic horizons but are applied to the following horizons or to the materials that are between given arbitrary depth limits that constitute the control section:

- a. lithic subgroups and shallow soils: particle-size classes are applied from the surface down to a lithic or paralithic contact, fragipan, duripan, or petrocalcic horizon, if any of these come within a depth of 36 cm (14 inches) or less or to 36 cm if the soil temperature is 0°C or less within this depth about 2 months after the summer solstice;
- b. other Entisols, Inceptisols, Spodosols, Oxisols, great groups without argillic or natric horizons in Aridisols and Mollisols, and great groups with fragipans in or above argillic horizons in Alfisols and Ultisols:
 - (1) from a depth of 25 cm (10 inches) down to a lithic or paralithic contact, fragipan, duripan, or petrocalcic horizon, if any of these is shallower than 1 m (40 inches), or to a depth of 25 cm (10 inches) below the level at which the soil temperature is 0°C about 2 months after the summer solstice, whichever is shallower;
 - (2) from a depth of 25 cm (10 inches) to a depth of 1 m (40 inches) if the regolith is thicker than 1 m (40 inches) but the named diagnostic horizons and subjacent Cca horizons are not, or if the named diagnostic horizons extend below 1 m (40 inches).
- c. Other soils in Alfisols and Ultisols and great groups in Aridisols and Mollisols that have argillic or natric horizons:
 - (1) if there are no strongly contrasting textures or fragipan, duripan, or petrocalcic horizon between the top of the argillic or natric horizon and 1 m (40 inches), particle-size classes are applied to the whole argillic or natric horizon if less than 50 cm (20 inches) thick or to the upper 50 cm (20 inches) of the argillic or natric horizon if it is more than 50 cm (20 inches), and;
 - (2) if there are horizons or layers with strongly contrasting textures within or below the argillic or natric horizon and within 40 inches, particle-size classes are applied from the top of the argillic or natric horizon to 40 inches 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 classes are applied from the top of the argillic horizon to the top of the fragipan, duripan, or petrocalcic horizon or to the upper 50 cm (20 inches) of the argillic or natric horizon, whichever of these is the least.

Chapter 6-3 GUIDE FOR TEXTURAL CLASSIFICATION IN SOIL FAMILIES



* Very fine sand (0.05 - 0.1) is treated as silt for family groupings; coarse fragments are considered the equivalent of coarse sand in the boundary between the silty and loamy classes.

COMPARISON OF PARTICLE SIZE SCALES

Sieve Openings in Inches		U. S. Standard Sieve Numbers														
		3	2	1 1/2	1	3/4	1/2	3/8	4	10	20	40	60	200		
USDA	GRAVEL			SAND					SILT			CLAY				
				Very Coarse	Coarse	Medium	Fine	Very fine								
UNIFIED	GRAVEL		SAND			SILT OR CLAY										
	Coarse	Fine	Coarse	Medium	Fine											
AASHO	GRAVEL OR STONE			SAND		SILT - CLAY										
	Coarse	Medium	Fine	Coarse	Fine				Silt	Clay						

100	50	10	5	2	1	0.5	0.42	0.25	0.1	0.05	0.02	0.01	0.005	0.002	0.001
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In applying particle-size classes, use the weighted average texture of the control section or of the horizons listed above, unless there are strongly contrasting textures within the control section or horizons. If there are strongly contrasting textures, both textures are used. Thus, if the upper part of the control is a loamy fine sand and the lower part is a clay, the texture is sandy over clayey. (Note that sandy includes fine as well as coarser sands).

The following particle-size classes are strongly contrasting if they occur within a vertical distance of 12.5 cm (5 inches).

1. Fragmental over sandy
2. Fragmental over loamy
3. Fragmental over clayey
4. Sandy-skeletal over loamy with less than 50 percent fine sand or coarser
5. Sandy-skeletal over clayey
6. Sandy over loamy with less than 50 percent fine sand or coarser
7. Sandy over clayey
8. Loamy-skeletal over sandy
9. Clayey-skeletal over sandy
10. Loamy-skeletal over clayey (more than 25% difference in clay percentages)
11. Coarse-loamy over fragmental
12. Coarse-loamy (50% fine sand or coarser) over sandy or sandy skeletal
13. Coarse-loamy over clayey
14. Coarse-silty over fragmental
15. Coarse-silty over sandy or sandy-skeletal
16. Coarse-silty over clayey
17. Fine-loamy over fragmental
18. Fine-loamy over sandy or sandy-skeletal
19. Fine-loamy over clayey (more than 25% difference in clay percentages)
20. Fine-silty over fragmental
21. Fine-silty over sandy or sandy-skeletal
22. Fine-silty over clayey (more than 25% difference in clay percentages)
23. Clayey over fragmental
24. Clayey over sandy or sandy-skeletal
25. Clayey over loamy (more than 25% difference in clay percentages)

The intent of the use of the strongly contrasting particle-size classes is to identify changes in pore size distribution that seriously affect water movement and retention and that have not been identified in higher categories. The list above is intended for use in grouping the soil series of the U. S. into families. It is not intended as a complete list. For example, a fine sand over coarse sand is common in the Udipsamments of western Europe but is not known to be important in the U. S. Classes 10, 19, 22 and 25 above should be used only if a distinction between the subclasses of clayey soils, fine and very fine, is also made.

The Use of the Different Particle-Size Groupings. Only the seven particle-size classes are used for lithic, arenic, and grossarenic subgroups, and in shallow families.

For Ultisols and Oxisols, subclasses of loamy textures are used, but not subclasses of clayey textures.

Andepts, Andaquepts, and at least parts of andic subgroups of other great groups cannot be dispersed readily for mechanical analyses. These soils are classified on the basis of combined texture, consistence, and mineralogical properties into 3 classes: cindery, ashy, and thixotropic. If the predominant size fraction is greater than 2 mm after prolonged rubbing, the family name is cindery. If the soil appears to be sandy or loamy after prolonged rubbing and lacks thixotropic properties, the term ashy is used. Soils with predominantly thixotropic properties are placed in thixotropic families. If only a part of the control section of a soil in an andic subgroup is cindery, ashy, or thixotropic, contrasting families are recognized but only the 7 particle-size classes are used. For example, we might use cindery over loamy but not cindery over fine-loamy.

Thixotropy is "a reversible gel-sol transformation under isothermal shearing stress following rest." Webster) 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 when broken down can rebuild itself. The break-down itself may be caused by one of several actions: by agitation, by shearing, or even 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 may 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. In the

Chapter 6

Thixotropy cont.

literature of soils of western United States, particularly of Hawaii, the consistence term "smeary" is used to characterize soil materials that are thixotropic.

Soils in which more than 1/3 of the clay fraction consists of carbonates are also placed on the basis of their apparent texture. If the apparent texture is fine-loamy, fine-silty, or clayey the term fine-carbonatic is used in place of the textural class name.

Two particle-size classes are used to separate families in Vertisols, fine if there is less than 60 percent clay and very fine if there is more than 60 percent clay in the weighted average of the control section.

2. Mineralogy: Mineralogy classes are based on the approximate mineralogical composition of selected size fractions of the same segment of the soil profile (control section) that is used for application of particle-size classes. No contrasting mineralogy families are recognized except where there is an ash or cinder overlay or an upper thixotropic layer and the ash or cinders or thixotropic layer extend at least 10 cm into the upper control section. In identifying and naming contrasting mineralogy families the 7 family particle-size classes are used for the lower part of the section. For example, ashy over loamy mixed, not ashy over coarse-loamy mixed. Otherwise, if there are contrasting particle-size classes in the control section the mineralogy of the upper part of the control section is definitive of the family mineralogy.

Mineral soils are placed in the first mineralogy class of the Key that accomodates them although they may appear to meet the requirements of other mineralogy classes. This is a Key, not a set of complete definitions. Mineralogy subclasses based on combined texture, consistence, and mineralogy classes are used to indicate important variations in Andaquepts, Andepts, and Andic subgroups.

It is recognized that it is normally impossible to be certain of the percentages of the various kinds of clay minerals. Quantitative identification methods are still lacking. Although much progress has been made in the past few decades, an element of judgment enters into the estimation. Not all of the evidence must come from X-ray, surface, and DTA determinations. Other physical and chemical properties suggest the mineralogy of many clayey soils. Volume changes, cation exchange capacities and consistence also are useful in estimating the nature of the clay. Determination of the clay mineralogy of clayey soils is based on the weighted average of the control section.

3. Reaction classes: Two classes, acid and nonacid, will be used in selected taxa, with definitions as follows:

a. Acid: pH less than 5.5 in H₂O (1:1) in control section (throughout).

b. Nonacid: pH 5.5 or more in at least some part of the control section.

Reaction classes are not to be used in sandy, sandy skeletal or fragmental families, but are to be used in other families in the following taxa:

Entisols	Humaquepts
Haplaquepts	Andaquepts

Thus, we have the following combinations reflecting the pH in the control section, and the presence or absence of carbonates, in all parts of the fine earth between 25 and 50 cm (10-20 inches) below the surface.

Psamments and Psammaquepts	No reaction classes.
Other Entisols and Aquepts, except Fragiaquepts	Acid, nonacid, and calcareous classes. (Note that "calcareous" implies "nonacid", and that both names are not needed for calcareous families.)
Aquolls	Calcareous and noncalcareous classes.

KEY TO MINEROLOGY CLASSES

Class	Definition	Determinant size fraction
Classes applied to loamy, silty, and clayey soils.		
Ferritic	More than 40 percent (weight) iron oxide extractable by citrate-dithionite, reported as Fe_2O_3 (or 28 percent reported as Fe).	Whole soil < 2 mm
Gibbsitic	More than 40 percent (weight) hydrated aluminum oxides reported as gibbsite and boehmite.	Whole soil < 2 mm
Oxidic	Less than 90 percent quartz and less than 40 percent of any other single mineral and the ratio of $\frac{\% \text{ extractable iron oxide and gibbsite}}{\% \text{ clay}} \geq 0.20$	For iron and clay ratio: whole soil < 2 mm For quartz & other minerals: 0.002 - 2 mm
Fine-carbonatic	More than 1/3 of the < 0.002 mm fraction consists of carbonates and the apparent texture of the soil is fine-loamy or fine-silty or clayey. Particle size classes are not used with this mineralogy.	< 0.002 mm
Serpentinitic	More than 40 percent (weight) serpentine minerals (antigorite, chrysotile, fibrolite and talc).	Whole soil < 2 mm
Classes applied to sandy, silty, and loamy soils.		
Glauconitic	More than 40 percent (weight) of glauconite.	Whole soil < 2 mm
Carbonatic	More than 40 percent (weight) carbonates (as $CaCO_3$) and gypsum, and carbonates are more than 65 percent of the sum of carbonates and gypsum.	Whole soil smaller than 2 mm, or whole soil smaller than 20 mm
Gypsic	Gypsum is more than 35 percent of the sum of carbonates and gypsum, and carbonates and gypsum are more than 40 percent by weight.	Whole soil smaller than 2 mm, or whole soil smaller than 20 mm
Ashy	More than 60 percent (weight $\frac{2}{1}$) volcanic ash, cinders or pumice, and dominantly smaller than 2 mm.	0.02 - 20 mm
Cindery	Cindery if dominantly larger than 2 mm.	0.02 - 20 mm
Micaceous	More than 40 percent (weight $\frac{2}{1}$) mica.	0.02 - 20 mm
Siliceous	More than 90 percent (weight $\frac{2}{1}$) of silica minerals (quartz, chalcedony, opal) and other minerals with hardness of 7 or more in the Mohs scale.	0.02 - 2 mm
Mixed	All others, with less than 40 percent of any one mineral other than quartz.	
Classes applied to clayey soils.		
Halloysitic	More than half by weight of halloysite with smaller amounts of allophane or kaolinite or both.	< 0.002 mm
Kaolinitic	More than half by weight of kaolinite, dickite and nacrite, and with smaller amounts of other 1:1 or nonexpanding 2:1 layer minerals or gibbsite.	< 0.002 mm
Montmorillonitic	More than half by weight of montmorillonite and nontronite, or a mixture with more montmorillonite than any other single clay mineral.	< 0.002 mm
Illitic	More than half by weight of illite (hydrous mica) commonly with > 3 percent K_2O .	< 0.002 mm
Vermiculitic	More than half by weight of vermiculite or more vermiculite than any other single clay mineral.	< 0.002 mm
Mixed	Other soils.*	< 0.002 mm
$\frac{1}{2}$	Or 2.5 x 15-bar water whichever is larger.	
$\frac{2}{2}$	Weight percentages as estimated from grain counts; usually, a count of one or two dominant size fractions of conventional mechanical analysis is sufficient for the placement of the soil.	

Mineralogy subclasses

Mineralogy subclasses are used in addition to mineralogy classes in some groups of soils.

Sulfureous (Tentative)	Soils containing either iron sulfates, commonly jarosite (straw-colored), if the pH after oxidation is less than 3.5; or more than 0.75 percent sulfur in the form of polysulfides if the soil contains less than three times as much carbonate (as $CaCO_3$ equiv.) only as sulfur (less than Ca^{++} than SO_4^{--} if all sulfur is oxidized).	Whole soil < 2 mm Histosols and Aquepts
Calcareous	Continuous presence of free carbonates in all parts of the fine earth fraction between depth of 25 cm and 50 cm (10 and 20 inch inches). (Use in Aquepts other than Fragiaquepts, in Aquolls, and in Entisols other than Psammments and Psammaquepts.)	Whole soil < 2 mm

* Sepiolitic, more than half by weight of sepiolite, attapulgite and palygorskite, should be used if found in soils that are not fine-carbonatic.

4. Soil temperature: Soil temperature classes, as named and defined in a and b below, are used as family differentiae in all orders. The names below are tentative and are used in the family descriptive name unless the name of a higher taxon carried the same limitation. Thus, frigid is implied in all Cryic great groups, and becomes redundant if used in the family name.

The Celsius (centigrade) scale is the standard. Approximate Fahrenheit equivalents are indicated parenthetically.

Soil Temperature Classes [at 50 cm (20 inches) depth]

- a. Soil with 5°C (9°F) or more difference between mean summer (June, July, and August) and mean winter (December, January, and February) temperatures, and with mean annual soil temperatures as follows:

(1) less than 8°C (47°F)	Frigid
(2) 8° to 15°C (47° to 59°F)	Mesic
(3) 15° to 22°C (59° to 72°F)	Thermic
(4) more than 22°C (72°F)	Hyperthermic

- b. Soils with less than 5°C (9°F) difference between mean summer and winter soil temperatures, and with mean annual soil temperatures as follows:

(1) less than 8°C (47°F)	Isofrigid
(2) 8° to 15°C (47° to 59°F)	Isomesic
(3) 15° to 22°C (59° to 72°F)	Isothermic
(4) more than 22°C (72°F)	Isohyperthermic

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

5. Other characteristics: Several other soil characteristics are needed in particular taxa to provide reasonable groupings of series into families. Some of these seem logical family criteria. Others probably should have been used in higher categories, but the lack of information about them makes it seem safer to use them as family differentiae at this time. These characteristics include:

- a. Permeability: Classes of moderate and slow permeability may be needed in some aquic subgroups if the accumulated differentiae have not already made the distinctions. It is thought that permeability classes will rarely be needed, but they may be needed in some families with clayey texture. The soils with saturated core permeabilities of 0.20 inches or less in some horizon should be grouped into "slowly permeable" families.
- b. Depth of soil: Classes of shallow and deep soils may be needed in all of the orders of mineral soils. Some distinctions are made in great groups, and in arenic and lithic subgroups, but there are still other soils that should be grouped according to depth. Some have a paralithic contact over soft rock, such as a clay shale, that is too compact for root penetration.

Soil Depth Classes

Micro: Less than 18 cm (7 inches) of solum (used in Cryic great groups only).

- Shallow: (1) Less than 50 cm (20 inches) to the upper boundary of a petrocalcic horizon or to a paralithic contact, used in all great groups of Entisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols and Ultisols except pergelic subgroups of the Cryic great groups (Cryaquepts, Cryumbrepts, Cryorthods, and so on). Note that the pergelic and lithic subgroups are also shallow, but the adjective "shallow" in the family name is redundant; or
- (2) Less than 1 m (40 inches) to a lithic or paralithic contact, used in Vertisols and Oxisols.

- c. Consistence: Some cemented horizons, such as duripans, are considered in the classification in categories above the family. Others, such as ortsteins, are not, but no single family should include soils with continuous cemented horizons, and soils without cemented horizons. Particularly to Spodosols, cementation of the spodic horizons needs to be used as a family differentia.
 - (1) For Spodosols, the following classes should be used:
 - (a) Ortstein: With all or part of the spodic horizon at least weakly cemented, when moist, into a massive horizon that is present in more than half of each pedon.
 - (b) Noncemented: Without cementation of the spodic horizon, when moist, into a massive horizon in at least half of each pedon.

Note that cementation of small volumes into shot or concretions does not constitute cementation into a massive horizon. The noncemented class normally will not carry any adjective in the family name to imply lack of cementation. The cemented class will carry the adjective "Ortstein" as a part of the family name.

Other characteristics--Cont.

- (2) Many calcic horizons are weakly cemented or even indurated. The petrocalcic horizon is expected to meet most if not all of the needs for recognition of cementation in these horizons. No cemented taxa are to be used in the family category.
- d. Moisture equivalent: Despite the emphasis given texture in the classification, there is remaining variability in the sandy soils, the sands, and the loamy sands. Some sands are very clean, almost completely free of silt and clay. Others have appreciable amounts. A moisture equivalent value of 2 percent seems to make a reasonable division of the sands that is appropriate at the family level. Two classes are to be recognized as follows in Quartzipsamments:
- (1) coated: With a moisture equivalent of 2 percent or more
- (2) uncoated: With a moisture equivalent of < 2 percent.

With additional study it is hoped that it will be possible to develop definitions that can be applied in the field. The moisture equivalent value used is the average of the control section, weighted for thickness. Moisture retained at one-tenth bar suction may be substituted for moisture equivalent.

- e. Slope, or shape of soil: Soils of aquic great groups normally have level planes, or concave surfaces, in places where the ground water saturates the soil during some season of the year. A few, however, are found on the sides of slopes where water cannot stand, and are kept wet by more or less continuous seepage of water from higher lying areas. In a very few, hydrostatic pressures keep the soils wet. No consistent internal morphologic clues have yet been found that distinguish these situations, but the 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 seem adequate, with these defined as they are in the Soil Survey Manual. It may be necessary to use slope classes in other orders, but they should not be used in families of Aquods or Albaqualfs.

FAMILY NAMES

Each family will require one or more names. One family name consists of a series of adjectives modifying the subgroup name. For these adjectives we take the class names given for texture, mineralogy, and so on, in family differentiae. To have consistent nomenclature, the order of adjectives is the texture, mineralogy class and subclass, reaction, temperature, permeability, depth, consistence, and coatings.

The other family name is the name of one of the series in the family. This name is underscored in the lists of series in each family. This is a shorter name intended primarily for use in conversations. This short name is most useful if the series is a common one that is well known in the locality. It may develop that some families will acquire several such names in different parts of the country, according to the series in the family that is best known locally.

CONTROL SECTION FOR SOIL SERIES

Primary attention at the series level is given to a control section. Many classes of soil within higher categories of the system have already been set apart on the basis of soil characteristics both within and without this control section. For the 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 portion of the regolith. Differences in soil or regolith outside the control section and not differentiae in categories higher than the series but relevant to the usefulness of the soils are bases for phase distinctions.

Whether or not there are well expressed genetic horizons, the portion of the soil to be considered in differentiating series within a family of mineral soils is as follows:

Cryic soils. From the mineral surface to a depth of 30 inches, or to a lithic or paralithic contact, or to a depth 10 inches below the level at which the soil temperature is 0°C about two months after the summer solstice, whichever is shallower.

Very shallow soils. From the mineral surface down to a lithic or paralithic contact if thickness of regolith is 1½ inches or less.

All other mineral soils. (Orders 1 through 9). From a depth of 10 inches down to (1) a lithic contact if it is within a depth of 40 inches, (2) a depth of 40 inches if the regolith is thicker than that but the named diagnostic horizons and subjacent Cca horizons are not, or (3) the bottom of the named diagnostic horizons and any subjacent Cca horizon if the thickness of both the named diagnostic horizons and the regolith exceeds 40 inches (about one meter), but not below a depth of 80 inches (roughly 2 meters)* (Note that calcic and gypsic horizons and duripans are diagnostic only if their upper boundaries are within 1 meter. Salic horizons are diagnostic if they start within 30 inches (or 75 cm) of the soil surface).

* A lower depth of 2 meters is tentative. The depth for the control section in grossarenic subgroups is still under discussion at the time of this printing.

CHAPTER 7

KEY TO ORDERS, SUBORDERS, AND GREAT GROUPS*

A. Mineral soils without a lithic or paralithic contact within 50 cm (20 inches) of the soil surface that have:

1. After the upper 18 cm (7 inches) are mixed, 30 percent or more clay in all horizons down to a lithic or a paralithic contact, or to a calcic horizon, or to 1 m (40 inches), whichever is shallower;
2. At some period in most years, cracks at least 1 cm wide at a depth of 50 cm (20 inches);
3. One or more of the following:
 - a. Gilgai;
 - b. At some depth between 25 cm and 1 m (10 and 40 inches), slickensides close enough to intersect;
 - c. At some depth between 25 cm and 1 m (10 and 40 inches), wedge-shaped or parallelepiped natural structural aggregates with their long axes tilted 10 to 60 degrees from horizontal.

ORDER 2 - Vertisols, p. 86

AA. Vertisols that are usually dry in all parts and have cracks that remain open throughout the year in most years. If inundated, the cracks may close for variable periods; if cultivated, the cracks may extend upwards only to the lower boundary of the Ap horizon.

Torrerts, p. 86

AB. Other Vertisols that have cracks that remain open for 90 cumulative days or more but not throughout the year in most years, and one or more of the following:

1. Cracks that open and close more than once during the year in most years;
2. A mean annual soil temperature of 22°C (72°F) or more;
3. Mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by less than 5°C (9°F).

Usterts, p. 87

ABA. Usterts that have moist chromas of less than 1.5 throughout the upper 30 cm (12 inches).

Pellusterts, p. 87

ABB. Other Usterts.

Chromusterts, p. 87

AC. Other Vertisols that have cracks that open and close once each year and remain open for 60 consecutive days or more during the year in more than 7 out of 10 years.

Xererts, p. 88

ACA. Xererts that have moist chromas of less than 1.5 throughout the upper 30 cm (12 inches).

Pelloxererts, p. 88

ACB. Other Xererts.

Chromoxererts, p. 88

AD. Other Vertisols that are usually moist in some part during most years and have cracks that open and close one or more times during the year but do not remain open for as many as 90 cumulative days; in a few years the soils may not crack.

Uderts, p. 86

ADA. Uderts that have moist chromas of less than 1.5 throughout the upper 30 cm (12 inches).

Pelluderts, p. 86

ADB. Other Uderts.

Chromuderts, p. 86

* Throughout the Key, unless specified otherwise, it is assumed that the soils are under natural conditions, that is, not irrigated and not artificially drained. The indicated moisture status refers to the period of the year when the soil is not frozen in any part. For example, if a soil is frozen in some part for 90 days, then the soil will be usually moist if it is moist in some part (but not necessarily the same part) between 18 cm and 50 cm (7 and 20 inches) depth for more than one-half of

KEY

- B. Other mineral soils that have no diagnostic horizon other than an ochric or an anthropic epipedon, an albic or an agric horizon, with or without any of the following:
1. A salic horizon, except that if the soil is saturated within 1 m (40 inches) for 1 month or more, and has not been irrigated, the upper boundary of the salic horizon must be 75 cm (30 inches) or more below the surface.
 2. If textures are finer than loamy fine sand, sodium saturation may exceed 15 percent in some part of the upper 50 cm (20 inches) only if sodium saturation increases or remains constant with depth below 50 cm (20 inches) and the soil is saturated with water within 1 m (40 inches) of the surface for 1 month or more when not frozen in any part;
 3. A calcic or gypsic horizon or duripan if its upper boundary is deeper than 1 m (40 inches) below the surface;
 4. Plinthite that forms a continuous phase if the upper boundary is deeper than 1.25 m (50 inches) below the surface;
 5. Buried diagnostic horizons other than a buried ochric epipedon if the surface of the buried solum is deeper than 50 cm (20 inches) or is at depths between 30 and 50 cm (12 and 20 inches) and the thickness of the buried solum is less than twice the thickness of the overlying deposits;
 6. Ironstone at any depth;
 7. If textures are coarser than loamy very fine sand to a depth of 1 m (40 inches), plinthite in the form of discrete nodules or disconnected, soft, red mottles if it constitutes less than half of the volume in all subhorizons.

ORDER 1 - Entisols, p. 70

- BA. Entisols that are either 1. permanently saturated with water and have dominant hues in all horizons below 25 cm (10 inches) that are (1) bluer than 10Y and (2) that change on exposure to the air; or 2. that are saturated with water at some period of the year or are artificially drained and that have, within 50 cm (20 inches) of the surface, dominant moist colors in the matrix as follows:

1. In horizons with textures finer than loamy fine sand
 - a. If there is mottling, chromas are 2 or less
 - b. If there is no mottling and values are less than 4, chromas are less than 1; if values are 4 or more, chromas are 1 or less
2. In horizons with textures of loamy fine sand or coarser
 - a. If hues are as red or redder than 10YR and there is mottling, chromas are 2 or less; if there is no mottling and values are less than 4, chromas are less than 1 or if values are 4 or more, chromas are 1 or less;
 - b. If hues are between 10YR and 10Y and there is distinct or prominent mottling, chromas are 3 or less; if there is no mottling, chromas are 1 or less;
 - c. Hues are bluer than 10Y;
 - d. Any color if the color is due to uncoated grains of sand.

Aquents, p. 70

- BAA. Aquents that have an N value of more than 0.5 and at least 8 percent clay and 3 percent organic matter in all subhorizons between 20 and 50 cm (8 and 20 inches), and mean annual soil temperatures more than 0°C (32°F).

Hydraquents, p. 72

- BAB. Other Aquents that have a mean annual soil temperature of less than 8°C (47°F) and have a mean summer soil temperature at 50 cm (20 inches) of less than 15°C (59°F) if they are drained and lack an O horizon or are cultivated; or if they are drained and have an O horizon, have a mean summer temperature at 50 cm (20 inches) of less than 8°C (47°F); or if they are undrained and have an O horizon, have a mean summer temperature of less than 6°C (43°F).

Cryaquents, p. 70

KEY

- BAC. Other Aquepts that have less than 5°C (9°F) difference between the mean summer and mean winter soil temperatures at 50 cm (20 inches).
Tropaquepts, p. 72
- BAD. Other Aquepts that have textures of loamy fine sand or coarser in all horizons below the Ap horizon or 25 cm (10 inches), whichever is deeper, to a depth of 1 m (40 inches) or to a lithic or paralithic contact, whichever is shallower, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more.
Psammaquepts, p. 72
- BAE. Other Aquepts.
- Haplaquepts, p. 71
- BE. Other Entisols that have below the Ap horizon or 25 cm (10 inches), whichever is deeper, textures of loamy fine sand or coarser in all parts either to a depth of 1 m (40 inches) or to a lithic or a paralithic contact, whichever is shallower; and that have no identifiable fragments of diagnostic horizons without discernible order within the series control section.
Psamments, p. 82
- BBA. Psamments that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of either less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon.
Cryopsamments, p. 82
- BBB. Other Psamments that have in the sand fraction more than 95 percent quartz, zircon, tourmaline, rutile, or other normally insoluble minerals that do not weather to liberate iron or aluminum.
Quartzipsamments, p. 82
- BBC. Other Psamments that are usually dry in most years in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or paralithic, whichever is shallower, or in some subhorizon above a lithic or paralithic contact shallower than 18 cm (7 inches).
Torriipsamments, p. 83
- BBD. Other Psamments that are dry for 90 cumulative days or more in most years in some subhorizon(s) between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or a paralithic contact, whichever is shallower, but are not continuously dry in all parts of the soil between these depths or in the subhorizon immediately above a lithic or paralithic contact shallower than 18 cm for as long as 60 consecutive days in more than 7 out of 10 years unless either the mean annual soil temperature is 22°C (72°F) or higher or the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by less than 5°C (9°F), or both.
Ustipsamments, p. 84
- BBE. Other Psamments that are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 cm (7 inches), whichever is deeper, and 50 cm (20 inches) or a lithic or a paralithic contact, whichever is shallower, or in the subhorizon immediately above a lithic or paralithic contact shallower than 18 cm (7 inches).
Xeropsamments, p. 84
- BBF. Other Psamments.
Udipsamments, p. 83
- BC. Other Entisols that lack fragments of diagnostic horizons that can be identified and have slopes of less than 25 percent and organic matter content that decreases irregularly with depth or remains above levels of 0.35 percent (0.2 percent carbon) for 1.25 m (50 inches); the mean annual soil temperature is more than 0°C (32°F). (Thin strata of sand or loamy sand may have less organic matter if the finer sediments at 1.25 m (50 inches) or below have 0.2 percent carbon or more.)
Fluvents, p. 73
- BCA. Fluvents that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at a depth of 50 cm (20 inches) of either less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon.
Cryofluvents, p. 73

BCB. Other Fluvents that are usually dry in most years in all parts between 18 cm and 50 cm (7 and 20 inches).

Torrifluvents, p. 74

BCC. Other Fluvents that are dry for 90 cumulative days or more in most years in some subhorizon between 18 cm and 50 cm (7 and 20 inches) but are not continuously dry in all parts between these depths for as long as 60 consecutive days in more than 7 out of 10 years unless the mean annual soil temperature is 22°C (72°F) or higher or the mean summer and mean winter soil temperatures at 50 cm (20 inches) depth differ by less than 5°C (9°F), or both.

Ustifluvents, p. 76

BCD. Other Fluvents that are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 cm and 50 cm (7 and 20 inches).

Xerofluvents, p. 77

BCE. Other Fluvents that have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more.

Udifluvents, p. 75

BCF. Other Fluvents.

Tropofluvents, p. 74

BD. Other Entisols that lack fragments of diagnostic horizons that can be identified within the series control section.

Orthents, p. 77

BDA. Other Orthents that have a mean annual soil temperature of less than 8°C (47°F) and have a mean summer soil temperature at a depth of 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, either of less than 15°C (59°F) if cultivated or without an O horizon, or of less than 8°C (47°F) if with an O horizon.

Cryorthents, p. 77

BDB. Other Orthents that are usually dry in most years in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or a paralithic contact, whichever is shallower, or in some subhorizon above a lithic or paralithic contact shallower than 18 cm (7 inches).

Torriorthents, p. 78

BDC. Other Orthents that are dry for 90 cumulative days or more in most years in some subhorizon(s) between 18 cm and 50 cm (7 and 20 inches) depth or above a lithic or a paralithic contact shallower than 50 cm (20 inches); but are not continuously dry in all parts of the soil between these depths or in the subhorizon immediately above a lithic or paralithic contact shallower than 18 cm (7 inches) for as long as 60 consecutive days in more than 7 out of 10 years unless either the mean annual soil temperature is 22°C (72°F) or higher or the mean summer and mean winter soil temperatures at 50 cm (20 inches) depth or at a lithic or paralithic contact, whichever is shallower, differ by less than 5°C (9°F), or both.

Ustorthents, p. 80

BDD. Other Orthents that are dry for 60 cumulative days or more in more than 7 out of 10 years in all parts of the soil between 18 cm and 50 cm (7 and 20 inches) or a lithic or a paralithic contact, whichever is shallower, or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches).

Xerorthents, p. 81

BDE. Other Orthents that have mean summer and mean winter soil temperatures at 50 cm (20 inches) or a lithic or a paralithic contact, whichever is shallower, that differ by 5°C (9°F) or more.

Udorthents, p. 79

KEY

BDF. Other Orthents.

Troporthents, p. 79

BE. Other Entisols that have fragments of diagnostic horizons that occur more or less without discernible order in the soil below any Ap horizon.

Arents, p. 73

C. Other mineral soils that have no spodic, argillic, natric, or oxic horizon unless it is a buried horizon or no petrocalcic horizon with its upper boundary within 1 m (40 inches) of the soil surface; that have no plinthite that forms a continuous phase within 30 cm (12 inches) of the mineral surface; and either:

1. Are usually moist between 18 and 50 cm (7 and 20 inches) or above a lithic or a paralithic contact shallower than 50 cm (20 inches); that lack a salic, or gypsic horizon within 1 m (40 inches) of the surface; and that have one or more of the following:

a. A conductivity of the saturation extract at 25°C (77°F) of less than 2 mmho per cm down to whichever of these depths is least: a lithic or a paralithic contact or within 1.25 m (50 inches) of the surface if particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey; and, if without a fragipan, with increase in depth in the C horizon but above the depths for the different particle-size classes specified above, either there is no increase in saturation with Na plus K or there is exchange acidity in excess of Na plus K; and with one or more of:

- (1) A cambic or a calcic horizon or both;
- (2) A fragipan that has no clay skins as thick as 1 mm;
- (3) A duripan with its upper boundary within 1 m (40 inches) of the surface.

b. Artificial drainage or saturation with water at some period of the year when not frozen, and at depths of less than 50 cm (20 inches) or immediately underlying an umbric epipedon, have a horizon with moist colors that meet one or more of the following requirements:

- (1) If there is mottling, chromas are 2 or less;
- (2) If there is no mottling, chromas are 1 or less.*

c. Sodium saturation of more than 15 percent in some part of the upper 50 cm (20 inches) that decreases with depth below 50 cm (20 inches) and the soil is saturated with water at some period within a depth of 1 m (40 inches); or

2. Have an umbric, histic, or plaggen epipedon; or a mollic epipedon with one or more of the following combinations of properties:

a. A bulk density of the fine earth fraction of less than 0.85 g per cc in the epipedon or the cambic horizon or both, and the exchange complex is dominated by amorphous materials;

b. ^{underlying} A cambic horizon with base saturation of less than 50 percent (by NH₄OAc) throughout or decreasing to less than 50 percent at a depth of 1.8 m (72 inches) below the surface, whichever is shallower;

c. The mean summer and mean winter soil temperatures differ by less than 5°C (9°F) when measured at a depth of 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, and one or both of:

(1) 35 percent or more clay with montmorillonitic mineralogy, and the epipedon rests on materials with less than 40 percent CaCO₃ equivalent;

(2) ~~A cambic horizon with base saturation that is less than 50 percent (by NH₄OAc) throughout or decreasing to less than 50 percent at a depth of 1.8 m (72 inches).~~

moist and dry values of the mollic epipedon are no darker than those of the underlying horizon

ORDER 3 - Inceptisols, p. 89

* If hues are redder than 10YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived.

KEY

CA. Inceptisols that either are saturated with water at some period of the year or artificially drained, and that have, at depths of less than 50 cm (20 inches), characteristics associated with wetness, namely, one or more of the following:

1. A histic epipedon;
2. Sodium saturation of more than 15 percent in some part of the upper 50 cm (20 inches) that decreases with depth below 50 cm (20 inches);
3. Dominant moist colors on ped faces, or in the matrix if peds are absent, as follows:
 - a. If there is mottling within the horizon, chromas are 2 or less;
 - b. If there is no mottling, chromas are 1 or less.*

Aquepts, p. 92

CAA. Aquepts that have a mean annual soil temperature of less than 8°C (47°F) and have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of less than 15°C (59°F) if they are drained and either cultivated or lack an O horizon; of less than 8°C (47°F) if they are drained and have an O horizon or a histic epipedon; and less than 6°C (43°F) if they are undrained and have an O horizon or a histic epipedon. N values are 0.5 or less in some horizon between 20 and 50 cm (8 and 20 inches) or the mean annual soil temperature is 0°C (32°F) or less.

Cryaquepts, p. 92

CAB. Other Aquepts that have plinthite that forms a continuous phase or constitutes more than half of the matrix within some subhorizon in the upper 1.25 m (50 inches) of the soil.

Plinthaquepts, p. 97

CAC. Other Aquepts that have a bulk density of the fine earth fraction of the soil of less than 0.85 g per cc in some horizon; no fragipan; and an exchange complex that is dominated by amorphous materials; or vitric volcanic ash, cinders, or other vitric pyroclastic materials constitute 60 percent or more of the silt, sand, and gravel fractions.

Andaquepts, p. 92

CAD. Other Aquepts that have less than 5°C (9°F) difference between the mean summer and mean winter soil temperatures at 50 cm (20 inches), or at a lithic or paralithic contact, whichever is shallower.

Tropequepts, p. 97

CAE. Other Aquepts that have a fragipan.

Fragiaquepts, p. 93

CAF. Other Aquepts that have sodium saturation that is more than 15 percent in some part of the upper 50 cm (20 inches) and that decreases with depth below 50 cm (20 inches).

Halaquepts, p. 94

CAG. Other Aquepts that have an umbric, a mollic, or a histic epipedon.

Humaquepts, p. 96

CAH. Other Aquepts that have an ochric epipedon.

Haplaquepts, p. 94

* If hues are redder than 10 YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived.

KEY

CB. Other Inceptisols that have a plaggan epipedon.

Flaggepts, p. 103

CC. Other Inceptisols that have one or both of:

1. A bulk density of the fine earth fraction of the soil of less than 0.85 g per cc in the epipedon or the cambic horizon or both and an exchange complex that is dominated by amorphous material;
2. Have 60 percent or more of vitric volcanic ash, cinders, or other vitric pyroclastic material in the silt, sand, and gravel fractions.

Andepts, p. 89

CCA. Andepts that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon, or of less than 8°C (47°F) if with an O horizon.

Cryandepts, p. 90

CCB. Other Andepts that have a duripan within 1 m (40 inches) of the surface.

Durandepts, p. 90

CCC. Other Andepts that have clays that dehydrate irreversibly into gravel-size aggregates.

Hydrandepts, p. 91

CCD. Other Andepts that have a mollic epipedon; and are thixotropic in some horizon or the 15-bar water is 20 percent or more based on the average for the whole soil in the control section.

Eutrandepts, p. 90

CCE. Other Andepts that have an umbric or ochric epipedon; and are thixotropic in some horizon or the 15-bar water is 20 percent or more based on the whole soil in the control section.

Dystrandepts, p. 90

CCF. Other Andepts.

Vitrandepts, p. 91

CD. Other Inceptisols that have a mean annual soil temperature of 8°C (47°F) or more and have less than 5°C (9°F) difference between the mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, and one of:

1. An umbric epipedon;
2. A mollic epipedon with one or both of the following:
 - a. 35 percent or more clay with montmorillonitic mineralogy, and the epipedon rests on materials with less than 40 percent CaCO₃ equivalent;
 - b. a cambic horizon with base saturation that is less than 50 percent (by NH₄OAc) throughout or decreasing to less than 50 percent at a depth of 1.8m (72 inches).
3. An ochric epipedon and a cambic horizon.

Tropepts, p. 103

CDA. Tropepts that have 50 percent or more base saturation (by NH₄OAc) throughout the epipedon and any cambic horizon, and either are dry in some horizon for 90 cumulative days or more in most years or have a horizon containing soft, powdery secondary lime within 1.5m (60 inches) of the surface.

Ustropepts, p. 106

KEY

- CDB. Other Tropepts with 50 percent or more base saturation (by NH_4OAc) throughout the epipedon and any cambic horizon.
Eutropepts, p. 104
- CDC. Other Tropepts with a mean annual soil temperature of 22°C (72°F) or more.
Dystropepts, p. 104
- CDD. Other Tropepts.
Humitropepts, p. 105
- CE. Other Inceptisols that have one of the following characteristics:
1. If the mean annual soil temperature is 8°C (47°F) or more, either an umbric or anthropic epipedon that is more than 25 cm (10 inches) thick or a mollic epipedon that is more than 25 cm (10 inches) thick if it is underlain by a cambic horizon with base saturation of less than 50 percent (by NH_4OAc) in some part;
 2. If the mean annual soil temperature is less than 8°C (47°F), either an umbric or a mollic epipedon if the mollic epipedon is underlain by a cambic horizon that has base saturation of less than 50 percent (by NH_4OAc) in some part.
Umbrepts, p. 107
- CEA. Umbrepts that have an anthropic epipedon.
Anthrumbrepts, p. 107
- CEB. Other Umbrepts that have a fragipan.
Fragiumbrepts, p. 108
- CEC. Other Umbrepts that have a mean annual soil temperature of less than 8°C (47°F) and have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon.
Cryumbrepts, p. 107
- CED. Other Umbrepts that are never dry, or are not dry for as much as 60 consecutive days in more than 7 out of 10 years in all subhorizons between 18 cm and 50 cm (7 and 20 inches) or a lithic or paralithic contact, whichever is shallower, or in the subhorizon immediately above a lithic or paralithic contact shallower than 18 cm (7 inches).
Haplumbrepts, p. 108
- CEE. Other Umbrepts.
Xerumbrepts, p. 109
- CF. Other Inceptisols.
Ochrepts, p. 98
- CFA. Ochrepts that have a fragipan.
Fragiochrepts, p. 101
- CFB. Other Ochrepts that have a duripan with its upper boundary within 1 m (40 inches) of the surface.
Durochrepts, p. 98
- CFC. Other Ochrepts that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon.
Cryochrepts, p. 98

KEY

CFD. Other Ochrepts that are dry for 90 cumulative days or more in most years in some subhorizon(s) of the soil between 18 cm and 50 cm (7 and 20 inches) depth or above a lithic or a paralithic contact shallower than 50 cm (20 inches) but are not continuously dry in all parts of the soil between these depths for as long as 60 consecutive days in more than 7 out of 10 years unless the mean annual soil temperature is 22°C (72°F) or higher, or the mean summer and mean winter soil temperatures at 50 cm depth differ by less than 5°C (9°F) or both.

Ustochrepts, p. 101

CFE. Other Ochrepts that are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 cm and 50 cm (7 and 20 inches) or a lithic or a paralithic contact, whichever is shallower, or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches).

Xerochrepts, p. 102

CFG. Other Ochrepts that have one or both of:

1. Carbonates in the cambic horizon or in the C horizon but within the soil;
2. Base saturation (by NH_4OAc) that is 60 percent or more in some subhorizon that is within 75 cm (30 inches) of the soil surface.

Eutrochrepts, p. 100

CFG. Other Ochrepts.

Dystrochrepts, p. 99

D. Other mineral soils that have an ochric epipedon but have no oxie or spodic horizon and one or more of the following combinations of properties:

1. No argillic or natric horizon but within 1 m (40 inches) of the surface have one or more of the following horizons: calcic, petrocalcic, gypsic, cambic, or duripan; and either are usually dry between 18 cm and 50 cm (7 and 20 inches) depth or a lithic or a paralithic contact, whichever is shallower or have a conductivity of the saturation extract that is 2 mmho per cm or greater at 25°C in some part above whichever of the following depths is least: a lithic or paralithic contact, 1.25 m (50 inches) if particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey; or with increase in depth within the C horizon but above the depths for the different particle-size classes specified above there is an increase in saturation with Na plus K in some part;
2. No argillic or natric horizon but have a salic horizon within 75 cm (30 inches) of the surface and are saturated with water within 1 m (40 inches) of the surface for one month or more;
3. A surface horizon that is not both hard and massive when dry; and argillic or natric horizon; and usually dry in most years in all parts of the soil between 18 cm and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in some subhorizon above a lithic or a paralithic contact shallower than 18 cm (7 inches).

ORDER 4 - Aridisols, p. 110

DA. Aridisols that lack an argillic or natric horizon unless it is a buried horizon.

Orthids, p. 115

DAA. Orthids that have a duripan with its upper boundary within 1 m (40 inches) of the surface.

Durorthids, p. 118

DAB. Other Orthids that:

1. Have a salic horizon within 75 cm (30 inches) of the surface if saturated with water (i.e. within the capillary fringe) within 1 m (40 inches) of the surface for 1 month or more; and
2. Lack a calcic or gypsic horizon above the salic horizon.

Salorthids, p. 120

DAC. Other Orthids that have a petrocalcic horizon with its upper boundary within 1 m (40 inches) of the soil surface.

Paleorthids, p. 119

KEY

- DAD. Other Orthids that:
1. Have either a calcic or gypsic horizon with an upper boundary within 1 m (40 inches) of the surface; and
 2. Are calcareous in all parts above the calcic horizon after the upper 18 cm (7 inches) are mixed unless textures are coarser than loamy very fine sand.
- Calciorthids, p. 115
- DAE. Other Orthids.
- Camborthids, p. 116
- DB. Other Aridisols.
- Argids, p. 110
- DBA. Argids that have a natric horizon with columnar structure above a duripan, and the upper boundary of the duripan is within 1 m (40 inches) of the soil surface.
- Nadurargids, p. 112
- DBB. Other Argids that have a duripan below an argillic horizon or below a natric horizon lacking columnar structure, and the upper boundary of the duripan is within 1 m (40 inches) of the soil surface.
- Durargids, p. 110
- DBC. Other Argids that have a natric horizon with columnar structure, and have no petrocalcic horizon with an upper boundary within 1 m (40 inches) of the soil surface.
- Natrargids, p. 113
- DBD. Other Argids that have either a petrocalcic horizon with an upper boundary within 1 m (40 inches) of the soil surface or that have an argillic horizon or prismatic or blocky natric horizon with both 35 percent or more clay in some part, and either:
1. An increase of 15 percent or more clay (absolute) within a vertical distance of 2.5 cm (1 inch) at the upper boundary of the argillic horizon; or
 2. An increase of 10 percent or more clay (absolute) if cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon.
- Paleargids, p. 114
- DBE. Other Argids.
- Haplargids, p. 111
- E. Other mineral soils that have a spodic horizon or a placic horizon cemented by iron that overlies a fragipan and that meets all the requirements of a spodic horizon except thickness.
- ORDER 6 - Spodosols, p. 151
- EA. Spodosols, either saturated* with water at some period or artificially drained, that 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 top of the spodic horizon;
 3. A duripan in the albic horizon;
 4. If free iron and manganese are lacking, or if moist color values are less than 4 in the upper part of the spodic horizon, either have:
 - a. No coatings of iron oxides on the individual grains of silt and sand in the materials in or immediately below the spodic horizon wherever the moist values are 4 or more and unless an Ap horizon rests directly on the spodic horizon there is a transition between the albic and spodic horizons at least 1 cm in thickness; or have
 - b. Fine or medium mottles of iron or manganese in the materials immediately below the spodic horizon.
- Aquods, p. 151

* If a placic horizon is present, the soil need not be saturated below the placic horizon.

KEY

EAA. Aquods that have a fragipan below the spodic horizon but that lack a placic horizon above the fragipan.

Fragiaquods, p. 152

EAB. Other Aquods that have no placic horizon but have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of:

1. Less than 15°C (59°F) if they are drained and lack an O horizon;
2. Less than 8°C (47°F) if they are drained and have an O horizon;
3. Less than 6°C (43°F) if they are undrained and have an O horizon or a histic epipedon.

Cryaquods, p. 151

EAC. Other Aquods that have a strongly cemented or indurated albic horizon that will not slake in water when a dry fragment is immersed.

Duraquods, p. 151

EAD. Other Aquods that have a placic horizon that rests on a spodic horizon, a fragipan, or an albic horizon that is underlain by a fragipan.

Placaquods, p. 153

EAE. Other Aquods that have a mean annual soil temperature of 8°C (47°F) or higher and mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by less than 5°C (9°F).

Tropaquods, p. 154

EAF. Other Aquods that have one or both of:

1. In more than 50 percent of each pedon, a spodic horizon with some subhorizon that contains dispersed organic matter and aluminum and lacks sufficient free iron to turn redder on ignition (less than 0.5 percent in the fine earth fraction expressed as Fe);
2. An Ap horizon that has a moist value of 3 or less and a moist chroma of 2 or less and that rests directly on a spodic horizon having in its upper part a subhorizon or some tongues with one or both of:
 - a. Dispersed organic matter and a moist value and moist chroma of 3 or less;
 - b. Less than 0.7 percent free iron expressed as Fe.

Haplaquods, p. 152

EAG. Other Aquods.

Sideraquods, p. 153

EB. Other Spodosols that have one or both of:

1. In more than 50 percent of each pedon a spodic horizon with a subhorizon that contains dispersed organic matter and aluminum and that lacks sufficient free iron to turn redder on ignition (less than 0.5 percent in the fine earth fraction expressed as Fe);
2. An Ap horizon with a moist value of 3 or less and a moist chroma of 2 or less and rests directly on a spodic horizon that has in its upper part a subhorizon or some tongues possessing one or both of:
 - a. Dispersed organic matter and a value and chroma of 3 or less when moist;
 - b. Less than 0.7 percent free iron expressed as Fe.

Humods, p. 155

EBA. Humods that have a placic horizon in the spodic horizon.

Placohumods, p. 156

EBB. Other Humods that have a mean annual soil temperature of 8°C (47°F) or higher and mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Trophumods, p. 156

KEY

EBC. Other Humods that have a fragipan below the spodic horizon.

Fragihumods, p. 155

EBD. Other Humods that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) either less than 15°C (59°F) if cultivated or without an O horizon or less than 8°C (47°F) if with an O horizon.

Cryohumods, p. 155

EBE. Other Humods.

Haplohumods, p. 155

EC. Other Spodosols that have a spodic horizon that has in some subhorizon a ratio of free iron (elemental) to carbon of 6 or less.

Orthods, p. 156

ECA. Orthods that have a placic horizon above or in the spodic horizon.

Placorthods, p. 159

ECB. Other Orthods that have a fragipan below the spodic horizon.

Fragiorthods, p. 157

ECC. Other Orthods that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon; or less than 8°C (47°F) if with an O horizon.

Cryorthods, p. 156

ECD. Other Orthods.

Haplorthods, p. 158

ED. Other Spodosols.

Ferrods, p. 154

F. Other mineral soils that have a mean annual soil temperature of 8°C (47°F) or higher; and if mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, differ by 5°C (9°F) or more, have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of 15°C (59°F) or higher if without an O horizon or 8°C (47°F) or higher if with an O horizon; nooxic horizon unless it underlies an argillic horizon; no plinthite that forms a continuous phase within 30 cm (12 inches) of the soil surface; and one of the following combinations of characteristics:

1. No fragipan and base saturation (by sum of cations) of less than 35 percent at 1.25 m (50 inches) below the upper boundary of the argillic horizon or 1.8 m (72 inches) below the soil surface or above a lithic or a paralithic contact, whichever is shallower;
2. A fragipan that:
 - a. Meets all of the requirements of an argillic horizon or that has clay skins 1 mm or more thick in some part;
 - b. Has base saturation (by sum of cations) of less than 35 percent at a depth of 75 cm (30 inches) below the upper boundary of the fragipan.

ORDER 6 - Ultisols, p. 184

FA. Ultisols, either saturated with water at some period or artificially drained, that have characteristics associated with wetness, namely: mottles, iron-manganese concretions > 2 mm or has moist chromas of 2 or less immediately below any Ap or Al horizon that has moist values of less than 3.5 when rubbed, and one of the following:

1. Dominant moist chromas of 2 or less in coatings on the surface of peds accompanied by mottles within the peds, or dominant chromas of 2 or less in the matrix of the argillic horizon accompanied by mottles of higher chromas (if hues are redder than 10YR because of parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived);

KEY

2. Moist chromas of 1 or less on surfaces of peds or in the matrix of the argillic horizon.

Aquults, p. 184

- FAA. Aquults that have plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Plinthaquults, p. 185

- FAB. Other Aquults that have a fragipan.

Fragiaquults, p. 184

- FAC. Other Aquults that have a mean annual soil temperature of 8°C (47°F) or higher and have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Tropaquults, p. 185

- FAD. Other Aquults that have an ochric epipedon.

Ochraquults, p. 184

- FAE. Other Aquults that have an umbric or a mollic epipedon.

Umbraquults, p. 186

- FB. Other Ultisols that:

1. Are dry for 90 cumulative days or more in most years in some subhorizon of the soil between 18 cm and 50 cm (10 and 20 inches) or above a lithic or a paralithic contact, shallower than 50 cm, but are not continuously dry in all parts of the soil between these depths for as long as 60 consecutive days unless the mean annual soil temperature is 22°C (72°F) or more or the mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, differ by less than 5°C (9°F);
2. Have less than 1.5 percent organic matter (0.87 percent carbon) in the upper 15 cm (6 inches) of the argillic horizon exclusive of an Ap;
3. Have less than 20 kg organic matter in a unit volume of 1 m² to a depth of 1 m (40 inches) below the base of any O horizon or the mineral surface.

Ustults, p. 194

- FBA. Ustults that have plinthite that forms a continuous phase or constitutes more than half of the volume in some horizon within 1.25 m (50 inches) of the soil surface.

Plinthustults, p. 195

- FBB. Other Ustults that have an argillic horizon that has less than 10 percent weatherable minerals in the 20 to 200 micron fraction in the upper 1 m (40 inches) and has a clay distribution with depth such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletal or other evidences of clay eluviation.

Paleustults, p. 195

- FBC. Other Ustults that have:

1. An epipedon with moist color values of less than 4 in all parts;
2. An argillic horizon with dry color values of less than 5 and no more than 1 unit higher than moist values.

Rhodustults, p. 195

- FBD. Other Ustults that have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, that differ by less than 5°C. (9°F).

Tropustults, p. 196

KEY

FBE. Other Ustults.

Haplustults, p. 194

FC. Other Ultisols that:

1. Are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 cm and 50 cm (7 and 20 inches) or a lithic or a paralithic contact, whichever is shallower;
2. Have less than 1.5 percent organic matter (0.87 percent carbon) in the upper 15 cm (6 inches) of the argillic horizon exclusive of any Ap;
3. Have less than 20 kg organic matter in a unit volume of 1 m² to a depth of 1 m (40 inches) below the base of any O horizon or the mineral surface.

Xerults, p. 196

FCA. Xerults that have an argillic horizon that has less than 10 percent weatherable minerals in the 20 to 200 micron fraction in the upper 1 m (40 inches) and has a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletons or other evidences of clay eluviation.

Palexerults, p. 197

FCB. Other Xerults.

Haploxerults, p. 197

FD. Other Ultisols that either:

1. Have 1.5 percent or more organic matter (0.87 percent carbon) in the upper 15 cm (6 inches) of the argillic horizon;
2. Have 20 kg or more organic matter in a unit volume of 1 m² to a depth of 1 m (40 inches) below the base of any O horizon or both.

Humults, p. 186

FDA. Humults that have an argillic horizon that has less than 10 percent weatherable minerals in the 20 to 200 micron fraction in the upper 1 m (40 inches) and has a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletons or other evidences of clay eluviation.

Palehumults, p. 187

FDB. Other humults that have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Tropohumults, p. 188

FDC. Other Humults.

Haplohumults, p. 186

FE. Other Ultisols.

Udults, p. 188

FEA. Udults that have a fragipan in or below the argillic horizon.

Fragiudults, p. 189

FEB. Other Udults that have plinthite that forms a continuous phase or constitutes more than half of the volume in some horizon within the upper 1.25 m (50 inches) of the soil.

Flinthudults, p. 192

FEC. Other Udults that have an argillic horizon that has less than 10 percent weatherable minerals in the 20 to 200 micron fraction in the upper 1 m (40 inches) and has a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletons or other evidences of clay eluviation.

Paleudults, p. 191

KEY

FED. Other Udults that have:

1. An epipedon with moist color values of less than 4 in all parts;
2. An argillic horizon with dry color values of less than 5 and no more than 1 unit higher than moist values.

Rhodudults, p. 192

FEE. Other Udults that have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Tropudults, p.193

FEF. Other Udults.

Hapludults, p. 190

- G. Other mineral soils that lack an oxic horizon and that either have a mollic* epipedon or have a surface horizon that, after mixing to 18 cm (7 inches) meets all requirements for a mollic epipedon except thickness and in addition have an upper subhorizon in an argillic or natric horizon that is more than 7.5 cm (3 inches) thick, and that meets the color, organic matter, base saturation, and structure requirements of a mollic epipedon, but that is separated from the surface horizon by an albic horizon. (Note that the combined thicknesses meet the thickness requirement for a mollic epipedon.)

ORDER 5 - Mollisols, p. 121

GA. Mollisols that have all of the following characteristics:

1. A mollic epipedon not more than 50 cm (20 inches) thick;
2. No argillic horizon;
3. No calcic horizon;
4. Material, including coarse fragments less than 7.5 cm (3 inches) in diameter, that has more than 40 percent calcium carbonate in or immediately below the mollic epipedon.

Rendolls, p. 132

GB. Other Mollisols that have:

1. An albic horizon immediately underlying the mollic epipedon, or that separates horizons that together meet all of the requirements of a mollic epipedon;
2. An argillic or natric horizon;
3. In the albic horizon and in the argillic or natric horizon, characteristics associated with wetness, namely: mottles, iron-manganese concretions larger than 2 mm, or both.

Albolls, p. 121

GBA. Albolls that have a natric horizon.

Natralbolls, p. 122

GBB. Other Albolls.

Argialbolls, p. 121

GC. Other Mollisols, either saturated with water at some period during the year or artificially drained, that have one or more of the following characteristics associated with wetness:

1. A histic epipedon;
2. Sodium saturation of more than 15 percent in the upper part of the mollic epipedon and decreasing saturation with increasing depth below 50 cm (20 inches);
3. One of the following combinations of moist colors, in and either immediately below the mollic epipedon or within 75 cm (30 inches) of the surface if a calcic horizon immediately underlies the mollic epipedon;
 - a. If the lower part of the mollic epipedon has chromas of 1 or less there are either:
 - (1) Distinct or prominent mottles in the lower mollic epipedon; or

* At present we are grouping a few soils with Mollisols that have epipedons meeting all requirements for a mollic epipedon except color value. These soils have more than 4 percent organic matter and more than 40 percent finely divided calcium carbonate throughout the epipedon. Some are grouped with Calciaquolls and some with Rendolls.

KEY

- (2) Colors immediately below the mollic epipedon or within 75 cm (30 inches) of the surface if a calcic horizon intervenes, with one of the following:
- Where hues are 10YR or redder and there are mottles, chromas are less than 1.5 on ped surfaces or in the matrix; where there are no mottles, chromas are less than 1;
 - Where the hue is nearest to 2.5Y and there are distinct or prominent mottles, chromas are 2 or less on ped surfaces or in the matrix; and where there are no mottles, chromas are 1 or less;
 - Where the nearest hue is 5Y or yellower and there are distinct or prominent mottles, chromas are 3 or less on ped surfaces or in the matrix; and where there are no mottles, chromas are 1 or less;
 - Hues are bluer than 10Y;
 - The color results from uncoated mineral grains;
- b. If the lower part of the mollic epipedon has chromas of more than 1 but not exceeding 2, there are either:
- Distinct or prominent mottles in the lower mollic epipedon; or
 - Base colors immediately below the mollic epipedon that have one or more of:
 - Values of 4 and chromas of 2 accompanied by some mottles with values of 4 or more and chromas of less than 2;
 - Values of 5 or more and chromas of 2 or less accompanied by mottles with higher chroma;
 - Values of 4 and chromas of less than 2.
4. A calcic horizon with its upper boundary within 40 cm (16 inches) of the surface.
- Aquolls, p. 122
- GCA. Aquolls that have a mean annual soil temperature of less than 8°C (47°F) and the mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, is less than 15°C (59°F) if the soil is drained and has no O horizon or histic epipedon; less than 8°C (47°F) if drained and with an O horizon; and less than 6°C (43°F) if the soil is undrained and has an O horizon or a histic epipedon.
- Cryaquolls, p. 124
- GGB. Other Aquolls that have a duripan within 1 m (40 inches) of the surface.
- Duraquolls, p. 125
- GCC. Other Aquolls that have a natric horizon.
- Natraquolls, p. 126
- GCD. Other Aquolls that have a calcic horizon with its upper boundary within 40 cm (16 inches) of the surface, and lack an argillic horizon unless it is a buried horizon.
- Calciquolls, p. 124
- GCE. Other Aquolls that have an argillic horizon.
- Argiquolls, p. 123
- GCF. Other Aquolls.
- Haplaquolls, p. 125
- GD. Other Mollisols that have a mean annual soil temperature of less than 8°C (47°F); and either a moist chroma of 1.5 or less in the mollic epipedon to a depth of 15 cm (6 inches) or more or a mean summer soil temperature at 50 cm (20 inches) or a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if without an O horizon and less than 8°C (47°F) if with an O horizon.
- Borolls, p. 126
- GDA. Borolls that have an argillic horizon with an upper boundary deeper than 60 cm* (24 inches) below the mineral surface and with textures finer than loamy fine sand in all subhorizons above the argillic horizon.
- Palebolls, p. 131

* If there is a surface mantle that has more than 60 percent vitric volcanic ash, cinders or other vitric pyroclastic materials, the depth to the argillic horizon is measured from the base of this mantle rather than from the mineral surface.

KEY

GDB. Other Borolls that have a mean summer soil temperature at 50 cm (20 inches) or a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if without an O horizon and less than 8°C (47°F) if with an O horizon.

Cryoborolls, p. 128

GDC. Other Borolls that have a natric horizon but have no cambic horizon that is above the natric horizon and separated from it by an albic horizon.

Natriborolls, p. 131

GDD. Other Borolls that have an argillic horizon but have no cambic horizon that is above the argillic horizon and separated from it by an albic horizon.

Argiborolls, p. 127

GDE. Other Borolls that have a mollic epipedon more than 50 cm (20 inches) thick that contains many worm casts and has a transition to the underlying horizon in which 25 percent or more of the matrix shows mixing of the epipedon and the underlying horizon in the form of worm casts or filled animal burrows.

Vermiborolls, p. 132

GDF. Other Borolls that have a calcic or gypsic horizon with its upper boundary within 1 m (40 inches) of the surface, and that are calcareous in all parts of all horizons above the calcic or gypsic horizon after the upper 18 cm (7 inches) are mixed unless textures are coarser than loamy very fine sand.

Calciborolls, p. 128

GDG. Other Borolls.

Hsploborolls, p. 130

GE. Other Mollisols that are not continuously dry in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches) for as long as 60 consecutive days in more than 7 out of 10 years unless the mean annual soil temperature is 22°C (72°F) or higher, or the mean summer and mean winter soil temperatures at 50 cm (20 inches) depth or at a lithic or a paralithic contact, whichever is shallower, differ by less than 5°C (9°F), or both; and with one or more of the following:

1. Dry for 90 cumulative days or more in most years in some subhorizon(s) of the soil between 18 and 50 cm (7 and 20 inches) or above a lithic or a paralithic contact shallower than 50 cm (20 inches);
2. Base saturation (by NH_4OAc) of 80 percent or higher in all parts of the soil above a lithic or a paralithic contact that occurs within 50 cm (20 inches) of the surface;
3. Within 1.5 m (60 inches) of the soil surface or within 50 cm (20 inches) below the base of any cambic or argillic horizon, either a calcic horizon or a horizon with concentrations of soft powdery lime in spheroidal forms, as coatings on peds, or disseminated in clay-size particles;*
4. Increasing saturation with Na plus K within 1.25 m (50 inches) of the surface if particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey.

Ustolls, p. 137

GEA. Ustolls that have a duripan within 1 m (40 inches) of the surface.

Durustolls, p. 139

GEB. Other Ustolls that have a natric horizon.

Natrustolls, p. 142

GEC. Other Ustolls that have a calcic or gypsic horizon with its upper boundary within 1 m (40 inches) of the surface, or a petrocalcic horizon that has its upper boundary within 1.5 m (60 inches) of the soil surface, and that are calcareous in all parts of all horizons above the calcic, petrocalcic, or gypsic horizon after the upper 18 cm (7 inches) are mixed unless textures are coarser than loamy very fine sand.

Calcustolls, p. 139

* If the lime is disseminated, the horizon(s) in which the lime is concentrated should have more lime than the underlying horizon and should have the maximum percentage of clay-sized lime.

- GED. Other Ustolls that have a petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface, or an argillic horizon with one or both:
1. A vertical clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface, and one or more of:
 - a. Hues redder than 10YR and chromas of more than 4 in the matrix;
 - b. Common coarse mottles with hues of 7.5YR or redder or chromas of more than 5;
 2. A particle-size class that is clayey in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary.

Paleustolls, p. 143

- GEE. Other Ustolls that have an argillic horizon.

Argiustolls, p. 137

- GEF. Other Ustolls that have a mollic epipedon below any Ap that is 50 percent or more by volume of worm holes and worm casts, or filled animal burrows, and either rests on a lithic contact or has a transition to the underlying horizon in which 25 percent or more of the material is discrete worm casts or filled animal burrows from the mollic epipedon and the underlying horizon.

Vermustolls, p. 144

- GEG. Other Ustolls.

Haplustolls, p. 140

- GF. Other Mollisols that are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or paralithic contact, shallower than 50 cm (20 inches) or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches).

Xerolls, p. 144

- GFA. Xerolls that have a duripan within 1 m (40 inches) of the soil surface.

Durixerolls, p. 147

- GFB. Other Xerolls that have a natric horizon but have no petrocalcic horizon that has its upper boundary within 1.5 m (60 inches) of the soil surface.

Natrixerolls, p. 149

- GFC. Other Xerolls that have a calcic, petrocalcic, or gypsic horizon with an upper boundary within 1.5 m (60 inches) of the soil surface, and that are calcareous in all parts of all horizons above the calcic, petrocalcic, or gypsic horizons after the upper 18 cm (7 inches) have been mixed unless textures are coarser than loamy very fine sand.

Calcixerolls,* p. 146

- GFD. Other Xerolls that have a petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface, or an argillic horizon with one or both:

1. A vertical clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface, and one or more of:
 - a. Hues redder than 10YR and chromas of more than 4 in the matrix;
 - b. Common coarse mottles with hues of 7.5YR or redder or chromas of more than 5, or both;
2. A particle-size class that is clayey in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary.

Palexerolls, p. 149

- GFE. Other Xerolls that have an argillic horizon.

Argixerolls, p. 145

- GFF. Other Xerolls.

Haploxerolls, p. 147

* Calcixerolls have not been studied sufficiently in the United States. The depth limits suggested for the calcic, petrocalcic, and gypsic horizons are tentative.

KEY

GG. Other Mollisols.

Udolls, p. 133

GGA. Udolls that have an argillic horizon with a clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface and with one or both:

1. Hues are redder than 10YR with chromas of more than 4 dominant in the matrix in at least the lower part of the argillic horizon;
2. There are many coarse mottles that have hues redder than 7.5YR or chromas of more than 5.

Paleudolls, p. 136

GGB. Other Udolls that have an argillic horizon.

Argiudolls, p. 134

GGC. Other Udolls that have a mollic epipedon that, below any Ap, is 50 percent or more by volume of worm holes, worm casts, or filled animal burrows and that either rests on a lithic contact or has a transition to the underlying horizon in which 25 percent or more of the material is discrete worm holes, worm casts, or filled animal burrows from the mollic epipedon and the underlying horizon.

Vermodolls, p. 136

GGD. Other Udolls.

Hapludolls, p. 134

H. Other mineral soils that lack an oxic horizon unless it underlies an argillic horizon, and that have one of the following combinations of properties:

1. No fragipan; an argillic or natric horizon; are usually moist in some part of the soil between 18 cm and 50 cm (7 and 20 inches) unless the epipedon is both hard and massive when dry; and base saturation (by sum of cations) is 35 percent or more at a depth of 1.25 m (50 inches) below the top of the argillic horizon or at 1.8 m (72 inches) below the soil surface or immediately above a lithic or a paralithic contact, whichever is shallower;
2. With a fragipan in or below the argillic horizon or with oriented clay skins 1 mm or more thick in some part of the fragipan; and base saturation (by sum of cations) of 35 percent or more at a depth of 75 cm (30 inches) below the upper boundary of the fragipan or immediately above a lithic or a paralithic contact, whichever is shallower.

ORDER 7 - Alfisols, p. 160

HA. Alfisols, either saturated with water at some season or artificially drained, that have characteristics associated with wetness, namely: mottles, iron-manganese concretions larger than 2 mm, or chromas of 2 or less immediately below any Ap horizon or below any dark Al that has moist values of less than 3.5 when rubbed, and one of the following:

1. Dominant chromas of 2 * or less in coatings on the surface of peds accompanied by mottles within the peds, or dominant chromas of 2 or less in the matrix of the argillic horizon accompanied by mottles of higher chromas;
2. If there are no mottles in the argillic horizon, chromas are 1 or less.

Aqualfs, p. 160

HAA. Aqualfs that have a natric horizon.

Natraqualfs, p. 162

HAB. Other Aqualfs that have a mean annual soil temperature of 8°C (47°F) or higher and mean summer and mean winter soil temperatures at 50 cm (20 inches) or above a lithic or paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Tropaqualfs, p. 163

HAC. Other Aqualfs that have a fragipan.

Fragiaqualfs, p. 161

HAD. Other Aqualfs that have an albic horizon tonguing into an argillic horizon and that lack a duripan.

Glossaqualfs, p. 161

* If hues are redder than 10YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived.

KEY

HAE. Other Aqualfs that have an abrupt textural change between the albic and argillic horizons, have slow or very slow permeability in the argillic horizon, and lack a duripan.

Albaqualfs, p. 160

HAF. Other Aqualfs that have an ochric epipedon and no duripan.

Ochraqualfs, p. 162

HAG. Other Aqualfs that have an umbric epipedon and no duripan.

Umbrqualfs, p. 164

HE. Other Alfisols that have a mean annual soil temperature $< 8^{\circ}\text{C}$ (47°F), and one or both of:

1. An albic horizon that is continuous and has moist chromas of 2 or less, and that tongues or interfingers into an argillic or natric horizon; if the epipedon has loamy fine sand or coarser textures and has an argillic horizon in lamellae, the albic horizon is continuous throughout each pedon from the base of the Ap horizon or 15 cm (6 inches), whichever is deeper, to the argillic horizon;
2. A mean summer soil temperature at 50 cm (20 inches) or above a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or lacking an O horizon, or less than 8°C (47°F) if with an O horizon.

Boralfs, p. 164

HBA. Boralfs with an argillic horizon with an upper boundary deeper than 60 cm (24 inches)* below the mineral surface and with textures finer than loamy fine sand in some subhorizon above the argillic horizon.

Paleboralfs, p. 167

HBB. Other Boralfs that have a fragipan.

Fragiboralfs, p. 166

HBC. Other Boralfs that have a natric horizon.

Natriboralfs, p. 167

HBD. Other Boralfs that have a mean summer soil temperature at 50 cm (20 inches) or above a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or lacking an O horizon, or less than 8°C (47°F) if with an O horizon.

Cryoboralfs, p. 165

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.

Eutrobalfs, p. 165

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

Glossoboralfs, p. 166

HC. Other Alfisols that are not continuously dry in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches) for as long as 60 consecutive days in more than 7 out of 10 years unless the mean annual soil temperature is 22°C (72°F) or higher, or the mean summer and mean winter soil temperatures at 50 cm (20 inches) depth or at a lithic or a paralithic contact, whichever is shallower, differ by less than 5°C (9°F), or both; and with one or more of the following:

1. Dry for 90 cumulative days or more in most years in some subhorizon(s) of the soil between 18 and 50 cm (7 and 20 inches) or above a lithic or a paralithic contact shallower than 50 cm (20 inches);
2. Base saturation (by NH_4OAc) of 80 percent or higher in all parts of the soil above a lithic or a paralithic contact that occurs within 50 cm (20 inches) of the surface;

* If there is a surface mantle that has more than 60 percent vitric volcanic ash, cinders, or other vitric pyroclastic materials, the depth to the argillic horizon is measured from the base of this mantle rather than from the mineral surface.

KEY

3. Within 1.5 m (60 inches) of the soil surface or within 50 cm (20 inches) below the base of an argillic horizon, either a calcic horizon or a horizon with concentrations of soft powdery lime in spheroidal forms, as coatings on peds, or disseminated in clay size particles;*
4. In the absence of a natric horizon, increasing saturation with Na plus K within 1.25 m (50 inches) of the surface if particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey.

Ustalfs, p. 174

- HCA. Ustalfs that have plinthite that forms a continuous phase or constitutes more than half of the matrix within some subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface.

Plinthustalfs, p. 178

- HCB. Other Ustalfs that have a duripan below an argillic or natric horizon, but within 1 m (40 inches) of the surface.

Durustalfs, p. 175

- HCC. Other Ustalfs that have a natric horizon.

Natrustalfs, p. 176

- HCD. Other Ustalfs that have a petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface, or an argillic horizon with one or both:

1. A vertical clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface, and one or more of:
 - a. Hues redder than 10YR and chromas of more than 4 in the matrix;
 - b. Common coarse mottles with hues of 7.5YR or redder or chromas of more than 5;
2. A particle-size class that is clayey in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary.

Paleustalfs, p. 177

- HCE. Other Ustalfs that have an argillic horizon that has colors in hues redder than 5YR with moist values of less than 4 and dry values no more than 1 unit higher than moist values.

Rhodustalfs, p. 178

- HCF. Other Ustalfs.

Haplustalfs, p. 175

- HD. Other Alfisols that are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches), or in the subhorizon immediately above a lithic or paralithic contact shallower than 18 cm (7 inches).

Xeralfs, p. 179

- HDA. Xeralfs that have plinthite that forms a continuous phase or that constitutes more than half of the matrix within some subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface.

Plinthoxeralfs, p. 183

- HDB. Other Xeralfs that have a duripan below the argillic or natric horizon, but within 1 m (40 inches) of the surface.

Durixeralfs, p. 179

- HDC. Other Xeralfs that have a natric horizon.

Natrixeralfs, p. 182

* If the lime is disseminated, the horizon(s) in which the lime is concentrated should have more lime than the underlying horizon and should have the maximum percentage of clay-sized lime.

KEY

HDD. Other Xeralfs that have an argillic horizon that in all parts has colors in hues redder than 5YR and moist values of less than 4 and dry values no more than 1 unit higher than moist values, and that have no petrocalcic horizon within 1.5 m (60 inches) of the soil surface.

Rhodoxeralfs, p. 183

HDE. Other Xeralfs that have a petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface, or an argillic horizon with one or both:

1. A vertical clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface, and one or more of:
 - a. Hues redder than 10YR and chromas of more than 4 in the matrix;
 - b. Common coarse mottles with hues of 7.5YR or redder or chromas of more than 5;
2. A particle-size class that is clayey in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary.

Palixeralfs, p. 182

HDF. Other Xeralfs.

Haploxeralfs, p. 180

HE. Other Alfisols.

Udalfs, p. 168

HEA. Udalfs that have an agric horizon.

Agrudalfs, p. 168

HEB. Other Udalfs that have a fragipan.

Fragiudalfs, p. 168

HEC. Other Udalfs that have a natric horizon.

Natrudalfs, p. 172

HED. Other Udalfs that have mean summer and mean winter soil temperatures at 50 cm (20 inches) or a lithic or a paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Tropudalfs, p. 173

HEE. Other Udalfs that have:

1. No continuous albic horizon above the argillic horizon;
2. A broken upper boundary of the argillic horizon;
3. Discrete nodules in the argillic horizon that range from 2.5 to 5 cm (1 to 2 inches) up to about 30 cm (12 inches) in diameter; exteriors of nodules are enriched and weakly cemented or indurated with iron and have redder hues or stronger chromas than interiors of nodules.

Ferrudalfs, p. 168

HEF. Other Udalfs that have an irregular or broken upper boundary of the argillic horizon with tongues of an albic or other eluvial horizon.

Glossudalfs, p. 169

HEG. Other Udalfs that have an argillic horizon with a clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface, and with one or more of the following:

1. Hues are redder than 10YR with chromas of more than 4 dominant in the matrix in at least the lower part of the argillic horizon;
2. Hues are 2.5YR or redder and moist values are less than 4 and dry values are less than 5 throughout the major part of the argillic horizon;
3. There are many coarse mottles that have hues redder than 7.5YR or chromas of more than 5, or both.

Paleudalfs*, p. 172

*Great group names and definitions are being proposed for criticism.

KEY

HEH. Other Udalfs.

Hapludalfs, p. 170

- I. Other mineral soils that have an oxic horizon, or plinthite that forms a continuous phase within 30 cm (12 inches) of the soil surface.

ORDER 9 - Oxisols, p. 198

IA. Oxisols that have one or more of the following:

1. Plinthite that forms a continuous phase within 30 cm (12 inches) of the mineral surface of the soil;
2. Either saturated with water at some time during the year, or artificially drained, and have an oxic horizon with one or both of the following characteristics associated with wetness:
 - a. A histic epipedon;
 - b. If free of mottles, immediately below any epipedon that has moist color values of less than 3.5 there are dominant chromas of 2 or less; or if there are distinct or prominent mottles within 50 cm (20 inches) of the surface, dominant chromas are 3 or less.

Aquox, p. 198

- IAA. Aquox that have sheets containing 30 percent or more gibbsite, or 20 percent or more by volume of gravel-size aggregates containing 30 percent or more gibbsite within 1 m (40 inches) of the mineral surface, but that have no plinthite that forms a continuous phase within 30 cm (12 inches) of the soil surface.

Gibbsiaquox, p. 198

- IAB. Other Aquox that have plinthite that forms a continuous phase within 1.25 cm (50 inches) of the surface.

Plinthaquox, p. 198

- IAC. Other Aquox that have an ochric epipedon.

Ochraquox, p. 198

- IAD. Other Aquox.

Umbraquox, p. 199

IB. Other Oxisols that have both of the following characteristics:

1. Are usually dry in most years in all parts of the soil between the Ap horizon or 18 cm (7 inches) and 2 m (80 inches) or a lithic or a paralithic contact, whichever is shallower.
2. Have an ochric epipedon that has moist color values of 4 or more in all subhorizons.

Torrox, p. 202

IC. Other Oxisols that have all of the following characteristics:

1. A horizon below the upper 18 cm (7 inches) that is dry for 60 consecutive days or more in most years in some subhorizon;
2. A mean annual soil temperature of 22°C (72°F) or more;
3. Either moist values in some subhorizon of the epipedon of less than 4 or are usually moist.

Ustox, p. 202

- ICA. Ustox that have a base retention value from NH_4Cl of 1 meq or less per 100 g clay in some subhorizon of the oxic horizon (or have 1 meq or less of extractable bases plus extractable aluminum per 100 g clay).

Acrustox, p. 203

ICB. Other Ustox that have both:

1. A mollic or umbric epipedon that is at least one unit of value darker (moist) or at least one unit of chroma lower (moist) than the oxic horizon;
2. Base saturation of 50 percent or more (by NH_4OAc) in the oxic horizon if the particle size class is clayey, or 35 percent or more if the particle size class is loamy.

KEY

ICC. Other Ustox.

Haplustox, p. 203

ID. Other Oxisols that:

1. Are always moist or have no period when the soil is dry in any horizon below the surface 18 cm (7 inches) for 60 consecutive days or more in most years.
2. Have 20 kg or more organic carbon per m² to a depth of 1 m (40 inches), exclusive of organic surface litter;
3. Have base saturation (by NH₄OAc) of less than 35 percent in the oxic horizon;
4. Have a mean annual soil temperature of less than 22°C (72°F).

Humox, p. 199

IDA. Humox that have an oxic horizon with a subhorizon that is darker in color and contains more organic carbon than the overlying subhorizon.

Sombrihumox, p. 200

IDB. Other Humox that have within 1 m (40 inches) of the surface, cemented sheets or a subhorizon with 20 percent or more by volume of gravel-size aggregates that contain 30 percent or more gibbsite.

Gibbsihumox, p. 199

IDC. Other Humox that have in all subhorizons of the oxic horizon, a cation retention capacity (from NH₄Cl) of more than 1 meq per 100 g clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 g of clay).

Haplohumox, p. 200

IDD. Other Humox.

Acrohumox, p. 199

IE. Other Oxisols that have no period when the soil is dry in any horizon below the surface 18 cm (7 inches) for 60 consecutive days or more in most years and either:

1. Have a mean annual soil temperature of 22°C (72°F) or more; or
2. Have less than 20 kg organic carbon per m² within 1 m (40 inches).

Orthox, p. 200

IEA. Orthox that have within 1.25 m (50 inches) of the surface sheets containing 30 percent or more gibbsite or a subhorizon with 20 percent or more by volume of gravel-size aggregates containing 30 percent or more gibbsite.

Gibbsiorthox, p. 201

IEB. Other Orthox that have:

1. In some subhorizon of the oxic horizon, a cation retention capacity of 1 meq or less (from NH₄Cl) per 100 g of clay (or 1 meq or less of extractable bases plus extractable aluminum per 100 g of clay);
2. No discernible structure in the oxic horizon or only very weak blocky or prismatic peds.

Acrorthox, p. 200

IEC. Other Orthox that have no anthropic epipedon and have base saturation of 35 percent or more (by NH₄OAc) in the epipedon and in all subhorizons of the oxic horizon to a depth of at least 1.25 m (50 inches).

Eutrorthox, p. 201

IED. Other Orthox that have either an umbric epipedon or an ochric epipedon that has more than 1 percent carbon in all subhorizons to 75 cm (30 inches) or more below the top of the mineral surface.

Umbriorthox, p. 202

IEE. Other Orthox.

Haplorthox, p. 201

ENTISOLS: ORDER 1

Mineral soils that have no diagnostic horizon other than an ochric or an anthropic epipedon, an albic or an agric horizon, with or without any of the following:

1. a salic horizon, except that if the soil is saturated with water within 1 m (40 inches) of the surface for 1 month or more, and has not been irrigated the upper boundary of the salic horizon must be 75 cm (30 inches) or more below the surface;
2. if textures are finer than loamy fine sand, sodium saturation may exceed 15 percent in some part of the upper 50 cm (20 inches) only if sodium saturation increases or remains constant with depth below 50 cm (20 inches) and the soil is saturated with water within 1 m (40 inches) of the surface for 1 month or more when not frozen in any part;
3. a calcic or gypsic horizon or duripan if its upper boundary is more than 1 m (40 inches) below the surface;
4. plinthite that forms a continuous phase if the upper boundary is deeper than 1.25 m (50 inches) below the surface;
5. if textures are coarser than loamy very fine sand to a depth of 1 m (40 inches), plinthite in the form of discrete nodules or disconnected soft red mottles if it constitutes less than half of the volume in all subhorizons;
6. buried diagnostic horizons other than a buried ochric epipedon if the surface of the buried solum is deeper than 50 cm (20 inches) or is at depths between 30 and 50 cm (12 and 20 inches) and the thickness of the buried solum is less than twice the thickness of the overlying deposits;
7. ironstone at any depth.

Aquents. Entisols that are either permanently saturated with water and have dominant hues in all horizons below 25 cm (10 inches) that are bluer than 10Y and that change on exposure to air; or are saturated with water at some period of the year or are artificially drained and that have at depths within 50 cm (20 inches) of the surface, dominant moist colors in the matrix as follows:

1. in horizons with textures finer than loamy fine sand
 - a. if there is mottling, chromas are 2 or less;
 - b. if there is no mottling and values are less than 4, chromas are less than 1; if values are 4 or more, chromas are 1 or less;
2. in horizons with textures of loamy fine sand or coarser
 - a. if hues are as red or redder than 10YR and there is mottling, chromas are 2 or less; if there is no mottling and values are less than 4, chromas are less than 1 or if values are 4 or more, chromas are 1 or less;
 - b. if hues are between 10YR and 10Y and there is distinct or prominent mottling, chromas are 3 or less; if there is no mottling, chromas are 1 or less;
 - c. hues are bluer than 10Y;
 - d. any color if the color is due to uncoated grains of sand.

Cryaquents. Aquents that

1. have a mean annual soil temperature of less than 8°C (47°F) and have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of less than 15°C (59°F) if they are drained and either lack an O horizon or are cultivated; or if they are drained and have an O horizon, have a mean summer temperature at 50 cm (20 inches) of less than 8°C (47°F); or if they are undrained and have an O horizon, have a mean summer temperature of less than 6°C (43°F);
2. have an N value of 0.5 or less in some subhorizon between 20 and 50 cm (8 and 20 inches) or the mean annual soil temperature is 0°C (32°F) or less.

Typic Cryaquents. Cryaquents that

- a. have no layer in the upper 75 cm (20 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction,

Entisols

Typic Cryaquents--Cont.

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;

- b. have a mean annual soil temperature of more than 0°C (32°F);
- c. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Andic Cryaquents. Cryaquents like the Typic except for a.

Pergelic Cryaquents. Cryaquents like the Typic except for b.

Vertic Cryaquents. Cryaquents like the Typic except for c.

Haplaquents. Aquents that

- 1. have soil temperatures warmer than those of Cryaquents and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;
- 2. have an N value of 0.5 or less in some subhorizon between 20 and 50 cm (8 and 20 inches);
- 3. have textures of loamy very fine sand or finer in some horizon below the Ap or 25 cm (10 inches), whichever is deeper, but above a depth of 1 m (40 inches) or a lithic or paralithic contact, whichever is shallower.

Typic Haplaquents. Haplaquents that

- a. have in 60 percent or more of the matrix in all subhorizons between the Ap or 25 cm (10 inches), whichever is deeper and 75 cm (30 inches) one or more of the following:
 - (1) if mottled and mean annual soil temperature is less than 15°C (59°F) moist chromas are 2 or less;
 - (2) if mottled and mean annual soil temperature is 15°C (59°F) or more:
 - (a) in hues of 2.5Y or redder* and moist values of more than 5, moist chromas are 2 or less,
 - (b) in hues of 2.5Y or redder and moist values of 5 or less, moist chromas are 1 or less,
 - (c) in hues yellower than 2.5Y, moist chromas are 2 or less;
 - (3) moist chromas are 1 or less with or without mottles.
- b. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

* If hues are 7.5YR or redder in the matrix: if peds are present, ped exteriors have dominant moist chromas of 1 or less and ped interiors have mottles with moist chromas of 2 or less; if peds are absent, moist chromas are 1 or less immediately below any surface horizon that has moist values of less than 3.5.

Entisols

Typic Haplaquents--Cont.

c. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
- (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aeric Haplaquents. Haplaquents like the Typic except for a.

Andic Haplaquents. Haplaquents like the Typic except for b.

Vertic Haplaquents. Haplaquents like the Typic except for c.

Hydraquents. Aquents that

1. have a mean annual soil temperature of more than 0°C (32°F);
2. have an N value of more than 0.5 and at least 8 percent clay and 3 percent organic matter in all subhorizons between 20 and 50 cm (8 and 20 inches);
3. have textures of loamy very fine sand or finer in some horizon below the Ap or 25 cm (10 inches), whichever is deeper, but above a depth of 1 m (40 inches) or a lithic or a paralithic contact, whichever is shallower.

(Subgroups not developed.)

Psammaquents. Aquents that

1. have soil temperatures warmer than those of Cryaquents and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;
2. have textures of loamy fine sand or coarser in all horizons below the Ap horizon or 25 cm (10 inches), whichever is deeper, to a depth of 1 m (40 inches) or to a lithic or a paralithic contact, whichever is shallower.

Typic Psammaquents. Psammaquents that

- a. have no lithic contact within 50 cm (20 inches) of the surface;
- b. have an Ap horizon with a moist value of 4 or more or with a dry value of 6 or more crushed and smoothed * or the Al horizon is less than 15 cm (6 inches) thick if its moist color value is lower than 3.5.

Lithic Psammaquents. Psammaquents like the Typic except for a.

Mollic Psammaquents. Psammaquents like the Typic except for b.

Tropaquents. Aquents that

1. have a mean annual soil temperature of 8°C (47°F) or more and have mean summer and mean winter soil temperature at 50 cm (20 inches) that differ by less than 5°C (9°F);
2. have an N value of 0.5 or less in some subhorizon between 20 and 50 cm (8 and 20 inches).

Typic Tropaquents. Tropaquents that

- a. have in 60 percent or more of the matrix in all subhorizons between the Ap or 25 cm (10 inches), whichever is deeper, and 75 cm (30 inches),

* Use knife and smooth to eliminate shadows.

Entisols

Typic Tropoquents--Cont.

- (1) if mottled
 - (a) in hues of 2.5Y or redder* and moist values more than 5, moist chromas are 2 or less,
 - (b) in hues of 2.5Y or redder and moist values are 5 or less, moist chromas are 1 or less,
 - (c) in hues yellower than 2.5Y, moist chromas are 2 or less, or
- (2) moist chromas are 1 or less with or without mottles.

Aeric Tropoquents. Tropoquents like the Typic except for a.

Arents. Entisols that

1. have fragments of diagnostic horizons that occur more or less without discernible order in the soil below any Ap horizon but within the series control section;
2. are not permanently saturated with water and lack the characteristics associated with wetness defined for Aquentis.

In many Arents a significant part of the solum is mixed enough to destroy diagnostic horizons but not to the extent that fragments can no longer be identified/.

Fluvents. Entisols that

1. have textures of loamy very fine sand or finer in some horizon below the Ap horizon or 25 cm (10 inches), whichever is deeper, but above a depth of 1 m (40 inches) or a lithic or a paralithic contact deeper than 50 cm (20 inches) but shallower than 1 m (40 inches);
2. have no 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 slopes of less than 25 percent;
4. have an organic matter content that decreases irregularly with depth or that remains above 0.35 percent (0.2 percent carbon) to a depth of 1.25 m (50 inches) or to a depth of 25 cm (10 inches) below the upper boundary of any layer that remains frozen until two months after the summer solstice, whichever is shallower. Thin strata of sand may have less organic matter if the finer sediments at 1.25 m (50 inches) or below have 0.35 percent (0.2 percent carbon) or more;
5. are not permanently saturated with water and lack the characteristics associated with wetness defined for Aquentis;
6. have a mean annual soil temperature of more than 0°C (32°F).

Cryofluvents. Fluvents that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at a depth of 50 cm (20 inches) of either less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon.

Typic Cryofluvents. Cryofluvents that

- a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;

* If hues are 7.5YR or redder in the matrix; if peds are present, ped exteriors have dominant moist chromas of 1 or less and ped interiors have mottles with moist chromas of 2 or less; if peds are absent, moist chromas are 1 or less immediately below any surface horizon that has moist values of less than 3.5.

Entisols

Typic Cryofluvents--Cont.

- b. have no mottles with chromas of 2 or less within 50 cm (20 inches) of the surface;
- c. lack 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 (20 inches) that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Andic Cryofluvents. Cryofluvents like the Typic except for a.

Aquic Cryofluvents. Cryofluvents like the Typic except for b.

Torrifluvents. Fluvents that

- 1. are warmer than Cryofluvents;
- 2. are usually dry in most years in all parts of the soil between 18 and 50 cm (7 and 20 inches).

Typic Torrifluvents. Torrifluvents that

- a. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;
- b. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
- c. have no prismatic or blocky structure with clay films on ped faces that have color values lower than in the matrix within 1 m (40 inches) of the soil surface.

Durorthidic Torrifluvents. Torrifluvents like the Typic except for a.

Vertic Torrifluvents. Torrifluvents like the Typic except for b.

Tropofluvents. Fluvents that

- 1. have a mean annual soil temperature of 8°C (47°F) or more and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by less than 5°C (9°F);
- 2. are not dry in more than 7 out of 10 years in all subhorizons between 18 and 50 cm (7 and 20 inches) for as much as 60 consecutive days, and are not dry in some subhorizon between these depths for as much as 90 cumulative days in most years.

Entisols

Typic Tropofluvents. Tropofluvents that

- a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- b. have no mottles within 50 cm (20 inches) of the surface with chromas of 2 or less, or, at depths between 50 cm and 1 m (20 and 40 inches) have no horizons that are saturated with water at some period or that are artificially drained and that have chromas of less than 1 or hues bluer than 10Y;
- c. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick, that contains either at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;
- d. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Andic Tropofluvents. Tropofluvents like the Typic except for a.

Aquic Tropofluvents. Tropofluvents like the Typic except for b.

Durorthidic Tropofluvents. Tropofluvents like the Typic except for c.

Vertic Tropofluvents. Tropofluvents like the Typic except for d.

Udifluvents. Fluvents that

1. have soil temperatures warmer than those of Cryofluvents, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;
2. are not dry in all subhorizons between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for as much as 60 consecutive days, and are not dry in some subhorizon between these depths for as much as 90 cumulative days in most years.

Typic Udifluvents. Fluvents that

- a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- b. have no mottles within 50 cm (20 inches) of the surface with chromas of 2 or less, or at depths between 50 cm and 1 m (20 and 40 inches) have no horizons that are saturated with water at some period or that are artificially drained and that have chromas of less than 1 or hues bluer than 10Y;
- c. have no buried mollic epipedon that is 20 cm (8 inches) or more thick and that has its upper boundary within 50 cm (20 inches) of the surface;
- d. lack the following combination of characteristics:

Entisols

Typic Udifluvents--Cont.

- (1) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
- (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Andic Udifluvents. Udifluvents like the Typic except for a.

Aquic Udifluvents. Udifluvents like the Typic except for b.

Thapto-Aquollic Udifluvents. Udifluvents like the Typic except for b and c.

Thapto-Mollic Udifluvents. Udifluvents like the Typic except for c.

Vertic Udifluvents. Udifluvents like the Typic except for d.

Ustifluvents. Fluvents that

1. have soil temperatures warmer than Cryofluvents;
2. are usually moist but are dry for 90 cumulative days or more in most years in some subhorizon between 18 and 50 cm (7 and 20 inches) but are not continuously dry in all subhorizons between these depths for as long as 60 consecutive days in more than 7 out of 10 years unless either the mean annual soil temperature is 22°C (72°F) or more or the mean summer and mean winter soil temperatures at 50 cm (20 inches) depth differ by less than 5°C (9°F).

Typic Ustifluvents. Ustifluvents that

- a. have no mottles within 50 cm (20 inches) of the surface with chromas of 2 or less or at depths within 1.5 m (60 inches) of the surface have no horizons that are saturated with water at some period or that are artificially drained and that have chromas of less than 1 or hues bluer than 10Y;
- b. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
- c. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a non-brittle matrix or is brittle and has firm consistence when moist.

Aquic Ustifluvents. Ustifluvents like the Typic except for a.

Aquic Vertic Ustifluvents. Ustifluvents like the Typic except for a and b.

Durorthidic Ustifluvents. Ustifluvents like the Typic except for c.

Vertic Ustifluvents. Ustifluvents like the Typic except for b.

Entisols

Xerofluvents. Fluvents that

1. have a mean annual soil temperature of 8°C (47°F) or more but less than 22°C (72°F), mean summer soil temperature at 50 cm (20 inches) of 15°C (59°F) or more, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;
2. are usually moist but are dry for 60 consecutive days or more in more than 7 out of 10 years in all subhorizons between 18 and 50 cm (7 and 20 inches).

Typic Xerofluvents. Xerofluvents that

- a. are not saturated with water during some period within 1.5 m (60 inches) of the surface;
- b. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist.
- c. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Xerofluvents. Xerofluvents like the Typic except for a.

Aquic Durorthidic Xerofluvents. Xerofluvents like the Typic except for a and b.

Durorthidic Xerofluvents. Xerofluvents like the Typic except for b.

Vertic Xerofluvents. Xerofluvents like the Typic except for c.

Orthents. Entisols that

1. have textures of loamy very fine sand or finer in some horizon below the Ap horizon or 25 cm (10 inches), whichever is deeper, but above a depth of 1 m (40 inches) or a lithic or paralithic contact, whichever is shallower;
2. have no 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 an organic matter content that decreases regularly with depth and reaches levels of 0.35 percent (0.2 percent carbon) or less within a depth of 1.25 m (50 inches), or within a depth of 25 cm (10 inches) below the upper boundary of any layer that remains frozen until two months after the summer solstice, whichever is shallower, or have mean annual soil temperatures of 0°C (32°F) or less;
4. are not permanently saturated with water and lack the characteristics associated with wetness defined for Aquents.

Cryorthents. Orthents that have a mean annual soil temperature of less than 8°C (47°F) and have a mean summer soil temperature at a depth of 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, of either less than 15°C (59°F) if cultivated or without an O horizon, or of less than 8°C (47°F) if with an O horizon.

Entisols

Typic Cryorthents. Cryorthents that

- a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- b. have no mottles with chromas of 2 or less within 50 cm (20 inches) of the surface;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. have a mean annual soil temperature of more than 0°C (32°F);
- e. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
- f. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a nonbrittle matrix, or is brittle and has firm consistence when moist.

Andic Cryorthents. Cryorthents like the Typic except for a.

Andic Aquic Cryorthents. Cryorthents like the Typic except for a and b.

Aquic Cryorthents. Cryorthents like the Typic except for b.

Lithic Cryorthents. Cryorthents like the Typic except for c.

Pergelic Cryorthents. Cryorthents like the Typic except for d.

Vertic Cryorthents. Cryorthents like the Typic except for e.

Torriorthents. Orthents that

1. have soil temperatures warmer than those of Cryorthents;
2. are usually dry in most years in all parts of the soil between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in some subhorizon above a lithic or a paralithic contact shallower than 18 cm (7 inches).

Typic Torriorthents. Torriorthents that

- a. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a non-brittle matrix or is brittle and has firm consistence when moist;
- b. have no lithic contact within 50 cm (20 inches) of the surface;
- c. lack 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 (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon; and

Entisols

Typic Torriorthents--Cont.

- (2) a coefficient of linear extensibility(COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
- (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Durorthidic Torriorthents. Torriorthents like the Typic except for a.

Lithic Torriorthents. Torriorthents like the Typic except for b.

Vertic Torriorthents. Torriorthents like the Typic except for c.

Troporthents. Orthents that

1. have a mean annual soil temperature of 8°C (47°F) or more and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by less than 5°C (9°F);
2. are not dry in some subhorizon(s) between 18 and 50 cm (7 and 20 inches) for as much as 90 cumulative days in most years.

Typic Troporthents. Troporthents that

- a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- b. are not saturated with water during some period within 1.5 m (60 inches) of the surface;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
- e. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contain either at least 20 percent durinodes in a non-brittle matrix or is brittle and has firm consistence when moist.

Andic Troporthents. Troporthents like the Typic except for a.

Aquic Troporthents. Troporthents like the Typic except for b.

Lithic Troporthents. Troporthents like the Typic except for c.

Vertic Troporthents. Troporthents like the Typic except for d.

Udorthents. Orthents that

1. have soil temperatures warmer than those of Cryorthents, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;

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Udorthents--Cont.

2. are not dry in all subhorizons between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for as much as 60 consecutive days, and are not dry in some subhorizon between these depths for as much as 90 cumulative days in most years.

Typic Udorthents. Udorthents that

- a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- b. are not saturated with water during some period within 1.5 m (60 inches) of the surface;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. have a control section with less than 50 percent by volume of worm holes, worm casts and filled animal burrows;
- e. lack 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 (20 inches), that are at least 30 cm (12 inches) 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, of at least 50 cm (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
- f. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist.

Andic Udorthents. Udorthents like the Typic except for a.

Aquic Udorthents. Udorthents like the Typic except for b.

Lithic Udorthents. Udorthents like the Typic except for c.

Vermic Udorthents. Udorthents like the Typic except for d.

Vertic Udorthents. Udorthents like the Typic except for e.

Ustorthents. Orthents that

1. have soil temperatures warmer than those of Cryorthents;
2. are usually moist but are dry for 90 cumulative days or more in most years in some subhorizon(s) between 18 and 50 cm (7 and 20 inches) or above a lithic or a paralithic contact shallower than 50 cm (20 inches) but are not continuously dry in all parts of the soil between these depths or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in the subhorizon immediately above a lithic or paralithic contact shallower than 18 cm (7 inches) for as long as 60 consecutive days in more than 7 out of 10 years unless either the mean annual soil temperature is 22°C (72°F) or higher or the mean summer and mean winter soil temperatures at 50 cm (20 inches) depth or at a lithic or paralithic contact, whichever is shallower, differ by less than 5°C (9°F), or both.

Typic Ustorthents. Ustorthents that

- a. are not saturated with water during some period within 1.5 m (60 inches) of the surface;

Entisols

Typic Ustorthents--Cont.

- b. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. have a control section with less than 50 percent by volume of worm holes, worm casts and filled animal burrows.
- e. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Ustorthents. Ustorthents like the Typic except for a.

Durorthidic Ustorthents. Ustorthents like the Typic except for b.

Lithic Ustorthents. Ustorthents like the Typic except for c.

Vermic Ustorthents. Ustorthents like the Typic except for d.

Vertic Ustorthents. Ustorthents like the Typic except for e.

Xerorthents. Orthents that

- 1. have a mean summer soil temperature at 50 cm (20 inches) of 15°C (59°F) or more and a mean annual soil temperature of 8°C (47°F) or more but less than 22°C (72°F) and mean summer and mean winter soil temperature at 50 cm (20 inches) that differ by 5°C (9°F), or more;
- 2. are usually moist but are dry for 60 consecutive days or more in more than 7 out 10 years in all subhorizons between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in a subhorizon, immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches).

Typic Xerorthents. Xerorthents that

- a. are not saturated with water during some season within 1.5 m (60 inches) of the surface;
- b. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and

Entisols

Typic Xerorthents--Cont.

- (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Xerorthents. Xerorthents like the Typic except for a.

Aquic Durorthidic Xerorthents. Xerorthents like the Typic except for a and b.

Lithic Xerorthents. Xerorthents like the Typic except for c.

Vartic Xerorthents. Xerorthents like the Typic except for d.

Psamments. Entisols that

1. have below the Ap horizon or 25 cm (10 inches), whichever is deeper, textures of loamy fine sand or coarser in all parts either to a depth of 1 m (40 inches) or to a lithic or a paralithic contact, whichever is shallower;
2. have no 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. are not permanently saturated with water and lack the characteristics associated with wetness defined for Aquents.

Cryopsamments. Psamments that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of either less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon.

Typic Cryopsamments. Cryopsamments that

- a. have no lamellae within 1.5 m (60 inches) of the soil surface that meet all requirements for an argillic horizon except thickness;
- b. have no mottles with chromas of 2 or less within 50 cm (20 inches) of the surface;
- c. have a mean annual soil temperature of more than 0°C (32°F).
- d. have no lithic contact within 50 cm (20 inches) of the surface.

Albic Cryopsamments. Cryopsamments like the Typic except for a and have base saturation of 35 percent or more in some horizon less than 1.25 m (50 inches) below the uppermost lamellae.

Aquic Cryopsamments. Cryopsamments like the Typic except for b.

Aquic Pergelic Cryopsamments. Cryopsamments like the Typic except for b and c.

Lithic Cryopsamments. Cryopsamments like the Typic except for d.

Quartzipsamments. Psamments that

1. have soil temperatures warmer than those of Cryopsamments;
2. have a sand fraction that is more than 95 percent quartz, zircon, tourmaline, rutile, or other normally insoluble minerals that do not weather to liberate iron or aluminum;

Typic Quartzipsamments. Quartzipsamments that

- a. have no mottles to a depth of 1 m (40 inches) that have chromas of 2 or less, or if the color is due to uncoated sand grains, a ground water table is within 1 m (40 inches) of the soil surface for less than 60 cumulative days in most years;
- b. have no albic horizon at the surface or immediately underlying an Al or Ap horizon that is underlain by another horizon having values more than 1 unit darker or having chromas of 6 or more;

Entisols

Typic Quartzipsamments--Cont.

- c. have no lithic contact within 50 cm (20 inches) of the surface;
 - d. have a clay fraction with a higher CEC than that of the clay of an oxic horizon;
 - e. have less than 5 percent plinthite in all horizons to a depth of 1 m (40 inches).
- Aquic Quartzipsamments. Quartzipsamments like the Typic except for a.

Aquodic Quartzipsamments. Quartzipsamments like the Typic except for b and have a ground water table within 1 m (40 inches) of the soil surface for 6 months or more in most years, or are artificially drained, and lack sufficient free iron to turn redder on ignition.

Lithic Quartzipsamments. Quartzipsamments like the Typic except for c.

Lithic Spodic Quartzipsamments. Quartzipsamments like the Typic except for b and c.

Oxic Quartzipsamments. Quartzipsamments like the Typic except for d with or without e.

Spodic Quartzipsamments. Quartzipsamments like the Typic except for b.

Torrripsamments. Psamments that

1. have soil temperatures warmer than those of Cryopsamments;
2. are usually dry in most years in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or paralithic contact shallower than 50 cm (20 inches) or in some subhorizon above a lithic or a paralithic contact shallower than 18 cm (7 inches);
3. have in the sand fraction, less than 95 percent quartz, zircon, tourmaline, rutile, or other normally insoluble minerals that do not weather to liberate iron or aluminum;

Typic Torrripsamments. Torrripsamments that

- a. have no lithic contact within 50 cm (20 inches) of the surface;
- b. have no lamellae within 1.5 m (60 inches) of the soil surface that meet all requirements for an argillic horizon except thickness; *
- c. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist.

Lithic Torrripsamments. Torrripsamments like the Typic except for a.

Udipsamments. Psamments that

1. have soil temperatures warmer than those of Cryopsamments and mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F), or more;
2. are not dry in all subhorizons between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in all subhorizons above a lithic or a paralithic contact shallower than 18 cm (7 inches) in more than 7 out of 10 years for as much as 60 consecutive days, and are not dry in some subhorizon between these depths for as much as 90 cumulative days in most years;
3. have in the sand fraction, less than 95 percent quartz, zircon, tourmaline, rutile, or other normally insoluble minerals that do not weather to liberate iron or aluminum.

Typic Udipsamments. Udipsamments that

- a. have no lamellae within 1.5 m (60 inches) of the soil surface that meet all requirements for an argillic horizon except thickness; *
- b. have no mottles with chromas of 2 or less to a depth of 1 m (40 inches);

* Clay content cannot be estimated with precision in lamella that are very thin. The lamella in alfic subgroups are usually observed to be about 0.5 to 1 cm thick but the total thickness is less than the required 15 cm (6 inches) for an argillic horizon.

Entisols

Typic Udipsamments--Cont.

- c. have no lithic contact within a depth of 50 cm (20 inches);
- d. have no albic horizon that is underlain by a horizon having color values 1 unit or more darker.

Alfic Udipsamments. Udipsamments like the Typic except for a and have base saturation of 35 percent or more in some horizon less than 1.25 m (50 inches) below the uppermost lamella.

Aquic Udipsamments. Udipsamments like the Typic except for b.

Lithic Udipsamments. Udipsamments like the Typic except for c.

Spodic Udipsamments. Udipsamments like the Typic except for d.

Utic Udipsamments. Udipsamments like the Typic except for a and have base saturation of less than 35 percent in some horizon less than 1.25 m (50 inches) below the uppermost lamella.

Ustipsamments. Psamments that

- 1. have soil temperatures warmer than those of Cryopsamments;
- 2. are usually moist but are dry for 90 cumulative days or more in most years in some sub-horizon(s) between 18 and 50 cm (7 and 20 inches), or above a lithic or a paralithic contact shallower than 50 cm (20 inches) but are not continuously dry in all sub-horizons between these depths or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in a subhorizon immediately above a lithic or paralithic contact shallower than 18 cm (7 inches) for as long as 60 consecutive days in more than 7 out of 10 years unless either:
 - a. the mean annual soil temperature is 22°C (72°F) or more; or
 - b. the mean summer and mean winter soil temperatures at 50 cm (20 inches) depth differ by less than 5°C (9°F), or both;
- 3. have in the sand fraction, less than 95 percent quartz, zircon, tourmaline, rutile, or other normally insoluble minerals that do not weather to liberate iron or aluminum.

Typic Ustipsamments. Ustipsamments that

- a. have no lamellae within 1.5 m (60 inches) of the soil surface that meet all requirements for an argillic horizon except thickness; *
- b. have no mottles with chromas of 2 or less to a depth of 1 m (40 inches);
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a nonbrittle matrix or is brittle and has firm consistence when moist.

Alfic Ustipsamments. Ustipsamments like the Typic except for a and have base saturation of 35 percent or more in some horizon less than 1.25 m (50 inches) below the uppermost lamellae.

Aquic Ustipsamments. Ustipsamments like the Typic except for b.

Lithic Ustipsamments. Ustipsamments like the Typic except for c.

Xeropsamments. Psamments that

- 1. have a mean summer soil temperature at 50 cm (20 inches) of 15°C (59°F) or more and a mean annual soil temperature of 8°C (47°F) or more but less than 22°C (72°F) and mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F), or more;

* Clay content cannot be estimated with precision in lamella that are very thin. The lamella in alfic subgroups are usually observed to be about 0.5 to 1 cm thick but the total thickness is less than the required 15 cm (6 inches) for an argillic horizon.

Entisols

Xeropsamments--Cont.

2. are usually moist but are dry for 60 consecutive days or more in more than 7 out of 10 years in all subhorizons between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches);
3. have in the sand fraction, less than 95 percent quartz, zircon, tourmaline, rutile, or other normally insoluble minerals that do not weather to liberate iron or aluminum.

Typic Xeropsamments. Xeropsamments that

- a. have no lamellae within 1.5 m (60 inches) of the soil surface that meet all requirements for an argillic horizon except thickness; *
- b. have no mottles with chromas of 2 or less to a depth of 1 m (40 inches);
- c. have no horizon within 1 m (40 inches) of the surface that is more than 15 cm (6 inches) thick that contains either at least 20 percent durinodes in a non-brittle matrix or is brittle and has firm consistence when moist;
- d. have no lithic contact within 50 cm (20 inches) of the surface.

Alfic Xeropsamments. Xeropsamments like the Typic except for a and have base saturation of 35 percent or more in some horizon less than 1.25 m (50 inches) below the uppermost lamellae.

Aquic Xeropsamments. Xeropsamments like the Typic except for b.

* Clay content cannot be estimated with precision in lamella that are very thin. The lamella in alfic subgroups are usually observed to be about 0.5 to 1 cm thick but the total thickness is less than the required 15 cm (6 inches) for an argillic horizon.

VERTISOLS: ORDER 2

Mineral soils without a lithic or paralithic contact within 50 cm (20 inches) of the soil surface that after the upper 18 cm (7 inches) are mixed, have 30 percent or more clay in all horizons down to a lithic or a paralithic contact, to a calcic horizon, or to 1 m (40 inches) whichever is shallower; at some period in most years, have cracks at least 1 cm wide at a depth of 50 cm (20 inches); and have one or more of the following:

1. gilgai;
2. at some depth between 25 cm and 1 m (10 and 40 inches) slickensides close enough to intersect;
3. at some depth between 25 cm and 1 m (10 and 40 inches) wedge-shaped or parallelepiped natural structural aggregates with their long axes tilted 10 to 60 degrees from the horizontal.

Torrerts. Vertisols that are usually dry and have cracks that remain open throughout the year in most years; if inundated, the cracks may close for variable periods; if cultivated, the cracks may extend upwards only to the lower boundary of the Ap horizon.

Torrerts. The definition of Torrerts at the great group level is equivalent to that at the suborder level.

Typic Torrerts. Torrerts that

- a. have a moist color value of 3.5 or more in more than half of each pedon in the surface horizon or the horizon that is darker than this is less than 30 cm (12 inches) thick;
- b. have no prismatic or blocky structure with clay skins on ped faces that have color values lower than in the matrix within 1 m (40 inches) of the soil surface.

Mollic Torrerts. Torrerts like the Typic except for a.

Paleustollic Torrerts. Torrerts like the Typic except for b.

Uderts. Vertisols that are usually moist in some part in most years and have cracks that open and close one or more times during the year but do not remain open for as many as 90 cumulative days during the year in most years or for as many as 60 consecutive days in more than 7 out of 10 years and in a few years the soils may not crack.

Chromuderts. Uderts that have moist chromas of 1.5 or more throughout the upper 30 cm (12 inches) in more than half of each pedon.

Typic Chromuderts. Chromuderts that

- a. lack distinct or prominent mottles within 50 cm (20 inches) of the surface;
- b. have color values of less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm (12 inches) in more than half of each pedon.

Aquic Chromuderts. Chromuderts like the Typic except for a.

Aquic Entic Chromuderts. Chromuderts like the Typic except for a and b.

Entic Chromuderts. Chromuderts like the Typic except for b.

Pelluderts. Uderts that have moist chromas of less than 1.5 throughout the upper 30 cm (12 inches) in more than half of each pedon.

Typic Pelluderts. Pelluderts that

- a. have in all subhorizons to a depth of 1 m (40 inches) dry and moist chromas of less than 1.5, or if chromas are 1.5 or higher there are distinct or prominent mottles or concretions due to segregated Fe or Mn;
- b. have color values of less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm (12 inches) in more than half of each pedon.

Chromic Pelluderts. Pelluderts like the Typic except for a.

Entic Pelluderts. Pelluderts like the Typic except for b.

Vertisols - 2

Usterts. Vertisols that have cracks that remain open for 90 cumulative days or more during the year but not throughout the year in most years and one or more of the following:

1. cracks that open and close more than once during the year in most years;
2. a mean annual soil temperature of 22°C (72°F) or more;
3. a mean summer and mean winter soil temperature at 50 cm (20 inches) depth that differ by less than 5°C (9°F).

Chromusterts. Usterts that have moist chromas of 1.5 or more throughout the upper 30 cm (12 inches) in more than half of each pedon.

Typic Chromusterts. Chromusterts that

- a. have color values of less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm (12 inches) in more than half of each pedon;
- b. lack a prismatic or blocky structure with clay skins on ped faces that have color values lower than in the matrix within 1 m (40 inches) of the soil surface;
- c. have cracks that remain open for more than 150 cumulative days during the year if mean annual soil temperature is more than 15°C (59°F).

Entic Chromusterts. Chromusterts like the Typic except for a.

Paleustollic Chromusterts. Chromusterts like the Typic except for b.

Udic Chromusterts. Chromusterts like the Typic except for c and have cracks that remain open from 90 to 150 cumulative days during the year.

Udorthentic Chromusterts. Chromusterts like the Typic except for a and c.

Pellusterts. Usterts that have moist chromas less than 1.5 throughout the upper 30 cm (12 inches), in more than half of each pedon.

Typic Pellusterts. Pellusterts that

- a. have in all subhorizons to a depth of 1 m (40 inches) dry and moist chromas of less than 1.5, or if chromas are 1.5 or higher there are distinct or prominent mottles or concretions due to segregated Fe or Mn;
- b. have color values of less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm (12 inches) in more than half of each pedon;
- c. have cracks that remain open for more than 150 cumulative days during the year if the mean annual soil temperature is more than 15°C (59°F);
- d. lack a prismatic or blocky structure with clay skins on ped faces that have color values lower than in the matrix within 1 m (40 inches) of the soil surface.

Chromic Pellusterts. Pellusterts like the Typic except for a.

Chromic Entic Pellusterts. Pellusterts like the Typic except for a and b.

Chromudic Pellusterts. Pellusterts like the Typic except for a and c.

Entic Pellusterts. Pellusterts like the Typic except for b.

Paleustollic Pellusterts. Pellusterts like the Typic except for d with or without c.

Udic Pellusterts. Pellusterts like the Typic except for c.

Udorthentic Pellusterts. Pellusterts like the Typic except for b and c.

Vertisols - 3

Xererts. Vertisols that have cracks that open and close once each year and remain open for 60 consecutive days or more in more than 7 out of 10 years and have mean annual soil temperatures less than 22°C (72°F), and mean summer and mean winter soil temperatures at 50 cm depth (20 inches) that differ by 5°C (9°F) or more.

Chromoxererts. Xererts that have moist chromas of 1.5 or more throughout the upper 30 cm (12 inches) in more than half of each pedon.

Typic Chromoxererts. Chromoxererts that

- a. lack distinct or prominent mottles within 50 cm (20 inches) of the surface;
- b. have color values of less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm (12 inches) in more than half of each pedon.

Aquic Chromoxererts. Chromoxererts like the Typic except for a.

Aquic Entic Chromoxererts. Chromoxererts like the Typic except for a and b.

Entic Chromoxererts. Chromoxererts like the Typic except for b.

Pelloxererts. Xererts that have moist chromas less than 1.5 throughout the upper 30 cm (12 inches) in more than half of each pedon.

Typic Pelloxererts. Pelloxererts that

- a. have in all subhorizons to a depth of 1 m (40 inches) dry and moist chromas of less than 1.5, or if chromas are 1.5 or higher there are distinct or prominent mottles or concretions due to segregated Fe or Mn;
- b. have color values of less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm (12 inches) in more than half of each pedon.

Chromic Pelloxererts. Pelloxererts like the Typic except for a.

Chromic Entic Pelloxererts. Pelloxererts like the Typic except for a and b.

Entic Pelloxererts. Pelloxererts like the Typic except for b.

INCEPTISOLS: ORDER 3

Inceptisols are mineral soils that have no spodic, argillic, natric, or oxic horizon unless it is a buried horizon; that have no plinthite that forms a continuous phase within 30 cm (12 inches) of the mineral surface; and either:

1. Are usually moist between 18 and 50 cm (7 and 20 inches) or above a lithic or a paralithic contact shallower than 50 cm (20 inches); that lack a salic, or gypsic horizon within 1 m (40 inches) of the surface; and that have one or more of the following:
 - a. A conductivity of the saturation extract at 25°C (77°F) of less than 2 mmho per cm down to whichever of these depths is least: a lithic or a paralithic contact or within 1.25 m (50 inches) of the surface if particle-size classes are sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey; and, if without a fragipan, with increase in depth in the C horizon but above the depths for the different particle-size classes specified above, either there is no increase in saturation with Na plus K or there is exchange acidity in excess of Na plus K; and with one or more of:
 - (1) A cambic or a calcic horizon or both;
 - (2) A fragipan that has no clay skins as thick as 1 mm;
 - (3) A duripan with its upper boundary within 1 m (40 inches) of the surface.
 - b. Artificial drainage or saturation with water at some period of the year when not frozen, and at depths of less than 50 cm (20 inches) or immediately underlying an umbric epipedon, have a horizon with dominant moist colors on ped faces, or in the matrix if peds are absent, as follows:
 - (1) If there is mottling, chromas are 2 or less;
 - (2) If there is no mottling, chromas are 1 or less*.
 - c. Sodium saturation of more than 15 percent in some part of the upper 50 cm (20 inches) that decreases with depth below 50 cm (20 inches) and the soil is saturated with water at some period within a depth of 1 m (40 inches); or
 2. Have an umbric, histic, or plaggen epipedon, or a mollic epipedon with one or more of the following combinations of properties:
 - a. A bulk density** of the fine earth fraction of less than 0.85 g per cc in the epipedon or the cambic horizon or both, and the exchange complex is dominated by amorphous materials;
 - b. A ^{underlying} cambic horizon with base saturation of less than 50 percent (by NH₄OAc) throughout or decreasing to less than 50 percent at a depth of 1.8 m (72 inches) below the surface, whichever is shallower;
 - c. The mean summer and mean winter soil temperatures differ by less than 5°C (9°F) when measured at a depth of 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, and one or both of:
 - (1) 35 percent or more clay with montmorillonitic mineralogy, and the epipedon rests on materials with less than 40 percent CaCO₃ equivalent;
 - (2) ~~a cambic horizon with base saturation that is less than 50 percent (by NH₄OAc) throughout or decreasing to less than 50 percent at a depth of 1.8 m (72 inches).~~
- Andepts. Inceptisols that moist and dry values of the mollic epipedon are no darker than those of the underlying horizon
1. have one or both of:
 - a. a bulk density of the fine earth fraction of the soil of less than 0.85 g per cc in the epipedon or the cambic horizon, or both, and the exchange complex is dominated by amorphous material;
 - b. more than 60 percent of vitric volcanic ash, cinders, or other vitric pyroclastic material in the silt, sand, and gravel fractions;
 2. are not saturated with water at any period or lack the characteristics associated with wetness defined for Aquepts;
 3. lack a plaggen epipedon.

* If hues are redder than 10YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived.

** Bulk density at field capacity (1/3-bar tension).

Inceptisols

Cryandepts. Andepts that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon, or of less than 8°C (47°F) if with an O horizon.

Typic Cryandepts. Cryandepts that

- a. lack mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- b. are not thixotropic and the 15-bar water retention is less than 20 percent on the average of the series control section.
- c. lack a lithic contact within 50 cm (20 inches) of the surface;
- d. have an umbric epipedon or a horizon that meets the requirements of an umbric epipedon if its upper boundary is within 50 cm (20 inches) of the surface;
- e. have a mean annual soil temperature of more than 0°C (32°F).

Aquic Cryandepts. Cryandepts like the Typic except for a.

Dystric Cryandepts. Cryandepts like the Typic except for b with or without d.

Dystric Lithic Cryandepts. Cryandepts like the Typic except for b and c.

Lithic Cryandepts. Cryandepts like the Typic except for c.

Durandepts. Andepts that

1. have a duripan within 1 m (40 inches) of the surface;
2. have soil temperatures warmer than Cryandepts;
3. lack clays that dehydrate irreversibly into gravel-size aggregates.

(Durandepts are not known to occur in the United States and subgroups have not been developed.)

Dystrandeps. (formerly Nermandepts) Andepts that

1. have an umbric or ochric epipedon and are thixotropic in some horizon or the 15-bar water retention is 20 percent or more based on the average for the whole soil between 25 cm and 1 m (10 and 40 inches) or a lithic or paralithic contact, whichever is shallower;
2. have soil temperatures warmer than those of Cryandepts;
3. lack clays that dehydrate irreversibly into gravel-size aggregates;
4. lack a duripan.

Typic Dystrandeps. Pellandepts that

- a. lack mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- b. have an umbric epipedon 25 cm (10 inches) or more thick;
- c. are not thixotropic in some horizon between 25 cm and 1 m (10 and 40 inches);
- d. lack a lithic contact within 50 cm (20 inches) of the surface;
- e. have cation exchange capacity of more than 30 meq per 100 g soil (by NH_4OAc) in all horizons above a lithic contact or 1 m (40 inches).

Entic Dystrandeps. Dystrandeps like the Typic except for b.

Hydric Dystrandeps. Dystrandeps like the Typic except for c.

Hydric Lithic Dystrandeps. Dystrandeps like the Typic except for c and d.

Oxic Dystrandeps. Dystrandeps like the Typic except for e.

Eutrandepts. (formerly Mollandepts) Andepts that

1. have a mollic epipedon and are thixotropic in some horizon or the 15-bar water retention is 20 percent or more based on the average for the whole soil between 25 cm and 1 m (10 and 40 inches) or a lithic or paralithic contact, whichever is shallower;

Eutrandepts--Cont.

2. have soil temperatures warmer than those of Cryandepts;
3. lack clays that dehydrate irreversibly into gravel-size aggregates;
4. lack a duripan within 1 m (40 inches) or a fragipan.

Typic Eutrandepts. Eutrandepts that

- a. lack mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- b. have a mollic epipedon 25 cm (10 inches) or more thick;
- c. lack a lithic contact within 50 cm (20 inches) of the surface;
- d. lack a subhorizon with soft, powdery, secondary lime within 1.5 m (60 inches) of the surface.

Aquic Eutrandepts. Eutrandepts like the Typic except for a.Entic Eutrandepts. Eutrandepts like the Typic except for b.Lithic Eutrandepts. Eutrandepts like the Typic except for c.Lithic Ustollic Eutrandepts. Eutrandepts like the Typic except for c and d.Ustollic Eutrandepts. Eutrandepts like the Typic except for d.Hydrandepts. Andepts that

1. have clays that dehydrate irreversibly into gravel-size aggregates;
2. have soil temperatures warmer than those of Cryandepts.

Typic Hydrandepts. Hydrandepts that

- a. lack a lithic contact within 50 cm (20 inches) of the surface.

Lithic Hydrandepts. Hydrandepts like the Typic except for a.Vitrandepts. Andepts that

1. are not thixotropic and the 15-bar water retention is less than 20 percent based on the average for the whole soil between 25 cm and 1 m (10 and 40 inches) or a lithic or paralithic contact, whichever is shallower;
2. have soil temperatures warmer than those of Cryandepts;
3. lack clays that dehydrate irreversibly into gravel-size aggregates;
4. lack a duripan within 1 m (40 inches).

Typic Vitrandepts. Vitrandepts that

- a. lack mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- b. lack a lithic contact within 50 cm (20 inches) of the surface;
- c. have an ochric epipedon.

Aquic Vitrandepts. Vitrandepts like the Typic except for a.Lithic Vitrandepts. Vitrandepts like the Typic except for b.Lithic Mollic Vitrandepts. Vitrandepts like the Typic except for b and c and have a mollic epipedon.Lithic Umbric Vitrandepts. Vitrandepts like the Typic except for b and c and have an umbric epipedon.Mollic Vitrandepts. Vitrandepts like the Typic except for c and have a mollic epipedon.Umbric Vitrandepts. Vitrandepts like the Typic except for c and have an umbric epipedon.

Inceptisols

Aquepts. Inceptisols that either:

1. have sodium saturation that is 15 percent or more in some part of the upper 50 cm (20 inches) and that decreases with depth below 50 cm (20 inches) and the soil is saturated with water at some period of the year within a depth of 1 m (40 inches), or;
2. are saturated with water at some period of the year or are artificially drained and that have at depths of less than 50 cm (20 inches) characteristics associated with wetness, namely, one or more of the following:
 - a. a histic epipedon;
 - b. moist colors on ped faces, if peds are present, or dominant colors in the matrix as follows:
 - (1) if there is mottling within the horizon, chromas are 2 or less;
 - (2) if there is no mottling chromas are 1 or less; if hues are redder than 10YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chroma is waived.

Andaquepts. Aquepts that

1. have a bulk density of the fine earth fraction of the soil of less than 0.85 g per cc in some horizon and an exchange complex that is dominated by amorphous materials or vitric volcanic ash, cinders, or other vitric pyroclastic materials constitute 60 percent or more of the silt, sand, and gravel fractions;
2. have soil temperatures warmer than those of Cryaquepts;
3. have less than 15 percent saturation with sodium in the upper 50 cm (20 inches) or have saturation that is constant or increases with depth below 50 cm (20 inches);
4. have an N value of 0.5 or less in some layer between 20 and 50 cm (8 and 20 inches);
5. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface;
6. lack a fragipan.

Typic Andaquepts. Andaquepts that

- a. have in 60 percent or more of the matrix in all subhorizons between the A1 and Ap and 75 cm (30 inches) one or more of the following:
 - (1) if mottled and if hues are 2.5Y or redder and moist values are 5 or more, moist chromas are 2 or less;
 - (2) if mottled and if hues are yellower than 2.5Y, moist chromas are 2 or less;
 - (3) if with or without mottles, moist chromas are 1 or less;
- b. have an umbric epipedon.

Aeric Andaquepts. Andaquepts like the Typic except for a.Aeric Mollic Andaquepts. Andaquepts like the Typic except for a and b and have a mollic epipedon.Haplic Andaquepts. Andaquepts like the Typic except for b and have an ochric epipedon.Mollic Andaquepts. Andaquepts like the Typic except for b and have a mollic epipedon.Cryaquepts. Aquepts that

1. have a mean annual soil temperature of less than 8°C (47°F) and have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if they are drained and either cultivated or lack an O horizon; of less than 8°C (47°F) if they are drained and have an O horizon or a histic epipedon; and less than 6°C (43°F) if they are undrained and have an O horizon or a histic epipedon;
2. have an N value of 0.5 or less in some horizon between 20 and 50 cm (8 and 20 inches) or the mean annual soil temperature is 0°C (32°F) or less.

Inceptisols

Typic Cryaquepts. Cryaquepts that

- a. have in 60 percent or more of the mass of all horizons between 15 and 50 cm (6 and 20 inches), chromas of 2 or less;
- b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- c. lack a histic epipedon;
- d. lack an umbric or a mollic epipedon;
- e. lack a lithic contact within 50 cm (20 inches) of the surface;
- f. have a mean annual soil temperature of more than 0°C (32°F).

Aeric Cryaquepts. Cryaquepts like the Typic except for a.

Aeric Humic Cryaquepts. Cryaquepts like the Typic except for a and d.

Andic Cryaquepts. Cryaquepts like the Typic except for b or b and d.

Andic Histic Cryaquepts. Cryaquepts like the Typic except for b and c.

Histic Cryaquepts. Cryaquepts like the Typic except for c or c and d.

Histic Lithic Pergelic Cryaquepts. Cryaquepts like the Typic except for c, e and f.

Histic Pergelic Cryaquepts. Cryaquepts like the Typic except for c and f.

Humic Cryaquepts. Cryaquepts like the Typic except for d.

Lithic Pergelic Cryaquepts. Cryaquepts like the Typic except for e and f.

Pergelic Cryaquepts. Cryaquepts like the Typic except for f.

Fragiaquepts. Aquepts that

1. have a fragipan;
2. have soil temperatures warmer than those of Cryaquepts;
3. have less than 15 percent saturation with sodium in the upper 50 cm (20 inches) or have saturation with sodium that is constant or increases with depth below 50 cm (20 inches);
4. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Fragiaquepts. Fragiaquepts that

- a. have an ochric epipedon;
- b. have colors diagnostic of the Aquepts in all horizons below the plow layer or, if there is no plow layer, below 15 cm (6 inches) and down to a depth of 75 cm (30 inches) or more.

Aeric Fragiaquepts. Fragiaquepts like the Typic except for b.

Humic Fragiaquepts. Fragiaquepts like the Typic except for a.

Inceptisols

Halaquepts. Aquepts that

1. have sodium saturation that is 15 percent or more in some part of the upper 50 cm (20 inches) and that decreases with depth below 50 cm (20 inches) and the soil is saturated with water at some period within a depth of 1 m (40 inches).
2. have an N value of 0.5 or less in some layer between 20 and 50 cm (8 and 20 inches);
3. have soil temperatures warmer than those of Cryaquepts;
4. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Halaquepts. Halaquepts that

- a. have chromas of 2 or less in hues of 5Y or redder in 60 percent or more of the matrix in all subhorizons between 15 and 75 cm (6 and 30 inches);
- b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- c. have an organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) within 1.25 m (50 inches) of the surface;
- d. have an ochric epipedon.

Aeric Halaquepts. Halaquepts like the Typic except for a.

Aeric Andic Halaquepts. Halaquepts like the Typic except for a and b.

Andic Halaquepts. Halaquepts like the Typic except for b.

Fluventic Halaquepts. Halaquepts like the Typic except for c with or without a.

Haplaquepts. Aquepts that

1. have soil temperatures warmer than those of Cryaquepts and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;
2. have an ochric epipedon;
3. have an exchange complex that is dominated by crystalline aluminosilicate clay minerals and have less than 60 percent vitric volcanic ash, cinders, or other vitric pyroclastic materials in the silt, sand, and gravel fractions;
4. have an N value of 0.5 or less in some layer between 20 and 50 cm (8 and 20 inches);
5. have less than 15 percent saturation with sodium in the upper 50 cm (20 inches) or with saturation that is constant or increases with depth below 50 cm (20 inches);
6. lack a fragipan;
7. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Haplaquepts. Haplaquepts that

- a. have in 60 percent or more of the matrix in all subhorizons between the A1 or Ap and 75 cm (30 inches) one or more of the following:
 - (1) if mottled and mean annual soil temperature is less than 15°C (59°F) moist chromas are 2 or less;
 - (2) if mottled and mean annual soil temperature is 15°C (59°F) or more:

Inceptisols

Typic Haplaquepts--Cont.

- (a) in hues of 2.5Y or redder* and moist values more than 5, moist chromas are 2 or less,
 - (b) in hues of 2.5Y or redder and moist values of 5 or less, moist chromas are 1 or less,
 - (c) in hues yellower than 2.5Y, moist chromas are 2 or less;
- (3) moist chromas are 1 or less with or without mottles.
- b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
 - c. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
 - d. lack a buried Histosol within 50 cm (20 inches) of the surface;
 - e. have an Ap horizon with a moist value of 4 or more or with a dry value of 6 or more crushed and smoothed** or the Al horizon is less than 15 cm (6 inches) thick if its moist color value is lower than 3.5;
 - f. have an N value of less than 0.9 between 50 and 80 cm (20 and 32 inches) and less than 0.5 in all layers between 30 and 50 cm (12 and 20 inches);
 - g. lack a lithic contact within 50 cm (20 inches) of the surface;
 - h. lack 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 (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend 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 (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aeric Haplaquepts. Haplaquepts like the Typic except for a or a and e.

Aeric Andic Haplaquepts. Haplaquepts like the Typic except for a and b.

Chromudertic Haplaquepts. Haplaquepts like the Typic except for a, c and h with or without e.

Fluventic Haplaquepts. Haplaquepts like the Typic except for c with or without a or e, or both.

Humic Haplaquepts. Haplaquepts like the Typic except for e and the base saturation is less than 50 percent in some horizon and does not increase with depth to 50 percent or more.

Lithic Haplaquepts. Haplaquepts like the Typic except for g.

Mollic Haplaquepts. Haplaquepts like the Typic except for e and the base saturation is 50 percent or more throughout or increases with depth to 50 percent or more.

Thapto-Histic Haplaquepts. Haplaquepts like the Typic except for c and d.

Vertic Haplaquepts. Haplaquepts like the Typic except for c and h with or without e.

* If hues are 7.5YR or redder in the matrix: if peds are present, ped exteriors have dominant moist chromas of 1 or less and ped interiors have mottles with moist chromas of 2 or less; if peds are absent, moist chromas are 1 or less immediately below any surface horizon that has moist values of less than 3.5.

** Use knife and smooth to eliminate shadows.

Inceptisols

Humaquepts. Aquepts that

1. have soil temperatures warmer than those of Cryaquepts and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;
2. have an umbric, mollic or a histic epipedon;
3. have an exchange complex that is dominated by crystalline aluminosilicate clay minerals and have less than 60 percent vitric volcanic ash, cinders or other vitric pyroclastic materials in the silt, sand, and gravel fractions;
4. have an N value of 0.5 or less in some layer between 20 and 50 cm (8 and 20 inches);
5. have less than 15 percent saturation with sodium in the upper 50 cm (20 inches) or have saturation with sodium that is constant or increases with depth below 50 cm (20 inches);
6. lack a fragipan;
7. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Humaquepts. Humaquepts that

- a. have chromas of 2 or less in hues of 5Y or redder in 60 percent or more of the matrix in all subhorizons between 15 and 75 cm (6 and 30 inches);
- b. have mottles within 30 cm (12 inches) below the base of the epipedon if the chromas to this depth are 1 or more and the hues are redder than 5Y;
- c. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- d. have an epipedon less than 60 cm (24 inches) thick;
- e. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- f. lack a histic epipedon;
- g. have an N value of less than 0.9 between 50 and 80 cm (20 and 32 inches) depths;
- h. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aeric Humaquepts. Humaquepts like the Typic except for a or b or both.

Cumillic Humaquepts. Humaquepts like the Typic except for d and e.

Inceptisols

Fluventic Humaquepts. Humaquepts like the Typic except for e.

Histic Humaquepts. Humaquepts like the Typic except for f.

Flinthaquepts. Aquepts that

1. have plinthite that forms a continuous phase or constitutes more than half of the matrix within some subhorizon in the upper 1.25 m (50 inches) of the soil;
2. have soil temperatures warmer than those of Cryaquepts.

(Subgroups have not been developed.)

Tropaquepts. Aquepts that

1. have a mean annual soil temperature of 8°C (47°F) or more and have less than 5°C (9°F) difference between the mean summer and mean winter soil temperatures at 50 cm (20 inches), or at a lithic or paralithic contact, whichever is shallower;
2. have less than 15 percent saturation with sodium in the upper 50 cm (20 inches) or have saturation that is constant or increases with depth below 50 cm (20 inches);
3. have an N value of 0.5 or less in some layer between 20 and 50 cm (8 and 20 inches);
4. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Tropaquepts. Tropaquepts that

- a. have in 60 percent or more of the matrix in all subhorizons between the A1 or Ap and 75 cm (30 inches) one or more of the following:
 - (1) if mottled and if hues are 2.5Y or redder and moist values are more than 5, moist chromas are 2 or less; if moist values are 5 or less, moist chromas are 1 or less;
 - (2) if mottled and if hues are yellower than 2.5Y, moist chromas are 2 or less;
 - (3) if with or without mottles, moist chromas are 1 or less;
- b. have organic matter content that decreases regularly with depth and, unless a lithic or paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- c. lack a histic epipedon;
- d. lack a lithic contact within 50 cm (20 inches) of the surface;
- e. lack a buried Histosol within 50 cm (20 inches) of the soil surface;
- f. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aeric Tropaquepts. Tropaquepts like the Typic except for a.

Aeric Fluventic Tropaquepts. Tropaquepts like the Typic except for a and b.

Fluventic Tropaquepts. Tropaquepts like the Typic except for b.

Inceptisols

Histic Tropaquepts. Tropaquepts like the Typic except for c.

Lithic Tropaquepts. Tropaquepts like the Typic except for d.

Thapto-Histic Tropaquepts. Tropaquepts like the Typic except for e.

Vertic Tropaquepts. Tropaquepts like the Typic except for f with or without b.

Ochrepts. Inceptisols that

1. have an ochric epipedon; or have an umbric or mollic epipedon 25 cm (10 inches) or less thick if (a) the mean annual soil temperature is 8°C (47°F) or more, or (b) the mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, is either 15°C (59°F) or more if cultivated or without an O horizon or 8°C (47°F) or more if with an O horizon;
2. have 5°C (9°F) or more difference between the mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower;
3. have an exchange complex that is dominated by crystalline aluminosilicate clay minerals and have less than 60 percent vitric volcanic ash, cinders, or other vitric pyroclastic materials in the silt, sand, and gravel fractions;
4. have chromas too high or hues too red for Aquepts or are never saturated with water and are not artificially drained;
5. lack a plaggen epipedon.

Cryochrepts. Ochrepts that

1. have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon;
2. lack a fragipan and lack a duripan with its upper boundary within 1 m (40 inches) of the soil surface.

Typic Cryochrepts. Cryochrepts that

- a. have a mean annual soil temperature of more than 0°C (32°F).
- b. lack a lithic contact within 50 cm (20 inches) of the surface;
- c. lack mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;
- d. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

Andic Cryochrepts. Cryochrepts like the Typic except for d.

Lithic Cryochrepts. Cryochrepts like the Typic except for b.

Durochrepts. Ochrepts that

1. have a duripan with its upper boundary within 1 m (40 inches) of the surface;
2. lack a fragipan.

Typic Durochrepts. Durochrepts that

- a. have a platy or massive, indurated duripan with its upper boundary within 1 m (40 inches) of the soil surface;
- b. have no distinct or prominent mottles within the upper 30 cm (12 inches).

Haplic Durochrepts. Durochrepts like the Typic except for a.

Inceptisols

Dystrochrepts. Ochrepts that

1. lack carbonates in the cambic horizon or in the C horizon within the soil;
2. have a base saturation less than 60 percent (by NH_4OAc) in all subhorizons that are within 75 cm (30 inches) of the soil surface;
3. are not dry for as much as 90 cumulative days in most years in any subhorizon of the soil between 18 and 50 cm (7 and 20 inches) or above a lithic or paralithic contact shallower than 50 cm (20 inches) and are not dry for as much as 60 consecutive days in more than 7 out of 10 years in all subhorizons between these depths;
4. lack a fragipan and lack a duripan with its upper boundary within 1 m (40 inches) of the soil surface;
5. have a mean annual soil temperature of 8°C (47°F) or more or have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of either 15°C (59°F) or more if cultivated or without an O horizon or 8°C (47°F) or more if with an O horizon.

Typic Dystrochrepts. Dystrochrepts that

- a. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc or less in the fine earth fraction, and that has either (1) 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.
- b. lack mottles with chromas of 2 or less within 50 cm (20 inches) of the surface;
- c. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- d. lack a lithic contact within 50 cm (20 inches) of the surface;
- e. lack an argillic horizon in any part of the pedon;
- f. lack an umbric or mollic epipedon.

Andic Dystrochrepts. Dystrochrepts like the Typic except for a.

Andic Aquic Dystrochrepts. Dystrochrepts like the Typic except for a and b.

Andic Umbric Dystrochrepts. Dystrochrepts like the Typic except for a and f.

Aquic Dystrochrepts. Dystrochrepts like the Typic except for b.

Aquic Fluventic Dystrochrepts. Dystrochrepts like the Typic except for b and c.

Fluventic Dystrochrepts. Dystrochrepts like the Typic except for c.

Fluventic Umbric Dystrochrepts. Dystrochrepts like the Typic except for c and f.

Lithic Dystrochrepts. Dystrochrepts like the Typic except for d.

Lithic Ruptic-Alfic Dystrochrepts. Dystrochrepts like the Typic except for d and e and base saturation (by sum of cations) is 35 percent or more in some part above the lithic contact but in less than half of each pedon.

Lithic Ruptic-Ultic Dystrochrepts. Dystrochrepts like the Typic except for d and e and base saturation (by sum of cations) is less than 35 percent above the lithic contact but in less than half of each pedon.

Ruptic-Alfic Dystrochrepts. Dystrochrepts like the Typic except for e and the base saturation (by sum of cations) is 35 percent or more at a depth of 1.25 m (50 inches) below the upper boundary of the argillic horizon but in less than half of each pedon.

Inceptisols

Dystrochrepts--Cont.

Ruptic-Ultic Dystrochrepts. Dystrochrepts like the Typic except for e and the base saturation (by sum of cations) is less than 35 percent at a depth of 1.25 m (50 inches) below the upper boundary of the argillic horizon but in less than half of each pedon.

Umbric Dystrochrepts. Dystrochrepts like the Typic except for f.

Eutrochrepts. Ochrepts that

1. have one or both of:
 - a. carbonates in the cambic horizon or in the C horizon but within the soil;
 - b. base saturation that is 60 percent or more (by NH_4OAc) in some subhorizon that is within 75 cm (30 inches) of the soil surface;
2. are not dry for as much as 90 cumulative days in most years in any subhorizon of the soil between 18 and 50 cm (7 and 20 inches) or above a lithic or paralithic contact shallower than 50 cm (20 inches) and are not dry for as much as 60 consecutive days in more than 7 out of 10 years in all subhorizons between these depths;
3. have a mean annual soil temperature of 8°C (47°F) or more or have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of either 15°C (59°F) or more if cultivated or without an O horizon or 8°C (47°F) or more if with an O horizon;
4. lack a fragipan or a duripan.

Typic Eutrochrepts. Eutrochrepts that

- a. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- b. have no mottles with chromas of 2 or less within 50 cm (20 inches) of the surface;
- c. have a texture of loamy very fine sand or finer within 50 cm (20 inches) of the surface;
- d. have carbonates in the cambic horizon in some part of each pedon but have less than 40 percent carbonates below the cambic horizon to a depth of 1 m (40 inches);
- e. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- f. have no lithic contact within 50 cm (20 inches) of the surface in any part of the pedon;
- g. have no argillic horizon in any part of the pedon;
- h. have an ochric epipedon;
- i. lack both of the following combinations of characteristics:
 - (1) (a) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches) and that are at least 30 cm (12 inches) long in some part and that extend to the surface or the base of an Ap, and
 - (b) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (c) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
 - (2) (a) have a lithic or paralithic contact or altered rock retaining its rock structure within 50 cm (20 inches) of the surface, and
 - (b) have horizons totalling 25 cm (10 inches) or more in thickness with 35 percent or more clay with montmorillonitic mineralogy.

Inceptisols

Eutrochrepts--Cont.

Andic Eutrochrepts. Eutrochrepts like the Typic except for a.

Andic Dystric Eutrochrepts. Eutrochrepts like the Typic except for a and d.

Aquic Eutrochrepts. Eutrochrepts like the Typic except for b with or without carbonates in the cambic horizon.

Aquic Dystric Eutrochrepts. Eutrochrepts like the Typic except for b and d.

Aquic Fluventic Eutrochrepts. Eutrochrepts like the Typic except for b and e with or without carbonates in the cambic horizon.

Arenic Eutrochrepts. Eutrochrepts like the Typic except for c.

Dystric Eutrochrepts. Eutrochrepts like the Typic except for d, and have no carbonates within 1 m (40 inches) of the surface.

Dystric Fluventic Eutrochrepts. Eutrochrepts like the Typic except for d and e.

Dystric Lithic Eutrochrepts. Eutrochrepts like the Typic except for d and f.

Fluventic Eutrochrepts. Eutrochrepts like the Typic except for e.

Lithic Eutrochrepts. Eutrochrepts like the Typic except for f.

Lithic Ruptic-Alfic Eutrochrepts. Eutrochrepts like the Typic except for f and g and have an argillic horizon in some part but in less than half of each pedon.

Lithic-Vertic Eutrochrepts. Eutrochrepts like the Typic except for f and i.

Rendollic Eutrochrepts. Eutrochrepts like the Typic except for d, and have more than 40 percent carbonates in some subhorizon within 1 m (40 inches) of the surface.

Ruptic-Alfic Eutrochrepts. Eutrochrepts like the Typic except for g and have an argillic horizon in some part but in less than half of each pedon.

Vertic Eutrochrepts. Eutrochrepts like the Typic except for i with or without e.

Fragiochrepts. Ochrepts that

1. have a fragipan;
2. lack a duripan with its upper boundary within 1 m (40 inches) of the soil surface.

Typic Fragiochrepts. Fragiochrepts that

- a. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- b. have no distinct or prominent mottles in the upper 30 cm (12 inches);
- c. have an ochric epipedon.

Andic Fragiochrepts. Fragiochrepts like the Typic except for a.

Aquic Fragiochrepts. Fragiochrepts like the Typic except for b.

Ustochrepts. Ochrepts that

1. are dry for 90 cumulative days or more in most years in some subhorizon of the soil between 18 and 50 cm (7 and 20 inches) depth or above a lithic or a paralithic contact shallower than 50 cm (20 inches) but are not continuously dry in all parts of the soil between these depths for as long as 60 consecutive days in more than 7 out of 10 years unless the mean annual soil temperature is 22°C (72°F) or higher;

Inceptisols

Ustochrepts--Cont.

2. lack a fragipan and lack a duripan with its upper boundary within 1 m (40 inches) of the soil surface;
3. have a mean annual soil temperature of 8°C (47°F) or more or have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of either 15°C (59°F) or more if cultivated or without an O horizon or 8°C (47°F) or more if with an O horizon.

Typic Ustochrepts. Ustochrepts that

- a. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- b. have no lithic contact within 50 cm (20 inches) of the surface;
- c. have less than 40 percent carbonates below the cambic horizon to a depth of 1 m (40 inches).
- d. lack both of the following combinations of characteristics:
 - (1) (a) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches) and that are at least 30 cm (12 inches) long in some part and that extend to the surface or the base of an Ap, and
 - (b) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (c) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
 - (2) (a) have a lithic or paralithic contact or altered rock retaining its rock structure within 50 cm (20 inches) of the surface, and
 - (b) have horizons totalling 25 cm (10 inches) or more in thickness with 35 percent or more clay with montmorillonitic mineralogy.
- e. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;
- f. have base saturation (by NH_4OAc) of 60 percent or more in some part of the soil within 75 cm (30 inches) of the surface;

Fluventic Ustochrepts. Ustochrepts like the Typic except for a.

Lithic Ustochrepts. Ustochrepts like the Typic except for b.

Lithic-Vertic Ustochrepts. Ustochrepts like the Typic except for b and d.

Rendollic Ustochrepts. Ustochrepts like the Typic except for c.

Vertic Ustochrepts. Ustochrepts like the Typic except for d with or without a.

Xerochrepts. Ochrepts that

1. are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact, whichever is shallower or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches).
2. have a mean annual soil temperature of 8°C (47°F) or more but less than 22°C (72°F), or of less than 8°C (47°F) if mean summer soil temperature is 15°C (59°F) or more and there is no O horizon, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) depth, or at a lithic or a paralithic contact shallower than 50 cm (20 inches) that differ by 5°C (9°F) or more;
3. lack a fragipan and lack a duripan with its upper boundary within 1 m (40 inches) of the soil surface.

Xerochrepts--Cont.Typic Xerochrepts. Xerochrepts that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;
- b. have base saturation (by NH_4OAc) of 60 percent or more in some part of the soil within 75 cm (30 inches) of the surface;
- c. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- d. have no lithic contact within 50 cm (20 inches) of the surface;
- e. lack both of the following combinations of characteristics:
 - (1) (a) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches) and that are at least 30 cm (12 inches) long in some part and that extend to the surface or the base of an Ap, and
 - (b) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (c) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
 - (2) (a) have a lithic or paralithic contact or altered rock retaining its rock structure within 50 cm (20 inches) of the surface, and
 - (b) have horizons totalling 25 cm (10 inches) or more in thickness with 35 percent or more clay with montmorillonitic mineralogy.
- f. have no calcic horizon within 1 m (40 inches) of the surface.

Aquic Xerochrepts. Xerochrepts like the Typic except for a.

Aquic Dystric Xerochrepts. Xerochrepts like the Typic except for a and b.

Dystric Xerochrepts. Xerochrepts like the Typic except for b.

Dystric Fluventic Xerochrepts. Xerochrepts like the Typic except for b and c.

Dystric Lithic Xerochrepts. Xerochrepts like the Typic except for b and d.

Lithic Xerochrepts. Xerochrepts like the Typic except for d.

Lithic-Vertic Xerochrepts. Xerochrepts like the Typic except for d and e.

Ruptic-Lithic Xerochrepts. Xerochrepts like the Typic except for d and have a lithic contact in some part but in less than half of each pedon.

Vertic Xerochrepts. Xerochrepts like the Typic except for e with or without c.

Flagepts. Inceptisols that have a plaggen epipedon. (No Flagepts in the United States. Subgroups have not been developed.)

Tropepts. Inceptisols that have a mean annual soil temperature of 8°C (47°F) or more and have less than 5°C (9°F) difference between the mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower; lack a plaggen epipedon, and have one of the following:

1. an umbric epipedon;
2. a mollic epipedon with one or both of the following:
 - a. 35 percent or more clay with montmorillonitic mineralogy and an epipedon that rests on materials with less than 40 percent CaCO_3 equivalent;
 - b. a ^{underlying} cambic horizon with base saturation that is less than 50 percent (by NH_4OAc) throughout, or decreasing to less than 50 percent at a depth of 1.8 m (72 inches);
3. an ochric epipedon and a cambic horizon.

Inceptisols

Tropepts--Cont.

Dystropepts. Tropepts that have a mean annual soil temperature of 22°C (72°F) or more, and have less than 50 percent base saturation (by NH_4OAc) in some part of the epipedon or cambic horizon.

Typic Dystropepts. Dystropepts that

- a. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- b. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- c. have a cambic horizon;
- d. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- e. have no lithic contact within 50 cm (20 inches) of the surface;
- f. have a cation exchange capacity (by NH_4OAc) of 24 or more meq per 100 g clay in all horizons above a lithic contact or 1 m (40 inches);
- g. lack 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 (20 inches) that are at least 30 cm (12 inches) long in some part and 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 (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches);
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Lithic Dystropepts. Dystropepts like the Typic except for a and e.

Entic Dystropepts. Dystropepts like the Typic except for c.

Fluventic Dystropepts. Dystropepts like the Typic except for d.

Fluventic Oxidic Dystropepts. Dystropepts like the Typic except for d and f and the CEC is < 24 meq per 100 g. clay or 2.5 x 15-bar water, whichever value is the higher.

Lithic Dystropepts. Dystropepts like the Typic except for e.

Oxidic Dystropepts. Dystropepts like the Typic except for f, and the CEC is < 24 meq per 100 g. clay or 2.5 X 15-bar water, whichever value is the higher.

Vertic Dystropepts. Dystropepts like the Typic except for g with or without c or d, or both.

Eutropepts. Tropepts that

1. have 50 percent or more base saturation (by NH_4OAc) throughout the epipedon and any cambic horizon;
2. are not dry for as much as 90 cumulative days in most years in any horizon;
3. have no horizon containing soft, powdery secondary lime within 1.5 m (60 inches) of the surface. (See Key, page 62, GE.3. Ustolls, for meaning of soft, powdery lime.)

Inceptisols

Typic Entropepts. Entropepts that

- a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- b. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- c. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- d. have a cation exchange capacity (by NH_4OAc) of 24 or more meq per 100 g clay in all horizons above a lithic contact or 1 m (40 inches);
- e. have no lithic contact within 50 cm (20 inches) of the surface;
- f. lack both of the following combinations of characteristics:
 - (1) (a) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches) and that are at least 30 cm (12 inches) long in some part and that extend to the surface or the base of an A_p , and
 - (b) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (c) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
 - (2) (a) have a lithic or paralithic contact or altered rock retaining its rock structure within 50 cm (20 inches) of the surface, and
 - (b) have horizons totalling 25 cm (10 inches) or more in thickness with 35 percent or more clay with montmorillonitic mineralogy;
- g. have a cambic horizon.

Andic Entropepts. Entropepts like the Typic except for a, with or without d.

Aquic Entropepts. Entropepts like the Typic except for b.

Aquic Fluventic Entropepts. Entropepts like the Typic except for b and c.

Fluventic Entropepts. Entropepts like the Typic except for c.

Fluventic Oxic Entropepts. Entropepts like the Typic except for c and d, and the CEC is < 24 meq per 100 g clay or 2.5×15 -bar water, whichever value is the higher.

Lithic Entropepts. Entropepts like the Typic except for e.

Lithic-Vertic Entropepts. Entropepts like the Typic except for e and f with or without g.

Oxic Entropepts. Entropepts like the Typic except for d, and the CEC is < 24 meq per 100 g clay or 2.5×15 -bar water, whichever value is the higher.

Vertic Entropepts. Entropepts like the Typic except for f with or without c or g, or both.

Humitropepts. Tropepts that have a mean annual soil temperature of less than 22°C (72°F), and have less than 50 percent base saturation (by NH_4OAc) in some part of the epipedon or cambic horizon.

Inceptisols

Typic Humitropepts. Humitropepts that

- a. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- b. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. have a cation exchange capacity (by NH_4OAc) of 24 or more meq per 100 g clay in all horizons above a lithic contact or 1 m (40 inches).

Andic Humitropepts. Humitropepts like the Typic except for a.

Aquic Lithic Humitropepts. Humitropepts like the Typic except for b and c.

Lithic Humitropepts. Humitropepts like the Typic except for c.

Oxic Humitropepts. Humitropepts like the Typic except for d and the CEC is < 24 meq per 100 g clay or 2.5 X 15-bar water, whichever value is the higher.

Ustropepts. Tropepts that

1. have 50 percent or more base saturation (by NH_4OAc) throughout the epipedon and any cambic horizon;
2. are either dry in some horizon for 90 cumulative days or more in most years or have a horizon containing soft, powdery secondary lime within 1.5 m (60 inches) of the surface. (See Key, p. 62, GE 3, Ustolls, for meaning of soft powdery lime.)

Typic Ustropepts. Ustropepts that

- a. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- b. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.35 percent (0.2 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- c. have a cambic horizon;
- d. have no lithic contact within 50 cm (20 inches) of the surface;
- e. have a cation exchange capacity (by NH_4OAc) of 24 or more meq per 100 g clay in all horizons above a lithic contact or 1 m (40 inches);
- f. lack both of the following combinations of characteristics:
 - (1) (a) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches) and that are at least 30 cm (12 inches) long in some part and that extend to the surface or the base of an Ap, and
 - (b) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (c) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
 - (2) (a) have a lithic or paralithic contact or altered rock retaining its rock structure within 50 cm (20 inches) of the surface, and
 - (b) have horizons totalling 25 cm (10 inches) or more in thickness with 35 percent or more clay with montmorillonitic mineralogy.

Aquic Fluventic Ustropepts. Ustropepts like the Typic except for a and b.

Fluventic Ustropepts. Ustropepts like the Typic except for b with or without c.

Fluventic Oxic Ustropepts. Ustropepts like the Typic except for b and e with or without c and the CEC is < 24 meq per 100 g clay or 2.5 X 15-bar water, whichever is the higher.

Inceptisols

Lithic Ustropepts. Ustropepts like the Typic except for d.

Lithic Oxid Ustropepts. Ustropepts like the Typic except for d and e, and the CEC is < 24 meq per 100 g clay or 2.5 x 15-bar water, whichever value is higher.

Lithic Vertic Ustropepts. Ustropepts like the Typic except for d and f with or without c.

Oxid Ustropepts. Ustropepts like the Typic except for e and the CEC is < 24 meq per 100 g clay or 2.5 X 15-bar water, whichever value is the higher.

Vertic Ustropepts. Ustropepts like the Typic except for f with or without b or c, or both.

Umbrepts. Inceptisols that

1. have an exchange complex that is dominated by crystalline aluminosilicate clay minerals and have less than 60 percent vitric volcanic ash, cinders, or other vitric pyroclastic materials in the silt, sand, and gravel fractions;
2. are not saturated with water at any season or lack the characteristics associated with wetness defined for Aquepts;
3. have 5°C (9°F) or more difference between the mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower;
4. lack a plaggen epipedon;
5. have one of the following characteristics:
 - a. if the mean annual soil temperature is 8°C (47°F) or more, have either an umbric or anthropic epipedon that is more than 25 cm (10 inches) thick or a mollic epipedon that is more than 25 cm (10 inches) thick if it is underlain by a cambic horizon with base saturation of less than 50 percent (by NH₄OAc) in some part;
 - b. if the mean annual soil temperature is less than 8°C (47°F), have either an umbric epipedon, or a mollic epipedon if the mollic epipedon is underlain by a cambic horizon that has base saturation of less than 50 percent (by NH₄OAc) in some part.

Anthrumbrepts. Umbrepts that

1. have an anthropic epipedon;
 2. have no fragipan.
- (Subgroups have not been developed.)

Cryumbrepts. Umbrepts that

1. have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon, or less than 8°C (47°F) if with an O horizon;
2. lack a fragipan;
3. lack an anthropic epipedon.

Typic Cryumbrepts. Cryumbrepts that

- a. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- b. have a cambic horizon;
- c. have no lithic contact within 50 cm (20 inches) of the surface;

Inceptisols

Typic Cryumbrepts--Cont.

- d. have a mean annual soil temperature of more than 0°C (32°F).
- e. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface.

Andic Cryumbrepts. Cryumbrepts like the Typic except for a.

Entic Cryumbrepts. Cryumbrepts like the Typic except for b.

Lithic Cryumbrepts. Cryumbrepts like the Typic except for c with or without b.

Lithic Pergelic Cryumbrepts. Cryumbrepts like the Typic except for c and d with or without b.

Pergelic Cryumbrepts. Cryumbrepts like the Typic except for d with or without b.

Fraglumbrepts. Umbrepts that

- 1. have a fragipan;
- 2. lack an anthropic epipedon.

(Subgroups have not been developed.)

Haplumbrepts. Umbrepts that

- 1. have an umbric or a mollic epipedon;
- 2. have soil temperatures warmer than those of Cryumbrepts;
- 3. have no fragipan;
- 4. are never dry or are not dry for as much as 60 consecutive days in more than 7 out of 10 years in all subhorizons between 18 and 50 cm (7 and 20 inches) or a lithic or paralithic contact shallower than 50 cm (20 inches) or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches).

Typic Haplumbrepts. Haplumbrepts that

- a. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- b. have no mottles with chromas of 2 or less within 50 cm (20 inches) of the surface;
- c. have a cambic horizon;
- d. have organic matter content that decreases regularly with depth and, unless a lithic or a paralithic contact occurs at shallower depths, reaches levels of 0.5 percent (0.29 percent organic carbon) or less within 1.25 m (50 inches) of the soil surface.
- e. have no lithic contact within 50 cm (20 inches) of the surface;
- f. have an umbric or mollic epipedon less than 50 cm (20 inches) thick;
- g. have textures finer than loamy fine sand within a depth of 50 cm (20 inches);
- h. have no duripan that has its upper boundary within 1 m (40 inches) of the surface.

Andic Haplumbrepts. Haplumbrepts like the Typic except for a.

Aquic Fluventic Haplumbrepts. Haplumbrepts like the Typic except for b and d.

Aquipsammentic Haplumbrepts. Haplumbrepts like the Typic except for b, c, and g.

Cumalic Haplumbrepts. Haplumbrepts like the Typic except for f and d with or without b or c, or both.

Duric Haplumbrepts. Haplumbrepts like the Typic except for h.

Entic Haplumbrepts. Haplumbrepts like the Typic except for c.

Inceptisols

Fluventic Haplumbrepts. Haplumbrepts like the Typic except for d.

Lithic Haplumbrepts. Haplumbrepts like the Typic except for e.

Pachic Haplumbrepts. Haplumbrepts like the Typic except for f with or without b or c, or both.

Quartzipsammentic Haplumbrepts. Haplumbrepts like the Typic except for c and g with or without f; have sandy textures to a depth of 1 m (40 inches) or more, and have in the sand fraction more than 95 percent quartz, zircon, tourmaline, rutile, or other normally insoluble minerals that do not weather to liberate iron or titanium.

Kerumbrepts. Umbrepts that

1. are dry for 60 consecutive days or more in more than 7 out of 10 years in all subhorizons between 18 and 50 cm (7 and 20 inches) or a lithic or paralithic contact shallower than 50 cm (20 inches) or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches);
2. have a mean annual soil temperature of 8°C (47°F) or more but less than 22°C (72°F), or of less than 8°C (47°F) if mean summer soil temperature is 15°C (59°F) or more and there is no C horizon, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) depth, or at a lithic or a paralithic contact shallower than 50 cm (20 inches) that differ by 5°C (9°F) or more;
3. have no anthropic epipedon or fragipan.

Typic Kerumbrepts. Kerumbrepts that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;
- b. have an umbric or mollic epipedon less than 50 cm (20 inches) thick;
- c. have a cambic horizon;
- d. have organic matter content that decreases regularly with depth and reaches levels of 0.5 percent (0.29 percent organic carbon) or less within depths of 1.25 m (50 inches) below the surface;
- e. have no lithic contact within 50 cm (20 inches) of the surface;

Axic Kerumbrepts. Kerumbrepts like the Typic except for a.

Mollic Kerumbrepts. Kerumbrepts like the Typic except for b and d with or without a or c, or both.

Entic Kerumbrepts. Kerumbrepts like the Typic except for c.

Fluventic Kerumbrepts. Kerumbrepts like the Typic except for d.

Lithic Kerumbrepts. Kerumbrepts like the Typic except for e with or without c.

Pachic Kerumbrepts. Kerumbrepts like the Typic except for b with or without a or c, or both.

ARIDISOLS: ORDER 4

Mineral soils that have no oxic or spodic horizons but have an ochric epipedon and one or more of the following combinations of properties:

1. have no argillic or natric horizon but within 1 m (40 inches) of the surface have one or more of the following horizons: calcic, petrocalcic, gypsic, cambic, or duripan; and either are usually dry between 18 and 50 cm (7 and 20 inches) depth or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in some subhorizon above a lithic or a paralithic contact shallower than 18 cm (7 inches) or have a conductivity of the saturation extract that is 2 mmho per cm or greater at 25°C in some part above whichever of the following depths is least: a lithic or paralithic contact, 1.25 m (50 inches) if particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey; or with increase in depth within the C horizon but above the depths for the different particle-size classes specified above there is an increase in saturation with Na plus K in some part;
2. have no argillic or natric horizon but have a salic horizon within 75 cm (30 inches) of the surface and are saturated with water within 1 m (40 inches) of the surface for one month or more;
3. have a surface horizon that is not both hard and massive when dry; an argillic or natric horizon; and are usually dry in most years in all parts of the soil between 18 and 50 cm (7 and 20 inches) or a lithic or paralithic contact shallower than 50 cm (20 inches) or in some subhorizon above a lithic or a paralithic contact shallower than 18 cm (7 inches);
4. after the upper 18 cm (7 inches) are mixed, have a clay content of less than 30 percent in some horizon within a depth of 1 m (40 inches) if there are cracks at least 1 cm wide at a depth of 50 cm at some period in most years and:
 - a. there is gilgai, or
 - b. at some depth between 25 cm and 1 m (10 and 40 inches), there are slickensides close enough to intersect or there are wedge-shaped or parallelepiped natural structural aggregates with their long axes tilted 10 to 60 degrees from the horizontal.

Argids. Aridisols that have an argillic or natric horizon.

Durargids. Argids that

1. have a duripan below an argillic horizon or below a prismatic or blocky natric horizon and the upper boundary of the duripan is within 1 m (40 inches) of the soil surface;
2. have no petrocalcic horizon that has its upper boundary within 1 m (40 inches) of the soil surface.

Typic Durargids. Durargids that

- a. have none of the following characteristics within 1 m (40 inches) of the surface:
 - (1) dominant chromas of 1 or less throughout and hues as yellow or yellower than 2.5Y in some portion;
 - (2) dominant chromas of 2 or less accompanied by mottles not due to segregated lime;
 - (3) dominant chromas of 2 or less accompanied by a decrease in the percentage of exchangeable sodium from the upper 25 cm (10 inches) to the underlying layer;
- b. have a platy or massive duripan that is indurated in some subhorizon;
- c. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have proportional carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4. (See figure A, page 120)

Aridisols

Typic Durargids--Cont.

- d. have no argillic horizon or prismatic or blocky matrix horizon that has both 35 percent or more clay in some part and either:
- (1) an increase of 15 percent or more clay (absolute) within a vertical distance of 2.5 cm (1 inch) at the upper boundary of the argillic horizon, or
 - (2) an increase of 10 percent or more clay (absolute) if cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon.

Aquic Durargids. Durargids like the Typic except for a or a and c.

Uspic Durargids. Durargids like the Typic except for b.

Uspic Mollic Durargids. Durargids like the Typic except for b and c and the duripan is brittle and has 20 percent or more by volume of durinodes in some subhorizon.

Mollic Durargids. Durargids like the Typic except for c.

Mollic Paleic Durargids. Durargids like the Typic except for c and d.

Urochreids. Aridisols that

- a. have no duripan within 1 m (40 inches) of the surface or columnar matrix horizon;
- b. have an argillic horizon or prismatic or blocky matrix horizon that has one or both of the following:
 - (1) less than 35 percent clay in all subhorizons;
 - (2) an increase of less than 15 percent clay (absolute) within a vertical distance of 2.5 cm (1 inch) at the upper boundary of the argillic horizon, or an increase of less than 10 percent clay (absolute) if cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon;
- c. have no lithic horizon that has its upper boundary within 1 m (40 inches) of the surface.

Urochreids (Haplochreids)

- a. have none of the following characteristics within 1 m (40 inches) of the surface:
 - (1) dominant chromas of 1 or less throughout and hues as yellow or paler than 2.5Y in some portion;
 - (2) dominant chromas of 2 or less accompanied by mottles not due to segregated lime;
 - (3) dominant chromas of 2 or less accompanied by a decrease in the percentage of exchangeable Ca from the upper 25 cm (10 inches) to the underlying layer;
- b. have textures finer than loamy fine sand in some subhorizon within the upper 50 cm (20 inches);
- c. have no brittle horizon that is 15 cm (6 inches) or more thick within 1 m (40 inches) of the surface that contains some opal coatings or some (less than 20 percent by volume) durinodes;
- d. have no lithic contact within 50 cm (20 inches) of the surface;
- e. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have proportional carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4; (See figure A, page 120)

Aridisols

Typic Haplargids--Cont.

- f. have no buried argillic horizon that has its upper boundary within 50 cm (20 inches) of the soil surface;
- g. have an argillic horizon that is continuous throughout the area of each pedon;
- h. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Haplargids. Haplargids like the Typic except for a or a and e.

Arenic Haplargids. Haplargids like the Typic except for b.

Duric Haplargids. Haplargids like the Typic except for c.

Duric Mollic Haplargids. Haplargids like the Typic except for c and e.

Lithic Haplargids. Haplargids like the Typic except for d.

Lithic Mollic Haplargids. Haplargids like the Typic except for d and e.

Mollic Haplargids. Haplargids like the Typic except for e.

Mollic Thapto-Argic Haplargids. Haplargids like the Typic except for e and f.

Ruptic-Entic Lithic Mollic Haplargids. Haplargids like the Typic except for d, e and g.

Vertic Haplargids. Haplargids like the Typic except for h or h and e.

Nadurargids. Argids that

- 1. have a columnar natric horizon above the duripan, and the upper boundary of the duripan is within 1 m (40 inches) of the soil surface;
- 2. have no petrocalcic horizon that has its upper boundary within 1 m (40 inches) of the soil surface.

Typic Nadurargids. Nadurargids that

- a. have neither of the following characteristics within 1 m (40 inches) of the surface:
 - (1) dominant chromas of 1 or less throughout and hues as yellow or yellower than 2.5Y in some portion;
 - (2) dominant chromas of 2 or less accompanied by mottles not due to segregated lime;
- b. have a platy or massive duripan that is indurated in some subhorizon;
- c. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have proportional carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4. (See figure A, page 120)

Aridisols

Aquic Nadurargids. Nadurargids like the Typic except for a or a and c.

Aquic Haplic Nadurargids. Nadurargids like the Typic except for a and b with or without c.

Haplic Nadurargids. Nadurargids like the Typic except for b.

Haplic Mollic Nadurargids. Nadurargids like the Typic except for b and c and the duripan is brittle and has 20 percent or more by volume of durinodes in some subhorizon.

Mollic Nadurargids. Nadurargids like the Typic except for c.

Natrargids. Argids that

1. have a columnar natric horizon;
2. have no petrocalcic horizon that has its upper boundary within 1 m (40 inches) of the soil surface;
3. have no duripan that has its upper boundary within 1 m (40 inches) of the surface.

Typic Natrargids. Natrargids that

- a. have neither of the following characteristics within 1 m (40 inches) of the surface:
 - (1) dominant chromas of 1 or less throughout and hues as yellow or yellower than 2.5Y in some portion;
 - (2) dominant chromas of 2 or less accompanied by mottles not due to segregated lime;
- b. have no brittle horizon that is 15 cm (6 inches) or more thick within 1 m (40 inches) of the surface that contains some opal coatings or some (less than 20 percent by volume) durinodes;
- c. have less than 2.5 cm (1 inch) of tonguing or interfingering of an albic horizon into the natric horizon except as gray coatings on the sides of columns;
- d. have no lithic contact within 50 cm (20 inches) of the surface;
- e. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have proportional carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4; (See figure A, page 120)
- f. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aridisols

- Aquic Natrargids. Natrargids like the Typic except for a or a and e.
- Aquic Duric Natrargids. Natrargids like the Typic except for a and b.
- Duric Natrargids. Natrargids like the Typic except for b.
- Duric Mollic Natrargids. Natrargids like the Typic except for b and e.
- Glossic Mollic Natrargids. Natrargids like the Typic except for c and e.
- Lithic Natrargids. Natrargids like the Typic except for d.
- Lithic Mollic Natrargids. Natrargids like the Typic except for d and e.
- Mollic Natrargids. Natrargids like the Typic except for e.
- Vertic Natrargids. Natrargids like the Typic except for f or f and e.

Paleargids. Argids that

1. have either a petrocalcic horizon that has its upper boundary within 1 m (40 inches) of the soil surface or that have an argillic horizon or prismatic or blocky natric horizon that has both 35 percent or more clay in some part, and either:
 - a. an increase of 15 percent or more clay (absolute) within a vertical distance of 2.5 cm (1 inch) at the upper boundary of the argillic horizon; or
 - b. an increase of 10 percent or more clay (absolute) if cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon;
2. have no duripan that has its upper boundary within 1 m (40 inches) of the surface.

Typic Paleargids. Paleargids that

- a. have no brittle horizon that is 15 cm (6 inches) or more thick within 1 m (40 inches) of the surface and that contains some opal coatings or some (less than 20 percent by volume) durinodes;
- b. have no lithic contact within 50 cm (20 inches) of the surface;
- c. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have proportional carbon contents. Of, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4; (See figure A, page 120)
- d. have no petrocalcic horizon with its upper boundary within 1 m (40 inches) of the surface;
- e. have no columnar natric horizon;
- f. have either:
 - (1) an increase of 15 percent or more clay (absolute) within a vertical distance of 2.5 cm (1 inch) at the upper boundary of the argillic horizon, or
 - (2) an increase of 10 percent or more clay (absolute) if cultivated and the lower boundary of the Ap horizon is the upper boundary of the argillic horizon.

Duric Paleargids. Paleargids like the Typic except for a.

Lithic Paleargids. Paleargids like the Typic except for b.

Aridisols

Lithic Mollic Paleargids. Paleargids like the Typic except for b and c.

Mollic Paleargids. Paleargids like the Typic except for c.

Mollic Petrocalcic Paleargids. Paleargids like the Typic except for c and d.

Petrocalcic Paleargids. Paleargids like the Typic except for d with or without f.

Orthids. Aridisols that

1. have no argillic or natric horizon unless it is a buried horizon, and;
2. have within 1 m (40 inches) of the surface one or more of the following horizons: calcic, petrocalcic, gypsic, cambic, or duripan; either are usually dry between 18 and 50 cm (7 and 20 inches) depth or a lithic or paralithic contact, whichever is shallower, or have a conductivity of the saturation extract that is 2 mmho per cm or greater at 25°C in some part above whichever of the following depths is least: a lithic or paralithic contact, 1.25 m (50 inches) if particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey; or with increase in depth within the C horizon but above the depths for the different particle-size classes specified above, there is an increase in saturation with Na plus K in some part, or;
3. have a salic horizon within 75 cm (30 inches) of the surface and are saturated with water within 1 m (40 inches) of the surface for one month or more.

Calciorthids. Orthids that

1. have either a calcic or gypsic horizon that has its upper boundary within 1 m (40 inches) of the surface;
2. are calcareous in all parts above the calcic horizon after the upper 18 cm (7 inches) are mixed unless textures are coarser than loamy very fine sand;
3. have no duripan that has its upper boundary within 1 m (40 inches) of the surface;
4. have no salic horizon above the calcic or gypsic horizon;
5. have no petrocalcic horizon that has its upper boundary within 1 m (40 inches) of the surface.

Typic Calciorthids. Calciorthids that

- a. have none of the following characteristics within 1 m (40 inches) of the surface:
 - (1) dominant chromas of 1 or less throughout the hues as yellow or yellower than 2.5Y in some portion;
 - (2) dominant chromas of 2 or less accompanied by mottles not due to segregated lime;
 - (3) dominant chromas of 2 or less accompanied by a decrease in the percentage of exchangeable Na from the upper 25 cm (10 inches) of the underlying layer;
- b. have no brittle horizon that is 15 cm (6 inches) or more thick within 1 m (40 inches) of the surface that contains some opal coatings or some (less than 20 percent by volume) durinodes;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have intermediate carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4; (See figure A, page 120)

Aridisols

Typic Calciorthids--Cont.

- e. are usually dry in all parts of the soil between depths of 18 and 50 cm (7 and 20 inches) or to a lithic or a paralithic contact shallower than 20 cm (20 inches);
- f. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Calciorthids. Calciorthids like the Typic except for a with or without d or e, or both.

Aquic Duric Calciorthids. Calciorthids like the Typic except for a and b with or without d or e, or both.

Lithic Calciorthids. Calciorthids like the Typic except for c.

Lithic Mollic Calciorthids. Calciorthids like the Typic except for c and d.

Mollic Calciorthids. Calciorthids like the Typic except for d.

Ustollic Calciorthids. Calciorthids like the Typic except for d and e and the soils are not continuously dry in all parts between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) in more than 7 out of 10 years for as long as 60 days if the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Xerollic Calciorthids. Calciorthids like the Typic except for d and e and the soils are continuously dry in all parts between 18 and 50 cm (7 and 20 inches) or a lithic or paralithic contact shallower than 50 cm (20 inches) in more than 7 out of 10 years for 60 days or more and the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Camborthids. Orthids that

1. have a cambic horizon;
2. have no duripan that has its upper boundary within 1 m (40 inches) of the surface;
3. have no salic horizon within 75 cm (30 inches) of the surface if saturated with water (i.e. within the capillary fringe) within 1 m (40 inches) of the surface for 1 month or more;
4. have no calcic or gypsic horizon that has an upper boundary within 1 m (40 inches) of the surface unless, after the upper 18 cm (7 inches) are mixed, some subhorizon above the calcic horizon is free of carbonates and textures are as fine or finer than loamy very fine sand;
5. have no petrocalcic horizon that has its upper boundary within 1 m (40 inches) of the surface.

Typic Camborthids. Camborthids that

- a. have none of the following characteristics within 1 m (40 inches) of the surface:

Aridisols

Typic Camborthids--Cont.

- (1) dominant chromas of 1 or less throughout and hues as yellow or yellower than 2.5Y in some portion;
 - (2) dominant chromas of 2 or less accompanied by mottles due to segregation of iron or manganese;
 - (3) dominant chromas of 2 or less accompanied by a decrease in the percentage of exchangeable Na from the upper 25 cm (10 inches) to the underlying layer;
- b. have no brittle horizon that is 15 cm (6 inches) or more thick within 1 m (40 inches) of the surface that contains some opal coatings or some (less than 20 percent by volume) durinodes;
 - c. have no lithic contact within 50 cm (20 inches) of the surface;
 - d. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 18 or more; or intermediate sand/clay ratios have proportional carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4; (See figure A, page 120)
 - e. are usually dry in all parts of the soil between depths of 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches);
 - f. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Camborthids. Camborthids like the Typic except for a with or without d or e, of both.

Aquic Duric Camborthids. Camborthids like the Typic except for a and b with or without d or e, or both.

Duric Camborthids. Camborthids like the Typic except for b.

Duric Lithic Camborthids. Camborthids like the Typic except for b and c.

Duric Mollic Camborthids. Camborthids like the Typic except for b and d.

Durustollic Camborthids. Camborthids like the Typic except for b, d, and e.

Lithic Camborthids. Camborthids like the Typic except for c.

Lithic Mollic Camborthids. Camborthids like the Typic except for c and d.

Mollic Camborthids. Camborthids like the Typic except for d.

Torrertic Camborthids. Camborthids like the Typic except for f or d and f, with or without b, and cracks remain open throughout the year.

Ustertic Camborthids. Camborthids like the Typic except for e and f or d, e, and f with or without b, and cracks do not remain open throughout the year.

Aridisols

Ustollic Camborthids. Camborthids like the Typic except for d and e and the soils are not continuously dry in all parts between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) in more than 7 out of 10 years for as long as 60 days if the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Xerertic Camborthids. Camborthids like the Typic except for e and f with or without b or d or both, and have (a) cracks that open and close once each year and remain open for 60 consecutive days or more during the year in more than 7 out of 10 years, and (b) mean annual soil temperatures less than 22°C (72°F) and mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more.

Xerollic Camborthids. Camborthids like the Typic except for d and e and the soils are continuously dry in all parts between 18 and 50 cm (7 and 20 inches) or a lithic or paralithic contact shallower than 50 cm (20 inches) in more than 7 out of 10 years for 60 days or more and the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Durorthids. Orthids that

1. have a duripan that has its upper boundary within 1 m (40 inches) of the surface and are with or without a cambic horizon;
2. have no petrocalcic horizon that has its upper boundary within 1 m (40 inches) of the surface.

Typic Durorthids. Durorthids that

- a. have none of the following characteristics within 1 m (40 inches) of the surface:
 - (1) dominant chromas of 1 or less throughout and hues as yellow or yellowish than 2.5Y in some portion;
 - (2) dominant chromas of 2 or less accompanied by mottles not due to segregated lime;
 - (3) dominant chromas of 2 or less accompanied by a decrease in the percentage of exchangeable sodium from the upper 25 cm (10 inches) to the underlying subhorizon;
- b. have a platy or massive duripan that is indurated in some subhorizon;
- c. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have proportional carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4; (See figure A, page 120)
- d. are usually dry in all parts of the soil between depths of 18 and 50 cm (7 and 20 inches) or to a lithic or a paralithic contact shallower than 50 cm (20 inches).

Aquic Durorthids. Durorthids like the Typic except for a with or without c or d, of both.

Aquentic Durorthids. Durorthids like the Typic except for a and b with or without c or d, or both.

Durixerollic Durorthids. Durorthids like the Typic except for c and d and the soils are continuously dry in all parts between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for 60 days or more and the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Aridisols

Durustollic Durorthids. Durorthids like the Typic except for c and d and the soils are not continuously dry in all parts between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for as long as 60 days if the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Entic Durorthids. Durorthids like the Typic except for b.

Entic Mollic Durorthids. Durorthids like the Typic except for b and c.

Haploxerollic Durorthids. Durorthids like the Typic except for b, c, and d and the soils are continuously dry in all parts between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for 60 days or more and the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Haplustollic Durorthids. Durorthids like the Typic except for b, c, and d and the soils are not continuously dry in all parts between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for as long as 60 days if the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Mollic Durorthids. Durorthids like the Typic except for c.

Paleorthids. Orthids that

1. have a petrocalcic horizon that has its upper boundary within 1 m (40 inches) of the soil surface;
2. have no duripan that has its upper boundary within 1 m (40 inches) of the soil surface;
3. have no salic horizon within 75 cm (30 inches) of the surface if saturated with water (i.e. within the capillary fringe) within 1 m (40 inches) of the surface for 1 month or more

Typic Paleorthids. Paleorthids that

- a. have none of the following characteristics within 1 m (40 inches) of the surface:
 - (1) dominant chromas of 1 or less throughout and hues as yellow or yellower than 2.5Y in some portion;
 - (2) dominant chromas of 2 or less accompanied by mottles not due to segregated lime;
 - (3) dominant chromas of 2 or less accompanied by a decrease in the percentage of exchangeable Na from the upper 25 cm (10 inches) to the underlying layer;
- b. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have intermediate carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4; (See figure A, page 120)
- c. are usually dry in all parts of the soil between depths of 18 and 50 cm (7 and 20 inches) or to a lithic or a paralithic contact shallower than 50 cm (20 inches).

Aquic Paleorthids. Paleorthids like the Typic except for a or a and c.

Mollic Paleorthids. Paleorthids like the Typic except for b.

Ustollic Paleorthids. Paleorthids like the Typic except for b and c and are not continuously dry in all parts between 18 and 50 cm (7 and 20 inches) or the upper boundary of a petrocalcic horizon shallower than 20 cm (20 inches) or in some part of the soil above a petrocalcic horizon with an upper boundary shallower than 18 cm (7 inches) in more than 7 out of 10 years for as long as 60 days if the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Aridisols

Xerollic Paleorthids. Paleorthids like the Typic except for b and c and are continuously dry in all parts of the soil between 18 and 50 cm (7 and 20 inches) or the upper boundary of a petrocalcic horizon shallower than 50 cm (20 inches) or in some part of the soil above a petrocalcic horizon with its upper boundary shallower than 18 cm (7 inches) in more than 7 out of 10 years for 60 days or more and the mean annual soil temperature is less than 22°C (72°F) and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more.

Salorthids. Orthids that

1. have a salic horizon within 75 cm (30 inches) of the surface if saturated with water (i.e. within the capillary fringe) within 1 m (40 inches) of the surface for 1 month or more;
2. have no calcic or gypsic horizon above the salic horizon;
3. have no duripan that has its upper boundary within 1 m (40 inches) of the surface.

Typic Salorthids. Salorthids that

- a. have a weighted average carbon content in the surface 38 cm (15 inches) of less than 0.58 percent (1 percent organic matter) if the weighted average sand/clay ratio for this depth is 1.0 or less; or 0.16 percent if the ratio is 13 or more; or intermediate sand/clay ratios have proportional carbon contents. Or, if the upper 18 cm (7 inches) are mixed, the color values are more than 4 when moist and more than 6 when dry or the chroma (wet or dry) is more than 4. (See figure A, below)

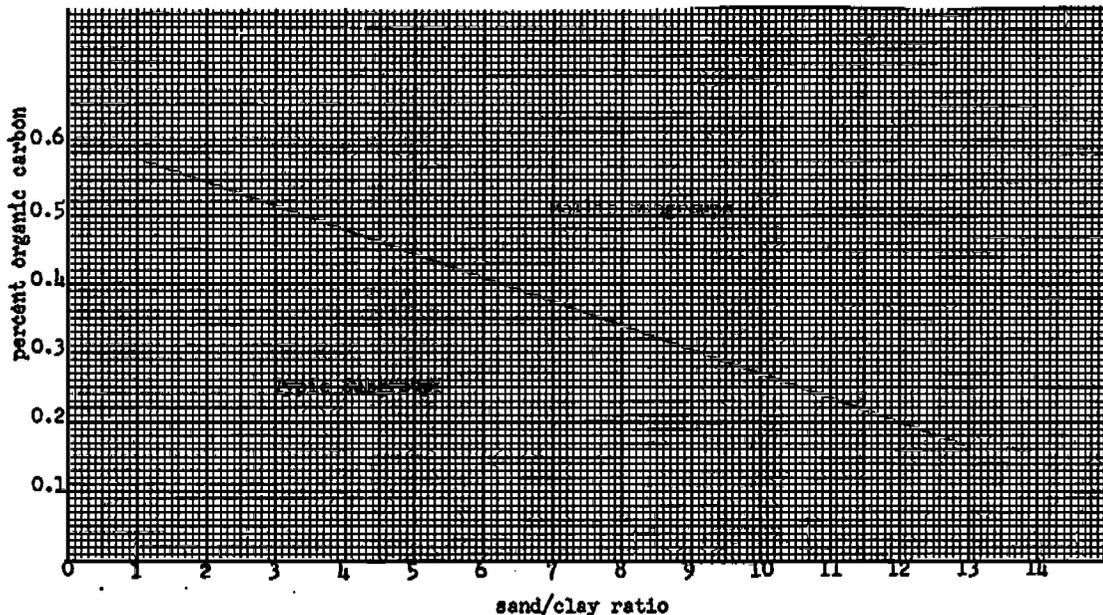
Mollic Salorthids. Salorthids like the Typic except for a.

Figure A. - Percent organic carbon as related to the sand/clay ratio to separate Mollic from Typic subgroups of Aridisols.

MOLLISOLS: ORDER 5

Mollisols are mineral soils that have either a mollic epipedon*, or that have a surface horizon that after mixing to 18 cm (7 inches) meets all requirements for a mollic epipedon except thickness and in addition have an upper subhorizon that is more than 7.5 cm (3 inches) thick in an argillic or natric horizon, that meets the color, organic matter, base saturation and structure requirements of a mollic epipedon, but that is separated from the surface horizon by an albic horizon (note that the combined thicknesses meet the thickness requirements for a mollic epipedon); and

1. if there is an argillic horizon, have base saturation of 50 percent (NH_4OAc) or more throughout the argillic horizon to a depth of 1.25 m (50 inches) below the upper boundary of the argillic horizon or 1.8 m (72 inches) below the surface of the soil, whichever is shallower; and
2. if there is a cambic horizon, have base saturation of 50 percent (by NH_4OAc) or more in all subhorizons to a depth of 1.8 m (72 inches) below the surface of the soil; and
3. have a bulk density of the fine earth fraction of 0.85 g per cc or more in the epipedon and in any cambic horizon if the exchange complex is dominated by amorphous materials; and
4. have less than 35 percent clay with montmorillonitic mineralogy throughout the epipedon if the epipedon rests on materials with less than 40 percent CaCO_3 equivalent or the moist and dry values of the mollic epipedon are no darker than those of underlying horizons and the mean summer and mean winter soil temperatures at 50 cm (20 inches) depth or at a lithic or paralithic contact, whichever is shallower, differ by less than 5°C (9°F); and
5. after the surface 18 cm (7 inches) are mixed, have less than 30 percent clay in some horizon down to a lithic or paralithic contact, or to a calcic horizon or to 1 m (40 inches) whichever is shallower if:
 - a. there are cracks at some period in most years that are at least 1 cm wide at a depth of 50 cm (20 inches), and
 - b. there is gilgai, or
 - c. there are slickensides close enough to intersect at some depth between 25 cm and 1 m (10 and 40 inches), or
 - d. there are wedge-shaped or parallelepiped natural structural aggregates with their long axes tilted 10° to 60° from horizontal at some depth between 25 cm and 1 m (10 and 40 inches); and
6. have no oxic horizon; and
7. have no spodic horizon.

Albolls. Albolls are Mollisols that

1. have an albic horizon that immediately underlies the mollic epipedon, or that separates horizons that together meet all requirements for a mollic epipedon;
2. have an argillic horizon or a natric horizon;
3. have in the albic horizon and in the argillic or natric horizon, characteristics associated with wetness, namely, mottles, iron-manganese concretions larger than 2 mm, or both.

Argialbolls. Albolls that have an argillic horizon but do not have a natric horizon.

Typic Argialbolls. Argialbolls that

- a. have an albic horizon that is at least 10 cm (4 inches) thick and that has chromas of 2 or less in more than half of the matrix;

* At present we are grouping a few soils with Mollisols that have epipedons meeting all requirements for a mollic epipedon except color value. These soils have more than 4 percent organic matter and more than 40 percent finely divided calcium carbonate throughout the epipedon. Some are grouped with Calciaquolls and some with Rendolls.

Mollisols

Typic Argialbolls--Cont.

- b. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- c. have an abrupt textural change from the albic to the argillic horizon;
- d. are never dry in all parts between 18 and 50 cm (7 and 20 inches) for as long as 30 consecutive days in more than 7 out of 10 years.

Aeric Argialbolls. Argialbolls like the Typic except for a or a and c.

Andic Argialbolls. Argialbolls like the Typic except for b.

Argiaquic Argialbolls. Argialbolls like the Typic except for c.

Argiaquic Xeric Argialbolls. Argialbolls like the Typic except for c and d.

Xeric Arbialbolls. Argialbolls like the Typic except for d.

Natralbolls. Albolls that have a natric horizon

(No subgroups are proposed at this time.)

Aquolls. Aquolls are Mollisols that are either saturated with water at some period during the year or are artificially drained and that have one or more of the following characteristics associated with wetness:

1. a histic epipedon;
2. sodium saturation of more than 15 percent in the upper part of the mollic epipedon and decreasing saturation with increasing depth below 50 cm (20 inches);
3. one of the following combinations of moist colors, in and either immediately below the mollic epipedon or within 75 cm (30 inches) of the surface if a calcic horizon immediately underlies the mollic epipedon or if the mollic epipedon is thicker than 75 cm (30 inches):
 - a. if the lower part of the mollic epipedon has chromas of 1 or less there are either:
 - (1) distinct or prominent mottles in the lower mollic epipedon; or
 - (2) colors immediately below the mollic epipedon or within 75 cm (30 inches) of the surface if a calcic horizon intervenes, with one of the following:
 - (a) if hues are 10YR or redder and there are mottles, chromas are less than 1.5 on ped surfaces or in the matrix; if there are no mottles, chromas are less than 1;
 - (b) if the hue is nearest to 2.5Y and there are distinct or prominent mottles, chromas are 2 or less on ped surfaces or in the matrix; if there are no mottles, chromas are 1 or less;
 - (c) if the nearest hue is 5Y or yellower and there are distinct or prominent mottles, chromas are 3 or less on ped surfaces or in the matrix; and if there are no mottles, chromas are 1 or less;
 - (d) hues are bluer than 10Y;
 - (e) the color results from uncoated mineral grains;
 - b. if the lower part of the mollic epipedon has chromas of more than 1 but not exceeding 2, there are either:

Mollisols

Aquolls--Cont.

- b. (1) distinct or prominent mottles in the lower mollic epipedon; or
- (2) base colors immediately below the mollic epipedon that have one or more of:
 - (a) values of μ and chromas of 2 accompanied by some mottles with values of μ or more and chromas of less than 2;
 - (b) values of μ and chromas of less than 2;
 - (c) values of 5 or more and chromas of 2 or less accompanied by mottles with high chromas;
- 4. a calcic horizon that has an upper boundary within 40 cm (16 inches) of the surface.

Argiaquolls. Aquolls that

- 1. have an argillic horizon but have no natric horizon or duripan;
- 2. have mean annual soil temperature of 8°C (47°F) or higher, or mean summer soil temperature at 50 cm (20 inches) of 15°C (59°F) or higher if the soil is drained and cultivated, or 8°C (47°F) or higher if the soil is drained and has an O horizon or a histic epipedon, or 6°C (43°F) or higher if the soil is undrained and has a histic epipedon or an O horizon.

Typic Argiaquolls. Argiaquolls that

- a. have no argillic horizon that has an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm (3 inches) from the upper boundary;
- b. have a mollic epipedon with chromas of 2 or less;
- c. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- d. have no disseminated carbonates below 18 cm (7 inches) in the lower part of the mollic epipedon and in the upper part of the argillic horizon;
- e. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Abruptic Argiaquolls. Argiaquolls like the Typic except for a.

Aeric Argiaquolls. Argiaquolls like the Typic except for b.

Arenic Argiaquolls. Argiaquolls like the Typic except for c and have a sandy epipedon between 50 cm and 1 m (20 and 40 inches) thick.

Calcic Argiaquolls. Argiaquolls like the Typic except for d.

Grossarenic Argiaquolls. Argiaquolls like the Typic except for c and have a sandy epipedon more than 1 m (40 inches) thick.

Vertic Argiaquolls. Argiaquolls like the Typic except for e.

Mollisols

Calcisquolls. Aquolls that

1. have a calcic horizon that has its upper boundary within 40 cm (16 inches) of the surface;
2. have mean annual soil temperatures of 8°C (47°F) or more, or have mean summer soil temperatures at 50 cm (20 inches) of 15°C (59°F) or more;
3. have no natric horizon, argillic horizon, or duripan unless it is a buried horizon.

Typic Calcisquolls. Calcisquolls that

- a. have distinct or prominent mottles reflecting segregations of iron and manganese within 50 cm (20 inches) of the surface, or if no mottles are within 50 cm (20 inches), the moist colors immediately below the mollic epipedon are neutral or have hues of 2.5Y or yellow and dominant chromas of less than 2;
- b. have a calcic horizon within or immediately below the epipedon and are calcareous in all parts above the calcic horizon after the upper 18 cm (7 inches) are mixed;
- c. have no salic horizon within 75 cm (30 inches) of the surface.

Aeric Calcisquolls. Calcisquolls like the Typic except for a.Haplic Calcisquolls. Calcisquolls like the Typic except for b.

Cryaquolls. Aquolls that have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of less than 15°C (59°F) if the soil is drained and has no O horizon or histic epipedon, less than 8°C (47°F) if drained and has an O horizon, and less than 6°C (43°F) if the soil is undrained and has an O horizon or a histic epipedon.

Typic Cryaquolls. Cryaquolls that

- a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- b. have no argillic horizon;
- c. have no calcic horizon within or immediately underlying the mollic epipedon;
- d. have a mollic epipedon less than 50 cm (20 inches) thick;
- e. have no histic epipedon;
- f. have a mean annual soil temperature of more than 0°C (32°F);
- g. lack 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 (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of and Ap horizon, and
 - (2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Mollisols

Andic Cryaquolls. Cryaquolls like the Typic except for a or a and d.

Argic Cryaquolls. Cryaquolls like the Typic except for b or b and c or b, c, and d.

Calcic Cryaquolls. Cryaquolls like the Typic except for c.

Cumilic Cryaquolls. Cryaquolls like the Typic except for d.

Histic Cryaquolls. Cryaquolls like the Typic except for e.

Pergelic Cryaquolls. Cryaquolls like the Typic except for f.

Vertic Cryaquolls. Cryaquolls like the Typic except for g with or without d.

Duraquolls. Aquolls that have a duripan within 1 m (40 inches) of the surface.

Typic Duraquolls. Duraquolls that

- a. have no argillic horizon;
- b. have no natric horizon.

Argic Duraquolls. Duraquolls like the Typic except for a.

Natric Duraquolls. Duraquolls like the Typic except for b.

Haplaquolls. Aquolls that

1. have no argillic or natric horizon;
2. have no duripan within 1 m (40 inches) of the surface;
3. have no calcic horizon with its upper boundary within 40 cm (16 inches) of the surface;
4. have a mean annual soil temperature of 8°C (47°F) or more, or have a mean summer soil temperature at 50 cm (20 inches) depth as follows:
 - a. if the soil is drained and cultivated, 15°C (59°F) or more;
 - b. if the soil is undrained and has an O horizon or a histic epipedon, 6°C (43°F) or more.

Typic Haplaquolls. Haplaquolls that

- a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- b. have no calcic horizon that has its upper boundary within 75 cm (30 inches) of the surface;
- c. have a mollic epipedon that is less than 60 cm (24 inches) thick;
- d. have no brittle horizon 15 cm (6 inches) or more thick that is within 1 m (40 inches) of the surface and that contains some opal coatings or some (less than 20 percent by volume) durinodes;
- e. have organic matter content that decreases regularly with depth and reaches a level of 0.5 percent (0.29 percent carbon) or less in some subhorizon within 1.25 m (50 inches) of the surface;
- f. have no histic epipedon;
- g. have no lithic contact within 50 cm (20 inches) of the surface;

Mollisols

Typic Haplaquolls--Cont.

h. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
- (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Andic Haplaquolls. Haplaquolls like the Typic except for a or a and c.

Calcic Haplaquolls. Haplaquolls like the Typic except for b.

Cumilic Haplaquolls. Haplaquolls like the Typic except for c or c and e.

Duric Haplaquolls. Haplaquolls like the Typic except for d.

Fluventic Haplaquolls. Haplaquolls like the Typic except for e.

Histic Haplaquolls. Haplaquolls like the Typic except for f.

Lithic Haplaquolls. Haplaquolls like the Typic except for g.

Vertic Haplaquolls. Haplaquolls like the Typic except for h with or without c or e, or both.

Natraquolls. Aquolls that

1. have a natric horizon,
2. have no duripan.

Typic Natraquolls. Natraquolls that

- a. have no brittle horizon 15 cm (6 inches) or more thick that is within 1 m (40 inches) of the surface and that contains some opal coatings or some (less than 20 percent by volume) durinodes.

Duric Natraquolls. Natraquolls like the Typic except for a.

Borolls. Borolls are Mollisols that

1. have a mean annual soil temperature of less than 8°C (47°F);
2. have either:
 - a. a moist chroma of 1.5 or less in the mollic epipedon to a depth of 15 cm (6 inches) or more, or
 - b. a mean summer soil temperature at 50 cm (20 inches) or a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if without an O horizon or less than 8°C (47°F) if with an O horizon;
3. have no albic horizon that has characteristics associated with wetness, namely, mottles, iron-manganese concretions larger than 2 mm, or both;
4. are not saturated with water at any period or lack the characteristics associated with wetness defined for Aquolls;
5. have no calcareous horizon that immediately underlies the mollic epipedon at depths of less than 50 cm (20 inches) and that has more than 40 percent calcium carbonate equivalent unless it is a calcic horizon. (Note that hard limestone bedrock is neither a soil horizon nor a part of a soil.)

Mollisols

Argiborolls. Borolls that

1. have an argillic horizon, but have no cambic horizon overlying the argillic horizon and separated from it by an albic horizon;
2. have no natric horizon;
3. have the upper boundary of the argillic horizon within 60 cm (24 inches) of the surface* or have textures coarser than loamy very fine sand in all sub-horizons above the argillic horizon;
4. have mean summer soil temperatures at 50 cm (20 inches) of 15°C (59°F) or more if without an O horizon, or of 8°C (47°F) or more if with an O horizon.

Typic Argiborolls. Argiborolls that

- a. have no argillic horizon that has an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm (3 inches) from the upper boundary;
- b. have no albic horizon underlying the mollic epipedon;
- c. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- d. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- e. have no albic horizon that tongues or interfingers into at least the upper part of the argillic horizon;
- f. have base saturation (by NH_4OAc) of more than 60 percent in all subhorizons of the argillic horizon;
- g. have no lithic contact within 50 cm (20 inches) of the surface;
- h. have a mollic epipedon less than 40 cm (16 inches) thick;
- i. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Abruptic Argiborolls. Argiborolls like the Typic except for a.

Albic Argiborolls. Argiborolls like the Typic except for a, b and d or a and d.

Andic Argiborolls. Argiborolls like the Typic except for c with or without h.

Aquic Argiborolls. Argiborolls like the Typic except for d.

Boralfic Argiborolls. Argiborolls like the Typic except for e.

Glossoboralfic Argiborolls. Argiborolls like the Typic except for e and f.

If there is a surface mantle that has more than 60 percent vitric volcanic ash, cinders or other vitric pyroclastic materials, the depth to the argillic horizon is measured from the base of this mantle rather than from the mineral surface.

Mollisols

Argiborolls--Cont.

Lithic Argiborolls. Argiborolls like the Typic except for g.

Pachic Argiborolls. Argiborolls like the Typic except for h with or without d.

Vertic Argiborolls. Argiborolls like the Typic except for i with or without h.

Calciborolls. Borolls that

1. have a calcic or gypsic horizon that has its upper boundary within 1 m (40 inches) of the surface, and that are calcareous in all parts of all horizons above the calcic or gypsic horizon after the upper 18 cm (7 inches) are mixed unless textures are coarser than loamy very fine sand.
2. have soil temperatures higher than those of Cryoborolls;
3. have no argillic or natric horizon unless it underlies a calcic or gypsic horizon.

Typic Calciborolls. Calciborolls that

- a. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- b. have a calcic horizon within or immediately underlying the mollic epipedon;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Calciborolls. Calciborolls like the Typic except for a.

Haplic Calciborolls. Calciborolls like the Typic except for b.

Lithic Calciborolls. Calciborolls like the Typic except for c or b and c.

Vertic Calciborolls. Calciborolls like the Typic except for d.

Cryoborolls. Borolls that

1. have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if without an O horizon, or of less than 8°C (47°F) if with an O horizon;
2. have no argillic horizon that has its upper boundary deeper than 60 cm (24 inches) below the surface* unless there are textures coarser than loamy very fine sand in all subhorizons above the argillic horizon.

Typic Cryoborolls. Cryoborolls that

- a. have no argillic horizon;
- b. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

* If there is a surface mantle that has more than 60 percent vitric volcanic ash, cinders or other vitric pyroclastic materials, the depth to the argillic horizon is measured from the base of this mantle rather than from the mineral surface.

Mollisols

Typic Cryoborolls--Cont.

- c. have no distinct or prominent mottles due to segregation of iron or manganese within 1 m (40 inches) of the surface;
- d. have no calcic horizon within or immediately underlying the mollic epipedon;
- e. have a mollic epipedon less than 40 cm (16 inches) thick;

- g. have no lithic contact with its upper boundary within 50 cm (20 inches) of the surface;
- h. have a mean annual soil temperature of more than 0°C (32°F);
- i. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
- j. have no albic horizon immediately below the mollic epipedon.

Abruptic Cryoborolls. Cryoborolls like the Typic except for a and j and have an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm (3 inches) from the upper boundary.

Andic Cryoborolls. Cryoborolls like the Typic except for b or b and e.

Andic Argic Cryoborolls. Cryoborolls like the Typic except for a and b with or without e.

Aquic Cryoborolls. Cryoborolls like the Typic except for c.

Argiaquic Cryoborolls. Cryoborolls like the Typic except for a and c.

Argic Cryoborolls. Cryoborolls like the Typic except for a.

Argic Lithic Cryoborolls. Cryoborolls like the Typic except for a and g.

Argic Pachic Cryoborolls. Cryoborolls like the Typic except for a and e with or without c.

Argic Vertic Cryoborolls. Cryoborolls like the Typic except for a and i with or without e.

Boralfic Cryoborolls. Cryoborolls like the Typic except for a with or without e or j, or both, and have an albic horizon that tongues or interfingers into at least the upper part of the argillic horizon.

Boralfic Lithic Cryoborolls. Cryoborolls like the Typic except for a and g with or without e or j, or both, and have an albic horizon that tongues or interfingers into at least the upper part of the argillic horizon.

Calcic Cryoborolls. Cryoborolls like the Typic except for d.

Calcic Pachic Cryoborolls. Cryoborolls like the Typic except for d and e with or without a or c, or both.

Mollisols

Cryoborolls--Cont.

Lithic Cryoborolls. Cryoborolls like the Typic except for g.

Natric Cryoborolls. Cryoborolls like the Typic except for a with or without j and have more than 15 percent saturation with exchangeable sodium in the major part of the argillic horizon.

Pachic Cryoborolls. Cryoborolls like the Typic except for e with or without a or c, or both.

Pergelic Cryoborolls. Cryoborolls like the Typic except for h.

Vertic Cryoborolls. Cryoborolls like the Typic except for i with or without e.

Haploborolls. Borolls that

1. have soil temperatures higher than those of Cryoborolls;
2. have no argillic or natric horizon unless it underlies a cambic horizon and is separated from the cambic horizon by an albic horizon;
3. have a transition between the mollic epipedon and the underlying horizon that has less than 25 percent by volume of worm holes, worm casts or filled animal burrows.

Typic Haploborolls. Haploborolls that

- a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- b. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- c. have a mollic epipedon less than 40 cm (16 inches) thick;
- d. have a cambic horizon or have a mollic epipedon that is between 25 and 40 cm (10 and 16 inches) thick and has one or more of the following in the lower portion:
 - (1) moderate or strong prismatic, blocky, or subangular blocky structure;
 - (2) higher chroma than the upper portion;
 - (3) higher value than the upper portion;
 - (4) redder hue than the upper portion;
- e. have a regular decrease in organic matter content with depth and a level of 0.5 percent (0.29 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- f. have no lithic contact with its upper boundary within 50 cm (20 inches) of the surface;
- g. lack 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 (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

Mollisols

Typic Haploborolls--Cont.

- (2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
- (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Andic Haploborolls. Haploborolls like the Typic except for a or a and c or a, b and c.

Aquic Haploborolls. Haploborolls like the Typic except for b or b and d.

Cumultic Haploborolls. Haploborolls like the Typic except for c and e, with or without b or d, or both. (The organic matter content decreases irregularly or it remains above 0.5 percent (0.29 percent carbon) at a depth of 1.25 m (50 inches).

Entic Haploborolls. Haploborolls like the Typic except for d.

Fluventic Haploborolls. Haploborolls like the Typic except for e or d and e.

Lithic Haploborolls. Haploborolls like the Typic except for f or d and f.

Pachic Haploborolls. Haploborolls like the Typic except for c with or without b or d, or both.

Vertic Haploborolls. Haploborolls like the Typic except for g, or g and e, or g, c and e

Natriborolls. Borolls that

1. have a natric horizon;
2. have no cambic horizon overlying the natric horizon and separated from it by an albic horizon;
3. have temperatures warmer than Cryoborolls.

Typic Natriborolls. Natriborolls that

- a. have no tonguing of an albic horizon more than 2.5 cm (1 inch) into the natric horizon;
- b. have a natric horizon that has a lower boundary deeper than 40 cm (16 inches);
- c. have more than 15 percent exchangeable sodium in the major part of the natric horizon.

Glossic Natriborolls. Natriborolls like the Typic except for a.

Leptic Natriborolls. Natriborolls like the Typic except for b.

Palebhorolls. Borolls that

1. have an argillic horizon that has an upper boundary deeper than 50 cm (24 inches) below the mineral surface;*
2. have textures finer than loamy fine sand in all subhorizons above the argillic horizon.

Typic Paleborolls. Paleborolls that

- a. have no argillic horizon with an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm (3 inches) from the upper boundary;
- b. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;

* If there is a surface mantle that has more than 60 percent vitric volcanic ash, cinders, or other vitric pyroclastic materials, the depth to the argillic horizon is measured from the base of this mantle rather than from the mineral surface.

Mollisols

Typic Paleborolls--Cont.

- c. have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of more than 15°C (59°F) if without an O horizon and more than 8°C (47°F) if with an O horizon;
- d. have base saturation (by NH_4OAc) of more than 60 percent in all subhorizons of the argillic horizon;
- e. have a mollic epipedon 60 cm (24 inches) or less thick.

Abruptic Paleborolls. Paleborolls like the Typic except for a.

Abruptic Cryic Paleborolls. Paleborolls like the Typic except for a and c.

Albic Paleborolls. Paleborolls like the Typic except for a and b.

Albic Cryic Paleborolls. Paleborolls like the Typic except for a, b and c.

Aquic Paleborolls. Paleborolls like the Typic except for b.

Aquic Cryic Paleborolls. Paleborolls like the Typic except for b and c.

Cryic Paleborolls. Paleborolls like the Typic except for c.

Cryic Glossoboralfic Paleborolls. Paleborolls like the Typic except for c and d.

Glossoboralfic Paleborolls. Paleborolls like the Typic except for d.

Pachic Paleborolls. Paleborolls like the Typic except for e with or without b.

Vermiborolls. Borolls that have no argillic or natric horizon but have a mollic epipedon with 50 percent or more by volume of worm holes, worm casts or filled animal burrows, that either rests on a lithic contact or has a transition to the underlying horizon in which 25 percent or more of the volume is worm holes, worm casts or filled animal burrows.

Typic Vermiborolls. Vermiborolls that

- a. have a mollic epipedon 75 cm (30 inches) or more thick.

Haplic Vermiborolls. Vermiborolls like the Typic except for a.

Rendolls. Rendolls are Mollisols that have no argillic or calcic horizon. They contain material, including coarse fragments less than 7.5 cm (3 inches) in diameter, that has more than 40 percent calcium carbonate equivalent in or immediately below the mollic epipedon. They have mollic epipedons that are not more than 50 cm (20 inches) thick.

Rendolls. Equivalent to suborder.

Typic Rendolls. Rendolls that

- a. have a mollic epipedon free of mottles of brown, strong brown, or reddish brown;
- b. have a mean annual soil temperature of 8°C (47°F) or higher and a mean summer soil temperature at 50 cm (20 inches) depth of 15°C (59°F) or higher;
- c. have no cambic horizon throughout the pedon;
- d. have no histic epipedon;
- e. have no lithic contact within 50 cm (20 inches) of the surface;
- f. lack 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 (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

Mollisols

Typic Rendolls--Cont.

- (2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
- (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Rendolls. Rendolls like the Typic except for a.

Cryic Rendolls. Rendolls like the Typic except for b.

Entic Rendolls. Rendolls like the Typic except that the dry color value of the epipedon is 6 or more after the surface 18 cm (7 inches) have been mixed.

Eutrochreptic Rendolls. Rendolls like the Typic except for c and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by 5°C (9°F) or more, and no subhorizon below a depth of 5 cm (2 inches) is dry for as much as 90 cumulative days in most years.

Eutropeptic Rendolls. Rendolls like the Typic except for c and the mean summer and mean winter soil temperatures at 50 cm (20 inches) differ by less than 5°C (9°F), and no subhorizon below a depth of 5 cm (2 inches) is dry for as much as 90 cumulative days in most years.

Haplustic Rendolls. Rendolls like the Typic except for c and some subhorizon below a depth of 5 cm (2 inches) is dry for 90 cumulative days or more in most years, and the mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a paralithic contact, whichever is shallower, differ by more than 5°C (9°F).

Histic Rendolls. Rendolls like the Typic except for b and d. (None in U. S.)

Lithic Rendolls. Rendolls like the Typic except for e.

Vertic Rendolls. Rendolls like the Typic except for f.

Udolls. Udolls are Mollisols that

1. have either:
 - a. mean annual soil temperatures of 8°C (47°F) or more; or
 - b. have a moist chroma of more than 1.5 in some part of the upper 15 cm (6 inches) of the mollic epipedon and have mean summer soil temperatures at 50 cm (20 inches) depth or a lithic or paralithic contact, whichever is shallower, of 15°C (59°F) or more if without an O horizon, or 8°C (47°F) or more if with an O horizon.
2. have no albic horizon with characteristics associated with wetness, namely, mottles, iron-manganese concretions, or both;
3. are not saturated with water at any period or lack the characteristics associated with wetness defined for Aquolls;
4. have no calcareous horizon that immediately underlies the mollic epipedon at depths of less than 50 cm (20 inches) and that has more than 40 percent calcium carbonate equivalent;
5. are continuously moist in any cambic or argillic horizon, or the soil is not dry in more than 7 out of 10 years for as much as 60 consecutive days in all horizons between 18 and 50 cm (7 and 20 inches) and it is not dry for as much as 90 cumulative days in any horizon between these depths in most years.
6. have no calcic horizon and have no concentration of soft powdery lime in spheroidal forms, as coatings, on peds, or disseminated in clay-size particles within 1.5 m (60 inches) of the soil surface or within 50 cm (20 inches) below the base of any cambic or argillic horizon;
7. if there is a lithic or paralithic contact within 50 cm (20 inches), have base saturation (by NH_4OAc) of less than 80 percent in some or all subhorizons.

Mollisols

Udolls-Cont.

Argiudolls. Udolls that have an argillic horizon that has clay distribution such that the clay decreases by 20 percent or more of the maximum clay content within 1.5 m (60 inches) of the surface if:

1. hues are redder than 10YR with chromas of more than 4 dominant in the matrix in at least the lower part of the argillic horizon; or
2. there are many coarse mottles that have hues redder than 7.5YR or chromas of more than 5.

Typic Argiudolls. Argiudolls that

- a. have colors as follows:
 - (1) immediately below the mollic epipedon (within 15 cm (6 inches) of the lower boundary) have hues of 10YR or redder and chromas of 3 or higher, and no mottles have chromas of 2 or less in values of 4 or more; and
 - (2) no matrix colors in hues 10YR or redder are as dark or darker than a value 2.5 with chroma of 2 or less to a depth of 50 cm (20 inches) if accompanied by faint mottling within that depth; and
 - (3) no matrix colors in hues 2.5Y or yellower are as dark or darker than a value of 4 with chroma of 3 or less to a depth of 50 cm (20 inches) if accompanied by faint mottling within 20 inches; and
 - (4) no mottles are present within 40 cm (16 inches) below the surface;
- b. have no albic horizon that tongues into at least the upper part of the argillic horizon;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. have textures finer than loamy fine sand in the argillic horizon, or the argillic horizon does not consist entirely of lamellae with a combined thickness of less than 15 cm (6 inches);
- e. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Argiudolls. Argiudolls that the Typic except for a.

Glossoboralfic Argiudolls. Argiudolls like the Typic except for b.

Lithic Argiudolls. Argiudolls like the Typic except for c.

Psammentic Argiudolls. Argiudolls like the Typic except for d.

Vertic Argiudolls. Argiudolls like the Typic except for e.

Hapludolls. Udolls that

1. have no argillic horizon;
2. have a transition between the mollic epipedon and the underlying horizon that has less than 25 percent by volume of worm holes, worm casts or filled animal burrows.

Mollisols

Typic Hapludolls. Hapludolls that

- a. have colors as follows:
 - (1) immediately below the mollic epipedon (within 15 cm (6 inches) of the lower boundary) have hues of 10YR or redder and chromas of 3 or higher, and no mottles have chromas of 2 or less in values of 4 or more; and
 - (2) no matrix colors in hues 10YR or redder are as dark or darker than values 2.5 with chroma of 2 or less to a depth of 50 cm (20 inches) if accompanied by faint mottling within that depth; and
 - (3) no matrix colors in hues 2.5Y or yellower are as dark or darker than value of 4 with chroma of 3 or less to a depth of 50 cm (20 inches) if accompanied by faint mottling within 20 inches; and
 - (4) no mottles are present within 40 cm (16 inches) below the surface;
- b. have a mollic epipedon less than 60 cm (24 inches) thick;
- c. have a cambic horizon, or the lower epipedon meets the requirements of a cambic horizon except for color value and organic matter content, and either the cambic horizon or the lower epipedon is free of carbonates in some part;
- d. have a regular decrease in organic matter content with depth to a level of 0.5 percent (0.29 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- e. have no lithic contact within 50 cm (20 inches) of the surface;
- f. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
- g. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

Aeric Hapludolls. Hapludolls like the Typic except for a.

Aeric Fluventic Hapludolls. Hapludolls like the Typic except for a and d.

Cumulic Hapludolls. Hapludolls like the Typic except for b and d with or without a or c, or both.

Entic Hapludolls. Hapludolls like the Typic except for c.

Fluventic Hapludolls. Hapludolls like the Typic except for d or c and d.

Lithic Hapludolls. Hapludolls like the Typic except for e with or without c.

Vermic Hapludolls. Hapludolls like the Typic except for b and c, and have a mollic epipedon that, below any Ap, has 50 percent or more by volume of worm holes, worm casts, or filled animal burrows. (Not known in U. S.)

Mollisols

Hapludolls--Cont.

Vertic Hapludolls. Hapludolls like the Typic except for f with or without all or any of a, b, or d.

Paleudolls. Udolls that have an argillic horizon with a clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface and with one or both of the following:

1. hues redder than 10YR with chromas of more than 4 dominant in the matrix in at least the lower part of the argillic horizon;
2. many coarse mottles that have hues redder than 7.5YR or chromas of more than 5.

Typic Paleudolls. Paleudolls that

- a. have an argillic horizon that has less than 35 percent clay in the upper half, and that, at its upper boundary, has less than 20 percent increase in clay (absolute) within 7.5 cm (3 inches) vertical distance and less than 15 percent within 2.5 cm (1 inch) vertical distance;
- b. have no mottles with chromas of 2 or less in the upper 50 cm (20 inches) of the argillic horizon;
- c. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Abruptic Paleudolls. Paleudolls like the Typic except for a.

Aquic Paleudolls. Paleudolls like the Typic except for b.

Vertic Paleudolls. Paleudolls like the Typic except for c and all or any part of a.

Vermudolls. Udolls that

1. have no argillic or natric horizon;
2. have a mollic epipedon that, below any Ap, has 50 percent or more by volume of worm holes, worm casts, or filled animal burrows and that either rests on a lithic contact or has a transition to the underlying horizon in which 25 percent or more of the material is discrete worm holes, worm casts or filled animal burrows from the mollic epipedon and the underlying horizon.

Typic Vermudolls. Vermudolls that

- a. have a mollic epipedon 75 cm (30 inches) or more thick;
- b. have no 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 worm holes, worm casts or filled animal burrows from the mollic epipedon and the underlying horizon;
- d. have no lithic contact within 50 cm (20 inches) of the surface;
- e. have a mollic epipedon with granular structure composed almost entirely below any Ap of worm holes, worm casts or filled animal burrows;

Mollisols

Typic Vermudolls--Cont.

f. have colors as follows:

- (1) immediately below the mollic epipedon (within 15 cm (6 inches) of the lower boundary) have hues of 10YR or redder and chromas of 3 or higher, and no mottles have chromas of 2 or less in values of 4 or more; and
- (2) no matrix colors in hues 10YR or redder are as dark or darker than value 2.5 with chroma of 2 or less to a depth of 50 cm (20 inches) if accompanied by faint mottling within that depth; and
- (3) no matrix colors in hues 2.5Y or yellower are as dark or darker than value of 4 with chroma of 3 or less to a depth of 50 cm (20 inches) if accompanied by faint mottling within 20 inches; and
- (4) no mottles are present within 40 cm (16 inches) below the surface;

Entic Vermudolls. Vermudolls like the Typic except for a.

Haplic Vermudolls. Vermudolls like the Typic except for b and c with or without

Lithic Vermudolls. Vermudolls like the Typic except for d and a with or without c.

Ustolls. Ustolls are Mollisols that

1. have temperatures too high or chromas too high for Borolls;
2. have no albic horizon with characteristics associated with wetness, namely, mottles, iron-manganese concretions larger than 2 mm, or both;
3. are not saturated with water at any period or lack the characteristics associated with wetness defined for Aquolls;
4. are not continuously dry in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches) for as long as 60 consecutive days in more than 7 out of 10 years unless the mean annual soil temperature is 22°C (72°F) or higher, or the mean summer and mean winter soil temperatures at 50 cm (20 inches) depth or at a lithic or a paralithic contact, whichever is shallower, differ by less than 5°C (9°F), or both; and with one or more of the following:
 - a. are dry for 90 cumulative days or more in most years in some subhorizon(s) of the soil between 18 and 50 cm (7 and 20 inches) or above a lithic or a paralithic contact shallower than 50 cm (20 inches);
 - b. have base saturation (by NH_4OAc) of 80 percent or higher in all parts of the soil above a lithic or a paralithic contact that occurs within 50 cm (20 inches) of the surface;
 - c. within 1.5 m (60 inches) of the soil surface or within 50 cm (20 inches) below the base of any cambic or argillic horizon, have either a calcic horizon or a horizon with concentrations of soft powdery lime in spheroidal forms, as coatings on peds, or disseminated in clay-size particles; *
 - d. have increasing saturation of Na plus K within 1.25 m (50 inches) of the surface if particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey.
5. have no calcareous horizon in or that immediately underlies the mollic epipedon at depths of less than 50 cm (20 inches) and that has more than 40 percent calcium carbonate equivalent unless it is a calcic horizon. (Note that hard limestone bedrock is neither a soil horizon nor a part of the soil.)

Argiustolls. Ustolls that

1. have an argillic horizon that has:
 - a. a vertical clay distribution such that the clay decreases from the maximum by more than 20 percent of that maximum clay content within a depth of less than 1.5 m (60 inches) from the soil surface if:

* If the lime is disseminated, the horizon(s) in which the lime is concentrated should have more lime than the underlying horizon and should have the maximum percentage of clay-sized lime.

Argiustolls--Cont.

- (1) hues are redder than 10YR and chromas are more than 4 in the matrix, or
 - (2) there are common coarse mottles with hues of 7.5YR or redder or chromas of more 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 (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary;
2. have no duripan with its upper boundary within 1 m (40 inches) of the surface;
 3. have no petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface;
 4. have no natric horizon.

Typic Argiustolls. Argiustolls that

- a. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- b. have no brittle horizon 15 cm (6 inches) or more thick within 1 m (40 inches) of the surface that contains some opal coatings or some (less than 20 percent by volume) durinodes;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. have less than 15 percent saturation with exchangeable sodium in the major part of the argillic horizon;
- e. have a mollic epipedon less than 50 cm (20 inches) thick;
- f. have either or both of:
 - (1) a calcic horizon or soft powdery secondary lime within a depth of 1 m (40 inches) if the particle-size class is sandy, 70 cm (28 inches) if loamy, and 60 cm (24 inches) if clayey;
 - (2) increasing saturation with Na plus K with increasing depth within 1.25 m (50 inches) if the particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey;
- g. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Argiustolls. Argiustolls like the Typic except for a or a and f.

Duric Argiustolls. Argiustolls like the Typic except for b.

Lithic Argiustolls. Argiustolls like the Typic except for c.

Lithic Udic Argiustolls. Argiustolls like the Typic except for c and f.

Natric Argiustolls. Argiustolls like the Typic except for d.

Pachic Argiustolls Argiustolls like the Typic except for e with or without a or f, or both.

Mollisols

Argiustolls--Cont.

Udic Argiustolls. Argiustolls like the Typic except for f.

Vertic Argiustolls. Argiustolls like the Typic except for g or g and e.

Calciustolls. Ustolls that

1. have a calcic or a gypsic horizon with its upper boundary within 1 m (40 inches) of the surface, or a petrocalcic horizon that has its upper boundary within 1.5 m (60 inches) of the soil surface, and that are calcareous in all parts of all horizons above the calcic, petrocalcic, or gypsic horizon after the upper 18 cm (7 inches) are mixed unless textures are coarser than loamy very fine sand;
2. have no argillic or natric horizon, or a duripan within 1 m (40 inches) of the surface.

Typic Calciustolls. Calciustolls that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;
- b. have a mollic epipedon that rests directly on the calcic horizon;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. have a mollic epipedon less than 50 cm (20 inches) thick;
- e. have no petrocalcic horizon with its upper boundary within 1 m (40 inches) of the surface;
- f. have no salic horizon within 75 cm (30 inches) of the surface;
- g. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Calciustolls. Calciustolls like the Typic except for a or a and b.

Haplic Calciustolls. Calciustolls like the Typic except for b.

Lithic Calciustolls. Calciustolls like the Typic except for c.

Pachic Calciustolls. Calciustolls like the Typic except for d with or without a or b, or both.

Petrocalcic Calciustolls. Calciustolls like the Typic except for e.

Petrocalcic Vertic Calciustolls. Calciustolls like the Typic except for e and g.

Salorthidic Calciustolls. Calciustolls like the Typic except for f.

Vertic Calciustolls. Calciustolls like the Typic except for g or g and d.

Durustolls. Ustolls that have a duripan within 1 m (40 inches) of the surface.

Mollisols

Typic Durustolls. Durustolls that

- a. have no mottles with chromas of 2 or less above the duripan;
- b. have a platy, massive, or prismatic duripan that is indurated in some subhorizon, or that is indurated and coated with opal or opal and sesquioxides in more than half of the surface of the upper boundary of the duripan;
- c. have an argillic horizon above the duripan.

Aquic Durustolls. Durustolls like the Typic except for a.Argic Durustolls. Durustolls like the Typic except for b.Entic Durustolls. Durustolls like the Typic except for b and c.Haplic Durustolls. Durustolls like the Typic except for c.Haplustolls. Ustolls that

1. have no argillic or natric horizon unless it is a buried horizon;
2. have no duripan with its upper boundary within 1 m (40 inches) of the surface;
3. have no calcic or gypsic horizon with its upper boundary within 1 m (40 inches) of the surface unless some part of some horizon overlying the calcic or gypsic horizon is free of carbonates after mixing the upper 18 cm (7 inches) and has a texture of loamy very fine sand or finer;
4. have a transition between the mollic epipedon and the underlying horizon that has less than 25 percent by volume of worm holes, worm casts or filled animal burrows.
5. have no petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface.

Typic Haplustolls. Haplustolls that

- a. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface or are not continuously saturated with water for 90 days or more within 1 m (40 inches) of the surface;
- b. have a mollic epipedon less than 50 cm (20 inches) thick;
- c. have no brittle horizon 15 cm (6 inches) or more thick within 1 m (40 inches) of the surface that contains some opal coatings or some (less than 20 percent by volume) durinodes;
- d. have a mollic epipedon overlying a cambic horizon; or have a mollic epipedon that is noncalcareous, at least in the upper half, and its lower portion has one or more of the following:
 - (1) moderate or strong prismatic, blocky, or subangular blocky structure;
 - (2) higher chroma than in the upper portion;
 - (3) higher value than in the upper portion;
 - (4) redder hues than in the upper portion;
- e. have a regular decrease in organic matter content with depth to a level of 0.5 percent (0.29 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- f. have no lithic contact within 50 cm (20 inches) of the surface;
- g. have no salic horizon within 75 cm (30 inches) of the surface;

Mollisols

Typic Haplustolls--Cont.

- h. lack both of the following combinations of characteristics:
- (1) (a) cracks at some period in most years that are 1 cm or more wide at a depth of 50 cm (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and
 - (b) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (c) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
 - (2) (a) have a lithic or paralithic contact or altered rock retaining its rock structure within 50 cm (20 inches) of the surface, and
 - (b) have horizons totalling 25 cm (10 inches) or more in thickness with 35 percent or more clay with montmorillonitic mineralogy;
- i. have either or both of:
- (1) a calcic horizon or soft powdery secondary lime within a depth of 70 cm (28 inches) of the surface if the particle-size class is loamy, 1 m (40 inches) if sandy, and 60 cm (24 inches) if clayey;
 - (2) increasing saturation with Na plus K with increasing depth within 1.25 m (50 inches) if the particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey.

Aquic Haplustolls. Haplustolls like the Typic except for a with or without d or i, or both.

Aquic Fluventic Haplustolls. Haplustolls like the Typic except for a and e with or without any or all of b, d, or i.

Cumilic Haplustolls. Haplustolls like the Typic except for b and e with or without any or all of a, d, or i. (The organic matter content decreases irregularly or it remains above 0.5 percent (0.29 percent carbon) at a depth of 1.25 m (50 inches).)

Duric Haplustolls. Haplustolls like the Typic except for c.

Entic Haplustolls. Haplustolls like the Typic except for d.

Entic Vermic Haplustolls. Haplustolls like the Typic except for d and have a mollic epipedon and a horizon with secondary carbonates, that below any Ap, have 50 percent or more by volume of worm holes, worm casts or filled animal burrows.

Fluventic Haplustolls. Haplustolls like the Typic except for e or d and e with or without i.

Lithic Haplustolls. Haplustolls like the Typic except for f with or without d or i, or both.

Lithic-Vertic Haplustolls. Haplustolls like the Typic except for f and h with or without d or i, or both.

Pachic Haplustolls. Haplustolls like the Typic except for b with or without all or any of a, d, or i.

Solorthodic Haplustolls. Haplustolls like the Typic except for g.

Udertic Haplustolls. Haplustolls like the Typic except for h and i with or without all or any of b, d, or e.

Mollisols

Haplustolls--Cont.

Udic Haplustolls. Haplustolls like the Typic except for i.

Udorthentic Haplustolls. Haplustolls like the Typic except for d and i.

Vermic Haplustolls. Haplustolls like the Typic except for b and d and have a mollic epipedon and either or both a cambic horizon, or a horizon with secondary carbonates that, below any Ap, has 50 percent or more by volume of worm holes, worm casts or filled animal burrows.

Vertic Haplustolls. Haplustolls like the Typic except for h, with or without all or any of b, d, or e.

Natrustolls. Ustolls that

1. have a natric horizon;
2. have no petrocalcic horizon with an upper boundary within 1.5 m (60 inches) of the surface;
3. have no duripan with an upper boundary within 1 m (40 inches) of the surface.

Typic Natrustolls. Natrustolls that

- a. have none of the following characteristics within 1 m (40 inches) of the surface:
 - (1) dominant chromas of 1 or less throughout and hues as yellow or yellower than 2.5Y in some portion;
 - (2) dominant chromas of 2 or less accompanied by mottles not due to segregated lime;
 - (3) dominant chromas of 2 or less accompanied by a decrease in the percentage of exchangeable sodium from the upper 25 cm (10 inches) layer to the underlying layer;
- b. have no brittle horizon 15 cm (6 inches) or more thick that is within 1 m (40 inches) of the surface and that contains some opal coatings or some (less than 20 percent by volume) durinodes;
- c. have no tonguing or interfingering of an albic horizon more than 2.5 cm (1 inch) into a natric horizon.
- d. have a natric horizon that has a lower boundary deeper than 40 cm (16 inches) from the surface;
- e. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Natrustolls. Natrustolls like the Typic except for a.

Aquic Duric Natrustolls. Natrustolls like the Typic except for a and b.

Duric Natrustolls. Natrustolls like the Typic except for b.

Mollisols

Natrustolls--Cont.

Glossic Natrustolls. Natrustolls like the Typic except for c.

Leptic Natrustolls. Natrustolls like the Typic except for d.

Vertic Natrustolls. Natrustolls like the Typic except for e.

Paleustolls. Ustolls that

1. have a petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface, or an argillic horizon that has either or both:
 - a. a vertical clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface, and one or both of:
 - (1) hues redder than 10YR and chromas of more than 4 in the matrix,
 - (2) common coarse mottles with hues of 7.5YR or redder or chromas of more than 5; or
 - b. a particle-size class that is clayey in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary;
2. have no duripan that has an upper boundary within 1 m (40 inches) of the soil surface;
3. have no natric horizon.

Typic Paleustolls. Paleustolls that

- a. have no increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary of the argillic horizon;
- b. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- c. have a mollic epipedon less than 50 cm (20 inches) thick;
- d. have no petrocalcic horizon within 1.5 m (60 inches) of the surface;
- e. have either or both of:
 - (1) a calcic horizon, or soft powdery secondary lime within a depth of 1 m (40 inches) if the particle-size class is sandy, 70 cm (28 inches) if loamy, and 60 cm (24 inches) if clayey, or
 - (2) increasing saturation with Na plus K with increasing depth within 1.25 m (50 inches) if the particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey;
- f. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Abruptic Paleustolls. Paleustolls like the Typic except for a.

Mollisols

Paleustolls-Cont.

- Abruptic Aquic Paleustolls. Paleustolls like the Typic except for a and b.
- Abruptic Udic Paleustolls. Paleustolls like the Typic except for a and e.
- Aquic Paleustolls. Paleustolls like the Typic except for b with or without e.
- Pachic Paleustolls. Paleustolls like the Typic except for c with or without b or e, or both.
- Petrocalcic Paleustolls. Paleustolls like the Typic except for d with or without a.
- Udertic Paleustolls. Paleustolls like the Typic except for e and f or b, e and f.
- Udic Paleustolls. Paleustolls like the Typic except for e.
- Vertic Paleustolls. Paleustolls like the Typic except for f or f and b.

Vermustolls. Ustolls that

1. have no argillic or natric horizon;
2. have a mollic epipedon, below any Ap, that is 50 percent or more by volume of worm holes and worm casts or filled animal burrows, and that either rests on a lithic contact or has a transition to the underlying horizon in which 25 percent or more of the material is discrete worm casts or filled animal burrows from the mollic epipedon and the underlying horizon.

Typic Vermustolls. Vermustolls that

- a. have a mollic epipedon 50 cm (20 inches) or more thick but less than 75 cm (30 inches) thick;
- b. have no cambic horizon;
- c. have a mollic epipedon, below any Ap, that has a transition to the underlying horizon in which 50 percent or more of the volume is worm holes and worm casts or filled animal burrows;
- d. have no lithic contact within 50 cm (20 inches) of the surface;
- e. have a mollic epipedon with granular structure composed almost entirely below any Ap of worm holes, worm casts or filled animal burrows;
- f. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface.

Entic Vermustolls. Vermustolls like the Typic except for a and the epipedon is less than 50 cm (20 inches) thick.

Haplic Vermustolls. Vermustolls like the Typic except for b and c with or without a and the epipedon is less than 75 cm (30 inches) thick.

Lithic Vermustolls. Vermustolls like the Typic except for d and a with or without b or c, or both, and the epipedon is less than 75 cm (30 inches) thick.

Pachic Vermustolls. Vermustolls like the Typic except for a and the epipedon is 75 cm (30 inches) or more thick.

Xerolls. Xerolls are Mollisols that

1. have either:
 - a. mean annual soil temperatures of 8°C (47°F) or more, or
 - b. have a moist chroma of more than 1.5 in some part of the upper 15 cm (6 inches) of the mollic epipedon and have mean summer soil temperatures at 50 cm (20 inches) depth or a lithic or paralithic contact, whichever is shallower, of 15°C (59°F) or more if without an O horizon, or 8°C (47°F) or more if with an O horizon;

Mollisols

Xerolls--Cont.

2. have no albic horizon with characteristics associated with wetness, namely, mottles, iron-manganese concretions, or both;
3. are not saturated with water at any period or lack the characteristics associated with wetness defined for Aquolls;
4. have no calcareous horizon in or that immediately underlies the mollic epipedon at depths of less than 50 cm (20 inches) and that has more than 40 percent calcium carbonate equivalent unless it is a calcic horizon. (Note that hard limestone bedrock is neither a soil horizon nor a part of the soil.)
5. are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 and 50 cm (7 and 20 inches), or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches).

Argixerolls. Xerolls that

1. have an argillic horizon but not a natric horizon;
2. have an argillic horizon that has:
 - a. a vertical clay distribution such that the clay decreases from the maximum by more than 20 percent of that maximum clay content within a depth of less than 1.5 m (60 inches) from the soil surface if:
 - (1) hues are redder than 10YR and chromas are more than 4 in the matrix, or
 - (2) there are common coarse mottles with hues of 7.5YR or redder or chromas of more than 5; and
 - b. 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 (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary;
3. have no duripan with its upper boundary within 1 m (40 inches) of the soil surface;
4. have no petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface;
5. have no calcic or gypsic horizon with its upper boundary within 1.5 m (60 inches) of the surface unless some part of some horizon overlying the calcic or gypsic horizon is free of carbonates after mixing the upper 18 cm (7 inches) and has a texture of loamy very fine sand or finer.

Typic Argixerolls. Argixerolls that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;
- b. have no albic horizon above the argillic horizon;
- c. have neither:
 - (1) a calcic horizon or soft powdery secondary lime within a depth of 1.5 m (60 inches) if the particle-size class is sandy, 1.1 m (43 inches) if loamy, and 90 cm (35 inches) if clayey, or above a lithic contact shallower than these depths, nor
 - (2) if without a calcic horizon or soft powdery secondary lime within the depths specified in (1) above, have no increasing saturation with Na plus K with increasing depth within the depths specified above;
- d. have no brittle horizon 15 cm (6 inches) or more thick that is within 1 m (40 inches) of the surface and that contains some opal coatings or some (less than 20 percent by volume) durinodes;
- e. have no lithic contact within 50 cm (20 inches) of the surface;
- f. have less than 15 percent saturation with exchangeable sodium in the major part of the argillic horizon;
- g. have a mollic epipedon less than 50 cm (20 inches) thick;

Mollisols

Typic Argixerolls--Cont.

- h. have base saturation of more than 75 percent throughout the argillic horizon or the upper 50 cm (20 inches);
- i. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Argixerolls. Argixerolls like the Typic except for a.

Aquic Calcic Argixerolls. Argixerolls like the Typic except for a and c.

Aquitic Argixerolls. Argixerolls like the Typic except for a and h.

Boralfic Argixerolls. Argixerolls like the Typic except for b with or without c or h, or both.

Calcic Argixerolls. Argixerolls like the Typic except for c.

Calcic Lithic Argixerolls. Argixerolls like the Typic except for c and e.

Calcic Pachic Argixerolls. Argixerolls like the Typic except for c and g with or without a.

Duric Argixerolls. Argixerolls like the Typic except for d with or without c.

Glossaqualfic Argixerolls. Argixerolls like the Typic except for a and b with or without c or h, or both.

Lithic Argixerolls. Argixerolls like the Typic except for e.

Lithic Ultic Argixerolls. Argixerolls like the Typic except for e and h.

Natric Argixerolls. Argixerolls like the Typic except for f with or without c.

Pachic Argixerolls. Argixerolls like the Typic except for g with or without a.

Pachic Ultic Argixerolls. Argixerolls like the Typic except for g and h with or without a.

Ultic Argixerolls. Argixerolls like the Typic except for h.

Vertic Argixerolls. Argixerolls like the Typic except for i with or without c.

Calcixerolls. Xerolls that

1. have a calcic, petrocalcic, or gypsic horizon with an upper boundary within 1.5 m (60 inches) of the soil surface; and
2. are calcareous in all parts of all horizons above the calcic, petrocalcic, or gypsic horizons after the upper 18 cm (7 inches) have been mixed unless textures are coarser than loamy very fine sand; and
3. have no natric horizon or duripan within 1 m (40 inches) of the soil surface.

(Calcixerolls do not occur in the U. S. The depth limits suggested for the calcic, petrocalcic, and gypsic horizons are tentative.)

Mollisols

Typic Calcixerolls. Calcixerolls that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface or are not continuously saturated with water for as long as 90 days within 1 m (40 inches) of the soil surface where undrained;
- b. have a mollic epipedon less than 50 cm (20 inches) thick;
- c. have a regular decrease in organic matter content with depth and the organic matter content reaches levels of less than 0.5 percent within 1.25 m of the soil surface;
- d. have a mollic epipedon that rests directly on a calcic horizon;
- e. have no lithic contact within 50 cm (20 inches) of the soil surface;
- f. have no petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface.

Aquic Calcixerolls. Calcixerolls like the Typic except for a.

Cumulic Calcixerolls. Calcixerolls like the Typic except for b and c with or without a. (The organic matter decreases irregularly or it remains above 0.5 percent (0.29 percent carbon) at a depth of 1.25 m (50 inches).)

Fluventic Calcixerolls. Calcixerolls like the Typic except for c.

Haplic Calcixerolls. Calcixerolls like the Typic except for d.

Lithic Calcixerolls. Calcixerolls like the Typic except for e.

Pachic Calcixerolls. Calcixerolls like the Typic except for b with or without a.

Petrocalcic Calcixerolls. Calcixerolls like the Typic except for f.

Durixerolls. Xerolls that have a duripan within 1 m (40 inches) of the surface.

Typic Durixerolls. Durixerolls that

- a. have no argillic horizon with an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary.
- b. have no mottles with chromas of 2 or less above the duripan;
- c. have a platy, massive or prismatic duripan that is indurated in some sub-horizon, or that is indurated and coated with opal or opal and sesquioxides in more than half of the surface of the upper boundary of the duripan;
- d. have an argillic horizon above the duripan.

Abruptic Durixerolls. Durixerolls like the Typic except for a.

Aquic Durixerolls. Durixerolls like the Typic except for b.

Argic Durixerolls. Durixerolls like the Typic except for c.

Entic Durixerolls. Durixerolls like the Typic except for c and d.

Haplic Durixerolls. Durixerolls like the Typic except for d.

Haploxerolls. Xerolls that

1. have no argillic or natric horizon, and that have no duripan within 1 m (40 inches) of the surface;
2. have no petrocalcic horizon with an upper boundary within 1.5 m (60 inches) of the surface;

Mollisols

Haploxerolls--Cont.

3. have no calcic or gypsic horizon with its upper boundary within 1.5 m (60 inches) of the surface unless some part of some horizon overlying the calcic or gypsic horizon is free of carbonates after mixing the upper 18 cm (7 inches) and has a texture of loamy very fine sand or finer.

Typic Haploxerolls. Haploxerolls that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface or are not continuously saturated with water for 90 days or more within 1 m (40 inches) of the surface where undrained;
- b. have neither:
 - (1) a calcic horizon or soft powdery secondary lime within a depth of 1.5 m (60 inches) if the particle-size class is sandy, 1.1 m (43 inches) if loamy, and 90 cm (35 inches) if clayey, or above a lithic contact shallower than these depths; nor
 - (2) increasing saturation with Na plus K with increasing depth within the depths specified above if without a calcic horizon or soft powdery secondary lime within the depths specified in (1) above;
- c. have a mollic epipedon less than 50 cm (20 inches) thick;
- d. have no brittle horizon 15 cm (6 inches) or more thick that is within 1 m (40 inches) of the surface and that contains some opal coatings or some (less than 20 percent by volume) durinodes;
- e. have a cambic horizon or the lower epipedon meets the requirements of a cambic horizon except for color value, and either the cambic horizon or the lower epipedon is free of carbonates in some part;
- f. have a regular decrease in organic matter content with depth to a level of 0.5 percent (0.29 percent organic carbon) or less within 1.25 m (50 inches) of the surface;
- g. have no lithic contact within 50 cm (20 inches) of the surface;
- h. have base saturation of more than 75 percent throughout the upper 75 cm (30 inches) or above a lithic or a paralithic contact, whichever is shallower;
- i. have no mollic epipedon with granular structure that, below any Ap, has 50 percent or more by volume of worm holes, worm casts, or filled animal burrows;
- j. lack 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 (20 inches) and that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Haploxerolls. Haploxerolls like the Typic except for a or a and e.

Aquic Calcic Haploxerolls. Haploxerolls like the Typic except for a and b.

Aquic Fluventic Haploxerolls. Haploxerolls like the Typic except for a and f with or without b or e, or both.

Aquiltic Haploxerolls. Haploxerolls like the Typic except for a and h with or without e.

Mollisols

Haploxerolls--Cont.

Calcic Haploxerolls. Haploxerolls like the Typic except for b.

Calcic Entic Haploxerolls. Haploxerolls like the Typic except for b and e.

Calcic Lithic Haploxerolls. Haploxerolls like the Typic except for b and g.

Calcic Pachic Haploxerolls. Haploxerolls like the Typic except for b and c with or without a or e, or both.

Cumlic Haploxerolls. Haploxerolls like the Typic except for c and f with or without all or any of a, b, or e.

Duric Haploxerolls. Haploxerolls like the Typic except for d with or without b.

Entic Haploxerolls. Haploxerolls like the Typic except for e.

Entic Ultic Haploxerolls. Haploxerolls like the Typic except for e and h.

Fluventic Haploxerolls. Haploxerolls like the Typic except for f or e and f with or without b.

Lithic Haploxerolls. Haploxerolls like the Typic except for g with or without e.

Lithic Ultic Haploxerolls. Haploxerolls like the Typic except for g and h with or without e.

Pachic Haploxerolls. Haploxerolls like the Typic except for c with or without a or e, or both.

Pachic Ultic Haploxerolls. Haploxerolls like the Typic except for c and h with or without a or e, or both.

Ultic Haploxerolls. Haploxerolls like the Typic except for h.

Vermic Haploxerolls. Haploxerolls like the Typic except for i with or without b.

Vertic Haploxerolls. Haploxerolls like the Typic except for j with or without all or any of b, c or f.

Natrixerolls. Xerolls that have a natric horizon, and that do not have a duripan within 1 m (40 inches) of the surface, or a petrocalcic horizon within 1.5 m (60 inches) of the surface.

Typic Natrixerolls. Natrixerolls that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the soil surface;
- b. have no brittle horizon 15 cm (6 inches) or more thick that is within 1 m (40 inches) of the surface and that contains some opal coatings or some (less than 20 percent by volume) durinodes;
- c. have more than 15 percent exchangeable sodium in the major part of the natric horizon and have no tonguing or interfingering of an albic horizon more than 2.5 m (1 inch) into a natric horizon.

Aquic Natrixerolls. Natrixerolls like the Typic except for a.

Duric Natrixerolls. Natrixerolls like the Typic except for b.

Glossic Natrixerolls. Natrixerolls like the Typic except for c.

Falaxerolls. Xerolls that

1. have a petrocalcic horizon that has its upper boundary within 1.5 m (60 inches) of the soil surface and that underlies horizons that are not calcareous in all parts, or have an argillic horizon with one or both of:
 - a. a vertical clay distribution such that the clay does not decrease by 20 percent of the maximum clay content within 1.5 m (60 inches) of the soil surface, and one or more of:

Mollisols

Palaxerolls--Cont.

- (1) hues redder than 10YR and chromas of more than 4 dominant in the matrix,
 - (2) common coarse mottles with hues of 7.5YR or redder or chromas of more than 5, or both;
- b. a particle-size class that is clayey in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary;
2. have no natric horizon unless it is underlain by a petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface;
 3. have no calcic, petrocalcic, or gypsic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface unless some part of some horizon overlying the calcic, petrocalcic, or gypsic horizon is free of carbonates after mixing the upper 18 cm (7 inches) and has a texture of loamy very fine sand or finer;
 4. have no duripan with its upper boundary within 1 m (40 inches) of the soil surface.

Typic Palaxerolls. Palaxerolls that

- a. have no argillic horizon with an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary;
- b. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;
- c. have no petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface;
- d. have a mollic epipedon less than 50 cm (20 inches) thick;
- e. have no natric horizon;
- f. have base saturation of more than 75 percent throughout the argillic horizon or in the upper 50 cm (20 inches), whichever is shallower;
- g. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or a paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Abruptic Palaxerolls. Palaxerolls like the Typic except for a.

Abruptic Aquic Palaxerolls. Palaxerolls like the Typic except for a and b.

Aquic Palaxerolls. Palaxerolls like the Typic except for b.

Petrocalcic Palaxerolls. Palaxerolls like the Typic except for c with or without a.

Pachic Palaxerolls. Palaxerolls like the Typic except for d or d and b.

Natric Petrocalcic Palaxerolls. Palaxerolls like the Typic except for e and c.

Ultic Palaxerolls. Palaxerolls like the Typic except for f.

Vertic Palaxerolls. Palaxerolls like the Typic except for g.

SPODOSOLS: ORDER 6

Spodosols are mineral soils that have a spodic horizon, or a placic horizon cemented by iron that overlies a fragipan and that meets all the requirements of a spodic horizon except thickness.

Aquods. Spodosols that are either saturated with water at some period or artificially drained (if a placic horizon or duripan is present, the soil need not be saturated below the placic horizon or duripan) and that 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 top of the spodic horizon;
3. a duripan in the albic horizon;
4. if free iron and manganese are lacking, or if the moist color value is less than 4 in the upper part of the spodic horizon, either:
 - a. have no coatings of iron oxides on the individual grains of silt and sand in the materials in or immediately below the spodic horizon wherever the moist value is 4 or more and unless an Ap horizon rests directly on the spodic horizon there is a transition between the albic and spodic horizons at least 1 cm in thickness;
 - b. have fine or medium mottles of iron or manganese in the materials immediately below the spodic horizon.

Cryaquods. Aquods that have no placic horizon or fragipan but have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of:

1. less than 15°C (59°F) if they are drained and have no O horizon;
2. less than 8°C (47°F) if they are drained and have an O horizon;
3. less than 6°C (43°F) if they are undrained and have an O horizon or a histic epipedon.

Typic Cryaquods. Cryaquods that

- a. have no lithic contact within 50 cm (20 inches) of the surface;
- b. have a mean annual soil temperature of more than 0°C (32°F);
- c. have in 50 percent or more of each pedon, a spodic horizon that lacks sufficient free iron to turn redder on ignition (less than 0.5 percent in the fine earth fraction expressed as Fe);
- d. have no mottles above the spodic horizon;
- e. have no argillic horizon underlying the spodic horizon;
- f. have a continuous spodic horizon that is 10 cm (4 inches) or more thick or that is very firm when moist.

Lithic Cryaquods. Cryaquods like the Typic except for a.

Pergelic Cryaquods. Cryaquods like the Typic except for b.

Sideric Cryaquods. Cryaquods like the Typic except for c and d.

Duraquods. Aquods that have an albic horizon that in at least some subhorizon is strongly enough cemented or indurated that a dry fragment will not slake when immersed in water; have temperatures warmer than those of Cryaquods. (Duraquods are not known to occur in the United States.)

Spodosols

Fragiaquods. Aquods that have a fragipan below the spodic horizon, but that have no duripan or placic horizon above the fragipan.

Typic Fragiaquods. Fragiaquods that

- a. have mean summer soil temperature at a depth of 50 cm (20 inches):
 - (1) of 6°C (43°F) or more if they have an O horizon and are undrained;
 - (2) of 8°C (47°F) or more if they have an O horizon and are drained;
 - (3) of 15°C (59°F) or more if they have no O horizon and are drained;
- b. have no histic epipedon;
- c. have less than 5 percent by volume of iron-cemented nodules, 2.5 to 30 cm (1 to 12 inches) in diameter, in any subhorizon of the spodic horizon;
- d. have no surface horizon more than 30 cm (12 inches) thick that meets all requirements of a plaggen epipedon except thickness;
- e. have a spodic horizon that has 1 percent or more organic matter (0.58 percent carbon) in the matrix of the first 30 cm (12 inches) below the top of the spodic horizon; or that have an upper subhorizon of the spodic horizon that
 - (1) has 4 percent or more organic matter (2.3 percent carbon) in the upper 2 cm, and that
 - (2) is continuous or is present in more than 90 percent of each pedon;
- f. have no argillic horizon.

Cryic Fragiaquods. Fragiaquods like the Typic except for a or a and b.

Haplaquods. (formerly Normaquods) Aquods that

1. have soil temperatures warmer than those of Cryaquods and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;
2. have one or both of the following:
 - a. in 50 percent or more of each pedon, a spodic horizon with some subhorizon that contains dispersed organic matter and aluminum and lacks sufficient free iron to turn redder on ignition (less than 0.5 percent in the fine earth fraction expressed as Fe);
 - b. an Ap horizon that has a moist value of 3 or less and a moist chroma of 2 or less, and that rests directly on a spodic horizon having in its upper part a subhorizon or some tongues with one or both of:
 - (1) dispersed organic matter and a moist value and moist chroma of 3 or less;
 - (2) less than 0.7 percent free iron expressed as Fe;
3. have no fragipan below the spodic horizon;
4. have no cemented or indurated subhorizon in any albic horizon that may be present.

Typic Haplaquods. Haplaquods that

- a. 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 (10 to 12 inches);
- b. have no argillic horizon underlying the spodic horizon;
- c. have less than 75 cm (30 inches) of a sandy epipedon (loamy fine sand or coarser) overlying the spodic horizon;
- d. have a spodic horizon that has 1 percent or more organic matter (0.58 percent carbon) in the matrix of the first 30 cm (12 inches) below the top of the spodic horizon, or that have an upper subhorizon of the spodic horizon that:

Spodosols

Typic Haplaquods--Cont.

- (1) has 4 percent or more of organic matter (2.3 percent carbon) in the upper 2 cm; and that
- (2) is continuous or is present in more than 90 percent of each pedon;
- e. have less than 5 percent by volume of iron-cemented nodules, 2.5 to 30 cm (1 to 12 inches) in diameter, in any subhorizon of the spodic horizon;
- f. have no lithic contact within 50 cm (20 inches) of the mineral soil surface;
- g. have no surface horizon more than 30 cm (12 inches) thick that meets all requirements of a plaggen epipedon except thickness;
- h. have no histic epipedon.

Aeric Haplaquods. Haplaquods like the Typic except for a.

Alfic Haplaquods. Haplaquods like the Typic except for b, with or without a and d; and have an albic horizon that tongues into the argillic horizon, or have either base saturation of 35 percent or more (by sum of cations) in some part of the argillic horizon, or a mean annual soil temperature less than 8°C (47°F).

Arenic Haplaquods. Haplaquods like the Typic except for a and c.

Entic Haplaquods. Haplaquods like the Typic except for a and d.

Ultic Haplaquods. Haplaquods like the Typic except for a and b; have no albic horizon that tongues into the argillic horizon, and have base saturation (by sum of cations) of less than 35 percent throughout the argillic horizon, and have a mean annual soil temperature of 8°C (47°F) or more.

Placaquods. Aquods that have a placic horizon that rests on a spodic horizon, a fragipan, or an albic horizon that is underlain by a fragipan. There may be a histic epipedon at the surface. The horizons above the placic horizon are saturated with water at some period and have faint to distinct mottles of low chromas.

Typic Placaquods. Placaquods that

- a. have a mean annual soil temperature of more than 0°C (32°F);
- b. have no histic epipedon.

(Placaquods occur in southern Alaska, but they are rare elsewhere in the United States.)

Sideraquods. Aquods that

1. have soil temperatures warmer than those of Cryaquods and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;
2. have one or both of the following:
 - a. in 50 percent or more of each pedon, a spodic horizon that contains in all subhorizons sufficient free iron to turn redder on ignition (0.5 percent or more in the fine earth fraction expressed as Fe),
 - b. an Ap horizon that has a moist value of more than 3 or a moist chroma of more than 2 and that rests directly on a spodic horizon, or an Ap horizon that has 0.7 percent or more free iron (expressed as Fe) in the fine earth fraction;
3. have no fragipan below the spodic horizon;
4. have no duripan or placic horizon above the spodic horizon.

Spodosols

Typic Sideraquods. Sideraquods that

- a. have a spodic horizon that either:
 - (1) is at least very firm when moist, or
 - (2) is thicker than 10 cm (4 inches) and contains 2 percent or more of organic matter (1.16 percent carbon) in the upper 10 cm (4 inches);
- b. have no histic epipedon;
- c. have no argillic horizon.

Entic Sideraquods. Sideraquods like the Typic except for item (2) under a.

Tropaquods. Aquods that

- 1. have mean annual soil temperatures of 8°C (47°F) or higher and mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by less than 5°C (9°F);
- 2. have no albic horizon with any subhorizon so strongly cemented that a dry fragment will not slake when immersed in water;
- 3. have no placic horizon above the spodic horizon.

Typic Tropaquods. Tropaquods that

- a. have no histic epipedon;
- b. have less than 5 percent by volume of iron-cemented nodules, 2.5 to 30 cm (1 to 12 inches) in diameter, in any subhorizon of the spodic horizon;
- c. have no surface horizon more than 30 cm (12 inches) thick that meets all the requirements of a plaggen epipedon except thickness;
- d. have no argillic horizon underlying the spodic horizon;
- e. have no lithic contact within 50 cm (20 inches) of the surface;
- f. 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 (10 to 12 inches);
- g. have no more than 75 cm (30 inches) of a sandy epipedon (loamy fine sand or coarser) overlying the spodic horizon.

Histic Tropaquods. Tropaquods like the Typic except for a.

Ferrods. Spodosols that

- 1. have a spodic horizon that has in all subhorizons a ratio of percentage of free iron(elemental) to percentage of carbon of more than 6.
- 2. are never saturated with water or do not have the characteristics associated with wetness as defined for Aquods.

Ferrods. The definition of Ferrods at the great group level is equivalent to that at the suborder level.

Typic Ferrods. Ferrods that

- a. have no argillic horizon underlying the spodic horizon;
- b. have no mottles with chromas of 2 or less within the spodic horizon.

Alfic Ferrods. Ferrods like the Typic except for a.

Aquic Ferrods. Ferrods like the Typic except for b.

Spodosols

Humods. Spodosols that

1. are never saturated with water, or do not have characteristics associated with wetness as defined for Aquods;
2. have one or both of:
 - a. in 50 percent or more of each pedon a spodic horizon with a subhorizon that contains dispersed organic matter and aluminum and that lacks sufficient free iron to turn redder on ignition (less than 0.5 percent in the fine earth fraction expressed as Fe),
 - b. an Ap horizon that has a moist value of 3 or less and a moist chroma of 2 or less and that rests directly on a spodic horizon having in its upper part a subhorizon or some tongues possessing one or both of:
 - (1) dispersed organic matter and a moist value and moist chroma of 3 or less;
 - (2) less than 0.7 percent free iron expressed as Fe.

(Humods probably occur, but have not been studied in the United States; the classification that follows is incomplete.)

Cryohumods. Humods that

1. have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) of either less than 15°C (59°F) if cultivated or without an O horizon or less than 8°C (47°F) if with an O horizon;
2. have no fragipan.

(No subgroup definitions are proposed at this time.)

Fragihumods. Humods that have a fragipan below the spodic horizon.

(No subgroup definitions are proposed at this time.)

Haplohumods. (formerly Normihumods) Humods that

1. have soil temperatures warmer than those of Cryohumods, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;
2. have no fragipan.

Typic Haplohumods. Haplohumods that

- a. have either:
 - (1) a spodic horizon that has 1 percent or more organic matter (0.58 percent carbon) in the matrix of the first 30 cm (12 inches) below the top of the spodic horizon, or
 - (2) an upper subhorizon of the spodic horizon that has 5 percent or more organic matter (2.9 percent carbon) in the upper 2 cm and that is continuous or is present in more than 90 percent of the area of each pedon;
- b. have less than 5 percent by volume of iron-cemented nodules, 2.5 to 30 cm (1 to 12 inches) in diameter, in any subhorizon of the spodic horizon;
- c. have no placic horizon in the spodic horizon;
- d. have no argillic horizon;
- e. have no surface horizon more than 30 cm (12 inches) thick that meets all the requirements for a plaggen epipedon except thickness.

Entic Haplohumods. Haplohumods like the Typic except for a.

Ferrudalfic Haplohumods. Haplohumods like the Typic except for b.

Spodosols

Placohumods. Humods that have a placic horizon in the spodic horizon. (No subgroup definitions are proposed at this time.)

Trophumods. Humods that have a mean annual soil temperature of 8°C (47°F) or higher and a mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Typic Trophumods. Trophumods that

- a. have either:
 - (1) a spodic horizon that has 1 percent or more organic matter (0.58 percent carbon) in the matrix of the first 30 cm (12 inches) below the top of the spodic horizon, or
 - (2) an upper subhorizon of the spodic horizon that has 5 percent or more organic matter (2.9 percent carbon) in the upper 2 cm and that is continuous or is present in more than 90 percent of the area of each pedon;
- b. have no argillic horizon;
- c. have no thin (less than 5 cm) subhorizon that is cemented with iron;
- d. have less than 5 percent by volume of iron-cemented nodules, 2.5 to 30 cm (1 to 12 inches) in diameter, in any subhorizon of the spodic horizon;
- e. have no surface horizon more than 30 cm (12 inches) thick that meets all requirements of the plaggen epipedon except thickness.

Ferrudalfic Trophumods. Trophumods like the Typic except for d.

Orthods. Spodosols that

1. have a spodic horizon that has in some subhorizon a ratio of percentage of free iron (elemental) to percentage of carbon of 6 or less;
2. have one of the following:
 - a. an Ap horizon that has a moist value of more than 3 or a moist chroma of more than 2 and that rests directly on a spodic horizon;
 - b. an Ap horizon that rests directly on a spodic horizon and the spodic horizon has in all parts moist values and chromas of more than 3 or has 0.7 percent or more free iron (elemental) in all parts;
 - c. a spodic horizon that lacks, or has in less than 50 percent of each pedon, any subhorizon that contains dispersed organic matter and aluminum and that lacks sufficient free iron to turn redder on ignition (less than 0.35 percent in the fine earth fraction, expressed as Fe);
3. are never saturated with water or lack the characteristics associated with wetness of Aquods.

Cryorthods. Orthods that

1. have a mean annual soil temperature of less than 8°C (47°F) and a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or without an O horizon; or of less than 8°C (47°F) if with an O horizon;
2. have no fragipan;
3. have no placic horizon above the spodic horizon.

Spodosols

Typic Cryorthods. Cryorthods that

- a. have no argillic horizon below the spodic horizon;
- b. have a cemented or indurated spodic horizon or 2 to 10 percent organic matter (1.16 to 5.8 percent carbon) in the upper 10 cm (4 inches) of the spodic horizon;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. have a mean annual soil temperature of more than 0°C (32°F).

Boralfic Cryorthods. Cryorthods like the Typic except for a.

Entic Cryorthods. Cryorthods like the Typic except for b in that they contain less than 2 percent organic matter in the upper 10 cm (4 inches) of the spodic horizon.

Humic Cryorthods. Cryorthods like the Typic except for b in that they contain more than 10 percent organic matter in the upper 10 cm (4 inches) of the spodic horizon.

Humic Lithic Cryorthods. Cryorthods like the Typic except for c and b in that they contain more than 10 percent organic matter in the upper 10 cm (4 inches) of the spodic horizon.

Humic Pergelic Cryorthods. Cryorthods like the Typic except for d and b and have more than 10 percent organic matter in the upper 10 cm (4 inches) of the spodic horizon.

Lithic Cryorthods. Cryorthods like the Typic except for c.

Lithic Pergelic Cryorthods. Cryorthods like the Typic except for c and d.

Pergelic Cryorthods. Cryorthods like the Typic except for d.

Fragiorthods. Orthods that

1. have a fragipan below the spodic horizon;
2. have no placic horizon above or in the spodic horizon.

Typic Fragiorthods. Fragiorthods that

- a. have no argillic horizon underlying the spodic horizon;
- b. have no distinct or prominent mottles in the spodic horizon;
- c. have a continuous spodic horizon that is very firm when moist (ortstein), or that is more than 10 cm (4 inches) thick and has 2 percent or more organic matter (1.16 percent carbon) in the upper 10 cm;
- d. have temperatures warmer than those of Cryorthods.
- e. have no intermittent upper subhorizon that has coatings of dispersed organic matter and that lacks sufficient free iron to turn redder on ignition (less than 0.35 percent in the fine earth fraction expressed as Fe); if plowed and the Ap horizon rests directly on the spodic horizon, there are no tongues of such a subhorizon;
- f. if plowed, and the upper part of the spodic horizon is thus mixed in the Ap (lacks a continuous albic horizon), has more than 2 percent organic matter (1.16 percent carbon) in the Ap horizon;
- g. have no surface horizon more than 30 cm (12 inches) thick that meets all the requirements for a plagen epipedon except thickness.

Alfic Fragiorthods. Fragiorthods like the Typic except for a; have base saturation of 35 percent or more in some part of the argillic horizon, or have an albic horizon that tongues into the argillic horizon or have a mean annual soil temperature less than 8°C (47°F).

Spodosols

Aquic Fragiorthods. Fragiorthods like the Typic except for b.

Aquic Entic Fragiorthods. Fragiorthods like the Typic except for b and c.

Cryic Fragiorthods. Fragiorthods like the Typic except for d.

Cryohumic Fragiorthods. Fragiorthods like the Typic except for d and e.

Entic Fragiorthods. Fragiorthods like the Typic except for c, because of low organic matter content.

Humic Fragiorthods. Fragiorthods like the Typic except for e.

Haplorthods. (formerly Normorthods) Orthods that

1. have soil temperatures warmer than those of Cryorthods, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;
2. have no fragipan;
3. have no placic horizon above or in the spodic horizon.

Typic Haplorthods. Haplorthods that

- a. have no argillic horizon below the spodic horizon;
- b. have a continuous spodic horizon that is very firm or extremely firm when moist (ortstein), or that is more than 10 cm (4 inches) thick and has at least 2 percent organic matter (1.16 percent organic carbon) in the upper 10 cm (4 inches);
- c. have no distinct or prominent mottles of approximate spherical shape in the spodic horizon unless the variability in color is associated with differences in consistence in such a manner that the redder or darker portions are extremely firm or very firm;
- d. have no chromas of 2 or less with mottles, or chromas of less than 2 without mottles, that are dominant in the matrix within 15 cm (6 inches) of the base of the spodic horizon but within 1 m (40 inches) of the surface of the soil;
- e. have no horizon 15 cm (6 inches) or more thick below the spodic horizon but within 1 meter (40 inches) of the surface that has a brittle matrix when wet and contains some durinodes;
- f. have no lithic contact within 50 cm (20 inches) of the surface;
- g. have no intermittent upper subhorizon that has coatings of dispersed organic matter and that lacks sufficient free iron to turn redder on ignition (less than 0.35 percent in the fine earth fraction expressed as Fe);
- h. have less than 10 percent organic matter (5.8 percent organic carbon) in the upper 10 cm (4 inches) of the spodic horizon;
- i. have 2 percent or more organic matter (1.16 percent organic carbon) in the Ap horizon if the disturbed layer extends into the upper part of the spodic horizon.

Alfic Haplorthods. Haplorthods like the Typic except for a or a and b and the argillic horizon either contains tongues of an albic horizon, or has base saturation of 35 percent or more in some part, or has a mean annual soil temperature of less than 8°C (47°F).

Aqualfic Haplorthods. Haplorthods like the Typic except for a and c, a and d, or a, c, and d, and the argillic horizon either contains tongues of an albic horizon or has base saturation of 35 percent or more in some part, or has a mean annual soil temperature of less than 8°C (47°F).

Spodosols

Aquic Haplorthods. Haplorthods like the Typic except for c or d, or c and d.

Aqueptic Haplorthods. Haplorthods like the Typic except for b and c with or without d.

Duric Haplorthods. Haplorthods like the Typic except for e.

Entic Haplorthods. Haplorthods like the Typic except for b, because of thickness or low organic matter content.

Entic Lithic Haplorthods. Haplorthods like the Typic except for f and b because of thickness or low organic matter content.

Humic Haplorthods. Haplorthods like the Typic except for g or h.

Lithic Haplorthods. Haplorthods like the Typic except for f.

Ultic Haplorthods. Haplorthods like the Typic except for a, or a and b, and the argillic horizon has base saturation throughout of less than 35 percent and has no tongues of an albic horizon, and has a mean annual soil temperature of 8°C (47°F) or more.

Placorthods. Orthods that have a placic horizon above or in the spodic horizon.

(No subgroup definitions are proposed at this time.)

ALFISOLS: ORDER 7

Alfisols are mineral soils that have no spodic or oxic horizon overlying an argillic horizon; that have no mollic epipedon; that have no surface horizon and an upper subhorizon of an argillic or natric horizon that are separated by an albic horizon but that together meet all requirements for a mollic epipedon; and that have one of the following combinations of properties:

1. have no fragipan but have an argillic or natric horizon; are usually moist in some part of the soil between 25 cm and 1 m (10 and 40 inches) unless the epipedon is both hard and massive when dry; and either have mean annual soil temperature less than 8°C (47°F), or have base saturation (by sum of cations) of 35 percent or more at a depth of 1.25 m (50 inches) below the top of the argillic horizon or at 1.8 m (72 inches) below the soil surface, or immediately above a lithic or paralithic contact, whichever is shallower;
2. have a fragipan in or below the argillic horizon or have oriented clay skins more than 1 mm thick in some part of the fragipan; and either have mean annual soil temperature less than 8°C (47°F), or have base saturation (by sum of cations) of 35 percent or more at a depth of 75 cm (30 inches) below the upper boundary of the fragipan or immediately above a lithic or a paralithic contact, whichever is shallower.

Aqualfs. Alfisols, either saturated with water at some season or artificially drained, that have characteristics associated with wetness, namely; mottles, iron-manganese concretions larger than 2 mm, or chromas of 2 or less immediately below any Ap horizon or below any dark A1 that has moist values of less than 3.5 when rubbed, and one of the following:

- a. dominant chromas of 2 or less in coatings on the surface or peds accompanied by mottles within the peds, or dominant chromas of 2 or less in the matrix of the argillic horizon * accompanied by mottles of higher chromas (if hues are redder than 10YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived);
- b. if there are no mottles in the argillic horizon, chromas are 1 or less.

Albaqualfs. Aqualfs that have an abrupt textural change between the albic and argillic horizons, are slowly or very slowly permeable in the argillic horizon, are without tonguing of the albic horizon into the argillic horizon, and have no fragipan, duripan, or natric horizon; have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more.

Typic Albaqualfs. Albaqualfs that

- a. have colors with chromas of 2 or less in 60 percent or more of the mass between the A1 or Ap horizon and a depth of 75 cm (30 inches);
- b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- c. have no horizon within 1 m (40 inches) of the surface that is brittle, that is 15 cm (6 inches) or more thick, and that contains some opal coatings or some (less than 20 percent) durinodes;
- d. have an A1 horizon less than 15 cm (6 inches) thick if its moist value is darker than 3.5, or an Ap horizon having a moist value of 4 or more, or a dry value of 6 or more when crushed and smoothed;
- e. lack 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 (20 inches) and that are at least 30 cm (12 inches) long in some part and that extend to the base of an Ap or an albic horizon, and
 - (2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and

* If the upper boundary of the argillic horizon is more than 50 cm (20 inches) below the mineral surface, the specified colors must come within 50 cm of the surface as well as in the argillic horizon.

Alfisols

Typic Albaqualfs--Cont.

- (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aeric Albaqualfs. Albaqualfs like the Typic except for a.
Duric Albaqualfs. Albaqualfs like the Typic except for c.
Mollic Albaqualfs. Albaqualfs like the Typic except for d.

Udolic Albaqualfs. Albaqualfs like the Typic except for a and d.

Vertic Albaqualfs. Albaqualfs like the Typic except for e.

Fragiaqualfs. Aqualfs that have a fragipan but no natric horizon.

Typic Fragiaqualfs. Fragiaqualfs that

- a. have no horizon between the A1 horizon and the fragipan with dominant chromas of more than 2 in hues of 10YR or redder, or more than 3 in hues of 2.5Y or yellow, and accompanied by mottles;
- b. have less than 5 percent (by volume) of plinthite in all subhorizons within 1.5 m (60 inches) of the surface;
- c. have an ochric epipedon; no A1 horizon thicker than 6 inches if its color value is less than 3.5 when moist; or have an Ap horizon with a moist color value of 4 or more, or with a dry color value of 6 or more when crushed and smoothed.

Aeric Fragiaqualfs. Fragiaqualfs like the Typic except for a.

Plinthic Fragiaqualfs. Fragiaqualfs like the Typic except for b.

Umbric Fragiaqualfs. Fragiaqualfs like the Typic except for c.

Glossaqualfs. Aqualfs that

1. have no fragipan, duripan, or natric horizon but that have an albic horizon tonguing into an argillic horizon;
2. have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more.

Typic Glossaqualfs. Glossaqualfs that

- a. have in 60 percent * or more of the matrix in all subhorizons between the A1 or Ap and 75 cm (30 inches) one or more of the following:
 - (1) if mottled and mean annual soil temperature is less than 15°C (59°F), moist chromas are 2 or less;
 - (2) if mottled and mean annual soil temperature is 15°C (59°F) or more:
 - (a) in hues of 2.5Y or redder and moist values more than 5, chromas are 2 or less, or
 - (b) in hues of 2.5Y or redder and moist values of 5 or less, moist chromas are 1 or less, or
 - (c) in hues yellower than 2.5Y, moist chromas are 2 or less;
 - (3) moist chromas are 1 or less with or without mottles;
- b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- c. have an A1 horizon less than 15 cm (6 inches) thick if its moist value is darker than 3.5, or an Ap horizon having a moist value of 4 or more, or a dry value of 6 or more when crushed and smoothed.

* If hues are 7.5YR or redder in the matrix: if peds are present, ped exteriors have dominant moist chromas of 1 or less in the argillic horizon, and ped interiors have mottles with moist chromas of 2 or less; if peds are absent, moist chromas are 1 or less immediately below any surface horizon that has moist values of less than 3.5.

Alfisols

Aeric Glossaqualfs. Glossaqualfs like the Typic except for a.

Arenic Glossaqualfs. Glossaqualfs like the Typic except for b.

Mollic Glossaqualfs. Glossaqualfs like the Typic except for c.

Natraqualfs. Aqualfs that have a natric horizon.

Typic Natraqualfs. Natraqualfs that

- a. have more than 15 percent saturation with sodium or more magnesium and sodium than calcium and hydrogen throughout the argillic horizon;
- b. have no tonguing or interfingering of an albic horizon into the natric horizon;
- c. have an Al horizon less than 15 cm (6 inches) thick if its moist value is darker than 3.5, or have an Ap horizon with a moist value of 4 or more;

Albic Natraqualfs. Natraqualfs like the Typic except for a.

Albic Glossic Natraqualfs. Natraqualfs like the Typic except for a and b.

Glossic Natraqualfs. Natraqualfs like the Typic except for b.

Mollic Natraqualfs. Natraqualfs like the Typic except for c.

Ochraqualfs. Aqualfs that

1. have an ochric epipedon, but have no fragipan, natric horizon, or duripan;
2. have no tonguing of an albic horizon into the argillic horizon;
3. have no abrupt textural change between the albic and argillic horizons;
4. have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more.

Typic Ochraqualfs. Ochraqualfs that

- a. have in 60 percent * or more of the matrix in all subhorizons between the Al or Ap and 75 cm (30 inches) one or more of the following:
 - (1) if mottled and mean annual soil temperature is less than 15°C (59°F), moist chromas are 2 or less;
 - (2) if mottled and mean annual soil temperature is 15°C (59°F) or more:
 - (a) in hues of 2.5Y or redder and moist values more than 5, chromas are 2 or less, or
 - (b) in hues of 2.5Y or redder and moist values of 5 or less, moist chromas are 1 or less, or
 - (c) in hues yellower than 2.5Y, moist chromas are 2 or less;
 - (3) moist chromas are 1 or less with or without mottles;
- b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- c. have an Al horizon less than 15 cm (6 inches) thick if its moist value is darker than 3.5, or an Ap horizon having a moist value of 4 or more, or a dry value of 6 or more when crushed and smoothed.

* If hues are 7.5YR or redder in the matrix: if peds are present, ped exteriors have dominant moist chromas of 1 or less in the argillic horizon, and ped interiors have mottles with moist chromas of 2 or less; if peds are absent, moist chromas are 1 or less immediately below any surface horizon that has moist values of less than 3.5.

Alfisols

Typic Ochraqualfs--Cont.

- d. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- e. lack 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 (20 inches) and that are at least 30 cm (12 inches) long in some part and that extend to the base of an Ap or an albic horizon, and
 - (2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aeric Ochraqualfs. Ochraqualfs like the Typic except for a.

Aeric Umbric Ochraqualfs. Ochraqualfs like the Typic except for a and c.

Andic Ochraqualfs. Ochraqualfs like the Typic except for b.

Andic Umbric Ochraqualfs. Ochraqualfs like the Typic except for b and c and have an epipedon that meets all requirements for an umbric epipedon except that it is too thin.

Arenic Ochraqualfs. Ochraqualfs like the Typic except for d.

Chromudertic Ochraqualfs. Ochraqualfs like the Typic except for a and e.

Mollic Ochraqualfs. Ochraqualfs like the Typic except for c and have an epipedon that meets all the requirements for a mollic epipedon except thickness.

Udollic Ochraqualfs. Ochraqualfs like the Typic except for a and c.

Umbric Ochraqualfs. Ochraqualfs like the Typic except for c and have an epipedon that meets all the requirements for an umbric epipedon except that it is too thin.

Vertic Ochraqualfs. Ochraqualfs like the Typic except for e or c and e.

Tropaqualfs. Aqualfs that

- 1. have a mean annual soil temperature of 8°C (47°F) or higher and mean summer and mean winter soil temperatures at 50 cm (20 inches) or above a lithic or paralithic contact, whichever is shallower, that differ by less than 5°C (9°F);
- 2. have no fragipan, natric horizon, or duripan.

Typic Tropaqualfs. Tropaqualfs that

- a. have in 60 percent * or more of the matrix in all subhorizons between the A1 or Ap and 75 cm (30 inches) one or more of the following:
 - (1) if mottled and mean annual soil temperature is less than 15°C (59°F), moist chromas are 2 or less;
 - (2) if mottled and mean annual soil temperature is 15°C (59°F) or more:
 - (a) in hues of 2.5Y or redder and moist values more than 5, chromas are 2 or less, or
 - (b) in hues of 2.5Y or redder and moist values of 5 or less, moist chromas are 1 or less, or
 - (c) in hues yellower than 2.5Y, moist chromas are 2 or less;

* If hues are 7.5YR or redder in the matrix: if peds are present, ped exteriors have dominant moist chromas of 1 or less in the argillic horizon, and ped interiors have mottles with moist chromas of 2 or less; if peds are absent, moist chromas are 1 or less immediately below any surface horizon that has moist values of less than 3.5.

Alfisols

Typic Tropoqualfs--Cont.

- (3) moist chromas are 1 or less with or without mottles;
- b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- c. have an Al horizon less than 15 cm (6 inches) thick if its moist value is darker than 3.5, or an Ap horizon having a moist value of 4 or more, or a dry value of 6 or more when crushed and smoothed.
- d. lack 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 (20 inches) and that are at least 30 cm (12 inches) long in some part and that extend to the base of an Ap or an albic horizon, and
 - (2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aeric Tropoqualfs. Tropoqualfs like the Typic except for a.

Aeric Mollic Tropoqualfs. Tropoqualfs like the Typic except for a and c.

Mollic Tropoqualfs. Tropoqualfs like the Typic except for c.

Vertic Tropoqualfs. Tropoqualfs like the Typic except for d.

Umbrqualfs. Aqualfs that

- 1. have an umbric epipedon but have no fragipan or natric horizon or duripan;
- 2. have no albic horizon that tongues into the argillic horizon and have no abrupt textural change between the albic and argillic horizons;
- 3. have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more.

Typic Umbrqualfs. Umbrqualfs that

- a. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- b. lack in the umbric epipedon and horizons above the argillic, soft discrete nodules that are 2.5 to 30 cm (1 to 12 inches) in diameter that constitute more than 5 percent of the volume, that are cemented by iron, and that are accompanied by an irregular or broken upper boundary of the argillic horizon.

Andic Umbrqualfs. Umbrqualfs like the Typic except for a.

Boralfs. Alfisols that

- 1. are not saturated with water at any season or lack the characteristics associated with wetness defined for Aqualfs;

Alfisols

Boralfs--Cont.

2. have a mean annual soil temperature of less than 8°C (47°F) and one or both of:
 - a. an albic horizon that is continuous, that has moist and dry chromas of 2 or less* dominant in the matrix of some subhorizon, and that tongues or interfingers into an argillic or natric horizon; if the epipedon has loamy fine sand or coarser textures and has an argillic horizon in lamellae, the albic horizon is continuous throughout each pedon from the base of the Ap horizon or 15 cm (6 inches), whichever is deeper, to the argillic horizon;
 - b. a mean summer soil temperature at 50 cm (20 inches) or above a lithic or paralithic contact, whichever is shallower, of either less than 15°C (59°F) if cultivated or lacking a O horizon, or less than 8°C (47°F) if with an O horizon.

Cryoboralfs. Boralfs that

1. have a mean summer soil temperature at 50 cm (20 inches) or above a lithic or paralithic contact, whichever is shallower, of less than 15°C (59°F) if cultivated or lacking an O horizon, or less than 8°C (47°F) if with an O horizon;
2. have no argillic horizon with its upper boundary deeper than 60 cm** (24 inches) below the mineral surface unless there are textures coarser than loamy very fine sand in all subhorizons above the argillic horizon;
3. have no fragipan or natric horizon.

Typic Cryoboralfs. Cryoboralfs that

- a. have an Ap horizon with moist color value of 4 or more or with a dry color value of 6 or more, crushed and smoothed; or an Al horizon with a moist color value of more than 3.5 if thicker than 15 cm (6 inches);
- b. lack an albic horizon that tongues into the argillic or natric horizon;
- c. lack a lithic contact within 50 cm (20 inches) of the surface;
- d. have an Ap with a moist value of more than 3, or the upper 6 inches of the soil have color values of more than 3.5.
- e. have a mean annual soil temperature of more than 0°C (32°F);
- f. have an argillic horizon that has a texture finer than loamy fine sand and is continuous vertically for at least the upper 15 cm (6 inches) (not in lamellae).

Andic Cryoboralfs. Cryoboralfs like the Typic except for a.

Glossic Cryoboralfs. Cryoboralfs like the Typic except for b.

Lithic Cryoboralfs. Cryoboralfs like the Typic except for c.

Mollic Cryoboralfs. Cryoboralfs like the Typic except for d.

Pergelic Cryoboralfs. Cryoboralfs like the Typic except for e.

Eutroboralfs. Boralfs that

1. have temperatures higher than those of Cryoboralfs;
2. have base saturation (by sum of cations) of 60 percent or more in all subhorizons of an argillic horizon;
3. have a dry horizon at some time during the year in most years.

* If hues are redder than 10YR because of red parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived.

** If there is a surface mantle that has more than 60 percent vitric volcanic ash, cinders or other vitric pyroclastic materials, the depth to the argillic horizon is measured from the base of this mantle rather than from the mineral surface. Note that even though the combined thickness of the albic and argillic horizons is less than 18 cm (7 inches) the soil is classified as a Cryoboralf if the argillic horizon can be identified.

Alfisol

Entroboralfs--Cont.

4. have no fragipan or natric horizon;
5. have an argillic horizon with its upper boundary within 60 cm * (24 inches) of the mineral surface unless there are textures coarser than loamy very fine sand in all subhorizons above the argillic horizon.

Typic Entroboralfs. Entroboralfs that

- a. have no mottles with chromas of 2 or less in the upper 25 cm (10 inches) of the argillic horizon; (this does not exclude the presence of bleached silt or sand coatings on pedis beside or below tongues of the albic horizon);
- b. have a texture finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- c. have tonguing of an albic horizon into the argillic horizon;
- d. have no lithic contact within 50 cm (20 inches) of the surface;
- e. have an Ap horizon with a moist value of more than 3 or an Al horizon less than 15 cm (6 inches) thick if the moist color value is less than 3.5.
- f. have an argillic horizon that has a texture finer than loamy fine sand and is continuous vertically for at least the upper 15 cm (6 inches) (not in lamellae).

Aquic Entroboralfs. Entroboralfs like the Typic except for a.

Arenic Entroboralfs. Entroboralfs like the Typic except for b.

Hapludic Entroboralfs. Entroboralfs like the Typic except for c.

Hapludic Litnic Entroboralfs. Entroboralfs like the Typic except for c and d.

Lithic Entroboralfs. Entroboralfs like the Typic except for d.

Mollic Entroboralfs. Entroboralfs like the Typic except for e.

Fragiboralfs. Boralfs that

1. have a fragipan but no natric horizon;
2. have an argillic horizon with its upper boundary within 60 cm * (24 inches) of the mineral surface unless there are textures coarser than loamy very fine sand in all subhorizons above the argillic horizon.

Typic Fragiboralfs. Fragiboralfs that

- a. have no mottles with chromas of 2 or less in the argillic horizon;
- b. have an albic horizon that tongues into the argillic horizon.

Aquic Fragiboralfs. Fragiboralfs like the Typic except for a.

Fragiudic Fragiboralfs. Fragiboralfs like the Typic except for b.

Glossoboralfs. Boralfs that

1. have temperatures higher than those of Cryoboralfs;
2. a. are never dry in any horizon in most years, or
 - b. have base saturation (by sum of cations) of less than 60 percent in some subhorizon of the argillic horizon;
3. have no fragipan or natric horizon;

* If there is a surface mantle that has more than 60 percent vitric volcanic ash, cinders or other vitric pyroclastic materials, the depth to the argillic horizon is measured from the base of this mantle rather than from the mineral surface.

Alfisols

Glossoboralfs--Cont.

4. have an argillic horizon with its upper boundary within 60 cm * (24 inches) of the mineral surface unless there are textures coarser than loamy very fine sand in all subhorizons above the argillic horizon.

Typic Glossoboralfs. Glossoboralfs that

- a. have no mottles with chromas of 2 or less in the upper 25 cm (10 inches) of the argillic horizon;
- b. have base saturation (by sum of cations) of less than 60 percent in some part of the argillic horizon;
- c. are permanently moist in all horizons if the base saturation (by sum of cations) is 60 percent or more in all the argillic horizon;
- d. have tonguing of an albic horizon into the argillic horizon;
- e. have no lithic contact within 50 cm (20 inches) of the surface;
- f. have an A1 less than 15 cm (6 inches) thick if the moist color value is less than 3.5, or an Ap horizon with a moist value of 4 or more, or a dry color value of 6 or more when crushed and smoothed.
- g. have an argillic horizon that has a texture finer than loamy fine sand and is continuous vertically for at least the upper 15 cm (6 inches) (not in lamellae).

Aquic Glossoboralfs. Glossoboralfs like the Typic except for a.

Entric Glossoboralfs. Glossoboralfs like the Typic except for c.

Hapludic Glossoboralfs. Glossoboralfs like the Typic except for d.

Lithic Glossoboralfs. Glossoboralfs like the Typic except for e.

Mollic Glossoboralfs. Glossoboralfs like the Typic except for f.

Natriboralfs. Boralfs that have a natric horizon (Natriboralfs occur in other countries but are not yet known in the United States. Subgroups are not developed.).

Paleboralfs. Boralfs that

1. have an argillic horizon that has an upper boundary deeper than 60 cm (24 inches) below the mineral surface*;
2. have textures finer than loamy fine sand in some subhorizon above the argillic horizon.

Typic Paleboralfs. Paleboralfs that

- a. have an argillic horizon with an increase in clay content of less than 20 percent (absolute) within a vertical distance of 7.5 cm (3 inches) from the upper boundary;
- b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- c. have no mottles with chromas of 2 or less within 1 m (40 inches) of the surface;
- d. have a mean summer soil temperature at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, of more than 15°C (59°F) if without an O horizon and more than 8°C (47°F) if with an O horizon;

* If there is a surface mantle that has more than 60 percent vitric volcanic ash, cinders or other vitric pyroclastic materials, the depth to the argillic horizon is measured from the base of this mantle rather than from the mineral surface.

Alfisol

Typic Paleboralfs--Cont.

- e. have base saturation (by NH_4OAc) of more than 60 percent in all subhorizons of the argillic horizon;
- f. have tonguing or interfingering of an albic horizon into the argillic horizon;
- g. have an A1 less than 15 cm (6 inches) thick if the moist color value is less than 3.5, or an Ap horizon with a moist value of 4 or more, or a dry color value of 6 or more when crushed and smoothed.

Abruptic Paleboralfs. Paleboralfs like the Typic except for a.

Aquic Paleboralfs. Paleboralfs like the Typic except for c.

Aquic Cryic Paleboralfs. Paleboralfs like the Typic except for c and d.

Cryic Paleboralfs. Paleboralfs like the Typic except for d.

Cryic Glossic Paleboralfs. Paleboralfs like the Typic except for d and e.

Cryic Mollic Paleboralfs. Paleboralfs like the Typic except for d and g.

Glossic Paleboralfs. Paleboralfs like the Typic except for e.

Udalfs. Alfisols that

1. have a mean summer soil temperature at 50 cm (20 inches) or above a lithic or paralithic contact, whichever is shallower, or 15°C (59°F) or more if cultivated or lacking an O horizon, or 8°C (47°F) or more if with an O horizon;
2. are usually moist, and are not dry in most years for as much as 60 consecutive days in all parts or 90 cumulative days in some horizon between 18 and 50 cm (7 and 20 inches) and lack a calcic horizon or a horizon with soft powdery secondary lime in or within 50 cm (20 inches) below the base of the argillic horizon;
3. are not saturated with water at any period or lack the characteristics associated with wetness defined for Aqualfs;
4. lack an albic horizon that is continuous, that has dominant moist and dry chromas of 2 or less in the matrix of some subhorizon, and that tongues or interfingers into an argillic or natric horizon, or have a mean annual soil temperature of 8°C (47°F) or more.

Agrudalfs. Udalfs that have an agric horizon. (These soils are not known in the United States.)

Ferrudalfs. Udalfs that

1. have no agric or natric horizon, or fragipan;
2. have no continuous albic horizon that has dominant chromas of 2 or less in the matrix of some subhorizon above the argillic horizon;
3. have a broken upper boundary of the argillic horizon;
4. have discrete nodules in the argillic horizon that range from 2.5 to 5 cm (1 to 2 inches) up to about 30 cm (12 inches) in diameter; exteriors of nodules are enriched and weakly cemented or indurated with iron and have redder hues or stronger chromas than interiors of nodules;
5. have mean summer and mean winter soil temperatures at 50 cm (20 inches) or a lithic or a paralithic contact, whichever is shallower, that differ by 5°C (9°F) or more.

(Typically textures are sandy and the argillic horizon consists of nodules arranged like broken lamellae. These soils have not been identified in the United States. The nodular, broken argillic horizon has often been confused with mottling.)

Fragiudalfs. Udalfs that

1. have a fragipan;
2. have no agric horizon.

Alfisol

Typic Fragiudalfs. Fragiudalfs that

- a. have no mottles with chromas of 2 or less within the upper 25 cm (10 inches) of the argillic horizon;
- b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.
- c. have an argillic horizon above the fragipan;
- d. have an Ap horizon with moist color value of 4 or more or with a dry color value of 6 or more, crushed and smoothed; or an Al horizon with a moist color value of more than 3.5 if thicker than 15 cm (6 inches);
- e. have a fragipan that has a brittle matrix in at least 70 percent of the cross section of the most strongly cemented subhorizon;
- f. have in the subhorizon directly above the fragipan, ped coatings that have dominant moist chromas of 3 or more; or if ped coatings consist of clean silt and sand grains (skeletalans), with chromas of 2 or less, the coatings are less than 1 mm thick;
- g. have no albic horizon tonguing into the argillic horizon from above.

Albaquic Fragiudalfs. Fragiudalfs like the Typic except for a, and within 3 inches vertical distance at the top of the argillic horizon, have a clay increase of more than 15 percent of the fine earth fraction.

Aqueptic Fragiudalfs. Fragiudalfs like the Typic except for a and f, with or without c, and between the fragipan and the Al or Ap, have a horizon with dominant chromas of 3 or more and mottles of 2 or less.

Aquic Fragiudalfs. Fragiudalfs like the Typic except for a.

Dystrandepitic Fragiudalfs. Fragiudalfs like the Typic except for b, c and d and the epipedon meets all requirements for an umbric epipedon except thickness.

Glossic Fragiudalfs. Fragiudalfs like the Typic except for g, with or without f.

Mollic Fragiudalfs. Fragiudalfs like the Typic except for b.

Ochreptic Fragiudalfs. Fragiudalfs like the Typic except for f, with or without c and have a horizon between the fragipan and the Al or Ap that

- (1) is 25 cm (10 inches) or more thick;
- (2) has chromas of 3 or more in the matrix;
- (3) has no mottles with chromas of 2 or less in the upper 25 cm (10 inches).

Umbraptic Fragiudalfs. Fragiudalfs like the Typic except for c and d and the epipedon meets all requirements for an umbric epipedon except thickness.

Glossudalfs. Udalfs that

1. have an albic horizon (or other eluvial horizon with clean silt or sand grains (skeletalans) as ped coatings) that tongues into the argillic horizon;
2. have no discrete nodules 2.5 to 30 cm (1 to 12 inches) in size in the argillic horizon with exteriors enriched, weakly cemented, or indurated with iron;
3. have mean summer and mean winter soil temperatures at 50 cm (20 inches) or a lithic or a paralithic contact that differ by 5°C (9°F) or more;
4. have no natric or agric horizons, and no fragipan.

Alfisols

Typic Glossudalfs. Glossudalfs that

- a. have no abrupt textural change if there are mottles in the upper 25 cm (10 inches) of the argillic horizon;
- b. have a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- c. have no mottles with chromas of 2 or less in the upper 25 cm (10 inches) of the argillic horizon, or within 75 cm (20 inches) of the surface, whichever depth is shallower;
- d. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- e. have no lithic contact within 50 cm (20 inches) of the surface.

Aquic Glossudalfs. Glossudalfs like the Typic except for c.Hapludalfs * (formerly Normudalfs). Udalfs that

1. have no albic horizon (or other eluvial horizon with clean silt or sand grains (skeletons) as ped coatings) that tongues into the argillic horizon;
2. have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;
3. have no fragipan or natric or agric horizons;
4. have an argillic horizon with a clay distribution such that the clay decreases by 20 percent or more of the maximum clay content within 1.5 m (60 inches) of the surface if:
 - a. hues are redder than 10YR with chromas of more than 4 dominant, or
 - b. hues are 2.5YR or redder, moist color values are less than 4 and dry color values are less than 5 throughout the major part of the argillic horizon, or
 - c. there are many coarse mottles that have hues redder than 7.5YR or chromas of more than 5.

Typic Hapludalfs. Hapludalfs that

- a. have no abrupt textural change if there are mottles in the upper 25 cm (10 inches) of the argillic horizon;
- b. lack a layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- c. have an argillic horizon that is free of mottles with chromas of 2 or less in the upper 25 cm (10 inches), or if the upper boundary of the argillic horizon is deeper than 50 cm (20 inches) have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;
- d. have within 50 cm (20 inches) of the surface textures finer than loamy fine sand in some subhorizon;

* No great group of Rhodudalfs has been provided. If Udalfs that fit the present definition of Hapludalfs are found with the colors of Rhodustalfs, addition of a great group of Rhodudalfs would need to be considered.

Typic Hapludalfs--Cont.

- e. have no interfingering of an albic horizon into the upper argillic horizon, with the albic horizon surrounding some peds;
- f. have no lithic contact within 50 cm (20 inches) of the surface;
- g. have an Ap horizon with a moist color value of 4 or more or with a dry color value of 6 or more (crushed and smoothed), or the A1 horizon is less than 15 cm (6 inches) thick if its moist value is lower than 3.5;
- h. have exchangeable sodium less than 10 percent of the cation exchange capacity throughout the argillic horizon;
- i. have an argillic horizon that is continuous horizontally, that is continuous vertically for at least the upper 20 cm (8 inches), and has a texture finer than loamy fine sand;
- j. have base saturation (by sum of cations) of more than 60 percent at a depth of 1.25 m (50 inches) below the top of the argillic horizon;
- k. lack 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 (20 inches) and that are at least 30 cm (12 inches) long in some part that extend 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Albaquic Hapludalfs. Hapludalfs like the Typic except for a and c.

Andic Hapludalfs. Hapludalfs like the Typic except for b.

Andic Glossoboric Hapludalfs. Hapludalfs like the Typic except for b and c.

Andic Mollic Hapludalfs. Hapludalfs like the Typic except for b and g.

Andic Mollic Glossoboric Hapludalfs. Hapludalfs like the Typic except for b, e and g.

Aquic Hapludalfs. Hapludalfs like the Typic except for c or c and j.

Aquic Arenic Hapludalfs. Hapludalfs like the Typic except for c and d.

Aquic Lithic Hapludalfs. Hapludalfs like the Typic except for c and f.

Aquollic Hapludalfs. Hapludalfs like the Typic except for c and g.

Arenic Hapludalfs. Hapludalfs like the Typic except for d.

Glossaquic Hapludalfs. Hapludalfs like the Typic except for e and c, or e, c and g.

Glossoboric Hapludalfs. Hapludalfs like the Typic except for e or e and g.

Lithic Hapludalfs. Hapludalfs like the Typic except for f.

Lithic Mollic Hapludalfs. Hapludalfs like the Typic except for f and g.

Mollic Hapludalfs. Hapludalfs like the Typic except for g.

Natraqaic Hapludalfs. Hapludalfs like the Typic except for c and h.

Natraboric Hapludalfs. Hapludalfs like the Typic except for h and e.

Natriborollic Hapludalfs. Hapludalfs like the Typic except for g, e and h.

Psammentic Hapludalfs. Hapludalfs like the Typic except for i or d and i.

Alfisol

Hapludalfs--Cont.

Ultic Hapludalfs. Hapludalfs like the Typic except for j.

Umbraquiltic Hapludalfs. Hapludalfs like the Typic except for c, g and j.

Vertic Hapludalfs. Hapludalfs like the Typic except for k.

Natrudalfs. Udalfs that have a natric horizon but no fragipan.

Typic Natrudalfs. Natrudalfs that

- a. have mottles with chromas of 2 or less within 25 cm (10 inches) of the upper boundary of the natric horizon;
- b. have in all parts of the natric horizon more than 15 percent saturation with sodium or more magnesium and sodium than calcium and hydrogen;
- c. have an Ap horizon with moist color values of more than 3 or an A1 horizon with a moist color value of more than 3.5 if thicker than 15 cm (6 inches);
- d. lack 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 (20 inches), that are at least 30 cm (12 inches) long in some part, that extend 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil of the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Vertic Natrudalfs. Natrudalfs like the Typic except for d.

Paleudalfs. Udalfs that have no natric or agric horizons or fragipan but have an argillic horizon with a clay distribution such that the content does not decrease from the maximum by as much as 20 percent of the maximum within a depth of 1.5 m (60 inches) from the surface and with one or more of the following:

1. hues are redder than 10YR and chromas are more than 4 in the matrix of at least the lower part of the argillic horizon; or
2. hues are 2.5YR or redder and moist values are less than 4 and dry values are less than 5 throughout the major part of the argillic horizon; or
3. many coarse mottles with hues redder than 7.5YR or chromas more than 5, or both.

Typic Paleudalfs. Paleudalfs that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the soil surface providing color is not due to uncoated grains of sand. If color is due to uncoated grains of sand, no mottles with chromas of 2 or less in the upper 12.5 cm (5 inches) of the argillic horizon;
- b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- c. have base saturation (by sum of cations) of more than 60 percent at a depth of 1.25 m (50 inches) below the top of the argillic horizon;
- d. have no increase of as much as 15 percent clay within a vertical distance of one inch at the upper boundary of the argillic horizon, and have no increase of as much as 10 percent clay between the plow layer and the uppermost subhorizon of the argillic horizon if the soil is cultivated and the lower boundary of the Ap is the upper boundary of the argillic horizon;

Typic Paleudalfs--Cont.

- e. have an Ap horizon with a moist color value of 4 or more or with a dry color value of 6 or more (crushed and smoothed), or the A1 horizon is less than 15 cm (6 inches) thick if its moist value is lower than 3.5;
- f. have an argillic horizon with dry color values of 5 or more in some subhorizon, and moist color value more than 1 unit less than the dry value;
- g. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches); and
 - (3) more than 35 percent clay in horizons that total more than 50 cm in thickness within the control section;
- h. have less than 5 percent (by volume) of plinthite in all subhorizons within 1.5 m (60 inches) of the surface;
- i. have an argillic horizon that is continuous horizontally, that is continuous vertically for at least the upper 20 cm (8 inches), and has a texture finer than loamy fine sand.

Albaquic Paleudalfs. Paleudalfs like the Typic except for a and d.

Aquic Paleudalfs. Paleudalfs like the Typic except for a.

Aquiltic Paleudalfs. Paleudalfs like the Typic except for a and e.

Arenic Paleudalfs. Paleudalfs like the Typic except for b and have sandy epipedons between 50 cm (20 inches) and 1 m (40 inches) thick.

Grossarenic Paleudalfs. Paleudalfs like the Typic except for b and have sandy epipedons more than 1 m (40 inches) thick.

Mollic Paleudalfs. Paleudalfs like the Typic except for c.

Plinthic Paleudalfs. Paleudalfs like the Typic except for h.

Rhodudultic Paleudalfs. Paleudalfs like the Typic except for c, e, and f.

Ultic Paleudalfs. Paleudalfs like the Typic except for e.

Vertic Paleudalfs. Paleudalfs like the Typic except for g.

Tropudalfs. Udalfs that

- 1. have mean summer and mean winter soil temperatures at 50 cm (20 inches) or a lithic or a paralithic contact, whichever is shallower, that differ by less than 5°C (9°F);
- 2. have no agric or natric horizons or a fragipan;
- 3. have an argillic horizon that has a clay distribution such that the clay decreases from the maximum by more than 20 percent of the maximum within a depth of 1.5 m (60 inches) from the surface if:
 - a. hues are redder than 10YR and chromas are more than 4 in the matrix of at least the lower part of the argillic horizon; or
 - b. hues are 2.5YR or redder and moist values are less than 4 and dry values are less than 5 throughout the major part of the argillic horizon; or
 - c. many coarse mottles with hues redder than 7.5YR or chromas more than 5, or both.

Alfisols

Typic Tropudalfs. Tropudalfs that

- a. have no lithic contact within 50 cm (20 inches) of the surface;
- b. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the soil surface providing color is not due to uncoated grains of sand. If color is due to uncoated grains of sand, no mottles with chromas of 2 or less in the upper 12.5 cm (5 inches) of the argillic horizon;
- c. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- d. have no abrupt textural change if there are mottles in the upper 25 cm (10 inches) of the argillic horizon;
- e. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- f. have an Ap horizon with a moist color value of 4 or more or with a dry color value of 6 or more (crushed and smoothed), or the A1 horizon is less than 15 cm (6 inches) thick if its moist value is lower than 3.5;
- g. have an argillic horizon that is continuous horizontally, that is continuous vertically for at least the upper 20 cm (8 inches), and has a texture finer than loamy fine sand;
- h. have base saturation (by sum of cations) of more than 60 percent at a depth of 1.25 m (50 inches) below the top of the argillic horizon;
- i. have more than 24 meq. CEC/100g clay (by NH_4OAc) and have a cation retention from NH_4Cl of more than 12 meq/100g clay in the major part of the argillic horizon.

Lithic Tropudalfs. Tropudalfs like the Typic except for a.Ustalfs. Alfisols that

1. have soil temperatures higher than those of Boralfs;
2. are not saturated with water at any period or lack the characteristics associated with wetness defined for Aqualfs;
3. are not continuously dry in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches) or in the subhorizon immediately above a lithic or a paralithic contact shallower than 18 cm (7 inches) for as long as 60 consecutive days in more than 7 out of 10 years unless the mean annual soil temperature is 22°C (72°F) or higher, or the mean summer and mean winter soil temperatures at 50 cm (20 inches) depth or at a lithic or a paralithic contact, whichever is shallower, differ by less than 5°C (9°F), or both, and have one or more of the following:
 - a. dry for 90 cumulative days or more in most years in some subhorizon(s) of the soil between 18 and 50 cm (7 and 20 inches) or above a lithic or a paralithic contact shallower than 50 cm (20 inches),
 - b. base saturation (by NH_4OAc) of 80 percent or higher in all parts of the soil above a lithic or a paralithic contact that occurs within 50 cm (20 inches) of the surface,
 - c. within 1.5 m (60 inches) of the soil surface or within 50 cm (20 inches) below the base of an argillic horizon, either a calcic horizon or a horizon with concentrations of soft powdery lime in spheroidal forms, as coatings on peds, or disseminated in clay size particles, *
 - d. no natric horizon but increasing saturation with Na plus K within 1.25 m (50 inches) of the surface if particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey.

* If the lime is disseminated, the horizon(s) in which the lime is concentrated should have more lime than the underlying horizon and should have the maximum percentage of clay-sized lime.

Alfisol

Durustalfs. Ustalfs that have a duripan within 1 m (40 inches) of the surface.

Typic Durustalfs. Durustalfs that

- a. have a massive platy or prismatic duripan that is indurated in some subhorizon or has more than half of its upper boundary indurated and coated with opal or opal and sesquioxides;
- b. have no mottles with chromas of 2 or less in the argillic horizon;
- c. have an argillic but not a natric horizon.

Haplic Durustalfs. Durustalfs like the Typic except for a and have an argillic horizon that has either less than 35 percent clay in all parts or has less than 15 percent clay increase within a vertical distance of 2.5 cm (1 inch) at the upper boundary of the argillic horizon.

Natric Durustalfs. Durustalfs like the Typic except for c.

Haplustalfs. Ustalfs that

1. have an argillic horizon but no natric horizon;
2. have no duripan with its upper boundary within 1 m (40 inches) of the surface;
3. have no petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the surface;
4. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within any subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface;
5. have an argillic horizon that has colors in hues no redder than 5YR, or that has moist values of 4 or more, or dry values more than 1 unit higher than moist values;
6. have an argillic horizon that has:
 - a. a clay distribution such that the content of clay decreases from the maximum by more than 20 percent of that maximum within a depth of less than 1.5 m (60 inches) from the surface if:
 - (1) hues are redder than 10YR and chromas are more than 4 in the matrix; or
 - (2) there are common coarse mottles with hues of 7.5YR or redder or chromas of more 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 (3 inches) or 15 percent within 2.5 cm (1 inch) at the upper boundary.

Typic Haplustalfs. Haplustalfs that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;
- b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- c. have no lithic contact within 50 cm (20 inches) of the surface;
- d. have CEC of more than 24 meq/100g clay (by NH_4OAc), and have a cation retention from NH_4Cl of more than 12 meq/100g clay in the major part of the argillic horizon. (See Oxidic horizon for definition of cation retention.)
- e. have an argillic horizon that is continuous horizontally, that is continuous vertically for at least the upper 20 cm (8 inches), is not composed entirely of lamellae, and has a texture finer than loamy fine sand;

Alfisol

Typic Haplustalfs--Cont.

f. have either or both:

- (1) a calcic horizon or soft powdery secondary lime within 1 m (40 inches) of the surface if particle-size class is sandy, 70 cm (28 inches) if loamy, and
- (2) increasing saturation with Na plus K with increasing depth within 1.25 m (50 inches) if the particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey;

g. have an argillic horizon with base saturation (by sum of cations) of 75 percent or more in some portion.

Aquic Haplustalfs. Haplustalfs like the Typic except for a or a and f.

Aquultic Haplustalfs. Haplustalfs like the Typic except for a and g; or a, f and g.

Arenic Haplustalfs. Haplustalfs like the Typic except for b.

Lithic Haplustalfs. Haplustalfs like the Typic except for c.

Lithic Ultic Haplustalfs. Haplustalfs like the Typic except for c and g; or c, f, and g.

Oxic Haplustalfs. Haplustalfs like the Typic except for d, or d and g.

Psammentic Haplustalfs. Haplustalfs like the Typic except for e, with or without g; or e and f, with or without g; or b, e, and f, with or without g.

Udic Haplustalfs. Haplustalfs like the Typic except for f.

Ultic Haplustalfs. Haplustalfs like the Typic except for g or f and g.

Natrustalfs. Ustalfs that have a natric horizon, but have no duripan with its upper boundary within 1 m (40 inches) of the surface, or plinthite that forms a continuous phase or constitutes more than half of the volume of any subhorizon within 1.25 m (50 inches) of the surface.

Typic Natrustalfs. Natrustalfs that

- a. have no mottles with chromas of 2 or less within 50 cm (20 inches) of the soil surface;
- b. have an Ap horizon with moist color values of more than 3 or an Al horizon having a moist color value of more than 3.5 if thicker than 15 cm (6 inches);
- c. have no salic horizon within 75 cm (30 inches) of the soil surface;
- d. lack 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 (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Natrustalfs. Natrustalfs like the Typic except for a.

Mollic Natrustalfs. Natrustalfs like the Typic except for b.

Salorthidic Natrustalfs. Natrustalfs like the Typic except for c.

Alfisol

Paleustalfs. Ustalfs that

1. have a petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the surface or have an argillic horizon that has one or both of:
 - a. a vertical clay distribution such that the clay does not decrease from the maximum by as much as 20 percent of that maximum within a depth of 1.5 m (60 inches) from the surface and one or both of:
 - (1) hues redder than 10YR and chromas of more than 4 in the matrix,
 - (2) common coarse mottles with hues of 7.5YR or redder or chromas of more than 5, or
 - b. a particle-size class that is clayey in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary;
2. have no duripan within 1 m (40 inches) of the surface and no natric horizon;
3. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within any subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface;

Typic Paleustalfs. Paleustalfs that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the soil surface providing color is not due to uncoated grains of sand. If color is due to uncoated grains of sand, no mottles occur with chromas of 2 or less in the upper 12.5 cm (5 inches) of the argillic horizon;
- b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- c. have less than 5 percent plinthite by volume in all subhorizons within 1.5 m (60 inches) of the soil surface;
- d. have either or both of:
 - (1) a calcic horizon, or soft powdery secondary lime within a depth of 1 m (40 inches) if particle-size class is sandy, 70 cm (28 inches) if loamy, and 60 cm (24 inches) if clayey, or
 - (2) increasing saturation with Na plus K with increasing depth within 1.25 m (50 inches) if the particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey;
- e. have an argillic horizon with base saturation (by sum of cations) of 75 percent or more in some part;
- f. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
- g. have no petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the soil surface;

Alfisols

Typic Paleustalfs--Cont.

- h. have a sandy or loamy particle-size class in the upper part of the argillic horizon, or have less than 20 percent (absolute) increase in clay within a vertical distance of 7.5 cm (3 inches) at the upper boundary of the argillic horizon and less than 15 percent clay (absolute) within 2.5 cm (1 inch);
- i. have a CEC of more than 24 meq/100 gm clay (by NH_4OAc) and have a cation retention from NH_4Cl of more than 12 meq/100 gm clay in the major part of the argillic horizon;
- j. have an argillic horizon that has colors in hues of 5YR or yellower in some part, or has moist values of 4 or more in some part or dry values that are more than 1 unit higher than moist values.

Aquic Paleustalfs. Paleustalfs like the Typic except for a or a and d.

Aquic Arenic Paleustalfs. Paleustalfs like the Typic except for a and b; or a, b and d; and with sandy epipedons between 50 cm and 1 m (20 and 40 inches) thick.

Aquultic Paleustalfs. Paleustalfs like the Typic except for a, d and e.

Aquultic Arenic Paleustalfs. Paleustalfs like the Typic except for a, b, d, and e, and with sandy epipedons between 50 cm and 1 m (20 and 40 inches) thick.

Aquultic Grossarenic Paleustalfs. Paleustalfs like the Typic except for a, b, d, and e, and with sandy epipedons that are thicker than 1 m (40 inches).

Arenic Paleustalfs. Paleustalfs like the Typic except for b and with sandy epipedons between 50 cm and 1 m (20 and 40 inches) thick.

Arenic Udic Paleustalfs. Paleustalfs like the Typic except for b and d and with sandy epipedons between 50 cm and 1 m (20 and 40 inches) thick.

Arenic Ultic Paleustalfs. Paleustalfs like the Typic except for b, d and e and with sandy epipedons between 50 cm and 1 m (20 and 40 inches) thick.

Grossarenic Paleustalfs. Paleustalfs like the Typic except for b and with sandy epipedons thicker than 1 m (40 inches).

Grossarenic Ultic Paleustalfs. Paleustalfs like the Typic except for b, d and e and with sandy epipedons thicker than 1 m (40 inches).

Petrocalcic Paleustalfs. Paleustalfs like the Typic except for g, with or without h or j.

Plinthic Paleustalfs. Paleustalfs like the Typic except for c.

Plinthudultic Paleustalfs. Paleustalfs like the Typic except for c, d and e.

Rhodic Paleustalfs. Paleustalfs like the Typic except for j.

Udertic Paleustalfs. Paleustalfs like the Typic except for d and f.

Udic Paleustalfs. Paleustalfs like the Typic except for d.

Ultic Paleustalfs. Paleustalfs like the Typic except for e and d.

Vertic Paleustalfs. Paleustalfs like the Typic except for f or f and h.

Plinthustalfs. Ustalfs that have plinthite that forms a continuous phase or constitutes more than half of the matrix within some subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface.

(Subgroups not developed)

Rhodustalfs. Ustalfs that

- 1. have an argillic horizon that has colors throughout in hues redder than 5YR with moist values of less than 4 and dry values no more than 1 unit higher than moist values;

Alfisols

Rhodustalfs--Cont.

2. have no natric horizon and have no duripan with an upper boundary within 1 m (40 inches) or a petrocalcic horizon with an upper boundary within 1.5 m (60 inches);
3. no plinthite that forms a continuous phase or constitutes more than half of the matrix within some subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface;
4. have an argillic horizon with a clay distribution such that:
 - a. the clay content decreases by 20 percent or more of the maximum clay content within 1.5 m (60 inches) of the surface if:
 - (1) chromas of more than 4 are dominant; or
 - (2) there are common coarse mottles that have chromas of more than 5; and
 - b. there is sandy or loamy particle-size class in the upper part if there is an increase of as much as 20 percent (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary.

Typic Rhodustalfs. Rhodustalfs that

- a. have no lithic contact within 50 cm (20 inches) of the surface;
- b. have more than 24 meq cation exchange capacity per 100 g clay (by NH_4OAc) and the cation retention from NH_4Cl is more than 12 meq per 100 g clay in the major part of the argillic horizon;
- c. have either or both of:
 - (1) a calcic horizon or soft powdery secondary lime within a depth of 1 m (40 inches) if the particle-size class is sandy, 70 cm (28 inches) if loamy, and 60 cm (24 inches) if clayey;
 - (2) increasing saturation with Na plus K with increasing depth within 1.25 m (50 inches) if the particle-size class is sandy, 90 cm (35 inches) if loamy, and 75 cm (30 inches) if clayey.

Lithic Rhodustalfs. Rhodustalfs like the Typic except for a.

Oxic Rhodustalfs. Rhodustalfs like the Typic except for b.

Udic Rhodustalfs. Rhodustalfs like the Typic except for c.

Xeralfs. Alfisols that

1. have a mean annual soil temperature between 8°C (47°F) and 22°C (72°F) and mean summer and mean winter soil temperatures at 50 cm (20 inches) depth that differ by 5°C (9°F) or more;
2. are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 cm (7 inches) and 50 cm (20 inches) or a lithic or a paralithic contact shallower than 50 cm (20 inches), or in the subhorizon immediately above a lithic or paralithic contact shallower than 18 cm (7 inches);
3. are not saturated with water at any period or lack the characteristics associated with wetness defined for Aqualfs.

Durixeralfs. Xeralfs that

1. have a duripan below the argillic or natric horizon but within 1 m (40 inches) of the surface;
2. have no plinthite that forms a continuous phase or that constitutes more than half of the matrix within any subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface.

Alfisol

Typic Durixeralfs. Durixeralfs that

- a. have an argillic horizon with less than 35 percent clay in all parts or there is either an increase of less than 15 percent clay (absolute) within a vertical distance of 2.5 m (1 inch) at the upper boundary of the argillic horizon or an increase of less than 10 percent clay (absolute) if cultivated and the lower boundary of the Ap is the upper boundary of the argillic horizon;
- b. have no mottles with chromas of 2 or less in the argillic horizon;
- c. have a duripan that is massive, platy, or prismatic and has more than half of the upper boundary that is indurated and coated with opal or opal and sesquioxides, or is indurated in some subhorizon below the upper boundary;
- d. have exchangeable sodium less than 15 percent of the cation exchange capacity throughout the argillic horizon;
- e. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm in thickness above the duripan.

Abruptic Durixeralfs. Durixeralfs like the Typic except for a.

Abruptic Aquic Durixeralfs. Durixeralfs like the Typic except for a and b.

Abruptic Haplic Durixeralfs. Durixeralfs like the Typic except for a and c.

Aquic Durixeralfs. Durixeralfs like the Typic except for b.

Aquic Haplic Durixeralfs. Durixeralfs like the Typic except for b and c.

Haplic Durixeralfs. Durixeralfs like the Typic except for c.

Natric Durixeralfs. Durixeralfs like the Typic except for d.

Vertic Durixeralfs. Durixeralfs like the Typic except for e.

Haploxeralfs. Xeralfs that

1. have an argillic horizon but no natric horizon, and no duripan within 1 m (40 inches) of the surface; and no petrocalcic horizon within 1.5 m (60 inches) of the surface;
2. have no plinthite that forms a continuous phase or that constitutes more than half of the matrix within some subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface;
3. have an argillic horizon that has colors in hues of 5YR or yellower in some part, or has moist values of 4 or more in some part, or dry values that are more than 1 unit higher than moist values;
4. have an argillic horizon with
 - a. less than 35 percent clay in all parts, or with more than 35 percent clay but with either an increase of less than 15 percent clay (absolute) within a vertical distance of 2.5 cm (1 inch) at the upper boundary of the argillic horizon or an increase of less than 10 percent clay (absolute) if cultivated and the lower boundary of the Ap is the upper boundary of the argillic horizon, and

Alfisols

Haploxeralfs--Cont.

- b. a clay distribution such that the content of clay decreases from the maximum by more than 20 percent of that maximum within a depth of less than 1.5 m (60 inches) from the surface if:
- (1) hues are redder than 10YR and chromas are more than 4 in the matrix; or
 - (2) there are common coarse mottles with hues of 7.5YR or redder or chromas of more than 5.

Typic Haploxeralfs. Haploxeralfs that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;
- b. have no fragipan with an upper boundary within 1 m (40 inches) of the surface;
- c. have an A1 horizon that is not as dark as a moist color value of 3.5 and does not contain more than 1.2 percent organic matter (0.7 percent organic carbon) throughout the upper 10 cm (4 inches), or have an Ap horizon with a moist color value of 3.5 or more or with less than 1.2 percent organic matter;
- d. have no lithic contact within 50 cm (20 inches) of the surface;
- e. have exchangeable sodium less than 15 percent of the cation exchange capacity (at pH 8.2) throughout the argillic horizon;
- f. have less than 5 percent (volume) of plinthite in all subhorizons within 1.5 m (60 inches) of the surface;
- g. have an argillic horizon with base saturation (by sum of cations) of 75 percent or more in some portion;
- h. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section.

Aquic Haploxeralfs. Haploxeralfs like the Typic except for a or a and c.

Aquultic Haploxeralfs. Haploxeralfs like the Typic except for a and f, with or without c.

Lithic Haploxeralfs. Haploxeralfs like the Typic except for d.

Lithic Mollic Haploxeralfs. Haploxeralfs like the Typic except for d and c.

Mollic Haploxeralfs. Haploxeralfs like the Typic except for c.

Natric Haploxeralfs. Haploxeralfs like the Typic except for e.

Ultic Haploxeralfs. Haploxeralfs like the Typic except for g or g and c.

Vertic Haploxeralfs. Haploxeralfs like the Typic except for h or c and h.

Alfisol

Natrixeralfs. Xeralfs that have a natric horizon but no duripan.

Typic Natrixeralfs. Natrixeralfs that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface.

Aquic Natrixeralfs. Natrixeralfs like the Typic except for a.

Palaxeralfs. Xeralfs that

1. have a petrocalcic horizon with its upper boundary within 1.5 m (60 inches) of the surface or have an argillic horizon that has one or both of:
 - a. a vertical clay distribution such that the clay does not decrease from the maximum by as much as 20 percent of that maximum within a depth of 1.5 m (60 inches) from the surface and one or both of:
 - (1) hues redder than 10YR and chromas of more than 4 in the matrix,
 - (2) common coarse mottles with hues of 7.5YR or redder or chromas of more than 5, or
 - b. a particle-size class that is clayey in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary;
2. have no duripan within 1 m (40 inches) of the surface;
3. have no plinthite that forms a continuous phase or that constitutes more than half of the matrix within any subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface;
4. have an argillic horizon that in some part has colors in hues of 5YR or yellower or that has either moist values of 4 or more or dry values more than 1 unit higher than moist values.

Typic Palaxeralfs. Palaxeralfs that

- a. have no mottles with chromas of 2 or less within 75 cm of the surface;
- b. have no lithic contact within 50 cm of the surface;
- c. have an Al horizon that has a moist color value that is more than 3.5 and does not contain more than 1.2 percent organic matter (0.7 percent organic carbon) in the upper 10 cm (4 inches), or have an Ap horizon with a moist color value of 3.5 or more and contains less than 1.2 percent organic matter;
- d. have more than 24 meq cation exchange capacity per 100 g clay (by NH_4OAc) and the cation retention from NH_4Cl is more than 12 meq per 100 g clay in the major part of the argillic horizon;
- e. have no petrocalcic horizon within 1.5 m (60 inches) of the surface;
- f. have an argillic horizon that has at least 75 percent base saturation (by sum of cations) in some portions;
- g. have an argillic horizon with a clayey particle-size class in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm (3 inches) or 15 percent clay (absolute) within 2.5 cm (1 inch) at the upper boundary;
- h. have less than 5 percent (volume) of plinthite in all subhorizons within 1.5 m (60 inches) of the surface.

Aquic Palaxeralfs. Palaxeralfs like the Typic except for a, or a and c.

Lithic Palaxeralfs. Palaxeralfs like the Typic except for b, with or without any of c, f, or g.

Haploxerultic Palaxeralfs. Palaxeralfs like the Typic except for f and g, with or without c.

Alfisols

Mollic Palexeralfs. Palexeralfs like the Typic except for c.

Petrocalcic Palexeralfs. Palexeralfs like the Typic except for e, or e and g.

Ultic Palexeralfs. Palexeralfs like the Typic except for f and g, with or without c.

Plinthoxeralfs. Xeralfs that have plinthite that forms a continuous phase or that constitutes more than half of the matrix within some subhorizon of the argillic horizon within 1.25 m (50 inches) of the soil surface.

(Subgroups not developed)

Rhodoxeralfs. Xeralfs that have an argillic horizon that in all parts has colors in hues redder than 5YR and moist values of less than 4 and dry values no more than 1 unit higher than moist values; and that do not have a natric horizon or a duripan.

Typic Rhodoxeralfs. Rhodoxeralfs that

- a. have an argillic horizon more than 15 cm (6 inches) thick and that is continuous in each pedon;
- b. have no lithic contact within 50 cm (20 inches) of the surface;
- c. have more than 24 meq cation exchange capacity per 100 g clay (by NH_4OAc) and the cation retention from NH_4Cl is more than 12 meq per 100 g clay in the major part of the argillic horizon;
- d. have no petrocalcic horizon within 1.5 m (60 inches) of the surface.

Lithic Rhodoxeralfs. Rhodoxeralfs like the Typic except for b.

Oxic Rhodoxeralfs. Rhodoxeralfs like the Typic except for c.

Petrocalcic Rhodoxeralfs. Rhodoxeralfs like the Typic except for d.

ULTISOLS: ORDER 8

Ultisols are mineral soils that

1. have one of the following combinations of characteristics:
 - a. have an argillic horizon but have no fragipan and have base saturation (by sum of cations) of less than 35 percent at 1.25 m (50 inches) below the upper boundary of the argillic horizon, or 1.8 m (72 inches) below the soil surface, or above a lithic or a paralithic contact, whichever is shallower, or
 - b. have a fragipan that
 - (1) meets all of the requirements of an argillic horizon or that has clay skins more than 1 mm thick in some part, and
 - (2) has base saturation (by sum of cations) of less than 35 percent at a depth of 75 cm (30 inches) below the upper boundary of the fragipan;
2. have a mean annual soil temperature of 8°C (47°F) or higher, and if mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, differ by 5°C (9°F) or more, have mean summer soil temperatures of 15°C (59°F) or higher if without an O horizon, or of 8°C (47°F) or higher if with an O horizon;
3. have no spodic horizon, and no oxic horizon unless it underlies an argillic horizon;
4. have no plinthite that forms a continuous phase within 30 cm (12 inches) of the surface.

Aquults. Ultisols that are either saturated with water at some season or are artificially drained, and that have characteristics associated with wetness, namely: mottles, iron-manganese concretions larger than 2mm or has moist chromas of 2 or less immediately below any Ap or Al horizon that has moist values of less than 3.5 when rubbed, and have one of the following:

1. dominant moist chromas of 2 or less in coatings on the surface of peds accompanied by mottles within the peds, or dominant moist chromas of 2 or less in the matrix of the argillic horizon accompanied by mottles of higher chromas (if hues are redder than 10YR because of parent materials that remain red after citrate-dithionite extraction, the requirement for low chromas is waived); or
2. moist chromas of 1 or less on surfaces of peds or in the matrix of the argillic horizon.

Fragiaquults. Aquults that have a fragipan but have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Fragiaquults. Fragiaquults that

- a. have an ochric epipedon;
- b. have mottles, and chromas of 2 or less in all horizons between the fragipan and the Al or Ap horizon;
- c. have less than 5 percent plinthite in any horizon within 1.5 m (60 inches) of the surface.

Plinthic Fragiaquults. Fragiaquults like the Typic except for c.

Plinthudic Fragiaquults. Fragiaquults like the Typic except for b and c.

Ochraqults. Aquults that

1. have no fragipan;
2. have an ochric epipedon;
3. have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more;

Ultisols

Ochraquults--Cont.

4. have no plinthite that forms a continuous phase or constitutes more than half of the matrix in all subhorizons within 1.25 m (50 inches) of the surface.

Typic Ochraquults. Ochraquults that

- a. (1) if mottled, have in 60 percent or more of the mass between the A1 or Ap and 75 cm (30 inches) one of the following:
- (a) if hues are 2.5Y or redder and moist values are more than 5, moist chromas are 2 or less, or if values are 5 or less, chromas are less than 2,
 - (b) if hues are yellower than 2.5Y, moist chromas are 2 or less,
 - (c) chromas are 1 or less with or without mottles;
- (2) have no horizon with dominant chromas of 3 or more within 75 cm (30 inches) of the surface;
- b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- c. have less than 5 percent plinthite in any horizon within 1.5 m (60 inches) of the surface;
- d. have no lithic contact within 50 cm (20 inches) of the surface;
- e. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

Aeric Ochraquults. Ochraquults like the Typic except for a.Areneic Ochraquults. Ochraquults like the Typic except for b with or without a, and have textures as coarse or coarser than loamy fine sand throughout the upper 50 cm (20 inches) but not extending below 1 m (40 inches).Areneic Plinthic Ochraquults. Ochraquults like the Typic except for b and c with or without a, and have textures as coarse or coarser than loamy fine sand throughout the upper 50 cm (20 inches) but not extending below 1 m (40 inches).Grossarenic Ochraquults. Ochraquults like the Typic except for b with or without a, and have textures as coarse or coarser than loamy fine sand extending to more than 1 m (40 inches).Plinthic Ochraquults. Ochraquults like the Typic except for c.Plinthaquults. Aquults that have plinthite that forms a continuous phase or constitutes more than half of the matrix of some subhorizon within 1.25 m (50 inches) of the surface.Typic Plinthaquults. Plinthaquults that

- a. have more than 24 meq CEC/100 g clay (by NH_4OAc) and have a cation retention from NH_4Cl of more than 12 meq/100 g clay in the major part of the argillic horizon (see Oxidic horizon for definition of cation retention);
- b. have plinthite that forms a continuous phase in or below the argillic horizon.

Oxidic Plinthaquults. Plinthaquults like the Typic except for a.Tropaquults. Aquults that

1. have no plinthite that forms a continuous phase or constitutes more than half of the matrix of any subhorizon within 1.25 m (50 inches) of the surface;
2. have a mean annual soil temperature of 8°C (47°F) or more and have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by less than 5°C (9°F).

Ultisols

Tropaquults--Cont.Typic Tropaquults. Tropaquults that

- a. have an A1 horizon less than 15 cm (6 inches) thick if its moist value is darker than 3.5, or an Ap horizon having a moist value of 4 or more;
- b. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- c. (1) if mottled, have in 60 percent or more of the mass between the A1 or Ap and 75 cm (30 inches) one of the following:
 - (a) if hues are 2.5Y or redder and moist values are more than 5, chromas are 2 or less, or if values are 5 or less, chromas are less than 2,
 - (b) if hues are yellower than 2.5Y, moist chromas are 2 or less, or
 - (c) chromas are 1 or less with or without mottles;
 (2) have no horizon with dominant chromas of 3 or more within 75 cm (30 inches) of the surface;
- d. have no plinthite that constitutes 5 percent or more of the matrix of any subhorizon within 1.5 m (60 inches) of the surface.

Aeric Umbric Tropaquults. Tropaquults like the Typic except for a and c.Umbrsquults. Aquults that

1. have an umbric or mollic epipedon;
2. have no fragipan;
3. have no plinthite that forms a continuous phase or constitutes more than half of the matrix of any subhorizon within 1.25 m (50 inches) of the surface;
4. have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by 5°C (9°F) or more.

Typic Umbrsquults. Umbrsquults that

- a. have no plinthite that constitutes 5 percent or more of the matrix of any subhorizon within 1.5 m (60 inches) of the surface.

Humults. Ultisols that are never saturated with water or that have redder hues or higher chromas than Aquults and that either:

1. have 1.5 percent or more organic matter (0.87 percent carbon) in the upper 15 cm (6 inches) of the argillic horizon; or
2. have 20 kg or more organic matter in a unit volume of 1m^2 to a depth of 1 m (40 inches) below the base of any O horizon, or both.

Haplohumults. Humults that

1. have no fragipan;
2. have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by 5°C (9°F) or more;
3. have either or both:
 - 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 (60 inches) and the layer in which the percentage of clay decreases does not show evidences of clay eluviation;

Haplohumults--Cont.

- b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches).

Typic Haplohumults. Haplohumults that

- a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- b. are never dry between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for as much as 60 consecutive days;
- c. have no mottles with chromas of 2 or less within the upper 25 cm (10 inches) of the argillic horizon;
- d. have no lithic contact within 50 cm (20 inches) of the mineral soil surface.

Andic Haplohumults. Haplohumults like the Typic except for a.Xeric Haplohumults. Haplohumults like the Typic except for b.Palehumults. Humults that

- 1. have an argillic horizon that in the upper 1 m (40 inches) has less than 10 percent weatherable minerals in the 20 to 200 micron fraction; and
- 2. have a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletons, or other evidences of clay eluviation.

Typic Palehumults. Palehumults that

- a. have more than 24 meq CEC/100g clay (by NH_4OAc) and have a cation retention from NH_4Cl of more than 12 meq/100g clay in the major part of the argillic horizon;
- b. have no mottles with chromas of 2 or less within the upper 25 cm (10 inches) of the argillic horizon;
- c. are never dry between 18 and 50 cm (7 and 20 inches) in more than 7 out of 10 years for as much as 60 consecutive days;
- d. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

Humoxic Palehumults. Palehumults like the Typic except for a, and have a mean annual soil temperature of less than 22°C (72°F).Orthoxic Palehumults. Palehumults like the Typic except for a, and either the mean annual soil temperature is 22°C (72°F) or higher, or the soils are dry in some horizon between 18 and 50 cm (7 and 20 inches) in most years but are not dry for 60 consecutive days or more.Xeric Palehumults. Palehumults like the Typic except for c, and have mean summer and mean winter soil temperatures at 50 cm (20 inches) that differ by 5°C (9°F) or more, and mean annual soil temperatures of less than 22°C (72°F).

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Tropohumults. Humults that

1. have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, that differ by less than 5°C (9°F);
2. have either or both:
 - 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 (60 inches) and the layer in which the percentage of clay decreases does not show evidences of clay eluviation,
 - b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches);
3. have no fragipan.

Typic Tropohumults. Tropohumults that

- a. have more than 24 meq CEC/100 g clay (by NH_4OAc) and have a cation retention from NH_4Cl of more than 12 meq/100 g clay in the major part of the argillic horizon (see Oxidic horizon for definition of cation retention);
- b. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the soil surface;
- c. have no lithic contact within 50 cm (20 inches) of the mineral soil surface;
- d. have no interruptions of the argillic horizon by ledges of bedrock within each pedon;
- e. have an argillic horizon with its upper boundary within 60 cm (24 inches) of the mineral soil surface;
- f. are not dry between 18 and 50 cm (7 and 20 inches) in most years for as much as 60 consecutive days;
- g. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

Humoxic Tropohumults. Tropohumults like the Typic except for a and have mean annual soil temperatures at 50 cm (20 inches) of less than 22°C (72°F).

Orthoxic Tropohumults. Tropohumults like the Typic except for a and either the mean annual soil temperature at 50 cm (20 inches) is 22°C (72°F) or higher, or the soils are dry in some horizon between 18 and 50 cm (7 and 20 inches) in most years, but are not dry for 60 consecutive days or more.

Udults. Ultisols that

1. are never saturated with water, or that have redder hues or higher chromas than Aquults;
2. have less than 1.5 percent organic matter (0.87 percent carbon) in the upper 15 cm (6 inches) of the argillic horizon and have less than 20 kg organic matter in a unit volume of 1 m² to a depth of 1 m (40 inches) below the base of any O horizon;
3. are always moist in all horizons, or are dry in more than 7 out of 10 years for less than 60 consecutive days in all horizons between 18 and 50 cm (7 and 20 inches), and for less than 90 cumulative days in some horizon between these depths in most years.

Fragiudults. Udults that have a fragipan in or below the argillic horizon.

Typic Fragiudults. Fragiudults that

- a. have no subhorizon immediately above the fragipan that has continuous coatings on ped faces (skeletons) that have dominant moist chromas of 2 or less and are more than 1 mm thick;
- b. have an argillic horizon above the fragipan;
- c. have no mottles with chromas of 2 or less in the upper 25 cm (10 inches) of the argillic horizon;
- d. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- e. have less than 5 percent plinthite nodules in any subhorizon within 1.5 m (60 inches) of the surface;
- f. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- g. have a fragipan that has a brittle matrix in at least 70 percent of the cross section of the most strongly cemented subhorizon;
- h. have an Ap horizon with a moist color value of 4 or more or with a dry value of 6 or more crushed and smoothed* or the A1 horizon is less than 15 cm (6 inches) thick if its moist color value is lower than 3.5.

Aqueptic Fragiudults. Fragiudults like the Typic except for a with or without b and have clay skins more than 1 mm thick in some part of the fragipan, and have between the fragipan and the surface a horizon that has:

- (1) chromas of 3 or more in the matrix,
- (2) mottles with chromas of 2 or less within 25 cm (10 inches) of its upper boundary,
- (3) very few or no clay skins.

Aquic Fragiudults. Fragiudults like the Typic except for c.

Arenic Plinthic Fragiudults. Fragiudults like the Typic except for d and e.

Ochreptic Fragiudults. Fragiudults like the Typic except for a with or without b and have clay skins more than 1 mm thick in some part of the fragipan and have between the fragipan and the surface a horizon 25 cm (10 inches) or more thick that has:

- (1) chromas of 3 or more in the matrix,
- (2) no mottles with chromas of 2 or less in the upper 25 cm (10 inches),
- (3) very few or no clay skins.

Plinthaqueptic Fragiudults. Fragiudults like the Typic except for e and a with or without b and have clay skins more than 1 mm thick in some part of the fragipan, and have between the fragipan and the surface a horizon that has:

- (1) chromas of 3 or more in the matrix,
- (2) mottles with chromas of 2 or less within 25 cm (10 inches) of its upper boundary,
- (3) very few or no clay skins.

Use knife and smooth to eliminate shadows.

Plinthic Ochreptic Fragluvents. Fragluvents like the Typic except for e and a with or without b and have between the fragipan and the surface a horizon 25 cm (10 inches) or more thick that has:

- (1) chromas of 3 or more in the matrix,
- (2) no mottles with chromas of 2 or less in the upper 25 cm (10 inches),
- (3) very few or no clay skins.

Hapluvents. (formerly Normuvents) Uvents that

1. have no fragipan;
2. have no plinthite that forms a continuous phase or constitutes more than half of the matrix in any horizon within 1.25 m (50 inches) of the surface;
3. have a moist color value of 4 or more in some part of the epipedon, or have an argillic horizon that has a dry color value of 5 or more in some subhorizon, or a moist color value of 4 or more;
4. have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by 5°C (9°F) or more;
5. have either or both:
 - 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 (60 inches) and the layer in which the percentage of clay decreases does not show evidences of clay eluviation,
 - b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches).

Typic Hapluvents.

- a. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum;
- b. have no mottles with chromas of 2 or less in the upper 60 cm (24 inches) of the argillic horizon;
- c. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- d. have an argillic horizon thicker than 25 cm (10 inches);
- e. have an Ap horizon with a moist color value of 4 or more or with a dry value of 6 or more crushed and smoothed * or the Al horizon is less than 15 cm (6 inches) thick if its moist color value is lower than 3.5;
- f. have no lithic contact within 50 cm (20 inches) of the surface of the mineral soil;
- g. have textures finer than loamy fine sand in some part of the argillic horizon, and have an argillic horizon that in at least its upper 25 cm (10 inches) has no lamellae;
- h. lack 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 (20 inches), that are at least 30 cm (12 inches) long in some part, and that extend upward to the surface or to the base of an Ap horizon, and

* Use knife and smooth to eliminate shadows.

Ultisols

Typic Hapludults--Cont.

- (2) a coefficient of linear extensibility (COLE) of 0.09 or more in a horizon or horizons at least 50 cm (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control sections;
1. have no interruptions of the argillic horizon by ledges of bedrock within each pedon;

Andic Hapludults. Hapludults like the Typic except for a.

Aquic Hapludults. Hapludults like the Typic except for b.

Arenic Hapludults. Hapludults like the Typic except for c, or c and d.

Humic Hapludults. Hapludults like the Typic except for e.

Lithic Hapludults. Hapludults like the Typic except for f.

Ochreptic Hapludults. Hapludults like the Typic except for d.

Psammentic Hapludults. Hapludults like the Typic except for g, or g and c.

Vertic Hapludults. Hapludults like the Typic except for h, with or without b.

Paleudults. Udults that

1. have both of the following:
 - a. an argillic horizon that in the upper 1 m (40 inches) has less than 10 percent weatherable minerals in the 20 to 200 micron fraction, and
 - b. a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletons or other evidences of clay eluviation;
2. have no fragipan;
3. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface.

Typic Paleudults. Paleudults that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the soil surface providing color is not due to uncoated grains of sand. If color is due to uncoated grains of sand, no mottles occur with chromas of 2 or less in the upper 12.5 cm (5 inches) of the argillic horizon;
- b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- c. have no subhorizon with more than 5 percent plinthite nodules within 1.5 m (60 inches) of the surface;
- d. have an Ap horizon with a moist color value of 4 or more or with a dry value of 6 or more crushed and smoothed * or the A1 horizon is less than 15 cm (6 inches) thick if its moist color value is lower than 3.5;
- e. have textures finer than loamy fine sand in some part of the argillic horizon and have no lamellae in at least the upper 1 m (40 inches) of the argillic horizon

Aquic Paleudults. Paleudults like the Typic except for a.

Aquic Arenic Paleudults. Paleudults like the Typic except for a and b and have a sandy epipedon 50 cm to 1 m (20 to 40 inches) thick.

* Use knife and smooth to eliminate shadows.

Ultisols

Aquic Grossarenic Paleudults. Paleudults like the Typic except for a and b, and have a sandy epipedon more than 1 m (40 inches) thick.

Aquic Psammentic Paleudults. Paleudults like the Typic except for a and e.

Arenic Paleudults. Paleudults like the Typic except for b and have a sandy epipedon 50 cm to 1 m (20 to 40 inches) thick.

Arenic Flinthaquic Paleudults. Paleudults like the Typic except for a, b, and c and have a sandy epipedon 50 cm to 1 m (20 to 40 inches) thick, and have mottles with chromas of 2 or less in addition to high chroma mottles in the sandy epipedon and in the upper 25 cm (10 inches) of the argillic horizon.

Arenic Flinthic Paleudults. Paleudults like the Typic except for b and c and have a sandy epipedon 50 cm to 1 m (20 to 40 inches) thick.

Grossarenic Paleudults. Paleudults like the Typic except for b and have a sandy epipedon more than 1 m (40 inches) thick.

Grossarenic Flinthic Paleudults. Paleudults like the Typic except for b and c and have a sandy epipedon more than 1 m (40 inches) thick.

Humic Paleudults. Paleudults like the Typic except for d.

Humic Psammentic Paleudults. Paleudults like the Typic except for d and e.

Flinthaquic Paleudults. Paleudults like the Typic except for a and c and have mottles with chromas of 2 or less in the upper 25 cm (10 inches) of the argillic horizon.

Flinthic Paleudults. Paleudults like the Typic except for c.

Psammentic Paleudults. Paleudults like the Typic except for e.

Plinthudults. Udults that

1. have plinthite that forms a continuous phase or constitutes more than half of the matrix within some subhorizon in the upper 1.25 m (50 inches) of the soil.

(Subgroups not developed).

Rhodudults. Udults that

1. have an epipedon with moist color values of less than 4 in all parts;
2. have an argillic horizon with dry color values of less than 5 in all subhorizons and no more than 1 unit higher than the moist values;
3. have no fragipan;
4. have no plinthite that forms a continuous phase or constitutes more than half of the matrix in any subhorizon in the upper 1.25 m (50 inches) of the soil.
5. have either or both:
 - 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 (60 inches) and the layer in which the percentage of clay decreases does not show evidences of clay eluviation,
 - b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches).

Typic Rhodudults. Rhodudults that

- a. have an argillic horizon that is continuous vertically and horizontally and has hues redder than 5YR;
- b. have textures finer than loamy fine sand in some part of the argillic horizon;

Ultisols

Typic Rhodudults--Cont.

- c. have no lithic contact within 50 cm (20 inches) of the surface.

Lithic Rhodudults. Rhodudults like the Typic except for c.

Psammentic Rhodudults. Rhodudults like the Typic except for b.

Tropudults. Udults that

1. have no fragipan;
2. have no plinthite that forms a continuous phase or constitutes more than half of the matrix in any subhorizon in the upper 1.25 m (50 inches) of the soil;
3. have mean summer and mean winter temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by less than 5°C (9°F);
4. have either or both:
 - 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 (60 inches) and the layer in which the percentage of clay decreases does not show evidences of clay eluviation,
 - b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches).
5. have an epipedon with moist color values of 4 or more in some subhorizon, or an argillic horizon that has a dry color value of 5 or more in some subhorizon or a moist color value of 4 or more.

Typic Tropudults. Tropudults that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the soil surface and no mottles with chromas of 2 or less in the upper 12.5 cm (5 inches) of the argillic horizon;
- b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- c. have an argillic horizon thicker than 25 cm (10 inches);
- d. have more than 24 meq cec/100 g clay (by NH₄OAc) and have a cation retention from NH₄Cl of more than 12 meq/100 g clay in the major part of the argillic horizon⁴ (see Oxic horizon for definition of cation retention);
- e. have no horizons with more than 5 percent by volume of plinthite within 1.5 m (60 inches) of the soil surface;
- f. lack 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 (20 inches), that are at least 30 cm (12 inches) 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 (20 inches) thick, and a potential linear extensibility of 6 cm or more in the upper 1 m (40 inches) of the soil or the whole soil if a lithic or paralithic contact is deeper than 50 cm (20 inches) but shallower than 1 m (40 inches), and
 - (3) more than 35 percent clay in horizons that total more than 50 cm (20 inches) in thickness within the control section;
- g. have textures finer than loamy fine sand in some part of the argillic horizon, and have an argillic horizon that in at least its upper 25 cm (10 inches) has no lamellae;

Ultisols

Typic Tropudults--Cont.

- h. have no interruption of the argillic horizon by ledges of bedrock within each pedon;
- i. have no lithic contact within 50 cm (20 inches) of the soil surface.

Aquic Tropudults. Tropudults like the Typic except for a.

Arenic Tropudults. Tropudults like the Typic except for b.

Dystropeptic Tropudults. Tropudults like the Typic except for c.

Oxic Tropudults. Tropudults like the Typic except for d.

Plinthic Tropudults. Tropudults like the Typic except for e.

Vertic Tropudults. Tropudults like the Typic except for f.

Ustults. Ultisols that

- 1. are never saturated with water or have redder hues or stronger chromas than Aquults;
- 2. are dry for 90 cumulative days or more in most years in some subhorizon of the soil between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact, whichever is shallower, but are not continuously dry in all parts of the soil between these depths for as long as 60 consecutive days unless the mean annual soil temperature is 22°C (72°F) or higher or the mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or a paralithic contact, whichever is shallower, differ by less than 5°C (9°F);
- 3. have less than 1.5 percent organic matter (0.87 percent carbon) in the upper 15 cm (6 inches) of the argillic horizon exclusive of any Ap;
- 4. have less than 20 kg organic matter in a unit volume of 1 m² to a depth of 1 m (40 inches) below the base of any O horizon or the mineral surface.

Haplustults. (formerly Normustults) Ustults that

- 1. have no fragipan;
- 2. have no plinthite that forms a continuous phase or constitutes more than half of the matrix in any horizon within 1.25 m (50 inches) of the surface;
- 3. have a moist color value of 4 or more in some part of the epipedon, or have an argillic horizon that has a dry color value of 5 or more in some subhorizon or a moist color value of 4 or more;
- 4. have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by 5°C (9°F) or more;
- 5. have either or both:
 - 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 (60 inches) and the layer in which the percentage of clay decreases does not show evidences of clay eluviation,
 - b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches).

Typic Haplustults. Haplustults that

- a. have no interruption of the argillic horizon by ledges of bedrock within each pedon;
- b. have no lithic contact within 50 cm (20 inches) of the mineral soil surface;
- c. have textures finer than loamy fine sand in some part of the argillic horizon and have an argillic horizon that has no lamellae in at least the upper 25 cm (10 inches);

Typic Haplustults--Cont.

- d. have no mottles with chromas of 2 or less in the upper 25 cm (10 inches) of the argillic horizon.

Ruptic-Lithic Haplustults. Haplustults like the Typic except for a and b.Paleustults. Ustults that

1. have both of the following:
 - a. an argillic horizon that in the upper 1 m (40 inches) has less than 10 percent weatherable minerals in the 20 to 200 micron fraction, and
 - b. a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletal or other evidences of clay eluviation;
2. have a moist color value of 4 or more in some part of the epipedon, or have an argillic horizon that has a dry color value of 5 or more in some subhorizon or a moist color of 4 or more;
3. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface;
4. have no fragipan.

Typic Paleustults. Paleustults that

- a. have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;
- b. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- c. have no horizons with more than 5 percent soft plinthite nodules within 1.5 m (60 inches) of the surface;
- d. have an irregular upper boundary of the argillic horizon unless an Ap rests directly on it or the argillic horizon is exposed at the surface.

Aquic Paleustults. Paleustults like the Typic except for a.Arenic Paleustults. Paleustults like the Typic except for b.Plinthic Paleustults. Paleustults like the Typic except for c.Plinthustults. Ustults that

1. have plinthite that forms a continuous phase or constitutes more than half of the matrix within some subhorizon in the upper 1.25 m (50 inches) of the soil.
- (Subgroups not developed)

Rhodustults. Ustults that lack a fragipan, and

1. have an epipedon with moist color values of less than 4 in all parts;
2. have an argillic horizon with dry color values of less than 5 in all subhorizons and no more than 1 unit higher than the moist values;
3. have no plinthite that forms a continuous phase or constitutes more than half of the matrix in any subhorizon in the upper 1.25 m (50 inches) of the soil;
4. have either or both:
 - 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 (60 inches) and the layer in which the percentage of clay decreases does not show evidences of clay eluviation;
 - b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches).

Ultisols

Typic Rhodustults. Rhodustults that

- a. have an argillic horizon that is continuous vertically and horizontally and has hues redder than 5YR;
- b. have textures finer than loamy fine sand in some part of the argillic horizon;
- c. have no lithic contact within 50 cm (20 inches) of the surface.

Tropustults. Ustults that

1. have no fragipan;
2. have no plinthite that forms a continuous phase or constitutes more than half of the matrix in any subhorizon in the upper 1.25 m (50 inches) of the soil;
3. have mean summer and mean winter temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by less than 5°C (9°F);
4. have either or both:
 - 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 (60 inches) and the layer in which the percentage of clay decreases does not show evidences of clay eluviation,
 - b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches);
5. have an epipedon with moist color values of 4 or more in some subhorizon, or an argillic horizon that has a dry color value of 5 or more in some subhorizon or a moist color value of 4 or more.

Typic Tropustults. Tropustults that

- a. have textures finer than loamy fine sand in some subhorizon within 50 cm (20 inches) of the surface;
- b. have more than 24 meq cec/100g clay (by NH₄OAc) and have a cation retention from NH₄Cl of more than 12 meq/100g clay in the major part of the argillic horizon (see Oxidic horizon for definition of cation retention);
- c. have less than 5 percent (by volume) of plinthite in all subhorizons within 1.5 m (60 inches) of the mineral soil surface;
- d. have no lithic contact within 50 cm (20 inches) of the mineral soil surface;
- e. have no mottles with chromas of 2 or less in the upper 25 cm (10 inches) of the argillic horizon;
- f. have textures finer than loamy fine sand in some part of the argillic horizon, and have an argillic horizon that, in at least its upper 25 cm (10 inches), has no lamellae;
- g. have no interruptions of the argillic horizon by ledges of bedrock within each pedon.

Arenic Tropustults. Tropustults like the Typic except for a.

Oxidic Tropustults. Tropustults like the Typic except for b.

Plinthic Tropustults. Tropustults like the Typic except for c.

Uerults. Ultisols that

1. have mean annual soil temperatures of less than 22°C (72°F), and have mean summer and mean winter soil temperatures at 50 cm (20 inches) or at a lithic or paralithic contact, whichever is shallower, that differ by 5°C (9°F) or more;
2. are dry for 60 consecutive days or more in more than 7 out of 10 years in all parts of the soil between 18 and 50 cm (7 and 20 inches) or a lithic or a paralithic contact, whichever is shallower;

Ultisols

Xerults--Cont.

3. have less than 1.5 percent organic matter (0.87 percent carbon) in the upper 15 cm (6 inches) of the argillic horizon exclusive of any Ap;
4. have less than 20 kg organic matter in a unit volume of 1 m² to a depth of 1 m (40 inches) below the base of any O horizon or the mineral surface;
5. are never saturated with water, or have redder hues or higher chromas than Aquults.

Haploxerults. Xerults that

1. have no fragipan;
2. have no plinthite that forms a continuous phase or constitutes more than half of the matrix in any horizon within 1.25 m (50 inches) of the surface;
3. have a moist color value of 4 or more in some part of the epipedon, or have an argillic horizon that has a dry color value of 5 or more in some subhorizon or a moist color value of 4 or more;
4. have either or both:
 - 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 (60 inches) and the layer in which the percentage of clay decreases does not show evidences of clay eluviation,
 - b. an argillic horizon with 10 percent or more weatherable minerals in the 20 to 200 micron fraction of the upper 1 m (40 inches).

Typic Haploxerults. Haploxerults that

- a. have no mottles with chromas of 2 or less in the upper 25 cm (10 inches) of the argillic horizon;
- b. have no lithic contact within 50 cm (20 inches) of the mineral soil surface;
- c. have textures finer than loamy fine sand in some part of the argillic horizon and with an argillic horizon that, in at least its upper 25 cm (10 inches), has no lamellae;
- d. have no layer in the upper 75 cm (30 inches) that has a texture finer than loamy fine sand, that is as much as 18 cm (7 inches) thick, that has a bulk density (at 1/3-bar tension) of 0.95 g/cc 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 more than 1.5 and more exchange acidity than the sum of bases plus KCl extractable aluminum.

Aquic Haploxerults. Haploxerults like the Typic except for a.

Lithic Haploxerults. Haploxerults like the Typic except for b.

Palloxerults. Xerults that

1. have both of the following:
 - a. an argillic horizon that in the upper 1 m (40 inches) has less than 10 percent weatherable minerals in the 20 to 200 micron fraction, and
 - b. a clay distribution such that the percentage of clay does not decrease from its maximum amount by more than 20 percent of that maximum within 1.5 m (60 inches) of the soil surface, or the layer in which the percentage of clay decreases shows skeletons or other evidences of clay eluviation;
2. have a moist color value of 4 or more in some part of the epipedon, or have an argillic horizon that has a dry color value of 5 or more in some subhorizon or a moist color value of 4 or more;
3. have no plinthite that forms a continuous phase or constitutes more than half of the matrix within 1.25 m (50 inches) of the surface;
4. have no fragipan.

OXISOLS: ORDER 9

Oxisols are mineral soils that have an oxic horizon at some depth within 2 meters (80 inches) of the surface* or plinthite that forms a continuous phase within 30 cm (12 inches) of the mineral surface of the soil. No spodic or argillic horizon overlies the oxic horizon.

It was pointed out in the 7th Approximation that the classification of the Oxisols had lagged behind that of the other orders of mineral soils. While we have accumulated data on a number of soils of Hawaii and Puerto Rico, the Oxisols are not extensive on these islands and are representative only of the Oxisols from basic rocks in Africa, South America, and Oceania. The classification presented here is an attempt to find a compromise between somewhat contrasting opinions. Probably it will satisfy no one. Yet as we pointed out in the 7th Approximation (page 11), compromises between divergent viewpoints are necessary in a large group of scientists and may actually produce a system with more general utility than a system arising from a single viewpoint. We have attempted to devise a system that can be applied with maximum accuracy in the field with the use of the simple tests that can be made in a field laboratory. The equipment required would include a microscope and stains for micromorphologic and mineralogical examinations, and glassware and chemicals for estimation of the cations retained by soil samples.

The classification of Oxisols that follows seems to produce satisfactory groupings of the limited numbers of the soils that we have in Hawaii and Puerto Rico. It needs to be tested more widely, however, for it is certain to have many shortcomings.

Aquox. Oxisols that have plinthite that forms a continuous phase within 30 cm (12 inches) of the mineral surface of the soil; or that are either saturated with water at some time during the year, or artificially drained, and have an oxic horizon that has one or both of the following characteristics associated with wetness:

1. a histic epipedon;
2. if free of mottles, dominant chromas are 2 or less immediately below any epipedon that has a moist color value of less than 3.5; or if mottled with distinct or prominent mottles within 50 cm (20 inches) of the surface, dominant chromas are 3 or less.

Gibbsiaquox. Aquox that have sheets containing 30 percent or more gibbsite, or 20 percent or more by volume of gravel-size aggregates containing 30 percent or more gibbsite within 1 m (40 inches) of the mineral surface, but that have no plinthite that forms a continuous phase within 30 cm (12 inches) of the soil surface. This group of soils is not known in the United States, and subgroups are not developed. It is believed that the typic subgroup should have gibbsite nodules from the surface down.

Ochraquox. Aquox that have an ochric epipedon, but have no plinthite that forms a continuous phase within the upper 1.25 m (50 inches), and have no sheets of gibbsite or aggregates cemented by gibbsite within the upper 1 m (40 inches). It is believed the typic subgroup should:

- a. have properties diagnostic of an oxic horizon at the surface or immediately below any thin surface horizon that has moist color values less than 3.5, and extending to a depth of 1 m (40 inches) or more;
- b. have no plinthite that forms a continuous phase within the upper 1 m (40 inches);
- c. have textures of sandy clay loam or finer throughout the oxic horizon.

Plinthaquox. Aquox that have plinthite that forms a continuous phase within 1.25 m (50 inches) of the surface. This group is not known in the United States. It is believed the typic subgroup should:

- a. have no plinthite that forms a continuous phase within the surface 30 cm (12 inches);
- b. have chromas of 2 or less in some part of the matrix of the non-plinthite materials within the horizon that contains plinthite, and in all overlying horizons;
- c. have an ochric epipedon.

A superic subgroup is proposed for Plinthaquox that have plinthite that forms a continuous phase at the surface, or within the surface 30 cm (12 inches).

* If the epipedon is thicker than 2 m (80 inches), and is immediately underlain by an oxic horizon, the soil is grouped with the Oxisols.

Umbraquox. Aquox that

1. have an umbric or histic epipedon;
2. have no plinthite that forms a continuous phase within 1.25 m (50 inches) of the surface;
3. have no gravel-size aggregates cemented by gibbsite or sheets of gibbsite within 1 m (40 inches) of the surface.

This group of soils is not known in the United States and subgroups are not developed. It is believed that the typic subgroups should:

- a. have an oxic horizon that has textures of sandy clay loam or finer;
- b. have an oxic horizon 1 m (40 inches) or more thick.

Humox. Oxisols that

1. are always moist or have no period when the soil is dry in any horizon below the surface 18 cm (7 inches) for 60 consecutive days or more in most years;
2. have 20 kg or more organic carbon per square meter within the upper 1 m (40 inches), exclusive of organic surface litter;
3. have mean annual soil temperatures of less than 22°C (72°F);
4. have base saturation (by NH_4OAc) of less than 35 percent in the oxic horizon.

Acrohumox. Humox that

1. have a cation retention capacity (from NH_4Cl) of 1 meq or less per 100 grams of clay in some subhorizon of the oxic horizon (or have 1 meq or less of extractable bases plus extractable aluminum per 100 grams clay);
2. have no subhorizon of the oxic horizon that is darker in color value and contains more organic carbon than the overlying subhorizon;
3. have no discernible structure, or only very weak blocky or prismatic structure;
4. have no sheets containing 30 percent or more gibbsite, and have less than 20 percent by volume of gravel-size aggregates containing 30 percent or more gibbsite within 1 m (40 inches) of the surface.

Typic Acrohumox. Acrohumox that

- a. have an ochric epipedon, or an umbric epipedon less than 75 cm (30 inches) thick;
- b. have no plinthite and have no mottles with chromas of 2 or less within 1.25 m (50 inches) of the soil surface;
- c. have an oxic horizon that extends to 1.25 m (50 inches) or more below the soil surface;
- d. have textures of sandy clay loam or finer in the oxic horizon.

Plinthic Acrohumox. Acrohumox like the Typic except for b.Gibbsihumox. Humox that

1. have within 1 m (40 inches) of the surface, cemented sheets or a subhorizon that has 20 percent or more by volume of gravel-size aggregates that contain 30 percent or more gibbsite.
2. have no discernible structure in the oxic horizon or have only very weak blocky or prismatic structure.

Oxisols

Typic Gibbsihumox. Gibbsihumox that

- a. have no mottles with chromas of 2 or less within a depth to the uppermost gibbsite sheet, or to 1 m (40 inches), whichever is shallower;
- b. have less than 50 percent by volume of plinthite in all horizons to a depth of 1.25 m (50 inches);
- c. have gravel-size aggregates cemented by gibbsite within the surface 25 cm (10 inches).

Haplohumox. Humox that

1. have in all subhorizons of the oxic horizon a cation retention capacity (from NH_4Cl) of more than 1 meq per 100 grams clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 grams clay);
2. have no subhorizon of the oxic horizon that is darker in color value and contains more organic carbon than the overlying subhorizon.

This group of soils is not well known in the United States and subgroups have not been tested. It is believed the typic subgroup should:

- a. have an ochric epipedon or an umbric epipedon that is less than 75 cm (30 inches) thick;
- b. have no plinthite within 1.25 m (50 inches) of the surface and have no dominant base colors or mottles with chromas of 2 or less within that depth;
- c. have an oxic horizon that extends to 1.25 m (50 inches) or more below the surface;
- d. have an oxic horizon with textures of sandy clay loam or finer;
- e. have no reflective ped faces showing pressure induced clay orientation;
- f. have less than 4 meq of KCl extractable aluminum per 100 grams of clay in the major part of the oxic horizon.

A Tropeptic Haplohumox subgroup is proposed that are like the Typic except for e.

Sombrihumox. Humox that have an oxic horizon with a subhorizon that is darker in color value and contains more organic carbon than the overlying horizon.

This group of soils is unknown in the United States and subgroups are not developed. It is suggested that the typic subgroups should have no visible structure between the A1 and the dark subhorizon of the oxic horizon.

Orthox. Oxisols exclusive of Aquox that have a mean annual soil temperature of 22°C (72°F) or more or have less than 20 kg organic carbon per square meter within the upper 1 m (40 inches), and have no period when the soil is dry in any horizon below the surface 18 cm (7 inches) for 60 consecutive days or more in most years.

Acrorthox. Orthox that

1. have in some subhorizon of the oxic horizon a cation retention capacity of 1 meq or less (from NH_4Cl) per 100 grams of clay (or 1 meq or less of extractable bases plus extractable aluminum per 100 grams of clay);
2. have no discernible structure in the oxic horizon or have only very weak blocky or prismatic structure;
3. have no sheets with 30 percent or more gibbsite or aggregates of gravel size containing 30 percent or more gibbsite within 1.25 m (50 inches) of the surface.

Typic Acrorthox. Acrorthox that

- a. have no plinthite or gravel-size aggregates cemented by gibbsite within 1 m (40 inches) of the surface;
- b. have an oxic horizon that extends to 2 m (80 inches) or more below the surface;

Oxisols

Typic Acrorthox--Cont.

- c. have textures of sandy clay loam or finer in the oxic horizon to a depth of at least 1 m (40 inches).

(Profile 27, p. 92, 7th Approximation, is considered representative of the Typic Acrorthox. Additional data on this profile are given in Table 15, p. 54).

Eutrorthox. Orthox that

1. have in all subhorizons of the oxic horizon a cation retention capacity (from NH_4Cl) of more than 1 meq per 100 grams of clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 grams of clay);
2. have base saturation (by NH_4OAc) of 35 percent or more in the epipedon and in all subhorizons of the oxic horizon to a depth of at least 1.25 m (50 inches);
3. have no anthropic epipedon.

Typic Eutrorthox. Eutrorthox that

- a. have an oxic horizon that extends to 1.25 m (50 inches) or more below the mineral surface;
- b. have no structure in the oxic horizon or have only very weak prismatic or blocky structure.
- c. have textures of sandy clay loam or finer in all parts of the oxic horizon within 1.25 m (50 inches) of the mineral surface;
- d. have no plinthite (that is not indurated) within 1.25 m (50 inches) of the surface;
- e. have no mottles with chromas of 2 or less accompanied by red or dark red mottles within 1.25 m (50 inches) of the surface;

Tropeptic Eutrorthox. Eutrorthox like the Typic except for a or b, or a and b.

Gibbsiorthox. Orthox that

1. have within 1.25 m (50 inches) of the surface, sheets containing 30 percent or more gibbsite or a subhorizon with 20 percent or more by volume of gravel-size aggregates containing 30 percent or more gibbsite.

Typic Gibbsiorthox. Gibbsiorthox that

- a. have gravel-size aggregates cemented by gibbsite within the surface 25 cm (10 inches);
- b. have no mottles with chromas of 2 or less within the upper 1 m (40 inches), or above the uppermost gibbsite sheet, whichever is shallower.

Haplorthox. Orthox that

1. have a cation retention capacity (from NH_4Cl) of more than 1 meq per 100 grams of clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 grams of clay) in all subhorizons of the oxic horizon;
2. have no sheets of gibbsite or gravel-size aggregates cemented by gibbsite within 1.25 m (50 inches) of the surface;
3. have an ochric epipedon and less than 1 percent organic carbon in some subhorizon that is within 75 cm (30 inches) of the mineral surface;
4. have base saturation (by NH_4OAc) of less than 35 percent in some subhorizon of the oxic horizon within 1.25 m (50 inches) of the mineral surface.

Typic Haplorthox. Haplorthox that

- a. have no mottles with chromas of 2 or less accompanied by red or dark red mottles within 1.25 m (50 inches) of the surface;

Oxisols

Typic Haplorthox--Cont.

- b. have no plinthite (that is not indurated) within 1.25 m (50 inches) of the surface;
- c. have textures of sandy clay loam or finer in all parts of the oxic horizon within 1.25 m (50 inches) of the mineral surface;
- d. have an oxic horizon that extends to 1.25 m (50 inches) or more below the mineral surface;
- e. have no structure in the oxic horizon or have only very weak prismatic or blocky structure.

Aquic Haplorthox. Haplorthox like the Typic except for a.

Plinthic Haplorthox. Haplorthox like the Typic except for b.

Psammentic Haplorthox. Haplorthox like the Typic except for c.

Tropeptic Haplorthox. Haplorthox like the Typic except for d or e or d and e.

Umbriorthox. Orthox that

- 1. have a cation retention capacity (from NH_4Cl) of more than 1 meq per 100 grams of clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 grams of clay) in all subhorizons of the oxic horizon;
- 2. have no sheets of gibbsite or gravel-size aggregates cemented by gibbsite within 1.25 m (50 inches) of the surface;
- 3. have either an umbric epipedon or an ochric epipedon that has more than 1 percent carbon in all subhorizons to 75 cm (30 inches) or more below the top of the mineral surface;
- 4. have base saturation (by NH_4OAc) of less than 35 percent in some subhorizon of the oxic horizon within 1.25 m (50 inches) of the mineral surface.

Typic Umbriorthox. Umbriorthox that

- a. have textures of sandy clay loam or finer in all parts of the oxic horizon within 1.25 m (50 inches) of the mineral surface;
- b. have an oxic horizon that extends to 1.25 m (50 inches) or more below the mineral surface;
- c. have no plinthite (that is not indurated) within 1.25 m (50 inches) of the surface;
- d. have no mottles that have chromas of 2 or less accompanied by red or dark red mottles within 1.25 m (50 inches) of the surface;
- e. have an umbric epipedon less than 1.25 m (50 inches) thick and have less than 1 percent carbon in some subhorizon within 1.25 m (50 inches) of the mineral surface.

Torrox. Oxisols that

- 1. are usually dry in most years in all parts of the soil between the Ap horizon or 18 cm (7 inches) and 2 m (80 inches) or a lithic or a paralithic contact, whichever is shallower;
- 2. have an ochric epipedon that has moist color values of 4 or more in all subhorizons.

Torrox are not known to occur in the United States. The suborder may not be needed and is suggested tentatively. It is possible that no subdivisions of the suborder will be needed at the great group level unless wide variations are found to exist in base saturation or base retention. The typic subgroup should probably have textures of sandy clay loam or finer throughout the oxic horizon.

Ustox. Oxisols that

- 1. have some subhorizon below the surface 18 cm (7 inches) that is dry for 60 consecutive days or more in most years;

Oxisols

Ustox--Cont.

2. have mean annual soil temperatures of 15°C (59°F) or more;
3. either have moist values of less than 4 in some part of the epipedon (A1 or Ap) or are usually moist.

Acrustox. Ustox that

1. have a cation retention capacity (from NH_4Cl) of 1 meq or less per 100 grams clay in some subhorizon of the oxic horizon (or have 1 meq or less of extractable bases plus extractable aluminum per 100 grams clay);
2. have an umbric or ochric epipedon;
3. have no discernible structure in the oxic horizon or have only very weak blocky or prismatic structure.

Typic Acrustox. Acrustox that

- a. have no plinthite or gravel-size aggregates cemented by gibbsite within 1 m (40 inches) of the surface;
- b. have an oxic horizon that extends to 2 m (80 inches) or more below the top of the mineral surface;
- c. have textures of sandy clay loam or finer in the oxic horizon to a depth of at least 1 m (40 inches).

Eustrustox. Ustox that

1. have a mollic or umbric epipedon that is at least one unit of value darker (moist) or one or more units of chroma lower (moist) than the oxic horizon and base saturation of 50 percent or more (by NH_4OAc) in the oxic horizon if the particle size class is clayey, or 35 percent or more if the particle-size class is loamy;
2. have a cation retention capacity (from NH_4Cl) of more than 1 meq per 100 grams clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 grams clay) in all subhorizons of the oxic horizon;

We would propose the following definition for the typic subgroup:

Typic Eustrustox. Eustrustox that

- a. have textures of sandy clay loam or finer in all parts of the oxic horizon;
- b. have an oxic horizon that extends to 1.25 m (50 inches) or more below the surface;
- c. have no plinthite (that is not indurated) within 1.25 m (50 inches) of the surface;
- d. have no mottles with chromas of 2 or less accompanied by red or dark red mottles within 1.25 m (50 inches) of the surface;
- e. have no structure in the oxic horizon, or have only weak blocky or prismatic structure.

Haplustox. Ustox that

1. have a cation retention capacity (from NH_4Cl) of more than 1 meq per 100 grams of clay (or have more than 1 meq of extractable bases plus extractable aluminum per 100 grams clay) in all subhorizons of the oxic horizon;
2. have no mollic epipedon, or a mollic epipedon that is less than 1 unit of value darker and has chromas that differ by less than 1 unit (moist colors) from the oxic horizon;
3. have base saturation (by NH_4OAc) of less than 50 percent in some part of the oxic horizon if the particle-size class is clayey and less than 35 percent if the particle-size class is loamy.

Oxisols

Typic Haplustox. Haplustox that

- a. have no mottles with chromas of 2 or less accompanied by red or dark red mottles within 1.25 m (50 inches) of the surface;
- b. have no plinthite (that is not indurated) within 1.25 m (50 inches) of the surface;
- c. have textures of sandy clay loam or finer in all parts of the oxic horizon;
- d. have an oxic horizon that extends to 1.25 m (50 inches) or more below the surface;
- e. have no structure in the oxic horizon or have only very weak blocky or prismatic structure.

Aquic Haplustox. Haplustox like the Typic except for a.

Plinthic Haplustox. Haplustox like the Typic except for b.

Psammentic Haplustox. Haplustox like the Typic except for c.

Ruptic-Lithic Haplustox. Haplustox like the Typic except for d and have a lithic contact but in less than half of each pedon.

Tropeptic Haplustox. Haplustox like the Typic except for e, or d, or e and d.

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