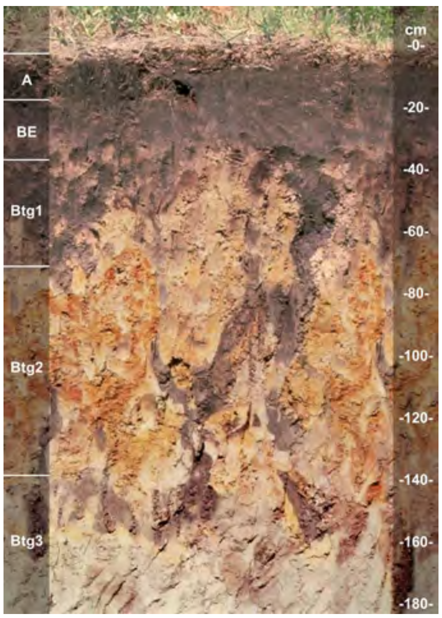
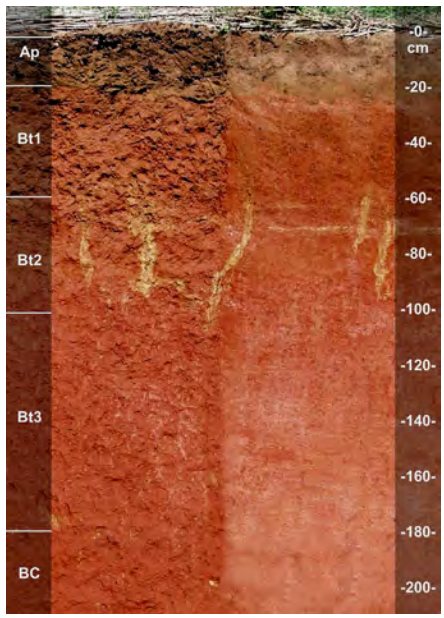
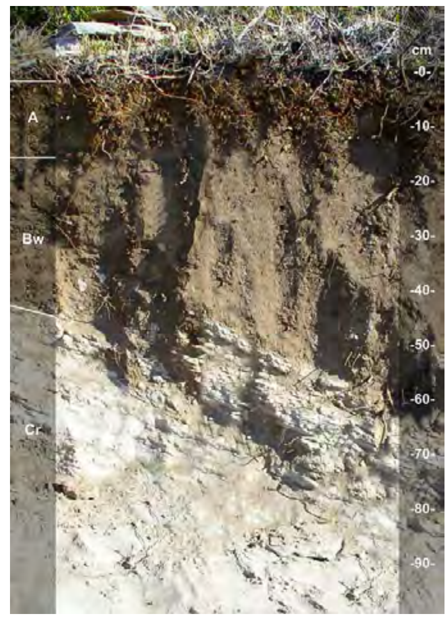
USDA Natural Resources Conservation Service
U.S. DEPARTMENT OF AGRICULTURE

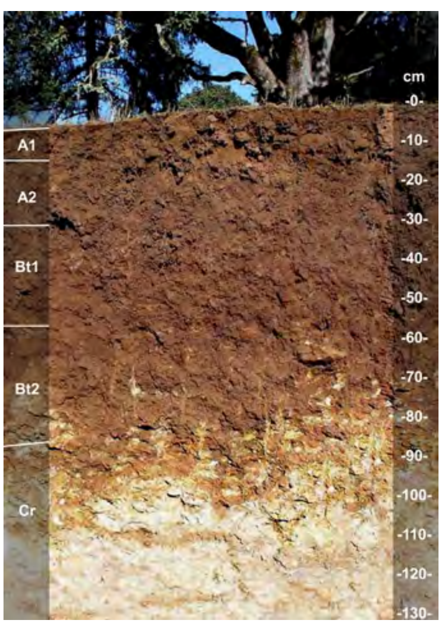
Keys to Soil Taxonomy

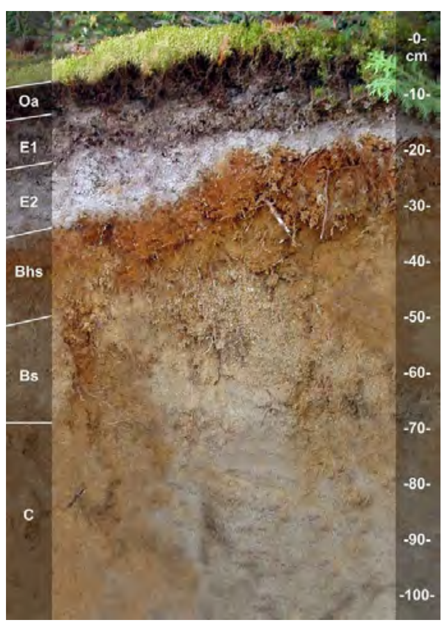
Thirteenth Edition, 2022

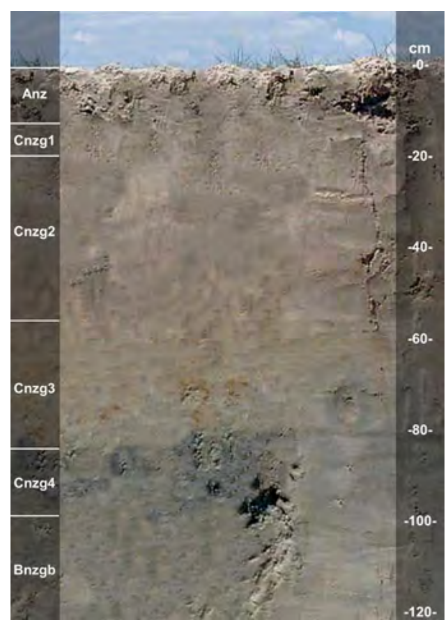












Keys to Soil Taxonomy

By Soil Survey Staff

United States Department of Agriculture
Natural Resources Conservation Service

Thirteenth Edition, 2022

Nondiscrimination Statement

Literature Citation

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Cover Images

Photos courtesy of John A. Kelley, retired NRCS soil scientist.

Clockwise from upper left:

- Grady series (fine, kaolinitic, thermic Typic Paleaquults) from soil survey of Houston County, Alabama. Photo taken in January 2000.
- Appomattox series (fine, mixed, semiactive, mesic Oxyaquic Hapludults), which is of small extent in Virginia, North Carolina, and other southern States adjacent to the Blue Ridge Mountains. Photo taken in January 2021.
- Whitetop series (ashy, glassy, frigid, shallow Vitrandic Haploxerolls) from soil survey of Bear Lake County Area, Idaho. Photo taken in January 2000.
- Noria series (mixed, hyperthermic Sodic Psammaquents) from soil survey of Kennedy and Kleberg Counties, Texas. Photo taken in August 2021.
- Adams series (sandy, isotic, frigid Typic Haplorthods), which is of large extent in northern New York and New England. Photo taken in January 2005.
- Dixonville series (fine, mixed, superactive, mesic Pachic Ultic Argixerolls), which occurs in western Oregon. Photo taken in January 2007.

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Preface

This publication, *Keys to Soil Taxonomy*, 13th edition, 2022, incorporates the amendments approved by the regional and national conferences of the National Cooperative Soil Survey since publication of the last edition of the Keys in 2014. The authors of the *Keys to Soil Taxonomy* are identified as the “Soil Survey Staff.” This term is meant to include all of the soil classifiers in the National Cooperative Soil Survey program and in the international community who have made significant contributions to the improvement of the taxonomic system.

Many changes in this edition are intended to make Soil Taxonomy more intelligible to cooperators who use soil surveys for conservation planning and land use purposes. For example, taxonomic names, such as Vertic Torrifluvents, can be daunting to the non-specialist. In chapter 1, the method for understanding taxonomic names, by dividing them into syllables (formative elements) from right to left, is explained. Tables of the Greek and Latin root words used as formative elements are provided. Understanding the combination of formative elements allows much insight about a particular soil and the landscape where it occurs.

More headings and endnotes have been added, especially in chapter 3, to aid the understanding of concepts. The headings are intended to break up long definitions containing multiple criteria by showing the reader the general concept for each criterion. Endnotes provide rationale for the criteria and refer the reader to citations for more explanation. Several photos of diagnostic features and a few charts were also added as aids for understanding concepts.

Several of the proposed changes resulted from a refinement of the definitions of existing taxa as more experience with those taxa was gained. In addition, new taxa have been added as a result of mapping formerly unmapped terrain, especially in Alaska. Still other amendments account for the changing needs of the soil survey database, particularly with regard to carbon buried at depths below 1 meter.

CHAPTER 1

The Soils That We Classify

The word "soil," like many common words, has several meanings. In its traditional meaning, soil is the natural medium for the growth of land plants, whether or not it has discernible soil horizons. This meaning is still the common understanding of the word, and the greatest interest in soil is centered on this meaning. People consider soil important because it supports plants that supply food, fibers, drugs, and other wants of humans and because it filters water and recycles wastes. Soil covers the earth's surface as a continuum, except on bare rock, in areas of perpetual frost, in deep water, or on the barren ice of glaciers. In this sense, soil has a thickness that is determined by the rooting depth of plants.

"Soil" in this text is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter *or* the ability to support rooted plants in a natural environment (Soil Survey Staff, 1999). A natural body of soil that is covered with a layer of human-transported material is within the concept of soil as used here (note 1).

The upper limit of soil is the boundary between soil and either air, shallow water, live plants, or plant materials that have not begun to decompose. Areas are not considered to have soil if the surface is permanently covered by water too deep (typically more than about 2.5 meters) for the growth of rooted plants. The horizontal boundaries of soil are areas where the soil grades to deep water, barren areas, rock, or ice. In some places the separation between soil and nonsoil is so gradual that clear distinctions cannot be made.

The lower boundary that separates soil from the nonsoil underneath is the most difficult to define. Soil consists of the horizons near the earth's surface that, in contrast to the underlying parent material, have been altered by the interactions of climate, relief, and living organisms over time. Commonly, soil grades at its lower boundary to hard rock or to earthy materials virtually devoid of animals, roots, or other marks of biological activity. The lowest depth of biological activity, however, is difficult to discern and is often gradual. For the practicality of soil survey, the lower boundary of soil is arbitrarily set at 200 centimeters (note 2). In soils where either biological activity or current pedogenic processes extend to depths greater than 200 centimeters, the lower limit of the soil for classification purposes is still 200 cm. In some cases the more weakly coherent bedrocks (paralithic materials, defined later) and unconsolidated bedrocks (some densic materials, defined later) have been described below the lower boundary of soil and used to differentiate soil series (series control section, defined in chapter 17). This is permissible even though the paralithic materials below a paralithic contact are not considered soil in the true sense. In areas where soil has thin, pedogenically cemented horizons (note 3) (i.e., petrocalcic and petrogypsic horizons, duripans, etc.) that are impermeable to roots, the soil extends as deep as the deepest cemented horizon, but not below 200 cm. For certain management goals, layers deeper than the lower boundary of the soil that is classified (200 cm) must also be described if they affect the content and movement of water and air or other interpretative concerns.

In the humid Tropics, earthy materials may extend to a depth of many meters with no obvious changes below the upper 1 or 2 meters, except for an occasional stone line. In many wet soils, gleyed soil material may begin a few centimeters below the surface and, in some areas, continue down for several meters apparently unchanged with increasing depth. The latter condition can arise through the gradual filling of a wet basin in which the A horizon is gradually added to the surface and becomes gleyed beneath. Finally, the A horizon rests on a thick mass of gleyed material that may be relatively uniform. In both of these situations, there is no alternative but to set the lower limit of soil at the arbitrary limit of 200 cm.

Soil, as defined in this text, does not need to have discernible genetic horizons, although the presence or absence of genetic horizons and their nature are of extreme importance in soil classification. Plants can be grown under glass in pots filled with earthy materials, such as peat or sand, or even in water. Under proper conditions all these media are productive for plants, but they are nonsoil here in the sense that they cannot be classified in the same system that is used for the soils of a survey area, county, or nation. Plants even grow on trees or in cracks of exposed bedrock (i.e., rock outcrop), but trees and rock outcrop are regarded as nonsoil.

Soil has many temporal properties that fluctuate hourly, daily, and seasonally. It may be alternately cold, warm, dry, or moist. Biological activity is slowed or stopped if the soil becomes too cold or too dry. The soil receives additions of fresh, undecomposed organic matter when leaves fall or grasses die. Soil is not static. The pH, soluble salts, amount of organic matter and carbon-nitrogen ratio, numbers of microorganisms, soil fauna, temperature, and moisture status all change with the seasons as well as with more extended periods of time. Soil must be viewed from both the short-term and long-term perspective.

Buried Soils

A buried soil is a sequence of genetic horizons in a pedon that is covered with a surface mantle of new soil material (defined in chapter 3 and below) that is 50 cm or more thick, a plaggen epipedon (defined in chapter 3), or a layer of human-transported material (defined below) that is 50 cm or more thick. The rules for the taxonomic classification of pedons that include a buried soil are given in chapter 4. Figure 3-4 shows a profile with a buried soil.

Surface Mantle of New Soil Material

A surface mantle of new soil material is a layer of naturally deposited mineral material that is largely unaltered, at least in the lower part. It may have a diagnostic surface horizon (epipedon) and/or a cambic horizon, but it has no other diagnostic subsurface horizon (all defined in chapter 3). However, there remains a layer 7.5 cm or more thick in the lower part of the new soil material that fails the requirements for all diagnostic horizons, as defined later, overlying a genetic horizon sequence that can be clearly identified as a buried soil in at least half of each pedon. The recognition of a surface mantle should not be based only on studies of associated soils. A surface mantle of new soil material that is less than 50 cm thick over a buried soil can be used to establish a phase of a soil series, or even another soil series, if the mantle affects use and management of the soil.

Surface Mantle of Human-Transported Material

Human-transported material (defined in chapter 3) is a layer of material intentionally deposited by humans. It consists of mineral and/or organic soil material. Since it is not "naturally deposited" and may include organic soil material, it does not meet the technical definition of a "mantle of new soil material." However, for the purposes of classifying the soil, the same rules apply. To be treated as a mantle in the context of determining whether a buried soil is present, the material must be largely unaltered, at least in the lower part. It may have a diagnostic surface horizon (epipedon) and/or a cambic horizon, but it has no other diagnostic subsurface horizons (defined in chapter 3).

However, there remains a layer 7.5 cm or more thick in the lower part of the human-transported material that fails the requirements for all diagnostic horizons, as defined later, overlying a genetic horizon sequence that can be clearly identified as a buried soil in at least half of each pedon. Human-transported material that is less than 50 cm thick over a buried soil can be used to establish a phase of a soil series, or even another soil series, if the human-transported material affects use and management of the soil.

Regardless of whether pedogenic development has taken place within the lower 7.5 cm, human-transported material maintains its status as a diagnostic material as described in chapter 3. Only its status as a kind of surface mantle for the consideration of the presence of a buried soil is affected.

Greek and Latin Formative Elements

Soil Taxonomy names are designed to be dissected into syllables (formative elements) from right to left. Doing so

Table 1-1. Formative elements in names of soil orders

Name of order	Formative element in name	Derivation/connotation	Pronunciation of formative element
Alfisols	alf	Al and Fe, via Marbut's "Pedalfers"	Alf
Andisols	and	Japanese, volcanic ash	Ando
Aridisols	id	L. *aridus*, dry	Arid
Entisols	ent	Recent	Ent
Gelisols	el	L. *gelare*, to freeze	Jell
Histosols	ist	Gr. *histos*, tissue	Histology
Inceptisols	ept	L. *inceptum*, beginning	Inception
Mollisols	oll	L. *mollis*, soft	Mollify
Oxisols	ox	F. *oxide*, oxide	Oxide
Spodosols	od	Gr. *spodos*, wood ash	Odd
Ultisols	ult	L. *ultimus*, last	Ultimate
Vertisols	ert	L. *verto*, turn	Invert

Table 1-2. Formative elements and adjectives (words ending in "ic") used in Soil Taxonomy names

Formative element or adjective	Derivation	Connotation
Abruptic	L. *abruptus*, torn off	Abrupt textural change
Acr	Modified from Gr. *arkos*, at the end	Extreme weathering
Aeric	Gr. *aerios*, air	Aeration
Al, Alic	Modified from aluminum	High aluminum, Al^{3+} status, low iron
Alb	L. *albus*, white	Presence of an albic horizon
Anhy	Gr. *anhydros*, waterless	Cold, dry
Anionic	Gr. *anion*	Positively charged colloids that adsorb anions
Anthr	Modified from Gr. *anthropos*, human	An anthropic epipedon
Aqu	L. *aqua*, water	Aquic conditions
Anthraquic	Modified from Gr. *anthropos*, human, and L. *aqua*, water	Controlled flooding
Ar	L. *arare*, to plow	Mixed horizon
Arenic	L. *arena*, sand	Sandy material between 50 and 100 cm thick
Arg	Modified from argillic horizon; L. *argilla*, clay	Presence of an argillic horizon
Calci, Calc	L. *calcis*, lime	Presence of a calcic horizon
Camb	L. *cambiare*, to change, alter	Presence of a cambic horizon
Chromic	Gr. *chroma*, color	High chroma
Cumulic	L. *cumulus*, to pile up, heap	Overthickened epipedon via deposition from overland flow
Cry	Gr. *kryos*, icy cold	Cold
Dur	L. *durus*, hard	Presence of a duripan
Durinodic	L. *durus*, hard	Presence of durinodes
Dystr, Dys	Modified from Gr. *dys*, ill; dystrophic, infertile	Low base saturation
Endo	Gr. *endon, endo*, within	Implying a ground water table
Epi	Gr. *epi*, on, above	Implying a perched water table
Eutr, Eutric	Modified from Gr. *eu*, good; eutrophic, fertile	High base saturation
Ferr	L. *ferrum*, iron	Presence of iron
Fibr	L. *fibra*, fiber	Least decomposed stage
Fluv	L. *fluvius*, river	Flood plain
Fol	L. *folia*, leaves	Mass of leaves
Fragi, Fragic	Modified from L. *fragilis*, brittle	Presence of a fragipan, fragic properties
Fragloss	Compound of fra(g) and gloss	See the formative elements "frag" and "gloss"
Fulv	L. *fulvus*, dull brownish yellow	Dark brown color, presence of organic carbon
Glac, Glacic	L. *glacialis*, icy	Ice lenses or wedges
Gloss, Glossic	Gr. *glossa*, tongue	Presence of a glossic horizon, tongued horizon boundaries
Grossarenic	L. *grossus*, thick, and L. *arena*, sand	Thick sandy layer
Gyps, Gypsic	L. *gypsum*, gypsum	Presence of a gypsic horizon
Hal, Halic	Gr. *hals*, salt	Salty
Hapl	Gr. *haplous*, simple	Minimum horizon development
Hem	Gr. *hemi*, half	Intermediate stage of decomposition

Table 1-2. Formative elements and adjectives (words ending in "ic") used in Soil Taxonomy names—Continued

Formative element or adjective	Derivation	Connotation
Hist	Gr. *histos*, tissue	Presence of organic materials
Hum, Humic	L. *humus*, earth	Presence, high amounts of organic matter
Hydr, Hydric	Gr. *hydor*, water	Presence of water
Kan, Kandic	From kandite, acronym for **Ka**olinite-**N**acrite-**Dic**kite	Predominantly of 1:1 layer silicate clays
Lamellic	L. *lamella*, thin plate	Presence of lamellae
Leptic	Gr. *leptos*, thin	A thin soil
Limnic	Modified from Gr. *limn*, lake	Presence of a limnic layer
Lithic	Gr. *lithos*, stone	Presence of a shallow lithic contact
Luv	Gr. *louo*, to wash	Illuvial
Melan	Gr. *melasanos*, black	Black, presence of organic carbon, melanic epipedon
Moll	L. *mollis*, soft	Presence of a mollic epipedon
Natr, Natric	Modified from L. *natrium*, sodium	Presence of a natric horizon, sodium
Nitric	Modified from *nitron*	Presence of nitrate salts
Ombroaquic	Gr. *ombros*, rain, and aquic	Surface wetness
Orth	Gr. *orthos*, true	The common ones
Oxyaquic	Oxy, representing oxygen, and aquic	Saturation without reduction and redox features
Pachic	Gr. *pachys*, thick	Overthickened epipedon via *in situ* soil formation
Pale	Gr. *paleos*, ancient	High degree of development
Per	L. *per*, throughout time	Perudic moisture regime
Petr	Gr. comb. form of *petra*, rock	A cemented horizon
Petrocalcic	Gr. *petra*, rock, and calcic from calcium	Presence of a petrocalcic horizon
Petroferric	Gr. *petra*, rock, and L. *ferrum*, iron	Presence of a petroferric contact (ironstone)
Petrogypsic	Gr. *petra*, rock, and L. *gypsum*, gypsum	Presence of a petrogypsic horizon
Petronodic	Modified from *petra*, rock, and *nodulus*, a little knot	Presence of concretions and/or nodules
Plac, Placic	Gr. base of *plax*, flat stone	Presence of a thin cemented pan, placic horizon
Plagg	Modified from Ger. *plaggen*, sod	Presence of a plaggen epipedon
Plinth, Plinthic	Gr. *plinthos*, brick	Presence of plinthite
Psamm	Gr. *psammos*, sand	Sandy texture
Quartz	Ger. *quarz*, quartz	High quartz content
Rend	From Polish *rendzina*, rich, shallow over calcareous	High carbonate content
Rhod, Rhodic	Gr. base of *rhodon*, rose	Dark red color
Ruptic	L. *ruptum*, broken	Intermittent or broken horizons
Sal	L. base of *sal*, salt	Presence of a salic horizon
Sapr	Gr. *saprose*, rotten	Most decomposed stage
Sodic	Modified from sodium	Presence of sodium salt
Somb, Sombric	F. *sombre*, dark	Presence of a sombric horizon
Sphagn	Gr. *sphagnos*, bog	Presence of sphagnum
Sulf, Sulfic	L. *sulfur*, sulfur	Presence of sulfides or their oxidation products

Table 1-2. Formative elements and adjectives (words ending in “ic”) used in Soil Taxonomy names—Continued

Formative element or adjective	Derivation	Connotation
Terric	L. *terra*, earth	A mineral substratum
Thapto(ic)	Gr. *thapto*, buried	A buried soil
Torr	L. *torridus*, hot and dry	Torric moisture regime
Turb	L. *turbidus*, disturbed	Presence of cryoturbation
Ud	L. *udus*, humid	Udic moisture regime
Umbr, Umbric	L. *umbra*, shade	Presence of a umbric epipedon
Ust	L. *ustus*, burnt	Ustic moisture regime
Verm	L. *vermes*, worms	Wormy or mixed by animals
Vitr	L. *vitrum*, glass	Presence of glass
Xanthic	Gr. *xanthos*	Yellow
Xer	Gr. *xeros*, dry	Xeric moisture regime

identifies the classification order, suborder, great group, subgroup, and family. Each level is progressively more specific, going from broadscale soil bodies that can be shown on continental-scale maps at the soil order level to detailed soil bodies that can be shown on farm-scale maps at the soil family level.

The use of Greek and Latin formative elements to construct the taxonomic names makes them connotative and insightful (tables 1-1 and 1-2), even for the non-specialist (Heller, 1963). For example, the soil classified at the subgroup level as Vertic Torrifluvents carries connotations of being geologically “recent” at the order level (table 1-1), associated with a flood plain at the suborder level (L. *fluvius*, river), in an arid region at the great group level (L. *torridus*, hot and dry), and having shrink-swell properties as indicated at the subgroup level (L. *verto*, turn).

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Endnotes

1. Soil definition

This definition was expanded in the 8th edition of the Keys (Soil Survey Staff, 1998) to include soils in areas of Antarctica (or other extreme environments) where pedogenesis occurs but where the climate is too harsh to support higher plant forms. This change was a recommendation of the International Committee on Permafrost Affected Soils (ICOMPAS, 1996). In addition, the expanded definition includes soils that are permanently covered by shallow water up to about 2.5 meters deep that exhibit some pedogenesis (in the form of horizon differentiation) but do not support higher plant forms (i.e., subaqueous soils).

2. Lower boundary

Soil survey field operations have commonly been conducted while walking over the land and using hand tools to examine the soil profile. The 2-meter lower limit for soil classification purposes reflects a practical constraint. For consistent application of Soil Taxonomy in soil survey operations, the 2-meter rule is applied even where conditions allow for routine use of truck-mounted power equipment or other methods to examine the soils to greater depth. Important information about the soil below 2 meters can be recognized for purposes of soil interpretation.

3. Cementation and coherence classes

In previous versions of the Keys, the rupture-resistance class terms for various degrees of "cementation" were used to describe the degree of consolidation for root-limiting layers. To determine cementation, an air-dry sample of the layer is submerged in water and tested for slaking (Soil Science Division Staff, 2017, pp. 181–185). Some root-restrictive layers, such as many bedrock layers, are not "cemented" but are rather held together by internal forces that do not involve the bonding of individual grains by cementing agents. Throughout the current version of the Keys, many of the references to cementation classes are replaced by coherence classes. This is a change in terms only, it does not result in any taxonomic class changes. The broader term "coherence" applies to all consolidated materials whether due to cementation or other factors. Pedogenically formed root-restrictive layers, such as petrocalcic horizons and duripans, exhibit various degrees of coherence that are the result of the accumulation of cementing agents due to pedogenic processes.

CHAPTER 2

Differentiae for Mineral Soils and Organic Soils

Soils are composed of both mineral and organic materials. Most soils are predominantly mineral material, but many soils have horizons composed of enough organic matter that the properties are primarily controlled by organic matter. In general, horizons that are less than about 20 percent organic matter, by weight, have properties that are more nearly those of mineral while horizons with more organic matter are considered organic soil materials and designated with an O master horizon. Organic soil materials are divided into different types depending on the amount of decomposition of the plant materials. Organic soil materials that occur in saturated conditions are often referred to as peat, mucky peat, or muck as the amount of decomposition increases. Fresh (totally undecomposed) plant material is referred to as litter.

Mineral and Organic Soil Material

Soil material (less than 2.0 mm in diameter) which has less than 12 percent (by weight) organic carbon is consider mineral soil materials.[*] Organic soil materials have 12 percent or more by weight organic carbon (note 1).

Distinction Between Mineral Soils and Organic Soils

For simplicity in writing definitions of taxa, a distinction is useful between what is a mineral soil and what is an organic soil. The thickness of the horizons that meet the criteria of organic soil materials is used to determine if the soil is classified as an organic soil. If that minimum is not met, the soil is mineral.[†] One exception is the Andisols (defined later). Most Andisols consist of mineral soil materials, but some may be dominated by organic soil materials. Those Andisols that exceed the organic carbon limit defined for mineral soils have a colloidal fraction dominated by short-range-order minerals or aluminum-humus complexes. The properties of these soils are believed to be more strongly affected by the mineral fraction than by the organic fraction. Therefore, the soils are included with the Andisols soil order rather than the organic soils.

[*] Twelve percent organic carbon is approximately equal to 20 percent organic matter.

[†] Mineral soils include all soils except the suborder Histels and the order Histosols.

The minimum thickness used to define an organic soil depends in part on the nature of the materials. A thick layer of sphagnum has a very low bulk density and contains less organic matter than a thinner layer of well-decomposed muck. The definition that follows is intended to classify soils as mineral if both of the following are true: the mineral portion is thick and the organic materials are no thicker than that permitted in the histic epipedon (see chapter 3).

The thickness of all organic horizons (O horizons) starting at the soil surface is used to determine the total thickness of organic soil material. This determination is different for buried soils (see chapter 1). An O horizon is considered an organic horizon if it meets the requirements of organic soil material, the plant materials are at least slightly decomposed, and the organic material is neither freshly fallen nor undecomposed plant litter.

Soil Surface

The term “soil surface” is based on the upper limit of soil. The upper limit of soil is the boundary between soil and either air, shallow water, live plants, or plant materials that have not begun to decompose. The soil surface is a horizon composed of either mineral soil material or organic soil material.

Mineral Soil Surface

The term “mineral soil surface” is the datum or horizontal plane used for measurements of depth or thickness in mineral soils (defined below). The mineral soil surface has two forms. It is either a soil surface composed of mineral soil material or it is the boundary between a horizon composed of organic soil material and a horizon composed of mineral soil material.

The upper boundary of the first horizon, encountered at or below the soil surface that is composed of mineral soil material, is considered the mineral soil surface (note 2). For example, a upland mineral soil with an 5-cm-thick Oi horizon within a horizon sequence of Oi-A-E-Bt-C has two surfaces for depth measurements. There is a soil surface at the boundary between either air or undecomposed plant material and the Oi horizon (at a depth of 0 cm). There is also a mineral soil surface at the boundary between the Oi and A horizons (at a depth of 5 cm).

Definition of Mineral Soils

Mineral soils are soils that have *either*:

1. Mineral soil materials that meet *one or more* of the following:

a. Overlie cindery, fragmental, or pumiceous materials and/or have voids* that are filled with 10 percent or less organic materials *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

b. When added with underlying cindery, fragmental, or pumiceous materials, total more than 10 cm between the soil surface and a depth of 50 cm; *or*

c. Constitute more than one-third of the total thickness of the soil to a densic, lithic, or paralithic contact or have a total thickness of more than 10 cm; *or*

d. If they are saturated with water for 30 days or more per year in normal years (or are artificially drained) and have organic materials with an upper boundary within 40 cm of the soil surface, have a total thickness of *either*:

(1) Less than 60 cm if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) Less than 40 cm if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more; *or*

2. More than 20 percent, by volume, mineral soil materials from the soil surface to a depth of 50 cm or to a glacic layer or a densic, lithic, or paralithic contact, whichever is shallowest; *and*

a. Permafrost within 100 cm of the soil surface; *or*

b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

Definition of Organic Soils

Organic soils have organic soil materials that:

1. Do not have andic soil properties in 60 percent or more of the thickness between the soil surface and either a depth of 60 cm or a densic, lithic, or paralithic contact or duripan if shallower; *and*

2. Meet *one or more* of the following:

a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices* *and* directly below these materials have a densic, lithic, or paralithic contact; *or*

b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

d. Are saturated with water for 30 days or more per year in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more; *or*

e. Are 80 percent or more of the volume from the soil surface to a depth of 50 cm or to a glacic layer or a densic, lithic, or paralithic contact, whichever is shallowest.

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

Endnotes

1. Organic carbon content

The distinction between organic and mineral soil materials has practical considerations. As the amount of soil organic matter increases, soils tend to absorb more water, have higher cation exchange capacity (CEC), and have a lower bulk density. In addition, soil materials rich in organic matter are subject to loss of organic matter upon disturbance and drainage (due to oxidation) and may subsequently subside appreciably due to volume loss.

The criteria used to separate mineral soil materials from organic soil materials has been revised with this edition of the *Keys to Soil Taxonomy*. The revised definition no longer considers soil saturation or clay content and instead uses 12 percent, by weight, soil organic carbon (SOC) as the single point of separation. This change was made for the purpose of simplification and was based on recent literature and analysis of KSSL data from thousands of samples focused on soil organic carbon.

Previous definitions considered clay content using a sliding scale and, later, using annual cumulative length of soil saturation. The sliding scale was used as early as the *7th Approximation of Soil Taxonomy* (1960). At that time, the sliding scale for organic soil materials was 30 percent

* Materials that meet the definition of the cindery, fragmental, or pumiceous substitute for particle-size class but have more than 10 percent, by volume, voids that are filled with organic soil materials are considered to be organic soil materials.

organic matter if the horizon had 50 percent clay and 20 percent organic matter if there was no clay. Intermediate clay contents required proportional amounts. Soil saturation was not considered. The same definition was used for identifying O horizons in mineral soils in *Soil Taxonomy* (1975). Neither the *7th Approximation* nor *Soil Taxonomy* defined O horizons in organic soils. Both indicated that a definition was currently under discussion.

From the first edition of *Soil Taxonomy* (Soil Survey Staff, 1975) to the 12th edition of *Keys to Soil Taxonomy* (Soil Survey Staff, 2014), a sliding scale was used for separating organic soil materials from mineral soil materials for wet soils (i.e., soils saturated for 30 days or more each year). The scale ranged from12 to 18 percent SOC by weight (roughly 20 to 30 percent organic matter), depending on the clay content. Soils rarely saturated for more than a few days were defined as organic if they contained 20 percent or more SOC by weight.

The reasoning for using different criteria for wet soils than for unsaturated soils is not well documented. One justification for the sliding scale was that coarser textured soil materials tend to hold relatively less water and have lower cation exchange capacity compared to soils with higher clay content. Therefore, it requires less organic carbon content to exert a significant influence on soil properties for those soils that are relatively low in clay. Morris et al. (2016) compiled bulk density and soil organic matter data from over 5000 samples and found that at approximately 25 percent soil organic matter (roughly 12 to 13 percent SOC) soil volume becomes a function of soil organic matter content. Analysis of over 3,000 KSSL samples with greater than 12 percent SOC showed no value in using the sliding scale (NCSS, 2018). Statistical analysis of the samples having SOC contents between 12 and 18 percent showed no relationship between bulk density and SOC and no relationship between CEC and SOC.

Literature Cited in Endnote 1

Morris, J.T., D. Barber, J. Callaway, R. Chambers, S. Hagen, C. Hopkinson, B. Johnson, P. Megonigal, S. Neubauer, T. Troxler, and C. Wigand. 2016. Contributions of Organic and Inorganic Matter to Sediment Volume and Accretion in Tidal Wetlands at Steady State. Earth's Future 4:110–121. doi:10.1002/2015EF000334

National Cooperative Soil Survey. 2018. Standards and Taxonomy Committee Proposals. Soil Taxonomy, Organic Soil Material. 2018 NCSS Regional Committees.

Soil Survey Staff. 1960. Soil Classification. A Comprehensive System, 7th Approximation. U.S. Department of Agriculture, Soil Conservation Service. U.S. Government Printing Office, Washington, D.C.

Soil Survey Staff. 1975. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys. Soil Conservation Service. U.S. Department of Agriculture Handbook 436.

Soil Survey Staff. 2014. Keys to Soil Taxonomy, 12th edition. USDA Natural Resources Conservation Service.

2. Mineral soil surface

For the purpose of applying Soil Taxonomy, the mineral soil surface is preferred to an organic layer as a starting point for measurement. Organic surface layers are susceptible to volume loss due to oxidation, compaction, fire, or other significant changes after disturbance. The mineral soil surface provides a more stable and durable datum relative to subsurface horizon thickness and depth.

CHAPTER 3

Horizons and Characteristics Diagnostic for the Higher Categories

This chapter defines the horizons and characteristics of both mineral and organic soils. It is divided into four parts—horizons and characteristics diagnostic for mineral soils, characteristics diagnostic for organic soils, horizons and characteristics diagnostic for both mineral and organic soils, and characteristics diagnostic for human-altered and human-transported soils. Table 3-1 shows the diagnostic horizons and characteristics arranged by kinds of material for which they are used.

The horizons and characteristics defined below are not in a key format. The "required characteristics" for horizons or features, however, are arranged as a key. Some diagnostic horizons are mutually exclusive, and some are not. An umbric epipedon, for example, could not also be a mollic epipedon. A kandic horizon with clay films, however, could also meet the definition of an argillic horizon. The exclusions are stated in the horizon definitions.

Horizons and Characteristics Diagnostic for Mineral Soils

The criteria for some of the following horizons and characteristics, such as histic and folistic epipedons, can be met in organic soils. They are diagnostic, however, only for the mineral soils.

Diagnostic Surface Horizons: The Epipedon

The epipedon (Gr. *epi*, over, upon, and *pedon*, soil) is a horizon that forms at or near the surface and in which most of the rock structure has been destroyed. It is darkened by organic matter or shows evidence of eluviation, or both. *Rock structure* (fig. 3-1) as used here and in other places in this taxonomy includes *fine stratification* (5 mm or less thick) in unconsolidated sediments (eolian, alluvial, lacustrine, or marine) and *saprolite* derived from consolidated rocks in which the unweathered minerals and pseudomorphs of weathered minerals retain their relative positions to each other (note 1).

Figure 3-1: Soil profile with rock structure as fine to coarse stratifications throughout. The upper 60 cm is recent eolian sand. The lower part consists of old alluvial deposits interspersed with eolian strata. The soil is a Torriorthent in the United Arab Emirates. Scale is in cm. (Photo courtesy of Dr. Craig Ditzler)

Any horizon may be at the surface of a truncated soil. The following section, however, is concerned with eight diagnostic horizons that have formed at or near the soil surface. These horizons can be covered by a surface mantle of new soil material or a surface mantle of human-transported material, both described in chapter 1. If the surface mantle has rock structure, the top of the epipedon is considered the soil surface unless the mantle meets the definition of buried soils in chapter 1. If the soil includes a buried soil, the epipedon, if one occurs, is at the soil surface and the epipedon of the buried soil is considered a buried epipedon and is not considered in selecting taxa unless the keys specifically indicate buried horizons, such as those in Thapto-Histic subgroups. A soil with a mantle thick enough to have a buried soil has no epipedon if

Table 3-1. Diagnostic Horizons and Characteristics Arranged by Kinds of Soil Material for Which They Are Used

Mineral Soils

Epipedons	Subsurface Horizons		Soil Characteristics	
Anthropic	Agric	Kandic	Abrupt textural change	Linear extensibility
Folistic	Albic	Natric	Albic materials	Lithologic discontinuity
Histic	Anhydritic	Ortstein	Andic soil properties	*n* value
Melanic	Argillic	Oxic	Anhydrous conditions	Petroferric contact
Mollic	Calic	Petrocalcic	Coefficient of linear extensibility	Plinthite
Ochric	Cambic	Petrogypsic	Durinodes	Resistant materials
Plaggen	Duripan	Placic	Fragic soil properties	Slickensides
Umbric	Fragipan	Salic	Free carbonates	Spodic materials
	Glossic	Sombric	Identifiable secondary carbonates	Volcanic ash
	Gypsic	Spodic	Interfingering of albic materials	Weatherable minerals
			Lamellae	

Organic Soils

Kinds of Soil Material	Thickness of Organic Soil Materials
Fibric soil material	Surface tier
Hemic soil material	Subsurface tier
Sapric soil material	Bottom tier
Humilluvic soil material	

Both Mineral and Organic Soils

Soil Characteristics		Kinds of Limnic Material	Soil Horizon or Layer
Aquic conditions	Paralithic contact	Coprogenous earth	Glacic layer
Cryoturbation	Paralithic materials	Diatomaceous earth	Sulfuric horizon
Densic contact	Permafrost	Marl	
Densic materials	Soil moisture regime		
Gelic materials	Soil temperature regime		
Lithic contact	Sulfidic materials		

Human-Altered and Human-Transported Materials or Layers

Anthropogenic Landforms and Microfeatures	Anthropogenic Material or Layers
Constructional anthropogenic landforms	Artifacts
Destructional anthropogenic landforms	Human-altered material
Constructional anthropogenic microfeatures	Human-transported material
Destructional anthropogenic microfeatures	Manufactured layer
	Manufactured layer contact

the soil has rock structure to the surface or has an Ap horizon less than 25 cm thick that is underlain by soil material with rock structure. The melanic epipedon (defined below) is unique among epipedons. It commonly forms in deposits of tephra and can receive fresh deposits of volcanic ash. Therefore, this horizon is permitted to have layers within and above the epipedon that are not part of the melanic epipedon.

A recent alluvial or eolian deposit that retains fine stratifications (5 mm or less thick) or an Ap horizon directly underlain by such stratified material is not included in the concept of the epipedon because there has not been enough time for soil-forming processes to erase these transient marks of deposition and for diagnostic and accessory properties to develop.

An epipedon is not the same as an A horizon. It may include part or all of an illuvial B horizon if the darkening by organic matter extends from the soil surface into or through the B horizon.

Anthropic Epipedon

The anthropic epipedon (fig. 3-2) (note 2) forms in human-altered or human-transported material (defined below). These epipedons form in soils which occur on anthropogenic landforms and microfeatures or which are higher than the adjacent soils by as much as or more than the thickness of the anthropic epipedon. They may also occur in excavated areas. Most anthropic epipedons contain artifacts other than those associated with agricultural practices (e.g., quicklime) and litter discarded by humans (e.g., aluminum cans). Anthropic epipedons may have an elevated phosphorus content from human additions of food debris (e.g., bones), compost, or manure, although a precise value is not required. Although

Figure 3-2: Soil profile in New York City that formed in human-transported material. It has a darkened anthropic epipedon and is rich in artifacts consisting of building materials such as brick, concrete, and metal. Scale is in cm. (Photo courtesy of Richard Shaw)

anthropic epipedons formed at the soil surface, they may now be buried. Most anthropic epipedons occur in soils of gardens, middens (Hester et al., 1975), and urban areas, and most also meet the definition of another diagnostic mineral epipedon or subsurface horizon.

The anthropic epipedon consists of mineral soil material that shows evidence of the purposeful alteration of soil properties or of earth-surface features by human activity. The field evidence of alteration is significant and excludes agricultural practices such as shallow plowing or addition of amendments, such as lime or fertilizer.

The anthropic epipedon includes eluvial horizons that are at or near the soil surface, and it extends to the base of horizons that meet all the criteria shown below or it extends to the top of the first underlying diagnostic illuvial horizon (defined below as an argillic, kandic, natric, or spodic horizon).

Required Characteristics

The anthropic epipedon consists of mineral soil material. It is required to have all of the following properties:

Physical Characteristics of Structure and Consistence

1. When dry, has structural units with a diameter of 30 cm or less; *and*

2. Has rock structure, including fine stratifications (5 mm or less thick), in less than one-half of the volume of all parts; *and*

3. Has an *n* value (defined below) of less than 0.7 or a fluidity class of nonfluid; *and*

Significant Anthropogenic Influence

4. Formed in human-altered or human-transported material (defined below) on an anthropogenic landform or microfeature (defined below); *and either*

    a. Directly overlies mine or dredged spoil material that has rock structure, a root-limiting layer (defined in chapter 17), or a lithologic discontinuity with horizons that are not derived from human-altered or human-transported material (defined below); *or*

    b. Has *one or more* of the following throughout:

        (1) Artifacts, other than agricultural amendments (e.g., quicklime) and litter discarded by humans (e.g., aluminum cans); *or*

        (2) Midden material (i.e., eating and cooking waste and associated charred products); *or*

        (3) Anthraquic conditions; *and*

Thickness

5. Has a minimum thickness that is *either*:

    a. The entire thickness of the soil above a root-limiting layer (defined in chapter 17) if one occurs within 25 cm of the soil surface; *or*

    b. 25 cm.

Folistic Epipedon

The folistic epipedon is a surface layer that is more or less freely drained and has sufficiently high amounts of organic carbon to be considered organic soil material. Typically, it is at least 15 cm thick. A few epipedons that are mineral material, bordering on organic, are included if cultivated.

Required Characteristics

The folistic epipedon is a layer (one or more horizons) that is saturated for less than 30 days (cumulative) in normal years (and is not artificially drained) (note 3) and *either*:

1. Consists of organic soil material that:

    a. Is 20 cm or more thick and either contains 75 percent

Figure 3-3: Soil profile in Alaska that has a histic epipedon extending to a depth of about 38 cm. The upper 20 cm is fibric soil material that has a high content of *Sphagnum* overlying more decomposed organic soil material. Scale is in cm. (Photo courtesy of Dr. David Weindorf)

or more (by volume) *Sphagnum* fibers or has a bulk density, moist, of less than 0.1 g/cm^3; *or*

b. Is 15 cm or more thick; *or*

2. Is an Ap horizon (note 4) that, when mixed to a depth of 25 cm, has an organic carbon content (by weight) of 8 percent or more.

Histic Epipedon

The histic epipedon (fig. 3-3) is a horizon that is periodically saturated with water and that has sufficiently high amounts of organic carbon to be considered organic soil material. Typically, it is at (or near) the surface and is peat or muck at least 20 cm thick.

Required Characteristics

The histic epipedon is a layer (one or more horizons) that is characterized by saturation (for 30 days or more, cumulative) and reduction for some time during normal years (or is artificially drained) and *either*:

1. Consists of organic soil material (note 5) that:

a. Is 20 to 60 cm thick and either contains 75 percent or more (by volume) *Sphagnum* fibers or has a bulk density, moist, of less than 0.1 g/cm^3; *or*

b. Is 20 to 40 cm thick; *or*

2. Is an Ap horizon (note 6) that, when mixed to a depth of 25 cm, has an organic carbon content (by weight) of 8 percent or more.

Melanic Epipedon

The melanic epipedon (note 7) (fig. 3-4) is a thick, very dark (commonly black) horizon at or near the soil surface. It is mostly associated with soils that formed in materials of volcanic origin, generally in a cool, humid environment. Admixtures of loess, alluvium, or colluvium may also be present in the parent material.

Required Characteristics

The melanic epipedon has *both* of the following:

Position in the Profile

1. An upper boundary at, or within 30 cm of, either the mineral soil surface or the upper boundary of an organic layer with andic soil properties (defined below), whichever is shallower; *and*

Thickness

2. In layers with a cumulative (note 8) thickness of 30 cm or more within a total thickness of 40 cm, *all* of the following:

Chemical Properties and Color

a. Andic soil properties throughout; *and*

b. A color value of 2.5 or less, moist, and chroma of 2 or less throughout; *and*

c. A melanic index (defined in the appendix) of 1.70 or less (note 9) throughout; *and*

d. 6 percent or more organic carbon as a weighted average and 4 percent or more organic carbon in all layers.

Mollic Epipedon

Required Characteristics

The mollic epipedon (fig. 3-5) consists of mineral soil material and, after mixing (note 10) of the upper 18 cm of the mineral soil or of the whole mineral soil if its depth to a densic, lithic, or paralithic contact, a petrocalcic horizon, or a duripan (all defined below) is less than 18 cm, has the following properties:

Physical Characteristics of Structure and Consistence

1. When dry, *either or both*:

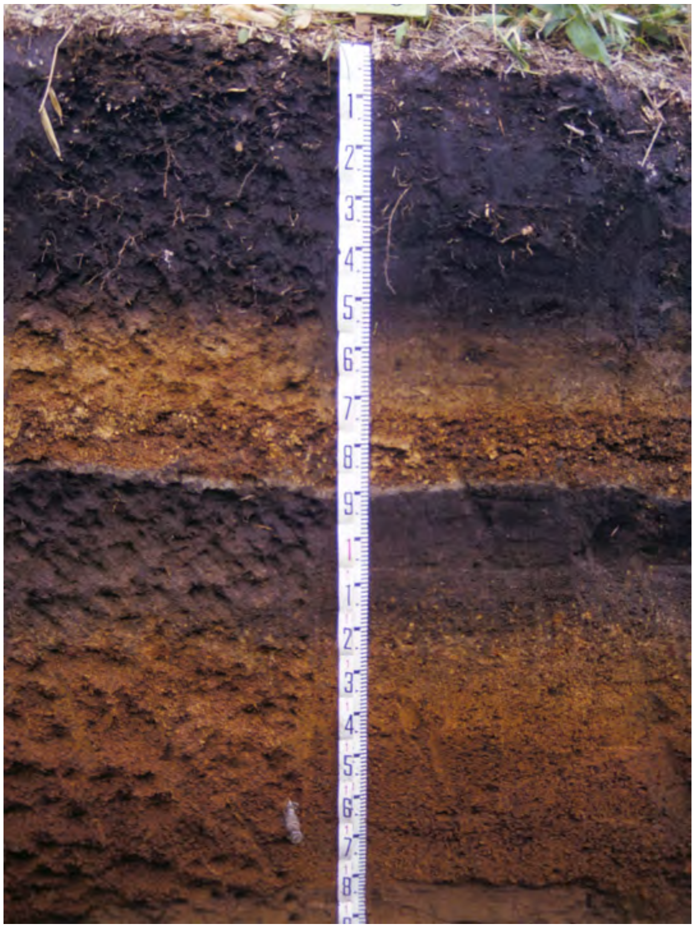

Figure 3-4: Profile of a soil in Japan with a melanic epipedon about 50 cm thick. An older surface layer of a buried soil is below a depth of 90 cm. Scale is in decimeters.

Figure 3-5: Soil with a mollic epipedon more than 1 meter thick that formed on the steppes of the Ukraine.

a. Structural units with a diameter of 30 cm or less or secondary structure with a diameter of 30 cm or less; *or*

b. A moderately hard or softer rupture-resistance class (note 11); *and*

2. Rock structure, including fine stratifications (5 mm or less thick), in less than one-half of the volume of all parts; *and*

3. An *n* value (note 12) (defined below) of less than 0.7 or a fluidity class of non-fluid; *and*

Color Characteristics with Adjustment for Calcium Carbonate Content (note 13)

4. *One* of the following:

a. *Both* of the following:

(1) Dominant color* with a value of 3 or less, moist, and of 5 or less, dry; *and*

(2) Dominant color with chroma of 3 or less, moist; *or*

b. A fine-earth fraction that has a calcium carbonate equivalent of 15 to 40 percent and colors with a value and chroma of 3 or less, moist; *or*

c. A fine-earth fraction that has a calcium carbonate equivalent of 40 percent or more and a color value of 5 or less, moist; *and*

Chemical Characteristics

5. A base saturation (by NH_4OAc) (note 14) of 50 percent or more throughout; *and*

6. An organic carbon content of:

a. 2.5 percent or more if the epipedon has a color value of 4 or 5, moist; *or*

b. 0.6 percent (absolute) more than that of the C horizon (if one occurs) if the mollic epipedon has a color value less than 1 unit lower or chroma less than 2 units lower (both moist and dry) than the C horizon; *or*

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* The concept of dominant color is defined in the *Soil Survey Manual* (Soil Science Division Staff, 2017, p.150).

c. 0.6 percent or more and the epipedon does not meet the qualifications in item 6a or 6b above; *and*

Thickness (note 15)

7. The minimum thickness of the epipedon is as follows:

a. 25 cm if:

(1) The texture class of the epipedon is loamy fine sand or coarser throughout; *or*

(2) There are no underlying diagnostic horizons (defined below) and the organic carbon content of the underlying materials decreases irregularly with increasing depth; *or*

(3) *Any* of the following, if present, are 75 cm or more below the mineral soil surface:

(a) The upper boundary of the shallowest of any identifiable secondary carbonates or a calcic horizon, petrocalcic horizon, duripan, or fragipan (defined below); *and/or*

(b) The lower boundary of the deepest of an argillic, cambic, natric, oxic, or spodic horizon; *or*

b. 10 cm if the epipedon has a texture class finer than loamy fine sand (when mixed) and it is directly above a densic, lithic, or paralithic contact, a petrocalcic horizon, or a duripan; *or*

c. 18 to 25 cm and the thickness is one-third or more of the total thickness between the mineral soil surface and:

(1) The upper boundary of the shallowest of any identifiable secondary carbonates or a calcic horizon, petrocalcic horizon, duripan, or fragipan; *and/or*

(2) The lower boundary of the deepest of an argillic, cambic, natric, oxic, or spodic horizon; *or*

d. 18 cm if none of the above conditions apply; *and*

Seasonal Soil Moisture State

8. Some part of the epipedon is moist for 90 days or more (cumulative) in normal years during times when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher, if the soil is not irrigated.

Ochric Epipedon

The ochric epipedon (fig. 3-6) fails to meet the definitions for any of the other seven epipedons because it is too thin or too dry, has too high a color value or chroma, contains too little organic carbon, has too high an *n* value, has too high a fluidity class or melanic index, or is both massive and hard or harder when dry. Many ochric epipedons have either a color value of 4 or more, moist, and 6 or more, dry, or chroma of 4

Figure 3-6: A soil profile with an ochric epipedon about 18 cm (7 inches) thick. Except for the ochric epipedon, this profile exhibits little pedogenic development. Scale is in inches.

or more, or they include an A or Ap horizon that has both low color values and low chroma but is too thin to be recognized as a mollic or umbric epipedon (and has less than 15 percent calcium carbonate equivalent in the fine-earth fraction). Ochric epipedons also include horizons of organic materials that are too thin to meet the requirements for a histic or folistic epipedon.

The ochric epipedon includes eluvial horizons that are at or near the soil surface, and it extends to the first underlying diagnostic illuvial horizon (defined below as an argillic, kandic, natric, or spodic horizon). If the underlying horizon is a B horizon of alteration (defined below as a cambic or oxic horizon) and there is no surface horizon that is appreciably darkened by humus, the lower limit of the ochric epipedon is the lower boundary of the plow layer or an equivalent depth (18 cm) in a soil that has not been plowed. Actually, the same horizon in an unplowed soil may be both part of the epipedon and part of the cambic horizon; the ochric epipedon and the subsurface diagnostic horizons are not all mutually exclusive. The ochric epipedon does not have rock structure and does not include finely stratified fresh sediments, nor can it be an Ap horizon directly overlying such deposits.

Required Characteristics

The ochric epipedon has *both* of the following:

1. It meets the definition for an "epipedon," including *all* of the following:

   a. It formed from pedogenic processes at or near the soil surface; *and*

   b. Most rock structure, including fine stratification, has been destroyed; *and*

   c. It has been darkened by organic matter and/or shows evidence of eluviation; *and*

2. It fails to meet one or more of the required characteristics of any other epipedon.

Plaggen Epipedon

The plaggen epipedon (fig. 3-7) is a thick, human-made mineral surface layer that has been produced by long-continued manuring (note 16). A plaggen epipedon can be identified by several means. Commonly, it contains artifacts, such as brick and potsherds, throughout its thickness. There may be earthy fragments (i.e., clods) of diverse materials, such as black sand and light gray sand, as large as the size held by a spade. The plaggen epipedon normally shows spade marks at least in its lower part. It may also contain remnants of thin stratified beds of sand that were probably produced on the soil surface by beating rains and were later buried. A map unit delineation of soils with plaggen epipedons would tend to occur on straight-sided anthropogenic landforms that are higher than adjacent land surfaces by as much as or more than the thickness of the plaggen epipedon (note 17).

Required Characteristics

The plaggen epipedon consists of mineral soil material and meets *all* of the following:

Significant Anthropogenic Influence

1. It occurs in soils on locally raised landforms *and* contains *one or both* of the following:

   a. Artifacts, other than agricultural amendments (e.g., quicklime) and litter discarded by humans (e.g., aluminum cans); *or*

   b. Spade marks below a depth of 30 cm; *and*

Figure 3-7: Profile of a soil from Holland with a plaggen epipedon about 70 cm thick that formed from long-term manuring. Scale colors are in 10-cm increments.

Color and Carbon Content

2. It has colors with a value of 4 or less, moist, and 5 or less, dry, and chroma of 2 or less; *and*

3. It has an organic carbon content of 0.6 percent or more; *and*

Thickness

4. It has a thickness of 50 cm or more of human-transported material (defined below); *and*

Seasonal Soil Moisture State

5. Some part of the epipedon is moist for 90 days or more (cumulative) in normal years during times when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher, if the soil is not irrigated.

Umbric Epipedon

The umbric epipedon (fig. 3-8) is a relatively thick, dark-colored, humus-rich surface horizon. It commonly forms in

Figure 3-8: Soil profile from South Korea with an umbric epipedon about 30 cm thick. Scale colors are in 10-cm increments.

humid, forested environments, but can also form in grasslands, forest-grassland transitions, tundra, tropical areas, or other environments. The supply of bivalent cations on the exchange complex is moderate to low. The low base status is mostly due to parent materials that are relatively low in base cations or the rate of leaching of base cations proceeding at a pace that keeps their concentration relatively low, or both. Most umbric epipedons have pH values less than 6.5.

Required Characteristics

The umbric epipedon consists of mineral soil material and, after mixing (note 18) of the upper 18 cm of the mineral soil or of the whole mineral soil if its depth to a densic, lithic, or paralithic contact, a petrocalcic horizon, or a duripan (all defined below) is less than 18 cm. It has the following properties:

Physical Characteristics of Structure and Consistence

1. When dry, *either or both*:

   a. Structural units with a diameter of 30 cm or less or secondary structure with a diameter of 30 cm or less; *or*

   b. A moderately hard or softer rupture-resistance class; *and*

2. Rock structure, including fine stratifications (5 mm or less thick), in less than one-half of the volume of all parts; *and*

3. An *n* value (note 12) (defined below) of less than 0.7 or a fluidity class of nonfluid; *and*

Color

4. Dominant color* with a value of 3 or less, moist, and 5 or less, dry, *and* chroma of 3 or less, moist; *and*

Chemical Characteristics

5. A base saturation (by NH_4OAc) of 50 percent or more throughout; *and*

6. An organic carbon content of:

   a. 0.6 percent (absolute) more than that of the C horizon (if one occurs) if the umbric epipedon has a color value less than 1 unit lower or chroma less than 2 units lower (both moist and dry) than the C horizon; *or*

   b. 0.6 percent or more and the epipedon does not meet the qualifications in item 6a above; *and*

Thickness (note 19)

7. The minimum thickness of the epipedon is as follows:

   a. 25 cm if:

      (1) The texture class of the epipedon is loamy fine sand or coarser throughout; *or*

      (2) There are no underlying diagnostic horizons (defined below) and the organic carbon content of the underlying materials decreases irregularly with increasing depth; *or*

      (3) *Any* of the following, if present, are 75 cm or more below the mineral soil surface:

         (a) The upper boundary of the shallowest of any identifiable secondary carbonates or a calcic horizon, petrocalcic horizon, duripan, or fragipan (defined below); *and/or*

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* The concept of dominant color is defined in the *Soil Survey Manual* (Soil Science Division Staff, 2017, p.150).

(b) The lower boundary of the deepest of an argillic, cambic, natric, oxic, or spodic horizon; *or*

b. 10 cm if the epipedon has a texture class finer than loamy fine sand (when mixed) and it is directly above a densic, lithic, or paralithic contact, a petrocalcic horizon, or a duripan; *or*

c. 18 to 25 cm and the thickness is one-third or more of the total thickness between the mineral soil surface; *and*

(1) The upper boundary of the shallowest of any identifiable secondary carbonates or a calcic horizon, petrocalcic horizon, duripan, or fragipan; *and/or*

(2) The lower boundary of the deepest of an argillic, cambic, natric, oxic, or spodic horizon; *or*

d. 18 cm if none of the above conditions apply; *and*

Soil Moisture State

8. Some part of the epipedon is moist for 90 days or more (cumulative) in normal years during times when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher, if the soil is not irrigated.

Diagnostic Subsurface Horizons

The horizons described in this section form below the surface of the soil, although in some areas they form directly below a layer of leaf litter. They are composed of mineral soil material. They may be exposed at the surface by truncation of the soil. Some of these horizons are designated as B horizons by many, but not all, pedologists and others are generally designated as parts of A or E horizons.

Agric Horizon

The agric horizon (note 20) is an illuvial horizon (note 21) that formed under cultivation and contains significant amounts of illuvial silt, clay, and humus.

Required Characteristics

Position in the Profile and Thickness

The agric horizon is directly below an Ap horizon and has a thickness of 10 cm or more and *either*:

Physical Properties and Color

1. 5 percent or more (by volume) wormholes, including coatings that are 2 mm or more thick and have a color value of 4 or less, moist, and chroma of 2 or less; *or*

2. 5 percent or more (by volume) lamellae that have a thickness of 5 mm or more and have a color value of 4 or less, moist, and chroma of 2 or less.

Figure 3-9: Soil profile from Michigan with a light-colored albic horizon extending to a depth of about 30 cm (1 foot). The albic horizon is underlain by a spodic horizon. Scale is in feet with 3-inch (about 7.5-cm) increments.

Albic Horizon

The albic horizon (fig. 3-9) is an eluvial horizon, 1 cm or more thick, that has 85 percent or more (by volume) albic material (defined below) (note 22). It generally occurs below an A horizon but may be at the mineral soil surface (note 23). Under the albic horizon there generally is an argillic, cambic, kandic, natric, or spodic horizon or a fragipan (defined below). The albic horizon may lie between a spodic horizon and either a fragipan or an argillic horizon, or it may be between an argillic or kandic horizon and a fragipan. It may lie between a mollic epipedon and an argillic or natric horizon or between a cambic horizon and an argillic, kandic, or natric horizon or a fragipan. The albic horizon may separate horizons that, if they were together, would meet the requirements for a mollic epipedon. It may separate lamellae that together meet the requirements for an argillic horizon. These lamellae are not considered to be part of the albic horizon.

Figure 3-10: A soil profile with an anhydritic horizon (depths of 0 to 55 cm) from the United Arab Emirates. Scale is in 10-cm increments. (Photo courtesy of Dr. Shabbir A. Shahid)

Required Characteristics

The albic horizon meets *both* of the following requirements:

Thickness

1. Is 1 cm or more thick; *and*

Composition

2. Is composed of 85 percent or more (by volume) albic materials (defined below).

Anhydritic Horizon

The anhydritic horizon (fig. 3-10) is a horizon in which anhydrite has accumulated through neoformation or transformation to a significant extent (note 24). It typically occurs as a subsurface horizon. It commonly occurs in conjunction with a salic horizon (defined below).

Required Characteristics

The anhydritic horizon meets *all* of the following requirements:

Thickness

1. Is 15 cm or more thick; *and*

Content of Anhydrite

2. Is 5 percent or more (by weight) anhydrite; *and*

3. Has anhydrite as the predominant calcium sulfate mineral with gypsum either absent or present only in minor amounts; *and*

4. Has a product of thickness (in cm) multiplied by the anhydrite content (percent by weight) of 150 or more (thus, a horizon 30 cm thick that is 5 percent anhydrite qualifies as an anhydritic horizon); *and*

Color

5. Has hue of 5Y, chroma (moist and dry) of 1 or 2, and value of 7 or 8.

Argillic Horizon

An argillic horizon (fig. 3-11) is normally a subsurface horizon with a significantly higher percentage of phyllosilicate clay (note 25) than the overlying soil material (note 26). It shows evidence of clay illuviation. The argillic horizon forms below the soil surface, but it may be exposed at the surface later by erosion.

Required Characteristics

For all argillic horizons (with or without an overlying eluvial layer)

1. All argillic horizons must meet *both* of the following requirements:

Thickness

a. *One* of the following:

(1) If the argillic horizon meets the particle-size class criteria for coarse-loamy, fine-loamy, coarse-silty, fine-silty, fine, or very-fine or is loamy or clayey, including skeletal counterparts, it must be at least 7.5 cm thick or at least one-tenth as thick as the sum of the thickness of all overlying horizons, whichever is greater; *or*

(2) If the argillic horizon meets the sandy or sandy-skeletal particle-size criteria, it must be at least 15 cm thick; *or*

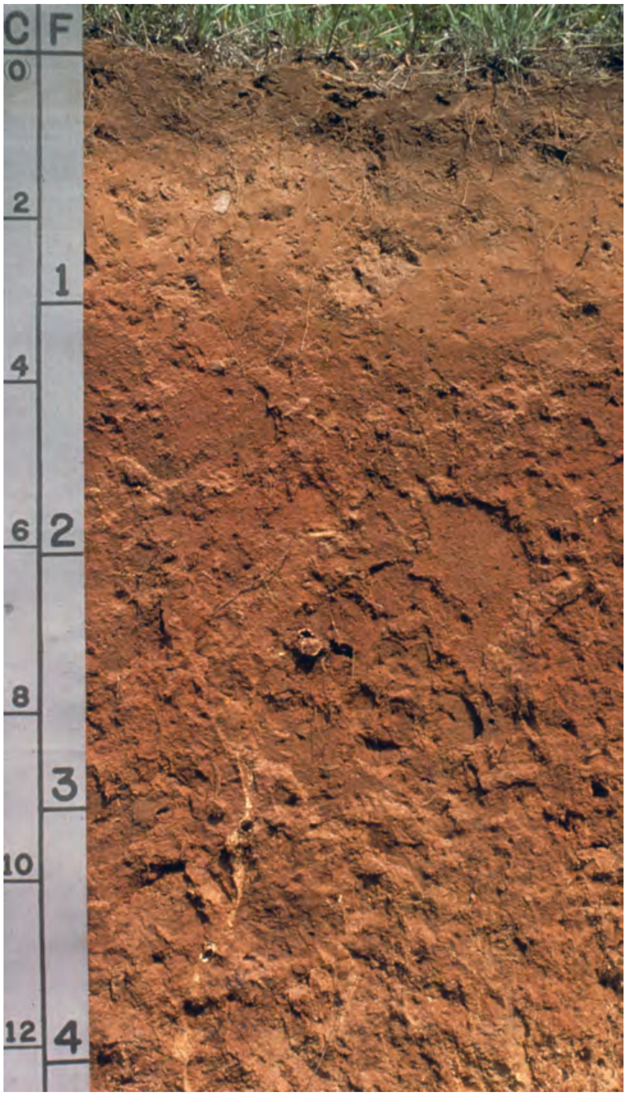

Figure 3-11: Soil profile with an argillic horizon between about 30 and 120 cm. Note the lighter colored eluvial horizon above the argillic horizon (depths of 10 to 30 cm). Scale is in decimeters (left) and feet (right).

(3) If the argillic horizon is composed entirely of lamellae, the combined thickness of the lamellae that are 0.5 cm or more thick must be 15 cm or more; *and*

Morphological Evidence of Illuvial Clay

b. Evidence of clay illuviation (note 27) in at least *one* of the following forms:

(1) Oriented clay bridging the sand grains; *or*

(2) Clay films (note 28) lining pores; *or*

(3) Clay films on both vertical and horizontal surfaces of peds; *or*

(4) Thin sections with oriented clay bodies that are more than 1 percent of the section (note 29); *or*

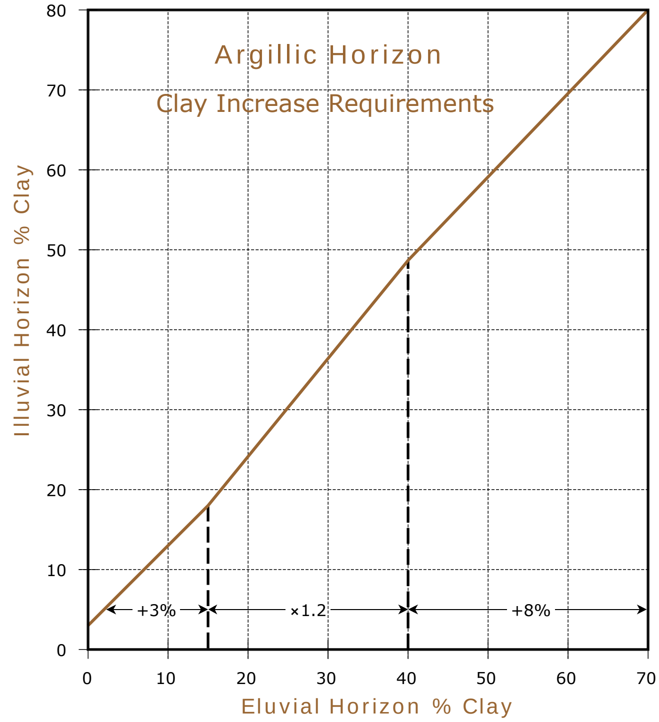

Figure 3-12: The argillic horizon requires more clay in the illuvial horizon than in the overlying eluvial horizon. The percent clay increase depends on the amount of clay in the eluvial horizon as illustrated by the graph.

(5) If the coefficient of linear extensibility is 0.04 or higher and the soil has distinct wet and dry seasons, then the ratio of fine clay to total clay in the illuvial horizon is greater by 1.2 times or more than the ratio in the eluvial horizon (note 30); *and*

Required clay increase for argillic horizons with an overlying eluvial layer (fig. 3-12)

2. If an eluvial horizon remains and there is no lithologic discontinuity between it and the illuvial horizon and no plow layer directly above the illuvial layer, then the illuvial horizon must contain more total clay than the eluvial horizon within a vertical distance of 30 cm or less, as follows (note 31):

a. If any part of the eluvial horizon has less than 15 percent total clay in the fine-earth fraction, the argillic horizon must contain at least 3 percent (absolute) more clay (10 percent vs. 13 percent, for example); *or*

b. If the eluvial horizon has 15 to 40 percent total clay in the fine-earth fraction, the argillic horizon must have at least 1.2 times more clay than the eluvial horizon; *or*

c. If the eluvial horizon has 40 percent or more total clay in the fine-earth fraction, the argillic horizon must contain at least 8 percent (absolute) more clay (42 percent vs. 50 percent, for example).

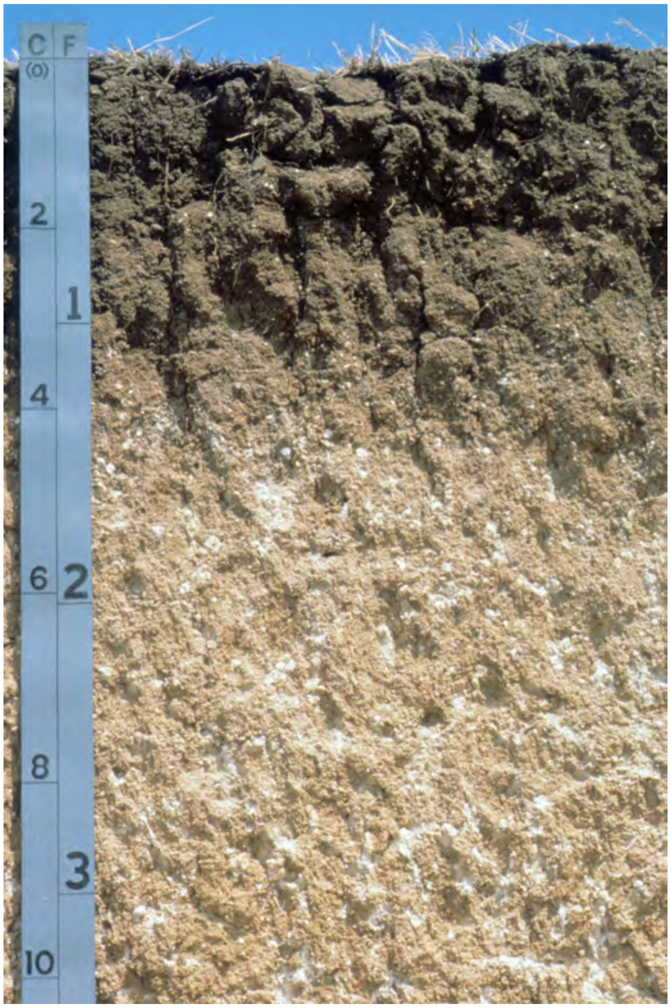

Figure 3-13: Soil profile with a calcic horizon in the subsoil beginning at a depth of about 30 cm. The white color is due to calcium carbonate accumulating as identifiable secondary carbonates. Scale is in decimeters (left) and feet (right).

Calcic Horizon

The calcic horizon (fig. 3-13) is an illuvial horizon in which secondary calcium carbonate or other carbonates have accumulated to a significant extent.

Required Characteristics

The calcic horizon has the following characteristics:

Thickness

1. Is 15 cm or more thick; *and*

Calcium Carbonate Equivalent (note 32)

2. Has *one or more* of the following:

a. 15 percent or more (by weight, fine-earth fraction) $CaCO_3$ equivalent; *and*

(1) Its $CaCO_3$ equivalent is 5 percent or more (absolute) higher than that of an underlying horizon; *or*

(2) Has 5 percent or more (by volume) identifiable secondary carbonates; *or*

b. 5 percent or more (by weight, fine-earth fraction) $CaCO_3$ equivalent; *and*

(1) Has less than 18 percent clay in the fine-earth fraction; *and*

(2) Meets the criteria for a sandy, sandy-skeletal, coarse-loamy, or loamy-skeletal particle-size class (note 33) (defined in chapter 17); *and*

(3) Has 5 percent or more (by volume) identifiable secondary carbonates or a $CaCO_3$ equivalent (by weight, fine-earth fraction) that is 5 percent or more (absolute) higher than that of an underlying horizon; *and*

Physical Properites

3. Is not cemented or indurated* in any part by carbonates, with or without other cementing agents, or is cemented in some part and the cemented part satisfies *one* of the following (note 34):

a. It is characterized by so much lateral discontinuity that roots can penetrate through noncemented zones or along vertical fractures with a horizontal spacing of less than 10 cm; *or*

b. The cemented layer is less than 1 cm thick and consists of a laminar cap underlain by a lithic or paralithic contact; *or*

c. The cemented layer is less than 10 cm thick.

Cambic Horizon

A cambic horizon is the result of physical alterations, chemical transformations, or removals or of a combination of two or more of these processes.

Required Characteristics

A cambic horizon has the following characteristics:

Thickness

1. Is an altered horizon 15 cm or more thick (if it is composed of lamellae, the combined thickness of the lamellae must be 15 cm or more); *and*

Texture

2. Has a texture class of very fine sand, loamy very fine sand, or finer (note 35); *and*

* The rupture-resistance class for air-dry submerged samples is less than extremely weakly coherent.

Evidence of Alteration

3. Has soil structure or the absence of rock structure, including fine stratifications (5 mm or less thick), in more than one-half of the volume; *and*

4. Shows additional evidence of alteration in *one* of the following forms:

Cambic horizons in wet soils

a. Has aquic conditions within 50 cm of the soil surface or artificial drainage and *all* of the following:

(1) Colors that do not change on exposure to air; *and*

(2) Dominant color, moist, on faces of peds or in the matrix as follows:

(a) Value of 3 or less and neutral colors with no hue (N) and zero chroma; *or*

(b) Value of 4 or more and chroma of 1 or less; *or*

(c) Any value, chroma of 2 or less, and redox concentrations; *or*

Cambic horizons in better drained soils

b. Does not have the combination of aquic conditions within 50 cm of the soil surface or artificial drainage and colors, moist, as defined in item 4a(2) above, and has soil structure or the absence of rock structure, including fine stratifications (5 mm or less thick), in more than one-half of the volume and *one or more* of the following properties:

(1) Higher chroma, higher value, redder hue, or higher clay content than the underlying horizon or an overlying horizon; *or*

(2) Evidence of the removal of carbonates or gypsum; *and*

Properties Excluded from Cambic Horizons

5. Has properties that do not meet the requirements for an anthropic, histic, folistic, melanic, mollic, plaggen, or umbric epipedon, a duripan or fragipan, or an argillic, calcic, gypsic, natric, oxic, petrocalcic, petrogypsic, placic, salic, spodic, or sulfuric horizon; *and*

6. Is not part of an Ap horizon and does not have a brittle manner of failure in more than 60 percent of the matrix.

Duripan

A duripan[*] (fig. 3-14) is a silica-cemented (note 36) subsurface horizon with or without auxiliary cementing agents. It can occur in conjunction with a petrocalcic horizon.

Figure 3-14: A series of duripans, each a few centimeters thick, have formed in the upper part of this Vitrixerand from Turkey. The soil formed in a deposit of volcanic ash and cinders.

Required Characteristics

A duripan meets *all* of the following requirements:

Pedogenic Cementation

1. It is cemented[†] or indurated in more than 50 percent of the volume of some subhorizon; *and*

2. Less than 50 percent of the volume of air-dry fragments slakes in 1N HCl even during prolonged soaking, but more than 50 percent slakes in concentrated KOH or NaOH or in alternating acid and alkali treatment (note 37); *and*

[*] The name “duripan” was adopted from the Australian term used for the same kind of horizon (Smith, 1986, p. 106).

[†] The rupture-resistance class for air-dry submerged samples is at least extremely weakly coherent.

Evidence of Secondary Silica Accumulation

3. It shows evidence of the accumulation of opal or other forms of silica, such as laminar caps, coatings, lenses, partly filled interstices, bridges between sand-sized grains, or coatings on rock and pararock fragments; *and*

Root Restriction

4. Because of lateral continuity, roots can penetrate the pan only along vertical fractures with a horizontal spacing of 10 cm or more.

Fragipan

The fragipan[*] is a subsurface horizon that restricts the entry of water and roots into the soil matrix due to its density, low macropore volume, and discontinuous pores. It is firm to extremely firm and has a strongly developed brittle manner of failure (fragic properties, defined below). These characteristics persist even when moisture content is near field capacity. Commonly, the fragipan has a relatively low content of organic matter and a higher bulk density (note 38) relative to the horizons above it.

Required Characteristics

A fragipan must have *all* of the following characteristics:

Thickness

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

Evidence of Pedogenesis (note 39)

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

Structure and Root Restriction

3. The layer has very coarse prismatic, columnar, or blocky structure of any grade, has weak structure of any size, or is massive. Separations between structural units that allow roots to enter have an average spacing of 10 cm or more on the horizontal dimensions; *and*

Consistence

4. Air-dry fragments of the natural soil fabric, 5 to 10 cm in diameter, from more than 50 percent of the layer slake (note 40) when they are submerged in water; *and*

5. The layer has, in 60 percent or more of the volume, a firm or firmer rupture-resistance class, a brittle manner of failure at or near field capacity, and virtually no roots; *and*

Noncalcareous (note 41)

6. The layer is not effervescent (in dilute HCl).

[*] The term fragipan was coined by Dr. Guy Smith in 1948 for horizons previously called "brittle pans" (Smith, 1986, p. 76).

Figure 3-15: Close-up of a glossic horizon. The argillic horizon parts (brownish areas) are separated by tongues of albic material (white areas). The albic material makes up more than 15 percent of the horizon. Scale is in inches.

Glossic Horizon

The glossic[†] (Gr. *glossa*, tongue) horizon (fig. 3-15) develops as a result of the degradation (note 42) of an argillic, kandic, or natric horizon from which clay and free iron oxides are removed. It consists of two major parts: (1) an argillic, kandic, fragipan, or natric horizon, and (2) albic materials.

Required Characteristics

The glossic horizon is 5 cm or more thick and consists of:

1. An eluvial part (albic materials, defined below), which constitutes 15 to 85 percent (by volume) of the glossic horizon; *and*

2. An illuvial part, i.e., remnants (pieces) of an argillic, kandic, or natric horizon (defined below).

[†] The glossic horizon was introduced with the 5th edition of the *Keys to Soil Taxonomy* (1992). It replaced the previously defined tongues of albic materials.

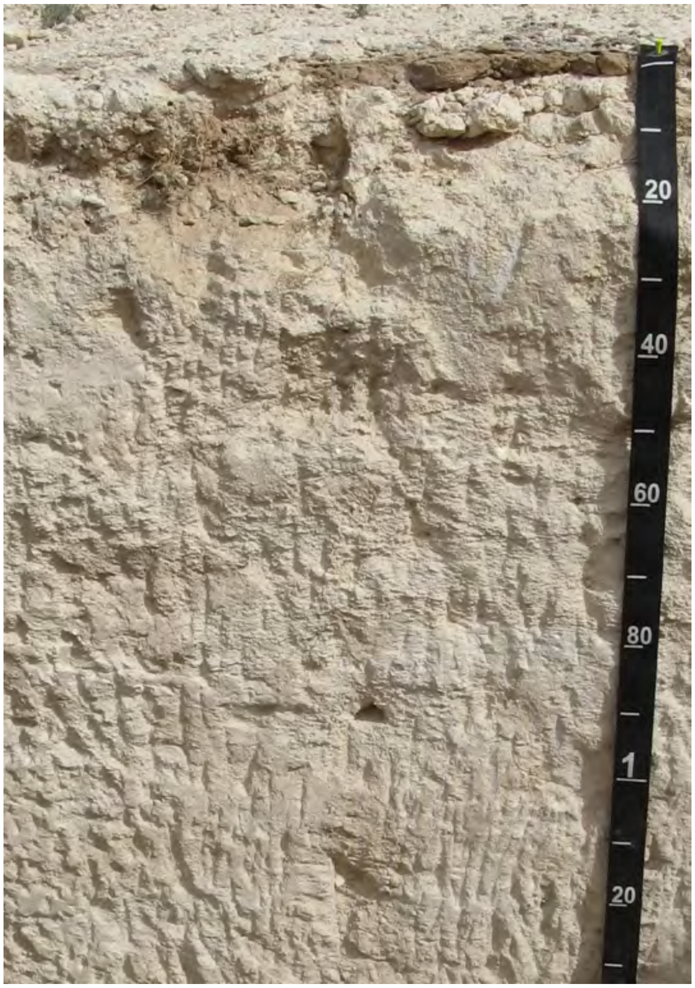

Figure 3-16: Soil profile with a thick white gypsic horizon that formed in highly gypsiferous eolian deposits. (Photo courtesy of Dr. David Weindorf)

Figure 3-17: Soil profile from North Carolina with a thick, reddish yellow kandic horizon below an ochric epipedon. The kandic horizon begins at a depth of about 16 inches (41 cm) and extends below the base of the photo. The soil is a Kandiudult. Scale is in inches.

Gypsic Horizon

The gypsic horizon (fig. 3-16) is a horizon in which gypsum has accumulated or been transformed to a significant extent (note 43). It typically occurs as a subsurface horizon, but it may occur at the surface in some soils.

Required Characteristics

A gypsic horizon meets *all* of the following requirements:

Thickness

1. Is 15 cm or more thick; *and*

Consistence and Rooting

2. Is not cemented by gypsum, with or without other cementing agents; is cemented and the cemented parts are less than 5 mm thick; or is cemented but, because of lateral discontinuity, roots can penetrate along vertical fractures with a horizontal spacing of less than 10 cm; *and*

Gypsum Content

3. Is 5 percent or more (by weight) gypsum and has 1 percent or more (by volume) visible secondary gypsum that has either accumulated or been transformed; *and*

4. Has a product of thickness, in cm, multiplied by the gypsum content (percent by weight) of 150 or more. Thus, a horizon 30 cm thick that is 5 percent gypsum qualifies as a gypsic horizon if it is 1 percent or more (by volume) visible gypsum and any cementation is as described in item 2 above.

Kandic Horizon

A kandic horizon (note 44) (fig. 3-17) is a subsurface horizon that has a significantly higher percentage of clay than the overlying horizon or horizons and the clays are dominated by those having low cation-exchange activity. The clay-sized fraction is composed predominantly of 1:1 layer silicate clays, mainly kaolinite, with varying amounts of oxyhydroxides of iron and aluminum.

Required Characteristics

The kandic horizon:

Underlies a Coarser Textured Surface Layer

1. Is a vertically continuous subsurface horizon that underlies a coarser textured surface horizon (note 45). The minimum thickness (note 46) of the surface horizon is 18 cm after mixing or 5 cm if the textural transition to the kandic horizon is abrupt and there is no densic, lithic, paralithic, or petroferric contact (defined below) within 50 cm of the mineral soil surface. In addition, the horizon*:*

Upper Boundary

Required clay increase (note 47)

2. Has its upper boundary:

a. At the point where the clay percentage (note 48) in the fine-earth fraction is increasing with depth within a vertical distance of 15 cm* and is *either*:

(1) 3 percent or more (absolute) higher than that in the overlying horizon if that horizon has less than 15 percent total clay in the fine-earth fraction; *or*

(2) 20 percent or more (relative) higher than that in the overlying horizon if that horizon has 15 to 40 percent total clay in the fine-earth fraction; *or*

(3) 8 percent or more (absolute) higher than that in the overlying horizon if that horizon has more than 40 percent total clay† in the fine-earth fraction; *and*

Depth

b. At a depth:

(1) Between 100 cm and 200 cm from the mineral soil surface if the upper 100 cm has a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout; *or*

(2) Within 100 cm from the mineral soil surface if the clay content in the fine-earth fraction of the overlying horizon is 20 percent or more; *or*

(3) Within 125 cm from the mineral soil surface for all other soils; *and*

Thickness

3. Has a thickness of *either*:

a. 30 cm or more; *or*

b. 15 cm or more if there is a densic, lithic, paralithic, or petroferric contact within 50 cm of the mineral soil surface and the kandic horizon constitutes 60 percent or more of the vertical distance between a depth of 18 cm and the contact; *and*

Texture

4. Has a texture class of loamy very fine sand or finer; *and*

Chemical Requirements

5. Has an apparent (note 49) CEC of 16 cmol(+) or less per kg clay (by 1N NH_4OAc pH 7) in 50 percent or more of its thickness between the point where the clay increase requirements are met and either a depth of 100 cm below that point or a densic, lithic, paralithic, or petroferric contact if shallower. (The percentage of clay is either measured by the pipette method or estimated to be 2.5 times [percent water retained at 1500 kPa tension minus percent organic carbon], whichever is higher, but no more than 100). In addition, the horizon:

No Stratification

6. Has a regular decrease in organic carbon content with increasing depth, no fine stratification, and no overlying layers more than 30 cm thick that have fine stratification and/or an organic carbon content that decreases irregularly with increasing depth.

Natric Horizon

A natric horizon is an illuvial horizon that is normally present in the subsurface and has a significantly higher percentage of silicate clay than the overlying horizons. It shows evidence of clay illuviation that has been accelerated by the dispersive properties of sodium (note 50).

Required Characteristics

Clay Increase for Natric Horizons with an Overlying Eluvial Layer

If an eluvial horizon remains and there is no lithologic discontinuity between it and the illuvial horizon and no plow layer directly above the illuvial horizon, then the illuvial horizon must contain more total clay than the eluvial horizon within a vertical distance of 30 cm or less, as follows:

Low clay in the overlying eluvial layer

1. If any part of the eluvial horizon has less than 15 percent total clay in the fine-earth fraction, the illuvial horizon must contain at least 3 percent (absolute) more clay (10 percent versus 13 percent, for example); *or*

---

* The distance of 15 cm was chosen to coincide with the commonly used field criteria for a diffuse horizon boundary.

† The 40 percent limit was chosen to coincide with clay texture on the textural triangle.

Moderate clay in the overlying eluvial layer

2. If the eluvial horizon has 15 to 40 percent total clay in the fine-earth fraction, the illuvial horizon must have at least 1.2 times more clay than the eluvial horizon; *or*

High clay in the overlying eluvial layer

3. If the eluvial horizon has 40 percent or more total clay in the fine-earth fraction, the illuvial horizon must contain at least 8 percent (absolute) more clay (42 percent versus 50 percent, for example).

All Natric Horizons with or without an Overlying Eluvial Layer

All natric horizons must meet the following requirements:

Thickness

4. Meet *one* of the following thickness requirements:

For loamy and clayey textures–

a. If the horizon meets the particle-size class criteria for coarse-loamy, fine-loamy, coarse-silty, fine-silty, fine, or very-fine or is loamy or clayey, including skeletal counterparts, it must be at least 7.5 cm thick or at least one tenth as thick as the sum of the thickness of all overlying horizons, whichever is greater; *or*

For sandy textures–

b. If the horizon meets sandy or sandy-skeletal particle-size class criteria, it must be at least 15 cm thick; *or*

For natric horizons composed of lamellae–

c. If the horizon is composed entirely of lamellae, the combined thickness of the lamellae that are 0.5 cm or more thick must be 15 cm or more; *and*

Morphological evidence of illuvial clay

5. Have evidence of clay illuviation in at least *one* of the following forms:

a. Oriented clay bridging the sand grains; *or*

b. Clay films lining pores; *or*

c. Clay films on both vertical and horizontal surfaces of peds; *or*

d. Thin sections with oriented clay bodies that are more than 1 percent of the section; *or*

e. If the coefficient of linear extensibility is 0.04 or higher and the soil has distinct wet and dry seasons, then the ratio of fine clay to total clay in the illuvial horizon is greater by 1.2 times or more than the ratio in the eluvial horizon; *and*

Structure (note 51)

6. Have *either*:

a. Columnar or prismatic structure in some part (generally the upper part), which may part to blocky structure; *or*

Figure 3-18: Soil profile of a Duraquod in Washington State that has a massive, horizontal, continuous ortstein layer below a depth of about 60 cm. The ortstein has been smoothed for the photo. Scale is in cm.

b. Both blocky structure and eluvial materials, which contain uncoated silt or sand grains and extend more than 2.5 cm into the horizon; *and*

Chemical requirements (note 52)

7. Have *either*:

a. An exchangeable sodium percentage (ESP) of 15 percent or more (or a sodium adsorption ratio [SAR] of 13 or more) in one or more horizons within 40 cm of its upper boundary; *or*

b. More exchangeable magnesium plus sodium than calcium plus extractable acidity (at pH 8.2) in one or more horizons within 40 cm of its upper boundary and the ESP is 15 or more (or the SAR is 13 or more) in one or more horizons within 200 cm of the mineral soil surface.

Ortstein

Ortstein (note 53) (fig. 3-18) is a horizon that consists of spodic materials (described below) that are at least partially pedogenically cemented. The cementing agents are generally

Figure 3-19: Profile of an Oxisol in Jamaica that has a highly weathered red, clayey oxic horizon below a slightly darkened ochric epipedon. Scale is in feet.

thought to be illuvial aluminum-humus complexes and other amorphous materials (note 54).

Required Characteristics

Ortstein meets *all* of the following:

1. Consists of spodic materials (defined below); *and*

2. Is in a layer that is 50 percent or more pedogenically cemented*; *and*

3. Is 25 mm or more thick.

Continuous ortstein is 90 percent or more pedogenically cemented and has lateral continuity. Because of this continuity, roots can penetrate only along vertical fractures with a horizontal spacing of 10 cm or more.

Oxic Horizon

Required Characteristics

The oxic horizon (fig. 3-19) is a subsurface horizon with chemical and mineralogical properties reflective of advanced weathering. It has sandy loam or a finer texture, a low cation-exchange capacity, and a low content of weatherable minerals (note 55). It does not have andic soil properties (defined below) and has *all* of the following characteristics:

Thickness

1. A thickness of 30 cm or more (note 56); *and*

Texture

2. A texture class of sandy loam or finer (note 57) in the fine-earth fraction; *and*

Mineralogy

3. Less than 10 percent (note 58) weatherable minerals in the 0.05 to 0.2 mm fraction; *and*

Loss of Rock Structure (note 59)

4. Rock structure in less than 5 percent of its volume, unless the lithorelicts with weatherable minerals are coated with sesquioxides; *and*

Limited Clay Increase at the Upper Boundary Transition (note 60)

5. Within a vertical distance of 15 cm or more from the upper boundary (i.e, diffuse), a clay increase, with increasing depth, of:

a. Less than 3 percent (absolute) in its fine-earth fraction if the fine-earth fraction of the overlying horizon contains less than 15 percent clay; *or*

b. Less than 20 percent (relative) in its fine-earth fraction if the fine-earth fraction of the overlying horizon contains 15 to 40 percent clay; *or*

c. Less than 8 percent (absolute) in its fine-earth fraction if the fine-earth fraction of the overlying horizon contains 40 percent or more clay; *and*

Cation-Exchange Capacity

6. An apparent CEC of 16 cmol(+) or less per kg clay (by 1N NH_4OAc pH 7). The percentage of clay is either measured by the pipette method or estimated to be 3 times [percent water retained at 1500 kPa tension minus percent organic carbon], whichever value is higher, but no more than 100 (note 61).

Petrocalcic Horizon

The petrocalcic horizon is an illuvial horizon in which secondary calcium carbonate or other carbonates have accumulated to the extent that the horizon is cemented or indurated (note 62).

Required Characteristics

A petrocalcic horizon meets the following requirements:

* The rupture-resistance class for air-dry submerged samples is at least extremely weakly coherent.

Figure 3-20: Soil landscape and close-up of a fragment of a petrogypsic horizon (inset) in the United Arab Emirates. (Photo courtesy of John Kelley)

Pedogenic Cementation and Root Restriction

1. The horizon is pedogenically cemented* or indurated by carbonates, with or without silica or other cementing agents; *and*

2. Because of lateral continuity, roots can penetrate only along vertical fractures with a horizontal spacing of 10 cm or more; *and*

Thickness

3. The horizon has a thickness of:

   a. 10 cm or more; *or*

   b. 1 cm or more if it consists of a laminar cap directly underlain by bedrock.

Petrogypsic Horizon

The petrogypsic horizon (fig. 3-20) is a horizon in which visible secondary gypsum has accumulated or has been transformed. The horizon is pedogenically cemented*, and the cementation is both laterally continuous and root limiting, even when the soil is moist (note 63). The horizon typically occurs as a subsurface horizon, but it may occur at the surface in some soils.

Required Characteristics

A petrogypsic horizon meets *all* of the following requirements:

Pedogenic Cementation and Root Restriction

1. Is cemented or indurated by gypsum, with or without other cementing agents; *and*

2. Because of lateral continuity, can be penetrated by roots only along vertical fractures with a horizontal spacing of 10 cm or more; *and*

Thickness and Gypum Content

3. Is 5 mm or more thick; *and*

4. Is 40 percent or more (by weight) gypsum.

Placic Horizon

The placic (Gr. base of *plax*, flat stone; meaning a thin cemented pan) horizon (fig. 3-21) is a thin, black to dark reddish pan that is cemented by iron (or iron and manganese) and organic matter (note 64).

Required Characteristics

A placic horizon meets the following requirements:

* The rupture-resistance class for air-dry submerged samples is at least extremely weakly coherent.

Figure 3-21: Profile of a soil in New Zealand (specifically a Placorthod) that has a thin, cemented placic horizon a few mm thick at the wavy contact between the dark yellowish brown material above and the reddish yellow material below (at a depth of about 50 cm, adjacent to the tape measure). Scale is in 5-cm increments.

Pedogenic Cementation and Root Restriction

1. The horizon is pedogenically cemented or indurated with iron or iron and manganese and organic matter, with or without other cementing agents; *and*

2. Because of lateral continuity, roots can penetrate only along vertical fractures with a horizontal spacing of 10 cm or more; *and*

Thickness

3. The horizon has a minimum thickness of 1 mm and, where associated with spodic materials (defined below), is less than 25 mm thick.

Salic Horizon

A salic horizon is a horizon of accumulation of salts that are more soluble than gypsum in cold water (note 65).

Required Characteristics

A salic horizon is 15 cm or more thick and has, for 90 consecutive days or more in normal years:

1. An electrical conductivity (EC) equal to or greater than 30 dS/m in the water extracted from a saturated paste; *and*

2. A product of the EC, in dS/m, and thickness, in cm, equal to 900 or more.

Sombric Horizon

A sombric (F. *sombre*, dark) horizon is a subsurface horizon in mineral soils that has formed under free drainage. It contains illuvial humus that is neither associated with aluminum, as is the humus in the spodic horizon, nor dispersed by sodium, as is common in the natric horizon. Consequently, the sombric horizon does not have the high cation-exchange capacity in its clay that characterizes a spodic horizon and does not have the high base saturation of a natric horizon. It does not underlie an albic horizon (note 66).

Sombric horizons are thought to be restricted to the cool, moist soils of high plateaus and mountains in tropical or subtropical regions. Because of strong leaching, their base saturation is low (less than 50 percent by NH_4OAc).

The sombric horizon has a lower color value or chroma, or both, than the overlying horizon and commonly contains more organic matter (note 67). It may have formed in an argillic, cambic, or oxic horizon. If peds are present, the dark colors are most pronounced on surfaces of peds.

Required Characteristics

The sombric horizon has the following requirements:

Organic Carbon Content

1. Organic carbon content is 0.6 percent or more and it is at least 0.2 percent higher than the horizon above; *and*

Color

2. Chroma is 4 or less and value is 4 or less (moist) or 5 or less (dry); *and*

3. Value and/or chroma are at least 1 unit darker than the horizon above; *and*

Thickness

4. The horizon is 15 cm or more thick; *and*

Chemical and Mineralogical Properties

5. pH is 5.0 or less; *and*

6. Al plus ½ Fe content (by ammonium oxalate) is:

   a. Less than 0.5 percent if volcanic glass content is less than 5 percent; *or*

   b. Less than 0.4 percent if volcanic glass content is 5 percent or more.

Spodic Horizon

A spodic horizon (see figure 3-9) is an illuvial layer with 85 percent or more spodic materials (defined below) (note 68).

Required Characteristics

A spodic horizon is normally a subsurface horizon underlying an O, A, Ap, or E horizon. It may, however, meet the definition of an umbric epipedon.

A spodic horizon must have 85 percent or more spodic materials in a layer 2.5 cm or more thick that is not part of any Ap horizon.

Diagnostic Soil Characteristics for Mineral Soils

Diagnostic soil characteristics are features of the soil that are used in various places in the keys or in the definitions of diagnostic horizons.

Abrupt Textural Change

An abrupt textural change is a specific kind of change that may occur between an epipedon composed of mineral soil material or an eluvial horizon and an underlying argillic, glossic, kandic, or natric horizon. It is characterized by a considerable increase in clay content within a very short vertical distance in the zone of contact.

In soils that have an abrupt textural change, there normally is no transitional horizon between a mineral epipedon or an eluvial horizon and an argillic, glossic, kandic, or natric horizon, or the transitional horizon is too thin to be sampled. Some soils, however, have a glossic horizon or interfingering of albic materials (defined below) into parts of an argillic, kandic, or natric horizon. The upper boundary of such a horizon is irregular or even discontinuous. Sampling this mixture as a single horizon might create the impression of a relatively thick transitional horizon, whereas the thickness of the actual transition at the contact may be no more than 1 mm (note 69).

Required Characteristics

An abrupt textural change meets *both* of the following requirements:

1. The noncarbonate clay content in the fine-earth fraction of the argillic, glossic, kandic, or natric horizon is at least 8 percent (by weight); *and*

2. The noncarbonate clay content in the fine-earth fraction of the argillic, glossic, kandic, or natric horizon must *either*:

   a. Double within a vertical distance of 7.5 cm or less if the clay content, in the fine-earth fraction of the epipedon composed of mineral soil material or the eluvial horizon, is less than 20 percent (e.g., an increase from 4 to 8 percent); *or*

   b. Increase by 20 percent or more (absolute) within a vertical distance of 7.5 cm or less (e.g., an increase from 22 to 42 percent) and the clay content in some part of the horizon is 2 times or more the amount contained in the overlying epipedon composed of mineral soil material or the eluvial horizon.

Albic Materials

Albic (L. *albus,* white) materials are soil materials with a color that is largely determined by the color of primary sand and silt particles rather than by the color of their coatings. This definition implies that clay and/or free iron oxides have been removed from the materials or that the oxides have been segregated to such an extent that the color of the materials is largely determined by the color of the primary particles (note 70). Figure 3-9 shows a soil profile with an albic horizon above a spodic horizon.

Required Characteristics

Albic materials have *one* of the following colors:

1. Chroma of 2 or less; *and either*

   a. A color value of 3, moist, and 6 or more, dry; *or*

   b. A color value of 4 or more, moist, and 5 or more, dry; *or*

2. Chroma of 3 or less; *and either*

a. A color value of 6 or more, moist; *or*

b. A color value of 7 or more, dry; *or*

3. Chroma that is controlled by the color of uncoated grains of silt or sand, hue of 5YR or redder, and the color values listed in item 1a or 1b above.

Andic Soil Properties

Andic soil properties commonly form during weathering of tephra or other parent materials containing a significant content of volcanic glass. Soils that are in cool, humid climates and have abundant organic carbon, however, may develop andic soil properties without the influence of volcanic glass. A suite of glass and glass-coated minerals rich in silica is termed volcanic glass in this taxonomy. These minerals are relatively soluble and undergo fairly rapid transformation when the soils are moist. Andic soil properties represent a stage in transition where weathering and transformation of primary alumino-silicates (e.g., volcanic glass) have proceeded only to the point of the formation of short-range-order materials, such as allophane, imogolite, and ferrihydrite, or of metal-humus complexes (note 71). The concept of andic soil properties includes moderately weathered soil material, rich in short-range-order materials or metal-humus complexes, or both, with or without volcanic glass (required characteristic 2) and weakly weathered soil, less rich in short-range-order materials with volcanic glass (required characteristic 3).

Relative amounts of allophane, imogolite, ferrihydrite, or metal-humus complexes in the colloidal fraction are inferred from laboratory analyses of aluminum, iron, and silica extracted by ammonium oxalate, and from phosphate retention. Soil scientists may use smeariness or pH in 1N sodium fluoride (NaF) as field indicators of andic soil properties. *Volcanic glass content* is the percent volcanic glass (by grain count) in the coarse silt and sand (0.02 to 2.0 mm) fraction. Most soil materials with andic soil properties consist of mineral soil materials, but some are organic soil materials with less than 25 percent organic carbon.

Required Characteristics

Soil materials with andic soil properties must have a fine-earth fraction that meets the following requirements:

1. Have less than 25 percent organic carbon (by weight) and *one or both* of items 2 and 3:

Rich in Short-Range-Order Minerals, Regardless of Glass Amount; Moderately Weathered

2. *All* of the following:

a. Bulk density, measured at 33 kPa water retention, of 0.90 g/cm^3 or less; *and*

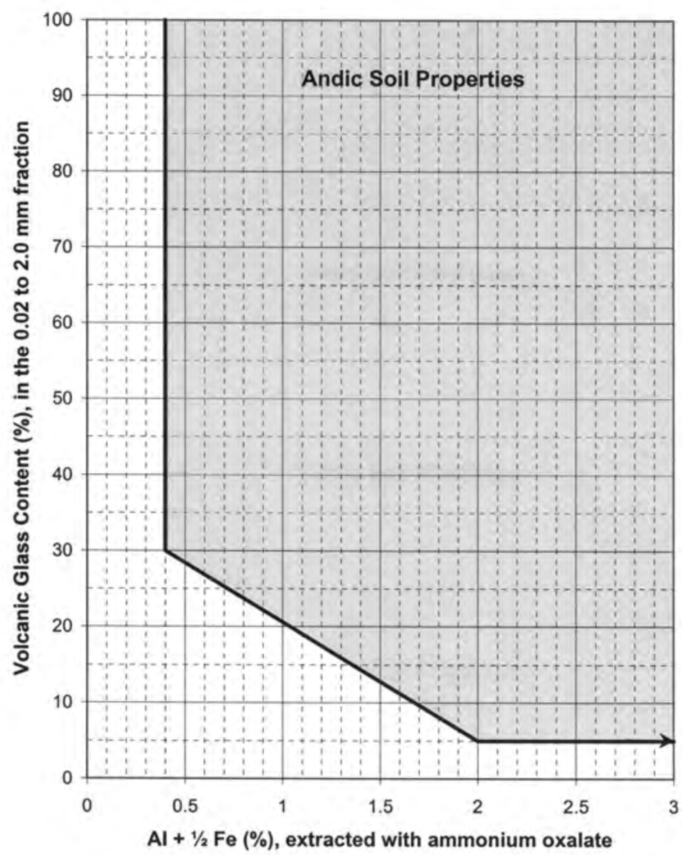

Figure 3-22: Soils that are plotted in the shaded area meet the andic soil properties criteria c, d, and e under item 3 of the required characteristics. To qualify as soils with andic properties, the soils must also meet the listed requirements for organic carbon content, phosphate retention, and particle-size distribution.

b. Phosphate retention of 85 percent or more; *and*

c. Al plus ½ Fe content (by ammonium oxalate) equal to 2.0 percent or more; *or*

Rich in Glass Content with Lower Content of Short-Range-Order Minerals; Less Weathered

3. *All* of the following:

a. 30 percent or more of the fine-earth fraction is 0.02 to 2.0 mm in size; *and*

b. Phosphate retention of 25 percent or more; *and*

c. Al plus ½ Fe content (by ammonium oxalate) equal to 0.4 percent or more; *and*

d. Volcanic glass content of 5 percent or more; *and*

e. [(Al plus ½ Fe content, percent) times (15.625)] + [volcanic glass content, percent] = 36.25 or more.

The shaded area in figure 3-22 illustrates criteria 3c, 3d, and 3e.

Anhydrous Conditions

Anhydrous (Gr. *anydros*, waterless) conditions refer to the moisture condition of soils in very cold deserts and other areas with permafrost (often dry permafrost) (note 72). These soils typically have low precipitation (usually less than 50 mm water equivalent per year) and a moisture content of less than 3 percent by weight. Anhydrous soil conditions are similar to the aridic (torric) soil moisture regimes (defined below), except that the soil temperature at 50 cm is less than 5 ^{o}C throughout the year in the soil layers with these conditions.

Required Characteristics

Soils with anhydrous conditions have a mean annual soil temperature of 0 ^{o}C or colder. The layer from 10 to 70 cm below the soil surface has a soil temperature of less than 5 ^{o}C throughout the year *and* this layer:

1. Includes no ice-impregnated permafrost; *and*

2. Is dry (water held at 1500 kPa or more) in one-half or more of the soil for one-half or more of the time the layer has a soil temperature above 0 ^{o}C; *or*

3. Has a rupture-resistance class of loose to slightly hard throughout when the soil temperature is 0 ^{o}C or colder, except where a pedogenically cemented horizon occurs.

Coefficient of Linear Extensibility (COLE)

The coefficient of linear extensibility (COLE) is a measure describing the proportional change in linear dimension of a soil clod due to shrinking and swelling with changes in moisture content. Higher values indicate greater potential for soil movement (note 73). COLE is calculated as the ratio of the difference between the moist length and dry length of a clod to its dry length. It is (Lm - Ld)/Ld, where Lm is the length at 33 kPa tension and Ld is the length when dry. COLE can be calculated from the differences in bulk density of the clod when moist and when dry. An estimate of COLE can be calculated in the field by measuring the distance between two pins in a clod of undisturbed soil at field capacity and again after the clod has dried. COLE does not apply if the shrinkage is irreversible.

Durinodes

Durinodes (L. *durus*, hard, and *nodus*, knot) are weakly coherent to pedogenically cemented nodules or concretions with a diameter of 1 cm or more. The cement is SiO_2, presumably opal and microcrystalline forms of silica. Durinodes are commonly associated with soils containing volcanic glass as the silica source. They break down in hot concentrated KOH after treatment with HCl to remove carbonates but do not break down with concentrated HCl alone. Dry durinodes do not slake appreciably in water, but prolonged soaking can result in spalling of very thin platelets. Durinodes have a firm or firmer rupture-resistance class and a brittle manner of failure when wet, both before and after treatment with acid. Some durinodes are roughly concentric when viewed in cross section, and concentric stringers of opal are visible under a hand lens.

Fragic Soil Properties

Fragic soil properties are the essential properties of a fragipan. They have neither the layer thickness nor volume requirements for the fragipan. Fragic soil properties are in subsurface horizons, although they can be at or near the surface in truncated soils. Aggregates with fragic soil properties have a firm or firmer rupture-resistance class and a brittle manner of failure when soil water is at or near field capacity. Air-dry fragments of the natural fabric, 5 to 10 cm in diameter, slake when they are submerged in water*. Aggregates with fragic soil properties show evidence of pedogenesis, including one or more of the following: oriented clay within the matrix or on faces of peds, redoximorphic features within the matrix or on faces of peds, strong or moderate soil structure, or coatings of albic materials or uncoated silt and sand grains on faces of peds or in seams. Peds with these properties are considered to have fragic soil properties regardless of whether or not the density and brittleness are pedogenic.

Required Characteristics

Soil aggregates with fragic soil properties must:

Evidence of Pedogenesis, but Not Pedogenic Cementation

1. Show evidence of pedogenesis within the aggregates or, at a minimum, on the faces of the aggregates; *and*

2. Slake when air-dry fragments of the natural fabric, 5 to 10 cm in diameter, are submerged in water; *and*

Consistence and Root Restriction

3. Have a firm or firmer rupture-resistance class and a brittle manner of failure when soil water is at or near field capacity; *and*

4. Restrict the entry of roots into the matrix when soil water is at or near field capacity.

Free Carbonates

The term “free carbonates” is used in the definitions of a number of taxa, is used as a criterion for the isotic mineralogy class, and is mentioned in the discussion of chemical analyses in the appendix. It refers to soil carbonates that are uncoated or unbound and that effervesce visibly or audibly when treated

* This assures that the firm and brittle nature of the material is not due to significant pedogenic cementation of the grains.

with cold, dilute HCl. The term “free carbonates” is nearly synonymous with the term “calcareous.” Soils that have free carbonates generally have calcium carbonate as a common mineral, although sodium and magnesium carbonates are also included in this concept. Soils or horizons with free carbonates may have inherited the carbonate compounds from parent materials without any translocation or transformation processes acting on them. There is no implication of pedogenesis in the concept of free carbonates (note 74), as there is in identifiable secondary carbonates (defined below), although most forms of secondary carbonates are freely effervescent.

Identifiable Secondary Carbonates

The term “identifiable secondary carbonates” is used in the definitions of a number of taxa. It refers to translocated authigenic calcium carbonate that has been precipitated in place from the soil solution rather than inherited from a soil parent material, such as calcareous loess or limestone residuum.

Identifiable secondary carbonates either may disrupt the soil structure or fabric, forming masses, nodules, concretions, or spheroidal aggregates (white eyes) that are soft and powdery when dry, or may be present as coatings in pores, on structural faces, or on the undersides of rock or pararock fragments[*]. If present as coatings, the secondary carbonates cover a significant part of the surfaces. Commonly, they coat all of the surfaces to a thickness of 1 mm or more. If little calcium carbonate is present in the soil, however, the surfaces may be only partially coated. The coatings must be thick enough to be visible when moist. Some horizons are entirely engulfed by carbonates. The color of these horizons is largely determined by the carbonates. The carbonates in these horizons are within the concept of identifiable secondary carbonates.

The filaments commonly seen in a dry calcareous horizon are within the meaning of identifiable secondary carbonates if the filaments are thick enough to be visible when the soil is moist. Filaments commonly branch on structural faces.

Interfingering of Albic Materials

The term “interfingering of albic materials” refers to albic materials that penetrate 5 cm or more into an underlying argillic, kandic, or natric horizon along vertical and, to a lesser degree, horizontal faces of peds. There need not be a continuous overlying albic horizon. The albic materials constitute less than 15 percent of the layer that they penetrate, but they form continuous skeletans (ped coatings of clean silt or sand defined by Brewer, 1976) 1 mm or more thick on the vertical faces of peds, which means a total width of 2 mm or more between abutting peds. Because quartz is such a common constituent of silt and sand, these skeletans are usually light gray when moist and nearly white when dry, but their color is determined in large part by the color of the sand or silt fraction.

Required Characteristics

Interfingering of albic materials is recognized if albic materials:

1. Penetrate 5 cm or more into an underlying argillic, kandic, or natric horizon; *and*

2. Are 2 mm or more thick between vertical faces of abutting peds; *and*

3. Constitute less than 15 percent (by volume) of the layer that they penetrate (note 75).

Lamellae

Lamellae (lamella, if singular) (fig. 3-23) are illuvial horizons less than 7.5 cm thick that formed in unconsolidated regolith more than 50 cm thick. Each lamella contains an accumulation of oriented silicate clay on or bridging sand and silt grains (and rock fragments if any are present). A lamella is required to have more silicate clay than the overlying eluvial horizon (an eluvial horizon is not required above the uppermost lamella if the soil is truncated) (note 76). Lamellae occur in a vertical series of two or more.

Lamellae may meet the requirements for either a cambic or an argillic horizon. A combination of two or more lamellae 15 cm or more thick is a cambic horizon if the texture class is very fine sand, loamy very fine sand, or finer. A combination of two or more lamellae meets the requirements for an argillic horizon if there is 15 cm or more cumulative thickness of lamellae that are 0.5 cm or more thick and that have a clay content of *either*:

1. 3 percent or more (absolute) higher than in the overlying eluvial horizon (e.g., 13 percent versus 10 percent) if any part of the eluvial horizon has less than 15 percent clay in the fine-earth fraction; *or*

2. 20 percent or more (relative) higher than in the overlying eluvial horizon (e.g., 24 percent versus 20 percent) if all parts of the eluvial horizon have more than 15 percent clay in the fine-earth fraction.

Linear Extensibility (LE)

Linear extensibility helps to predict the potential of a soil to shrink and swell. The LE of a soil layer is the product of the thickness, in cm, multiplied by the COLE of the layer in question. The LE of a soil is the sum of these products for all soil horizons. Linear extensibility is a criterion for most Vertic subgroups in this taxonomy and is calculated as summed products from the mineral soil surface to a depth of 100 cm or to a root-limiting layer (defined in chapter 17).

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[*] Forms of carbonate accumulation are described in the *Soil Survey Manual* (Soil Science Division Staff, 2017, pp. 173–175).

Figure 3-23: Profile of a soil that has an argillic horizon composed of lamellae. (Photo courtesy of John Kelley)

Lithologic Discontinuities

Lithologic discontinuities are significant changes in particle-size distribution or mineralogy that represent differences in lithology within a soil. A lithologic discontinuity can also denote an age difference. For information on using horizon designations for lithologic discontinuities, see the *Soil Survey Manual* (Soil Science Division Staff, 2017, pp. 107–109) and chapter 18 of this document.

Not everyone agrees on the degree of change required for a lithologic discontinuity. No attempt is made to quantify lithologic discontinuities. The discussion below is meant to serve as a guideline (note 77).

Several lines of field evidence can be used to evaluate lithologic discontinuities. In addition to mineralogical and textural differences that may require laboratory studies, certain observations can be made in the field. These include but are not limited to the following:

1. **Abrupt textural contacts**.—An abrupt change in particle-size distribution, which is not solely a change in clay content resulting from pedogenesis, can often be observed.

2. **Contrasting sand sizes**.—Significant changes in sand size can be detected. For example, if material containing mostly medium sand or finer sand abruptly overlies material containing mostly coarse sand and very coarse sand, one can assume that there are two different materials. Although the materials may be of the same mineralogy, the contrasting sand sizes result from differences in energy at the time of deposition by water and/or wind.

3. **Bedrock lithology vs. rock fragment lithology in the soil**.—If a soil with rock fragments overlies a lithic contact, one would expect the rock fragments to have a lithology similar to that of the material below the lithic contact. If many of the rock fragments do not have the same lithology as the underlying bedrock, the soil is not derived completely from the underlying bedrock.

4. **Stone lines**.—The occurrence of a horizontal line of rock fragments in the vertical sequence of a soil indicates that the soil may have developed in more than one kind of parent material. The material above the stone line is most likely transported, and the material below may be of different origin.

5. **Inverse distribution of rock fragments**.—A lithologic discontinuity is commonly indicated by an erratic distribution of rock fragments. The percentage of rock fragments decreases with increasing depth. This line of evidence is useful in areas of soils that have relatively unweathered rock fragments.

6. **Rock fragment weathering rinds**.—Horizons containing rock fragments with no rinds that overlie horizons containing rocks with rinds suggest that the upper material is in part depositional and not related to the lower part in time and perhaps in lithology.

7. **Shape of rock fragments**.—Soil horizons containing angular rock fragments overlying horizons containing well rounded rock fragments may indicate a discontinuity. This line of evidence represents different mechanisms of transport (colluvial vs. alluvial) or even different transport distances.

8. **Soil color**.—Abrupt changes in color that are not the result of pedogenic processes can be used as indicators of discontinuity.

9. **Micromorphological features**.—Marked differences in the size and shape of resistant minerals in one horizon and not in another are indicators of differences in materials.

Use of Laboratory Data

Discontinuities are not always readily apparent in the field. In these cases laboratory data are necessary. Even with laboratory data, detecting discontinuities may be difficult. The decision is a qualitative or perhaps a partly quantitative judgment. General concepts of lithology as a function of depth might include:

1. *Laboratory data - visual scan*.—The array of laboratory data is assessed in an attempt to determine if a field-designated discontinuity is corroborated and if any data show evidence of a discontinuity not observed in the field. One must sort changes in lithology from changes caused by pedogenic processes. In most cases the quantities of sand and coarser fractions are not altered significantly by soil-forming processes. Therefore, an abrupt change in sand size or sand mineralogy is a clue to lithologic change. Gross soil mineralogy and the resistant mineral suite are other clues.

2. *Data on a clay-free basis*.—A common manipulation in assessing lithologic change is computation of sand and silt separates on a carbonate-free, clay-free basis (percent fraction; e.g., fine sand and very fine sand, divided by percent sand plus silt, times 100). Clay distribution is subject to pedogenic change and may either mask inherited lithologic differences or produce differences that are not inherited from lithology. The numerical array computed on a clay-free basis can be inspected visually or plotted as a function of depth.

Another aid used to assess lithologic changes is computation of the ratios of one sand separate to another. The ratios can be computed and examined as a numerical array, or they can be plotted. The ratios work well if sufficient quantities of the two fractions are available. Low quantities magnify changes in ratios, especially if the denominator is low.

n Value and Fluidity

The *n* value (Pons and Zonneveld, 1965) characterizes the relation between the percentage of water in a soil under field conditions and its percentages of inorganic clay and humus. It is helpful in predicting whether a soil can be grazed by livestock or can support other loads and in predicting what degree of subsidence would occur after drainage.

For mineral soil materials that are not thixotropic (note 78), the *n* value can be calculated by the following formula:

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

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

Few data for calculations of the *n* value are available in the United States, but the critical *n* value of 0.7 can be approximated closely in the field by a simple test of squeezing a soil sample in the palm of a hand. See table 3-2.

Table 3-2: *n* Value as Determined by Field Tests

***n* value**	**Fluidity class**	**Field test***
< 0.7	Nonfluid (deformable)	No material flows through the fingers after full compression
0.7 - 1	Slightly fluid	After full compression, some material flows thru the fingers but most remains in the palm of the hand
> 1 - < 2	Moderately fluid	After full pressure, most material flows through the fingers: a small residue remains in the palm of the hand
≥ 2	Very fluid	Under very gentle pressure, most material flows through the fingers like a slightly viscous fluid and very little or no residue remains

* See: Soil Science Division Staff. 2017. Soil Survey Manual. C. Ditzler, K. Scheffe, and H.C. Monger (eds.). USDA Handbook 18. p. 188, Table 3-12.

Petroferric Contact

A petroferric (Gr. *petra*, rock, and L. *ferrum*, iron; implying ironstone) contact (fig. 3-24) is a boundary between soil and a continuous layer of indurated material in which iron is an important cement and organic matter is either absent or present only in traces. The indurated layer must be continuous within the limits of each pedon, but it may be fractured if the average lateral distance between fractures is 10 cm or more. The fact that this ironstone layer contains little or no organic matter distinguishes it from a placic horizon and an indurated spodic horizon (ortstein), both of which contain organic matter.

Several features can aid in making the distinction between a lithic contact and a petroferric contact. First, a petroferric contact is roughly horizontal. Second, the material directly below a petroferric contact contains a high amount of iron (normally 30 percent or more Fe_2O_3). Third, the ironstone sheets below a petroferric contact are thin; their thickness ranges from a few centimeters to very few meters. Sandstone, on the other hand, may be thin or very thick, may be level-bedded or tilted, and may contain only a small percentage of Fe_2O_3. The petroferric contact is generally recognized in some tropical and subtropical areas where layers of ironstone have formed in the soil as sesquioxides accumulated. In the Tropics, the ironstone is generally more or less vesicular.

Plinthite

Plinthite (Gr. *plinthos*, brick) (fig. 3-25) is an iron-rich, humus-poor mixture of clay with quartz and other minerals. It commonly occurs as dark red redox concentrations that typically form platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to

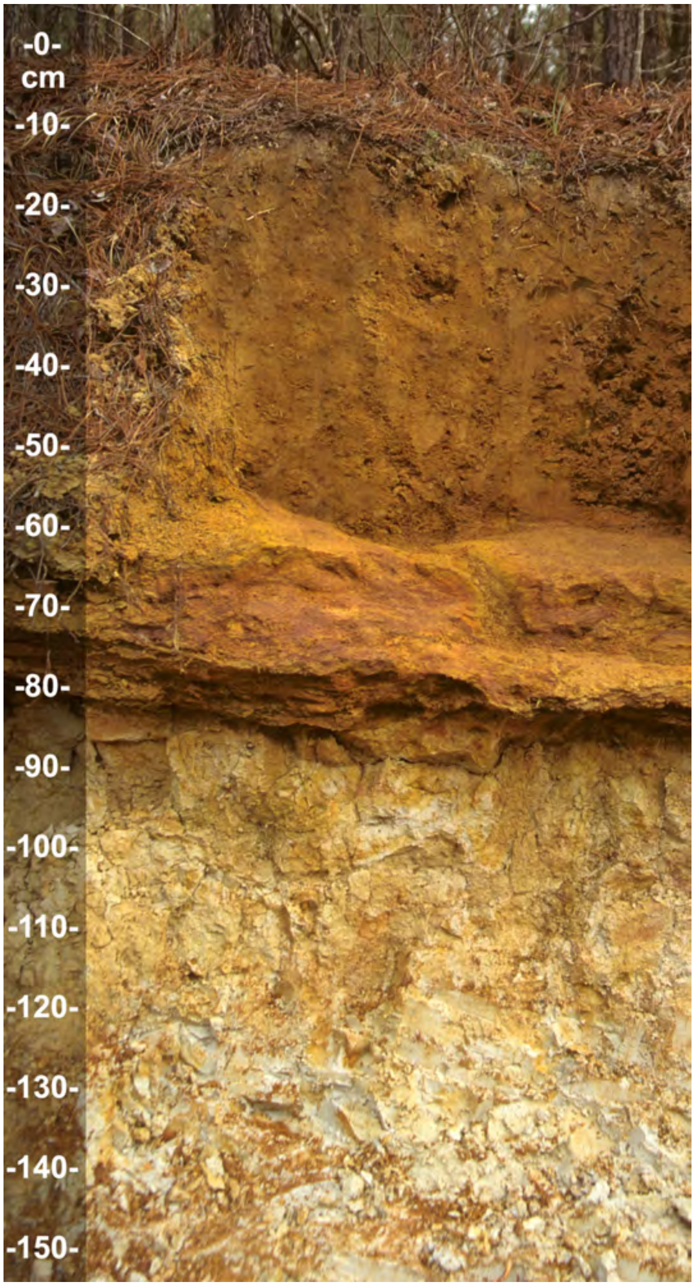

Figure 3-24: A soil with a petroferric contact (at a depth of about 80 cm) at the upper boundary between the unconsolidated soil material above and the indurated ironstone sheet below. The soil material below the ironstone is unconsolidated. (Photo courtesy of John Kelley)

irregular aggregates on exposure to repeated wetting and drying, especially if it is also exposed to heat from the sun (note 79). The lower boundary of a zone in which plinthite occurs generally is diffuse or gradual, but it may be abrupt at a lithologic discontinuity.

Plinthite may occur as a constituent of a number of horizons, such as an epipedon, a cambic horizon, an argillic horizon, an oxic horizon, or a C horizon. It is one form of the material that has been called laterite. It normally forms in a horizon below the surface, but it may form at the surface in a seep area at the base of a slope.

Figure 3-25: Plinthite (firm, dark red concentrations) in a soil near College Station, Texas. (Photo courtesy of Dr. David Weindorf)

From a genetic viewpoint, plinthite forms by segregation of iron. In many places iron probably has been added from other horizons or from the higher adjacent soils. Generally, plinthite forms in a horizon that is saturated with water for some time during the year. Initially, iron is normally segregated in the form of soft, more or less clayey, red or dark red redox concentrations. These concentrations are not considered plinthite unless there has been enough segregation of iron to permit their irreversible hardening on exposure to repeated wetting and drying.

The identification of plinthite in the field is somewhat subjective because an exact definition including measurable properties has not been adopted. Therefore, no “required characteristics” are provided. The following discussion provides general guidance for identifying plinthite.

Plinthite is firm or very firm when the soil moisture content is near field capacity and hard when the moisture content is below the wilting point. Plinthite occurs as discrete bodies larger than 2 mm that can be separated from the matrix. A moist aggregate of plinthite will withstand moderate rolling between thumb and forefinger and is less than strongly cemented. Moist or air-dried plinthite will not slake when submerged in water, even with gentle agitation. Plinthite does not harden irreversibly as a result of a single cycle of drying and rewetting. After a single drying, it will remoisten and then

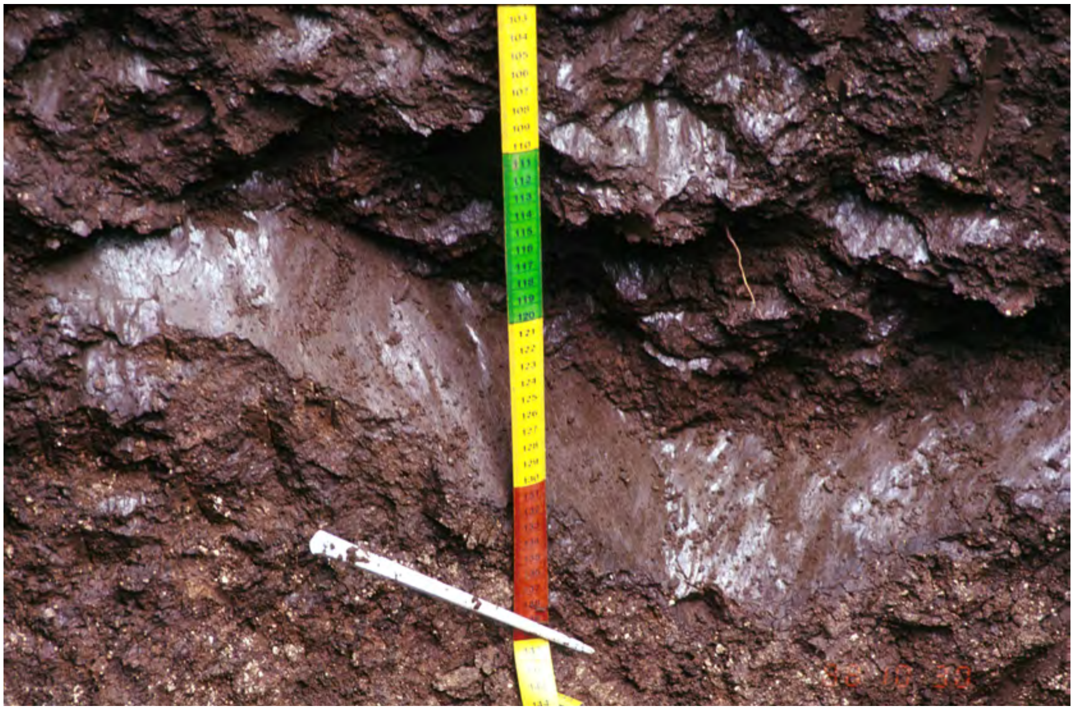

Figure 3-26: Close-up of slickensides in the lower part of a Vertisol in India. Scale is in cm.

can be dispersed in large part if it is shaken in water with a dispersing agent.

In a moist soil, plinthite is soft enough to be cut with a spade. After irreversible hardening, it is no longer considered plinthite but becomes ironstone. Indurated ironstone materials can be broken or shattered with a spade but cannot be dispersed if they are shaken in water with a dispersing agent.

A small amount of plinthite in the soil does not form a continuous phase; that is, the individual redox concentrations or aggregates are not connected with each other. If a large amount of plinthite is present, it may form a continuous phase. Individual aggregates of plinthite in a continuous phase are interconnected, and the spacing of cracks or zones that roots can enter is 10 cm or more.

If a continuous layer is indurated, it becomes a massive ironstone layer that has irregular, somewhat tubular inclusions of yellowish, grayish, or white clayey material. If the layer is exposed, these inclusions may be washed out, leaving an ironstone that has many coarse tubular pores.

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

Resistant Minerals

Several references are made to resistant minerals in this taxonomy. Obviously, the stability of a mineral in the soil is a partial function of the soil moisture regime. Where resistant minerals are referred to in the definitions of diagnostic horizons and of various taxa, a humid climate, past or present, is always assumed.

Resistant minerals are durable minerals in the 0.02 to 2.0 mm fraction. Examples are quartz, zircon, tourmaline, beryl, anatase, rutile, iron oxides and oxyhydroxides, 1:1 dioctahedral phyllosilicates (kandites), gibbsite, and hydroxy-aluminum interlayered 2:1 minerals (Burt and Soil Survey Staff, 2014). For a list of minerals considered to be resistant, see the *Soil Survey Laboratory Information Manual* (Soil Survey Staff, 2011, pp. 295–297).

Slickensides

Slickensides (fig. 3-26) are polished and grooved surfaces and generally have dimensions exceeding 5 cm. They are produced when one soil mass slides past another. If there are sand grains present in the otherwise clayey matrix, they may form striations as the surfaces slip past one another. Some slickensides occur at the lower boundary of a slip surface where a mass of soil moves downward on a relatively steep slope. Slickensides result directly from the swelling of clay minerals and shear failure. They are very common in swelling clays that undergo marked changes in moisture content (note 80).

Spodic Materials

Spodic materials (note 81) form in an illuvial horizon that normally underlies a histic, ochric, or umbric epipedon or an albic horizon. In most undisturbed areas, spodic materials underlie an albic horizon. They may occur within an umbric epipedon or an Ap horizon (note 82).

A horizon consisting of spodic materials normally has an optical density of oxalate extract (ODOE) value of 0.25 or more, and that value is commonly at least 2 times as high as the ODOE value in an overlying eluvial horizon. This increase in ODOE value indicates an accumulation of translocated organic materials in an illuvial horizon. Soils with spodic materials show evidence that organic materials and aluminum, with or without iron, have been moved from an eluvial horizon to an illuvial horizon.

Definition

Spodic materials are mineral soil materials that do not have all of the properties of an argillic or kandic horizon; are dominated by active amorphous materials that are illuvial and composed of organic matter and aluminum, with or without iron; and have *both* of the following:

Chemical Requirements for All Spodic Materials

1. A pH value in water (1:1) of 5.9 or less and an organic carbon content of 0.6 percent or more; *and*

2. *One or both* of the following:

Color Requirements Alone if an Albic Horizon is Present (note 83)

a. An overlying albic horizon that extends horizontally through 50 percent or more of each pedon and, directly under the albic horizon, colors, moist (crushed and smoothed sample), as follows:

(1) Hue of 5YR or redder; *or*

(2) Hue of 7.5YR, value of 5 or less, and chroma of 4 or less; *or*

(3) Hue of 10YR or neutral and value and chroma of 2 or less; *or*

(4) A color of 10YR 3/1; *or*

Alternative Criteria Using Color Plus Pedogenic Cementation or Laboratory Data if Item “a” Above is Not Met

b. With or without an albic horizon and one of the colors listed above or hue of 7.5YR, value, moist, of 5 or less, and chroma of 5 or 6 (crushed and smoothed sample), and *one or more* of the following morphological or chemical properties:

(1) Pedogenic cementation by organic matter and aluminum, with or without iron, in 50 percent or more of each pedon and a very firm or firmer rupture-resistance class in the cemented part; *or*

(2) 10 percent or more cracked coatings on sand grains; *or*

(3) Al plus $^{1}/_{2}$ Fe percentages (by ammonium oxalate) totaling 0.50 or more, and half that amount or less in an overlying umbric epipedon (or subhorizon of an umbric), ochric epipedon, or albic horizon; *or*

(4) An optical density of oxalate extract (ODOE) value of 0.25 or more, and a value half as high or lower in an overlying umbric epipedon (or subhorizon of an umbric), ochric epipedon, or albic horizon.

Volcanic Glass

Volcanic glass is defined in this taxonomy as optically isotropic translucent glass or pumice of any color. It includes glass, pumice, glass-coated crystalline minerals, glass aggregates, and glassy materials.

Volcanic glass is typically a dominant component in relatively unweathered tephra. Weathering and mineral transformation of volcanic glass can produce short-range-order minerals, such as allophane, imogolite, and ferrihydrite.

Volcanic glass content is the percent (by grain count) of glass, glass-coated mineral grains, glass aggregates, and glassy materials in the 0.02 to 2.0 mm fraction. Typically, the content is determined for one particle-size fraction (i.e., coarse silt, very fine sand, or fine sand) and used as an estimate of glass content in the 0.02 to 2.0 mm fraction.

Volcanic glass content is a criterion in classification of andic soil properties, subgroups with the formative element “vitr(i),” families with “ashy” substitutes for particle-size class, and the glassy mineralogy class.

Weatherable Minerals

Several references are made to weatherable minerals in this taxonomy. Obviously, the stability (i.e., ability to remain unaltered) of a mineral in a soil is a partial function of the soil moisture regime. Where weatherable minerals are referred to in the definitions of diagnostic horizons and of various taxa in this taxonomy, a humid climate, either present or past, is always assumed. Examples of the minerals that are included in the meaning of weatherable minerals are all 2:1 phyllosilicates, chlorite, sepiolite, palygorskite, allophane, 1:1 trioctahedral phyllosilicates (serpentines), feldspars, feldspathoids, ferromagnesian minerals, volcanic glass, zeolites, dolomite, and apatite in the 0.02 to 2.0 mm fraction. For a list of minerals considered to be weatherable, see the *Soil Survey Laboratory Information Manual* (Soil Survey Staff, 2011, pp. 295–297).

This definition of the term “weatherable minerals” is restrictive because the intent is to include, in the definitions of diagnostic horizons and various taxa, only those weatherable minerals that are unstable in a humid climate compared to other minerals, such as quartz and 1:1 lattice clays, but that are more resistant to weathering than calcite. Calcite, carbonate aggregates, anhydrite, gypsum, and halite are not considered weatherable minerals because they are mobile in the soil. Mobile minerals appear to be recharged in some otherwise strongly weathered soils.

Characteristics Diagnostic for Organic Soils

Following are descriptions of the characteristics that are used only with organic soils.

Kinds of Organic Soil Materials

Three different kinds of organic soil materials are distinguished in this taxonomy, based on the degree of decomposition of the plant materials from which the organic materials are derived. They are (1) fibric, (2) hemic, and (3) sapric. Because of the importance of fiber content in the definitions of these materials, fibers are defined before the kinds of organic soil materials.

Fibers

Fibers are pieces of plant tissue in organic soil materials (excluding live roots) that:

1. Are large enough to be retained on a 100-mesh sieve (openings 0.15 mm across) when the materials are screened; *and*

2. Show evidence of the cellular structure of the plants from which they are derived; *and*

3. Either are 20 mm or less in their smallest dimension or are decomposed enough to be crushed and shredded with the fingers.

Pieces of wood that are larger than 20 mm in cross section and are so undecomposed that they cannot be crushed and shredded with the fingers, such as large branches, logs, and stumps, are not considered fibers but are considered wood fragments (comparable to rock fragments in mineral soils). Wood fragments may be in the soil or on the soil surface.

Fibric Soil Materials

Fibric soil materials are organic soil materials that *either*:

1. Contain three-fourths or more (by volume) fibers after rubbing, excluding wood fragments (defined above); *or*

2. Contain two-fifths or more (by volume) fibers after rubbing, excluding coarse fragments, and yield color values and chromas of 7/1, 7/2, 8/1, 8/2, or 8/3 (fig. 3-27) on white chromatographic or filter paper that is inserted into a paste made of the soil materials in a saturated sodium-pyrophosphate solution.

Hemic Soil Materials

Hemic (Gr. *hemi*, half; implying intermediate decomposition) soil materials are intermediate in their degree of decomposition between the less decomposed fibric and more decomposed sapric materials. Their morphological features give intermediate values for fiber content, bulk density, and water content. Hemic soil materials are partly altered both physically and biochemically.

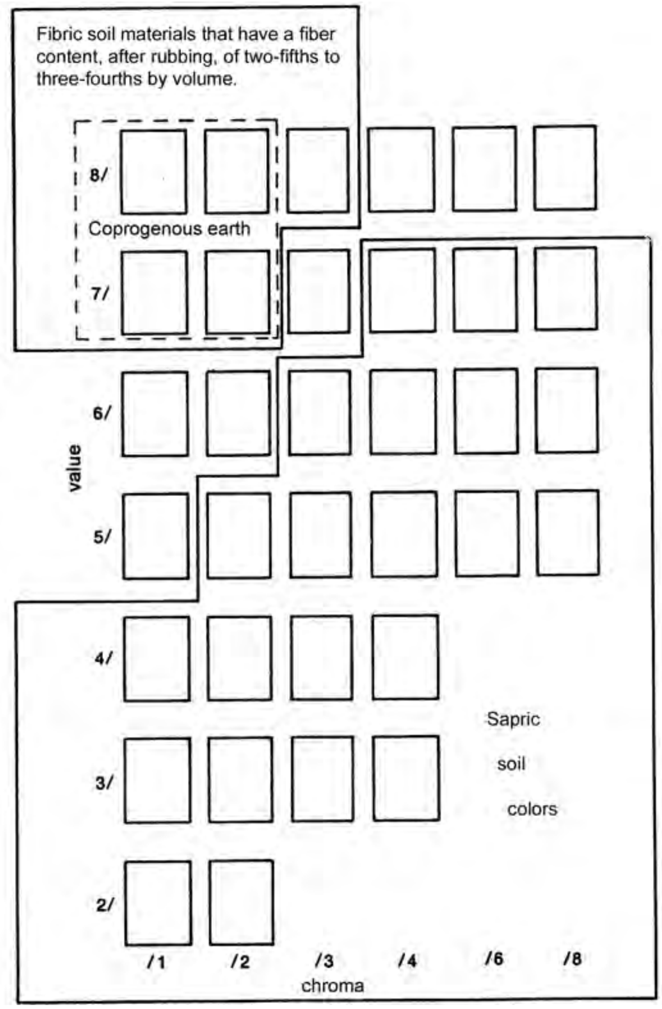

Figure 3-27: Value and chroma of pyrophosphate solution of fibric and sapric soil materials.

Sapric Soil Materials

Sapric (Gr. *sapros*, rotten) soil materials are the most highly decomposed of the three kinds of organic soil materials. They have the smallest amount of plant fiber, the highest bulk density, and the lowest water content on a dry-weight basis at saturation. Sapric soil materials are commonly very dark gray to black. They are relatively stable; i.e., they change very little physically and chemically with time in comparison to other organic soil materials.

Sapric materials have the following characteristics:

1. The fiber content, after rubbing, is less than one-sixth (by volume), excluding wood fragments (defined above); *and*

2. The color of the sodium-pyrophosphate extract on white chromatographic or filter paper is below or to the right of a line drawn to exclude blocks 5/1, 6/2, and 7/3 (fig. 3-37). If few or no fibers can be detected and the color of the pyrophosphate extract is to the left of or above this line, the possibility that the material is limnic must be considered.

Humilluvic Material

Humilluvic material, i.e., illuvial humus, accumulates in the lower parts of some organic soils that are acid and have been drained and cultivated. The humilluvic material has a C^{14} age that is not older than the overlying organic materials. It has very high solubility in sodium pyrophosphate and rewets very slowly after drying. Most commonly, it accumulates near a contact with a sandy mineral horizon.

To be recognized as a differentia in classification, the humilluvic material must constitute one-half or more (by volume) of a layer 2 cm or more thick.

Thickness of Organic Soil Materials (Control Section of Histosols and Histels)

The thickness of organic materials over limnic materials, mineral materials, water, or permafrost is used to define Histosols and Histels.

For practical reasons, an arbitrary control section has been established for the classification of Histosols and Histels. Depending on the kinds of soil material in the surface layers, the control section (note 84) has a thickness of either 130 cm or 160 cm from the soil surface if there is no densic, lithic, or paralithic contact, thick layer of water, or permafrost within the respective limit. The thicker control section is used if the surface layers to a depth of 60 cm either contain three-fourths or more fibers derived from *Sphagnum*, *Hypnum*, or other mosses or have a bulk density of less than 0.1 g/cm^3. Layers of water, which may be between a few centimeters and many meters thick in these soils, are considered to be the lower boundary of the control section only if the water extends below a depth of 130 or 160 cm, respectively. A densic, lithic, or paralithic contact, if shallower than 130 or 160 cm, constitutes the lower boundary of the control section. In some soils the lower boundary is 25 cm below the upper limit of permafrost. An unconsolidated mineral substratum shallower than those limits does not change the lower boundary of the control section.

The control section of Histosols and Histels is divided somewhat arbitrarily into three tiers—surface, subsurface, and bottom*.

* The concept of "tiers" is used in organic soils because they lack diagnostic horizons as defined for mineral soils.

Surface Tier

The surface tier of a Histosol or Histel extends from the soil surface to a depth of 60 cm if either (1) the materials within that depth are fibric and three-fourths or more of the fiber volume is derived from *Sphagnum* or other mosses or (2) the materials have a bulk density of less than 0.1 g/cm^3. Otherwise, the surface tier extends from the soil surface to a depth of 30 cm.

Some organic soils have a mineral surface layer less than 40 cm thick as a result of flooding, volcanic eruptions, additions of mineral materials to increase soil strength or reduce the hazard of frost, or other causes. If such a mineral layer is less than 30 cm thick, it constitutes the upper part of the surface tier; if it is 30 to 40 cm thick, it constitutes the whole surface tier and part of the subsurface tier.

Subsurface Tier

The subsurface tier is normally 60 cm thick. If the control section ends at a shallower depth (at a densic, lithic, or paralithic contact or a water layer or in permafrost), however, the subsurface tier extends from the lower boundary of the surface tier to the lower boundary of the control section. It includes any unconsolidated mineral layers that may be present within those depths.

Bottom Tier

The bottom tier is 40 cm thick unless the control section has its lower boundary at a shallower depth (at a densic, lithic, or paralithic contact or a water layer or in permafrost).

Thus, if the organic materials are thick, there are two possible thicknesses of the control section, depending on the presence or absence and the thickness of a surface mantle of fibric moss or other organic material that has a low bulk density (less than 0.1 g/cm^3). If the fibric moss extends to a depth of 60 cm and is the dominant material within this depth (three-fourths or more of the volume), the control section is 160 cm thick. If the fibric moss is thin or absent, the control section extends to a depth of 130 cm.

Horizons and Characteristics Diagnostic for Both Mineral and Organic Soils

Following are descriptions of the horizons and characteristics that are diagnostic for both mineral and organic soils.

Aquic Conditions

Soils with aquic (L. *aqua*, water) conditions are those that currently undergo continuous or periodic saturation and reduction. The presence of these conditions is indicated by redoximorphic features, except in Histosols and Histels, and can be verified by measuring saturation and reduction, except in artificially drained soils. Artificial drainage is defined here as the removal of free water from soils having aquic conditions by surface mounding, ditches, or subsurface tiles or the prevention of surface or ground water from reaching the soils by dams, levees, surface pumps, or other means. In these soils, water table levels and/or their duration are changed significantly in connection with specific types of land use. Upon removal of the drainage practices, aquic conditions would return. In the keys, artificially drained soils are included with soils that have aquic conditions.

Elements of aquic conditions are as follows (note 85):

1. Saturation is characterized by zero or positive pressure in the soil water* and can generally be determined by observing free water in an unlined auger hole. Problems may arise, however, in clayey soils with peds, where an unlined auger hole may fill with water flowing along faces of peds while the soil matrix is and remains unsaturated (bypass flow). Such free water may incorrectly suggest the presence of a water table, while the actual water table occurs at greater depth. Use of well sealed piezometers or tensiometers is therefore recommended for measuring saturation. Problems may still occur, however, if water runs into piezometer slits near the bottom of the piezometer hole or if tensiometers with slowly reacting manometers are used. The first problem can be overcome by using piezometers with smaller slits and the second by using transducer tensiometry, which reacts faster than manometers. Soils are considered wet if they have pressure heads greater than -1 kPa. Only macropores, such as cracks between peds or channels, are then filled with air, while the soil matrix is usually still saturated. Obviously, exact measurements of the wet state can be obtained only with tensiometers. For operational purposes, the use of piezometers is recommended as a standard method.

The duration of saturation required for creating aquic conditions varies, depending on the soil environment, and is not specified.

Three types of saturation are defined:

a. *Endosaturation.*—The soil is saturated with water in all layers from the upper boundary of saturation to a depth of 200 cm or more from the mineral soil surface, or to a paralithic or lithic contact, whichever is shallower.

b. *Episaturation.*—The soil is saturated with water in one or more layers within 200 cm of the mineral soil surface and also has one or more unsaturated layers, with an upper boundary above a depth of 200 cm, below the saturated layer. The zone of saturation, i.e., the water table, is perched on top of a layer with relatively low hydraulic conductivity, including discontinuities, pedogenic horizons, and densic contacts.

c. *Anthric saturation.*—This term refers to a special kind of aquic condition that occurs in soils that are cultivated and irrigated (flood irrigation). Soils with anthraquic conditions must meet the requirements for aquic conditions and in addition have *both* of the following:

(1) A tilled surface layer and a directly underlying slowly permeable layer that has, for 3 months or more in normal years, *both*:

(a) Saturation and reduction; *and*

(b) Chroma of 2 or less in the matrix; *and*

(2) A subsurface horizon with *one or more* of the following:

(a) Redox depletions with a color value of 4 or more, moist, and chroma of 2 or less in macropores; *or*

(b) Redox concentrations of iron and/or manganese; *or*

(c) 2 times or more the amount of iron (extractable by dithionite-citrate) than is contained in the tilled surface layer.

2. The degree of reduction in a soil can be characterized by the direct measurement of redox potentials (note 86). Direct measurements should take into account chemical equilibria as expressed by stability diagrams in standard soil textbooks. Reduction and oxidation processes are also a function of soil pH. Obtaining accurate measurements of the degree of reduction in a soil is difficult. In the context of this taxonomy, however, only a degree of reduction that results in reduced iron is considered, because it produces the visible redoximorphic features that are identified in the keys. A simple field test is available to determine if reduced iron ions are present. A freshly broken surface of a field-wet soil sample is treated with alpha,alpha-dipyridyl in neutral, 1N ammonium acetate solution. The appearance of a strong red color on the freshly broken surface indicates the presence of reduced iron ions (i.e., Fe^{2+}). A positive reaction to the alpha,alpha-dipyridyl field test for ferrous iron (Childs, 1981) may be used to confirm the existence of reducing conditions and is especially useful in situations where, despite saturation, normal morphological indicators of such conditions are either absent or obscured (as by the dark colors characteristic of melanic great groups). A negative reaction, however, does not imply that reducing conditions are always absent. It may only mean that the level of free iron in the soil is below the sensitivity limit of the test or that the soil is in an oxidized phase at the time of testing. For soils with very low levels of iron, the use of a field test such as Indicator of Reduction in Soils (IRIS) tubes painted with ferric iron may be warranted in order to document reducing conditions. Use of alpha,alpha-dipyridyl in

* This corresponds to the “satiated, wet” class (free water present) in the *Soil Survey Manual* (Soil Science Division Staff, 2017, p. 209).

a 10 percent solution of aceticacid is not recommended because the acid is likely to change soil conditions, for example, by dissolving $CaCO_3$.

The duration of reduction required for creating aquic conditions is not specified.

3. Redoximorphic features (note 87) associated with wetness result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. The reduced iron and manganese ions are mobile and may be transported by water as it moves through the soil. Certain redox patterns occur as a function of the patterns in which the ion-carrying water moves through the soil and as a function of the location of aerated zones in the soil. Redox patterns are also affected by the fact that manganese is reduced more rapidly than iron, while iron oxidizes more rapidly upon aeration. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redox processes in a soil may result in redoximorphic features that are defined as follows:

a. *Redox concentrations.*—These are zones of apparent accumulation of Fe-Mn oxides, including:

(1) Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure. Boundaries commonly are diffuse if formed *in situ* and sharp after pedoturbation. Sharp boundaries may be relict features in some soils.

(2) Masses, which are noncemented concentrations of substances within the soil matrix.

(3) Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.

b. *Redox depletions.*—These are zones of low chroma (chromas less than those in the matrix) where either Fe-Mn oxides alone or both Fe-Mn oxides and clay have been stripped out, including:

(1) Iron depletions, i.e., zones that contain low amounts of Fe and Mn oxides but have a clay content similar to that of the adjacent matrix (often referred to as albans or neoalbans).

(2) Clay depletions, i.e., zones that contain low amounts of Fe, Mn, and clay (often referred to as silt coatings or skeletans).

c. *Reduced matrix.*—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

In soils that have no visible redoximorphic features, a reaction to an alpha,alpha-dipyridyl (note 88) solution satisfies the requirement for redoximorphic features.

Field experience indicates that it is not possible to define a specific set of redoximorphic features that is uniquely characteristic of all of the taxa in one particular category. Therefore, color patterns that are unique to specific taxa are referenced in the keys.

Anthraquic conditions are a variant of episaturation and are associated with controlled flooding (for such crops as wetland rice and cranberries), which causes reduction processes in the saturated, puddled surface soil and oxidation of reduced and mobilized iron and manganese in the unsaturated subsoil.

Cryoturbation

Cryoturbation (frost churning) (fig. 3-28) is the mixing of the soil matrix within the pedon that results in irregular or broken horizons, involutions, accumulation of organic matter on the permafrost table, oriented rock fragments, and silt caps on rock fragments*.

Densic Contact

A densic (L. *densus*, thick) contact is a contact between soil and densic materials (defined below). It has no cracks, or the spacing of cracks that roots can enter is 10 cm or more.

Densic Materials

Densic materials are relatively unaltered materials (do not meet the requirements for any other named diagnostic horizons (note 89) or any other diagnostic soil characteristic) that have a noncoherent rupture-resistance class. The bulk density or the organization is such that roots cannot enter, except in cracks. These are mostly earthy materials, such as till, volcanic mudflows, and some mechanically compacted materials, for example, mine spoil. Some rocks with a noncoherent rupture-resistance class can be considered densic materials if they are dense or resistant enough to keep roots from entering, except in cracks.

* Cryoturbation and gelic materials were introduced in the 8th edition of the *Keys to Soil Taxonomy* (1998) as a result of the recommendations of the International Committee on Permafrost Affected Soils (ICOMPAS).

Figure 3-28: Soil profile from Alaska exhibiting mixing of the surface layer into the subsoil due to cryoturbation.

Densic materials slake when an air-dry sample is placed in water and thus differ from paralithic materials and the material below a lithic contact, neither of which slake due to their degree of coherence.

Densic materials have, at their upper boundary, a densic contact if they have no cracks or if the spacing of cracks that roots can enter is 10 cm or more. These materials can be used to differentiate soil series if the materials are within the series control section.

Gelic Materials

Gelic materials are mineral or organic soil materials that show evidence of cryoturbation (frost churning) and/or ice segregation in the active layer (seasonal thaw layer) and/or the upper part of the permafrost. Cryoturbation is manifested by irregular and broken horizons, involutions, accumulation of organic matter on top of and within the permafrost, oriented rock fragments, and silt-enriched layers. The characteristic structures associated with gelic materials include platy, blocky, or granular macrostructures; the structural results of sorting; and orbiculic, conglomeric, banded, or vesicular microfabrics. Ice segregation is manifested by ice lenses, vein ice, segregated ice crystals, and ice wedges. Cryopedogenic processes that lead to gelic materials are driven by the physical volume change of water to ice, moisture migration along a thermal gradient in the frozen system, or thermal contraction of the frozen material by continued rapid cooling.

Glacic Layer

A glacic layer (fig. 3-29) is massive ice or ground ice in the form of ice lenses or wedges. The layer is 30 cm or more thick and contains 75 percent or more visible ice.

Kinds of Limnic Materials

Limnic materials include both organic and inorganic materials that were either (1) deposited in water by precipitation or through the action of aquatic organisms, such as algae or diatoms, or (2) derived from underwater and floating aquatic plants and subsequently modified by aquatic animals. They include coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

Coprogenous Earth

A layer of coprogenous earth (sedimentary peat) is a limnic layer that:

1. Contains many fecal pellets with diameters between a few hundredths of a millimeter and a few millimeters; *and*

2. Has a color value of 4 or less, moist; *and*

3. Either forms a slightly viscous water suspension and is nonplastic or slightly plastic but not sticky, or shrinks upon drying, forming clods that are difficult to rewet and often tend to crack along horizontal planes; *and*

4. Either yields a saturated sodium-pyrophosphate extract on white chromatographic or filter paper that has a color value of 7 or more and chroma of 2 or less (see figure 3-27) or has a cation-exchange capacity of less than 240 cmol(+) per kg organic matter (measured by loss on ignition), or both.

Diatomaceous Earth

A layer of diatomaceous earth is a limnic layer that:

1. If not previously dried, has a matrix color value of 3, 4, or 5, which changes irreversibly on drying as a result of the irreversible shrinkage of organic matter coatings on diatoms (identifiable by microscopic, 440 X, examination of dry samples); *and*

2. Either yields a saturated sodium-pyrophosphate extract on white chromatographic or filter paper that has a color value of 8 or more and chroma of 2 or less or has a cation-exchange capacity of less than 240 cmol(+) per kg organic matter (measured by loss on ignition), or both.

Marl

A layer of marl is a limnic layer that:

1. Has a color value of 5 or more, moist; *and*

2. Reacts with dilute HCl to evolve CO_2.

The color of marl usually does not change irreversibly on drying because a layer of marl contains too little organic matter, even before it has been shrunk by drying, to coat the carbonate particles.

Lithic Contact

A lithic contact is the boundary between soil and a coherent underlying material. Except in Ruptic-Lithic subgroups, the underlying material must be virtually continuous within the limits of a pedon. Cracks that can be penetrated by roots are few, and their horizontal spacing is 10 cm or more. The underlying material must be sufficiently coherent when moist to make hand digging with a spade impractical, although the material may be chipped or scraped with a spade. The material

Figure 3-29: An ice wedge forms a glacic layer in a frozen soil in Alaska. (Photo courtesy of Dr. David Weindorf)

Figure 3-30: Soil profile with an abrupt wavy boundary at the paralithic contact. The paralithic material below the contact is relatively soft, weathered bedrock that can be dug with a spade. (Photo courtesy of John Kelley)

below a lithic contact must be in a strongly coherent or more coherent rupture-resistance class. Commonly, the material is indurated. The underlying material considered here does not include diagnostic soil horizons, such as a duripan or a petrocalcic horizon.

A lithic contact is diagnostic at the subgroup level if it is within 125 cm of the mineral soil surface in Oxisols* and within 50 cm of the mineral soil surface in all other mineral soils. In Gelisols composed mainly of organic soil materials, the lithic contact is diagnostic at the subgroup level if it is within 50 cm of the soil surface in Folistels or within 100 cm of the soil surface in Fibristels, Hemistels, and Sapristels. In Histosols the lithic contact must be at the lower boundary of the control section to be recognized at the subgroup level.

Paralithic Contact

A paralithic (lithic-like) contact (fig. 3-30) is a contact between soil and paralithic materials (defined below) where the paralithic materials have no cracks or the spacing of cracks that roots can enter is 10 cm or more.

Paralithic Materials

Paralithic materials are relatively unaltered materials (do not meet the requirements for any other named diagnostic horizons or any other diagnostic soil characteristic) that have an extremely weakly coherent to moderately coherent rupture-resistance class. Coherence, bulk density, and the organization are such that roots cannot enter, except in cracks. Paralithic materials have, at their upper boundary, a paralithic contact if they have no cracks or if the spacing of cracks that roots can enter is 10 cm or more. Commonly, these materials are partially weathered bedrock or weakly consolidated bedrock, such as sandstone, siltstone, or shale. Paralithic materials can be used to differentiate soil series if the materials are within the series control section. Fragments of paralithic materials 2.0 mm or more in diameter are referred to as pararock fragments.

Permafrost

Permafrost is defined as a thermal condition in which a material (including soil material) remains below 0 ^{o}C for 2

* The 125 cm depth was adopted for Oxisols with the 3rd edition of the *Keys to Soil Taxonomy* (1987) as a result of the recommendations of the International Committee for Oxisols (ICOMOX).

or more years in succession. Those gelic materials having permafrost contain the unfrozen soil solution that drives cryopedogenic processes. Permafrost may be impregnated by ice or, in the case of insufficient interstitial water, may be dry. The frozen layer has a variety of ice lenses, vein ice, segregated ice crystals, and ice wedges. The permafrost table is in dynamic equilibrium with the environment.

Soil Moisture Regimes

The term "soil moisture regime" refers to the presence or absence either of ground water or of water held at a tension of less than 1500 kPa in the soil or in specific horizons during periods of the year. Water held at a tension of 1500 kPa or more is not available to keep most mesophytic plants alive. The availability of water is also affected by dissolved salts. If a soil is saturated with water that is too salty to be available to most plants, it is considered salty rather than dry. Consequently, a horizon is considered dry when the moisture tension is 1500 kPa or more and is considered moist if water is held at a tension of less than 1500 kPa but more than zero. A soil may be continuously moist in some or all horizons either throughout the year or for some part of the year. It may be either moist in winter and dry in summer or the reverse. In the Northern Hemisphere, summer refers to June, July, and August and winter refers to December, January, and February.

Normal Years

In the discussions that follow and throughout the keys, the term "normal years" is used. A normal year is defined as a year that has:

1. Annual precipitation that is plus or minus one standard deviation of the long-term (30 years or more) mean annual precipitation; *and*

2. Mean monthly precipitation that is plus or minus one standard deviation of the long-term monthly precipitation for 8 of the 12 months.

For the most part, normal years can be calculated from the mean annual precipitation; however, when catastrophic events occur during a year, the standard deviations of the monthly means should also be calculated. The term "normal years" replaces the terms "most years" and "6 out of 10 years," which were used in the previous edition of *Soil Taxonomy* (Soil Survey Staff, 1975). When precipitation data are evaluated to determine if the criterion for the presence of aquic conditions, or number of days that the moisture control section is moist, or number of days that some part of the soil is saturated has been met, it is permissible to include data from periods with below normal rainfall. Similarly, when precipitation data are evaluated to determine if the criterion for the number of days that the moisture control section is dry has been met, it is permissible to include data from periods with above normal rainfall. It is assumed that if the criteria are met during these periods, they will also be met during normal years (note 90).

Soil Moisture Control Section

The intent in defining the soil moisture control section is to facilitate estimation of soil moisture regimes from climatic data*. The upper boundary of this control section is the depth to which a dry (tension of more than 1500 kPa, but not air-dry) soil will be moistened by 2.5 cm of water within 24 hours. The lower boundary is the depth to which a dry soil will be moistened by 7.5 cm of water within 48 hours. These depths do not include the depth of moistening along any cracks or animal burrows that are open to the surface.

If 7.5 cm of water moistens the soil to a densic, lithic, paralithic, or petroferric contact or to a petrocalcic or petrogypsic horizon or a duripan, the contact or the upper boundary of the cemented horizon constitutes the lower boundary of the soil moisture control section. If a soil is moistened to one of these contacts or horizons by 2.5 cm of water, the soil moisture control section is the boundary of the contact itself. The control section of such a soil is considered moist if the contact or upper boundary of the cemented horizon has a thin film of water. If that upper boundary is dry, the control section is considered dry.

The moisture control section of a soil extends approximately (1) from 10 to 30 cm below the soil surface if the particle-size class of the soil is fine-loamy, coarse-silty, fine-silty, or clayey; (2) from 20 to 60 cm if the particle-size class is coarse-loamy; and (3) from 30 to 90 cm if the particle-size class is sandy. If the soil contains rock and pararock fragments that do not absorb and release water, the limits of the moisture control section are deeper. The limits of the soil moisture control section are affected not only by the particle-size class but also by differences in soil structure or pore-size distribution or by other factors that influence the movement and retention of water in the soil.

Classes of Soil Moisture Regimes

The soil moisture regimes are defined in terms of the level of ground water and in terms of the seasonal presence or absence of water held at a tension of less than 1500 kPa in the moisture control section. It is assumed in the definitions that the soil supports whatever vegetation it is capable of supporting, i.e., crops, grass, or native vegetation, and that the amount of stored moisture is not being increased by irrigation or fallowing. These cultural practices affect the soil moisture conditions as long as they are continued.

Aquic soil moisture regime.—The aquic (L. *aqua*, water) soil moisture regime is a reducing regime in a soil that is virtually free of dissolved oxygen because it is saturated by water. Some soils are saturated with water at times while

* The Newhall model was designed for this purpose.

dissolved oxygen is present, either because the water is moving or because the environment is unfavorable for microorganisms (e.g., if the temperature is less than 1 °C); such a regime is not considered aquic.

It is not known how long a soil must be saturated before it is said to have an aquic soil moisture regime, but the duration must be at least a few days, because it is implicit in the concept that dissolved oxygen is virtually absent. Because dissolved oxygen is removed from ground water by respiration of microorganisms, roots, and soil fauna, it is also implicit in the concept that the soil temperature is above biologic zero for some time while the soil is saturated. Biologic zero is defined as 5 °C in this taxonomy. In some of the very cold regions of the world, however, biological activity occurs at temperatures below 5 °C.

Very commonly, the level of ground water fluctuates with the seasons; it is highest in the rainy season or in fall, winter, or spring if cold weather virtually stops evapotranspiration. There are soils, however, in which the ground water is always at or very close to the surface. Examples are soils in tidal marshes or in closed, landlocked depressions fed by perennial streams. Such soils are considered to have a peraquic soil moisture regime.

Aridic and torric soil moisture regimes.—The terms "aridic" (L. *aridus*, dry) and "torric" (L. *torridus*, hot and dry) are used for the same moisture regime but in different categories of the taxonomy.

In the aridic (torric) soil moisture regime, the moisture control section is, in normal years:

1. Dry in all parts for more than half of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is above 5 °C; *and*

2. Moist in some or all parts for less than 90 consecutive days when the soil temperature at a depth of 50 cm below the soil surface is above 8 °C.

Soils that have an aridic (torric) soil moisture regime normally occur in areas of arid climates. A few are in areas of semiarid climates and either have physical properties that keep them dry, such as a crusty surface that virtually precludes the infiltration of water, or are on steep slopes where runoff is high. There is little or no leaching in this soil moisture regime, and soluble salts accumulate in the soils if there is a source.

The limits set for soil temperature exclude from these soil moisture regimes soils in the very cold and dry polar regions and in areas at high elevations. Such soils are considered to have anhydrous conditions (defined earlier).

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

The udic soil moisture regime is common to the soils of humid climates that have well distributed rainfall; have enough rain in summer that the amount of stored moisture plus rainfall is approximately equal to, or exceeds, the amount of evapotranspiration; or have adequate winter rains to recharge the soils and cool, foggy summers, as in coastal areas. Water moves downward through the soils at some time in normal years.

In climates where precipitation exceeds evapotranspiration in all months of normal years, the moisture tension rarely reaches 100 kPa in the soil moisture control section, although there are occasional brief periods when some stored moisture is used. The water moves through the soil in all months when it is not frozen. Such an extremely wet soil moisture regime is called perudic (L. *per*, throughout in time, and L. *udus*, humid). In the names of most taxa, the formative element "ud" is used to indicate either a udic or a perudic regime; the formative element "per" is used in selected taxa.

Ustic soil moisture regime.—The ustic (L. *ustus*, burnt; implying dryness) soil moisture regime is intermediate between the aridic regime and the udic regime. Its concept is one of moisture that is limited but is present at a time when conditions are suitable for plant growth. The concept of the ustic soil moisture regime is not applied to soils that have permafrost (defined above).

If the mean annual soil temperature is 22 °C or higher or if the mean summer and winter soil temperatures differ by less than 6 °C at a depth of 50 cm below the soil surface, the soil moisture control section in areas of the ustic soil moisture regime is dry in some or all parts for 90 or more cumulative days in normal years. It is moist, however, in some part either for more than 180 cumulative days per year or for 90 or more consecutive days.

If the mean annual soil temperature is lower than 22 °C and if the mean summer and winter soil temperatures differ by 6 °C or more at a depth of 50 cm below the soil surface, the soil moisture control section in areas of the ustic soil moisture regime is dry in some or all parts for 90 or more cumulative days in normal years, but it is not dry in all parts for more than half of the cumulative days when the soil temperature at a depth of 50 cm is higher than 5 °C. If in normal years the moisture control section is moist in all parts for 45 or more consecutive days in the 4 months following the winter solstice, the moisture control section is dry in all parts for less than 45 consecutive days in the 4 months following the summer solstice.

In tropical and subtropical regions that have a monsoon climate with either one or two dry seasons, summer and winter seasons have little meaning. In those regions the soil moisture regime is ustic if there is at least one rainy season of 3 months or more. In temperate regions of subhumid or semiarid climates, the rainy seasons are usually spring and summer or spring and fall, but never winter. Native plants are mostly annuals or plants that have a dormant period while the soil is dry.

Xeric soil moisture regime.—The xeric (Gr. *xeros*, dry) soil moisture regime is the typical moisture regime in areas of Mediterranean climates, where winters are moist and cool and summers are warm and dry. The moisture, which falls during the winter, when potential evapotranspiration is at a minimum, is particularly effective for leaching. In areas of a xeric soil moisture regime, the soil moisture control section, in normal years, is dry in all parts for 45 or more consecutive days in the 4 months following the summer solstice and moist in all parts for 45 or more consecutive days in the 4 months following the winter solstice. Also, in normal years, the moisture control section is moist in some part for more than half of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C or for 90 or more consecutive days when the soil temperature at a depth of 50 cm is higher than 8 °C. The mean annual soil temperature is lower than 22 °C, and the mean summer and mean winter soil temperatures differ by 6 °C or more either at a depth of 50 cm below the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower.

Soil Temperature Regimes

Following is a description of the soil temperature regimes used in defining classes at various categorical levels in this taxonomy.

Classes of Soil Temperature Regimes

Gelic (L. *gelare*, to freeze).— Soils in this temperature regime have a mean annual soil temperature at or below 0 °C (in Gelic suborders and Gelic great groups) or 1 °C or lower (in Gelisols) either at a depth of 50 cm below the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower.

Cryic (Gr. *kryos*, coldness; indicating very cold soils).—Soils in this temperature regime have a mean annual temperature between 0 and 8 °C but do not have permafrost.

1. In mineral soils the mean summer soil temperature (June, July, and August in the Northern Hemisphere and December, January, and February in the Southern Hemisphere) either at a depth of 50 cm below the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower, is as follows (note 91):

   a. If the soil is not saturated with water during some part of the summer *and*:

      (1) If there is no O horizon: between 0 and 15 °C; *or*

      (2) If there is an O horizon: between 0 and 8 °C; *or*

   b. If the soil is saturated with water during some part of the summer *and*:

      (1) If there is no O horizon: between 0 and 13 °C; *or*

      (2) If there is an O horizon or a histic epipedon: between 0 and 6 °C.

2. In organic soils the mean annual soil temperature is between 0 and 6 °C.

Cryic soils that have an aquic soil moisture regime commonly are churned by frost.

Isofrigid soils can also have a cryic soil temperature regime. A few with organic materials in the upper part are exceptions.

The concepts of the soil temperature regimes described below are used in defining classes of soils in the lower categories of Soil Taxonomy (i.e., family and soil series).

Frigid.—A soil with a frigid soil temperature regime is warmer in summer than a soil with a cryic regime, but its mean annual temperature is between 0 and 8 °C and the difference between mean summer (June, July, and August) and mean winter (December, January, and February) soil temperatures is 6 °C or more either at a depth of 50 cm below the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower.

Mesic.—The mean annual soil temperature is 8 °C or higher but lower than 15 °C, and the difference between mean summer and mean winter soil temperatures is 6 °C or more either at a depth of 50 cm below the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower.

Thermic.—The mean annual soil temperature is 15 °C or higher but lower than 22 °C, and the difference between mean summer and mean winter soil temperatures is 6 °C or more either at a depth of 50 cm below the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower.

Hyperthermic.—The mean annual soil temperature is 22 °C or higher, and the difference between mean summer and mean winter soil temperatures is 6 °C or more either at a depth of 50 cm below the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower.

If the name of a soil temperature regime has the prefix *iso*, the mean summer and mean winter soil temperatures differ by less than 6 °C at a depth of 50 cm or at a densic, lithic, or paralithic contact, whichever is shallower.

Isofrigid.—The mean annual soil temperature is lower than 8 °C.

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

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

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

Sulfidic Materials*

Sulfidic materials contain oxidizable sulfur compounds (elemental S or most commonly sulfide minerals, such as pyrite or iron monosulfides). They are mineral or organic soil materials that have a pH value of more than 3.5 and that become significantly more acid when oxidized. Sulfidic materials accumulate as a soil or sediment that is permanently saturated, generally with brackish water. The sulfates in the water are biologically reduced to sulfides as the materials accumulate. Sulfidic materials most commonly accumulate in coastal marshes near the mouth of rivers that carry noncalcareous sediments, but they may occur in freshwater marshes if there is sulfur in the water. Upland sulfidic materials may have accumulated in a similar manner in the geologic past.

If a soil containing sulfidic materials is drained or if sulfidic materials are otherwise exposed to aerobic conditions, the sulfides oxidize and form sulfuric acid. The pH value, which normally is near neutrality before drainage or exposure, may drop below 3. The acid may induce the formation of iron and aluminum sulfates. The iron hydroxysulfate mineral jarosite (fig. 3-31) may segregate, forming the yellow redoximorphic concentrations that commonly characterize a sulfuric horizon. The transition from sulfidic materials to a sulfuric horizon normally requires only a few months and may occur within a few weeks. A sample of sulfidic materials, if air-dried slowly in shade for about 2 months with occasional remoistening, becomes extremely acid.

Required Characteristics

Sulfidic materials have *one or both* of the following:

Observed pH Change Over Time in Controlled Conditions

1. A pH value (1:1 in water) of more than 3.5 and, when the materials are incubated at room temperature as a layer 1 cm thick under moist aerobic conditions (repeatedly moistened and dried on a weekly basis), the pH decreases by 0.5 or more units to a value of 4.0 or less (1:1 by weight in water or in a minimum of water to permit measurement) within 16 weeks or longer until the pH reaches a nearly constant value if the pH is still dropping after 16 weeks; *or*

Chemical Analysis

2. A pH value (1:1 in water) of more than 3.5 and 0.75 percent or more S (dry mass), mostly in the form of sulfides, and less than three times as much calcium carbonate equivalent as S.

Hyposulfidic Materials

Hyposulfidic materials, like sulfidic materials, contain oxidizable sulfur compounds or sulfide materials and become more acid when oxidized; however, they do not decrease in pH enough to meet the requirements for sulfidic materials when incubated under moist aerobic conditions for 16 weeks. Hyposulfidic materials form under similar conditions and through similar processes as sulfidic materials but do not have enough oxidizable sulfur compounds net of any potentially neutralizing compounds to become extremely acid after oxidation.

Figure 3-31: Jarosite concentrations (yellow) within peds from a sulfuric horizon.

Required Characteristics

Hyposulfidic materials have *both* of the following:

1. Evidence of the presence of sulfides as indicated by a positive reliable indicator such as the production of hydrogen sulfide odor upon addition of HCl (modified “whiff test”), color change with application of 3 percent H_2O_2 (peroxide color change test), and effervescence with addition of 30 percent H_2O_2; *and*

2. An initial pH value (1:1 in water) of 4.0 or more and, when the materials are incubated at room temperature as a layer 1 cm thick under moist aerobic conditions (repeatedly moistened and dried on a weekly basis), the pH decreases by 1 or more units, but remains at a value of greater than 4.0 after 16 weeks.

Sulfuric Horizon

Brackish water sediments frequently contain pyrite or other iron sulfide minerals (or, rarely, elemental sulfur), which form sulfuric acid upon the oxidation of the sulfur forms they contain and/or upon the oxidation and hydrolysis of the iron in the

* The concept of sulfidic materials aligns with the concept of hypersulfidic materials used in other international soil taxonomy systems, including the World Reference Base for Soil Resources (WRB) and the Australian Soil Classification.

iron sulfides. Pyrite is an iron sulfide mineral that forms as a result of the microbial decomposition of organic matter under anaerobic conditions. Pyrite forms after iron oxide and sulfate from sea water (or other sources) become reduced to ferrous iron and sulfide, respectively, and then combine to form a very insoluble compound (see description of the sulfidization process given by Fanning and Fanning, 1989, or Fanning et al., 2002). Characteristically, the pyrite crystals occur as nests or framboids composed of bipyramidal crystals of pyrite. In an oxidizing environment, pyrite oxidizes and the products of oxidation (and the hydrolysis of the ferric iron produced) are iron oxides (and under sufficiently acidic and oxidizing conditions, jarosite and/or schwertmannite) and sulfuric acid. The jarosite has a straw-yellow color and frequently lines pores in the soil. Jarosite concentrations are among the indicators of a sulfuric horizon, but jarosite is not present in all sulfuric horizons.

The low pH and high amount of soluble sulfates, and/or underlying sulfidic materials, are other indicators of a sulfuric horizon. A quick test of sulfidic materials is a rapid fall in pH on drying or after treatment with an oxidizing agent, such as hydrogen peroxide.

A sulfuric (L. *sulfur*) horizon forms as a result of drainage (most commonly artificial drainage) and oxidation of sulfide-rich mineral or organic soil materials. It can form in areas where sulfidic materials have been exposed as a result of surface mining, dredging, or other earth-moving operations. A sulfuric horizon is detrimental to most plants and, if sufficiently acid at the soil surface, may prevent plant growth or limit it to certain plant species, such as *Phragmites australis,* that can tolerate the acidity under certain conditions.

Required Characteristics

The sulfuric horizon has the following properties:

Thickness

1. Is 15 cm or more thick and composed of either mineral or organic soil material; *and*

Reaction

2. Has a pH value (1:1 by weight in water or in a minimum of water to permit measurement) of 3.5 or less *or* less than 4.0 if sulfide or other S-bearing minerals that produce sulfuric acid upon their oxidation are present; *and*

Evidence of Sulfuric Acid Presence

3. Shows evidence that the low pH value is caused by sulfuric acid. The evidence is *one or more* of the following:

   a. Concentrations of jarosite, schwertmannite, or other iron and/or aluminum sulfates or hydroxysulfate minerals; *or*

   b. 0.05 percent or more water-soluble sulfate; *or*

   c. The layer directly underlying the horizon consists of sulfidic materials (defined above).

Characteristics Diagnostic for Human-Altered and Human-Transported Soils

Following are descriptions of the characteristics that are diagnostic for human-altered and human-transported soils. The diagnostic surface and subsurface horizons that may be present in these soils are defined above.

Anthropogenic Landforms

Anthropogenic landforms are discrete, artificial landforms that are mappable at common survey scales, such as 1:10,000 to 1:24,000. For more information on these terms, see Part 629 of the *National Soil Survey Handbook* (U.S. Department of Agriculture).

Constructional Anthropogenic Landforms

Constructional anthropogenic landforms include the following:

1. Artificial islands
2. Artificial levees
3. Burial mounds
4. Dumps
5. Dredge-deposit shoals
6. Dredge spoil banks
7. Filled marshland
8. Earthworks
9. Fill
10. Filled pits
11. Filled enclosures
12. Irrigationally raised land
13. Raised land
14. Landfills
15. Locally raised landforms
16. Middens
17. Mounds
18. Railroad beds
19. Reclaimed land
20. Rice paddies
21. Road beds
22. Sanitary landfills
23. Spoil banks
24. Spoil piles

Destructional Anthropogenic Landforms

Destructional anthropogenic landforms include the following:

1. Beveled cuts
2. Borrow pits
3. Canals
4. Cuts (i.e., road or railroad)
5. Cutbanks
6. Dredged channels

7. Earthworks
8. Floodways
9. Gravel pits
10. Leveled land
11. Log landings
12. Openpit mines
13. Quarries
14. Rice paddies
15. Sand pits
16. Scalped areas
17. Sewage lagoons
18. Surface mines

Anthropogenic Microfeatures

Anthropogenic microfeatures are discrete, artificial features formed on or near the earth's surface (and which may now be buried) typically too small to delineate at common survey scales, such as larger than 1:10,000. For more information on these terms, see Part 629 of the *National Soil Survey Handbook* (U.S. Department of Agriculture).

Constructional Anthropogenic Microfeatures

Constructional anthropogenic microfeatures include the following:

1. Breakwater (i.e., groins or jetties)
2. Burial mounds
3. Conservation terraces
4. Dikes
5. Double-bedding mounds
6. Dumps
7. Embankments
8. Fills
9. Hillslope terraces
10. Interfurrows
11. Middens
12. Revetments (i.e., seawalls)
13. Rice paddies
14. Spoil banks
15. Spoil piles

Destructional Anthropogenic Microfeatures

Destructional anthropogenic microfeatures include the following:

1. Cutbanks
2. Ditches
3. Furrows
4. Hillslope terraces
5. Impact craters
6. Skid trails
7. Scalped areas

Anthropogenic Material or Layers

Artifacts

Artifacts (L. *arte*, by skill, and *factum*, to do or make) are materials created, modified, or transported from their source by humans usually for a practical purpose in habitation, manufacturing, excavation, agriculture, or construction activities. Examples of discrete (> 2 mm) artifacts are bitumen (asphalt), brick, cardboard, carpet, cloth, coal combustion byproducts, concrete, glass, metal, paper, plastic, rubber, and both treated and untreated wood products. Mechanically abraded rocks (e.g., rocks with metal scrape marks or gouges), rocks worn smooth or shaped by physical action (e.g., grinding stones), or physically broken and shaped rocks and debitage (e.g., stone tool flakes) are artifacts. Examples of nonpersistent artifacts repeatedly added to soil to improve agricultural production include biosolids, aglime, quicklime, and synthetic inorganic fertilizers. Humans have also added midden material to the soil to increase agricultural productivity, but these additions (e.g., bones, shells, and cooking waste and associated charred byproducts) have persisted to produce long-term (hundreds to thousands of years) changes in soil properties (e.g., Terra Preta de Indio soils). Artifacts also include litter discarded by humans (e.g., aluminum cans) that appears to serve no apparent purpose or function for alteration of soil.

Human-Altered Material

Human-altered material is parent material for soil that has undergone anthroturbation (soil mixing or disturbance by humans). It occurs in soils that have either been used for gardening, been deeply mixed in place, excavated, and replaced, or been compacted in place for the artificial ponding of water. Human-altered material may be composed of either organic or mineral soil material. It may contain artifacts (e.g., shells or bones) used as agricultural amendments, but the majority of the material has no evidence that it was transported from outside of the pedon.

Human-altered material occurs in soils which are disturbed for various reasons. For example, human-altered material occurs in agricultural soils which are deeply plowed or ripped to disrupt a root-limiting layer (defined in chapter 17) or other physical restriction. Gravesites in cemeteries contain human-altered material as well as artifacts. Densic contacts form at the top of wet, slowly permeable (i.e., puddled) layers when they are compacted by humans, and they destroy structure and impede water percolation. Subsequent artificial ponding in such human-altered material results in anthric saturation (defined above) for the purpose of growing crops like rice in paddy soils.

Diagnostic horizons formed by significant illuviation (e.g., argillic or petrocalcic horizons) have not been documented as occurring in human-altered material. However, laterally tracing an illuvial horizon or diagnostic characteristic to find a discontinuity where the horizon or characteristic is abruptly absent can be used to identify human-altered material. The lateral discontinuity typically extends along linear boundaries. When the lateral discontinuity occurs at the edge of an anthropogenic landform or microfeature (defined above), it confirms the destructional origin of the landform or feature and identifies the human-altered material produced through excavation. It is often the preponderance of evidence (best professional judgment) along with published or historical evidence and onsite observations that allows the most consistent identification of excavated human-altered material.

Required Characteristics

Human-altered material meets *both* of the following:

1. It occurs in *one* of the following:

   a. A field tilled with a subsoiler to a depth of 50 cm or more to break up an impermeable or root-restrictive layer; *or*

   b. A destructional (excavated) anthropogenic landform or microfeature (e.g., borrow pit); *or*

   c. A field ponded for agriculture (e.g., rice paddy); *and*

2. It does not meet the requirements of human-transported material (defined below) *and* has evidence of purposeful alteration by humans which results in *one* of the following:

   a. 3 percent or more (by volume) mechanically detached and re-oriented pieces of diagnostic horizons or characteristics in a horizon or layer 7.5 cm or more thick; *or*

   b. 50 percent or more (by volume) divergent-shaped (from L. *divergent*, to veer)* structures in a horizon or layer 7.5 cm or more thick that formed from traffic or mechanical pressure exceeding the shear strength of moist loamy or clayey soil material; *or*

   c. Excavated and replaced soil material overlying either bones or artifacts arranged in ceremonial position or human body parts prepared to prevent decay; *or*

   d. Mechanically abraded rock fragments; *or*

   e. Excavated and replaced soil material unconformably overlying features (e.g., scrape marks) that indicate excavation by mechanical tools in some part of the pedon; *or*

   f. An abrupt lateral discontinuity of subsurface horizons and characteristics at the edge of a refilled or unfilled destructional (excavated) anthropogenic landform or microfeature; *or*

   g. Anthraquic conditions in a horizon or layer 7.5 cm or more thick; *or*

   h. A densic contact or thick platy structure in at least 50 percent of a pedon accompanied by additional evidence (e.g., scrape marks) that it was formed by human-induced mechanical compaction.

* Surfaces that formed by shearing intersect irregularly in diverging and converging directions.

Human-Transported Material

Human-transported material is parent material for soil that has been moved horizontally onto a pedon from a source area outside of that pedon by purposeful human activity, usually with the aid of machinery or hand tools. This material often contains a lithologic discontinuity or a buried horizon just below an individual deposit. In some cases it is not possible to distinguish between human-transported material and parent material from mass movement processes (e.g., landslides) without intensive onsite examination and analysis.

Human-transported material may be composed of either organic or mineral soil material and may contain detached pieces of diagnostic horizons which are derived from excavated soils. It may also contain artifacts (e.g., asphalt) that are not used as agricultural amendments (e.g., biosolids) or are litter discarded by humans (e.g., aluminum cans). Human-transported material has evidence that it did not originate from the same pedon which it overlies. In some soils, irregular distribution with depth or in proximity away from an anthropogenic landform, feature, or constructed object (e.g., a road or building) of modern products (e.g., radioactive fallout, deicers, or lead-based paint) may mark separate depositions of human-transported materials or mark the boundary with *in situ* soil material below or beside the human-transported material. In other soils, a discontinuity exists between the human-transported material and the parent material (e.g., a 2C horizon) or root-limiting layer (e.g., a 2R layer) beneath it. Multiple forms of evidence may be required to identify human-transported material where combinations of human actions and natural processes interact. Examples of these combinations include human-transported material deposited by dredging adjacent to active beaches, human- or water-deposited litter on flood plains and beneath water bodies, and deposits from natural geologic events (e.g., airfall volcanic ash) mantling anthropogenic landforms and microfeatures. Therefore, it is often the preponderance of evidence, including published or historical evidence and onsite observations, that allows identification of human-transported material.

Required Characteristics

Human-transported material meets *both* of the following:

1. It occurs *either*:

   a. On a constructional anthropogenic landform or microfeature (e.g., an artificial levee); *or*

   b. Within the boundaries of a destructional (excavated) anthropogenic landform or microfeature (e.g., borrow pit); *and*

2. It has evidence of purposeful transportation by humans and an origin outside of the pedon by at least *one* of the following:

a. A layer of soil material 7.5 cm or more thick which unconformably overlies material that has no evidence of originating outside of the pedon (e.g., an *in situ*, laterally continuous kandic horizon); *or*

b. Artifacts other than agricultural amendments (e.g., quicklime) and litter discarded by humans (e.g., aluminum cans); *or*

c. Mechanically detached pieces of diagnostic horizons or characteristics or saprolite (isovolumetric, weathered, uncemented pseudomorphs of weathered bedrock) that do not correspond with the underlying material. The pieces commonly have random orientation relative to each other and the soil surface and contrast abruptly in texture, mineralogy, or color with the surrounding material; *or*

d. Soil material that contains mechanically abraded rock or pararock fragments; *or*

e. Mechanically fractured rock or pararock fragments with splintered or sharp edges that do not correspond with the fragments in the underlying soil material (i.e., fractures that cut through rather than between individual minerals); *or*

f. Mechanical scrape marks at some part of the boundary between materials that do not correspond with each other; *or*

g. Soil material 7.5 cm or more thick that overlies a manufactured layer contact; *or*

h. Bridging voids* between rock fragments in a horizon or layer 7.5 cm or more thick in mine spoil with at least 35 percent (by volume) rock fragments; *or*

i. An irregular distribution pattern of modern anthropogenic particulate artifacts (e.g., radioactive fallout or immobile pollutants) or discrete artifacts that are unrelated to the deposition or transportation processes of natural parent materials such as eolian material, alluvium, or colluvium. The irregular distribution occurs above or across the contact between soil materials that do not correspond with each other or laterally with distance away from a source (e.g., the amount of lead-based paint decreases away from a building).

Manufactured Layer

A manufactured layer is an artificial, root-limiting layer beneath the soil surface consisting of nearly continuous, human-manufactured materials whose purpose is to form an impervious barrier. The materials used to make the layer impervious include geotextile liners, asphalt, concrete, rubber, and plastic. The presence of manufactured layers can be used to differentiate soil series.

* A void created when soil materials with a high content of rock fragments are transported and deposited without packing or sorting. The result is a trio of rock fragments stacked in a manner than prevents fine earth from filling the void.

Manufactured Layer Contact

A manufactured (L. *humanus*, of or belonging to man, and L. *factum*, to do or make) layer contact is an abrupt contact between soil and a manufactured layer (defined above). It has no cracks, or the spacing of cracks that roots can enter is 10 cm or more.

Subgroups for Human-Altered and Human-Transported Soils

The following subgroup adjectives recognize distinct groups of human-altered and human-transported soils. Soils using these adjectives are considered extragrades since they do not represent an intergrade to any other named taxon (Soil Survey Staff, 1999). They are listed in order of interpretive significance as a guide, but the significance and order may change slightly depending on the great group in which they are recognized. They are not used in combination with each other even though some soils may have properties of several subgroups. These adjectives may be combined alphabetically with adjectives connoting other soil properties, such as high organic matter content (e.g., Anthropic Humic) or the presence of sulfidic materials (e.g., Anthroportic Sulfic), to form the names for additional extragrade subgroups. Additional adjectives for other properties will generally increase the importance of the subgroup and result in higher placement within a key to subgroups.

1. **Anthraquic** (modified from Gr. *anthropos*, human, and L. *aqua*, water).—Soils that have anthraquic conditions (i.e., anthric saturation). These soils are extensive in flooded rice paddies.

2. **Anthrodensic** (modified from Gr. *anthropos*, human, and L. *densus*, marked by compactness).—Soils that have a densic contact due to mechanical compaction (e.g., a compacted mine spoil) in more than 90 percent of the pedon (measured laterally) within 100 cm of the mineral soil surface.

3. **Anthropic** (modified from Gr. *anthropos*, human).—Soils that have an anthropic epipedon based on the presence of artifacts or midden material.

4. **Plaggic** (modified from Ger. *plaggen*, sod).—Soils that have a plaggen epipedon.

5. **Haploplaggic** (Gr. *haplous*, simple, and Ger. *plaggen*, sod).—Soils that have a surface horizon 25 cm to less than 50 cm thick that meets all of the requirements for a plaggen epipedon except thickness.

6. **Anthroportic** (modified from Gr. *anthropos*, human, and L. *portāre,* to carry).—Soils that formed in 50 cm or more of human-transported material. This adjective is used primarily for soils that formed in human-transported material of dredged or mine spoil areas as well as for soils of urban areas and transportation corridors.

7. **Anthraltic** (modified from Gr. *anthropos*, human, and L. *alterāre*, to change).—Soils that formed in 50 cm or more of human-altered material. This adjective is used primarily for human-altered material where ripping or deep plowing has fractured and displaced diagnostic subsurface horizons that were root-limiting (e.g., duripans) and in excavated areas (e.g., borrow pits).

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Endnotes

Rock structure

1. The prevalence of rock structure that persists in the soil material is an indication that little pedogenic development has occurred. The lack of rock structure throughout most of a layer is a diagnostic criterion included in many of the definitions of diagnostic epipedons and subsurface horizons described in this chapter.

Anthropic epipedon

2. The concept and definition of the anthropic epipedon was significantly revised from earlier editions of *Soil Taxonomy* at the recommendation of the International Committee for Anthropogenic Soils (ICOMANTH) in 2014. These changes were included in the 12th edition of the *Keys to Soil Taxonomy*. The original concept for the anthropic epipedon was to recognize epipedons formed due to long-term human habitation, as evidenced by addition of middens, and to provide a place for mollic-like epipedons formed by long-term irrigation in arid areas, such as those that have been observed in Egypt and in the Americas, as a result of Native American cultural practices (Smith, 1986, pp. 101–102). The major changes included the requirement that the epipedon be formed in human-transported or human-altered material, the elimination of requirements shared with the mollic epipedon (such as color, organic carbon, and base saturation), the elimination of the requirement for elevated phosphorous levels, and the exclusion of many mollic-like epipedons formed due to long-term irrigation of arid soils.

Folistic epipedon

3. Guy Smith expressed the opinion that an alternate phrasing of this would be to say that they "do not have an aquic soil moisture regime" (Smith, 1986, p. 184). Today, we could specify that they do not have aquic conditions.

4. Most folistic epipedons consist of organic soil material (defined in chapter 2). Criterion 2 provides for a folistic epipedon that is an Ap horizon consisting of mineral soil material.

Histic epipedon

5. The upper thickness ranges in items 1a and 1b equate to the values where the soil being classified is considered an organic soil rather than a mineral soil, and therefore technically no longer has a histic epipedon.

6. Most histic epipedons consist of organic soil material. Item 2 provides for a histic epipedon that is composed of mineral soil material. Cultivation and other similar disturbances tend to lead to loss of organic matter (especially the less decomposed fibric and hemic kinds) and development of structure due to drying, shrinking, enhanced aeration, and increased oxidation of the organic matter (Ewing et al., 2012). To accommodate this reduction in organic matter, the histic epipedon can be within the upper limits of the organic carbon requirement for mineral soil material. This adjustment was included to avoid taxonomic changes due to cultivation. See the 6th attribute of Soil Taxonomy (Soil Survey Staff, 1999, chapter 2). A histic epipedon consisting of mineral soil material can also be part of a mollic or umbric epipedon.

Melanic epipedon

7. The melanic epipedon was recommended for addition to Soil Taxonomy as a result of work by the International Committee for Andisols (ICOMAND). The concept originated in Japan. The epipedon was adopted and appeared in the 4th edition of the *Keys to Soil Taxonomy* (1990).

8. Due to the depositional nature of the soil material making up many of these pedons, the melanic epipedon may have some thin intervening layers of loess or other non-volcanic materials that do not meet all the required characteristics; therefore, the required thickness is cumulative.

9. A melanic index value of less than 1.70 indicates that fulvic acids make up more than about 40 percent of the combined total of humic and fulvic acids in the organic fraction of the soil, thus suggesting a significant contribution from grass or grass-like plants.

Mollic epipedon

10. Mixing to 18 cm is specified so that cultivated and uncultivated soils are treated the same. For undisturbed soils, "mixing" can generally be accomplished by calculating a weighted average for the property in question. Thorough physical mixing can also be performed if necessary. The use of a surface layer as a diagnostic criterion at a very high taxonomic level (soil order) in some ways violates the 6th attribute of Soil Taxonomy, i.e., keeping cultivated and undisturbed profiles together in the same class (see Soil Survey Staff, 1998, *Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys*, chapter 2). Cultivation and subsequent erosion can cause a soil to change classification

where the mollic epipedon then fails minimum thickness requirements. Dr. Guy Smith struggled with this dilemma (Smith, 1986, p. 197) as have others over the years (for example, Olson et. al., 2005).

11. The restriction against being structureless (massive) and having hard, very hard, or harder consistence when dry was introduced to exclude some soils in Southern California and possibly elsewhere in the world that have carbon content and color meeting the criteria for the mollic epipedon, but that have adverse physical properties not shared by other soils with mollic epipedons (Smith, 1986, p. 156).

12. The *n* value is described in Pons and Zonneveld (1965). It is a calculated value based on the percentage of water held under field conditions as well as percentages of silt, sand, clay, and organic matter. It expresses the relative ability of soil under natural conditions to support a load such as grazing cattle or machinery. See the *Soil Survey Manual* (Soil Science Division Staff, 2017, p. 189) for correlation of *n* value with fluidity classes. A fluidity class of nonfluid (i.e., deformable) is approximately equivalent to an *n* value of less than 0.7.

13. Finely divided $CaCO_3$ acts as a white pigment and causes the soil to have a high color value, especially when dry. To compensate for the color of the carbonates, the mollic epipedon can have lighter color if the epipedon averages more than 15 percent carbonates.

14. The ammonium acetate method was chosen because many mollic epipedons (particularly those with an ustic soil moisture regime) contain free carbonates, so that the alternative sum of bases method is not useful. The 50 percent limit was a preliminary estimate based on limited data. It was not criticized so it has remained (Smith, 1986, p. 40).

15. A single standard thickness criterion is not used to define the mollic epipedon. The minimum required thickness depends on the overall depth and texture of the soil. The reason the minimum required thickness varies is to recognize the overall importance of the melanization process relative to other processes in the specific soil profile being evaluated. Allowance for a mollic epipedon less than 25 cm thick acknowledges the predominance of the melanization process in some soil profiles relative to other soil-forming processes.

Plaggen epipedon

16. Guy Smith referred to the plaggen epipedon as "primarily a European epipedon" (Smith, 1986, p. 91). The earliest documented evidence for plaggen management dates to the Late Bronze Age, 3,000 years ago on the Island of Sylt, Denmark (Blume and Leinweber, 2004). Documented dates suggest that the technique became common in northwestern Europe around 1,000 years ago (Luise et al., 2014). The practice of adding manure and other amendments to improve the soil was mostly associated with the poorly fertile, sandy Spodosols. The practice mostly ceased by the turn of the 19th century, when fertilizers became available. Soils with plaggen epipedons were celebrated as the "Soil of the Year" in Germany in 2013 (Luise et al., 2014).

17. It should be noted that while the plaggen epipedon represents a soil-building management practice, it is at the expense of large areas of nearby (often low-lying) soils that were excavated and degraded to produce the bedding materials (Luise et al., 2014).

Umbric epipedon

18. Mixing to 18 cm is specified so that cultivated and uncultivated soils are treated the same. For undisturbed soils, "mixing" can generally be accomplished by calculating a weighted average for the property in question. Thorough physical mixing can also be performed if necessary.

19. A single standard thickness criterion is not used to define the umbric epipedon. The minimum required thickness depends on the overall depth and texture of the soil. The reason the minimum required thickness varies is to recognize the overall importance of the melanization process relative to other processes in the specific soil profile being evaluated. Allowance for a mollic epipedon less than 25 cm thick acknowledges the predominance of the melanization process in some soil profiles relative to other soil-forming processes.

Agric horizon

20. The agric horizon is not currently used to define any taxa. Prior to the 2nd edition of *Soil Taxonomy* it was used to define the now obsolete Agrudalfs. By its nature, the agric horizon is a relatively recently formed horizon (post cultivation) superimposed on the upper part of an existing diagnostic horizon, such as an argillic or cambic horizon, which is used in the classification. However, the agric horizon can be used as a defining characteristic for a soil series, or phase of a series. Agric horizons have not been commonly recognized in the United States, although they likely occur.

21. The pedogenic process contributing to the formation of the agric horizon is a unique form of illuviation occurring as a result of repeated anthropogenic disturbance of the overlying eluvial layer (Ap) and its impact on the underlying layer where illuviation takes place. The large pores in the plow layer and the absence of vegetation immediately after plowing permit a turbulent flow of muddy water to the base of the plow layer. Water enters wormholes or fine cracks between peds at the base of the plow layer, and the suspended materials are deposited as the water is withdrawn into capillary pores. The macropores in the form of worm channels, root channels, and surfaces of peds in the horizon underlying the plow layer become coated with a dark-colored mixture of organic matter, silt, and clay. The accumulations on the inside surfaces of wormholes become thick and can eventually fill the holes. If worms are scarce, the accumulations may take the form of lamellae formed by infilling structural pores that range in thickness from a few mm to about 1 cm. The lamellae and the coatings on the sides of

wormholes always have a lower color value and chroma than the soil matrix.

Albic horizon

22. The dominant processes leading to the formation of the albic horizon are argilluviation and/or podzolization. Argilluviation is the process of clay removal from the albic into an underlying horizon, such as an argillic horizon. Podzolization is the process of translocating iron and aluminum along with organic matter from the albic horizon into an underlying horizon, commonly a spodic or cambic horizon. Each process results in the stripping and eluviation of clay and iron oxides to the extent that the color of the horizon is the color of the primary sand and silt grains (often quartz) with few coatings remaining to provide a brownish or reddish pigment that masks the primary grain color.

23. By convention, the ochric epipedon includes any underlying eluvial horizons and extends to the first illuvial layer. Therefore, many albic horizons are also considered to be part of the ochric epipedon.

Anhydritic horizon

24. Anhydrite ($CaSO_4$) is a dehydrated analog of gypsum ($CaSO_4 \bullet 2H_2O$). X-ray diffraction is required to distinguish anhydrite from gypsum. Wilson et al. (2013) report that quantification of anhydrite can be determined by the difference between the results from analysis by the acetone method (gypsum plus anhydrite) and low-temperature weight loss (for gypsum). In most environments, anhydrite is unstable and will readily combine with water when present, thus converting to the more stable mineral gypsum. However, anhydrite has been observed to remain stable after it forms in some strongly saline soils with high temperatures in Middle Eastern sabkhas, even when in contact with hypersaline ground water. It is theorized that the anhydrate-to-gypsum transformation is inhibited under strongly reducing conditions and in the presence of hydrogen sulfate. As a result, the geographic distribution of the anhydritic horizon is restricted to relatively few areas having favorable conditions (Shahid et al., 2007; Sarmast et al., 2016).

Argillic horizon

25. Clay-sized calcium carbonate particles are not considered when evaluating a horizon for identification as an argillic horizon. Eluvial and illuvial horizon clay content comparisons are based upon silicate clays only. When present, carbonate clay must be subtracted from total clay when evaluating particle-size distribution data for the required clay increase of an argillic horizon.

26. Textural differentiation in soils with argillic horizons results from one or more processes acting simultaneously or sequentially and affecting surface horizons or subsurface horizons, or both. The degree to which a process, or several processes, operate varies widely from soil to soil. In some soils clay illuviation alone is significant, while in others clay illuviation is overshadowed by *in situ* weathering and dissolution of clays in the upper layers, leaching of the dissolved constituents to the subsoil, and neoformation of clays in the argillic horizon. In other cases, clay may be produced directly in the subsoil by weathering of primary minerals. Not all the processes are completely understood. However, the argillic horizon requires at least some evidence of clay illuviation.

27. Evidence of clay illuviation must be present in at least some part of the argillic horizon. Clay films, for example, may be evident only in the lower part of the argillic horizon in some soils. This is particularly true in some argillic horizons on old surfaces where the overlying eluvial horizon is highly weathered and thus little or no clay is produced and moving out of the layer today (for example, some Arenic and Grossarenic Paleudults). Clay films in the upper part of the argillic horizon in such soils may be disrupted by biological activity faster than they are produced. As clay continues to migrate deeper into the argillic, the clay films may be observable only in the lower parts of the argillic horizon.

28. Pressure faces are sometimes mistaken for clay films because they have a similar smooth, shiny appearance. The clay in clay films coats the surface, including sand grains, with a noticeable thickness of illuvial clay. If the surface feature is a pressure face alone, the sand grains are not coated with clay and the surface feature has little discernable thickness.

29. The 1 percent limit was chosen because it was assumed that if clay films are evident in the field there probably is also at least 1 percent identifiable oriented clay in thin sections. This assumption was not contradicted during testing of earlier versions of Soil Taxonomy, so this criterion has remained as originally proposed (Smith, 1986, p. 86).

30. These soils exhibit significant shrinking and swelling with seasonal moisture change. Where illuvial clay is present, the stress applied to ped surfaces may destroy incipient clay films as they form. In many such clayey horizons, identifying clay films is difficult or impossible. The higher proportion of fine clay in the illuvial horizon compared to the eluvial horizon is considered evidence of clay translocation.

31. The values “3 percent,” “1.2 times,” and “8 percent” were chosen because they are thought to be the minimum contrasts in clay content that can be reliably determined in the field by experienced soil scientists (Smith, 1986, p. 86).

Calcic horizon

32. The change in required calcium carbonate equivalent (5 percent vs. 15 percent) for soils with less than or more than 18 percent clay, respectively, does not allow for a smooth transition from one case to the other. Smith (1986, p. 94) suggests that a sliding scale for required CCE based on clay content may have been more appropriate, but this has never been proposed.

33. Particle-size class terms are used in this required characteristic as a convenient proxy for many possible combinations of USDA texture class and texture modifier and do not imply that the soil meeting this option for the diagnostic horizon also meets the particle-size class criteria in the family classification.

34. The criteria given here are provided to allow the calcic horizon to contain pedogenically cemented layers that are too thin or discontinuous to meet the criteria for a petrocalcic horizon.

Cambic horizon

35. Textures coarser than very fine sand were excluded from the cambic horizon because so little alteration is necessary to produce a color change in sandy soils. Dr. Guy Smith, in his discussion of the cambic horizon (Smith, 1986, p. 102), paraphrased Dr. Roy Simonson as saying, “It doesn’t take much paint to make a barn red. And in this case, it doesn’t take much to color a sand grain.”

Duripan

36. The most common form of silica (SiO_2) is the highly stable mineral quartz, which is inherited from the parent material. By contrast, the pedogenic forms of silica found in the duripan are less crystalline and partially hydrated. Pedogenic silica commonly consists of opal-A, opal-CT, chalcedony, and microcrystalline quartz (Monger and Kelly, 2002).

37. Criterion 3 requires a sequential treatment of (1) HCl to dissolve any carbonates cementing the layer, and (2) either KOH or NaOH to dissolve any silica cementing the layer. By estimating the volume of air-dry fragments that slake during each treatment, a determination can be made as to which is the dominant cementing agent.

Fragipan

38. It should be noted that no minimum bulk density value is required for the identification of a fragipan. Absolute values vary considerably and bulk density *per se* is not directly responsible for root limitation in the horizon. (For an example, see Lindbo et al., 1994.)

39. Fragipans show evidence of pedogenesis, other than density and brittleness, such as oriented clay in the matrix or on the faces of peds, albic materials or coatings of albic materials on the faces of peds or in seams, soil structure, and/or redoximorphic features in the matrix or on the faces of peds. The fragipan, due to its pedogenic nature, stands in contrast to other nonpedogenic root-restrictive layers, such as those composed of paralithic materials (soft bedrock), or densic materials (for example, dense basal till). Given its pedogenic nature, it is recognized as a diagnostic horizon at a fairly high level in the taxonomy.

40. To be a fragipan, air-dry samples must slake when submerged in water. This criterion assures that the firm and brittle nature of the horizon is not due to significant pedogenic cementation of the grains making up the horizon. The factors giving rise to the unique properties of the fragipan are not fully understood. Close packing of the grains along with weak chemical bonds with silica, aluminum, or clay and iron oxides possibly play a role. Rupture-resistance classes and the tests for determining them are described in the *Soil Survey Manual* (Soil Science Division Staff, 2017, pp. 181–185).

41. Fragipans are not observed in calcareous materials. This suggests that carbonates hinder fragipan formation (Smith, 1986, p 77). This criterion was added with the 9th edition of the *Keys to Soil Taxonomy* (2003) to exclude some soils with carbonate-containing dense till.

Glossic horizon

42. This degradation includes removal of clay and free iron oxides. The pedogenic processes generally considered to be responsible include argilluviation, which moves clay downward and blocks pores in the illuvial layer below; podzolization and development of albic materials; ferrolysis, which produces iron-rich materials in tongues of albic material penetrating the illuvial layer; and gleization (either localized between peds or throughout the horizon) resulting from periodic saturation and reduction. The material between the peds resulting from eluviation processes consists of light-colored and comparatively lighter textured albic material. The process of eluviation gradually progresses from the exterior of the peds to their interior. The glossic horizon generally continues to develop downward as the upper part of the illuvial horizon is degraded. The glossic horizon is commonly considered to be a mark of pedogenic age and landscape stability, especially as this horizon moves progressively downward into the illuvial layer and is overlain by an increasingly thick albic horizon.

Gypsic horizon

43. The concept of the gypsic horizon having gypsum that has either accumulated (illuvial) or been at least partly transformed in place was introduced in the 11th edition of the *Keys to Soil Taxonomy* (2010). Prior to this it was required to be illuvial in nature. Where illuvial in nature, the gypsum has been dissolved in one part of the profile, transferred to another part, and then precipitated near the wetting front where it accumulates over time. In soils that have ground water near the surface, capillary rise and evaporation plus transpiration can result in significant upward movement and accumulation of gypsum, sometimes at the soil surface. Many other gypsic horizons are not illuvial in nature. In soils that formed in highly gypsiferous parent material, such as residuum from gypsum rock, or eolian gypsum sands, it can be difficult, if not impossible, to distinguish gypsum that has undergone some degree of pedogenesis from gypsum that is lithogenic. This is because gypsum is relatively easily dissolved in water and then reprecipitated in place upon drying without being transferred significantly within the profile. It can be very difficult to distinguish gypsum that is truly illuvial in nature from gypsum that has simply been altered in place due to periodic wetting and drying (figure 3-16 is an example of such a situation). In either case, some degree of pedogenesis has likely taken place with gypsum that is, or has been, subject to wetting and drying. For this reason, there must simply be at least 1 percent, by volume, of the horizon with gypsum that has been transformed in order to qualify as a gypsic horizon.

Kandic horizon

44. The concept of the kandic horizon and the “kandi” and “kanhapli” great groups of soils are the result of the work of the International Committee on the Classification of Low Activity Clays (ICOMLAC). A summary is in Soil Management Support Services (1986). These revisions were introduced in 1987 with the 3rd edition of the *Keys to Soil Taxonomy*.

45. The identification of a kandic horizon requires that an overlying, coarser textured horizon be present for comparison. There is no provision therefore for identifying a kandic horizon exposed at the surface in a truncated soil. Such a horizon would likely meet the criteria for either an oxic or cambic horizon. If there is evidence of illuvial clay, it may meet the criteria for an argillic horizon since a provision for truncated soils is provided for the argillic horizon.

46. Originally, the proposed definition required mixing the upper 18 cm of the surface in all cases before verifying the required clay increase. This criterion is used throughout Soil Taxonomy to keep cultivated and uncultivated pedons in the same taxa. At the request of the Australians, an exception was created to allow as little as 5 cm for the coarser textured surface layer if there is an abrupt textural transition to the kandic. This allows for the recognition of kandic horizons in these soils.

47. The kandic horizon does not require that the increase in clay be due to illuviation. Textural differentiation in pedons with kandic horizons may result from one or more processes acting simultaneously or sequentially, affecting surface horizons, subsurface horizons, or both. In addition to illuviation, the clay difference between the surface and subsurface may be due to clay destruction in the surface layer, selective removal of fine particles from the surface due to erosion, or a lithologic discontinuity below the surface layer. The difficulty of finding evidence of clay illuviation in Ultisols and Alfisols dominated by low-activity clay was one of the important motivations for defining the kandic horizon without a requirement for illuvial clay (Soil Management Support Services, 1986).

48. The percentage of clay used in this determination is the higher of either (1) that measured by the pipette method, or (2) that estimated by the formula: 2.5 times [percent water retained at 1500 kPa tension minus percent organic carbon], but not more than 100. Incomplete clay dispersion when using the pipette method is a common problem with many low-activity clay samples, thus the use of this formula is included as a criterion.

49. The term “apparent” is used here with CEC and ECEC to indicate that the calculation is for the clay fraction alone, not the entire fine-earth fraction. A mathematical adjustment of CEC and ECEC is performed to report them on a kg of clay basis:

$$\text{ACEC} = [(\text{CEC-7/clay \%}) \times 100]$$
$$\text{AECEC} = [(\text{ECEC/clay \%}) \times 100]$$

These calculations are used as a kind of surrogate for the more difficult and expensive determination of clay mineralogy as an easier way to document the dominance of low-activity clay in the horizon. Although easier to obtain, it must be recognized that CEC values per unit of clay are by definition low in these soils. Therefore, small errors in the measurements of exchangeable cations and clay content can result in significant variation in the calculated values for apparent CEC and apparent ECEC. This becomes more of a problem as clay content decreases and is one of the reasons for the exclusion of sandy textures from the kandic horizon (Kimble et al., 1993).

Natric horizon

50. The natric horizon is a special kind of argillic horizon. Like the argillic horizon, it is a subsoil horizon enriched with illuvial clay. In addition to the properties of the argillic horizon, the natric horizon has elevated levels of sodium, which enhances the dispersion of clay particles, thus facilitating illuviation. There is no field test that can be used to confirm the presence of sodium in the horizon. Laboratory analysis is required. Soil-related clues that may indicate the presence of sodium include high pH, columnar or prismatic structure in the subsoil with light-colored eluvial caps and penetrations, puddled and sealed surfaces (“slick spots”) in the field, sodium-tolerant natural vegetation, or the poor response of cultivated crops.

51. Many natric horizons have columnar or prismatic structure in at least part of the horizon. This structure, however, may be weakly expressed, especially in some coarser textured natric horizons. Some natric horizons have a blocky structure accompanied by eluvial materials on the upper surfaces of peds that extend into the horizon.

52. Magnesium is considered in the definition of the natric horizon (item 7b in the section on required characteristics). This is because as sodium is removed, magnesium follows in the leaching sequence if chlorides are low and sulfates are high. If leaching continues, the magnesium also is eventually replaced. When replacement reaches the point where the amount of exchangeable sodium is less than 15 percent and the amount of magnesium and sodium is less than that of calcium and exchange acidity in upper subhorizons that have a total thickness of 40 cm or more, the horizon is no longer considered natric. The remains of such former natric horizons are evident in soils in which the characteristic columnar structure is clearly evident but all other properties have been altered because of a greatly changed environment or continued leaching.

Ortstein

53. Ortstein is used explicitly in Soil Taxonomy as a family-level rupture-resistance class term for some Spodosols. These soils have a spodic horizon that is at least partially pedogenically cemented (50 percent or more laterally) in some part. A spodic horizon that is continuously cemented laterally (at least 90 percent cemented) qualifies for a “dur” great group of some Spodosols, but the great group criteria do not specifically require the cemented layer to be ortstein as defined here.

54. Iron, manganese, and aluminum weathered from ferromagnesian minerals (such as hornblende, amphiboles, pyroxene, and olivine), along with dissolved organic carbon,

are eluviated from the upper part of the acid soil and moved downward into the subsoil, where they accumulate and form a spodic horizon. In addition, some amorphous minerals such as allophane and ferrihydrite are commonly present. The iron, manganese, and aluminum interact with organic matter to form metal-humus complexes in the form of amorphous gels coating the grains of the horizon matrix.

Oxic horizon

55. These are minerals that are "weatherable" in a humid climate. They include minerals such as 2:1 phyllosilicates, allophane, feldspars, dolomite, etc. The intent is to include only those minerals that are unstable in a humid climate compared to other more resistant minerals, such as quartz and 1:1 lattice clays that are more resistant to weathering than calcite. Calcite, carbonate aggregates, anhydrite, gypsum, and halite are not considered weatherable minerals here because they are mobile in the soil and may be recharged in some otherwise strongly weathered soils (for example, from falling dust or by evaporative wicking processes above a water table). For soil classification purposes, the content of weatherable minerals is determined by petrographic analysis (grain counts) of grains 0.02 to 2.0 mm in size (coarse silt to very coarse sand) or other grain size as specified in the various keys. *Soil Taxonomy* does not contain a list of minerals considered to be weatherable or resistant. Rather it refers to the *Soil Survey Laboratory Information Manual* (Soil Survey Staff, 2011, pp. 295–297).

56. The oxic horizon is at least 30 cm thick. This limit ensures that thin horizons with oxic-like properties that are transitional to another diagnostic horizon (such as an argillic horizon), or to underlying saprolite, are not included as oxic horizons (Smith, 1986, p. 106).

57. Originally, the oxic horizon required a minimum clay content of 15 percent to support the separation of Oxisols from Oxic great groups of Quartzipsamments (Smith, 1986, p.107). This criterion was dropped in the 3rd edition of the *Keys to Soil Taxonomy* (1987) and replaced with these texture classes, as recommended by the International Committee on Oxisols (ICOMOX). This was done to allow a wider range of clay in coarse-loamy families of Oxisols (previously restricted to just 15 to 18 percent). However, it leaves open the possibility for an oxic horizon with appreciable silt to have nearly zero clay. Small errors in the calculations of CEC and ECEC produce large variation in computed values when converted to a clay fraction basis for these low-clay oxic horizons. This can be problematic when assessing the chemical criteria for oxic horizons. Most oxic horizons, however, have low silt contents, so this is not a common problem.

58. The 10 percent weatherable mineral limit was set to approximate a base cation reserve of only about 25 cmol(+)/kg soil (Herbillon, 1988).

59. This requirement excludes saprolitic materials that are completely weathered chemically, but not yet physically altered, from the oxic horizon (Smith, 1986, p. 107).

60. For the oxic horizon, any increase in clay cannot exceed a value of between 4 and 8 percent, depending on the texture of the surface layer. These limits are used to separate the oxic and kandic horizons. The main difference between the oxic and kandic horizons is that the kandic horizon has a marked clay increase from the surface layer to the subsoil, while the oxic horizon does not.

61. Laboratory analysis for particle-size determination in low-activity clay soils such as these may be hindered by poor dispersion of clay particles in the standard pretreatment process. This is because clay particles may be bound more strongly than the standard pretreatment with sodium hexametaphosphate and mechanical shaking can effectively separate. While alternate laboratory methods could be used to achieve better dispersion, this is not practical on a routine basis in soil survey work and not deemed necessary for classification purposes. Rather, determination of the clay content for application of the oxic horizon criteria requires that the amount measured by pipette using the standard procedure be compared to the calculated value used in the criterion. A slightly different equation using a factor of 2.5 rather than 3 is used to determine clay content for the kandic horizon and other soils where poor dispersion is a problem. Holzhey and Kimble (1988), however, reported that a factor of 3 was better than 2.5 for use with the Oxisols.

Petrocalcic horizon

62. The petrocalcic horizon is essentially an advanced-stage calcic horizon where so much secondary calcium carbonate has accumulated in the layer that the pores have become plugged and the grains cemented. Air-dry fragments do not slake in water but will slake in HCl, thus confirming calcium carbonate as the cementing agent. The carbonates may have been deposited (e.g., as dust) from outside the profile or, in naturally calcareous parent materials, the carbonates may be dissolved and reprecipitated locally within the horizon. Igneous parent materials with high concentrations of calcium, such as basalts, also give rise to the formation of petrocalcic horizons. Petrocalcic horizons are commonly found in arid or semiarid environments where deep leaching and removal of soluble salts like calcium carbonate do not occur. For a brief discussion of the stages of carbonate accumulation see the *Soil Survey Manual* (Soil Science Division Staff, 2017, pp. 175–176).

Petrogypsic horizon

63. The petrogypsic horizon is essentially an advanced-stage gypsic horizon where so much secondary gypsum has accumulated in the layer that the pores have become plugged and the grains cemented. Air-dry fragments do not readily slake in water. Commonly, the gypsum was naturally occurring in the parent materials, where it was dissolved and reprecipitated locally within the horizon. Petrogypsic horizons are commonly found in arid or semiarid environments where deep leaching and removal of soluble salts like gypsum do not occur.

Placic horizon

64. Within spodic materials, the placic horizon is differentiated from ortstein primarily based on thickness. Placic

horizons that are within spodic materials are less than 25 mm thick (ortstein is 25 mm or more thick). There is no maximum thickness criterion for placic horizons that are not in spodic materials. Placic horizons are sufficiently continuous laterally to allow roots to enter the horizon with no closer than an average 10 cm spacing. In addition, ortstein consists of spodic materials while a placic horizon may or may not meet the definition of spodic materials. Alumino-humus complexes appear to be more important in the formation of ortstein while iron and organic matter precipitation due to redox processes is more important in placic horizon formation (Lapan and Wang, 1999).

Salic horizon

65. Halite is one of the more common salts in salic horizons, but other salts also occur. The salic horizon may be either in the subsoil (where precipitation leaches salts downward) or at the surface (where salts are wicking upward from a water table within the profile). Where this horizon is at the surface, there may be a polygonal pattern of slightly elevated ridges caused by surface heaving as the salt crystals accumulate. In the laboratory, the salt concentration is evaluated by measuring electrical conductivity of a saturated paste extract. The level of salt concentration may vary seasonally as salts are partially leached during rainy periods and accumulate through evapotranspiration during dry periods. In extremely arid areas, such as parts of Chile and Antarctica, where measurable precipitation rarely occurs, salic horizons have a hard or rigid rupture-resistance class. These types of salic horizons are physical barriers to roots, but air-dry submerged samples slake in water and, therefore, are not considered pedogenically cemented.

Sombric horizon

66. Sombric horizon genesis is not well understood. Some hypotheses described by Bockheim (2012) include buried surface layers, charcoal accumulation due to burning, conversion of lower parts of previously formed thick surface horizons due to climate and vegetation change, and migration of clay-humus complexes into the subsoil. Additional study is needed to better understand these unique soil horizons. Sombric horizons are not known to occur in the United States and were included in Soil Taxonomy with a relatively incomplete understanding of their extent, genesis, and properties (Smith, 1986, p. 223).

67. In the field, a sombric horizon may be mistaken for a buried A horizon. The reverse is also a problem in that buried surface layers can be mistaken for a sombric horizon. The sombric horizon can be distinguished from some buried epipedons by lateral tracing. It is a continuous layer roughly paralleling the soil surface. Also, in thin sections the organic matter of a sombric horizon appears to be dark-colored humus that is concentrated on ped surfaces and in pores and is not uniformly dispersed throughout the matrix (as would be expected if the horizon were a buried surface layer).

Spodic horizon

68. The International Committee for Spodosols (ICOMOD) proposed significant revisions to the Spodosol order and the spodic horizon, which were adopted with the 5th edition of the *Keys to Soil Taxonomy* (1995). The development of criteria emphasizing field-observable morphology was an important aspect of the committee's work. As a result, the current criteria utilize field-observable morphology as much as possible to identify Spodosols while keeping the necessary laboratory data to a minimum. An important result of ICOMOD's work was the introduction of sodic materials as a diagnostic characteristic.

Abrupt textural change

69. An abrupt textural change significantly restricts the downward movement of water. From the standpoint of soil genesis, it generally suggests that the soil formed on a relatively stable geomorphic surface of significant age.

Albic materials

70. Relatively unaltered layers of light-colored sand, volcanic ash, or other materials deposited by wind or water are not considered albic materials, although they may have the same color and apparent morphology. These deposits are parent materials that are not characterized by the removal of clay and/or free iron and do not overlie an illuvial horizon or other soil horizon, except for a buried soil. Light-colored krotovinas or filled root channels should be considered albic materials only if they have no fine stratifications or lamellae, if any sealing along the krotovina walls has been destroyed, and if these intrusions have been leached of free iron oxides and/or clay after deposition.

Andic soil properties

71. Andic soil materials are similar to spodic materials, with one significant difference being the illuvial nature of spodic materials. Spodic materials have been translocated within the soil profile. Andic soil materials have formed in place with little or no translocation within the profile.

Anhydrous conditions

72. Anhydrous conditions were proposed as a diagnostic feature by the International Committee on Permafrost Affected Soils (ICOMPAS) and adopted with the 8th edition of the *Keys to Soil Taxonomy* (1998), effectively replacing the moisture regime in the classification for very cold and dry permafrost-affected soils (e.g., Anhyorthels). This was done rather than either revising the aridic moisture regime to include Gelisols or introducing a new moisture regime for these dry Gelisols.

Coefficient of linear extensibility (COLE)

73. COLE is used in Soil Taxonomy as a criterion for argillic and natric horizons to identify conditions of high shrink-swell potential (COLE > 0.4) where the visual evidence of clay illuviation (such as oriented clay occurring as clay films

on faces of peds and in pores) is likely to be destroyed due to soil movement. Values of COLE for individual horizons can be summed over horizon thickness to determine overall potential for soil movement for the soil profile (linear extensibility). This is useful in making interpretations for soils subject to significant shrinking and swelling with moisture change.

Free carbonates

74. Free carbonates may be a precipitate dispersed throughout the soil matrix, or they may have been present in the original parent material. Therefore, their presence does not automatically imply pedogenesis. In some situations, their presence or absence in a soil horizon may infer leaching or a lack thereof.

Interfingering of albic materials

75. By inference, a horizon with interfingering of albic materials may be on a genetic pathway to forming a glossic horizon. Once the albic materials comprise 15 percent or more of the volume, a glossic horizon is recognized.

Lamellae

76. Lamellae are pedogenic in nature, not simply fine stratifications in layered deposits. They have the effect of slowing water movement through the soil profile, thus increasing the time the water is available for plant uptake. In addition, depending on the kind of clay minerals, lamellae may also have the effect of concentrating much of the overall CEC and fertility of the soil into the volume of soil composed of individual lamella.

Lithologic discontinuities

77. Lithologic discontinuity is one of just a few diagnostic characteristics lacking a clear, quantitative definition. It is somewhat subjective since there is no simple way to construct a universally applicable definition to recognize all conditions reflecting a change in lithology or age. Because of this, individual soil scientists will sometimes differ about recognizing a lithologic discontinuity in a given soil profile (Smith, 1986, pp. 73–74). The presence of a lithologic discontinuity is not used explicitly in any criteria in Soil Taxonomy, although many soils having a contrasting family particle-size class have a lithologic discontinuity. In addition, some soil series definitions include the presence of a lithologic discontinuity as a criterion.

n *value*

78. Soil materials that are thixotropic exhibit a greasy feel and a release of water when pressure is applied to a field moist sample, i.e., rubbed between the fingers. This is due to the unusually high water retention capacity of the material. Examples are soils with significant amounts of amorphic materials with high surface area from convoluted hollow microscopic shapes, such as soils with andic soil properties or spodic materials. In soil descriptions, this property is described using smeariness classes (Soil Science Division Staff, 2017, p. 189).

Plinthite

79. The number of wetting and drying cycles required for irreversible hardening is not specified and likely varies depending on local conditions. Plinthite that has become hard can often be observed by tracing the layer containing plinthite to a nearby roadcut or other exposure where it has become hardened over time.

Slickensides

80. Slickensides are considered to be pedogenic when associated with soil peds or features such as wedges or bowls in Vertisols. The term “slickenside” is also used in a geogenic context (nonpedogenic) when associated with tectonic or mass movement features, such as faults or slump blocks.

Spodic materials

81. Spodic materials impart unique properties to the soil, including a high cation-exchange capacity, a large surface area relative to its particle-size distribution, high water retention, reddish color, low pH, and a high content of organic carbon. Ortstein and some placic horizons are composed of spodic materials. Spodic materials are similar to andic soil materials; one significant difference is that spodic materials are illuvial in nature while andic soil materials formed in place with little or no translocation. The ODOE test and extractions of aluminum and iron by ammonium acetate are used to support the inference of illuviation for spodic materials. Spodic materials were proposed as a diagnostic characteristic for Soil Taxonomy by the International Committee for Spodosols (ICOMOD) and appeared in the 5th edition of the *Keys to Soil Taxonomy* (1992).

82. The recognition of spodic materials in an Ap horizon avoids the problem of cultivation causing a change in the classification of a soil with a very shallow spodic horizon.

83. A primary goal of the International Committee for Spodosols (ICOMOD) was to put as much emphasis as possible on field morphology and less emphasis on laboratory data for the identification of Spodosols. Criterion 2a allows many spodic horizons to be identified based on field morphology alone. Where this does not work, criterion 2b is used to test for the presence of spodic materials in the suspected spodic horizon.

Control section for organic soils

84. The use of two control section depths based on kinds of organic materials was established based on the assumption that these soils would react differently to drainage. It was supposed that after drainage and subsequent volume loss due to oxidation, the lower density organic soil materials with the thicker control section would subside more than the higher density soil materials and eventually have about the same control section thickness that the higher bulk density organic materials would. (Smith, 1986, p. 182).

Aquic conditions

85. The definition of aquic conditions does not include any specified depth. Aquic conditions can occur at any depth

in the soil. The depth required for any taxonomic class, such as a suborder or subgroup, is specified in the keys. Beginning with the 5th edition of the *Keys to Soil Taxonomy* (1992), aquic conditions replaced the requirement for an aquic soil moisture regime as a diagnostic criterion. This was proposed by the International Committee on Aquic Moisture Regimes (ICOMAQ). The aquic soil moisture regime became obsolete for classifying a soil at the suborder level. Although still recognized in Soil Taxonomy, it is no longer mentioned in any of the keys to suborders. It has been replaced in the keys by aquic conditions. Even though the aquic moisture regime is not used in the keys, soils are still recognized as having an aquic (or peraquic) soil moisture regime in their descriptions.

86. Reduction is not defined in a quantitative way due to the difficulty of setting threshold redox potential (Eh) values reflecting many possible environmental conditions, especially pH (as shown in pH/Eh diagrams depicting the stability of mineral species). In addition, no minimum time period is specified for the soil to be saturated because this would vary from place to place. The degree of reduction required is (for practical reasons) equated with that needed to reduce iron since this results in the morphological expression of redox features given in the keys and can also be documented with field tools such as dyes (i.e., alpha,alpha-dipyridyl) or IRIS tubes. These techniques are easier to perform and interpret than measuring redox potential directly with electronic instruments.

87. As recommended by ICOMAQ, the term “mottles” is no longer used to describe morphology associated with wetness. Furthermore, the term “mottles with chroma 2 or less” was removed from the keys beginning with the 5th edition in 1992. The more precise terms introduced for redoximorphic features (along with their color and location) are used to document the morphological expression of saturation and reduction. The term “mottles” is used to describe color patterns that are due to conditions other than redox processes (such as lithochromic color variation).

88. Alph,alpha-dipyridyl is a compound that when dissolved in 1N ammonium acetate is used to detect the presence of reduced iron (Fe^{2+}). It is used as a simple field test in wet soils, particularly those with no visible redoximorphic features, to confirm that the soil is reduced. A positive reaction satisfies the criterion for redoximorphic features in the definition of aquic conditions in Soil Taxonomy. It should be noted that a positive reaction will only occur when the iron is currently in a reduced state. If this soil is tested when the iron is in an oxidized state (such as during the dry season), no reaction will occur even though the soil is subject to periodic saturation and reduction.

Densic materials

89. All other diagnostic horizons are mutually exclusive of also being recognized as densic materials. Therefore, a plow pan or other mechanically compacted layer that formed in the upper part of a diagnostic horizon, such as a cambic horizon, is not considered to have densic materials or a densic contact.

Normal years

90. The term “normal years” has a rigorous definition utilizing a statistical analysis of the variability of annual and monthly precipitation data to identify a given year as normal as opposed to abnormally wet or dry. In practice it has been found to be difficult to apply the definition in some cases because an unexpectedly large number of years failed the definition and therefore could not be included in analysis to determine the soil moisture regime class. The application of the definition of normal years was relaxed a bit with the 11th edition of the *Keys to Soil Taxonomy* to allow some of these years to be used in the determination under the circumstances described in the definition.

Cryic soil temperature regime

91. The criteria for the cryic soil temperature regime are designed to take into account the moderating effect of an organic surface layer and/or the presence of water on soil temperature. The presence of an organic surface layer in particular can be impacted by occasional fire or other disturbance. Removal of the O layer results in warmer summer temperatures.

CHAPTER 4

Identification of the Taxonomic Class of a Soil

The taxonomic class of a specific soil can be determined by using the keys that follow in this and other chapters. It is assumed that the user is familiar with the definitions of soil and buried soils (defined in chapter 1), mineral and organic soil material (defined in chapter 2), and the diagnostic horizons and characteristics (defined in chapter 3). Users should also be familiar with the meanings of the terms used for describing soils given in the *Soil Survey Manual* (Soil Science Division Staff, 2017) and the *Field Book for Describing and Sampling Soils* (Schoeneberger et al., 2012). Chapter 18 of this publication is an excerpt from the *Soil Survey Manual* that contains the symbolic designations for genetic soil horizons and layers[*]. Although not a part of Soil Taxonomy, the designations are reproduced in this publication for convenience. The appendix of this publication contains general descriptions of the laboratory methods for physical, chemical, organic, and mineralogical properties and where they are used as criteria in Soil Taxonomy. The index at the back of this publication indicates the pages on which definitions of terms are given.

Numerical Criteria and Rounding

Conventional rules should be used to round numerical values. Numerical values are rounded to the same number of digits as used in the taxonomic criteria. For example, Soil Taxonomy requires using percentages for clay content in whole numbers (integers) when applying taxonomic criteria such as the required characteristics of the argillic horizon and the key to particle-size classes (defined in chapter 17). However, primary characterization data supplied from soil laboratories often report clay content, by weight, in tenths of a percent (one decimal place). When measured data are applied in classifying the soil, one must first note the level of precision used as a class limit and then round the measured data to the same level of precision. Conventional rules are used for rounding numbers in Soil Taxonomy (note 1).

Soil Color

Soil colors (hue, value, and chroma) are used in many of the taxonomic criteria. Required colors are listed with the assumption that standard color chips of the Munsell soil color system are used as the standard (Soil Science Division Staff, 2017, pp. 145–151). Colors should be recorded to the closest matching chip.

Soil colors typically change value, and some change hue and chroma, depending on the water state. In many of the criteria of the keys, the water state is specified. If no water state is specified, the soil is considered to meet the criterion if it does so when moist or dry or both moist and dry.

Some criteria specify that the color is to be determined on a crushed and smoothed sample. This is important where the peds have dark coatings on the surface and so the surface may show only the color of the coatings of peds. The color of the matrix in such situations can be determined only by crushing or briefly rubbing the sample. Prolonged rubbing should be avoided because it may cause darkening of a sample if soft iron-manganese concretions are present. Crushing should be just sufficient to mix the coatings with the matrix. The dry color value should be determined after the crushed sample is dry enough that continued drying would produce no further change and the sample has been smoothed to eliminate shadows.

Mixing

In some cases, it is specified that the surface layer is to be mixed, generally to a depth of 18 cm. This is because surface layers are routinely mixed by plowing in cultivated areas. Mixing is specified so that cultivated and uncultivated soils are treated the same. For undisturbed soils, “mixing” can generally be accomplished by calculating a weighted average for the property in question. Thorough physical mixing can also be performed on a representative sample if necessary.

Air-Dry Condition

Some criteria specify the use of an air-dry sample. For laboratory tests, dry samples are obtained by placing the soil in an oven at 30 to 35 degrees C for several days. This is generally called “oven-dry.” Where the text refers to field tests, such as assessing dry color or determining the rupture-resistance class, a sample is considered air-dry when it has been exposed to the air for enough time that the color no longer changes and it has entered a dry state as described in the *Soil Survey Manual* (Soil Science Division Staff, 2017, p. 209). The amount of time needed will vary depending on factors such as sample size, air temperature, humidity, and exposure to direct sunlight. For

[*] Chapter 18 has been updated to include corrections and additions since the *Soil Survey Manual* was published.

color determination, only the surface of a ped is observed and a dry state (where no further change in color is observed) can often be achieved in a matter of several minutes under favorable conditions. An air-dry state for a ped (including the interior) may take a few hours or days. This state can be achieved faster by warming the sample in an oven.

Fine-Earth Fraction and Whole Soil

Some criteria in these keys specify that they be applied to the fine-earth fraction of the soil while others must be applied to the whole soil. The fine-earth fraction consists of mineral particles less than 2 mm in diameter (sand, silt, and clay). The whole soil consists of all particle-size fractions up to and including boulders with maximum horizontal dimensions less than those of the pedon*.

In the laboratory, whole-soil samples obtained from the field are treated to remove organic matter and then dried, crushed, and sieved to remove rock fragments so that just the fine-earth fraction remains for analysis.

Moisture Regimes That Border on Ustic or Xeric

Some criteria for subgroups in the Aridisols order and Torri great groups of Entisols and for the suborders Xerolls and Ustolls contain the phrase "…a soil moisture regime that borders on xeric" or "…borders on ustic." This phrase is not precisely defined because a definition would have to vary geographically with regional climate patterns. Even so, in many (but not all) cases some quantitative moisture pattern criteria are included in the specific criterion.

Despite the difficulty of providing a clear definition, the overall concept is clear. It is intended for soils that have an aridic (or torric) soil moisture regime that is slightly too dry to be xeric or ustic. Those soils qualifying as ustic subgroups (or the Ustolls suborder) receive most of their precipitation in the warm season (or rainy season in the Tropics). Those soils that qualify as xeric subgroups (or the Xerolls suborder) receive most of their precipitation in the cool season. From a practical standpoint, the locations of these areas tend to be reflected in the native plant community or local agricultural practices because of the slightly higher moisture availability.

Systematic Use of the Keys

All of the keys in this taxonomy are designed in such a way that the user can determine the correct classification of a soil by going through the keys sequentially. The user must start at the beginning of the Key to Soil Orders and eliminate, one by one, all classes that include criteria that do not fit the soil in question. The soil belongs to the first class listed for which it meets all the required criteria.

In classifying a specific soil, the user of Soil Taxonomy begins by checking through the Key to Soil Orders to determine the name of the first order that, according to the criteria listed, includes the soil in question. The next step is to go to the page indicated to find the Key to Suborders of that particular order. Next, the user sequentially goes through the key to identify the suborder that includes the soil, i.e., the first in the list for which the soil meets all the required criteria. The same procedure is used to find the great group class of the soil in the Key to Great Groups of the identified suborder. Likewise, going through the Key to Subgroups of that great group, the user selects as the correct subgroup the name of the first taxon for which the soil meets all of the required criteria (note 2).

Arrangement of the Keys

Technical Aspects

The taxonomic classes within each of the keys are purposely presented in a specific order so that the classes deemed most important are encountered first. For example, in most of the orders the first suborder listed is for soils with aquic conditions close to the surface (i.e., Aqualfs, Aquents, etc.). This feature is considered very important from both a genetic and management standpoint. So, the order of classes within each key is based on technical considerations.

The last class listed in each of the keys from order to subgroup is simply identified as "other." This class includes any soils within the group that do not meet any of the criteria presented for the other classes preceding it in the key. For example, in the Key to Soil Orders the last entry is for "Other soils – Entisols." Because of this catch-all feature, any soil encountered in the field can be classified and none are omitted.

Alphabetical Presentation for Convenience

For convenience of use, the overall organization of the text as the user progresses from one level to another in the system (soil order to suborder, to great group, to subgroup) is alphabetical. So although the order in which the classes are presented within the keys is based on technical considerations, the order in which the keys themselves are presented in the text is alphabetical.

The chapters for each order are presented sequentially, beginning with the Alfisols and continuing alphabetically through the Vertisols. Each chapter begins with a key to the suborders. The individual keys for the great groups within the suborders and the keys to subgroups within the great groups are presented alphabetically within each chapter. This allows the user to easily find the keys for a specific class in the system. However, when the keys are used sequentially to classify a soil (as described above), one must move from one part of text to

* For practical reasons, the percent, by volume, of rock fragments or artifacts larger than 75 mm are generally estimated in the field and not included with physical samples for laboratory analysis. If necessary, the percent by weight of these materials can also be determined in the field by weighing a carefully selected and sufficiently large sample.

another by turning to the indicated page number listed in the keys after the identified suborder and great group taxonomic names.

Classification Codes

Special codes are shown throughout the keys identifying the overall keying order position for every taxon. To illustrate this, consider the Alfisols. In the key to soil orders, the Alfisols are the tenth soil order encountered in the key, identified as item J. However, they are the first soil order chapter presented in the text because of alphabetical placement. Within the Alfisols, Udalfs are the fifth suborder presented in the key, so they have the code JE. Within the text for the Alfisols chapter, the key to great groups of Udalfs is the third key presented due to its order alphabetically. Within the key to great groups within Udalfs, the first class in the key is Natrudalfs, with the code JEA. Following this same pattern, the third subgroup listed in the key under Natrudalfs is Aquic Natrudalfs, with the code JEAC. This code indicates that this subgroup is encountered as the user sequentially progresses from keying positions 10, 5, 1, and 3 when moving from soil order to subgroup in the keys.

In cases where there are more than 26 subgroups within a great group (for example Hapludalfs), a lowercase letter is added at the end of the code (JEJZa, JEJZb, etc.).

Family Classification

The family level is determined, in a similar manner, after the subgroup has been determined. Chapter 17 can be used, as one would use other keys in this taxonomy, to determine which components are part of the family. The family, however, typically has more than one component, and therefore the entire chapter must be used. One must go through the keys to control sections for classes used as components of a family to determine the control section before using the keys to classes.

The descriptions and definitions of individual soil series are not included in this text. Definitions of the series and the control section are given in chapter 17.

Other Considerations for Use of the Keys

In the Key to Soil Orders and the other keys that follow, the diagnostic horizons and the properties described do not include those below a densic, lithic, paralithic, or petroferric contact.

Determining the Soil Surface if Recent Deposits are Present

The properties of buried soils and the properties of a surface mantle of new soil material or a surface mantle of human-transported material are considered on the basis of whether or not the soil meets the meaning of the term “buried soil” given in chapter 1.

If a soil has a surface mantle of new soil material or a surface mantle of human-transported material and is not a buried soil, the top of the original surface layer is considered the soil surface for determining depth to and thickness of diagnostic horizons and most other diagnostic soil characteristics. The only properties of the surface mantle of new soil material or a surface mantle of human-transported material that are considered are soil temperature, soil moisture (including aquic conditions), and any andic or vitrandic properties and family criteria.

If a soil profile includes a buried soil, the present soil surface is used to determine soil moisture and temperature as well as depth to and thickness of diagnostic horizons and other diagnostic soil characteristics. Diagnostic horizons of the buried soil are not considered in selecting taxa unless the criteria in the keys specifically indicate buried horizons, such as in Thapto-Histic subgroups. Although most other diagnostic soil characteristics of the buried soil are not considered, organic carbon if of Holocene age, andic soil properties, base saturation, and all properties used to determine family and series placement are considered.

Understanding Depth Criteria

If diagnostic horizons or characteristics are criteria that must be “within” a specified depth measured from the soil surface, then the upper boundary of the first subhorizon meeting the requirements for the diagnostic horizon or characteristic must be within the specified depth.

Key to Soil Orders

A. Soils that have:

1. Permafrost within 100 cm of the soil surface; *or*

2. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

Gelisols, p. 189

B. Other soils that:

1. Do not have andic soil properties in 60 percent or more of the thickness between the soil surface and either a depth of 60 cm or a densic, lithic, or paralithic contact or duripan if shallower; *and*

2. Have organic soil materials that meet *one or more* of the following:

a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices* *and* directly below these materials have a densic, lithic, or paralithic contact; *or*

b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

* Materials that meet the definition of the cindery, fragmental, or pumiceous substitute for particle-size class but that have more than 10 percent, by volume, voids filled with organic soil materials are considered to be organic soil materials.

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c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

d. Are saturated with water for 30 days or more per year in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more.

Histosols, p. 199

C. Other soils that do not have a plaggen epipedon or an argillic or kandic horizon above a spodic horizon, *and* have *one or more* of the following:

1. A spodic horizon, an albic horizon in 50 percent or more of each pedon, and a cryic or gelic soil temperature regime; *or*

2. An Ap horizon containing 85 percent or more spodic materials; *or*

3. A spodic horizon with *all* of the following characteristics:

a. *One or more* of the following:

(1) A thickness of 10 cm or more; *or*

(2) An overlying Ap horizon; *or*

(3) Cementation in 50 percent or more of each pedon; *or*

(4) A texture class that is finer than coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand in the fine-earth fraction *and* a frigid temperature regime in the soil; *or*

(5) A cryic or gelic temperature regime in the soil; *and*

b. An upper boundary within the following depths from the mineral soil surface: *either*

(1) Less than 50 cm; *or*

(2) Less than 200 cm if the soil has a texture class of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand, in the fine-earth fraction, in some horizon between the mineral soil surface and the spodic horizon; *and*

c. A lower boundary as follows:

(1) *Either* at a depth of 25 cm or more below the mineral soil surface or at the top of a duripan or fragipan or at a densic, lithic, paralithic, or petroferric contact, whichever is shallowest; *or*

(2) At any depth,

(a) If the spodic horizon has a texture class that is finer than coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand in the fine-earth fraction *and* the soil has a frigid temperature regime; *or*

(b) If the soil has a cryic or gelic temperature regime; *and*

d. *Either*:

(1) A directly overlying albic horizon in 50 percent or more of each pedon; *or*

(2) No andic soil properties in 60 percent or more of the thickness *either*:

(a) Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

(b) Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Spodosols, p. 311

D. Other soils that have andic soil properties in 60 percent or more of the thickness *either*:

1. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Andisols, p. 117

E. Other soils that have *either*:

1. An oxic horizon within 150 cm of the mineral soil surface and no kandic horizon within that depth; *or*

2. 40 percent or more (by weight) clay in the fine-earth fraction between the mineral soil surface and a depth of

18 cm (after mixing) *and* a kandic horizon that has the weatherable-mineral properties of an oxic horizon and has its upper boundary within 100 cm of the mineral soil surface.

Oxisols, p. 295

F. Other soils that have:

1. A layer 25 cm or more thick, within 100 cm of the mineral soil surface, that has *either* slickensides *or* wedge-shaped peds that have their long axes tilted 10 to 60 degrees from the horizontal; *and*

2. A weighted average of 30 percent or more clay in the fine-earth fraction either between the mineral soil surface and a depth of 18 cm or in an Ap horizon, whichever is thicker, *and* 30 percent or more clay in the fine-earth fraction of all horizons between a depth of 18 cm and either a depth of 50 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower; *and*

3. Cracks* that open and close periodically.

Vertisols, p. 343

G. Other soils that:

1. Have:

a. An aridic soil moisture regime; *and*

b. An ochric or anthropic epipedon; *and*

c. *One or more* of the following within 100 cm of the soil surface: a cambic horizon with a lower depth of 25 cm or more; a cryic soil temperature regime and a cambic horizon; an anhydritic, calcic, gypsic, petrocalcic, petrogypsic, or salic horizon; or a duripan; *or*

d. An argillic or natric horizon; *or*

2. Have a salic horizon; *and*

a. Saturation with water in one or more layers within 100 cm of the soil surface for 1 month or more during a normal year; *and*

b. A moisture control section that is dry in some or all parts at some time during normal years; *and*

c. No sulfuric horizon within 150 cm of the mineral soil surface.

Aridisols, p. 137

H. Other soils that have *either*:

1. An argillic or kandic horizon, but no fragipan, and a base saturation (by sum of cations) of less than 35 percent at one of the following depths:

a. If the epipedon has a texture class of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand in the fine-earth fraction throughout, then the base saturation criterion is met at *either*:

(1) 125 cm below the upper boundary of the argillic horizon (but no deeper than 200 cm below the mineral soil surface) or 180 cm below the mineral soil surface, whichever is deeper; *or*

(2) At a densic, lithic, paralithic, or petroferric contact if shallower; *or*

b. The shallowest of the following depths:

(1) 125 cm below the upper boundary of the argillic or kandic horizon; *or*

(2) 180 cm below the mineral soil surface; *or*

(3) At a densic, lithic, paralithic, or petroferric contact; *or*

2. A fragipan and *both* of the following:

a. Either an argillic or a kandic horizon above, within, or below the fragipan, or clay films 1 mm or more thick in one or more of its subhorizons; *and*

b. A base saturation (by sum of cations) of less than 35 percent at the shallowest of the following depths:

(1) 75 cm below the upper boundary of the fragipan; *or*

(2) 200 cm below the mineral soil surface; *or*

(3) At a densic, lithic, paralithic, or petroferric contact.

Ultisols, p. 321

I. Other soils that have *both* of the following:

1. *Either*:

a. A mollic epipedon; *or*

b. *Both:*

(1) A surface horizon that meets all the requirements for a mollic epipedon except thickness after the soil has been mixed to a depth of 18 cm; *and*

(2) A subhorizon more than 7.5 cm thick, within the upper part of an argillic, kandic, or natric horizon, that meets the color, organic carbon content, base

* A crack is a separation between gross polyhedrons. If the surface is strongly self-mulching, i.e., a mass of granules, or if the soil is cultivated while cracks are open, the cracks may be filled mainly by granular materials from the surface, but they are open in the sense that the polyhedrons are separated. A crack is regarded as open if it controls the infiltration and percolation of water in a dry, clayey soil.

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saturation, and structure requirements of a mollic epipedon but is separated from the surface horizon by an albic horizon; *and*

2. A base saturation of 50 percent or more (by NH_4OAc) in all horizons *either:*

a. Between the upper boundary of any argillic, kandic, or natric horizon and a depth of 125 cm below that boundary; *or*

b. Between the mineral soil surface and a depth of 180 cm; *or*

c. Between the mineral soil surface and a densic, lithic, or paralithic contact, whichever depth is shallowest.

Mollisols, p. 247

J. Other soils that do not have a plaggen epipedon and that have *either*:

1. An argillic, kandic, or natric horizon; *or*

2. A fragipan that has clay films 1 mm or more thick in some part.

Alfisols, p. 73

K. Other soils that do not have a positive water potential at the soil surface for more than 21 hours each day in all years and that have *either*:

1. *One or more* of the following:

a. A cambic horizon that is within 100 cm of the mineral soil surface and has a lower boundary at a depth of 25 cm or more below the mineral soil surface; *or*

b. A calcic, petrocalcic, gypsic, petrogypsic, or placic horizon or a duripan within a depth of 100 cm of the mineral soil surface; *or*

c. A fragipan or an oxic, sombric, or spodic horizon within 200 cm of the mineral soil surface; *or*

d. A sulfuric horizon within 150 cm of the mineral soil surface; *or*

e. A cryic or gelic soil temperature regime and a cambic horizon; *or*

2. No sulfidic materials within 50 cm of the mineral soil surface *and both*:

a. In one or more horizons between 20 and 50 cm below the mineral soil surface, either an *n* value of 0.7 or less (or a fluidity class of nonfluid) or less than 8 percent clay in the fine-earth fraction; *and*

b. *One or more* of the following:

(1) A folistic, histic, mollic, plaggen, or umbric epipedon; *or*

(2) A salic horizon; *or*

(3) In 50 percent or more of the layers between the mineral soil surface and a depth of 50 cm, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more), which decreases with increasing depth below 50 cm, *and* also ground water within 100 cm of the mineral soil surface at some time during the year when the soil is not frozen in any part.

Inceptisols, p. 207

L. Other soils.

Entisols, p. 165

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Endnotes

1. *Conventional rules for rounding number*s

If the digit immediately to the right of the last significant figure is more than 5, round up to the next higher digit. For example, 34.8 rounds to 35 (round up because the digit to be dropped is more than halfway between 34 and 35).

If the digit immediately to the right of the last significant figure is less than 5, round down to the next lower digit. For example, 34.4 rounds to 34 (round down because the digit to be dropped is less than halfway between 34 and 35).

If the digit immediately to the right of the last significant figure is equal to 5, round to the adjacent even number, either up or down. Some examples are 17.5 rounds to 18 (round up because the result is an even number) and 34.5 rounds to 34 (round down because the result is an even number).

2. *Typic subgroups*

One slightly different characteristic of the construction of the keys is at the subgroup level. The last item in all the subgroup keys is the class called “Typic.” It is reserved for any soils that do not meet the criteria defined for the other subgroups preceding it within the key. These are not necessarily the most extensive soils nor do they necessarily represent the central concept of the great group. In all cases, however, the Typic subgroup is the last subgroup listed in the key to subgroups within that particular great group. This was not always the case. In the 1st edition of *Soil Taxonomy*, the keys to subgroups were constructed in such a way that the Typic subgroup was listed first and defined by its required properties. All the other subgroups were defined by indicating how they differed from the Typic subgroup. This format had three significant consequences. First, the soils defined by the group were to some degree considered to be typical, representing a central concept. Second, many of the other subgroups had to be defined with negatively worded statements to indicate that they were lacking some feature required for the Typic subgroup. This wording proved to be confusing for many readers, especially those who did not have English as their first language. Third, it was possible to encounter soils that could not be assigned to a subgroup because they did not fit the definitions of any listed class. Therefore, beginning with the 4th edition of the *Keys to Soil Taxonomy* (1990), the keys to subgroups were rearranged and rewritten to follow a pattern using positively worded statements as much as possible to describe the properties required for each subgroup. The Typic subgroup was moved from the first position to the last position in the key and was simply defined as “all other” members of the great group. The change helped make the wording of the keys somewhat easier to understand. In addition, any soil not meeting the criteria for any preceding subgroup would, by default, fall into the Typic subgroup. In cases where this is unsatisfactory, a new subgroup can be proposed.

CHAPTER 5

Alfisols

Key to Suborders

JA. Alfisols that have, in one or more horizons within 50 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) *and* have *one or both* of the following:

1. Redoximorphic features in all layers between either the lower boundary of an Ap horizon or a depth of 25 cm below the mineral soil surface, whichever is deeper, and a depth of 40 cm; *and one* of the following within the upper 12.5 cm of the argillic, natric, glossic, or kandic horizon:

   a. 50 percent or more redox depletions with chroma of 2 or less on faces of peds and redox concentrations within peds; *or*

   b. Redox concentrations and 50 percent or more redox depletions with chroma of 2 or less in the matrix; *or*

   c. 50 percent or more redox depletions with chroma of 1 or less on faces of peds or in the matrix, or both; *or*

2. In the horizons that have aquic conditions, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aqualfs, p. 73

JB. Other Alfisols that have a cryic or isofrigid soil temperature regime.

Cryalfs, p. 82

JC. Other Alfisols that have an ustic soil moisture regime.

Ustalfs, p. 97

JD. Other Alfisols that have a xeric soil moisture regime.

Xeralfs, p. 109

JE. Other Alfisols.

Udalfs, p. 86

Aqualfs

Key to Great Groups

JAA. Aqualfs that have a cryic soil temperature regime.

Cryaqualfs, p. 75

JAB. Other Aqualfs that have one or more horizons, at a depth between 30 and 150 cm from the mineral soil surface, in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Plinthaqualfs, p. 81

JAC. Other Aqualfs that have a duripan.

Duraqualfs, p. 75

JAD. Other Aqualfs that have a natric horizon.

Natraqualfs, p. 81

JAE. Other Aqualfs that have a fragipan within 100 cm of the mineral soil surface.

Fragiaqualfs, p. 79

JAF. Other Aqualfs that have a kandic horizon.

Kandiaqualfs, p. 80

JAG. Other Aqualfs that have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 50 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts.

Vermaqualfs, p. 82

JAH. Other Aqualfs that have an abrupt textural change between the ochric epipedon or albic horizon and the argillic horizon *and* have a saturated hydraulic conductivity of 0.4 cm/hr (1.0 µm/sec) or slower (moderately low or lower K_{sat} class) in the argillic horizon.

Albaqualfs, p. 74

JAI. Other Aqualfs that have a glossic horizon.

Glossaqualfs, p. 79

JAJ. Other Aqualfs that have episaturation.

Epiaqualfs, p. 77

JAK. Other Aqualfs.

Endoaqualfs, p. 75

Albaqualfs

Key to Subgroups

JAHA. Albaqualfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more below the mineral soil surface.
Arenic Albaqualfs

JAHB. Other Albaqualfs that have *both* of the following:

1. *One or both*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Chroma of 3 or more in 40 percent or more of the matrix between the lower boundary of the A or Ap horizon and a depth of 75 cm from the mineral soil surface.
Aeric Vertic Albaqualfs

JAHC. Other Albaqualfs that have *both* of the following:

1. *One or both*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. An Ap horizon or materials between the mineral soil surface and a depth of 18 cm that, after mixing, have *one or more* of the following:

a. A color value, moist, of 4 or more; *or*

b. A color value, dry, of 6 or more; *or*

c. Chroma of 4 or more.
Chromic Vertic Albaqualfs

JAHD. Other Albaqualfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.
Vertic Albaqualfs

JAHE. Other Albaqualfs that have *both*:

1. Chroma of 3 or more in 40 percent or more of the matrix between the lower boundary of the A or Ap horizon and a depth of 75 cm from the mineral soil surface; *and*

2. A mollic epipedon, or the upper 18 cm of the mineral soil meets all of the requirements for a mollic epipedon, except for thickness, after mixing.
Udollic Albaqualfs

JAHF. Other Albaqualfs that have chroma of 3 or more in 40 percent or more of the matrix between the lower boundary of the A or Ap horizon and a depth of 75 cm from the mineral soil surface.
Aeric Albaqualfs

JAHG. Other Albaqualfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.
Aquandic Albaqualfs

JAHH. Other Albaqualfs that have a mollic epipedon, or the upper 18 cm of the mineral soil meets all of the requirements for a mollic epipedon, except for thickness, after mixing.
Mollic Albaqualfs

JAHI. Other Albaqualfs that have an umbric epipedon, or the upper 18 cm of the mineral soil meets all of the requirements for an umbric epipedon, except for thickness, after mixing.

Umbric Albaqualfs

JAHJ. Other Albaqualfs.

Typic Albaqualfs

Cryaqualfs

Key to Subgroups

JAAA. All Cryaqualfs (provisionally).

Typic Cryaqualfs

Duraqualfs

Key to Subgroups

JACA. All Duraqualfs (provisionally).

Typic Duraqualfs

Endoaqualfs

Key to Subgroups

JAKA. Endoaqualfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Endoaqualfs

JAKB. Other Endoaqualfs that have *both* of the following:

1. *One or both*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. An Ap horizon or materials between the mineral soil surface and a depth of 18 cm that, after mixing, have *one or more* of the following:

a. A color value, moist, of 4 or more; *or*

b. A color value, dry, of 6 or more; *or*

c. Chroma of 4 or more.

Chromic Vertic Endoaqualfs

JAKC. Other Endoaqualfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Endoaqualfs

JAKD. Other Endoaqualfs that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, one or a combination of the following colors:

a. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

(1) If peds are present, chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. In 50 percent or more of the matrix, hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more if there are no redox concentrations.

Aeric Fragic Endoaqualfs

JAKE. Other Endoaqualfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Endoaqualfs

JAKF. Other Endoaqualfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm below the mineral soil surface.

Arenic Endoaqualfs

JAKG. Other Endoaqualfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more below the mineral soil surface.

Grossarenic Endoaqualfs

JAKH. Other Endoaqualfs that have *both*:

1. A mollic epipedon, or the upper 18 cm of the mineral soil meets all of the requirements for a mollic epipedon, except for thickness, after mixing; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, one or a combination of the following colors:

a. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

(1) If peds are present, chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. In 50 percent or more of the matrix, hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more; *or*

(2) Chroma of 2 or more if there are no redox concentrations.

Udollic Endoaqualfs

JAKI. Other Endoaqualfs that have *both*:

1. An umbric epipedon, or the upper 18 cm of the mineral soil meets all of the requirements for an umbric epipedon, except for thickness, after mixing; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, one or a combination of the following colors:

a. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

(1) If peds are present, chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. In 50 percent or more of the matrix, hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more; *or*

(2) Chroma of 2 or more if there are no redox concentrations.

Aeric Umbric Endoaqualfs

JAKJ. Other Endoaqualfs that have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

1. Hue of 7.5YR or redder; *and*

a. If peds are present, chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

b. If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

2. Hue of 10YR or yellower *and either*:

a. Both a color value of 3 or more (moist) and chroma of 3 or more; *or*

b. Chroma of 2 or more if there are no redox concentrations.

Aeric Endoaqualfs

JAKK. Other Endoaqualfs that have a mollic epipedon, or the upper 18 cm of the mineral soil meets all of the requirements for a mollic epipedon, except for thickness, after mixing.

Mollic Endoaqualfs

JAKL. Other Endoaqualfs that have an umbric epipedon, or the upper 18 cm of the mineral soil meets all of the requirements for an umbric epipedon, except for thickness, after mixing.

Umbric Endoaqualfs

JAKM. Other Endoaqualfs.

Typic Endoaqualfs

Epiaqualfs

Key to Subgroups

JAJA. Epiaqualfs that have *all* of the following:

1. *One or both*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more (both moist and dry); *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations; *and*

3. An Ap horizon or materials between the mineral soil surface and a depth of 18 cm that, after mixing, have *one or more* of the following:

a. A color value, moist, of 4 or more; *or*

b. A color value, dry, of 6 or more; *or*

c. Chroma of 4 or more.

Aeric Chromic Vertic Epiaqualfs

JAJB. Other Epiaqualfs that have *both* of the following:

1. *One or both*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more (both moist and dry); *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Vertic Epiaqualfs

JAJC. Other Epiaqualfs that have *both* of the following:

1. *One or both*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. An Ap horizon or materials between the mineral soil surface and a depth of 18 cm that, after mixing, have *one or more* of the following:

a. A color value, moist, of 4 or more; *or*

b. A color value, dry, of 6 or more; *or*

c. Chroma of 4 or more.

Chromic Vertic Epiaqualfs

JAJD. Other Epiaqualfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Epiaqualfs

JAJE. Other Epiaqualfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Epiaqualfs

JAJF. Other Epiaqualfs that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more (both moist and dry); *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Fragic Epiaqualfs

JAJG. Other Epiaqualfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Epiaqualfs

JAJH. Other Epiaqualfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm below the mineral soil surface.

Arenic Epiaqualfs

JAJI. Other Epiaqualfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more below the mineral soil surface.

Grossarenic Epiaqualfs

JAJJ. Other Epiaqualfs that have *both*:

1. An umbric epipedon, or the upper 18 cm of the mineral soil meets all of the requirements for an umbric epipedon, except for thickness, after mixing; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more (both moist and dry); *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Umbric Epiaqualfs

JAJK. Other Epiaqualfs that have *both*:

1. A mollic epipedon, or the upper 18 cm of the mineral soil meets all of the requirements for a mollic epipedon, except for thickness, after mixing; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more (both moist and dry); *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations.

Udollic Epiaqualfs

JAJL. Other Epiaqualfs that have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

1. Hue of 7.5YR or redder; *and*

a. If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

b. If peds are absent, chroma of 2 or more (both moist and dry); *or*

2. Hue of 10YR or yellower *and either*:

a. Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

b. Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Epiaqualfs

JAJM. Other Epiaqualfs that have a mollic epipedon, or the upper 18 cm of the mineral soil meets all of the requirements for a mollic epipedon, except for thickness, after mixing.

Mollic Epiaqualfs

JAJN. Other Epiaqualfs that have an umbric epipedon, or the upper 18 cm of the mineral soil meets all of the requirements for an umbric epipedon, except for thickness, after mixing.

Umbric Epiaqualfs

JAJO. Other Epiaqualfs.

Typic Epiaqualfs

Fragiaqualfs

Key to Subgroups

JAEA. Fragiaqualfs that have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts.

Vermic Fragiaqualfs

JAEB. Other Fragiaqualfs that have, between the A or Ap horizon and a fragipan, a horizon with 50 percent or more chroma of 3 or more if hue is 10YR or redder or of 4 or more if hue is 2.5Y or yellower.

Aeric Fragiaqualfs

JAEC. Other Fragiaqualfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Fragiaqualfs

JAED. Other Fragiaqualfs that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Fragiaqualfs

JAEE. Other Fragiaqualfs.

Typic Fragiaqualfs

Glossaqualfs

Key to Subgroups

JAIA. Glossaqualfs that have a histic epipedon.

Histic Glossaqualfs

JAIB. Other Glossaqualfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more below the mineral soil surface.

Arenic Glossaqualfs

JAIC. Other Glossaqualfs that have *both*:

1. Fragic soil properties:

   a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

   b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, one or a combination of the following colors:

   a. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

      (1) If peds are present, chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

      (2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

   b. In 50 percent or more of the matrix, hue of 10YR or yellower *and either*:

      (1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

      (2) Chroma of 2 or more if there are no redox concentrations.

Aeric Fragic Glossaqualfs

JAID. Other Glossaqualfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Glossaqualfs

JAIE. Other Glossaqualfs that have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

1. Hue of 7.5YR or redder; *and*

   a. If peds are present, chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

   b. If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

2. Hue of 10YR or yellower *and either*:

   a. Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

   b. Chroma of 2 or more if there are no redox concentrations.

Aeric Glossaqualfs

JAIF. Other Glossaqualfs that have a mollic epipedon, or the upper 18 cm of the mineral soil meets the requirements for a mollic epipedon after mixing.

Mollic Glossaqualfs

JAIG. Other Glossaqualfs.

Typic Glossaqualfs

Kandiaqualfs

Key to Subgroups

JAFA. Kandiaqualfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm below the mineral soil surface.

Arenic Kandiaqualfs

JAFB. Other Kandiaqualfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more below the mineral soil surface.

Grossarenic Kandiaqualfs

JAFC. Other Kandiaqualfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandiaqualfs

JAFD. Other Kandiaqualfs that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more (both moist and dry); *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Umbric Kandiaqualfs

JAFE. Other Kandiaqualfs that have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

1. Hue of 7.5YR or redder; *and*

a. If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

b. If peds are absent, chroma of 2 or more (both moist and dry); *or*

2. Hue of 10YR or yellower *and either*:

a. Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

b. Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Kandiaqualfs

JAFF. Other Kandiaqualfs that have an umbric epipedon, or the upper 18 cm of the mineral soil meets the color requirements for an umbric epipedon after mixing.

Umbric Kandiaqualfs

JAFG. Other Kandiaqualfs.

Typic Kandiaqualfs

Natraqualfs

Key to Subgroups

JADA. Natraqualfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natraqualfs

JADB. Other Natraqualfs that have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts.

Vermic Natraqualfs

JADC. Other Natraqualfs that have *both*:

1. A glossic horizon or interfingering of albic materials into the natric horizon; *and*

2. An exchangeable sodium percentage of less than 15 and less magnesium plus sodium than calcium plus extractable acidity either throughout the upper 15 cm of the natric horizon or in all horizons within 40 cm of the mineral soil surface, whichever is deeper.

Albic Glossic Natraqualfs

JADD. Other Natraqualfs that have an exchangeable sodium percentage of less than 15 and less magnesium plus sodium than calcium plus extractable acidity either throughout the upper 15 cm of the natric horizon or in all horizons within 40 cm of the mineral soil surface, whichever is deeper.

Albic Natraqualfs

JADE. Other Natraqualfs that have a glossic horizon or interfingering of albic materials into the natric horizon.

Glossic Natraqualfs

JADF. Other Natraqualfs that have a mollic epipedon, or the upper 18 cm of the mineral soil meets the color requirements for a mollic epipedon after mixing.

Mollic Natraqualfs

JADG. Other Natraqualfs.

Typic Natraqualfs

Plinthaqualfs

Key to Subgroups

JABA. All Plinthaqualfs (provisionally).

Typic Plinthaqualfs

Vermaqualfs

Key to Subgroups

JAGA. Vermaqualfs that have an exchangeable sodium percentage of 7 or more (or a sodium adsorption ratio of 6 or more) *either or both*:

1. Throughout the upper 15 cm of the argillic horizon; *and/or*

2. Throughout all horizons within 40 cm of the mineral soil surface.

Natric Vermaqualfs

JAGB. Other Vermaqualfs.

Typic Vermaqualfs

Cryalfs

Key to Great Groups

JBA. Cryalfs that have *all* of the following:

1. An argillic, kandic, or natric horizon that has its upper boundary 60 cm or more below *both*:

a. The mineral soil surface; *and*

b. The lower boundary of any surface mantle containing 30 percent or more vitric volcanic ash, cinders, or other vitric pyroclastic materials; *and*

2. A texture class finer than loamy fine sand in one or more horizons above the argillic, kandic, or natric horizon; *and*

3. Either a glossic horizon or interfingering of albic materials into the argillic, kandic, or natric horizon.

Palecryalfs, p. 85

JBB. Other Cryalfs that have a glossic horizon.

Glossocryalfs, p. 82

JBC. Other Cryalfs.

Haplocryalfs, p. 83

Glossocryalfs

Key to Subgroups

JBBA. Glossocryalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Glossocryalfs

JBBB. Other Glossocryalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Glossocryalfs

JBBC. Other Glossocryalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Glossocryalfs

JBBD. Other Glossocryalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Glossocryalfs

JBBE. Other Glossocryalfs that have, in one or more subhorizons within the upper 25 cm of the argillic, kandic, or natric horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Glossocryalfs

JBBF. Other Glossocryalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Glossocryalfs

JBBG. Other Glossocryalfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Glossocryalfs

JBBH. Other Glossocryalfs that have *all* of the following:

1. A xeric soil moisture regime; *and*

2. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

3. A base saturation (by NH_4OAc) of 50 percent or more in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Xerollic Glossocryalfs

JBBI. Other Glossocryalfs that have *both*:

1. A xeric soil moisture regime; *and*

2. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Umbric Xeric Glossocryalfs

JBBJ. Other Glossocryalfs that meet *all* of the following:

1. Are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years; *and*

2. Have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

3. Have a base saturation (by NH_4OAc) of 50 percent or more in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Ustollic Glossocryalfs

JBBK. Other Glossocryalfs that have a xeric soil moisture regime.

Xeric Glossocryalfs

JBBL. Other Glossocryalfs that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Glossocryalfs

JBBM. Other Glossocryalfs that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

2. A base saturation (by NH_4OAc) of 50 percent or more in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Mollic Glossocryalfs

JBBN. Other Glossocryalfs that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Umbric Glossocryalfs

JBBO. Other Glossocryalfs that have a base saturation (by NH_4OAc) of 50 percent or more in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Eutric Glossocryalfs

JBBP. Other Glossocryalfs.

Typic Glossocryalfs

Haplocryalfs

Key to Subgroups

JBCA. Haplocryalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplocryalfs

JBCB. Other Haplocryalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplocryalfs

JBCC. Other Haplocryalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haplocryalfs

JBCD. Other Haplocryalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haplocryalfs

JBCE. Other Haplocryalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplocryalfs

JBCF. Other Haplocryalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplocryalfs

JBCG. Other Haplocryalfs that have an argillic horizon that meets *one* of the following:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Haplocryalfs

JBCH. Other Haplocryalfs that have a sandy or sandy-skeletal particle-size class throughout the upper 75 cm of the argillic, kandic, or natric horizon or throughout the entire argillic, kandic, or natric horizon if it is less than 75 cm thick.

Psammentic Haplocryalfs

JBCI. Other Haplocryalfs that:

1. Have an argillic, kandic, or natric horizon that is 35 cm or less thick; *and*

2. Do not have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Inceptic Haplocryalfs

JBCJ. Other Haplocryalfs that have *all* of the following:

1. A xeric soil moisture regime; *and*

2. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

3. A base saturation (by NH_4OAc) of 50 percent or more in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Xerollic Haplocryalfs

JBCK. Other Haplocryalfs that have *both*:

1. A xeric soil moisture regime; *and*

2. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Umbric Xeric Haplocryalfs

JBCL. Other Haplocryalfs that meet *all* of the following:

1. Are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years; *and*

2. Have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

3. Have a base saturation (by NH_4OAc) of 50 percent or more in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Ustollic Haplocryalfs

JBCM. Other Haplocryalfs that have a xeric soil moisture regime.

Xeric Haplocryalfs

JBCN. Other Haplocryalfs that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Haplocryalfs

JBCO. Other Haplocryalfs that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

2. A base saturation (by NH_4OAc) of 50 percent or more in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Mollic Haplocryalfs

JBCP. Other Haplocryalfs that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Umbric Haplocryalfs

JBCQ. Other Haplocryalfs that have a base saturation (by NH_4OAc) of 50 percent or more in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Eutric Haplocryalfs

JBCR. Other Haplocryalfs.

Typic Haplocryalfs

Palecryalfs

Key to Subgroups

JBAA. Palecryalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Palecryalfs

JBAB. Other Palecryalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Palecryalfs

JBAC. Other Palecryalfs that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Palecryalfs

JBAD. Other Palecryalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Palecryalfs

JBAE. Other Palecryalfs that have a xeric soil moisture regime.

Xeric Palecryalfs

JBAF. Other Palecryalfs that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Palecryalfs

JBAG. Other Palecryalfs that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

2. A base saturation (by NH_4OAc) of 50 percent or more in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Mollic Palecryalfs

JBAH. Other Palecryalfs that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Umbric Palecryalfs

JBAI. Other Palecryalfs.

Typic Palecryalfs

Udalfs

Key to Great Groups

JEA. Udalfs that have a natric horizon.

Natrudalfs, p. 95

JEB. Other Udalfs that have *both*:

1. A glossic horizon; *and*

2. In the argillic or kandic horizon, discrete nodules, 2.5 to 30 cm in diameter, that:

a. Are enriched with iron and extremely weakly coherent to indurated; *and*

b. Have exteriors with either a redder hue or a higher chroma than the interiors.

Ferrudalfs, p. 87

JEC. Other Udalfs that have *both*:

1. A glossic horizon; *and*

2. A fragipan within 100 cm of the mineral soil surface.

Fraglossudalfs, p. 87

JED. Other Udalfs that have a fragipan within 100 cm of the mineral soil surface.

Fragiudalfs, p. 87

JEE. Other Udalfs that meet *all* of the following:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Have a kandic horizon; *and*

3. Within 150 cm of the mineral soil surface, *either*:

a. Do not have a clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content [Clay is measured as noncarbonate clay or is based on the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon), whichever value is greater, but no more than 100]; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Kandiudalfs, p. 93

JEF. Other Udalfs that have a kandic horizon.

Kanhapludalfs, p. 94

JEG. Other Udalfs that:

1. Do not have a densic, lithic, or paralithic contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

a. Do not have a clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content [Clay is measured as noncarbonate clay or is based on the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon), whichever value is greater, but no more than 100]; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction; *and*

3. Have an argillic horizon with *one or more* of the following:

a. In 50 percent or more of the matrix of one or more subhorizons in its lower one-half, hue of 7.5YR or redder and chroma of 5 or more; *or*

b. In 50 percent or more of the matrix of horizons that total more than one-half the total thickness, hue of 2.5YR or redder, value, moist, of 3 or less, and value, dry, of 4 or less; *or*

c. Many coarse redox concentrations with hue of 5YR or redder or chroma of 6 or more, or both, in one or more subhorizons; *or*

4. Have a frigid soil temperature regime and *all* of the following:

a. An argillic horizon that has its upper boundary 60 cm or more below *both*:

(1) The mineral soil surface; *and*

(2) The lower boundary of any surface mantle containing 30 percent or more vitric volcanic ash, cinders, or other vitric pyroclastic materials; *and*

b. A texture class finer than loamy fine sand in one or more horizons above the argillic horizon; *and*

c. Either a glossic horizon or interfingering of albic materials into the argillic horizon.

Paleudalfs, p. 95

JEH. Other Udalfs that have, in *all* subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodudalfs, p. 97

JEI. Other Udalfs that have a glossic horizon.

Glossudalfs, p. 88

JEJ. Other Udalfs.

Hapludalfs, p. 90

Ferrudalfs

Key to Subgroups

JEBA. Ferrudalfs that have, in one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Ferrudalfs

JEBB. Other Ferrudalfs.

Typic Ferrudalfs

Fragiudalfs

Key to Subgroups

JEDA. Fragiudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Fragiudalfs

JEDB. Other Fragiudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Fragiudalfs

JEDC. Other Fragiudalfs that have, in one or more horizons within 40 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fragiudalfs

JEDD. Other Fragiudalfs that are saturated with water in one or more layers above the fragipan in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Fragiudalfs

JEDE. Other Fragiudalfs.

Typic Fragiudalfs

Fraglossudalfs

Key to Subgroups

JECA. Fraglossudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Fraglossudalfs

JECB. Other Fraglossudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Fraglossudalfs

JECC. Other Fraglossudalfs that have, in one or more subhorizons within the upper 25 cm of the argillic or kandic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fraglossudalfs

JECD. Other Fraglossudalfs that are saturated with water in one or more layers above the fragipan in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Fraglossudalfs

JECE. Other Fraglossudalfs.

Typic Fraglossudalfs

Glossudalfs

Key to Subgroups

JEIA. Glossudalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Aquertic Glossudalfs

JEIB. Other Glossudalfs that have *both*:

1. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Oxyaquic Vertic Glossudalfs

JEIC. Other Glossudalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Glossudalfs

JEID. Other Glossudalfs that have *both*:

1. In one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Glossudalfs

JEIE. Other Glossudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Glossudalfs

JEIF. Other Glossudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Glossudalfs

JEIG. Other Glossudalfs that have *both*:

1. Fragic soil properties:

   a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

   b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

   a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

   b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Fragiaquic Glossudalfs

JEIH. Other Glossudalfs that:

1. In one or more subhorizons within 75 cm of the mineral soil surface, have redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of the argillic horizon at a depth of 50 cm or more below the mineral soil surface.

Aquic Arenic Glossudalfs

JEII. Other Glossudalfs that have, in one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Glossudalfs

JEIJ. Other Glossudalfs that:

1. Are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both:*

   a. 20 or more consecutive days; *or*

   b. 30 or more cumulative days; *and*

2. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of the argillic horizon at a depth of 50 cm or more below the mineral soil surface.

Arenic Oxyaquic Glossudalfs

JEIK. Other Glossudalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Glossudalfs

JEIL. Other Glossudalfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Glossudalfs

JEIM. Other Glossudalfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more below the mineral soil surface.

Arenic Glossudalfs

JEIN. Other Glossudalfs that have a glossic horizon less than 50 cm in total thickness.

Haplic Glossudalfs

JEIO. Other Glossudalfs.

Typic Glossudalfs

Hapludalfs

Key to Subgroups

JEJA. Hapludalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Hapludalfs

JEJB. Other Hapludalfs that have *all* of the following:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface; *and*

3. An Ap horizon or materials between the mineral soil surface and a depth of 18 cm that, after mixing, have *one or more* of the following:

a. A color value, moist, of 4 or more; *or*

b. A color value, dry, of 6 or more; *or*

c. Chroma of 4 or more.

Aquertic Chromic Hapludalfs

JEJC. Other Hapludalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Aquertic Hapludalfs

JEJD. Other Hapludalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Oxyaquic Vertic Hapludalfs

JEJE. Other Hapludalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. An Ap horizon or materials between the mineral soil surface and a depth of 18 cm that, after mixing, have *one or more* of the following:

a. A color value, moist, of 4 or more; *or*

b. A color value, dry, of 6 or more; *or*

c. Chroma of 4 or more.

Chromic Vertic Hapludalfs

JEJF. Other Hapludalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Hapludalfs

JEJG. Other Hapludalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Hapludalfs

JEJH. Other Hapludalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Hapludalfs

JEJI. Other Hapludalfs that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Fragiaquic Hapludalfs

JEJJ. Other Hapludalfs that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Fragic Oxyaquic Hapludalfs

JEJK. Other Hapludalfs that:

1. In one or more horizons within 75 cm of the mineral soil surface, have redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Aquic Arenic Hapludalfs

JEJL. Other Hapludalfs that:

1. Are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both:*

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days; *and*

2. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy

fine sand throughout a layer extending from the mineral soil surface to the top of the argillic horizon at a depth of 50 cm or more below the mineral soil surface.

Arenic Oxyaquic Hapludalfs

JEJM. Other Hapludalfs that have anthraquic conditions.

Anthraquic Hapludalfs

JEJN. Other Hapludalfs that have *all* of the following:

1. An abrupt textural change; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface; *and*

3. A base saturation (by sum of cations) of less than 60 percent at a depth of 125 cm from the top of the argillic horizon, at a depth of 180 cm from the mineral soil surface, or directly above a densic, lithic, or paralithic contact, whichever is shallowest.

Albaquultic Hapludalfs

JEJO. Other Hapludalfs that have *both*:

1. An abrupt textural change; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Albaquic Hapludalfs

JEJP. Other Hapludalfs that have *both*:

1. Interfingering of albic materials in the upper part of the argillic horizon; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Glossaquic Hapludalfs

JEJQ. Other Hapludalfs that have *both*:

1. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface; *and*

2. A base saturation (by sum of cations) of less than 60 percent at a depth of 125 cm from the top of the argillic horizon, at a depth of 180 cm from the mineral soil surface, or directly above a densic, lithic, or paralithic contact, whichever is shallowest.

Aquultic Hapludalfs

JEJR. Other Hapludalfs that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Aquollic Hapludalfs

JEJS. Other Hapludalfs that have redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

1. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

2. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Aquic Hapludalfs

JEJT. Other Hapludalfs that have *both*:

1. A mollic epipedon, or the upper 18 cm of the mineral soil meets the color requirements for a mollic epipedon after mixing; *and*

2. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Mollic Oxyaquic Hapludalfs

JEJU. Other Hapludalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Hapludalfs

JEJV. Other Hapludalfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Hapludalfs

JEJW. Other Hapludalfs that have an argillic horizon that meets *one* of the following:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Hapludalfs

JEJX. Other Hapludalfs that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Hapludalfs

JEJY. Other Hapludalfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Hapludalfs

JEJZ. Other Hapludalfs that have interfingering of albic materials in one or more subhorizons of the argillic horizon.

Glossic Hapludalfs

JEJZa. Other Hapludalfs that:

1. Have an argillic horizon that is 35 cm or less thick; *and*

2. Do not have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Inceptic Hapludalfs

JEJZb. Other Hapludalfs that have a base saturation (by sum of cations) of less than 60 percent at a depth of 125 cm below the top of the argillic horizon, at a depth of 180 cm below the mineral soil surface, or directly above a densic, lithic, or paralithic contact, whichever is shallowest.

Ultic Hapludalfs

JEJZc. Other Hapludalfs that have a mollic epipedon, or the upper 18 cm of the mineral soil meets all the color requirements for a mollic epipedon after mixing.

Mollic Hapludalfs

JEJZd. Other Hapludalfs.

Typic Hapludalfs

Kandiudalfs

Key to Subgroups

JEEA. Kandiudalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthaquic Kandiudalfs

JEEB. Other Kandiudalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiudalfs

JEEC. Other Kandiudalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Kandiudalfs

JEED. Other Kandiudalfs that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. Have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Kandiudalfs

JEEE. Other Kandiudalfs that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more; *and*

2. Have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Grossarenic Plinthic Kandiudalfs

JEEF. Other Kandiudalfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Kandiudalfs

JEEG. Other Kandiudalfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more.

Grossarenic Kandiudalfs

JEEH. Other Kandiudalfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandiudalfs

JEEI. Other Kandiudalfs that have, in *all* subhorizons in the upper 75 cm of the kandic horizon or throughout the entire kandic horizon if less than 75 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodic Kandiudalfs

JEEJ. Other Kandiudalfs that have a mollic epipedon, or the upper 18 cm of the mineral soil meets the color requirements for a mollic epipedon after mixing.

Mollic Kandiudalfs

JEEK. Other Kandiudalfs.

Typic Kandiudalfs

Kanhapludalfs

Key to Subgroups

JEFA. Kanhapludalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Kanhapludalfs

JEFB. Other Kanhapludalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kanhapludalfs

JEFC. Other Kanhapludalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Kanhapludalfs

JEFD. Other Kanhapludalfs that have, in *all* subhorizons in the upper 50 cm of the kandic horizon or throughout the entire kandic horizon if less than 50 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodic Kanhapludalfs

JEFE. Other Kanhapludalfs.

Typic Kanhapludalfs

Natrudalfs

Key to Subgroups

JEAA. Natrudalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrudalfs

JEAB. Other Natrudalfs that have *both*:

1. Either a glossic horizon or interfingering of albic materials into the natric horizon; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the natric horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the natric horizon is 50 cm or more below the mineral soil surface.

Glossaquic Natrudalfs

JEAC. Other Natrudalfs that have redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

1. Within the upper 25 cm of the natric horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

2. Within 75 cm of the mineral soil surface if the upper boundary of the natric horizon is 50 cm or more below the mineral soil surface.

Aquic Natrudalfs

JEAD. Other Natrudalfs.

Typic Natrudalfs

Paleudalfs

Key to Subgroups

JEGA. Paleudalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleudalfs

ALF

JEGB. Other Paleudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Paleudalfs

JEGC. Other Paleudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Paleudalfs

JEGD. Other Paleudalfs that have anthraquic conditions.

Anthraquic Paleudalfs

JEGE. Other Paleudalfs that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Fragiaquic Paleudalfs

JEGF. Other Paleudalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthaquic Paleudalfs

JEGG. Other Paleudalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A glossic horizon or, in the upper part of the argillic horizon, one or more subhorizons that have 5 percent or more (by volume) clay depletions with chroma of 2 or less.

Glossaquic Paleudalfs

JEGH. Other Paleudalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A clay increase of 15 percent or more (absolute) in the fine-earth fraction within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon.

Albaquic Paleudalfs

JEGI. Other Paleudalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Paleudalfs

JEGJ. Other Paleudalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Paleudalfs

JEGK. Other Paleudalfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Paleudalfs

JEGL. Other Paleudalfs that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

2. Have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Paleudalfs

JEGM. Other Paleudalfs that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more; *and*

2. Have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Grossarenic Plinthic Paleudalfs

JEGN. Other Paleudalfs that have an argillic horizon that meets *one* of the following:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Paleudalfs

JEGO. Other Paleudalfs that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Paleudalfs

JEGP. Other Paleudalfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Paleudalfs

JEGQ. Other Paleudalfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Paleudalfs

JEGR. Other Paleudalfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Paleudalfs

JEGS. Other Paleudalfs that have *either*:

1. A glossic horizon; *or*

2. In the upper part of the argillic horizon, one or more subhorizons that have 5 percent or more (by volume) skeletans with chroma of 2 or less; *or*

3. 5 percent or more (by volume) albic materials in some subhorizon of the argillic horizon.

Glossic Paleudalfs

JEGT. Other Paleudalfs that have, in *all* subhorizons in the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if less than 75 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodic Paleudalfs

JEGU. Other Paleudalfs that have a mollic epipedon, or the upper 18 cm of the mineral soil meets the color requirements for a mollic epipedon after mixing.

Mollic Paleudalfs

JEGV. Other Paleudalfs.

Typic Paleudalfs

Rhodudalfs

Key to Subgroups

JEHA. All Rhodudalfs (provisionally).

Typic Rhodudalfs

Ustalfs

Key to Great Groups

JCA. Ustalfs that have a duripan within 100 cm of the mineral soil surface.

Durustalfs, p. 98

JCB. Other Ustalfs that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Plinthustalfs, p. 109

JCC. Other Ustalfs that have a natric horizon.

Natrustalfs, p. 103

JCD. Other Ustalfs that meet *all* of the following:

1. Have a kandic horizon; *and*

2. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

3. Within 150 cm of the mineral soil surface, *either*:

a. Do not have a clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content [Clay is measured as noncarbonate clay or is based on the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon), whichever value is greater, but no more than 100]; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Kandiustalfs, p. 102

JCE. Other Ustalfs that have a kandic horizon.

Kanhaplustalfs, p. 103

JCF. Other Ustalfs that have *one or more* of the following:

1. A petrocalcic horizon within 150 cm of the mineral soil surface; *or*

2. No densic, lithic, or paralithic contact within 150 cm of the mineral soil surface *and* an argillic horizon that has *both*:

a. Within 150 cm of the mineral soil surface, *either*:

(1) With increasing depth, no clay decrease of 20 percent or more (relative) from the maximum clay content [Clay is measured as noncarbonate clay or is based on the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon), whichever value is greater, but no more than 100]; *or*

(2) 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction; *and*

b. In the lower one-half of the argillic horizon, one or more subhorizons with *either or both*:

(1) Hue of 7.5YR or redder and chroma of 5 or more in 50 percent or more of the matrix; *or*

(2) Common or many coarse redox concentrations with hue of 7.5YR or redder or chroma of 6 or more, or both; *or*

3. No densic, lithic, or paralithic contact within 50 cm of the mineral soil surface *and* an argillic horizon that has 35 percent or more noncarbonate clay throughout one or more subhorizons in its upper part, and *one or both* of the following:

a. At its upper boundary, a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm; *or*

b. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon.

Paleustalfs, p. 106

JCG. Other Ustalfs that have, in *all* subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodustalfs, p. 109

JCH. Other Ustalfs.

Haplustalfs, p. 98

Durustalfs

Key to Subgroups

JCAA. All Durustalfs (provisionally).

Typic Durustalfs

Haplustalfs

Key to Subgroups

JCHA. Haplustalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplustalfs

JCHB. Other Haplustalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquertic Haplustalfs

JCHC. Other Haplustalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Oxyaquic Vertic Haplustalfs

JCHD. Other Haplustalfs that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Haplustalfs

JCHE. Other Haplustalfs that have *both*:

1. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Udertic Haplustalfs

JCHF. Other Haplustalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplustalfs

JCHG. Other Haplustalfs that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Aquic Arenic Haplustalfs

JCHH. Other Haplustalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. An argillic horizon that has a base saturation (by sum of cations) of less than 75 percent throughout.

Aquultic Haplustalfs

JCHI. Other Haplustalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplustalfs

JCHJ. Other Haplustalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplustalfs

JCHK. Other Haplustalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haplustalfs

JCHL. Other Haplustalfs that have an argillic horizon that meets *one* of the following:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Haplustalfs

JCHM. Other Haplustalfs that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Haplustalfs

JCHN. Other Haplustalfs that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

2. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Arenic Aridic Haplustalfs

JCHO. Other Haplustalfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Haplustalfs

JCHP. Other Haplustalfs that have *both*:

1. A calcic horizon within 100 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Calcidic Haplustalfs

JCHQ. Other Haplustalfs that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

a. Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Haplustalfs

JCHR. Other Haplustalfs that have a CEC of less than 24 cmol(+)/kg clay (by 1N NH_4OAc pH 7) in 50 percent or more *either* of the argillic horizon if less than 100 cm thick *or* of its upper 100 cm.

Kanhaplic Haplustalfs

JCHS. Other Haplustalfs that:

1. Have an argillic horizon that is 35 cm or less thick; *and*

2. Do not have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Inceptic Haplustalfs

JCHT. Other Haplustalfs that have *both*:

1. A calcic horizon within 100 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 105 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Calcic Udic Haplustalfs

JCHU. Other Haplustalfs that have an argillic horizon with a base saturation (by sum of cations) of less than 75 percent throughout.

Ultic Haplustalfs

JCHV. Other Haplustalfs that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Haplustalfs

JCHW. Other Haplustalfs that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 105 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Haplustalfs

JCHX. Other Haplustalfs.

Typic Haplustalfs

Kandiustalfs

Key to Subgroups

JCDA. Kandiustalfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more.

Grossarenic Kandiustalfs

JCDB. Other Kandiustalfs that:

1. In one or more horizons within 75 cm of the mineral soil surface, have redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Aquic Arenic Kandiustalfs

JCDC. Other Kandiustalfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandiustalfs

JCDD. Other Kandiustalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiustalfs

JCDE. Other Kandiustalfs that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. When neither irrigated nor fallowed to store moisture, have *either*:

a. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Arenic Aridic Kandiustalfs

JCDF. Other Kandiustalfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Kandiustalfs

JCDG. Other Kandiustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

a. Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Aridic Kandiustalfs

JCDH. Other Kandiustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for 135 cumulative days or less per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120

cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Kandiustalfs

JCDI. Other Kandiustalfs that have, in *all* subhorizons in the upper 75 cm of the kandic horizon or throughout the entire kandic horizon if less than 75 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodic Kandiustalfs

JCDJ. Other Kandiustalfs.

Typic Kandiustalfs

Kanhaplustalfs

Key to Subgroups

JCEA. Kanhaplustalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Kanhaplustalfs

JCEB. Other Kanhaplustalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kanhaplustalfs

JCEC. Other Kanhaplustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

a. Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Kanhaplustalfs

JCED. Other Kanhaplustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for 135 cumulative days or less per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Kanhaplustalfs

JCEE. Other Kanhaplustalfs that have, in *all* subhorizons in the upper 50 cm of the kandic horizon or throughout the entire kandic horizon if less than 50 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodic Kanhaplustalfs

JCEF. Other Kanhaplustalfs.

Typic Kanhaplustalfs

Natrustalfs

Key to Subgroups

JCCA. Natrustalfs that have a salic horizon within 75 cm of the mineral soil surface.

Salidic Natrustalfs

JCCB. Other Natrustalfs that have *all* of the following:

1. Visible crystals of gypsum or salts more soluble than gypsum, or both, within 40 cm of the soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

3. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Leptic Torrertic Natrustalfs

JCCC. Other Natrustalfs that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Natrustalfs

JCCD. Other Natrustalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Aquertic Natrustalfs

JCCE. Other Natrustalfs that have *both* of the following:

1. Visible crystals of gypsum or salts more soluble than gypsum, or both, within 40 cm of the soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Leptic Natrustalfs

JCCF. Other Natrustalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrustalfs

JCCG. Other Natrustalfs that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Aquic Arenic Natrustalfs

JCCH. Other Natrustalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Natrustalfs

JCCI. Other Natrustalfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Natrustalfs

JCCJ. Other Natrustalfs that have a petrocalcic horizon within 150 cm of the mineral soil surface.

Petrocalcic Natrustalfs

JCCK. Other Natrustalfs that have visible crystals of gypsum or salts more soluble than gypsum, or both, within 40 cm of the mineral soil surface.

Leptic Natrustalfs

JCCL. Other Natrustalfs that have *both* of the following:

1. An exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) in 50 percent or more of the natric horizon; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Haplargidic Natrustalfs

JCCM. Other Natrustalfs that have *both:*

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. A glossic horizon or interfingering of albic materials into the natric horizon.

Aridic Glossic Natrustalfs

JCCN. Other Natrustalfs that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

a. Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Natrustalfs

JCCO. Other Natrustalfs that have a mollic epipedon, or the upper 18 cm of the mineral soil meets the color requirements for a mollic epipedon after mixing.

Mollic Natrustalfs

JCCP. Other Natrustalfs.

Typic Natrustalfs

Paleustalfs

Key to Subgroups

JCFA. Paleustalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquertic Paleustalfs

JCFB. Other Paleustalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Oxyaquic Vertic Paleustalfs

JCFC. Other Paleustalfs that have *both*:

1. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for four-tenths or less of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Udertic Paleustalfs

JCFD. Other Paleustalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleustalfs

JCFE. Other Paleustalfs that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Aquic Arenic Paleustalfs

JCFF. Other Paleustalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Paleustalfs

JCFG. Other Paleustalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Paleustalfs

JCFH. Other Paleustalfs that have an argillic horizon that meets *one* of the following:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Paleustalfs

JCFI. Other Paleustalfs that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Paleustalfs

JCFJ. Other Paleustalfs that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

2. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Arenic Aridic Paleustalfs

JCFK. Other Paleustalfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Paleustalfs

JCFL. Other Paleustalfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Paleustalfs

JCFM. Other Paleustalfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Paleustalfs

JCFN. Other Paleustalfs that have a petrocalcic horizon within 150 cm of the mineral soil surface.

Petrocalcic Paleustalfs

JCFO. Other Paleustalfs that have both:

1. When neither irrigated nor fallowed to store moisture, *either*:

a. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *and*

2. A calcic horizon *either* within 100 cm of the mineral soil surface if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy, *or* within 60 cm if it is loamy, *or* within 50 cm if it is clayey, *and* free carbonates in all horizons above the calcic horizon.

Calcidic Paleustalfs

JCFP. Other Paleustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A frigid soil temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

a. Is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Aridic Paleustalfs

JCFQ. Other Paleustalfs that have a CEC of less than 24 cmol(+)/kg clay (by 1N NH_4OAc pH 7) in 50 percent or more *either* of the argillic horizon if less than 100 cm thick *or* of its upper 100 cm.

Kandic Paleustalfs

JCFR. Other Paleustalfs that have, in *all* subhorizons in the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if less than 75 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodic Paleustalfs

JCFS. Other Paleustalfs that have an argillic horizon with a base saturation (by sum of cations) of less than 75 percent throughout.

Ultic Paleustalfs

JCFT. Other Paleustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for four-tenths or less of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Paleustalfs

JCFU. Other Paleustalfs.

Typic Paleustalfs

Plinthustalfs

Key to Subgroups

JCBA. All Plinthustalfs (provisionally).

Typic Plinthustalfs

Rhodustalfs

Key to Subgroups

JCGA. Rhodustalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Rhodustalfs

JCGB. Other Rhodustalfs that have a CEC of less than 24 cmol(+)/kg clay (by 1N NH_4OAc pH 7) in 50 percent or more *either* of the argillic horizon if less than 100 cm thick *or* of its upper 100 cm.

Kanhaplic Rhodustalfs

JCGC. Other Rhodustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for four-tenths or less of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Rhodustalfs

JCGD. Other Rhodustalfs.

Typic Rhodustalfs

Xeralfs

Key to Great Groups

JDA. Xeralfs that have a duripan within 100 cm of the mineral soil surface.

Durixeralfs, p. 110

JDB. Other Xeralfs that have a natric horizon.

Natrixeralfs, p. 113

JDC. Other Xeralfs that have a fragipan within 100 cm of the mineral soil surface.

Fragixeralfs, p. 110

JDD. Other Xeralfs that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Plinthoxeralfs, p. 115

JDE. Other Xeralfs that have, in *all* subhorizons in the upper 100 cm of the argillic or kandic horizon or throughout the entire argillic or kandic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodoxeralfs, p. 115

JDF. Other Xeralfs that have *one or more* of the following:

1. A petrocalcic horizon within 150 cm of the mineral soil surface; *or*

2. No densic, lithic, or paralithic contact within 150 cm of the mineral soil surface *and* an argillic or kandic horizon that has *both*:

a. Within 150 cm of the mineral soil surface, *either*:

(1) With increasing depth, no clay decrease of 20 percent or more (relative) from the maximum clay content [Clay is measured as noncarbonate clay or is based on the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon), whichever value is greater, but no more than 100]; *or*

(2) 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction; *and*

b. A base at a depth of 150 cm or more; *or*

3. No densic, lithic, or paralithic contact within 50 cm of the mineral soil surface *and* an argillic or kandic horizon that has 35 percent or more noncarbonate clay throughout one or more subhorizons in its upper part, and *one or both* of the following:

a. A clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm, either within the argillic or kandic horizon or at its upper boundary; *or*

b. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic or kandic horizon.

Palexeralfs, p. 113

JDG. Other Xeralfs.

Haploxeralfs, p. 111

Durixeralfs

Key to Subgroups

JDAA. Durixeralfs that have a natric horizon.

Natric Durixeralfs

JDAB. Other Durixeralfs that have, above the duripan, *one or both* of the following:

1. Cracks that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick; *or*

2. A linear extensibility of 6.0 cm or more.

Vertic Durixeralfs

JDAC. Other Durixeralfs that have, in one or more subhorizons within the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Durixeralfs

JDAD. Other Durixeralfs that have *both*:

1. An argillic horizon that has 35 percent or more noncarbonate clay throughout one or more subhorizons totaling 7.5 cm or more in thickness, and *one or both* of the following:

a. A clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm, either within the argillic horizon or at its upper boundary; *or*

b. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon; *and*

2. A duripan that is strongly coherent or less coherent in all subhorizons.

Abruptic Haplic Durixeralfs

JDAE. Other Durixeralfs that have an argillic horizon that has 35 percent or more noncarbonate clay throughout one or more subhorizons totaling 7.5 cm or more in thickness, and *one or both* of the following:

1. A clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm, either within the argillic horizon or at its upper boundary; *or*

2. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon.

Abruptic Durixeralfs

JDAF. Other Durixeralfs that have a duripan that is strongly coherent or less coherent in all subhorizons.

Haplic Durixeralfs

JDAG. Other Durixeralfs.

Typic Durixeralfs

Fragixeralfs

Key to Subgroups

JDCA. Fragixeralfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Fragixeralfs

JDCB. Other Fragixeralfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Fragixeralfs

JDCC. Other Fragixeralfs that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Mollic Fragixeralfs

JDCD. Other Fragixeralfs that have, in one or more horizons within 40 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fragixeralfs

JDCE. Other Fragixeralfs that, above the fragipan, do not have an argillic or kandic horizon with clay films on both vertical and horizontal faces of any peds.

Inceptic Fragixeralfs

JDCF. Other Fragixeralfs.

Typic Fragixeralfs

Haploxeralfs

Key to Subgroups

JDGA. Haploxeralfs that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. A color value, moist, of 3 or less and 0.7 percent or more organic carbon either throughout an Ap horizon or throughout the upper 10 cm of an A horizon.

Lithic Mollic Haploxeralfs

JDGB. Other Haploxeralfs that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. An argillic or kandic horizon that is discontinuous horizontally in each pedon.

Lithic Ruptic-Inceptic Haploxeralfs

JDGC. Other Haploxeralfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haploxeralfs

JDGD. Other Haploxeralfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haploxeralfs

JDGE. Other Haploxeralfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Haploxeralfs

JDGF. Other Haploxeralfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk

ALF

density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haploxeralfs

JDGG. Other Haploxeralfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haploxeralfs

JDGH. Other Haploxeralfs that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic or kandic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic or kandic horizon is 50 cm or more below the mineral soil surface.

Fragiaquic Haploxeralfs

JDGI. Other Haploxeralfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. An argillic or kandic horizon that has a base saturation (by sum of cations) of less than 75 percent in one or more subhorizons within its upper 75 cm or above a densic, lithic, or paralithic contact, whichever is shallower.

Aquultic Haploxeralfs

JDGJ. Other Haploxeralfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haploxeralfs

JDGK. Other Haploxeralfs that have an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) in one or more subhorizons of the argillic or kandic horizon.

Natric Haploxeralfs

JDGL. Other Haploxeralfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Haploxeralfs

JDGM. Other Haploxeralfs that have an argillic horizon that meets *one* of the following:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Haploxeralfs

JDGN. Other Haploxeralfs that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Haploxeralfs

JDGO. Other Haploxeralfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Haploxeralfs

JDGP. Other Haploxeralfs that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Haploxeralfs

JDGQ. Other Haploxeralfs that:

1. Have an argillic or kandic horizon that is 35 cm or less thick; *and*

2. Do not have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Inceptic Haploxeralfs

JDGR. Other Haploxeralfs that have an argillic or kandic horizon that has a base saturation (by sum of cations) of less than 75 percent in one or more subhorizons within its upper 75 cm or above a densic, lithic, or paralithic contact, whichever is shallower.

Ultic Haploxeralfs

JDGS. Other Haploxeralfs that have a color value, moist, of 3 or less and 0.7 percent or more organic carbon either throughout the upper 10 cm of the mineral soil (unmixed) or throughout the upper 18 cm of the mineral soil after mixing.

Mollic Haploxeralfs

JDGT. Other Haploxeralfs.

Typic Haploxeralfs

Natrixeralfs

Key to Subgroups

JDBA. Natrixeralfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrixeralfs

JDBB. Other Natrixeralfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Natrixeralfs

JDBC. Other Natrixeralfs.

Typic Natrixeralfs

Palexeralfs

Key to Subgroups

JDFA. Palexeralfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Palexeralfs

JDFB. Other Palexeralfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Palexeralfs

JDFC. Other Palexeralfs that have throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Palexeralfs

JDFD. Other Palexeralfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Palexeralfs

JDFE. Other Palexeralfs that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic or kandic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic or kandic horizon is 50 cm or more below the mineral soil surface.

Fragiaquic Palexeralfs

JDFF. Other Palexeralfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Palexeralfs

JDFG. Other Palexeralfs that have a petrocalcic horizon within 150 cm of the mineral soil surface.

Petrocalcic Palexeralfs

JDFH. Other Palexeralfs that have an argillic horizon that meets *one* of the following:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Palexeralfs

JDFI. Other Palexeralfs that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Palexeralfs

JDFJ. Other Palexeralfs that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic or kandic horizon at a depth of 50 cm or more.

Arenic Palexeralfs

JDFK. Other Palexeralfs that have an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) in one or more horizons within 100 cm of the mineral soil surface.

Natric Palexeralfs

JDFL. Other Palexeralfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Palexeralfs

JDFM. Other Palexeralfs that have a calcic horizon within 150 cm of the mineral soil surface.

Calcic Palexeralfs

JDFN. Other Palexeralfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Palexeralfs

JDFO. Other Palexeralfs that have an argillic or kandic horizon that has a base saturation (by sum of cations) of less than 75 percent throughout.

Ultic Palexeralfs

JDFP. Other Palexeralfs with an argillic or kandic horizon that has, *either or both*:

1. Less than 35 percent clay throughout all subhorizons within 15 cm of its upper boundary; *or*

2. At its upper boundary, a clay increase of less than 20 percent (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm and of less than 15 percent (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm.

Haplic Palexeralfs

JDFQ. Other Palexeralfs that have a color value, moist, of 3 or less and 0.7 percent or more organic carbon either throughout the upper 10 cm of the mineral soil (unmixed) or throughout the upper 18 cm of the mineral soil after mixing.

Mollic Palexeralfs

JDFR. Other Palexeralfs.

Typic Palexeralfs

Plinthoxeralfs

Key to Subgroups

JDDA. All Plinthoxeralfs (provisionally).

Typic Plinthoxeralfs

Rhodoxeralfs

Key to Subgroups

JDEA. Rhodoxeralfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Rhodoxeralfs

JDEB. Other Rhodoxeralfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Rhodoxeralfs

JDEC. Other Rhodoxeralfs that have a petrocalcic horizon within 150 cm of the mineral soil surface.

Petrocalcic Rhodoxeralfs

JDED. Other Rhodoxeralfs that have a calcic horizon within 150 cm of the mineral soil surface.

Calcic Rhodoxeralfs

JDEE. Other Rhodoxeralfs that have an argillic or kandic horizon that is either less than 35 cm thick or is discontinuous horizontally in each pedon.

Inceptic Rhodoxeralfs

JDEF. Other Rhodoxeralfs.

Typic Rhodoxeralfs

CHAPTER 6

Andisols

Key to Suborders

DA. Andisols that have *either*:

1. A histic epipedon; *or*

2. In a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallowest, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquands, p. 117

DB. Other Andisols that have a gelic soil temperature regime.

Gelands, p. 124

DC. Other Andisols that have a cryic soil temperature regime.

Cryands, p. 121

DD. Other Andisols that have an aridic soil moisture regime.

Torrands, p. 124

DE. Other Andisols that have a xeric soil moisture regime.

Xerands, p. 135

DF. Other Andisols that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

1. Within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. Between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Vitrands, p. 134

DG. Other Andisols that have an ustic soil moisture regime.

Ustands, p. 132

DH. Other Andisols.

Udands, p. 125

Aquands

Key to Great Groups

DAA. Aquands that have a gelic soil temperature regime.

Gelaquands, p. 119

DAB. Other Aquands that have a cryic soil temperature regime.

Cryaquands, p. 118

DAC. Other Aquands that have, in half or more of each pedon, a placic horizon within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Placaquands, p. 120

DAD. Other Aquands that have, in 75 percent or more of each pedon, a coherent, pedogenically cemented horizon within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duraquands, p. 118

DAE. Other Aquands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

1. Within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact within that depth; *or*

2. Between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact.

Vitraquands, p. 120

DAF. Other Aquands that have a melanic epipedon.

Melanaquands, p. 119

DAG. Other Aquands that have episaturation.

Epiaquands, p. 119

DAH. Other Aquands.

Endoaquands, p. 118

Cryaquands

Key to Subgroups

DABA. Cryaquands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Cryaquands

DABB. Other Cryaquands that have a histic epipedon.

Histic Cryaquands

DABC. Other Cryaquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Cryaquands

DABD. Other Cryaquands.

Typic Cryaquands

Duraquands

Key to Subgroups

DADA. Duraquands that have a histic epipedon.

Histic Duraquands

DADB. Other Duraquands that have a sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Acraquoxic Duraquands

DADC. Other Duraquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Duraquands

DADD. Other Duraquands.

Typic Duraquands

Endoaquands

Key to Subgroups

DAHA. Endoaquands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Endoaquands

DAHB. Other Endoaquands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) coherent, pedogenically cemented soil material within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Endoaquands

DAHC. Other Endoaquands that have a histic epipedon.

Histic Endoaquands

DAHD. Other Endoaquands that have more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Alic Endoaquands

DAHE. Other Endoaquands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Endoaquands

DAHF. Other Endoaquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Endoaquands

DAHG. Other Endoaquands.

Typic Endoaquands

Epiaquands

Key to Subgroups

DAGA. Epiaquands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) coherent, pedogenically cemented soil material within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Epiaquands

DAGB. Other Epiaquands that have a histic epipedon.

Histic Epiaquands

DAGC. Other Epiaquands that have more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Alic Epiaquands

DAGD. Other Epiaquands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Epiaquands

DAGE. Other Epiaquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Epiaquands

DAGF. Other Epiaquands.

Typic Epiaquands

Gelaquands

Key to Subgroups

DAAA. Gelaquands that have a histic epipedon.

Histic Gelaquands

DAAB. Other Gelaquands that have gelic materials within 200 cm of the mineral soil surface.

Turbic Gelaquands

DAAC. Other Gelaquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Gelaquands

DAAD. Other Gelaquands.

Typic Gelaquands

Melanaquands

Key to Subgroups

DAFA. Melanaquands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Melanaquands

DAFB. Other Melanaquands that have a sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Acraquoxic Melanaquands

DAFC. Other Melanaquands that have *both*:

1. On undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. More than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm of the mineral soil surface or of the top of

an organic layer with andic soil properties, whichever is shallower.

Hydric Pachic Melanaquands

DAFD. Other Melanaquands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Melanaquands

DAFE. Other Melanaquands that have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Pachic Melanaquands

DAFF. Other Melanaquands that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Melanaquands

DAFG. Other Melanaquands.

Typic Melanaquands

Placaquands

Key to Subgroups

DACA. Placaquands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Placaquands

DACB. Other Placaquands that have *both*:

1. A histic epipedon; *and*

2. A horizon 15 cm or more thick that has 20 percent or more (by volume) coherent, pedogenically cemented soil material within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Histic Placaquands

DACC. Other Placaquands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) coherent, pedogenically cemented soil material within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Placaquands

DACD. Other Placaquands that have a histic epipedon.

Histic Placaquands

DACE. Other Placaquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Placaquands

DACF. Other Placaquands.

Typic Placaquands

Vitraquands

Key to Subgroups

DAEA. Vitraquands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Vitraquands

DAEB. Other Vitraquands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) coherent, pedogenically cemented soil material within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Vitraquands

DAEC. Other Vitraquands that have a histic epipedon.

Histic Vitraquands

DAED. Other Vitraquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Vitraquands

DAEE. Other Vitraquands.

Typic Vitraquands

Cryands

Key to Great Groups

DCA. Cryands that have, in 75 percent or more of each pedon, a coherent, pedogenically cemented horizon within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duricryands, p. 121

DCB. Other Cryands that have, on undried samples, a 1500 kPa water retention of 100 percent or more, by weighted average, throughout *either*:

1. One or more layers with a total thickness of 35 cm between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. 60 percent or more of the horizon thickness between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Hydrocryands, p. 123

DCC. Other Cryands that have a melanic epipedon.

Melanocryands, p. 123

DCD. Other Cryands that have a layer that meets the depth, thickness, and organic carbon requirements for a melanic epipedon.

Fulvicryands, p. 122

DCE. Other Cryands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

1. Within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. Between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Vitricryands, p. 123

DCF. Other Cryands.

Haplocryands, p. 122

Duricryands

Key to Subgroups

DCAA. Duricryands that have, in some subhorizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Duricryands

DCAB. Other Duricryands that have *both*:

1. No horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic properties, whichever is shallower; *and*

2. Saturation with water in one or more layers above the coherent, pedogenically cemented horizon in normal years for *either or both:*

   a. 20 or more consecutive days; *or*

   b. 30 or more cumulative days.

Eutric Oxyaquic Duricryands

DCAC. Other Duricryands that are saturated with water in one or more layers above the coherent, pedogenically cemented horizon in normal years for *either or both:*

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Oxyaquic Duricryands

DCAD. Other Duricryands that have no horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic properties, whichever is shallower.

Eutric Duricryands

DCAE. Other Duricryands.

Typic Duricryands

Fulvicryands

Key to Subgroups

DCDA. Fulvicryands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Fulvicryands

DCDB. Other Fulvicryands that have a folistic epipedon.

Folistic Fulvicryands

DCDC. Other Fulvicryands that have *both*:

1. No horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic properties, whichever is shallower; *and*

2. Throughout a layer 50 cm or more thick within 60 cm of the mineral soil surface or of the top of an organic layer with andic properties, whichever is shallower:

   a. More than 6.0 percent organic carbon, by weighted average; *and*

   b. More than 4.0 percent organic carbon in all parts.

Eutric Pachic Fulvicryands

DCDD. Other Fulvicryands that have no horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic properties, whichever is shallower.

Eutric Fulvicryands

DCDE. Other Fulvicryands that have, throughout a layer 50 cm or more thick within 60 cm of the mineral soil surface or of the top of an organic layer with andic properties, whichever is shallower:

1. More than 6.0 percent organic carbon, by weighted average; *and*

2. More than 4.0 percent organic carbon in all parts.

Pachic Fulvicryands

DCDF. Other Fulvicryands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Vitric Fulvicryands

DCDG. Other Fulvicryands.

Typic Fulvicryands

Haplocryands

Key to Subgroups

DCFA. Haplocryands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Haplocryands

DCFB. Other Haplocryands that have a folistic epipedon.

Folistic Haplocryands

DCFC. Other Haplocryands that have, in some subhorizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Haplocryands

DCFD. Other Haplocryands that are saturated with water within 100 cm of the mineral soil surface in normal years for *either or both:*

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplocryands

DCFE. Other Haplocryands that have more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Alic Haplocryands

DCFF. Other Haplocryands that have an albic horizon overlying a cambic horizon in 50 percent or more of each pedon or have a spodic horizon in 50 percent or more of each pedon.

Spodic Haplocryands

DCFG. Other Haplocryands that have a sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Haplocryands

DCFH. Other Haplocryands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Vitric Haplocryands

DCFI. Other Haplocryands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Haplocryands

DCFJ. Other Haplocryands that have a xeric soil moisture regime.

Xeric Haplocryands

DCFK. Other Haplocryands.

Typic Haplocryands

Hydrocryands

Key to Subgroups

DCBA. Hydrocryands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Hydrocryands

DCBB. Other Hydrocryands that have a placic horizon within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Placic Hydrocryands

DCBC. Other Hydrocryands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Hydrocryands

DCBD. Other Hydrocryands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Hydrocryands

DCBE. Other Hydrocryands.

Typic Hydrocryands

Melanocryands

Key to Subgroups

DCCA. Melanocryands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer that has andic soil properties, whichever is shallower.

Lithic Melanocryands

DCCB. Other Melanocryands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Vitric Melanocryands

DCCC. Other Melanocryands.

Typic Melanocryands

Vitricryands

Key to Subgroups

DCEA. Vitricryands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer that has andic soil properties, whichever is shallower.

Lithic Vitricryands

DCEB. Other Vitricryands that have a folistic epipedon.

Folistic Vitricryands

DCEC. Other Vitricryands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Vitricryands

DCED. Other Vitricryands that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Vitricryands

DCEE. Other Vitricryands that have an albic horizon overlying a cambic horizon in 50 percent or more of each pedon *or* have a spodic horizon in 50 percent or more of each pedon.

Spodic Vitricryands

DCEF. Other Vitricryands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Vitricryands

DCEG. Other Vitricryands that have a xeric soil moisture regime and a mollic or umbric epipedon.

Humic Xeric Vitricryands

DCEH. Other Vitricryands that have a xeric soil moisture regime.

Xeric Vitricryands

DCEI. Other Vitricryands that have *both*:

1. An argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire argillic or kandic horizon if it is less than 50 cm thick.

Ultic Vitricryands

DCEJ. Other Vitricryands that have an argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Vitricryands

DCEK. Other Vitricryands that have a mollic or umbric epipedon.

Humic Vitricryands

DCEL. Other Vitricryands.

Typic Vitricryands

Gelands

Key to Great Groups

DBA. All Gelands are considered Vitrigelands.

Vitrigelands, p. 124

Vitrigelands

Key to Subgroups

DBAA. Vitrigelands that have a mollic or umbric epipedon.

Humic Vitrigelands

DBAB. Other Vitrigelands that have gelic materials within 200 cm of the mineral soil surface.

Turbic Vitrigelands

DBAC. Other Vitrigelands.

Typic Vitrigelands

Torrands

Key to Great Groups

DDA. Torrands that have, in 75 percent or more of each pedon, a coherent, pedogenically cemented horizon within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duritorrands, p. 125

DDB. Other Torrands that have, on air-dried samples, a 1500 kPa water retention of less than 15 percent throughout 60 percent or more of the thickness *either*:

1. Within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever

is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. Between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Vitritorrands, p. 125

DDC. Other Torrands.

Haplotorrands, p. 125

Duritorrands

Key to Subgroups

DDAA. Duritorrands that have a petrocalcic horizon within 100 cm of the mineral soil surface.

Petrocalcic Duritorrands

DDAB. Other Duritorrands that have, on air-dried samples, a 1500 kPa water retention of less than 15 percent throughout 60 percent or more of the thickness *either*:

1. Between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, if there is no paralithic contact or duripan within that depth, and a point 60 cm below that depth; *or*

2. Between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a paralithic contact or a duripan.

Vitric Duritorrands

DDAC. Other Duritorrands.

Typic Duritorrands

Haplotorrands

Key to Subgroups

DDCA. Haplotorrands that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplotorrands

DDCB. Other Haplotorrands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) coherent, pedogenically cemented soil material within 100 cm of the mineral soil surface.

Duric Haplotorrands

DDCC. Other Haplotorrands that have a calcic horizon within 125 cm of the mineral soil surface.

Calcic Haplotorrands

DDCD. Other Haplotorrands.

Typic Haplotorrands

Vitritorrands

Key to Subgroups

DDBA. Vitritorrands that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Vitritorrands

DDBB. Other Vitritorrands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) coherent, pedogenically cemented soil material within 100 cm of the mineral soil surface.

Duric Vitritorrands

DDBC. Other Vitritorrands that have, in one or more horizons at a depth between 50 and 100 cm from the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Vitritorrands

DDBD. Other Vitritorrands that have a calcic horizon within 125 cm of the mineral soil surface.

Calcic Vitritorrands

DDBE. Other Vitritorrands.

Typic Vitritorrands

Udands

Key to Great Groups

DHA. Udands that have, in half or more of each pedon, a placic horizon within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Placudands, p. 132

DHB. Other Udands that have, in 75 percent or more of each pedon, a coherent, pedogenically cemented horizon within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Durudands, p. 126

DHC. Other Udands that have a melanic epipedon.

Melanudands, p. 130

DHD. Other Udands that have, on undried samples, a 1500 kPa water retention of 100 percent or more, by weighted average, throughout *either*:

1. One or more layers with a total thickness of 35 cm between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. 60 percent or more of the horizon thickness between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Hydrudands, p. 129

DHE. Other Udands that have a layer that meets the depth, thickness, and organic carbon requirements for a melanic epipedon.

Fulvudands, p. 126

DHF. Other Udands.

Hapludands, p. 127

Durudands

Key to Subgroups

DHBA. Durudands that have, in one or more horizons above the coherent, pedogenically cemented horizon, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Durudands

DHBB. Other Durudands that have no horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic properties, whichever is shallower.

Eutric Durudands

DHBC. Other Durudands that have a sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the coherent, pedogenically cemented horizon.

Acrudoxic Durudands

DHBD. Other Durudands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick above the coherent, pedogenically cemented horizon.

Hydric Durudands

DHBE. Other Durudands that have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Pachic Durudands

DHBF. Other Durudands.

Typic Durudands

Fulvudands

Key to Subgroups

DHEA. Fulvudands that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. No horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the lithic contact.

Eutric Lithic Fulvudands

DHEB. Other Fulvudands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Fulvudands

DHEC. Other Fulvudands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Fulvudands

DHED. Other Fulvudands that are saturated with water within 100 cm of the mineral soil surface in normal years for *either or both:*

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Fulvudands

DHEE. Other Fulvudands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Fulvudands

DHEF. Other Fulvudands that have a sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Fulvudands

DHEG. Other Fulvudands that have *both*:

1. An argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm of the argillic or kandic horizon.

Ultic Fulvudands

DHEH. Other Fulvudands that have *both*:

1. No horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. Throughout a layer 50 cm or more thick within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower:

a. More than 6.0 percent organic carbon, by weighted average; *and*

b. More than 4.0 percent organic carbon in all parts.

Eutric Pachic Fulvudands

DHEI. Other Fulvudands that have no horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Eutric Fulvudands

DHEJ. Other Fulvudands that have, throughout a layer 50 cm or more thick within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower:

1. More than 6.0 percent organic carbon, by weighted average; *and*

2. More than 4.0 percent organic carbon in all parts.

Pachic Fulvudands

DHEK. Other Fulvudands that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Fulvudands

DHEL. Other Fulvudands.

Typic Fulvudands

Hapludands

Key to Subgroups

DHFA. Hapludands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Hapludands

DHFB. Other Hapludands that have anthraquic conditions.

Anthraquic Hapludands

DHFC. Other Hapludands that have *both*:

1. A horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. In one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is

shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Duric Hapludands

DHFD. Other Hapludands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Hapludands

DHFE. Other Hapludands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Hapludands

DHFF. Other Hapludands that are saturated with water within 100 cm of the mineral soil surface in normal years for *either or both:*

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Hapludands

DHFG. Other Hapludands that have more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Alic Hapludands

DHFH. Other Hapludands that have *both*:

1. A sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. On undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Hydric Hapludands

DHFI. Other Hapludands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, *both*:

1. A sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more; *and*

2. A layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Acrudoxic Thaptic Hapludands

DHFJ. Other Hapludands that have *both*:

1. A sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. An argillic or kandic horizon that has *both*:

a. An upper boundary within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

b. A base saturation (by sum of cations) of less than 35 percent throughout its upper 50 cm.

Acrudoxic Ultic Hapludands

DHFK. Other Hapludands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more.

Acrudoxic Hapludands

DHFL. Other Hapludands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Vitric Hapludands

DHFM. Other Hapludands that have *both*:

1. On undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. At a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Hydric Thaptic Hapludands

DHFN. Other Hapludands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Hapludands

DHFO. Other Hapludands that have *both*:

1. A sum of extractable bases (by NH_4OAc) of more than 25.0 cmol(+) per kg in the fine-earth fraction throughout one or more horizons with a total thickness of 15 cm or more at a depth between 25 and 75 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. At a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Eutric Thaptic Hapludands

DHFP. Other Hapludands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Hapludands

DHFQ. Other Hapludands that have a sum of extractable bases (by NH_4OAc) of more than 25.0 cmol(+) per kg in the fine-earth fraction throughout one or more horizons with a total thickness of 15 cm or more at a depth between 25 and 75 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Eutric Hapludands

DHFR. Other Hapludands that have an oxic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Oxic Hapludands

DHFS. Other Hapludands that have *both*:

1. An argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm of the argillic or kandic horizon.

Ultic Hapludands

DHFT. Other Hapludands that have an argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Hapludands

DHFU. Other Hapludands.

Typic Hapludands

Hydrudands

Key to Subgroups

DHDA. Hydrudands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Hydrudands

DHDB. Other Hydrudands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Hydrudands

DHDC. Other Hydrudands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, *both*:

1. A sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more; *and*

2. A layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Acrudoxic Thaptic Hydrudands

DHDD. Other Hydrudands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more.

Acrudoxic Hydrudands

DHDE. Other Hydrudands that have, at depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Hydrudands

DHDF. Other Hydrudands that have at a depth between 25 and 75 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a sum of extractable bases (by NH_4OAc) of more than 25.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 15 cm or more.

Eutric Hydrudands

DHDG. Other Hydrudands that have *both*:

1. An argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm of the argillic or kandic horizon.

Ultic Hydrudands

DHDH. Other Hydrudands.

Typic Hydrudands

Melanudands

Key to Subgroups

DHCA. Melanudands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer that has andic soil properties, whichever is shallower.

Lithic Melanudands

DHCB. Other Melanudands that have anthraquic conditions.

Anthraquic Melanudands

DHCC. Other Melanudands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Melanudands

DHCD. Other Melanudands that have *both*:

1. A sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+) per kg

in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Vitric Melanudands

DHCE. Other Melanudands that have *both*:

1. A sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+) per kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. On undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Hydric Melanudands

DHCF. Other Melanudands that have a sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+) per kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Melanudands

DHCG. Other Melanudands that have *both*:

1. More than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Pachic Vitric Melanudands

DHCH. Other Melanudands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Vitric Melanudands

DHCI. Other Melanudands that have *both*:

1. On undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. More than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Pachic Melanudands

DHCJ. Other Melanudands that have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Pachic Melanudands

DHCK. Other Melanudands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Melanudands

DHCL. Other Melanudands that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Melanudands

DHCM. Other Melanudands that have *both*:

1. An argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm of the argillic or kandic horizon.

Ultic Melanudands

DHCN. Other Melanudands that have a sum of extractable bases (by NH_4OAc) of more than 25.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 15 cm or more at a depth between 25 and 75 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Eutric Melanudands

DHCO. Other Melanudands.

Typic Melanudands

Placudands

Key to Subgroups

DHAA. Placudands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer that has andic soil properties, whichever is shallower.

Lithic Placudands

DHAB. Other Placudands that have, in one or more horizons at a depth between 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the placic horizon, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Placudands

DHAC. Other Placudands that have a sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the placic horizon.

Acrudoxic Placudands

DHAD. Other Placudands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Placudands

DHAE. Other Placudands.

Typic Placudands

Ustands

Key to Great Groups

DGA. Ustands that have, in 75 percent or more of each pedon, a coherent, pedogenically cemented horizon within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Durustands, p. 132

DGB. Other Ustands.

Haplustands, p. 133

Durustands

Key to Subgroups

DGAA. Durustands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Durustands

DGAB. Other Durustands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Durustands

DGAC. Other Durustands that have a melanic, mollic, or umbric epipedon.

Humic Durustands

DGAD. Other Durustands.

Typic Durustands

Haplustands

Key to Subgroups

DGBA. Haplustands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Haplustands

DGBB. Other Haplustands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Haplustands

DGBC. Other Haplustands that have *both*:

1. A sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 15.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 60 cm or more within 75 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Dystric Vitric Haplustands

DGBD. Other Haplustands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Vitric Haplustands

DGBE. Other Haplustands that have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Pachic Haplustands

DGBF. Other Haplustands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Haplustands

DGBG. Other Haplustands that have a calcic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Calcic Haplustands

DGBH. Other Haplustands that have a sum of extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 15.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 60 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Dystric Haplustands

DGBI. Other Haplustands that have an oxic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Oxic Haplustands

DGBJ. Other Haplustands that have *both*:

1. An argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire argillic or kandic horizon if it is less than 50 cm thick.

Ultic Haplustands

DGBK. Other Haplustands that have an argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Haplustands

DGBL. Other Haplustands that have a melanic, mollic, or umbric epipedon.

Humic Haplustands

DGBM. Other Haplustands.

Typic Haplustands

Vitrands

Key to Great Groups

DFA. Vitrands that have an ustic soil moisture regime.

Ustivitrands, p. 134

DFB. Other Vitrands.

Udivitrands, p. 134

Udivitrands

Key to Subgroups

DFBA. Udivitrands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Udivitrands

DFBB. Other Udivitrands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Udivitrands

DFBC. Other Udivitrands that are saturated with water within 100 cm of the mineral soil surface in normal years for *either or both:*

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Udivitrands

DFBD. Other Udivitrands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Udivitrands

DFBE. Other Udivitrands that have *both*:

1. An argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm of the argillic or kandic horizon.

Ultic Udivitrands

DFBF. Other Udivitrands that have an argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Udivitrands

DFBG. Other Udivitrands that have a melanic, mollic, or umbric epipedon.

Humic Udivitrands

DFBH. Other Udivitrands.

Typic Udivitrands

Ustivitrands

Key to Subgroups

DFAA. Ustivitrands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Ustivitrands

DFAB. Other Ustivitrands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Ustivitrands

DFAC. Other Ustivitrands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Ustivitrands

DFAD. Other Ustivitrands that have a calcic horizon within 125 cm of the soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Calcic Ustivitrands

DFAE. Other Ustivitrands that have a melanic, mollic, or umbric epipedon.

Humic Ustivitrands

DFAF. Other Ustivitrands.

Typic Ustivitrands

Xerands

Key to Great Groups

DEA. Xerands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

1. Within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. Between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Vitrixerands, p. 136

DEB. Other Xerands that have a melanic epipedon.

Melanoxerands, p. 136

DEC. Other Xerands.

Haploxerands, p. 135

Haploxerands

Key to Subgroups

DECA. Haploxerands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Haploxerands

DECB. Other Haploxerands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Haploxerands

DECC. Other Haploxerands that have, at a depth between 25 and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Haploxerands

DECD. Other Haploxerands that have a calcic horizon within 125 cm of the mineral soil surface.

Calcic Haploxerands

DECE. Other Haploxerands that have *both*:

1. An argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm of the argillic or kandic horizon.

Ultic Haploxerands

DECF. Other Haploxerands that have *both*:

1. A mollic or umbric epipedon; *and*

2. An argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Humic Haploxerands

DECG. Other Haploxerands that have an argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Haploxerands

DECH. Other Haploxerands that have a mollic or umbric epipedon.

Humic Haploxerands

DECI. Other Haploxerands.

Typic Haploxerands

Melanoxerands

Key to Subgroups

DEBA. Melanoxerands that have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Pachic Melanoxerands

DEBB. Other Melanoxerands.

Typic Melanoxerands

Vitrixerands

Key to Subgroups

DEAA. Vitrixerands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Vitrixerands

DEAB. Other Vitrixerands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Vitrixerands

DEAC. Other Vitrixerands that have, at a depth between 25 and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic carbon content 1 percent or more (absolute) lower.

Thaptic Vitrixerands

DEAD. Other Vitrixerands that have *both*:

1. A melanic, mollic, or umbric epipedon; *and*

2. An argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Humic Vitrixerands

DEAE. Other Vitrixerands that have *both*:

1. An argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire argillic or kandic horizon if it is less than 50 cm thick.

Ultic Vitrixerands

DEAF. Other Vitrixerands that have an argillic or kandic horizon within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Vitrixerands

DEAG. Other Vitrixerands that have a melanic, mollic, or umbric epipedon.

Humic Vitrixerands

DEAH. Other Vitrixerands.

Typic Vitrixerands

CHAPTER 7

Aridisols

Key to Suborders

GA. Aridisols that have a cryic soil temperature regime.

Cryids, p. 153

GB. Other Aridisols that have a salic horizon within 100 cm of the soil surface.

Salids, p. 163

GC. Other Aridisols that have a duripan within 100 cm of the soil surface.

Durids, p. 156

GD. Other Aridisols that have a gypsic or petrogypsic horizon within 100 cm of the soil surface and do not have a petrocalcic horizon overlying these horizons.

Gypsids, p. 159

GE. Other Aridisols that have an argillic or natric horizon and do not have a petrocalcic horizon within 100 cm of the soil surface.

Argids, p. 137

GF. Other Aridisols that have a calcic or petrocalcic horizon within 100 cm of the soil surface.

Calcids, p. 146

GG. Other Aridisols.

Cambids, p. 148

Argids

Key to Great Groups

GEA. Argids that have a duripan or a petrocalcic or petrogypsic horizon within 150 cm of the soil surface.

Petroargids, p. 145

GEB. Other Argids that have a natric horizon.

Natrargids, p. 142

GEC. Other Argids that do not have a densic, lithic, or paralithic contact within 50 cm of the soil surface and have *either*:

1. An argillic horizon that has 35 percent or more noncarbonate clay throughout one or more subhorizons in its upper part, and *one or both* of the following:

   a. A clay increase of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm either within the argillic horizon or at its upper boundary; *or*

   b. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon; *or*

2. An argillic horizon that extends to 150 cm or more from the soil surface, that does not have a clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content, and that has, in 50 percent or more of the matrix in some part between 100 and 150 cm, *either*:

   a. Hue of 7.5YR or redder and chroma of 5 or more; *or*

   b. Hue of 7.5YR or redder and value, moist, of 3 or less and value, dry, of 4 or less.

Paleargids, p. 144

GED. Other Argids that have a gypsic horizon within 150 cm of the soil surface.

Gypsiargids, p. 139

GEE. Other Argids that have a calcic horizon within 150 cm of the soil surface.

Calciargids, p. 137

GEF. Other Argids.

Haplargids, p. 140

Calciargids

Key to Subgroups

GEEA. Calciargids that have a lithic contact within 50 cm of the soil surface.

Lithic Calciargids

GEEB. Other Calciargids that have *both*:

1. *One or both* of the following:

   a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower; *and*

2. A soil moisture regime that borders on xeric and have a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Xerertic Calciargids

GEEC. Other Calciargids that have both:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower; *and*

3. A soil moisture regime that borders on ustic and have a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Ustertic Calciargids

GEED. Other Calciargids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower.

Vertic Calciargids

GEEE. Other Calciargids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Calciargids

GEEF. Other Calciargids that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

2. Have a soil moisture regime that borders on ustic and have a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Arenic Ustic Calciargids

GEEG. Other Calciargids that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Calciargids

GEEH. Other Calciargids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist; *and*

2. A soil moisture regime that borders on xeric and have a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Durinodic Xeric Calciargids

GEEI. Other Calciargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Calciargids

GEEJ. Other Calciargids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. A soil moisture regime that borders on xeric and have a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Petronodic Xeric Calciargids

GEEK. Other Calciargids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Petronodic Ustic Calciargids

GEEL. Other Calciargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Calciargids

GEEM. Other Calciargids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Calciargids

GEEN. Other Calciargids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Calciargids

GEEO. Other Calciargids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Calciargids

GEEP. Other Calciargids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Calciargids

GEEQ. Other Calciargids.

Typic Calciargids

Gypsiargids

Key to Subgroups

GEDA. Gypsiargids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Are saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Gypsiargids

GEDB. Other Gypsiargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that either contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Gypsiargids

GEDC. Other Gypsiargids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Gypsiargids

GEDD. Other Gypsiargids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Gypsiargids

GEDE. Other Gypsiargids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Xeric Gypsiargids

GEDF. Other Gypsiargids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Ustic Gypsiargids

GEDG. Other Gypsiargids.

Typic Gypsiargids

Haplargids

Key to Subgroups

GEFA. Haplargids that have *both*:

1. A lithic contact within 50 cm of the soil surface; *and*

2. An argillic horizon that is discontinuous throughout each pedon.

Lithic Ruptic-Entic Haplargids

GEFB. Other Haplargids that have *both*:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Lithic Xeric Haplargids

GEFC. Other Haplargids that have *both*:

1. A lithic contact within 50 cm of the soil surface; *and*

3. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Lithic Ustic Haplargids

GEFD. Other Haplargids that have a lithic contact within 50 cm of the soil surface.

Lithic Haplargids

GEFE. Other Haplargids that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Xerertic Haplargids

GEFF. Other Haplargids that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Ustertic Haplargids

GEFG. Other Haplargids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower.

Vertic Haplargids

GEFH. Other Haplargids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Haplargids

GEFI. Other Haplargids that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

2. Have a soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Arenic Ustic Haplargids

GEFJ. Other Haplargids that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Haplargids

GEFK. Other Haplargids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Durinodic Xeric Haplargids

GEFL. Other Haplargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Haplargids

GEFM. Other Haplargids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Petronodic Ustic Haplargids

GEFN. Other Haplargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Haplargids

GEFO. Other Haplargids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Haplargids

GEFP. Other Haplargids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Haplargids

GEFQ. Other Haplargids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Xeric Haplargids

GEFR. Other Haplargids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Ustic Haplargids

GEFS. Other Haplargids.

Typic Haplargids

Natrargids

Key to Subgroups

GEBA. Natrargids that have *both*:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Lithic Xeric Natrargids

GEBB. Other Natrargids that have *both*:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Lithic Ustic Natrargids

GEBC. Other Natrargids that have a lithic contact within 50 cm of the soil surface.

Lithic Natrargids

GEBD. Other Natrargids that:

2. Have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher; *and*

1. Have *one or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in most years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Xerertic Natrargids

GEBE. Other Natrargids that:

1. Have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher; *and*

2. Have *one or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in most years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Ustertic Natrargids

GEBF. Other Natrargids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in most years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrargids

GEBG. Other Natrargids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Natrargids

GEBH. Other Natrargids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Durinodic Xeric Natrargids

GEBI. Other Natrargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Natrargids

GEBJ. Other Natrargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Natrargids

GEBK. Other Natrargids that have *both*:

1. Skeletans covering 10 percent or more of the surfaces of peds at a depth of 2.5 cm or more below the upper boundary of the natric horizon; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Glossic Ustic Natrargids

GEBL. Other Natrargids that have *both*:

1. An exchangeable sodium percentage of less than 15 (or an SAR of less than 13) in 50 percent or more of the natric horizon; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Haplic Ustic Natrargids

GEBM. Other Natrargids that have *both*:

1. An exchangeable sodium percentage of less than 15 (or an SAR of less than 13) in 50 percent or more of the natric horizon; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Haploxeralfic Natrargids

GEBN. Other Natrargids that have an exchangeable sodium percentage of less than 15 (or an SAR of less than 13) in 50 percent or more of the natric horizon.

Haplic Natrargids

GEBO. Other Natrargids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Natrargids

GEBP. Other Natrargids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Natrargids

GEBQ. Other Natrargids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Natrargids

GEBR. Other Natrargids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Natrargids

GEBS. Other Natrargids that have skeletans covering 10 percent or more of the surfaces of peds at a depth of 2.5 cm or more below the upper boundary of the natric horizon.

Glossic Natrargids

GEBT. Other Natrargids.

Typic Natrargids

Paleargids

Key to Subgroups

GECA. Paleargids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleargids

GECB. Other Paleargids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Paleargids

GECC. Other Paleargids that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

2. Have a soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Arenic Ustic Paleargids

GECD. Other Paleargids that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Paleargids

GECE. Other Paleargids that have a calcic horizon within 150 cm of the soil surface.

Calcic Paleargids

GECF. Other Paleargids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Durinodic Xeric Paleargids

GECG. Other Paleargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Paleargids

GECH. Other Paleargids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Petronodic Ustic Paleargids

GECI. Other Paleargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Paleargids

GECJ. Other Paleargids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Paleargids

GECK. Other Paleargids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Paleargids

GECL. Other Paleargids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the surface is 5 °C or higher.

Xeric Paleargids

GECM. Other Paleargids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the surface is 5 °C or higher.

Ustic Paleargids

GECN. Other Paleargids.

Typic Paleargids

Petroargids

Key to Subgroups

GEAA. Petroargids that have *both*:

1. A petrogypsic horizon within 150 cm of the soil surface; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the surface is 5 °C or higher.

Petrogypsic Ustic Petroargids

GEAB. Other Petroargids that have a petrogypsic horizon within 150 cm of the soil surface.

Petrogypsic Petroargids

GEAC. Other Petroargids that have *both*:

1. A duripan within 150 cm of the soil surface; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Duric Xeric Petroargids

GEAD. Other Petroargids that have a duripan within 150 cm of the soil surface.

Duric Petroargids

GEAE. Other Petroargids that have a natric horizon.

Natric Petroargids

GEAF. Other Petroargids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Petroargids

GEAG. Other Petroargids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Petroargids

GEAH. Other Petroargids.

Typic Petroargids

Calcids

Key to Great Groups

GFA. Calcids that have a petrocalcic horizon within 100 cm of the soil surface.

Petrocalcids, p. 148

GFB. Other Calcids.

Haplocalcids, p. 146

Haplocalcids

Key to Subgroups

GFBA. Haplocalcids that have *both*:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Lithic Xeric Haplocalcids

GFBB. Other Haplocalcids that have *both*:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Lithic Ustic Haplocalcids

GFBC. Other Haplocalcids that have a lithic contact within 50 cm of the soil surface.

Lithic Haplocalcids

GFBD. Other Haplocalcids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplocalcids

GFBE. Other Haplocalcids that:

1. Are *either*:

a. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

b. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years; *and*

2. Have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Aquic Durinodic Haplocalcids

GFBF. Other Haplocalcids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Haplocalcids

GFBG. Other Haplocalcids that have *both*:

1. A duripan within 150 cm of the soil surface; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Duric Xeric Haplocalcids

GFBH. Other Haplocalcids that have a duripan within 150 cm of the soil surface.

Duric Haplocalcids

GFBI. Other Haplocalcids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Durinodic Xeric Haplocalcids

GFBJ. Other Haplocalcids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Haplocalcids

GFBK. Other Haplocalcids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Petronodic Xeric Haplocalcids

GFBL. Other Haplocalcids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Petronodic Ustic Haplocalcids

GFBM. Other Haplocalcids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Haplocalcids

GFBN. Other Haplocalcids that have *both*:

1. A horizon at least 25 cm thick within 100 cm of the soil surface that has an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Sodic Xeric Haplocalcids

GFBO. Other Haplocalcids that have *both*:

1. A horizon at least 25 cm thick within 100 cm of the soil surface that has an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Sodic Ustic Haplocalcids

GFBP. Other Haplocalcids that have a horizon at least 25 cm thick within 100 cm of the soil surface that has an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years.

Sodic Haplocalcids

GFBQ. Other Haplocalcids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

   a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

   b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Haplocalcids

GFBR. Other Haplocalcids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Haplocalcids

GFBS. Other Haplocalcids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Haplocalcids

GFBT. Other Haplocalcids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Haplocalcids

GFBU. Other Haplocalcids.

Typic Haplocalcids

Petrocalcids

Key to Subgroups

GFAA. Petrocalcids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Petrocalcids

GFAB. Other Petrocalcids that have a natric horizon.

Natric Petrocalcids

GFAC. Other Petrocalcids that have *both*:

1. An argillic horizon within 100 cm of the soil surface; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeralfic Petrocalcids

GFAD. Other Petrocalcids that have *both*:

1. An argillic horizon within 100 cm of the soil surface; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustalfic Petrocalcids

GFAE. Other Petrocalcids that have an argillic horizon within 100 cm of the soil surface.

Argic Petrocalcids

GFAF. Other Petrocalcids that have *both*:

1. A calcic horizon overlying the petrocalcic horizon; *and*

2. A lithic contact within 50 cm of the soil surface.

Calcic Lithic Petrocalcids

GFAG. Other Petrocalcids that have a calcic horizon overlying the petrocalcic horizon.

Calcic Petrocalcids

GFAH. Other Petrocalcids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Petrocalcids

GFAI. Other Petrocalcids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Petrocalcids

GFAJ. Other Petrocalcids.

Typic Petrocalcids

Cambids

Key to Great Groups

GGA. Cambids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquicambids, p. 149

GGB. Other Cambids that have a duripan or a petrocalcic or petrogypsic horizon within 150 cm of the soil surface.

Petrocambids, p. 152

GGC. Other Cambids.

Haplocambids, p. 150

Aquicambids

Key to Subgroups

GGAA. Aquicambids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years.

Sodic Aquicambids

GGAB. Other Aquicambids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Durinodic Xeric Aquicambids

GGAC. Other Aquicambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Aquicambids

GGAD. Other Aquicambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Aquicambids

GGAE. Other Aquicambids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Aquicambids

GGAF. Other Aquicambids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Aquicambids

GGAG. Other Aquicambids that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Aquicambids

GGAH. Other Aquicambids that meet *both* of the following:

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have an irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Aquicambids

GGAI. Other Aquicambids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Aquicambids

GGAJ. Other Aquicambids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Aquicambids

GGAK. Other Aquicambids.

Typic Aquicambids

Haplocambids

Key to Subgroups

GGCA. Haplocambids that have *both*:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Lithic Xeric Haplocambids

GGCB. Other Haplocambids that have *both*:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Lithic Ustic Haplocambids

GGCC. Other Haplocambids that have a lithic contact within 50 cm of the soil surface.

Lithic Haplocambids

GGCD. Other Haplocambids that have *both*:

1. *One or both* of the following:

   a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

   b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xerertic Haplocambids

GGCE. Other Haplocambids that have *both*:

1. *One or both* of the following:

   a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

   b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustertic Haplocambids

GGCF. Other Haplocambids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower.

Vertic Haplocambids

GGCG. Other Haplocambids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist*; and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Durinodic Xeric Haplocambids

GGCH. Other Haplocambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Haplocambids

GGCI. Other Haplocambids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Petronodic Xeric Haplocambids

GGCJ. Other Haplocambids that have *both*:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Petronodic Ustic Haplocambids

GGCK. Other Haplocambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Haplocambids

GGCL. Other Haplocambids that have *both*:

1. A horizon at least 25 cm thick within 100 cm of the soil surface that has an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Sodic Xeric Haplocambids

GGCM. Other Haplocambids that have *both*:

1. A horizon at least 25 cm thick within 100 cm of the soil surface that has an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years; *and*

2. A soil moisture regime that borders on ustic and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Sodic Ustic Haplocambids

GGCN. Other Haplocambids that have a horizon at least 25 cm thick within 100 cm of the soil surface that has an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years.

Sodic Haplocambids

GGCO. Other Haplocambids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Haplocambids

GGCP. Other Haplocambids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Haplocambids

GGCQ. Other Haplocambids that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Haplocambids

GGCR. Other Haplocambids that meet *all* of the following:

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

3. Have an irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Xerofluventic Haplocambids

GGCS. Other Haplocambids that meet *all* of the following:.

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

3. Have an irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Ustifluventic Haplocambids

GGCT. Other Haplocambids that have *both* of the following:

1. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Haplocambids

GGCU. Other Haplocambids that have an anthropic epipedon.

Anthropic Haplocambids

GGCV. Other Haplocambids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Haplocambids

GGCW. Other Haplocambids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Haplocambids

GGCX. Other Haplocambids.

Typic Haplocambids

Petrocambids

Key to Subgroups

GGBA. Petrocambids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years.

Sodic Petrocambids

GGBB. Other Petrocambids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Petrocambids

GGBC. Other Petrocambids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Petrocambids

GGBD. Other Petrocambids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Petrocambids

GGBE. Other Petrocambids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Ustic Petrocambids

GGBF. Other Petrocambids.

Typic Petrocambids

Cryids

Key to Great Groups

GAA. Cryids that have a salic horizon within 100 cm of the soil surface.

Salicryids, p. 156

GAB. Other Cryids that have a duripan, petrocalcic horizon, or petrogypsic horizon within 100 cm of the soil surface.

Petrocryids, p. 155

GAC. Other Cryids that have a gypsic horizon within 100 cm of the soil surface.

Gypsicryids, p. 154

GAD. Other Cryids that have an argillic or natric horizon.

Argicryids, p. 153

GAE. Other Cryids that have a calcic horizon within 100 cm of the soil surface.

Calcicryids, p. 154

GAF. Other Cryids.

Haplocryids, p. 155

Argicryids

Key to Subgroups

GADA. Argicryids that have a lithic contact within 50 cm of the soil surface.

Lithic Argicryids

GADB. Other Argicryids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide throughout a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argicryids

GADC. Other Argicryids that have a natric horizon within 100 cm of the soil surface.

Natric Argicryids

GADD. Other Argicryids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

   a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

   b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Argicryids

GADE. Other Argicryids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Argicryids

GADF. Other Argicryids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Xeric Argicryids

GADG. Other Argicryids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Argicryids

GADH. Other Argicryids.

Typic Argicryids

Calcicryids

Key to Subgroups

GAEA. Calcicryids that have a lithic contact within 50 cm of the soil surface.

Lithic Calcicryids

GAEB. Other Calcicryids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Calcicryids

GAEC. Other Calcicryids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Calcicryids

GAED. Other Calcicryids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Calcicryids

GAEE. Other Calcicryids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Calcicryids

GAEF. Other Calcicryids.

Typic Calcicryids

Gypsicryids

Key to Subgroups

GACA. Gypsicryids that have a calcic horizon.

Calcic Gypsicryids

GACB. Other Gypsicryids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Gypsicryids

GACC. Other Gypsicryids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted

by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Gypsicryids

GACD. Other Gypsicryids.

Typic Gypsicryids

Haplocryids

Key to Subgroups

GAFA. Haplocryids that have a lithic contact within 50 cm of the soil surface.

Lithic Haplocryids

GAFB. Other Haplocryids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide throughout a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplocryids

GAFC. Other Haplocryids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Haplocryids

GAFD. Other Haplocryids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Haplocryids

GAFE. Other Haplocryids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Haplocryids

GAFF. Other Haplocryids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Haplocryids

GAFG. Other Haplocryids.

Typic Haplocryids

Petrocryids

Key to Subgroups

GABA. Petrocryids that have *both*:

1. A duripan that is strongly coherent or less coherent in all subhorizons within 100 cm of the soil surface; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xereptic Petrocryids

GABB. Other Petrocryids that have *both*:

1. A duripan within 100 cm of the soil surface; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Duric Xeric Petrocryids

GABC. Other Petrocryids that have a duripan within 100 cm of the soil surface.

Duric Petrocryids

GABD. Other Petrocryids that have a petrogypsic horizon within 100 cm of the soil surface.

Petrogypsic Petrocryids

GABE. Other Petrocryids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Xeric Petrocryids

GABF. Other Petrocryids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Ustic Petrocryids

GABG. Other Petrocryids.

Typic Petrocryids

Salicryids

Key to Subgroups

GAAA. Salicryids that are saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Salicryids

GAAB. Other Salicryids.

Typic Salicryids

Durids

Key to Great Groups

GCA. Durids that have a natric horizon above the duripan.

Natridurids, p. 158

GCB. Other Durids that have an argillic horizon above the duripan.

Argidurids, p. 156

GCC. Other Durids.

Haplodurids, p. 157

Argidurids

Key to Subgroups

GCBA. Argidurids that have *one or both* of the following:

1. Cracks between the soil surface and the top of the duripan that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that is above the duripan; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and the top of the duripan.

Vertic Argidurids

GCBB. Other Argidurids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Argidurids

GCBC. Other Argidurids that have *both*:

1. An argillic horizon that has 35 percent or more noncarbonate clay throughout one or more subhorizons and *one or more* of the following:

   a. A clay increase of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm either within the argillic horizon or at its upper boundary; *or*

   b. If there is an Ap horizon directly above the argillic horizon, a clay increase of 10 percent or more (absolute, in the fine-earth fraction) at the upper boundary of the argillic horizon; *or*

   c. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Abruptic Xeric Argidurids

GCBD. Other Argidurids that have an argillic horizon that has 35 percent or more noncarbonate clay throughout one or more subhorizons and *one or more* of the following:

1. A clay increase of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm either within the argillic horizon or at its upper boundary; *or*

2. If there is an Ap horizon directly above the argillic horizon, a clay increase of 10 percent or more (absolute, in the fine-earth fraction) at the upper boundary of the argillic horizon; *or*

3. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon.

Abruptic Argidurids

GCBE. Other Argidurids that have *both*:

1. A duripan that is strongly coherent or less coherent in all subhorizons; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Haploxeralfic Argidurids

GCBF. Other Argidurids that have a duripan that is strongly coherent or less coherent in all subhorizons.

Argidic Argidurids

GCBG. Other Argidurids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Argidurids

GCBH. Other Argidurids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Argidurids

GCBI. Other Argidurids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Argidurids

GCBJ. Other Argidurids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Argidurids

GCBK. Other Argidurids.

Typic Argidurids

Haplodurids

Key to Subgroups

GCCA. Haplodurids that meet *both* of the following:

1. Have a duripan that is strongly coherent or less coherent in all subhorizons; *and*

2. Are *either*:

a. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

b. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquicambidic Haplodurids

GCCB. Other Haplodurids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Haplodurids

GCCC. Other Haplodurids that have *both*:

1. A duripan that is strongly coherent or less coherent in all subhorizons; *and*

2. A soil moisture regime that borders on xeric, a mean annual soil temperature lower than 22 °C, and a difference of 5 °C or more between mean summer and mean winter soil temperatures at a depth of 50 cm.

Xereptic Haplodurids

GCCD. Other Haplodurids that have a duripan that is strongly coherent or less coherent in all subhorizons.

Cambidic Haplodurids

GCCE. Other Haplodurids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Haplodurids

GCCF. Other Haplodurids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Haplodurids

GCCG. Other Haplodurids that have a soil moisture regime that borders on xeric, a mean annual soil temperature lower than 22 ^{o}C, and a difference of 5 ^{o}C or more between mean summer and mean winter soil temperatures at a depth of 50 cm.

Xeric Haplodurids

GCCH. Other Haplodurids that have have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Ustic Haplodurids

GCCI. Other Haplodurids.

Typic Haplodurids

Natridurids

Key to Subgroups

GCAA. Natridurids that have *one or both* of the following:

1. Cracks between the soil surface and the top of the duripan that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that is above the duripan; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and the top of the duripan.

Vertic Natridurids

GCAB. Other Natridurids that meet *both* of the following:

1. Have a duripan that is strongly coherent or less coherent in all subhorizons; *and*

2. Are *either*:

a. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

b. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Natrargidic Natridurids

GCAC. Other Natridurids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Natridurids

GCAD. Other Natridurids that have *both*:

1. A duripan that is strongly coherent or less coherent in all subhorizons; *and*

2. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Natrixeralfic Natridurids

GCAE. Other Natridurids that have a duripan that is strongly coherent or less coherent in all subhorizons.

Natrargidic Natridurids

GCAF. Other Natridurids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ºC or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Natridurids

GCAG. Other Natridurids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Natridurids

GCAH. Other Natridurids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ºC or higher.

Xeric Natridurids

GCAI. Other Natridurids.

Typic Natridurids

Gypsids

Key to Great Groups

GDA. Gypsids that have a petrogypsic or petrocalcic horizon within 100 cm of the soil surface.

Petrogypsids, p. 162

GDB. Other Gypsids that have a natric horizon within 100 cm of the soil surface.

Natrigypsids, p. 161

GDC. Other Gypsids that have an argillic horizon within 100 cm of the soil surface.

Argigypsids, p. 159

GDD. Other Gypsids that have a calcic horizon within 100 cm of the soil surface.

Calcigypsids, p. 160

GDE. Other Gypsids.

Haplogypsids, p. 161

Argigypsids

Key to Subgroups

GDCA. Argigypsids that have a lithic contact within 50 cm of the soil surface.

Lithic Argigypsids

GDCB. Other Argigypsids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argigypsids

GDCC. Other Argigypsids that have a calcic horizon overlying the gypsic horizon.

Calcic Argigypsids

GDCD. Other Argigypsids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes, nodules, or concretions.

Petronodic Argigypsids

GDCE. Other Argigypsids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ºC or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Argigypsids

GDCF. Other Argigypsids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Argigypsids

GDCG. Other Argigypsids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^oC or higher.

Xeric Argigypsids

GDCH. Other Argigypsids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^oC or higher.

Ustic Argigypsids

GDCI. Other Argigypsids.

Typic Argigypsids

Calcigypsids

Key to Subgroups

GDDA. Calcigypsids that have a lithic contact within 50 cm of the soil surface.

Lithic Calcigypsids

GDDB. Other Calcigypsids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes, nodules, or concretions.

Petronodic Calcigypsids

GDDC. Other Calcigypsids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^oC or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Calcigypsids

GDDD. Other Calcigypsids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Calcigypsids

GDDE. Other Calcigypsids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^oC or higher.

Xeric Calcigypsids

GDDF. Other Calcigypsids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^oC or higher.

Ustic Calcigypsids

GDDG. Other Calcigypsids.

Typic Calcigypsids

Haplogypsids

Key to Subgroups

GDEA. Haplogypsids that have a lithic contact within 50 cm of the soil surface.

Lithic Haplogypsids

GDEB. Other Haplogypsids that have a gypsic horizon within 18 cm of the soil surface.

Leptic Haplogypsids

GDEC. Other Haplogypsids that have, in a horizon at least 25 cm thick within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years.

Sodic Haplogypsids

GDED. Other Haplogypsids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes, nodules, or concretions.

Petronodic Haplogypsids

GDEE. Other Haplogypsids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

   a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

   b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Haplogypsids

GDEF. Other Haplogypsids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Haplogypsids

GDEG. Other Haplogypsids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Xeric Haplogypsids

GDEH. Other Haplogypsids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher.

Ustic Haplogypsids

GDEI. Other Haplogypsids.

Typic Haplogypsids

Natrigypsids

Key to Subgroups

GDBA. Natrigypsids that have a lithic contact within 50 cm of the soil surface.

Lithic Natrigypsids

GDBB. Other Natrigypsids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrigypsids

GDBC. Other Natrigypsids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes, nodules, or concretions.

Petronodic Natrigypsids

GDBD. Other Natrigypsids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative)

when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Natrigypsids

GDBE. Other Natrigypsids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Natrigypsids

GDBF. Other Natrigypsids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Natrigypsids

GDBG. Other Natrigypsids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Natrigypsids

GDBH. Other Natrigypsids.

Typic Natrigypsids

Petrogypsids

Key to Subgroups

GDAA. Petrogypsids that have a petrocalcic horizon within 100 cm of the soil surface.

Petrocalcic Petrogypsids

GDAB. Other Petrogypsids that have a calcic horizon overlying the petrogypsic horizon.

Calcic Petrogypsids

GDAC. Other Petrogypsids that have *both*:

1. A soil moisture regime that borders on xeric and a moisture control section that, in normal years, is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Petrogypsids

GDAD. Other Petrogypsids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Petrogypsids

GDAE. Other Petrogypsids that have a soil moisture regime that borders on xeric and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Xeric Petrogypsids

GDAF. Other Petrogypsids that have a soil moisture regime that borders on ustic and, in normal years, are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher.

Ustic Petrogypsids

GDAG. Other Petrogypsids.

Typic Petrogypsids

Salids

Key to Great Groups

GBA. Salids that are saturated with water in one or more layers within 100 cm of the mineral soil surface for 1 month or more in normal years.

Aquisalids, p. 163

GBB. Other Salids.

Haplosalids, p. 163

Aquisalids

Key to Subgroups

GBAA. Aquisalids that have an anhydritic horizon within 100 cm of the soil surface.

Anhydritic Aquisalids

GBAB. Other Aquisalids that have a gypsic or petrogypsic horizon within 100 cm of the soil surface.

Gypsic Aquisalids

GBAC. Other Aquisalids that have a calcic or petrocalcic horizon within 100 cm of the soil surface.

Calcic Aquisalids

GBAD. Other Aquisalids.

Typic Aquisalids

Haplosalids

Key to Subgroups

GBBA. Haplosalids that have a duripan within 100 cm of the soil surface.

Duric Haplosalids

GBBB. Other Haplosalids that have a petrogypsic horizon within 100 cm of the soil surface.

Petrogypsic Haplosalids

GBBC. Other Haplosalids that have an anhydritic horizon within 100 cm of the soil surface.

Anhydritic Haplosalids

GBBD. Other Haplosalids that have a gypsic horizon within 100 cm of the soil surface.

Gypsic Haplosalids

GBBE. Other Haplosalids that have a calcic horizon within 100 cm of the soil surface.

Calcic Haplosalids

GBBF. Other Haplosalids.

Typic Haplosalids

CHAPTER 8

Entisols

Key to Suborders

LA. Entisols that have a field observable water table 2 cm or more above the soil surface for more than 21 hours of each day in all years.

Wassents, p. 185

LB. Other Entisols that have *one or more* of the following:

1. Aquic conditions and sulfidic materials within 50 cm of the mineral soil surface; *or*

2. Permanent saturation with water and a reduced matrix in all horizons below 25 cm from the mineral soil surface; *or*

3. In a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm below the mineral soil surface, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

a. A texture class finer than loamy fine sand and, in 50 percent or more of the matrix, *one or more* of the following:

(1) Neutral colors with no hue (N) and zero chroma; *or*

(2) Chroma of 1 or less and a color value, moist, of 4 or more; *or*

(3) Chroma of 2 or less and redox concentrations; *or*

b. A texture class of loamy fine sand or coarser and, in 50 percent or more of the matrix, *one or more* of the following:

(1) Neutral colors with no hue (N) and zero chroma; *or*

(2) Hue of 10YR or redder, a color value, moist, of 4 or more, and chroma of 1; *or*

(3) Hue of 10YR or redder, chroma of 2 or less, and redox concentrations; *or*

(4) Hue of 2.5Y or yellower, chroma of 3 or less, and distinct or prominent redox concentrations; *or*

(5) Hue of 2.5Y or yellower and chroma of 1; *or*

(6) Hue of 5GY, 5G, 5BG, or 5B; *or*

(7) Any color if it results from uncoated sand grains; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquents, p. 166

LC. Other Entisols that have less than 35 percent (by volume) rock fragments and a texture class of loamy fine sand or coarser in all layers (sandy loam lamellae are permitted) within the particle-size control section.

Psamments, p. 181

LD. Other Entisols that do not have a densic, lithic, or paralithic contact within 25 cm of the mineral soil surface, a total thickness of 50 cm or more of human-transported material in the surface horizons, *or* a surface mantle of new soil material 50 cm or more thick that is not derived from alluvial deposition, *and* they:

1. Do not occur on an anthropogenic landform or microfeature; *and*

2. Have a slope of less than 25 percent; *and*

3. Have *one or both* of the following:

a. An organic carbon content (Holocene age) of 0.2 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower; *and*

4. Have a soil temperature regime:

a. That is warmer than cryic; *or*

b. That is gelic or cryic and the soil has:

(1) No gelic materials; *and*

(2) Either a slope of less than 5 percent or less than 15 percent volcanic glass in the 0.02 to 2.0 mm fraction in some part of the particle-size control section.

Fluvents, p. 170

LE. Other Entisols.

Orthents, p. 176

Aquents

Key to Great Groups

LBA. Aquents that have sulfidic materials within 50 cm of the mineral soil surface.

Sulfaquents, p. 169

LBB. Other Aquents that have, in all horizons at a depth between 20 and 50 cm below the mineral soil surface, both an *n* value of more than 0.7 or a fluidity class of slightly fluid or higher and 8 percent or more clay in the fine-earth fraction.

Hydraquents, p. 168

LBC. Other Aquents that have a gelic soil temperature regime.

Gelaquents, p. 168

LBD. Other Aquents that have a cryic soil temperature regime.

Cryaquents, p. 166

LBE. Other Aquents that have less than 35 percent (by volume) rock fragments and a texture class of loamy fine sand or coarser in all layers (sandy loam lamellae are permitted) within the particle-size control section.

Psammaquents, p. 169

LBF. Other Aquents that do not have a total thickness of 50 cm or more of human-transported material in the surface horizons *or* a surface mantle of new soil material 50 cm or more thick that is not derived from alluvial deposition, *and* they:

1 Do not occur on an anthropogenic landform or microfeature; *and*

2. Have a slope of less than 25 percent; *and*

3. Have *one or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquents, p. 167

LBG. Other Aquents that have episaturation.

Epiaquents, p. 167

LBH. Other Aquents.

Endoaquents, p. 166

Cryaquents

Key to Subgroups

LBDA. Cryaquents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Cryaquents

LBDB. Other Cryaquents.

Typic Cryaquents

Endoaquents

Key to Subgroups

LBHA. Endoaquents that have, within 100 cm of the mineral soil surface, *one or both* of the following:

1. Sulfidic materials; *or*

2. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0 and does not have sulfide or other sulfur-bearing minerals.

Sulfic Endoaquents

LBHB. Other Endoaquents that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Endoaquents

LBHC. Other Endoaquents that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Endoaquents

LBHD. Other Endoaquents that have, in one or more horizons between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, colors in 50 percent or more of the matrix as follows:

1. Hue of 2.5Y or redder, a color value, moist, of 6 or more, and chroma of 3 or more; *or*

2. Hue of 2.5Y or redder, a color value, moist, of 5 or less, and chroma of 2 or more; *or*

3. Hue of 5Y and chroma of 3 or more; *or*

4. Hue of 5Y or redder and chroma of 2 or more if there are no redox concentrations.

Aeric Endoaquents

LBHE. Other Endoaquents that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing; *and*

2. A base saturation (by NH_4OAc) of less than 50 percent in some part within 100 cm of the mineral soil surface.

Humaqueptic Endoaquents

LBHF. Other Endoaquents that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing.

Mollic Endoaquents

LBHG. Other Endoaquents.

Typic Endoaquents

Epiaquents

Key to Subgroups

LBGA. Epiaquents that have, in one or more horizons between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, colors in 50 percent or more of the matrix as follows:

1. Hue of 2.5Y or redder, a color value, moist, of 6 or more, and chroma of 3 or more; *or*

2. Hue of 2.5Y or redder, a color value, moist, of 5 or less, and chroma of 2 or more; *or*

3. Hue of 5Y and chroma of 3 or more; *or*

4. Chroma of 2 or more if there are no redox concentrations.

Aeric Epiaquents

LBGB. Other Epiaquents that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing; *and*

2. A base saturation (by NH_4OAc) of less than 50 percent in some part within 100 cm of the mineral soil surface.

Humaqueptic Epiaquents

LBGC. Other Epiaquents that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing.

Mollic Epiaquents

LBGD. Other Epiaquents.

Typic Epiaquents

Fluvaquents

Key to Subgroups

LBFA. Fluvaquents that have, within 100 cm of the mineral soil surface, *one or both* of the following:

1. Sulfidic materials; *or*

2. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0 and does not have sulfide or other sulfur-bearing minerals.

Sulfic Fluvaquents

LBFB. Other Fluvaquents that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Fluvaquents

LBFC. Other Fluvaquents that have a buried layer of organic soil materials, 40 cm or more thick, within 200 cm of the mineral soil surface.

Thapto-Histic Fluvaquents

LBFD. Other Fluvaquents that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Fluvaquents

LBFE. Other Fluvaquents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Fluvaquents

LBFF. Other Fluvaquents that have, in one or more horizons between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, colors in 50 percent or more of the matrix as follows:

1. Hue of 2.5Y or redder, a color value, moist, of 6 or more, and chroma of 3 or more; *or*

2. Hue of 2.5Y or redder, a color value, moist, of 5 or less, and chroma of 2 or more; *or*

3. Hue of 5Y and chroma of 3 or more; *or*

4. Chroma of 2 or more if there are no redox concentrations.

Aeric Fluvaquents

LBFG. Other Fluvaquents that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing; *and*

2. A base saturation (by NH_4OAc) of less than 50 percent in some part within 100 cm of the mineral soil surface.

Humaqueptic Fluvaquents

LBFH. Other Fluvaquents that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing.

Mollic Fluvaquents

LBFI. Other Fluvaquents.

Typic Fluvaquents

Gelaquents

Key to Subgroups

LBCA. All Gelaquents.

Typic Gelaquents

Hydraquents

Key to Subgroups

LBBA. Hydraquents that have, within 100 cm of the mineral soil surface, *one or both* of the following:

1. Sulfidic materials; *or*

2. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0 and does not have sulfide or other sulfur-bearing minerals.

Sulfic Hydraquents

LBBB. Other Hydraquents that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Hydraquents

LBBC. Other Hydraquents that have a buried layer of organic soil materials, 40 cm or more thick, within 200 cm of the mineral soil surface.

Thapto-Histic Hydraquents

LBBD. Other Hydraquents that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a

combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon

Thapto-Humic Hydraquents

LBBE. Other Hydraquents.

Typic Hydraquents

Psammaquents

Key to Subgroups

LBEA. Psammaquents that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Psammaquents

LBEB. Other Psammaquents that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Psammaquents

LBEC. Other Psammaquents that have a horizon, 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that meets *one or more* of the following:

1. In 25 percent or more of each pedon, is extremely weakly coherent or more coherent due to pedogenic cementation by organic matter and aluminum, with or without iron; *or*

2. Has Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. Has an ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Psammaquents

LBED. Other Psammaquents that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing; *and*

2. A base saturation (by NH_4OAc) of less than 50 percent in some part within 100 cm of the mineral soil surface.

Humaqueptic Psammaquents

LBEE. Other Psammaquents that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing.

Mollic Psammaquents

LBEF. Other Psammaquents that have a buried layer of organic soil materials, 40 cm or more thick, within 200 cm of the mineral soil surface.

Thapto-Histic Psammaquents

LBEG. Other Psammaquents that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Psammaquents

ENT

LBEH. Other Psammaquents that have a total thickness of less than 50 cm of human-transported material in the surface horizons and *one or both* of the following:

1. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Psammaquents

LBEI. Other Psammaquents.

Typic Psammaquents

Sulfaquents

Key to Subgroups

LBAA. Sulfaquents that have a histic epipedon and, in some horizons at a depth between 20 and 50 cm below the mineral soil surface, *either or both*:

1. An *n* value of 0.7 or less or a fluidity class of nonfluid; *or*

2. Less than 8 percent clay in the fine-earth fraction.

Histic-Haplic Sulfaquents

LBAB. Other Sulfaquents that have, in some horizons at a depth between 20 and 50 cm below the mineral soil surface, *either or both*:

1. An *n* value of 0.7 or less or a fluidity class of nonfluid; *or*

2. Less than 8 percent clay in the fine-earth fraction.

Haplic Sulfaquents

LBAC. Other Sulfaquents that have a histic epipedon.

Histic Sulfaquents

LBAD. Other Sulfaquents that have a buried layer of organic soil materials, 40 cm or more thick, within 200 cm of the mineral soil surface.

Thapto-Histic Sulfaquents

LBAE. Other Sulfaquents that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Sulfaquents

LBAF. Other Sulfaquents that have a total thickness of less than 50 cm of human-transported material in the surface horizons and *one or both* of the following:

1. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Sulfaquents

LBAG. Other Sulfaquents.

Typic Sulfaquents

Fluvents

Key to Great Groups

LDA. Fluvents that that have a gelic soil temperature regime.

Gelifluvents, p. 171

LDB. Other Fluvents that have a cryic soil temperature regime.

Cryofluvents, p. 170

LDC. Other Fluvents that have a xeric soil moisture regime.

Xerofluvents, p. 175

LDD. Other Fluvents that have an ustic soil moisture regime.

Ustifluvents, p. 173

LDE. Other Fluvents that have an aridic (or torric) soil moisture regime.

Torrifluvents, p. 171

LDF. Other Fluvents.

Udifluvents, p. 172

Cryofluvents

Key to Subgroups

LDBA. Cryofluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and percent aluminum plus $^1/_2$ the iron percentage (by ammonium oxalate) totaling more than 1.0.

Andic Cryofluvents

LDBB. Other Cryofluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Cryofluvents

LDBC. Other Cryofluvents that have, in one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Cryofluvents

LDBD. Other Cryofluvents that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Cryofluvents

LDBE. Other Cryofluvents that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing.

Mollic Cryofluvents

LDBF. Other Cryofluvents.

Typic Cryofluvents

Gelifluvents

Key to Subgroups

LDAA. Gelifluvents that have, in one or more horizons within 100 cm of the mineral soil surface, both redox depletions with chroma of 2 or less and aquic conditions for some time in normal years (or artificial drainage).

Aquic Gelifluvents

LDAB. Other Gelifluvents.

Typic Gelifluvents

Torrifluvents

Key to Subgroups

LDEA. Torrifluvents that have:

1. *One or both* of the following:

   a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

   b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. A moisture control section that, in normal years, is dry in all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher; *and*

3. An aridic (or torric) soil moisture regime that borders on ustic.

Ustertic Torrifluvents

LDEB. Other Torrifluvents that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Torrifluvents

LDEC. Other Torrifluvents that have:

1. A moisture control section that, in normal years, is dry in all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 ^{o}C or higher; *and*

2. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) soil moisture regime that borders on xeric; *and*

3. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

   a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

   b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

      (1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

      (2) [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrixerandic Torrifluvents

LDED. Other Torrifluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Torrifluvents

LDEE. Other Torrifluvents that have, in one or more horizons within 100 cm of the soil surface, both redox depletions with chroma of 2 or less and aquic conditions for some time in normal years (or artificial drainage).

Aquic Torrifluvents

LDEF. Other Torrifluvents that are saturated with water in one or more layers within 150 cm of the soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Torrifluvents

LDEG. Other Torrifluvents that have:

1. A horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist; *and*

2. A moisture control section that, in normal years, is dry in all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

3. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) soil moisture regime that borders on xeric

Duric Xeric Torrifluvents

LDEH. Other Torrifluvents that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Duric Torrifluvents

LDEI. Other Torrifluvents that have *both*:

1. A moisture control section that, in normal years, is dry in all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. An aridic (or torric) soil moisture regime that borders on ustic.

Ustic Torrifluvents

LDEJ. Other Torrifluvents that have *both*:

1. A moisture control section that, in normal years, is dry in all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) soil moisture regime that borders on xeric.

Xeric Torrifluvents

LDEK. Other Torrifluvents that have an anthropic epipedon.

Anthropic Torrifluvents

LDEL. Other Torrifluvents.

Typic Torrifluvents

Udifluvents

Key to Subgroups

LDFA. Udifluvents that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. *Either or both* of the following:

a. In one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *or*

b. In one or more horizons within 100 cm of the mineral soil surface, a color value, moist, of 4 or more *and either*:

(1) Neutral colors with no hue (N) and zero chroma; *or*

(2) Hue of 5GY, 5G, 5BG, or 5B and also aquic conditions for some time in normal years (or artificial drainage).

Aquertic Udifluvents

LDFB. Other Udifluvents that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Udifluvents

LDFC. Other Udifluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Udifluvents

LDFD. Other Udifluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Udifluvents

LDFE. Other Udifluvents that have *either*:

1. In one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *or*

2. In one or more horizons within 100 cm of the mineral soil surface, a color value, moist, of 4 or more *and either*:

a. Neutral colors with no hue (N) and zero chroma; *or*

b. Hue of 5GY, 5G, 5BG, or 5B and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Udifluvents

LDFF. Other Udifluvents that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Udifluvents

LDFG. Other Udifluvents that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing.

Mollic Udifluvents

LDFH. Other Udifluvents.

Typic Udifluvents

Ustifluvents

Key to Subgroups

LDDA. Ustifluvents that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. *Either or both* of the following:

a. In one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *or*

b. In one or more horizons within 150 cm of the mineral soil surface, a color value, moist, of 4 or more *and either*:

(1) Neutral colors with no hue (N) and zero chroma; *or*

(2) Hue of 5GY, 5G, 5BG, or 5B and also aquic conditions for some time in normal years (or artificial drainage).

Aquertic Ustifluvents

LDDB. Other Ustifluvents that that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Ustifluvents

LDDC. Other Ustifluvents that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Ustifluvents

LDDD. Other Ustifluvents that have anthraquic conditions.

Anthraquic Ustifluvents

LDDE. Other Ustifluvents that have *either*:

1. In one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *or*

2. In one or more horizons within 150 cm of the mineral soil surface, a color value, moist, of 4 or more *and either*:

a. Neutral colors with no hue (N) and zero chroma; *or*

b. Hue of 5GY, 5G, 5BG, or 5B and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Ustifluvents

LDDF. Other Ustifluvents that are saturated with water in one or more layers within 150 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Ustifluvents

LDDG. Other Ustifluvents that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is moist in some or all parts for less than 180 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Aridic Ustifluvents

LDDH. Other Ustifluvents that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for less than 105 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for less than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Ustifluvents

LDDI. Other Ustifluvents that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing.

Mollic Ustifluvents

LDDJ. Other Ustifluvents.

Typic Ustifluvents

Xerofluvents

Key to Subgroups

LDCA. Xerofluvents that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Xerofluvents

LDCB. Other Xerofluvents that have:

1. In one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *or*

2. In one or more horizons within 150 cm of the mineral soil surface, a color value, moist, of 4 or more *and either*:

   a. Neutral colors with no hue (N) and zero chroma; *or*

   b. Hue bluer than 10Y and also aquic conditions for some time in normal years (or artificial drainage); *and*

3. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

   a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

   b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

   c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

      (1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

      (2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Xerofluvents

LDCC. Other Xerofluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Xerofluvents

LDCD. Other Xerofluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Xerofluvents

LDCE. Other Xerofluvents that have *either*:

1. In one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *or*

2. In one or more horizons within 150 cm of the mineral soil surface, a color value, moist, of 4 or more *and either*:

   a. Neutral colors with no hue (N) and zero chroma; *or*

   b. Hue of 5GY, 5G, 5BG, or 5B; *or*

   c. Aquic conditions for some time in normal years.

Aquic Xerofluvents

LDCF. Other Xerofluvents that are saturated with water in one or more layers within 150 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Xerofluvents

LDCG. Other Xerofluvents that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Durinodic Xerofluvents

LDCH. Other Xerofluvents that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing.

Mollic Xerofluvents

LDCI. Other Xerofluvents.

Typic Xerofluvents

Orthents

Key to Great Groups

LEA. Orthents that have a gelic soil temperature regime.

Gelorthents, p. 176

LEB. Other Orthents that have a cryic soil temperature regime.

Cryorthents, p. 176

LEC. Other Orthents that have an aridic (or torric) soil moisture regime.

Torriorthents, p. 176

LED. Other Orthents that have a xeric soil moisture regime.

Xerorthents, p. 181

LEE. Other Orthents that have an ustic soil moisture regime.

Ustorthents, p. 179

LEF. Other Orthents.

Udorthents, p. 178

Cryorthents

Key to Subgroups

LEBA. Cryorthents that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Cryorthents

LEBB. Other Cryorthents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Cryorthents

LEBC. Other Cryorthents that have, in one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Cryorthents

LEBD. Other Cryorthents that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Cryorthents

LEBE. Other Cryorthents that have lamellae within 200 cm of the mineral soil surface.

Lamellic Cryorthents

LEBF. Other Cryorthents.

Typic Cryorthents

Gelorthents

Key to Subgroups

LEAA. Gelorthents that have, in one or more horizons within 100 cm of the mineral soil surface, both redox depletions with chroma of 2 or less and aquic conditions for some time in normal years (or artificial drainage).

Aquic Gelorthents

LEAB. Other Gelorthents that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Gelorthents

LEAC. Other Gelorthents.

Typic Gelorthents

Torriorthents

Key to Subgroups

LECA. Torriorthents that have *all* of the following:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A moisture control section that, in normal years, is dry in

all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

3. A hyperthermic, thermic, mesic, frigid, or *iso* soil temperature regime and an aridic (or torric) soil moisture regime that borders on ustic.

Lithic Ustic Torriorthents

LECB. Other Torriorthents that have *all* of the following:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A moisture control section that, in normal years, is dry in all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

3. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) soil moisture regime that borders on xeric.

Lithic Xeric Torriorthents

LECC. Other Torriorthents that have a lithic contact within 50 cm of the soil surface.

Lithic Torriorthents

LECD. Other Torriorthents that have:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. A moisture control section that, in normal years, is dry in all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

3. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) soil moisture regime that borders on xeric.

Xerertic Torriorthents

LECE. Other Torriorthents that have:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. A moisture control section that, in normal years, is dry in all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

3. An aridic (or torric) soil moisture regime that borders on ustic.

Ustertic Torriorthents

LECF. Other Torriorthents that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Torriorthents

LECG. Other Torriorthents that have 50 cm or more of human-altered material.

Anthraltic Torriorthents

LECH. Other Torriorthents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Torriorthents

LECI. Other Torriorthents that have, in one or more horizons within 100 cm of the soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Torriorthents

LECJ. Other Torriorthents that are saturated with water in one or more layers within 150 cm of the soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Torriorthents

LECK. Other Torriorthents that have a horizon within 100 cm of the soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Duric Torriorthents

LECL. Other Torriorthents that have *both*:

1. A moisture control section that, in normal years, is dry in all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. A hyperthermic, thermic, mesic, frigid, or *iso* soil temperature regime and an aridic (or torric) soil moisture regime that borders on ustic.

Ustic Torriorthents

LECM. Other Torriorthents that have *both*:

1. A moisture control section that, in normal years, is dry in all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 °C or higher; *and*

2. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) soil moisture regime that borders on xeric.

Xeric Torriorthents

LECN. Other Torriorthents.

Typic Torriorthents

Udorthents

Key to Subgroups

LEFA. Udorthents that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Udorthents

LEFB. Other Udorthents that have *both* of the following:

1. A densic contact due to mechanical compaction in more than 90 percent of the pedon (measured laterally) within 100 cm of the soil surface; *and*

2. An exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) in a horizon at least 25 cm thick within 100 cm of the soil surface.

Anthrodensic Sodic Udorthents

LEFC. Other Udorthents that have a densic contact due to mechanical compaction in more than 90 percent of the pedon (measured laterally) within 100 cm of the soil surface.

Anthrodensic Udorthents

LEFD. Other Udorthents that have an anthropic epipedon.

Anthropic Udorthents

LEFE. Other Udorthents that have 50 cm or more of human-transported material.

Anthroportic Udorthents

LEFF. Other Udorthents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Udorthents

LEFG. Other Udorthents that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Udorthents

LEFH. Other Udorthents that are saturated with water in one or more layers within 150 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Udorthents

LEFI. Other Udorthents that have 50 percent or more (by volume) wormholes, wormcasts, and filled animal burrows between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 100 cm or a densic, lithic, paralithic, or petroferric contact, whichever is shallower.

Vermic Udorthents

LEFJ. Other Udorthents.

Typic Udorthents

Ustorthents

Key to Subgroups

LEEA. Ustorthents that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C.

Aridic Lithic Ustorthents

LEEB. Other Ustorthents that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Ustorthents

LEEC. Other Ustorthents that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C.

Torrertic Ustorthents

LEED. Other Ustorthents that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Ustorthents

LEEE. Other Ustorthents that have anthraquic conditions.

Anthraquic Ustorthents

LEEF. Other Ustorthents that have a densic contact due to mechanical compaction in more than 90 percent of the pedon (measured laterally) within 100 cm of the soil surface.

Anthrodensic Ustorthents

LEEG. Other Ustorthents that have 50 cm or more of human-transported material.

Anthroportic Ustorthents

LEEH. Other Ustorthents that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Ustorthents

LEEI. Other Ustorthents that are saturated with water in one or more layers within 150 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Ustorthents

LEEJ. Other Ustorthents that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Durinodic Ustorthents

LEEK. Other Ustorthents that have *both*:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitritorrandic Ustorthents

LEEL. Other Ustorthents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Ustorthents

LEEM. Other Ustorthents that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is moist in some or all parts for less than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Aridic Ustorthents

LEEN. Other Ustorthents that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for less than 105 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for less than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Ustorthents

LEEO. Other Ustorthents that have 50 percent or more (by volume) wormholes, wormcasts, and filled animal burrows between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 100 cm or a densic, lithic, paralithic, or petroferric contact, whichever is shallower.

Vermic Ustorthents

LEEP. Other Ustorthents.

Typic Ustorthents

Xerorthents

Key to Subgroups

LEDA. Xerorthents that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Xerorthents

LEDB. Other Xerorthents that have *both* of the following:

1. 50 cm or more of human-altered material; *and*

2. An exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) in a horizon at least 25 cm thick within 100 cm of the soil surface.

Anthraltic Sodic Xerorthents

LEDC. Other Xerorthents that have 50 cm or more of human-altered material.

Anthraltic Xerorthents

LEDD. Other Xerorthents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Xerorthents

LEDE. Other Xerorthents that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Xerorthents

LEDF. Other Xerorthents that are saturated with water in one or more layers within 150 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Xerorthents

LEDG. Other Xerorthents that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Durinodic Xerorthents

LEDH. Other Xerorthents that have a base saturation (by NH_4OAc) of less than 60 percent in all horizons at a depth between 25 and 75 cm below the mineral soil surface or in the horizon directly above a root-limiting layer (defined in chapter 17) that is at a shallower depth.

Dystric Xerorthents

LEDI. Other Xerorthents.

Typic Xerorthents

Psamments

Key to Great Groups

LCA. Psamments that have a cryic soil temperature regime.

Cryopsamments, p. 181

LCB. Other Psamments that have an aridic (or torric) soil moisture regime.

Torripsamments, p. 183

LCC. Other Psamments that have, in the 0.02 to 2.0 mm fraction within the particle-size control section, a total of more than 90 percent (by weighted average) resistant minerals.

Quartzipsamments, p. 182

LCD. Other Psamments that have an ustic soil moisture regime.

Ustipsamments, p. 184

LCE. Other Psamments that have a xeric soil moisture regime.

Xeropsamments, p. 185

LCF. Other Psamments.

Udipsamments, p. 183

Cryopsamments

Key to Subgroups

LCAA. Cryopsamments that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Cryopsamments

LCAB. Other Cryopsamments that have, in one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Cryopsamments

LCAC. Other Cryopsamments that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Cryopsamments

LCAD. Other Cryopsamments that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction containing 5 percent or more volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Cryopsamments

LCAE. Other Cryopsamments that have a horizon 5 cm or more thick that meets *one or more* of the following:

1. In 25 percent or more of each pedon, is extremely weakly coherent or more coherent due to pedogenic cementation by organic matter and aluminum, with or without iron; *or*

2. Has Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. Has an ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Cryopsamments

LCAF. Other Cryopsamments that have lamellae within 200 cm of the mineral soil surface.

Lamellic Cryopsamments

LCAG. Other Cryopsamments.

Typic Cryopsamments

Quartzipsamments

Key to Subgroups

LCCA. Quartzipsamments that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Quartzipsamments

LCCB. Other Quartzipsamments that have *both*:

1. In one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A horizon, 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that meets *one or more* of the following:

   a. In 25 percent or more of each pedon, is extremely weakly coherent or more coherent due to pedogenic cementation by organic matter and aluminum, with or without iron; *or*

   b. Has Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

   c. Has an ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Aquodic Quartzipsamments

LCCC. Other Quartzipsamments that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Quartzipsamments

LCCD. Other Quartzipsamments that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Quartzipsamments

LCCE. Other Quartzipsamments that meet *all* of the following:

1. Have an ustic soil moisture regime; *and*

2. Have a clay fraction with a CEC of 16 cmol(+) or less per kg clay (by 1N NH_4OAc pH 7); *and*

3. The sum of the weighted average silt plus 2 times the weighted average clay (both by weight) is more than 5.

Ustoxic Quartzipsamments

LCCF. Other Quartzipsamments that meet *all* of the following:

1. Have a udic soil moisture regime; *and*

2. Have a clay fraction with a CEC of 16 cmol(+) or less per kg clay (by 1N NH_4OAc pH 7); *and*

3. The sum of the weighted average silt plus 2 times the weighted average clay (both by weight) is more than 5.

Udoxic Quartzipsamments

LCCG. Other Quartzipsamments that have 5 percent or more (by volume) plinthite in one or more horizons within 100 cm of the mineral soil surface.

Plinthic Quartzipsamments

LCCH. Other Quartzipsamments that have *both*:

1. Lamellae within 200 cm of the mineral soil surface; *and*

2. An ustic soil moisture regime.

Lamellic Ustic Quartzipsamments

LCCI. Other Quartzipsamments that have lamellae within 200 cm of the mineral soil surface.

Lamellic Quartzipsamments

LCCJ. Other Quartzipsamments that have an ustic soil moisture regime.

Ustic Quartzipsamments

LCCK. Other Quartzipsamments that have a xeric soil moisture regime.

Xeric Quartzipsamments

LCCL. Other Quartzipsamments that have a horizon, 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that meets *one or more* of the following:

1. In 25 percent or more of each pedon, is extremely weakly coherent or more coherent due to pedogenic cementation by organic matter and aluminum, with or without iron; *or*

2. Has Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. Has an ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Quartzipsamments

LCCM. Other Quartzipsamments.

Typic Quartzipsamments

Torripsamments

Key to Subgroups

LCBA. Torripsamments that have a lithic contact within 50 cm of the soil surface.

Lithic Torripsamments

LCBB. Other Torripsamments that are saturated with water in one or more layers within 150 cm of the mineral soil surface in normal years for *either or both:*

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Torripsamments

LCBC. Other Torripsamments that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction containing 5 percent or more volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Torripsamments

LCBD. Other Torripsamments that have a horizon within 100 cm of the soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Haploduridic Torripsamments

LCBE. Other Torripsamments that have *both*:

1. A moisture control section that, in normal years, is dry in all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 ^oC or higher; *and*

2. An aridic (or torric) soil moisture regime that borders on ustic.

Ustic Torripsamments

LCBF. Other Torripsamments that have *both*:

1. A moisture control section that, in normal years, is dry in all parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is 5 ^oC or higher; *and*

2. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) soil moisture regime that borders on xeric.

Xeric Torripsamments

LCBG. Other Torripsamments that have, in all horizons from a depth of 25 to 100 cm, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A color value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Torripsamments

LCBH. Other Torripsamments.

Typic Torripsamments

Udipsamments

Key to Subgroups

LCFA. Udipsamments that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Udipsamments

LCFB. Other Udipsamments that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Udipsamments

LCFC. Other Udipsamments that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Udipsamments

LCFD. Other Udipsamments that have a horizon, 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that meets *one or more* of the following:

1. In 25 percent or more of each pedon, is extremely weakly coherent or more coherent due to pedogenic cementation by organic matter and aluminum, with or without iron; *or*

2. Has Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. Has an ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Udipsamments

LCFE. Other Udipsamments that have lamellae within 200 cm of the mineral soil surface.

Lamellic Udipsamments

LCFF. Other Udipsamments that have a surface horizon between 25 and 50 cm thick that meets all of the requirements for a plaggen epipedon except thickness.

Haploplaggic Udipsamments

LCFG. Other Udipsamments.

Typic Udipsamments

Ustipsamments

Key to Subgroups

LCDA. Ustipsamments that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Ustipsamments

LCDB. Other Ustipsamments that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Ustipsamments

LCDC. Other Ustipsamments that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Ustipsamments

LCDD. Other Ustipsamments that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is moist in some or all parts for less than 180 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C.

Aridic Ustipsamments

LCDE. Other Ustipsamments that have lamellae within 200 cm of the mineral soil surface.

Lamellic Ustipsamments

LCDF. Other Ustipsamments that have, in all horizons from a depth of 25 to 100 cm, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A color value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Ustipsamments

LCDG. Other Ustipsamments.

Typic Ustipsamments

Xeropsamments

Key to Subgroups

LCEA. Xeropsamments that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Xeropsamments

LCEB. Other Xeropsamments that have *both*:

1. In one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Aquic Durinodic Xeropsamments

LCEC. Other Xeropsamments that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Xeropsamments

LCED. Other Xeropsammets that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Xeropsamments

LCEE. Other Xeropsamments that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction containing 5 percent or more volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Xeropsamments

LCEF. Other Xeropsamments that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Durinodic Xeropsamments

LCEG. Other Xeropsamments that have lamellae within 200 cm of the mineral soil surface.

Lamellic Xeropsamments

LCEH. Other Xeropsamments that have a base saturation (by NH_4OAc) of less than 60 percent in all horizons at a depth between 25 and 75 cm below the mineral soil surface or in the horizon directly above a root-limiting layer (defined in chapter 17) that is at a shallower depth.

Dystric Xeropsamments

LCEI. Other Xeropsamments.

Typic Xeropsamments

Wassents

Key to Great Groups

LAA. Wassents that have, in all horizons within 100 cm of the mineral soil surface, an electrical conductivity of less than 0.6 dS/m in a 1:5 (soil:water), by volume, supernatant (not extract).

Frasiwassents, p. 186

LAB. Other Wassents that have less than 35 percent (by volume) rock fragments and a texture class of loamy fine sand or coarser in all layers within the particle-size control section.

Psammowassents, p. 187

LAC. Other Wassents that have a horizon or horizons with a combined thickness of at least 15 cm within 50 cm of the mineral soil surface that contain sulfidic materials.

Sulfiwassents, p. 188

LAD. Other Wassents that have, in all horizons at a depth between 20 and 50 cm below the mineral soil surface, both an *n* value of more than 0.7 or a fluidity class of slighty fluid or higher and 8 percent or more clay in the fine-earth fraction.

Hydrowassents, p. 187

LAE. Other Wassents that have a total thickness of less than 50 cm of human-transported material in the surface horizons and *one or both* of the following:

1. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluviwassents, p. 186

LAF. Other Wassents.

Haplowassents, p. 187

Fluviwassents

Key to Subgroups

LAEA. Fluviwassents that have a horizon or horizons with a combined thickness of at least 15 cm within 100 cm of the mineral soil surface that contain sulfidic materials.

Sulfic Fluviwassents

LAEB. Other Fluviwassents that have a lithic contact within 100 cm of the mineral soil surface.

Lithic Fluviwassents

LAEC. Other Fluviwassents that have a buried layer of organic soil materials, 40 cm or more thick, within 200 cm of the mineral soil surface.

Thapto-Histic Fluviwassents

LAED. Other Fluviwassents that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Fluviwassents

LAEE. Other Fluviwassents that have chroma of 3 or more in 40 percent or more of the matrix of one or more horizons between a depth of 15 and 100 cm from the soil surface.

Aeric Fluviwassents

LAEF. Other Fluviwassents.

Typic Fluviwassents

Frasiwassents

Key to Subgroups

LAAA. Frasiwassents that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

2. In all horizons at a depth between 20 and 50 cm below the mineral soil surface, both an *n* value of more than 0.7 or a fluidity class slightly fluid or higher and 8 percent or more clay in the fine-earth fraction.

Humic Fluic Frasiwassents

LAAB. Other Frasiwassents that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Frasiwassents

LAAC. Other Frasiwassents that have, in all horizons at a depth between 20 and 50 cm below the mineral soil surface, both an *n* value of more than 0.7 or a fluidity class of slightly fluid or higher and 8 percent or more clay in the fine-earth fraction.

Fluic Frasiwassents

LAAD. Other Frasiwassents that have a lithic contact within 100 cm of the mineral soil surface.

Lithic Frasiwassents

LAAE. Other Frasiwassents that have less than 35 percent (by volume) rock fragments and a texture class of loamy fine sand or coarser in all layers within the particle-size control section.

Psammentic Frasiwassents

LAAF. Other Frasiwassents that have a buried layer of organic soil materials, 40 cm or more thick, within 200 cm of the mineral soil surface.

Thapto-Histic Frasiwassents

LAAG. Other Frasiwassents that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Frasiwassents

LAAH. Other Frasiwassents that have a total thickness of less than 50 cm of human-transported material in the surface horizons and *one or both* of the following:

1. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Frasiwassents

LAAI. Other Frasiwassents that have chroma of 3 or more in 40 percent or more of the matrix of one or more horizons between a depth of 15 and 100 cm from the soil surface.

Aeric Frasiwassents

LAAJ. Other Frasiwassents.

Typic Frasiwassents

Haplowassents

Key to Subgroups

LAFA. Haplowassents that have a horizon or horizons with a combined thickness of at least 15 cm within 100 cm of the mineral soil surface that contain sulfidic materials.

Sulfic Haplowassents

LAFB. Other Haplowassents that have a lithic contact within 100 cm of the mineral soil surface.

Lithic Haplowassents

LAFC. Other Haplowassents that have chroma of 3 or more in 40 percent or more of the matrix of one or more horizons between a depth of 15 and 100 cm from the soil surface.

Aeric Haplowassents

LAFD. Other Haplowassents.

Typic Haplowassents

Hydrowassents

Key to Subgroups

LADA. Hydrowassents that have a horizon or horizons with a combined thickness of at least 15 cm within 100 cm of the mineral soil surface that contain sulfidic materials.

Sulfic Hydrowassents

LADB. Other Hydrowassents that have, in all horizons at a depth between 20 and 100 cm below the mineral soil surface, both an *n* value of more than 0.7 or a fluidity class of slightly fluid or higher and 8 percent or more clay in the fine-earth fraction.

Grossic Hydrowassents

LADC. Other Hydrowassents that have a lithic contact within 100 cm of the mineral soil surface.

Lithic Hydrowassents

LADD. Other Hydrowassents that have a buried layer of organic soil materials, 40 cm or more thick, within 200 cm of the mineral soil surface.

Thapto-Histic Hydrowassents

LADE. Other Hydrowassents that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Hydrowassents

LADF. Other Hydrowassents.

Typic Hydrowassents

Psammowassents

Key to Subgroups

LABA. Psammowassents that have a horizon or horizons with a combined thickness of at least 15 cm within 100 cm of the mineral soil surface that contain sulfidic materials.

Sulfic Psammowassents

LABB. Other Psammowassents that have a lithic contact within 100 cm of the mineral soil surface.

Lithic Psammowassents

LABC. Other Psammowassents that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Psammowassents

LABD. Other Psammowassents that have a total thickness of less than 50 cm of human-transported material in the surface horizons and *one or both* of the following:

1. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Psammowassents

LABE. Other Psammowassents that have chroma of 3 or more in 40 percent or more of the matrix of one or more horizons between a depth of 15 and 100 cm from the soil surface.

Aeric Psammowassents

LABF. Other Psammowassents.

Typic Psammowassents

Sulfiwassents

Key to Subgroups

LACA. Sulfiwassents that have a lithic contact within 100 cm of the mineral soil surface.

Lithic Sulfiwassents

LACB. Other Sulfiwassents that have, in some horizons at a depth between 20 and 50 cm below the mineral soil surface, *either or both*:

1. An *n* value of 0.7 or less or a fluidity class of nonfluid; *or*

2. Less than 8 percent clay in the fine-earth fraction.

Haplic Sulfiwassents

LACC. Other Sulfiwassents that have a buried layer of organic soil materials, 40 cm or more thick, within 200 cm of the mineral soil surface.

Thapto-Histic Sulfiwassents

LACD. Other Sulfiwassents that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Sulfiwassents

LACE. Other Sulfiwassents that have a total thickness of less than 50 cm of human-transported material in the surface horizons and *one or both* of the following:

1. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Sulfiwassents

LACF. Other Sulfiwassents that have chroma of 3 or more in 40 percent or more of the matrix of one or more horizons between a depth of 15 and 100 cm from the soil surface.

Aeric Sulfiwassents

LACG. Other Sulfiwassents.

Typic Sulfiwassents

CHAPTER 9

Gelisols

Key to Suborders

AA. Gelisols that have organic soil materials that meet *one or more* of the following:

1. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

2. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

3. Comprise 80 percent or more, by volume, from the soil surface to a depth of 50 cm or to a glacic layer or a densic, lithic, or paralithic contact, whichever is shallower.

Histels[*], p. 189

AB. Other Gelisols that have one or more horizons showing cryoturbation in the form of irregular, broken, or distorted horizon boundaries, involutions, the accumulation of organic matter on top of the permafrost, ice or sand wedges, and oriented rock fragments.

Turbels, p. 195

AC. Other Gelisols.

Orthels, p. 191

Histels

Key to Great Groups

AAA. Histels that are saturated with water for less than 30 cumulative days during normal years (and are not artificially drained).

Folistels, p. 190

AAB. Other Histels that are saturated with water for 30 or more cumulative days during normal years and that have *both*:

1. A glacic layer within 100 cm of the soil surface; *and*

2. Less than three-fourths (by volume) *Sphagnum* fibers in the organic soil material to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Glacistels, p. 190

AAC. Other Histels that have a greater thickness of fibric soil materials than any other kind of organic soil material to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Fibristels, p. 189

AAD. Other Histels that have a greater thickness of hemic soil materials than any other kind of organic soil material to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Hemistels, p. 190

AAE. Other Histels.

Sapristels, p. 190

Fibristels

Key to Subgroups

AACA. Fibristels that have a lithic contact within 100 cm of the soil surface.

Lithic Fibristels

AACB. Other Fibristels that have a layer of mineral soil material 30 cm or more thick within 100 cm of the soil surface.

Terric Fibristels

AACC. Other Fibristels that meet *one* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Fibristels

GEL

[*] When the Gelisols order was adopted in 1998 there was debate about whether these organic soils with permafrost should be in the Gelisols order (Histels) or remain as Histosols (with a new suborder "Gelists"). It was decided that the presence of permafrost was the most significant feature for understanding and interpreting these soils, so they are included here.

AACD. Other Fibristels that meet *both* of the following:

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have, within the organic soil materials, either one layer of mineral soil material 5 cm or more thick or two or more layers of any thickness within 100 cm of the soil surface.

Fluvaquentic Fibristels

AACE. Other Fibristels in which three-fourths or more (by volume) of the fibric soil materials are derived from *Sphagnum* to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Sphagnic Fibristels

AACF. Other Fibristels.

Typic Fibristels

Folistels

Key to Subgroups

AAAA. Folistels that have a lithic contact within 50 cm of the soil surface.

Lithic Folistels

AAAB. Other Folistels that have a glacic layer within 100 cm of the soil surface.

Glacic Folistels

AAAC. Other Folistels.

Typic Folistels

Glacistels

Key to Subgroups

AABA. Glacistels that have a greater thickness of hemic soil materials than any other kind of organic soil material in the upper 50 cm.

Hemic Glacistels

AABB. Other Glacistels that have a greater thickness of sapric soil materials than any other kind of organic soil material in the upper 50 cm.

Sapric Glacistels

AABC. Other Glacistels.

Typic Glacistels

Hemistels

Key to Subgroups

AADA. Hemistels that have a lithic contact within 100 cm of the soil surface.

Lithic Hemistels

AADB. Other Hemistels that have one or more limnic layers with a total thickness of 5 cm or more within the control section.

Limnic Hemistels

AADC. Other Hemistels that have a layer of mineral soil material 30 cm or more thick within 100 cm of the soil surface.

Terric Hemistels

AADD. Other Hemistels that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Hemistels

AADE. Other Hemistels that meet *both* of the following:

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have, within the organic soil materials, either one layer of mineral soil material 5 cm or more thick or two or more layers of any thickness within 100 cm of the soil surface.

Fluvaquentic Hemistels

AADF. Other Hemistels.

Typic Hemistels

Sapristels

Key to Subgroups

AAEA. Sapristels that have a lithic contact within 100 cm of the soil surface.

Lithic Sapristels

AAEB. Other Sapristels that have one or more limnic layers with a total thickness of 5 cm or more within the control section.

Limnic Sapristels

AAEC. Other Sapristels that have a layer of mineral soil material 30 cm or more thick within 100 cm of the soil surface.

Terric Sapristels

AAED. Other Sapristels that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Sapristels

AAEE. Other Sapristels that meet *both* of the following:

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have, within the organic soil materials, either one layer of mineral soil material 5 cm or more thick or two or more layers of any thickness within 100 cm of the soil surface.

Fluvaquentic Sapristels

AAEF. Other Sapristels.

Typic Sapristels

Orthels

Key to Great Groups

ACA. Orthels that have a histic epipedon.

Historthels, p. 193

ACB. Other Orthels that have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years (or artificial drainage).

Aquorthels, p. 191

ACC. Other Orthels that have anhydrous conditions.

Anhyorthels, p. 191

ACD. Other Orthels that have a mollic epipedon.

Mollorthels, p. 194

ACE. Other Orthels that have an umbric epipedon.

Umbrorthels, p. 195

ACF. Other Orthels that have an argillic horizon within 100 cm of the mineral soil surface.

Argiorthels, p. 192

ACG. Other Orthels that have, below the Ap horizon or below a depth of 25 cm, whichever is deeper, less than 35 percent (by volume) rock fragments and a texture class of loamy fine sand or coarser in all layers within the particle-size control section.

Psammorthels, p. 194

ACH. Other Orthels.

Haplorthels, p. 192

Anhyorthels

Key to Subgroups

ACCA. Anhyorthels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Anhyorthels

ACCB. Other Anhyorthels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Anhyorthels

ACCC. Other Anhyorthels that have a petrogypsic horizon within 100 cm of the mineral soil surface.

Petrogypsic Anhyorthels

ACCD. Other Anhyorthels that have a gypsic horizon within 100 cm of the mineral soil surface.

Gypsic Anhyorthels

ACCE. Other Anhyorthels that have *both* of the following:

1. A horizon 15 cm or more thick that has a nitrate concentration of 118 mmol(-)/L or more in a 1:5 soil:water extract; *and*

2. The product of horizon thickness (in cm) times nitrate concentration [in mmol(-)/L] is 3,500 or more.

Nitric Anhyorthels

ACCF. Other Anhyorthels that have a salic horizon within 100 cm of the mineral soil surface.

Salic Anhyorthels

ACCG. Other Anhyorthels that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Anhyorthels

ACCH. Other Anhyorthels.

Typic Anhyorthels

Aquorthels

Key to Subgroups

ACBA. Aquorthels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Aquorthels

ACBB. Other Aquorthels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Aquorthels

ACBC. Other Aquorthels that have a sulfuric horizon or sulfidic materials within 100 cm of the mineral soil surface.

Sulfuric Aquorthels

ACBD. Other Aquorthels that have *either*:

1. Organic soil materials that are discontinuous at the surface; *or*

2. Organic soil materials at the surface that change in thickness fourfold or more within a pedon.

Ruptic-Histic Aquorthels

ACBE. Other Aquorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Aquorthels

ACBF. Other Aquorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Aquorthels

ACBG. Other Aquorthels that have a salic horizon within 100 cm of the mineral soil surface.

Salic Aquorthels

ACBH. Other Aquorthels that have less than 35 percent (by volume) rock fragments and a texture class of loamy fine sand or coarser in all layers within the particle-size control section.

Psammentic Aquorthels

ACBI. Other Aquorthels that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Aquorthels

ACBJ. Other Aquorthels that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Aquorthels

ACBK. Other Aquorthels.

Typic Aquorthels

Argiorthels

Key to Subgroups

ACFA. Argiorthels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Argiorthels

ACFB. Other Argiorthels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Argiorthels

ACFC. Other Argiorthels that have a natric horizon.

Natric Argiorthels

ACFD. Other Argiorthels.

Typic Argiorthels

Haplorthels

Key to Subgroups

ACHA. Haplorthels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplorthels

ACHB. Other Haplorthels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Haplorthels

ACHC. Other Haplorthels that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Haplorthels

ACHD. Other Haplorthels that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Haplorthels

ACHE. Other Haplorthels that have a folistic epipedon.

Folistic Haplorthels

ACHF. Other Haplorthels that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time during normal years (or artificial drainage).

Aquic Haplorthels

ACHG. Other Haplorthels that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Haplorthels

ACHH. Other Haplorthels.

Typic Haplorthels

Historthels

Key to Subgroups

ACAA. Historthels that have a lithic contact within 50 cm of the soil surface.

Lithic Historthels

ACAB. Other Historthels that have a glacic layer within 100 cm of the soil surface.

Glacic Historthels

ACAC. Other Historthels that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Historthels

ACAD. Other Historthels that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Historthels

ACAE. Other Historthels that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Historthels

ACAF. Other Historthels that have more than 40 percent, by volume, organic soil materials from the soil surface to a depth of 50 cm in 75 percent or less of the pedon.

Ruptic Historthels

ACAG. Other Historthels.

Typic Historthels

Mollorthels

Key to Subgroups

ACDA. Mollorthels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Mollorthels

ACDB. Other Mollorthels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Mollorthels

ACDC. Other Mollorthels that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time during normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Mollorthels

ACDD. Other Mollorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Mollorthels

ACDE. Other Mollorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Mollorthels

ACDF. Other Mollorthels that have a folistic epipedon.

Folistic Mollorthels

ACDG. Other Mollorthels that have *both*:

1. A mollic epipedon that is 40 cm or more thick with a texture class finer than loamy fine sand; *and*

2. A slope of less than 25 percent.

Cumulic Mollorthels

ACDH. Other Mollorthels that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years (or artificial drainage).

Aquic Mollorthels

ACDI. Other Mollorthels.

Typic Mollorthels

Psammorthels

Key to Subgroups

ACGA. Psammorthels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Psammorthels

ACGB. Other Psammorthels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Psammorthels

ACGC. Other Psammorthels that have a horizon 5 cm or more thick that has *one or more* of the following:

1. In 25 percent or more of each pedon, is extremely weakly coherent or more coherent due to pedogenic cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Psammorthels

ACGD. Other Psammorthels.

Typic Psammorthels

Umbrorthels

Key to Subgroups

ACEA. Umbrorthels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Umbrorthels

ACEB. Other Umbrorthels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Umbrorthels

ACEC. Other Umbrorthels that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time during normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Umbrorthels

ACED. Other Umbrorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Umbrorthels

ACEE. Other Umbrorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Umbrorthels

ACEF. Other Umbrorthels that have a folistic epipedon.

Folistic Umbrorthels

ACEG. Other Umbrorthels that have *both*:

1. An umbric epipedon that is 40 cm or more thick with a texture class finer than loamy fine sand; *and*

2. A slope of less than 25 percent.

Cumulic Umbrorthels

ACEH. Other Umbrorthels that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years (or artificial drainage).

Aquic Umbrorthels

ACEI. Other Umbrorthels.

Typic Umbrorthels

Turbels

Key to Great Groups

ABA. Turbels that have, in 30 percent or more of the pedon, more than 40 percent, by volume, organic soil materials from the soil surface to a depth of 50 cm which meet the saturation requirement for a histic epipedon.

Histoturbels, p. 196

ABB. Other Turbels that have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years (or artificial drainage).

Aquiturbels, p. 196

ABC. Other Turbels that have anhydrous conditions.

Anhyturbels, p. 196

ABD. Other Turbels that have a mollic epipedon.

Molliturbels, p. 197

ABE. Other Turbels that have an umbric epipedon.

Umbriturbels, p. 198

ABF. Other Turbels that have less than 35 percent (by volume) rock fragments and a texture class of loamy fine sand or coarser in all layers within the particle-size control section.

Psammoturbels, p. 197

ABG. Other Turbels.

Haploturbels, p. 196

Anhyturbels

Key to Subgroups

ABCA. Anhyturbels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Anhyturbels

ABCB. Other Anhyturbels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Anhyturbels

ABCC. Other Anhyturbels that have a petrogypsic horizon within 100 cm of the mineral soil surface.

Petrogypsic Anhyturbels

ABCD. Other Anhyturbels that have a gypsic horizon within 100 cm of the mineral soil surface.

Gypsic Anhyturbels

ABCE. Other Anhyturbels that have *both* of the following:

1. A horizon 15 cm or more thick that has a nitrate concentration of 118 mmol(-)/L or more in a 1:5 soil:water extract; *and*

2. The product of horizon thickness (in cm) times nitrate concentration [in mmol(-)/L] is 3,500 or more.

Nitric Anhyturbels

ABCF. Other Anhyturbels that have a salic horizon within 100 cm of the mineral soil surface.

Salic Anhyturbels

ABCG. Other Anhyturbels that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Anhyturbels

ABCH. Other Anhyturbels.

Typic Anhyturbels

Aquiturbels

Key to Subgroups

ABBA. Aquiturbels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Aquiturbels

ABBB. Other Aquiturbels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Aquiturbels

ABBC. Other Aquiturbels that have a sulfuric horizon or sulfidic materials within 100 cm of the mineral soil surface.

Sulfuric Aquiturbels

ABBD. Other Aquiturbels that have *either*:

1. Organic soil materials that are discontinuous at the surface; *or*

2. Organic soil materials at the surface that change in thickness fourfold or more within a pedon.

Ruptic-Histic Aquiturbels

ABBE. Other Aquiturbels that have less than 35 percent (by volume) rock fragments and a texture class of loamy fine sand or coarser in all layers within the particle-size control section.

Psammentic Aquiturbels

ABBF. Other Aquiturbels.

Typic Aquiturbels

Haploturbels

Key to Subgroups

ABGA. Haploturbels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haploturbels

ABGB. Other Haploturbels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Haploturbels

ABGC. Other Haploturbels that have a folistic epipedon.

Folistic Haploturbels

ABGD. Other Haploturbels that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years (or artificial drainage).

Aquic Haploturbels

ABGE. Other Haploturbels.

Typic Haploturbels

Histoturbels

Key to Subgroups

ABAA. Histoturbels that have a lithic contact within 50 cm of the soil surface.

Lithic Histoturbels

ABAB. Other Histoturbels that have a glacic layer within 100 cm of the soil surface.

Glacic Histoturbels

ABAC. Other Histoturbels that have more than 40 percent, by volume, organic soil materials from the soil surface to a depth of 50 cm in 75 percent or less of the pedon.

Ruptic Histoturbels

ABAD. Other Histoturbels.

Typic Histoturbels

Molliturbels

Key to Subgroups

ABDA. Molliturbels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Molliturbels

ABDB. Other Molliturbels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Molliturbels

ABDC. Other Molliturbels that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time during normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Molliturbels

ABDD. Other Molliturbels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Molliturbels

ABDE. Other Molliturbels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Molliturbels

ABDF. Other Molliturbels that have a folistic epipedon.

Folistic Molliturbels

ABDG. Other Molliturbels that have *both*:

1. A mollic epipedon that is 40 cm or more thick with a texture class finer than loamy fine sand; *and*

2. A slope of less than 25 percent.

Cumulic Molliturbels

ABDH. Other Molliturbels that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years (or artificial drainage).

Aquic Molliturbels

ABDI. Other Molliturbels.

Typic Molliturbels

Psammoturbels

Key to Subgroups

ABFA. Psammoturbels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Psammoturbels

ABFB. Other Psammoturbels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Psammoturbels

ABFC. Other Psammoturbels that have a horizon 5 cm or more thick that has *one or more* of the following:

1. In 25 percent or more of each pedon, is extremely weakly coherent or more coherent due to pedogenic cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Psammoturbels

ABFD. Other Psammoturbels.

Typic Psammoturbels

Umbriturbels

Key to Subgroups

ABEA. Umbriturbels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Umbriturbels

ABEB. Other Umbriturbels that have a glacic layer within 100 cm of the mineral soil surface.

Glacic Umbriturbels

ABEC. Other Umbriturbels that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time during normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Umbriturbels

ABED. Other Umbriturbels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Umbriturbels

ABEE. Other Umbriturbels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Umbriturbels

ABEF. Other Umbriturbels that have a folistic epipedon.

Folistic Umbriturbels

ABEG. Other Umbriturbels that have *both*:

1. An umbric epipedon that is 40 cm or more thick with a texture class finer than loamy fine sand; *and*

2. A slope of less than 25 percent.

Cumulic Umbriturbels

ABEH. Other Umbriturbels that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years (or artificial drainage).

Aquic Umbriturbels

ABEI. Other Umbriturbels.

Typic Umbriturbels

CHAPTER 10

Histosols

Key to Suborders

BA. Histosols that are saturated with water for less than 30 cumulative days during normal years (and are not artificially drained).

Folists, p. 200

BB. Other Histosols that have a field observable water table 2 cm or more above the soil surface for more than 21 hours of each day in all years.

Wassists, p. 203

BC. Other Histosols that:

1. Meet *either* of the following:

a. *If* there is no continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of fibric soil materials than any other kind of organic soil materials in the organic parts of the subsurface tier; *or*

b. *If* there is a continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of fibric soil materials than any other kind of organic soil materials in the combined thickness of the organic parts of the surface and subsurface tiers; *and*

2. Do not have a sulfuric horizon within 50 cm of the soil surface; *and*

3. Do not have sulfidic materials within 100 cm of the soil surface.

Fibrists, p. 199

BD. Other Histosols that meet *either* of the following:

1. *If* there is no continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of sapric soil materials than any other kind of organic soil materials in the organic parts of the subsurface tier; *or*

2. *If* there is a continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of sapric soil materials than any other kind of organic soil materials in the combined thickness of the organic parts of the surface and subsurface tiers.

Saprists, p. 202

BE. Other Histosols.

Hemists, p. 201

Fibrists

Key to Great Groups

BCA. Fibrists that have a cryic soil temperature regime.

Cryofibrists, p. 199

BCB. Other Fibrists in which *Sphagnum* fibers constitute three-fourths or more of the volume to *either*:

1. A depth of 90 cm from the soil surface; *or*

2. To a densic, lithic, or paralithic contact, fragmental materials, or other mineral soil materials if at a depth of less than 90 cm.

Sphagnofibrists, p. 200

BCC. Other Fibrists.

Haplofibrists, p. 200

Cryofibrists

Key to Subgroups

BCAA. Cryofibrists that have a layer of water within the control section, below the surface tier.

Hydric Cryofibrists

BCAB. Other Cryofibrists that have a lithic contact at the lower boundary of the control section.

Lithic Cryofibrists

BCAC. Other Cryofibrists that have a layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Cryofibrists

BCAD. Other Cryofibrists that meet *both* of the following:

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have, within the organic soil materials, either one layer of mineral soil material 5 cm or more thick or two or more layers of mineral soil material of any thickness in the control section, below the surface tier.

Fluvaquentic Cryofibrists

BCAE. Other Cryofibrists in which three-fourths or more of the fiber volume in the surface tier is derived from *Sphagnum*.

Sphagnic Cryofibrists

BCAF. Other Cryofibrists.

Typic Cryofibrists

Haplofibrists

Key to Subgroups

BCCA. Haplofibrists that have a layer of water within the control section, below the surface tier.

Hydric Haplofibrists

BCCB. Other Haplofibrists that have a lithic contact at the lower boundary of the control section.

Lithic Haplofibrists

BCCC. Other Haplofibrists that have one or more limnic layers with a total thickness of 5 cm or more within the control section.

Limnic Haplofibrists

BCCD. Other Haplofibrists that have a layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Haplofibrists

BCCE. Other Haplofibrists that meet *both* of the following:

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have, within the organic soil materials, either one layer of mineral soil material 5 cm or more thick or two or more layers of mineral soil material of any thickness in the control section, below the surface tier.

Fluvaquentic Haplofibrists

BCCF. Other Haplofibrists that have one or more layers of hemic and sapric materials with a total thickness of 25 cm or more in the control section, below the surface tier.

Hemic Haplofibrists

BCCG. Other Haplofibrists.

Typic Haplofibrists

Sphagnofibrists

Key to Subgroups

BCBA. Sphagnofibrists that have a layer of water within the control section, below the surface tier.

Hydric Sphagnofibrists

BCBB. Other Sphagnofibrists that have a lithic contact at the lower boundary of the control section.

Lithic Sphagnofibrists

BCBC. Other Sphagnofibrists that have one or more limnic layers with a total thickness of 5 cm or more within the control section.

Limnic Sphagnofibrists

BCBD. Other Sphagnofibrists that have a layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Sphagnofibrists

BCBE. Other Sphagnofibrists that meet *both* of the following:

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have, within the organic soil materials, either one layer of mineral soil material 5 cm or more thick or two or more layers of mineral soil material of any thickness in the control section, below the surface tier.

Fluvaquentic Sphagnofibrists

BCBF. Other Sphagnofibrists that have one or more layers of hemic and sapric materials with a total thickness of 25 cm or more in the control section, below the surface tier.

Hemic Sphagnofibrists

BCBG. Other Sphagnofibrists.

Typic Sphagnofibrists

Folists

Key to Great Groups

BAA. Folists that have a cryic soil temperature regime.

Cryofolists, p. 201

BAB. Other Folists that have an aridic (or torric) soil moisture regime.

Torrifolists, p. 201

BAC. Other Folists that have an ustic or xeric soil moisture regime.

Ustifolists, p. 201

BAD. Other Folists.
Udifolists, p. 201

Cryofolists

Key to Subgroups

BAAA. Cryofolists that have a lithic contact within 50 cm of the soil surface.
Lithic Cryofolists

BAAB. Other Cryofolists.
Typic Cryofolists

Torrifolists

Key to Subgroups

BABA. Torrifolists that have a lithic contact within 50 cm of the soil surface.
Lithic Torrifolists

BABB. Other Torrifolists.
Typic Torrifolists

Udifolists

Key to Subgroups

BADA. Udifolists that have a lithic contact within 50 cm of the soil surface.
Lithic Udifolists

BADB. Other Udifolists.
Typic Udifolists

Ustifolists

Key to Subgroups

BACA. Ustifolists that have a lithic contact within 50 cm of the soil surface.
Lithic Ustifolists

BACB. Other Ustifolists.
Typic Ustifolists

Hemists

Key to Great Groups

BEA. Hemists that have a sulfuric horizon within 50 cm of the soil surface.
Sulfohemists, p. 202

BEB. Other Hemists that have sulfidic materials within 100 cm of the soil surface.
Sulfihemists, p. 202

BEC. Other Hemists that have a horizon 2 cm or more thick in which humilluvic material constitutes one-half or more of the volume.
Luvihemists, p. 202

BED. Other Hemists that have a cryic soil temperature regime.
Cryohemists, p. 201

BEE. Other Hemists.
Haplohemists, p. 201

Cryohemists

Key to Subgroups

BEDA. Cryohemists that have a layer of water within the control section, below the surface tier.
Hydric Cryohemists

BEDB. Other Cryohemists that have a lithic contact at the lower boundary of the control section.
Lithic Cryohemists

BEDC. Other Cryohemists that have a layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.
Terric Cryohemists

BEDD. Other Cryohemists that meet *both* of the following:

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have, within the organic soil materials, either one layer of mineral soil material 5 cm or more thick or two or more layers of mineral soil material of any thickness in the control section, below the surface tier.
Fluvaquentic Cryohemists

BEDE. Other Cryohemists.
Typic Cryohemists

Haplohemists

Key to Subgroups

BEEA. Haplohemists that have a layer of water within the control section, below the surface tier.
Hydric Haplohemists

BEEB. Other Haplohemists that have a lithic contact at the lower boundary of the control section.

Lithic Haplohemists

BEEC. Other Haplohemists that have one or more limnic layers with a total thickness of 5 cm or more within the control section.

Limnic Haplohemists

BEED. Other Haplohemists that have a layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Haplohemists

BEEE. Other Haplohemists that meet *both* of the following:

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have, within the organic soil materials, either one layer of mineral soil material 5 cm or more thick or two or more layers of mineral soil material of any thickness in the control section, below the surface tier.

Fluvaquentic Haplohemists

BEEF. Other Haplohemists that have one or more layers of fibric materials with a total thickness of 25 cm or more in the control section, below the surface tier.

Fibric Haplohemists

BEEG. Other Haplohemists that have one or more layers of sapric materials with a total thickness of 25 cm or more below the surface tier.

Sapric Haplohemists

BEEH. Other Haplohemists.

Typic Haplohemists

Luvihemists

Key to Subgroups

BECA. All Luvihemists (provisionally).

Typic Luvihemists

Sulfihemists

Key to Subgroups

BEBA. Sulfihemists that have a layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Sulfihemists

BEBB. Other Sulfihemists.

Typic Sulfihemists

Sulfohemists

Key to Subgroups

BEAA. All Sulfohemists (provisionally).

Typic Sulfohemists

Saprists

Key to Great Groups

BDA. Saprists that have a sulfuric horizon within 50 cm of the soil surface.

Sulfosaprists, p. 203

BDB. Other Saprists that have sulfidic materials within 100 cm of the soil surface.

Sulfisaprists, p. 203

BDC. Other Saprists that have a cryic soil temperature regime.

Cryosaprists, p. 202

BDD. Other Saprists.

Haplosaprists, p. 203

Cryosaprists

Key to Subgroups

BDCA. Cryosaprists that have a lithic contact at the lower boundary of the control section.

Lithic Cryosaprists

BDCB. Other Cryosaprists that have one or more limnic layers with a total thickness of 5 cm or more within the control section.

Limnic Cryosaprists

BDCC. Other Cryosaprists that have a layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Cryosaprists

BDCD. Other Cryosaprists that meet *both* of the following:

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have, within the organic soil materials, either one layer of mineral soil material 5 cm or more thick or two or more layers of mineral soil material of any thickness in the control section, below the surface tier.

Fluvaquentic Cryosaprists

BDCE. Other Cryosaprists.

Typic Cryosaprists

Haplosaprists

Key to Subgroups

BDDA. Haplosaprists that have a lithic contact at the lower boundary of the control section.

Lithic Haplosaprists

BDDB. Other Haplosaprists that have one or more limnic layers with a total thickness of 5 cm or more within the control section.

Limnic Haplosaprists

BDDC. Other Haplosaprists that have *both*:

1. Throughout a layer 30 cm or thick that has its upper boundary within the control section, an electrical conductivity of 30 dS/m or more (1:1 soil:water) for 6 months or more during normal years; *and*

2. A layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Halic Terric Haplosaprists

BDDD. Other Haplosaprists that have, throughout a layer 30 cm or thick that has its upper boundary within the control section, an electrical conductivity of 30 dS/m or more (1:1 soil:water) for 6 months or more during normal years.

Halic Haplosaprists

BDDE. Other Haplosaprists that have a layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Haplosaprists

BDDF. Other Haplosaprists that meet *both* of the following:

1. Have a total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

2. Have, within the organic soil materials, either one layer of mineral soil material 5 cm or more thick or two or more layers of mineral soil material of any thickness in the control section, below the surface tier.

Fluvaquentic Haplosaprists

BDDG. Other Haplosaprists that have one or more layers of fibric or hemic materials with a total thickness of 25 cm or more in the control section, below the surface tier.

Hemic Haplosaprists

BDDH. Other Haplosaprists.

Typic Haplosaprists

Sulfisaprists

Key to Subgroups

BDBA. Sulfisaprists that have a lithic contact at the lower boundary of the control section.

Lithic Sulfisaprists

BDBB. Other Sulfisaprists that have a layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Sulfisaprists

BDBC. Other Sulfisaprists.

Typic Sulfisaprists

Sulfosaprists

Key to Subgroups

BDAA. All Sulfosaprists (provisionally).

Typic Sulfosaprists

Wassists

Key to Great Groups

BBA. Wassists that have, in all horizons within 100 cm of the soil surface, an electrical conductivity of less than 0.6 dS/m in a 1:5 (soil:water), by volume, supernatant (not extract).

Frasiwassists, p. 203

BBB. Other Wassists that have a horizon or horizons, with a combined thickness of at least 15 cm within 50 cm of the soil surface, that contain sulfidic materials.

Sulfiwassists, p. 204

BBC. Other Wassists.

Haplowassists, p. 204

Frasiwassists

Key to Subgroups

BBAA. Frasiwassists that have a layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Frasiwassists

BBAB. Other Frasiwassists that:

1. Have *either*:

a. *If* there is no continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* a greater thickness of fibric soil materials than any other kind of organic soil materials in the organic parts of the subsurface tier; *or*

b. *If* there is a continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* a greater thickness of fibric soil materials than any other kind of organic soil materials in the combined thickness of the organic parts of the surface and subsurface tiers; *and*

2. Do not have sulfidic materials within 100 cm of the soil surface.

Fibric Frasiwassists

BBAC. Other Frasiwassists that meet *either* of the following:

1. *If* there is no continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of sapric soil materials than any other kind of organic soil materials in the organic parts of the subsurface tier; *or*

2. *If* there is a continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of sapric soil materials than any other kind of organic soil materials in the combined thickness of the organic parts of the surface and subsurface tiers.

Sapric Frasiwassists

BBAD. Other Frasiwassists.

Typic Frasiwassists

Haplowassists

Key to Subgroups

BBCA. Haplowassists that have a horizon or horizons, with a combined thickness of 15 cm within 100 cm of the soil surface, that contain sulfidic materials.

Sulfic Haplowassists

BBCB. Other Haplowassists that have a layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Haplowassists

BBCC. Other Haplowassists that meet *either* of the following:

1. *If* there is no continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of fibric soil materials than any other kind of organic soil materials in the organic parts of the subsurface tier; *or*

2. *If* there is a continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of fibric soil materials than any other kind of organic soil materials in the combined thickness of the organic parts of the surface and subsurface tiers.

Fibric Haplowassists

BBCD. Other Haplowassists that meet *either* of the following:

1. *If* there is no continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of sapric soil materials than any other kind of organic soil materials in the organic parts of the subsurface tier; *or*

2. *If* there is a continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of sapric soil materials than any other kind of organic soil materials in the combined thickness of the organic parts of the surface and subsurface tiers.

Sapric Haplowassists

BBCE. Other Haplowassists.

Typic Haplowassists

Sulfiwassists

Key to Subgroups

BBBA. Sulfiwassists that have a layer of mineral soil material 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Sulfiwassists

BBBB. Other Sulfiwassists that meet *either* of the following:

1. *If* there is no continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of fibric soil materials than any other kind of organic soil materials in the organic parts of the subsurface tier; *or*

2. *If* there is a continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of fibric soil materials than any other kind of organic soil materials in the combined thickness of the organic parts of the surface and subsurface tiers.

Fibric Sulfiwassists

BBBC. Other Sulfiwassists that meet *either* of the following:

1. *If* there is no continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the

subsurface tier, *then* have a greater thickness of sapric soil materials than any other kind of organic soil materials in the organic parts of the subsurface tier; *or*

2. *If* there is a continuous layer of mineral soil material 40 cm or more thick that has its upper boundary within the subsurface tier, *then* have a greater thickness of sapric soil materials than any other kind of organic soil materials in the combined thickness of the organic parts of the surface and subsurface tiers.

Sapric Sulfiwassists

BBBD. Other Sulfiwassists.

Typic Sulfiwassists

CHAPTER 11

Inceptisols

Key to Suborders

KA. Inceptisols that have *one or more* of the following:

1. In a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm from the mineral soil surface, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

a. A histic epipedon; *or*

b. A sulfuric horizon within 50 cm of the mineral soil surface; *or*

c. A layer directly under the epipedon, or within 50 cm of the mineral soil surface, that has, on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

(1) 2 or less if there are redox concentrations; *or*

(2) 1 or less; *or*

d. Within 50 cm of the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated; *or*

2. An exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in half or more of the soil volume within 50 cm of the mineral soil surface, a decrease in ESP (or SAR) values with increasing depth below 50 cm, and ground water within 100 cm of the mineral soil surface for some time during the year.

Aquepts, p. 207

KB. Other Inceptisols that have a gelic soil temperature regime.

Gelepts, p. 221

KC. Other Inceptisols that have a cryic soil temperature regime.

Cryepts, p. 215

KD. Other Inceptisols that have an ustic soil moisture regime.

Ustepts, p. 231

KE. Other Inceptisols that have a xeric soil moisture regime.

Xerepts, p. 239

KF. Other Inceptisols.

Udepts, p. 223

Aquepts

Key to Great Groups

KAA. Aquepts that have a sulfuric horizon within 50 cm of the mineral soil surface.

Sulfaquepts, p. 214

KAB. Other Aquepts that have, within 100 cm of the mineral soil surface, one or more horizons in which plinthite or a diagnostic horizon that is extremely weakly coherent or more coherent due to pedogenic cementation either forms a continuous phase or constitutes one-half or more of the volume.

Petraquepts, p. 214

KAC. Other Aquepts that have *either*:

1. A salic horizon; *or*

2. In one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, an exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) and a decrease in ESP (or SAR) values with increasing depth below 50 cm.

Halaquepts, p. 213

KAD. Other Aquepts that have a fragipan within 100 cm of the mineral soil surface.

Fragiaquepts, p. 212

KAE. Other Aquepts that have a geogenic densic contact within 100 cm of the mineral soil surface.

Densiaquepts, p. 209

KAF. Other Aquepts that have a gelic soil temperature regime.

Gelaquepts, p. 212

KAG. Other Aquepts that have a cryic soil temperature regime.

Cryaquepts, p. 208

KAH. Other Aquepts that have, in one or more layers at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts.

Vermaquepts, p. 214

KAI. Other Aquepts that have a histic, melanic, mollic, or umbric epipedon.

Humaquepts, p. 213

KAJ. Other Aquepts that have episaturation.

Epiaquepts, p. 211

KAK. Other Aquepts.

Endoaquepts, p. 209

Cryaquepts

Key to Subgroups

KAGA. Cryaquepts that have, within 150 cm of the mineral soil surface, *one or more* of the following:

1. A sulfuric horizon; *or*

2. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0 and does not have sulfide or other sulfur-bearing minerals; *or*

3. Sulfidic materials.

Sulfic Cryaquepts

KAGB. Other Cryaquepts that have both a histic epipedon and a lithic contact within 50 cm of the mineral soil surface.

Histic Lithic Cryaquepts

KAGC. Other Cryaquepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Cryaquepts

KAGD. Other Cryaquepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Cryaquepts

KAGE. Other Cryaquepts that have a histic epipedon.

Histic Cryaquepts

KAGF. Other Cryaquepts that have one or more limnic layers with a total thickness of 12.5 centimeters or more beginning at or within 100 centimeters of the soil surface.

Limnic Cryaquepts

KAGG. Other Cryaquepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Cryaquepts

KAGH. Other Cryaquepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Cryaquepts

KAGI. Other Cryaquepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

   a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

   b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Cryaquepts

KAGJ. Other Cryaquepts that have *both*:

1. Chroma of 3 or more in 40 percent or more of the matrix of one or more horizons at a depth between 15 and 50 cm from the mineral soil surface; *and*

2. A mollic or umbric epipedon.

Aeric Humic Cryaquepts

KAGK. Other Cryaquepts that have chroma of 3 or more in 40 percent or more of the matrix of one or more horizons at a depth between 15 and 50 cm from the mineral soil surface.

Aeric Cryaquepts

KAGL. Other Cryaquepts that have a mollic or umbric epipedon.

Humic Cryaquepts

KAGM. Other Cryaquepts.

Typic Cryaquepts

Densiaquepts

Key to Subgroups

KAEA. Densiaquepts that have, in 50 percent or more of the matrix of one or more horizons, *either* between the plow layer and a depth of 75 cm below the mineral soil surface, or if there is no plow layer, between depths of 15 and 75 cm, chroma of *either*:

1. 3 or more; *or*

2. 2 or more if there are no redox concentrations.

Aeric Densiaquepts

KAEB. Other Densiaquepts that have a histic, mollic, or umbric epipedon.

Humic Densiaquepts

KAEC. Other Densiaquepts.

Typic Densiaquepts

Endoaquepts

Key to Subgroups

KAKA. Endoaquepts that have, within 150 cm of the mineral soil surface, *one or more* of the following:

1. A sulfuric horizon; *or*

2. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0 and does not have sulfide or other sulfur-bearing minerals; *or*

3. Sulfidic materials.

Sulfic Endoaquepts

KAKB. Other Endoaquepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Endoaquepts

KAKC. Other Endoaquepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Endoaquepts

KAKD. Other Endoaquepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Endoaquepts

KAKE. Other Endoaquepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a

combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Endoaquepts

KAKF. Other Endoaquepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, *one* of the following colors:

a. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

(1) If peds are present, either chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. In 50 percent or more of the matrix, hue of 10YR or yellower; *and either*

(1) Both a color value, moist, and chroma of 3 or more; *or*

(2) Chroma of 2 or more if there are no redox concentrations; *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Endoaquepts

KAKG. Other Endoaquepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Endoaquepts

KAKH. Other Endoaquepts that have fragic soil properties *either*:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Endoaquepts

KAKI. Other Endoaquepts that have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, *one* of the following colors:

1. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

a. If peds are present, either chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

b. If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

2. In 50 percent or more of the matrix, hue of 10YR or yellower and *either*:

a. Both a color value, moist, and chroma of 3 or more; *or*

b. Chroma of 2 or more if there are no redox concentrations.

Aeric Endoaquepts

KAKJ. Other Endoaquepts that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing; *and*

2. A base saturation (by NH_4OAc) of less than 50 percent in some part within 100 cm of the mineral soil surface.

Humic Endoaquepts

KAKK. Other Endoaquepts that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing.

Mollic Endoaquepts

KAKL. Other Endoaquepts.

Typic Endoaquepts

Epiaquepts

Key to Subgroups

KAJA. Epiaquepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Epiaquepts

KAJB. Other Epiaquepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

 a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

 b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Epiaquepts

KAJC. Other Epiaquepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Epiaquepts

KAJD. Other Epiaquepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

 a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

 b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Epiaquepts

KAJE. Other Epiaquepts that have fragic soil properties *either*:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Epiaquepts

KAJF. Other Epiaquepts that have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, *one* of the following colors:

1. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

 a. If peds are present, either chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

 b. If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

2. In 50 percent or more of the matrix, hue of 10YR or yellower and *either*:

 a. Both a color value, moist, and chroma of 3 or more; *or*

 b. Chroma of 2 or more if there are no redox concentrations.

Aeric Epiaquepts

KAJG. Other Epiaquepts that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout

the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing; *and*

2. A base saturation (by NH_4OAc) of less than 50 percent in some part within 100 cm of the mineral soil surface.

Humic Epiaquepts

KAJH. Other Epiaquepts that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 15 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 15 cm after mixing.

Mollic Epiaquepts

KAJI. Other Epiaquepts.

Typic Epiaquepts

Fragiaquepts

Key to Subgroups

KADA. Fragiaquepts that have between the plow layer and a depth of 75 cm below the mineral soil surface or, if there is no plow layer, between depths of 15 and 75 cm, one or more horizons with 50 percent or more of the matrix having chroma of *either*:

1. 3 or more; *or*

2. 2 or more if there are no redox concentrations.

Aeric Fragiaquepts

KADB. Other Fragiaquepts that have a histic, mollic, or umbric epipedon.

Humic Fragiaquepts

KADC. Other Fragiaquepts.

Typic Fragiaquepts

Gelaquepts

Key to Subgroups

KAFA. Gelaquepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Gelaquepts

KAFB. Other Gelaquepts that have a histic epipedon.

Histic Gelaquepts

KAFC. Other Gelaquepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Gelaquepts

KAFD. Other Gelaquepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Gelaquepts

KAFE. Other Gelaquepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Gelaquepts

KAFF. Other Gelaquepts that have a mollic or umbric epipedon.

Humic Gelaquepts

KAFG. Other Gelaquepts that have gelic materials within 200 cm of the mineral soil surface.

Turbic Gelaquepts

KAFH. Other Gelaquepts.

Typic Gelaquepts

Halaquepts

Key to Subgroups

KACA. Halaquepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Halaquepts

KACB. Other Halaquepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Halaquepts

KACC. Other Halaquepts that have within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, one or more horizons that have:

1. A combined thickness of 15 cm or more; *and*

2. 20 percent or more (by volume) soil material that is extremely weakly coherent or more coherent due to pedogenic cementation.

Duric Halaquepts

KACD. Other Halaquepts that have, at a depth between 15 and 75 cm from the mineral soil surface, one or more horizons with chroma of 3 or more in 40 percent or more of the matrix.

Aeric Halaquepts

KACE. Other Halaquepts.

Typic Halaquepts

Humaquepts

Key to Subgroups

KAIA. Humaquepts that have an *n* value of *either*:

1. More than 0.7 or a fluidity class of slightly fluid or higher (and less than 8 percent clay) in one or more layers at a depth between 20 and 50 cm from the mineral soil surface; *or*

2. More than 0.9 or a fluidity class of moderately fluid or higher in one or more layers at a depth between 50 and 100 cm.

Hydraquentic Humaquepts

KAIB. Other Humaquepts that have a histic epipedon.

Histic Humaquepts

KAIC. Other Humaquepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Humaquepts

KAID. Other Humaquepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Humaquepts

KAIE. Other Humaquepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. An umbric or mollic epipedon that is 60 cm or more thick; *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Humaquepts

KAIF. Other Humaquepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Humaquepts

KAIG. Other Humaquepts that have, at a depth between 15 and 75 cm from the mineral soil surface, one or more subhorizons with hue of 5Y or redder and chroma of 3 or more in more than 40 percent of the matrix.

Aeric Humaquepts

KAIH. Other Humaquepts.

Typic Humaquepts

Petraquepts

Key to Subgroups

KABA. Petraquepts that have *both*:

1. A histic epipedon; *and*

2. A placic horizon.

Histic Placic Petraquepts

KABB. Other Petraquepts that have a placic horizon.

Placic Petraquepts

KABC. Other Petraquepts that have one or more horizons within 125 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Plinthic Petraquepts

KABD. Other Petraquepts.

Typic Petraquepts

Sulfaquepts

Key to Subgroups

KAAA. Sulfaquepts that have a salic horizon within 75 cm of the mineral soil surface.

Salidic Sulfaquepts

KAAB. Other Sulfaquepts that have an *n* value of *either*:

1. More than 0.7 or a fluidity class of slightly fluid or higher (and 8 or more percent clay) in one or more layers at a depth between 20 and 50 cm from the mineral soil surface; *or*

2. More than 0.9 or a fluidity class of moderately fluid or higher in one or more layers at a depth between 50 and 100 cm from the mineral soil surface.

Hydraquentic Sulfaquepts

KAAC. Other Sulfaquepts.

Typic Sulfaquepts

Vermaquepts

Key to Subgroups

KAHA. Vermaquepts that have an exchangeable sodium percentage of 7 or more (or a sodium adsorption ratio [SAR] of 6 or more) in one or more subhorizons within 100 cm of the mineral soil surface.

Sodic Vermaquepts

KAHB. Other Vermaquepts.

Typic Vermaquepts

Cryepts

Key to Great Groups

KCA. Cryepts that have an umbric or mollic epipedon.

Humicryepts, p. 219

KCB. Other Cryepts that have a calcic or petrocalcic horizon within 100 cm of the mineral soil surface.

Calcicryepts, p. 215

KCC. Other Cryepts that meet *both* of the following:

1. Do not have free carbonates within 200 cm of the mineral soil surface; *and*

2. Have a base saturation (by NH_4OAc) of less than 50 percent, *either:*

a. In one-half or more of the thickness between 25 and 75 cm below the mineral soil surface and there is no placic horizon, duripan, fragipan, or densic, lithic, or paralithic contact within 50 cm of the mineral soil surface; *or*

b. In a layer, 10 cm or more thick, directly above a placic horizon, duripan, fragipan, or densic, lithic, or paralithic contact within 50 cm of the mineral soil surface.

Dystrocryepts, p. 215

KCD. Other Cryepts.

Haplocryepts, p. 217

Calcicryepts

Key to Subgroups

KCBA. Calcicryepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calcicryepts

KCBB. Other Calcicryepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Calcicryepts

KCBC. Other Calcicryepts that have a xeric soil moisture regime.

Xeric Calcicryepts

KCBD. Other Calcicryepts that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Calcicryepts

KCBE. Other Calcicryepts.

Typic Calcicryepts

Dystrocryepts

Key to Subgroups

KCCA. Dystrocryepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Dystrocryepts

KCCB. Other Dystrocryepts that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus ½ Fe (by ammonium oxalate) of 1.0 percent or more; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Dystrocryepts

KCCC. Other Dystrocryepts that have *both*:

1. A xeric soil moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus ½ Fe (by ammonium oxalate) of 1.0 percent or more.

Haploxerandic Dystrocryepts

KCCD. Other Dystrocryepts that have *both*:

1. A xeric soil moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrixerandic Dystrocryepts

KCCE. Other Dystrocryepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus ½ Fe (by ammonium oxalate) of 1.0 percent or more.

Andic Dystrocryepts

KCCF. Other Dystrocryepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Dystrocryepts

KCCG. Other Dystrocryepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Dystrocryepts

KCCH. Other Dystrocryepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Dystrocryepts

KCCI. Other Dystrocryepts that have a folistic epipedon.

Folistic Dystrocryepts

KCCJ. Other Dystrocryepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Dystrocryepts

KCCK. Other Dystrocryepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Dystrocryepts

KCCL. Other Dystrocryepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Dystrocryepts

KCCM. Other Dystrocryepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Dystrocryepts

KCCN. Other Dystrocryepts that have a horizon 5 cm or more thick that has *one or more* of the following:

1. 25 percent or more of the horizon in each pedon is extremely weakly coherent or more coherent due to pedogenic cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus ½ Fe (by ammonium oxalate) of 0.25 percent or more and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more and a value half as high or lower in an overlying horizon.

Spodic Dystrocryepts

KCCO. Other Dystrocryepts that have a xeric soil moisture regime.

Xeric Dystrocryepts

KCCP. Other Dystrocryepts that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Dystrocryepts

KCCQ. Other Dystrocryepts that have a base saturation (by NH_4OAc) of 50 percent or more in one or more horizons between 25 and 50 cm from the mineral soil surface.

Eutric Dystrocryepts

KCCR. Other Dystrocryepts.

Typic Dystrocryepts

Haplocryepts

Key to Subgroups

KCDA. Haplocryepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplocryepts

KCDB. Other Haplocryepts that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus ½ Fe (by ammonium oxalate) of 1.0 percent or more; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Haplocryepts

KCDC. Other Haplocryepts that have *both*:

1. A xeric soil moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus ½ Fe (by ammonium oxalate) of 1.0 percent or more.

Haploxerandic Haplocryepts

KCDD. Other Haplocryepts that have *both*:

1. A xeric soil moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrixerandic Haplocryepts

KCDE. Other Haplocryepts that have *both*:

1. A moisture control section that is dry in some part for 45 or more days (cumulative) in normal years; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus ½ Fe (by ammonium oxalate) of 1.0 percent or more.

Haplustandic Haplocryepts

KCDF. Other Haplocryepts that have *both*:

1. A moisture control section that is dry in some part for 45 or more days (cumulative) in normal years; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Ustivitrandic Haplocryepts

KCDG. Other Haplocryepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus ½ Fe (by ammonium oxalate) of 1.0 percent or more.

Andic Haplocryepts

KCDH. Other Haplocryepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haplocryepts

KCDI. Other Haplocryepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Haplocryepts

KCDJ. Other Haplocryepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Haplocryepts

KCDK. Other Haplocryepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplocryepts

KCDL. Other Haplocryepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplocryepts

KCDM. Other Haplocryepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Haplocryepts

KCDN. Other Haplocryepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Haplocryepts

KCDO. Other Haplocryepts that have identifiable secondary carbonates within 100 cm of the mineral soil surface.

Calcic Haplocryepts

KCDP. Other Haplocryepts that have a xeric soil moisture regime.

Xeric Haplocryepts

KCDQ. Other Haplocryepts that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Haplocryepts

KCDR. Other Haplocryepts.

Typic Haplocryepts

Humicryepts

Key to Subgroups

KCAA. Humicryepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Humicryepts

KCAB. Other Humicryepts that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus ½ Fe (by ammonium oxalate) of 1.0 percent or more; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Humicryepts

KCAC. Other Humicryepts that have *both*:

1. A xeric soil moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus ½ Fe (by ammonium oxalate) of 1.0 percent or more.

Haploxerandic Humicryepts

KCAD. Other Humicryepts that have *both*:

1. A xeric soil moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrixerandic Humicryepts

KCAE. Other Humicryepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus ½ Fe (by ammonium oxalate) of 1.0 percent or more.

Andic Humicryepts

KCAF. Other Humicryepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Humicryepts

KCAG. Other Humicryepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Humicryepts

KCAH. Other Humicryepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Humicryepts

KCAI. Other Humicryepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Humicryepts

KCAJ. Other Humicryepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Humicryepts

KCAK. Other Humicryepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Humicryepts

KCAL. Other Humicryepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Humicryepts

KCAM. Other Humicryepts that have a horizon 5 cm or more thick that has *one or more* of the following:

1. 25 percent or more of the horizon in each pedon is extremely weakly coherent or more coherent due to pedogenic cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus ½ Fe (by ammonium oxalate) of 0.25 percent or more and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more and a value half as high or lower in an overlying horizon.

Spodic Humicryepts

KCAN. Other Humicryepts that have a xeric soil moisture regime.

Xeric Humicryepts

KCAO. Other Humicryepts that have a base saturation (by NH_4OAc) of 50 percent or more, *either*:

1. In one-half or more of the total thickness between 25 and 75 cm from the mineral soil surface; *or*

2. In some part of the 10 cm thickness directly above a densic, lithic, or paralithic contact that occurs less than 50 cm below the mineral soil surface.

Eutric Humicryepts

KCAP. Other Humicryepts.

Typic Humicryepts

Gelepts

Key to Great Groups

KBA. Gelepts that have an umbric or mollic epipedon.

Humigelepts, p. 222

KBB. Other Gelepts that have a base saturation (by NH_4OAc) of less than 50 percent, *either*:

1. In one or more horizons totaling 25 cm or more in thickness within 50 cm below the mineral soil surface and there is no placic horizon, duripan, fragipan, or densic, lithic, or paralithic contact within 50 cm of the mineral soil surface; *or*

2. In one-half or more of the thickness between the mineral soil surface and the top of a placic horizon, duripan, fragipan, or densic, lithic, or paralithic contact occurring within 50 cm of the mineral soil surface.

Dystrogelepts, p. 221

KBC. Other Gelepts.

Haplogelepts, p. 221

Dystrogelepts

Key to Subgroups

KBBA. Dystrogelepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Dystrogelepts

KBBB. Other Dystrogelepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Dystrogelepts

KBBC. Other Dystrogelepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Dystrogelepts

KBBD. Other Dystrogelepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Dystrogelepts

KBBE. Other Dystrogelepts that do not have irregular or broken horizon boundaries, and have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Dystrogelepts

KBBF. Other Dystrogelepts that have gelic materials within 200 cm of the mineral soil surface.

Turbic Dystrogelepts

KBBG. Other Dystrogelepts.

Typic Dystrogelepts

Haplogelepts

Key to Subgroups

KBCA. Haplogelepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplogelepts

KBCB. Other Haplogelepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^{1}/_{2}$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haplogelepts

KBCC. Other Haplogelepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplogelepts

KBCD. Other Haplogelepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Haplogelepts

KBCE. Other Haplogelepts that do not have irregular or broken horizon boundaries, and have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

   a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

   b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Haplogelepts

KBCF. Other Haplogelepts that have gelic materials within 200 cm of the mineral soil surface.

Turbic Haplogelepts

KBCG. Other Haplogelepts.

Typic Haplogelepts

Humigelepts

Key to Subgroups

KBAA. Humigelepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Humigelepts

KBAB. Other Humigelepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus ½ Fe (by ammonium oxalate) of 1.0 percent or more.

Andic Humigelepts

KBAC. Other Humigelepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Humigelepts

KBAD. Other Humigelepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Humigelepts

KBAE. Other Humigelepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Humigelepts

KBAF. Other Humigelepts that do not have irregular or broken horizon boundaries, and have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

   a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

   b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Humigelepts

KBAG. Other Humigelepts that have gelic materials within 200 cm of the mineral soil surface.

Turbic Humigelepts

KBAH. Other Humigelepts that have a base saturation (by NH_4OAc) of 50 percent or more, *either*:

1. In one-half or more of the total thickness between 25 and 75 cm from the mineral soil surface; *or*

2. In some part of the 10 cm thickness directly above a densic, lithic, or paralithic contact that occurs less than 50 cm below the mineral soil surface.

Eutric Humigelepts

KBAI. Other Humigelepts.

Typic Humigelepts

Udepts

Key to Great Groups

KFA. Udepts that have a sulfuric horizon within 50 cm of the mineral soil surface.

Sulfudepts, p. 231

KFB. Other Udepts that have a duripan or another horizon that is extremely weakly coherent or more coherent due to pedogenic cementation within 100 cm of the mineral soil surface.

Durudepts, p. 223

KFC. Other Udepts that have a fragipan within 100 cm of the mineral soil surface.

Fragiudepts, p. 229

KFD. Other Udepts that have a geogenic densic contact within 100 cm of the mineral soil surface.

Densiudepts, p. 223

KFE. Other Udepts that have an umbric or mollic epipedon.

Humudepts, p. 229

KFF. Other Udepts that have *one or both* of the following:

1. Free carbonates throughout; *or*

2. A base saturation (by NH_4OAc) of 60 percent or more in one or more horizons at a depth between 25 and 75 cm from the mineral soil surface or directly above a root-limiting layer (defined in chapter 17) that is at a shallower depth.

Eutrudepts, p. 227

KFG. Other Udepts.

Dystrudepts, p. 224

Densiudepts

Key to Subgroups

KFDA. Densiudepts that have, in one or more horizons within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Densiudepts

KFDB. Other Densiudepts that have *one or both* of the following:

1. An umbric or mollic epipedon; *or*

2. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Densiudepts

KFDC. Other Densiudepts.

Typic Densiudepts

Durudepts

Key to Subgroups

KFBA. Durudepts that have *both*:

1. In one or more horizons above the duripan and within 60 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more, above the duripan and within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Durudepts

KFBB. Other Durudepts that have, throughout one or more horizons with a total thickness of 18 cm or more, above the duripan and within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Durudepts

KFBC. Other Durudepts that have, throughout one or more horizons with a total thickness of 18 cm or more, above the duripan and within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Durudepts

KFBD. Other Durudepts that have, in one or more horizons above the duripan and within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Durudepts

KFBE. Other Durudepts.

Typic Durudepts

Dystrudepts

Key to Subgroups

KFGA. Dystrudepts that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Lithic Dystrudepts

KFGB. Other Dystrudepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Dystrudepts

KFGC. Other Dystrudepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Dystrudepts

KFGD. Other Dystrudepts that have a densic contact due to mechanical compaction in more than 90 percent of the pedon (measured laterally) within 100 cm of the soil surface.

Anthrodensic Dystrudepts

KFGE. Other Dystrudepts that have human-transported material that is 50 cm or more thick.

Anthroportic Dystrudepts

KFGF. Other Dystrudepts that have *both*:

1. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Dystrudepts

KFGG. Other Dystrudepts that have *both*:

1. In one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *and*

2. Saturation with water within 100 cm of the mineral soil surface in normal years for *either or both:*

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Andic Oxyaquic Dystrudepts

KFGH. Other Dystrudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Dystrudepts

KFGI. Other Dystrudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Dystrudepts

KFGJ. Other Dystrudepts that have *both*:

1. Fragic soil properties *either*:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions in normal years (or artificial drainage).

Fragiaquic Dystrudepts

KFGK. Other Dystrudepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Dystrudepts

KFGL. Other Dystrudepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Dystrudepts

KFGM. Other Dystrudepts that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

2. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Humic Dystrudepts

KFGN. Other Dystrudepts that have, in one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Dystrudepts

KFGO. Other Dystrudepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Dystrudepts

KFGP. Other Dystrudepts that have fragic soil properties *either*:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Dystrudepts

KFGQ. Other Dystrudepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Dystrudepts

KFGR. Other Dystrudepts that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

2. A sandy particle-size class in all subhorizons throughout the particle-size control section.

Humic Psammentic Dystrudepts

KFGS. Other Dystrudepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Humic Dystrudepts

KFGT. Other Dystrudepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Dystrudepts

KFGU. Other Dystrudepts that have a horizon 5 cm or more thick that has *one or more* of the following:

1. 25 percent or more of the horizon in each pedon is extremely weakly coherent or more coherent due to pedogenic cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Dystrudepts

KFGV. Other Dystrudepts that have, in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower:

1. A CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+) per kg clay; *or*

2. Both a ratio of measured clay in the fine-earth fraction to percent water retained at 1500 kPa tension of 0.6 or more and the following: the CEC (by 1N NH_4OAc pH 7) divided by the product of three times [percent water retained at 1500 kPa tension minus percent organic carbon (but no more than 1.00)] is less than 24.

Oxic Dystrudepts

KFGW. Other Dystrudepts that have *both*:

1. In each pedon a cambic horizon that includes 10 to 50 percent (by volume) illuvial parts that otherwise meet the requirements for an argillic, kandic, or natric horizon; *and*

2. A base saturation (by sum of cations) of 35 percent or more either at a depth of 125 cm from the top of the cambic horizon or directly above a densic, lithic, or paralithic contact if shallower.

Ruptic-Alfic Dystrudepts

KFGX. Other Dystrudepts that have in each pedon a cambic horizon that includes 10 to 50 percent (by volume) illuvial parts that otherwise meet the requirements for an argillic, kandic, or natric horizon.

Ruptic-Ultic Dystrudepts

KFGY. Other Dystrudepts that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Dystrudepts

KFGZ. Other Dystrudepts.

Typic Dystrudepts

Eutrudepts

Key to Subgroups

KFFA. Eutrudepts that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

2. A lithic contact within 50 cm of the mineral soil surface.

Humic Lithic Eutrudepts

KFFB. Other Eutrudepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Eutrudepts

KFFC. Other Eutrudepts that have *both*:

1. *One or both* of the following:

   a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

   b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquertic Eutrudepts

KFFD. Other Eutrudepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Eutrudepts

KFFE. Other Eutrudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Eutrudepts

KFFF. Other Eutrudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Eutrudepts

KFFG. Other Eutrudepts that have anthraquic conditions.

Anthraquic Eutrudepts

KFFH. Other Eutrudepts that have *both*:

1. Fragic soil properties *either*:

   a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

   b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions in normal years (or artificial drainage).

Fragiaquic Eutrudepts

KFFI. Other Eutrudepts that meet *one or both* of the following:

INC

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Eutrudepts

KFFJ. Other Eutrudepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Eutrudepts

KFFK. Other Eutrudepts that meet *both* of the following:

1. Have, in one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Do not have free carbonates throughout any horizon within 100 cm of the mineral soil surface.

Aquic Dystric Eutrudepts

KFFL. Other Eutrudepts that have, in one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Eutrudepts

KFFM. Other Eutrudepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Eutrudepts

KFFN. Other Eutrudepts that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Eutrudepts

KFFO. Other Eutrudepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Eutrudepts

KFFP. Other Eutrudepts that do not have free carbonates throughout any horizon within 100 cm of the mineral soil surface, and have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Dystric Fluventic Eutrudepts

KFFQ. Other Eutrudepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Eutrudepts

KFFR. Other Eutrudepts that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand in all horizons within 50 cm of the mineral soil surface.

Arenic Eutrudepts

KFFS. Other Eutrudepts that do not have free carbonates throughout any horizon within 100 cm of the mineral soil surface.

Dystric Eutrudepts

KFFT. Other Eutrudepts that have a $CaCO_3$ equivalent of 40 percent or more, including fragments 2 to 75 mm in diameter, in all horizons between the top of the cambic horizon and either a depth of 100 cm from the mineral soil surface or a densic, lithic, or paralithic contact if shallower.

Rendollic Eutrudepts

KFFU. Other Eutrudepts that have a cambic horizon that includes 10 to 50 percent (by volume) illuvial parts that otherwise meet the requirements for an argillic, kandic, or natric horizon.

Ruptic-Alfic Eutrudepts

KFFV. Other Eutrudepts that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Eutrudepts

KFFW. Other Eutrudepts.

Typic Eutrudepts

Fragiudepts

Key to Subgroups

KFCA. Fragiudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Fragiudepts

KFCB. Other Fragiudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Fragiudepts

KFCC. Other Fragiudepts that have, in one or more horizons within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fragiudepts

KFCD. Other Fragiudepts that have *one or both* of the following:

1. An umbric or mollic epipedon; *or*

2. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Fragiudepts

KFCE. Other Fragiudepts.

Typic Fragiudepts

Humudepts

Key to Subgroups

KFEA. Humudepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Humudepts

KFEB. Other Humudepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Humudepts

KFEC. Other Humudepts that have *both*:

1. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Humudepts

KFED. Other Humudepts that have *both*:

1. In one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *and*

2. Saturation with water within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Andic Oxyaquic Humudepts

KFEE. Other Humudepts that have, in one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Humudepts

KFEF. Other Humudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Humudepts

KFEG. Other Humudepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Humudepts

KFEH. Other Humudepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Humudepts

KFEI. Other Humudepts that have, in one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Humudepts

KFEJ. Other Humudepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Humudepts

KFEK. Other Humudepts that have a sandy particle-size class in all subhorizons throughout the particle-size control section.

Psammentic Humudepts

KFEL. Other Humudepts that have, in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower:

1. A CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+) per kg clay; *or*

2. Both a ratio of measured clay in the fine-earth fraction to percent water retained at 1500 kPa tension of 0.6 or more and the following: the CEC (by 1N NH_4OAc pH 7) divided by the product of three times [percent water retained at 1500 kPa tension minus percent organic carbon (but no more than 1.00)] is less than 24.

Oxic Humudepts

KFEM. Other Humudepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. An umbric or mollic epipedon that is 50 cm or more thick; *and*

4. *One or both* of the following:

   a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

   b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Humudepts

KFEN. Other Humudepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

   a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

   b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Humudepts

KFEO. Other Humudepts that have an umbric or mollic epipedon that is 50 cm or more thick.

Pachic Humudepts

KFEP. Other Humudepts that have a base saturation (by NH_4OAc) of 60 percent or more *either*:

1. In one-half or more of the total thickness between 25 and 75 cm from the mineral soil surface; *or*

2. In some part of the 10 cm thickness directly above a densic, lithic, or paralithic contact that occurs less than 50 cm below the mineral soil surface.

Eutric Humudepts

KFEQ. Other Humudepts that do not have a cambic horizon and do not, in any part of\ the umbric or mollic epipedon, meet the requirements for a cambic horizon, except for the color requirements.

Entic Humudepts

KFER. Other Humudepts.

Typic Humudepts

Sulfudepts

Key to Subgroups

KFAA. All Sulfudepts (provisionally).

Typic Sulfudepts

Ustepts

Key to Great Groups

KDA. Ustepts that have a duripan within 100 cm of the mineral soil surface.

Durustepts, p. 233

KDB. Other Ustepts that have *both*:

1. A calcic horizon within 100 cm of the mineral soil

surface or a petrocalcic horizon within 150 cm of the mineral soil surface; *and*

2. Either free carbonates or a texture class of loamy fine sand or coarser, in all parts above the calcic or petrocalcic horizon, after the soil between the mineral soil surface and a depth of 18 cm has been mixed.

Calciustepts, p. 232

KDC. Other Ustepts that have an umbric or mollic epipedon.

Humustepts, p. 239

KDD. Other Ustepts that have *both* of the following:

1. No free carbonates within 200 cm of the mineral soil surface; *and*

2. A base saturation (by NH_4OAc) of less than 60 percent in all horizons at a depth between 25 and 75 cm from the mineral soil surface.

Dystrustepts, p. 233

KDE. Other Ustepts.

Haplustepts, p. 235

Calciustepts

Key to Subgroups

KDBA. Calciustepts that have a petrocalcic horizon and a lithic contact within 50 cm of the mineral soil surface.

Lithic Petrocalcic Calciustepts

KDBB. Other Calciustepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calciustepts

KDBC. Other Calciustepts that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Torrertic Calciustepts

KDBD. Other Calciustepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Calciustepts

KDBE. Other Calciustepts that have a petrocalcic horizon within 100 cm of the mineral soil surface.

Petrocalcic Calciustepts

KDBF. Other Calciustepts that have a gypsic horizon within 100 cm of the mineral soil surface.

Gypsic Calciustepts

KDBG. Other Calciustepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Calciustepts

KDBH. Other Calciustepts that have, when neither irrigated nor fallowed to store moisture, *one* of the following:

1. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil

temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Calciustepts

KDBI. Other Calciustepts that have, when neither irrigated nor fallowed to store moisture, *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for four-tenths or less of the consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Calciustepts

KDBJ. Other Calciustepts.

Typic Calciustepts

Durustepts

Key to Subgroups

KDAA. All Durustepts (provisionally).

Typic Durustepts

Dystrustepts

Key to Subgroups

KDDA. Dystrustepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Dystrustepts

KDDB. Other Dystrustepts that have *both*:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Dystrustepts

KDDC. Other Dystrustepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Dystrustepts

KDDD. Other Dystrustepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Dystrustepts

KDDE. Other Dystrustepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Dystrustepts

KDDF. Other Dystrustepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Dystrustepts

KDDG. Other Dystrustepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Dystrustepts

KDDH. Other Dystrustepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

   a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

   b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Dystrustepts

KDDI. Other Dystrustepts that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

   a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

   b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Aridic Dystrustepts

KDDJ. Other Dystrustepts that have, in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower:

1. A CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+) per kg clay; *or*

2. Both a ratio of measured clay in the fine-earth fraction to percent water retained at 1500 kPa tension of 0.6 or more and the following: the CEC (by 1N NH_4OAc pH 7) divided by the product of three times [percent water retained at 1500 kPa tension minus percent organic carbon (but no more than 1.00)] is less than 24.

Oxic Dystrustepts

KDDK. Other Dystrustepts that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Dystrustepts

KDDL. Other Dystrustepts.

Typic Dystrustepts

Haplustepts

Key to Subgroups

KDEA. Haplustepts that have:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *either*:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Aridic Lithic Haplustepts

KDEB. Other Haplustepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplustepts

KDEC. Other Haplustepts that have *both*:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 105 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Udertic Haplustepts

KDED. Other Haplustepts that have *both*:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Haplustepts

KDEE. Other Haplustepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplustepts

KDEF. Other Haplustepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haplustepts

KDEG. Other Haplustepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haplustepts

KDEH. Other Haplustepts that have anthraquic conditions.

Anthraquic Haplustepts

KDEI. Other Haplustepts that have a densic contact due to mechanical compaction in more than 90 percent of the pedon (measured laterally) within 100 cm of the soil surface.

Anthrodensic Haplustepts

KDEJ. Other Haplustepts that have human-transported material that is 50 cm or more thick.

Anthroportic Haplustepts

KDEK. Other Haplustepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplustepts

KDEL. Other Haplustepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplustepts

KDEM. Other Haplustepts that have, in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower:

1. A CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+) per kg clay; *or*

2. Both a ratio of measured clay in the fine-earth fraction to percent water retained at 1500 kPa tension of 0.6 or more and the following: the CEC (by 1N NH_4OAc pH 7) divided by the product of three times [percent water retained at 1500 kPa tension minus percent organic carbon (but no more than 1.00)] is less than 24.

Oxic Haplustepts

KDEN. Other Haplustepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Haplustepts

KDEO. Other Haplustepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Haplustepts

KDEP. Other Haplustepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Torrifluventic Haplustepts

KDEQ. Other Haplustepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 105 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Udifluventic Haplustepts

KDER. Other Haplustepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Haplustepts

KDES. Other Haplustepts that have a gypsic horizon within 100 cm of the mineral soil surface.

Gypsic Haplustepts

KDET. Other Haplustepts that have *both*:

1. A calcic horizon within 100 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Haplocalcidic Haplustepts

KDEU. Other Haplustepts that have *both*:

1. A calcic horizon within 100 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 105 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Calcic Udic Haplustepts

KDEV. Other Haplustepts that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Haplustepts

KDEW. Other Haplustepts that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Haplustepts

KDEX. Other Haplustepts that have a base saturation (by sum of cations) of less than 60 percent in some horizon between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Dystric Haplustepts

KDEY. Other Haplustepts that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 105 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Haplustepts

KDEZ. Other Haplustepts.

Typic Haplustepts

Humustepts

Key to Subgroups

KDCA. Humustepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Humustepts

KDCB. Other Humustepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Humustepts

KDCC. Other Humustepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Humustepts

KDCD. Other Humustepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Humustepts

KDCE. Other Humustepts that have, in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower:

1. A CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+) per kg clay; *or*

2. Both a ratio of measured clay in the fine-earth fraction to percent water retained at 1500 kPa tension of 0.6 or more and the following: the CEC (by 1N NH_4OAc pH 7) divided by the product of three times [percent water retained at 1500 kPa tension minus percent organic carbon (but no more than 1.00)] is less than 24.

Oxic Humustepts

KDCF. Other Humustepts that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^oC; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^oC; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^oC; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^oC.

Aridic Humustepts

KDCG. Other Humustepts.

Typic Humustepts

INC

Xerepts

Key to Great Groups

KEA. Xerepts that have a duripan within 100 cm of the mineral soil surface.

Durixerepts, p. 240

KEB. Other Xerepts that have a fragipan within 100 cm of the mineral soil surface.

Fragixerepts, p. 243

KEC. Other Xerepts that have an umbric or mollic epipedon.

Humixerepts, p. 245

KED. Other Xerepts that have *both*:

1. A calcic horizon within 100 cm of the mineral soil surface or a petrocalcic horizon within 150 cm of the mineral soil surface; *and*

2. Free carbonates in all parts above the calcic or petrocalcic horizon, after the soil between the mineral soil surface and a depth of 18 cm has been mixed.

Calcixerepts, p. 240

KEE. Other Xerepts that have *both* of the following:

1. No free carbonates within 200 cm of the mineral soil surface; *and*

2. A base saturation (by NH_4OAc) of less than 60 percent in all horizons at a depth between 25 and 75 cm from the mineral soil surface.

Dystroxerepts, p. 241

KEF. Other Xerepts.

Haploxerepts, p. 243

Calcixerepts

Key to Subgroups

KEDA. Calcixerepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calcixerepts

KEDB. Other Calcixerepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Calcixerepts

KEDC. Other Calcixerepts that have a petrocalcic horizon within 100 cm of the mineral soil surface.

Petrocalcic Calcixerepts

KEDD. Other Calcixerepts that have an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in one or more subhorizons within 100 cm of the mineral soil surface.

Sodic Calcixerepts

KEDE. Other Calcixerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Calcixerepts

KEDF. Other Calcixerepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Calcixerepts

KEDG. Other Calcixerepts.

Typic Calcixerepts

Durixerepts

Key to Subgroups

KEAA. Durixerepts that have *both*:

1. In one or more horizons above the duripan and within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more, above the duripan and within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Durixerepts

KEAB. Other Durixerepts that have, throughout one or more horizons with a total thickness of 18 cm or more, above the duripan and within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus 1/2 Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Durixerepts

KEAC. Other Durixerepts that have, throughout one or more horizons with a total thickness of 18 cm or more, above the duripan and within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Durixerepts

KEAD. Other Durixerepts that have, in one or more horizons above the duripan and within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Durixerepts

KEAE. Other Durixerepts that have a duripan that is strongly coherent or less coherent in all subhorizons.

Entic Durixerepts

KEAF. Other Durixerepts.

Typic Durixerepts

Dystroxerepts

Key to Subgroups

KEEA. Dystroxerepts that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Lithic Dystroxerepts

KEEB. Other Dystroxerepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Dystroxerepts

KEEC. Other Dystroxerepts that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus 1/2 Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Dystroxerepts

KEED. Other Dystroxerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus 1/2 Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Dystroxerepts

KEEE. Other Dystroxerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Dystroxerepts

KEEF. Other Dystroxerepts that have *both*:

1. Fragic soil properties *either*:

 a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

 b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions in normal years (or artificial drainage).

Fragiaquic Dystroxerepts

KEEG. Other Dystroxerepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Dystroxerepts

KEEH. Other Dystroxerepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

4. *One or both* of the following:

 a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

 b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Dystroxerepts

KEEI. Other Dystroxerepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Dystroxerepts

KEEJ. Other Dystroxerepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Dystroxerepts

KEEK. Other Dystroxerepts that have fragic soil properties *either*:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Dystroxerepts

KEEL. Other Dystroxerepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing; *and*

4. *One or both* of the following:

 a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

 b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Humic Dystroxerepts

KEEM. Other Dystroxerepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

 a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

 b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Dystroxerepts

KEEN. Other Dystroxerepts that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Dystroxerepts

KEEO. Other Dystroxerepts.

Typic Dystroxerepts

Fragixerepts

Key to Subgroups

KEBA. Fragixerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Fragixerepts

KEBB. Other Fragixerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Fragixerepts

KEBC. Other Fragixerepts that have, in one or more horizons within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fragixerepts

KEBD. Other Fragixerepts that have *one or both* of the following:

1. An umbric or mollic epipedon; *or*

2. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Fragixerepts

KEBE. Other Fragixerepts.

Typic Fragixerepts

Haploxerepts

Key to Subgroups

KEFA. Haploxerepts that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Lithic Haploxerepts

KEFB. Other Haploxerepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haploxerepts

KEFC. Other Haploxerepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haploxerepts

KEFD. Other Haploxerepts that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

   a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

   b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Haploxerepts

KEFE. Other Haploxerepts that have *both*:

1. In one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus 1/2 Fe percentages (by ammonium oxalate) totaling more than 1.0; *and*

2. Saturation with water within 100 cm of the mineral soil surface in normal years for *either or both:*

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Andic Oxyaquic Haploxerepts

KEFF. Other Haploxerepts that have, in one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus 1/2 Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haploxerepts

KEFG. Other Haploxerepts that have *both*:

1. Saturation with water within 100 cm of the mineral soil surface in normal years for *either or both:*

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Oxyaquic Vitrandic Haploxerepts

KEFH. Other Haploxerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haploxerepts

KEFI. Other Haploxerepts that have a gypsic horizon within 100 cm of the mineral soil surface.

Gypsic Haploxerepts

KEFJ. Other Haploxerepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haploxerepts

KEFK. Other Haploxerepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Haploxerepts

KEFL. Other Haploxerepts that have fragic soil properties *either*:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Haploxerepts

KEFM. Other Haploxerepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a

combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Haploxerepts

KEFN. Other Haploxerepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Haploxerepts

KEFO. Other Haploxerepts that have a calcic horizon or identifiable secondary carbonates within *one* of the following particle-size class and depth combinations:

1. A sandy or sandy-skeletal particle-size class and within 150 cm of the mineral soil surface; *or*

2. A clayey, clayey-skeletal, fine, or very-fine particle-size class and within 90 cm of the mineral soil surface; *or*

3. Any other particle-size class and within 110 cm of the mineral soil surface.

Calcic Haploxerepts

KEFP. Other Haploxerepts that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) either throughout the upper 18 cm of the mineral soil (unmixed) or between the mineral soil surface and a depth of 18 cm after mixing.

Humic Haploxerepts

KEFQ. Other Haploxerepts.

Typic Haploxerepts

Humixerepts

Key to Subgroups

KECA. Humixerepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Humixerepts

KECB. Other Humixerepts that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Humixerepts

KECC. Other Humixerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Humixerepts

KECD. Other Humixerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Humixerepts

KECE. Other Humixerepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Humixerepts

KECF. Other Humixerepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Humixerepts

KECG. Other Humixerepts that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Humixerepts

KECH. Other Humixerepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. An umbric or mollic epipedon that is 50 cm or more thick; *and*

4. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Humixerepts

KECI. Other Humixerepts that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Humixerepts

KECJ. Other Humixerepts that have an umbric or mollic epipedon that is 50 cm or more thick.

Pachic Humixerepts

KECK. Other Humixerepts that do not have a cambic horizon and do not, in any part of the umbric or mollic epipedon, meet the requirements for a cambic horizon, except for the color requirements.

Entic Humixerepts

KECL. Other Humixerepts.

Typic Humixerepts

CHAPTER 12

Mollisols

Key to Suborders

IA. Mollisols that have *all* of the following:

1. An argillic or natric horizon; *and*

2. An albic horizon that has chroma of 2 or less and is 2.5 cm or more thick, has its lower boundary 18 cm or more below the mineral soil surface, and either lies directly below the mollic epipedon or separates horizons that together meet all of the requirements for a mollic epipedon; *and*

3. In one or more subhorizons of the albic horizon and/or of the argillic or natric horizon and within 100 cm of the mineral soil surface, redox concentrations in the form of masses or concretions, or both, and also aquic conditions for some time in normal years (or artificial drainage); *and*

4. A soil temperature regime that is warmer than cryic.

Albolls, p. 248

IB. Other Mollisols that have, in a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm from the mineral soil surface, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

Elevated sodium

1. An exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in the upper part of the mollic epipedon and a decrease in ESP (or SAR) values with increasing depth below 50 cm from the mineral soil surface; *or*

Diagnostic horizons

2. A histic epipedon overlying the mollic epipedon; *or*

3. A calcic or petrocalcic horizon within 40 cm of the mineral soil surface; *or*

4. A mollic epipedon, with chroma of 1 or less, that extends to a lithic contact within 30 cm of the mineral soil surface; *or*

Colors in lower part of the mollic epipedon

5. *One* of the following colors:

a. **Chroma of 1 or less** in the lower part of the mollic epipedon;* *and either*

(1) Distinct or prominent redox concentrations in the lower part of the mollic epipedon; *or*

(2) Either directly below the mollic epipedon or within 75 cm of the mineral soil surface if a calcic horizon intervenes, **a color value, moist, of 4 or more** and *one* of the following:

(a) 50 percent or more **chroma of 1** on faces of peds or in the matrix *and:*

1. Hue of 10YR or redder and redox concentrations; *or*

2. Hue of 2.5Y or yellower; *or*

(b) 50 percent or more **chroma of 2 or less** on faces of peds or in the matrix, hue of 2.5Y, and redox concentrations; *or*

(c) 50 percent or more **chroma of 3 or less** on faces of peds or in the matrix, hue of 5Y, and redox concentrations; *or*

(d) 50 percent or more **neutral colors** with no hue (N) and zero chroma on faces of peds or in the matrix; *or*

(e) **Gley colors** with hue of 5GY, 5G, 5BG, or 5B; *or*

(f) **Any color** if it results from uncoated sand grains; *or*

b. **Chroma of 2** in the lower part of the mollic epipedon *and either:*

(1) Distinct or prominent redox concentrations in the lower part of the mollic epipedon; *or*

(2) Directly below the mollic epipedon, *one* of the following matrix colors:

(a) A color **value, moist, of 4, chroma of 2,** and some redox depletions with a color value, moist, of 4 or more and chroma of 1 or less; *or*

* If the mollic epipedon extends to a lithic contact within 30 cm of the mineral soil surface, the requirement for redoximorphic features is waived.

(b) A color **value, moist, of 5 or more, chroma of 2 or less**, and redox concentrations; *or*

(c) A color **value, moist, of 4 and chroma of 1 or less**; *or*

Positive reaction to alpha,alpha-dipyridyl

6. At a depth between 40 and 50 cm from the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquolls, p. 249

IC. Other Mollisols that:

1. Have a mollic epipedon that is less than 50 cm thick; *and*

2. Do not have an argillic or calcic horizon; *and*

3. Have, either within or directly below the mollic epipedon, a $CaCO_3$ equivalent of 40 percent or more in the mineral soil materials that are less than 75 mm in diameter; *and*

4. Have *either or both*:

a. A udic soil moisture regime; *or*

b. A cryic soil temperature regime.

Rendolls, p. 258

ID. Other Mollisols that have a gelic soil temperature regime.

Gelolls, p. 257

IE. Other Mollisols that have a cryic soil temperature regime.

Cryolls, p. 253

IF. Other Mollisols that have either a xeric soil moisture regime or an aridic soil moisture regime that borders on xeric.

Xerolls, p. 283

IG. Other Mollisols that have either an ustic soil moisture regime or an aridic soil moisture regime that borders on ustic.

Ustolls, p. 267

IH. Other Mollisols.

Udolls, p. 259

Albolls

Key to Great Groups

IAA. Albolls that have a natric horizon.

Natralbolls, p. 249

IAB. Other Albolls.

Argialbolls, p. 248

Argialbolls

Key to Subgroups

IABA. Argialbolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. If not irrigated, a moisture control section that in normal years is dry in all parts for 45 or more consecutive days during the 120 days following the summer solstice.

Xerertic Argialbolls

IABB. Other Argialbolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower..

Vertic Argialbolls

IABC. Other Argialbolls that:

1. Do not have an abrupt textural change from the albic to the argillic horizon; *and*

2. If not irrigated, have a moisture control section that in normal years is dry in all parts for 45 or more consecutive days during the 120 days following the summer solstice.

Argiaquic Xeric Argialbolls

IABD. Other Argialbolls that do not have an abrupt textural change from the albic to the argillic horizon.

Argiaquic Argialbolls

IABE. Other Argialbolls that, if not irrigated, have a moisture control section that in normal years is dry in all parts for 45 or more consecutive days during the 120 days following the summer solstice.

Xeric Argialbolls

IABF. Other Argialbolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Argialbolls

IABG. Other Argialbolls.

Typic Argialbolls

Natralbolls

Key to Subgroups

IAAA. Natralbolls that have visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface.

Leptic Natralbolls

IAAB. Other Natralbolls.

Typic Natralbolls

Aquolls

Key to Great Groups

IBA. Aquolls that have a cryic soil temperature regime.

Cryaquolls, p. 250

IBB. Other Aquolls that have a duripan within 100 cm of the mineral soil surface.

Duraquolls, p. 250

IBC. Other Aquolls that have a natric horizon.

Natraquolls, p. 253

IBD. Other Aquolls that have a calcic or gypsic horizon within 40 cm of the mineral soil surface but do not have an argillic horizon unless it is a buried horizon.

Calciaquolls, p. 250

IBE. Other Aquolls that have an argillic horizon.

Argiaquolls, p. 249

IBF. Other Aquolls that have episaturation.

Epiaquolls, p. 252

IBG. Other Aquolls.

Endoaquolls, p. 251

Argiaquolls

Key to Subgroups

IBEA. Argiaquolls that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Argiaquolls

IBEB. Other Argiaquolls that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Argiaquolls

IBEC. Other Argiaquolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argiaquolls

IBED. Other Argiaquolls that have *one or both* of the following:

1. An argillic horizon that has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm, either within the horizon or at its upper boundary; *or*

2. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon.

Abruptic Argiaquolls

IBEE. Other Argiaquolls.

Typic Argiaquolls

Calciaquolls

Key to Subgroups

IBDA. Calciaquolls that have a petrocalcic horizon within 100 cm of the mineral soil surface.

Petrocalcic Calciaquolls

IBDB. Other Calciaquolls that *either* have 50 percent or more chroma of 3 or more on faces of peds or in the matrix of one or more horizons within 75 cm of the mineral soil surface *or* have the following colors directly below the mollic epipedon:

1. Hue of 2.5Y or yellower and chroma of 3 or more; *or*

2. Hue of 10YR or redder and chroma of 2 or more; *or*

3. Hue of 2.5Y or yellower and chroma of 2 or more if there are no distinct or prominent redox concentrations.

Aeric Calciaquolls

IBDC. Other Calciaquolls.

Typic Calciaquolls

Cryaquolls

Key to Subgroups

IBAA. Cryaquolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Cryaquolls

IBAB. Other Cryaquolls that have a histic epipedon.

Histic Cryaquolls

IBAC. Other Cryaquolls that have a buried layer of organic soil materials, 40 cm or more thick, that has its upper boundary within 200 cm of the mineral soil surface.

Thapto-Histic Cryaquolls

IBAD. Other Cryaquolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Cryaquolls

IBAE. Other Cryaquolls that have an argillic horizon.

Argic Cryaquolls

IBAF. Other Cryaquolls that have a calcic horizon either within or directly below the mollic epipedon.

Calcic Cryaquolls

IBAG. Other Cryaquolls that have a mollic epipedon that is 50 cm or more thick.

Cumulic Cryaquolls

IBAH. Other Cryaquolls that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Cryaquolls

IBAI. Other Cryaquolls.

Typic Cryaquolls

Duraquolls

Key to Subgroups

IBBA. Duraquolls that have a natric horizon.

Natric Duraquolls

IBBB. Other Duraquolls that have *one or both* of the following:

1. Cracks between the soil surface and the top of the duripan that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that is above the duripan; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and the top of the duripan.

Vertic Duraquolls

IBBC. Other Duraquolls that have an argillic horizon.

Argic Duraquolls

IBBD. Other Duraquolls.

Typic Duraquolls

Endoaquolls

Key to Subgroups

IBGA. Endoaquolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Endoaquolls

IBGB. Other Endoaquolls that have *both* of the following:

1. A mollic epipedon that is 60 cm or more thick; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Vertic Endoaquolls

IBGC. Other Endoaquolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower; *and*

4. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Vertic Endoaquolls

IBGD. Other Endoaquolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Endoaquolls

IBGE. Other Endoaquolls that have a histic epipedon.

Histic Endoaquolls

IBGF. Other Endoaquolls that have a buried layer of organic soil materials, 40 cm or more thick, that has its upper boundary within 200 cm of the mineral soil surface.

Thapto-Histic Endoaquolls

IBGG. Other Endoaquolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Endoaquolls

IBGH. Other Endoaquolls that have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Duric Endoaquolls

IBGI. Other Endoaquolls that have a mollic epipedon that is 60 cm or more thick.

Cumulic Endoaquolls

IBGJ. Other Endoaquolls that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Endoaquolls

IBGK. Other Endoaquolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Endoaquolls

IBGL. Other Endoaquolls.

Typic Endoaquolls

Epiaquolls

Key to Subgroups

IBFA. Epiaquolls that have *both* of the following:

1. A mollic epipedon that is 60 cm or more thick; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Vertic Epiaquolls

IBFB. Other Epiaquolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower; *and*

4. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Vertic Epiaquolls

IBFC. Other Epiaquolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Epiaquolls

IBFD. Other Epiaquolls that have a histic epipedon.

Histic Epiaquolls

IBFE. Other Epiaquolls that have a buried layer of organic soil materials, 40 cm or more thick, that has its upper boundary within 200 cm of the mineral soil surface.

Thapto-Histic Epiaquolls

IBFF. Other Epiaquolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Epiaquolls

IBFG. Other Epiaquolls that have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Duric Epiaquolls

IBFH. Other Epiaquolls that have a mollic epipedon that is 60 cm or more thick.

Cumulic Epiaquolls

IBFI. Other Epiaquolls that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Epiaquolls

IBFJ. Other Epiaquolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Epiaquolls

IBFK. Other Epiaquolls.

Typic Epiaquolls

Natraquolls

Key to Subgroups

IBCA. Natraquolls that have a petrocalcic horizon within 100 cm of the mineral soil surface.

Petrocalcic Natraquolls

IBCB. Other Natraquolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natraquolls

IBCC. Other Natraquolls that have a glossic horizon or interfingering of albic materials into the natric horizon.

Glossic Natraquolls

IBCD. Other Natraquolls.

Typic Natraquolls

Cryolls

Key to Great Groups

IEA. Cryolls that have a duripan within 100 cm of the mineral soil surface.

Duricryolls, p. 255

IEB. Other Cryolls that have a natric horizon.

Natricryolls, p. 257

IEC. Other Cryolls that have *both* of the following:

1. An argillic horizon that has its upper boundary 60 cm or more below the mineral soil surface; *and*

2. A texture class finer than loamy fine sand in all horizons above the argillic horizon.

Palecryolls, p. 257

IED. Other Cryolls that have an argillic horizon.

Argicryolls, p. 254

IEE. Other Cryolls that have *both* of the following:

1. A calcic or petrocalcic horizon within 100 cm of the mineral soil surface; *and*

2. In all parts above the calcic or petrocalcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, either free carbonates or a texture class of loamy fine sand or coarser.

Calcicryolls, p. 255

IEF. Other Cryolls.

Haplocryolls, p. 255

Argicryolls

Key to Subgroups

IEDA. Argicryolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Argicryolls

IEDB. Other Argicryolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argicryolls

IEDC. Other Argicryolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Argicryolls

IEDD. Other Argicryolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Argicryolls

IEDE. Other Argicryolls that have *one or both* of the following:

1. An argillic horizon that has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm, either within the horizon or at its upper boundary; *or*

2. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon.

Abruptic Argicryolls

IEDF. Other Argicryolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Argicryolls

IEDG. Other Argicryolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Argicryolls

IEDH. Other Argicryolls that have *both* of the following:

1. A mollic epipedon that is 40 cm or more thick and has a texture class finer than loamy fine sand; *and*

2. A calcic horizon within 100 cm of the mineral soil surface.

Calcic Pachic Argicryolls

IEDI. Other Argicryolls that have a mollic epipedon that is 40 cm or more thick and has a texture class finer than loamy fine sand.

Pachic Argicryolls

IEDJ. Other Argicryolls that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Argicryolls

IEDK. Other Argicryolls that have *either*:

1. Above the argillic horizon, an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon; *or*

2. A glossic horizon, *or* interfingering of albic materials into the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon.

Alfic Argicryolls

IEDL. Other Argicryolls that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Argicryolls

IEDM. Other Argicryolls that have a xeric soil moisture regime.

Xeric Argicryolls

IEDN. Other Argicryolls.

Typic Argicryolls

Calcicryolls

Key to Subgroups

IEEA. Calcicryolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calcicryolls

IEEB. Other Calcicryolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Calcicryolls

IEEC. Other Calcicryolls that have a petrocalcic horizon within 100 cm of the mineral soil surface.

Petrocalcic Calcicryolls

IEED. Other Calcicryolls that have a mollic epipedon that is 40 cm or more thick and has a texture class finer than loamy fine sand.

Pachic Calcicryolls

IEEE. Other Calcicryolls that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Calcicryolls

IEEF. Other Calcicryolls that have a xeric soil moisture regime.

Xeric Calcicryolls

IEEG. Other Calcicryolls.

Typic Calcicryolls

Duricryolls

Key to Subgroups

IEAA. Duricryolls that have an argillic horizon.

Argic Duricryolls

IEAB. Other Duricryolls that have a calcic horizon above the duripan.

Calcic Duricryolls

IEAC. Other Duricryolls.

Typic Duricryolls

Haplocryolls

Key to Subgroups

IEFA. Haplocryolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplocryolls

IEFB. Other Haplocryolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplocryolls

IEFC. Other Haplocryolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haplocryolls

IEFD. Other Haplocryolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

    a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

    b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haplocryolls

IEFE. Other Haplocryolls that have *all* of the following:

1. A mollic epipedon that is 40 cm or more thick and has a texture class finer than loamy fine sand; *and*

2. A slope of less than 25 percent; *and*

3. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

4. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower; *and*

5. In one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Cumulic Haplocryolls

IEFF. Other Haplocryolls that have *all* of the following:

1. A mollic epipedon that is 40 cm or more thick and has a texture class finer than loamy fine sand; *and*

2. A slope of less than 25 percent; *and*

3. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

4. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Haplocryolls

IEFG. Other Haplocryolls that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Haplocryolls

IEFH. Other Haplocryolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

    a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

    b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower; *and*

4. In one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Fluvaquentic Haplocryolls

IEFI. Other Haplocryolls that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplocryolls

IEFJ. Other Haplocryolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplocryolls

IEFK. Other Haplocryolls that have *both* of the following:

1. A mollic epipedon that is 40 cm or more thick and has a texture class finer than loamy fine sand; *and*

2. A calcic horizon within 100 cm of the mineral soil surface.

Calcic Pachic Haplocryolls

IEFL. Other Haplocryolls that have a mollic epipedon that is 40 cm or more thick and has a texture class finer than loamy fine sand.

Pachic Haplocryolls

IEFM. Other Haplocryolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Haplocryolls

IEFN. Other Haplocryolls that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Haplocryolls

IEFO. Other Haplocryolls that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Haplocryolls

IEFP. Other Haplocryolls that have a xeric soil moisture regime.

Xeric Haplocryolls

IEFQ. Other Haplocryolls.

Typic Haplocryolls

Natricryolls

Key to Subgroups

IEBA. All Natricryolls.

Typic Natricryolls

Palecryolls

Key to Subgroups

IECA. Palecryolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Palecryolls

IECB. Other Palecryolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Palecryolls

IECC. Other Palecryolls that have *one or both* of the following:

1. An argillic horizon that has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm, either within the horizon or at its upper boundary; *or*

2. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon.

Abruptic Palecryolls

IECD. Other Palecryolls that have a mollic epipedon that is 40 cm or more thick and has a texture class finer than loamy fine sand.

Pachic Palecryolls

IECE. Other Palecryolls that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Palecryolls

IECF. Other Palecryolls that have a xeric soil moisture regime.

Xeric Palecryolls

IECG. Other Palecryolls.

Typic Palecryolls

Gelolls

Key to Great Groups

IDA. All Gelolls.

Haplogelolls, p. 257

Haplogelolls

Key to Subgroups

IDAA. Haplogelolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplogelolls

IDAB. Other Haplogelolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haplogelolls

IDAC. Other Haplogelolls that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplogelolls

IDAD. Other Haplogelolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; or

2. 30 or more cumulative days.

Oxyaquic Haplogelolls

IDAE. Other Haplogelolls that have gelic materials within 200 cm of the mineral soil surface.

Turbic Haplogelolls

IDAF. Other Haplogelolls that have *both* of the following:

1. A mollic epipedon that is 40 cm or more thick and has a texture class finer than loamy fine sand; *and*

2. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Haplogelolls

IDAG. Other Haplogelolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. Less than 50 cm (total thickness) of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and *either*:

(1) A depth of 125 cm below the mineral soil surface; *or*

(2) A densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Haplogelolls

IDAH. Other Haplogelolls that have *both* of the following:

1. A mollic epipedon that is 40 cm or more thick; *and*

2. A texture class finer than loamy fine sand.

Pachic Haplogelolls

IDAI. Other Haplogelolls.

Typic Haplogelolls

Rendolls

Key to Great Groups

ICA. Rendolls that have a cryic soil temperature regime.

Cryrendolls, p. 258

ICB. Other Rendolls.

Haprendolls, p. 258

Cryrendolls

Key to Subgroups

ICAA. Cryrendolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Cryrendolls

ICAB. Other Cryrendolls.

Typic Cryrendolls

Haprendolls

Key to Subgroups

ICBA. Haprendolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haprendolls

ICBB. Other Haprendolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haprendolls

ICBC. Other Haprendolls that have a cambic horizon.

Inceptic Haprendolls

ICBD. Other Haprendolls that have a color value, dry, of 6 or more either in the upper 18 cm of the mollic epipedon, after mixing, or in an Ap horizon that is 18 cm or more thick.

Entic Haprendolls

ICBE. Other Haprendolls.

Typic Haprendolls

Udolls

Key to Great Groups

IHA. Udolls that have a natric horizon.

Natrudolls, p. 265

IHB. Other Udolls that:

1. Have a calcic or petrocalcic horizon within 100 cm of the mineral soil surface; *and*

2. Do not have an argillic horizon above the calcic or petrocalcic horizon; *and*

3. Have free carbonates in all parts above the calcic or petrocalcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed.

Calciudolls, p. 262

IHC. Other Udolls that have *one or both* of the following:

1. *All* of the following:

a. No densic, lithic, or paralithic contact within 150 cm of the mineral soil surface; *and*

b. Within 150 cm of the mineral soil surface, a clay decrease, with increasing depth, of less than 20 percent (relative) from the maximum noncarbonate clay content; *and*

c. *One or more* of the following:

(1) In 50 percent or more of the matrix of one or more subhorizons in the lower half of the argillic horizon, hue of 7.5YR or redder and chroma of 5 or more; *or*

(2) In 50 percent or more of the matrix of horizons that total more than one-half the total thickness of the argillic horizon, hue of 2.5YR or redder, a value, moist, of 3 or less, and a value, dry, of 4 or less; *or*

(3) Many redox concentrations with hue of 5YR or redder or chroma of 6 or more, or both, in one or more subhorizons of the argillic horizon; *or*

2. A frigid soil temperature regime and *both* of the following:

a. An argillic horizon that has its upper boundary 60 cm or more below the mineral soil surface; *and*

b. A texture class finer than loamy fine sand in all horizons above the argillic horizon.

Paleudolls, p. 266

IHD. Other Udolls that have an argillic horizon.

Argiudolls, p. 259

IHE. Other Udolls that have a mollic epipedon that:

1. Either below an Ap horizon or below a depth of 18 cm from the mineral soil surface*, contains 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows; *and*

2. Either rests on a lithic contact or has a transition zone to the underlying horizon in which 25 percent or more of the soil volume consists of discrete wormholes, wormcasts, or animal burrows filled with material from the mollic epipedon and from the underlying horizon.

Vermudolls, p. 267

IHF. Other Udolls.

Hapludolls, p. 262

Argiudolls

Key to Subgroups

IHDA. Argiudolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Argiudolls

IHDB. Other Argiudolls that have a petrocalcic horizon within 100 cm of the mineral soil surface.

Petrocalcic Argiudolls

IHDC. Other Argiudolls that have *both* of the following:

1. Aquic conditions for some time in normal years (or artificial drainage) *either*:

a. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

b. Within 75 cm of the mineral soil surface, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

(1) A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

* The upper part is excluded because plowing or other disturbance would destroy some or all of these features.

(2) Hue of 10YR or redder and chroma of 2 or less; *or*

(3) Hue of 2.5Y or yellower and chroma of 3 or less; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Aquertic Argiudolls

IHDD. Other Argiudolls that have *both* of the following:

1. In normal years, saturation with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Oxyaquic Vertic Argiudolls

IHDE. Other Argiudolls that have *both* of the following:

1. A mollic epipedon that has a texture class finer than loamy fine sand and that is *either:*

a. 40 cm or more thick in a frigid soil temperature regime; *or*

b. 50 cm or more thick; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Pachic Vertic Argiudolls

IHDF. Other Argiudolls that have:

1. Above the argillic horizon, an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon; *or*

2. A glossic horizon, *or* interfingering of albic materials into the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon; *and*

3. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Alfic Vertic Argiudolls

IHDG. Other Argiudolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argiudolls

IHDH. Other Argiudolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Argiudolls

IHDI. Other Argiudolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Argiudolls

IHDJ. Other Argiudolls that have *both* of the following:

1. Aquic conditions for some time in normal years (or artificial drainage) *either*:

a. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

b. Within 75 cm of the mineral soil surface, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

(1) A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

(2) Hue of 10YR or redder and chroma of 2 or less; *or*

(3) Hue of 2.5Y or yellower and chroma of 3 or less; *and*

2. A mollic epipedon that has a texture class finer than loamy fine sand and that is *either:*

a. 40 cm or more thick in a frigid soil temperature regime; *or*

b. 50 cm or more thick.

Aquic Pachic Argiudolls

IHDK. Other Argiudolls that have a mollic epipedon that has a texture class finer than loamy fine sand and that is *either:*

1. 40 cm or more thick in a frigid soil temperature regime; *or*

2. 50 cm or more thick.

Pachic Argiudolls

IHDL. Other Argiudolls that have aquic conditions for some time in normal years (or artificial drainage) *either*:

1. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

2. Within 75 cm of the mineral soil surface, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

a. A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

b. Hue of 10YR or redder and chroma of 2 or less; *or*

c. Hue of 2.5Y or yellower and chroma of 3 or less.

Aquic Argiudolls

IHDM. Other Argiudolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Argiudolls

IHDN. Other Argiudolls that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Argiudolls

IHDO. Other Argiudolls that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Argiudolls

IHDP. Other Argiudolls that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Argiudolls

IHDQ. Other Argiudolls that have *one or both* of the following:

1. An argillic horizon that has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical

distance of 7.5 cm, either within the horizon or at its upper boundary; *or*

2. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon.

Abruptic Argiudolls

IHDR. Other Argiudolls that have *either*:

1. Above the argillic horizon, an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon; *or*

2. A glossic horizon, *or* interfingering of albic materials into the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon.

Alfic Argiudolls

IHDS. Other Argiudolls that have a CEC of less than 24 cmol(+)/kg clay (by 1N NH_4OAc pH 7) in 50 percent or more either of the argillic horizon if less than 100 cm thick or of its upper 100 cm.

Oxic Argiudolls

IHDT. Other Argiudolls that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Argiudolls

IHDU. Other Argiudolls.

Typic Argiudolls

Calciudolls

Key to Subgroups

IHBA. Calciudolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calciudolls

IHBB. Other Calciudolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Calciudolls

IHBC. Other Calciudolls that have *both* of the following:

1. An anthropic epipedon; *and*

2. A petrocalcic horizon that formed in human-transported material within 100 cm of the mineral soil surface.

Anthropic Petrocalcic Calciudolls

IHBD. Other Calciudolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Calciudolls

IHBE. Other Calciudolls that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Calciudolls

IHBF. Other Calciudolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Calciudolls

IHBG. Other Calciudolls.

Typic Calciudolls

Hapludolls

Key to Subgroups

IHFA. Hapludolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Hapludolls

IHFB. Other Hapludolls that have a petrocalcic horizon within 100 cm of the mineral soil surface.

Petrocalcic Hapludolls

IHFC. Other Hapludolls that have *both* of the following:

1. Aquic conditions for some time in normal years (or artificial drainage) *either*:

a. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

b. Within 75 cm of the mineral soil surface, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

(1) A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

(2) Hue of 10YR or redder and chroma of 2 or less; *or*

(3) Hue of 2.5Y or yellower and chroma of 3 or less; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Aquertic Hapludolls

IHFD. Other Hapludolls that have *both* of the following:

1. A mollic epipedon that has a texture class finer than loamy fine sand and that is *either:*

a. 40 cm or more thick in a frigid soil temperature regime; *or*

b. 50 cm or more thick; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Pachic Vertic Hapludolls

IHFE. Other Hapludolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Hapludolls

IHFF. Other Hapludolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al + $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Hapludolls

IHFG. Other Hapludolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Hapludolls

IHFH. Other Hapludolls that have *all* of the following:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. *Either*:

a. A frigid soil temperature regime and a mollic epipedon that is 40 cm or more thick, of which less than 50 percent meets sandy or sandy-skeletal particle-size class criteria, and there is no densic or paralithic contact and no sandy or sandy-skeletal particle-size class at a depth between 40 and 50 cm from the mineral soil surface; *or*

b. A mollic epipedon that is 60 cm or more thick, of which 50 percent or more of the thickness has a texture class finer than loamy fine sand; *and*

3. A slope of less than 25 percent; *and*

4. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

5. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Aquic Cumulic Hapludolls

IHFI. Other Hapludolls that have *all* of the following:

1. *Either*:

a. A frigid soil temperature regime and a mollic epipedon that is 40 cm or more thick, of which less than 50 percent meets sandy or sandy-skeletal particle-size class criteria, and there is no densic or paralithic contact and no sandy or sandy-skeletal particle-size class at a depth between 40 and 50 cm from the mineral soil surface; *or*

b. A mollic epipedon that is 60 cm or more thick, of which 50 percent or more of the thickness has a texture class finer than loamy fine sand; *and*

2. A slope of less than 25 percent; *and*

3. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

4. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Hapludolls

IHFJ. Other Hapludolls that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Hapludolls

IHFK. Other Hapludolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. Aquic conditions for some time in normal years (or artificial drainage) *either*:

a. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

b. Within 75 cm of the mineral soil surface, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

(1) A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

(2) Hue of 10YR or redder and chroma of 2 or less; *or*

(3) Hue of 2.5Y or yellower and chroma of 3 or less; *and*

4. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Hapludolls

IHFL. Other Hapludolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Hapludolls

IHFM. Other Hapludolls that have *both* of the following:

1. Aquic conditions for some time in normal years (or artificial drainage) *either*:

a. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

b. Within 75 cm of the mineral soil surface, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

(1) A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

(2) Hue of 10YR or redder and chroma of 2 or less; *or*

(3) Hue of 2.5Y or yellower and chroma of 3 or less; *and*

2. A mollic epipedon that has a texture class finer than loamy fine sand and that is *either*:

a. 40 cm or more thick in a frigid soil temperature regime; *or*

b. 50 cm or more thick.

Aquic Pachic Hapludolls

IHFN. Other Hapludolls that have a mollic epipedon that has a texture class finer than loamy fine sand and that is *either*:

1. 40 cm or more thick in a frigid soil temperature regime; *or*

2. 50 cm or more thick.

Pachic Hapludolls

IHFO. Other Hapludolls that have aquic conditions for some time in normal years (or artificial drainage) *either*:

1. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

2. Within 75 cm of the mineral soil surface, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

a. A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

b. Hue of 10YR or redder and chroma of 2 or less; *or*

c. Hue of 2.5Y or yellower and chroma of 3 or less.

Aquic Hapludolls

IHFP. Other Hapludolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Hapludolls

IHFQ. Other Hapludolls that have *both*:

1. A mollic epipedon that is 60 cm or more thick that has a texture class finer than loamy fine sand and contains 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows either below an Ap horizon or below a depth of 18 cm from the mineral soil surface*; *and*

2. Either do not have a cambic horizon and do not, in the lower part of the mollic epipedon, meet the requirements for a cambic horizon, except for the color requirements, or have free carbonates throughout either the cambic horizon or the lower part of the mollic epipedon.

Vermic Hapludolls

IHFR. Other Hapludolls that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Hapludolls

IHFS. Other Hapludolls that *either*:

1. Do not have a cambic horizon and do not, in any part of the mollic epipedon below 25 cm from the mineral soil surface, meet the requirements for a cambic horizon, except for the color requirements; *or*

2. Have free carbonates throughout the cambic horizon or in all parts of the mollic epipedon below a depth of 25 cm from the mineral soil surface.

Entic Hapludolls

IHFT. Other Hapludolls.

Typic Hapludolls

Natrudolls

Key to Subgroups

IHAA. Natrudolls that have a petrocalcic horizon within 100 cm of the mineral soil surface.

Petrocalcic Natrudolls

* The upper part is excluded because plowing or other disturbance would destroy some or all of these features.

IHAB. Other Natrudolls that have *both* of the following:

1. Visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface*; and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Leptic Vertic Natrudolls

IHAC. Other Natrudolls that have *both* of the following:

1. A glossic horizon or interfingering of albic materials into the natric horizon*; and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Glossic Vertic Natrudolls

IHAD. Other Natrudolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrudolls

IHAE. Other Natrudolls that have visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface.

Leptic Natrudolls

IHAF. Other Natrudolls that have *one or both* of the following:

1. A natric horizon that has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm, either within the horizon or at its upper boundary; *or*

2. An abrupt textural change between the eluvial horizon and the upper boundary of the natric horizon.

Abruptic Natrudolls

IHAG. Other Natrudolls that have a glossic horizon or interfingering of albic materials into the natric horizon.

Glossic Natrudolls

IHAH. Other Natrudolls that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Natrudolls

IHAI. Other Natrudolls.

Typic Natrudolls

Paleudolls

Key to Subgroups

IHCA. Paleudolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleudolls

IHCB. Other Paleudolls that have *both* of the following:

1. Aquic conditions for some time in normal years (or artificial drainage) *either*:

a. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

b. Within 75 cm of the mineral soil surface, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

(1) A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

(2) Hue of 10YR or redder and chroma of 2 or less; *or*

(3) Hue of 2.5Y or yellower and chroma of 3 or less; *and*

2. A mollic epipedon that has a texture class finer than loamy fine sand and that is *either:*

a. 40 cm or more thick in a frigid soil temperature regime; *or*

b. 50 cm or more thick.

Aquic Pachic Paleudolls

IHCC. Other Paleudolls that have a mollic epipedon that has a texture class finer than loamy fine sand and that is 50 cm or more thick.

Pachic Paleudolls

IHCD. Other Paleudolls that have, in one or more subhorizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Paleudolls

IHCE. Other Paleudolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Paleudolls

IHCF. Other Paleudolls that have *both* of the following:

1. A calcic horizon within 100 cm of the mineral soil surface; *and*

2. In all parts above the calcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, either free carbonates or a texture class of loamy fine sand or coarser.

Calcic Paleudolls

IHCG. Other Paleudolls.

Typic Paleudolls

Vermudolls

Key to Subgroups

IHEA. Vermudolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Vermudolls

IHEB. Other Vermudolls that have a mollic epipedon that is less than 75 cm thick.

Haplic Vermudolls

IHEC. Other Vermudolls.

Typic Vermudolls

Ustolls

Key to Great Groups

IGA. Ustolls that have a duripan within 100 cm of the mineral soil surface.

Durustolls, p. 273

IGB. Other Ustolls that have a natric horizon.

Natrustolls, p. 279

IGC. Other Ustolls that:

1. Have either a calcic or gypsic horizon within 100 cm of the mineral soil surface or a petrocalcic horizon within 150 cm of the mineral soil surface; *and*

2. Do not have an argillic horizon above the calcic, gypsic, or petrocalcic horizon; *and*

3. In all parts above the calcic, gypsic, or petrocalcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, have either free carbonates or a texture class of loamy fine sand or coarser.

Calciustolls, p. 271

IGD. Other Ustolls that have *either*:

1. A petrocalcic horizon within 150 cm of the mineral soil surface; *or*

2. An argillic horizon that has *one or both* of the following:

a. With increasing depth, no clay decrease of 20 percent or more (relative) from the maximum noncarbonate clay content within 150 cm of the mineral soil surface (and there is no densic, lithic, or paralithic contact within that depth); *and either*

(1) Hue of 7.5YR or redder and chroma of 5 or more in the matrix; *or*

(2) Common redox concentrations with hue of 7.5YR or redder or chroma of 6 or more, or both; *or*

b. 35 percent or more noncarbonate clay throughout one or more subhorizons in its upper part, and *one or both* of the following:

(1) A clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm, either within the argillic horizon or at its upper boundary (and there is no densic, lithic, or paralithic contact within 50 cm of the mineral soil surface); *or*

(2) An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon (and there is no densic, lithic, or paralithic contact within 50 cm of the mineral soil surface).

Paleustolls, p. 281

IGE. Other Ustolls that have an argillic horizon.

Argiustolls, p. 268

IGF. Other Ustolls that have a mollic epipedon that:

1. Either below an Ap horizon or below a depth of 18 cm from the mineral soil surface*, contains 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows; *and*

2. Either rests on a lithic contact or has a transition zone to the underlying horizon in which 25 percent or more of the soil volume consists of discrete wormholes, wormcasts, or animal burrows filled with material from the mollic epipedon and from the underlying horizon.

Vermustolls, p. 283

IGG. Other Ustolls.

Haplustolls, p. 273

Argiustolls

Key to Subgroups

IGEA. Argiustolls that have *both* of the following:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Lithic Argiustolls

IGEB. Other Argiustolls that have *both* of the following:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. Above the argillic horizon, either an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon.

Alfic Lithic Argiustolls

IGEC. Other Argiustolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Argiustolls

IGED. Other Argiustolls that have *both* of the following:

1. In one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Aquertic Argiustolls

IGEE. Other Argiustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

* The upper part is excluded because plowing or other disturbance would destroy some or all of these features.

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Argiustolls

IGEF. Other Argiustolls that have *all* of the following:

1. A mollic epipedon that has a texture class finer than loamy fine sand and that is *either:*

a. 40 cm or more thick in a frigid soil temperature regime; *or*

b. 50 cm or more thick; *and*

2. When neither irrigated nor fallowed to store moisture, *either:*

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

3. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Pachic Udertic Argiustolls

IGEG. Other Argiustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *either:*

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Udertic Argiustolls

IGEH. Other Argiustolls that have *both* of the following:

1. A mollic epipedon that has a texture class finer than loamy fine sand and that is *either:*

a. 40 cm or more thick in a frigid soil temperature regime; *or*

b. 50 cm or more thick; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Pachic Vertic Argiustolls

IGEI. Other Argiustolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argiustolls

IGEJ. Other Argiustolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Argiustolls

IGEK. Other Argiustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitritorrandic Argiustolls

IGEL. Other Argiustolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Argiustolls

IGEM. Other Argiustolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Argiustolls

IGEN. Other Argiustolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Argiustolls

IGEO. Other Argiustolls that have a mollic epipedon that has a texture class finer than loamy fine sand and that is *either*:

1. 40 cm or more thick in a frigid soil temperature regime; *or*

2. 50 cm or more thick.

Pachic Argiustolls

IGEP. Other Argiustolls that have *either*:

1. Above the argillic horizon, an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon; *or*

2. A glossic horizon, *or* interfingering of albic materials into the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon.

Alfic Argiustolls

IGEQ. Other Argiustolls that have *both* of the following:

1. A calcic horizon within 100 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Calcidic Argiustolls

IGER. Other Argiustolls that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Aridic Argiustolls

IGES. Other Argiustolls that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C.

Udic Argiustolls

IGET. Other Argiustolls that have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either is brittle and has some opal coats or has 20 percent or more (by volume) durinodes.

Duric Argiustolls

IGEU. Other Argiustolls.

Typic Argiustolls

Calciustolls

Key to Subgroups

IGCA. Calciustolls that have a salic horizon within 75 cm of the mineral soil surface.

Salidic Calciustolls

IGCB. Other Calciustolls that have a petrocalcic horizon and a lithic contact within 50 cm of the mineral soil surface.

Lithic Petrocalcic Calciustolls

IGCC. Other Calciustolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calciustolls

IGCD. Other Calciustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Calciustolls

IGCE. Other Calciustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Udertic Calciustolls

IGCF. Other Calciustolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Calciustolls

IGCG. Other Calciustolls that have a petrocalcic horizon within 100 cm of the mineral soil surface.

Petrocalcic Calciustolls

IGCH. Other Calciustolls that have a gypsic horizon within 100 cm of the mineral soil surface.

Gypsic Calciustolls

IGCI. Other Calciustolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Calciustolls

IGCJ. Other Calciustolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Calciustolls

IGCK. Other Calciustolls that have a mollic epipedon that has a texture class finer than loamy fine sand and that is *either*:

1. 40 cm or more thick in a frigid soil temperature regime; *or*

2. 50 cm or more thick.

Pachic Calciustolls

IGCL. Other Calciustolls that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Calciustolls

IGCM. Other Calciustolls that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for four-tenths or less of the consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Calciustolls

IGCN. Other Calciustolls.

Typic Calciustolls

Durustolls

Key to Subgroups

IGAA. Durustolls that have a natric horizon above the duripan.

Natric Durustolls

IGAB. Other Durustolls that:

1. Do not have an argillic horizon above the duripan; *and*

2. Have an aridic soil moisture regime that borders on ustic.

Haploduridic Durustolls

IGAC. Other Durustolls that have an aridic soil moisture regime that borders on ustic.

Argiduridic Durustolls

IGAD. Other Durustolls that do not have an argillic horizon above the duripan.

Entic Durustolls

IGAE. Other Durustolls that have a duripan that is strongly coherent or less coherent in all subhorizons.

Haplic Durustolls

IGAF. Other Durustolls.

Typic Durustolls

Haplustolls

Key to Subgroups

IGGA. Haplustolls that have a salic horizon within 75 cm of the mineral soil surface.

Salidic Haplustolls

IGGB. Other Haplustolls that have a lithic contact within 50 cm of the mineral soil surface in part of each pedon* and below 50 cm in other parts of each pedon.

Ruptic-Lithic Haplustolls

IGGC. Other Haplustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

* The lithic contact may either be present in only part of each pedon, or it may fluctuate in depth from less than 50 cm to more than 50 cm in each pedon.

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. A lithic contact within 50 cm of the mineral soil surface.

Aridic Lithic Haplustolls

IGGD. Other Haplustolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplustolls

IGGE. Other Haplustolls that have *both* of the following:

1. In one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Aquertic Haplustolls

IGGF. Other Haplustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Haplustolls

IGGG. Other Haplustolls that have *all* of the following:

1. A mollic epipedon that has a texture class finer than loamy fine sand and that is *either*:

a. 40 cm or more thick in a frigid soil temperature regime; *or*

b. 50 cm or more thick*; and*

2. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

3. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Pachic Udertic Haplustolls

IGGH. Other Haplustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Udertic Haplustolls

IGGI. Other Haplustolls that have *both* of the following:

1. A mollic epipedon that has a texture class finer than loamy fine sand and that is *either*:

a. 40 cm or more thick in a frigid soil temperature regime; *or*

b. 50 cm or more thick; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Pachic Vertic Haplustolls

IGGJ. Other Haplustolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplustolls

IGGK. Other Haplustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years remains moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

2. An apparent CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+)/kg clay in 50 percent or more of the soil volume

between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. (If the ratio of [percent water retained at 1500 kPa tension minus percent organic carbon] to the percentage of measured clay is 0.6 or more, then the percentage of clay is considered to equal either the measured percentage of clay or three times [percent water retained at 1500 kPa tension minus percent organic carbon], whichever value is higher, but no more than 100.)

Torroxic Haplustolls

IGGL. Other Haplustolls that have an apparent CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+)/kg clay in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. (If the ratio of [percent water retained at 1500 kPa tension minus percent organic carbon] to the percentage of measured clay is 0.6 or more, then the percentage of clay is considered to equal either the measured percentage of clay or three times [percent water retained at 1500 kPa tension minus percent organic carbon], whichever value is higher, but no more than 100.)

Oxic Haplustolls

IGGM. Other Haplustolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haplustolls

IGGN. Other Haplustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitritorrandic Haplustolls

IGGO. Other Haplustolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haplustolls

IGGP. Other Haplustolls that have *all* of the following:

1. In one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. *Either*:

a. A frigid soil temperature regime and a mollic epipedon that is 40 cm or more thick, of which less than 50 percent meets sandy or sandy-skeletal particle-size class criteria, and there is no densic or paralithic contact and no sandy or sandy-skeletal particle-size class at a depth between 40 and 50 cm from the mineral soil surface; *or*

b. A mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand; *and*

3. A slope of less than 25 percent; *and*

4. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

5. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Aquic Cumulic Haplustolls

IGGQ. Other Haplustolls that have *all* of the following:

1. *Either*:

a. A frigid soil temperature regime and a mollic epipedon that is 40 cm or more thick, of which less than 50 percent meets sandy or sandy-skeletal particle-size class criteria, and there is no densic or paralithic contact and no sandy or sandy-skeletal particle-size class at a depth between 40 and 50 cm from the mineral soil surface; *or*

b. A mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand; *and*

2. A slope of less than 25 percent; *and*

3. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

4. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Haplustolls

IGGR. Other Haplustolls that have anthraquic conditions.

Anthraquic Haplustolls

IGGS. Other Haplustolls that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Haplustolls

IGGT. Other Haplustolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. In one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

4. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Haplustolls

IGGU. Other Haplustolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in most years (or artificial drainage).

Aquic Haplustolls

IGGV. Other Haplustolls that have a mollic epipedon that has a texture class finer than loamy fine sand and that is *either*:

1. 40 cm or more thick in a frigid soil temperature regime; *or*

2. 50 cm or more thick.

Pachic Haplustolls

IGGW. Other Haplustolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplustolls

IGGX. Other Haplustolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *and*

4. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Torrifluventic Haplustolls

IGGY. Other Haplustolls that:

1. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *and*

2. *Either*:

a. Do not have a cambic horizon and do not, in any part of the mollic epipedon below 25 cm from the mineral soil surface, meet the requirements for a cambic horizon, except for the color requirements; *or*

b. Have free carbonates throughout the cambic horizon or in all parts of the mollic epipedon below a depth of 25 cm from the mineral soil surface.

Torriorthentic Haplustolls

IGGZ. Other Haplustolls that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

b. Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Aridic Haplustolls

IGGZa. Other Haplustolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Haplustolls

IGGZb. Other Haplustolls that have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either is brittle and has some opal coats or has 20 percent or more (by volume) durinodes.

Duric Haplustolls

IGGZc. Other Haplustolls:

1. When neither irrigated nor fallowed to store moisture, have *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

2. *Either*:

a. Do not have a cambic horizon and do not, in any part of the mollic epipedon below 25 cm from the mineral soil surface, meet the requirements for a cambic horizon, except for the color requirements; *or*

b. Have free carbonates throughout either the cambic horizon or in all parts of the mollic epipedon below a depth of 25 cm from the mineral soil surface.

Udorthentic Haplustolls

IGGZd. Other Haplustolls that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C.

Udic Haplustolls

IGGZe. Other Haplustolls that *either*:

1. Do not have a cambic horizon and do not, in any part of the mollic epipedon below 25 cm from the mineral soil surface, meet the requirements for a cambic horizon, except for the color requirements; *or*

2. Have free carbonates throughout either the cambic horizon or in all parts of the mollic epipedon below a depth of 25 cm from the mineral soil surface.

Entic Haplustolls

IGGZf. Other Haplustolls.

Typic Haplustolls

Natrustolls

Key to Subgroups

IGBA. Natrustolls that have *all* of the following:

1. Visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

3. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Leptic Torrertic Natrustolls

IGBB. Other Natrustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Natrustolls

IGBC. Other Natrustolls that have *both* of the following:

1. Visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Leptic Vertic Natrustolls

IGBD. Other Natrustolls that have *both* of the following:

1. A glossic horizon or interfingering of albic materials into a natric horizon; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Glossic Vertic Natrustolls

IGBE. Other Natrustolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrustolls

IGBF. Other Natrustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *and*

2. Visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface.

Aridic Leptic Natrustolls

IGBG. Other Natrustolls that have visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface.

Leptic Natrustolls

IGBH. Other Natrustolls that have, in one or more horizons at a depth between 50 and 100 cm from the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *one* of the following:

1. 50 percent or more chroma of 1 or less and hue of 2.5Y or yellower; *or*

2. 50 percent or more chroma of 2 or less and redox concentrations; *or*

3. 50 percent or more chroma of 2 or less and also a higher exchangeable sodium percentage (or sodium adsorption ratio) between the mineral soil surface and a depth of 25 cm than in the underlying horizon.

Aquic Natrustolls

IGBI. Other Natrustolls that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

b. Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Aridic Natrustolls

IGBJ. Other Natrustolls that have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Duric Natrustolls

IGBK. Other Natrustolls that have a glossic horizon or interfingering of albic materials into a natric horizon.

Glossic Natrustolls

IGBL. Other Natrustolls.

Typic Natrustolls

Paleustolls

Key to Subgroups

IGDA. Paleustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Paleustolls

IGDB. Other Paleustolls that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Udertic Paleustolls

IGDC. Other Paleustolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleustolls

IGDD. Other Paleustolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Paleustolls

IGDE. Other Paleustolls that have a mollic epipedon that has a texture class finer than loamy fine sand and that is 50 cm or more thick.

Pachic Paleustolls

IGDF. Other Paleustolls that have a petrocalcic horizon within 150 cm of the mineral soil surface.

Petrocalcic Paleustolls

IGDG. Other Paleustolls that have *both* of the following:

1. A calcic horizon within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

a. Sandy or sandy-skeletal and within 100 cm of the mineral soil surface; *or*

b. Clayey, clayey-skeletal, fine, or very-fine and within 50 cm of the mineral soil surface; *or*

c. Any other class and within 60 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ºC; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC.

Calcidic Paleustolls

IGDH. Other Paleustolls that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ºC; *and*

b. Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC.

Aridic Paleustolls

IGDI. Other Paleustolls that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ºC.

Udic Paleustolls

IGDJ. Other Paleustolls that have a calcic horizon within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

1. Sandy or sandy-skeletal and within 100 cm of the mineral soil surface; *or*

2. Clayey, clayey-skeletal, fine, or very-fine and within 50 cm of the mineral soil surface; *or*

3. Any other class and within 60 cm of the mineral soil surface.

Calcic Paleustolls

IGDK. Other Paleustolls that have free carbonates throughout after the surface horizons have been mixed to a depth of 18 cm.

Entic Paleustolls

IGDL. Other Paleustolls.

Typic Paleustolls

Vermustolls

Key to Subgroups

IGFA. Vermustolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Vermustolls

IGFB. Other Vermustolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Vermustolls

IGFC. Other Vermustolls that have a mollic epipedon that is 75 cm or more thick.

Pachic Vermustolls

IGFD. Other Vermustolls that have a mollic epipedon that is less than 50 cm thick.

Entic Vermustolls

IGFE. Other Vermustolls.

Typic Vermustolls

Xerolls

Key to Great Groups

IFA. Xerolls that have a duripan within 100 cm of the mineral soil surface.

Durixerolls, p. 287

IFB. Other Xerolls that have a natric horizon.

Natrixerolls, p. 292

IFC. Other Xerolls that have *either*:

1. A petrocalcic horizon within 150 cm of the mineral soil surface; *or*

2. An argillic horizon that has *one or both* of the following:

a. With increasing depth, no clay decrease of 20 percent or more (relative) from the maximum noncarbonate clay content within 150 cm of the mineral soil surface (and there is no densic, lithic, or paralithic contact within that depth); *and either*

(1) Hue of 7.5YR or redder and chroma of 5 or more in the matrix; *or*

(2) Common redox concentrations with hue of 7.5YR or redder or chroma of 6 or more, or both; *or*

b. 35 percent or more noncarbonate clay throughout one or more subhorizons in its upper part, and *one or both* of the following:

(1) A clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm, either within the argillic horizon or at its upper boundary (and there is no densic, lithic, or paralithic contact within 50 cm of the mineral soil surface); *or*

(2) An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon (and there is no densic, lithic, or paralithic contact within 50 cm of the mineral soil surface).

Palexerolls, p. 293

IFD. Other Xerolls that have *both* of the following:

1. A calcic or gypsic horizon within 150 cm of the mineral soil surface; *and*

2. In all parts above the calcic or gypsic horizon, after the surface soil has been mixed to a depth of 18 cm, either free carbonates or a texture class of loamy fine sand or coarser.

Calcixerolls, p. 286

IFE. Other Xerolls that have an argillic horizon.

Argixerolls, p. 284

IFF. Other Xerolls.

Haploxerolls, p. 288

Argixerolls

Key to Subgroups

IFEA. Argixerolls that have *both* of the following:

1. An aridic soil moisture regime; *and*

2. A lithic contact within 50 cm of the mineral soil surface.

Aridic Lithic Argixerolls

IFEB. Other Argixerolls that have *both* of the following:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either the mineral soil surface or an Ap horizon, whichever is deeper, and the lithic contact.

Lithic Ultic Argixerolls

IFEC. Other Argixerolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Argixerolls

IFED. Other Argixerolls that have *both* of the following:

1. An aridic soil moisture regime; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Argixerolls

IFEE. Other Argixerolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argixerolls

IFEF. Other Argixerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Argixerolls

IFEG. Other Argixerolls that have *both* of the following:

1. An aridic soil moisture regime*; and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitritorrandic Argixerolls

IFEH. Other Argixerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Argixerolls

IFEI. Other Argixerolls that have *both* of the following:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Aquultic Argixerolls

IFEJ. Other Argixerolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial draiange).

Aquic Argixerolls

IFEK. Other Argixerolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Argixerolls

IFEL. Other Argixerolls that have *either*:

1. Above the argillic horizon, an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon; *or*

2. A glossic horizon, *or* interfingering of albic materials into the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon.

Alfic Argixerolls

IFEM. Other Argixerolls that have *both* of the following:

1. A calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

a. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

b. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

c. Any other class and within 110 cm of the mineral soil surface*; and*

2. A mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand.

Calcic Pachic Argixerolls

IFEN. Other Argixerolls that have *both* of the following:

1. A mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand; *and*

2. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever

is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Pachic Ultic Argixerolls

IFEO. Other Argixerolls that have a mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand.

Pachic Argixerolls

IFEP. Other Argixerolls that have *both* of the following:

1. A horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist; *and*

2. An aridic soil moisture regime.

Argiduridic Argixerolls

IFEQ. Other Argixerolls that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Duric Argixerolls

IFER. Other Argixerolls that have *both* of the following:

1. A calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

a. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

b. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

c. Any other class and within 110 cm of the mineral soil surface*; and*

2. An aridic soil moisture regime.

Calciargidic Argixerolls

IFES. Other Argixerolls that have an aridic soil moisture regime.

Aridic Argixerolls

IFET. Other Argixerolls that have a calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

1. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

2. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

3. Any other class and within 110 cm of the mineral soil surface.

Calcic Argixerolls

IFEU. Other Argixerolls that have a base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Ultic Argixerolls

IFEV. Other Argixerolls.

Typic Argixerolls

Calcixerolls

Key to Subgroups

IFDA. Calcixerolls that have *both* of the following:

1. An aridic soil moisture regime; *and*

2. A lithic contact within 50 cm of the mineral soil surface.

Aridic Lithic Calcixerolls

IFDB. Other Calcixerolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calcixerolls

IFDC. Other Calcixerolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Calcixerolls

IFDD. Other Calcixerolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Calcixerolls

IFDE. Other Calcixerolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Calcixerolls

IFDF. Other Calcixerolls that have a mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand.

Pachic Calcixerolls

IFDG. Other Calcixerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. Both:

a. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Calcixerolls

IFDH. Other Calcixerolls that have an aridic soil moisture regime.

Aridic Calcixerolls

IFDI. Other Calcixerolls that have a mollic epipedon that has, below any Ap horizon, 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows.

Vermic Calcixerolls

IFDJ. Other Calcixerolls.

Typic Calcixerolls

Durixerolls

Key to Subgroups

IFAA. Durixerolls that have *one or both* of the following:

1. Cracks between the soil surface and the top of the duripan that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that is above the duripan; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and the top of the duripan.

Vertic Durixerolls

IFAB. Other Durixerolls that have *both* of the following:

1. An aridic soil moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitritorrandic Durixerolls

IFAC. Other Durixerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Durixerolls

IFAD. Other Durixerolls that have, in one or more horizons above the duripan, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Durixerolls

IFAE. Other Durixerolls that have *all* of the following:

1. An aridic soil moisture regime; *and*

2. *One or both* of the following:

a. An argillic horizon that has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm, either within the horizon or at its upper boundary; *or*

b. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon; *and*

3. A duripan that is neither very strongly coherent nor indurated in any subhorizon.

Paleargidic Durixerolls

IFAF. Other Durixerolls that have *both* of the following:

1. An aridic soil moisture regime*; and*

2. *One or both* of the following:

a. An argillic horizon that has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm, either within the horizon or at its upper boundary; *or*

b. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon.
Abruptic Argiduridic Durixerolls

IFAG. Other Durixerolls that:

1. Have an aridic soil moisture regime; *and*

2. Do not have an argillic horizon above the duripan; *and*

3. Have a duripan that is neither very strongly coherent nor indurated in any subhorizon.
Cambidic Durixerolls

IFAH. Other Durixerolls that:

1. Have an aridic soil moisture regime*; and*

2. Do not have an argillic horizon above the duripan.
Haploduridic Durixerolls

IFAI. Other Durixerolls that have *both* of the following:

1. An aridic soil moisture regime; *and*

2. A duripan that is neither very strongly coherent nor indurated in any subhorizon.
Argidic Durixerolls

IFAJ. Other Durixerolls that have an aridic soil moisture regime.
Argiduridic Durixerolls

IFAK. Other Durixerolls that have *both* of the following:

1. A duripan that is neither very strongly coherent nor indurated in any subhorizon; *and*

2. *One or both* of the following:

a. An argillic horizon that has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm, either within the horizon or at its upper boundary; *or*

b. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon.
Haplic Palexerollic Durixerolls

IFAL. Other Durixerolls that have *one or both* of the following:

1. An argillic horizon that has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute, in the fine-earth fraction) within a vertical distance of 2.5 cm, either within the horizon or at its upper boundary; *or*

2. An abrupt textural change between the eluvial horizon and the upper boundary of the argillic horizon.
Palexerollic Durixerolls

IFAM. Other Durixerolls that:

1. Have a duripan that is neither very strongly coherent nor indurated in any subhorizon*; and*

2. Do not have an argillic horizon above the duripan.
Haplic Haploxerollic Durixerolls

IFAN. Other Durixerolls that do not have an argillic horizon above the duripan.
Haploxerollic Durixerolls

IFAO. Other Durixerolls that have a duripan that is neither very strongly coherent nor indurated in any subhorizon.
Haplic Durixerolls

IFAP. Other Durixerolls.
Typic Durixerolls

Haploxerolls

Key to Subgroups

IFFA. Haploxerolls that have *both* of the following:

1. An aridic soil moisture regime; *and*

2. A lithic contact within 50 cm of the mineral soil surface.
Aridic Lithic Haploxerolls

IFFB. Other Haploxerolls that have *both* of the following:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either the mineral soil surface or an Ap horizon, whichever is deeper, and the lithic contact.
Lithic Ultic Haploxerolls

IFFC. Other Haploxerolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haploxerolls

IFFD. Other Haploxerolls that have *both* of the following:

1. An aridic soil moisture regime; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Haploxerolls

IFFE. Other Haploxerolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haploxerolls

IFFF. Other Haploxerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haploxerolls

IFFG. Other Haploxerolls that have *both* of the following:

1. An aridic soil moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitritorrandic Haploxerolls

IFFH. Other Haploxerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haploxerolls

IFFI. Other Haploxerolls that have *all* of the following:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand; *and*

3. A slope of less than 25 percent; *and*

4. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

5. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Aquic Cumulic Haploxerolls

IFFJ. Other Haploxerolls that have *all* of the following:

1. A mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand; *and*

2. A slope of less than 25 percent; *and*

3. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

4. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower; *and*

5. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Ultic Haploxerolls

IFFK. Other Haploxerolls that have *all* of the following:

1. A mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand; *and*

2. A slope of less than 25 percent; *and*

3. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

4. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Haploxerolls

IFFL. Other Haploxerolls that meet *one or both* of the following:

1. Have a buried layer that meets criteria for a histic, mollic, umbric, or melanic epipedon within 200 cm of the soil surface; *or*

2. Have buried O and dark-colored A horizons (moist value of 3 or less), within 200 cm of the soil surface and with a combined thickness of 20 cm or more, that have 1.0 percent or more Holocene-age organic carbon.

Thapto-Humic Haploxerolls

IFFM. Other Haploxerolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

4. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Haploxerolls

IFFN. Other Haploxerolls that have *both* of the following:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Aquic Duric Haploxerolls

IFFO. Other Haploxerolls that have *both* of the following:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Aquultic Haploxerolls

IFFP. Other Haploxerolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haploxerolls

IFFQ. Other Haploxerolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haploxerolls

IFFR. Other Haploxerolls that have *both* of the following:

1. A calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

a. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

b. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

c. Any other class and within 110 cm of the mineral soil surface; *and*

2. A mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand.

Calcic Pachic Haploxerolls

IFFS. Other Haploxerolls that have *both* of the following:

1. A mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand; *and*

2. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Pachic Ultic Haploxerolls

IFFT. Other Haploxerolls that have a mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand.

Pachic Haploxerolls

IFFU. Other Haploxerolls that have *all* of the following:

1. An aridic soil moisture regime; *and*

2. A slope of less than 25 percent; *and*

3. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

4. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Torrifluventic Haploxerolls

IFFV. Other Haploxerolls that have *both* of the following:

1. An aridic soil moisture regime; *and*

2. A horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Duridic Haploxerolls

IFFW. Other Haploxerolls that have *both* of the following:

1. An aridic soil moisture regime; *and*

2. A calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

a. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

b. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

c. Any other class and within 110 cm of the mineral soil surface.

Calcidic Haploxerolls

IFFX. Other Haploxerolls that have *both* of the following:

1. An aridic soil moisture regime; *and*

2. A sandy particle-size class in all horizons within 100 cm of the mineral soil surface.

Torripsammentic Haploxerolls

IFFY. Other Haploxerolls that:

1. Have an aridic soil moisture regime; *and*

2. *Either*:

a. Do not have a cambic horizon and do not, in any part of the mollic epipedon below 25 cm from the mineral soil surface, meet the requirements for a cambic horizon, except for the color requirements; *or*

b. Have free carbonates throughout the cambic horizon or in all parts of the mollic epipedon below a depth of 25 cm from the mineral soil surface.

Torriorthentic Haploxerolls

IFFZ. Other Haploxerolls that have an aridic soil moisture regime.

Aridic Haploxerolls

IFFZa. Other Haploxerolls that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Duric Haploxerolls

IFFZb. Other Haploxerolls that have a sandy particle-size class in all horizons within 100 cm of the mineral soil surface.

Psammentic Haploxerolls

IFFZc. Other Haploxerolls that have *all* of the following:

1. A slope of less than 25 percent; *and*

2. A total thickness of less than 50 cm of human-transported material in the surface horizons; *and*

3. *One or both* of the following:

a. An organic carbon content (Holocene age) of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

b. An irregular decrease in organic carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Haploxerolls

IFFZd. Other Haploxerolls that have a mollic epipedon that has granular structure and that has, below any Ap horizon, 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows.

Vermic Haploxerolls

IFFZe. Other Haploxerolls that have a calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

1. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

2. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

3. Any other class and within 110 cm of the mineral soil surface.

Calcic Haploxerolls

IFFZf. Other Haploxerolls that:

1. Do not have a cambic horizon and do not, in the lower part of the mollic epipedon, meet the requirements for a cambic horizon, except for the color requirements; *and*

2. Have a base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Entic Ultic Haploxerolls

IFFZg. Other Haploxerolls that have a base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Ultic Haploxerolls

IFFZh. Other Haploxerolls that *either*:

1. Do not have a cambic horizon and do not, in any part of the mollic epipedon below 25 cm from the mineral soil surface, meet the requirements for a cambic horizon, except for the color requirements; *or*

2. Have free carbonates throughout the cambic horizon or in all parts of the mollic epipedon below a depth of 25 cm from the mineral soil surface.

Entic Haploxerolls

IFFZi. Other Haploxerolls.

Typic Haploxerolls

Natrixerolls

Key to Subgroups

IFBA. Natrixerolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrixerolls

IFBB. Other Natrixerolls that have *both* of the following:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Aquic Duric Natrixerolls

IFBC. Other Natrixerolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normals years (or artificial drainage).

Aquic Natrixerolls

IFBD. Other Natrixerolls that have an aridic soil moisture regime.

Aridic Natrixerolls

IFBE. Other Natrixerolls that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Duric Natrixerolls

IFBF. Other Natrixerolls.

Typic Natrixerolls

Palexerolls

Key to Subgroups

IFCA. Palexerolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Palexerolls

IFCB. Other Palexerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Palexerolls

IFCC. Other Palexerolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Palexerolls

IFCD. Other Palexerolls that have a mollic epipedon that is 50 cm or more thick and has a texture class finer than loamy fine sand.

Pachic Palexerolls

IFCE. Other Palexerolls that have *both* of the following:

1. A petrocalcic horizon within 150 cm of the mineral soil surface; *and*

2. An aridic soil moisture regime.

Petrocalcidic Palexerolls

IFCF. Other Palexerolls that have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has at least a firm rupture-resistance class when moist.

Duric Palexerolls

IFCG. Other Palexerolls that have an aridic soil moisture regime.

Aridic Palexerolls

IFCH. Other Palexerolls that have a petrocalcic horizon within 150 cm of the mineral soil surface.

Petrocalcic Palexerolls

IFCI. Other Palexerolls that have a base saturation (by sum of cations) of 75 percent or less in one or more subhorizons either within the argillic horizon if more than 50 cm thick or within its upper 50 cm.

Ultic Palexerolls

IFCJ. Other Palexerolls that have an argillic horizon that has *either*:

1. Less than 35 percent clay in the upper part; *or*

2. At its upper boundary, a clay increase that is both less than 20 percent (absolute) within a vertical distance of 7.5 cm and less than 15 percent (absolute) within a vertical distance of 2.5 cm, in the fine-earth fraction.

Haplic Palexerolls

IFCK. Other Palexerolls.

Typic Palexerolls

CHAPTER 13

Oxisols

Key to Suborders

EA. Oxisols that have aquic conditions for some time in normal years (or artificial drainage) in one or more horizons within 50 cm of the mineral soil surface and have *one or more* of the following:

1. A histic epipedon; *or*

2. An epipedon with a color value, moist, of 3 or less and, directly below it, a horizon with chroma of 2 or less; *or*

3. Distinct or prominent redox concentrations within 50 cm of the mineral soil surface, an epipedon, and, directly below it, a horizon with *one or both* of the following:

   a. 50 percent or more hue of 2.5Y or yellower; *or*

   b. Chroma of 3 or less; *or*

4. Within 50 cm of the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquox, p. 295

EB. Other Oxisols that have an aridic soil moisture regime.

Torrox, p. 300

EC. Other Oxisols that have an ustic or xeric soil moisture regime.

Ustox, p. 305

ED. Other Oxisols that have a perudic soil moisture regime.

Perox, p. 296

EE. Other Oxisols.

Udox, p. 301

Aquox

Key to Great Groups

EAA. Aquox that have, in one or more subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more.

Acraquox, p. 295

EAB. Other Aquox that have plinthite forming a continuous phase* within 125 cm of the mineral soil surface.

Plinthaquox, p. 296

EAC. Other Aquox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutraquox, p. 295

EAD. Other Aquox.

Haplaquox, p. 296

Acraquox

Key to Subgroups

EAAA. Acraquox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Acraquox

EAAB. Other Acraquox that have, directly below an epipedon, a horizon 10 cm or more thick that has 50 percent or more chroma of 3 or more.

Aeric Acraquox

EAAC. Other Acraquox.

Typic Acraquox

Eutraquox

Key to Subgroups

EACA. Eutraquox that have a histic epipedon.

Histic Eutraquox

EACB. Other Eutraquox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Eutraquox

* As large amounts of iron accumulate over time, the individual plinthite bodies coalesce and become interconnected throughout one or more layers, forming one continuous mass of plinthite. If irreversibly hardened, the mass becomes a layer of indurated ironstone.

EACC. Other Eutraquox that have, directly below an epipedon, a horizon 10 cm or more thick that has 50 percent or more chroma of 3 or more.

Aeric Eutraquox

EACD. Other Eutraquox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Eutraquox

EACE. Other Eutraquox.

Typic Eutraquox

Haplaquox

Key to Subgroups

EADA. Haplaquox that have a histic epipedon.

Histic Haplaquox

EADB. Other Haplaquox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Haplaquox

EADC. Other Haplaquox that have, directly below an epipedon, a horizon 10 cm or more thick that has 50 percent or more chroma of 3 or more.

Aeric Haplaquox

EADD. Other Haplaquox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Haplaquox

EADE. Other Haplaquox.

Typic Haplaquox

Plinthaquox

Key to Subgroups

EABA. Plinthaquox that have, directly below an epipedon, a horizon 10 cm or more thick that has 50 percent or more chroma of 3 or more.

Aeric Plinthaquox

EABB. Other Plinthaquox.

Typic Plinthaquox

Perox

Key to Great Groups

EDA. Perox that have a sombric horizon within 150 cm of the mineral soil surface.

Sombriperox, p. 300

EDB. Other Perox that have, in one or more subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more.

Acroperox, p. 296

EDC. Other Perox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutroperox, p. 297

EDD. Other Perox that have a kandic horizon within 150 cm of the mineral soil surface.

Kandiperox, p. 299

EDE. Other Perox.

Haploperox, p. 298

Acroperox

Key to Subgroups

EDBA. Acroperox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact*; and*
2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Acroperox

EDBB. Other Acroperox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Acroperox

EDBC. Other Acroperox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*
2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Acroperox

EDBD. Other Acroperox that that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Acroperox

EDBE. Other Acroperox that have a delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick within 125 cm of the mineral soil surface.

Anionic Acroperox

EDBF. Other Acroperox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Acroperox

EDBG. Other Acroperox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Acroperox

EDBH. Other Acroperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

    a. Hue of 2.5YR or redder; *and*

    b. A value, moist, of 3 or less.

Humic Rhodic Acroperox

EDBI. Other Acroperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Acroperox

EDBJ. Other Acroperox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Acroperox

EDBK. Other Acroperox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Acroperox

EDBL. Other Acroperox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Acroperox

EDBM. Other Acroperox.

Typic Acroperox

Eutroperox

Key to Subgroups

EDCA. Eutroperox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Eutroperox

EDCB. Other Eutroperox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Eutroperox

EDCC. Other Eutroperox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact*; and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Eutroperox

EDCD. Other Eutroperox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Eutroperox

EDCE. Other Eutroperox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Eutroperox

EDCF. Other Eutroperox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Eutroperox

EDCG. Other Eutroperox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Eutroperox

EDCH. Other Eutroperox that have a kandic horizon within 150 cm of the mineral soil surface.

Kandiudalfic Eutroperox

EDCI. Other Eutroperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. An oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Humic Inceptic Eutroperox

EDCJ. Other Eutroperox that have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Inceptic Eutroperox

EDCK. Other Eutroperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

   a. Hue of 2.5YR or redder; *and*

   b. A value, moist, of 3 or less.

Humic Rhodic Eutroperox

EDCL. Other Eutroperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Eutroperox

EDCM. Other Eutroperox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Eutroperox

EDCN. Other Eutroperox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Eutroperox

EDCO. Other Eutroperox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Eutroperox

EDCP. Other Eutroperox.

Typic Eutroperox

Haploperox

Key to Subgroups

EDEA. Haploperox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Haploperox

EDEB. Other Haploperox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Haploperox

EDEC. Other Haploperox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Haploperox

EDED. Other Haploperox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Haploperox

EDEE. Other Haploperox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Haploperox

EDEF. Other Haploperox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Haploperox

EDEG. Other Haploperox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haploperox

EDEH. Other Haploperox that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haploperox

EDEI. Other Haploperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Haploperox

EDEJ. Other Haploperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Haploperox

EDEK. Other Haploperox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Haploperox

EDEL. Other Haploperox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Haploperox

EDEM. Other Haploperox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Haploperox

EDEN. Other Haploperox.

Typic Haploperox

Kandiperox

Key to Subgroups

EDDA. Kandiperox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Kandiperox

EDDB. Other Kandiperox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Kandiperox

EDDC. Other Kandiperox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Kandiperox

EDDD. Other Kandiperox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Kandiperox

EDDE. Other Kandiperox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Kandiperox

EDDF. Other Kandiperox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Kandiperox

EDDG. Other Kandiperox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiperox

EDDH. Other Kandiperox that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kandiperox

EDDI. Other Kandiperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from

the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Kandiperox

EDDJ. Other Kandiperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Kandiperox

EDDK. Other Kandiperox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Kandiperox

EDDL. Other Kandiperox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Kandiperox

EDDM. Other Kandiperox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Kandiperox

EDDN. Other Kandiperox.

Typic Kandiperox

Sombriperox

Key to Subgroups

EDAA. Sombriperox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Sombriperox

EDAB. Other Sombriperox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Sombriperox

EDAC. Other Sombriperox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Sombriperox

EDAD. Other Sombriperox.

Typic Sombriperox

Torrox

Key to Great Groups

EBA. Torrox that have, in one or more subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more.

Acrotorrox, p. 300

EBB. Other Torrox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutrotorrox, p. 300

EBC. Other Torrox.

Haplotorrox, p. 300

Acrotorrox

Key to Subgroups

EBAA. Acrotorrox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Acrotorrox

EBAB. Other Acrotorrox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Acrotorrox

EBAC. Other Acrotorrox.

Typic Acrotorrox

Eutrotorrox

Key to Subgroups

EBBA. Eutrotorrox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Eutrotorrox

EBBB. Other Eutrotorrox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Eutrotorrox

EBBC. Other Eutrotorrox.

Typic Eutrotorrox

Haplotorrox

Key to Subgroups

EBCA. Haplotorrox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Haplotorrox

EBCB. Other Haplotorrox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Haplotorrox

EBCC. Other Haplotorrox.

Typic Haplotorrox

Udox

Key to Great Groups

EEA. Udox that have a sombric horizon within 150 cm of the mineral soil surface.

Sombriudox, p. 305

EEB. Other Udox that have, in one or more subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more.

Acrudox, p. 301

EEC. Other Udox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutrudox, p. 302

EED. Other Udox that have a kandic horizon within 150 cm of the mineral soil surface.

Kandiudox, p. 304

EEE. Other Udox.

Hapludox, p. 303

Acrudox

Key to Subgroups

EEBA. Acrudox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Acrudox

EEBB. Other Acrudox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Acrudox

EEBC. Other Acrudox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Acrudox

EEBD. Other Acrudox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Acrudox

EEBE. Other Acrudox that have, within 125 cm of the mineral soil surface, *both*:

1. A delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Anionic Aquic Acrudox

EEBF. Other Acrudox that have a delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick within 125 cm of the mineral soil surface.

Anionic Acrudox

EEBG. Other Acrudox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Acrudox

EEBH. Other Acrudox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Acrudox

EEBI. Other Acrudox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutric Acrudox

EEBJ. Other Acrudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

   a. Hue of 2.5YR or redder; *and*

   b. A value, moist, of 3 or less.

Humic Rhodic Acrudox

EEBK. Other Acrudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

3. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Acrudox

EEBL. Other Acrudox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Acrudox

EEBM. Other Acrudox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Acrudox

EEBN. Other Acrudox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Acrudox

EEBO. Other Acrudox.

Typic Acrudox

Eutrudox

Key to Subgroups

EECA. Eutrudox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Eutrudox

EECB. Other Eutrudox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Eutrudox

EECC. Other Eutrudox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Eutrudox

EECD. Other Eutrudox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Eutrudox

EECE. Other Eutrudox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Eutrudox

EECF. Other Eutrudox that have, in one or more horizons within 125 cm of the mineral soil surface, 5 percent or more (by volume) plinthite.

Plinthic Eutrudox

EECG. Other Eutrudox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Eutrudox

EECH. Other Eutrudox that have a kandic horizon within 150 cm of the mineral soil surface.

Kandiudalfic Eutrudox

EECI. Other Eutrudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. An oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Humic Inceptic Eutrudox

EECJ. Other Eutrudox that have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Inceptic Eutrudox

EECK. Other Eutrudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Eutrudox

EECL. Other Eutrudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Eutrudox

EECM. Other Eutrudox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Eutrudox

EECN. Other Eutrudox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Eutrudox

EECO. Other Eutrudox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Eutrudox

EECP. Other Eutrudox.

Typic Eutrudox

Hapludox

Key to Subgroups

EEEA. Hapludox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Hapludox

EEEB. Other Hapludox have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Hapludox

EEEC. Other Hapludox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Hapludox

EEED. Other Hapludox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Hapludox

EEEE. Other Hapludox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Hapludox

EEEF. Other Hapludox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Hapludox

EEEG. Other Hapludox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Hapludox

EEEH. Other Hapludox that have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Inceptic Hapludox

EEEI. Other Hapludox that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Hapludox

EEEJ. Other Hapludox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Hapludox

EEEK. Other Hapludox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color

value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Hapludox

EEEL. Other Hapludox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Hapludox

EEEM. Other Hapludox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Hapludox

EEEN. Other Hapludox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Hapludox

EEEO. Other Hapludox.

Typic Hapludox

Kandiudox

Key to Subgroups

EEDA. Kandiudox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Kandiudox

EEDB. Other Kandiudox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Kandiudox

EEDC. Other Kandiudox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Kandiudox

EEDD. Other Kandiudox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Kandiudox

EEDE. Other Kandiudox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Kandiudox

EEDF. Other Kandiudox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Kandiudox

EEDG. Other Kandiudox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiudox

EEDH. Other Kandiudox that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kandiudox

EEDI. Other Kandiudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

   a. Hue of 2.5YR or redder; *and*

   b. A value, moist, of 3 or less.

Humic Rhodic Kandiudox

EEDJ. Other Kandiudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Kandiudox

EEDK. Other Kandiudox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Kandiudox

EEDL. Other Kandiudox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Kandiudox

EEDM. Other Kandiudox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Kandiudox

EEDN. Other Kandiudox.

Typic Kandiudox

Sombriudox

Key to Subgroups

EEAA. Sombriudox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Sombriudox

EEAB. Other Sombriudox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Sombriudox

EEAC. Other Sombriudox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Sombriudox

EEAD. Other Sombriudox.

Typic Sombriudox

Ustox

Key to Great Groups

ECA. Ustox that have a sombric horizon within 150 cm of the mineral soil surface.

Sombriustox, p. 309

ECB. Other Ustox that have, in one or more subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more.

Acrustox, p. 305

ECC. Other Ustox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutrustox, p. 306

ECD. Other Ustox that have a kandic horizon within 150 cm of the mineral soil surface.

Kandiustox, p. 308

ECE. Other Ustox.

Haplustox, p. 307

Acrustox

Key to Subgroups

ECBA. Acrustox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Acrustox

ECBB. Other Acrustox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Acrustox

ECBC. Other Acrustox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Acrustox

ECBD. Other Acrustox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Acrustox

ECBE. Other Acrustox that have, within 125 cm of the mineral soil surface, *both*:

1. A delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Anionic Aquic Acrustox

ECBF. Other Acrustox that have a delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick within 125 cm of the mineral soil surface.

Anionic Acrustox

ECBG. Other Acrustox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Acrustox

ECBH. Other Acrustox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Acrustox

ECBI. Other Acrustox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutric Acrustox

ECBJ. Other Acrustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

    a. Hue of 2.5YR or redder; *and*

    b. A value, moist, of 3 or less.

Humic Rhodic Acrustox

ECBK. Other Acrustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Acrustox

ECBL. Other Acrustox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Acrustox

ECBM. Other Acrustox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Acrustox

ECBN. Other Acrustox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Acrustox

ECBO. Other Acrustox.

Typic Acrustox

Eutrustox

Key to Subgroups

ECCA. Eutrustox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Eutrustox

ECCB. Other Eutrustox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Eutrustox

ECCC. Other Eutrustox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Eutrustox

ECCD. Other Eutrustox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Eutrustox

ECCE. Other Eutrustox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Eutrustox

ECCF. Other Eutrustox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Eutrustox

ECCG. Other Eutrustox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Eutrustox

ECCH. Other Eutrustox that have a kandic horizon within 150 cm of the mineral soil surface.

Kandiustalfic Eutrustox

ECCI. Other Eutrustox that have *both*:

1. 16 kg/m² or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. An oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Humic Inceptic Eutrustox

ECCJ. Other Eutrustox that have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Inceptic Eutrustox

ECCK. Other Eutrustox that have *both*:

1. 16 kg/m² or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Eutrustox

ECCL. Other Eutrustox that have *both*:

1. 16 kg/m² or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Eutrustox

ECCM. Other Eutrustox that have 16 kg/m² or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Eutrustox

ECCN. Other Eutrustox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Eutrustox

ECCO. Other Eutrustox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Eutrustox

ECCP. Other Eutrustox.

Typic Eutrustox

Haplustox

Key to Subgroups

ECEA. Haplustox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Haplustox

ECEB. Other Haplustox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Haplustox

ECEC. Other Haplustox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Haplustox

ECED. Other Haplustox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Haplustox

ECEE. Other Haplustox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Haplustox

ECEF. Other Haplustox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Haplustox

ECEG. Other Haplustox that have, within 125 cm of the mineral soil surface, *both*:

1. The lower boundary of the oxic horizon; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aqueptic Haplustox

ECEH. Other Haplustox that have, within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplustox

ECEI. Other Haplustox that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplustox

ECEJ. Other Haplustox that have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Inceptic Haplustox

ECEK. Other Haplustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

   a. Hue of 2.5YR or redder; *and*

   b. A value, moist, of 3 or less.

Humic Rhodic Haplustox

ECEL. Other Haplustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Haplustox

ECEM. Other Haplustox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Haplustox

ECEN. Other Haplustox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Haplustox

ECEO. Other Haplustox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Haplustox

ECEP. Other Haplustox.

Typic Haplustox

Kandiustox

Key to Subgroups

ECDA. Kandiustox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Kandiustox

ECDB. Other Kandiustox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Kandiustox

ECDC. Other Kandiustox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Kandiustox

ECDD. Other Kandiustox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Kandiustox

ECDE. Other Kandiustox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Kandiustox

ECDF. Other Kandiustox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Kandiustox

ECDG. Other Kandiustox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiustox

ECDH. Other Kandiustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Kandiustox

ECDI. Other Kandiustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Kandiustox

ECDJ. Other Kandiustox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Kandiustox

ECDK. Other Kandiustox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Kandiustox

ECDL. Other Kandiustox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Kandiustox

ECDM. Other Kandiustox.

Typic Kandiustox

Sombriustox

Key to Subgroups

ECAA. Sombriustox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Sombriustox

ECAB. Other Sombriustox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Sombriustox

ECAC. Other Sombriustox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Sombriustox

ECAD. Other Sombriustox.

Typic Sombriustox

CHAPTER 14

Spodosols

Key to Suborders

CA. Spodosols that have aquic conditions for some time in normal years (or artificial drainage) in one or more horizons within 50 cm of the mineral soil surface and have *one or both* of the following:

1. A histic epipedon; *or*

2. Within 50 cm of the mineral soil surface, aquic conditions in an albic or a spodic horizon.

Aquods, p. 311

CB. Other Spodosols that have a gelic soil temperature regime.

Gelods, p. 315

CC. Other Spodosols that have a cryic soil temperature regime.

Cryods, p. 313

CD. Other Spodosols that have 6.0 percent or more organic carbon in a layer 10 cm or more thick within the spodic horizon.

Humods, p. 316

CE. Other Spodosols.

Orthods, p. 316

Aquods

Key to Great Groups

CAA. Aquods that have a cryic soil temperature regime.

Cryaquods, p. 312

CAB. Other Aquods that have less than 0.10 percent iron (by ammonium oxalate) or at least 3 times as much ammonium oxalate extractable aluminum as iron in 75 percent or more of the spodic horizon.

Alaquods, p. 311

CAC. Other Aquods that have a fragipan within 100 cm of the mineral soil surface.

Fragiaquods, p. 313

CAD. Other Aquods that have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.

Placaquods, p. 313

CAE. Other Aquods that have, in 90 percent or more of each pedon, a pedogenically cemented horizon that is extremely weakly coherent or more coherent within 100 cm of the mineral soil surface.

Duraquods, p. 312

CAF. Other Aquods that have episaturation.

Epiaquods, p. 313

CAG. Other Aquods.

Endoaquods, p. 312

Alaquods

Key to Subgroups

CABA. Alaquods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Alaquods

CABB. Other Alaquods that have, in 90 percent or more of each pedon, a pedogenically cemented horizon that is extremely weakly coherent or more coherent within 100 cm of the mineral soil surface.

Duric Alaquods

CABC. Other Alaquods that have a histic epipedon.

Histic Alaquods

CABD. Other Alaquods that:

1. Within 200 cm of the mineral soil surface, have an argillic or kandic horizon that has a base saturation (by sum of cations) of 35 percent or more in some part; *and*

2. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil

surface to the top of a spodic horizon at a depth of 75 to 125 cm.

Alfic Arenic Alaquods

CABE. Other Alaquods that:

1. Have an argillic or kandic horizon within 200 cm of the mineral soil surface; *and*

2. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm.

Arenic Ultic Alaquods

CABF. Other Alaquods that:

1. Have an umbric epipedon; *and*

2. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm.

Arenic Umbric Alaquods

CABG. Other Alaquods that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm.

Arenic Alaquods

CABH. Other Alaquods that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 125 cm or more.

Grossarenic Alaquods

CABI. Other Alaquods that have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation (by sum of cations) of 35 percent or more in some part.

Alfic Alaquods

CABJ. Other Alaquods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.

Ultic Alaquods

CABK. Other Alaquods that have an ochric epipedon.

Aeric Alaquods

CABL. Other Alaquods.

Typic Alaquods

Cryaquods

Key to Subgroups

CAAA. Cryaquods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Cryaquods

CAAB. Other Cryaquods that have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.

Placic Cryaquods

CAAC. Other Cryaquods that have, in 90 percent or more of each pedon, a pedogenically cemented horizon that is extremely weakly coherent or more coherent within 100 cm of the mineral soil surface.

Duric Cryaquods

CAAD. Other Cryaquods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Cryaquods

CAAE. Other Cryaquods that have a spodic horizon less than 10 cm thick in 50 percent or more of each pedon.

Entic Cryaquods

CAAF. Other Cryaquods.

Typic Cryaquods

Duraquods

Key to Subgroups

CAEA. Duraquods that have a histic epipedon.

Histic Duraquods

CAEB. Other Duraquods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Duraquods

CAEC. Other Duraquods.

Typic Duraquods

Endoaquods

Key to Subgroups

CAGA. Endoaquods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Endoaquods

CAGB. Other Endoaquods that have a histic epipedon.
Histic Endoaquods

CAGC. Other Endoaquods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.
Andic Endoaquods

CAGD. Other Endoaquods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.
Argic Endoaquods

CAGE. Other Endoaquods that have an umbric epipedon.
Umbric Endoaquods

CAGF. Other Endoaquods.
Typic Endoaquods

Epiaquods

Key to Subgroups

CAFA. Epiaquods that have a lithic contact within 50 cm of the mineral soil surface.
Lithic Epiaquods

CAFB. Other Epiaquods that have a histic epipedon.
Histic Epiaquods

CAFC. Other Epiaquods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.
Andic Epiaquods

CAFD. Other Epiaquods that have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation (by sum of cations) of 35 percent or more in some part.
Alfic Epiaquods

CAFE. Other Epiaquods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.
Ultic Epiaquods

CAFF. Other Epiaquods that have an umbric epipedon.
Umbric Epiaquods

CAFG. Other Epiaquods.
Typic Epiaquods

Fragiaquods

Key to Subgroups

CACA. Fragiaquods that have a histic epipedon.
Histic Fragiaquods

CACB. Other Fragiaquods that have a surface horizon between 25 and 50 cm thick that meets all of the requirements for a plaggen epipedon except thickness.
Haploplaggic Fragiaquods

CACC. Other Fragiaquods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.
Argic Fragiaquods

CACD. Other Fragiaquods.
Typic Fragiaquods

Placaquods

Key to Subgroups

CADA. Placaquods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.
Andic Placaquods

CADB. Other Placaquods.
Typic Placaquods

Cryods

Key to Great Groups

CCA. Cryods that have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.
Placocryods, p. 315

CCB. Other Cryods that have, in 90 percent or more of each pedon, a pedogenically cemented horizon that is extremely weakly coherent or more coherent within 100 cm of the mineral soil surface.
Duricryods, p. 314

CCC. Other Cryods that have 6.0 percent or more organic carbon throughout a layer 10 cm or more thick within the spodic horizon.
Humicryods, p. 314

CCD. Other Cryods.
Haplocryods, p. 314

Duricryods

Key to Subgroups

CCBA. Duricryods that have *both*:

1. Redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Aquandic Duricryods

CCBB. Other Duricryods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm of either the mineral soil surface or the top of an organic layer with andic properties, whichever is shallower.

Andic Duricryods

CCBC. Other Duricryods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Duricryods

CCBD. Other Duricryods that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Duricryods

CCBE. Other Duricryods that have 6.0 percent or more organic carbon throughout a layer 10 cm or more thick within the spodic horizon.

Humic Duricryods

CCBF. Other Duricryods.

Typic Duricryods

Haplocryods

Key to Subgroups

CCDA. Haplocryods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplocryods

CCDB. Other Haplocryods that have *both*:

1. Redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Aquandic Haplocryods

CCDC. Other Haplocryods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Haplocryods

CCDD. Other Haplocryods that have a folistic epipedon.

Folistic Haplocryods

CCDE. Other Haplocryods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplocryods

CCDF. Other Haplocryods that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplocryods

CCDG. Other Haplocryods that have less than 1.2 percent* organic carbon in the upper 10 cm of the spodic horizon.

Entic Haplocryods

CCDH. Other Haplocryods.

Typic Haplocryods

Humicryods

Key to Subgroups

CCCA. Humicryods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Humicryods

CCCB. Other Humicryods that have *both*:

1. Redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions

* This value equates to approximately 2 percent organic matter.

for some time in normal years (or artificial drainage); *and*

2. Have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Aquandic Humicryods

CCCC. Other Humicryods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Humicryods

CCCD. Other Humicryods that have a folistic epipedon.

Folistic Humicryods

CCCE. Other Humicryods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Humicryods

CCCF. Other Humicryods that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Humicryods

CCCG. Other Humicryods.

Typic Humicryods

Placocryods

Key to Subgroups

CCAA. Placocryods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Placocryods

CCAB. Other Placocryods that have 6.0 percent or more organic carbon in a layer 10 cm or more thick within the spodic horizon.

Humic Placocryods

CCAC. Other Placocryods.

Typic Placocryods

Gelods

Key to Great Groups

CBA. Gelods that have 6.0 percent or more organic carbon throughout a layer 10 cm or more thick within the spodic horizon.

Humigelods, p. 315

CBB. Other Gelods.

Haplogelods, p. 315

Haplogelods

Key to Subgroups

CBBA. Haplogelods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplogelods

CBBB. Other Haplogelods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Haplogelods

CBBC. Other Haplogelods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplogelods

CBBD. Other Haplogelods that have gelic materials within 200 cm of the mineral soil surface.

Turbic Haplogelods

CBBE. Other Haplogelods.

Typic Haplogelods

Humigelods

Key to Subgroups

CBAA. Humigelods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Humigelods

CBAB. Other Humigelods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Humigelods

CBAC. Other Humigelods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Humigelods

CBAD. Other Humigelods that have gelic materials within 200 cm of the mineral soil surface.

Turbic Humigelods

CBAE. Other Humigelods.

Typic Humigelods

Humods

Key to Great Groups

CDA. Humods that have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.

Placohumods, p. 316

CDB. Other Humods that have, in 90 percent or more of each pedon, a pedogenically cemented horizon that is extremely weakly coherent or more coherent within 100 cm of the mineral soil surface.

Durihumods, p. 316

CDC. Other Humods that have a fragipan within 100 cm of the mineral soil surface.

Fragihumods, p. 316

CDD. Other Humods.

Haplohumods, p. 316

Durihumods

Key to Subgroups

CDBA. Durihumods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Durihumods

CDBB. Other Durihumods.

Typic Durihumods

Fragihumods

Key to Subgroups

CDCA. All Fragihumods (provisionally).

Typic Fragihumods

Haplohumods

Key to Subgroups

CDDA. Haplohumods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplohumods

CDDB. Other Haplohumods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Haplohumods

CDDC. Other Haplohumods that have a surface horizon between 25 and 50 cm thick that meets all of the requirements for a plaggen epipedon except thickness.

Haploplaggic Haplohumods

CDDD. Other Haplohumods.

Typic Haplohumods

Placohumods

Key to Subgroups

CDAA. Placohumods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Placohumods

CDAB. Other Placohumods.

Typic Placohumods

Orthods

Key to Great Groups

CEA. Orthods that have, in 50 percent or more of each pedon, a placic horizon within 100 cm of the mineral soil surface.

Placorthods, p. 320

CEB. Other Orthods that have, in 90 percent or more of each pedon, a pedogenically cemented horizon that is extremely weakly coherent or more coherent within 100 cm of the mineral soil surface.

Durorthods, p. 317

CEC. Other Orthods that have a fragipan within 100 cm of the mineral soil surface.

Fragiorthods, p. 317

CED. Other Orthods that have less than 0.10 percent iron (by ammonium oxalate) in 75 percent or more of the spodic horizon.

Alorthods, p. 317

CEE. Other Orthods.

Haplorthods, p. 318

Alorthods

Key to Subgroups

CEDA. Alorthods that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Alorthods

CEDB. Other Alorthods that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm; *and*

2. Have an argillic or kandic horizon below the spodic horizon.

Arenic Ultic Alorthods

CEDC. Other Alorthods that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm.

Arenic Alorthods

CEDD. Other Alorthods that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 125 cm or more; *and*

2. Have, in 10 percent or more of each pedon, less than 3.0 percent organic carbon in the upper 2 cm of the spodic horizon.

Entic Grossarenic Alorthods

CEDE. Other Alorthods that have, in 10 percent or more of each pedon, less than 3.0 percent organic carbon in the upper 2 cm of the spodic horizon.

Entic Alorthods

CEDF. Other Alorthods that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 125 cm or more.

Grossarenic Alorthods

CEDG. Other Alorthods that have a surface horizon between 25 and 50 cm thick that meets all of the requirements for a plaggen epipedon except thickness.

Haploplaggic Alorthods

CEDH. Other Alorthods that have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation (by sum of cations) of 35 percent or more in some part.

Alfic Alorthods

CEDI. Other Alorthods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.

Ultic Alorthods

CEDJ. Other Alorthods.

Typic Alorthods

Durorthods

Key to Subgroups

CEBA. Durorthods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Durorthods

CEBB. Other Durorthods.

Typic Durorthods

Fragiorthods

Key to Subgroups

CECA. Fragiorthods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fragiorthods

CECB. Other Fragiorthods that:

1. Are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days; *and*

2. Have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation (by sum of cations) of 35 percent or more in some part.

Alfic Oxyaquic Fragiorthods

CECC. Other Fragiorthods that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Fragiorthods

CECD. Other Fragiorthods that have a surface horizon between 25 and 50 cm thick that meets all of the requirements for a plaggen epipedon except thickness.

Haploplaggic Fragiorthods

CECE. Other Fragiorthods that have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation (by sum of cations) of 35 percent or more in some part.

Alfic Fragiorthods

CECF. Other Fragiorthods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.

Ultic Fragiorthods

CECG. Other Fragiorthods that have a spodic horizon that has *one* of the following:

1. A texture class of very fine sand, loamy very fine sand, or finer and *all* of the following:

a. A thickness of 10 cm or less; *and*

b. A weighted average of less than 1.2 percent* organic carbon; *and*

c. Within the upper 7.5 cm, *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample); *or*

2. A texture class of loamy fine sand, fine sand, or coarser and *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample) in the upper 2.5 cm.

Entic Fragiorthods

CECH. Other Fragiorthods.

Typic Fragiorthods

* This value equates to approximately 2 percent organic matter.

Haplorthods

Key to Subgroups

CEEA. Haplorthods that have a lithic contact within 50 cm of the mineral soil surface and *either*:

1. A spodic horizon with a texture class of very fine sand, loamy very fine sand, or finer and *all* of the following:

a. A thickness of 10 cm or less; *and*

b. A weighted average of less than 1.2 percent* organic carbon; *and*

c. Within the upper 7.5 cm, *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample); *or*

2. A spodic horizon with a texture class of loamy fine sand, fine sand, or coarser and *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample) in the upper 2.5 cm.

Entic Lithic Haplorthods

CEEB. Other Haplorthods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplorthods

CEEC. Other Haplorthods that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Fragiaquic Haplorthods

CEED. Other Haplorthods that have *both*:

1. Redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation (by sum of cations) of 35 percent or more in some part.

Aqualfic Haplorthods

CEEE. Other Haplorthods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. A spodic horizon with a texture class of very fine sand, loamy very fine sand, or finer and *all* of the following:

a. A thickness of 10 cm or less; *and*

b. A weighted average of less than 1.2 percent* organic carbon; *and*

c. Within the upper 7.5 cm, *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample); *or*

2. A spodic horizon with a texture class of loamy fine sand, fine sand, or coarser and *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample) in the upper 2.5 cm.

Aquentic Haplorthods

CEEF. Other Haplorthods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplorthods

CEEG. Other Haplorthods that have:

1. Within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation (by sum of cations) of 35 percent or more in some part; *and*

2. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Alfic Oxyaquic Haplorthods

CEEH. Other Haplorthods that have:

1. Within 200 cm of the mineral soil surface, an argillic or kandic horizon; *and*

2. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Oxyaquic Ultic Haplorthods

CEEI. Other Haplorthods that have fragic soil properties *either*:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Haplorthods

CEEJ. Other Haplorthods that have *both*:

1. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days; *and*

2. Below the spodic horizon but not below an argillic horizon, lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Oxyaquic Haplorthods

CEEK. Other Haplorthods that have, below the spodic horizon but not below an argillic horizon, lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Haplorthods

CEEL. Other Haplorthods that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplorthods

CEEM. Other Haplorthods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Haplorthods

CEEN. Other Haplorthods that have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation (by sum of cations) of 35 percent or more in some part.

Alfic Haplorthods

CEEO. Other Haplorthods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.

Ultic Haplorthods

CEEP. Other Haplorthods that have a spodic horizon that has *one* of the following:

1. A texture class of very fine sand, loamy very fine sand, or finer and *all* of the following:

a. A thickness of 10 cm or less; *and*

b. A weighted average of less than 1.2 percent* organic carbon; *and*

* This value equates to approximately 2 percent organic matter.

c. Within the upper 7.5 cm, *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample); *or*

2. A texture class of loamy fine sand, fine sand, or coarser and *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample) in the upper 2.5 cm.

Entic Haplorthods

CEEQ. Other Haplorthods.

Typic Haplorthods

Placorthods

Key to Subgroups

CEAA. All Placorthods (provisionally).

Typic Placorthods

CHAPTER 15

Ultisols

Key to Suborders

HA. Ultisols that have aquic conditions for some time in normal years (or artificial drainage) in one or more horizons within 50 cm of the mineral soil surface and *one or both* of the following:

1. Redoximorphic features in all layers between either the lower boundary of an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 40 cm and *one* of the following within the upper 12.5 cm of the argillic or kandic horizon:

a. Redox concentrations and 50 percent or more redox depletions with chroma of 2 or less either on faces of peds or in the matrix; *or*

b. 50 percent or more redox depletions with chroma of 1 or less either on faces of peds or in the matrix; *or*

c. Distinct or prominent redox concentrations and 50 percent or more hue of 2.5Y or 5Y in the matrix and also a thermic, isothermic, or warmer soil temperature regime; *or*

2. Within 50 cm of the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquults, p. 321

HB. Other Ultisols that have *one or both* of the following:

1. 0.9 percent[*] (by weighted average) or more organic carbon in the upper 15 cm of the argillic or kandic horizon; *or*

2. 12 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humults, p. 325

HC. Other Ultisols that have a udic soil moisture regime.

Udults, p. 328

HD. Other Ultisols that have an ustic soil moisture regime.

Ustults, p. 336

[*] This value equates to approximately 1.5 percent organic matter.

HE. Other Ultisols.

Xerults, p. 340

Aquults

Key to Great Groups

HAA. Aquults that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase[†] or constitutes one-half or more of the volume.

Plinthaquults, p. 325

HAB. Other Aquults that have a fragipan within 100 cm of the mineral soil surface.

Fragiaquults, p. 323

HAC. Other Aquults that have an abrupt textural change between the ochric epipedon or albic horizon and the argillic or kandic horizon *and* have a saturated hydraulic conductivity of 0.4 cm/hr (1.0 µm/sec) or slower (moderately low or lower K_{sat} class) in the argillic or kandic horizon.

Albaquults, p. 322

HAD. Other Aquults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Have a kandic horizon; *and*

3. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) clay depletions on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Kandiaquults, p. 323

[†] As large amounts of iron accumulate over time, the individual plinthite bodies coalesce and become interconnected throughout one or more layers, forming one continuous mass of plinthite. If irreversibly hardened, the mass becomes a layer of indurated ironstone.

HAE. Other Aquults that have a kandic horizon.
Kanhaplaquults, p. 324

HAF. Other Aquults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) clay depletions on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.
Paleaquults, p. 324

HAG. Other Aquults that have an umbric or mollic epipedon.
Umbraquults, p. 325

HAH. Other Aquults that have episaturation.
Epiaquults, p. 322

HAI. Other Aquults.
Endoaquults, p. 322

Albaquults

Key to Subgroups

HACA. Albaquults that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.
Vertic Albaquults

HACB. Other Albaquults that have a kandic horizon.
Kandic Albaquults

HACC. Other Albaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.
Aeric Albaquults

HACD. Other Albaquults.
Typic Albaquults

Endoaquults

Key to Subgroups

HAIA. Endoaquults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.
Arenic Endoaquults

HAIB. Other Endoaquults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.
Grossarenic Endoaquults

HAIC. Other Endoaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.
Aeric Endoaquults

HAID. Other Endoaquults.
Typic Endoaquults

Epiaquults

Key to Subgroups

HAHA. Epiaquults that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.
Vertic Epiaquults

HAHB. Other Epiaquults that have *both* of the following:

1. Fragic soil properties *either*:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25

cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Fragic Epiaquults

HAHC. Other Epiaquults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Epiaquults

HAHD. Other Epiaquults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Epiaquults

HAHE. Other Epiaquults that have fragic soil properties *either*:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Epiaquults

HAHF. Other Epiaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Epiaquults

HAHG. Other Epiaquults.

Typic Epiaquults

Fragiaquults

Key to Subgroups

HABA. Fragiaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and the fragipan.

Aeric Fragiaquults

HABB. Other Fragiaquults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Fragiaquults

HABC. Other Fragiaquults that have a mollic or umbric epipedon.

Umbric Fragiaquults

HABD. Other Fragiaquults.

Typic Fragiaquults

Kandiaquults

Key to Subgroups

HADA. Kandiaquults that have an ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface.

Acraquoxic Kandiaquults

HADB. Other Kandiaquults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. Have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Kandiaquults

HADC. Other Kandiaquults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. Have a mollic or umbric epipedon.

Arenic Umbric Kandiaquults

HADD. Other Kandiaquults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Kandiaquults

HADE. Other Kandiaquults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more.

Grossarenic Kandiaquults

HADF. Other Kandiaquults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandiaquults

HADG. Other Kandiaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Kandiaquults

HADH. Other Kandiaquults that have a mollic or umbric epipedon.

Umbric Kandiaquults

HADI. Other Kandiaquults.

Typic Kandiaquults

Kanhaplaquults

Key to Subgroups

HAEA. Kanhaplaquults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Kanhaplaquults

HAEB. Other Kanhaplaquults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kanhaplaquults

HAEC. Other Kanhaplaquults that have *both* of the following:

1. 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm; *and*

2. A mollic or umbric epipedon.

Aeric Umbric Kanhaplaquults

HAED. Other Kanhaplaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Kanhaplaquults

HAEE. Other Kanhaplaquults that have a mollic or umbric epipedon.

Umbric Kanhaplaquults

HAEF. Other Kanhaplaquults.

Typic Kanhaplaquults

Paleaquults

Key to Subgroups

HAFA. Paleaquults that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleaquults

HAFB. Other Paleaquults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

2. Have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Paleaquults

HAFC. Other Paleaquults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

3. Have a mollic or umbric epipedon.

Arenic Umbric Paleaquults

HAFD. Other Paleaquults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Paleaquults

HAFE. Other Paleaquults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Paleaquults

HAFF. Other Paleaquults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Paleaquults

HAFG. Other Paleaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Paleaquults

HAFH. Other Paleaquults that have a mollic or umbric epipedon.

Umbric Paleaquults

HAFI. Other Paleaquults.

Typic Paleaquults

Plinthaquults

Key to Subgroups

HAAA. Plinthaquults that have a kandic horizon or a CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+)/kg clay in 50 percent or more (by volume) of the argillic horizon if less than 100 cm thick or of its upper 100 cm.

Kandic Plinthaquults

HAAB. Other Plinthaquults.

Typic Plinthaquults

Umbraquults

Key to Subgroups

HAGA. Umbraquults that have 5 to 50 percent (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Umbraquults

HAGB. Other Umbraquults.

Typic Umbraquults

Humults

Key to Great Groups

HBA. Humults that have a sombric horizon within 100 cm of the mineral soil surface.

Sombrihumults, p. 328

HBB. Other Humults that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase* or constitutes one-half or more of the volume.

Plinthohumults, p. 328

HBC. Other Humults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Have a kandic horizon; *and*

3. Within 150 cm of the mineral soil surface, *either*:

   a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

   b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Kandihumults, p. 326

HBD. Other Humults that have a kandic horizon.

Kanhaplohumults, p. 327

HBE. Other Humults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

   a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

   b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Palehumults, p. 328

HBF. Other Humults.

Haplohumults, p. 326

* As large amounts of iron accumulate over time, the individual plinthite bodies coalesce and become interconnected throughout one or more layers, forming one continuous mass of plinthite. If irreversibly hardened, the mass becomes a layer of indurated ironstone.

Haplohumults

Key to Subgroups

HBFA. Haplohumults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplohumults

HBFB. Other Haplohumults that have *both* of the following:

1. In one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Aquandic Haplohumults

HBFC. Other Haplohumults that have, in one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplohumults

HBFD. Other Haplohumults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haplohumults

HBFE. Other Haplohumults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Haplohumults

HBFF. Other Haplohumults that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplohumults

HBFG. Other Haplohumults that have an ustic soil moisture regime.

Ustic Haplohumults

HBFH. Other Haplohumults that have a xeric soil moisture regime.

Xeric Haplohumults

HBFI. Other Haplohumults.

Typic Haplohumults

Kandihumults

Key to Subgroups

HBCA. Kandihumults that meet *all* of the following:

1. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, have a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *and*

2. In one or more horizons within 75 cm of the mineral soil surface, have redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

3. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

   a. 20 or more consecutive days; *or*

   b. 30 or more cumulative days.

Andic Ombroaquic Kandihumults

HBCB. Other Kandihumults that have *both* of the following:

1. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *and*

2. An ustic soil moisture regime.

Ustandic Kandihumults

HBCC. Other Kandihumults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kandihumults

HBCD. Other Kandihumults that have, in one or more subhorizons within the upper 25 cm of the kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandihumults

HBCE. Other Kandihumults that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

2. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Ombroaquic Kandihumults

HBCF. Other Kandihumults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandihumults

HBCG. Other Kandihumults that have an ustic soil moisture regime.

Ustic Kandihumults

HBCH. Other Kandihumults that have a xeric soil moisture regime.

Xeric Kandihumults

HBCI. Other Kandihumults that have an anthropic epipedon.

Anthropic Kandihumults

HBCJ. Other Kandihumults.

Typic Kandihumults

Kanhaplohumults

Key to Subgroups

HBDA. Kanhaplohumults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Kanhaplohumults

HBDB. Other Kanhaplohumults that have *both* of the following:

1. An ustic soil moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Ustandic Kanhaplohumults

HBDC. Other Kanhaplohumults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kanhaplohumults

HBDD. Other Kanhaplohumults that have, in one or more subhorizons within the upper 25 cm of the kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Kanhaplohumults

HBDE. Other Kanhaplohumults that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

2. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Ombroaquic Kanhaplohumults

HBDF. Other Kanhaplohumults that have an ustic soil moisture regime.

Ustic Kanhaplohumults

HBDG. Other Kanhaplohumults that have a xeric soil moisture regime.

Xeric Kanhaplohumults

HBDH. Other Kanhaplohumults that have an anthropic epipedon.

Anthropic Kanhaplohumults

HBDI. Other Kanhaplohumults.

Typic Kanhaplohumults

Palehumults

Key to Subgroups

HBEA. Palehumults that have *both* of the following:

1. In one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Aquandic Palehumults

HBEB. Other Palehumults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Palehumults

HBEC. Other Palehumults that have, in one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Palehumults

HBED. Other Palehumults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Palehumults

HBEE. Other Palehumults that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Palehumults

HBEF. Other Palehumults that have an ustic soil moisture regime.

Ustic Palehumults

HBEG. Other Palehumults that have a xeric soil moisture regime.

Xeric Palehumults

HBEH. Other Palehumults.

Typic Palehumults

Plinthohumults

Key to Subgroups

HBBA. All Plinthohumults.

Typic Plinthohumults

Sombrihumults

Key to Subgroups

HBAA. All Sombrihumults.

Typic Sombrihumults

Udults

Key to Great Groups

HCA. Udults that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase* or constitutes one-half or more of the volume.

Plinthudults, p. 336

HCB. Other Udults that have a fragipan within 100 cm of the mineral soil surface.

Fragiudults, p. 329

HCC. Other Udults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Have a kandic horizon; *and*

3. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Kandiudults, p. 331

* As large amounts of iron accumulate over time, the individual plinthite bodies coalesce and become interconnected throughout one or more layers, forming one continuous mass of plinthite. If irreversibly hardened, the mass becomes a layer of indurated ironstone.

HCD. Other Udults that have a kandic horizon.
Kanhapludults, p. 333

HCE. Other Udults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.
Paleudults, p. 334

HCF. Other Udults that have *both* of the following:

1. An epipedon that has a color value, moist, of 3 or less throughout; *and*

2. In all subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 100 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value.
Rhodudults, p. 336

HCG. Other Udults.
Hapludults, p. 330

Fragiudults

Key to Subgroups

HCBA. Fragiudults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic or kandic horizon at a depth of 50 to 100 cm.
Arenic Fragiudults

HCBB. Other Fragiudults that have *both* of the following:

1. In one or more horizons within 40 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.
Plinthaquic Fragiudults

HCBC. Other Fragiudults that meet *both* of the following:

1. *One or more* of the following:

a. Have a glossic horizon above the fragipan; *or*

b. Do not have, above the fragipan, an argillic or kandic horizon that has clay films on both vertical and horizontal surfaces of any peds; *or*

c. Between the argillic or kandic horizon and the fragipan, have one or more horizons with 50 percent or more chroma of 3 or less and with a clay content 3 percent or more (absolute, in the fine-earth fraction) lower than that in both the argillic or kandic horizon and the fragipan; *and*

2. In one or more horizons within 40 cm of the mineral soil surface, have redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).
Glossaquic Fragiudults

HCBD. Other Fragiudults that have, in one or more subhorizons above the fragipan and within the upper 25 cm of the argillic or kandic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).
Aquic Fragiudults

HCBE. Other Fragiudults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.
Plinthic Fragiudults

HCBF. Other Fragiudults that meet *one or more* of the following:

1. Have a glossic horizon above the fragipan; *or*

2. Do not have, above the fragipan, an argillic or kandic horizon that has clay films on both vertical and horizontal surfaces of any peds; *or*

3. Between the argillic or kandic horizon and the fragipan, have one or more horizons with 50 percent or more chroma of 3 or less and with a clay content 3 percent or more (absolute, in the fine-earth fraction) lower than that in both the argillic or kandic horizon and the fragipan.
Glossic Fragiudults

HCBG. Other Fragiudults that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) in *either*:

1. An Ap horizon that is 18 cm or more thick; *or*

2. The surface layer after mixing of the upper 18 cm.

Humic Fragiudults

HCBH. Other Fragiudults.

Typic Fragiudults

Hapludults

Key to Subgroups

HCGA. Hapludults that have *either or both*:

1. In each pedon, a discontinuous lithic contact* within 50 cm of the mineral soil surface; *and/or*

2. In each pedon, a discontinuous argillic horizon that is interrupted by ledges of bedrock.

Lithic-Ruptic-Entic Hapludults

HCGB. Other Hapludults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Hapludults

HCGC. Other Hapludults that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Hapludults

HCGD. Other Hapludults that have *both* of the following:

1. Fragic soil properties *either*:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Fragiaquic Hapludults

HCGE. Other Hapludults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

2. Have, in one or more layers within 100 cm of the mineral soil surface, *one or both* of the following:

a. Redox concentrations and aquic conditions for some time in normal years (or artificial drainage); *or*

b. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and aquic conditions for some time in normal years (or artificial drainage).

Aquic Arenic Hapludults

HCGF. Other Hapludults that have, in one or more layers within 100 cm of the mineral soil surface, *one or both* of the following:

1. Redox concentrations and aquic conditions for some time in normal years (or artificial drainage); *or*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and aquic conditions for some time in normal years (or artificial drainage).

Aquic Hapludults

HCGG. Other Hapludults that have fragic soil properties *either*:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Hapludults

HCGH. Other Hapludults that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Hapludults

HCGI. Other Hapludults that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or

* The lithic contact may either be present in only part of each pedon, or it may fluctuate in depth from less than 50 cm to more than 50 cm in each pedon.

more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Hapludults

HCGJ. Other Hapludults that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Hapludults

HCGK. Other Hapludults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Hapludults

HCGL. Other Hapludults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Hapludults

HCGM. Other Hapludults that:

1. Do not have a densic, lithic, or paralithic contact within 50 cm of the mineral soil surface; *and*

2. Have an argillic horizon that is 25 cm or less thick.

Inceptic Hapludults

HCGN. Other Hapludults that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) in *either*:

1. An Ap horizon that is 18 cm or more thick; *or*

2. The surface layer after mixing of the upper 18 cm.

Humic Hapludults

HCGO. Other Hapludults.

Typic Hapludults

Kandiudults

Key to Subgroups

HCCA. Kandiudults that have *all* of the following:

1. A texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface; *and*

3. In one or more layers either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm of the kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Arenic Plinthaquic Kandiudults

HCCB. Other Kandiudults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. Have, in one or more layers either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm of the kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Arenic Kandiudults

HCCC. Other Kandiudults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. Have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Kandiudults

HCCD. Other Kandiudults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil

surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. Have, in all subhorizons in the upper 75 cm of the kandic horizon or throughout the entire kandic horizon if it is less than 75 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value.

Arenic Rhodic Kandiudults

HCCE. Other Kandiudults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Kandiudults

HCCF. Other Kandiudults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more; *and*

2. Have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Grossarenic Plinthic Kandiudults

HCCG. Other Kandiudults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more.

Grossarenic Kandiudults

HCCH. Other Kandiudults that have *both* of the following:

1. An ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Acrudoxic Plinthic Kandiudults

HCCI. Other Kandiudults that have an ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface.

Acrudoxic Kandiudults

HCCJ. Other Kandiudults that have *both* of the following:

1. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface; *and*

2. In one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Kandiudults

HCCK. Other Kandiudults that have *both* of the following:

1. In one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) particles 2.0 mm or larger in diameter, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Kandiudults

HCCL. Other Kandiudults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kandiudults

HCCM. Other Kandiudults that have, in one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiudults

HCCN. Other Kandiudults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandiudults

HCCO. Other Kandiudults that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

2. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Ombroaquic Kandiudults

HCCP. Other Kandiudults that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Kandiudults

HCCQ. Other Kandiudults that have a sombric horizon within 150 cm of the mineral soil surface.

Sombric Kandiudults

HCCR. Other Kandiudults that have, in all subhorizons in the upper 75 cm of the kandic horizon or throughout the entire kandic horizon if it is less than 75 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Kandiudults

HCCS. Other Kandiudults.

Typic Kandiudults

Kanhapludults

Key to Subgroups

HCDA. Kanhapludults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Kanhapludults

HCDB. Other Kanhapludults that have *both* of the following:

1. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface; *and*

2. In one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Kanhapludults

HCDC. Other Kanhapludults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. Have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Kanhapludults

HCDD. Other Kanhapludults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Kanhapludults

HCDE. Other Kanhapludults that have an ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface.

Acrudoxic Kanhapludults

HCDF. Other Kanhapludults that have *both* of the following:

1. Fragic soil properties *either*:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Fragiaquic Kanhapludults

HCDG. Other Kanhapludults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kanhapludults

HCDH. Other Kanhapludults that have, in one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Kanhapludults

HCDI. Other Kanhapludults that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

2. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

   a. 20 or more consecutive days; *or*

   b. 30 or more cumulative days.

Ombroaquic Kanhapludults

HCDJ. Other Kanhapludults that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Kanhapludults

HCDK. Other Kanhapludults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kanhapludults

HCDL. Other Kanhapludults that have fragic soil properties *either*:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Kanhapludults

HCDM. Other Kanhapludults that have, in all subhorizons in the upper 50 cm of the kandic horizon or throughout the entire kandic horizon if it is less than 50 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Kanhapludults

HCDN. Other Kanhapludults.

Typic Kanhapludults

Paleudults

Key to Subgroups

HCEA. Paleudults that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years and slickensides or wedge-shaped peds in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleudults

HCEB. Other Paleudults that have a horizon 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that has *one or more* of the following:

1. 25 percent or more of the horizon in each pedon is extremely weakly coherent or more coherent due to pedogenic cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Paleudults

HCEC. Other Paleudults that have *all* of the following:

1. A texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface; *and*

3. In one or more layers either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm

of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Arenic Plinthaquic Paleudults

HCED. Other Paleudults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

2. Have, in one or more layers either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Arenic Paleudults

HCEE. Other Paleudults that have anthraquic conditions.

Anthraquic Paleudults

HCEF. Other Paleudults that have *both* of the following:

1. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface; *and*

2. In one or more layers either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Paleudults

HCEG. Other Paleudults that have *both* of the following:

1. Fragic soil properties *either*:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more layers either within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Fragiaquic Paleudults

HCEH. Other Paleudults that have, in one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Paleudults

HCEI. Other Paleudults that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Paleudults

HCEJ. Other Paleudults that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Paleudults

HCEK. Other Paleudults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

2. Have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Paleudults

HCEL. Other Paleudults that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Paleudults

HCEM. Other Paledults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy

fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more; *and*

2. Have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Grossarenic Plinthic Paleudults

HCEN. Other Paleudults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Paleudults

HCEO. Other Paleudults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

2. Have, in all subhorizons in the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value.

Arenic Rhodic Paleudults

HCEP. Other Paleudults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Paleudults

HCEQ. Other Paleudults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Paleudults

HCER. Other Paleudults that have fragic soil properties *either*:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Paleudults

HCES. Other Paleudults that have, in all subhorizons in the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Paleudults

HCET. Other Paleudults.

Typic Paleudults

Plinthudults

Key to Subgroups

HCAA. All Plinthudults.

Typic Plinthudults

Rhodudults

Key to Subgroups

HCFA. Rhodudults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Rhodudults

HCFB. Other Rhodudults that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Rhodudults

HCFC. Other Rhodudults.

Typic Rhodudults

Ustults

Key to Great Groups

HDA. Ustults that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase* or constitutes one-half or more of the volume.

Plinthustults, p. 340

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* As large amounts of iron accumulate over time, the individual plinthite bodies coalesce and become interconnected throughout one or more layers, forming one continuous mass of plinthite. If irreversibly hardened, the mass becomes a layer of indurated ironstone.

HDB. Other Ustults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Have a kandic horizon; *and*

3. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Kandiustults, p. 338

HDC. Other Ustults that have a kandic horizon.

Kanhaplustults, p. 339

HDD. Other Ustults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Paleustults, p. 340

HDE. Other Ustults that have *both* of the following:

1. An epipedon that has a color value, moist, of 3 or less throughout; *and*

2. In all subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 100 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value.

Rhodustults, p. 340

HDF. Other Ustults.

Haplustults, p. 337

Haplustults

Key to Subgroups

HDFA. Haplustults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplustults

HDFB. Other Haplustults that have a petroferric contact within 100 cm of the mineral soil surface.

Petroferric Haplustults

HDFC. Other Haplustults that have, in one or more layers both within the upper 12.5 cm of the argillic horizon and within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplustults

HDFD. Other Haplustults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more below the mineral soil surface.

Arenic Haplustults

HDFE. Other Haplustults that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

2. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Ombroaquic Haplustults

HDFF. Other Haplustults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Haplustults

HDFG. Other Haplustults that have a CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+)/kg clay in 50 percent or more of the entire argillic horizon if less than 100 cm thick or of its upper 100 cm.

Kanhaplic Haplustults

HDFH. Other Haplustults.

Typic Haplustults

Kandiustults

Key to Subgroups

HDBA. Kandiustults that have an ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface.

Acrustoxic Kandiustults

HDBB. Other Kandiustults that have, in one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiustults

HDBC. Other Kandiustults that:

1. Have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 cm or more; *and*

2. Have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Kandiustults

HDBD. Other Kandiustults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 cm or more.

Arenic Kandiustults

HDBE. Other Kandiustults that have *both* of the following:

1. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *and*

2. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that is dry in some part for 135 or fewer of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C.

Udandic Kandiustults

HDBF. Other Kandiustults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kandiustults

HDBG. Other Kandiustults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandiustults

HDBH. Other Kandiustults that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A thermic, mesic, or colder soil temperature regime and a moisture control section that in normal years is dry in some part for more than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Aridic Kandiustults

HDBI. Other Kandiustults that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for 135 or fewer of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C.

Udic Kandiustults

HDBJ. Other Kandiustults that have, in all subhorizons in the upper 75 cm of the kandic horizon or throughout the entire kandic horizon if it is less than 75 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Kandiustults

HDBK. Other Kandiustults.

Typic Kandiustults

Kanhaplustults

Key to Subgroups

HDCA. Kanhaplustults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Kanhaplustults

HDCB. Other Kanhaplustults that have an ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface.

Acrustoxic Kanhaplustults

HDCC. Other Kanhaplustults that have, in one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Kanhaplustults

HDCD. Other Kanhaplustults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Kanhaplustults

HDCE. Other Kanhaplustults that have *both* of the following:

1. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *and*

2. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for 135 or fewer of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udandic Kanhaplustults

HDCF. Other Kanhaplustults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kanhaplustults

HDCG. Other Kanhaplustults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kanhaplustults

HDCH. Other Kanhaplustults that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

2. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Ombroaquic Kanhaplustults

HDCI. Other Kanhaplustults that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A thermic, mesic, or colder soil temperature regime and a moisture control section that in normal years is dry in some part for more than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Aridic Kanhaplustults

HDCJ. Other Kanhaplustults that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for 135 or fewer of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C.

Udic Kanhaplustults

HDCK. Other Kanhaplustults that have, in all subhorizons in the upper 50 cm of the kandic horizon or throughout the entire kandic horizon if it is less than 50 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Kanhaplustults

HDCL. Other Kanhaplustults.

Typic Kanhaplustults

Paleustults

Key to Subgroups

HDDA. All Paleustults.

Typic Paleustults

Plinthustults

Key to Subgroups

HDAA. Plinthustults that have *either*:

1. A densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *or*

2. Within 150 cm of the mineral soil surface, *both*:

a. With increasing depth, a clay decrease of 20 percent or more (relative) from the maximum clay content; *and*

b. Less than 5 percent (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *or*, below that layer, a clay increase of less than 3 percent (absolute) in the fine-earth fraction.

Haplic Plinthustults

HDAB. Other Plinthustults.

Typic Plinthustults

Rhodustults

Key to Subgroups

HDEA. Rhodustults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Rhodustults

HDEB. Other Rhodustults that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Rhodustults

HDEC. Other Rhodustults.

Typic Rhodustults

Xerults

Key to Great Groups

HEA. Xerults that:

1. Do not have a densic, lithic, or paralithic contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds or 5 percent or more (by volume) plinthite, or both, in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Palexerults, p. 341

HEB. Other Xerults.

Haploxerults, p. 340

Haploxerults

Key to Subgroups

HEBA. Haploxerults that have *both* of the following:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. In each pedon, a discontinuous argillic or kandic horizon that is interrupted by ledges of bedrock.

Lithic Ruptic-Inceptic Haploxerults

HEBB. Other Haploxerults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haploxerults

HEBC. Other Haploxerults that have, in one or more subhorizons within the upper 25 cm of the argillic or kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Haploxerults

HEBD. Other Haploxerults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haploxerults

HEBE. Other Haploxerults that have an argillic or kandic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic or kandic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic or kandic horizon) and one or more parts of the argillic or kandic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Haploxerults

HEBF. Other Haploxerults that have a sandy particle-size class throughout the upper 75 cm of the argillic or kandic horizon or throughout the entire horizon if it is less than 75 cm thick.

Psammentic Haploxerults

HEBG. Other Haploxerults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic or kandic horizon at a depth of 50 to 100 cm.

Arenic Haploxerults

HEBH. Other Haploxerults that have a texture class (fine-earth fraction) of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand throughout a layer extending from the mineral soil surface to the top of an argillic or kandic horizon at a depth of 100 cm or more.

Grossarenic Haploxerults

HEBI. Other Haploxerults.

Typic Haploxerults

Palexerults

Key to Subgroups

HEAA. Palexerults that have *both* of the following:

1. In one or more subhorizons within the upper 25 cm of the argillic or kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Aquandic Palexerults

HEAB. Other Palexerults that have, in one or more subhorizons within the upper 25 cm of the argillic or kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by *both* redox concentrations and aquic conditions for some time in normal years (or artificial drainage).

Aquic Palexerults

HEAC. Other Palexerults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Palexerults

HEAD. Other Palexerults.

Typic Palexerults

CHAPTER 16

Vertisols

Key to Suborders*

FA. Vertisols that have, in one or more horizons within 50 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *one or both* of the following:

1. In more than half of each pedon, either on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

a. 2 or less if redox concentrations are present; *or*

b. 1 or less; *or*

2. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquerts, p. 343

FB. Other Vertisols that have a cryic soil temperature regime.

Cryerts, p. 347

FC. Other Vertisols that in normal years have *both*:

1. A thermic, mesic, or frigid soil temperature regime; *and*

2. If not irrigated during the year, cracks that remain *both*:

a. 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

b. Closed for 60 or more consecutive days during the 90 days following the winter solstice.

Xererts, p. 353

FD. Other Vertisols that, if not irrigated during the year, have cracks in normal years that remain closed for less than 60 consecutive days during a period when the soil temperature at a depth of 50 cm from the soil surface is higher than 8 ^{o}C.

Torrerts, p. 347

FE. Other Vertisols that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Usterts, p. 350

FF. Other Vertisols.

Uderts, p. 349

Aquerts

Key to Great Groups

FAA. Aquerts that have within 100 cm of the mineral soil surface *either*:

1. A sulfuric horizon; *or*

2. Sulfidic materials.

Sulfaquerts, p. 347

FAB. Other Aquerts that have a salic horizon within 100 cm of the mineral soil surface.

Salaquerts, p. 346

FAC. Other Aquerts that have a duripan within 100 cm of the mineral soil surface.

Duraquerts, p. 344

FAD. Other Aquerts that have a natric horizon within 100 cm of the mineral soil surface.

Natraquerts, p. 346

FAE. Other Aquerts that have a calcic horizon within 100 cm of the mineral soil surface.

Calciaquerts, p. 344

FAF. Other Aquerts that have, throughout one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, *both*:

1. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 ^{o}C; *and*

* The application of the moisture control section for determining moisture regimes cannot be adequately applied in Vertisols. Deep cracks form during dry periods. Rain and runoff enter the cracks and rewet the soil simultaneously from both above and below, bypassing the control section. Therefore, the seasonal cracking pattern is used as a surrogate to identify the moisture regimes (except in Aquerts).

2. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in 1:1 water).

Dystraquerts, p. 344

FAG. Other Aquerts that have episaturation.

Epiaquerts, p. 346

FAH. Other Aquerts.

Endoaquerts, p. 345

Calciaquerts

Key to Subgroups

FAEA. Calciaquerts that have, in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or the upper boundary of a duripan if shallower, 50 percent or more colors as follows:

1. Hue of 2.5Y or redder and *either*:

   a. A color value, moist, of 6 or more and chroma of 3 or more; *or*

   b. A color value, moist, of 5 or less and chroma of 2 or more; *or*

2. Hue of 5Y and chroma of 3 or more; *or*

3. Chroma of 2 or more and no redox concentrations.

Aeric Calciaquerts

FAEB. Other Calciaquerts.

Typic Calciaquerts

Duraquerts

Key to Subgroups

FACA. Duraquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Duraquerts

FACB. Other Duraquerts that have a thermic, mesic, or frigid soil temperature regime and that, if not irrigated during the year, have cracks in normal years that remain *both*:

1. 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

2. Closed for 60 or more consecutive days during the 90 days following the winter solstice.

Xeric Duraquerts

FACC. Other Duraquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Ustic Duraquerts

FACD. Other Duraquerts that have, in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or the upper boundary of the duripan if shallower, 50 percent or more colors as follows:

1. Hue of 2.5Y or redder and *either*:

   a. A color value, moist, of 6 or more and chroma of 3 or more; *or*

   b. A color value, moist, of 5 or less and chroma of 2 or more; *or*

2. Hue of 5Y and chroma of 3 or more; *or*

3. Chroma of 2 or more and no redox concentrations.

Aeric Duraquerts

FACE. Other Duraquerts that have, in one or more horizons within 30 cm of the mineral soil surface, *one or both* of the following in more than half of each pedon:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more.

Chromic Duraquerts

FACF. Other Duraquerts.

Typic Duraquerts

Dystraquerts

Key to Subgroups

FAFA. Dystraquerts that have, in one or more horizons within 100 cm of the mineral soil surface, jarosite concentrations and a pH value of 4.0 or less (1:1 water, air-dried slowly in shade).

Sulfaqueptic Dystraquerts

FAFB. Other Dystraquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Dystraquerts

FAFC. Other Dystraquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Ustic Dystraquerts

FAFD. Other Dystraquerts that have, in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, 50 percent or more colors as follows:

1. Hue of 2.5Y or redder and *either*:

   a. A color value, moist, of 6 or more and chroma of 3 or more; *or*

   b. A color value, moist, of 5 or less and chroma of 2 or more; *or*

2. Hue of 5Y and chroma of 3 or more; *or*

3. Chroma of 2 or more and no redox concentrations.

Aeric Dystraquerts

FAFE. Other Dystraquerts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Dystraquerts

FAFF. Other Dystraquerts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Dystraquerts

FAFG. Other Dystraquerts that have, in one or more horizons within 30 cm of the mineral soil surface, *one or both* of the following in more than half of each pedon:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more.

Chromic Dystraquerts

FAFH. Other Dystraquerts.

Typic Dystraquerts

Endoaquerts

Key to Subgroups

FAHA. Endoaquerts that have, throughout a layer 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Endoaquerts

FAHB. Other Endoaquerts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Endoaquerts

FAHC. Other Endoaquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Endoaquerts

FAHD. Other Endoaquerts that have a thermic, mesic, or frigid soil temperature regime and that, if not irrigated during the year, have cracks in normal years that remain *both*:

1. 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

2. Closed for 60 or more consecutive days during the 90 days following the winter solstice.

Xeric Endoaquerts

FAHE. Other Endoaquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Ustic Endoaquerts

FAHF. Other Endoaquerts that have, in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, 50 percent or more colors as follows:

1. Hue of 2.5Y or redder and *either*:

   a. A color value, moist, of 6 or more and chroma of 3 or more; *or*

   b. A color value, moist, of 5 or less and chroma of 2 or more; *or*

2. Hue of 5Y and chroma of 3 or more; *or*

3. Chroma of 2 or more and no redox concentrations.

Aeric Endoaquerts

FAHG. Other Endoaquerts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Endoaquerts

FAHH. Other Endoaquerts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Endoaquerts

FAHI. Other Endoaquerts that have, in one or more horizons within 30 cm of the mineral soil surface, *one or both* of the following in more than half of each pedon:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more.

Chromic Endoaquerts

FAHJ. Other Endoaquerts.

Typic Endoaquerts

Epiaquerts

Key to Subgroups

FAGA. Epiaquerts that have, throughout a layer 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Epiaquerts

FAGB. Other Epiaquerts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Epiaquerts

FAGC. Other Epiaquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Epiaquerts

FAGD. Other Epiaquerts that have a thermic, mesic, or frigid soil temperature regime and that, if not irrigated during the year, have cracks in normal years that remain *both*:

1. 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

2. Closed for 60 or more consecutive days during the 90 days following the winter solstice.

Xeric Epiaquerts

FAGE. Other Epiaquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Ustic Epiaquerts

FAGF. Other Epiaquerts that have, in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, 50 percent or more colors as follows:

1. Hue of 2.5Y or redder and *either*:

   a. A color value, moist, of 6 or more and chroma of 3 or more; *or*

   b. A color value, moist, of 5 or less and chroma of 2 or more; *or*

2. Hue of 5Y and chroma of 3 or more; *or*

3. Chroma of 2 or more and no redox concentrations.

Aeric Epiaquerts

FAGG. Other Epiaquerts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Epiaquerts

FAGH. Other Epiaquerts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Epiaquerts

FAGI. Other Epiaquerts that have, in one or more horizons within 30 cm of the mineral soil surface, *one or both* of the following in more than half of each pedon:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more.

Chromic Epiaquerts

FAGJ. Other Epiaquerts.

Typic Epiaquerts

Natraquerts

Key to Subgroups

FADA. All Natraquerts.

Typic Natraquerts

Salaquerts

Key to Subgroups

FABA. Salaquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Salaquerts

FABB. Other Salaquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Ustic Salaquerts

FABC. Other Salaquerts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Salaquerts

FABD. Other Salaquerts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Salaquerts

FABE. Other Salaquerts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*
2. A color value, dry, of 6 or more; *or*
3. Chroma of 3 or more.

Chromic Salaquerts

FABF. Other Salaquerts.

Typic Salaquerts

Sulfaquerts

Key to Subgroups

FAAA. Sulfaquerts that have a salic horizon within 75 cm of the mineral soil surface.

Salic Sulfaquerts

FAAB. Other Sulfaquerts that do not have a sulfuric horizon within 100 cm of the mineral soil surface.

Sulfic Sulfaquerts

FAAC. Other Sulfaquerts.

Typic Sulfaquerts

Cryerts

Key to Great Groups

FBA. Cryerts that have 10 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 50 cm.

Humicryerts, p. 347

FBB. Other Cryerts.

Haplocryerts, p. 347

Haplocryerts

Key to Subgroups

FBBA. Haplocryerts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Haplocryerts

FBBB. Other Haplocryerts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*
2. A color value, dry, of 6 or more; *or*
3. Chroma of 3 or more.

Chromic Haplocryerts

FBBC. Other Haplocryerts.

Typic Haplocryerts

Humicryerts

Key to Subgroups

FBAA. Humicryerts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Humicryerts

FBAB. Other Humicryerts.

Typic Humicryerts

Torrerts

Key to Great Groups

FDA. Torrerts that have a salic horizon within 100 cm of the soil surface.

Salitorrerts, p. 348

FDB. Other Torrerts that have a gypsic horizon within 100 cm of the soil surface.

Gypsitorrerts, p. 348

FDC. Other Torrerts that have a calcic or petrocalcic horizon within 100 cm of the soil surface.

Calcitorrerts, p. 347

FDD. Other Torrerts.

Haplotorrerts, p. 348

Calcitorrerts

Key to Subgroups

FDCA. Calcitorrerts that have a petrocalcic horizon within 100 cm of the soil surface.

Petrocalcic Calcitorrerts

FDCB. Other Calcitorrerts that have a densic, lithic, or paralithic contact or a duripan within 100 cm of the soil surface.
Leptic Calcitorrerts

FDCC. Other Calcitorrerts that have a layer, 25 cm or more thick within 100 cm of the soil surface, that contains less than 27 percent clay in its fine-earth fraction.
Entic Calcitorrerts

FDCD. Other Calcitorrerts that have, in one or more horizons within 30 cm of the soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*
2. A color value, dry, of 6 or more; *or*
3. Chroma of 3 or more.

Chromic Calcitorrerts

FDCE. Other Calcitorrerts.
Typic Calcitorrerts

Gypsitorrerts

Key to Subgroups

FDBA. Gypsitorrerts that have, in one or more horizons within 30 cm of the soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*
2. A color value, dry, of 6 or more; *or*
3. Chroma of 3 or more.

Chromic Gypsitorrerts

FDBB. Other Gypsitorrerts.
Typic Gypsitorrerts

Haplotorrerts

Key to Subgroups

FDDA. Haplotorrerts that have, throughout a layer 15 cm or more thick within 100 cm of the soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.
Halic Haplotorrerts

FDDB. Other Haplotorrerts that have, in one or more horizons within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.
Sodic Haplotorrerts

FDDC. Other Haplotorrerts that have a densic, lithic, or paralithic contact or a duripan within 100 cm of the soil surface.
Leptic Haplotorrerts

FDDD. Other Haplotorrerts that have a layer, 25 cm or more thick within 100 cm of the soil surface, that contains less than 27 percent clay in its fine-earth fraction.
Entic Haplotorrerts

FDDE. Other Haplotorrerts that have, in one or more horizons within 30 cm of the soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*
2. A color value, dry, of 6 or more; *or*
3. Chroma of 3 or more.

Chromic Haplotorrerts

FDDF. Other Haplotorrerts.
Typic Haplotorrerts

Salitorrerts

Key to Subgroups

FDAA. Salitorrerts that have, in one or more horizons within 100 cm of the soil surface, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*
2. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Salitorrerts

FDAB. Other Salitorrerts that have a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon within 100 cm of the soil surface.
Leptic Salitorrerts

FDAC. Other Salitorrerts that have a layer, 25 cm or more thick within 100 cm of the soil surface, that contains less than 27 percent clay in its fine-earth fraction.
Entic Salitorrerts

FDAD. Other Salitorrerts that have, in one or more horizons within 30 cm of the soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*
2. A color value, dry, of 6 or more; *or*
3. Chroma of 3 or more.

Chromic Salitorrerts

FDAE. Other Salitorrerts.

Typic Salitorrerts

Uderts

Key to Great Groups

FFA. Uderts that have, throughout one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, *both*:

1. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 ^{o}C; *and*

2. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in saturated paste).

Dystruderts, p. 349

FFB. Other Uderts.

Hapluderts, p. 349

Dystruderts

Key to Subgroups

FFAA. Dystruderts that have, in one or more horizons within 100 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Dystruderts

FFAB. Other Dystruderts that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Dystruderts

FFAC. Other Dystruderts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Dystruderts

FFAD. Other Dystruderts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Dystruderts

FFAE. Other Dystruderts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Dystruderts

FFAF. Other Dystruderts.

Typic Dystruderts

Hapluderts

Key to Subgroups

FFBA. Hapluderts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Hapluderts

FFBB. Other Hapluderts that have, in one or more horizons within 100 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Hapluderts

FFBC. Other Hapluderts that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Hapluderts

FFBD. Other Hapluderts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Hapluderts

FFBE. Other Hapluderts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Hapluderts

FFBF. Other Hapluderts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Hapluderts

FFBG. Other Hapluderts.

Typic Hapluderts

Usterts

Key to Great Groups

FEA. Usterts that have, throughout one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, *both*:

1. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 °C; *and*

2. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in saturated paste).

Dystrusterts, p. 350

FEB. Other Usterts that have a salic horizon within 100 cm of the mineral soil surface.

Salusterts, p. 352

FEC. Other Usterts that have a gypsic horizon within 100 cm of the mineral soil surface.

Gypsiusterts, p. 351

FED. Other Usterts that have a calcic or petrocalcic horizon within 100 cm of the mineral soil surface.

Calciusterts, p. 350

FEE. Other Usterts.

Haplusterts, p. 351

Calciusterts

Key to Subgroups

FEDA. Calciusterts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calciusterts

FEDB. Other Calciusterts that have, throughout a layer 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Calciusterts

FEDC. Other Calciusterts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Calciusterts

FEDD. Other Calciusterts that have a petrocalcic horizon within 100 cm of the mineral soil surface.

Petrocalcic Calciusterts

FEDE. Other Calciusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Calciusterts

FEDF. Other Calciusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days per year.

Udic Calciusterts

FEDG. Other Calciusterts that have a densic, lithic, or paralithic contact or a duripan within 100 cm of the mineral soil surface.

Leptic Calciusterts

FEDH. Other Calciusterts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Calciusterts

FEDI. Other Calciusterts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Calciusterts

FEDJ. Other Calciusterts.

Typic Calciusterts

Dystrusterts

Key to Subgroups

FEAA. Dystrusterts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Dystrusterts

FEAB. Other Dystrusterts that have, in one or more horizons within 100 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Dystrusterts

FEAC. Other Dystrusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Dystrusterts

FEAD. Other Dystrusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days.

Udic Dystrusterts

FEAE. Other Dystrusterts that have a densic, lithic, or paralithic contact or a duripan within 100 cm of the mineral soil surface.

Leptic Dystrusterts

FEAF. Other Dystrusterts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Dystrusterts

FEAG. Other Dystrusterts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*
2. A color value, dry, of 6 or more; *or*
3. Chroma of 3 or more.

Chromic Dystrusterts

FEAH. Other Dystrusterts.

Typic Dystrusterts

Gypsiusterts

Key to Subgroups

FECA. Gypsiusterts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Gypsiusterts

FECB. Other Gypsiusterts that have, throughout a layer 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Gypsiusterts

FECC. Other Gypsiusterts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Gypsiusterts

FECD. Other Gypsiusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Gypsiusterts

FECE. Other Gypsiusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days per year.

Udic Gypsiusterts

FECF. Other Gypsiusterts that have a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon within 100 cm of the mineral soil surface.

Leptic Gypsiusterts

FECG. Other Gypsiusterts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Gypsiusterts

FECH. Other Gypsiusterts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*
2. A color value, dry, of 6 or more; *or*
3. Chroma of 3 or more.

Chromic Gypsiusterts

FECI. Other Gypsiusterts.

Typic Gypsiusterts

Haplusterts

Key to Subgroups

FEEA. Haplusterts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplusterts

FEEB. Other Haplusterts that have, throughout a layer 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Haplusterts

FEEC. Other Haplusterts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Haplusterts

FEED. Other Haplusterts that have a petrocalcic horizon within 150 cm of the mineral soil surface.

Petrocalcic Haplusterts

FEEE. Other Haplusterts that have a gypsic horizon within 150 cm of the mineral soil surface.

Gypsic Haplusterts

FEEF. Other Haplusterts that have a calcic horizon within 150 cm of the mineral soil surface.

Calcic Haplusterts

FEEG. Other Haplusterts that have *both*:

1. A densic, lithic, or paralithic contact within 100 cm of the mineral soil surface; *and*

2. If not irrigated during the year, cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Leptic Haplusterts

FEEH. Other Haplusterts that have, if not irrigated during the year, cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Haplusterts

FEEI. Other Haplusterts that have *both*:

1. A densic, lithic, or paralithic contact within 100 cm of the mineral soil surface; *and*

2. If not irrigated during the year, cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days per year.

Leptic Udic Haplusterts

FEEJ. Other Haplusterts that have *both*:

1. A layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction; *and*

2. If not irrigated during the year, cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days per year.

Entic Udic Haplusterts

FEEK. Other Haplusterts that have *both*:

1. In one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

    a. A color value, moist, of 4 or more; *or*

    b. A color value, dry, of 6 or more; *or*

    c. Chroma of 3 or more; *and*

2. If not irrigated during the year, cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days per year.

Chromic Udic Haplusterts

FEEL. Other Haplusterts that have, if not irrigated during the year, cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days per year.

Udic Haplusterts

FEEM. Other Haplusterts that have a densic, lithic, or paralithic contact or a duripan within 100 cm of the mineral soil surface.

Leptic Haplusterts

FEEN. Other Haplusterts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Haplusterts

FEEO. Other Haplusterts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Haplusterts

FEEP. Other Haplusterts.

Typic Haplusterts

Salusterts

Key to Subgroups

FEBA. Salusterts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Salusterts

FEBB. Other Salusterts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Salusterts

FEBC. Other Salusterts that have, in one or more horizons within 100 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Salusterts

FEBD. Other Salusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Salusterts

FEBE. Other Salusterts that have a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon within 100 cm of the mineral soil surface.

Leptic Salusterts

FEBF. Other Salusterts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Salusterts

FEBG. Other Salusterts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Salusterts

FEBH. Other Salusterts.

Typic Salusterts

Xererts

Key to Great Groups

FCA. Xererts that have a duripan within 100 cm of the mineral soil surface.

Durixererts, p. 353

FCB. Other Xererts that have a calcic or petrocalcic horizon within 100 cm of the mineral soil surface.

Calcixererts, p. 353

FCC. Other Xererts.

Haploxererts, p. 354

Calcixererts

Key to Subgroups

FCBA. Calcixererts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calcixererts

FCBB. Other Calcixererts that have a petrocalcic horizon within 100 cm of the mineral soil surface.

Petrocalcic Calcixererts

FCBC. Other Calcixererts that, if not irrigated during the year, have cracks in normal years that remain 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 180 or more consecutive days.

Aridic Calcixererts

FCBD. Other Calcixererts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Calcixererts

FCBE. Other Calcixererts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Calcixererts

FCBF. Other Calcixererts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Calcixererts

FCBG. Other Calcixererts.

Typic Calcixererts

Durixererts

Key to Subgroups

FCAA. Durixererts that have, throughout a layer 15 cm or more thick above the duripan, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Durixererts

FCAB. Other Durixererts that have, in one or more horizons above the duripan, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Durixererts

FCAC. Other Durixererts that have, in one or more horizons above the duripan, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Durixererts

FCAD. Other Durixererts that, if not irrigated during the year, have cracks in normal years that remain 5 mm or more wide, through a thickness of 25 cm or more above the duripan, for 180 or more consecutive days.

Aridic Durixererts

FCAE. Other Durixererts that, if not irrigated during the year, have cracks in normal years that remain 5 mm or more wide, through a thickness of 25 cm or more above the duripan, for less than 90 consecutive days.

Udic Durixererts

FCAF. Other Durixererts that have a duripan that is not indurated in any subhorizon.

Haplic Durixererts

FCAG. Other Durixererts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Durixererts

FCAH. Other Durixererts.

Typic Durixererts

Haploxererts

Key to Subgroups

FCCA. Haploxererts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haploxererts

FCCB. Other Haploxererts that have, throughout a layer 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Haploxererts

FCCC. Other Haploxererts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Haploxererts

FCCD. Other Haploxererts that, if not irrigated during the year, have cracks in normal years that remain 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 180 or more consecutive days.

Aridic Haploxererts

FCCE. Other Haploxererts that have, in one or more horizons within 100 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Haploxererts

FCCF. Other Haploxererts that, if not irrigated during the year, have cracks in normal years that remain 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 90 consecutive days.

Udic Haploxererts

FCCG. Other Haploxererts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Haploxererts

FCCH. Other Haploxererts that have a layer, 25 cm or more thick within 100 cm of the mineral soil surface, that contains less than 27 percent clay in its fine-earth fraction.

Entic Haploxererts

FCCI. Other Haploxererts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Haploxererts

FCCJ. Other Haploxererts.

Typic Haploxererts

CHAPTER 17

Family and Series Differentiae and Names

Families and series serve purposes that are largely pragmatic; the series name is abstract, and the technical family name is descriptive. In this chapter the descriptive terms used in the names of families are defined, the control sections to which the terms apply are given, and the criteria, including the taxa in which they are used, are indicated (note 1).

Family Differentiae for Mineral Soils and Mineral Layers of Some Organic Soils

The following differentiae are used to distinguish families of mineral soils and the mineral layers of some organic soils within a subgroup. The class names of these differentiae are used to form the family name. The class names are listed and defined in the same sequence (shown below) in which they appear in the family names.

Particle-size classes and their substitutes
Human-altered and human-transported material classes
Mineralogy classes
Cation-exchange activity classes
Calcareous and reaction classes
Soil temperature classes
Soil depth classes
Rupture-resistance classes
Classes of coatings on sands
Classes of permanent cracks

Particle-Size Classes and Their Substitutes

Definition of Particle-Size Classes and Their Substitutes for Mineral Soils

The first part of the family name is the name of either a particle-size class or a substitute for a particle-size class. The term “particle-size class” is used to characterize the grain-size composition of the whole soil, including both the fine earth and the rock and pararock fragments up to the size of a pedon, but it excludes organic matter and salts more soluble than gypsum. Substitutes for particle-size classes are used for soils that have andic soil properties or a high content of volcanic glass, pumice, cinders, rock fragments, or gypsum. In general, the weighted average particle-size class of the whole particle-size control section (defined below) determines what particle-size class is used for the family name.

Development of particle-size classes for Soil Taxonomy

The particle-size classes of this taxonomy represent a compromise between conventional divisions in pedologic and engineering classifications. Engineering classifications have set the limit between sand and silt at a diameter of 74 microns, while pedological classifications have set it at either 20, 50, or 63 microns. The USDA and this taxonomy use a diameter of 50 microns to set the limit between sand and silt. Engineering classifications have been based on grain-size percentages, by weight, in the soil fraction less than 75 mm (3 inches) in diameter, while texture classes in pedologic classifications have been based on percentages, by weight, in the fraction less than 2.0 mm in diameter. In engineering classifications, the separate very fine sand (diameter between 50 and 100 microns or 0.05 and 0.1 mm) has been subdivided at 74 microns. In defining the particle-size classes for this taxonomy, a similar division has been made, but in a different way. Soil materials that have a texture class of fine sand or loamy fine sand normally have an appreciable amount of very fine sand, most of which is coarser than 74 microns. A silty sediment, such as loess, may also contain an appreciable amount of very fine sand, most of which is finer than 74 microns. Thus, in the design of particle-size classes for this taxonomy, the very fine sand has been allowed to “float” (note 2). It is included with the sand fraction if the texture class (fine-earth fraction) of a soil is fine sand, loamy fine sand, or coarser. It is treated as silt, however, if the texture class is very fine sand, loamy very fine sand, sandy loam, silt loam, or finer.

Generalized versus narrowly defined classes

No single set of particle-size classes seems adequate to serve as family differentiae for all of the different kinds of soil. Thus, this taxonomy provides 2 generalized and 10 more narrowly defined classes, which permit relatively fine distinctions between families of soils for which particle size is important, while providing broader groupings for soils in which narrowly defined particle-size classes would produce undesirable separations. Thus, the term “clayey” is used for some soil families to indicate a clay content of 35 percent (30 percent in Vertisols) or more in specific horizons, while in other families the more narrowly defined terms “fine” and “very-fine” indicate that these horizons have a clay content either of 35 percent (30 percent in Vertisols) to 60 percent or of 60 percent or more in their fine-earth fraction.

Fine earth, rock and pararock fragments, and artifacts

Fine earth refers to particles smaller than 2 mm in diameter. Rock fragments are particles 2 mm or more in diameter that are strongly coherent or more resistant to rupture and include all particles with horizontal dimensions smaller than the size of a pedon. Coherent fragments 2 mm or more in diameter that are in a rupture-resistance class that is less than strongly coherent are referred to as pararock fragments. Pararock fragments, like rock fragments, include all particles between 2 mm and a horizontal dimension smaller than the size of a pedon. Most pararock fragments are broken into particles less than 2 mm in diameter during the preparation of samples for particle-size analysis in the laboratory. Therefore, pararock fragments are generally included with the fine earth in the assignment of particle-size classes. However, cinders, lapilli, pumice, and pumicelike fragments are treated as general fragments in the pumiceous and cindery substitute classes (defined below), regardless of their rupture-resistance class. Rock fragments and pararock fragments may be of either geologic or pedogenic origin. Artifacts (defined in chapter 3) are of human origin. Artifacts 2 mm or larger in diameter which are both cohesive and persistent[*] (e.g., brick) are treated as rock fragments for the assignment of particle-size classes.

Particle-size substitutes

Substitutes for particle-size classes are used for soils that have andic soil properties or a high content of volcanic glass, pumice, cinders, rock fragments, or gypsum. These materials cannot be readily dispersed and have variable results of dispersion. The substitute classes dominated by rock and pararock fragments have too little fine-earth material for valid data, and soil properties are dominated by the fragments. Consequently, normal particle-size classes do not adequately characterize these soils. Substitutes for particle-size class names are used for those parts of soils that have andic soil properties or a high content of volcanic glass, pumice, or cinders, as is the case with Andisols and many Andic and Vitrandic subgroups of other soil orders. The “gypseous” substitutes for particle-size class are used for mineral soils (e.g., Aridisols) that have a high content of gypsum. Some Spodosols, whether identified in Andic subgroups or not, have andic soil properties in some horizons within the particle-size control section, and particle-size substitute class names are used for these horizons.

Soils with no particle-size or substitute class

Neither a particle-size class nor a substitute for a particle-size class is used for Psamments, Psammaquents, Psammowassents, Psammoturbels, Psammorthels, and Psammentic subgroups that meet sandy particle-size class criteria. These taxa, by definition, meet sandy particle-size class criteria (i.e., have a texture class of sand or loamy sand), so the sandy particle-size class is considered redundant in the family name. The ashy substitute class, however, is used in these taxa if appropriate (e.g., high content of volcanic glass).

Application to soils with significant amorphous mineral content

Particle-size classes are applied, although with reservations, to the control sections of soils with spodic horizons and other horizons that do not have andic soil properties but contain significant amounts of allophane, imogolite, ferrihydrite, or aluminum-humus complexes. The isotic mineralogy class (defined below) is helpful in identifying these particle-size classes.

Strongly Contrasting Particle-Size Classes

If the particle-size control section consists of two parts with strongly contrasting particle-size or substitute classes (listed below), if both parts are 12.5 cm or more thick (including parts not in the control section), and if the transition zone between them is less than 12.5 cm thick, both class names are used (note 3). For example, the family particle-size class is sandy over clayey if all of the following criteria are met: the soil meets criterion D (listed below) under the control section for particle-size classes or their substitutes; any Ap horizon is less than 30 cm thick; the weighted average particle-size class of the upper 30 cm of the soil is sandy; the weighted average of the lower part is clayey; and the transition zone is less than 12.5 cm thick. If a substitute name applies to one or more parts of the particle-size control section and the parts are not strongly contrasting classes, the name of the thickest part (cumulative) is used as the soil family name.

Aniso Class[†]

If the particle-size control section includes more than one pair of the strongly contrasting classes, listed below, then the soil is assigned to an aniso class named for the pair of adjacent classes that contrast most strongly. The aniso class is considered a modifier of the particle-size class name and is set off by commas after the particle-size name. An example is a sandy over clayey, aniso, mixed, active, mesic Aridic Haplustoll.

Application of Generalized Particle-Size Classes

Two generalized particle-size classes, loamy and clayey, are used for shallow classes (defined below) and for soils in Arenic,

[*] Artifact cohesion is the relative ability of an artifact to remain intact after significant disturbance and is based on whether the artifact can be easily broken into pieces less than 2 mm in diameter either by hand or with a mortar and pestle. Cohesive artifacts cannot easily be broken. Artifact persistence is the relative ability of artifacts to withstand weathering and decay over time. Persistent artifacts remain intact for a decade or more. Part 618 of the *National Soil Survey Handbook* (available online) contains more information on the data elements used for describing artifacts.

[†] For guidance on the application of the aniso class, see Soil Survey Technical Note Number 3. (Online at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_053570)

Grossarenic, and Lithic subgroups. The clayey class is used for all strongly contrasting particle-size classes with more than 35 percent clay (30 percent in Vertisols). The loamy particle-size class is used for contrasting classes, where appropriate, to characterize the lower part of the particle-size control section. The generalized classes, where appropriate, are also used for all strongly contrasting particle-size classes that include a substitute class. For example, loamy over pumiceous or cindery (not fine-loamy over pumiceous or cindery) is used.

Six generalized classes, defined later in this chapter, are used for Terric subgroups of Histosols and Histels.

Control Section for Particle-Size Classes and Their Substitutes in Mineral Soils

The particle-size and substitute class names listed below are applied to certain horizons, or to the soil materials within specific depth limits, that have been designated as the control section for particle-size classes and their substitutes (note 4). The lower boundary of the control section may be at a specified depth (in centimeters) below the mineral soil surface or below the upper boundary of an organic layer with andic soil properties, or it may coincide with the upper boundary of a root-limiting layer (defined below).

Root-Limiting Layers

The concept of root-limiting layers as used in this taxonomy defines the base of the soil horizons considered for most (but not all) differentiae at the family level. The properties of soil materials above the base and within the control section are used for assignment of classes, such as particle-size classes and their substitutes. One notable exception to the concept of root-limiting layers is in assignment of soil depth classes (defined below) to soils with fragipans. Unless otherwise indicated, the following are considered root-limiting layers in this chapter: a duripan; a fragipan; petrocalcic, petrogypsic, and placic horizons; continuous ortstein (i.e., 90 percent or more pedogenically cemented and with lateral continuity); and densic, lithic, manufactured layer, paralithic, and petroferric contacts (note 5).

Key to the Control Section for Particle-Size Classes and Their Substitutes in Mineral Soils

The following list of particle-size control sections for particular kinds of mineral soils is arranged as a key. This key, like other keys in this taxonomy, is designed in such a way that the reader makes the correct classification by going through the key systematically, starting at the beginning and eliminating one by one all classes that include criteria that do not fit the soil in question. The soil belongs to the first class for which it meets all of the criteria listed.

The upper boundary of an argillic, natric, or kandic horizon is used in the following key. This boundary is not always obvious. If one of these horizons is present but the upper boundary is irregular or broken, as in an A/B or B/A horizon, the depth at which half or more of the volume has the fabric of an argillic, natric, or kandic horizon should be considered the upper boundary. Brief headers are provided before each of the lettered criteria in the key to help the user understand the purpose for each one.

Thin soil over a root-limiting layer

A. *If* the mineral soil has a root-limiting layer (listed above) within 36 cm of the mineral soil surface or below the upper boundary of organic soil materials with andic soil properties, whichever is shallower, *then* the control section is from the mineral soil surface or the upper boundary of the organic soil materials with andic soil properties, whichever is shallower, to the root-limiting layer; *or*

Andisols

B. *If* the soil is an Andisol, *then* the control section is between either the mineral soil surface or the upper boundary of an organic layer with andic soil properties, whichever is shallower, and the shallower of the following: (a) a depth 100 cm below the starting point, or (b) a root-limiting layer; *or*

Mostly soils with a clay-enriched subsoil within 100 cm (or that are in Arenic or Grossarenic subgroups)

C. *If* the soil is an Alfisol or Ultisol or is in one of the great groups of Aridisols and Mollisols (excluding soils in Lamellic subgroups) that have an argillic, kandic, or natric horizon that has its upper boundary within 100 cm of the mineral soil surface and its lower boundary at a depth of 25 cm or more below the mineral soil surface or that are in a Grossarenic or Arenic subgroup, *then* use items 1 through 4 below. For other soils, go to section D below.

1. *If* there is a strongly contrasting particle-size class (defined and listed later) within or below the argillic, kandic, or natric horizon and within 100 cm of the mineral soil surface, *then* the control section is the upper 50 cm of the argillic, kandic, or natric horizon or to a depth of 100 cm, whichever is deeper, but not below the upper boundary of a root-limiting layer; *or*

2. *If* all parts of the argillic, kandic, or natric horizon are in or below a fragipan, *then* the control section is between a depth of 25 cm from the mineral soil surface and the top of the fragipan; *or*

3. *If* a fragipan is at a depth of less than 50 cm below the top of the argillic, kandic, or natric horizon, *then* the control section is between the upper boundary of the argillic, kandic, or natric horizon and the top the fragipan; *or*

4. For other soils that meet section C above: The control section is *either* the whole argillic, kandic, or natric horizon if it is 50 cm or less thick *or* the control section is the upper 50 cm of the horizon if it is more than 50 cm thick.

Mostly soils with a clay-enriched subsoil starting at least 100 cm deep or that are in a Lamellic subgroup (but not in an Arenic or Grossarenic subgroup)

D. *If* the soil is either an Alfisol, Ultisol, Aridisol, or Mollisol and it is either in a Lamellic subgroup *or* has an argillic, kandic, or natric horizon that has its upper boundary at a depth of 100 cm or more from the mineral surface (and is not in a Grossarenic or Arenic subgroup), *then* the control section is between the lower boundary of an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and 100 cm below the mineral soil surface or a root-limiting layer, whichever is shallower; *or*

Soils with a clay-enriched subsoil with a lower boundary at a shallow depth

E. *If* the soil has an argillic or natric horizon that has its lower boundary at a depth of less than 25 cm from the mineral soil surface, *then* the control section is between the upper boundary of the argillic or natric horizon and a depth of 100 cm below the mineral soil surface or a root-limiting layer, whichever is shallower; *or*

All Wassents

F. *If* the soil is a Wassent, *then* the control section is between the mineral soil surface and the shallower of the following: (a) a depth of 100 cm below the mineral soil surface, or (b) a root-limiting layer; *or*

All other mineral soils

G. For all other mineral soils: The control section is between the lower boundary of an Ap horizon or a depth of 25 cm below the mineral soil surface, whichever is deeper, and the shallower of the following: (a) a depth of 100 cm below the mineral soil surface, or (b) a root-limiting layer.

Key to the Particle-Size and Substitute Classes of Mineral Soils

This key, like other keys in this taxonomy, is designed in such a way that the reader makes the correct classification by going through the key systematically, starting at the beginning and eliminating one by one all classes that include criteria that do not fit the soil or layer in question. The class or substitute name for each layer within the control section must be determined from the key. If any two layers meet the criteria for strongly contrasting particle-size classes (listed below), the soil is named for that strongly contrasting class. If more than one pair meets the criteria for strongly contrasting classes, the soil is also in an aniso class named for the pair of adjacent classes that contrast most strongly. If the soil has none of the strongly contrasting classes, the weighted average soil materials (note 6) within the particle-size control section generally determine the class. Exceptions are soils that are not strongly contrasting and that have a substitute class name for one or more parts of the control section. In these soils the class or substitute name of the thickest (cumulative) part within the control section is used to determine the family name.

In the classes under item C below, "clay" excludes clay-sized carbonates. Carbonates of clay size are treated as silt. If the ratio of percent water retained at 1500 kPa tension to the percentage of measured clay is 0.25 or less or 0.6 or more in half or more of the particle-size control section or part of the particle-size control section in strongly contrasting classes, then poor dispersion or other factors are assumed to be hindering accurate particle-size analysis by standard laboratory procedures. In this case, the percentage of clay is estimated by the formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon). See section "Other Information Useful in Classifying Soils" in the appendix for more information. Brief headers are provided throughout the key to help the user understand the general purpose of each section.

Soils with less than 10 percent, by volume, fine-earth and that meet criteria for a substitute particle-size class

A. Mineral soils that have a fine-earth component (including associated medium and finer pores) of less than 10 percent of the total volume in *one* of the following: (1) in the thickest part of the control section (if the control section is not in one of the strongly contrasting particle-size classes listed below); *or* (2) in a part of the control section that qualifies as an element in one of the strongly contrasting particle-size classes listed below; *or* (3) throughout the control section; *and* that meet one of the following sets of substitute class criteria:

1. Have, in the whole soil, both of the following:

   a. More than 60 percent (by weight) volcanic ash, cinders, lapilli, pumice, and pumicelike* fragments; *and*

   b. In the fraction 2 mm or larger in diameter, two-thirds or more (by volume) pumice and/or pumicelike fragments.

Pumiceous

or

2. Have, in the whole soil, *both* of the following:

   a. More than 60 percent (by weight) volcanic ash, cinders, lapilli, pumice, and pumicelike fragments; *and*

   b. In the fraction 2 mm or larger in diameter, less than two-thirds (by volume) pumice and/or pumicelike fragments.

Cindery

or

* Pumicelike fragments are vesicular pyroclastic materials other than pumice that have an apparent specific gravity (including vesicles) of less than 1.0 g/cm^3.

3. Have a fine-earth component of less than 10 percent (including associated medium and finer pores) of the total volume.

Fragmental

or

Soils with 10 percent or more, by volume, fine earth and meet the criteria for a substitute particle-size class

B. Other mineral soils that have a fine-earth component of 10 percent or more (including associated medium and finer pores) of the total volume and meet, in the thickest portion of the control section (if the control section is not in one of the strongly contrasting particle-size classes listed below), *or* in a portion of the control section that qualifies as a part in one of the strongly contrasting particle-size classes listed below, *or* throughout the control section, one of the following sets of substitute class criteria:

Soils that have andic soil properties and a low capacity to absorb and retain water or have a significant glass content in the fine earth

1. They:

a. Have andic soil properties and have a water content at 1500 kPa tension of less than 30 percent on undried samples and less than 12 percent on dried samples; *or*

b. Do not have andic soil properties, have 30 percent or more of the fine-earth fraction in the 0.02 to 2.0 mm fraction, and have a volcanic glass content (by grain count) of 30 percent or more in the 0.02 to 2.0 mm fraction; *and*

c. Have *one* of the following:

(1) A total of 35 percent or more (by volume) rock and pararock fragments, of which two-thirds or more (by volume) is pumice or pumicelike fragments.

Ashy-pumiceous

or

(2) 35 percent or more (by volume) rock fragments.

Ashy-skeletal

or

(3) Less than 35 percent (by volume) rock fragments.

Ashy

or

Soils that have andic soil properties and an intermediate capacity to absorb and retain water

2. They have a fine-earth fraction that has andic soil properties *and* that has a water content at 1500 kPa tension of less than 100 percent on undried samples; *and*

a. Have a total of 35 percent or more (by volume) rock and pararock fragments, of which two-thirds or more (by volume) is pumice or pumicelike fragments.

Medial-pumiceous

or

b. Have 35 percent or more (by volume) rock fragments.

Medial-skeletal

or

c. Have less than 35 percent (by volume) rock fragments.

Medial

or

Soils with andic soil properties and a high capacity to absorb and retain water

3. They have a fine-earth fraction that has andic soil properties and that has a water content at 1500 kPa tension of 100 percent or more on undried samples; *and*

a. Have a total of 35 percent or more (by volume) rock and pararock fragments, of which two-thirds or more (by volume) is pumice or pumicelike fragments.

Hydrous-pumiceous

or

b. Have 35 percent or more (by volume) rock fragments.

Hydrous-skeletal

or

c. Have less than 35 percent (by volume) rock fragments.

Hydrous

or

Soils with a high content of limnic materials

4. They have a fine-earth fraction consisting of limnic material and having a ratio of water content at 15 bar tension to clay of more than 0.6, moist bulk density of less than 0.80 g/cm^3, and moist liquid limit of more than 100.

Diatomaceous

or

Soils with a high content of gypsum

5. They have, in the fraction less than 20 mm in diameter, 40 percent or more (by weight) gypsum *and* one of the following:

a. A total of 35 percent or more (by volume) rock fragments.

Gypseous-skeletal

or

b. Less than 35 percent (by volume) rock fragments and 50 percent or more (by weight) particles with diameters of 0.1 to 2.0 mm.

Coarse-gypseous

or

c. Less than 35 percent (by volume) rock fragments.

Fine-gypseous

or

Soils where all (or part) of the control section materials are not covered in item A or B above

C. Other mineral soils for which the classes are applied: (a) to the thickest part of the control section (if part of the control section has a substitute for particle-size class and is not in one of the strongly contrasting particle-size classes listed below); *or* (b) to a part of the control section that qualifies as an element in one of the strongly contrasting particle-size classes listed below; *or* (c) throughout the control section; *and* that meet one of the following sets of particle-size class criteria.

Soils with 35 percent of more rock fragments and/or cohesive artifacts

1. Have a total content of rock fragments, plus any artifacts 2 mm or larger in diameter which are both cohesive and persistent, of 35 percent or more (by volume) *and* a texture class of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand in the fine-earth fraction.

Sandy-skeletal

or

2. Have a total content of rock fragments, plus any artifacts 2 mm or larger in diameter which are both cohesive and persistent, of 35 percent or more (by volume) and less than 35 percent (by weight) clay.

Loamy-skeletal

or

3. Have a total content of rock fragments, plus any artifacts 2 mm or larger in diameter which are both cohesive and persistent, of 35 percent or more (by volume).

Clayey-skeletal

or

Sandy soils

4. Have a texture class of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand in the fine-earth fraction.

Sandy

or

Generalized class for select loamy soils

5. Have a texture class of loamy very fine sand, very fine sand, or finer, including less than 35 percent (by weight) clay in the fine-earth fraction (excluding Vertisols), and are in a shallow family (defined below) or in a Lithic, Arenic, or Grossarenic subgroup, or the layer is a part in a strongly contrasting particle-size class (listed below).

Loamy

or

Narrowly defined classes for other loamy soils

6. Have, in the fraction less than 75 mm in diameter, 15 percent or more (by weight) particles with diameters of 0.1 to 75 mm (fine sand or coarser, including gravel and artifacts 2 to 75 mm in diameter which are both cohesive and persistent) *and*, in the fine-earth fraction, less than 18 percent (by weight) clay.

Coarse-loamy

or

7. Have, in the fraction less than 75 mm in diameter, 15 percent or more (by weight) particles with diameters of 0.1 to 75 mm (fine sand or coarser, including gravel and artifacts 2 to 75 mm in diameter which are both cohesive and persistent) *and*, in the fine-earth fraction, 18 to less than 35 percent (by weight) clay (Vertisols are excluded).

Fine-loamy

or

8. Have, in the fraction less than 75 mm in diameter, less than 15 percent (by weight) particles with diameters of 0.1 to 75 mm (fine sand or coarser, including gravel and artifacts 2 to 75 mm in diameter which are both cohesive and persistent) *and*, in the fine-earth fraction, less than 18 percent (by weight) clay.

Coarse-silty

or

9. Have, in the fraction less than 75 mm in diameter, less than 15 percent (by weight) particles with diameters of 0.1 to 75 mm (fine sand or coarser, including gravel and artifacts 2 to 75 mm in diameter which are both cohesive and persistent) *and*, in the fine-earth fraction, 18 to less than 35 percent (by weight) clay (Vertisols are excluded).

Fine-silty

or

Generalized class for select clayey soils

10. Have 35 percent or more (by weight) clay (more than 30 percent in Vertisols) and are in a shallow family (defined below) or in a Lithic, Arenic, or Grossarenic subgroup, or the layer is a part in a strongly contrasting particle-size class (listed below).

Clayey

or

Narrowly defined classes for other clayey soils

11. Have (by weighted average) less than 60 percent (by weight) clay in the fine-earth fraction.

Fine

or

12. Have 60 percent or more (by weight) clay.

Very-fine

Strongly Contrasting Particle-Size Classes

The purpose of strongly contrasting particle-size classes is to identify changes in pore-size distribution or composition that are not identified in higher soil categories and that seriously affect the movement and retention of water and/or nutrients.

Application

The particle-size or substitute classes listed below are considered strongly contrasting if both parts are 12.5 cm or more thick (including the thickness of these parts not entirely within the particle-size control section; however, substitute class names are used only if the soil materials to which they apply extend 10 cm or more into the upper part of the particle-size control section) and if the transition zone between the two parts of the particle-size control section is less than 12.5 cm thick. If more than one pair of strongly contrasting pairs is present within the particle-size control section, the aniso class term (described above) is used.

Combination names

Some classes, such as sandy and sandy-skeletal, have been combined in the following list. In those cases the combined name is used as the family class if part of the control section meets the criteria for either class.

The following classes are listed alphabetically and are not presented in a key format.

1. Ashy over clayey
2. Ashy over clayey-skeletal
3. Ashy over loamy
4. Ashy over loamy-skeletal
5. Ashy over medial (if the water content at 1500 kPa tension in dried samples of the fine-earth fraction is 10 percent or less for the ashy part and 15 percent or more for the medial part)
6. Ashy over medial-skeletal
7. Ashy over pumiceous or cindery
8. Ashy over sandy or sandy-skeletal
9. Ashy-skeletal over clayey
10. Ashy-skeletal over fragmental or cindery (if the volume of the fine-earth fraction is 35 percent or more [absolute] greater in the ashy-skeletal part than in the fragmental or cindery part)
11. Ashy-skeletal over loamy-skeletal
12. Ashy-skeletal over sandy or sandy-skeletal
13. Cindery over loamy
14. Cindery over medial
15. Cindery over medial-skeletal
16. Clayey over coarse-gypseous
17. Clayey over fine-gypseous (if there is an absolute difference of 15 percent or more gypsum between the two parts of the control section)
18. Clayey over fragmental
19. Clayey over gypseous-skeletal
20. Clayey over loamy (if there is an absolute difference of 25 percent or more between clay percentages of the fine-earth fraction in the two parts of the control section)
21. Clayey over loamy-skeletal (if there is an absolute difference of 25 percent or more between clay percentages of the fine-earth fraction in the two parts of the control section)
22. Clayey over sandy or sandy-skeletal
23. Clayey-skeletal over sandy or sandy-skeletal
24. Coarse-loamy over clayey
25. Coarse-loamy over fragmental
26. Coarse-loamy over sandy or sandy-skeletal (if the coarse-loamy material contains less than 50 percent, by weight, fine sand or coarser sand)
27. Coarse-silty over clayey
28. Coarse-silty over sandy or sandy-skeletal
29. Fine-loamy over clayey (if there is an absolute difference of 25 percent or more between clay percentages of the fine-earth fraction in the two parts of the control section)
30. Fine-loamy over fragmental
31. Fine-loamy over sandy or sandy-skeletal
32. Fine-silty over clayey (if there is an absolute difference of 25 percent or more between clay percentages of the fine-earth fraction in the two parts of the control section)
33. Fine-silty over fragmental
34. Fine-silty over sandy or sandy-skeletal
35. Hydrous over clayey
36. Hydrous over clayey-skeletal
37. Hydrous over fragmental
38. Hydrous over loamy
39. Hydrous over loamy-skeletal
40. Hydrous over sandy or sandy-skeletal
41. Loamy over ashy or ashy-pumiceous

42. Loamy over coarse-gypseous (if there is an absolute difference of 15 percent or more gypsum between the two parts of the control section)
43. Loamy over fine-gypseous (if there is an absolute difference of 15 percent or more gypsum between the two parts of the control section)
44. Loamy over pumiceous or cindery
45. Loamy over sandy or sandy-skeletal (if the loamy material contains less than 50 percent, by weight, fine sand or coarser sand)
46. Loamy-skeletal over cindery (if the volume of the fine-earth fraction is 35 percent or more [absolute] greater in the loamy-skeletal part than in the cindery part)
47. Loamy-skeletal over clayey (if there is an absolute difference of 25 percent or more between clay percentages of the fine-earth fraction in the two parts of the control section)
48. Loamy-skeletal over fragmental (if the volume of the fine-earth fraction is 35 percent or more [absolute] greater in the loamy-skeletal part than in the fragmental part)
49. Loamy-skeletal over gypseous-skeletal (if there is an absolute difference of 15 percent or more gypsum between the two parts of the control section)
50. Loamy-skeletal over sandy or sandy-skeletal (if the loamy material contains less than 50 percent, by weight, fine sand or coarser sand)
51. Medial over ashy (if the water content at 1500 kPa tension in dried samples of the fine-earth fraction is 15 percent or more for the medial part and 10 percent or less for the ashy part)
52. Medial over ashy-pumiceous or ashy-skeletal (if the water content at 1500 kPa tension in dried samples of the fine-earth fraction is 15 percent or more for the medial part and 10 percent or less for the ashy part)
53. Medial over clayey
54. Medial over clayey-skeletal
55. Medial over fragmental
56. Medial over hydrous (if the water content at 1500 kPa tension in undried samples of the fine-earth fraction is 75 percent or less for the medial part)
57. Medial over loamy
58. Medial over loamy-skeletal
59. Medial over pumiceous or cindery
60. Medial over sandy or sandy-skeletal
61. Medial-skeletal over fragmental or cindery (if the volume of the fine-earth fraction is 35 percent or more [absolute] greater in the medial-skeletal part than in the fragmental or cindery part)
62. Medial-skeletal over loamy-skeletal
63. Medial-skeletal over sandy or sandy-skeletal
64. Pumiceous or ashy-pumiceous over loamy
65. Pumiceous or ashy-pumiceous over loamy-skeletal
66. Pumiceous or ashy-pumiceous over medial
67. Pumiceous or ashy-pumiceous over medial-skeletal
68. Pumiceous or ashy-pumiceous over sandy or sandy-skeletal
69. Sandy over clayey
70. Sandy over loamy (if the loamy material contains less than 50 percent, by weight, fine sand or coarser sand)
71. Sandy-skeletal over loamy (if the loamy material contains less than 50 percent, by weight, fine sand or coarser sand)

Human-Altered and Human-Transported Material Classes

Human-altered and human-transported material classes are intended to provide useful information on the behavior and interpretations for use of soils which formed in human-altered or human-transported material (defined in chapter 3).

Use of Human-Altered and Human-Transported Material Classes

Human-altered and human-transported material classes are only used in taxa of mineral soils where one of the following occurs: (1) human-altered or human-transported material extends from the soil surface to a depth of 50 cm or to a root-limiting layer, whichever is shallower; or (2) the soil classifies in an Anthraltic, Anthraquic, Anthrodensic, Anthropic, Anthroportic, Haploplaggic, or Plaggic extragrade subgroup (defined in chapter 3). In other taxa, the class is omitted from the family name and the parent material is identified at the soil series level.

Examples of soils that are named using human-altered and human-transported material classes and that formed in human-transported material are a fine, methanogenic, mixed, active, nonacid, thermic Anthrodensic Ustorthent, which was compacted during construction of a sanitary landfill, and a fine-loamy, spolic, mixed, active, calcareous, mesic Anthroportic Udorthent, which resulted from reclamation of a surface coal mine. An example of a soil that is named using a human-altered and human-transported material class and that formed in human-altered material as a result of mechanical displacement of a preexisting natric horizon is a fine, araric, smectitic, calcareous, thermic Anthraltic Sodic Xerorthent.

Key to the Control Section for Human-Altered and Human-Transported Material Classes

The control section for the human-altered and human-transported material classes is from the soil surface to one of the following depths, whichever is shallower:

1. 200 cm; *or*

2. The lower boundary of the deepest horizon formed in human-altered or human-transported material; *or*

3. A lithic or paralithic contact.

Key to Human-Altered and Human-Transported Material Classes

The following key to human-altered and human-transported material classes is designed to make important distinctions in the order of most importance to human health and safety. The soil belongs to the first class for which it meets all of the required criteria.

A. Mineral soils that have, in some part of the human-altered and human-transported material control section, one of the following:

1. The detectible evolution (>1.6 ppb) of methanethiol (i.e., methyl mercaptan) odor from the decomposition of nonpersistent artifacts (e.g., garbage, wood-mill pulp, sewage treatment plant byproducts) *or* evidence of the collection and/or burning of methane gas.

Methanogenic

or

2. A horizon or layer 7.5 cm or more thick, with more than 35 percent (by volume) artifacts of asphalt (bitumen) that are 2 mm in diameter or larger.

Asphaltic

or

3. A horizon or layer 7.5 cm or more thick, with more than 35 percent (by volume) artifacts of concrete that are 2 mm in diameter or larger.

Concretic

or

4. A horizon or layer 7.5 cm or more thick, with more than 40 percent (by weight) artifacts of synthetic gypsum products such as flue gas desulfurization gypsum, phosphogypsum, or fluorogypsum (e.g., drywall or plaster) in the fine-earth fraction.

Gypsifactic

or

5. A horizon or layer 7.5 cm or more thick, with more than 35 percent (by volume) artifacts of coal combustion byproducts (e.g., bottom ash or coal slag) that are 2 mm in diameter or larger.

Combustic

or

6. A horizon or layer 7.5 cm or more thick, with more than 15 percent (by grain count in the 0.02 to 0.25 mm fraction) artifacts of light-weight, coal combustion byproducts (e.g., fly ash scrubbed from emission stacks).

Ashifactic

or

7. A horizon or layer 7.5 cm or more thick, with more than 5 percent (by grain count in the 0.02 to 0.25 mm fraction) artifacts of pyrolysis (e.g., fuel coke or biochar).

Pyrocarbonic

or

8. A horizon or layer 50 cm or more thick, with 35 percent or more (by volume) artifacts which are both cohesive and persistent *and* are 2 mm in diameter or larger.

Artifactic

or

9. A horizon or layer 50 cm or more thick, with 15 percent or more (by volume) artifacts which are both cohesive and persistent *and* are 2 mm in diameter or larger.

Pauciartifactic

or

10. A horizon or layer 50 cm or more thick, with finely stratified (5 cm or less thick) human-transported material that was water-deposited (e.g., sediment from dredging or irrigation).

Dredgic

or

11. A horizon or layer 50 cm or more thick of human-transported material.

Spolic

or

12. A horizon or layer 7.5 cm or more thick, with 3 percent or more (by volume) mechanically detached and re-oriented pieces of diagnostic horizons or characteristics.

Araric

or

B. All other soils: No human-altered or human-transported material classes are used.

Mineralogy Classes

The mineralogy of soils is useful in making predictions about soil behavior and responses to management. Some mineralogy classes occur or are important only in certain taxa or particle-size classes, and others are important in all particle-size classes. A mineralogy class is assigned to all mineral soils, except for Quartzipsamments[*].

Control Section for Mineralogy Classes

The control section for mineralogy classes is the same as that defined for the particle-size classes and their substitutes.

Key to Mineralogy Classes

This key, like other keys in this taxonomy, is designed in such a way that the reader makes the correct classification by going through the key systematically, starting at the beginning and eliminating one by one any classes that include criteria that do not fit the soil in question. The soil belongs to the first class for which it meets all of the required criteria. The user should first check the criteria in section A and, if the soil in question does not meet the criteria listed there, proceed to sections B, C, etc., until the soil meets the criteria listed. All criteria are based on a weighted average.

Application for strongly contrasting particle-size classes

For soils with strongly contrasting particle-size classes, mineralogy classes are used for both of the named parts of particle-size classes or substitute classes, unless they are the same. The same mineralogy class name cannot be used for both parts of the control section (e.g., “mixed over mixed”). Examples of soils that require assignment of two different mineralogy classes are a clayey over sandy or sandy-skeletal, smectitic over mixed, thermic Vertic Haplustept and an ashy-skeletal over loamy-skeletal, glassy over mixed (if the ashy-skeletal part has 30 percent or more volcanic glass), superactive Vitrandic Argicryoll. Examples of soils that are not assigned two mineralogy classes are an ashy over clayey, mixed (if both the ashy part with andic soil properties and the clayey part without andic soil properties are mixed), superactive, mesic Typic Vitraquand and a fine-loamy over sandy or sandy-skeletal, mixed (if both the fine-loamy and sandy or sandy-skeletal parts are mixed), active, frigid Pachic Argiudoll.

Arrangement of the key

The key to mineralogy class terms is divided into five sections broadly grouping different kinds of soils. Twenty-four class terms are used, some occurring in more than one of the five sections of the key.

Sections A, B, D, and E of the key have a “mixed” class of “all other soils” as the last member, thus catching any remaining soils that meet the criteria for the grouping[†].

[*] As defined, all Quartzipsamments also meet the definition for the siliceous mineralogy class, so including the class term would be redundant.

[†] Collectively, the soils assigned to the mixed mineralogy class have a very wide range of mineralogical properties.

Classes applied to many highly weathered soils

A. Oxisols and “kandi” and “kanhap” great groups of Alfisols and Ultisols that in the mineralogy control section have:

1. More than 40 percent (by weight) iron oxide as Fe_2O_3 (more than 28 percent Fe), extractable by dithionite-citrate, in the fine-earth fraction.

Ferritic

or

2. More than 40 percent (by weight) gibbsite in the fine-earth fraction.

Gibbsitic

or

3. Both:

a. 18 to 40 percent (by weight) iron oxide as Fe_2O_3 (12.6 to 28 percent Fe), extractable by dithionite-citrate, in the fine-earth fraction; *and*

b. 18 to 40 percent (by weight) gibbsite in the fine-earth fraction.

Sesquic

or

4. 18 to 40 percent (by weight) iron oxide as Fe_2O_3 (12.6 to 28 percent Fe), extractable by dithionite-citrate, in the fine-earth fraction.

Ferruginous

or

5. 18 to 40 percent (by weight) gibbsite in the fine-earth fraction.

Allitic

or

6. More than 50 percent (by weight) kaolinite plus halloysite, dickite, nacrite, and other 1:1 or nonexpanding 2:1 layer minerals and gibbsite *and* less than 10 percent (by weight) smectite minerals (montmorillonite, beidellite, and nontronite) in the fraction less than 0.002 mm in diameter, *and* more kaolinite than halloysite.

Kaolinitic

or

7. More than 50 percent (by weight) halloysite plus kaolinite and allophane *and* less than 10 percent (by weight) smectite minerals (montmorillonite, beidellite, and nontronite) in the fraction less than 0.002 mm in diameter.

Halloysitic

or

8. All other soils in section A.

Mixed

or

Classes applied to soil layers with a substitute particle-size class (except fragmental)

B. Other soils with horizons in the mineralogy control section that have a substitute class that replaces the particle-size class, other than fragmental, and that have:

1. 40 percent or more (by weight) gypsum either in the fine-earth fraction or in the fraction less than 20 mm in diameter, whichever has a higher percentage of gypsum.

Hypergypsic

or

2. 30 percent or more (by weight) diatoms, plant opal, and sponge spicules in the fine-earth fraction.

Opaline

or

3. Both:

a. A sum of 8 times the Si (percent by weight extracted by ammonium oxalate from the fine-earth fraction) plus 2 times the Fe (percent by weight extracted by ammonium oxalate from the fine-earth fraction) of 5 or more; *and*

b. The product of 8 times the Si is more than the product of 2 times the Fe.

Amorphic

or

4. A sum of 8 times the Si (percent by weight extracted by ammonium oxalate from the fine-earth fraction) plus 2 times the Fe (percent by weight extracted by ammonium oxalate from the fine-earth fraction) of 5 or more.

Ferrihydritic

or

5. 30 percent or more (by grain count) volcanic glass in the 0.02 to 2.0 mm fraction.

Glassy

or

6. All other soils in section B.

Mixed

or

Classes applied to mineral layers in any other soils

C. Other mineral soils and soils in Terric subgroups of Histosols and Histels that have horizons or layers in the mineralogy control section composed of mineral soil material that has:

1. Any particle-size class and 15 percent or more (by weight) anhydrite, either in the fine-earth fraction or in the fraction less than 20 mm in diameter, whichever has a higher percentage of anhydrite.

Anhydritic

or

2. Any particle-size class and 15 percent or more (by weight) gypsum, either in the fine-earth fraction or in the fraction less than 20 mm in diameter, whichever has a higher percentage of gypsum.

Gypsic

or

3. Any particle-size class and more than 40 percent (by weight) carbonates (expressed as $CaCO_3$) plus gypsum, either in the fine-earth fraction or in the fraction less than 20 mm in diameter, whichever has a higher percentage of carbonates plus gypsum.

Carbonatic

or

4. Any particle-size class, except for fragmental, and more than 40 percent (by weight) iron oxide as Fe_2O_3 (more than 28 percent Fe) extractable by dithionite-citrate, in the fine-earth fraction.

Ferritic

or

5. Any particle-size class, except for fragmental, and more than 40 percent (by weight) gibbsite and boehmite in the fine-earth fraction.

Gibbsitic

or

6. Any particle-size class, except for fragmental, and more than 40 percent (by weight) magnesium-silicate minerals, such as the serpentine minerals (antigorite, chrysotile, and lizardite) plus talc, olivines, Mg-rich pyroxenes, and Mg-rich amphiboles, in the fine-earth fraction.

Magnesic

or

7. Any particle-size class, except for fragmental, and more than 20 percent (by weight) glauconitic pellets in the fine-earth fraction.

Glauconitic

or

Classes applied to all clayey soil layers not covered by section A or C above

D. Other mineral soils and soils in Terric subgroups of Histosols and Histels that have a clayey, clayey-skeletal, fine, or very-fine particle-size class and have horizons or layers composed of mineral soil material that:

1. In the fine-earth fraction, have a total percent (by weight) iron oxide as Fe_2O_3 (percent Fe extractable by dithionite-citrate times 1.43) plus the percent (by weight) gibbsite of more than 10.

Parasesquic

or

2. In the fraction less than 0.002 mm in diameter:

a. Have more than 50 percent (by weight) halloysite plus kaolinite and allophane *and* more halloysite than any other single kind of clay mineral.

Halloysitic

or

b. Have more than 50 percent (by weight) kaolinite plus halloysite, dickite, nacrite, and other 1:1 or nonexpanding 2:1 layer minerals and gibbsite *and* less than 10 percent (by weight) smectite minerals (montmorillonite, beidellite, and nontronite).

Kaolinitic

or

c. Have more smectite minerals (montmorillonite, beidellite, and nontronite), by weight, than any other single kind of clay mineral.

Smectitic

or

d. Have more than 50 percent (by weight) illite (hydrous mica) and commonly more than 4 percent K_2O.

Illitic

or

e. Have more vermiculite than any other single kind of clay mineral.

Vermiculitic

or

f. In more than one-half of the thickness, have *all* of the following:

(1) No free carbonates; *and*

(2) A sodium fluoride pH (NaF pH) of 8.4 or more; *and*

(3) A ratio of 1500 kPa water to measured clay of 0.6 or more.

Isotic

or

g. All other soils in section D.

Mixed

or

Classes applied to all other soils not covered above

E. All other soils (except for Quartzipsamments) that have horizons or layers composed of mineral soil material that has:

1. More than 45 percent (by grain count) mica and stable mica pseudomorphs in the 0.02 to 0.25 mm fraction.

Micaceous

or

2. A total percent (by weight) iron oxide as Fe_2O_3 (percent Fe extractable by dithionite-citrate times 1.43) plus the percent (by weight) gibbsite of more than 10 in the fine-earth fraction.

Parasesquic

or

3. In more than one-half of the thickness, *all* of the following:

a. No free carbonates; *and*

b. A sodium fluoride pH (NaF pH) of 8.4 or more; *and*

c. A ratio of 1500 kPa water to measured clay of 0.6 or more.

Isotic

or

4. More than 90 percent (by weight or grain count) silica minerals (quartz, chalcedony, or opal) and other resistant minerals in the 0.02 to 2.0 mm fraction.

Siliceous

or

5. All other soil properties.

Mixed

Cation-Exchange Activity Classes

The cation-exchange activity classes are used to make interpretations about the nutrient-holding capacity of soils and their suites of colloids. The cation-exchange capacity (CEC) is determined by NH_4OAc at pH 7 on the fine-earth fraction. The CEC of the organic matter, sand, silt, and clay is included in the determination. The criteria for the classes use ratios of CEC to the percent, by weight, of silicate clay, calculated by weighted average in the control section. In the following classes "clay" excludes clay-sized carbonates. Percent carbonate clay must be subtracted from percent total clay before the CEC to clay ratio is calculated. If the ratio of percent water retained at 1500 kPa tension to the percentage of measured clay is 0.25 or less or 0.6 or more in half or more of the particle-size control section (or in a part of contrasting families), then the percentage of clay is estimated by the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon). See appendix for more information.

Use of the Cation-Exchange Activity Classes

Cation-exchange activity classes are used for soils classified in the mixed or siliceous mineralogy classes of clayey, clayey-skeletal, coarse-loamy, coarse-silty, fine, fine-loamy, fine-silty, loamy, loamy-skeletal, and very-fine particle-size classes. They are not assigned to Histosols and Histels nor to Oxisols or “kandi” and “kanhap” great groups and subgroups of Alfisols and Ultisols because assigning classes to organic soils or taxa defined by low-activity clay would be misleading or redundant information. Cation-exchange activity classes are not assigned to Psamments, “psamm” great groups of Entisols and Gelisols, Psammentic subgroups, or other soils with sandy or sandy-skeletal particle-size classes or the fragmental substitute class because the low clay content causes cation-exchange activity classes to be less useful and less reliable. Soils with other substitutes for particle-size class (e.g., ashy) or with mineralogy classes such as smectitic also are not assigned cation-exchange activity classes, since such soils have a high cation-exchange capacity (CEC) and/or the clay mineralogy dictates soil properties.

Application for soils with contrasting particle-size classes

For soils with strongly contrasting particle-size classes, where both named parts of the control section use a cation-exchange activity class, the class associated with the particle-size class that has the most clay is named. For example, in a pedon with a classification of fine-loamy over clayey, mixed, active, calcareous, thermic Typic Udorthent, the cation-exchange activity class “active” is associated with the clayey, lower part of the control section. For other soils with strongly contrasting particle-size classes, where one named part of the control section uses a cation-exchange activity class and one named part does not, the class is associated with the part which requires usage. For example, in a pedon with a classification of coarse-loamy over sandy or sandy-skeletal, mixed, superactive, calcareous, mesic Oxyaquic Ustifluvent, the cation-exchange activity class “superactive” is associated with the coarse-loamy, upper part of the control section.

Control Section for Cation-Exchange Activity Classes (note 7)

The control section for cation-exchange activity classes is the same as that used to determine the particle-size and mineralogy classes.

Key to Cation-Exchange Activity Classes

A. Soils that are not Histosols, Histels, Oxisols, or Psamments, that are not in “psamm” great groups of Entisols or Gelisols, that are not in Psammentic subgroups, that are not in “kandi” or “kanhap” great groups or subgroups of Alfisols or Ultisols, that do not have a sandy or sandy-skeletal particle-size class or any substitute for a particle-size class throughout the entire control section, and that have:

1. A mixed or siliceous mineralogy class; *and*

2. A ratio of cation-exchange capacity (by 1N NH_4OAc pH 7) to percent clay (by weight) of:

a. 0.60 or more.
Superactive

or

b. 0.40 to 0.60.
Active

or

c. 0.24 to 0.40.
Semiactive

or

d. Less than 0.24.
Subactive

or

B. All other soils: No cation-exchange activity classes are used.

Calcareous and Reaction Classes of Mineral Soils

The presence or absence of carbonates, soil reaction, and the presence of high concentrations of aluminum in mineral soils are treated together because they are so intimately related. There are four classes—calcareous, acid, nonacid, and allic. These classes are defined below in the key to calcareous and reaction classes. They are not used in all taxa, nor is more than one used in the same taxon.

Use of the Calcareous Class

The calcareous class is used in the names of the families of Entisols, Gelisols, Aquands, Aquepts, Aquolls, and all Gelic suborders and Gelic great groups, but it is not used for any of the following:

1. Calciaquolls, Natraquolls, and Argiaquolls

2. Cryaquolls and Duraquolls that have an argillic or natric horizon

3. Duraquands and Placaquands

4. Sulfaquepts, Fragiaquepts, and Petraquepts

5. Psamments, Psammaquents, Psammowassents, Psammoturbels, Psammorthels, and Psammentic subgroups that have no particle-size class

6. Sandy, sandy-skeletal, cindery, pumiceous, or fragmental families

7. Families with anhydritic, carbonatic, gypsic, or hypergypsic mineralogy

8. Histels

Use of the Acid and Nonacid Reaction Classes

The acid and nonacid classes are used in the names of the families of Entisols, Gelisols, Aquands, Aquepts, and all Gelic suborders and Gelic great groups, but they are not used for any of the following:

1. Duraquands and Placaquands

2. Sulfaquepts, Fragiaquepts, and Petraquepts

3. Psamments, Psammaquents, Psammowassents, Psammoturbels, Psammorthels, and Psammentic subgroups that have no particle-size class

4. Sandy, sandy-skeletal, cindery, pumiceous, or fragmental families

5. Families with anhydritic, carbonatic, gypsic, or hypergypsic mineralogy

6. Histels

Use of the Allic Class

The allic class is used only in families of Oxisols.

Control Section for Calcareous and Reaction Classes

The control section for the calcareous class is one of the following:

1. For all Gelisols (except for Histels), all Gelic suborders and Gelic great groups, and the Wassents suborder: The layer from the mineral soil surface to a depth of 25 cm or to a root-limiting layer, whichever is shallower.

2. For soils with a root-limiting layer that is 25 cm or less below the mineral soil surface: A 2.5-cm-thick layer directly above the root-limiting layer.

3. For soils with a root-limiting layer that is 26 to 50 cm below the mineral soil surface: The layer between a depth of 25 cm below the mineral soil surface and the root-limiting layer.

4. For all other listed soils: Between a depth of 25 and 50 cm below the mineral soil surface.

The control section for the acid and nonacid classes is one of the following:

1. For all Gelisols (except for Histels) and all Gelic suborders and Gelic great groups: The layer from the mineral soil surface to a depth of 25 cm or to a root-limiting layer, whichever is shallower.

2. For all other listed soils: The same control section depths as those for particle-size classes.

The control section for the allic class is the same as that for particle-size classes.

Key to Calcareous and Reaction Classes

A. Oxisols that have a layer, 30 cm or more thick within the control section, that contains more than 2 cmol(+) of KCl-extractable Al per kg soil in the fine-earth fraction.

Allic

B. Other listed soils that, in the fine-earth fraction, effervesce (in cold dilute HCl) in all parts of the control section.

Calcareous

C. Other listed soils with a pH of less than 5.0 in 0.01 M $CaCl_2$ (1:2) (about pH 5.5 in H_2O, 1:1) throughout the control section.

Acid

D. Other listed soils with a pH of 5.0 or more in 0.01 M $CaCl_2$ (1:2) in some or all layers in the control section.

Nonacid

It should be noted that a soil containing dolomite is calcareous and that effervescence of dolomite, when treated with cold dilute HCl, is slow.

The calcareous, acid, nonacid, and allic classes are listed in the family name, when appropriate, following the mineralogy and cation-exchange activity classes.

Soil Temperature Classes

Soil temperature classes, as named and defined here, are used as part of the family name in both mineral and organic soils (note 8). Temperature class names are used as part of the family name unless the criteria for a higher taxon carry the same limitation. Thus, frigid is implied in all cryic suborders, great groups, and subgroups and would be redundant if used in the names of families within these classes.

The Celsius (centigrade) scale is the standard. It is assumed that the temperature is that of a soil not being irrigated.

Control Section for Soil Temperature

The control section for soil temperature is either at a depth of 50 cm below the soil surface or at the upper boundary of a root-limiting layer, whichever is shallower. The soil temperature classes, defined in terms of the mean annual soil temperature and the difference between mean summer and mean winter temperatures, are determined by the following key.

Key to Soil Temperature Classes

A. Gelisols and Gelic suborders and great groups that have a mean annual soil temperature as follows:

1. -10 ^{o}C or lower.

Hypergelic

or

2. -4 ºC to -10 ºC.

Pergelic

or

3. +1 ºC to -4 ºC.

Subgelic

or

B. Other soils that have a difference in soil temperature of 6 ºC or more between mean summer (June, July, and August in the Northern Hemisphere) and mean winter (December, January, and February in the Northern Hemisphere) and a mean annual soil temperature of:

1. Lower than 8 ºC (47 ºF).

Frigid

or

2. 8 ºC (47 ºF) to 15 ºC (59 ºF).

Mesic

or

3. 15 ºC (59 ºF) to 22 ºC (72 ºF).

Thermic

or

4. 22 ºC (72 ºF) or higher.

Hyperthermic

or

C. All other soils that have a mean annual soil temperature as follows:

1. Lower than 8 ºC (47 ºF).

Isofrigid

or

2. 8 ºC (47 ºF) to 15 ºC (59 ºF).

Isomesic

or

3. 15 ºC (59 ºF) to 22 ºC (72 ºF).

Isothermic

or

4. 22 ºC (72 ºF) or higher.

Isohyperthermic

Soil Depth Classes

Soil depth classes are used in all families of mineral soils and Histels that have a root-limiting layer at a specified depth from the mineral soil surface, except for those families in Lithic subgroups (defined below) and those with a fragipan (note 9). The root-limiting layers included in soil depth classes are duripans; petrocalcic, petrogypsic, and placic horizons; continuous ortstein (i.e., the ortstein is 90 percent or more pedogenically cemented and has lateral continuity); and densic, lithic, manufactured layer, paralithic, and petroferric contacts. Soil depth classes for Histosols are given later in this chapter. One soil depth class name, “shallow,” is used to characterize certain soil families that have one of the depths indicated in the following key.

Key to Soil Depth Classes for Mineral Soils and Histels

A. Oxisols that are less than 100 cm deep (from the mineral soil surface) to a root-limiting layer and are not in a Lithic subgroup.

Shallow

or

B. Other mineral soils and Folistels that are less than 50 cm deep (from the mineral soil surface) to a root-limiting layer and are not in a Lithic subgroup.

Shallow

or

C. Other Histels that are less than 50 cm deep to a root-limiting layer.

Shallow

or

D. All other Histels and mineral soils: No soil depth class is used.

Rupture-Resistance Classes

In this taxonomy, some partially pedogenically cemented soil materials, such as durinodes, serve as differentiae in categories above the family, while others, such as partially cemented spodic materials (ortstein), do not. No single family, however, should include soils both with and without partially cemented horizons. In Spodosols, a partially cemented spodic horizon is used as a family differentia. The following rupture-resistance class is defined for families of Spodosols:

A. Spodosols that have an ortstein horizon.

Ortstein

or

B. All other soils: No rupture-resistance class is used.

Classes of Coatings on Sands

Despite the emphasis given to particle-size classes in this taxonomy, variability remains in the sandy particle-size class, which includes sands and loamy sands. Some sands are very clean, i.e., almost completely free of silt and clay, while others are mixed with appreciable amounts of finer grains. Clay is more efficient at coating sand than silt. A weighted average silt plus 2 times the weighted average clay* of more than 5 makes a reasonable division of the sands at the family level. Two classes of Quartzipsamments are defined in terms of their content of silt plus 2 times their content of clay.

Control Section for Classes of Coatings on Sands

The control section for classes of coatings is the same as that for particle-size classes or their substitutes and for mineralogy classes.

Key to Classes of Coatings on Sands

A. Quartzipsamments that have a sum of the weighted average silt (by weight) plus 2 times the weighted average clay (by weight) of more than 5.

Coated

or

B. Other Quartzipsamments.

Uncoated

Classes of Permanent Cracks

Some Hydraquents consolidate or shrink after drainage and become Fluvaquents or Humaquepts (note 10). In the process they can form polyhedrons roughly 12 to 50 cm in diameter, depending on their *n* value and texture. These polyhedrons are separated by cracks that range in width from 2 mm to more than 1 cm. The polyhedrons may shrink and swell with changes in the moisture content of the soils, but the cracks are permanent and can persist for several hundreds of years, even if the soils are cultivated (note 11). The cracks permit rapid movement of water through the soils, either vertically or laterally. Such soils may have the same texture, mineralogy, and other family properties as soils that do not form cracks or that have cracks that open and close depending on the season. Soils with permanent cracks are very rare in the United States, but a few have been recognized.

Control Section for Classes of Permanent Cracks

The control section for classes of permanent cracks is from the base of any plow layer or 25 cm from the soil surface, whichever is deeper, to 100 cm below the soil surface.

Key to Classes of Permanent Cracks

A. Fluvaquents or Humaquepts that have, throughout a layer 50 cm or more thick, continuous, permanent, lateral and vertical cracks 2 mm or more wide, spaced at average lateral intervals of less than 50 cm.

Cracked

or

* The values used for silt and clay are percent by weight.

B. All other Fluvaquents and Humaquepts: No class of permanent cracks is used.

Family Differentiae for Organic Soils

Most of the differentiae that are used to distinguish families of organic soils (Histosols and Histels) have already been defined, either because they are used as differentiae in mineral soils as well as organic soils or because their definitions are used for the classification of some Histosols and Histels in categories above the family. In the following descriptions, differentiae not previously mentioned are defined and the classes in which they are used are enumerated.

The order in which class names, if appropriate for a particular soil, are placed in the family names of Histosols and Histels is as follows:

Particle-size classes
Mineralogy classes, including the nature of limnic deposits in Histosols
Reaction classes
Soil temperature classes
Soil depth classes (used only with Histosols)

Particle-Size Classes

Particle-size classes are used only for the family names of Terric subgroups of Histosols and Histels. The classes are determined from the properties of the mineral soil materials in the control section through use of the key to particle-size classes. Only the classes listed below are used. Contrasting particle-size classes are not used. The six classes defined below are more generalized than those used for mineral soils.

Control Section for Particle-Size Classes

The particle-size control section is the upper 30 cm of the mineral layer or of that part of the mineral layer that is within the control section for Histosols and Histels (given in chapter 3), whichever is thicker.

Key to Particle-Size Classes of Organic Soils

A. Terric subgroups of Histosols and Histels that have (by weighted average) in the particle-size control section:

1. A fine-earth component of less than 10 percent (including associated medium and finer pores) of the total volume.

Fragmental

or

2. A texture class of coarse sand, sand, fine sand, loamy coarse sand, loamy sand, or loamy fine sand in the fine-earth fraction.

Sandy or sandy-skeletal

or

3. Less than 35 percent (by weight) clay in the fine-earth fraction and a total content of rock fragments plus any artifacts 2 mm or larger in diameter which are both cohesive and persistent of 35 percent or more (by volume).
Loamy-skeletal

or

4. A total content of rock fragments plus any artifacts 2 mm or larger in diameter which are both cohesive and persistent of 35 percent or more (by volume).
Clayey-skeletal

or

5. A clay content of 35 percent or more (by weight) in the fine-earth fraction.
Clayey

or

6. All other Terric subgroups of Histosols and Histels.
Loamy

or

B. All other Histosols and Histels: No particle-size class is used.

Mineralogy Classes

There are three different kinds of mineralogy classes recognized for families in certain great groups and subgroups of Histosols. The first kind is the ferrihumic soil material defined below. The second consists of three types of limnic materials—coprogenous earth, diatomaceous earth, and marl, defined in chapter 3. The third is mineral layers of Terric subgroups. The key to mineralogy classes for these mineral layers is the same as that for mineral soils. Terric subgroups of Histels also have the same mineralogy classes as those for mineral soils.

Ferrihumic Soil Material and Mineralogy Class

Ferrihumic soil material, i.e., bog iron, is an authigenic (formed in place) deposit consisting of hydrated iron oxide mixed with organic matter, either dispersed and soft or cemented into large aggregates, in a mineral or organic layer that has *all* of the following characteristics:

1. Saturation with water for more than 6 months per year (or artificial drainage); *and*

2. 2 percent or more (by weight) iron concretions having lateral dimensions ranging from less than 5 to more than 100 mm and containing 10 percent or more (by weight) free iron oxide (7 percent or more Fe) extractable by dithionite-citrate and 1 percent or more (by weight) organic matter; *and*

3. A dark reddish or brownish color that changes little on drying.

The ferrihumic mineralogy class is used for families of Fibrists, Hemists, and Saprists, but it is not used for Folists, Sphagnofibrists, or Sphagnic subgroups of other great groups. If the ferrihumic class is used in the family name of a Histosol, no other mineralogy classes are used in that family because the presence of iron is considered to be by far the most important mineralogical characteristic.

Mineralogy Classes Applied Only to Limnic Subgroups

Limnic materials (defined in chapter 3) with a thickness of 5 cm or more are mineralogy class criteria if the soil does not also have ferrihumic mineralogy. The following family classes are used: coprogenous, diatomaceous, and marly.

Mineralogy Classes Applied Only to Terric Subgroups

For Histosols and Histels in Terric subgroups, the key to mineralogy classes for mineral soils is used unless a Histosol also has ferrihumic mineralogy.

Control Sections

Control Section for the Ferrihumic Mineralogy Class and Mineralogy Classes Applied to Limnic Subgroups

The control section for the ferrihumic mineralogy class and the classes applied to Limnic subgroups is the same as the control section for Histosols.

Control Section for Mineralogy Classes Applied Only to Terric Subgroups

For Terric subgroups of Histosols and Histels, the control section for mineralogy classes is the same as that used for the particle-size classes.

Key to Mineralogy Classes

A. Histosols (except for Folists, Sphagnofibrists, and Sphagnic subgroups of other great groups) that have ferrihumic soil material within the control section for Histosols.
Ferrihumic

or

B. Other Histosols that have, within the control section for Histosols, limnic materials, 5 cm or more thick, that consist of:

1. Coprogenous earth.
Coprogenous

or

2. Diatomaceous earth.
Diatomaceous

or

3. Marl.
Marly

or

C. Histels and other Histosols in Terric subgroups: The key to mineralogy classes for mineral soils is used.

or

D. All other Histels and Histosols: No mineralogy class is used.

Reaction Classes

Reaction classes are used in all families of Histosols and Histels. The three classes recognized are defined in the following key:

A. Histosols that have field reaction (effervescence) with dilute HCl (indicative of secondary carbonates) throughout the surface tier.

Kalkic

or

B. Histosols and Histels that have a pH value, on undried samples, of 4.5 or more (in 0.01 M $CaCl_2$) in one or more layers of organic soil materials within the control section for Histosols.

Euic

or

C. All other Histosols and Histels.

Dysic

Soil Temperature Classes

The soil temperature classes of Histosols are determined through use of the same key and definitions as those used for mineral soils. Histels have the same temperature classes as other Gelisols.

Soil Depth Classes

Soil depth classes refer to the depth to a root-limiting layer or to a pumiceous, cindery, or fragmental substitute class. The root-limiting layers included in soil depth classes of Histosols are duripans; petrocalcic, petrogypsic, and placic horizons; continuous ortstein (i.e., the ortstein is 90 percent or more pedogenically cemented and has lateral continuity); and densic, lithic, manufactured layer, paralithic, and petroferric contacts. The following key is used for families in all subgroups of Histosols. The shallow class is not used in the Folists suborder (note 12). These classes are not used in Histels which use the same depth classes as for mineral soils described in a previous section.

Key to Soil Depth Classes for Histosols

A. Histosols that are less than 18 cm deep to a root-limiting layer or to a pumiceous, cindery, or fragmental substitute class.

Micro

or

B. Other Histosols, excluding Folists, that have a root-limiting layer or a pumiceous, cindery, or fragmental substitute class at a depth between 18 and 50 cm from the soil surface.

Shallow

or

C. All other Histosols: No soil depth class is used.

Series Differentiae Within a Family

The function of the series is pragmatic, and differences within a family that affect the use of a soil should be considered in classifying soil series. The separation of soils at the series level of this taxonomy can be based on any property that is used as criteria at higher levels in the system. Other properties of the soil that are not used elsewhere in the system can also be used. The criteria most commonly used include presence of, depth to, thickness of, and expression of horizons and properties diagnostic for the higher categories and differences in texture, mineralogy, soil moisture, soil temperature, and amounts of organic matter. The limits of the properties used as differentiae must be more narrowly defined than the limits for the family. The properties used, however, must be reliably observable or be inferable from other soil properties or from the setting or vegetation.

The differentiae used must be within the series control section. Differences in soil or regolith that are outside the series control section and that have not been recognized as series differentiae but are relevant to potential uses of certain soils are considered as a basis for phase distinctions.

Soil Series Definitions

There is no key for identifying soil series. Identification is done by comparing a soil description to the soils currently recognized in the same family.

The definitions for individual soil series are not contained within the text of *Soil Taxonomy*. In the United States, descriptions for each soil series along with the range of their key properties are contained in the Official Soil Series Descriptions database.

Descriptions of soil series established outside the United States can be maintained locally using whatever system is considered appropriate.

Control Section for the Differentiation of Series

The control section for the soil series is similar to that for the family, but it has a few important differences. The particle-size and mineralogy control sections for families end at the upper boundary of certain diagnostic subsurface horizons, such as a duripan, fragipan, or petrocalcic horizon, because these horizons have few roots. The thickness of such root-limiting horizons is taken into account in differentiating concepts of competing soil series, when they occur within the series control section. In contrast, the thickness of such horizons is not used in the control sections for the family. The series control section includes materials starting at the soil surface and extends into the first 25 cm of densic materials, a manufactured layer, or paralithic materials, if the densic, manufactured layer, or paralithic contacts, respectively, are less than 125 cm below the mineral soil surface. In contrast, the properties of materials below any densic, lithic, manufactured layer, paralithic, or petroferric contact are not used for classification in the categories above the series (i.e., order through family). The properties of horizons and layers below the particle-size control section, a depth between 100 and 150 cm (or to 200 cm if in a diagnostic horizon) from the mineral soil surface, also are considered in the series category of this taxonomy.

Key to the Control Section for the Differentiation of Series

The part of a soil to be considered in differentiating series within a family is as follows:

Mineral soils with permafrost within 150 cm

A. For mineral soils that have permafrost within 150 cm of the soil surface, the control section is from the soil surface to the shallowest of the following:

1. A lithic or petroferric contact; *or*

2. A depth of 100 cm if the depth to permafrost is less than 75 cm; *or*

3. 25 cm below the upper boundary of permafrost (but not more than 150 cm) if that boundary is 75 cm or more below the soil surface; *or*

4. 25 cm below a densic, manufactured layer, or paralithic contact (but not more than 150 cm); *or*

5. A depth of 150 cm; *or*

Mineral soils with no permafrost or with permafrost below 150 cm

B. For other mineral soils, the control section is from the soil surface to the shallowest of the following:

1. A lithic or petroferric contact; *or*

2. A depth of either 25 cm below a densic, manufactured layer, or paralithic contact or 150 cm below the soil surface, whichever is shallower, if there is a densic, manufactured layer, or paralithic contact within 150 cm; *or*

3. A depth of 150 cm if the base of the deepest diagnostic horizon is less than 150 cm from the soil surface; *or*

4. The lower boundary of the deepest diagnostic horizon or a depth of 200 cm, whichever is shallower, if the lower boundary of the deepest diagnostic horizon is 150 cm or more below the soil surface; *or*

All organic soils

C. For organic soils (Histosols and Histels), the control section is from the soil surface to the shallowest of the following:

1. A lithic or petroferric contact; *or*

2. A depth of 25 cm below a densic, manufactured layer, or paralithic contact; *or*

3. A depth of 100 cm if the depth to permafrost is less than 75 cm; *or*

4. 25 cm below the upper boundary of permafrost if that boundary is between a depth of 75 and 125 cm below the soil surface; *or*

5. The base of the bottom tier.

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Endnotes

Family differentiae

1. The intent of the family level is to group the soils within a subgroup having similar physical and chemical properties. These properties include capacity factors such as soil texture, mineralogy, or depth, as well as intensity factors such as soil temperature, reaction, or cation-exchange activity. Soil families are generally defined by properties that are considered important for the use and management of the soil, such as those related to agronomic or engineering purposes. This idea of grouping series having similar important properties into families

that reflect similar response to use and management is one that began with the "third approximation" early in the development of Soil Taxonomy (Smith, 1986, p. 135). Therefore, there is less emphasis on factors reflecting genetic processes at the family level than there is in the higher categories.

The International Committee on the Classification of Families (ICOMFAM) proposed a definition for the family, one that emphasized that the purpose of the family is to recognize properties that reflect soil genetic processes and controls on those processes. The ICOMFAM proposal intended to revise the stated intent of the family in a way that better aligned with the genetic bias of higher categories. This proposed change was not adopted. The current language in the 2nd edition of *Soil Taxonomy* (Soil Survey Staff, 1999, p. 123) reiterates the original family purpose. It states that families are defined by grouping soils "having similar physical and chemical properties that affect their responses to management and manipulation for use." Soil properties are used in this category without regard to their significance as marks of processes or lack of them. It is not entirely clear why the proposal was not adopted. However, even if it had been adopted, it would have had relatively minor impact on the properties being used as family criteria because most can be seen as being important both to genetic process controls as well as to considerations for use and management. Only minor revisions to the language describing the intent of the family category appear in the 2nd edition of *Soil Taxonomy* as compared to the first.

Particle-size distribution, silt vs. very-fine sand

2. In the early development of the family particle-size classes, efforts were made to coordinate grain size definitions among pedologists, engineers, and geologists. These efforts were not successful. This is evident by reviewing a comparison of various systems for defining particle-size classes, such as depicted on p. 2-45 of the *Field Book for Describing and Sampling Soils* (Schoeneberger et. al., 2012). Therefore, the provision to allow the fine sand to "float" when assigning the family particle-size class depending on the overall texture of the material was devised as a sort of compromise between engineering and agricultural purposes (Smith, 1986, p. 140).

Strongly contrasting particle-size classes

3. Water movement and rooting patterns are significantly affected by abrupt changes in texture. It should be noted that the list of strongly contrasting particle-size classes does not include all possible combinations. New classes are added to Soil Taxonomy as they are encountered in the field, determined to be useful, and proposed for addition to the list. However, the requirements for what should qualify as "strongly contrasting," other than thickness of the layers and the transition zone between layers, are not defined. For the most part, classes that are adjacent to one another in the key are not considered contrasting unless a qualifier is added (see, for example, "fine-loamy over clayey"). Even some nonadjacent classes use qualifiers, such as "clayey over fine gypseous." Judgement is required when proposing and approving new classes.

Particle-size control section, depths

4. A proposal was made by the International Committee on the Classification of Families (ICOMFAM) to define the depth limits of the particle-size control section more uniformly in mineral soils, by reducing the emphasis on clay-enriched subsoil layers. This was primarily due to a perceived confusion about the control section in soils with argillic, natric, or kandic horizons where only some or all of the horizon is considered. If the proposal had been adopted, most soils with clay-enriched subsoils would have had a particle-size control section at 25 to 100 cm (or to a root-limiting layer), the same as most other soils. This proposal was not adopted. It would have had a significant impact on the classification of many existing soil series that have argillic, natric, or kandic horizons. Potential impacts would include an increase in the number of soils with a contrasting particle-size class (where it would occur between some E to Bt horizons), as well as changes in particle-size class due to the need to perform a weighted average of clay content over a now thicker zone (for example, fine-loamy becoming coarse-loamy, fine becoming fine-loamy, etc.).

Root-limiting layers

5. It should be noted that the concept of root-limiting layers as used to determine the control section for family level classification is limited to layers that present physical impedance to roots. It does not include other root-inhibiting factors such as chemical limitations (e.g., aluminum toxicity), permanent high water table and accompanying anaerobic conditions, or temperature (permafrost). These features are considered either directly or indirectly for placement in classes above the family level. These properties are also important from a use and management perspective and are also commonly considered in that context. See the *Soil Survey Manual* for a brief discussion (Soil Science Division Staff, 2017, pp. 118–119).

Weighted average calculation

6. This is a simple mathematical calculation used to determine the average amount of a soil constituent (e.g., percent clay) within a specified part of the soil (commonly the particle-size control section). This technique is useful because soils are typically described and sampled in the field by individual genetic horizons and layers which rarely coincide exactly with the control section depths specified in Soil Taxonomy. Calculating a weighted average by summing the product of the measured value of the constituent times thickness for each layer within the control section and dividing by the total thickness of the control section is a way to simulate the mixing of multiple samples. This allows one to obtain a single average value for the constituent of interest.

Cation-exchange activity classes

7. Cation-exchange activity classes were proposed by the International Committee on the Classification of Families (ICOMFAM) and included in the 7th edition of the *Keys to Soil Taxonomy* (1996). Early in the committee's deliberations, five classes were discussed. In the final report, just three classes were proposed based on a review of existing data. However, four classes were ultimately adopted. Presumably, there continued to be debate about the optimum number of classes. Over time, the practical experience of applying these classes has resulted in some difficulty due to the prevalence of laboratory data for multiple pedons in a series that span class boundaries. Perhaps just three classes as originally proposed would have been easier to apply since with fewer classes there would be less opportunity to straddle a class boundary.

Soil temperature classes

8. Soil Taxonomy uses soil temperature classes as well as soil temperature regimes (see chapter 3) and this sometimes presents confusion. The classes described here are used at the family level for most soils. The soil temperature regimes are used for purposes other than family classification. The two coldest temperature regimes (gelic and cryic) are used at the suborder or great group level for a few select cold soils (e.g., Gelods and Cryaquepts). The remaining temperature regimes (frigid and warmer) share names and definitions with their counterpart temperature classes. These regimes are not used in the names of any classes above the family, but they are included within some criteria in the keys for identifying higher taxa or for identifying some diagnostic horizons.

Depth classes

9. Most soils in Lithic subgroups are not assigned a shallow depth class at the family level because this would be redundant. The same depth (50 cm) is used for the Lithic subgroup as is used for the family depth class. Exceptions are for Lithic subgroups of Fibristels, Hemistels, and Sapristels. For these taxa, the Lithic subgroup criterion is "less than 100 cm." The shallow family class then is used if the lithic contact is within 50 cm.

The reason for excluding the fragipan as a type of root-limiting layer in the shallow family class is not entirely clear. It was first explicitly excluded with the 7th edition of the *Keys to Soil Taxonomy* (1996). Also at this time, the changes to the family criteria recommended by the International Committee on the Classification of Families (ICOMFAM) took effect. However, the ICOMFAM final report does not include a recommendation for this change. The naturally occurring range in depth to many fragipans straddles 50 cm for many soil series. It would be problematic to split the series into two families based on depth to the fragipan alone, especially since this distinction would likely be difficult to depict on soil maps at commonly used scales.

Classes of permanent cracks

10. The process of consolidation and shrinkage as used here involves a set of complex processes that include: (1) physical changes (due to decreased volume as water is removed and oxidation speeds decomposition), (2) chemical changes (due to decomposition and breakdown of organic molecules, resulting in increasingly resistant forms remaining), and (3) biological changes (due to mechanical mixing and reduction in size of the organic materials along with ped formation). Collectively these processes are referred to as "ripening."

11. In these unique soils, much of the shrinkage that occurs when the soil is drained and dries out is irreversible. Upon rewetting the soil does not swell again to the extent that the cracks close completely. The cracks are permanent. Cracks that open and close seasonally, such as those in many Vertic Fluvaquents, do not qualify for the cracked family class because the cracks are not permanently open.

Histosol depth classes

12. The shallow class is not used with Folists because the criteria for the Lithic subgroup specifies that a lithic contact is at a depth of less than 50 cm. The use of the shallow family class term would therefore be redundant. However, Lithic subgroups for other Histosols specify a lithic contact within the control section, thus allowing it to be at a depth of more than 50 cm; so the shallow family class is warranted for use where the lithic contact is within 50 cm. There are no subgroups of Histosols that are defined by the presence of any of the other root-limiting layers. If these layers are present within 50 cm, the use of the shallow family class term would be appropriate.

CHAPTER 18

Designations for Horizons and Layers

This chapter describes soil layers and genetic soil horizons. The genetic horizons are not the equivalent of the diagnostic horizons of Soil Taxonomy. While designations of genetic horizons express a qualitative judgment about the kinds of changes that are believed to have taken place in a soil, diagnostic horizons are quantitatively defined features that are used to differentiate between taxa. A diagnostic horizon may encompass several genetic horizons, and the changes implied by genetic horizon designations may not be large enough to justify recognition of different diagnostic horizons.

Master Horizons and Layers

The capital letters O, L, V, A, E, B, C, R, M, and W represent the master horizons and layers of soils. These letters are the base symbols to which other characters are added to complete the designations. Most horizons and layers are given a single capital-letter symbol; some require two.

O horizons or layers: *These are horizons or layers dominated by organic soil materials. Some are saturated with water for long periods or were once saturated but are now artificially drained; others have never been saturated.*

Some O horizons or layers consist of slightly decomposed to highly decomposed litter, such as leaves, needles, twigs, moss, and lichens, that has been deposited on the surface of either mineral or organic soils. Other O horizons or layers consist of organic materials that were deposited under saturated conditions and have decomposed to varying stages. The mineral fraction of such material constitutes only a small percentage of the volume of the material and generally much less than half of its weight. Some soils consist entirely of materials designated as O horizons or layers.

An O horizon or layer may be at the surface of a mineral soil, or it may be at any depth below the surface if it is buried. A horizon formed by illuviation of organic material into a mineral subsoil is not an O horizon, although some horizons that formed in this manner contain considerable amounts of organic matter. Horizons or layers composed of limnic materials are not designated as O horizons.

L horizons or layers: *These are horizons or layers that include both organic and mineral limnic materials that were either (1) deposited in water by precipitation or through the actions of aquatic organisms, such as algae and diatoms, or (2) derived from underwater and floating aquatic plants and subsequently modified by aquatic animals.*

L horizons or layers include coprogenous earth (sedimentary peat), diatomaceous earth, and marl. They have only the following subordinate distinctions: co, di, or ma. They do not have the subordinate distinctions of the other master horizons and layers.

V horizons: *These are mineral horizons that formed at the soil surface or below a layer of rock fragments (e.g., desert pavement), a physical or biological crust, or recently deposited eolian material. They are characterized by the predominance of vesicular pores and have platy, prismatic, or columnar structure.*

Porosity in a V horizon may include vughs and collapsed vesicles in addition to the spherical vesicular pores. V horizons formed in eolian material but may be underlain by soil horizons that formed in residuum, alluvium, or other transported materials. Because of their eolian origin, they are typically enriched in particle-size fractions ranging from silt through fine sand. Rarely, the V horizon is massive rather than structured. The structural arrangement of particles and vesicular porosity differentiates this horizon from the loose, unaltered eolian deposits that may occur above it. Underlying B horizons commonly have redder hues than the V horizon and lack vesicular pores (Turk et al., 2011).

Transitional and combination horizons with V horizon material occur in certain circumstances. Although uncommon, an AV or VA horizon may occur. It is both enriched in organic matter and contains vesicular pores. BV or VB horizons may indicate vesicular horizons that contain clay or carbonate coatings, or other properties of the underlying B horizon. EV or VE transitional horizons may also occur, especially in sodic soils.

Combination horizons of the V horizon with A, B, or E horizons may occur in bioturbated zones, such as shrub islands or areas where surface cover associated with the vesicular horizon (e.g., desert pavement) is patchy. Vesicular pores have been observed to reform quickly after physical disruption (Yonovitz and Drohan, 2009).

A horizons: *These are mineral horizons that formed at the surface or below an O horizon. They exhibit obliteration of all or much of the original rock structure** and show one or both of*

* Rock structure includes fine stratification (5 mm or less thick) in unconsolidated sediments (eolian, alluvial, lacustrine, or marine) and saprolite derived from consolidated rocks in which the unweathered minerals and pseudomorphs of weathered minerals retain their relative positions to each other.

the following: (1) an accumulation of humified organic matter closely mixed with the mineral fraction and not dominated by properties characteristic of a V horizon (defined above) or characteristic of an E or B horizon (defined below) or (2) properties resulting from cultivation, pasturing, or similar kinds of disturbance.

If a surface horizon has properties of both A and E horizons but the feature emphasized is an accumulation of humified organic matter, it is designated as an A horizon. In some areas, such as areas in warm, arid climates, the undisturbed surface horizon is less dark than the adjacent underlying horizon and contains only small amounts of organic matter. It has a morphology distinct from the C layer, although the mineral fraction is unaltered or only slightly altered by weathering. Such a horizon is designated as an A horizon because it is at the surface. Recent alluvial or eolian deposits that retain fine stratification are not considered to be A horizons unless cultivated.

E horizons: *These are mineral horizons in which the main feature is the eluvial loss of silicate clay, iron, aluminum, or some combination of these, leaving a concentration of sand and silt particles. They exhibit obliteration of all or much of the original rock structure.*

An E horizon is most commonly differentiated from an underlying B horizon in the same sequum by a color of higher value or lower chroma, or both, by coarser texture, or by a combination of these properties. In some soils the color of the E horizon is that of the sand and silt particles, but in many soils coatings of iron oxides or other compounds mask the color of the primary particles. An E horizon is most commonly differentiated from an overlying A horizon by its lighter color. It generally contains less organic matter than the A horizon. An E horizon is commonly near the soil surface, below an O, V, or A horizon and above a B horizon. However, the symbol E can be used for eluvial horizons that are at the soil surface, that are within or between parts of the B horizon, or that extend to depths greater than those of normal observation, if the horizons have resulted from pedogenic processes.

B horizons: *These are mineral horizons that formed below an A, V, E, or O horizon. They exhibit obliteration of all or much of the original rock structure and show one or more of the following as evidence of pedogenesis:*

1. Illuvial concentration of silicate clay, iron, aluminum, humus, sesquioxides, carbonates, anhydrite, gypsum, salts more soluble than gypsum, or silica, alone or in combination;

2. Evidence of the removal, addition, or transformation of carbonates, anhydrite, and/or gypsum;

3. Residual concentration of oxides, sesquioxides, and silicate clay, alone or in combination;

4. Coatings of sesquioxides that make the horizon color conspicuously lower in value, higher in chroma, or redder in hue than overlying and underlying horizons, without apparent illuviation of iron;

5. Alteration that forms silicate clay or liberates oxides, or both, and that forms pedogenic structure if volume changes accompany changes in moisture content;

6. Brittleness; *or*

7. Strong gleying when accompanied by other evidence of pedogenic change.

All of the different kinds of B horizons are, or were originally, subsurface horizons. Examples of B horizons are horizons (which may or may not be pedogenically cemented) with illuvial concentrations of carbonates, gypsum, anhydrite, or silica that are the result of pedogenic processes and are contiguous to other genetic horizons and brittle horizons that show other evidence of alteration, such as prismatic structure or illuvial accumulation of clay.

Examples of layers that are not B horizons are layers in which clay films either coat rock fragments or cover finely stratified unconsolidated sediments, regardless of whether the films were formed in place or by illuviation; layers into which carbonates have been illuviated but that are not contiguous to an overlying genetic horizon; and layers with strong gleying but no other pedogenic changes.

C horizons or layers: *These are mineral horizons or layers, excluding strongly coherent and harder bedrock, that are little affected by pedogenic processes and lack the properties of O, A, V, E, B, or L horizons. The material of C horizons or layers may be either like or unlike the material from which the solum has presumably formed. The C horizon may have been modified, even if there is no evidence of pedogenesis.*

Included as C layers (typically designated Cr) are sediment, saprolite, bedrock, and other geologic materials that have a moderately coherent or less coherent rupture-restistance class. The excavation difficulty in these materials commonly is low or moderate. Some soils form in material that is already highly weathered, and if such material does not meet the requirements for A, V, E, or B horizons, it is designated by the letter C. Changes that are not considered pedogenic are those not related to the overlying horizons. Some layers that have accumulations of silica, carbonates, gypsum, or more soluble salts are included in C horizons, even if cemented. However, if a cemented layer formed through pedogenic processes, versus geologic processes (e.g., lithification), it is considered a B horizon.

R layers: *These layers consist of strongly coherent to indurated bedrock.*

Granite, basalt, quartzite, limestone, and sandstone are examples of bedrock that commonly are coherent enough to be designated by the letter R. The excavation difficulty commonly exceeds high. The R layer is sufficiently coherent when moist to make hand digging with a spade impractical, although the layer may be chipped or scraped. Some R layers can be ripped with heavy power equipment. The bedrock may have fractures, but these are generally too few or too widely spaced to allow root penetration. The fractures may be coated or filled with clay or other material.

M layers: *These are root-limiting layers beneath the soil surface consisting of nearly continuous, horizontally oriented, human-manufactured materials.*

Examples of materials designated by the letter M include geotextile liners, asphalt, concrete, rubber, and plastic, if they are present as continuous, horizontal layers.

W layers: *These are water layers within or beneath the soil surface.*

The water layer is designated as Wf if it is permanently frozen and as W if it is not permanently frozen. The W (or Wf) designation is not used for shallow water, ice, or snow above the soil surface.

Transitional and Combination Horizons

Horizons dominated by properties of one master horizon but having subordinate properties of another.—Two capital-letter symbols are used for such transitional horizons, e.g., AB, EB, BE, or BC. The first of these symbols indicates that the properties of the horizon so designated dominate the transitional horizon. An AB horizon, for example, has characteristics of both an overlying A horizon and an underlying B horizon, but it is more like the A horizon than the B horizon.

In some cases, a horizon can be designated as transitional even if one of the master horizons to which it presumably forms a transition is not present. A BE horizon may be recognized in a truncated soil if its properties are similar to those of a BE horizon in a soil from which the overlying E horizon has not been removed by erosion. A BC horizon may be recognized even if no underlying C horizon is present; it is transitional to assumed parent materials.

Horizons with two distinct parts that have recognizable properties of the two kinds of master horizons indicated by the capital letters.—The two capital letters designating such combination horizons are separated by a virgule (/), e.g., E/B, B/E, or B/C. Most of the individual parts of one horizon component are surrounded by the other. The designation may be used even when horizons similar to one or both of the components are not present, provided that the separate components can be recognized in the combination horizon. The first symbol is that of the horizon with the greater volume.

Single sets of horizon designators do not cover all situations; therefore, some improvising is needed. For example, Lamellic Udipsamments have lamellae that are separated from each other by eluvial layers. Because it is generally not practical to describe each lamella and eluvial layer as a separate horizon, the horizons can be combined but the components are described separately. One horizon then has several lamellae and eluvial layers and can be designated as an "E and Bt" horizon. The complete horizon sequence for these soils could be: Ap-Bw-E and Bt1-E and Bt2-C.

Suffix Symbols

Lowercase letters are used as suffixes to designate specific subordinate distinctions within master horizons and layers. The term "accumulation" is used in many of the definitions of such suffixes to indicate that these horizons must contain more of the material in question than is presumed to have been present in the parent material. The use of a suffix symbol is not restricted only to those horizons that meet certain criteria for diagnostic horizons and other criteria as defined in *Soil Taxonomy*. If there is any evidence of accumulation, the appropriate suffix (or suffixes) should be assigned. The suffix symbols and their meanings are as follows:

a *Highly decomposed organic material*

This symbol is used with O horizons to indicate the most highly decomposed organic materials, which have a fiber content of less than 17 percent (by volume) after rubbing.

b *Buried genetic horizon*

This symbol is used to indicate identifiable buried horizons with major genetic features that were developed before burial. Genetic horizons may or may not have formed in the overlying material, which may be either like or unlike the assumed parent material of the buried horizon. This symbol is not used to separate horizons composed of organic soil material, that are forming at the soil surface, from underlying horizons composed of mineral soil material. It may be used for organic soils, but only if they are buried by mineral soil materials.

c *Concretions or nodules*

This symbol indicates a significant accumulation of concretions or nodules. Pedogenic cementation is required. The cementing agent commonly is iron, aluminum, manganese, or titanium. It cannot be silica, dolomite, calcite, gypsum, anhydrite, or soluble salts.

co *Coprogenous earth*

This symbol, used only with L horizons, indicates a limnic layer of coprogenous earth (sedimentary peat).

d *Physical root restriction*

This symbol indicates noncoherent, root-restricting layers in naturally occurring or human-made sediments or materials. Examples of natural layers are dense till and some noncoherent shales and siltstones. Examples of human-made dense layers are plowpans and mechanically compacted zones in human-transported material.

di *Diatomaceous earth*

This symbol, used only with L horizons, indicates a limnic layer of diatomaceous earth.

e *Organic material of intermediate decomposition*

This symbol is used with O horizons to indicate organic materials of intermediate decomposition. The fiber content of these materials is 17 to less than 40 percent (by volume) after rubbing.

f *Frozen soil or water*

This symbol indicates that a horizon or layer contains permanent ice. The symbol is not used for seasonally frozen layers or for dry permafrost.

ff *Dry permafrost*

This symbol indicates a horizon or layer that is continually colder than 0 ºC and does not contain enough ice to be cemented by it. This suffix is not used for horizons or layers that have a temperature warmer than 0 ºC at some time of the year.

g *Strong gleying*

This symbol indicates either that iron has been reduced and removed during soil formation or that saturation with stagnant water has preserved it in a reduced state. Most of the affected layers have chroma of 2 or less, and many have redox concentrations. The low chroma can represent either the color of reduced iron or the color of uncoated sand and silt particles from which iron has been removed. The symbol g is not used for materials of low chroma that have no history of wetness, such as some shales or E horizons. If the symbol is used with B horizons, pedogenic change (e.g., soil structure) in addition to gleying is implied. If no other pedogenic change besides gleying has taken place, the horizon is designated Cg.

h *Illuvial accumulation of organic matter*

This symbol is used with B horizons to indicate the accumulation of illuvial, dispersible humic materials. The illuvial humic material coats sand and silt particles, resulting in a dark-colored horizon having a value and chroma, moist, of 3 or less. The symbol h is used in combination with s (e.g., Bhs) if the illuvial humic materials are complexed with metals such as aluminum and/or iron. In some horizons, the humic coatings have bridged, coalesced, or filled pores and cemented the horizon (Bhsm).

i *Slightly decomposed organic material*

This symbol is used with O horizons to indicate the least decomposed of the organic materials. The fiber content of these materials is 40 percent or more (by volume) after rubbing.

j *Accumulation of jarosite*

Jarosite is a potassium (ferric) iron hydroxy sulfate mineral, $KFe_3(SO_4)_2(OH)_6$, that is commonly an alteration product of pyrite that has been exposed to an oxidizing environment. Jarosite has hue of 2.5Y or yellower and normally has chroma of 6 or more, although chroma as low as 3 or 4 has been reported. It forms in preference to iron (hydr)oxides in active acid sulfate soils at pH of 3.5 or less and can be stable in post-active acid sulfate soils for long periods of time at higher pH.

jj *Evidence of cryoturbation*

Evidence of cryoturbation includes irregular and broken horizon boundaries, sorted rock fragments, and organic soil materials occurring as bodies and broken layers within and/or between mineral soil layers. The organic bodies and layers are most commonly at the contact between the active layer and the permafrost.

k *Accumulation of secondary carbonates*

This symbol indicates an accumulation of visible pedogenic calcium carbonate (less than 50 percent, by volume). Carbonate accumulations occur as carbonate filaments, coatings, masses, nodules, disseminated carbonate, or other forms.

kk *Engulfment of horizon by secondary carbonates*

This symbol indicates major accumulations of pedogenic calcium carbonate. The suffix kk is used when the soil fabric is plugged with fine grained pedogenic carbonate (50 percent or more, by volume) that occurs as an essentially continuous medium. The suffix corresponds to stage III of the carbonate morphogenetic stages (Gile et al., 1966) or a higher stage.

m *Pedogenic cementation*

This symbol indicates continuous or nearly continuous pedogenic cementation. It is used only for horizons that are 90 percent or more cemented, although they may be fractured. The cemented layer is physically root-restrictive. The predominant cementing agent (or the two dominant ones) may be indicated by adding defined letter suffixes, singly or in pairs. The horizon suffix kkm (and less commonly km) indicates cementation by carbonates; qm, cementation by silica; sm, cementation by iron; yym, cementation by gypsum; kqm, cementation by carbonates and silica; and zm, cementation by salts more soluble than gypsum. The symbol m is not used for permanently frozen layers impregnated by ice.

ma *Marl*

This symbol, used only with L horizons, indicates a limnic layer of marl.

n *Accumulation of sodium*

This symbol indicates an accumulation of exchangeable sodium.

o *Residual accumulation of sesquioxides*

This symbol indicates a residual accumulation of sesquioxides.

p *Tillage or other disturbance*

This symbol indicates a disturbance of a horizon by mechanical means, pasturing, or similar uses. A disturbed organic horizon is designated Op. A disturbed mineral horizon is designated Ap even though it is clearly a former E, B, or C horizon.

q *Accumulation of silica*

This symbol indicates an accumulation of secondary silica.

r *Weathered or soft bedrock*

This symbol is used with C to indicate layers of bedrock that have a moderately coherent or less coherent rupture-resistance class. Examples are weathered igneous rock and partly consolidated sandstone, siltstone, or shale. The excavation difficulty is low to high.

s *Illuvial accumulation of metals complexed with organic matter*

This symbol is used with B horizons to indicate the accumulation of illuvial, dispersible humic materials complexed with significant Fe and Al metal components (organo-metal). The horizons have either a color value or chroma, moist, of greater than 3. The symbol h is used in combination with s (e.g., Bhs) if the moist value and chroma are 3 or less.

se *Presence of sulfides*

This symbol indicates the presence of sulfides in mineral or organic horizons. Horizons with sulfides typically have dark colors (e.g., value of 4 or less, chroma of 2 or less). These horizons typically form in soils associated with coastal environments that are permanently saturated or submerged (i.e., tidal marshes or estuaries). Soil materials which have sulfidization actively occurring emanate hydrogen sulfide gas, which is detectable by its odor (Fanning and Fanning, 1989; Fanning et al., 2002). Sulfides may also occur in upland environments that have a source of sulfur. Soils in such environments are often of geologic origin and may not produce a hydrogen sulfide odor. Examples include soils that formed in parent materials derived from coal deposits, such as lignite, and soils that formed in coastal plain deposits, such as glauconite, that have not been oxidized because of thick layers of overburden.

ss *Presence of slickensides*

This symbol indicates the presence of pedogenic slickensides. Slickensides result directly from the swelling of clay minerals and shear failure, commonly at angles of 20 to 60 degrees above horizontal. They are indicators that other vertic characteristics, such as wedge-shaped peds and surface cracks, may be present.

t *Accumulation of silicate clay*

This symbol indicates an accumulation of silicate clay that either has formed within a horizon and subsequently has been translocated within the horizon or has been moved into the horizon by illuviation, or both. At least some part of the horizon should show evidence of clay accumulation either as coatings on surfaces of peds or in pores, as lamellae, or as bridges between mineral grains.

u *Presence of human-manufactured materials (artifacts)*

This symbol indicates the presence of objects or materials that have been created or modified by humans, usually for a practical purpose in habitation, manufacturing, excavation, or construction activities. Examples of artifacts are bitumen (asphalt), boiler slag, bottom ash, brick, cardboard, carpet, cloth, coal combustion byproducts, concrete (detached pieces), debitage (i.e., stone tool flakes), fly ash, glass, metal, paper, plasterboard, plastic, potsherd, rubber, treated wood, and untreated wood products.

v *Plinthite*

This symbol indicates the presence of iron-rich, humus-poor, reddish material that is firm or very firm when moist and is less than strongly cemented. The material hardens irreversibly when exposed to the atmosphere and to repeated wetting and drying.

w *Development of color or structure*

This symbol is used only with B horizons to indicate the development of color or structure, or both, with little or no apparent illuvial accumulation of material. It should not be used to indicate a transitional horizon.

x *Fragipan character*

This symbol indicates a genetically developed layer that has a combination of firmness and brittleness and commonly a higher bulk density than the adjacent layers. Some part of the layer is physically root-restrictive.

y *Accumulation of gypsum*

This symbol indicates an accumulation of gypsum. The suffix y is used when the horizon fabric is dominated by soil particles or minerals other than gypsum. Gypsum is present in amounts that do not significantly obscure or disrupt other features of the horizon. In unique but rare soils, this symbol may be used to connote the presence of anhydrite.

yy *Dominance of horizon by gypsum*

This symbol indicates a horizon that is dominated by the presence of gypsum. The gypsum content may be due to an accumulation of secondary gypsum, the transformation of primary gypsum inherited from parent material, or other processes. The suffix yy is used when the horizon fabric has such an abundance of gypsum (generally 50 percent or more, by volume) that pedogenic and/or lithologic features are obscured or disrupted by growth of gypsum crystals. Colors associated with horizons that have suffix yy typically are highly whitened (e.g., value of 7 through 9.5 and chroma of 4 or less). In unique but rare soils, this symbol may be used to connote the presence of anhydrite.

z *Accumulation of salts more soluble than gypsum*

This symbol indicates an accumulation of salts that are more soluble than gypsum.

Conventions for Using Letter Suffixes

Many master horizons and layers that are symbolized by a single capital letter have one or more lowercase letter suffixes. The following rules apply:

1. Letter suffixes directly follow the capital letter of the master horizon or layer, or the prime symbol, if used.

2. More than three suffixes are rarely used.

3. If more than one suffix is needed, the following letters, if used, are written first: a, d, e, h, i, r, s, t, and w. Except in the Bhs horizon or Crt* layer designations, none of these letters is used in combination for a single horizon.

4. If more than one suffix is needed and the horizon is not buried, the following symbols, if used, are written last: c, f, g, m, v, and x. Examples are Bjc and Bkkm. If any of these suffixes are used together in the same horizon, symbols c and g are written last (e.g., Btvg), with one exception. For horizons using symbol f together with any of the other symbols in this rule, symbol f (frozen soil or water) is written last, e.g., Cdgf.

5. If a genetic horizon is buried, the suffix b is written last, e.g., Oab.

6. Suffix symbols h, s, and w are not used with g, k, kk, n, o, q, y, yy, or z.

7. If the above rules do not apply to certain suffixes, such as k, kk, q, y, or yy, the suffixes may be listed together in order of assumed dominance or listed alphabetically if dominance is not a concern.

A B horizon that has a significant accumulation of clay and also shows evidence of a development of color or structure, or both, is designated Bt (suffix symbol t has precedence over symbols w, s, and h). A B horizon that is gleyed or has accumulations of carbonates, sodium, silica, gypsum, or salts more soluble than gypsum or residual accumulations of sesquioxides carries the appropriate symbol: g, k, kk, n, q, y, yy, z, or o. If illuvial clay also is present, t precedes the other symbol, e.g., Bto.

Vertical Subdivision

Commonly, a horizon or layer identified by a single letter or a combination of letters has to be subdivided. For this purpose, numbers are added to the letters of the horizon designation. These numbers follow all the letters. Within a sequence of C horizons, for example, successive horizons may be designated C1, C2, C3, etc. If the lower horizons are strongly gleyed and the upper horizons are not strongly gleyed, they may be designated C1-C2-Cg1-Cg2 or C-Cg1-Cg2-R.

These conventions apply whatever the purpose of the subdivision. In many soils a horizon that could be identified by a single set of letters is subdivided because of the need to recognize differences in morphological features, such as structure, color, or texture. These divisions are numbered consecutively, but the numbering starts again with 1 wherever in the profile any letter of the horizon symbol changes, e.g., Bt1-Bt2-Btk1-Btk2 (not Bt1-Bt2-Btk3-Btk4). The numbering of vertical subdivisions within consecutive horizons is not interrupted at a discontinuity (indicated by a numerical prefix) if the same letter combination is used in both materials, e.g., Bs1-Bs2-2Bs3-2Bs4 (not Bs1-Bs2-2Bs1-2Bs2).

During sampling for laboratory analyses, thick soil horizons are sometimes subdivided even though differences in morphology are not evident in the field. These subdivisions are identified by numbers that follow the respective horizon designations. For example, four subdivisions of a Bt horizon sampled by 10-cm increments are designated Bt1, Bt2, Bt3, and Bt4. If the horizon has already been subdivided because of differences in morphological features, the set of numbers that identifies the additional sampling subdivisions follows the first number. For example, three subdivisions of a Bt2 horizon sampled by 10-cm increments are designated Bt21, Bt22, and Bt23. The descriptions for each of these sampling subdivisions can be the same, and a statement indicating that the horizon has been subdivided only for sampling purposes can be added.

Discontinuities

Numbers are used as prefixes to horizon designations (preceding the capital letters A, V, E, B, C, and R) to indicate discontinuities in mineral soils. These prefixes are distinct from the numbers that are used as suffixes denoting vertical subdivisions.

* Indicates weathered bedrock or saprolite in which clay films are present.

A discontinuity that can be identified by a number prefix is a significant change in particle-size distribution or mineralogy that indicates a difference in the parent material from which the horizons have formed and/or a significant difference in age, unless that difference in age is indicated by the suffix b. Symbols that identify discontinuities are used only when they can contribute substantially to an understanding of the relationships among horizons. The stratification common to soils that formed in alluvium is not designated as a discontinuity, unless particle-size distribution differs markedly from layer to layer (i.e., particle-size classes are strongly contrasting), even though genetic horizons may have formed in the contrasting layers.

Where a soil has formed entirely in one kind of material, the whole profile is understood to be material 1 and the number prefix is omitted from the symbol. Similarly, the uppermost material in a profile consisting of two or more contrasting materials is understood to be material 1, but the number is omitted. Numbering starts with the second layer of contrasting material, which is designated 2. Underlying contrasting layers are numbered consecutively. Even when the material of a layer below material 2 is similar to material 1, it is designated 3 in the sequence; the numbers indicate a change in materials, not types of material. Where two or more consecutive horizons have formed in the same kind of material, the same prefix number indicating the discontinuity is applied to all the designations of horizons in that material, e.g., Ap-E-Bt1-2Bt2-2Bt3-2BC. The suffix numbers designating vertical subdivisions of the Bt horizon continue in consecutive order across the discontinuity. However, vertical subdivisions do not continue across lithologic discontinuities if the horizons are not consecutive or contiguous to each other. If other horizons intervene, another vertical numbering sequence begins for the lower horizons, e.g., A-C1-C2-2Bw1-2Bw2-2C1-2C2.

If an R layer is present below a soil that has formed in residuum and if the material of the R layer is judged to be like the material from which the soil has developed, the number prefix is not used. The prefix is used, however, if it is thought that the R layer would produce material unlike that in the solum, e.g., A-Bt-C-2R or A-Bt-2R. If part of the solum has formed in residuum, the symbol R is given the appropriate prefix, e.g., Ap-Bt1-2Bt2-2Bt3-2C1-2C2-2R.

A buried genetic horizon (designated by the letter b) presents special problems. It is obviously not in the same deposit as the overlying horizons. Some buried horizons, however, have formed in material that is lithologically like the overlying deposit. A prefix is not used to distinguish material of such a buried horizon. If the material in which a horizon of a buried soil has formed is lithologically unlike the overlying material, the discontinuity is indicated by a number prefix and the symbol for the buried horizon also is used, e.g., Ap-Bt1-Bt2-BC-C-2ABb-2Btb1-2Btb2-2C.

Discontinuities between different kinds of layers in organic soils are not identified. In most cases such differences are identified either by letter-suffix designations if the different layers are organic materials (e.g., Oe vs. Oa) or by the master horizon symbol if the different layers are mineral or limnic materials (e.g., Oa vs. Ldi).

Use of the Prime Symbol

If two or more horizons with identical number prefixes and letter combinations are separated by one or more horizons with a different horizon designation in a pedon, identical letter and number symbols can be used for those horizons that have the same characteristics. For example, the sequence A-E-Bt-E-Btx-C identifies a soil that has two E horizons. To emphasize this characteristic, the prime symbol (´) is added after the master-horizon symbol of the lower of the two horizons that have identical designations, e.g., A-E-Bt-E´-Btx-C. The prime symbol, where appropriate, is placed after the capital-letter horizon designation and before the lowercase suffix letter symbols that follow it, e.g., B´t.

The prime symbol is not used unless all letters and number prefixes are completely identical. The sequence A-Bt1-Bt2-2E-2Bt1-2Bt2 is an example. It has two Bt master horizons of different lithologies; thus, the Bt horizons are not identical and the prime symbol is not needed. The prime symbol is used for soils with lithologic discontinuities when horizons have identical designations, e.g., A-C-2Bw-2Bc-2B´w-3Bc. In this example, the soil has two identical 2Bw horizons but two different Bc horizons (a 2Bc and a 3Bc), so the prime symbol is used only with the lower 2Bw horizon (2B´w). In the rare cases where three layers have identical letter symbols, double prime symbols can be used for the lowest of these horizons, e.g., E´´.

Vertical subdivisions of horizons or layers (number suffixes) are not taken into account when the prime symbol is assigned. The sequence A-E-Bt-E´-B´t1-B´t2-B´t3-C is an example.

These same principles apply in designating layers of organic soils. The prime symbol is used only to distinguish two or more horizons that have identical symbols, e.g., Oi-C-O´i-C´ (when the soil has two identical Oi and C layers) and Oi-C-Oe-C´ (when the soil has two identical C layers). The prime symbol is added to the lower layers to differentiate them from the upper ones.

Use of the Caret Symbol

The caret symbol (^) is used as a prefix to master horizon designations to indicate mineral or organic horizons formed in human-transported material. This material has been moved horizontally onto a pedon from a source area outside of that pedon by purposeful human activity, usually with the aid of machinery or hand tools. All horizons and layers that formed in human-transported material are indicated by a caret prefix (e.g., ^A-^C-Ab-Btb). When they can contribute substantially to an understanding of the relationship of the horizons or layers, number prefixes may be used before the caret symbol to indicate the presence of discontinuities within the human-transported material (e.g., ^Au-^Bwu-^BCu-2^Cu1-2^Cu2) or between the human-transported material and underlying horizons formed in other parent materials (e.g., ^A-^C1-2^C2-3Bwb).

Sample Horizon and Layer Sequences

The following examples illustrate some common horizon and layer sequences of important soils (subgroup taxa) and the use of numbers to identify vertical subdivisions and discontinuities. Transitional horizons, combination horizons, and the use of the prime and caret symbols are also illustrated. The examples were selected from soil descriptions on file and modified to reflect present conventions.

Mineral soils

Typic Hapludoll: A1-A2-Bw-BC-C
Typic Haplustoll: Ap-A-Bw-Bk-Bky1-Bky2-C
Cumulic Haploxeroll: Ap-A-Ab-C-2C-3C
Typic Argialboll: Ap-A-E-Bt1-Bt2-BC-C
Typic Argiaquoll: A-AB-BA-Btg-BCg-Cg
Alfic Udivitrand: Oi-A-Bw1-Bw2-2E/Bt-2Bt/E1-2Bt/E2-2Btx1-2Btx2
Entic Haplorthod: Oi-Oa-E-Bs1-Bs2-BC-C
Typic Haplorthod: Ap-E-Bhs-Bs-BC-C1-C2
Typic Fragiudalf: Oi-A-E-BE-Bt1-Bt2-B/E-Btx1-Btx2-C
Typic Haploxeralf: A1-A2-BAt-2Bt1-2Bt2-2Bt3-2BC-2C
Glossic Hapludalf: Ap-E-B/E-Bt1-Bt2-C
Typic Paleudult: A-E-Bt1-Bt2-B/E-B´t1-B´t2-B´t3
Typic Hapludult: Oi-A1-A2-BA-Bt1-Bt2-BC-C
Arenic Plinthic Paleudult: Ap-E-Bt-Btc-Btv1-Btv2-BC-C
Xeric Haplodurid: A-Bw-Bkq-2Bkqm
Vertic Natrigypsid: A-Btn-Btkn-Bky-2By-2BCy-2Cr
Typic Calciargid: A-Bt-Btk1-Btk2-C
Typic Camborthid: V-Bw-C
Typic Dystrudept: Ap-Bw1-Bw2-C-R
Typic Fragiudept: Ap-Bw-E-Bx1-Bx2-C
Typic Endoaquept: Ap-AB-Bg1-Bg2-BCg-Cg
Typic Haplustert: Ap-A-Bss-BCss-C
Typic Hapludox: Ap-A/B-Bo1-Bo2-Bo3-Bo4-Bo5
Typic Udifluvent: Ap-C-Ab-C´
Anthrodensic Ustorthent: ^Ap-^C/B-^Cd-2C
Anthroportic Udorthent: ^Ap-^Cu-Ab-Btb-C
Glacic Histoturbel: Oi-OA-Bjjg-Wf-Cgf
Typic Aquiturbel: Oi-OA-Bjjg-Cjjg-Cjjgf

Organic soils

Typic Haplosaprist: Oap-Oa1-Oa2-Oa3-C
Typic Sphagnofibrist: Oi1-Oi2-Oi3-Oe
Limnic Haplofibrist: Oi-Lco-O´i1-O´i2-L´co-Oe-C
Lithic Cryofolist: Oi-Oa-R
Typic Hemistel: Oi-Oe-Oef

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Appendix

Laboratory Methods for Soil Taxonomy

Sources of information

The standard laboratory methods upon which the operational definitions of the second edition of *Soil Taxonomy* (Soil Survey Staff, 1999) are based are described in the *Soil Survey Laboratory Methods Manual* (Burt and Soil Survey Staff, 2014). The Charles E. Kellogg Soil Survey Laboratory (KSSL) of the National Soil Survey Center in Lincoln, Nebraska, is where many of the standard methods were developed and are routinely performed to support the characterization and classification of soils. Laboratory data for the National Cooperative Soil Survey (NCSS) program is available from KSSL and cooperators' laboratories in the online NCSS soil characterization database.

The *Soil Survey Laboratory Methods Manual* documents methodology and serves as a reference for the laboratory analyst. The *Soil Survey Laboratory Information Manual* (Soil Survey Staff, 2011) is a companion manual that provides brief summaries of the KSSL methods as well as detailed discussion of the use and application of the resulting data. The *Soil Survey Field and Laboratory Methods Manual* (Soil Survey Staff, 2009) is a how-to reference for the scientist in a soil survey office setting.

Operational definitions

Pedon characterization data, or any soil survey data, are most useful when the operations for collecting the data are well understood. The mental pictures and conceptual definitions that aid in visualizing properties and processes often differ from the information supplied by an analysis. Also, results differ by method, even though two methods may carry the same name or the same concept. There is uncertainty in comparing one bit of data with another without knowledge of how both bits were gathered. Operational definitions (definitions tied to a specific method) are needed. Soil Taxonomy has many class limits, at all categorical levels, that are based on chemical or physical properties determined in the laboratory. One can question the rationale for a given class limit, but that is not the purpose of this appendix. This appendix is designed to show what procedures are used for measuring given class limits. By using specific class limits, everyone will come to the same classification if they follow the same procedures.

This taxonomy is based almost entirely on criteria that are defined operationally. One example is the definition of "clay" as used in the criteria for particle-size classes. There is no one definition of clay that works well for all soils. Hence, a process for testing the validity of a pipette clay measurement and a default operation for those situations where the clay measurement is not valid, are defined. The default method is based on a gravimetric water content measurement at 1500 kPa tension and on percent organic carbon. See the section "Other Information Useful in Classifying Soils" below for more information.

Data Elements Used in Classifying Soils

Laboratory method codes

Detailed explanations of laboratory methods are given in the *Soil Survey Laboratory Methods Manual* (Burt and Soil Survey Staff, 2014). Each method is listed by code on the data sheet at the beginning of the chapters describing soil orders in the second edition of *Soil Taxonomy*. On the data sheets presented with each order, the method code (e.g., 3A1 for particles less than 2 mm) is shown for each determination made. These data sheets should be consulted for reference to the *Soil Survey Laboratory Methods Manual*. This manual specifies method codes for pedon sampling, sample handling, site selection, sample collection, and sample preparation.

Units of measurement

The units of measurement reported on the data sheets in the second edition of *Soil Taxonomy* and some units used as criteria in the *Keys to Soil Taxonomy* are not SI (international system of units) units. Older data sets are especially likely to present results in non-SI units. The following are conversions to SI units of measurement:

1 meq/100 g = 1 mmol (±) kg^{-1}
1 meq/liter = 1 mmol (±) L^{-1}
1 mmho/cm = 1 dS m^{-1}
15 bar = 1500 kPa
$^{1}/_{3}$ bar = 33 kPa
$^{1}/_{10}$ bar = 10 kPa
1 percent = 10 g kg^{-1}

Particle-size class and texture class

In this taxonomy, the terms "particle-size analysis" (size separates), "texture," and "particle-size classes" are all used. Particle-size analysis is needed to determine both texture and particle-size classes. Texture class differs from particle-size class in that texture includes only the fine-earth fraction (less than 2 mm), while particle-size includes both the fraction less than 2 mm in diameter and the fraction equal to or more than 2 mm.

Physical Analyses

In this section, the various types of physical analysis of soil samples are presented in alphabetical order and briefly discussed.

Bulk density is obtained typically by equilibration of Saran-coated natural fabric clods at designated pressure differentials. Bulk densities are determined at two or more water contents. For coarse textured and moderately coarse textured soils, they are determined when the sample is at 10 kPa tension and when ovendry. For soils of medium and finer texture, the bulk density is determined when the sample is at 33 kPa tension and when ovendry. Bulk density is used as a criterion in the definitions of mineral and organic soils, the required characteristics for folistic and histic epipedons, the key to soil orders (i.e., Histosols), the required characteristics for andic soil properties, and the intergrade subgroups of Andic (except Kandic), Aquandic, and Vitrandic ("vitr"). Bulk density measured at 33 kPa tension is also used to convert other analytical results to a volumetric basis. For example, the Humults suborder has a critical limit of 12 kilograms or more of organic carbon per square meter (kg/m^2) between the mineral soil surface and a depth of 100 cm. The calculation is described below in the section "Other Information Useful in Classifying Soils."

Coefficient of linear extensibility (COLE) is a derived value. It is computed from the difference in bulk density between a moist clod and an ovendry clod. It is based on the shrinkage of a natural soil clod between a water content of 33 kPa (10 kPa for sandier soils) and ovendry. It is used to compute linear extensibility (defined below). COLE multiplied by 100 is called linear extensibility percent (LEP).

Linear extensibility (LE) of a soil layer is the product of the thickness, in centimeters, multiplied by the COLE of the layer in question. The LE of a soil is the sum of these products for all soil horizons from the mineral soil surface to a depth of 100 cm or to a root-limiting layer, whichever is shallower. Linear extensibility is used as an alternate criterion in Vertic ("ertic") subgroups throughout Soil Taxonomy.

Particle-size analysis in the laboratory determines the proportion of the various size particles (separates) in a soil sample. The values for sand, silt, and clay content as well as their various size fractions are reported in percent of the < 2 mm material (fine-earth fraction) on a dry weight basis. Material 2 mm or larger in diameter (e.g., rock fragments) are visually estimated or measured separately (on a volume basis) and sieved out of the sample; thus they are not considered in the analysis of the sample. Of the material smaller than 2 mm in diameter, the amount of the five sand fractions is determined by sieving. The amount of the silt and clay fractions is determined by a differential rate of settling in water. Either the pipette or hydrometer method is used for measuring silt and clay contents. Organic matter and dissolved mineral matter are removed in the pipette procedure but not in the hydrometer procedure. The two procedures are generally very similar, but a few samples, especially those with a high content of organic matter or a high content of soluble salts, exhibit wide discrepancies. Routinely removing these substances (and, for some samples, carbonates, iron, and silica) helps the dispersion process prior to fractioning the soil separates and measuring them. For samples suspected of having andic soil properties, the samples are not dried and are analyzed in a field-moist state. This protocol avoids the irreversible hardening of colloids into microaggregates that occurs during drying and which decreases measured clay contents. For soils with a high content of gypsum (> 40 percent), the samples are dispersed using sonication and an aqueous ethanol solution to prevent dissolution of gypsum prior to particle-size analysis.

Particle-size analysis data is used in the definitions of soil texture class (Soil Science Division Staff, 2017). They are used in Soil Taxonomy for many criteria based on texture class, clay content, sand fraction content, and content of coarse silt through very coarse sand (0.02 to 2 mm). The ratios discussed below in the section "Other Information Useful in Classifying Soils" are useful internal checks of the validity of particle-size analyses.

Water content (retention) is the soil water content at a given soil water tension. In KSSL data, it is computed and reported as gravimetric water content on a fine-earth (< 2 mm) basis. Measurements of water content are commonly made at 33 kPa (10 kPa for coarse textured and some moderately coarse textured soils) and 1500 kPa tension. The water content at 1500 kPa tension is determined by desorption of crushed and sieved fine-earth (< 2 mm) soil material which may be undried (i.e., field-moist) or air-dried. Water content at 1500 kPa tension is used as a criterion in the Vitrands suborder; in the Vitric ("vitr") and Hydric ("hydr") great groups and subgroups of Andisols; for the ashy, medial, and hydrous substitutes for particle-size class; and for several strongly contrasting particle-size classes. Measurement of 1500 kPa water content on undried samples is particularly important for soils suspected of having andic soil properties since it is needed for classification in the ashy, medial, and hydrous substitutes for particle-size class.

Chemical Analyses

In this section, general classes of chemical analysis are grouped under main headings. Individual analyses within each group are then presented.

Ion Exchange and Extractable Cations

Cation-exchange capacity (CEC) as determined with ammonium acetate (1N NH_4OAc) at pH 7 (CEC-7), by sum of cations at pH 8.2 (CEC-8.2), and by bases plus aluminum is used for different purposes in Soil Taxonomy. The CEC depends on the method of analysis as well as the nature of the exchange complex. CEC by ammonium acetate is measured at pH 7. CEC by the sum of cations at pH 8.2 is calculated by adding the sum of bases and the extractable acidity (defined below). CEC by bases plus aluminum, or effective cation-exchange capacity (ECEC), is derived by adding the sum of extractable bases and the KCl-extractable Al. Aluminum extracted by 1N KCl is negligible if the extractant pH rises toward 5.5. ECEC then is equal to extractable bases. CEC and ECEC are reported on KSSL data sheets as 1 cmol (+) kg^{-1} soil.

The reported CEC may differ from the CEC of the soil at its natural pH. The standard methods allow the comparison of one soil with another even though the pH of the extractant differs from the pH of the natural soil. Cation-exchange capacity by ammonium acetate and by sum of cations applies to all soils. CEC at pH 8.2 is not reported if the soil contains free carbonates, gypsum, or significant amounts of soluble salts because bases, such as calcium, are extracted from these soluble (i.e., mobile) substances.

The effective cation-exchange capacity (ECEC) is reported only for acid soils. ECEC is not reported for soils having soluble salts, although it can be calculated by subtracting the soluble components from the extractable components. ECEC also may be defined as bases plus aluminum plus hydrogen. That is the more common definition for agronomic interpretations. This taxonomy specifies bases plus aluminum.

Generally, the ECEC is less than the CEC at pH 7, which in turn is less than the CEC at pH 8.2. If the soil is dominated by positively charged colloids (e.g., iron oxides), however, the trend is reversed. Most soils have negatively charged colloids, which cause the CEC to increase with increasing pH. This difference in CEC is commonly called the pH-dependent or variable charge. The CEC at the soil pH can be estimated by plotting the CEC of the soil vs. the pH of the extractant on a graph and reading the CEC at the soil pH. CEC measurements at pH levels other than those described in the paragraphs above and CEC derived by using other extracting cations will yield somewhat different results. It is important to know the procedure, pH, and extracting cation used before CEC data are evaluated or data from different sources are compared.

If the ratio of CEC-7 or ECEC to percent clay is multiplied by 100, the product represents the cation-exchange capacity of just the clay fraction and is expressed in whole numbers which are cmol(+)/kg clay. The CEC-7 and ECEC of the clay fraction are used directly in this taxonomy in the required characteristics of the kandic and oxic horizons. The CEC-7 of the clay fraction is also used as a criterion in Kandic and Kanhaplic subgroups of Alfisols and Ultisols, Udoxic and Ustoxic subgroups of Quartzipsamments, and Oxic subgroups of Inceptisols and Mollisols. The ECEC of the clay fraction is used as criteria for Acric (“acr”) great groups of Oxisols and Acric (“acr”) subgroups of Ultisols.

Extractable acidity is the acidity released from the soil by a barium chloride-triethanolamine solution buffered at pH 8.2. It includes all the acidity generated by replacement of the hydrogen and aluminum from permanent and pH-dependent exchange sites. It is reported as 1 cmol (+) kg^{-1} soil. Extractable acidity data are reported on some data sheets as exchangeable acidity and on others as exchangeable H^+. Extractable acid is used to calculate the cation-exchange capacity by the sum of cations method (CEC-8.2) and is also used as an option in the required characteristics of the natric horizon.

Extractable aluminum is the amount of aluminum extracted by 1N KCl. It is considered exchangeable and a measure of the “active” acidity present in soils with a 1:1 water pH $\leq$ 5.5. Extractable aluminum is measured at KSSL by atomic absorption. Many laboratories measure the aluminum by titration with a base to the phenolphthalein end point. Titration measures exchangeable acidity as well as extractable aluminum. Soils with a pH below 4.0 or 4.5 are likely to have values determined by atomic absorption similar to values determined by titration because very little hydrogen is typically on the exchange complex. If there is a large percentage of organic matter, however, some hydrogen may be present. For some soils it is important to know which procedure was used. Extractable aluminum is reported as 1 cmol (+) kg^{-1} soil. It is used to calculate ECEC and in the criteria for Alic and some Eutric subgroups of Andisols.

Sum of extractable bases is the sum of the basic cations calcium, magnesium, sodium, and potassium that are extracted with ammonium acetate buffered at pH 7. The bases are extracted from the cation-exchange complex by displacement with ammonium ions. They are equilibrated, filtered in an auto-extractor, and measured by atomic absorption. The individual cations and the sum of cations are reported as 1 cmol (+) kg^{-1} soil. The term “extractable bases” is used instead of “exchangeable bases” because soluble salts and some bases from carbonates can be included in the extract.

Exchangeable magnesium plus sodium and calcium plus extractable acidity (at pH 8.2) is used as a criterion for the natric horizon and Albic subgroups of Natraqualfs. The extractable acidity is measured at pH 8.2, and the magnesium, sodium, and calcium are extracted at pH 7.0 with ammonium acetate. See the paragraphs above on extractable acidity and extractable bases.

Base saturation is reported on the data sheets as the percentage of the cation-exchange capacity (CEC) occupied by the four basic cations described above. It is reported in KSSL data by two methods: sum of cations at pH 8.2 and ammonium acetate at pH 7. Base saturation by ammonium acetate is equal to the sum of extractable bases, divided by the CEC by ammonium acetate (CEC-7), and multiplied by 100. If calcium carbonate or gypsum are present in a sample, then the extractable calcium may contain calcium from these minerals and the base saturation is assumed to be 100 percent.

Base saturation by sum of cations is equal to the sum of bases extracted by ammonium acetate, divided by the CEC by sum of cations (CEC-8.2), and multiplied by 100. This value is not reported if either extractable calcium or extractable acidity is omitted. Differences between the two methods of determining base saturation reflect the amount of the pH-dependent CEC. Class definitions in this taxonomy specify which method is used.

The sum of exchangeable cations is considered equal to the sum of bases extracted by ammonium acetate unless carbonates, gypsum, or other salts are present. When these salts are present, the sum of the bases extracted by ammonium acetate typically exceeds 100 percent of the CEC. Therefore, a base saturation of 100 percent is assumed. The amount of calcium from carbonates is usually much larger than the amount of magnesium from the carbonates. Extractable calcium is shown on KSSL datasheets even if carbonates (reported as calcium carbonate) are present. The base saturation (by CEC-7) is set to 100 percent if significant amounts of carbonates or gypsum are present. Base saturation by ammonium acetate is used in this taxonomy in the required characteristics for the mollic and umbric epipedons, the key to soil orders (Mollisols), and many great groups (e.g., Eutrudepts) and subgroups (e.g., Eutric Haplocryalfs) in several orders. Base saturation by sum of cations is used in the key to soil orders to identify Ultisols and in several Alfic, Dystric, and Ultic subgroups of Alfisols, Andisols, Inceptisols, Mollisols, and Spodosols (e.g., Alfic Fragiorthods).

Soil pH

The pH of soil is measured in water and salt solutions by several methods. It is measured by a digital pH meter in a soil-water solution, soil-salt solution, or saturated paste. The extent of the dilution is shown in the heading on the data sheets. A ratio of 1:1 means one part dry soil and one part water, by weight.

The *1:1 water pH* is determined in a solution of one part dry soil mixed with one part water. It is used directly in the required characteristics for sulfidic materials, Sulfic subgroups of Entisols and Inceptisols, and the Sulfaqueptic Dystraquerts subgroup. It is also used in a calculation with 1N KCl pH (described below).

The *1:2 $CaCl_2$ pH* is determined in a solution of one part soil to two parts 0.01N calcium chloride ($CaCl_2$). It is used in mineral soils as a criterion for Dystric (“dystr”) great groups of Vertisols and in the key to calcareous and reaction classes. It is used in organic soils (i.e., Histosols and Histels) in the key to reaction classes.

The *1N KCl pH* is measured in a solution of 1N potassium chloride (KCl) mixed 1:1 with soil. It is used directly as a criterion for the Acric (“acr”) great groups of Oxisols. It is also used in a simple calculation with the 1:1 water pH. The “delta pH” (a term for 1N KCl pH minus 1:1 water pH) is used as a criterion for the Anionic subgroups of Oxisols.

Measurement of pH in a dilute salt solution is common because it tends to mask seasonal variations in pH. Readings in 0.01N $CaCl_2$ tend to be uniform regardless of the time of year and are more popular in regions with less acidic soils. Readings in 1N KCl also tend to be uniform and are more popular in regions with more acidic soils. If KCl is used to extract exchangeable aluminum, the pH reading (in KCl) shows the pH at which the aluminum was extracted.

The *saturated paste pH* is usually compared to the 1:1 water pH and the 1:2 $CaCl_2$ pH. The usual pH sequence is as follows: 1:1 water pH > 1:2 $CaCl_2$ pH > saturated paste pH. If the saturated paste pH is > 1:2 $CaCl_2$ pH, the soil is nonsaline. If the saturated paste pH is ≥ 1:1 water pH, the soil may be sodium saturated and does not have free carbonates. The saturated paste pH is used as a criterion for the Dystrusterts and Dystruderts great groups.

The *oxidized pH* is used to determine whether known or suspected sulfidic materials are present and whether they will oxidize to form a sulfuric horizon. Soil materials that have a pH value (1:1 water pH) of more than 3.5 are incubated at room temperature in a 1-cm-thick layer under moist, aerobic conditions and repeatedly dried and remoistened on a weekly basis. Sulfidic materials show a drop in pH of 0.5 or more units to a pH value of 4.0 or less (1:1 by weight in water or in a minimum of water to permit measurement) within 16 weeks or longer, if the pH is still dropping after 16 weeks, until the pH reaches a nearly constant value.

The *sodium fluoride pH (NaF pH)* is measured in a suspension of 1 gram of soil in 50 ml 1N NaF after stirring for 2 minutes. A NaF pH of 9.4 or more is a strong indicator that short-range-order minerals dominate the soil exchange complex. A NaF pH of 8.4 or more is a criterion for the isotic mineralogy class. It indicates a significant influence of short-range-order minerals on the exchange complex. Soil materials with free carbonates also have high NaF pH values. NaF is poisonous with ingestion and eye contact and moderately hazardous with skin contact.

Sulfur and Extractable Anions

Nitrate concentration is measured in a 1:5 soil:water extract. The nitrate content (NO_3^-) of the extract is measured by a flow-injection analyzer. The results are reported in mmol(-) L^{-1} and are used in a simple calculation as criteria for Nitric subgroups of Gelisols.

Phosphate retention refers to the percent phosphorus retained by soil after equilibration with 1,000 mg/kg phosphorus solution for 24 hours. This analyte is also referred to as New Zealand (NZ) phosphorus retention. Percent phosphate retention is used in the required characteristics for andic soil properties. It identifies soils in which phosphorus fixation may be a problem affecting agronomic uses.

Total sulfur (S) is the content of organic and inorganic forms of sulfur. KSSL uses a combustion technique for analysis of total S. It is reported as percent of air-dry, fine-earth material. Total sulfur is used, along with 1:1 water pH, as a criterion in the required characteristics for sulfidic materials.

Water-soluble sulfate is used as a criterion for the sulfuric horizon. The sulfate content (SO_4^{2-}) is measured from a 1:500 soil:water extract using an ion chromatograph. The sulfate content is initially measured in mg L^{-1} and later converted to percent in the soil. It is reported as aqueous-extractable sulfate to the nearest hundredths of a percent.

Carbonates and Calcium Sulfates

Calcium carbonate equivalent is the amount of carbonates in the soil as measured by treating the sample with 3N HCl. The evolved carbon dioxide is measured manometrically. The amount of carbonate is then calculated as a calcium carbonate equivalent regardless of the form of carbonates (dolomite, sodium carbonate, magnesium carbonate, etc.) in the sample. Calcium carbonate equivalent is reported as a percentage of the total dry weight of the sample. It can be reported on material that is either less than 2 mm or less than 20 mm in diameter. Calcium carbonate equivalent is used in the required characteristics for the mollic epipedon and calcic horizon and in criteria for the Rendolls suborder, the Rendollic Eutrudepts subgroup, and the carbonatic mineralogy class.

Gypsum content is determined by extraction in water and precipitation in acetone. The amount of gypsum ($CaSO_4 \bullet 2H_2O$) is reported as a percentage of the total dry weight of the fraction less than 2 mm in diameter and the fraction less than 20 mm in diameter. Drying soils to oven-dryness, the standard base for reporting the data, removes part of the water of hydration from the gypsum. Many measured values, particularly water retention values, must be recalculated to compensate for the weight of the water of hydration lost during drying. Gypsum content is used in the required characteristics for gypsic and petrogypsic horizons and as criteria for the gypseous substitute classes, several strongly contrasting particle-size classes, and the hypergypsic, gypsic, and carbonatic mineralogy classes.

Anhydrite content is quantified by the difference in two analytical procedures. Anhydrite ($CaSO_4$) and gypsum are both extracted and measured by a procedure using acetone to precipitate dissolved calcium sulfate from an aqueous solution. The acetone procedure commonly used to quantify gypsum also extracts anhydrite, and for soils with both of these minerals, the results of the analysis represent the sum of gypsum and anhydrite in the soil. Gypsum (but not anhydrite) is quantified by thermal gravimetric analysis, a method that measures the weight loss of a sample by heating it from 20 to 200 ºC at a rate of 2 ºC per minute. The weight of water loss between 75 and 115 ºC is used to quantify the gypsum based on a theoretical weight loss of 20.9 percent (Karathanasis and Harris, 1994). Therefore, the percent anhydrite in a sample can be derived from the difference between the acetone method (Σgypsum+anhydrite) and thermal (gypsum) procedure. More details can be found in Wilson et al. (2013). Anhydrite content is used in the required characteristics for the anhydritic horizon and as a criterion for the anhydritic mineralogy class.

Soluble Salts

Electrical conductivity (EC) is the conductivity of electricity through the water extracted from saturated soil paste. It is reported as dS/m and is used as a criterion for the salic horizon and in Halic subgroups of Vertisols.

Electrical conductivity 1:1 is the electrolytic conductivity of a suspension of 1 part soil to 1 part water. The results are used to classify some saline organic soils composed of highly decomposed organic materials into the Halic subgroups of Haplosaprists. The conductivity is reported as dS/m.

Electrical conductivity 1:5 by volume ($EC_{1:5\ vol}$) is the electrolytic conductivity of a diluted, unfiltered supernatant of 1 part soil to 5 parts distilled water as measured by volume. The $EC_{1:5\ vol}$ is used to indicate the threshold between different taxa for freshwater and brackish subaqueous soils. It is reported as dS/m.

Exchangeable sodium percentage (ESP) is reported as a percentage of the CEC by ammonium acetate at pH 7. Water-soluble sodium is converted to 1 cmol (+) kg^{-1} soil. This value is subtracted from extractable sodium, divided by the CEC (by ammonium acetate), and multiplied by 100. An ESP of 15 percent or more is used in this taxonomy as a criterion for the natric horizon, the Halaquepts great group, Natric subgroups, and most Sodic subgroups.

Sodium adsorption ratio (SAR) was developed as a measure of irrigation water quality. This calculated value uses the soluble calcium, magnesium, and sodium content (reported in mmol(+) L^{-1}) determined in water extracted from a saturated paste and measured by atomic absorption spectrophotometry. The formula is $SAR = Na/[(Ca+Mg)/2]^{0.5}$. An SAR of 13 or more is used as an alternate criterion to the exchangeable sodium percentage criterion for the natric horizon, the Halaquepts great group, Natric subgroups, and most Sodic subgroups.

Selective Dissolutions

Ammonium oxalate extractable aluminum, iron, and silicon are determined by a single extraction made in the dark with 0.2 M ammonium oxalate at a pH of 3.5. The amount of aluminum, iron, and silicon is measured by atomic absorption and reported as a percentage of the total dry weight of the fine-earth fraction. The procedure extracts iron, aluminum, and silicon from organic matter and from amorphous mineral material. It is used in conjunction with dithionite-citrate and pyrophosphate extractions (described below) to identify the sources of iron and aluminum in the soil. Pyrophosphate extracts iron and aluminum associated with organic materials. Dithionite-citrate extracts iron from iron oxides and oxyhydroxides as well as from organic matter. A field test using potassium hydroxide (KOH) can be used to estimate the amount of aluminum that is extractable by ammonium oxalate (Soil Survey Staff, 2009).

The oxalate-extractable aluminum plus one-half iron contents are used as criteria for andic soil properties and spodic materials (used for classifying soils in the Andisol and Spodosol orders) and in the Andic and Spodic subgroups in other orders. The relative amounts of oxalate-extractable iron and silicon are used to define the amorphic and ferrihydritic mineralogy classes.

Optical density of oxalate extract (ODOE) is determined with a spectrophotometer using a 430 nm wavelength. An increase in the ODOE value in an illuvial horizon, relative to an overlying eluvial horizon, indicates an accumulation of translocated organic materials. The optical density of oxalate extract is used in the definition of spodic materials as well as Spodic subgroups of Entisols, Gelisols, Inceptisols, and Ultisols.

Dithionite-citrate extractable iron is the percentage of iron as Fe_2O_3 removed in a single extraction. It is measured by atomic absorption and reported as a percentage of the total dry weight. The iron is primarily from ferric oxides (e.g., hematite and magnetite) and iron oxyhydroxides (e.g., goethite). Aluminum substituted into these minerals is extracted simultaneously. The dithionite reduces the ferric iron, and the citrate stabilizes the iron by chelation. Iron and aluminum bound in organic matter are extracted if the citrate is a stronger chelator than the organic molecules. Manganese extracted by this procedure also is recorded. The iron extracted is commonly related to the clay distribution within a pedon. Percent iron oxide extracted by dithionite-citrate is used to define anthric saturation (anthraquic conditions), the ferritic, ferruginous, sesquic, and parasesquic mineralogy classes, and ferrihumic soil material.

Organic Analyses

In this section, the various analyses related to amounts and kinds of organic matter are presented in alphabetical order.

Color of sodium-pyrophosphate extract is used as a criterion in the identification of different kinds of organic soil materials and limnic materials. A saturated solution is made by adding 1 g of sodium pyrophosphate to 4 ml of distilled water, and a moist organic matter sample is added to the solution. The sample is mixed and allowed to stand overnight, chromatographic paper is dipped in the solution, and the color of the paper is compared to the chips of a Munsell soil-color chart.

Fiber content is determined for horizons of organic soil material on the decomposed plant materials that are less than 20 mm in cross section. The fiber content is reported as percent, by volume, before rubbing and after rubbing between the thumb and fingers. Only the fiber content after rubbing is used as criteria in Soil Taxonomy since it partially defines the three kinds of organic soil materials (fibric, hemic, and sapric) used to classify organic soils (i.e., Histosols and Histels). The rubbed fiber content is in the definitions of suffix symbols "a," "e," and "i" which are used with master symbol "O" to designate horizons in both organic and mineral soils (Soil Science Division Staff, 2017).

Melanic index is used in the required characteristics of the melanic epipedon. It is related to the ratio of the humic and fulvic acids in the organic fraction of the soil (Honna et al., 1988). It is used to distinguish humified organic matter thought to result from large amounts of gramineous vegetation from humified organic matter formed from forest vegetation. The melanic index is calculated as the absorbance of the extracting solution at wavelength 450 nm over the absorbance at wavelength 520 nm.

Organic carbon data in the NCSS soil characterization database have been determined mostly by wet digestion (Walkley, 1935). Because of environmental concerns about waste products, however, that method is no longer used at KSSL. The method that is currently used at KSSL to determine organic carbon is a dry combustion procedure that determines the percent total carbon. Total carbon is the sum of organic and inorganic carbon. In calcareous horizons the content of organic carbon is determined by subtracting the amount of inorganic carbon contributed by carbonates from the total carbon data (percent organic carbon = percent total carbon – [% < 2 mm $CaCO_3$ x 0.12]). The content of organic carbon determined by this computation is very close to the content determined by the wet digestion method. Values for organic carbon are multiplied by the Van Bemmelen factor of 1.724 to estimate percent organic matter. Organic carbon content is used in many places in Soil Taxonomy. For example, it is used for the definition of mineral soil material, the required characteristics of diagnostic surface horizons (such as a histic epipedon), and criteria for taxa that connote the presence of horizons high in organic matter (such as the Humults suborder).

Organic matter is determined by measuring the mineral content of a sample using loss on ignition (LOI). The percent organic matter is calculated by difference (i.e., 100 – percent mineral content). The organic matter content measured by LOI is used with CEC data in criteria which define coprogenous earth and diatomaceous earth.

Mineral Analyses

Mineralogy of the clay, silt, and sand fractions is needed for classification in some taxa. X-ray diffraction (XRD) and thermal and petrographic analyses are classically viewed as mineralogy techniques, although some mineralogy classes (e.g., ferritic, amorphic, gypsic, carbonatic, and isotic) are determined by chemical and/or physical analyses.

X-ray diffraction

Halloysite, illite, kaolinite, smectite, vermiculite, and other minerals in the clay fraction (less than 0.002 mm) may be identified by XRD analysis. Relative peak positions identify clay minerals, and peak intensities are the basis for semi-quantitative estimates of mineral percent, by weight, in the clay fraction. KSSL reports relative peak intensities of clay minerals from XRD in a five-class system that generally corresponds to percent, by weight, of a mineral (class 1 = 0 to 2 percent, class 2 = 3 to 9 percent, class 3 = 10 to 29 percent, class 4 = 30 to 50 percent, and class 5 = more than 50 percent). There are multiple potential interferences in the analysis of a clay sample (Burt and Soil Survey Staff, 2014). Peak intensities may be attenuated by one or more interferences, and the reported class may underestimate the actual amount of mineral present. Thus, these assigned percentages are given for informational use only and should not be used to quantify minerals in a clay fraction. Clay minerals are listed in the order of decreasing quantity on the data sheet. XRD is used to determine smectitic, vermiculitic, illitic, kaolinitic, and halloysitic mineralogy classes in Soil Taxonomy. Some family classes require a clay mineral to be more than one-half (by weight) of the clay fraction, corresponding to XRD class 5. Other mineralogy classes require more of the specified mineral than any other single mineral, corresponding to the clay mineral being listed in the first ordinal position on the KSSL data sheet.

Thermal analysis

Kaolinite and gibbsite may be determined by thermal analysis. Results from this analysis are reported as percent, by weight, in the clay fraction and are more quantitative than the results of XRD for these minerals. Thermal analysis is a technique in which the dried sample (typically the clay fraction) is heated in a controlled environment. Certain minerals undergo decomposition at specific temperature ranges, and the mineral can be quantified when compared to standard clays. Results may be used to determine kaolinitic and gibbsitic family mineralogy classes, complementary to or *in lieu* of XRD data.

Petrographic analysis

Resistant minerals, weatherable minerals, volcanic glass, magnesium-silicate minerals, glauconitic pellets, mica, and stable mica pseudomorphs may be determined by petrographic analysis. Magnesium-silicate minerals (e.g., serpentine minerals) and glauconitic pellets are reported as percent, by weight, in the fine-earth fraction (less than 2.0 mm). Resistant minerals, weatherable minerals, and volcanic glass are determined as percent of total grains counted in the coarse silt through very coarse sand (0.02 to 2.0 mm) fractions, while mica and stable mica pseudomorphs are determined in the 0.02 to 0.25 mm fractions (coarse silt, very fine sand, and fine sand).

Individual mineral grains in a specific particle-size fraction are mounted on a glass slide, identified, and counted (at least 300 grains) under a polarizing light microscope. Data are reported as percent of grains counted for a specific size fraction. This percentage is generally regarded as equivalent to weight percent for spherical minerals. Alternative techniques are available for determining weight percent micas and other platy grains in a soil separate. The usual KSSL protocol is to count mineral grains in either the coarse silt (0.02 to 0.05 mm), very fine sand (0.05 to 0.10 mm), or fine sand (0.10 to 0.25 mm) fraction, whichever has the highest weight percent based on particle-size analysis. Mineral or glass content in the analyzed fraction is assumed to be representative of the content in the whole 0.02 to 2.0 mm or fine-earth fraction. It may be necessary to count additional fractions to obtain a reliable estimate of volcanic glass content in soil materials with a non-uniform distribution of glass in dominant particle-size fractions. If more than one fraction is counted, the weighted average of the counted fractions may be calculated to represent glass content in the 0.02 to 2.0 mm fraction. For soils expected to have significant amounts of glass in dominant fractions of medium, coarse, or very coarse sand, grain counts are needed.

Two general types of petrographic analysis are conducted at KSSL: (1) complete mineral grain count, in which all minerals in the sample are identified and counted; or (2) a glass count, in which glass, glass aggregates, glass-coated minerals, and glassy materials are identified and quantified and all other minerals are counted as “other.” Other isotropic grains, such as plant opal, sponge spicules, and diatoms, also are identified and quantified in the glass count grain studies. Glass-coated grains are crystalline mineral grains in which more than 50 percent of the grain is coated with glass. Grains coated with glass are either specifically identified (e.g., glass-coated feldspar) or are identified with a general category (e.g., glass-coated grain) depending on the level of certainty. “Glassy materials” is a general category for grains that have optical properties of glass but lack definitive characteristics of glass, glass-coated grains, or glass aggregates. Percent of total resistant minerals is reported on the KSSL data sheet. (Calcite and more soluble minerals are included in determinations of the percentage of resistant minerals reported on the laboratory data sheet but are not included in the values used in this taxonomy.) Total percent volcanic glass, weatherable minerals, or other groups of minerals used in classification may be calculated by summing the percent of individual minerals included in the group. A current, complete list of minerals in each category is in the *Soil Survey Laboratory Information Manual* (Soil Survey Staff, 2011).

Other Information Useful in Classifying Soils

Volumetric calculations

Volumetric amounts of organic carbon are used in some taxonomic criteria (e.g., Humults suborder). The following calculation is used: (Datum [percent*] times bulk density [at 33 or 10 kPa] times thickness [cm]) divided by 10. This calculation is normally used for organic carbon, but it can be used for some other measurements. Each horizon is calculated separately, and the product of the calculations can be summed to any desired depth, commonly 100 cm.

* The value for the property is entered as percent (e.g., 6.5), not expressed as a decimal (0.065).

Ratios of key data

Ratios that can be developed from the data are useful in making internal checks of the data, in making management-related interpretations, and in answering taxonomic questions. Some of the ratios are used as criteria in determining argillic, kandic, natric, or oxic horizons.

1500 kPa tension to clay

The ratio of water content at 1500 kPa tension to clay content is used to indicate the relevancy of a particle-size analysis. If the ratio is 0.6 or more and the soil does not have andic soil properties, incomplete dispersion of the clay is assumed. For most soils, clay is estimated by the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon). For a typical soil with well dispersed clays, the 1500 kPa water to clay ratio is 0.4. Some soil-related factors that can cause deviation from the 0.4 value are: (1) low-activity clays (kaolinites, chlorites, and some micas), which tend to have a ratio of 0.35 or below; (2) iron oxides and clay-sized carbonates, which tend to decrease the ratio; (3) organic matter, which increases the ratio because it increases the water content at 1500 kPa; (4) andic and spodic materials and materials with an isotic mineralogy class, which increase the ratio because they do not disperse well; (5) large amounts of gypsum or anhydrite, which decrease the ratio to less than 0.3; and (6) clay minerals within grains of sand and silt, which hold water at 1500 kPa and thus increase the ratio (which are most common in shale and in pseudomorphs of primary minerals in saprolite).

CEC by ammonium acetate at pH 7 (CEC-7) to percent total clay

The ratio of CEC by ammonium acetate at pH 7 (CEC-7) to percent total clay can be used to estimate clay mineralogy and clay dispersion. The following ratios are typical for the following classes of clay mineralogy: less than 0.2, kaolinitic; 0.2–0.3, kaolinitic or mixed; 0.3–0.5, mixed or illitic; 0.5–0.7, mixed or smectitic; and more than 0.7, smectitic. These ratios are most valid when some detailed mineralogy data are available. As described previously, if the ratio of 1500 kPa water to clay is 0.25 or less or 0.6 or more, the measured clay content and the calculated ratio of CEC-7 to percent clay is not valid. The ratio of CEC-7 to percent clay is used as a criterion in applying cation-exchange activity classes for certain loamy and clayey soils which have either mixed or siliceous mineralogy. It is important to note that the ratio must be recalculated for soils which contain clay-sized carbonates since carbonate clay is excluded from the concept of "clay" for taxonomic classifications. Measured carbonate clay is subtracted from measured total clay to arrive at a valid number for the silicate (i.e., noncarbonate) clay fraction, and the ratio is recalculated.

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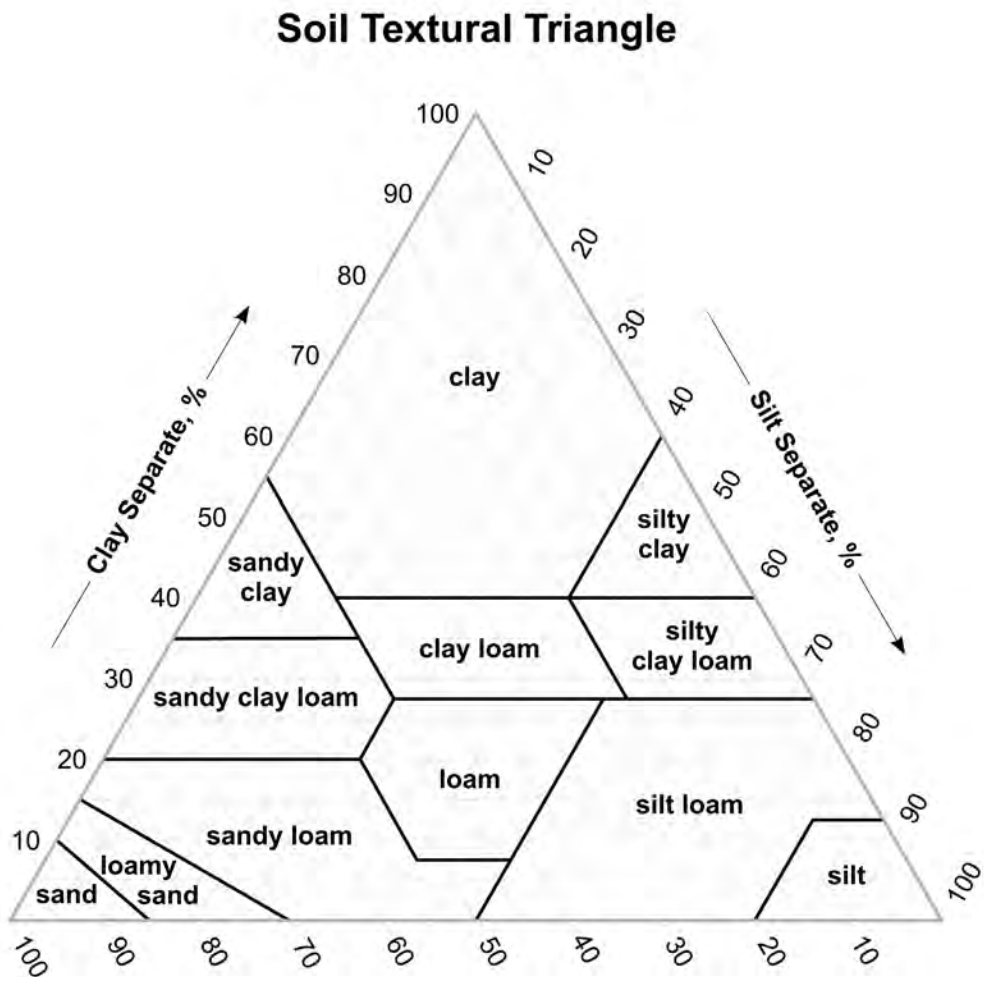
Percentages of clay (less than 0.002 mm), silt (0.002 to 0.05 mm), and sand (0.05 to 2.0 mm) in the basic soil texture classes



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