Natural Resources Conservation Service

Salina, Kansas
November 2011

Central Great Plains MO5

Sampling Procedures for Laboratory Analysis of Soils

Designations for Master Horizons and Layers in Soils

Conversion Table

inches	cm rounded	cm	inches rounded
1	3	1	0
2	5	2	1
3	8	3	1
4	10	4	2
5	13	5	2
6	15	6	2
7	18	7	3
8	20	8	3
9	23	9	4
10	25	10	4
11	28	11	4
12	30	12	5
13	33	13	5
14	36	14	6
15	38	15	6
16	41	16	6
17	43	17	7
18	46	18	7
19	48	19	7
20	51	20	8
21	53	21	8
22	56	22	9
23	58	23	9
24	61	24	9
25	64	25	10
30	76	30	12
35	89	34	13
40	102	40	16
45	114	45	18
50	127	50	20
60	152	60	24
70	178	70	28
80	203	80	31
90	229	90	35
100	254	100	39

Introduction

This guide is intended to be a supplement to existing technical guidance. The Field Book for Describing and Sampling Soils, version 2.0 contains information regarding all aspects of describing soils and landscapes. The Soil Survey Laboratory Methods Manual, Soil Survey Investigations Report No. 42, versions 3.0 and 4.0, contain information about procedures for sample collection and handling; however, they are not in a format suitable for use in the field.

Most of the information in this guide is based on National Soil Survey Staff, Principles and Procedures for using Soil Survey Laboratory Data, Course Guide, 1983. There are also excerpts from Chapter 3 of the Soil Survey Manual that relate to horizon nomenclature and rock fragments.

This guide was prepared by the Natural Recourses Conservation Service (NRCS) Central Great Plains Major Land Resource Area (MLRA) Office (MO5), Salina, Kansas, in November 2011, to provide a field reference of techniques for soil scientists collecting soil characterization samples.

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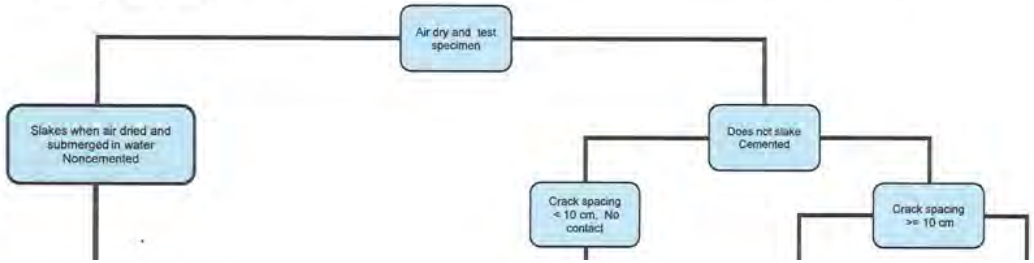
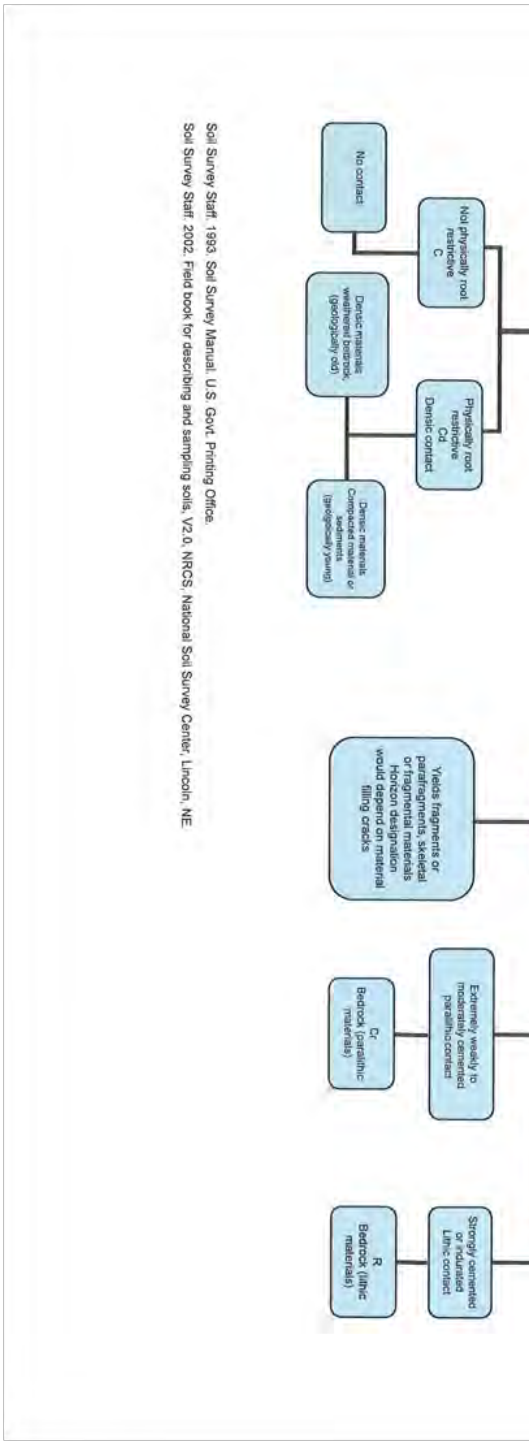
NSSC, 5/2001 (Modified by MO5 Soils Staff, 2008)

Substrata Material Classification Decision Tree

C, Cd. Cr horizons: Horizons, excluding strongly cemented or harder bedrock, that are little affected by pedogenic processes and lack properties of O,A,E and B horizons, Soil Survey Staff, 1993
R horizons: Strongly cemented or indurated bedrock, Soil Survey Staff, 1993

The test for cementation is not a field test; the specimen must first be air dried and then submerged in water for a minimum of 1 hour prior to test see Soil Survey Manual p.173 and Field Book for Describing and Sampling Soils p.2-50





Soil Survey Staff. 1993. Soil Survey Manual. U.S. Govt. Printing Office.

Soil Survey Staff. 2002. Field book for describing and sampling soils, V2.0. NRCS, National Soil Survey Center, Lincoln, NE.

Sampling Soils

The analyst and the reviewer of data assume the sample is representative of the soil (horizon) being characterized. A concerted effort is made to keep analytical variability small. Precise laboratory work means the principal variability in characterization data resides in sample variability. In other words, sampling is the precision-limiting variable. As a result, the site selection, sample, and processing of the sample are extremely important.

Selecting the Site

Primary responsibility rests with the field soil scientist to select a site that represents the soil and soil landscape. The site must also be free from extraneous contamination. Contrary to approaches in other work, sites are not selected at random. Rather, the scientist uses field observations to develop a concept and establish the range of properties for a soil. Sites ***representative*** of the soil as it occurs in the survey area are purposefully selected for sampling. A Form NRCS-SOI-232 should be completed at the site before the sampling crew arrives.

Several site selection techniques are used to enhance the reliability and the usefulness of subsequent data. Techniques include selection of paired pedons, transect sites, and satellite sites. Paired pedons provide a double check on a large number of soil properties and a clue toward variability between morphologically matched pedons.

Transects are a tool for studying soils in a landscape continuum. Sites can be selected to emphasize study of specific variables such as topography, moisture or temperature regimes, or factors related to chronology, climate, geomorphology, geology, and vegetation. If transects should cross geomorphic boundaries, all geomorphic components, even if they are not sampled, must be considered when interpreting results. Specific sites should be selected for their predictive value as well as to characterize the point in question.

Satellite sites allow a check of critical properties on several samples referenced to the principal characterization site. Satellite sites can be selected to assess variability of a soil property in modal samples, or to demonstrate the range of a soil property for the series in a limited area.

Describing pedons and horizon nomenclature

The objective of the pedon description is to record the soil properties that allow us to interpret the pedogenic history, classify the soil, and make a record for future users. To fully understand and get the most information from the lab data you need to know who, what, where, when and why the pedon was sampled. ***Use pedon notes to capture group discussion about the parent materials, pedogenesis, classification, landscape, geomorphology and interpretations when the pedon is being sampled***.

Authors of the description should include the entire sampling party. Everyone present has input into the description and discussion of the pedon's properties and classification, and should be listed as a describer.

Use **pedon notes** to document assumptions made relevant to classification decisions. There are many times the lab data necessary to classify a pedon is not immediately available, but we do make assumptions about how much organic matter, carbonates, gypsum, salt, clay increase, soil moisture control section, etc.

Examples:

1. For an Aridisol. In this pedon it is assumed that in normal years the soil moisture control section is dry in all parts for the number of days that would meet the aridic moisture regime based on the texture and rainfall distribution of the area.

2. For an Aquoll. The presence of aquic conditions in normal years is assumed based on texture, bulk density, presence of redoximorphic features and rainfall distribution in the area.

3. For a Vertisol. The pedon was sampled when moist and no cracks were observed; however, the dark organic stains in lower horizons and experience of describers that work in the area suggest this soil cracks to the surface when dry.

4. For a paleosol in different parent material. The consensus of the group was that the upper part of the pedon formed in loess and a paleosol formed in alluvium based on the increase in sand content and the increase in coarse and very coarse sand.

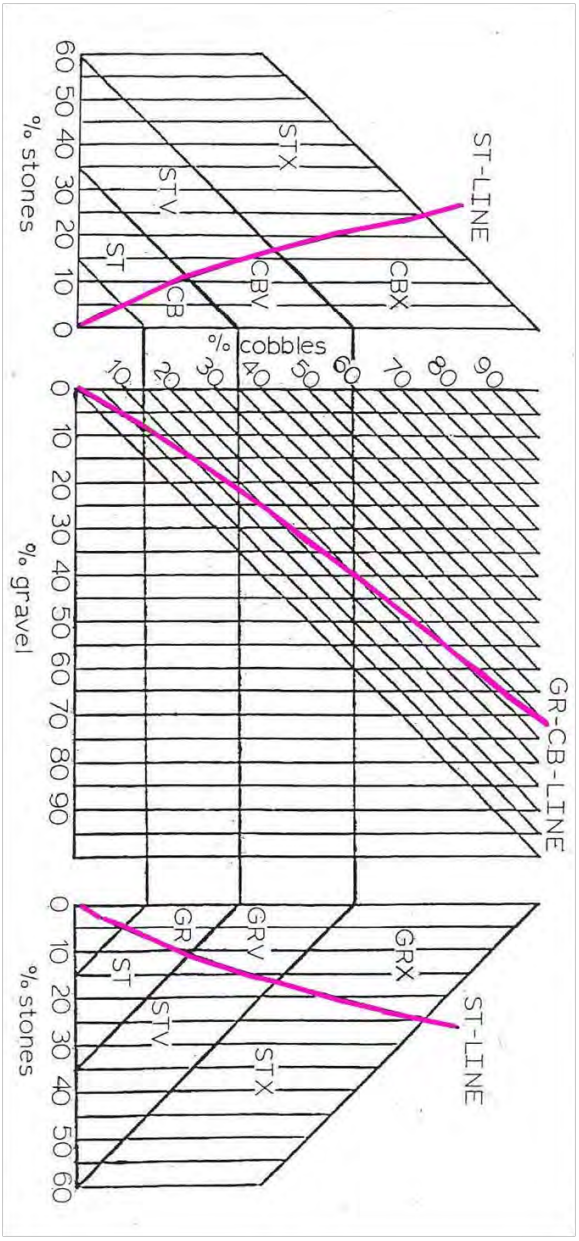
5. For a soil with a marginal calcic horizon. There was much debate about the presence of a calcic horizon. Based on field estimates of carbonate

To Be Used When Boulders and Stones Are Present

Instructions:

1. Find gravel percentage line (vertical)
2. Find cobble percentage line (slanted at 45°)
3. Find intersect of gravel and cobble percentage lines
4. If intersect is: (a) left of the GR-CB line, go horizontally left
   (b) right of the GR-CB line, go horizontally right
5. To intercept of stone percentage line (vertical) and name after symbol in area intercept
6. If intersect falls exactly on a line between classes use the modifier of the higher class, i.e., use CBX when point falls on line between CBX and CBV; or use STX when point falls on line between CBX and STX
7. When boulders are present add their percentage to the stone percentage and follow the chart. If a "stony" modifier is then determined, and the % stones is ≥2X the % boulders, use the "stony" modifier. Otherwise, use a "bouldery" modifier
8. When there is a mixture of rock and pararock fragments, doe not combine rock and pararock percentages to determine the modifier. Rock fragment modifiers have precedence when the percentage of rock fragments is ≥ 15% regardless of the percent pararocks. Use pararock modifiers when the percent pararocks is ≥ 15% and the percent of rock fragments is < 15%
9. Substitute channer (CN), flagstone (FL), and pararock (PGR, PCB, PST, PBY, PCN, PFL) modifiers when appropriate
10. When there is ≥ 90% rock fragments (< 10% fine earth) no modifiers are use. Instead, use the appropriate "In Lieu of Texture" term of the dominant size class, i.e., gravel, cobbles, stones, boulders

The rations of GR:CB and GR:ST contained in this guide are the same rations identified in exhibit 618-11 of the 2001 NSSH. The original authors of this guide are unknown. This guide was updated by the MO6 staff March 2002.



and the field experience of the sampling party, the calcic horizon is assumed to extend from 30-42 cm.

There have been interesting questions and discussions about horizon nomenclature. For example, can a “z” (accumulation of salts) be used with an A horizon, can a “t” be used with a soil that does not have an argillic horizon? Can a “z” be used with a “w”? There is a lot of national guidance on horizon nomenclature and designations in the National Soil Survey Handbook, Keys to Taxonomy, Soil Survey Manual, Field Book for Describing and Sampling Soils ver. 2.0, and MO5 Technical Note 5. All of that guidance however, does not always answer a specific question like can a “z” be used with an “A”.

Do not attempt to make the horizon nomenclature describe what is observed. Taking that a step further, do not assume the next user of that description will be able to conclude the same thing about the pedogenic processes based on nomenclature.

If the A horizon has accumulations of salt that are interpreted as pedogenic there is not a problem with calling the horizon an Az, **and** describing the size, hardness, shape, location, and all the other elements of a concentration. Include a horizon note to explain the sampling party thinks theses salts are pedogenic accumulations. Do not put a “z” on the horizon and then fail to describe the concentrations assuming the “z” will be understood by the next user of the description as the salts are from a pedogenic source.

In a related example, the A horizon has an accumulation of salts that is believed to be related to irrigation water. The author(s) may not want to put a “z” on this horizon (their choice), but the concentrations should still be described and a pedon horizon note included that explains that it was concluded that salt accumulations were related to irrigation and not pedogenic so a “z” was not used. Even if this horizon was called an “Az” the same pedon horizon note is appropriate and should be included.

Every time a horizon subscript is used there should be an appropriate and related concentration, ped surface feature, or other feature documented in the appropriate subtable. **Enter notes** explaining why things are described a certain way, use notes to document your thoughts on pedogenic processes active in the pedon.

Liberal use of **pedon horizon notes** is highly encouraged. Do not rely on the database and description generator

to adequately describe what you observed. If a feature has a unique shape, size, or position, describe it in a horizon note. If the amount is less than 1 percent and the database does not allow for less than 1, make a note that there is less than 1 percent.

When sampling for lab analysis, always include a field estimate of percent of clay and sand for every horizon. Overtime, this will help improve your field estimates.

Make sure you populate diagnostic features and what is populated supports the classification. A mollisol should have a mollic epipedon, a vertisol should have slickensides, cracks or some other diagnostic feature. However, read and re-read Keys to Soil Taxonomy as you classify the pedon. Just because the soil has a mollic epipedon doesn't mean it is a mollisol. Only Histisols and Entisols are excluded from having a mollic epipedon.

Remember you are describing and classifying a pedon, it is three dimensional not just the two dimensional profile or 1.5 in. core from a probe tube you are looking at. Classify the pedon, do not just use the classification of the series you have in mind.

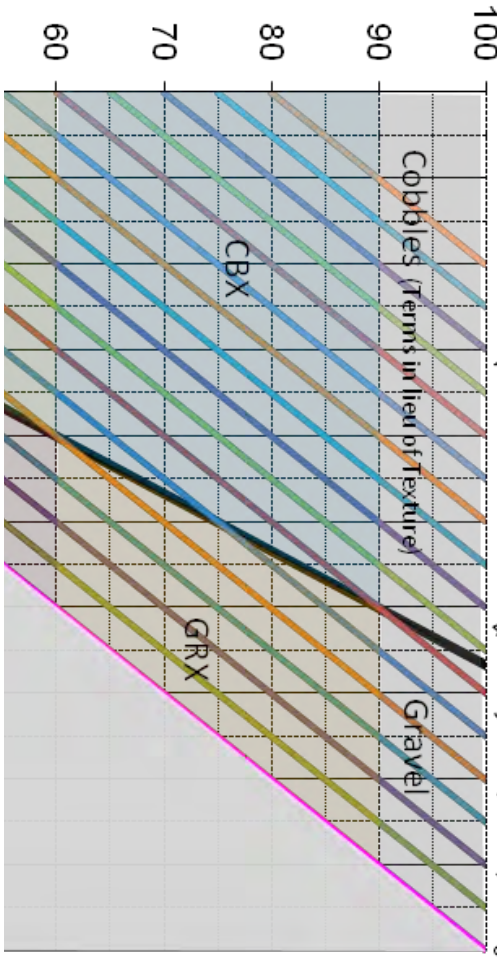
Do not be mechanical in describing and classifying a pedon. Think through the pedogenic process; document them with more than the short hand nomenclature and fields that the National Soil Information System (NASIS) allows us to capture. **Make notes,** capture your thought process and discussions when it is a group working together. We are not describing a pedon just because it is fun to do, nor should it be an exercise in following rules of nomenclature.

It is recommended that a correlation tray or box sample be collected for future reference.

Sampling the Pedon

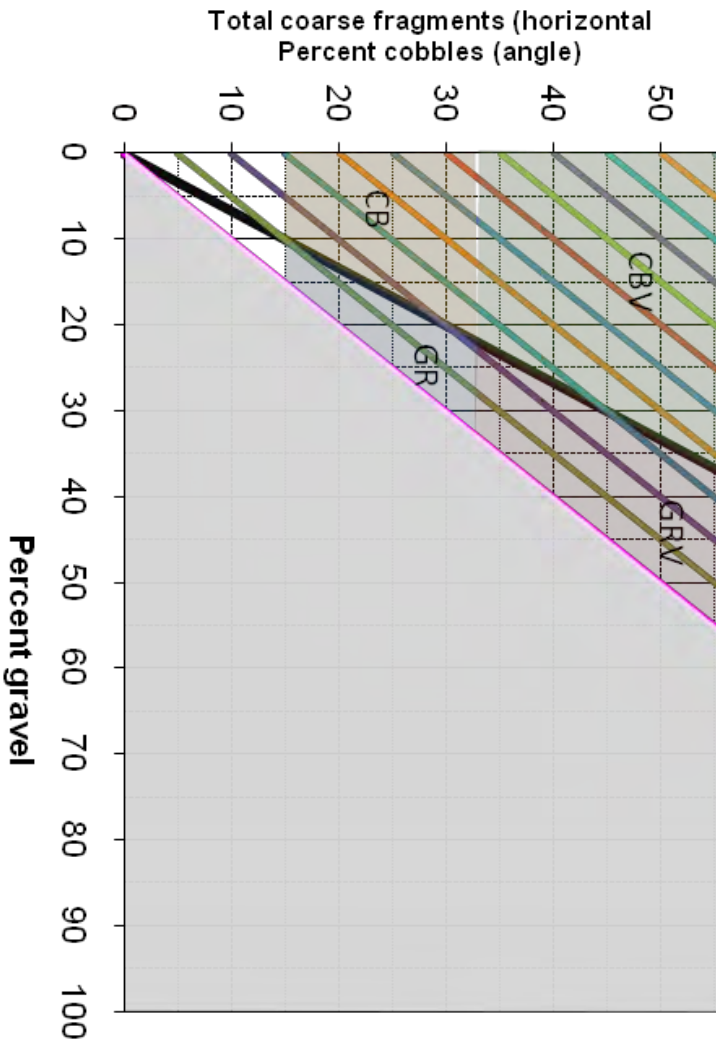
The sampling party has responsibility to obtain samples representative of the pedons selected for characterization. Decisions are necessary on how deep to sample, horizon delineation, thickness of horizon (or interval) sampled, what material should be excluded from the sample, and the usefulness of compositing samples. The sampling party ensures that site and pedon descriptions are adequate.

Pedons for characterization studies should be sampled to a depth of 2 meters, if possible. The sampling party needs to be alert to taxonomic questions that may arise and sample appropriately to resolve the questions; e.g., base



Instructions:

1. This chart is intended for use when only gravel and cobble size fragments are present. Stones and boulders when present can change the outcome.
2. Find the gravel percentage (X axis).
3. Find the cobble percentage line (slanted at 45 degrees)
4. Find intersect of the gravel and cobble percentage lines.
5. If intercepts is:
   (a) left of the GR-CB 1.5 ratio line modifier is cobbly.



(b) right of the GR-CB 1.5 ratio line modifier is gravelly.

6. When there is a mixture of rock and pararock fragments, do not combine rock and pararock percentages to determine modifier. Rock fragments have precedence when the percentage of rock fragments is >= 15%.

7. Substitute channer (CN), flagstone (FL) and pararock modifiers when appropriate.

8. For >= 90% rock fragments (<10% fine earth) no modifiers are used. Use the appropriate "In Lieu of Texture" term of the dominant size class.

saturation for Alfisol vs. Ultisol may require subsampling at a specific depth. Appropriate sampling increments depend on the kind of material and the proximity of the horizon to the soil surface. **Horizons in the upper meter would normally be split for sampling if they are more than 30 cm (12 in) thick. Uniform horizons below 1 meter are normally split for sampling if they are more than 75 cm (30 in) thick.** The sampling party must exercise judgment and, depending on the pedon, may vary from these rules of thumb.

The ideal sample contains all soil material within the horizon in proportion to their occurrence in the pedon. The sampler attempts to approximate the ideal by carefully sampling a selected section of the horizon. The sample is normally taken along a pit face from horizon boundary to horizon boundary and between arbitrary lateral limits.

Lateral limits encompass short-range variability observed at the site. If a recurring pattern (e.g., mottles, durinodes, nodules, plinthite) is discerned, extend the lateral limits to 4 or 5 cycles of the pattern. If this results in too much material, the sample is mixed, quartered, and subsampled. At some point, the repeat cycles become too large or soil properties change sufficiently that lateral extension is impractical or undesirable. An example is the gilgai pattern in Vertisols. Proper characterization may warrant the sampling of two sets of horizons or pedons.

If a horizon is stratified or otherwise contains contrasting materials, each material may be carefully described. Some contrasting materials can be sampled independently, but in many cases the materials are intertwined to the point that practicality dictates they be sampled together. However, each material should be described and the proportions noted. A decision on what, if any, materials should be excluded from the sample is an integral part of collecting a representative sample. The sampling party may decide to include soil material in cicada casts and nodules as part of the sample, but to exclude material from a badger tunnel. Supplemental sampling techniques are sometimes useful in answering specific questions. For base saturation, a relatively thin band of soil can be taken at the depth critical for taxonomic placement. Clay maxima within a horizon can be sampled separately as can clay bands, clay pockets, plinthite, or any other features selected for special study. In most cases, the special samples are taken in addition to the representative sample.

Coarse fragments >20 mm (¾ in) can be selectively excluded from all samples sent to the laboratory, except for bulk density clods. The coarse fragments are always weighed or estimated at the time of sampling and estimates of the 2 to 5 mm, 5 to 20 mm, 20 to 75 mm (¾ to 3 in, coarse gravel), 75 to 250 mm (3 to 10 in, cobbles), and >250 mm fractions recorded in the descriptions. Clods may contain coarse fragments as long as they have at least 100 g (3 oz.) of <2 mm material.

Bagged samples. The size (weight) of the sample needed to be representative of the horizon depends on the diameter of the largest particles in the soil material. A rule of thumb is that sample weight be 100 times the weight of the largest particle. **In sampling for laboratory characterization, the practice is to weigh about 18 kg (40 lbs) of soil material in the field to obtain the percent of 20 to 75 mm (¾ in to 3 in) material. This is adequate for a maximum particle diameter of about 50 mm (2 in) according to the rule of thumb. To obtain adequate values from materials containing up to 75 mm (3 in) fragments, about 60 kg (132 lb) must be screened. About 4 kg (9 lb) of soil material per horizon is adequate for horizons with a maximum particle diameter around 30 mm (1.2 in). If the sample contains no particles greater than 2 mm, then a sample weight of 1.5 kg (4 lb) is adequate. If there are many fragments >75 mm, obviously weight sampling is impractical and volume should be estimated visually.**

Rock fragments 75 to 250 mm and >250 mm require prohibitive amounts of sample to obtain weight estimates (see Table 1). Because of this, volume estimates should be made for the fragments >250 mm, 75 to 250 mm, and 20 to 75 mm and recorded on the field sheets and pedon description. Weights for the 20 to 75 mm and the <75 mm fractions should be determined based on samples of the size in Table 1 using a scale and recorded on the field sheets and pedon description. **The laboratory sample is of the <20 mm (¾ in) size fraction.**

Table 2. Terms for Rock Fragments

Shape and Size[1]	Noun	Adjective
Spherical, cubelike, or equiaxial:		
2 to 75 mm diameter	Pebbles	Gravelly
2 to 5 mm diameter	Fine	Fine gravelly
5 to 20 mm diameter	Medium	Medium gravelly
20 to 75 mm diameter	Coarse	Coarse gravelly
75 to 250 mm diameter	Cobbles	Cobbly
250 to 600 mm diameter	Stones	Stony
≥600 mm diameter	Boulders	Bouldery
Flat:		
2 to 150 mm long	Channers	Channery
150 to 380 mm long	Flagstones	Flaggy
380 to 600 mm long	Stones	Stony
≥600 mm long	Boulders	Bouldery

[1]The roundness of the fragments may be indicated as angular (strongly developed faces with sharp edges), irregular (prominent flat faces with incipient rounding or corners), subrounded (detectable flat faces with well-rounded corners), and rounded (flat faces absent or nearly absent with all corners).

gether. Furthermore, the interpretations program requires weight rather than volume estimates. For interpretations, the weight percent >250, 75 to 250, 5 to 75, and 2 to 5 mm are required; the first two are on a whole soil basis, and the latter two are on a <75 mm basis. For the >250 and 75 to 250 mm sizes, weighing is generally impracticable. Volume percentage estimates would be made from areal percentage measurements by point-count or line-intersect methods. Length of the transect or area of the exposure should be 50 and preferably 100 times the area or dimensions of the rock fragment size that encompasses about 90 percent of the rock fragment volume. For the <75 mm weight, measurements are feasible but may require 50 to 60 kg of sample if appreciable rock fragments near 75 mm are present. An alternative is to obtain volume estimates for the 20 to 75 mm and weight estimates for the <20 mm. This is favored because of the difficulty in visual evaluation of the 2 to 5 mm size separations. The weight percentages of 5 to 20 and 2 to 5 mm may be converted to volume estimates and placed on a <75 mm base by computation. The adjectival form of a class name of rock fragments (Table 2) is used as a modifier of the textural class name: "gravelly loam," "stony loam."

Table 1. Sample size required based on maximum coarse fragment sizes

If Max Particle Size	Field Moist Weight to Be Sieved	Field Moist Weight Excluding >20 mm Particles to Submit	
<2 mm		4-5 lbs minimum	Sieving not necessary. Submit representative sample of <20 mm.
2-20 mm		10 lbs	Sieving not necessary. Make field volume estimates of 2-5, 5-20. Submit representative sample of <20 mm.
20-50 mm	40 lbs	10 lbs	Sieve 40 lbs. Make field volume estimates of 2-5, 5-20, >20. Submit representative sample of <20 mm.
50-75 mm	135 lbs	10 lbs	Sieve 135 lbs. Make volume estimates of 2-5, 5-20, 20-75. Submit representative sample of <20 mm.
>75	>2,000 lbs	10 lbs	Sieving not practical. Make volume estimates of all fractions. Submit representative sample.

Estimating the volume of rock fragments. The most important objective is to obtain the data needed to complete an interpretation record. A second objective is to have the volume of >2 mm particles to be used in the adjustment of quantities measured on the <2 mm to a whole soil basis such as COLE, water retention, etc. The area of the horizon exposure should be about 100 times the face area of a cube that is the same volume as the size of rock fragment that encompasses 90 percent of the volume of the rock fragments. Suppose the effectively largest rock fragment is 7.5 x 7.5 x 3 cm. The volume is 169 cm^3 and the face area of a cube of that area is 30 cm^2. The area of horizon needed (assuming the 100 fold rule) would be 3,000 cm^2. If the horizon is 20 cm thick, the exposure should be at least 1.5 m in length. If the rock fragment was a cube 250 mm (25 cm) on edge, and assuming a 30 cm thick horizon, an exposure 21 m in length would be needed.

A useful strategy is to obtain the percentage of larger rock fragments for several horizons combined, in particular the particle-size control section. For the example above of 250 mm rock fragments, increasing the thickness from 30 to 75 cm would reduce the length of the exposure to 8.4 cm.

Horizons should not be thinner than the thickness of the rock fragments.

The label. Labeling is critical. Include the following on the label to ensure there are no mistakes:

1. Pedon and horizon number
2. Depth
3. Horizon designation

Including the soil name is helpful. Use waterproof ink, and label the outside of the container. For plastic bags, staple a tag between folds at the top of the bag—on the outside.

Assignment of Soil Survey Number. The unique identifier for any sampling site is the soil survey number assigned at the time of sampling. It is also the number by which the data for that sample may be retrieved from the pedon data record. Assign soil survey numbers as follows:

1. Begin with S to indicate special sample
2. Use the last two digits of the fiscal year
3. List the two-letter state FIPS code
4. List the three digit county FIPS code
5. Number each pedon chronologically within the fiscal year

Example: S 05 MO 095 005

S = special sample
05 = sampled in 2005
MO = sampled in Missouri
095 = sampled in Jackson County, Missouri
005 = fifth pedon sampled in Jackson County in 2005

A field number can also be assigned. In instances where there may be a sub sample collected, or an extra sample collected for separate handling and processing, the field number is appropriate. For example, S11CO121001 has 5 horizons, the Ap 0-17 cm and a subsample of the 0-5 cm are being collected, the appropriate labels are shown as follows.

Organic soils:

Typic Medisaprist: Op-Oa1-Oa2-Oa3-C
Typic Sphagnofibrist: Oi1-Oi2-Oi3-Oe
Limnic Borofibrist: Oi-C-O´i1-O´i2-C´-Oe-C´
Lithic Cryofolist: Oi-Oa-R

Rock fragments. Rock fragments are unattached pieces of rock 2 mm in diameter or larger that are strongly cemented or more resistant to rupture. Rock fragments include all sizes that have horizontal dimensions less than the size of a pedon.

Rock fragments are described by size, shape, and, for some, the kind of rock. The classes are pebbles, cobbles, channers, flagstones, stones, and boulders. If a size or range of sizes predominates, the class is modified, for example: "fine pebbles," "cobbles 100 to 150 mm in diameter," "channers 25 to 50 mm in length."

Gravel is a collection of pebbles that have diameters ranging from 2 to 75 mm. The term is applied to the collection of pebbles in a soil layer with no implication of geological formalization. The terms "pebble" and "cobble" are generally restricted to rounded or subrounded fragments; however, they can be used to describe angular fragments if they are not flat. Words like chert, limestone, and shale refer to a kind of rock, not a piece of rock. The composition of the fragments can be given: "chert pebbles," "limestone channers." The upper size of gravel is 3 in (75 mm). This coincides with the upper limit used by many engineers for grain-size distribution computations. The 5 mm and 20 mm divisions for the separation of fine, medium, and coarse gravel coincide with the sizes of openings in the "number 4" screen (4.76 mm) and the "¾ in" screen (19.05 mm) used in engineering.

The 75 mm (3 in) limit separates gravel from cobbles. The 250 mm (10 in) limit separates cobbles from stones, and the 600 mm (24 in) limit separates stones from boulders. The 150 mm (channers) and 380 mm (flagstones) limits for thin, flat fragments follow conventions used for many years to provide class limits for plate-shaped and crudely spherical rock fragments that have about the same soil use implications as the 250 mm limit for spherical shapes.

Rock fragments in the soil. Historically, the total volume of rock fragments of all sizes has been used to form classes. The interpretations program imposes requirements that cannot be met by grouping all sizes of rock fragments to-

them from the upper.

Use of the Caret Symbol

The “caret” symbol (^) is used as a prefix to master horizon designations to indicate mineral or organic layers of human-transported material. This material has been moved horizontally onto a pedon from a source area outside of that pedon by directed human activity, usually with the aid of machinery. All horizons and layers 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, Arabic numeral prefixes may be used before the caret symbol to indicate the presence of discontinuities within the human-transported material or between the human-transported material and underlying layers (e.g., ^A-^C1-2^C2-3Bwb).

Sample Horizons and Sequences

The following examples illustrate some common horizon and layer sequences of important soils and the use of Arabic numerals to identify their subdivisions. 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 Haploboroll: Ap-A-Bw-Bk-Bky1-Bky2-C
Cumulic Haploboroll: Ap-A-Bw1-Bw2-BC-Ab-Bwb1-Bwb2-2C
Typic Argialboll: Ap-A-E-Bt1-Bt2-BC-C
Typic Argiaquoll: A-AB-BA-Btg-BCg-Cg
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-A3-2Bt1-2Bt2-2Bt3-2BC-2C
Glossoboric 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
Typic Haplargid: A-Bt-Bk1-Bk2-C
Entic Durorthid: A-Bw-Bq-Bqm-2Ab-2Btkb-3Byb-3Bqmb-3Bqkb
Typic Dystrochrept: Ap-Bw1-Bw2-C-R
Typic Fragiochrept: Ap-Bw-E-Bx1-Bx2-C
Typic Haplaquept: Ap-AB-Bg1-Bg2-BCg-Cg
Typic Udifluvent: Ap-C-Ab-C´
Typic Haplustert: Ap-A-AC-C1-C2

Figure 1. Labels for bulk material sample bags, field # 6 is a subsample of the Ap horizon

BULK DENSITY

1. Take **three clods** per horizon for bulk density.
2. Make all clods egg-shaped about 5 to 7 cm diameter, 6 to 8 cm tall (fist-sized), large enough to fill but not distort the compartments of the clod box.
3. Place bulk density clod in hairnet.
4. If dry, moisten surface of clods with spray of water to prevent deep penetration of Saran.
5. Dip ***once*** **quickly** in Saran to **cover all** surfaces.
6. Suspend clods from clothesline to dry.
7. When **dry** put coated clod in plastic bag and place in the correct order in cell of clod box. DO NOT remove hairnet.
8. Label the cells with pedon ID, horizon, and depth as in Figure 2.

Mixing Saran:

The National Soil Survey Laboratory will furnish, on request, pre-weighted packets of Saran. Soil Survey Investigation Report No. 42, ver. 4.0 p. 76, directs us to use a

resin to solvent ratio of 1:4 in the field. The 1:4 ratio is 540 g of Saran resin mixed with 1 gal of Acetone. Mix until all Saran resin is dissolved.

Figure 2. Bulk Density clods, 3 per horizon, box and cells labeled with pedonid, horizon, depth, and field number

NATURAL FABRIC

1. Make up a **separate box** from those for the bulk density. **DO NOT** mix bulk density and natural fabric samples in the same box.
2. Take **two clods** per horizon for natural fabric (thin section analysis).
3. Make clods the same size as those for bulk density.
4. When collecting the clod maintain the orientation of the clod.
5. Place a staple in the **top** of the clod so the lab knows how to orient the clod when the thin sections are made. They can make horizontal orientation or vertical orientation thin sections.
6. **DO NOT** dip the clod in Saran.
7. Place the undipped clod in a plastic bag and place the bag wrapped clod in a cell of the box and **label** the cell.

material, however, 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 or by the master symbol if the different layers are mineral.

Use of the Prime Symbol

If two or more horizons with identical Arabic numeral 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: B´t.

The prime symbol is not used unless all letters and Arabic numeral 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: A-C-2Bw-2Bc-2B´w-3Bc. This soil has two identical 2Bw horizons but has 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´´.

Vertical subdivisions of horizons or layers (Arabic numeral 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

eralogy that indicates a difference in the 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: 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: 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 Arabic numeral 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: Ap-Bt1-2Bt2-2Bt3-2C1-2C2-2R.

A buried 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

Figure 3. Natural Fabric clods 2 per horizon, not dipped in Saran, staple in top for orientation, label with pedonid, horizon, depths, and field number (if used)

Processing the sample:

Processing begins in the field as the sample is taken. Only at this point can a decision be made as to whether the sample is representative of the horizon. The sample should be thoroughly mixed before taking a subsample for laboratory analyses. Mixing can be done in the field, in the laboratory, or both.

Techniques for crushing and sieving samples can affect results significantly. The sampling party should make notes to alert the processor to possible problems such as pararock fragments, $CaCO^3$ concretions, or other coarse fragments that should be saved, discarded, or in someway analyzed differently.

Excerpts from Chapter 3, Soil Survey Manual

A description of the soils is essential in any soil survey. This chapter provides standards and guidelines for describing most soil properties and for describing the necessary related facts. For some soils, standard terms are not adequate and must be supplemented by a narrative. The length of time that cracks remain open, the patterns of soil tem-

perature and moisture, and the variations in size, shape, and hardness of clods in the surface layer must be observed over time and summarized.

This chapter does not include a discussion of every possible soil property. For some soils, other properties need to be described. Good judgment will decide what properties merit attention in detail for any given pedon (sampling unit). Observations must not be limited by preconceived ideas about what is important.

Although the format of the description and the order in which individual properties are described are less important than the content of the description, a standard format has distinct advantages. The reader can find information more rapidly, and the writer is less likely to omit important features. Furthermore, a standard format makes it easier to code data for automatic processing. If forms are used, they must include space for all possible information. Formats for recording and retrieving information about pedons will be discussed in more detail in Chapter 5.

Each investigation of the internal properties of a soil is made on a soil body of some dimensions. The body may be larger than a pedon or represent a portion of a pedon. During field operations, many soils are investigated by examining the soil material removed by a sampling tube or an auger. For rapid investigations of thin soils, a small pit can be dug and a section of soil removed with a spade. All of these are samples of pedons. Knowledge of the internal properties of a soil is derived mainly from studies of such samples. They can be studied more rapidly than entire pedons; consequently, a much larger number can be studied in many more places. For many soils, the information obtained from such a small sample describes the pedon from which it is taken with few omissions. For other soils, however, important properties of a pedon are not observable in the smaller sample, and detailed studies of entire pedons may be needed. Complete study of an entire pedon requires the exposure of a vertical section and the removal of horizontal sections layer by layer. Horizons are studied in both horizontal and vertical dimensions.

Some General Terms Used in Describing Soils

Several of the general terms for internal elements of the soil are described here; other more specific terms are described or defined in the following sections.

A soil profile is exposed by a vertical cut through the soil. It is commonly conceived as a plane at right angles to

Vertical Subdivision

Commonly, a horizon or layer identified by a single letter or a combination of letters has to be subdivided. For this purpose, Arabic numerals are added to the letters of the horizon designation. These numerals follow all the letters. Within a C horizon, for example, successive layers may be designated C1, C2, C3. If the lower part is gleyed and the upper part is not gleyed, the layers 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 with Arabic numerals, 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 Arabic numerals that follow the respective horizon designations. For example, four layers 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 Arabic numerals that identifies the additional sampling subdivisions follows the first numeral. For example, three layers 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

Arabic numerals are used as prefixes to horizon designations (preceding the letters A, E, B, C, and R) to indicate discontinuities in mineral soils. These prefixes are distinct from the Arabic numerals that are used as suffixes denoting vertical subdivisions.

A discontinuity that can be identified by a number prefix is a significant change in particle-size distribution or min-

Colors associated with horizons that have suffix yy typically are highly whitened with value of 7 through 9.5 and chroma of 2 or less.

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 should directly follow the capital letter.
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 or Crt horizon designations, none of these letters are used in combination in 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. Some examples: Btc, Bkm, and Bsv.
5. If a horizon is buried, the suffix b is written last. It is used only for buried mineral soils.
6. If the above rules do not apply to certain suffixes, such as k, kk, q, or y, the suffixes may be listed together in order of assumed dominance or they are 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 (t has precedence over 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, n, q, y, z, or o. If illuvial clay also is present, t precedes the other symbol: Bto.

Unless needed for explanatory purposes, the suffixes h, s, and w are not used with g, k, n, q, y, z, or o.

the surface. In practice, a description of a soil profile includes soil properties that can be determined only by inspecting volumes of soil. A description of a pedon is commonly based on examination of a profile, and the properties of the pedon are projected from the properties of the profile. The width of a profile ranges from a few decimeters to several meters or more. It should be sufficient to include the largest structural units.

A soil horizon is a layer, approximately parallel to the surface of the soil, distinguishable from adjacent layers by a distinctive set of properties produced by the soil-forming processes. The term layer, rather than horizon, is used if all of the properties are believed to be inherited from the parent material or no judgment is made as to whether the layer is genetic.

The solum (plural, sola) of a soil consists of a set of horizons that are related through the same cycle of pedogenic processes. In terms of soil horizons described in this chapter, a solum consists of A, E, and B horizons and their transitional horizons and some O horizons. Included are horizons with an accumulation of carbonates or more soluble salts if they are either within, or contiguous to, other genetic horizons and are judged to be at least partly produced in the same period of soil formation. The solum of a soil presently at the surface, for example, includes all horizons now forming. It includes a bisequum (to be discussed). It does not include a buried soil or a layer unless it has acquired some of its properties by currently active soil-forming processes. The solum of a soil is not necessarily confined to the zone of major biological activity. Its genetic horizons may be expressed faintly to prominently. A solum does not have a maximum or a minimum thickness.

Solum and soils are not synonymous. Some soils include layers that are not affected by soil formation. These layers are not part of the solum. The number of genetic horizons ranges from one to many. An A horizon that is 10 cm thick overlying bedrock is, by itself, the solum. A soil that consists only of recently deposited alluvium or recently exposed soft sediment does not have a solum. As much as 50 cm of recently deposited sediment is disregarded in classifying the underlying set of genetic horizons (Soil Taxonomy). These thin deposits are not part of the solum but may be otherwise important. By the same convention, a soil is not considered to be buried (*Soil Taxonomy*) unless there is at least 50 cm of overlying sediment that has no genetic horizons in the lower part.

In terms of soil horizons described in this chapter, a

solum consists of A, E, and B horizons and their transitional horizons and some O horizons. Included are horizons with an accumulation of carbonates or more soluble salts if they are either within, or contiguous, to other genetic horizons and are judged to be at least partly produced in the same period of soil formation.

The lower limit, in a general sense, in many soils should be related to the depth of rooting to be expected for perennial plants, assuming that water state and chemistry are not limiting. In some soils the lower limit of the solum can be set only arbitrarily and needs to be defined in relation to the particular soil. For example, horizons of carbonate accumulation are easily visualized as part of the solum in many soils in arid and semiarid environments. To conceive of hardened carbonate accumulations extending for 5 meters or more below the B horizon as part of the solum is more difficult. Gleyed soil material begins in some soils a few centimeters below the surface and continues practically unchanged to a depth of many meters. Gleying immediately below the A horizon is likely to be related to the processes of soil formation in the modern soil. At great depth, gleying is likely to be relict or related to processes that are more geological than pedological. Much the same kind of problem exists in some deeply weathered soils in which the deepest material penetrated by roots is very similar to the weathered material at much greater depth.

For some soils, digging deep enough to reveal all of the relationships between soils and plants is not practical. Roots of plants, for example, may derive much of their moisture from fractured bedrock close to the surface. Descriptions should indicate the nature of the soil-rock contact and as much as can be determined about the upper part of the underlying rock.

A sequum (plural, sequa) is a B horizon together with any overlying eluvial horizons. A single sequum is considered to be the product of a specific combination of soil-forming processes.

Most soils have a single sequum, but some have two or more. A Spodosol, for example, can form in the upper part of an Alfisol, producing an eluviated zone and a spodic horizon underlain by another eluviated zone overlying an argillic horizon. Such a soil has two sequa. Soils in which two sequa have formed, one above the other in the same deposit, are said to be bisequal.

If two sequa formed in different deposits at different

u *Presence of human-manufactured materials (artifacts)*

This symbol indicates the presence of manufactured artifacts that have been created or modified by humans, usually for a practical purpose in habitation, manufacturing, excavation, or construction activities. Examples of artifacts are processed wood products, liquid petroleum products, coal combustion by-products, asphalt, fibers and fabrics, bricks, cinder blocks, concrete, plastic, glass, rubber, paper, cardboard, iron and steel, altered metals and minerals, sanitary and medical waste, garbage, and landfill waste.

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. It 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.

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. 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.

p *Tillage or other disturbance*

This symbol indicates a disturbance of the surface layer 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 are moderately cemented or less cemented. Examples are weathered igneous rock and partly consolidated sandstone, siltstone, or shale. The excavation difficulty is low to high.

s *Illuvial accumulation of sesquioxides and organic matter*

This symbol is used with B to indicate an accumulation of illuvial, amorphous, dispersible complexes of organic matter and sesquioxides if both the organic matter and sesquioxide components are significant and if either the color value or chroma, moist, of the horizon is 4 or more. The symbol is also used in combination with h as “Bhs” if both the organic matter and sesquioxide components are significant and if the color value and chroma, moist, are 3 or less.

ss *Presence of slickensides*

This symbol indicates the presence of 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.

times, the soil is not bisequal. For example, a soil having an A-E-B horizon sequence may form in material that was deposited over another soil that already had an A-E-B horizon sequence. Each set of A-E-B horizons is a sequum but the combination is not a bisequum. The lower set is a buried soil.

If the horizons of the upper sequum extend into the underlying sequum, the affected layer is considered part of the upper sequum. For example, the A horizon of the lower soil may retain some of its original characteristics and also have some characteristics of the overlying soil. Here, too, the soils are not considered bisequal; the upper part of the lower soil is the parent material of the lower part of the currently forming soil. In many soils the distinction cannot be made with certainty. Nevertheless, the distinction is useful when it can be made. Where some of the C material of the upper sequum remains, the distinction is clear.

Contrasting materials. Changes with depth that are not primarily related to pedogenesis but rather to geological processes are contrasting soil materials if they are sufficient to affect use and management. The term discontinuity is applied to certain kinds of contrasting soil materials.

Unconsolidated contrasting soil material may differ in pore-size distribution, particle-size distribution, mineralogy, bulk density, or other properties. Some of the differences may not be readily observable in the field. Some deposits are clearly stratified, such as some lake sediments and glacial outwash, and the discontinuities may be sharply defined.

Contrasting materials can be confused with the effects of soil formation. Silt content may decrease regularly with depth in soils presumed to have formed in glacial till. The higher silt content in the upper part of these soils can be explained by factors other than soil formation. In some of these soils, small amounts of eolian material may have been deposited on the surface over the centuries and mixed by insects and rodents with the underlying glacial till. In others, the silt distribution reflects water sorting.

Inferences about contrasting properties inherited from differing layers of geologic material may be noted when the soil is described. Generally, each identifiable layer that differs clearly in properties from adjacent layers is recognized as a subhorizon. Whether it is recognized as a discontinuity or not depends on the degree of contrast with overlying and underlying layers and the thickness. For many soils, the properties inherited from even sharply contrasting layers are

not consistent from place to place and are described in general terms. The C layer of a soil in stratified lake sediments, for example, might be described as follows: "consists of layers of silt and clay, 1 to 20 cm thick; the aggregate thickness of layers of silt and that of the layers of clay are in a ratio of about 4 to 1; material is about 80 percent silt."

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, 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: *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 layers consist of undecomposed or partially decomposed litter (such as leaves, needles, twigs, moss, and lichens) that has been deposited on the surface. They may be on top of either mineral or organic soils. Other O layers consist of organic material that was deposited under saturated conditions and has 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 layer may be on the surface of a mineral soil, or it may be at any depth below the surface if it is buried. A horizon formed by the illuviation of organic material into a mineral subsoil is not an O horizon, although some horizons that have formed in this manner contain considerable amounts of organic matter.

L horizons or layers: *Limnic horizons or layers include*

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 the stage III plugged horizon or higher of the carbonate morphogenetic stages (Gile et al., 1966).

m *Cementation or induration*

This symbol indicates continuous or nearly continuous cementation. It is used only for horizons that are more than 90 percent 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.

ma *Marl*

This symbol, used only with L, 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.

ers that have a temperature warmer than 0°C 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 g is used with B, pedogenic change 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 to indicate the accumulation of illuvial, amorphous, dispersible complexes of organic matter and sesquioxides if the sesquioxide component is dominated by aluminum but is present only in very small quantities. The organosesquioxide material coats sand and silt particles. In some horizons these coatings have coalesced, filled pores, and cemented the horizon. The symbol h is also used in combination with s as “Bhs” if the amount of the sesquioxide component is significant but the color value and chroma, moist, of the horizon are 3 or less.

This symbol is used with O 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 chromas as low as 3 or 4 have 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

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 are used only in *Histosols*. 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.

A horizons: *Mineral horizons that have 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 the following: (1) an accumulation of humified organic matter closely mixed with the mineral fraction and not dominated by properties characteristic of E or B horizons (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 of 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: *Mineral horizons in which the main feature is the loss of silicate clay, iron, aluminum, or some combination of these, leaving a concentration of sand and silt particles. These horizons 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 surface, below an O or A horizon and above a B horizon, but eluvial horizons that are within or between parts of the B horizon or extend to depths greater than those of normal observation

can be assigned the letter E if they are pedogenic.

B horizons: *Horizons that have formed below an A, E, or O horizon. They are dominated by the obliteration of all or much of the original rock structure and show one or more of the following:*

1. *Illuvial concentration of silicate clay, iron, aluminum, humus, carbonates, gypsum, or silica, alone or in combination.*
2. *Evidence of the removal, addition, or transformation of carbonates and/or gypsum.*
3. *Residual concentration of oxides.*
4. *Coatings of sesquioxides that make the horizon conspicuously lower in color value, higher in chroma, or redder in hue, without apparent illuviation of iron.*
5. *Alteration that forms silicate clay or liberates oxides, or both, and that forms a granular, blocky, or prismatic structure if volume changes accompany changes in moisture content.*
6. *Brittleness.*
7. *Strong gleying.*

All of the different kinds of B horizons are, or were originally, subsurface horizons. Some examples included as B horizons where contiguous to other genetic horizons are layers of illuvial concentration of carbonates, gypsum, or silica that are the result of pedogenic processes (and may or may not be cemented) and brittle layers 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 gleying but no other pedogenic changes.

C horizons or layers: *Horizons or layers, excluding strongly cemented and harder bedrock, that are little affected by pedogenic processes and lack the properties of O, A, E, or B horizons. Most are mineral layers. 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 sedi-

b *Buried genetic horizon*

This symbol is used in mineral soils 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 soil. This symbol is not used in organic soils, nor is it used to separate an organic layer from a mineral layer.

c *Concretions or nodules*

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

co *Coprogenous earth*

This symbol, used only with L, indicates a limnic layer of coprogenous earth (or sedimentary peat).

d *Physical root restriction*

This symbol indicates noncemented, root-restricting layers in naturally occurring or human-made sediments or materials. Examples are dense basal till, plowpans, and other mechanically compacted zones.

di *Diatomaceous earth*

This symbol, used only with L, indicates a limnic layer of diatomaceous earth.

e *Organic material of intermediate decomposition*

This symbol is used with O to indicate organic materials of intermediate decomposition. The fiber content of these materials is 17 to 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°C and does not contain enough ice to be cemented by ice. This suffix is not used for horizons or lay-

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 described separately. One horizon then has several lamellae and eluvial layers and can be designated 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 kinds of master horizons and layers. The term “accumulation” is used in many of the definitions of such horizons 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 suffix symbols and their meanings are as follows:

a *Highly decomposed organic material*

This symbol is used with O to indicate the most highly decomposed organic materials, which have a fiber content of less than 17 percent (by volume) after rubbing.

ment, saprolite, bedrock, and other geologic materials that are moderately cemented or less cemented. 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, 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. If a cemented layer formed through pedogenic processes, however, it is considered a B horizon.

R layers: *Strongly cemented to indurated bedrock.*

Granite, basalt, quartzite, limestone, and sandstone are examples of bedrock 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 cracks, but these are generally too few and too small to allow root penetration. The cracks may be coated or filled with clay or other material.

M layers: *Root-limiting subsoil layers consisting of nearly continuous, horizontally oriented, human-manufactured materials.*

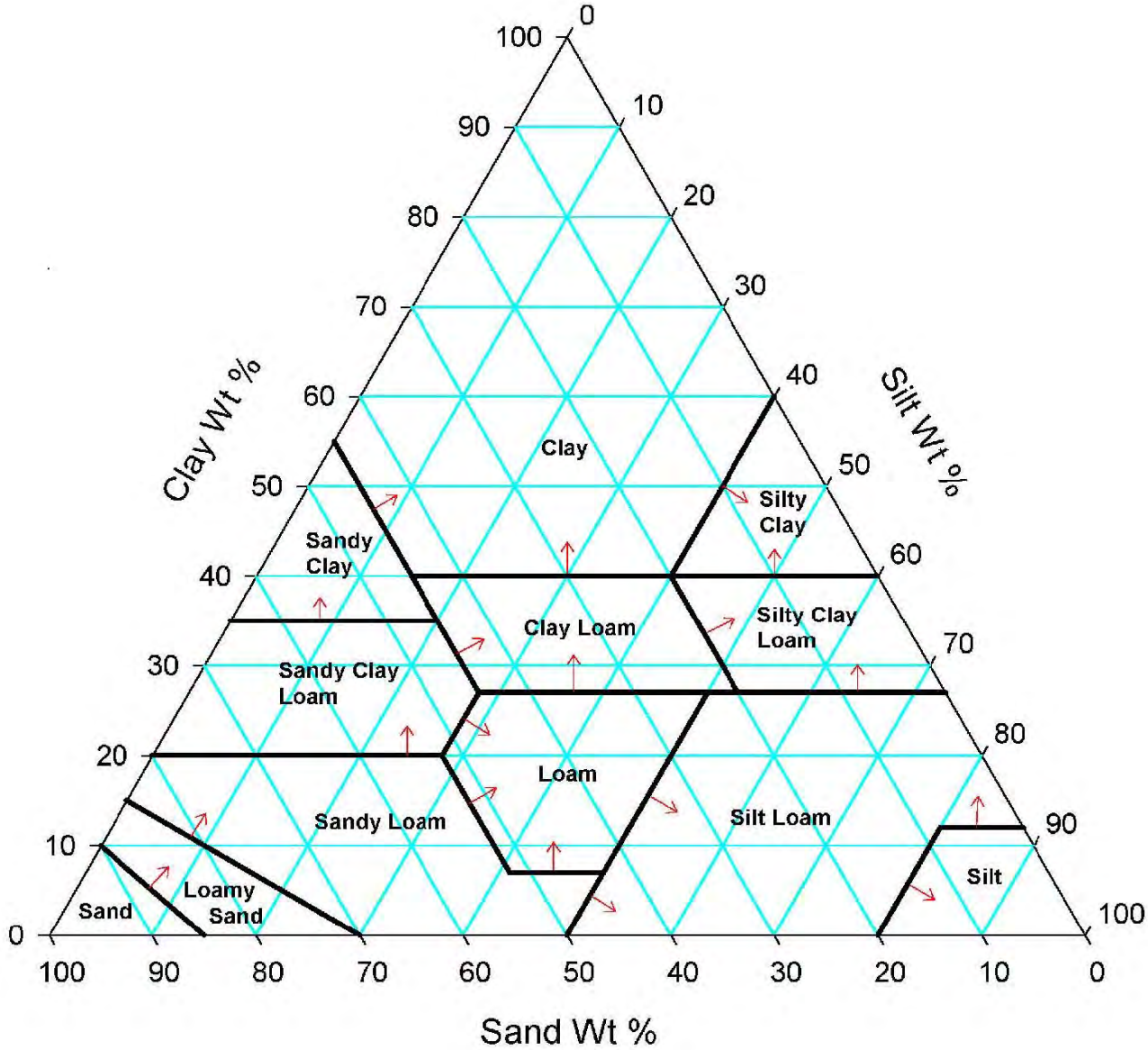
Examples of materials designated by the letter M are geotextile liners, asphalt, concrete, rubber, and plastic.

W layers: *Water*

This symbol indicates water layers within or beneath the soil. 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

Texture Triangle