Lesson 6: Soil Horizons

The first lesson states some reasons for studying soil. In subsequent lessons, factors and processes that affect the soil are discussed, along with three of the basic soil properties: color, texture, and structure. With this information, the horizons can be located and their properties can be determined. The properties from a particular soil can be interpreted in terms of factors and processes of soil formation. The student can also learn how to describe and interpret soil properties.

A soil horizon is a layer of soil parallel to the earth's surface. It has a unique set of physical, chemical, and biological properties. The properties of soil horizons, such as texture, color, and structure, are the results of the soil-forming processes, and they distinguish each horizon from other horizons above and below it.

Pedon and Soil Profiles

When soil horizons are studied, the student needs to know how much of the soil must be observed or studied. The smallest volume that can be called "soil" is a **pedon** (peh-don). A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from 10 to 100 square feet (1–10 square meters), depending on the variability of the soil.

Also, if soil horizons are to be studied, a soil profile is needed. A soil profile is a vertical section (a cut or a hole in the ground) of a soil pedon beginning at the surface and continuing down through all of its horizons, including the parent material.

Master Soil Horizons

Soil horizons are named using combinations of letters and numbers. Six general kinds of horizons may occur in soil profiles. They are named with the capital letters O, A, E, B, C, and R. These are called **master horizons.** In Figure 6.1, each master horizon is shown in the relative position in which it occurs in a soil profile. All six master horizons are shown, even though a soil usually has only three or four horizons.

Gradual changes from one master horizon to another give rise to transitional horizons. These are named with two letters, for example, AB, BA, and BC. Subordinate divisions of master horizons are named by adding lower case letters, for example, Ap, Bt, and Cr. Thick horizons may be subdivided using Arabic numerals, such as A1 and A2, or Bw1, Bw2, and Bw3. Transitional horizons, subordinate divisions of master horizons, and subdivisions of thick horizons are discussed later in this lesson.

A single soil profile may never have all the horizons that are possible. Most Missouri soils have A, B, C, and one or two transitional horizons. Other Missouri soils may have an A horizon resting directly on a C or R horizon, or an A-E-B-C horizon sequence, or even an O-E-B-C horizon sequence. Originally, the letters A, B, and C were used to indicate the consecutive order of the horizons. Later, for more clarity, O, E, and R were added, O meaning "organic," E meaning "eluviation," and R meaning "bedrock."

Because all six master horizons occur somewhere in Missouri or the United States, it is important to know what each one is and how it differs from the others. Each master horizon has a distinct set of properties.

O Horizon

The O stands for "organic." O horizons do not have to be 100 percent organic matter material. Forest soils usually have thin organic horizons at the surface. They consist of leaves and twigs in various stages of decay.

Wet soils in bogs or drained swamps often have O horizons of peat or muck. Very few soils in Missouri have O horizons of this kind. Most soils in Missouri have only thin O horizons, and these are usually forests. O horizons are destroyed by plowing and do not occur in cultivated areas.

A Horizon

The A horizon is the surface horizon of a mineral soil. Its unique characteristic is a dark color formed by the addition of humus. See Plates 2, 7, 10, 12, and 13, pp. 50-A to 50-D. The A horizon is also typified by a granular or fine blocky structure (aggregate shape) and friable consistence (easily crushed).

The thickness of the A horizon ranges from a few inches in most forested soils to more than 30 inches in some upland prairie soils and some alluvial soils on flood plains. Every cultivated agricultural soil has an A horizon.

A horizons are extremely important in maintaining soil fertility and providing a favorable environment for root growth. They should be protected from erosion and compaction.

E Horizon

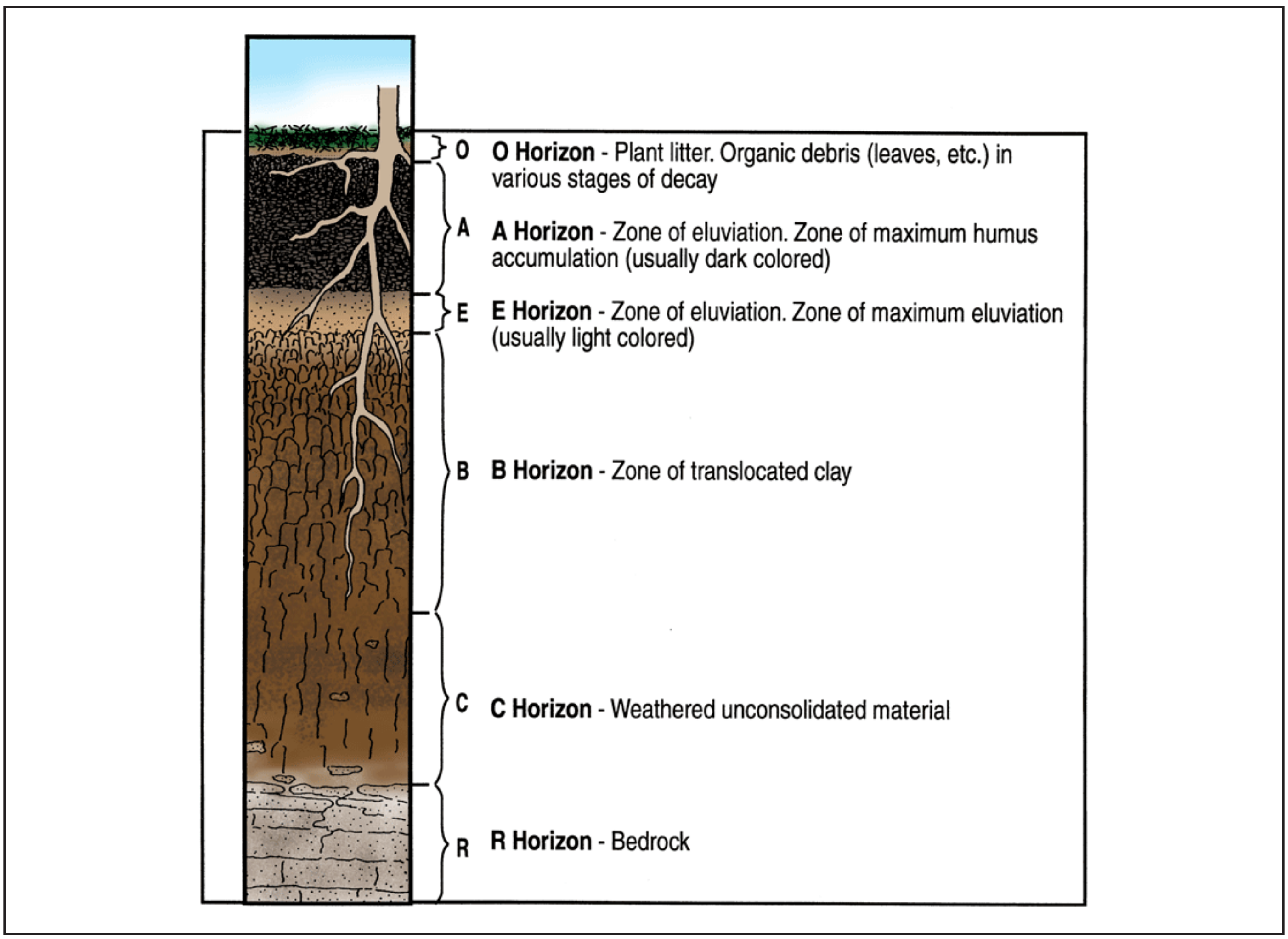
This horizon is generally grayish brown to white in color. It is not present in all Missouri soils, but when it is, it occurs immediately beneath an O or an A horizon. See Plates 11, 12, and 13, pp. 50-C and 50-D. E horizons are light colored because nearly all the iron and organic matter have been removed. One can think of the E as meaning "eluviation" or "leaching" (This horizon was formerly referred to as the A2 horizon.)

E horizons occur in most forested soils that have not been cultivated, and in several of the prairie soils in Missouri. In most soils, the E horizon has noticeably less clay than the B horizon beneath it.

B Horizon

The B horizon is the subsoil layer that generally changes the most because of soil-forming processes. Several kinds of changes are possible.

Figure 6.1 – Master Horizons



In some soils, the B horizon has bright yellowish-brown, reddish-brown, or red colors. See Plates 5 and 9, pp. 50-B and 50-C. In others, it has the most evident blocky or prismatic structure. See Plate 6, p. 50-B. (Lesson 5 has a detailed discussion on structure.) Many B horizons have more clay than other horizons, and clay films may be visible. Kinds of B horizons are discussed more fully in the section, "Subordinate Divisions of Master Horizons," in this lesson.

C Horizon

The C horizon is weathered, unconsolidated geologic material below the A or B horizon. Anything that one can dig with a spade, which has not been changed very much by the soil-forming processes, is considered C horizon.

R Horizon

R stands for "bedrock." It refers to hard bedrock that one cannot easily dig with a spade. Depending on the depth to bedrock, the R horizon may occur directly beneath any of the other master horizons. See Plate 1, p. 50-A.

Horizon Boundaries

The boundary between any two horizons can vary both in distinctness and in form. Some boundaries are very sharp. Others merge gradually into the horizon below.

The nature of the boundary provides clues to soil development and to certain aspects of soil behavior. An abrupt boundary, for example, may indicate a sudden change to another kind of material, either geologic or formed by soil development. Such a change may limit root penetration, or it may signal a different rate of water movement through the soil. See Plate 20, p. 50-E. Gradual boundaries, on the other hand, may indicate a very young soil, or a deep, highly weathered, old soil. See Plates 2, 5, and 21, pp. 50-A, 50-B, and 50-F. Terms used to describe boundary distinctness are "abrupt," "clear," "gradual," and "diffuse." See Figure 6.2.

The form, or shape, of horizon boundaries also may be described. Evaluation of this characteristic, however, requires careful examination of a soil profile to be sure that the true relationship between soil horizons has been discovered. Terms used to describe boundary form are "smooth," "wavy," "irregular," and "broken." See Figure 6.3.

Figure 6.2 – Classes of Horizon Boundary Distinctness

Abrupt:
Boundary is less than 1 inch (2.5 cm) wide.

Clear:
Boundary is 1–2.5 inches (2.5–6 cm) wide.

Gradual:
Boundary is 2.5–5 inches (6–12.5 cm) wide.

Diffuse:
Boundary is more than 5 inches (12.5 cm) wide.

Figure 6.3 – Classes of Horizon Boundary Form

Smooth:
Nearly a plane.

Wavy:
Shallow pockets are wider than they are deep.

Irregular:
Pockets are deeper than their width.

Broken:
Parts of the horizon are unconnected with other parts.

Transitional Horizons

Master horizons rarely change abruptly from one to another. Instead, the changes occur gradually throughout a zone that may be 5 to 10 inches thick. These zones are called **transitional horizons**. There are three common ones in Missouri soils: AB, BA, and BC. See Figure 6.4.

AB Horizon

This transitional horizon occurs between the A and B horizons. It is dominated by properties of the A, but some of the properties of the B are evident. Dark colors associated with organic matter are fading because organic matter is decreasing. The structure often changes from granular to subangular blocky. See Plate 22, p. 50-F.

BA Horizon

This horizon also occurs between the A and the B, but it has more characteristics of the B horizon. Generally, the structure will be the same type as the B, but less strongly expressed. The color may be a little darker than the B, or the clay content may be less than the maximum in the B. See Plate 23, p. 50-F.

BC Horizon

This is a transition from the B to the C horizon. Properties of the B are dominant, but some influence of the C horizon is evident. In some pedons, the clay content will be less than the maximum in the B, but more than in the C. The C is structureless (massive), and the BC has structure, but the BC may have larger units and be more weakly expressed than the B.

Subordinate Divisions of Master Horizons

Many horizons are the result of unique processes that leave a distinct mark on the horizon. These horizons are identified with a lower-case letter immediately following the master horizon symbol. More than 25 letters and combinations of letters are possible. Only the eight subordinate divisions of master horizons most common in Missouri are discussed here.

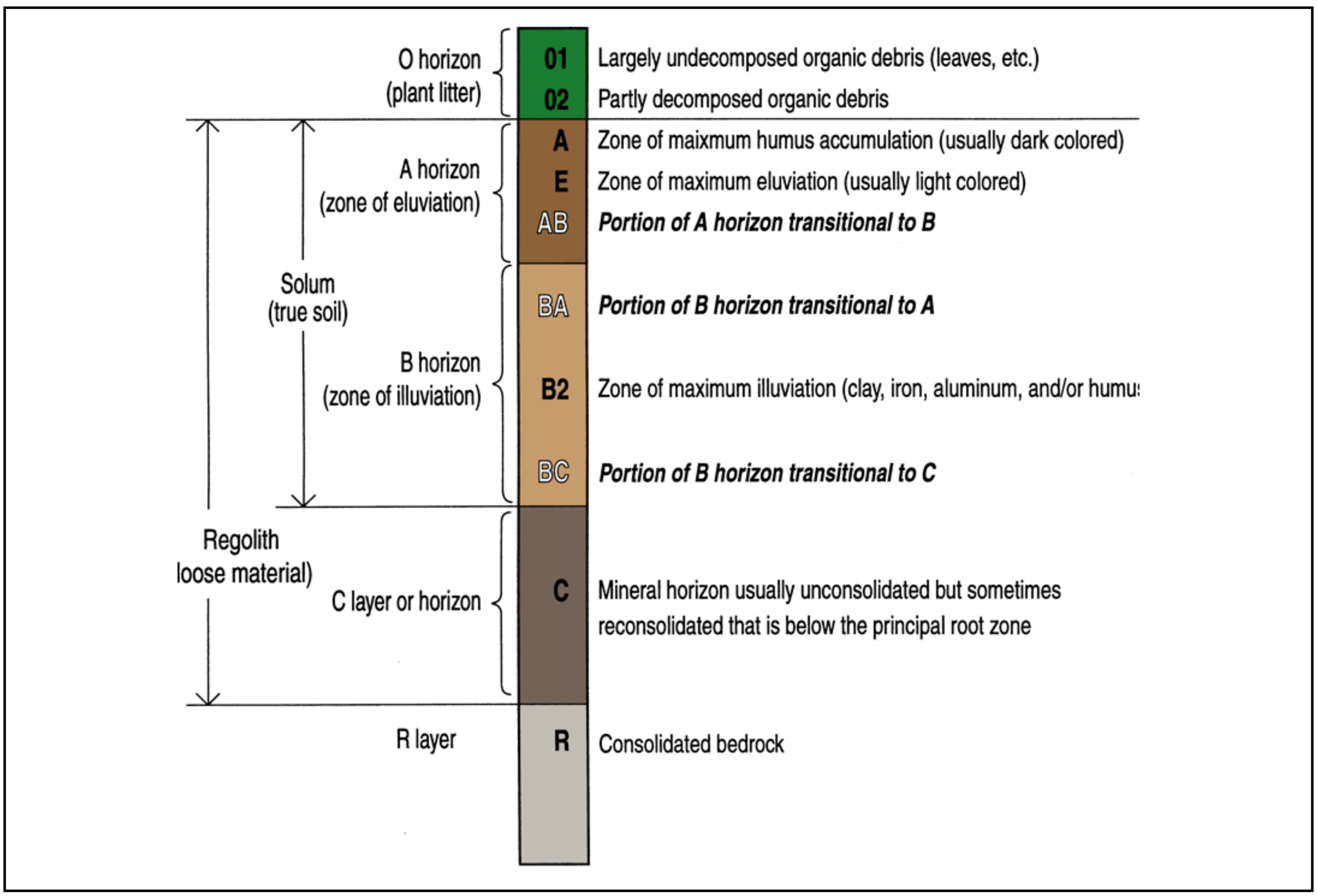
Oi Horizon

The Oi horizon is a layer covering the A horizon with a layer of slightly decomposed twigs and leaves.

Ap Horizon

The surface horizon of any soil that has been plowed or cultivated is called the "plow layer." That is what the "p"

Figure 6.4 – Transitional Horizons



stands for. Cultivation thoroughly mixes the upper 8–12 inches (20–30 cm) of the soil and destroys any natural horizons that may have been present.

If the original A was very thick, plowing converts the upper part into an Ap, and the lower part remains simply as an A horizon. If the original A was very thin, then the Ap could rest on a B, C, or transitional horizon. Even where a soil has been severely eroded, such that all the original A is gone, plowing an exposed B or C horizon would automatically make the surface horizon an Ap. See Plates 4 and 24, pp. 50-A and 50-F.

Bt Horizon

The "t" stands for "translocated clay." Textural B horizons have distinctly more clay in them than the horizons above or below them. One may feel the difference by working a small amount of moist soil between the thumb and index finger. Soil that is high in clay content will ribbon or feel slick. See Figure 4.5 in Lesson 4.

Some of the clay comes from the soil horizons above the Bt horizon. Water moving down through the soil carries very fine clay particles with it. When the downward movement stops, the clay particles are deposited, building up the waxy coatings called clay films. Some of the clay also comes from the weathering of original minerals in the Bt horizon.

Bt horizons are quite common in Missouri soils. They usually have well-developed, blocky, or prismatic structure. See Plates 6 and 11, pp. 50-B and 50-C.

Bg Horizon

The "g" stands for "gleyed" (glayed). That means the horizon is very wet for long periods of time. Iron in the soil is chemically reduced, and much of it has been leached out of the soil. As a result, gleyed horizons are usually dark gray. See Plate 13, p. 50-D. They may also be mottled.

Gleyed horizons usually indicate that the soil is poorly or very poorly drained. Gleying is not restricted to the B horizon. Other gleyed horizons include the Ag, Eg, BAg, BCg, and Cg.

Bw Horizon

Think of the "w" as meaning "weathered." Bw horizons have been changed by weathering, but not enough to form a Bt or Bg. In Missouri soils, the Bw differs from the C by having weak or moderate blocky structure. The Bw may also have a brighter color, and it may be more leached than the C. Bw horizons are common in young soils of flood plains and low stream terraces. See Plate 4, p. 50-A.

Bx Horizon

This refers to a special feature called a **fragipan** (fraj-ah-pan). It typically is a massive, dense, but not cemented, soil horizon. This horizon is often mottled and has seams of gray silt scattered throughout. See Plates 25, 26, and 27, p. 50-G. The fragipan is so dense that neither plant roots nor water can readily penetrate, except in the gray silt seams. In Missouri, fragipans occur mostly in gently sloping upland soils and some high terrace soils in southern Missouri.

Bk Horizon

This horizon has an accumulation of translocated calcium carbonate, or free lime. Carbonates leached from upper horizons have been redeposited in the Bk horizon. There are visible white streaks or nodules of free lime. A way to test for lime is to apply a drop of diluted hydrochloric acid (10% HCl) on the soil. Nodules of fine lime will bubble violently (effervesce).

Some soils on the Missouri River flood plain and in the uplands of northwest Missouri have free lime throughout their profiles. The "k" is used only to indicate a horizon enriched in visible deposits of carbonates by translocation. A Bk horizon may very well have an ordinary C horizon beneath it that contains only its original amount of calcium carbonate.

Cr Horizon

The Cr horizon consists of weathered bedrock, or rock that is soft enough to slice with a knife or a spade. The original rock structure is often visible, but the rock is not hard enough to be designated as an R horizon.

Subdivisions of Thick Horizons

Sometimes one or two of the master horizons or subordinate divisions in a soil are so thick that they need to be classified into special subdivisions. Subdivisions are vertical sequences within any single horizon. Small changes in texture, color, or structure are commonly used to make the subdivision.

Subdivisions are always indicated by a number immediately following the letter symbol(s). Figure 6.5 offers a few examples of some thick soil horizons that are subdivided.

Figure 6.5 – Subdivisions of Thick Horizons

Thick A Horizon: A1, A2

Thick Bg Horizon: Bg1, Bg2

Thick Bt Horizon: Bt1, Bt2

Thick Bw Horizon: Bw1, Bw2

Thick C Horizon: C1, C2

Bt { **Bt1** / **Bt2**

Lithologic Discontinuities

Parent material is the geologic material from which soils form. It may be material from a flood deposit (alluvium), material weathered from rock in place (residuum), windblown material (loess), material moved by gravity (colluvium), or material moved by glaciers (glacial till). When all the horizons of a soil have formed in a single kind of parent material, the ordinary A, B, and C designations for those horizons are used.

Some soils, however, have formed in more than one kind of parent material. A flooding river, for example, may deposit fresh silt on top of older sands and gravels. In northern Missouri soils, loess may be deposited on glacial till. In southern Missouri soils, it is common to have a very thin layer of loess over residuum or colluvium, or colluvium may be deposited on residuum.

If soil horizons are developed in more than one parent material, a number is placed in front of the horizon letter symbol to indicate its position from the top down. This is referred to in soil science as a **lithologic discontinuity**. A lithologic discontinuity expresses a significant change in texture and/or mineralogy that indicates a difference in parent material from which the horizons formed. The geologic material at the surface is always assumed to be first, and the number 1 is never used. The second geologic material is indicated by a 2, the third by a 3, and so on. Thus, a soil formed in silt over gravel could have the following set of horizons: A-AB-B-2BC-2C. See Plates 9, 17, and 28, pp. 50-C, 50-E, and 50-G.

Common Horizon Sequences

Several official Missouri profiles that are presently used by the United States Department of Agriculture's Natural Resources Conservation Service are listed in Figure 6.6. The names of the horizons in the typical profile are given, along with the landform. Nearly all geographic areas of Missouri are represented on this list.

Figure 6.7 gives an example of an Official Soil Description (OSD) of the Menfro series. It is a soil common to the hills adjacent to the Missouri and Mississippi Rivers.

Summary

The smallest volume that can be called a soil is a pedon. A pedon is three-dimensional and large enough to permit study of all horizons.

A soil profile is a vertical section of a soil pedon beginning at the surface and continuing down through all of the horizons, including the parent material. Six kinds of horizons may occur in soil profiles. They are called master horizons and are named with capital letters: O, A, E, B, C, and R.

The boundary between any two horizons can vary both in distinctness and in form. Some boundaries are very sharp (abrupt), while others are gradual. Most changes in horizons are gradual. Generally, if the change occurs over more than 5 inches, there is a zone called a transitional horizon. A transitional horizon usually has properties of both the horizon above and the one below. Transitional horizons are named by using the two capital letters of the two horizons they separate.

Some horizons have special features, which are identified by a lower-case letter immediately following the master horizon letter symbol.The eight most common in Missouri are i (slightly decomposed organic material), p (plow layer), t (translocated clay), g (gleyed), w (weathered), x (fragipan), k (translocated calcium), and r (soft bedrock).

Some horizons are very thick but may have small changes in texture, color, or structure, which require further division. Thick horizons are identified by adding a numeral after the letter symbol(s).

Lithologic discontinuities are soils formed in more than one parent material. They are indicated by a numeral placed in front of the letter symbol(s).

Some common horizon sequences are listed. An Official Soil Description is given.

Figure 6.6 – Common Horizon Sequences in Missouri

Arbela:
Ap, E, Btg, BCg (flood plain)

Arisburg:
Ap, A, Bt, Btg1, Btg2, Btg3, Btg4, Cg (upland)

Armstrong:
Ap, E, BE, Bt1, 2Bt2, 2Bt3, 2Bt4, 2BC (upland)

Barco:
A1, A2, Bt1, Bt2, Bt3, Bt4, Cg (upland)

Bardley:
A, E, 2Bt1, 2Bt2, 2Bt3, R (upland)

Bolivar:
Ap, E, BE, Bt1, Bt2, Bt3, Cr, R (upland, see Plate 1, p. 50-A)

Caneyville:
Oi, A, E, Bt1, Bt2, R (upland)

Cedargap:
A1, A2, A3, C1, C2 (flood plain)

Chariton:
Ap, E, BE, Btg1, Btg2, Btg3, 2Cg (stream terrace)

Clarksville:
Oi, A, E, BE, Bt1, Bt2, 2Bt3, 2Bt4, 2C (upland)

Creldon:
A1, A2, Bt1, Bt2, Bt3, 2Btx1, 2Btx2, 3Bt1, 3Bt2 (upland)

Dockery:
Ap, C1, C2, C3, C4 (flood plain)

Gasconade:
A, Bw, R (upland)

Gepp:
A, E, BE, 2Bt1, 2Bt2 (upland, see Plate 28, p. 50-G)

Grundy:
Ap, A, BA, Btg1, Btg2, Btg3, Btg4, Cg (upland, see Plate 7, p. 50-B)

Hamburg:
A, AC, C1, C2 (upland)

Lebanon:
Ap, BE, Bt1, Bt2, Bt3, 2Ex, 2Bx, 2Bt1, 2Bt2, 2Bt3 (upland)

Leonard:
Ap, Btg1, Btg2, 2Btg3, 2Btg4, 2Btg5 (upland)

Menfro:
Ap, E, BE, Bt1, Bt2, Bt3, C (upland, see Plate 24, p. 50-F)

Niangua:
A, E, 2Bt1, 2Bt2, 2Bt3, 2R (upland)

Nodaway:
Ap, C (flood plain)

Racket:
A1, A2, A3, A4, 2C (flood plain)

Sibley:
Ap, A1, A2, Bt1, Bt2, Bt3, C1, C2 (upland)

Vesser:
Ap, E1, E2, Btg1, Btg2, BCg (flood plain)

Figure 6.7 – Sample of an Official Soil Description (OSD)

MENFRO SERIES

The Menfro series consists of very deep, well-drained, moderately permeable soils formed in thick loess deposits on upland ridgetops, backslopes, and benches adjacent to the Missouri and Mississippi Rivers and their major tributaries. Slopes range from 2 to 60%. Mean annual temperature is 56° F, and mean annual precipitation is 36 inches.

TAXONOMIC CLASS: Fine-silty, mixed, mesic Typic Hapludalfs.

TYPICAL PEDON: Menfro silt loam-pasture. (Colors are for moist soil unless otherwise stated.)

Ap: 0–6 inches; dark brown (10YR 3/3) silt loam; dark brown (10YR 4/3) rubbed; pale brown (10YR 6/3) dry; moderate, very fine granular structure; very friable; many fine roots; neutral; abrupt smooth boundary. (6–9 inches thick)

E: 6–12 inches; dark brown (10YR 4/3) silt loam; weak, thin, platy structure parting to weak very fine subangular blocky; friable; common fine roots; moderately acid; clear smooth boundary. (0–8 inches thick)

BE: 12–15 inches; dark yellowish brown (10YR 4/4) silt loam; weak fine subangular blocky structure; friable; common fine roots; moderately acid; clear smooth boundary. (0–8 inches thick)

Bt1: 15–30 inches; dark brown (7.5YR 4/4) silty clay loam; moderate fine and medium subangular blocky structure; firm; few fine roots; many faint clay films on faces of peds; slightly acid; clear smooth boundary.

Bt2: 30–40 inches; dark brown (7.5YR 4/4) silty clay loam; strong medium angular blocky structure; firm; few fine roots; many distinct clay films on faces of peds; common fine pores and old root channels with clay linings; slightly acid; gradual smooth boundary.

Bt3: 40–68 inches; dark yellowish brown (10YR 4/4) silty clay loam; weak fine subangular blocky structure; friable; few faint clay films on faces of peds and vertical surfaces; slightly acid; diffuse wavy boundary. (Combined thickness of the Bt horizon is 24–75 inches.)

C: 68–86 inches; dark brown (10YR 4/3) silt loam; few fine faint brown (10YR 5/3) mottles; massive; friable; slightly acid.

TYPE LOCATION: Boone County, Missouri. About 40 feet west of center Rocheport Road, 450 feet south of the south end of Rocheport overpass over interstate 70; about 132 feet east and 1,320 feet north of the southewest corner of sec. 8, T. 48 N., R. 14 W.

Credits

Huddleston, J. Herbert, and Gerald F. Kling. *Manual for Judging Oregon Soils*. Corvallis: Oregon State University Extension Service, 1984.

Soil Survey Division Staff. *Soil Survey Manual, Handbook #18,* rev. Washington, DC: U.S. Government Printing Office, U.S. Department of Agriculture, Soil Conservation Service, 1993.

Soil Survey Division Staff, Lincoln, Nebraska. *National Soils Survey Handbook* (Title 430-VI). Washington, DC: U.S. Department of Agriculture, Soil Conservation Service, 1993.