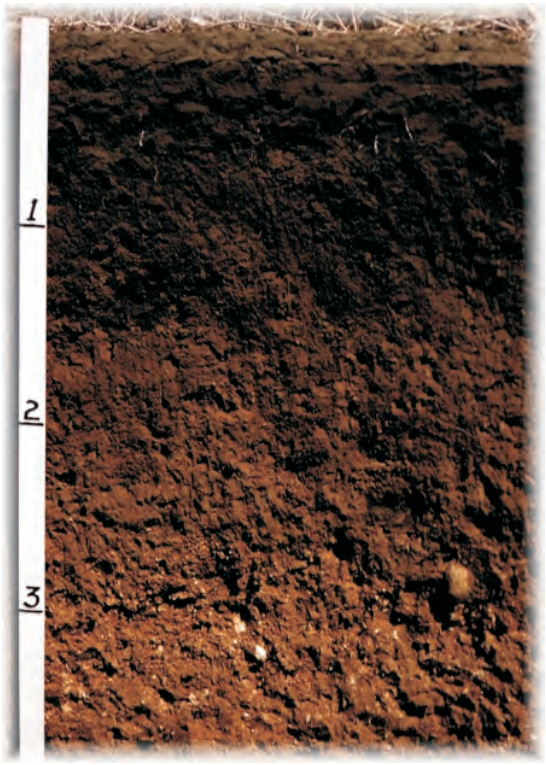
Explaining a Soil Profile

HAVE YOU NOTICED at construction sites how a cross section of soil has a layered look? Soil near the top of the cross section is often dark, and soil below appears lighter. What you have seen is a soil profile. In this unit, factors that contribute to the layered look you have seen will be discussed.



(Courtesy, Natural Resources Conservation Service, USDA)

Objective:

Explain the soil profile.

Key Terms:

addition
eluviation
illuviation
loss
soil horizons
soil profile
solum
subsoil
substratum
topsoil
transformation
translocation

Soil Profile

A **soil profile** is a vertical cross section of the soil. When exposed, various **soil horizons**, or layers of soil, become apparent. Each horizon of soil may be different from the other horizons in physical or chemical ways. The differences are developed from the interaction of such soil-forming factors as parent material, slope, native vegetation, weathering, and climate.

A soil profile is usually studied to a depth of 3 to 5 feet. To see the soil profile, soil cores may be taken or holes dug to expose the profile. A soil core or auger allows the extraction of a cylinder of soil for study.

FIGURE 1. Soil profile. (Courtesy, Natural Resources Conservation Service, USDA)

CHANGES TO THE SOIL PROFILE

As a soil ages, horizontal layers develop and changes result. The causes of these changes are classified as four processes. Each process occurs differently at various depths in the soil.

- **Addition**—This process occurs as materials such as fallen leaves, windblown dust, or chemicals from air pollution are added to the soil.
- **Loss**—This process occurs when materials are lost from the soil because of deep leaching or erosion from the surface.
- **Translocation**—This process involves the movement of materials within the soil. It can occur with deeper leaching into the soil or with upward movement caused by evaporating water.
- **Transformation**—In this process, materials are altered in the soil. Examples are organic-matter decay, weathering of minerals to smaller particles, and chemical reactions.

SOIL HORIZONS

There are three primary soil horizons, called master horizons. They are *A, B,* and *C.* These are part of a system for naming soil horizons in which each layer is identified by a code: *O, A, E, B, C,* and *R.*

The *O* horizon is an organic layer made up of partially decayed plant and animal debris. It generally occurs in undisturbed soil, such as in a forest.

The *A* horizon is often referred to as the **topsoil** and is the surface layer where organic matter accumulates. Over time, this layer loses clay, iron, and other materials because of leaching. The movement of organic matter, chemical substances, and mineral particles from the upper horizons of soil to the lower horizons by the downward movement of water is called

ON THE JOB...

CAREER CONNECTION: Soil Scientist

Soil scientists study the chemical, physical, biological, and mineral characteristics of soil. Their study of the soil is frequently associated with plant growth. The work of a soil scientist might include the responses of various soil types to fertilizers, soil composition, and drainage patterns. Soil scientists are called upon to provide information and recommendations to nursery owners and operators regarding the best use of land, plant growth, and soil erosion. Application of precision technologies has grown in importance for practicing soil scientists.

A soil scientist generally pursues an associate's or baccalaureate degree in soil science. Many soil scientists obtain further formal education through postgraduate studies.

Numerous career opportunities are available with government agencies conducting soil surveys and classifying and mapping soils. Private industry also provides opportunities for qualified individuals.

(Courtesy, Natural Resources Conservation Service, USDA)

eluviation. The *A* horizon provides the best environment for the growth of plant roots, microorganisms, and other life.

The *E* horizon is the zone of greatest eluviation. Because the clay, chemicals, and organic matter are leached, the color of the *E* horizon is very light. This horizon usually occurs in sandy forest soils with high amounts of rainfall.

The *B* horizon is often referred to as the **subsoil**. It is often called the "zone of accumulation" because chemicals leached from the *A* and *E* horizons accumulate here. The accumulation of organic matter, chemical substances, and mineral particles in the lower horizons of soil from the upper horizons as a result of the downward movement of water is called **illuviation**. The *B* horizon has less organic matter and more clay than the A horizon. Together, the *A, E,* and *B* horizons are known as the **solum**. This is where most of the plant roots grow.

The *C* horizon is called the **substratum**. It lacks the properties of the *A* and *B* horizons because it is influenced less by the soil-forming processes. It is usually the parent material of the soil.

The *R* horizon is the underlying bedrock, such as limestone, sandstone, or granite. It is found beneath the *C* horizon.

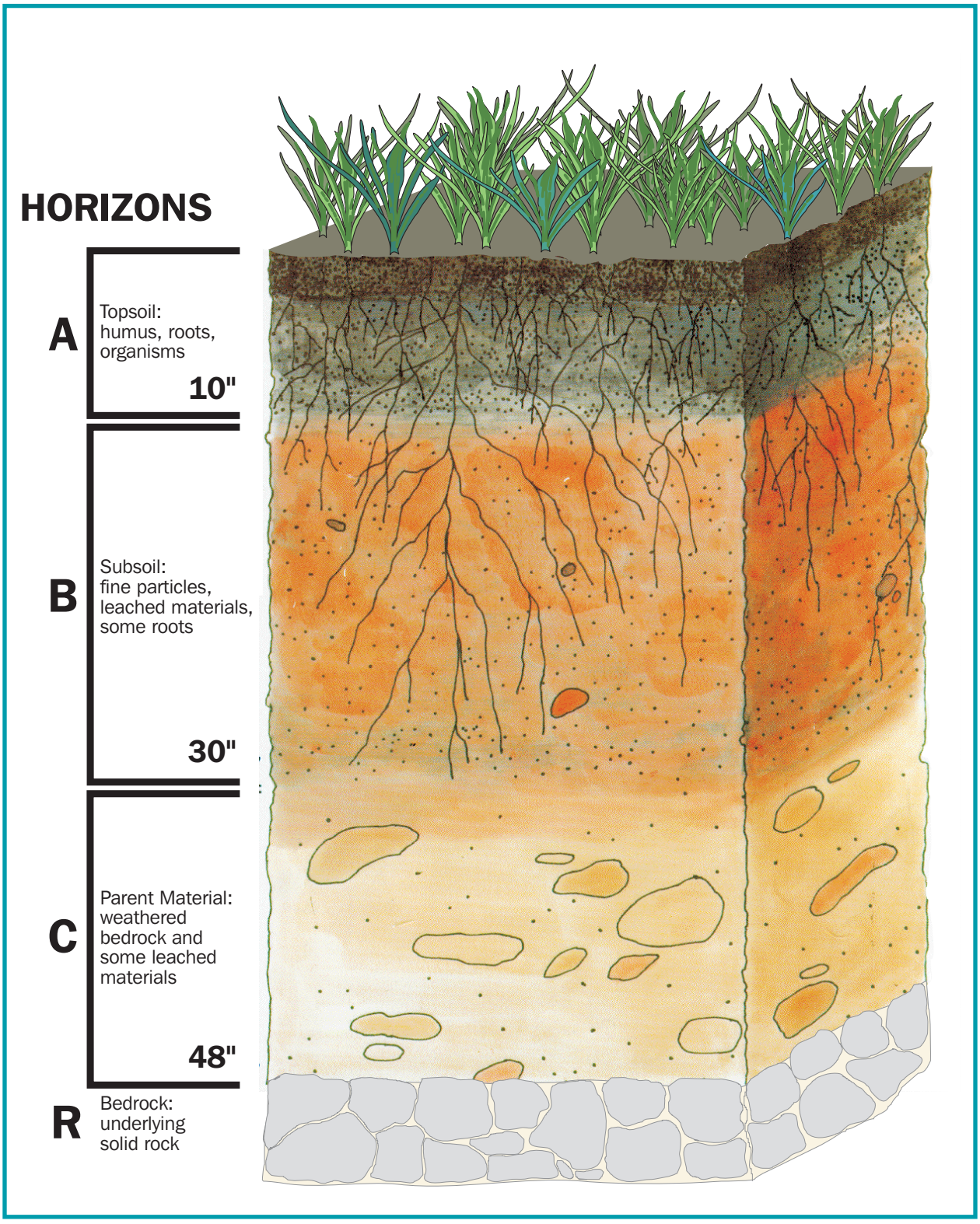


FIGURE 2. Diagram of a soil profile.

Summary:

A soil profile is a vertical cross section of the soil. The differences are developed from the interaction of such soil-forming factors as parent material, slope, native vegetation, weathering, and climate.

As a soil ages, horizontal layers develop and changes result. The causes of these changes are classified as four processes: addition, loss, translocation, and transformation.

There are three primary soil horizons, called master horizons. They are *A, B,* and *C.* These are part of a system for naming soil horizons in which each layer is identified by a code: *O, A, E, B, C,* and *R.* The *A* horizon is often referred to as the topsoil The *B* horizon is often referred to as the subsoil. The *C* horizon is called the substratum.

Checking Your Knowledge:

1. What is a soil profile?
2. What factors are involved in the development of soil profiles?
3. What are the four classes of changes to soil horizons?
4. What are the master horizons?
5. How do eluviation and illuviation differ?

Expanding Your Knowledge:

Participate in a soils career development event with your classmates. Apply your knowledge of soil profiles during the competition. An alternative is to dig a hole several feet deep into a soil that has not been disturbed. Study the profile of the soil and identify the horizons.

Web Links:

Soil Profiles
https://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/soil_systems/soil_development_profiles.html

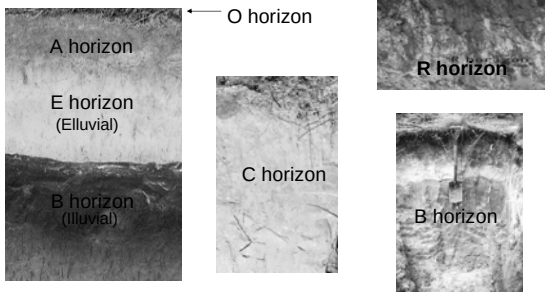
Soil Horizons
http://serc.carleton.edu/NAGTWorkshops/visualization/collections/soil_horizons.html

Soil Layers
http://www.petrik.com/PUBLIC/library/misc/aw5_s_layers.htm

Soil Morphology and Classification

Master Horizons

Enough information?



Sub-horizon designations

Sub-horizon designations

Subordinate distinctions within master horizons

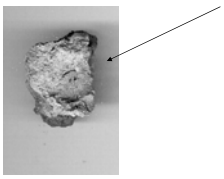
p – plowing/disturbance
t – clay accumulation
g – gleying
h – illuvial organic matter
w – development of color/structure
o – oxic

Subordinate distinction (p = plowed)

Disturbed surface horizon (cultivation, pasture, forestry)
Used with the A master horizon (e.g. Ap horizon)

Subordinate distinction (t = clay accumulation)

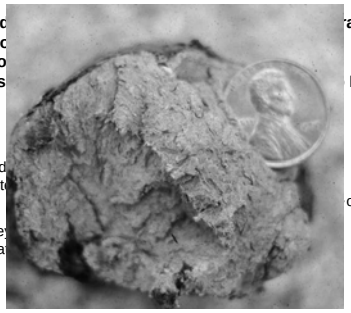
Translocation of clay or formed in place
Coatings or discrete
Used with the B master horizon (e.g. Bt)
If reduced, can be used with the g sub horizon (Btg)



*

Subordinate distinction (g = gleying)

•Oxygen d ration.
• Reductic
• low chro
• Often us E and C horizon.

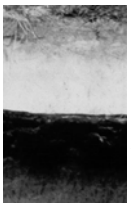


Fe^{3+} oxid mat oxidized

Fe^{2+} gley ma

Subordinate distinction (h = organic accumulation)

- Accumulation of illuvial organic matter-metal complexes
- Coatings on sand and discrete particles
- h = “humic”
- value and chroma approximately 3 or less
- Used with the B master horizon (e.g. Bh horizon)



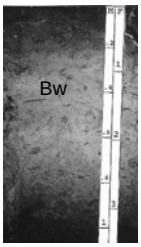
← Bh horizon
“spodic horizon”

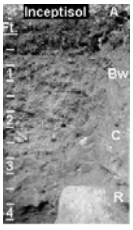
*

Subordinate distinction (w = color or stucture)

Non-illuvial development of color or structure
“w” can = “weak”

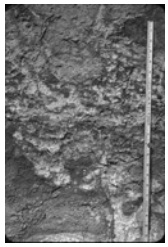
Commonly used with the B master horizon (e.g. Bw)





Subordinate distinction (o = oxic horizon)

Low activity clays
Few weatherable materials
Little rock structure
Fe and Al oxides



Subordinate distinctions

g – gleying
h – illuvial organic matter
p – plowing/disturbance
t – clay accumulation
w – development of color/structure
o – oxic

Subordinate distinctions and Organic Matter

Subordinate distinction (a, e, i)

Denotes the degree of organic matter decomposition in the O horizon.

Oa – highly decomposed (sapric)
Oe – moderately decomposed (hemic)
Oi – slightly decomposed (fibric)

Sapric –most decomposed, low plant fiber, low water content
Hemic – intermediate decompostion
Fibric – least decomposed, recognizable fibers

Summary

Master: O, A, E, B, C, R

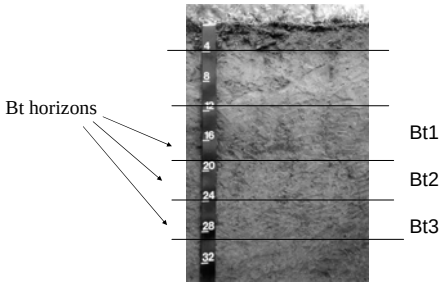
Sub horizon symbols: g, h, p, t, w and a,e,i

Examples: Oa, Oe, Oi
Bt
Bg
Btg
Bw
Ap

Other Designations

Vertical Subdivisions

Characterized by similar master and/or subordinate properties separated by “degree”.



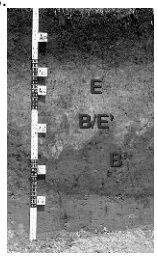
Transitional Horizons

Transitional layers between master horizons.

AE
EB
BE

Dominant character

Subordinate Character



Synthesis

Ap

AE

E

Bh

Btg1

Btg2

Soil Taxonomy

Soil Classification/Taxonomy

Hierarchical

Based on soil profile characteristics and the concept of soils as a natural body.

Observable properties: color, texture, structure, pH, O.M…

Soil Profile

Genesis

1883 V.V. Dukachaev: climate, vegetation, soil

1927 C.F. Marbut (USDA) applied to U.S. (1965)

Soil Classification/Taxonomy

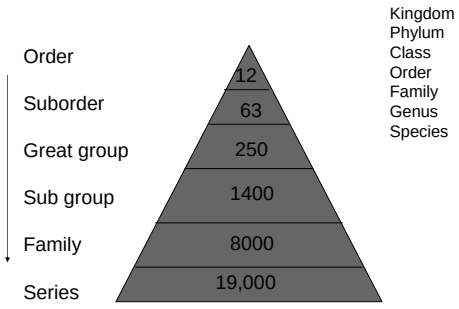
USDA classification system

Soil Survey Staff 1965

Soil Taxonomy published 1975

- Adamsville: Hyperthermic, uncoated Aquic Quartzipsamment

Soil Taxonomy Hierarchy



Units for Soil Classification

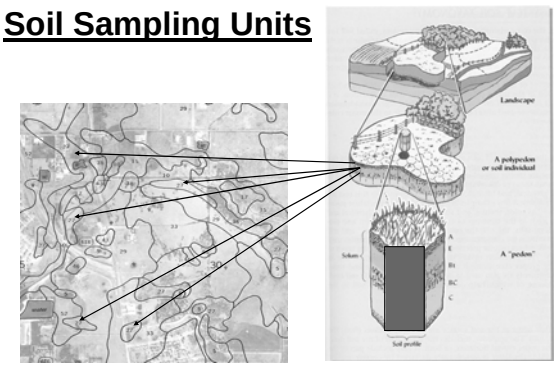
Pedon – smallest three-dimensional unit that displays the full range of properties characteristic of a given soil. (1-10 m^2 of area)

- the fundamental unit of soil classification

Polypedon – group of closely associated pedons in the field

Soil Series – class of soils world-wide which share a common suite of soil profile properties

Soil Sampling Units



Malabar Series

Diagnostic Horizons

Surface

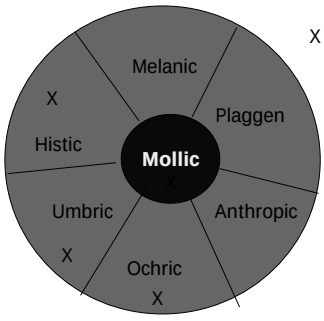
Subsurface

Diagnostic Surface Horizons

Epipedons

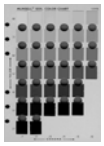
Mollic
Umbric
Ochric
Histic
Melanic
Plaggen
Anthropic

Diagnostic Surface Horizons



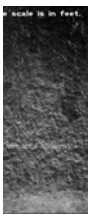
X = Florida

Mollic Epipedon



Thickness	> 18-25 cm
Color	value < 3.5 moist
	chroma < 3.5 moist
Organic Carbon	> 0.6 %
Base Saturation	> 50 %
Structure	strongly developed

Organic carbon = organic matter x 0.5



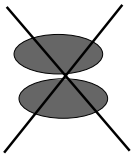
Umbric Epipedon

Meets all criteria of the Mollic epipedon, except base saturation < 50%

Chemically different than Mollic

Ochric Epipedon

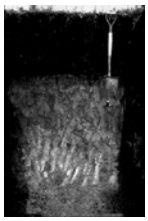
Too: thin
light
low in O.M



Ochric = pale

Extremely common

Histic Epipedon



Organic horizon
Formed in wet areas
Black to dark brown
Low bulk density
20-30 cm thick

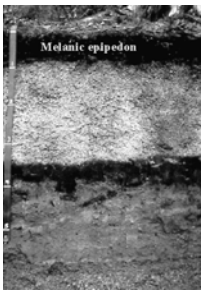
Organic = > 20% - 35% O.M.
(water saturation, clay content)

Melanic Epipedon

Similar in properties to Mollic

Formed in volcanic ash

Lightweight, Fluffy



Anthropic Horizon

- Resembles mollic (color, o.m.)
- Use by humans
- Shells and bones
- Water from humans

Plaggen Epipedon

Produced by long-term (100s yrs.) manuring

Old, human-made surface horizon

Absent in U.S.

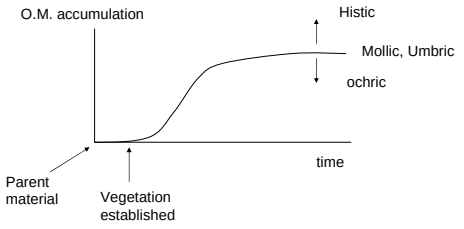
> 50 cm thick

Diagnostic Surface Horizons

Epipedons

Mollic Umbric Ochric	Very common
Histic Melanic	"specialized"
Plaggen Anthropic	Human-derived

Organic Matter Accumulation



t_{max} = 3000 yrs

Diagnostic Sub-surface Horizons

Diagnostic Subsurface Horizons

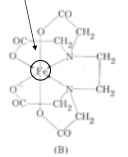
Formation
Translocation
Transformation

Clays Organic Matter Oxides

Subsurface Horizons

Formation
Translocation
Transformation

Organic Matter	Clays	Oxides
Dark colors Metals (Fe, Al)	smectites Kaolinite	Iron Aluminum



Also: salts, carbonates, sulfides

Diagnostic Subsurface Horizons

Albic	Natric
Argillic	Agric
Spodic	Calcic
Oxic	Gypsic
Cambic	Salic
Kandic	Duripan
Sombric	Fragipan
sulfuric	Placic

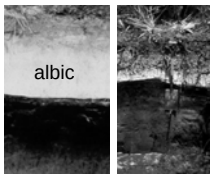
Sub-Horizon Designations

Diagnostic Subsurface Horizons

Albic (white) Horizon

Light-colored (Value > 6 moist)
Elluvial (E master horizon*)
Low in clay, Fe and Al oxides
Generally sandy textured
Low chemical reactivity (low CEC)
Typically overlies Bh or Bt horizons

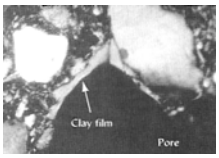
*not all E horizons are albic horizons

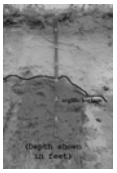


Diagnostic Subsurface Horizons

Argillic Horizon

- Illuvial accumulation of silicate clays
- Illuvial based on overlying horizon
- Clay bridges
- Clay coatings





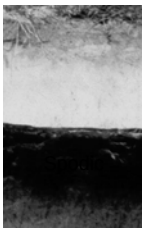
Diagnostic Subsurface Horizons

Argillic Horizon		Kandic Horizon
High	Activity of Clays	Low
Necessary	Illuviation of clay	Not Necessary

Diagnostic Subsurface Horizons

Spodic Horizon

- Illuvial accumulation of organic matter and aluminum (+/- iron)
- Dark colored (value, chroma < 3)
- Low base saturation (acidic)
- Formed under humid acid conditions

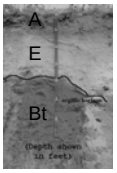


Elluviation and Illuviation

Elluviation (E horizon)

Organic matter → Bh horizon → Spodic horizon

Clays → Bt horizon → Argillic horizon



Diagnostic Subsurface Horizons

Oxic horizon

- Highly weathered (high temperatures, high rainfall)
  - High in Fe, Al oxides
  - High in low-activity clays (kaolinite < smectite < vermiculite) ← activity →

Diagnostic Horizons

Epipedons	Subsurface
Mollic	Albic
Umbric	Kandic
Ochric	Argillic
Histic	Spodic
Melanic	Oxic
Plaggen	
Anthropic	

Soil Taxonomy

Diagnostic Epipedons
Diagnostic Subsurface horizons
Moisture Regimes
Temperature Regimes