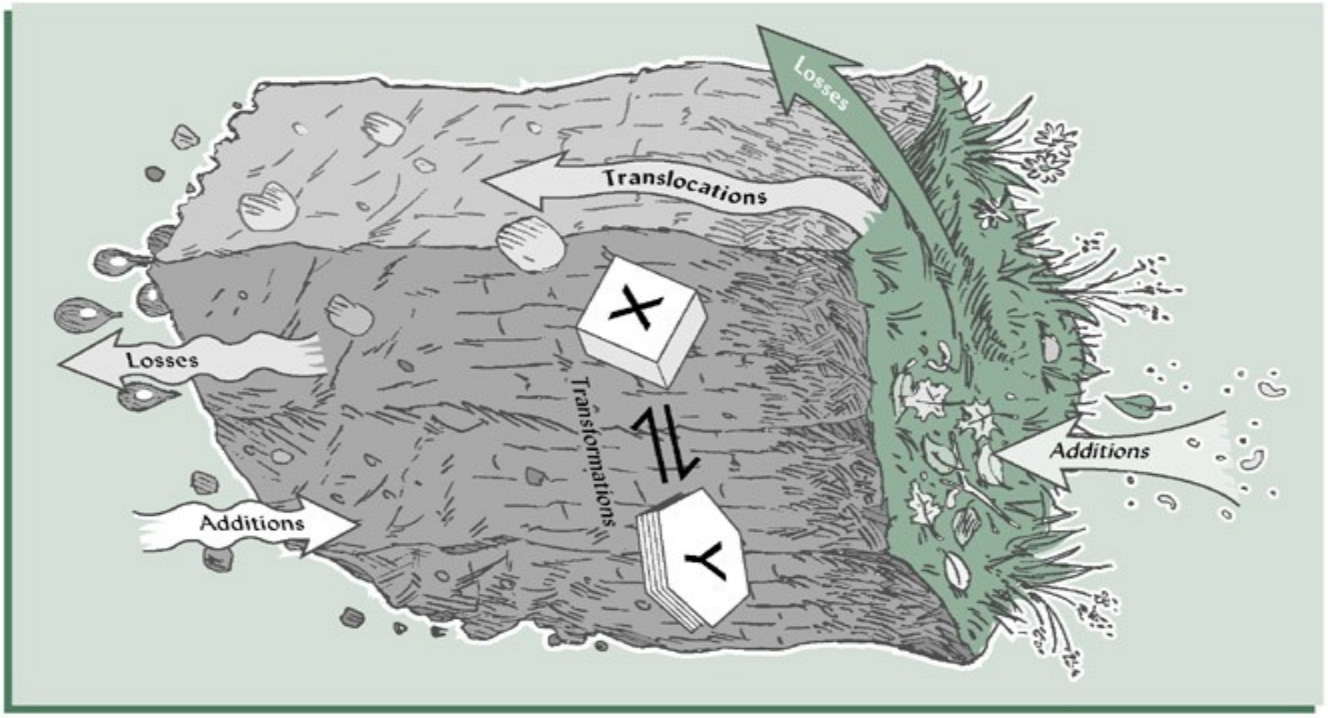
SOIL PROFILE

Soil genetic horizons

-HORIZON: soil layer parallel to surface with characteristics produced by soil-forming processes

(based on qualitative judgement)

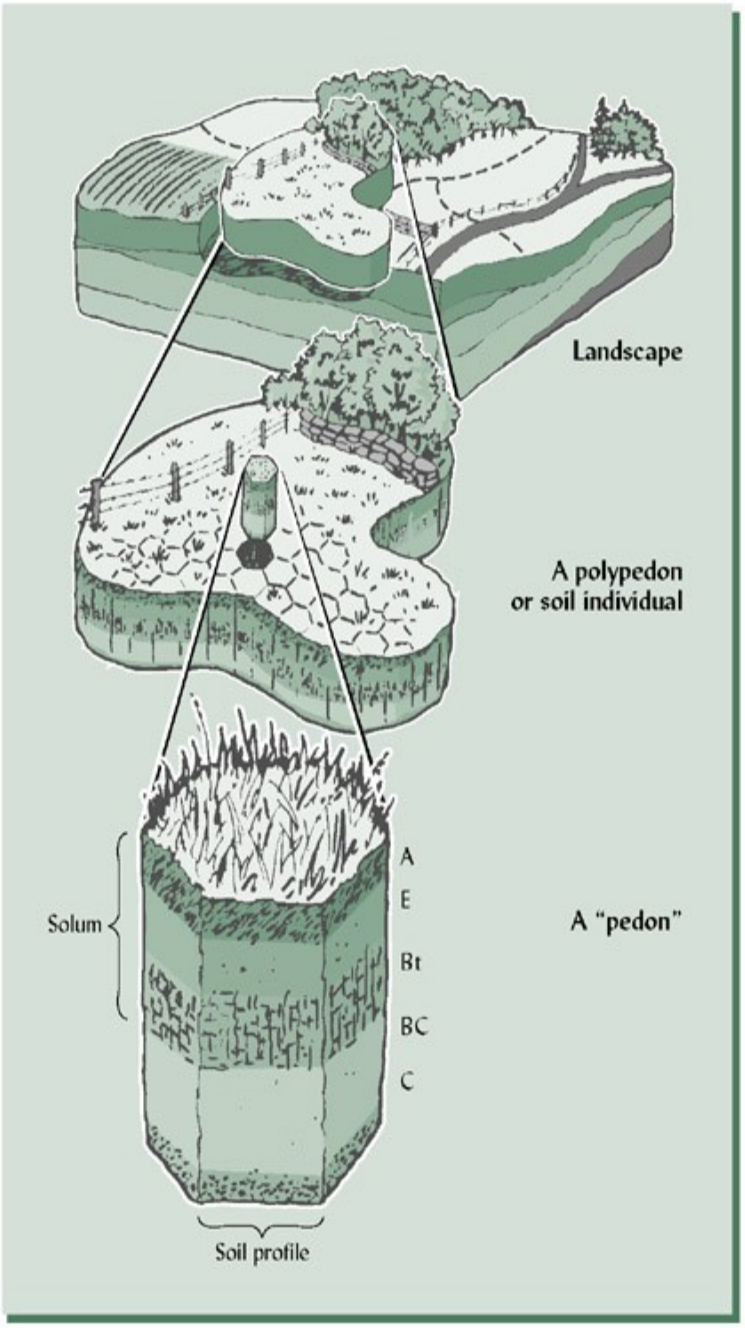

Losses
Translocations
X
Losses
Transformations
Additions
Y
Additions

3 basic soil units (scale)

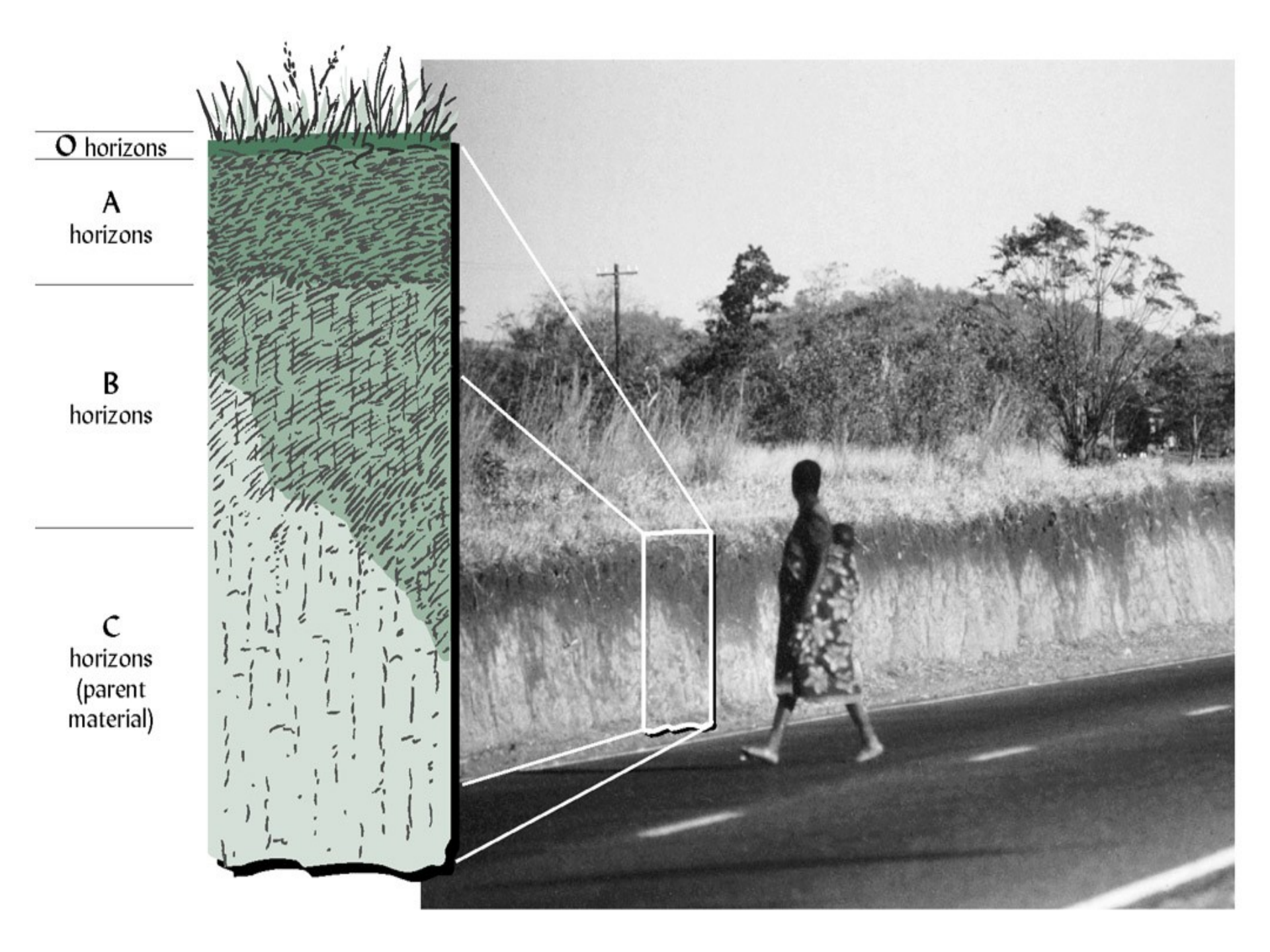
Pedon: smallest volume called a soil

Polypedon: soil body (2 or more pedons) in which soils are relatively uniform

Soil Series: groups of like polypedons


Landscape
A polypedon
or soil individual
A "pedon"
Solum
A
E
Bt
BC
C
Soil profile

profile: one side of pedon, showing all horizons; 2-D


O horizons
A horizons
B horizons
C horizons (parent material)

Master horizons

O

A

E

B

C

R

O horizon

Organic material

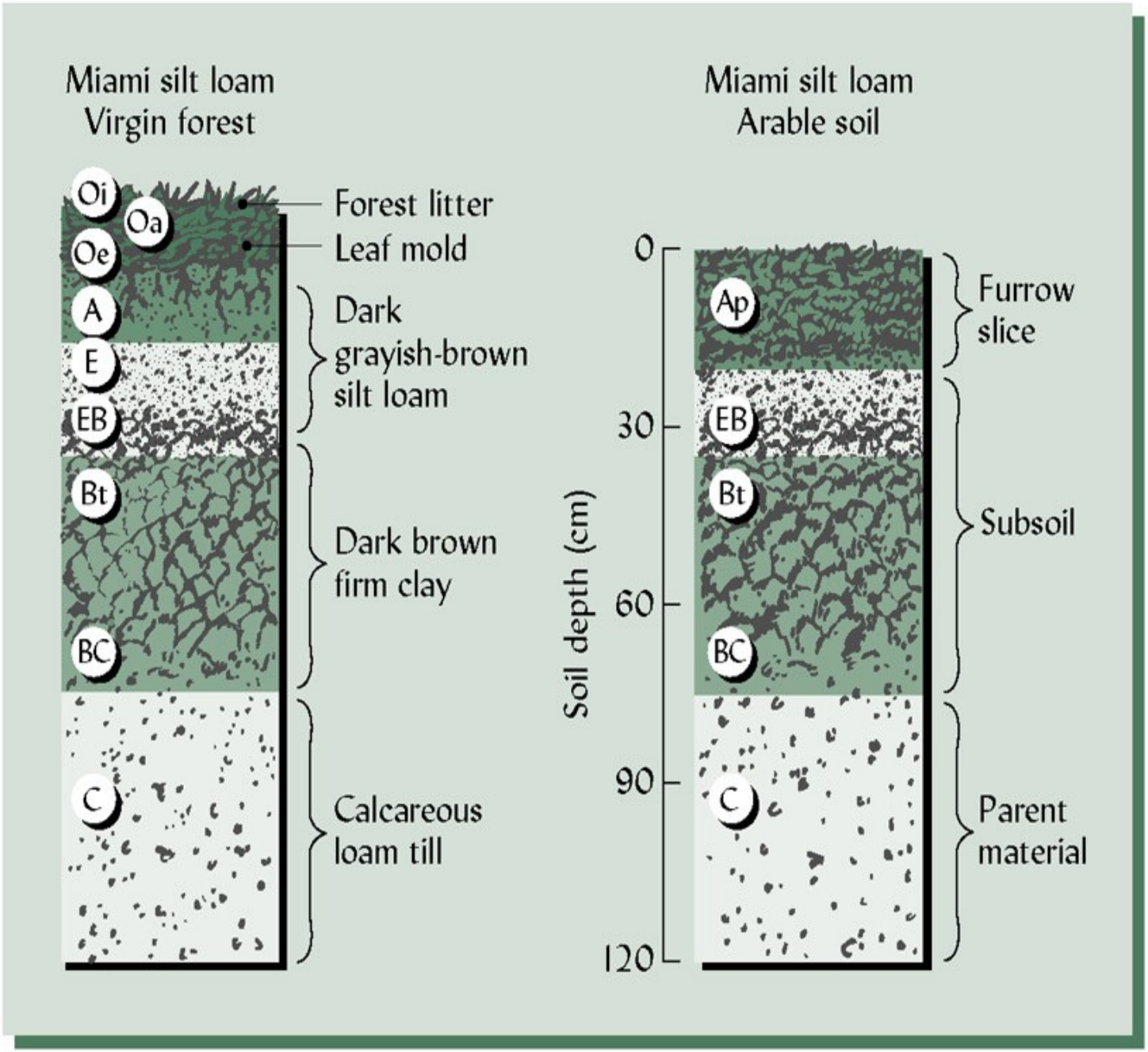
Oi slightly decomposed (litter)
Oe intermediate decomposition
Oa highly decomposed

A horizon

- topmost *mineral horizon*

  (<12% O.M. ; if clayey: <18% O.M.)
- accumulation of well-decomposed O.M.
- Often bioturbated

- OR surface horizon disturbed by plowing (Ap)


Miami silt loam
Virgin forest
Oi
Oa
Oe
A
E
EB
Bt
BC
C
Forest litter
Leaf mold
Dark grayish-brown silt loam
Dark brown firm clay
Calcareous loam till
Miami silt loam
Arable soil
Soil depth (cm)
0
30
60
90
120
Ap
EB
Bt
BC
C
Furrow slice
Subsoil
Parent material

E horizon

- LOSS of
  - silicate clay, Fe & Al oxides, humus by *eluviation*
  - carbonates, gypsum by leaching
- lighter color than A
- coarser texture than B *due to clay loss*

LEACHING : removal of soluble minerals (Ca, Mg, Na) in solution

ELUVIATION : loss (by water) of suspended materials (clay, humus, oxides)

”emigrating”

ILLUVIATION : accumulation of suspended materials (clay, humus, oxides) and/or precipitated materials from solution (Ca, Mg, Na)

“immigrating”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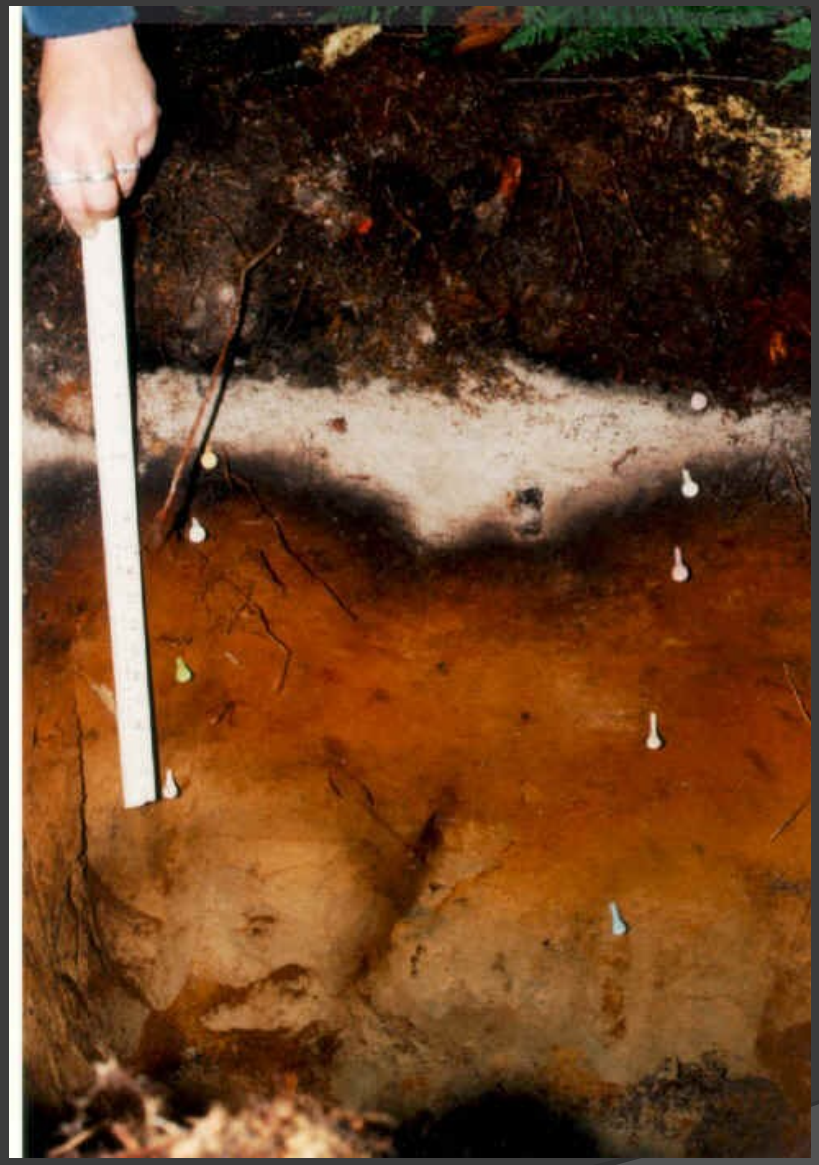
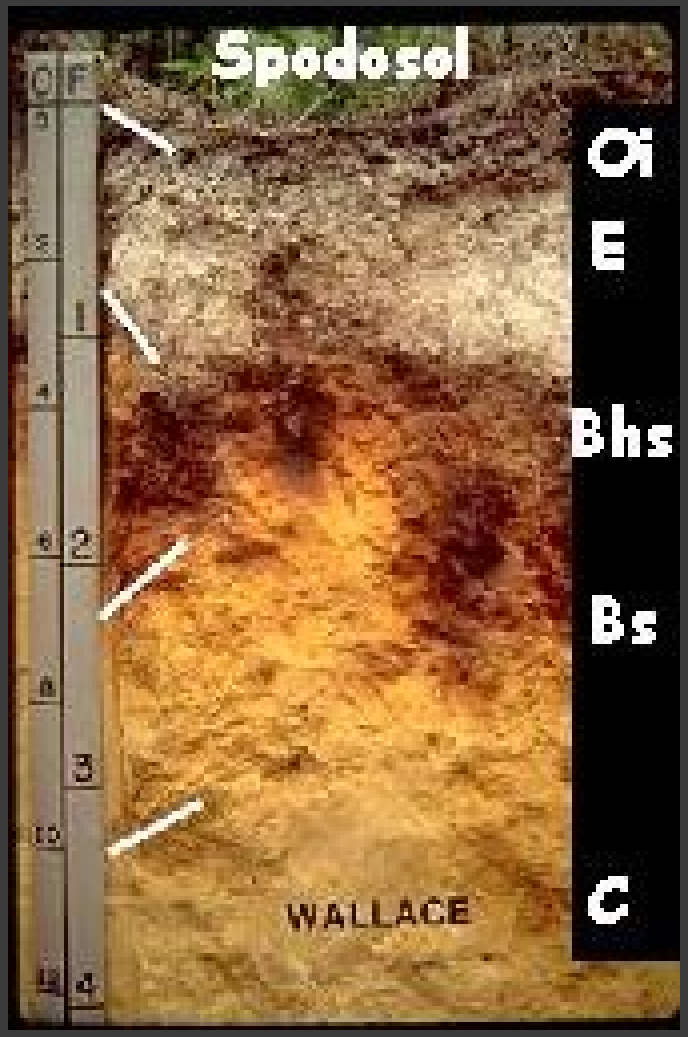
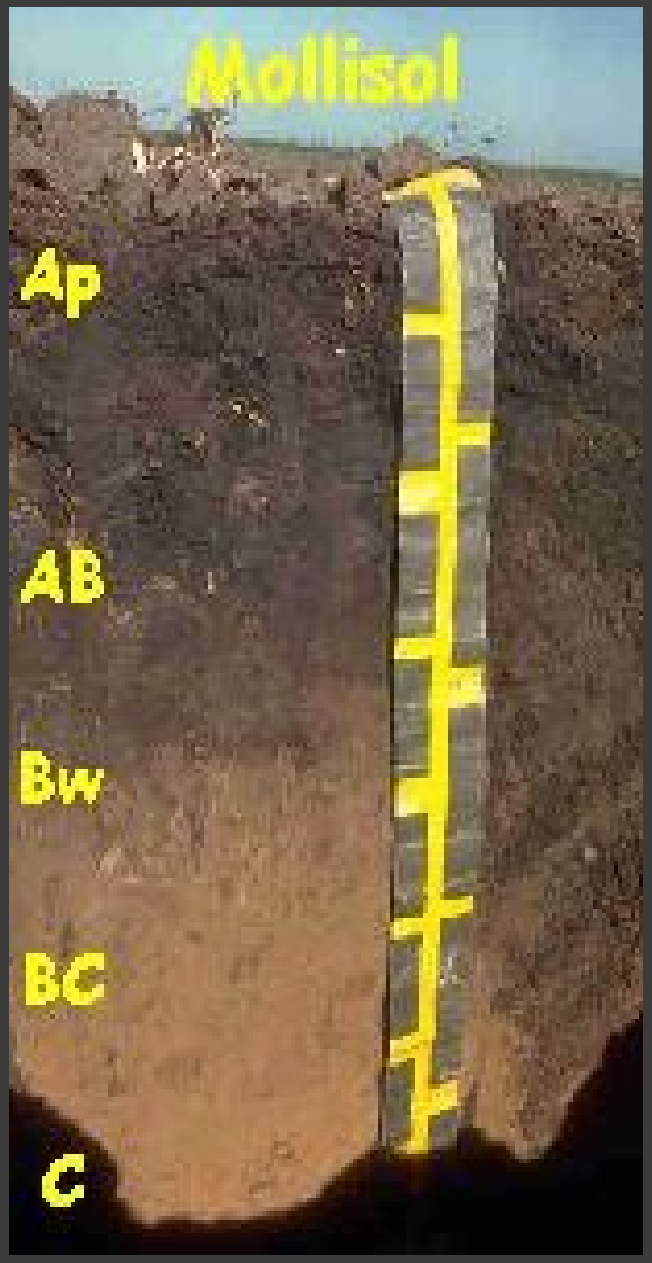


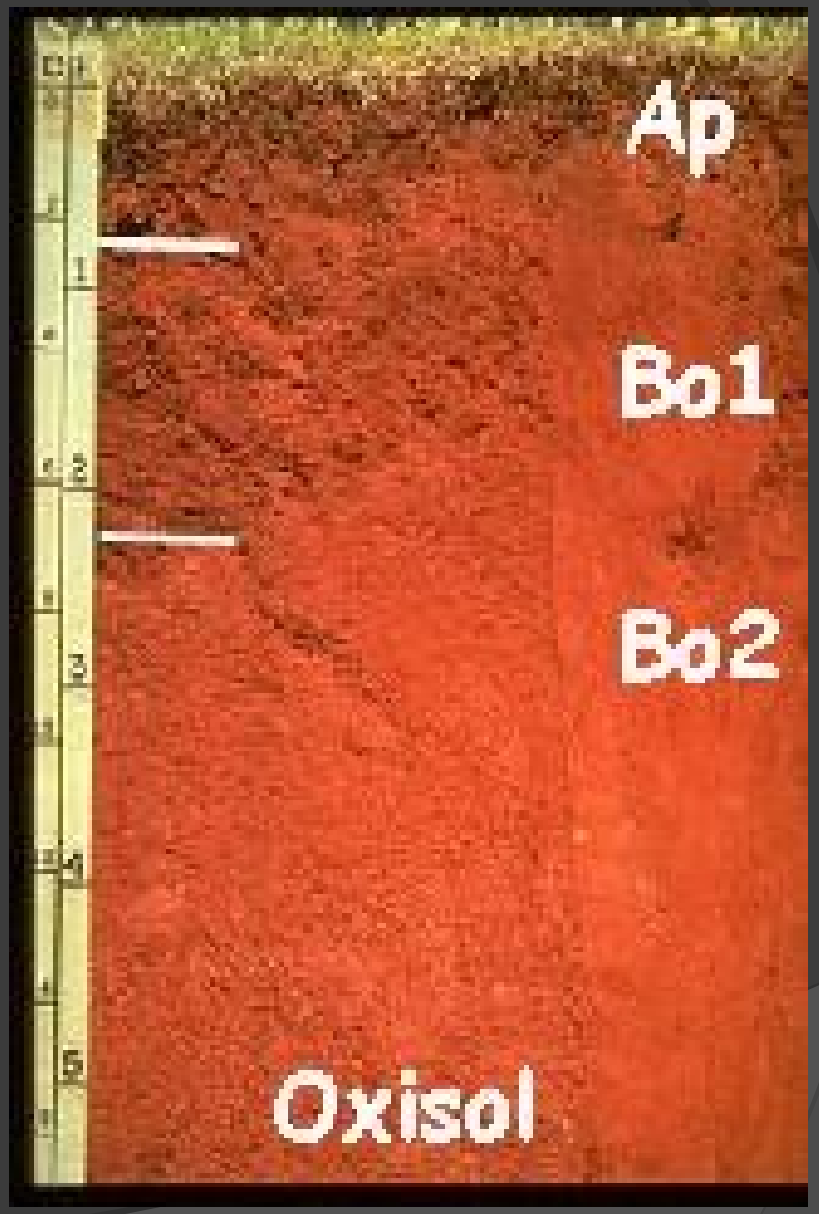
B horizon

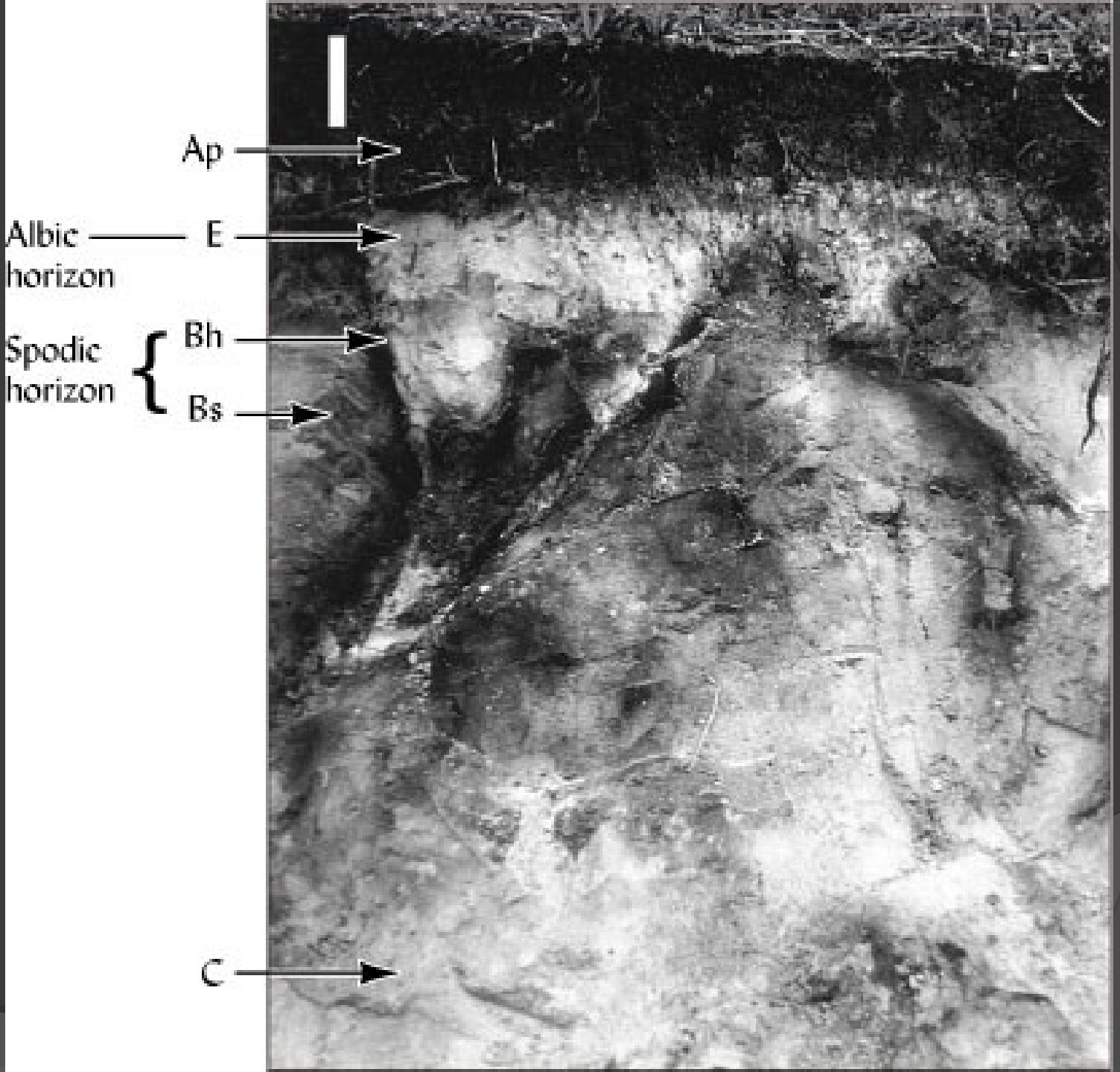
- ACCUMULATED (illuviated) silicate clay, Fe & Al oxides, carbonates, gypsum, humus

- distinguished from A :
  - stronger, redder, or darker *color*
  - OR different *texture*


Spodosol
O F
Oi
E
Bhs
Bs
C
WALLACE

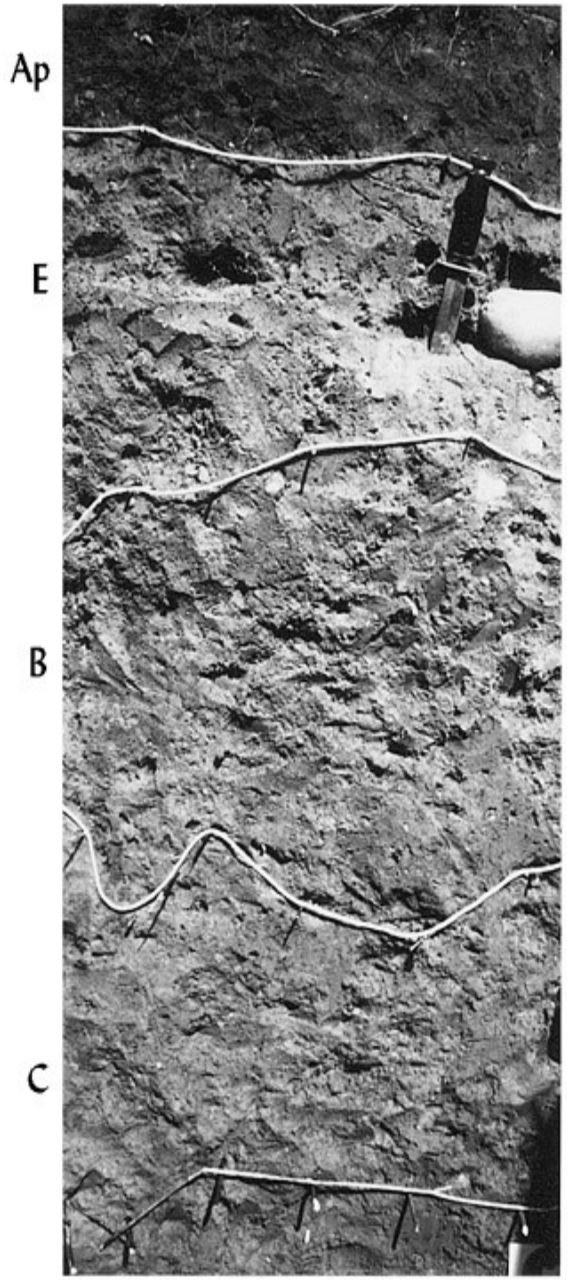

Mollisol
Ap
AB
Bw
BC
C


Ap
Bo1
Bo2
Oxisol


Ap
Albic horizon
E
Spodic horizon
Bh
Bs
C

C horizon

- Mineral horizon (not bedrock) underlying A,E,B horizons
- not affected by soil-forming processes
- may be parent material

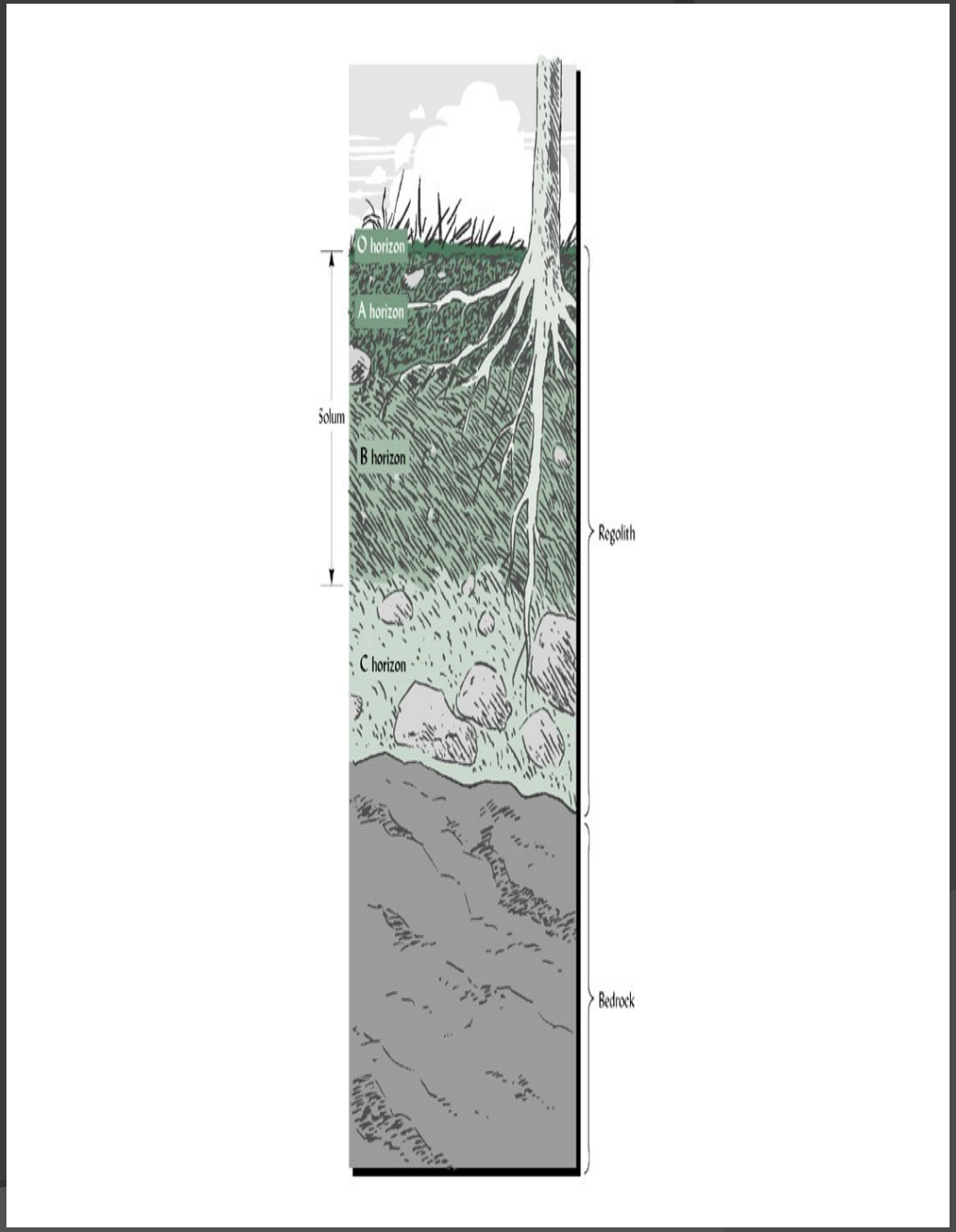

Ap
E
B
C

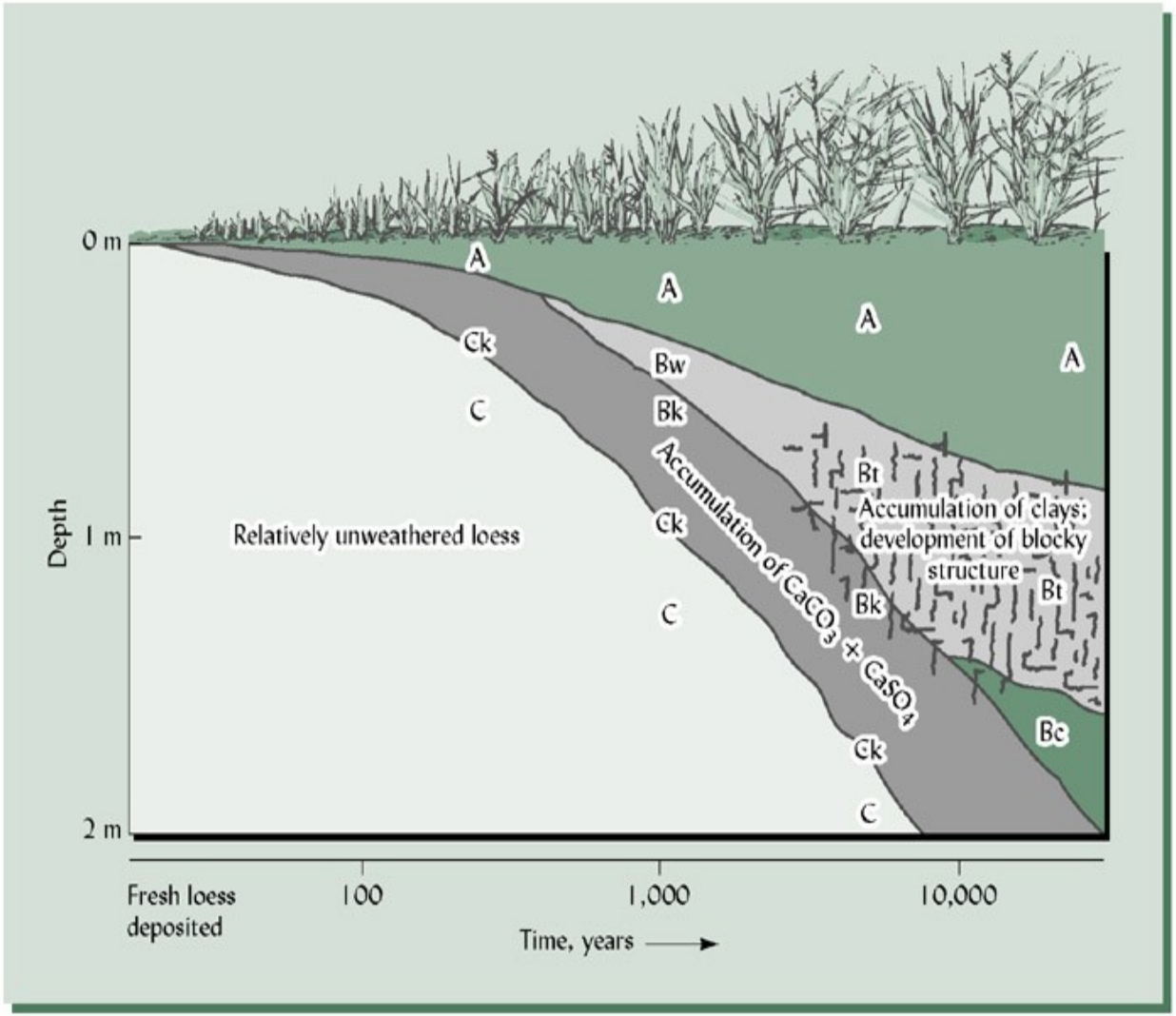
R horizon

Consolidated rock

Solum = “true soil”:

O, A, E, B




0 m
1 m
2 m
Depth
A
A
A
A
Ck
C
Bw
Bk
Accumulation of $CaCO_3$ + $CaSO_4$
Ck
C
Relatively unweathered loess
Bt
Accumulation of clays; development of blocky structure
Bk
Bt
Bc
Ck
C
Fresh loess deposited
100
1,000
10,000
Time, years

Transitional horizons

Zone of transition between master horizons

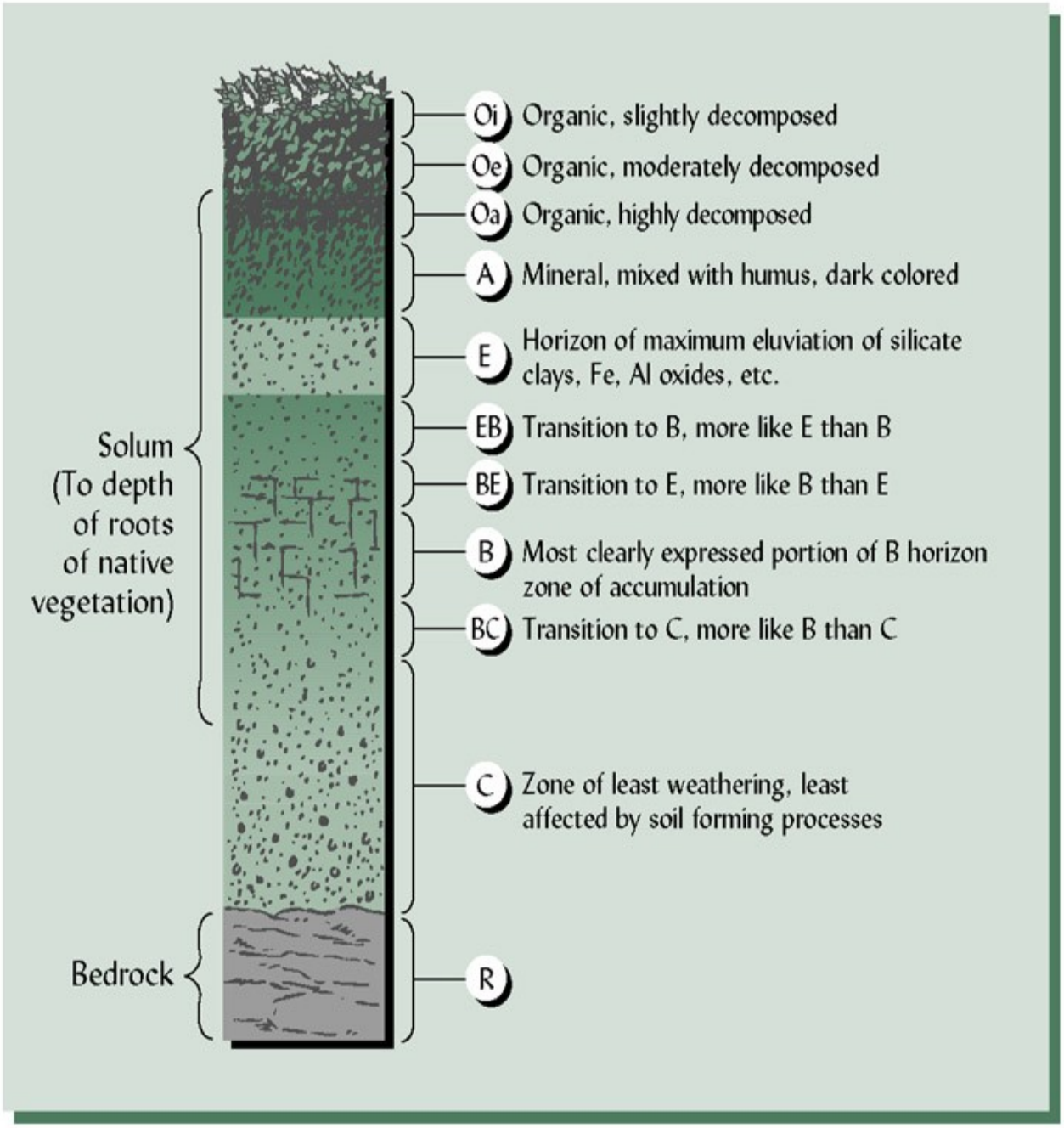
AB A→B; A dominates

BA A→B; B dominates

AC A→C; A dominates

EB E→B; E dominates

etc….


Solum
(To depth
of roots
of native
vegetation)
Bedrock
Oi
Organic, slightly decomposed
Oe
Organic, moderately decomposed
Oa
Organic, highly decomposed
A
Mineral, mixed with humus, dark colored
E
Horizon of maximum eluviation of silicate clays, Fe, Al oxides, etc.
EB
Transition to B, more like E than B
BE
Transition to E, more like B than E
B
Most clearly expressed portion of B horizon zone of accumulation
BC
Transition to C, more like B than C
C
Zone of least weathering, least affected by soil forming processes
R

Mixed horizons

One horizon scattered within another horizon

B/A mixed A&B; B is matrix for A

E/B E is matrix

etc….

Numbers *after* letters

Changes within master horizon for which there is no subhorizon designation

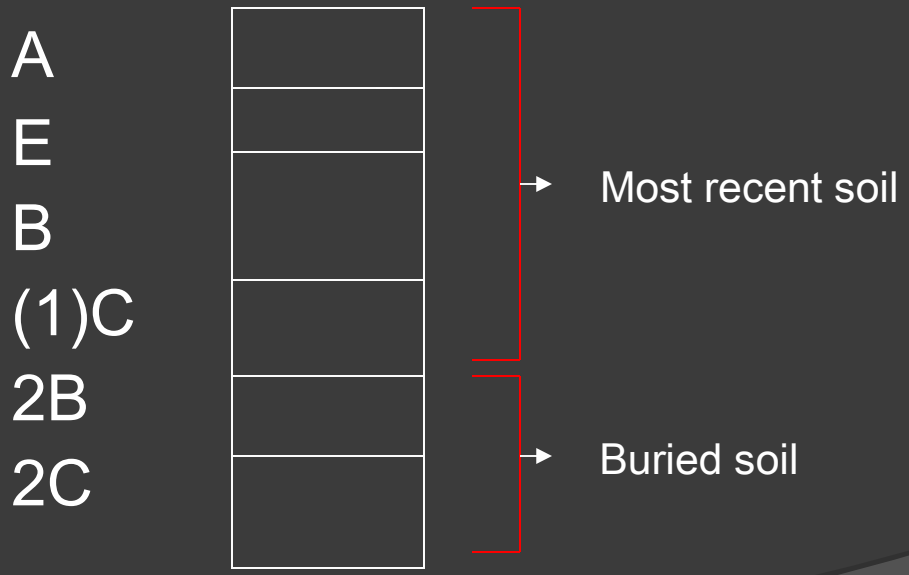
e.g., A1 A2 for color change within A

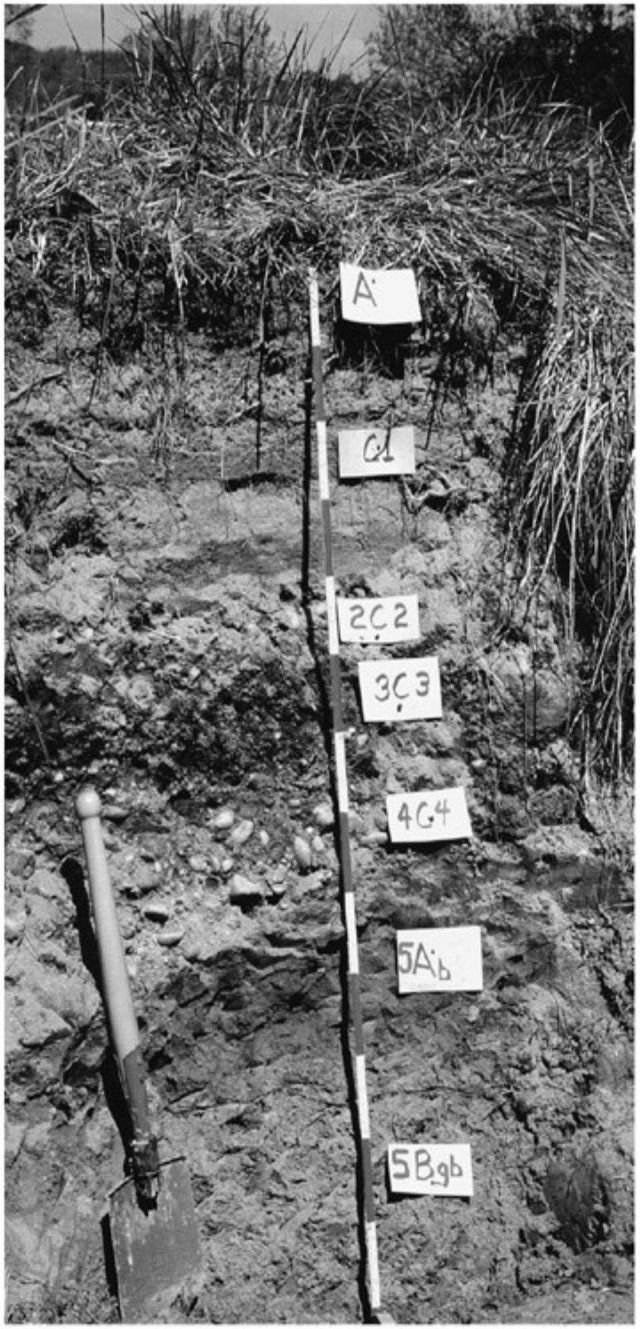

Ap
C1
C2
Fluvent

Numbers *before* letters:

Lithologic discontinuities

e.g., soil has A, E, B horizon formed on one parent material and a second soil formed on another




A
C1
2C2
3C3
4G4
5Ab
5Bgb

Subhorizons

Lowercase letters symbolizing divisions within master horizons or characteristics of master horizons

TABLE 2.6 Lowercase Letter Symbols to Designate Subordinate Distinctions Within Master Horizons

Letter	*Distinction*	*Letter*	*Distinction*
a	Organic matter, highly decomposed	n	Accumulation of sodium
b	Buried soil horizon	o	Accumulation of Fe and Al oxides
c	Concretions or nodules	p	Plowing or other disturbance
d	Dense unconsolidated materials	q	Accumulation of silica
e	Organic matter, intermediate decomposition	r	Weathered or soft bedrock
f	Frozen soil	s	Illuvial accumulation of O.M.[a] and Fe and Al oxides
g	Strong gleying (mottling)	ss	Slickensides (shiny clay wedges)
h	Illuvial accumulation of organic matter	t	Accumulation of silicate clays
i	Organic matter, slightly decomposed	v	Plinthite (high iron, red material)
j	Jarosite (yellow sulfur mineral)	w	Distinctive color or structure
jj	Cryoturbation (frost churning)	x	Fragipan (high bulk density, brittle)
k	Accumulation of carbonates	y	Accumulation of gypsum
m	Cementation or induration	z	Accumulation of soluble salts

[a] O.M. = organic matter.

Subordinate Distinctions within Master Horizons

Lower case letters are used to designate specific features within master horizons. They are listed in alphabetical order below:

a: Highly decomposed organic material. The 'a' is used only with the O master horizon. The rubbed fiber content < 17 % of the volume.

b: Buried genetic horizon. It is not used in organic soils or to identify a buried O master horizon.

c: Concretions of hard nonconcretionary nodules. This symbol is used only for iron, aluminium, manganese, or titanium cemented nodules or concretions.

d: Physical root restriction. It is used to indicate naturally occurring or humanly induced layers such as basal till, plow pans, and other mechanically compacted zones. Roots do not enter except along fracture planes.

e: Organic material of intermediate decomposition. This symbol is only used in combination with an O master horizon with rubbed fiber content between 17 - 40 % of the volume.

f: Frozen soil. The horizon must contain permanent ice.

g: Gleying: This symbol is used in B and C horizons to indicate low chroma color (<= 2), caused by reduction of iron in stagnant saturated conditions. The iron may or may not be present in the ferrous form (Fe^{2+}). The g is used to indicate either total gleying or the presence of gleying in a mottled pattern. It is not used in E horizons, which are commonly of low chroma, or in C horizons where the low chroma colors are inherited form the parent material and no evidence of saturation is apparent.

h: Illuvial accumulation of organic matter: Used only in B horizons. The h indicates an accumulation of illuvial, amorphous, dispersible organic matter with or without sequioxide component. If the sequioxide component contains enough iron so that the color value and chroma exceed 3 additionally a s is used (hs). The organosequioxide complexes may coat sand and silt particles, or occur as discrete pellets, or fill voids and cement the horizon (use of m).

i: Slightly decomposed organic material. Used only in combination with an O master horizon to designate that the rubbed fiber content is > 40 % of the volume.

k: Accumulation of carbonates, usually calcium carbonate. Used with B and C horizons.

m: Cementation or induration: Used with any master horizon, except R, where > 90 % of the horizon is cemented and roots penetrate only through cracks. The cementing material is identified by the appropriate letter:

km: carbonate

qm: silica

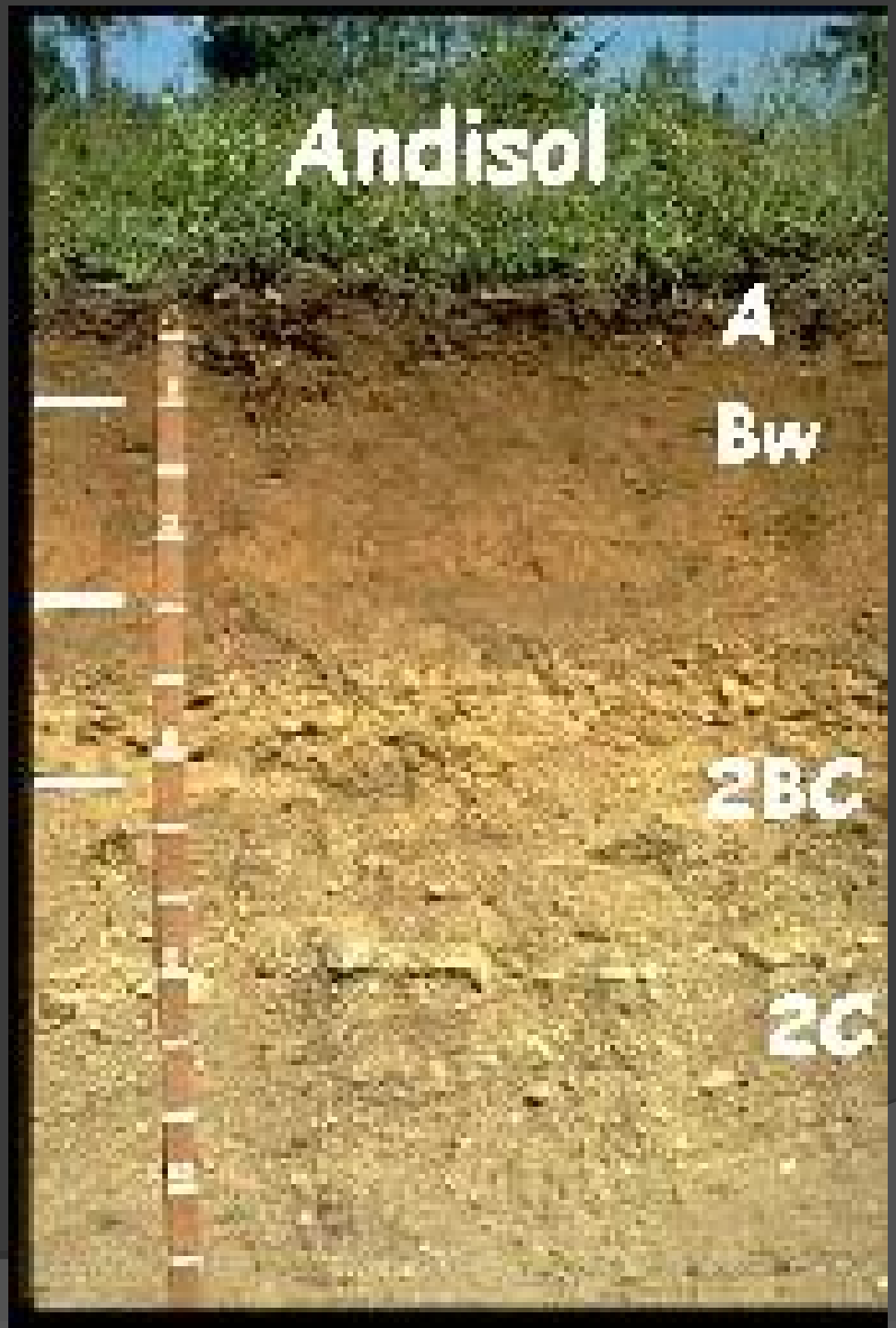
sm: iron

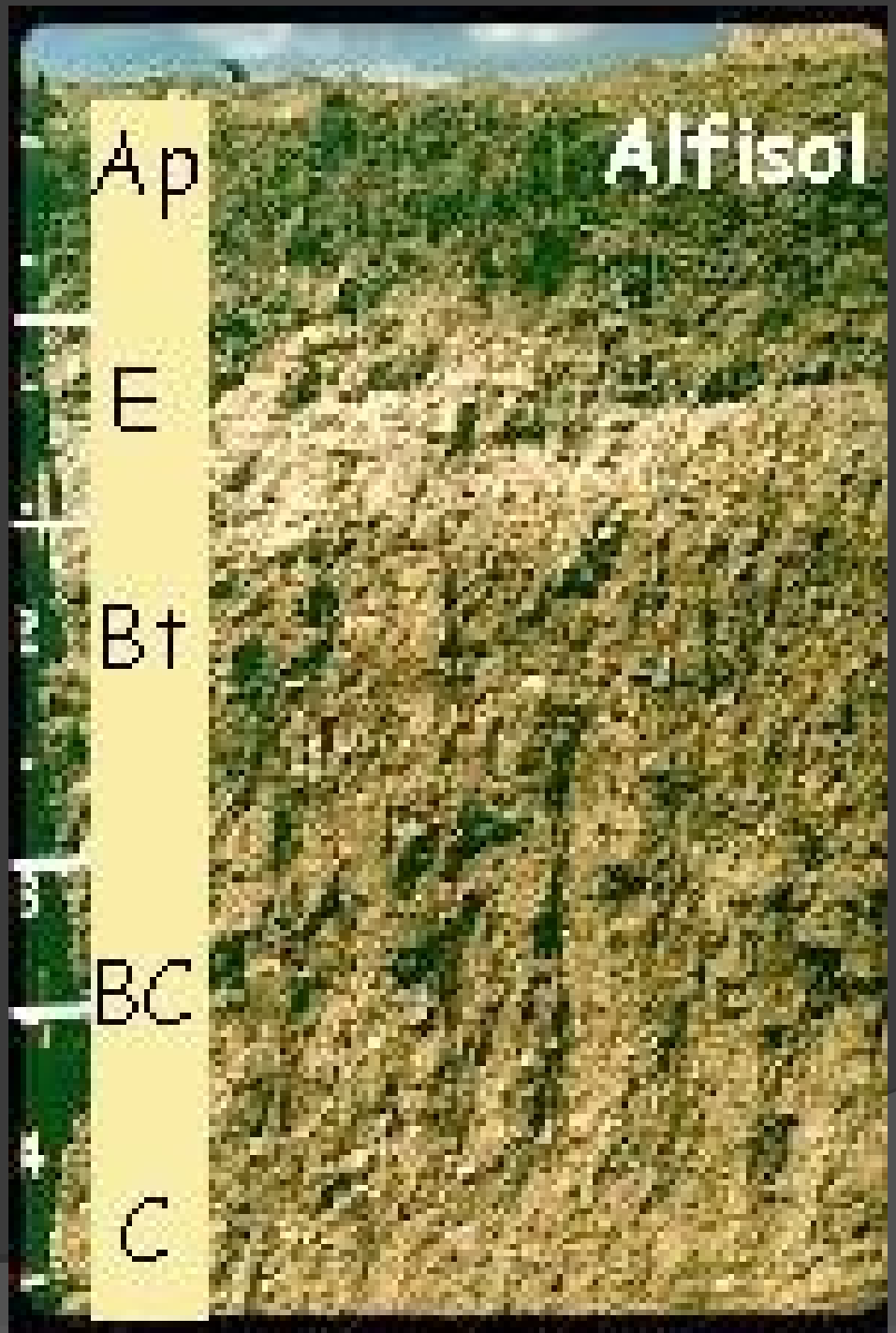
ym: gypsum

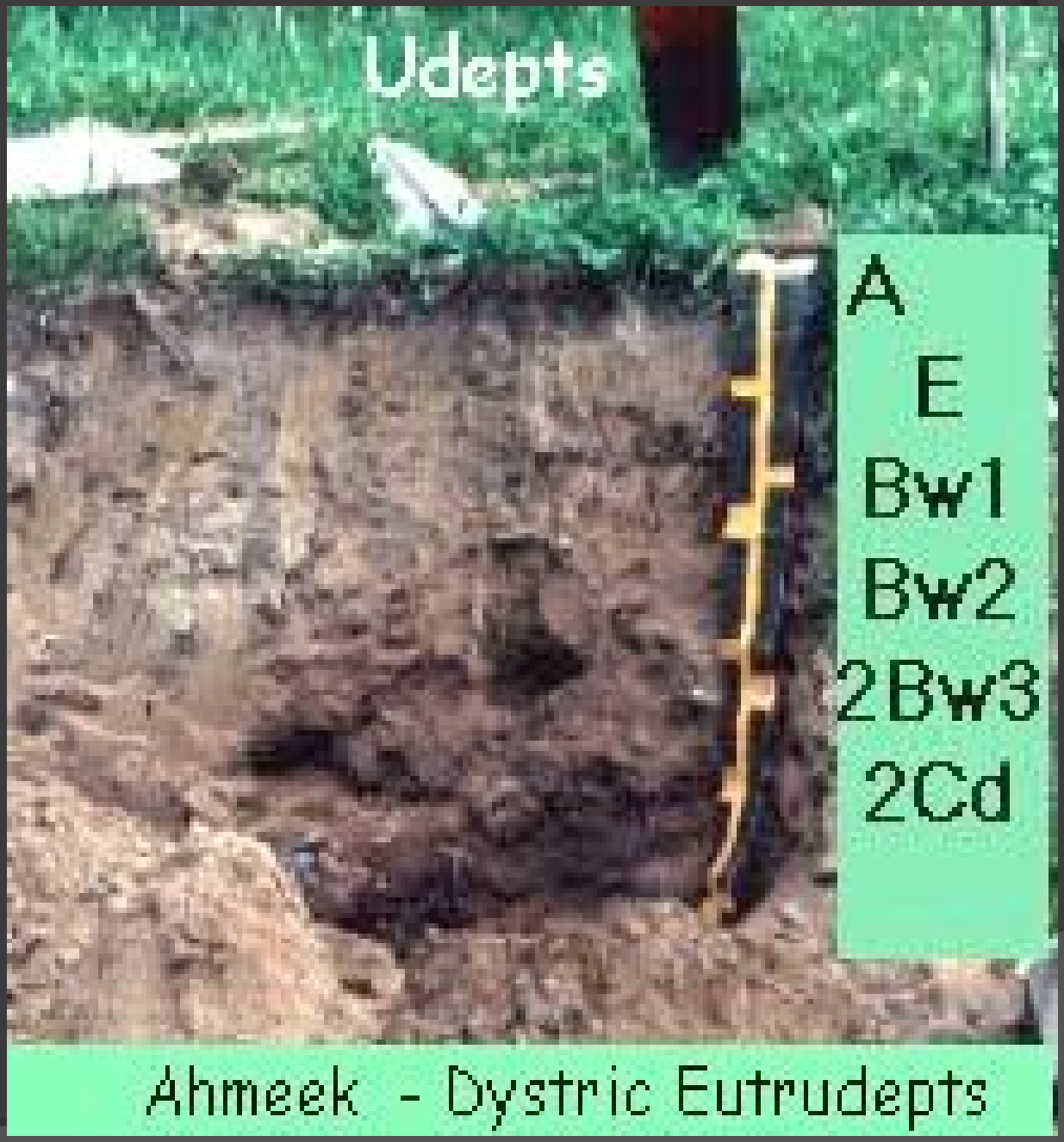
kqm: both lime and silica

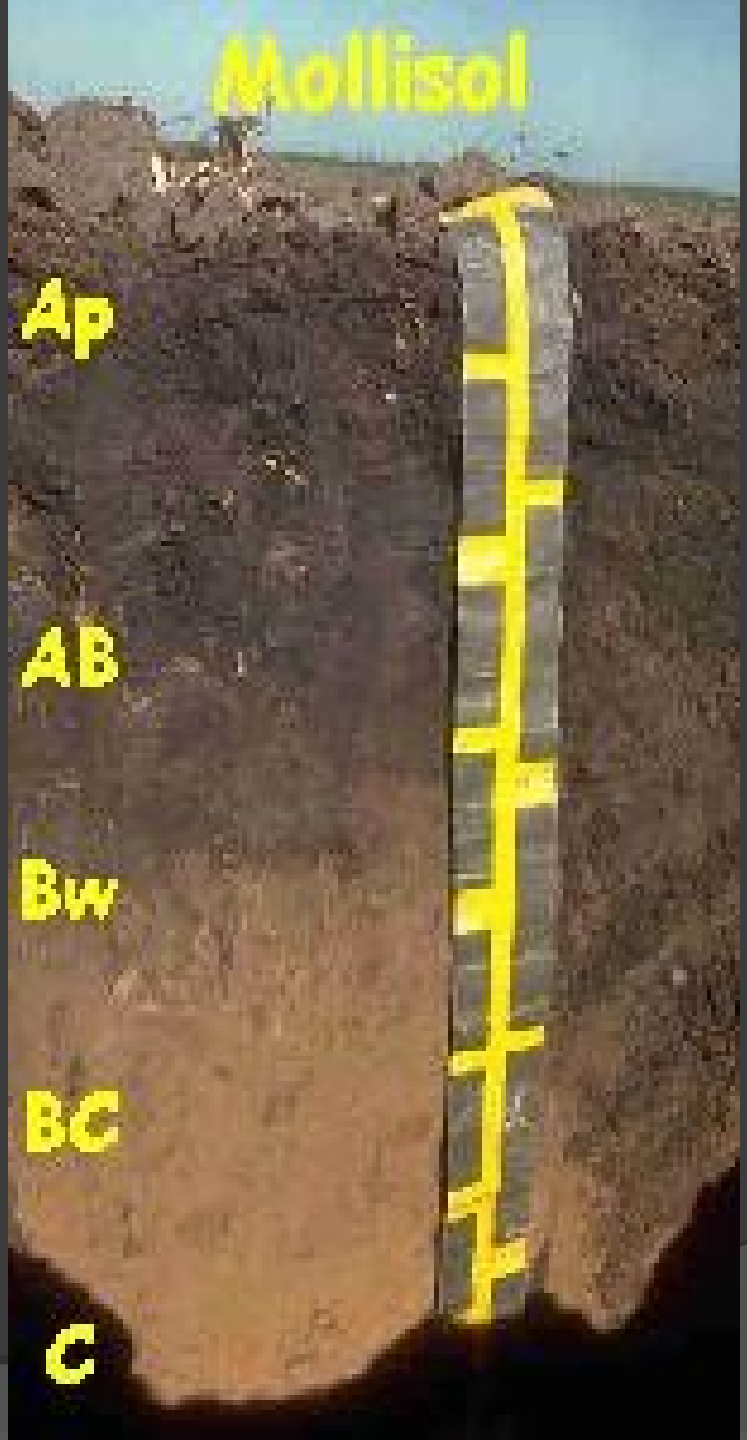
zm: salts more soluble than gypsum

n: Accumulation of sodium: This symbol is used on any master horizon showing morphological properties indicative of high levels of exchangeable sodium.
o: Residual accumulation of sesquioxides.
p: Tillage or other cultivation disturbance (e.g. plowing, hoeing). This symbol is only used in combination with the master horizon A or O.
q: Accumulation of silica: This symbol is used with any master horizon, except R, where secondary silica has accumulated.
r: Weathered soft bedrock: This symbol is only used in combination with the master C horizon. It designates saprolite or dense till that is hard enough that roots only penetrate along cracks, but which is soft enough that it can be dug with a spade or shovel.
s: Illuvial accumulation of sesquioxides and organic matter. This symbol is only used in combination with B horizons. It indicates the presence of illuvial iron oxides. It is often used in conjunction with h when the color is =< 3 (chroma and value).
ss: Presence of slickensides. They are formed by shear failure as clay material swell upon wetting. Their presence is an indicator of vertic characteristics.
t: Accumulation of silicate clay: The presence of silicate clay forming coats on ped faces, in pores, or on bridges between sand-sized material grains. The clay coats may be either formed by illuviation or concentrated by migration within the horizon. Usually used in combination with B horizons, but it may be used in C or R horizons also.
v: Plinthite: This symbol is used in B and C horizons that are humus poor and iron rich. The material usually has reticulate mottling of reds, yellows, and gray colors.
w: Development of color and structure. This symbol is used for B horizons that have developed structure or color different, usually redder than that of the A or C horizons, but do not have apparent illuvial accumulations.
x: Fragipan character: This symbol is used to designate genetically developed firmness, brittleness, or high bulk density in B or C horizons. No cementing agent is evident.
y: Accumulation of gypsum. This symbol is used in B and C horizons to indicated genetically accumulated gypsum.
z: Accumulation of salts more soluble than gypsum. This symbol is used in combination with B and C horizons.


Andisol
A
Bw
2BC
2C


Alfisol
Ap
E
Bt
BC
C


Udepts
A
E
Bw1
Bw2
2Bw3
2Cd
Ahmeek - Dystric Eutrudepts


Mollisol
Ap
AB
Bw
BC
C

some terminology...

- Colloidal : submicroscopic
  - humus and clay are colloidal

- Humus: ultimate stage of organic decay
  - predominately protein, gums, lignin

- Sesquioxides: 1½ oxygens for each Fe, Al
  - sesquioxides of Fe, Al:

Fe_2O_3 Al_2O_3

Diagnostic Subsurface Horizons

- The accumulation of substances such as silica, iron, aluminium, carbonate, and other salts can result in cemented layers, which change the physical, chemical, and biological behavior of the soil. For example, a cemented layer retards percolation and restrict root activity. Furthermore, the availability of nutrients for plant growth is reduced, i.e., the cation exchange capacity is reduced. There are accumulations in the soil which show the enrichment of one substance and / or the depletion of another substance. This can be expressed by diagnostic subsurface horizons, which are listed in alphabetically order below. It should be stressed that some characteristics can be measured only in the laboratory and not in the field.

Agric horizon: It is formed directly under the plow layer and has silt, clay, and humus accumulated as thick, dark lamallae.
Albic horizon: Typically this is a light-colored E horizon with the color value >= 5 (dry) or >=4 (moist).
Argillic horizon: It is formed by illuviation of clay (generally a B horizon, where the accumulation of clay is denoted by a lower case 't') and illuviation argillans are usually observable unless there is evidence of stress cutans. Requirements to meet an argillic horizon are:
1/10 as thick as all overlying horizons
>= 1.2 times more clay than horizon above, or:
If eluvial layer < 15 % clay, then >= 3 % more clay, or:
If eluvial layer > 40 % clay, then >= 8 % more clay.
Calcic horizon: This layer has a secondary accumulation of carbonates, usually of calcium or magnesium. Requirements:
>= 15 cm thick
>= 5 % carbonate than an underlying layer
Cambic horizon: This subsurface often shows weak indication of either an argillic or spodic horizon, but not enough to qualify as either. It may be conceptually regarded as a signature of early stages of soil development, i.e soil structure or color development. Requirements:
Texture: loamy very fine sand or finer texture
Formation of soil structure
Development of soil color
Duripan: It is a subsurface horizon cemented by illuvial silica. Air-dry fragments from more than 50 % of the horizon do not slake in water or HCl but do slake in hot concentrated KOH.
Fragipan: These subsoil layers are of high bulk density, brittle when moist, and very hard when dry. They do not soften on wetting, but can be broken in the hands. Air-dry fragements slake when immersed in water. Fragipan genesis as outlined in Soil Taxonomy is largely dependent on physical processes and requires a forest vegetation and minimal physical disturbance. Desiccation and shrinking cause develoment of a network of polygonal cracks in the zone of fragipan formation. Subsequent rewetting washes very fine sand, silt, and clay-sized particles from the overlying horizons into the cracks. Upon wetting, the added materials and plant roots growing into the cracks result in compression or the interprism materials. Close packing and binding of the matrix material with clay is responsible for the hard consistence of the dry prisms. Iron is usually concentrated along the bleached boundaries of the prisms. It has also been postulated that clay and sequioxides cements to be binding agents in fragipans.
Glossic horizon: It occurs usually between an overlying albic horizon and an underlying argillic, kandic, or natric horizon or fragipan. Requirements:
>= 5 cm thick
Albic material between 15% to 85 %, rest: material like the underlying horizon

Kandic horizon: It is composed of low activity clays, which are accumulated at its upper boundary. Clay skins may or may not be present. It is considered that clay translocation is involved in the process of kandic formation, however, clay skins may be subsequentlz disrupted or destroyed by physical and chemical weathering, or they may have formed in situ. Requirements:

Mottles are present (yellow color: jarosite)

Within a distance of < 15 cm at its upper boundary the clay content increases by > 1.2 times

Abrupt or clear textural boundary to the upper horizon

At pH 7: low-activity clays with CEC of <= 16 cmol/kg and ECEC (effective CEC) of <= 12 cmol/kg

Natric horizon: It is a subsurface horizons with accumulation of clay minerals and sodium. Requirements:

Same as argillic horizon

Prismatic or columnar structure

> 15 % of the CEC is saturated with Na^{+}, or:

More exchangeable Na^{+} plus Mg^{2+} than Ca^{2+}

Oxic horizon: Requirements:

>= 30 cm thick

Texture: sandy loam or finer

At pH 7: CEC of <= 16 cmol/kg and ECEC of <= 12 cmol/kg (i.e., a high content of 1:1 type clay minerals)

Clay content is more gradual than required by the kandic horizon

< 10 % weatherable minerals in the sand

< 5 % weatherable minerals by volume rock structure (i.e., indicative of a very strongly weathered material)

Petrocalcic horizon: It is an indurated calcic horizon. Requirements:
At least 1/2 of a dry fragment breaks down when immersed in acid but does not break down when immersed in water

Petrogypsic horizon: This is a strongly cemented gypsic horizon. Dry fragments will not slake in H_2O.

Placic horizon: This is a dark reddish brown to black pan of iron and / or manganese. Requirements:
2 - 10 mm thick
It has to lie within 50 cm of the soil surface
Boundary: wavy
Slowly permeable

Salic horizon: This is an subsurface horizon accumulated by secondary soluble salts. Requirements:
>= 15 cm thick
Enrichment of secondary soluble salts such that electrical conductivity exceeds 30 dS/m more than 90 days each year

Sombric horizon: Formed by illuviation of humus (dark bron to black color) but not of aluminium or sodium. Requirements:
At pH 7: base saturation < 50 %
Not under an albic horizon
Free-draining horizon

Spodic horizon: This horizon has an illuvial accumulation of sequioxides and / or organic matter. There are many specific limitations dealing with aluminium, iron, and organic matter content, and clay ratios, depending on whether the overlying horizon is virgin or cultivated.

Sulfuric horizon: This is a very acid mineral or organic soil horizon. Requirements:
pH < 3.5