GEOL 408/508

SOIL CLASSIFICATION

Chapter 3

Brady and Weil, Rev. 14th Ed.

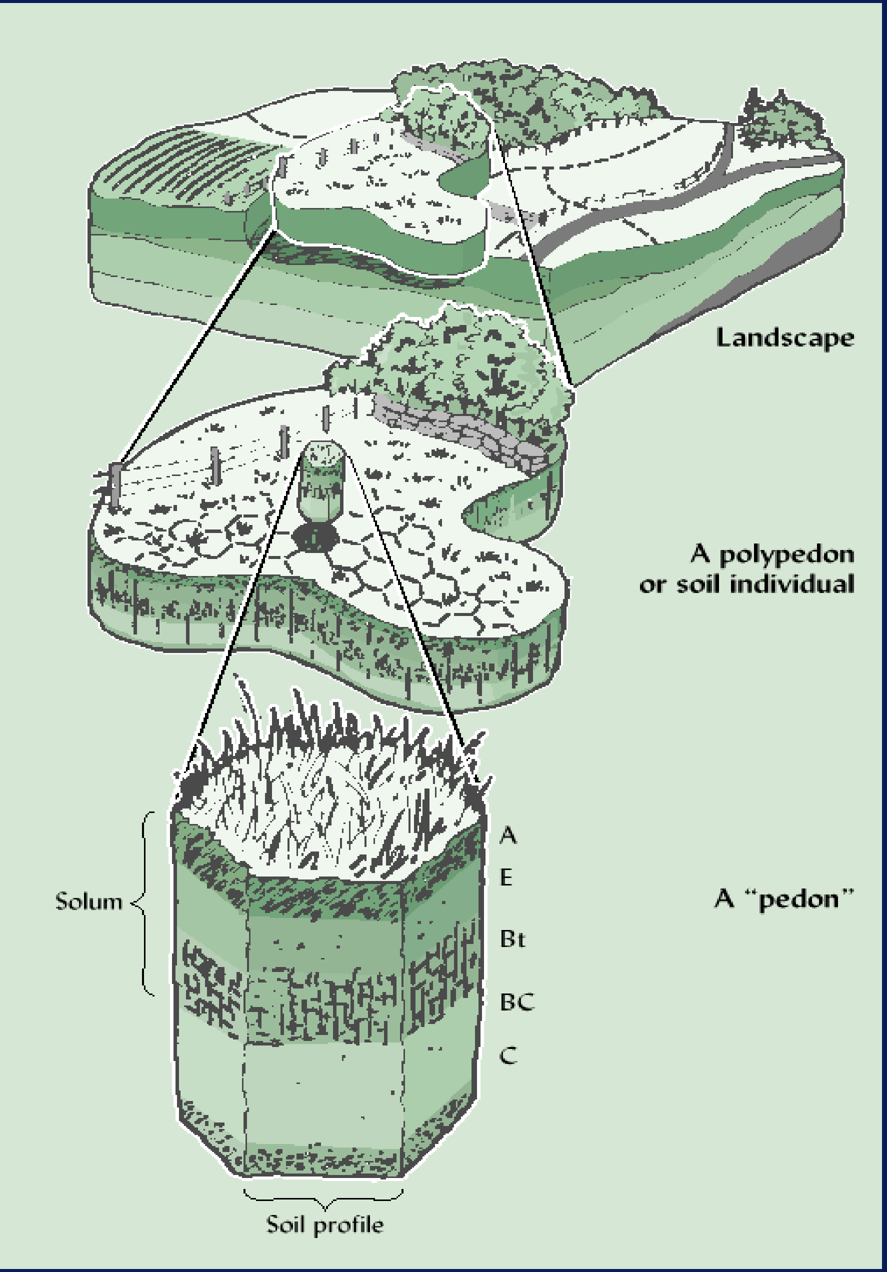
CONCEPT OF INDIVIDUAL SOILS

A schematic diagram to illustrate the concept of pedon and of the soil profile that characterizes it.

Note that several contiguous pedons with similar characteristics are grouped together in a larger area (outlined by broken lines) called a polypedon or soil individual.

Several soil individuals are present in this landscape.

(FIGURE 3.1)



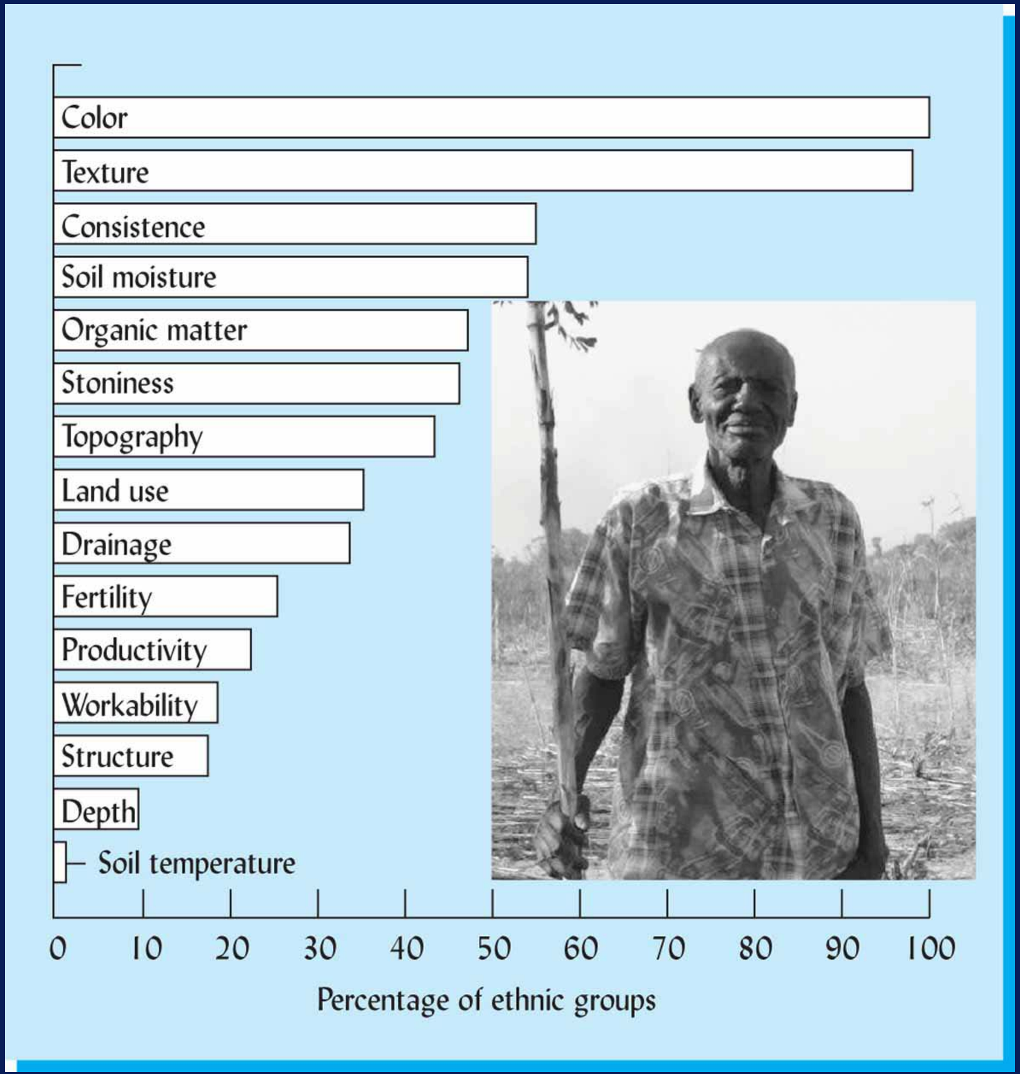
COMPREHENSIVE CLASSIFICATION SYSTEM: SOIL TAXONOMY

Bases of Soil Classification:

Soil Taxonomy **is based on the chemical, physical and biological properties of soils as they are found today.**

Examples are : moisture & temperature status, color, structure, mineralogy, organic matter and clay content.

Soil characteristics used in soil classification among 62 ethnic groups around the world. [Data: Barrera- Bassols et al. (2006); photo: R. Weil] (FIGURE 3.2)



DIAGNOSTIC SURFACE HORIZONS

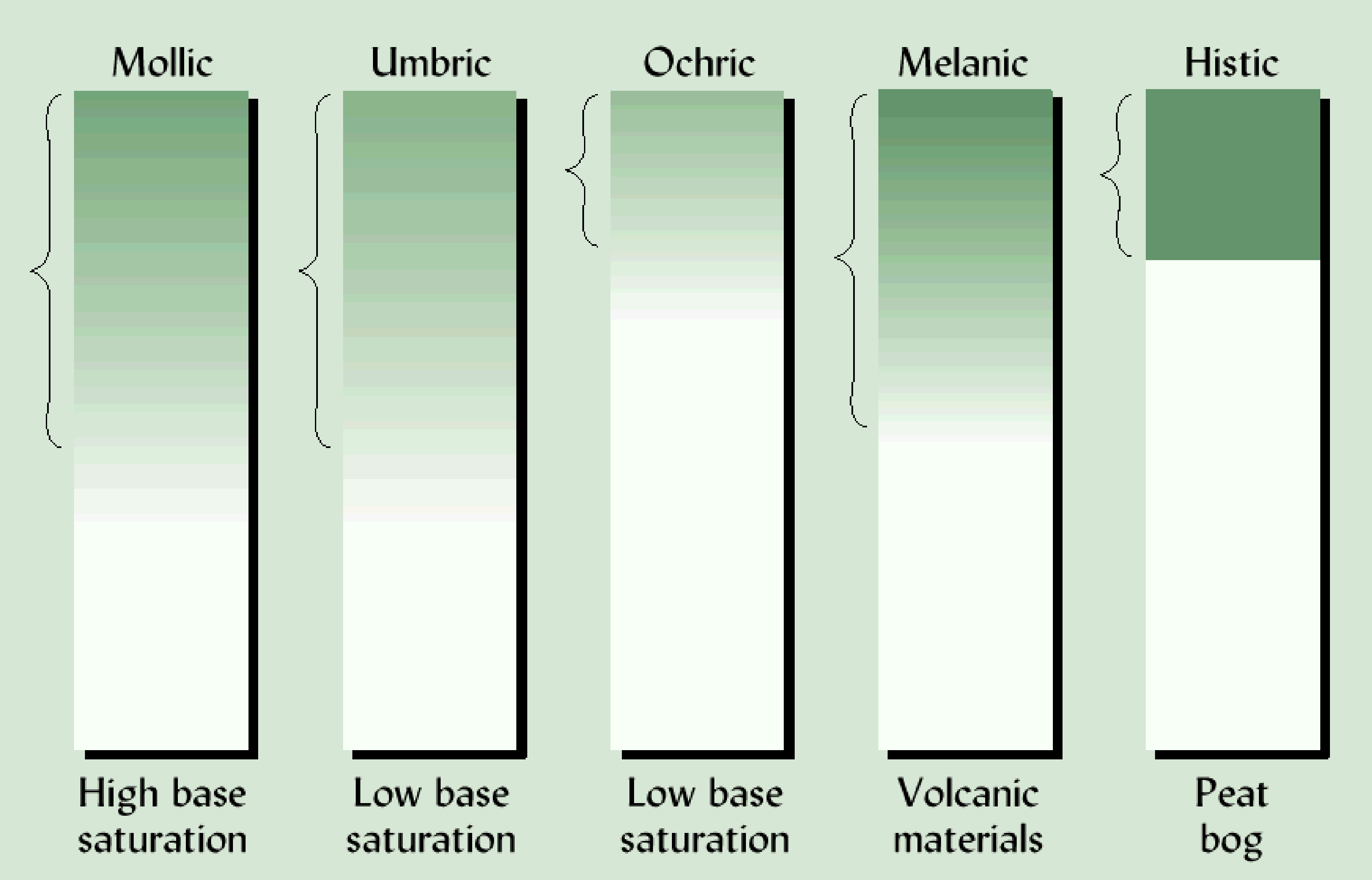
Diagnostic horizon: a horizon having specific soil characteristics that are indicative of certain classes of soils.

Epipedon: a diagnostic horizon that occurs at the soil surface.

There are five naturally occurring and two human generated epipedons.

DIAGNOSTIC SURFACE HORIZONS

Mollic	**Thick, dark-colored, high base saturation, strong structure**
Umbric	**Same as mollic except low base saturation**
Ochric	**Light colored, low OM, may be hard and massive when dry**
Melanic	**Thick, black, high in OM (>6% org. C), common in volcanic soils**
Histic (O)	**Very high in organic content, wet during some part of the year**
Anthropic	**Human-modified molliclike horizon, high in available P**
Plaggen	**Human-made sodlike horizon created by years of manuring**



Representative profile characteristics of five surface diagnostic horizons (epipedons). The comparative organic matter levels and distribution are indicated by the darkness of colors. (FIGURE 3.3)

DIAGNOSTIC SUBSURFACE HORIZONS

Argillic (Bt)	**Silicate clay accumulation**
Natric (Btn)	**Argillic, high in Na, columnar or prismatic structure**
Spodic (Bh, Bs)	**OM, Fe & Al oxides accumulation**
Cambic (Bw, Bg)	**Changed or altered by physical movement or by chemical reactions, generally nonilluval**
Agric (A or B)	**Organic & clay accumulation just below the plow layer resulting from cultivation**
Oxic (Bo)	**Highly weathered, primarily mixture of Fe, Al oxides & non-sticky-type silicate clays**
Duripan (qm)	**Hardpan, strongly cemented by silica**

DIAGNOSTIC SUBSURFACE HORIZONS

Fragipan (x)	Brittle pan, usually loamy textured, dense
Albic (E)	Light-colored, clay, Fe & Al oxides mostly removed
Calcic (k)	Accumulation of $CaCO_3$ or $CaCO_3 \cdot MgCO_3$
Gypsic (y)	Accumulation of gypsum
Salic (z)	Accumulation of salts
Kandic	Accumulation of low-activity clays
Petrocalcic (km)	Cemented calcic horizon
Petrogypsic (ym)	Cemented gypsic horizon
Placic (sm)	Thin pan cemented with Fe alone or with Mn or OM
Sombric (Bh)	OM accumulation
Sulfuric	Highly acid with Jarosite mottles

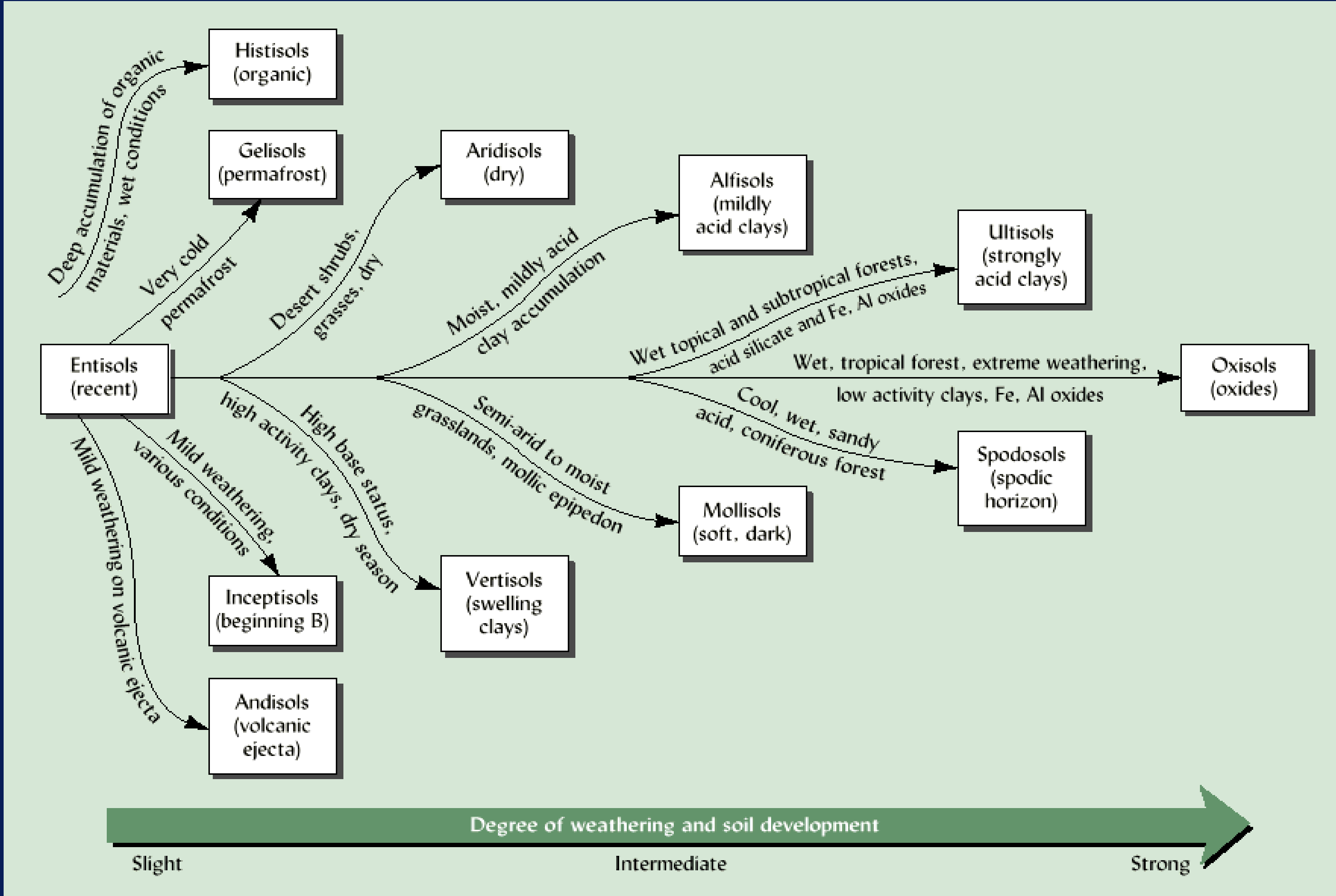
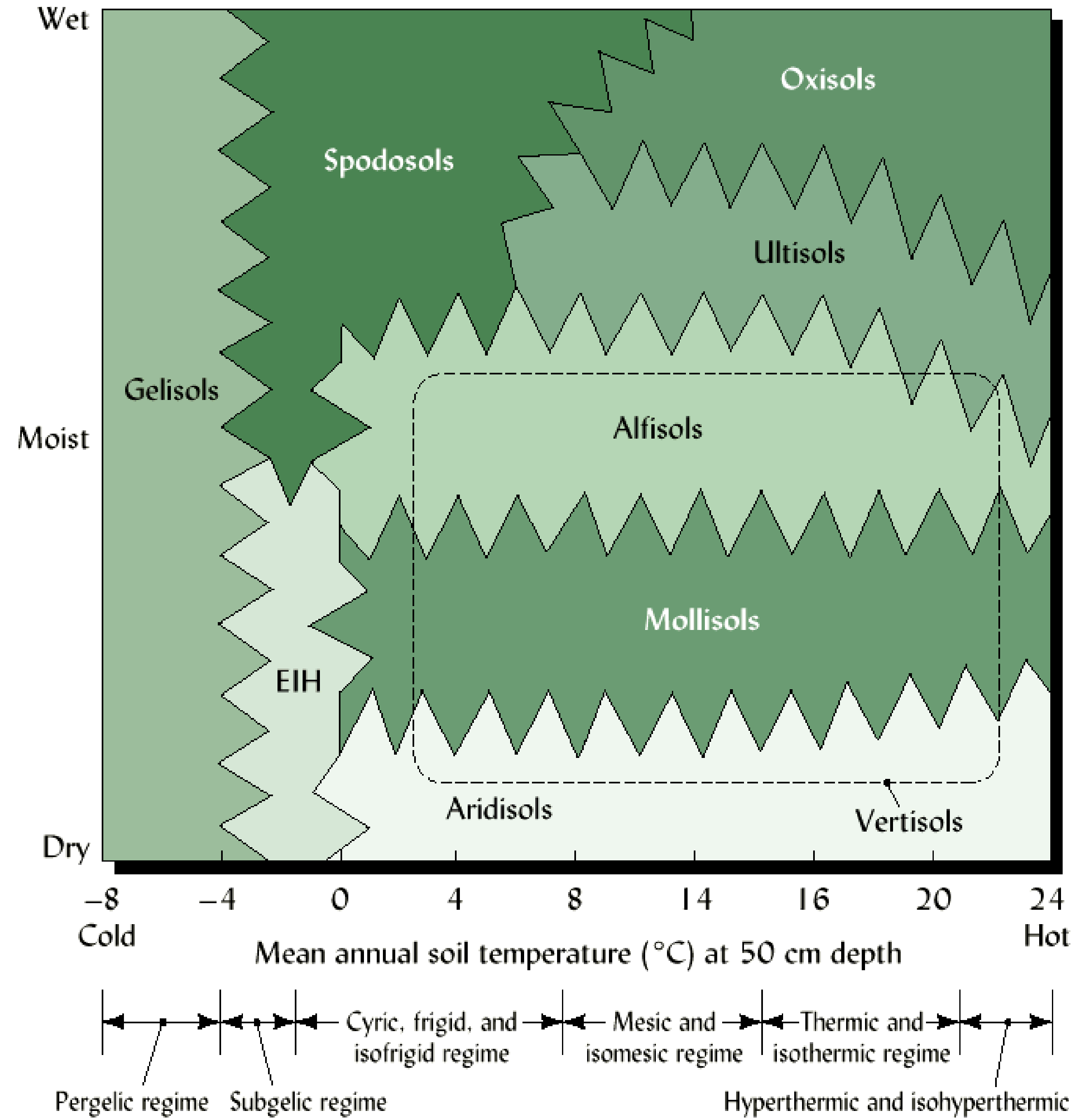


Diagram showing general degree of weathering and soil development in the different orders of mineral soils classified in Soil Taxonomy. Also shown are the general climatic and vegetative conditions under which soils in each order are formed. (FIGURE 3.8)

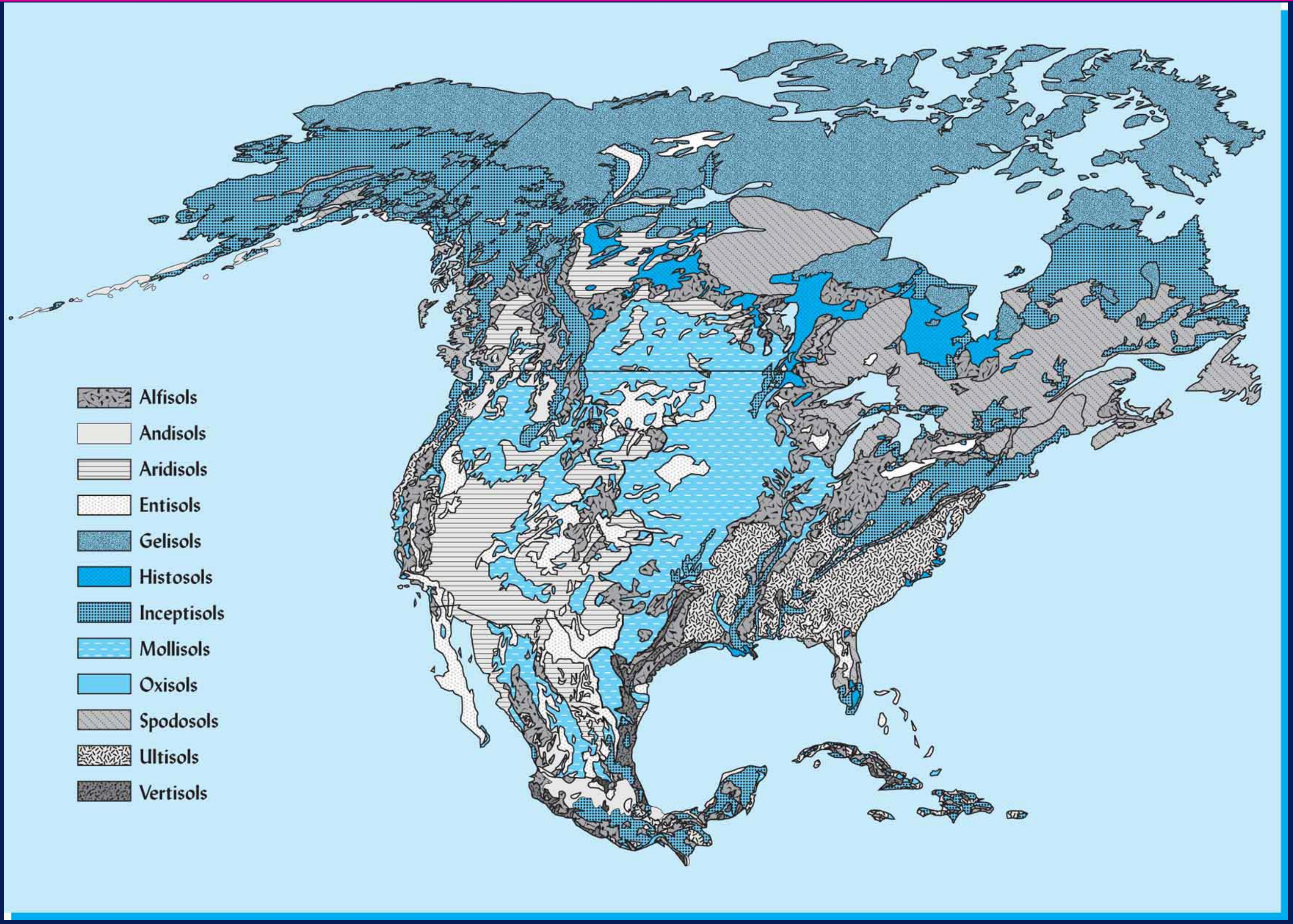
Diagram showing the general soil moisture and soil temperature regimes that characterize the most extensive soils in each of eight soil orders.

Soils of the other four orders (Andisols, Entisols, Inceptisols, and Histosols) may be found under any of the soil moisture and temperature conditions (including the area marked EIH).

Major areas of Vertisols are found only where clayey materials are in abundance and are most extensive where the soil moisture and temperature conditions approximate those shown inside the box with broken lines.
(FIGURE 3.9)



Simplified soils map of North America showing the general distribution of the 12 soil orders defined by *Soil Taxonomy* (**FIGURE 3.10**).



ENTISOLS

(RECENT: LITTLE IF ANY PROFILE DEVELOPMENT)

- Very young soils
  - recent alluvium
  - soils containing non-weatherable material
- Soils without natural genetic subsurface horizons, or only the beginnings of such horizons
- Most have ochric epipedon
- Some have horizons produced by man's activities
- Very diverse (property wise) group of soils
- Occur under widely varying environmental conditions

ENTISOLS

Ochric epipedon

B horizon

Typic Quartzipsamment
from eastern TX

C horizon

INCEPTISOLS

(FEW DIAGNOSTIC FEATURES: INCEPTION OF B HORIZON)

- Soils with quickly formed diagnostic horizons
  - color or structure cambic
- No significant eluviation or illuviation, except for carbonates or silica
- Have ochric or umbric epipedons and/or cambic horizons
- Significantly more profile development than Entisols
- Do not include soils that are placed into: Aridisols, Gelisols or Andisols

INCEPTISOLS

A horizon

Typic Dystrudept
from WVa

Cambic horizon

C horizon

ANDISOLS

(VOLCANIC ASH SOILS)

- Generally found in recently deposited volcanic materials
- Generally formed on volcanic ash and cinders
- Have not had time to become highly weathered
- Young soils (generally 5000 - 10,000 years)
- Principal soil-forming processes:

  rapid weathering of ash to produce allophane, imogolite and ferrihydrate
- Andic properties:

  high content of volcanic glasses and/or

  high content of amorphous or poorly crystalline Fe and Al minerals

ANDISOLS

Melanic epipedon

Typic Melanudand, western Tanzania

Weathered ash

Weathered ash, ? Bs

GELISOLS

(PERMAFROST AND FROST CHURNING)

- Young soils with little profile development
- Principal defining feature is presence of permafrost layer
- Permafrost = temps < 0 ˚C for > 2 consecutive years
- Permafrost is within 100 cm of soil surface
- With cryoturbation, permafrost within 200 cm of surface
- May have mollic, histic, umbric, calcic or argillic horizons

GELISOLS

Histic epipedon

Active layer

Typic Aquaterbel, Alaska

Permafrost

HISTOSOLS

(ORGANIC SOILS WITHOUT PERMAFROST)

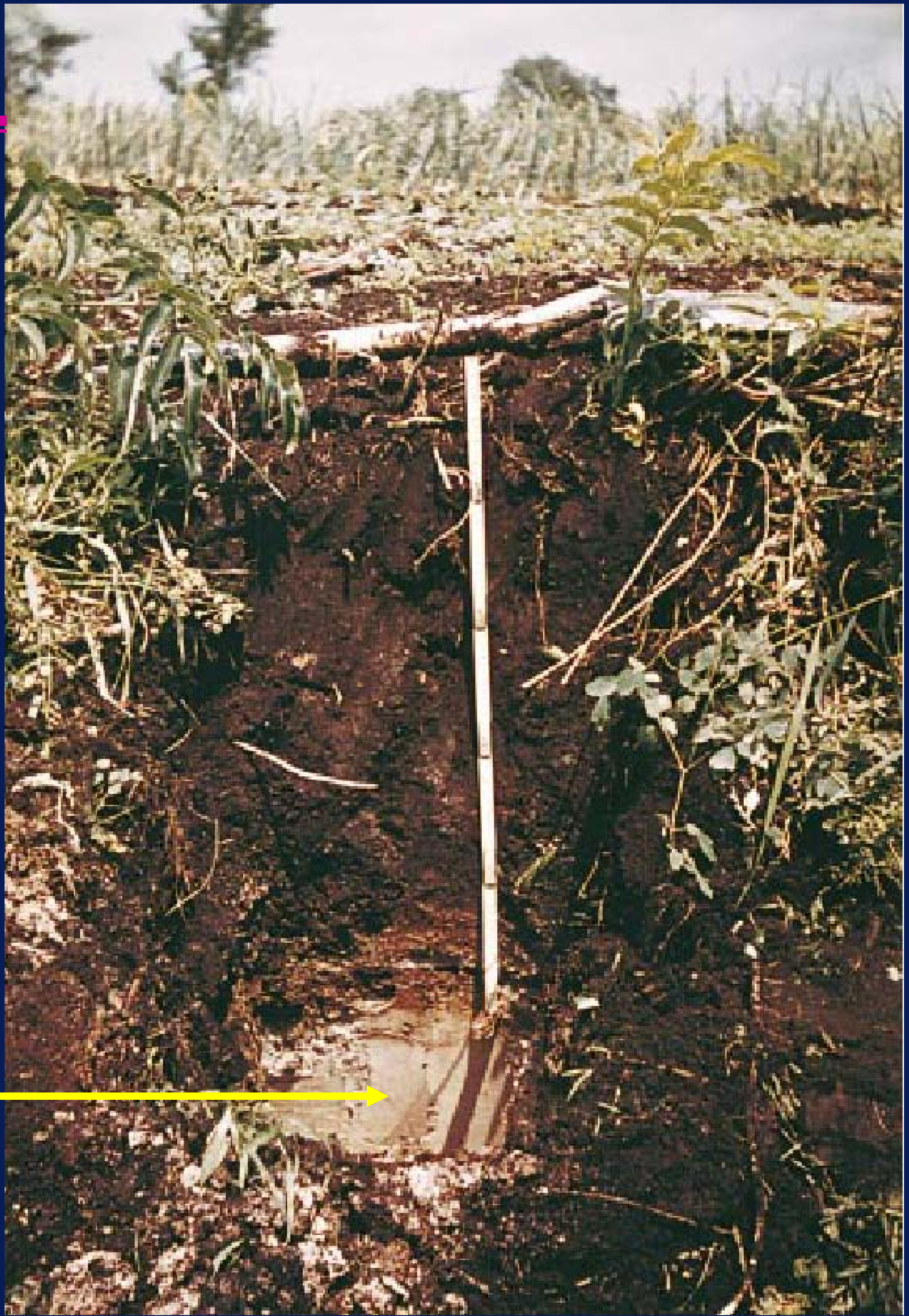
- One or more thick layers of organic soil material
- High organic carbon content (gen. > 35%; see footnote 6, p. 80)
- Little profile differentiation
- Typically formed in a water-saturated environment; wetland soils
- Can be found in most any climate

HISTOSOLS

Limnic Haplosaprist, southern MI

Sapric material

Lacustrine clay



ARIDISOLS

(SOILS OF DRY PLACES)

- Water deficiency is a major characteristic
- Can support vegetation for no longer than 90 consecutive days
- Have an ochric epipedon
- Have one or more diagnostic horizons (calcic, gypsic, salic, natric, argillic)
- May have petrocalcic horizon
- 2nd most extensive soil order (12% in world; 9% in US)
- Can be highly productive with irrigation; salt accumulation can be major problem

ARIDISOLS

Ochric epipedon

Typic Haplocambid, western NV

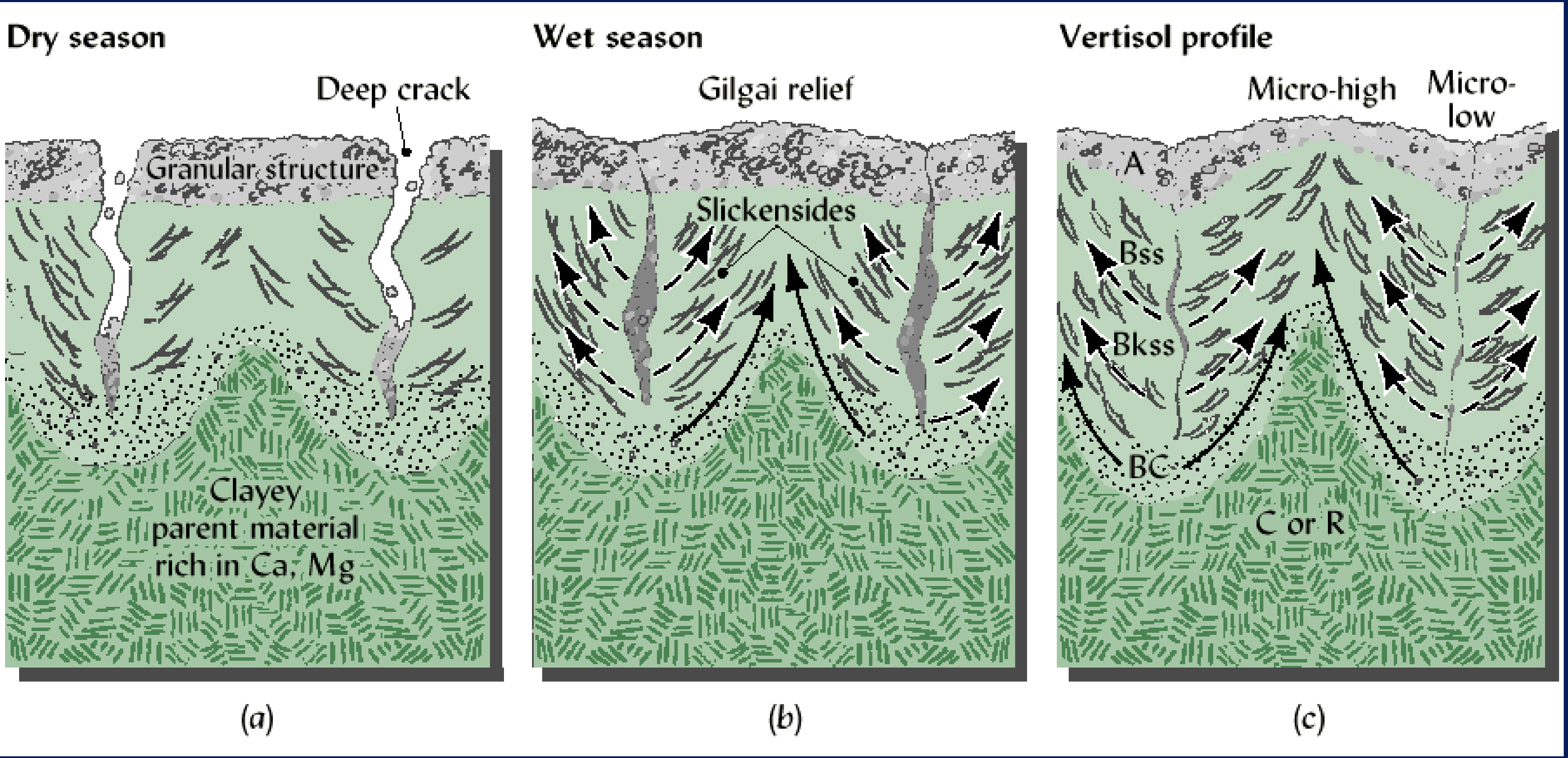
Bk horizon

Ck horizon

VERTISOLS

(DARK, SWELLING AND CRACKING CLAYS)

- Main soil forming process is shrinking/swelling as soils undergo wetting and drying
- Have > 30% shrink/swell type clays to depth of > 1m
- Most are dark (many blackish) in color to depth > 1m
- Color does not necessarily indicate high % OM
- Generally develop in areas with high Ca and Mg



Vertisols typically are high in swelling-type clay and have developed wedgelike structures the subsoil horizons. (a) During the dry season, large cracks appear as the clay shrinks upon drying. Some of the surface soil granules fall into cracks under the influence of wind and animals. This action causes a partial mixing, or inversion, of the horizons. (b) During the wet season, rainwater pours down the cracks, wetting the soil near the bottom of the cracks first, and then the entire profile. As the clay absorbs water, it swells the cracks shut, entrapping the collected granular soil. (c) These processes result in a Vertisol profile that typically exhibits gilgai, cracks more than 1 m deep, and slickensides in a Bss horizon. (FIGURE 3.23)

VERTISOLS

Typic Haplustert, Queensland, Australia

Whatta' mess!

MOLLISOLS

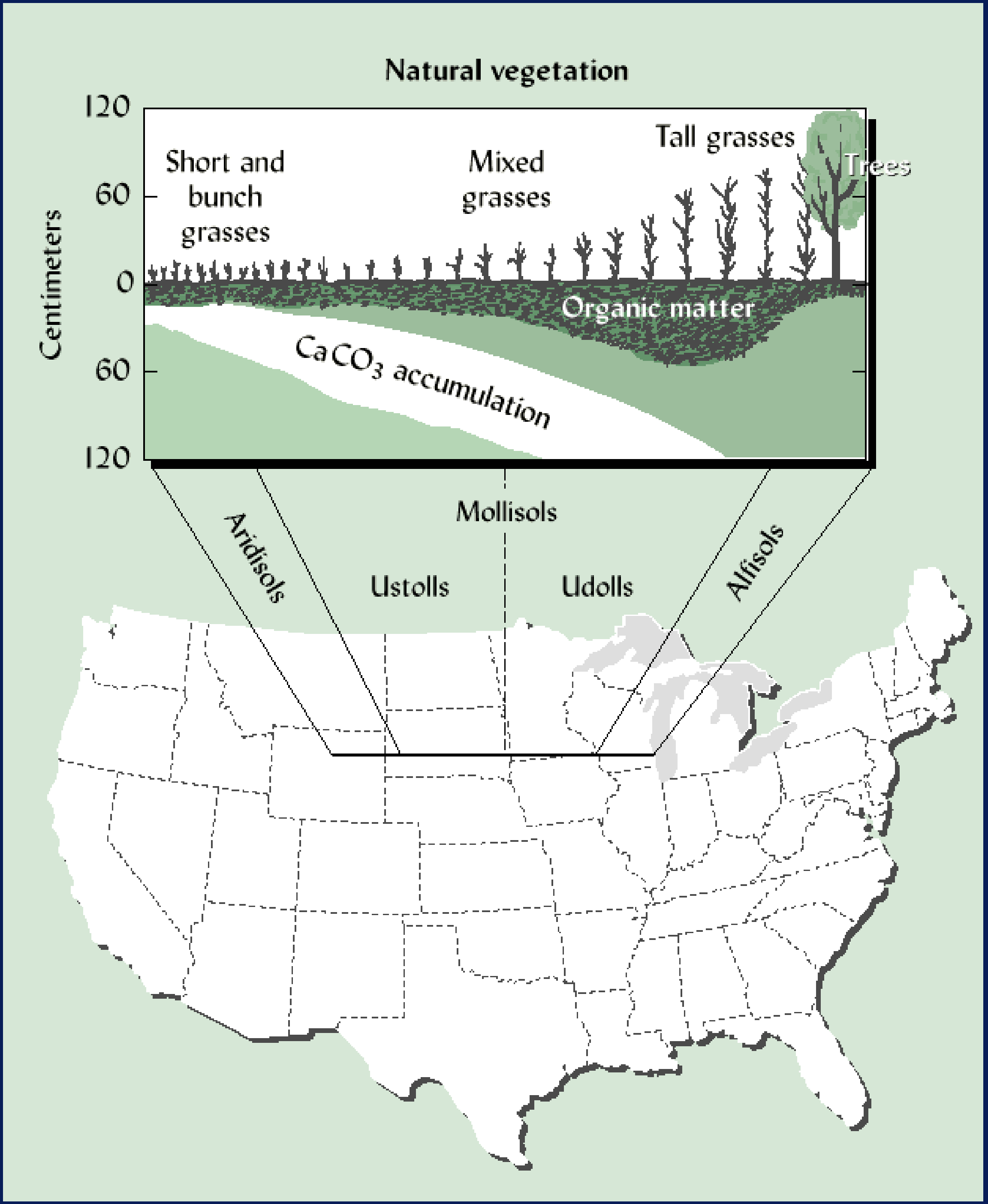
(DARK, SOFT SOILS OF GRASSLANDS)

- Soils with a mollic epipedon
- Mostly developed under grass vegetation
- Base saturation > 50%
- May have agillic, natric, albic or cambic horizon; but not oxic or spodic horizon
- Principal soil forming process is accumulation of Ca-Mg-rich OM (forms mollic epipedon)
- Generally the most productive soil order

Correlation between natural grassland vegetation and certain soil orders is graphically shown for a transect across north central United States.

The control, of course, is climate. Note the deeper organic matter and deeper zone of calcium accumulation, sometimes underlain by gypsum, as one proceeds from the drier areas in the west toward the more humid region where prairie soils are found.

Alfisols may develop under grassland vegetation, but more commonly occur under forests and have lighter-colored surface horizons. (FIGURE 3.24)



MOLLISOLS

Mollic Epipedon
(A horizon)

A Typic Hapludoll
from Central Iowa

Bk horizon

Ck horizon

ALFISOLS

(ARGILLIC OR NATRIC HORIZON, MEDIUM TO HIGH BASES)

- More strongly weathered than previously discussed orders
- Typically have ochric or umbric epipedon
- Have argillic or natric horizon
- Have > 35% base saturaion
- Usually moist > 90 days in growing season
- Weathered soils, rich in Fe and Al

ALFISOLS

Aeric Epiaqualf from western NY

Argillic Horizon

Where is the E horizon?

B or B/C

ULTISOLS

(ARGILLIC HORIZON, LOW BASES)

- More highly weathered than Alfisols
  - more acid
  - base saturation < 35%
- Mean annual temperature > 8˚C; warm to tropical climates
- Moist for 90 days during growing season
- Usually form under forest vegetation
- May be very productive agricultural soils
- May find plinthite formations (Fe oxide accumulation, hardens irreversibly when dried

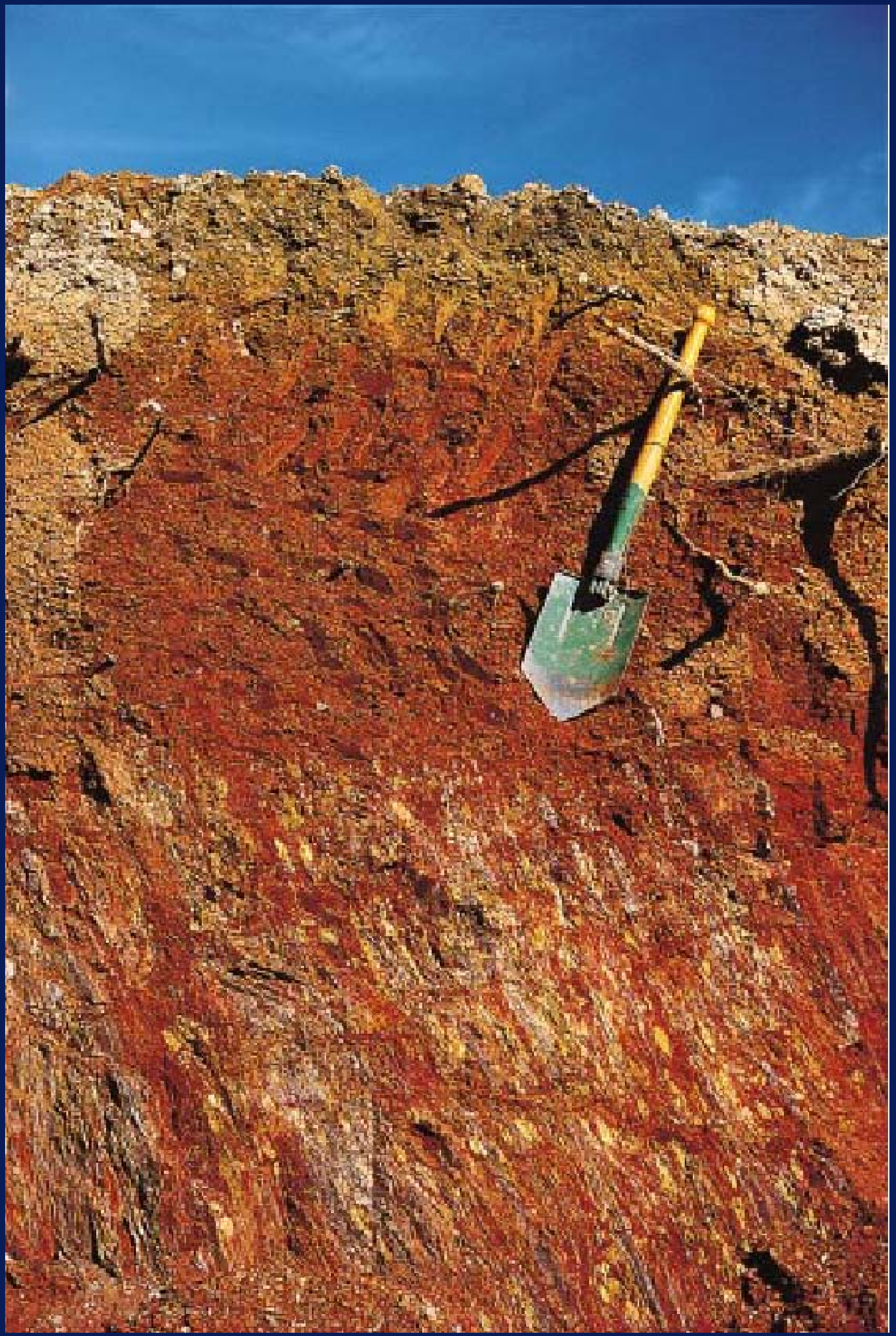
ULTISOLS

Ap horizon

B horizon

Typic Hapludult from central VA

Metamorphic rock structure in saprolite (C)



SPODOSOLS

(ACID, SANDY FOREST SOILS, LOW BASES)

- Generally occur on moist, acid, coarse texured parent materials, cool to cold climates
- Found in NE US; northern Europe & Russia, central & eastern Canada
- Have diagnostic spodic horizon (subsurface accumulation of Al & Fe oxides and OM
- Generally have albic horizon (not diagnostic for Spodosols)
- Form under forest vegetation
- Not naturally fertile; need careful management if cultivated

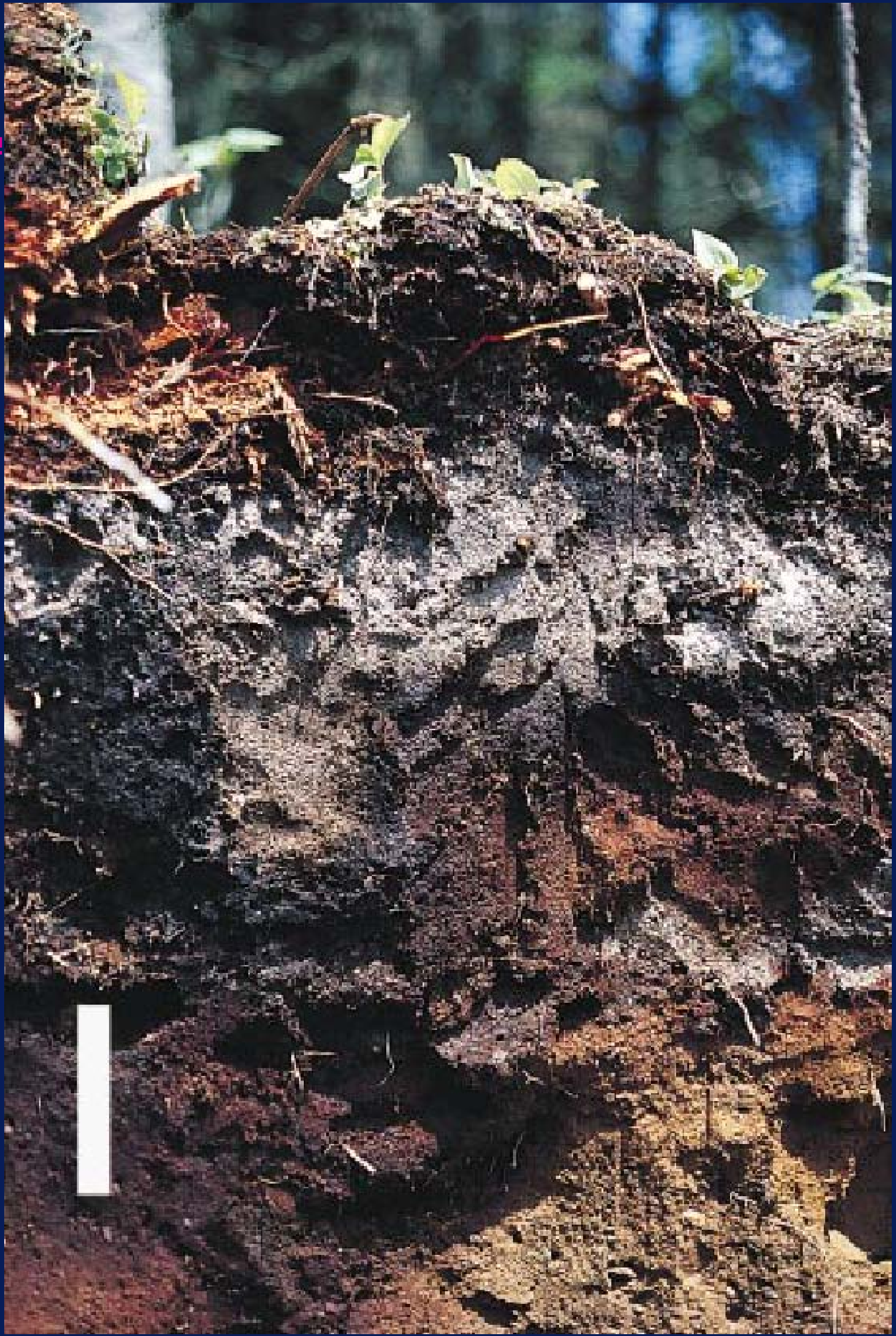
SPODOSOLS

O horizon

Albic (E) horizon

Humic Cryorthod from northern Quebec

Spodic horizon (Bh, Bs)



OXISOLS

(OXIC HORIZON, HIGHLY WEATHERED)

- Most highly weathered soils in classification system
- Have ochric or umbric epipedon
- Form in hot climates with nearly year-round moisture
- Native vegetation thought to be tropical rain forest
- Have deep oxic horizon, enriched in Al & Fe oxide clays
- Few weatherable minerals remain
- Low natural fertility and extreme P fixing capacity
- Easily excavated, do not shrink-swell, stable on slopes

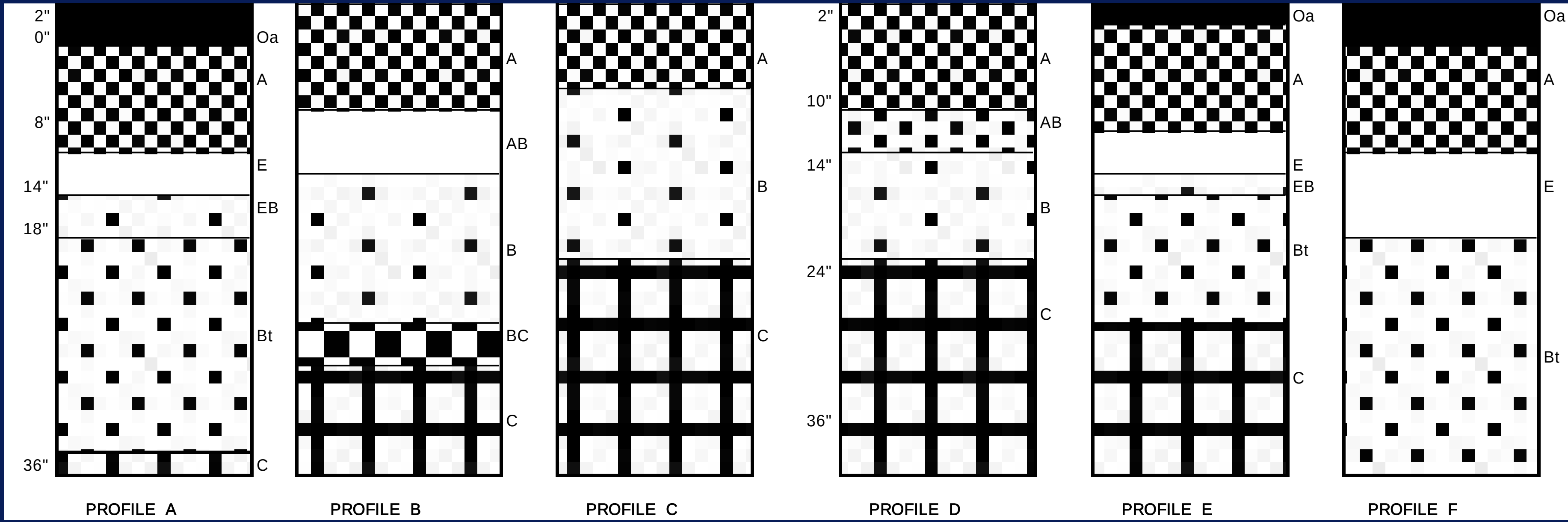
OXISOLS

Udeptic Hapludox from central Puerto Rico

Where's the A horizon?

Where's the B horizon?

RANK THE RELATIVE AGE OF THESE SOIL PROFILES



SOIL TAXONOMY

Order - based on observable soil properties

Suborder - based on properties and horizonation from differences in soil moisture & soil temperature

Great Group - based on presence or absence of diagnostic horizons & arrangements of horizons

Sub group - Typic, central concept of great group, of gradation towards other orders, suborders or great groups

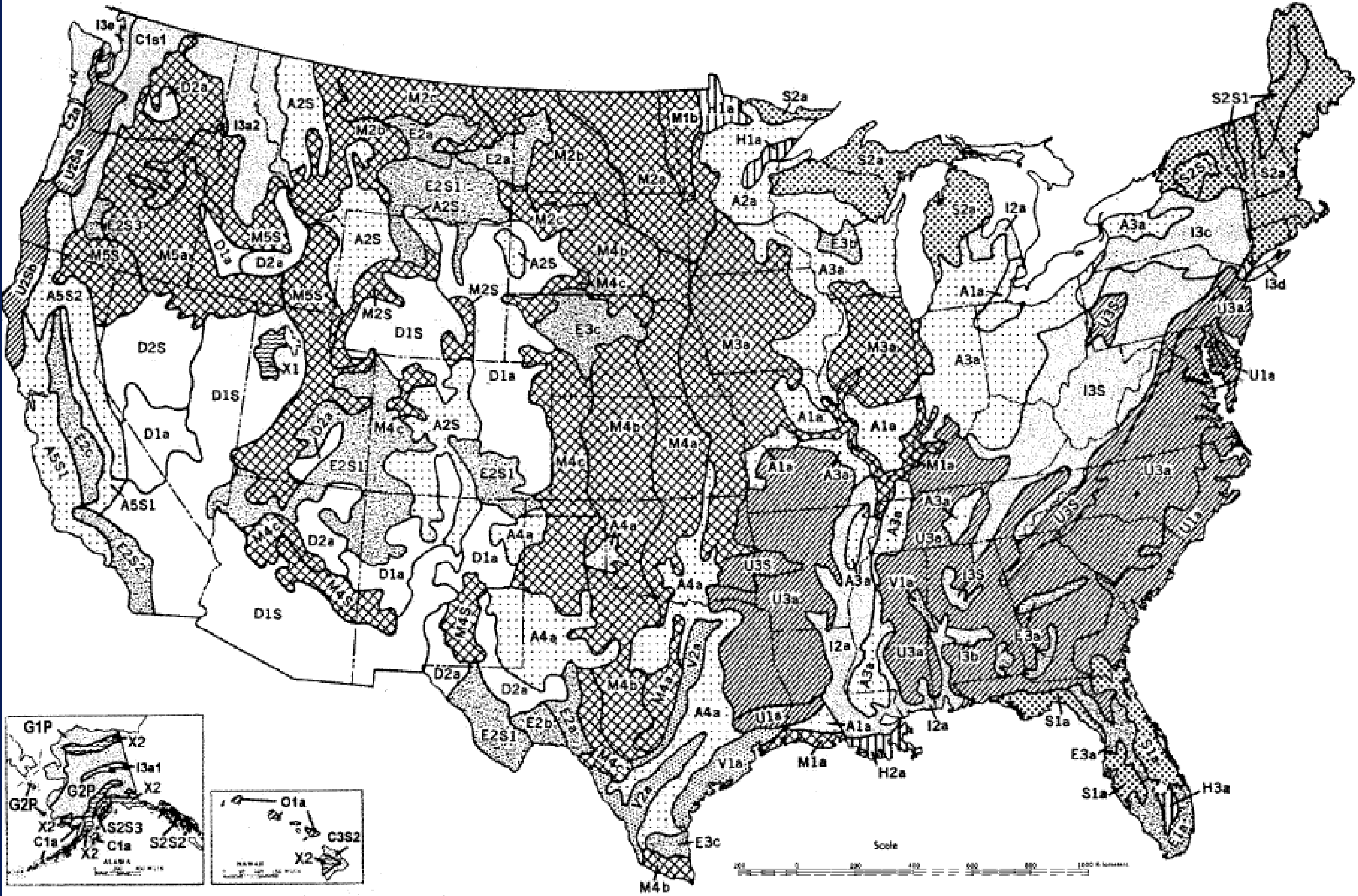
Family - based on properties important to the growth of vegetation

SOIL TAXONOMY

Series -defined by a specific range of soil properties involving primarily he kind, thickness and arrangement of horizons - use local names

Type -describes surface texture, slope, stoniness, erosion, saltiness or other features - No Longer Used

PATTERN OF SOIL ORDERS AND SUBORDERS IN THE US



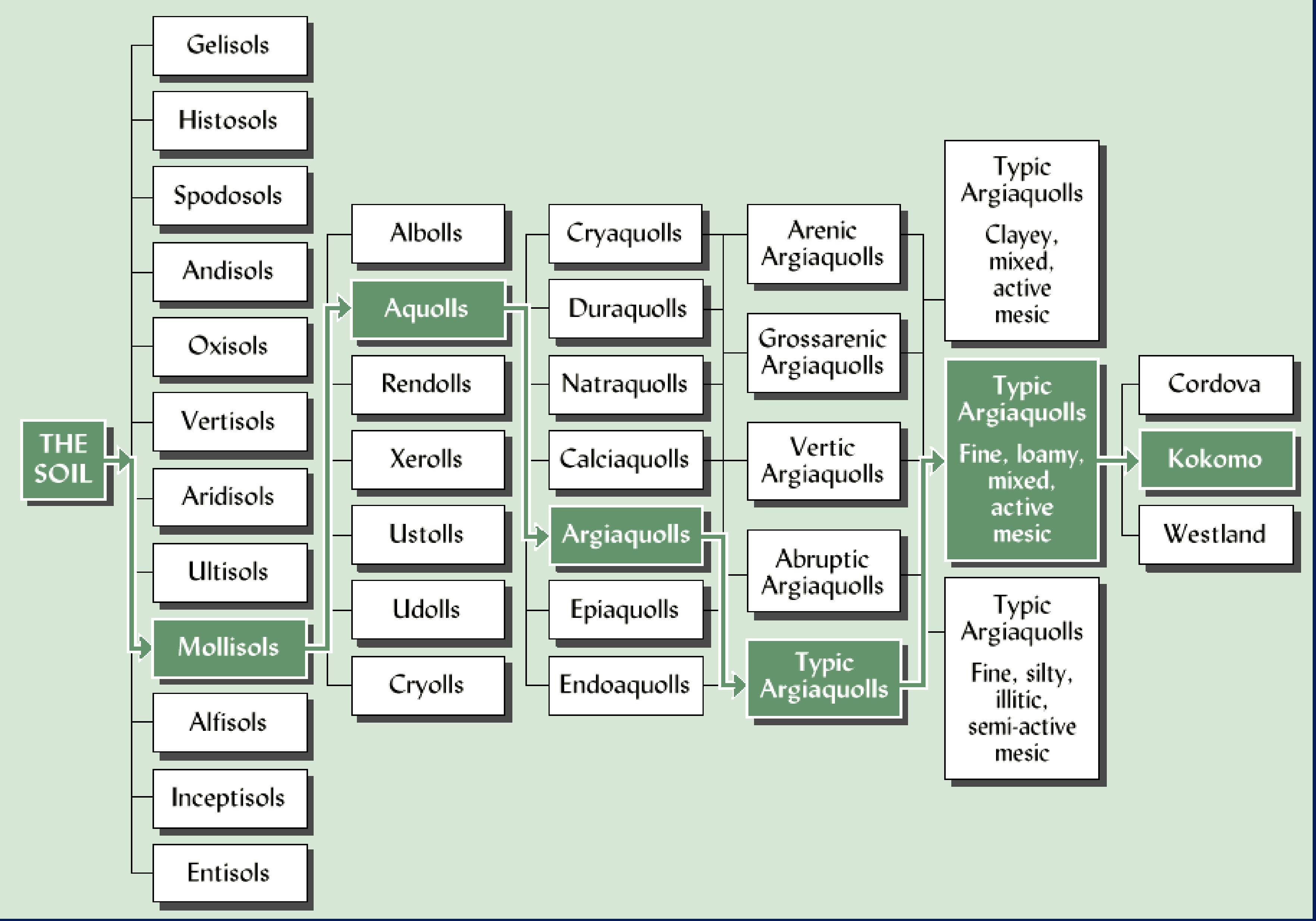
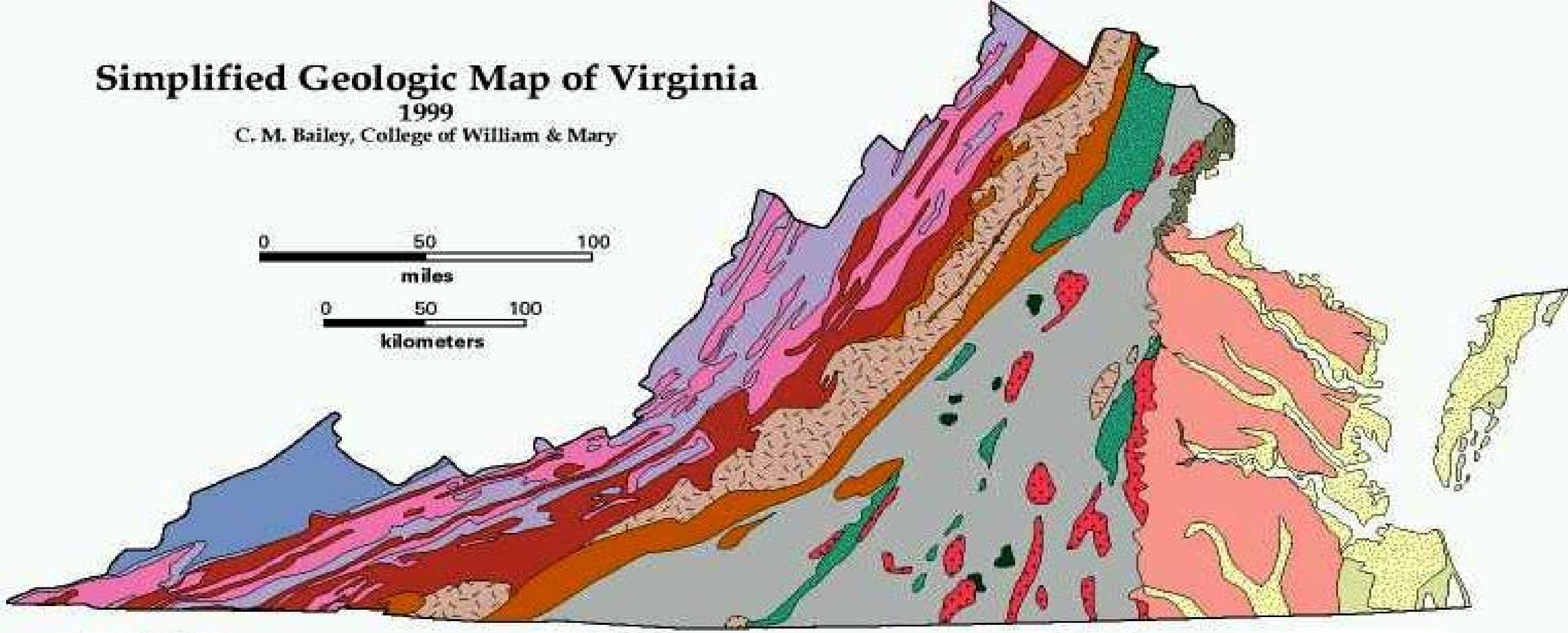


Diagram illustrating how one soil (Kokomo) keys out in the overall classification scheme. (FIGURE 3.28)



PROTEROZOIC
1 billion-550 million years ago

Basalt Granite Gneiss

PALEOZOIC
550 million-250 million years ago

Granite Gabbro Limestone Sandstone Shale Shale and Coal

MESOZOIC
250 million Š 65 million years ago

Clay and San Conglomerate

CENOZOIC
65 million years ago Š present

Sand Sand and Mar Sand, Mud, Peat

FIELD ASSOCIATIONS OF SOILS