

# Introduction to the Archaeological Record: Soils, Sediments, and a Little Stratigraphy

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# The Archaeological Record

- A (continuous) scatter of artifacts *in their matrices*.
- Making observations on the record usually requires destroying part of it.

*Given the destructive character of archaeological excavation, the observations you make can never be repeated and the records you create are the only records there will ever be. We therefore take our obligations for completeness, accuracy, and standardization in excavation and recording very seriously. We expect you to do the same. Study the field and lab manuals carefully.*

- Transcription is impossible.
- What should you record??

# Geoarchaeology

- “archaeology pursued with the help of geological models and methods”
- geological methods offer clues about which attributes of the record are likely to be informative about ...
  - formation processes
    - depositional processes
    - post-depositional alteration
  - landscape and environmental reconstruction

## Two kinds of matrix in which artifacts occur

### **Soil**

- the result of *in-situ* pedogenic processes at work on stable parent material over a long period of time (centuries, millenia)

### **Sediment**

- particles accumulated, precipitated, or deposited by natural and cultural processes.

# Four Kinds of Sediment

- clastic: fragments of rock (**clasts**) deposited by water, gravity, wind, ice, people.
- chemical: precipitation of ions and oxides dissolved in water (e.g. salts left by evaporation)
- organic: decomposition or accumulation of organic matter (dead stuff).
- pyroclastic sediments: volcanics.

*Clasts created by physical and chemical weathering*

# Clastic Sediments: Basic Concepts

**Clastic Sediments occur in deposits.**

-a **deposit** is a sedimentary unit formed under constant physical conditions with constant delivery of the same material during deposition.

**How do you recognize a deposit?**

- look for zones with homogeneous, visible **lithology** (clast size, morphology, composition, and arrangement).
- these are “**lithostratigraphic units**” (layers, zones)

**Homogeneous lithology allows you to *infer***

- constant source (where the clasts came from).
- constant transport agent (how the clasts got there).

**How many lithostratigraphic units?...**



# Clastic Sediments

## Transport agents for clastic sediments

- water: *alluvium*
- gravity *colluvium*
- wind *loess*
- ice *(glacial) till*
- people *fill*

## Transport agents cause variation in deposit lithology

- clast size
- size sorting
- roundness
- fabric : clast vs. matrix support
- bedding (massive vs. laminations)

# Clast or Grain Size

## Units of measurement

- $\mu\text{m}$  ("microns") =  $1/1000 \text{ mm}$
- $\phi = -\log_2(\text{mm})$

## Determinants of Clast Size

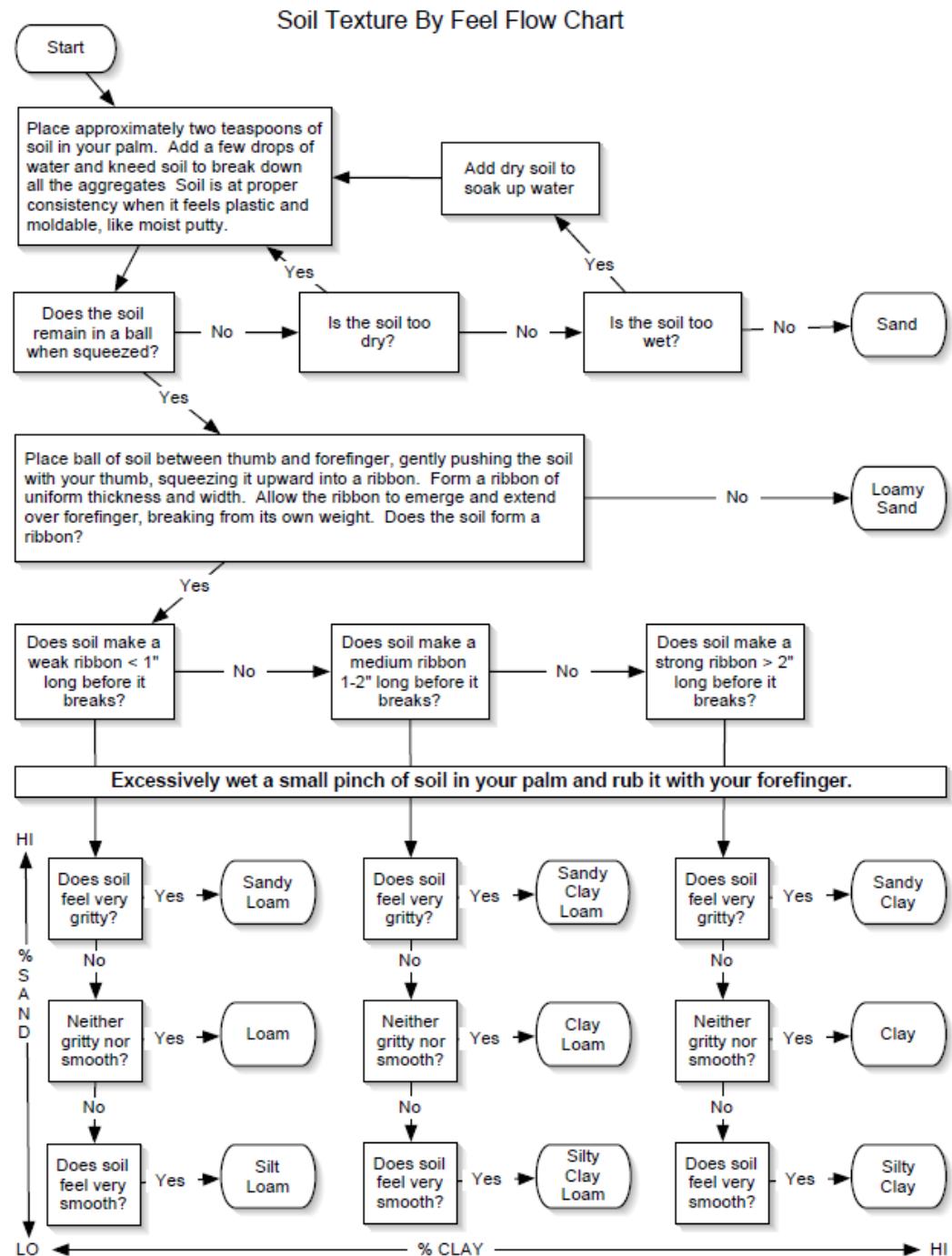
- Sediment source
- Energy of the transport mechanism

Inclusions

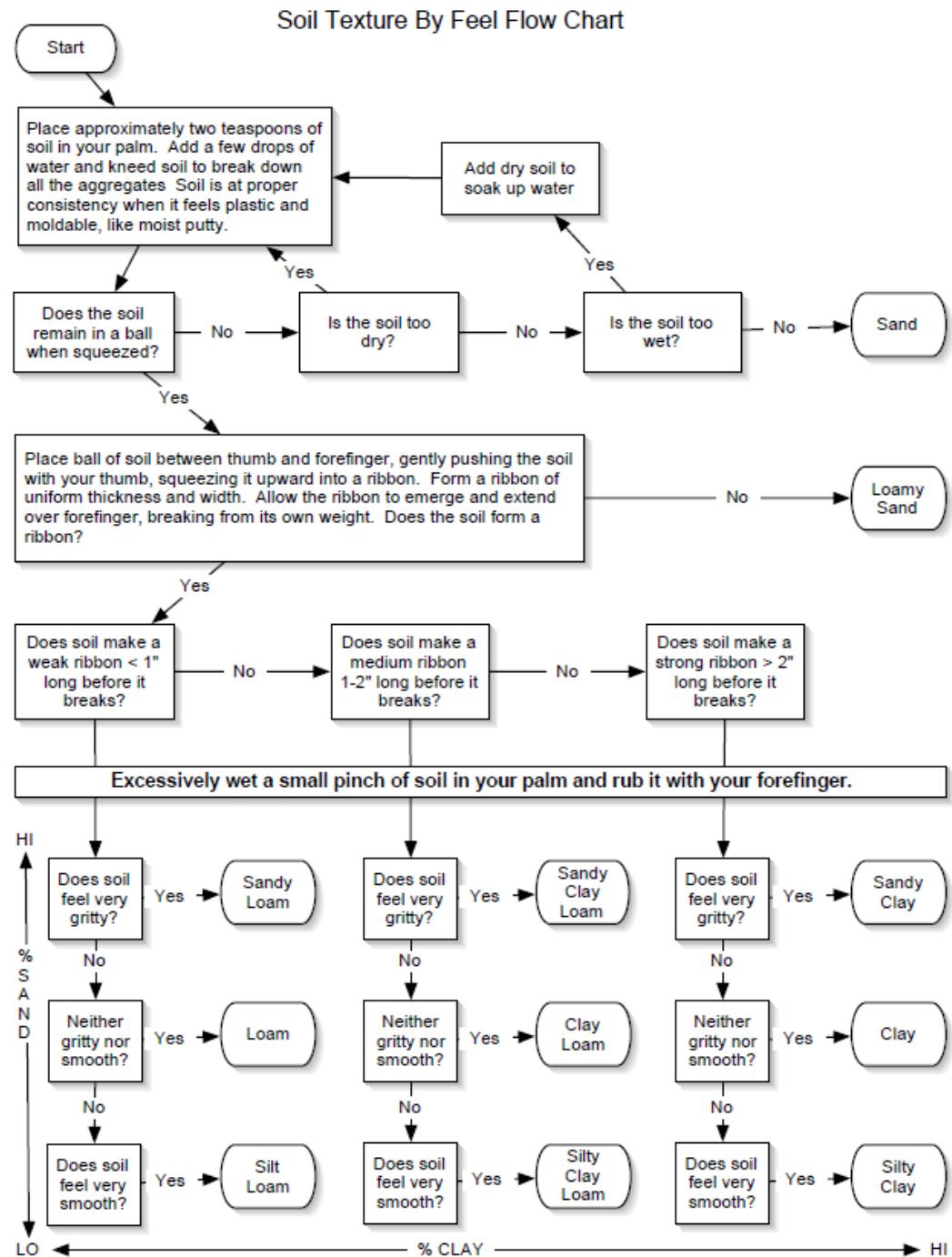
Fines

Class Name		Size Range (mm)	Size Range ( $\mu\text{m}$ )	Phi Units
<b>Boulders</b>	Very Large	4096-2048		-11
	Large	2048-1024		-10
	Medium	1024-512		-9
	Small	512-256		-8
<b>Cobbles</b>	Large	256-128		-7
	Small	128-64		-6
<b>Gravel Pebbles</b>	Very Coarse	64-32		-5
	Coarse	32-16		-4
	Medium	16-8		-3
	Fine	8-4		-2
<b>Granules</b>	Very Fine	4-2		-1
<b>Sand</b>	Very Coarse	2-1	2000-1000	0
	Coarse	1-0.5	1000-500	1
	Medium	0.5-0.25	500-250	2
	Fine		250-125	3
	Very Fine		125-62	4
<b>Silt</b>	Coarse		62-31	5
	Medium		31-16	6
	Fine		16-8	7
	Very Fine		8-4	8
<b>Clay</b>	Coarse		4-2	9
	Medium		2-1	10
	Fine		1-0.5	11
	Very Fine		0.5-0.24	12

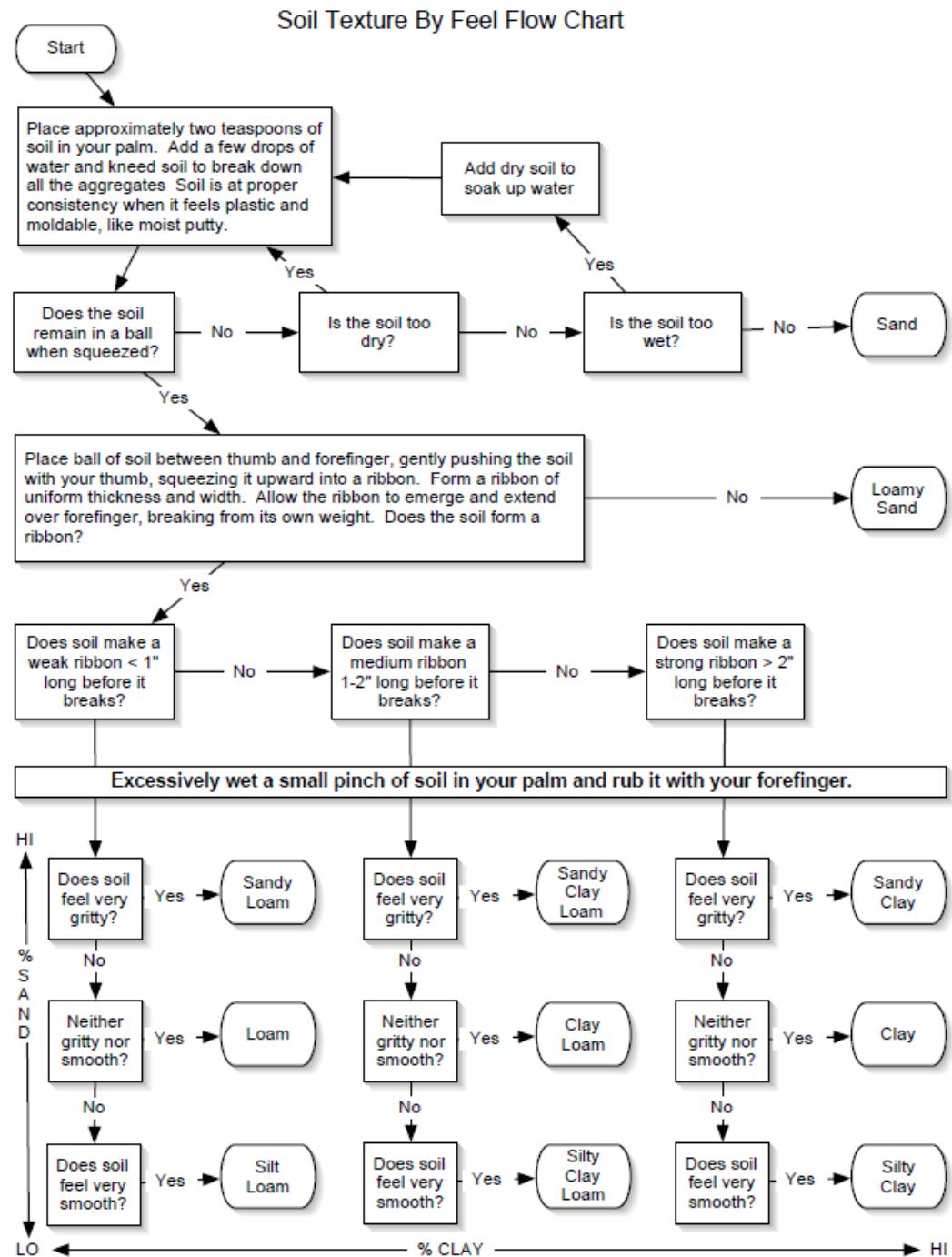
# Field Key for USDA Textural Classes



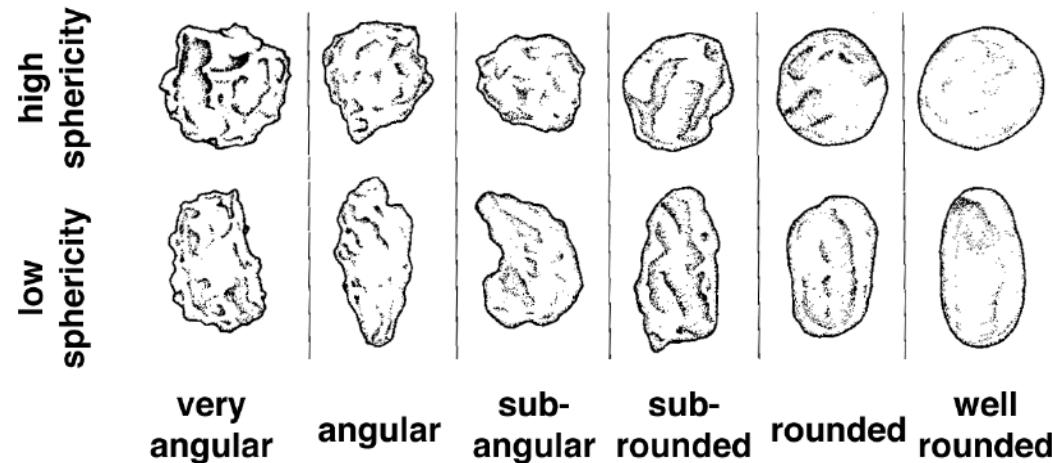
# Field Key for USDA Textural Classes



# Field Key for USDA Textural Classes For Fine-Grained Sediments

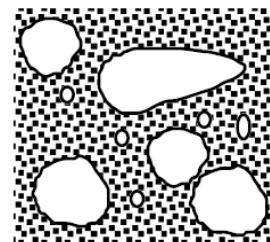


## Roundness



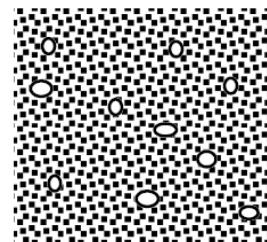
*Clast history: recent fragmentation vs. history of abrasion, weathering after fragmentation.*

## Sorting



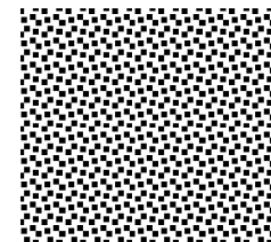
POORLY SORTED

Melting ice (till)  
Debris flows  
Mudflows



MOD. SORTED

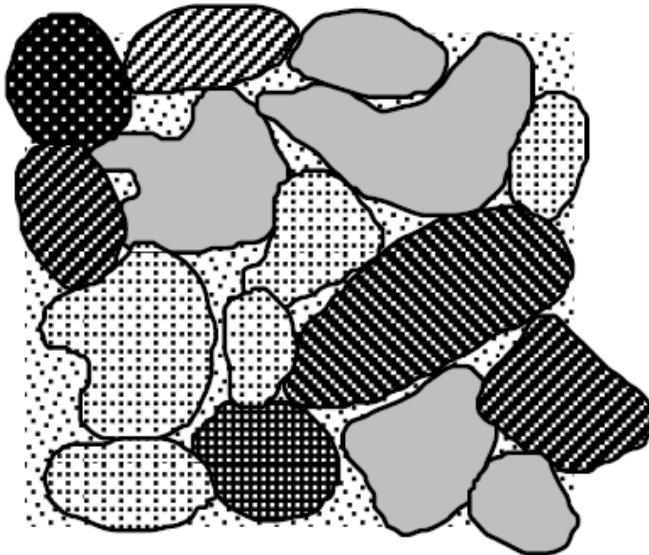
Rivers  
Tidal currents  
Surf



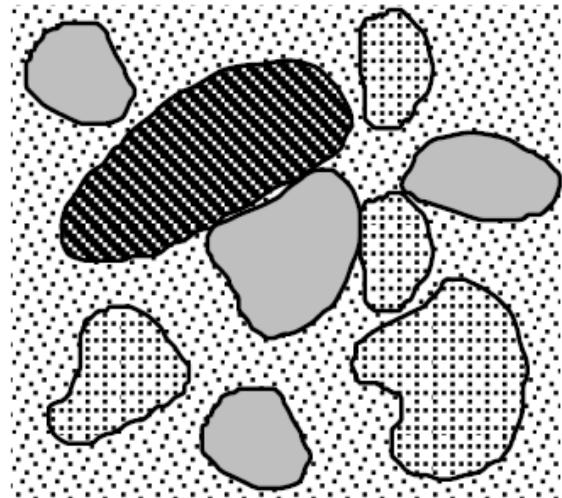
WELL SORTED

Wind  
Some beaches

## Fabric



Clast Support



Matrix Support

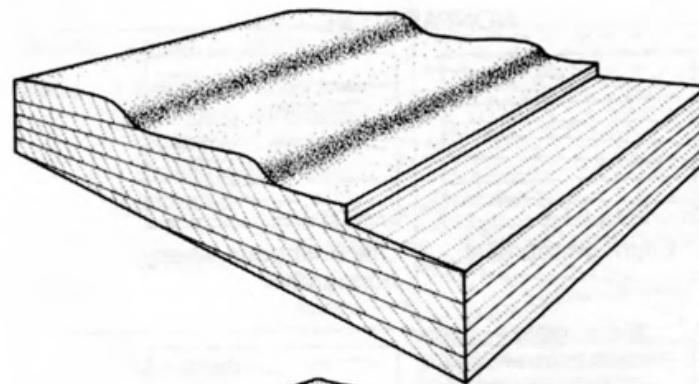
Matrix support is common in poorly sorted sediments (fill, till, colluvium).

Clast Support may result from later infiltration of fine-grained sediments.

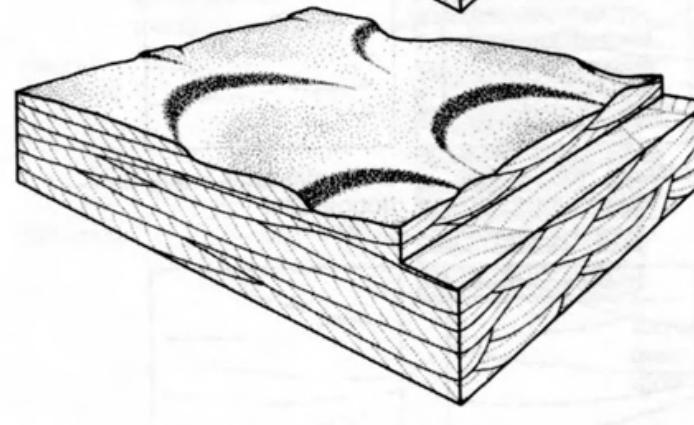
# Alluvial and Aeolian Sediments: Bedding

- small-scale sedimentary structures within larger deposits (layers)
- usually associated with fluid (water or wind) deposition

**Lamina**

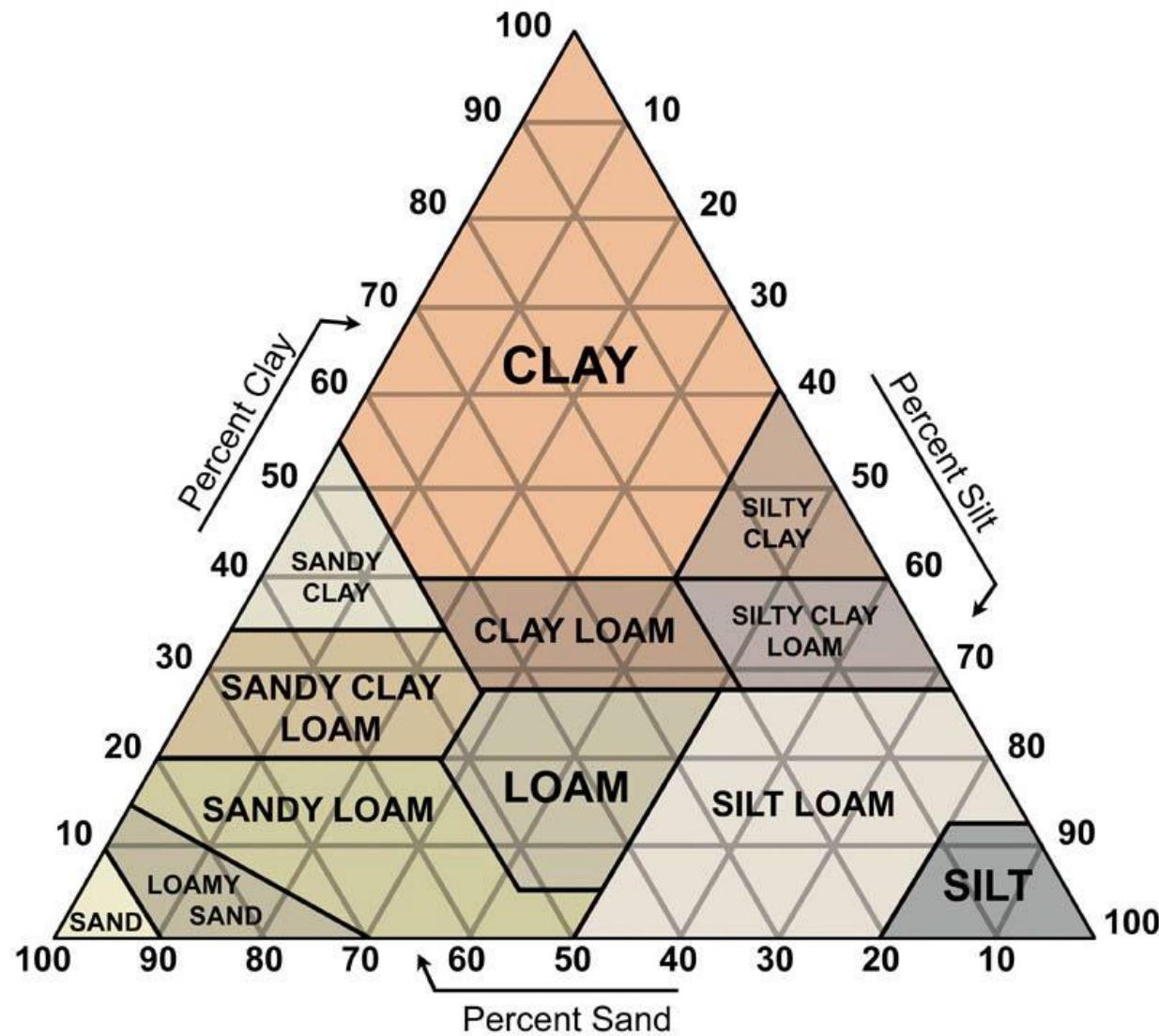


**Cross-bedding**



# USDA Textural Classes for Mixtures of Fines

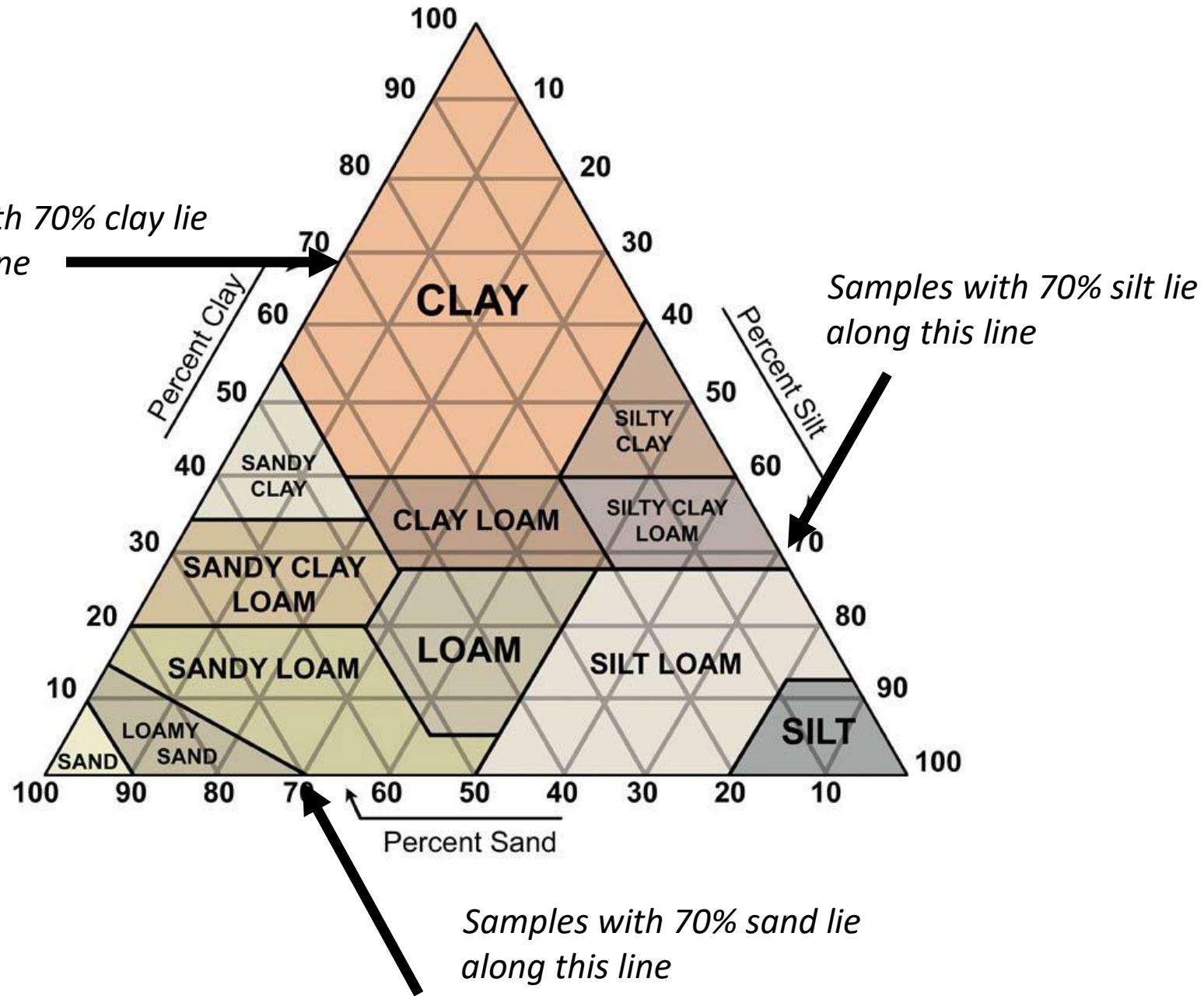
## Ternary Plot



# USDA Textural Classes for Mixtures of Fines

## Ternary Plot

*Samples with 70% clay lie along this line*



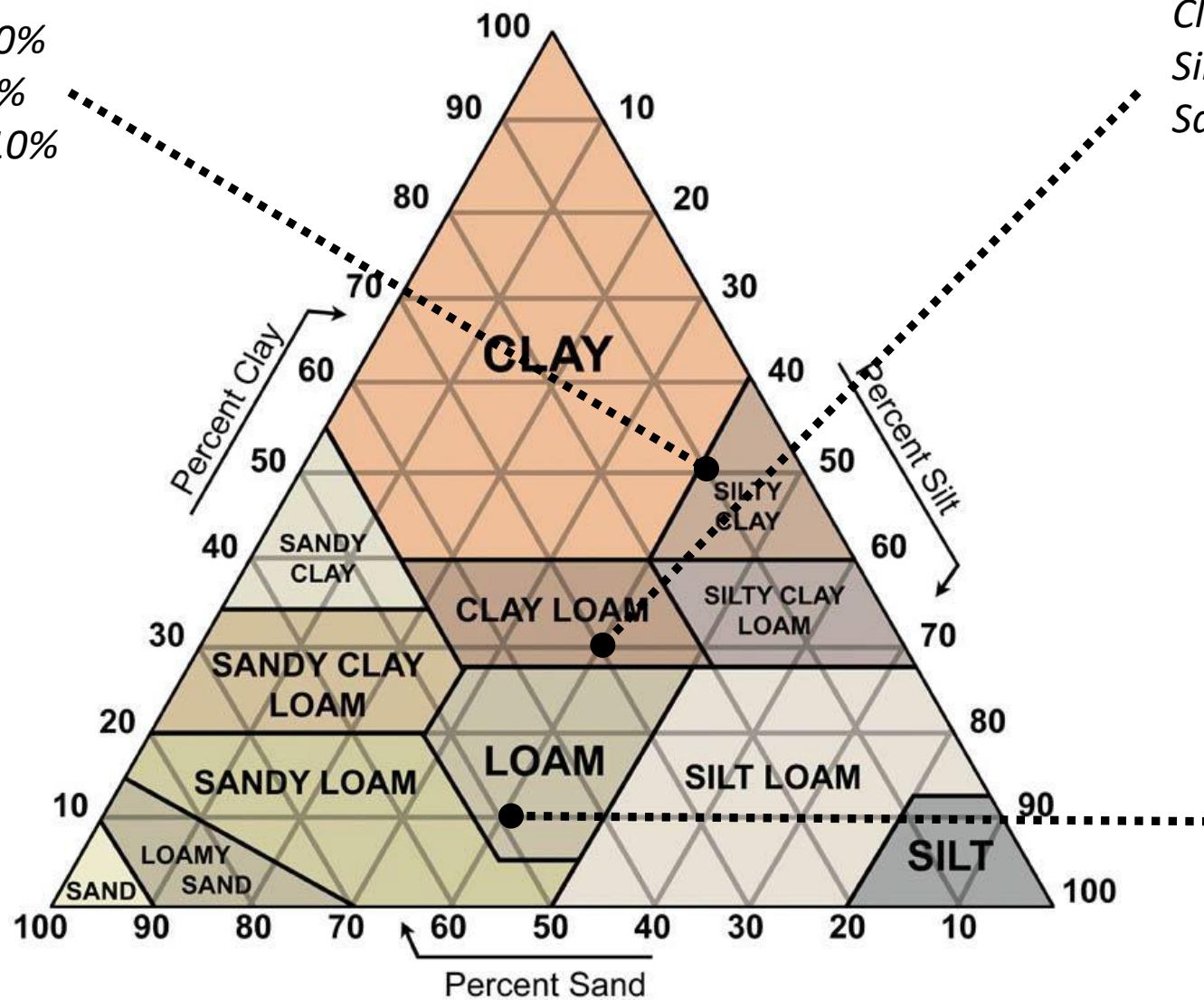
*Samples with 70% sand lie along this line*

# USDA Textural Classes for Mixtures of Fines

## Ternary Plot

Clay: 50%  
Silt: 40%  
Sand: 10%

Clay: 30%  
Silt: 40%  
Sand: 30%

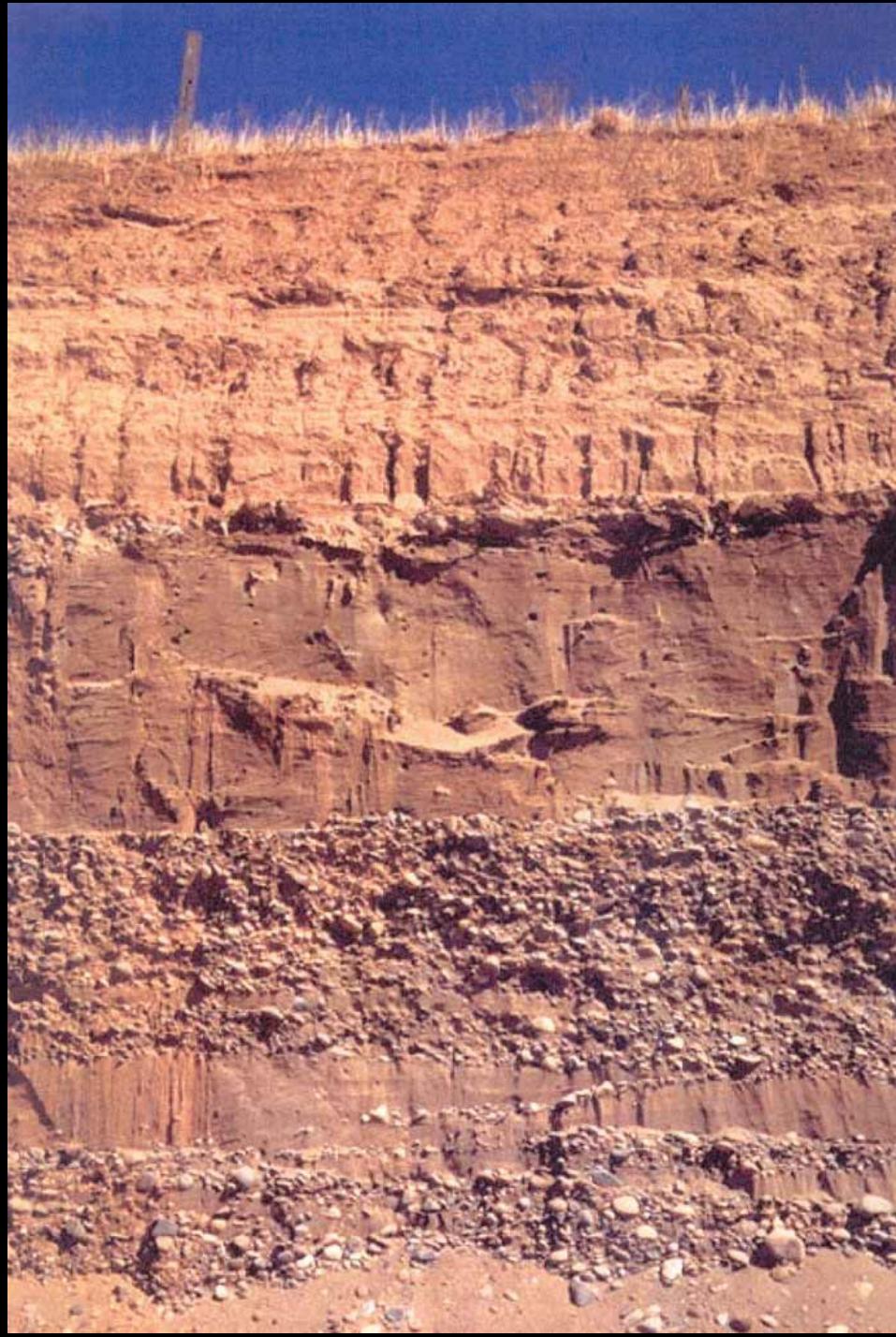




# Clastic: Alluvium



Clastic: Alluvium, laminations  
PG92 (Flowerdew Hundred)





Clastic:Till



Clastic:Loess (wind)



Clastic: Colluvium (gravity, “lubricated” by water)



# Clastic: Pyroclastic Flow





Clastic: Fill (people)





# Lithology is not the only dimension of variation

- We can look to other attributes of clasts so define homogeneous units within and among "lithostratigraphic units".
  - chemistry: "chemostratigraphic units"
  - biological taxa: "biostratigraphic units"
    - fauna
    - pollen
    - phytoliths
  - artifacts: "ethnostratigraphic units"
- Lots to be learned by comparing litho-, bio-, and ethnostratigraphic units.
  - one motivation for excavating in "arbitrary" vertical units with a single lithological unit.

***Stratigraphy: (sensu stricto) the study of relationships among different kinds of stratigraphic units.***

***Stratification: phenomenon of the layers in the ground.***

# Soil

*Soil is the result of in-situ **pedogenic processes** at work on stable parent material over a prolonged period of time.*

## Pedogenic processes?

- Addition

- rain adds water, dust adds minerals, dead plants and animals and poop from live animals all add organic mater.

- Loss

- water evaporates, plants take up nutrients or elements, elements are leached into ground water

- Translocation

- gravity pulls water and dissolved materials, including clay, down, evaporation can pull dissolved materials up. OM can move in many directions due to roots and critters (**bioturbation**)

- Transformation

- decomposition, physical and chemical weathering, oxidation/reduction (reddening/graying of iron compounds), formation of clay minerals

# Soil Profile

- If the parent material is stable and exposed at the surface, a **soil profile** will develop over time. Stable means no erosion and no deposition.

- Comprise of **soil horizons**

**O:** organic matter (dead stuff).

**A:** eluvial horizon, mineral matter mixed with humified (decomposed) organics. **Ap**— plowzone.

[**E:** eluvial horizon, less organics than A and less clay than B.]

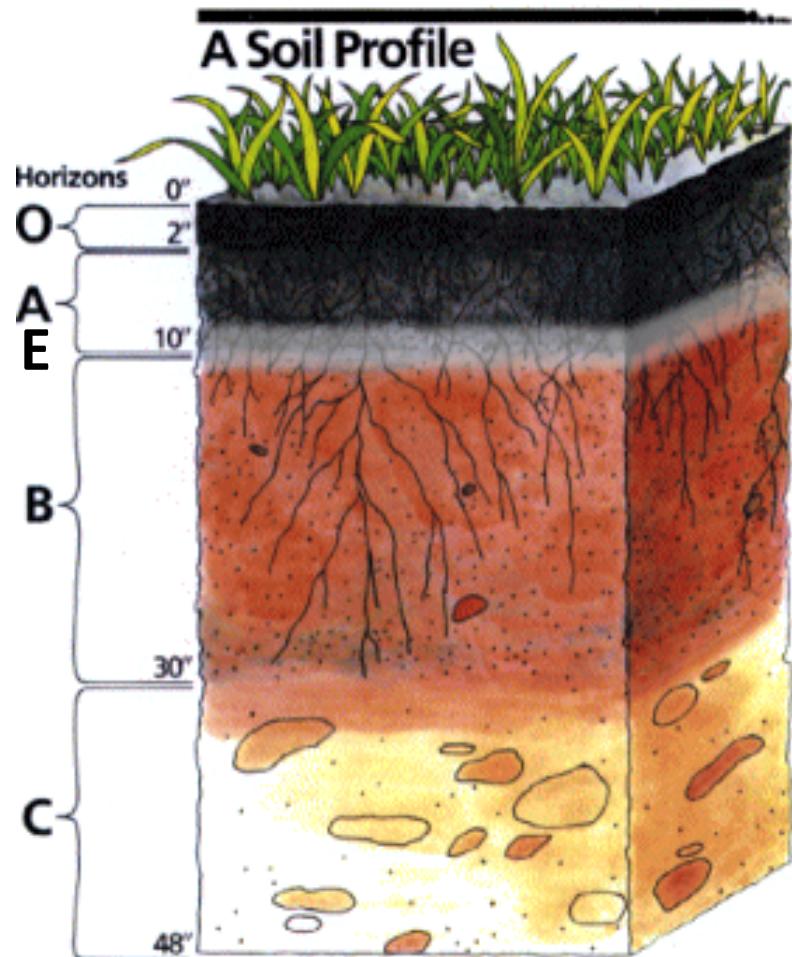
**B:** illuvial horizon, concentrated clay –"argillic", (iron and aluminum oxides).

[**K:** illuvial horizon, calcium oxides, mainly lime (CaO), calcium carbonate CaCO<sub>3</sub>: *drier climates only*]

[**G:** Gleyed horizons (reduced, anoxic): *water logged soils only*]

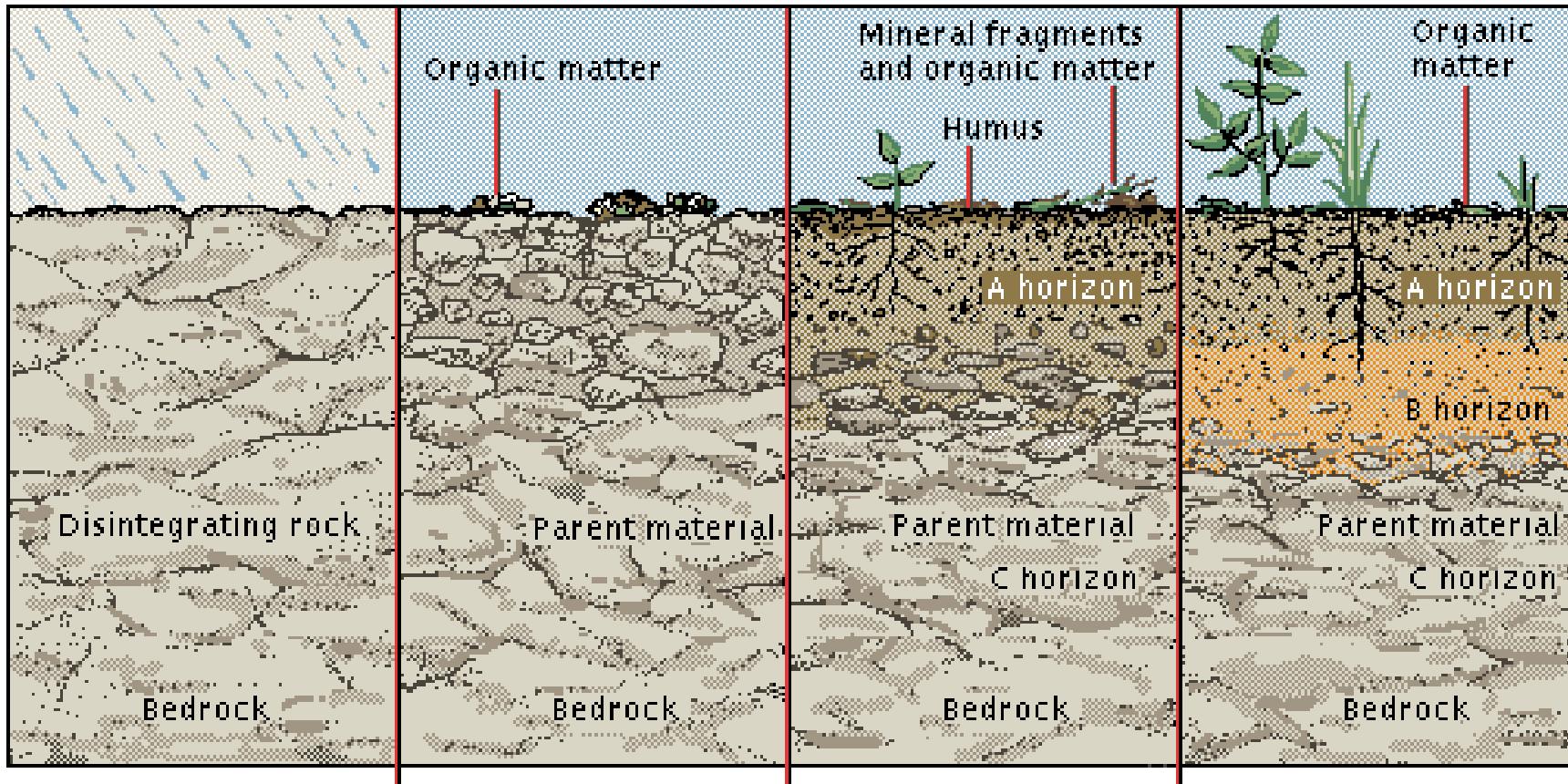
**C:** weathered parent material.

**R:** regolith – unaltered parent material.



# Soil Formation

*- Requires time and a stable surface!*



Bedrock begins  
to disintegrate

Organic materials  
facilitate disintegration

Horizons form

Developed soil sup-  
ports thick vegetation

I

II

III

IV

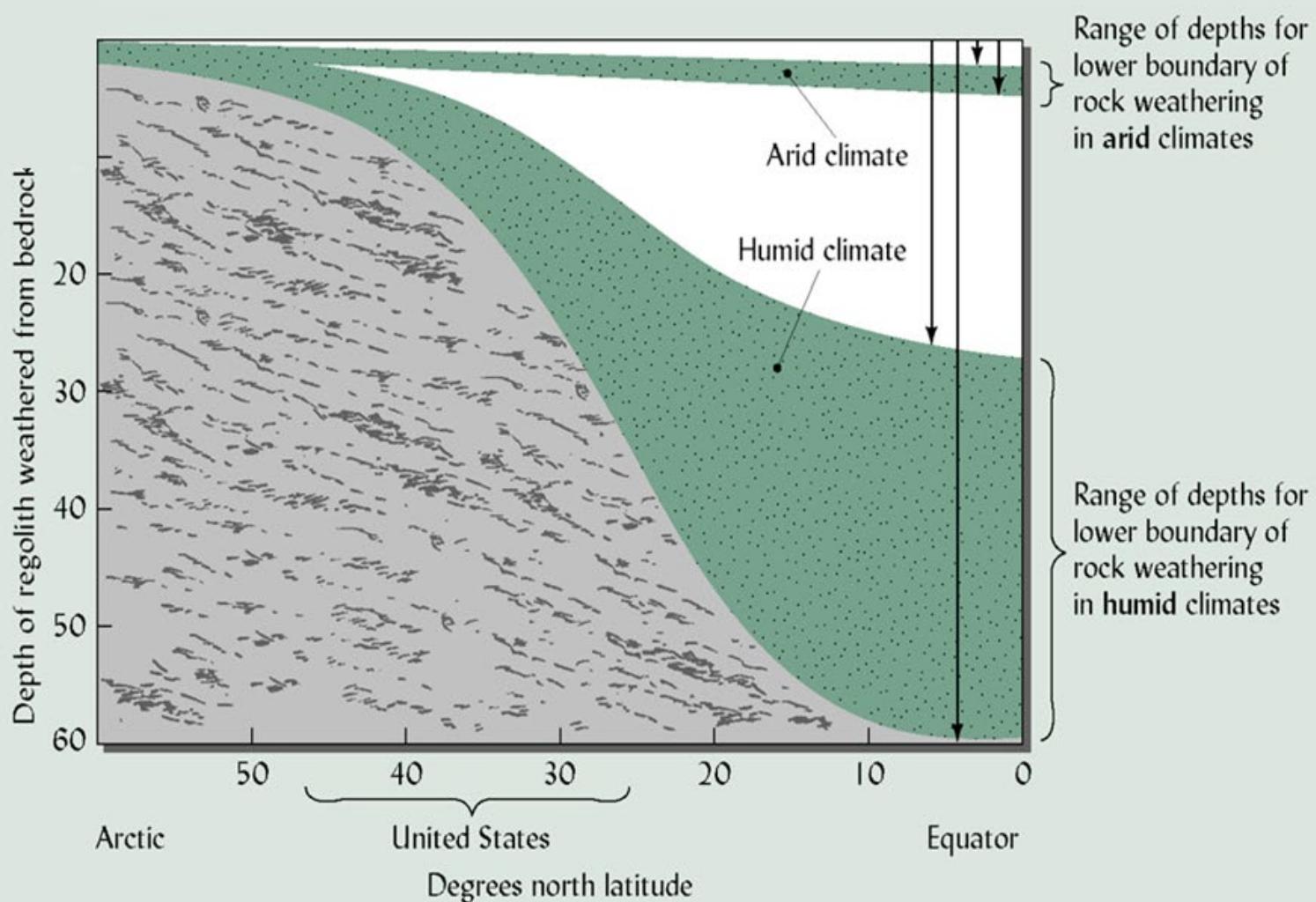
# Soil Formation

**Five Soil Forming Factors** (Hans Jenny) control what the outcome of these *pedogenic processes* looks like.

- Climate: temperature, rainfall
  - higher temperature, **and** rainfall interact to speed up soil formation
- Parent material: rock vs. sediment.
- Topography: slope, drainage patterns.
- Organisms: effects of plants and animals including humans.
  - move stuff around within a soil horizon
  - add organic material to it
- Time: length of time over which soil formation has taken place.
  - ***no time, no soil!!***

# Climate

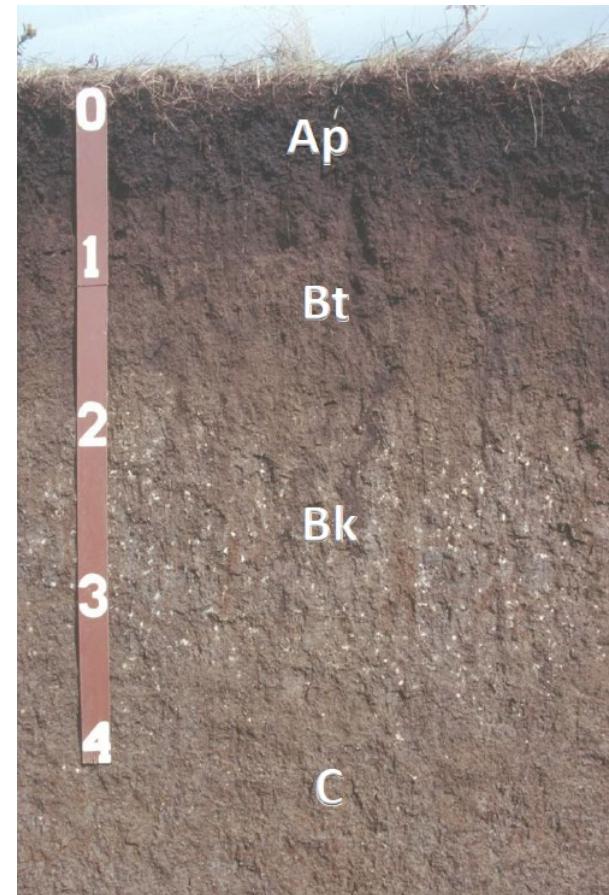
- higher temperature **and** rainfall interact to speed up soil formation



# Climate

## Rainfall

- With less rainfall, you get a Bk (or K) horizon in addition to or instead of a Bt horizon
- Bt horizon: dominated by clays, Fe and Al Oxides (t=translocated: lots of illuviated clay)
- Bk horizon: carbonate accumulation – usually nodules of calcium carbonate



# Climate

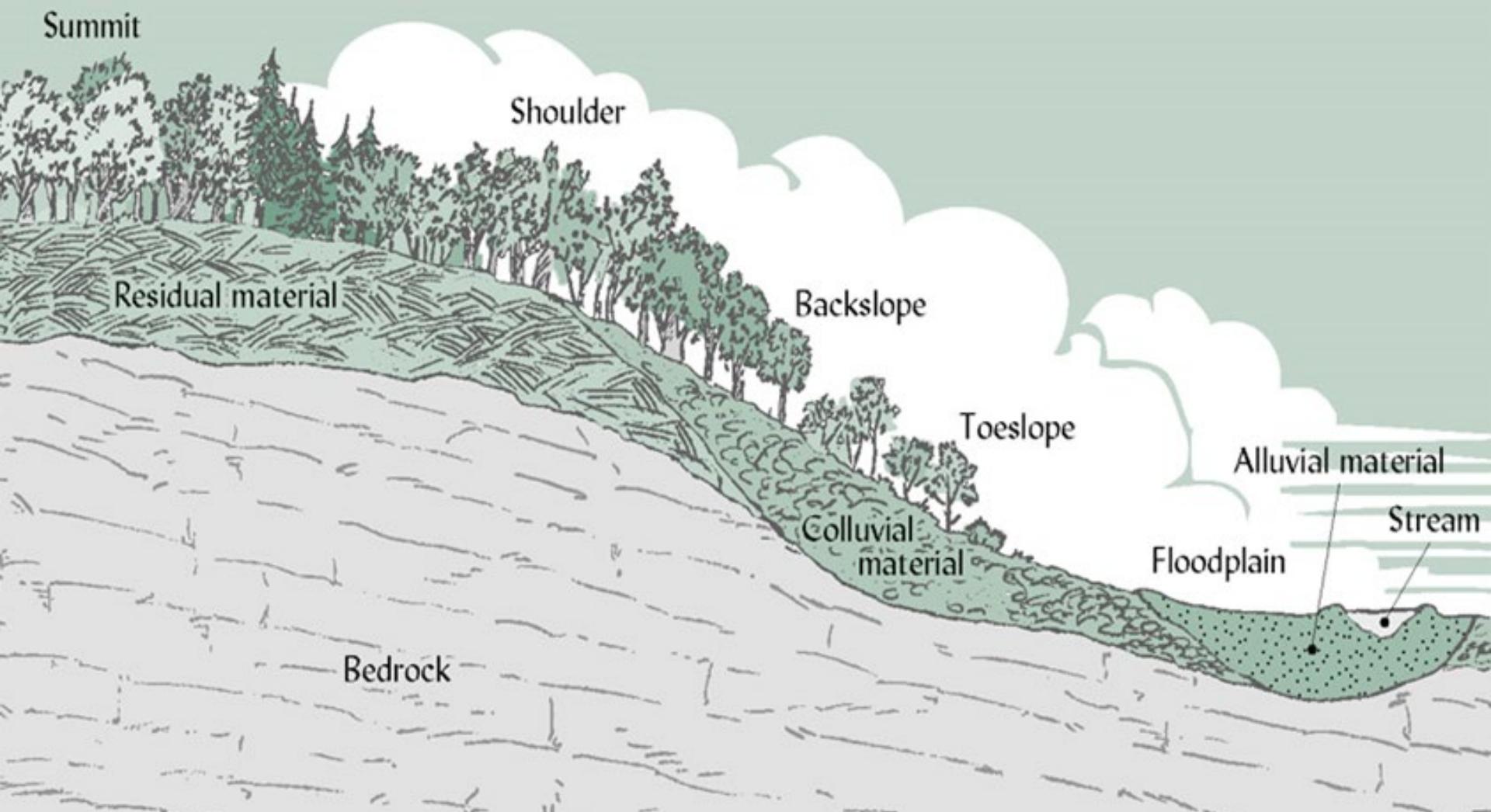
## Rainfall

- Bk horizon occur in the U.S. west, areas with < 30 inches of rainfall/year



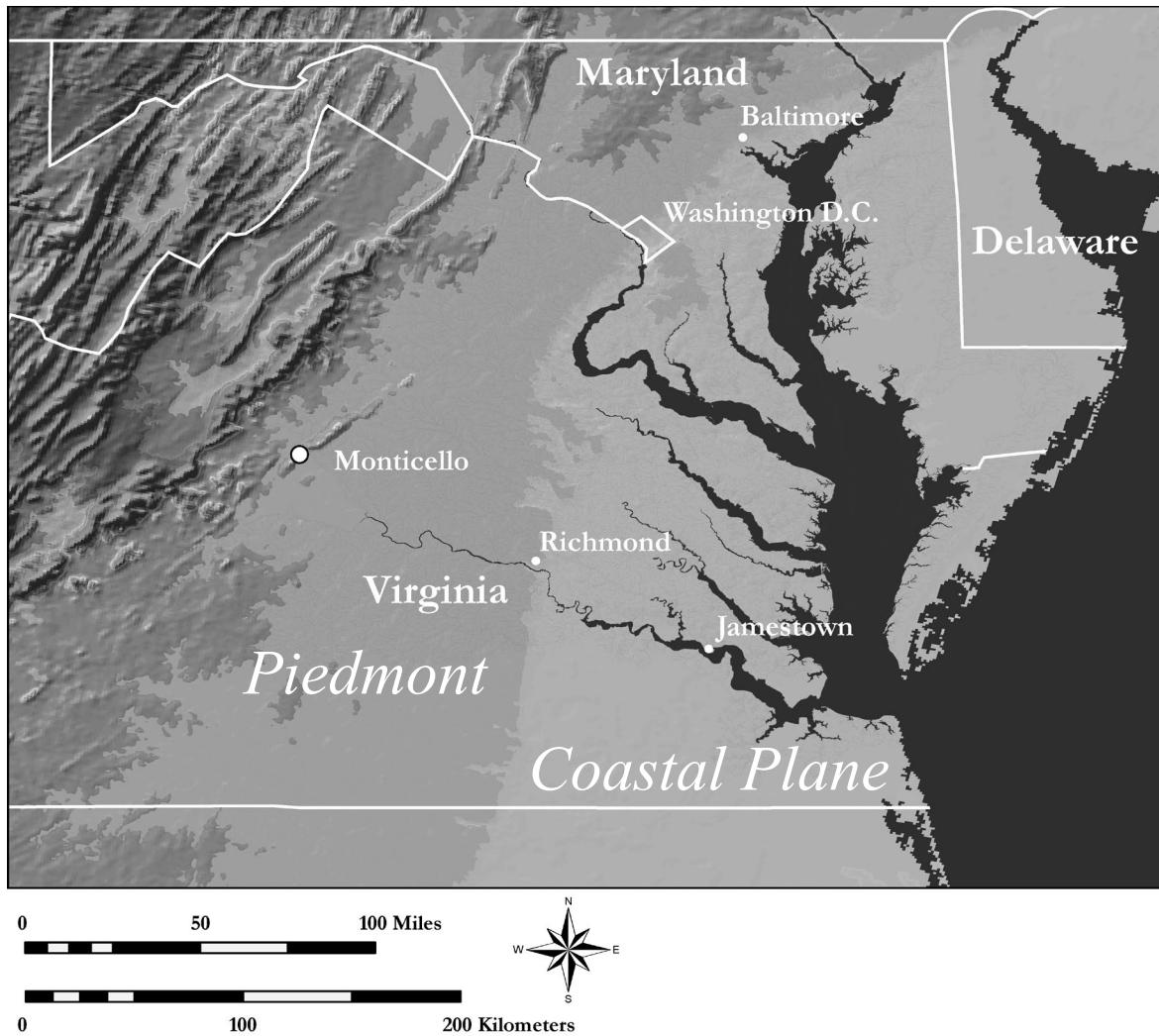
# Parent Material

- soils formed on *residual* vs. *transported parent material*



# Classification of soils by kind of parent material

1. **Residual** parent material: formed in place on rock.
2. **Transported** parent material: formed on sediment.



# Topography

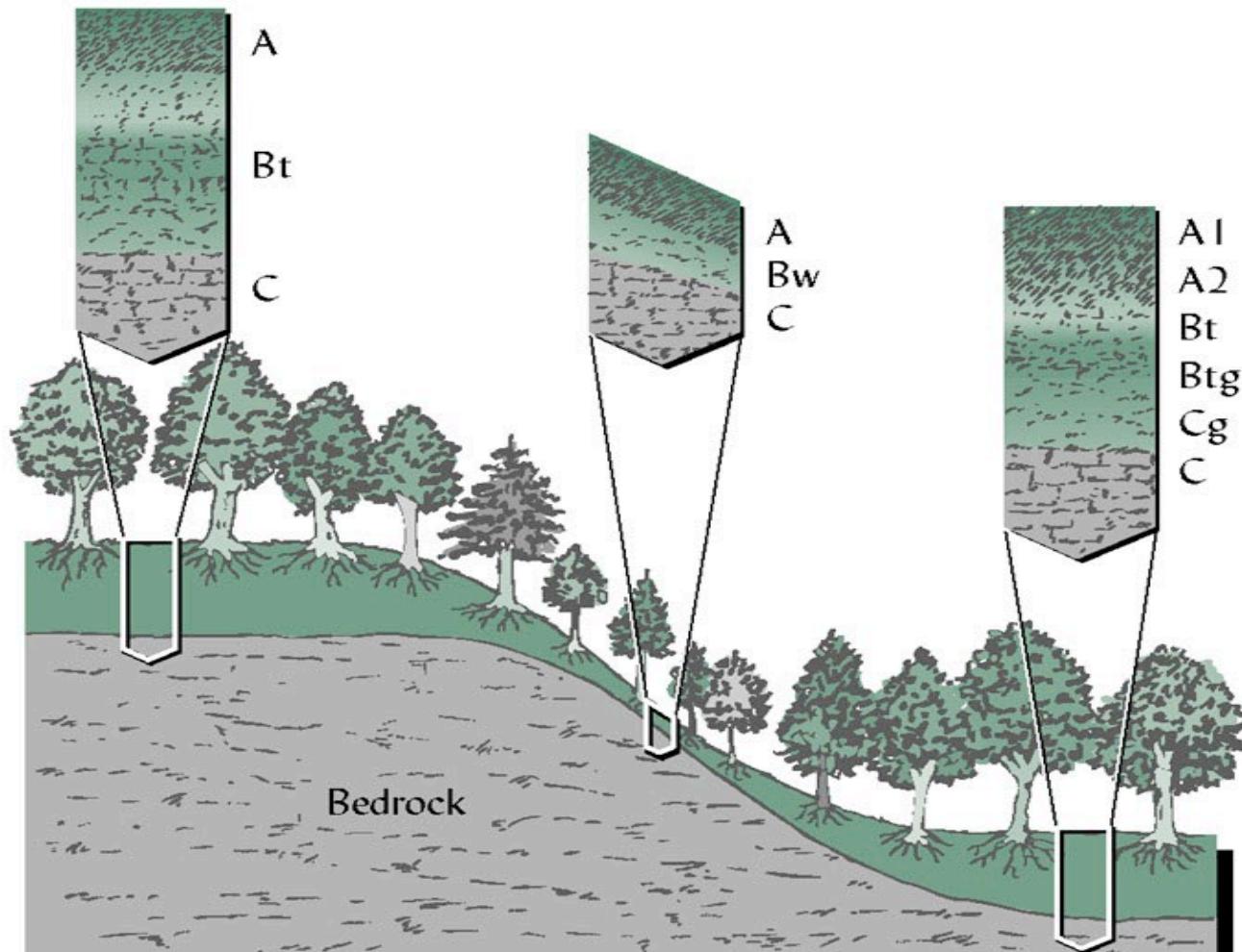
- Flat valley floor and ridge tops: soil profile deepens at a greater rate than it is removed
- Slopes: soil removal happens faster than profile deepening.

## Pedological geekery:

**Bt**: Translocated. Lots of illuviated clay.

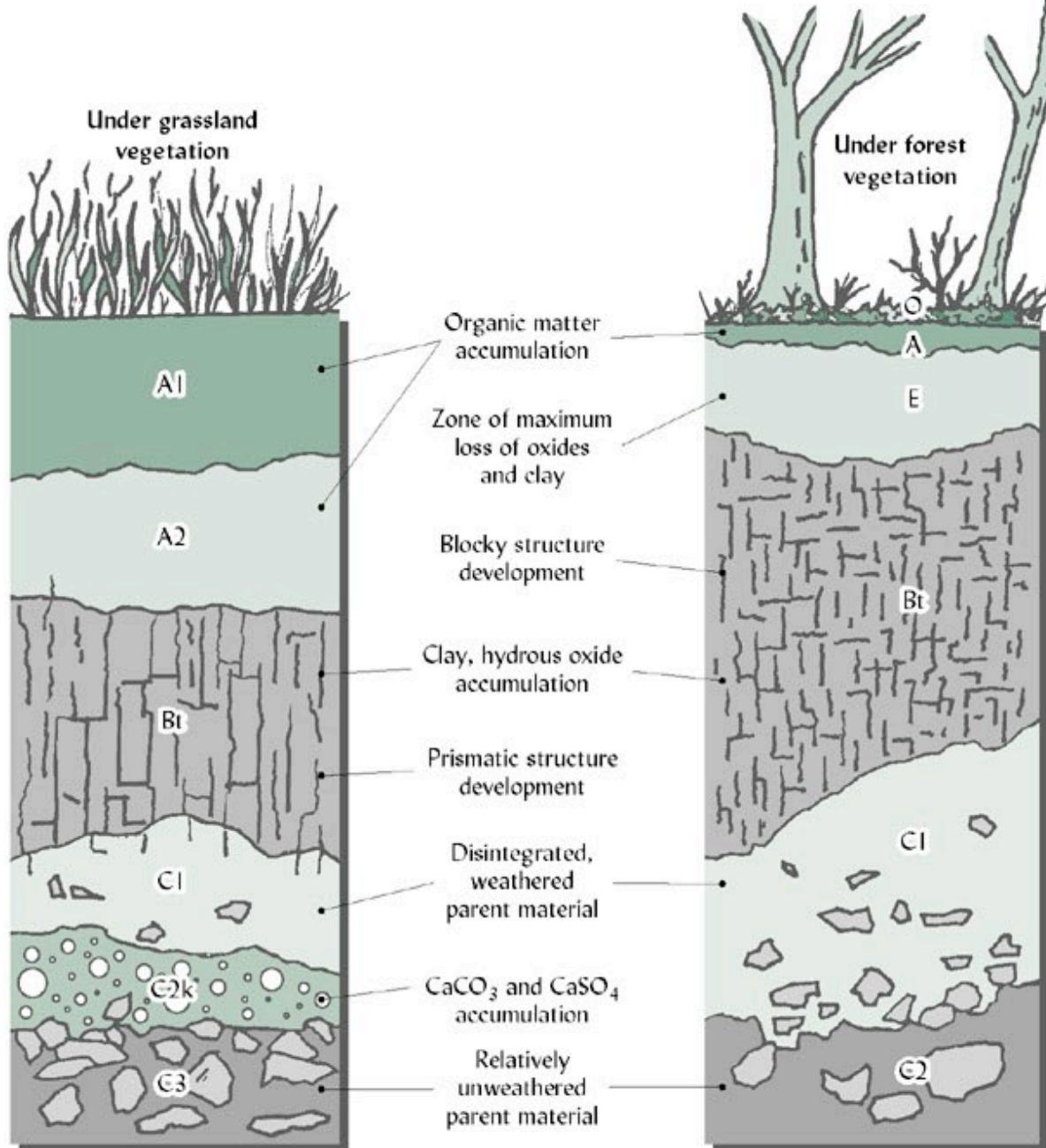
**Bw**: Weak. Color or structure difference, but not much illuviated clay.

**Btg** : Gleyed. Water logging leads to reduction (vs. oxidation).

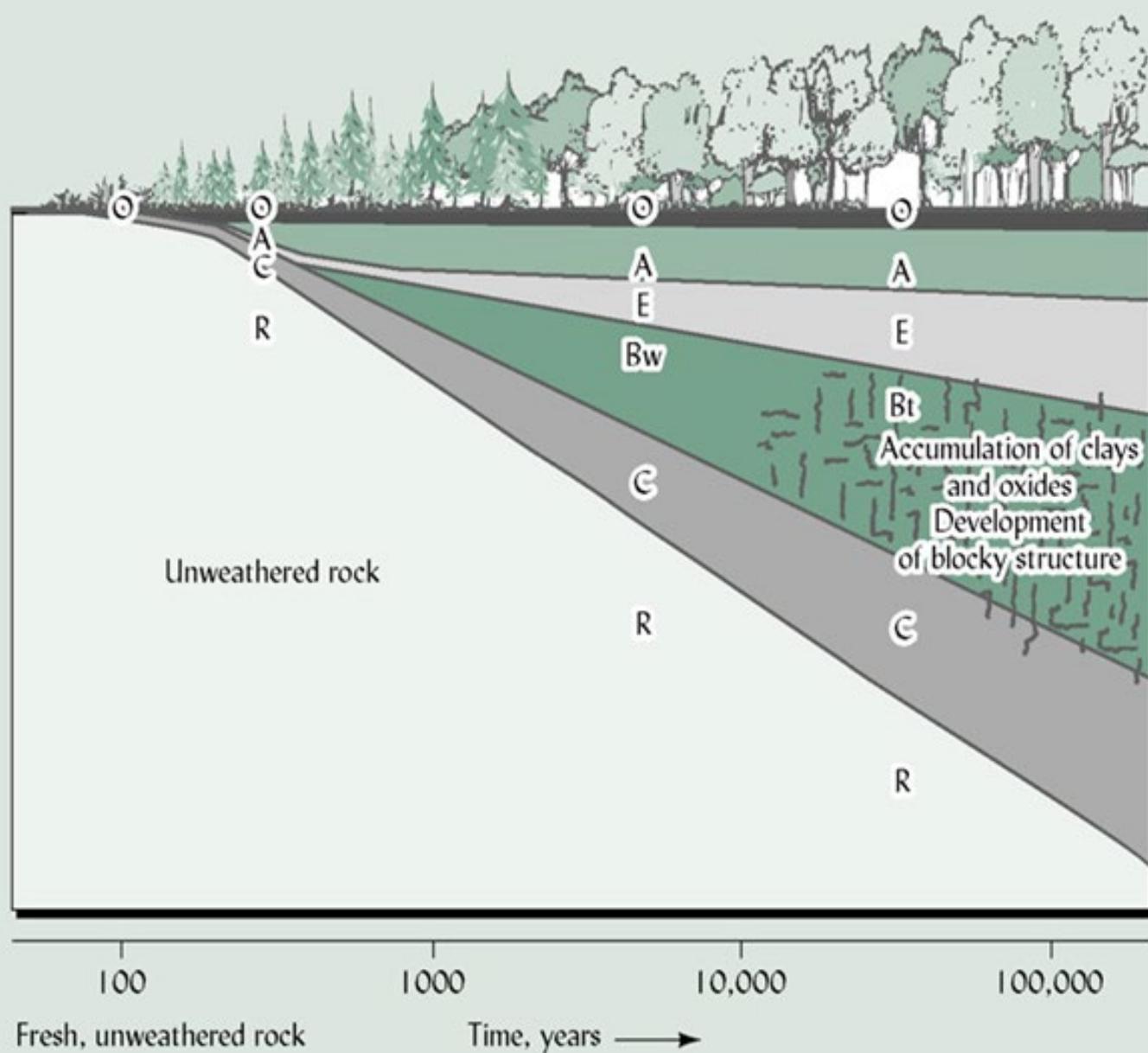


# Organisms

- e.g. plants
- Grass lands have thin O horizon, but thick A horizons because of dense grass root systems.
- Forests have thick O horizons, but thin A horizons.



# Time



## Parent Material Type

- rock
- sediment

## Climate

- temperature
- rainfall

*Higher temp and rainfall speed chemical weathering*

*Thermal expansion, frost wedging*

*Gentle slopes aid chemical weathering*

## Topography

- slope
- drainage

*Steep slopes aid physical weathering*

## **Chemical weathering**

- dissolution ( $CO_2 + H_2O \rightarrow H_2CO_3$ )
- alteration

*Production of clay minerals*

*Greater susceptibility*

*Additional surface area*

## **Physical weathering**

- bedrock breakage
- fragmentation

*Production of small particles*

## **Soil**

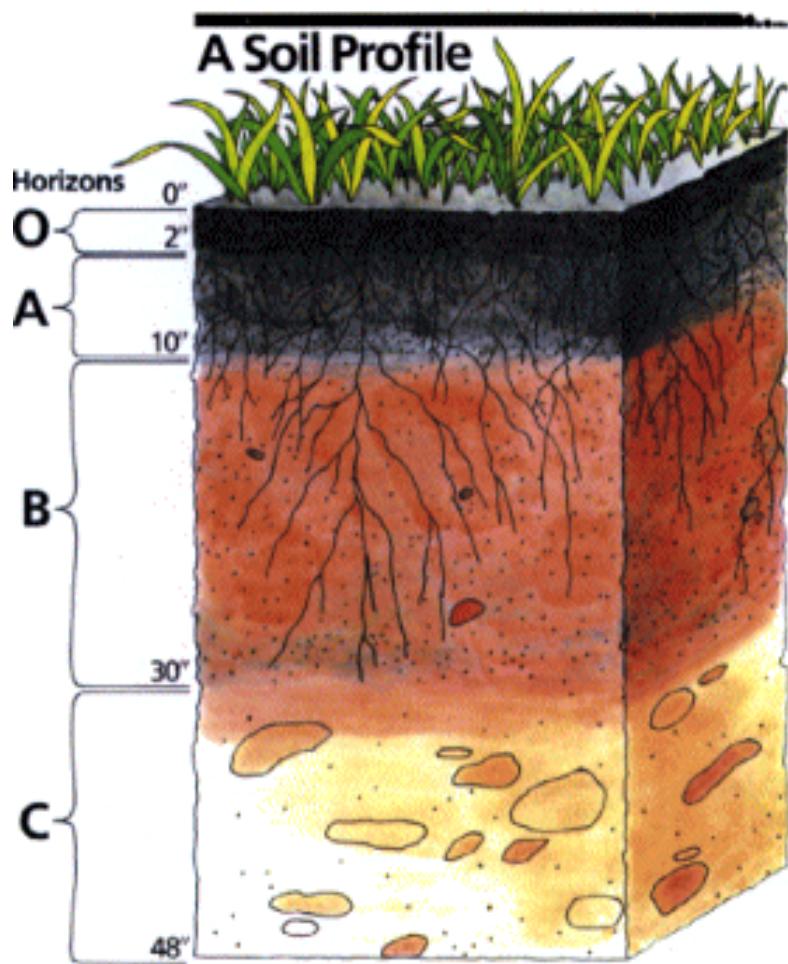
- clay and other minerals
- organic matter

## Organisms

- dead stuff (humus)
- bioturbation (roots, worms, insects)

## How do you recognize a *soil horizon* with a *soil profile*?

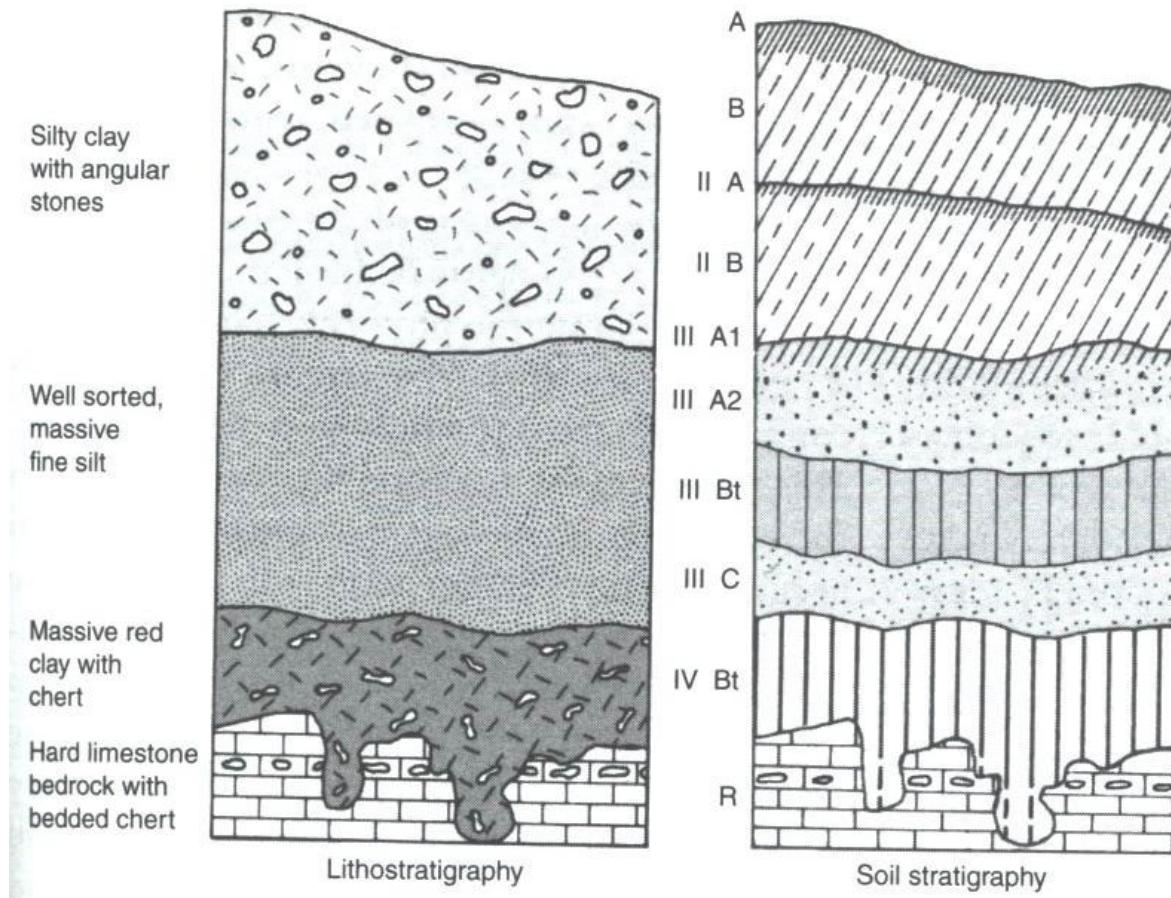
- Look for vertical, clinal variation in physical, chemical, organic properties predicted by the soil formation model.
- Illuviation concentrates clay (and Fe and Al) from the parent material in the B horizon,
- Illuviation and leaching and depletes more mobile elements: e.g. K, P, Ca.
- Novel input from the O horizon, leached into A and to a lesser extent the B horizon.
- Successive components of a soil horizon (A, B, C) are “**pedostratigraphic units**” (~layers, zones).



# Soil vs. Sediment

Two Kinds of “natural” homogeneous zones.

- lithostratigraphic units
- pedostratigraphic units
- *these can be superimposed on one another!*



# Soil vs. Sediment

**Is it a pedostratigraphic unit or a lithostratigraphic unit?**

- *an inference.*

**Implications for excavation methodology and recording.**

- We need a neutral term – “**context**.”
- Context descriptions are informed by sedimentology and pedology.
- Context descriptions should record attribute or variable values.
- Keep inference about their meaning separate: "interpretation"