Environmental Geology - Chapter 10
Soil Resources

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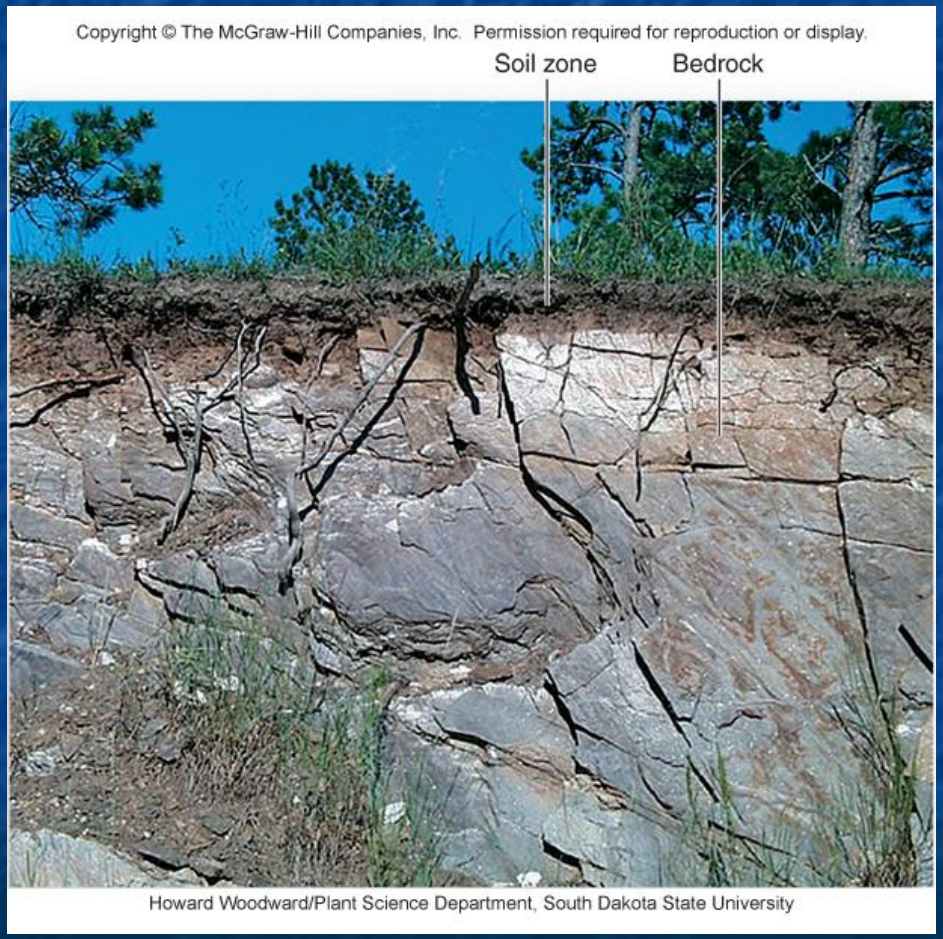
Soil

- Produced by interaction of atmosphere, hydrosphere and geosphere
- Gases and precipitation weather rocks and minerals
- Precipitation infiltrates soil and recharges groundwater
- Fertile soil vital to human life

Formation of Soils

- **Soil** – layer of weathered mineral and/or organic material capable of supporting plant life
- **Regolith** – loose weathered material; soil, small rocks, dust
- **Sediment** – soil or dust that has been *transported* by wind, water or ice
- **Bedrock** – soild rock



Formation of Soils

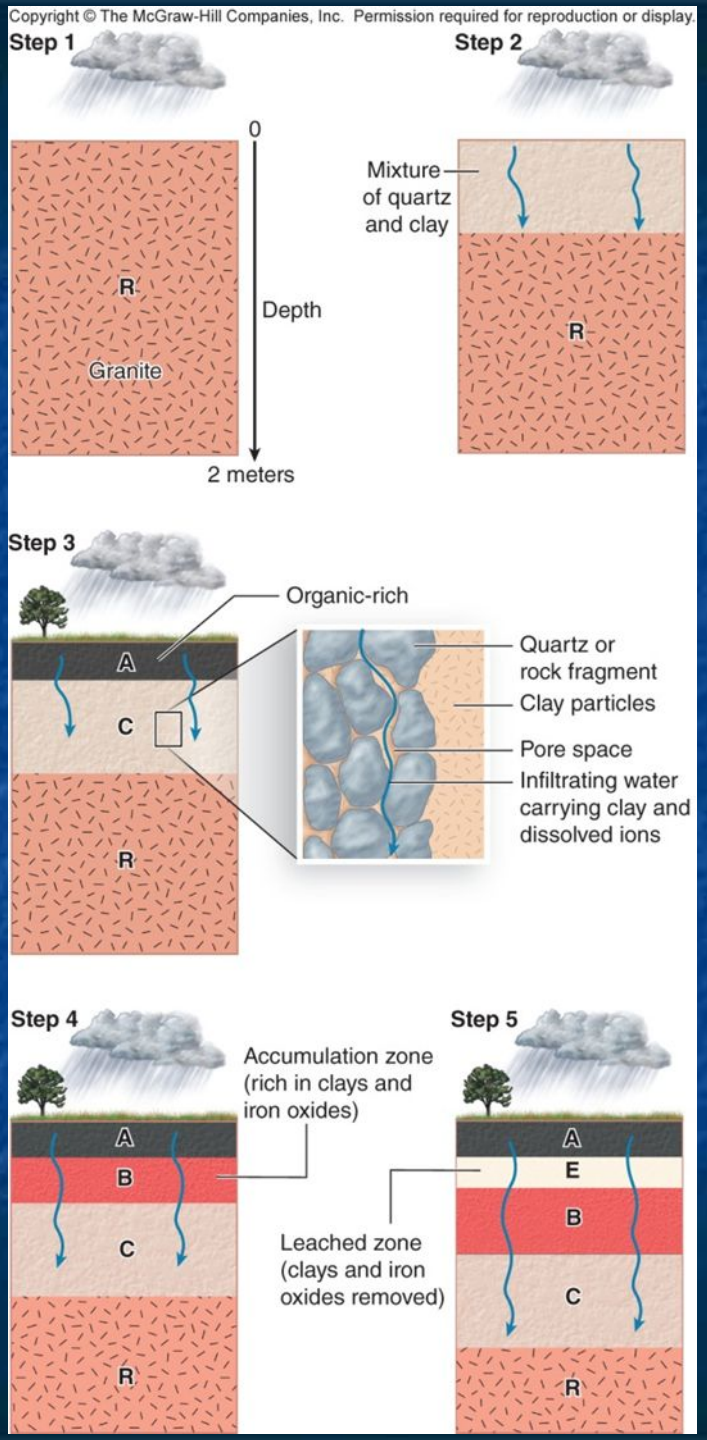
- Weathering – rocks begin to disintegrate and decompose
  - Physical – frost/freeze, roots, wind breaking rocks apart, fires and solar heating
  - Chemical – chemical reaction, rain water dissolving rock
    - Quartz (mineral in granite) resistant to chemical weathering
    - Calcite (mineral in limestone and marble) weathers easily
    - Feldspars (Fe and Mg) and silicates weather into clay minerals

Soil Horizons

- **Soil horizons** – layers in soil that developed due to continued weathering and infiltration of water
- **Topsoil** - organic matter plus weathered rock minerals
- **Soil profile** – characteristics such as color, texture and structure

Figure 10.4, Page 298

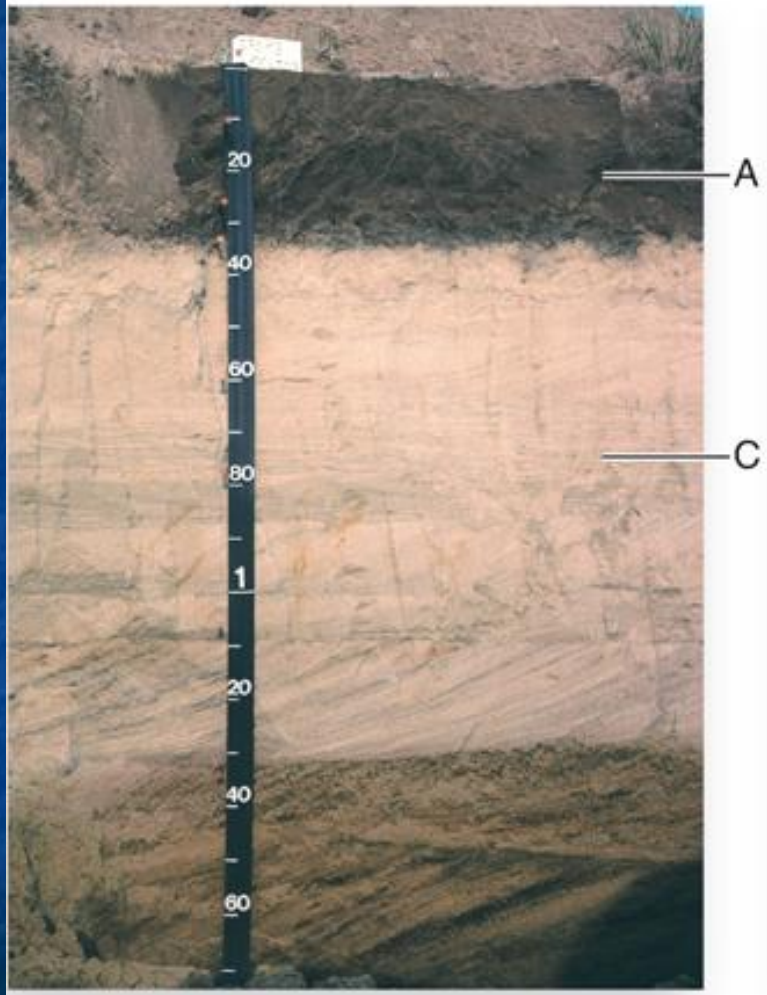
- R horizon – unweather rock w/in a few meters from surface
  - Feldspar minerals weather to clay and granite crumbles
- A horizon – uppermost, organic rich, "topsoil"
- C horizon – remaining weather material
- B horizon – continued weather and infiltration lowers original bedrock forming zone of accumulation of clay minerals



Soil Horizons Cont.

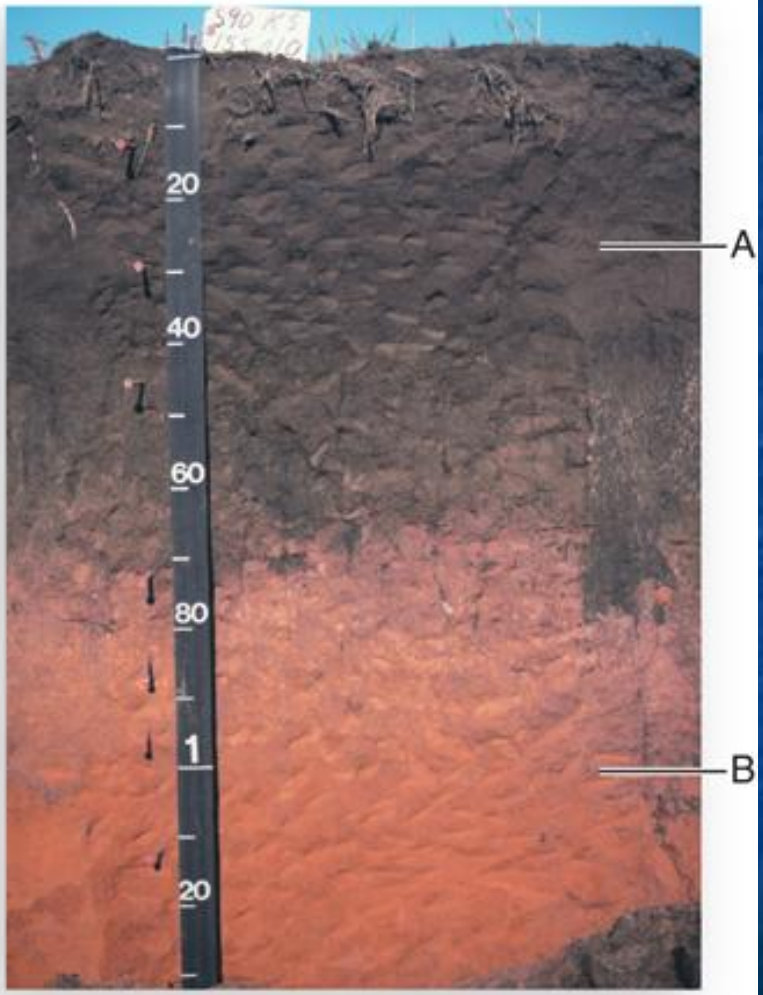
- E horizon – zone of leaching; minerals have been flushed from soil; found in older well drained soils or in conifer forests
- O horizon – only in wet soil environments with lush vegetation; uppermost layer hypoxic and rich in organic matter

Soil Color



A

Photo by Jim Fortner, USDA-NRCS



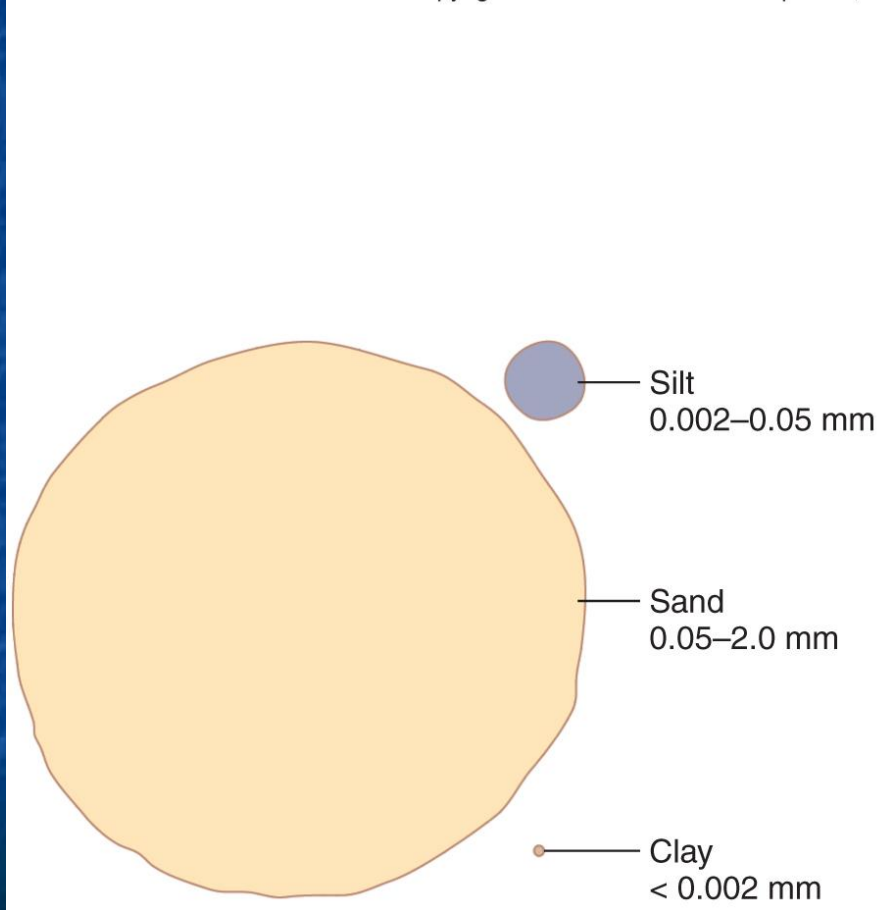
B

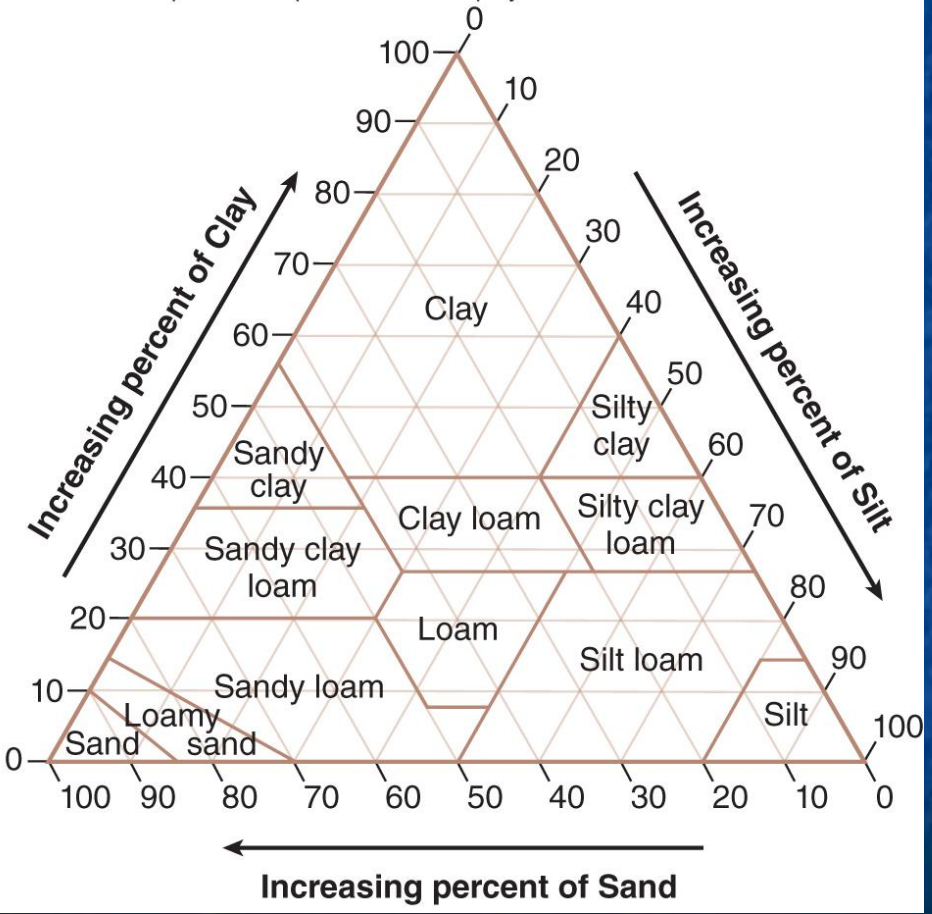
Photo by Jim Fortner, USDA-NRCS

Soil Texture

- Soil scientists classify soils into 12 classes based on texture
- Loam soil – 40% sand, 40% silt, 20% clay; best for agriculture
- Sandy loam – sand rich soil
- Texture determines permeability, drought resistance, fertility, ease of tillage

Soil Texture





Soil Structure

- How soil particles are arranged
- When dug up, undisturbed soil breaks into peds or aggregates
  - Granular clumps, flat and plate like, blocky or elongated
  - Affects infiltration and roots

Soil Forming Factors

1. Parent material – original weathered product
2. Organisms
3. Climate
4. Topography
5. Time

Soil Forming Factors

- **Parent material** – the C horizon, original weathering product or organic material from which soil forms.
- Often is the bedrock
- Or may be sediment that soil forms upon
- Alluvium – soils that form upon river sediment
- Loess – soil formed upon sediment deposited by wind or glaciers
- Residual soils – from parent material formed by weathering of underlying bedrock

Soil Forming Factors

- Organisms – borrowing animals, insects, microbes
- Organisms break down minerals, create space for water and oxygen to flow and circulate
- Mounds overturn soil
- Soil as a “living” system

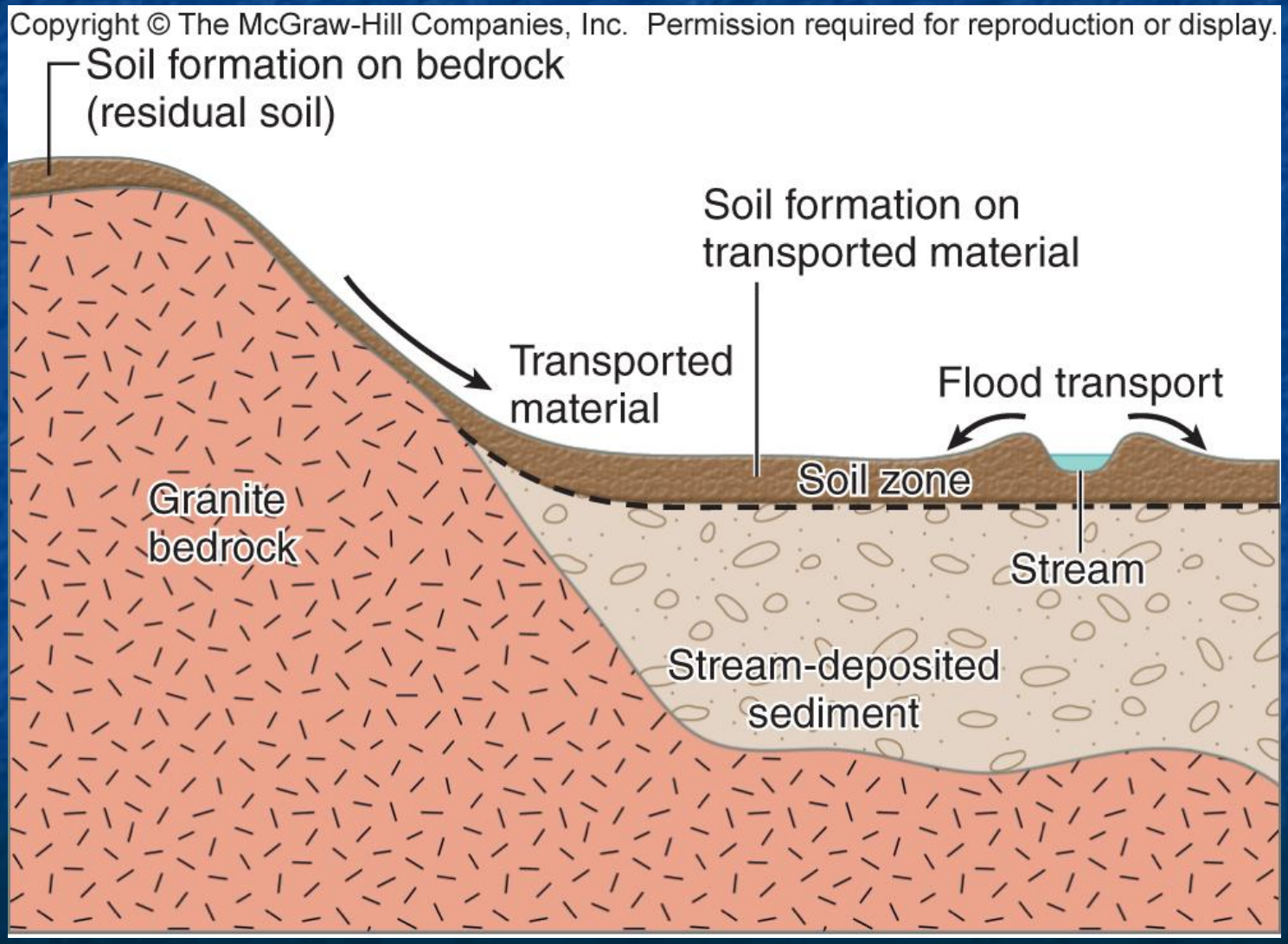
Soil Forming Factors

- Climate – rainfall and temperate determine animal and plant life and weathering of rocks
- Rich topsoil requires organic matter
- Areas with extreme temps and low precipitation usually have poor soils
- Erosion removes A horizon

Soil Forming Factors

- Topography – shape of landscape
- Slope and vertical relief
- Plains vs mountains
- Aspect – orientation of slope to sun
- Depth of water table; low lying areas tend to be saturated

Soil Forming Factors

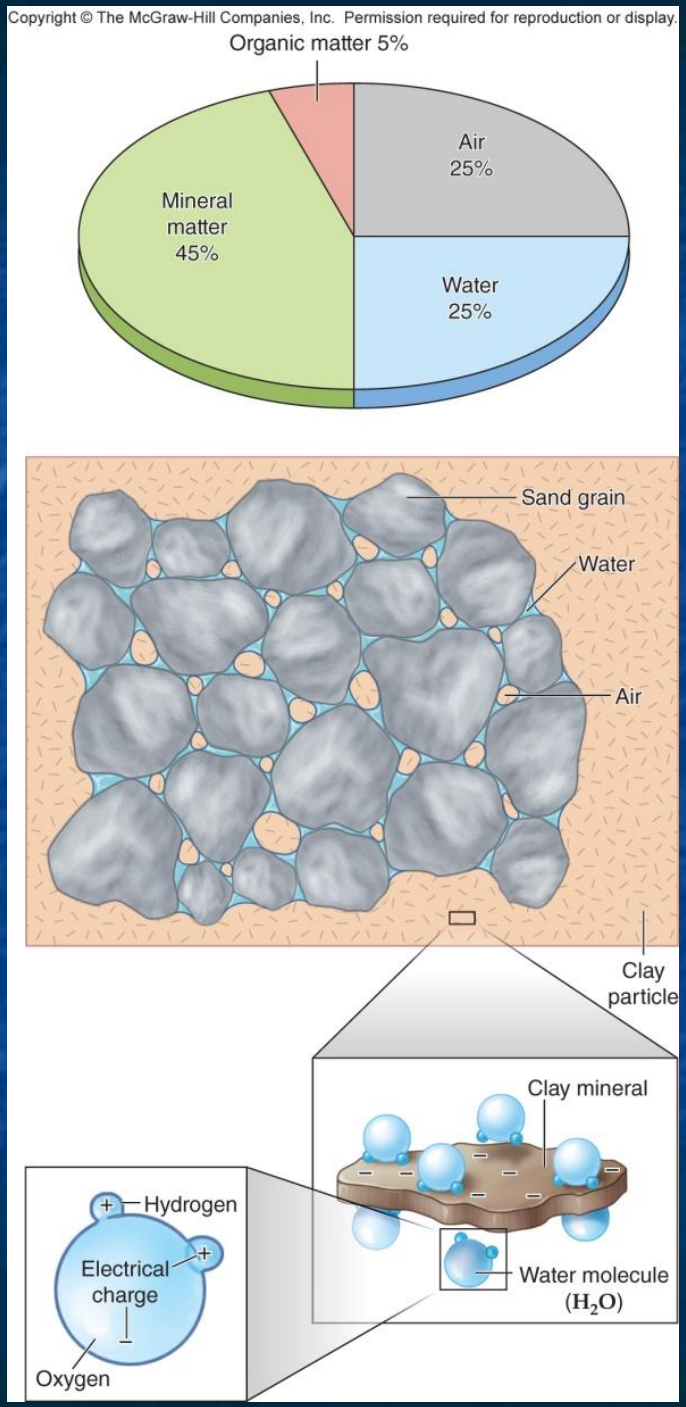


Soil Forming Factors

- Time – weathering takes a long time
- Horizons develop more quickly in warm, humid climates
- Under good conditions – A and C form in few hundred years or less
- Several hundred years for A, B, C
- Deeply weathered soils take 5,000 – 10,000 yrs
- Tropical soil enriched in Al – 100,000 yrs
- **Paleosol** – geologic event buries soil with new sediment; new sequence of horizons forms

Soil Components

- Soils consist of approx. 45% minerals, 5% organic, 50% void space that water and air can occupy
- Dipolar water molecules attracted to negatively charge clay molecules
- Figure 10.14 page 306



Classification of Soils

TABLE 10.1 Simplified version of the soil classification system used by soil scientists. Soils are broken down into 12 major categories called orders, which are based on the characteristics of different horizons found within a soil. Although the dominant soil-forming factor(s) is listed for each soil order, all five factors are involved in the development of any soil.

Order	Simplified Description	Dominant Soil-Forming Factor(s)
Alfisols	Soils that are not strongly leached and have a subsurface horizon of clay accumulation. Common in forested areas where the climate is humid to subhumid.	Climate and living organisms
Andisols	Soils that form in volcanic ash and contain aluminum-rich silicates that actively bind with organic compounds.	Parent material
Aridisols	Soils that form in dry climates with low organic matter and that often have subsurface horizons with salt accumulations.	Climate
Entisols	Young soils lacking subsurface horizons because the parent material recently accumulated or because of constant erosion. Common on floodplains and steep mountain terrain.	Time and topography
Gelisols	Weakly weathered soils that contain permafrost in the profile. Common in higher latitudes.	Climate
Histosols	Soils with a thick organic-rich O horizon that contains very little mineral matter (e.g., quartz and clay). Common in poorly drained areas.	Topography
Inceptisols	Soils with weakly developed subsurface horizons because they are either young or the climate does not promote rapid weathering.	Time and climate
Mollisols	Soils that are not strongly leached and have an organic-rich A horizon. Common in grasslands where the climate is semiarid to subhumid.	Climate and organisms
Oxisols	Very old, extremely leached and weathered soils with a subsurface accumulation of iron and aluminum oxides. Common in humid tropical climates.	Climate and time
Spodosols	Soils that have a well-developed B horizon rich in iron and aluminum oxides. Form in cold, moist climates under pine vegetation and sandy parent material.	Parent material, organisms, and climate
Ultisols	Strongly leached soils (but not as strong as oxisols) with subsurface accumulation of clay. Common in humid tropical and subtropical climates.	Climate, time, and organisms
Vertisols	Soils that develop deep, wide cracks when dry due to the presence of swelling clays.	Parent material

Engineering Classification

TABLE 10.2 Simplified version of the Unified Soil Classification System used in engineering. Here soils are grouped primarily on the proportion of different grain sizes (gravel, sand, silt, and clay).

Major Divisions	Subdivisions	Soil Name	Symbol
Coarse-Grained Soils (> 50% of grains visible with naked eye)	Gravels	Well graded gravel	GW
		Poorly graded gravel	GP
		Silty gravel	GM
		Clayey gravel	GC
	Sands	Well graded sand	SW
		Poorly graded sand	SP
		Silty sand	SM
		Clayey sand	SC
Fine-Grained Soils (< 50% of grains visible with naked eye)	Silts	Plastic silt	ML
		Nonplastic silt	MH
		Organic silt	OL
	Clays	Low-plastic clay	CL
		High-plastic clay	CH
		Organic clay	OH
Organic Soils	Organic Matter	Peat	PT

Soil Properties

- Porosity – fraction of void (pore) space in rock or sediment where water can flow; determines how much water available to plants
  - Saturated = void spaces full of water
- Soil moisture & drought resistance – controlled by mineral composition and dipolar water molecules
  - Cohesion vs Adhesion
  - Soils with high concentration of sand and clay susceptible to drought
  - Soils with high percentage of silt and moderate amounts of clay (loam) best for agriculture

Soil Properties

- Permeability – how easily water can flow through pore spaces and ability to drain
  - Clay soils have low permeability
  - Sandy soils have higher permeability
- Plasticity – ability of soil to deform without breaking; increases with clay content. Increases water content makes fine grained material flow similar to a liquid.
- Strength & sensitivity – *strength* is resistance to being deformed or how well particles stick together. *Sensitivity* – how easily disturbed material loses strength.

Soil Properties

- Compressibility – ability to compact under force or load. Quartz sand vs clay. More compaction = less permeability.
- Shrink-swell – Soil expands or swells when wet and shrinks with dry. "Expanding clays." Can put lots of pressure upon structures, buildings, utility lines, underground pipes.
  - Used for commercial products; seals in well casings
- Ion exchange capacity – process by which dissolved ions attach to soil particles

Soil as a Resource

- Agricultural food production
  - Soil fertility
  - Essential nutrients – N, P, K, Ca, Mg, S
- Minerals and energy
  - Aluminum – result from weathering of igneous rock
  - Kaolinite clay – soft, fine grained, commercial products
  - Peat – organic rich, can be dried and used as fuel, gardening mulch
  - Phosphorous for use as fertilizer

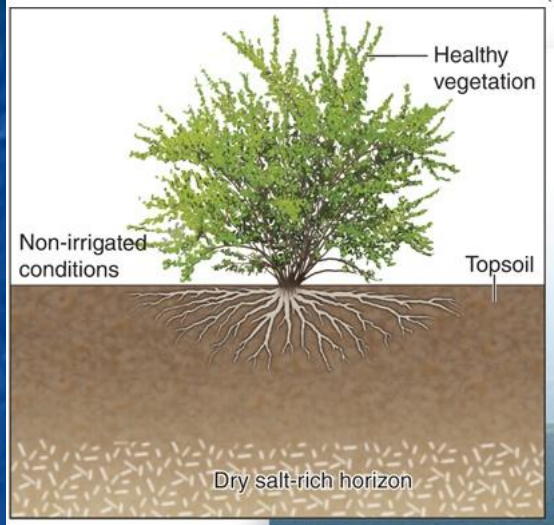
Soil Loss

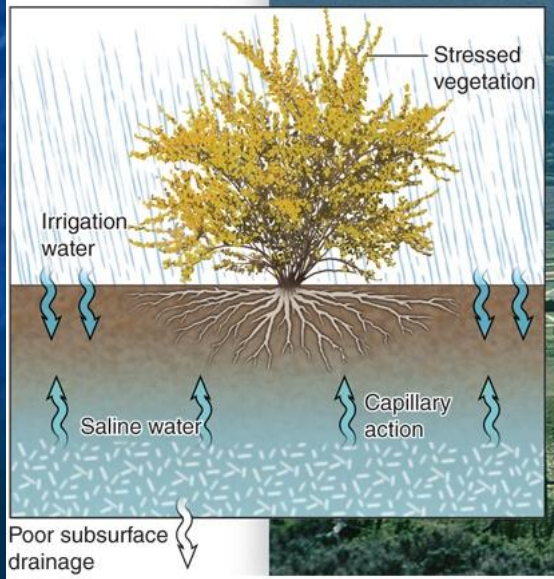
- Soil erosion – movement of soil particles away from their place of origin
  - Natural – rain and wind
  - Man-made – human activities accelerate erosion process
- Consequences – loss of nutrients, top soil, sediment pollution downstream or downslope
- See Figure 10.27 page 317

Soil Loss

- Mitigation
  - Contour plowing
  - Crop stripping
  - No till farming
  - Grassed waterways
  - Terracing
  - Stream buffers
  - Silt fences
  - Retention basins
  - Slope vegetation cover

Salinization of Soils





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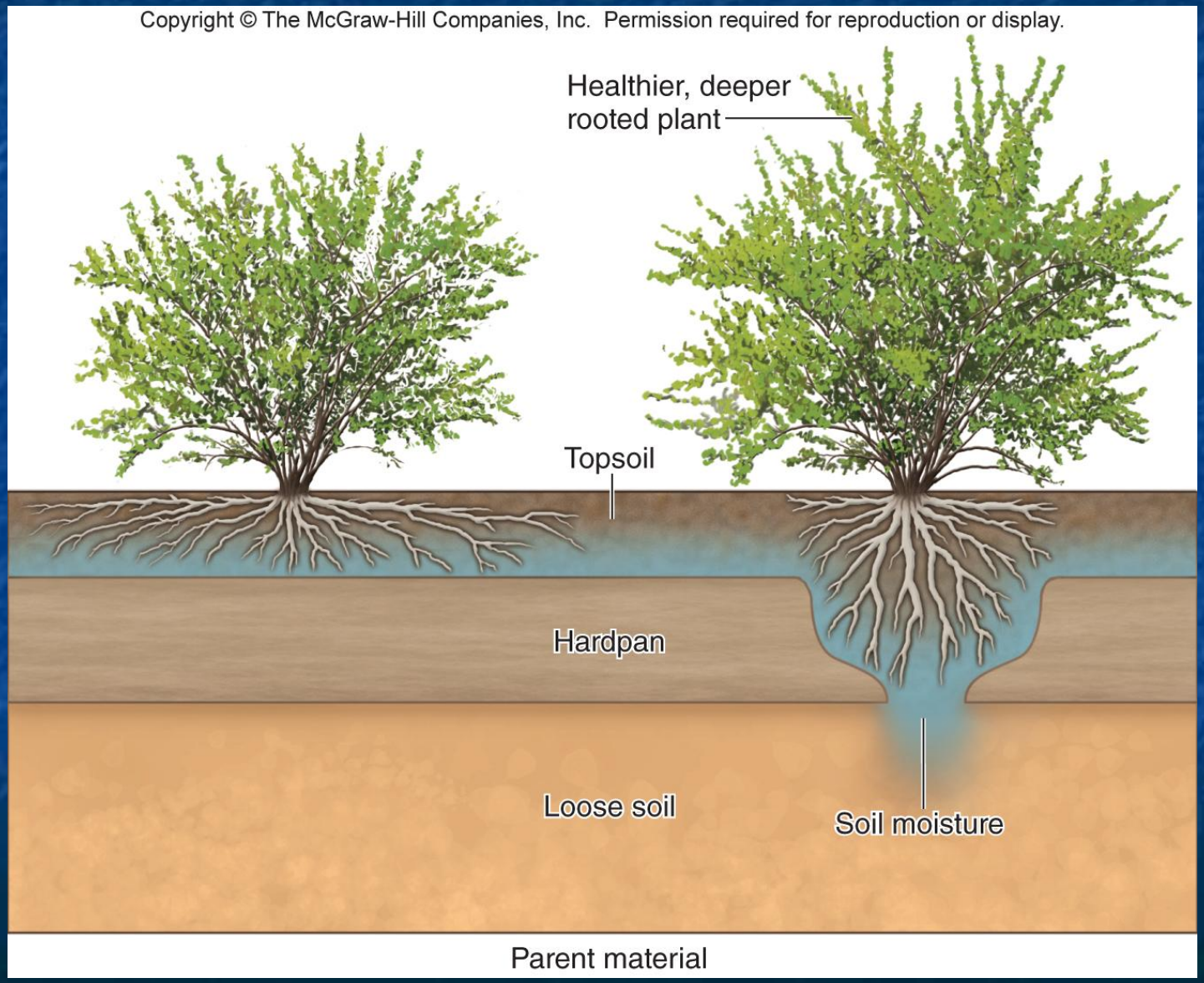
Hardpans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Healthier, deeper rooted plant
Topsoil
Hardpan
Loose soil
Soil moisture
Parent material