Earth Science, 10e

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Weathering, Soil, and Mass Wasting Chapter 3

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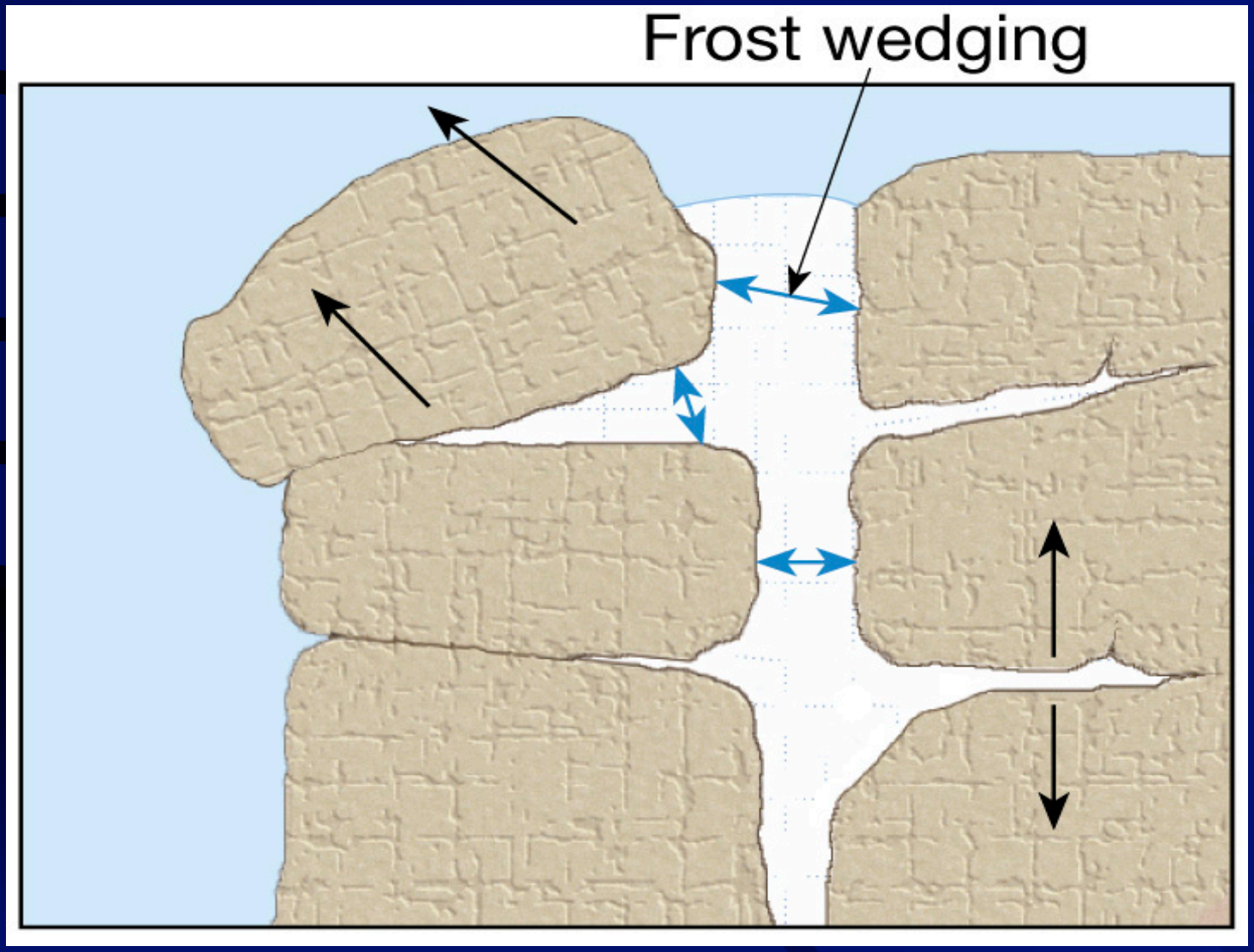
Earth's external processes

- Weathering – the disintegration and decomposition of material at or near the surface
- Mass wasting – the transfer of rock material downslope under the influence of gravity
- Erosion – the incorporation and transportation of material by a mobile agent, usually water, wind, or ice

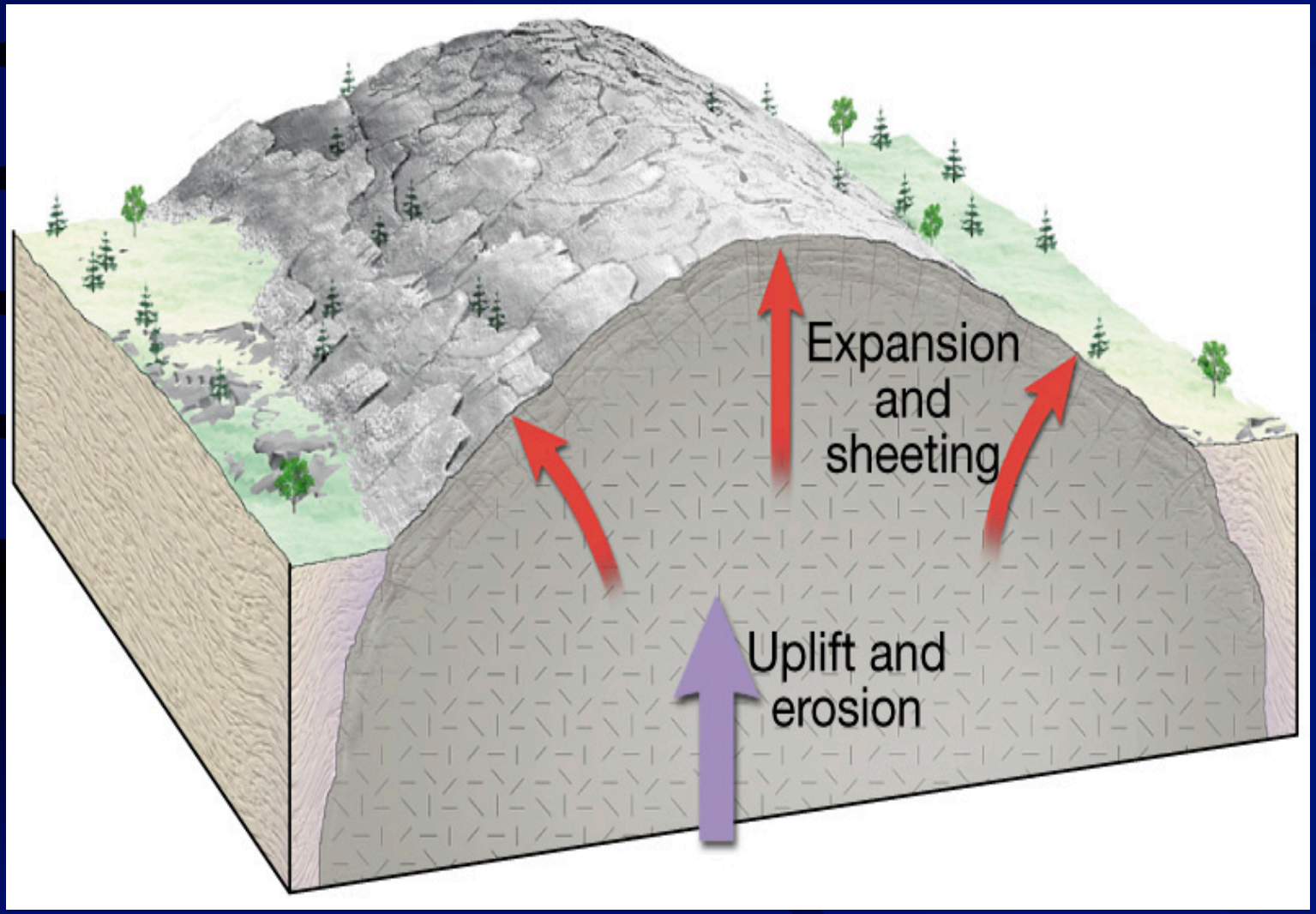
Weathering

- Two kinds of weathering
  - Mechanical weathering
    - Breaking of rocks into smaller pieces
    - Processes of mechanical weathering
      - Frost wedging
      - Unloading
      - Biological activity

Frost wedging



Unloading and exfoliation of igneous rocks



Weathering

- Two kinds of weathering
  - Chemical weathering
    - Alters the internal structures of minerals by removing or adding elements
    - Most important agent is water
      - Oxygen dissolved in water oxidizes materials
      - Carbon dioxide (CO_2) dissolved in water forms carbonic acid and alters the material

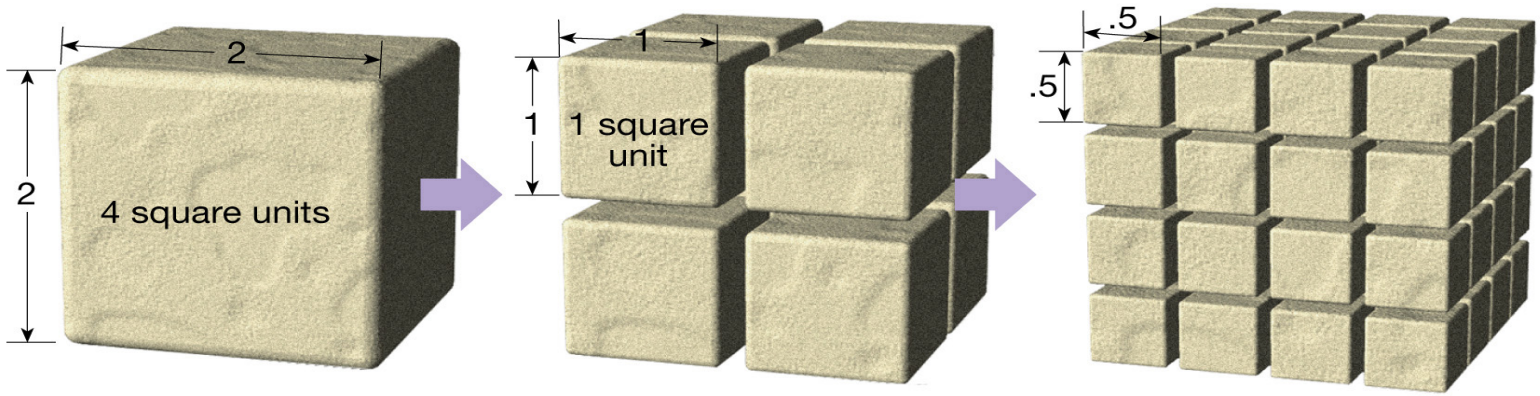
Weathering

- Two kinds of weathering
  - Chemical weathering
    - Weathering of granite
      - Weathering of potassium feldspar produces clay minerals, soluble salt (potassium bicarbonate), and silica in solution
      - Quartz remains substantially unaltered
      - Weathering of silicate minerals produces insoluble iron oxides and clay minerals

Rates of weathering

- Advanced mechanical weathering aids chemical weathering by increasing the surface area
- Important factors
  - Rock characteristics
    - Mineral composition and solubility
    - Physical features such as joints

Increase in surface area by mechanical weathering



4 square units ×
6 sides ×
1 cube =
24 square units

1 square unit ×
6 sides ×
8 cubes =
48 square units

.25 square unit ×
6 sides ×
64 cubes =
96 square units

Rates of weathering

- Important factors
  - Climate
    - Temperature and moisture are the most crucial factors
    - Chemical weathering is most effective in areas of warm temperatures and abundant moisture

Rates of weathering

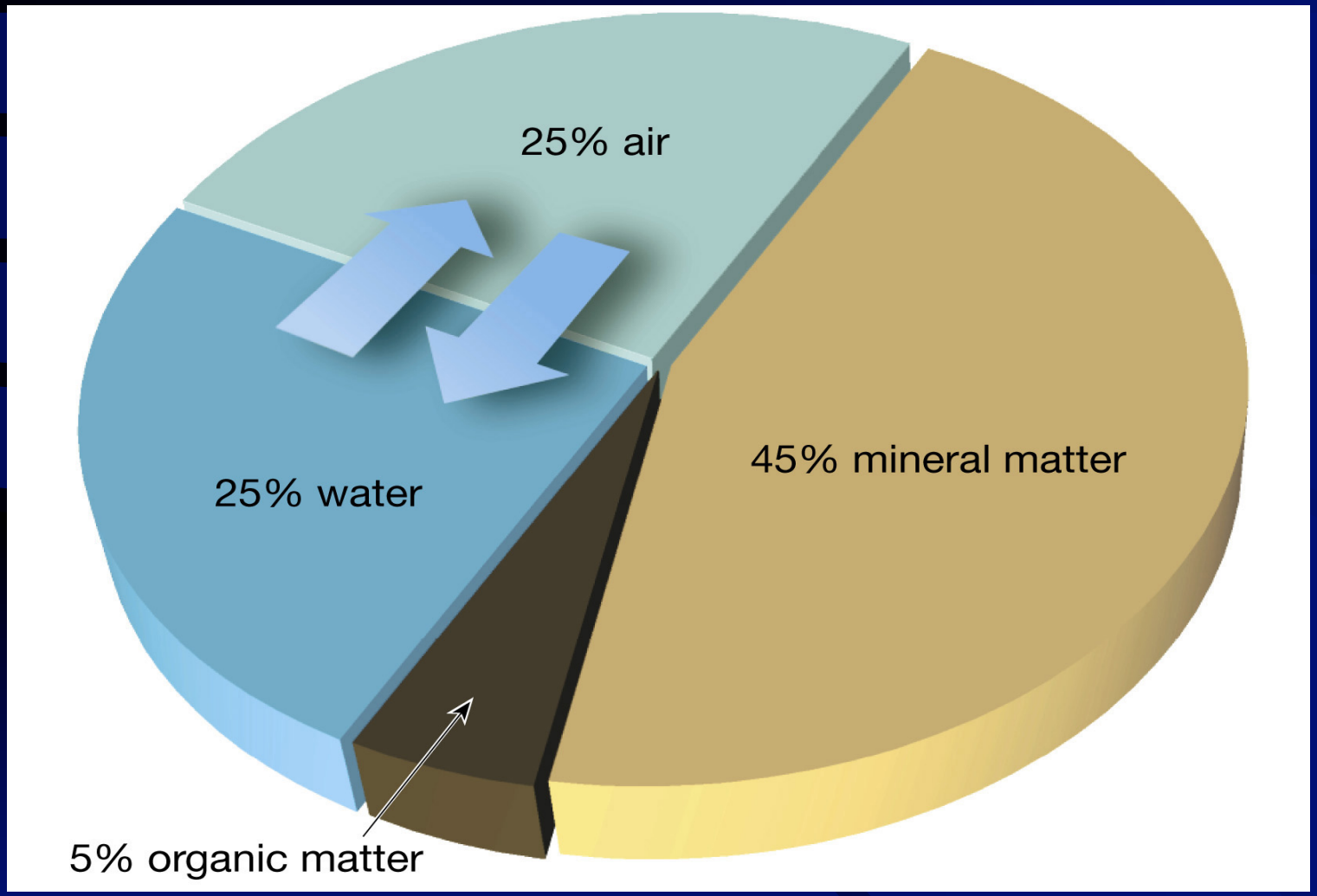
- Differential weathering
  - Caused by variations in composition
  - Creates unusual and spectacular rock formations and landforms

Joint-controlled weathering in igneous rocks

Soil

- An interface in the Earth system
- Soil is a combination of mineral matter, water, and air – that portion of the regolith (rock and mineral fragments) that supports the growth of plants

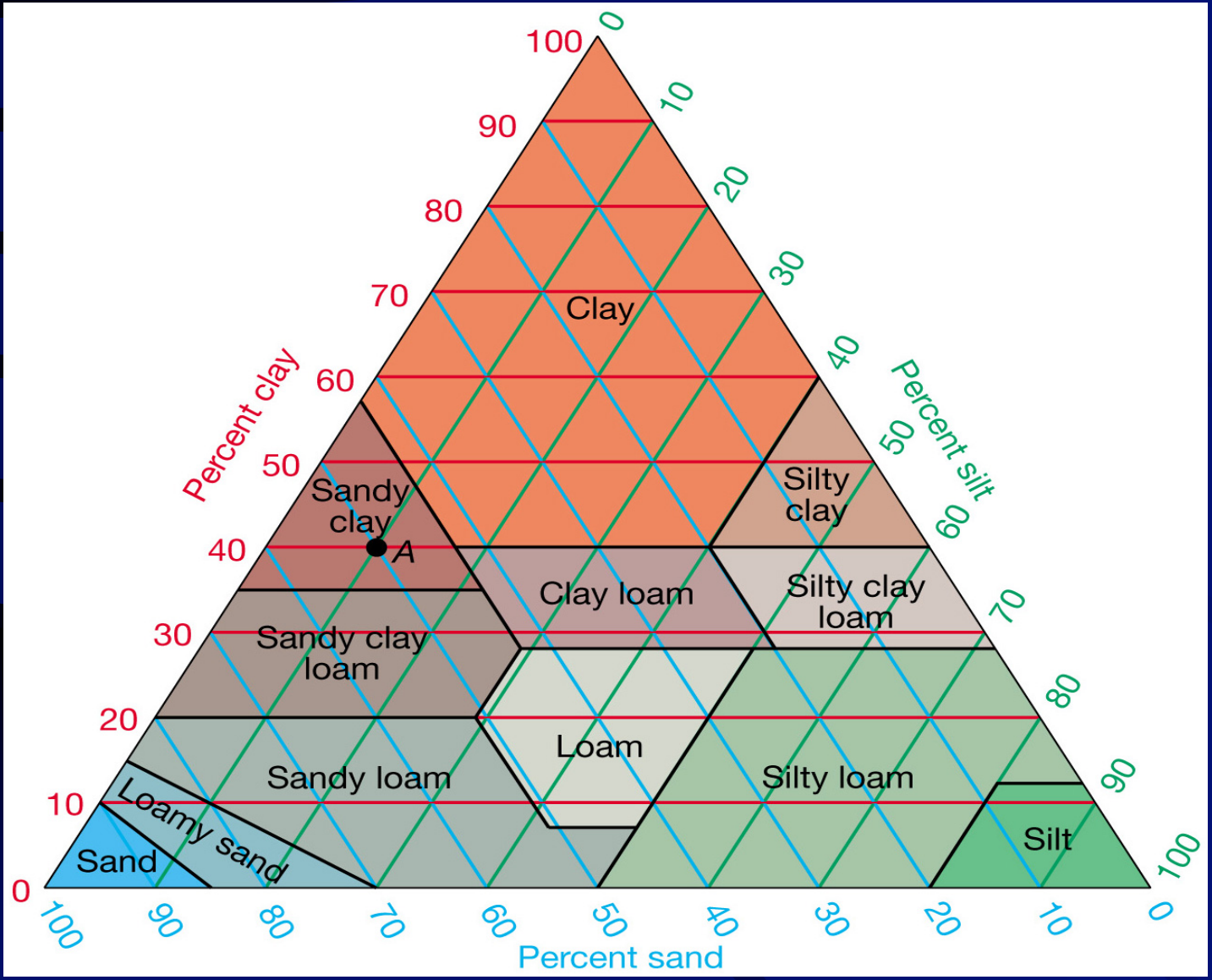
Typical components in a soil that yields good plant growth



Soil

- Soil texture and structure
  - Texture refers to the proportions of different particle sizes
    - Sand (large size)
    - Silt
    - Clay (small size)
  - Loam (a mixture of all three sizes) is best suited for plant life

Soil Texture



Soil

- Soil texture and structure
  - Structure
    - Soil particles clump together to give a soil its structure
    - Four basic soil structures
      - Platy
      - Prismatic
      - Blocky
      - Spheroidal

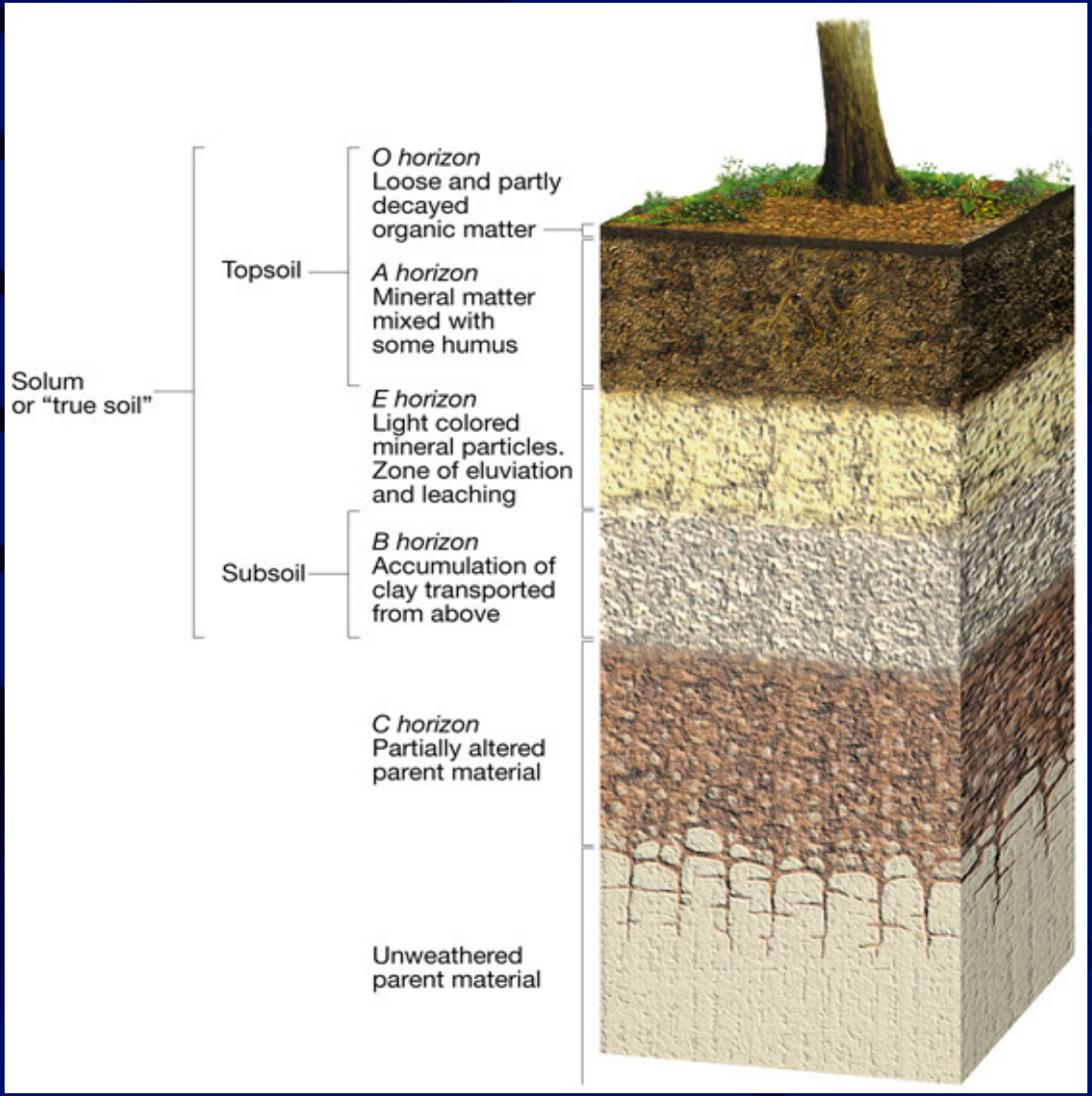
Soil

- Soil Profile
  - Soil forming processes operate from the surface downward
  - Horizons – zones or layers of soil
  - Horizons in temperate regions
    - *O* – organic matter
    - *A* – organic and mineral matter
    - *E* – little organic matter

Soil

- Soil Profile
  - Horizons in temperate regions
    - *B* – zone of accumulation
    - *C* – partially altered parent material
  - *O* and *A* together called topsoil
  - *O, A, E,* and *B* together called solum, or "true soil"

An idealized soil profile



A soil profile showing different horizons

Soil

- Soil types
  - Hundreds of soil types worldwide
  - Three very generic types
    - Pedalfer
      - Accumulation of iron oxides and Al-rich clays in the B-horizon
      - Best developed under forest vegetation

Soil

- Soil types
  - Three very generic types
    - Pedocal
      - Accumulate calcium carbonate
      - Associated with drier grasslands
    - Laterite
      - Hot, wet, tropical climates
      - Intense chemical weathering

TABLE 5.2 **Summary of Soil Types**

Climate	Temperate humid (>63 cm rainfall)	Temperate dry (<63 cm rainfall)		Tropical (heavy rainfall)	Extreme arctic or desert
Vegetation	Forest	Grass and brush		Grass and trees	Almost none, so no humus develops
Typical Area	Eastern U.S.	Western U.S.			
Soil Type	Pedalfer	Pedocal			Laterite
Topsoil	Sandy, light-colored; acid	Commonly enriched in calcite; whitish color	Zones not developed	Enriched in iron (and aluminium) brick-red color	No real soil forms, because there is no organic material. Chemical weathering is very slow.
Subsoil	Enriched in aluminum, iron and clay; brown color	Enriched in calcite; whitish color		All other elements removed by leaching	
Remarks	Extreme development in conifer forests, because abundant humus makes groundwater very acidic. Produces light gray soil because of removal of iron.	Caliche is name applied to the accumulation of calcite.		Apparently bacteria destroy humus, so no acid is available to remove iron.	

Weathering creates ore deposits

- Process called secondary enrichment
  - Concentrates metals into economical deposits
  - Takes place in one of two ways
    - Removing undesired material from the decomposing rock, leaving the desired elements behind
    - Desired elements are carried to lower zones and deposited

Weathering creates ore deposits

- Examples
  - Bauxite, the principal ore of aluminum
  - Many copper and silver deposits

Soil

- Controls of soil formation
  - Parent material
    - Residual soil – parent material is the bedrock
    - Transported soil – parent material has been carried from elsewhere and deposited
  - Time
    - Important in all geologic processes
    - Amount of time to evolve varies for different soils

Soil

- Controls of soil formation
  - Climate
  - Plants and animals
    - Organisms influence the soil's physical and chemical properties
    - Furnish organic matter to soil

Soil

- Controls of soil formation
  - Slope
    - Angle
      - Steep slopes often have poorly developed soils
      - Optimum is a flat-to-undulating upland surface
    - Orientation (direction the slope is facing) influences
      - Soil temperature
      - Moisture

Soil

- Soil erosion
  - Recycling of Earth materials
  - Natural rates of erosion depend on
    - Soil characteristics
    - Climate
    - Slope
    - Type of vegetation

Soil

- Soil erosion
  - Soil erosion and sedimentation can cause
    - Reservoirs to fill with sediment
    - Contamination by pesticides and fertilizers

Mass Wasting

- The downslope movement of rock, regolith, and soil under the direct influence of gravity
- Gravity is the controlling force
- Important triggering factors
  - Saturation of the material with water
    - Destroys particle cohesion
    - Water adds weight

Mass Wasting

- Important triggering factors
  - Oversteepening of slopes
    - Unconsolidated granular particles assume a stable slope called the angle of repose
    - Stable slope angle is different for various materials
    - Oversteepened slopes are unstable
  - Removal of anchoring vegetation
  - Ground vibrations from earthquakes

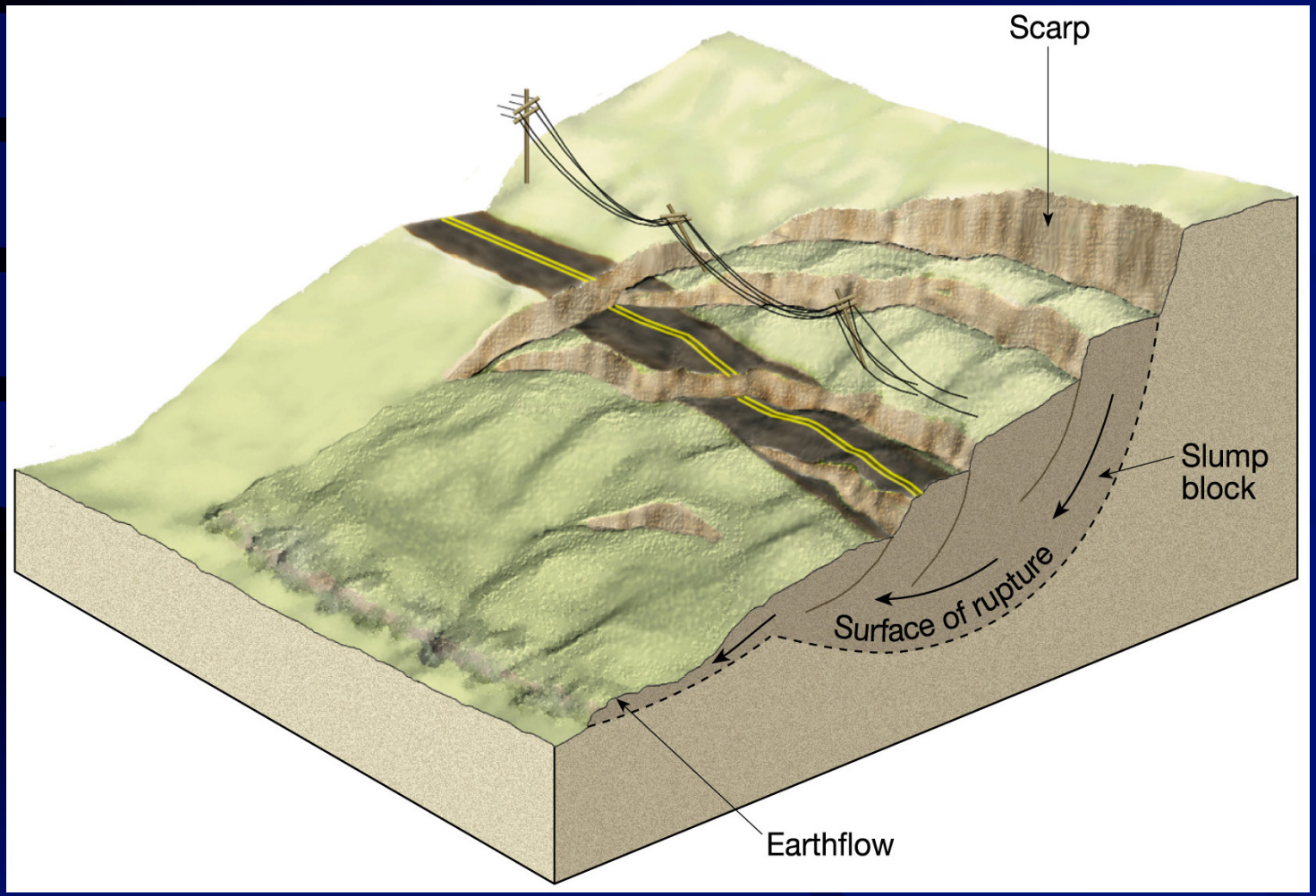
Mass Wasting

- Types of mass wasting processes
  - Generally each type is defined by
    - The material involved – debris, mud, Earth, or rock
    - The movement of the material
      - Fall (free-fall of pieces)
      - Slide (material moves along a well-defined surface)
      - Flow (material moves as a viscous fluid)

Mass Wasting

- Types of mass wasting processes
  - Generally each type is defined by
    - The rate of the movement
      - Fast
      - Slow curved
  - Forms of mass wasting
    - Slump
      - Rapid movement along a surface
      - Occur along oversteepened slopes

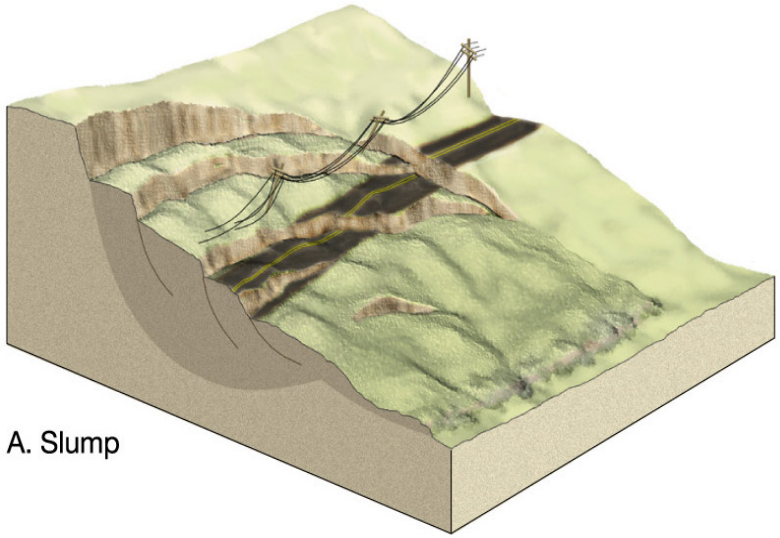
A slump with an earthflow at the base



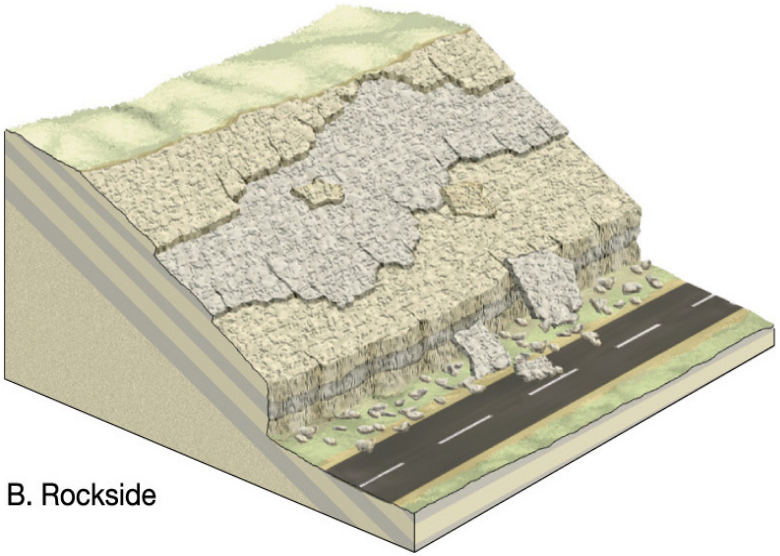
Mass Wasting

- Types of mass wasting processes
  - Forms of mass wasting
    - Rockslide
      - Rapid
      - Blocks of bedrock move down a slope
    - Debris flow (mudflow)
      - Rapid flow of debris with water
      - Often confined to channels
      - Serious problem in dry areas with heavy rains
      - Debris flows composed mostly of volcanic materials are called lahars

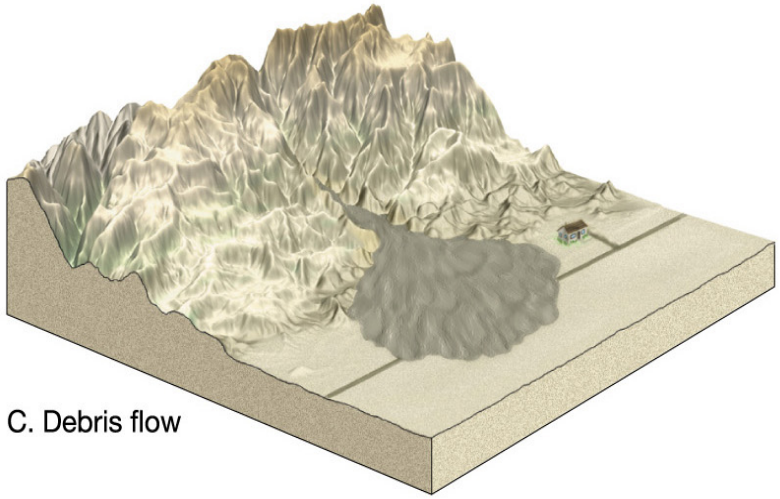
Forms of mass wasting



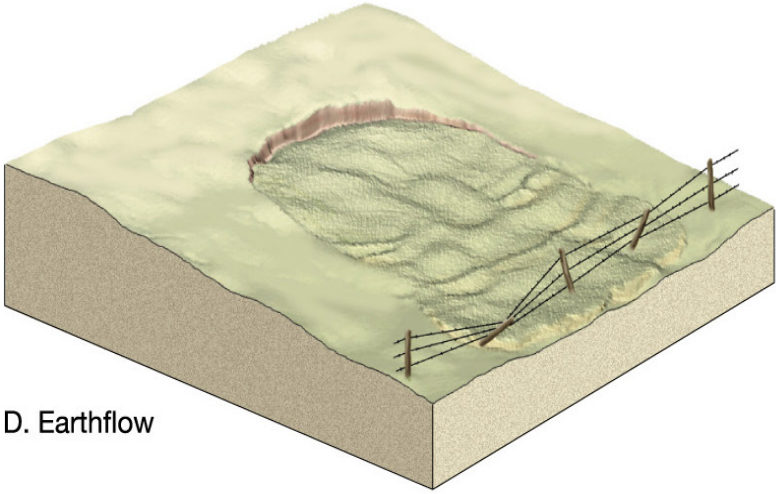
A. Slump



B. Rockside



C. Debris flow



D. Earthflow

Mass Wasting

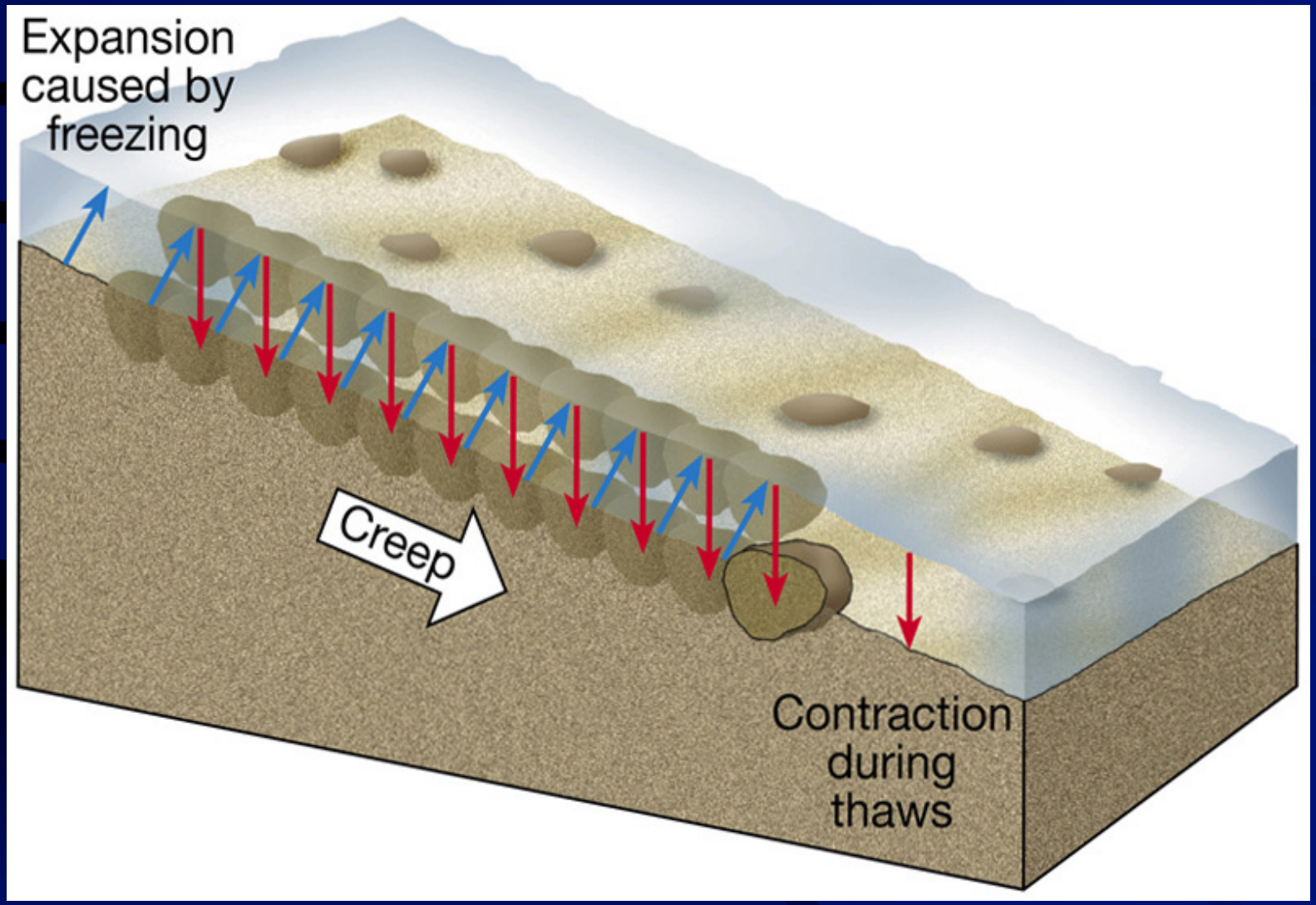
- Types of mass wasting processes
  - Forms of mass wasting
    - Earthflow
      - Rapid
      - Typically occur on hillsides in humid regions
      - Water saturates the soil
      - Liquefaction - a special type of earthflow sometimes associated with earthquakes

An earthflow on a newly formed slope

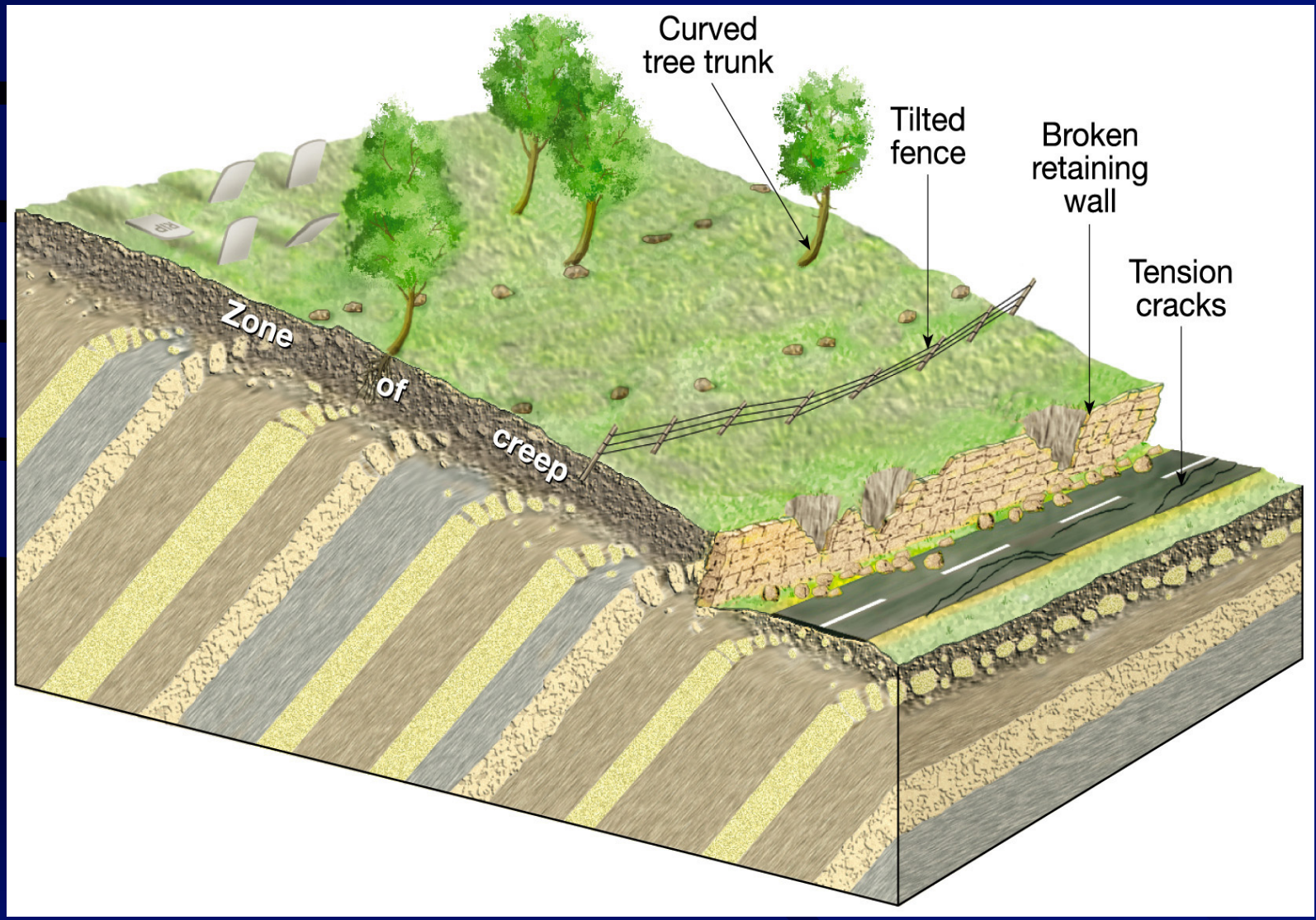
Mass Wasting

- Types of mass wasting processes
  - Forms of mass wasting
    - Creep
      - Slow movement of soil and regolith downhill
      - Causes fences and utility poles to tilt
    - Solifluction
      - Slow movement in areas underlain by permafrost
      - Upper (active) soil layer becomes saturated and slowly flows over a frozen surface below

Creep


Expansion
caused by
freezing
Creep
Contraction
during
thaws

Some visible effects of creep



Ground subsidence in Alaska due to solifluction

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