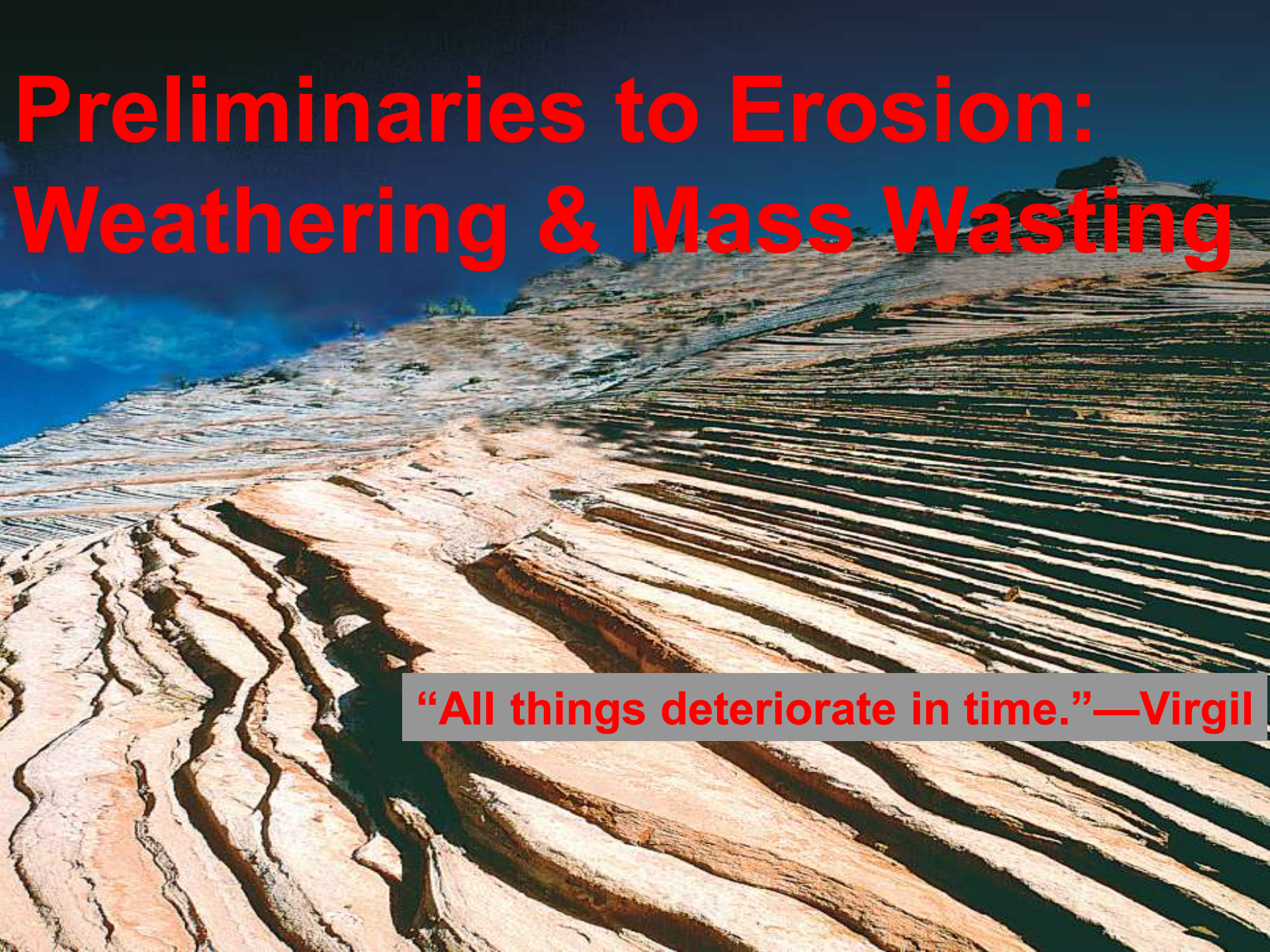
Preliminaries to Erosion: Weathering & Mass Wasting



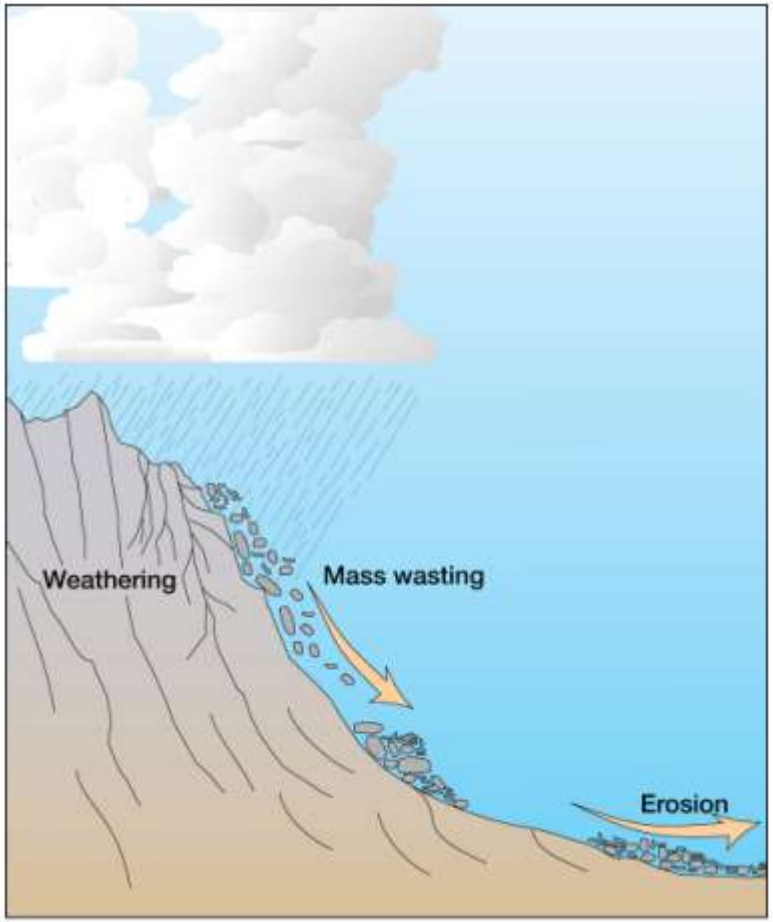
"All things deteriorate in time."—Virgil

Preliminaries to Erosion: Weathering and Mass Wasting

- Denudation
- The Impact of Weathering and Mass Wasting on the Landscape
- Weathering and Rock Openings
- Weathering Agents
- Mass Wasting

❖ Denudation

- Disintegration, wearing away, and removal of rock material
- Involves three activities:
  - Weathering
  - Mass wasting
  - Erosion
- Results in the lowering of continental surfaces



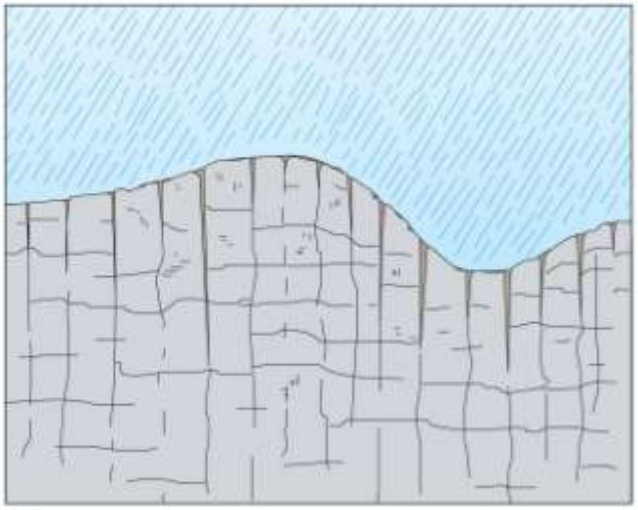
❖ The Impact of Weathering and Mass Wasting Processes on the Landscape

- Weathering and mass wasting work relentlessly to shape Earth's surface.
- The deeply scarred walls of valleys are evidence of their tremendous potential for shaping the land.
- The two processes aid erosion by either disintegrating rocks on slopes or by sending the weathered debris into turbulent streams below.

– The scarred walls of Grand Canyon of the Colorado River are a testament to the awesome forces of weathering and mass wasting.

❖ Weathering and Rock Openings

- Weathering
  - Mechanical weathering
  - Chemical weathering
- Openings in Rock
  - Microscopic Openings
  - Joints
  - Faults
  - Lava vesicles
  - Solution cavities



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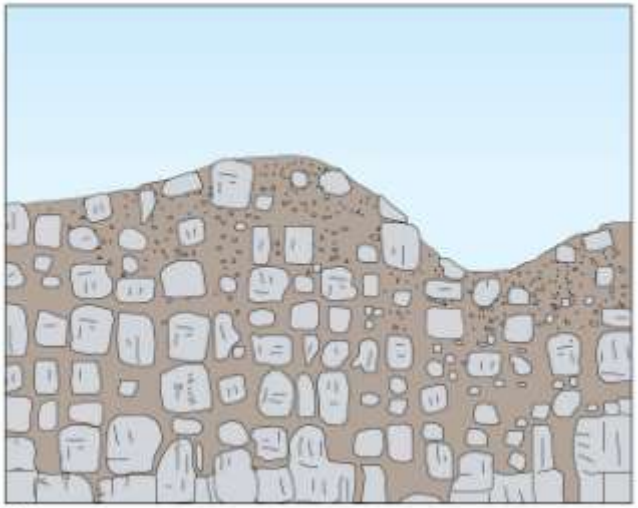
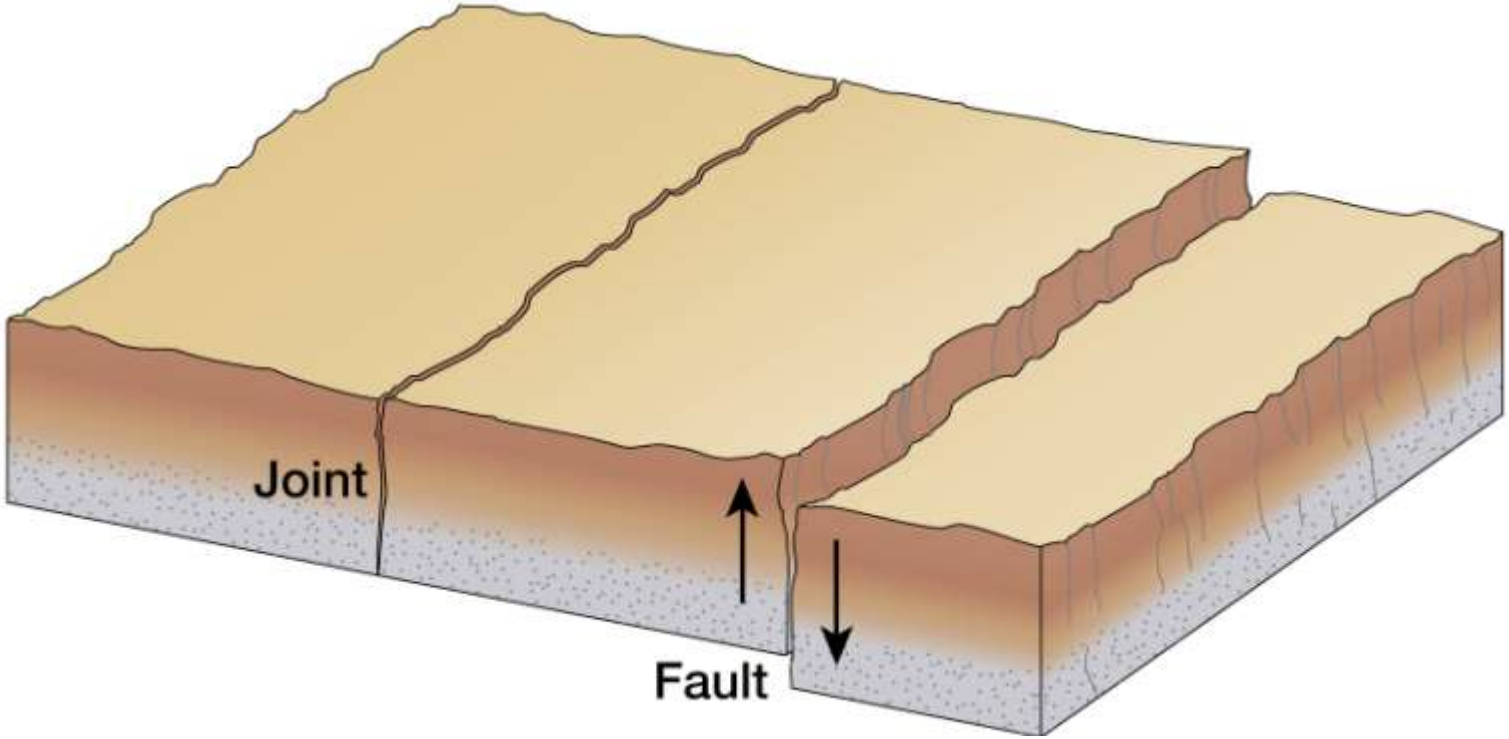
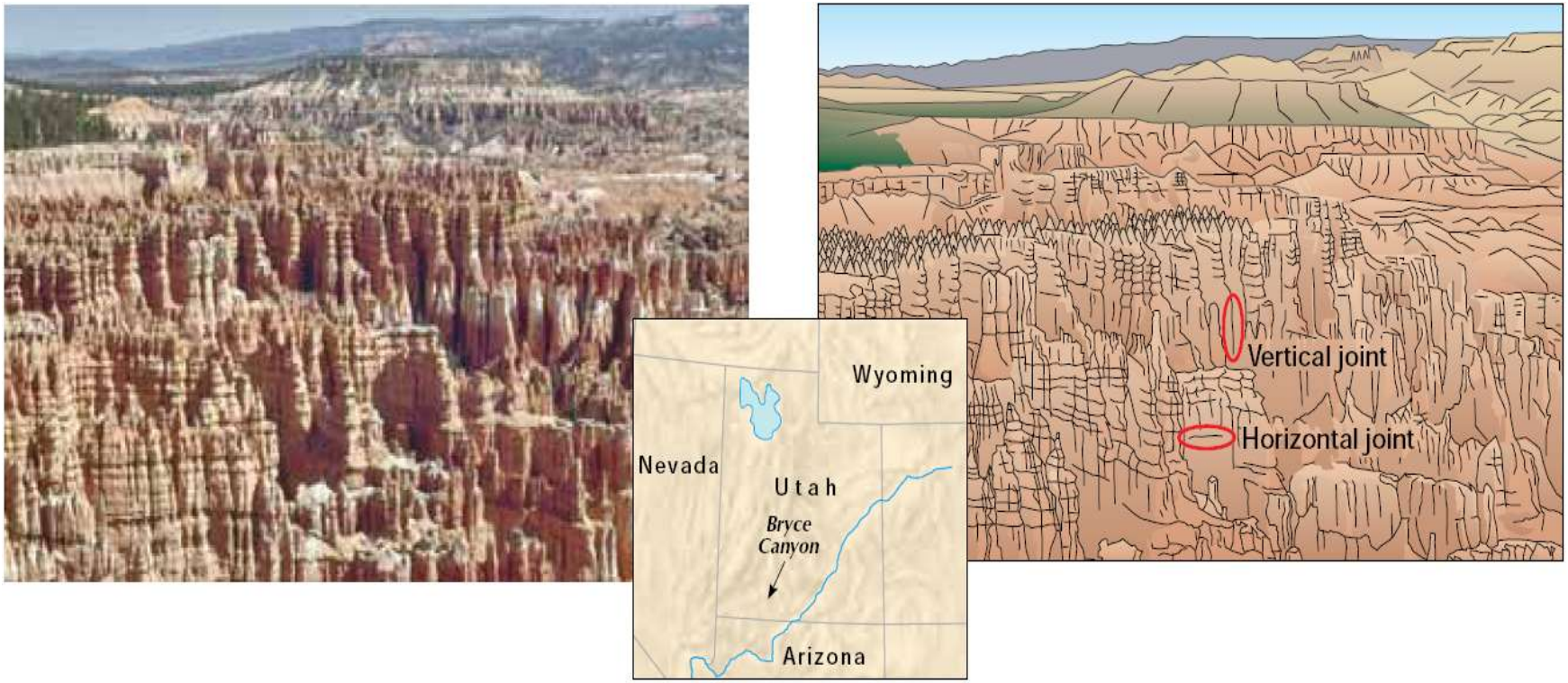


(b)

- The Importance of Jointing
  - Plain of weakness in rock
    - Makes rock susceptible to weathering
  - Joint versus Fault



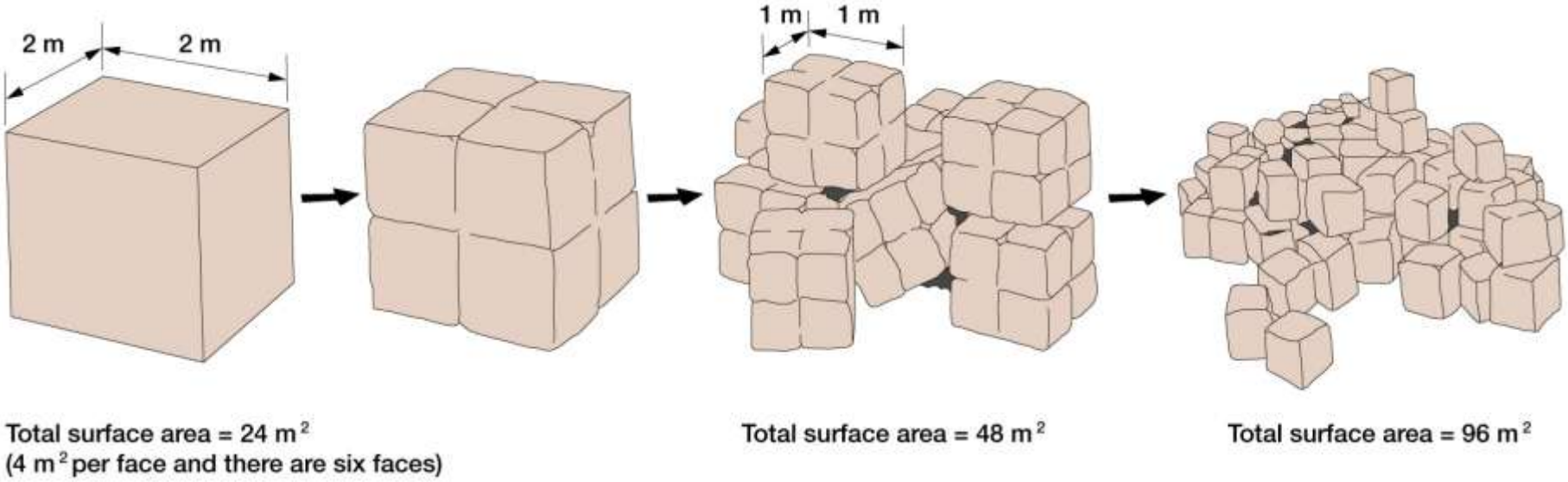
– Joint System
  - Extends great distances (vertically and horizontally)
  - Master joints



- Mechanical Weathering

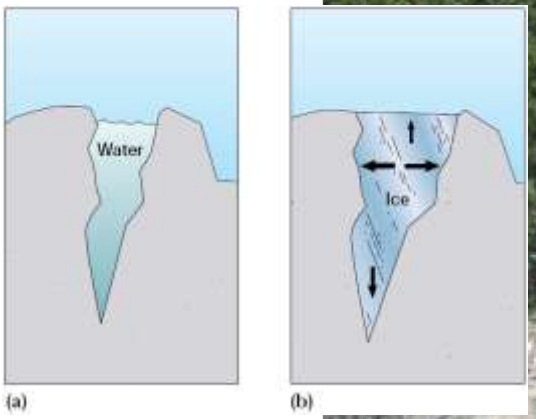
  Animation (Mechanical Weathering)

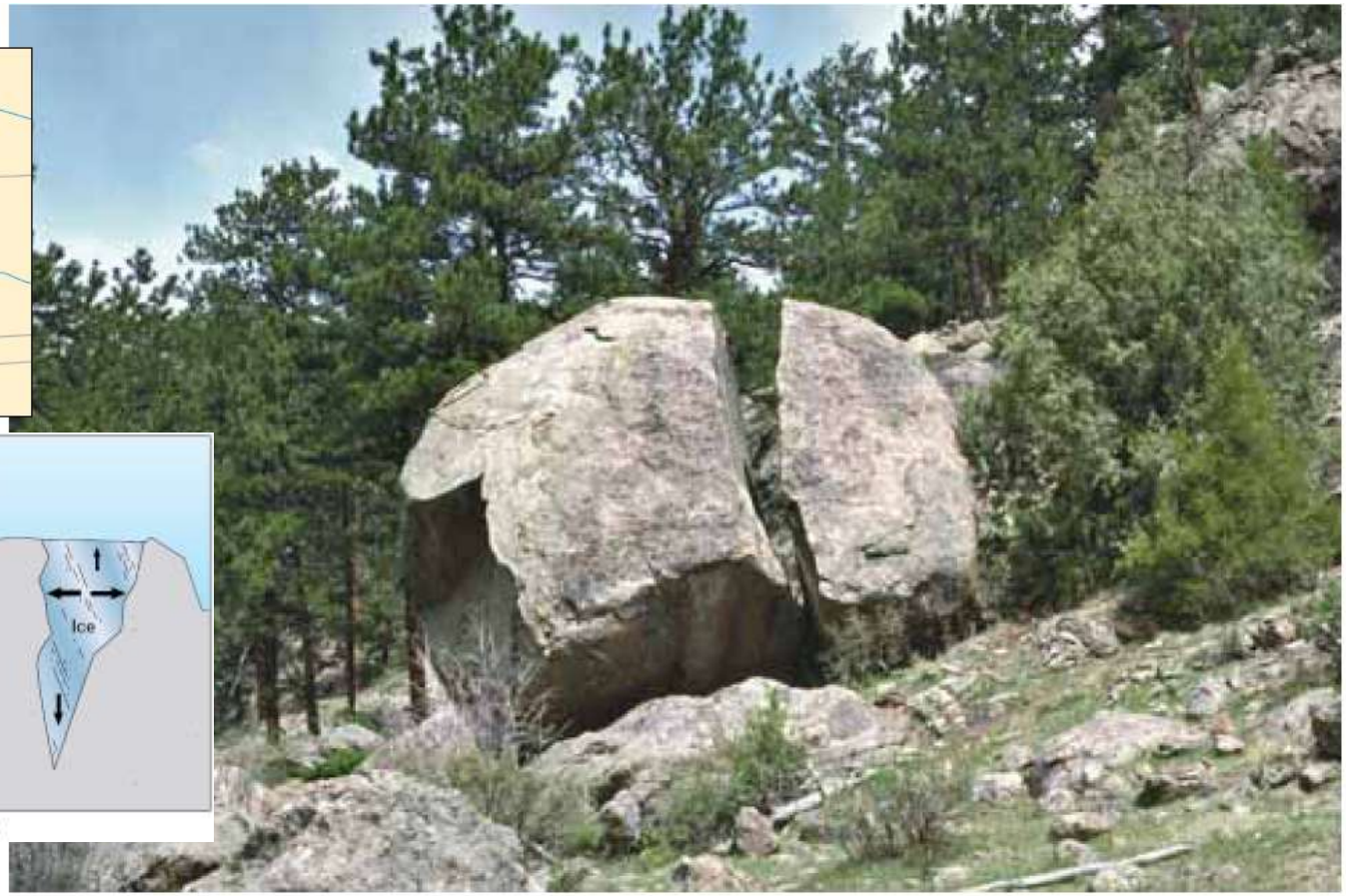
  – Physical disintegration of rock
  – No change in its chemical composition
  – Increases surface area for chemical weathering



– Mechanical

- Frost Wedging



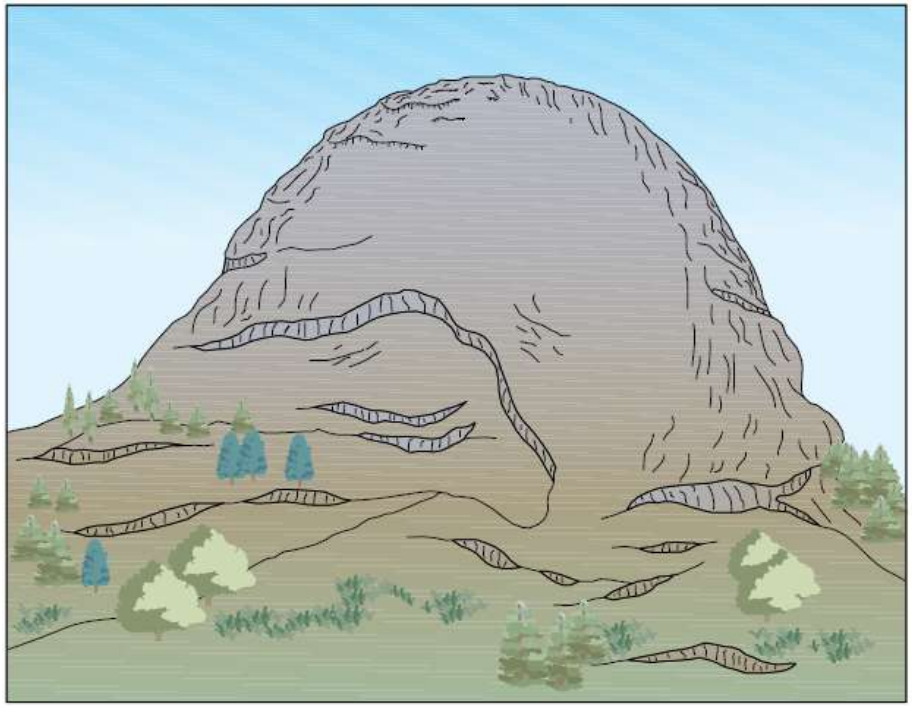


- Salt Wedging
  - Growth of salt crystals in rock openings
  - Granular disintegration

- Temperature Changes
  - Day to night (diurnal) changes
  - Winter to summer (seasonal) changes
  - Especially effective in high mountain elevations

Alps, Austria-Italy border

- Exfoliation
  - Curved and concentric sets of joints
    - » Unloading and pressure release
  - Mainly in granite and related intrusive igneous rocks



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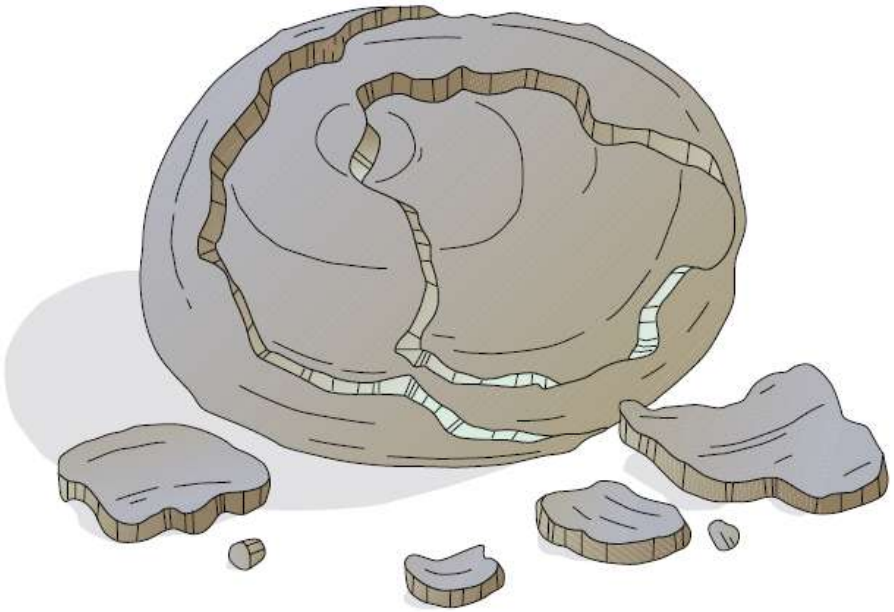
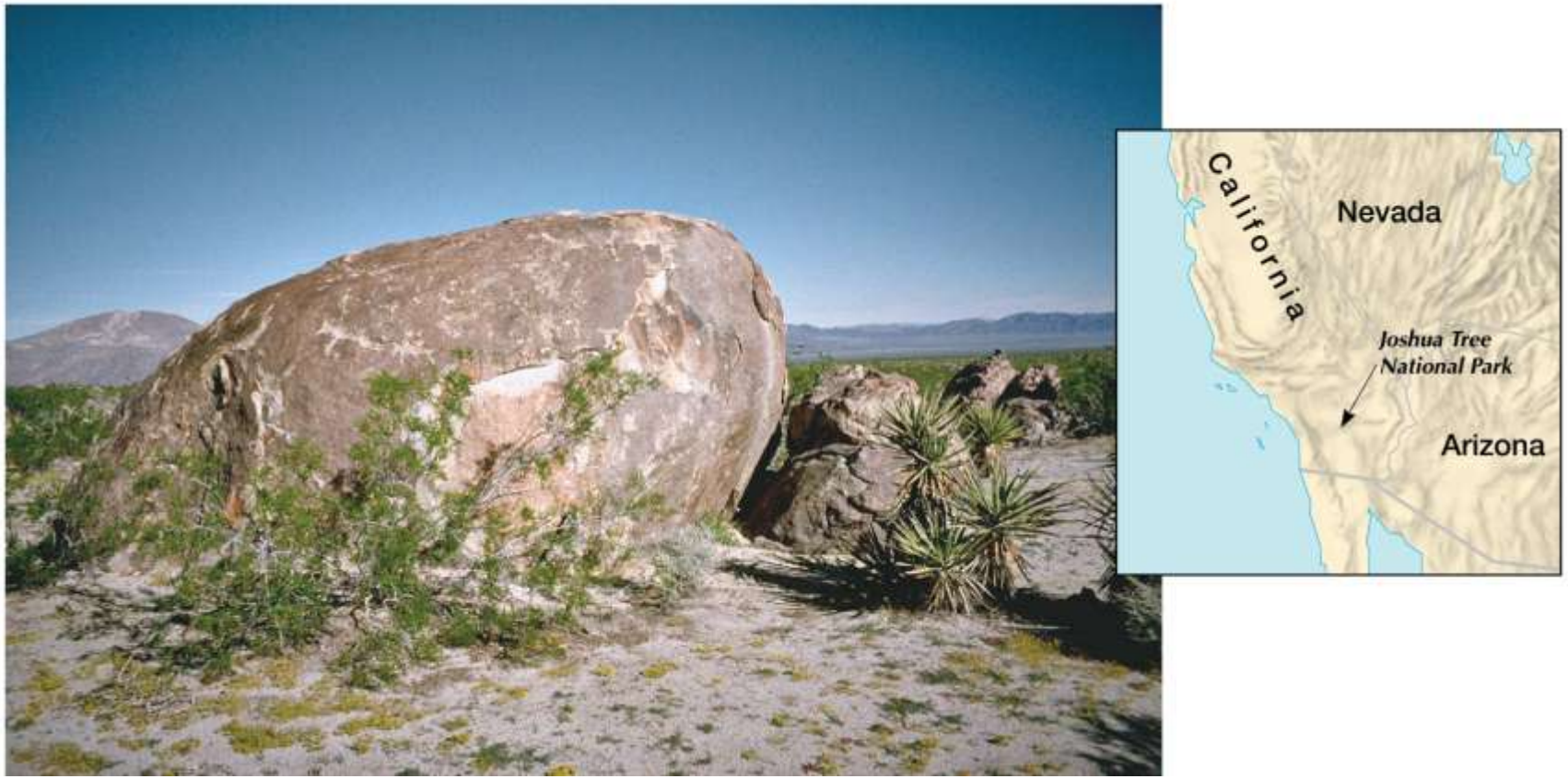


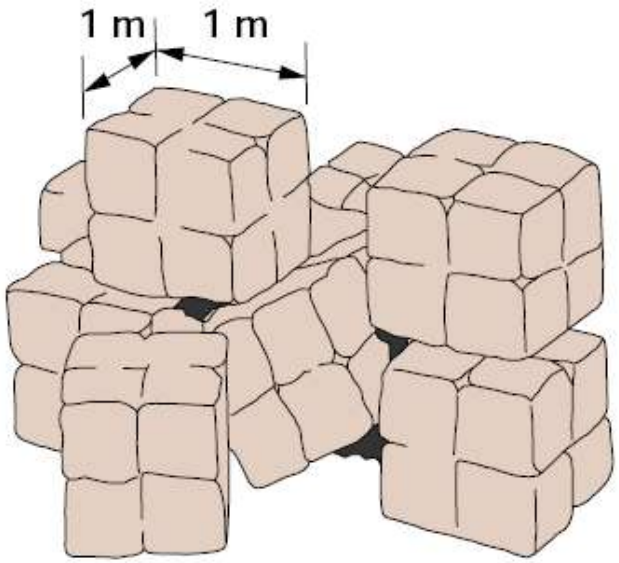
(b)

Two large exfoliation domes in Yosemite National Park

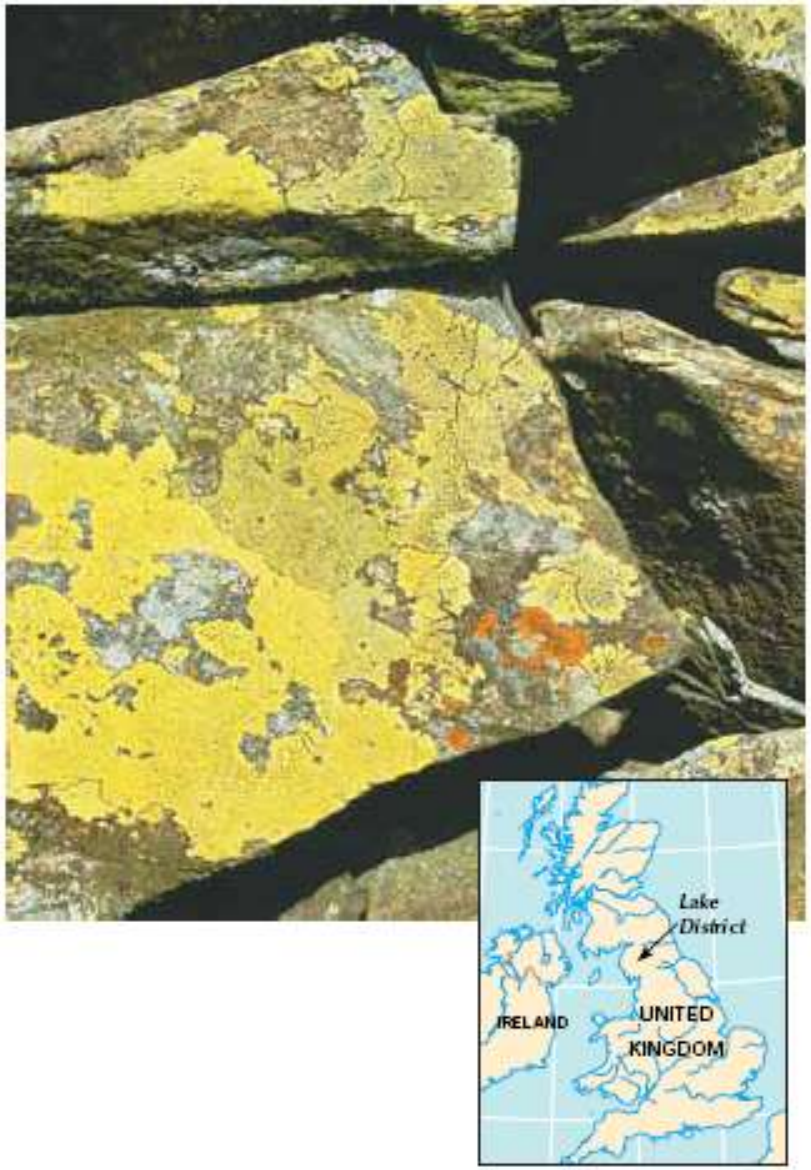


Exfoliated boulder in Joshua Tree National Park

- Chemical Weathering
  - Chemical alteration of rock minerals
  - Enhanced by mechanical weathering
  - Rates
    - High rates: Warm, moist environments – wet tropics
    - Low rates: Cold lands and deserts
  - Processes
    - Oxidation
    - Hydrolysis
    - Carbonation

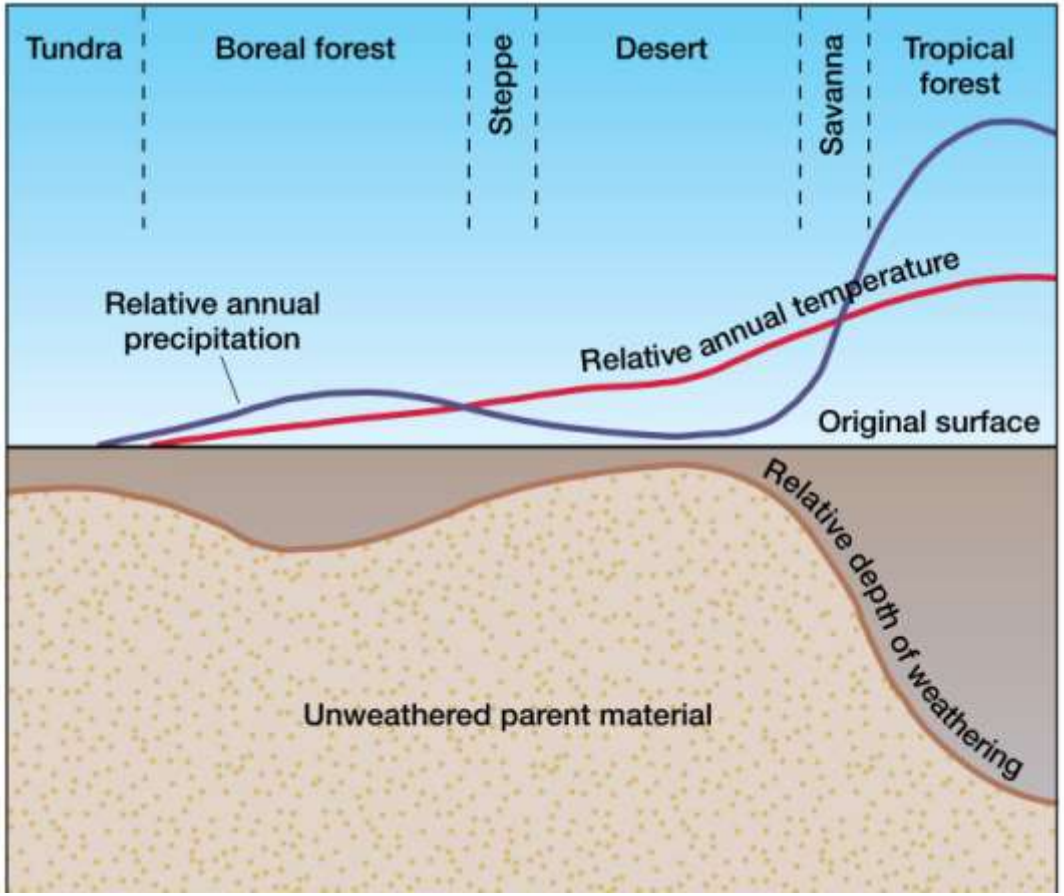


- Biological Weathering
  - Root penetration
  - Burrowing animals
  - Organic acids
    - e.g., from lichens



- Photo 1: Scrub Oak, San Bernardino Mountains, CA
- Photo 2: Termite Mound, Venezuela
- Photo 3: Lichens, Lake District, England.

- Climate and Weathering
  - Moisture is usually more important than temperature



❖ Mass Wasting

Animation (Mass Wasting)

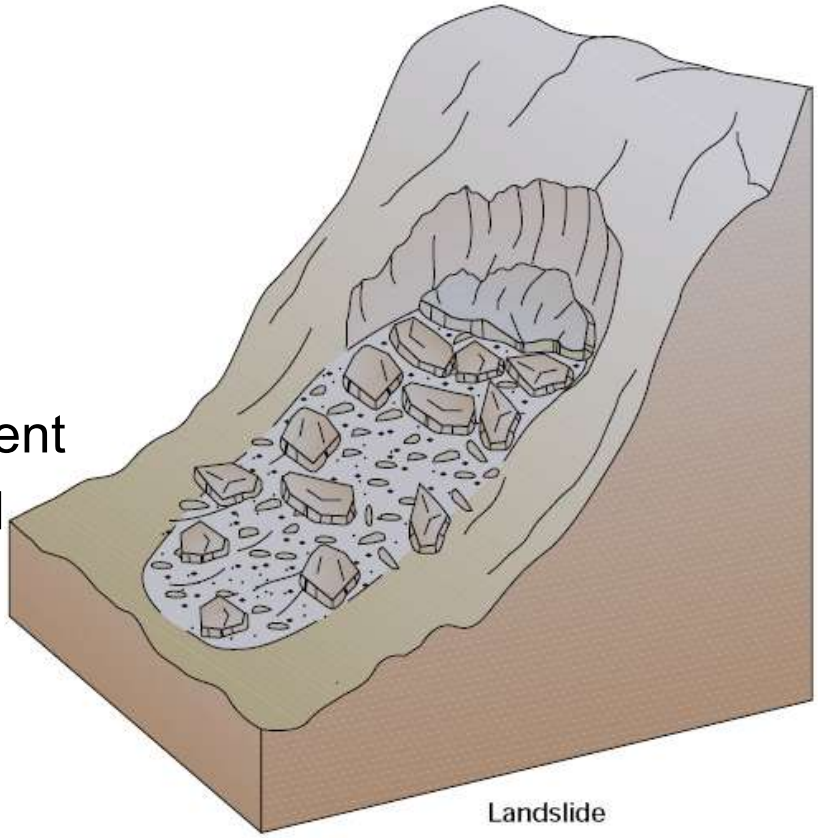
- Gravity (down slope) transfer
  - Angle of repose
    - Steepest angle without down slope transfer
  - Accumulation of weathered material
    - Soil
    - Regolith
    - Fragmented rock
  - Facilitators
    - Water
    - Clays

- Rock Fall (Fall)
  - Talus cone

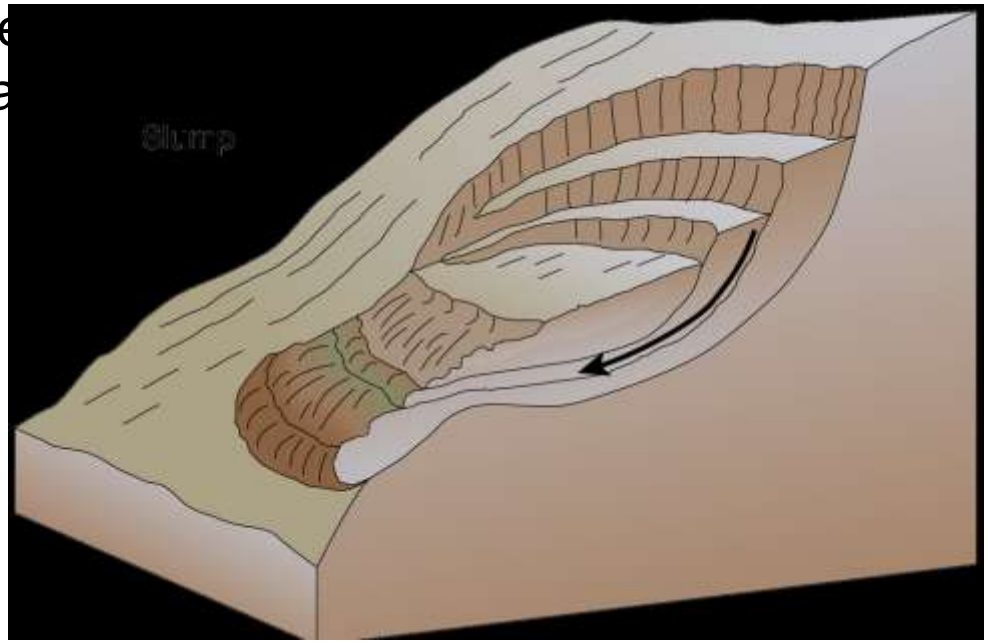
- Slide

  Animation (Eruptions of Mount St. Helens)

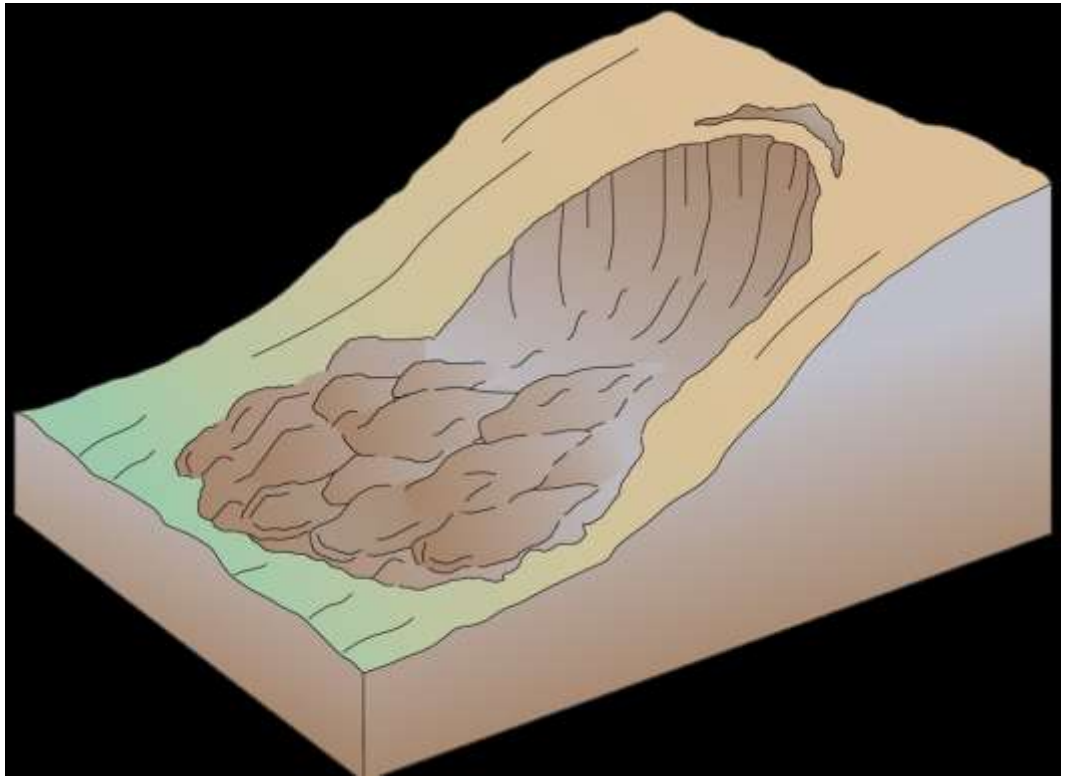
  – Landslide
    - Slope failure
      - Heavy rains
      - Earthquake
      - Geological weakness (jointing)
    - Rapid downslope movement
    - Large, rigid mass (no fluid flow) of weathered rock



– Slump
  - Weathered debris rotates along a curved plane
  - Concave side face upward
  - Crescent-shaped scarp face marks the top
  - Bulging lobe of wate saturated material a base of the slide



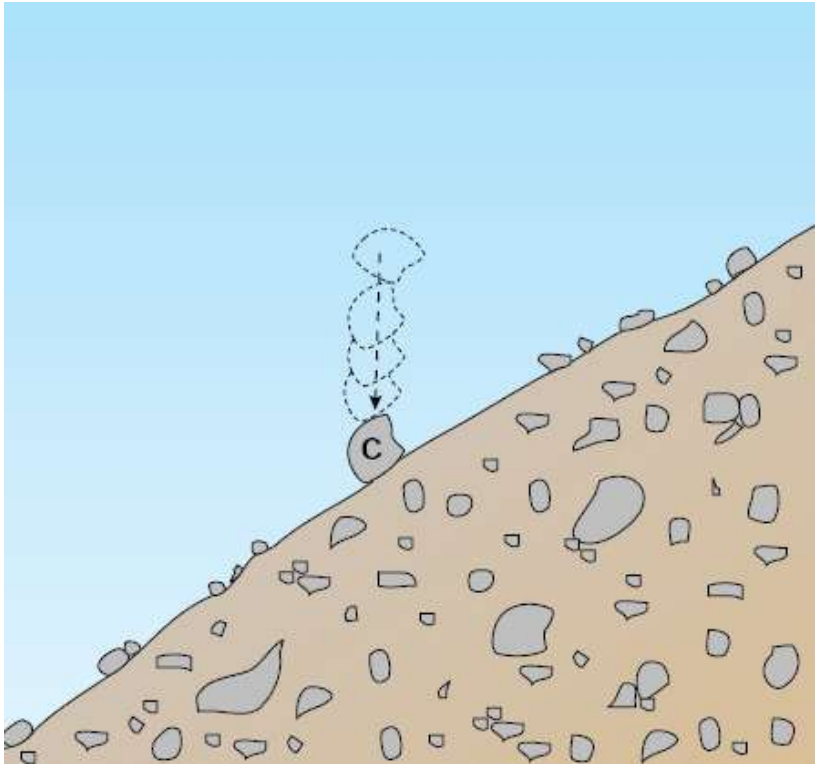
- Flow
  - Water-saturated weathered debris with high clay fraction is an important catalyst
  - Earth flow
    - Relatively rigid, slower moving than the mudflow



- Mudflow
  - Arid and semi-arid slopes
  - Heavy rains saturate slope causing slope failure
  - Fluid flow follows stream network
  - Alternate name: Debris flow, if large boulders are numerous
  - More dangerous than the earth flow

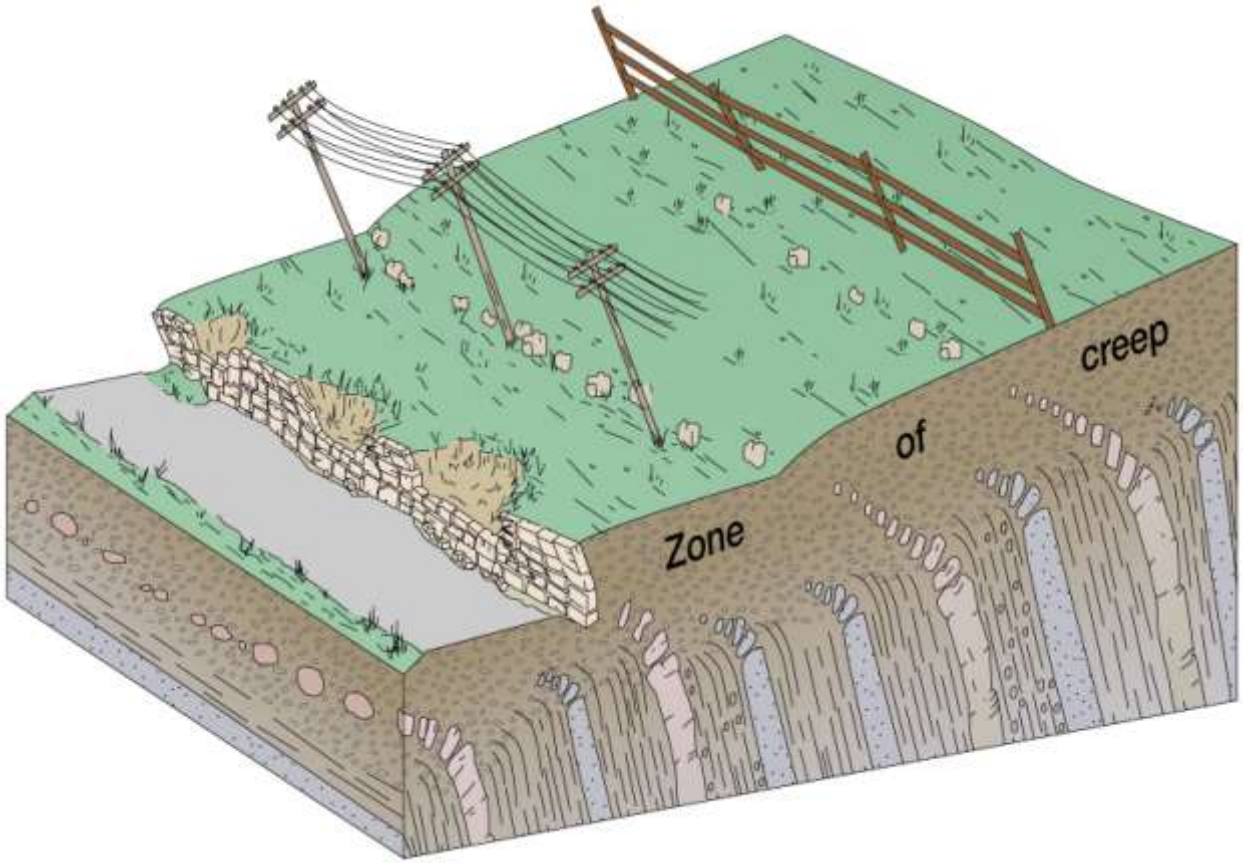
Caraballeda, Venezuela (1999). Series of debris flows devastated this coastal city.

- Creep
  - Slowest moving mass wasting process
  - Entire slope is involved
  - Particle-by-particle movement
  - Conditions
    - Freeze-thaw temperature pattern
    - Wet-dry precipitation pattern



Freeze –thaw condition

– Visual Evidence of Creep



Displacement and/or bending of fences, utility poles and retaining walls

– Solifluction (“soil flowage”)
  - Form of creep
  - Tundra areas

❖ Summary

- Weathering and mass wasting contribute to the wearing down (denudation) of Earth's surface.
- Openings in rocks (particularly joints) allow weathering to take place deep below the surface.
- Weathering loosens surface and near-surface material in bedrock and makes it prone to mass wasting and erosion.

- There are three general forms of weathering: mechanical, biological and chemical.
- Mechanical weathering processes include frost wedging, salt wedging and temperature changes in rock.
- Biological weathering is relatively minor; it involves the effects that burrowing animals, plant root penetration and organic acids have on the other two weathering processes.
- Chemical weathering weakens the chemical makeup of rock minerals.

- Mass wasting involves the gravitational transfer of weathered materials down slopes.
- The three general weathering processes are interrelated and are influenced to varying degrees by the climate.
- There a several mass wasting processes, but they all transfer weathered materials down slopes under the influence of gravity.