Objectives

• Describe the two major kinds of rock weathering.
• Identify three end products of weathering.
• Describe soil horizons.
• Explain the difference between weathering, erosion, and mass wasting.
• Describe how ice, water, and air transport regolith across Earth's surface.
• Define and give examples of mass wasting by slope failure and/or sediment flow.

Weathering-The First Step in the Rock Cycle
Weathering—The First Step in the Rock Cycle

- How rocks disintegrate
  - Weathering
    - The chemical and physical breakdown of rock exposed to air, moisture and living organisms
  - Regolith
    - A loose layer of fragments that covers much of Earth’s surface
  - Soil
    - The uppermost layer of regolith, which can support rooted plants

- Mechanical weathering
  - The breakdown of rock into solid fragments by physical processes
  - Chemical composition of rock NOT altered

- Chemical weathering
  - The decomposition of rocks and minerals by chemical and biochemical reactions

Processes:
- Pressure release
- Frost action
- Plants and animals
- Abrasion

- Joints
  - A fracture of rock, along which no appreciable movement has occurred
  - Sheet jointing or exfoliation
  - Frost wedging

- Abrasion
  - The gradual wearing down of bedrock by the constant battering of loose particles transported by wind, water or ice
Weathering-the First Step in the Rock Cycle

Joshua Tree National Monument

- Landscape that formed in two stages; deep weathering of granitic rocks along joints (humid climate) with spheroidal weathering; followed by climate change to arid climate; exposure of core stones

Sheeting or exfoliation: Weathering of thin slabs of rock from an outcrop
Pressure release

- Expansion of rock as pressure is removed by erosion—as rock expands, fractures formed perpendicular to direction of pressure release
- Known as sheeting or exfoliation

Frost wedging: water expands by 9% in volume as it freezes: Causes breaking of rock along existing or new joints

Andesite slabs and fragments produced by frost shattering-southwestern Montana
Canadian Rockies

BIOLOGICAL ACTIVITY - ROOT WEDGING

Abrasion: once a depression is formed on the rock surface, it is deepened by winds blowing sand across the surface
Chemical weathering

- Dissolution
  - The separation of materials into ions in a solution by a solvent, such as water or acid
  - Rainwater acts as weak solution of carbonic acid
  - Anthropogenic actions influence acidity of rainwater

Chemical Weathering

[Image of Obelisk in Egypt and Obelisk in New York]

Chemical weathering
Factors affecting weathering

- Tectonic setting
  - Young, rising mountains weather quicker
  - Mechanical weathering most common

Factors affecting weathering

- Rock composition
  - Minerals weather at different rates
    - Calcite weathers quickly through dissolution
    - Quartz is very resistant to chemical and mechanical weathering

Factors affecting weathering

- Rock structure
  - Distribution of joints influence rate of weathering
    - Relatively close joints weather faster
Factors affecting weathering

• Topography
  – Weathering occurs faster on steeper slopes
    • Rockslides

Factors affecting weathering

• Vegetation
  – Contribute to mechanical and chemical weathering
  – Promotes weathering due to increased water retention
  – Vegetation removal increases soil loss

Factors affecting weathering

• Biologic activity
  – Presence of bacteria can increase breakdown of rock
Factors affecting weathering

- Climate
  - Chemical weathering more prevalent in warm, wet tropical climates
    - Mechanical weathering less important
  - Mechanical weathering more prevalent in cold, dry regions
    - Chemical weathering occurs slowly

Products of Weathering

- Clay
  - Tiny mineral particles of any kind that have physical properties like those of the clay minerals
  - A family of hydrous alumino-silicate minerals
Products of Weathering

- **Sand**
  - A sediment made of relatively coarse mineral grains

- **Soil**
  - Mixture of minerals with different grain sizes, along with some materials of biologic origin

- **Humus**
  - Partially decayed organic matter in soil

**Soil horizons**

- One of a succession of zones or layers within a soil profile
- Each horizon has a distinct physical, chemical, and biologic characteristic

**Soil profiles**

- The sequence of soil horizons from the surface down to the underlying bedrock
Soils and climate

Prairie soil: South Dakota

Soils and climate

Forest soil: Michigan

Erosion by water

- Erosion
  - The wearing away of bedrock and transport of loosened particles by a fluid, such as water
- Bed Load
  - Sediment moved along the bottom of a stream
- Saltation
  - Bouncing movement along bed of stream
- Suspended load
  - Silt and clay that move in suspension
- Dissolved load
  - Molecules that are dissolved in the water
Erosion by water

- Saltation is primary mechanism
- Bed load (contains sand, pebbles, boulders)

Erosion and Mass Wasting

- Erosion by wind
  - Saltation is primary mechanism

- Erosion by ice
  - Glacier
    - A semi-permanent or perenially frozen body of ice, consisting of recrystallized snow, that moves under the pull of gravity
White Desert, Egypt

Erosion by glaciers
Erosion by glaciers

Mass Wasting

- Mass wasting
  - The downslope movement of regolith and/or bedrock masses due to the pull of gravity
- Slope failure
  - Falling, slumping or sliding of relatively coherent masses of rock
  - Three basic types
    - Fall: vertical (or near vertical) drop of rock fragments
    - Slide: rapid displacement of rock/ regolith down steep or slippery slope
    - Slump: rotational movement of material

Mass Wasting

Rock slide

Rock fall
Slump

Direction of motion

Slides

Great Lakes coastal slumps/slides
Mass Wasting

- Flow
  - Any mass-wasting process that involves a flowing motion of regolith containing water and/or air within its pores
    - Sharry flows
    - Granular flow

- Creep
  - The imperceptibly slow downslope granular flow of regolith

Erosion and Mass Wasting

- Slurry flows
- Granular flows

Dec., 2004 Debris flow
Madison Canyon slide, 1959

Flowed uphill on opposite side of valley; buried campground with 26 people; formed temporary lake; Corps of Engineers excavated spillway to prevent catastrophic overtopping and flood.

Frank Slide, Alberta

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**VISUALIZING**

Safety Factor and Landslide Prediction

- Factor of safety (FS)
  - The balance between destabilizing forces (shear stress) and stabilizing forces (shear strength)

- Tectonics and mass wasting
  - World’s major historic landslides clustered near converging lithospheric plates
    - High mountains
    - Earthquake