Weathering & Mass-Wasting Processes Part II

- Definitions: Weathering, Erosion, and Mass-Wasting
- Types of Weathering
  - Mechanical Weathering
  - Chemical Weathering
  - Biological Weathering
  - Differential Weathering
- Types of Erosion
  - Fluvial, Aeolian, Ice: Glacial and Periglacial, Gravity
- Types of Mass Wasting
- Deposition
- Weathering, Erosion and Mass Wasting in the Landscape

Definitions

- **Weathering** is the physical disintegration or chemical alteration of rocks at or near the Earth's surface.
- **Erosion** is the physical removal and transportation of weathered material by water, wind, ice, or gravity.
- **Mass wasting** is the transfer or movement of rock or soil down slope primarily by gravity.
- **Deposition** is the process by which weathered and eroded materials are laid down or placed in a location that is different from their source.

Erosion

- **Water** erodes rocks and the landscapes by transporting weathered materials from their source to another location where they are deposited.

- **Wind** erodes materials by picking them up and temporarily transporting them from their source to another location where they are deposited.

- fluvial erosion (water)
- aeolian (wind) erosion
- rocks falls or landslides (mass-wasting) erosion

Erosion

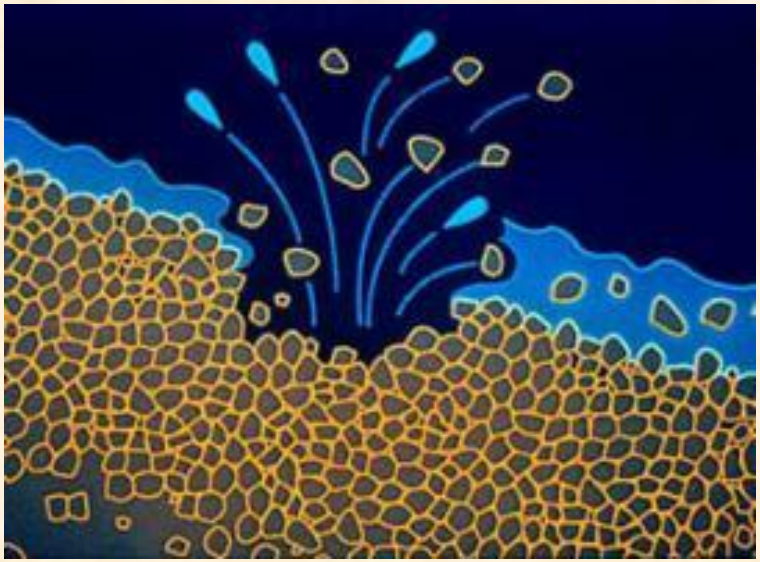
- **Ice** erosion occurs when particles are plucked up or incorporated by moving ice, such as a glaciers, and are transported downhill.

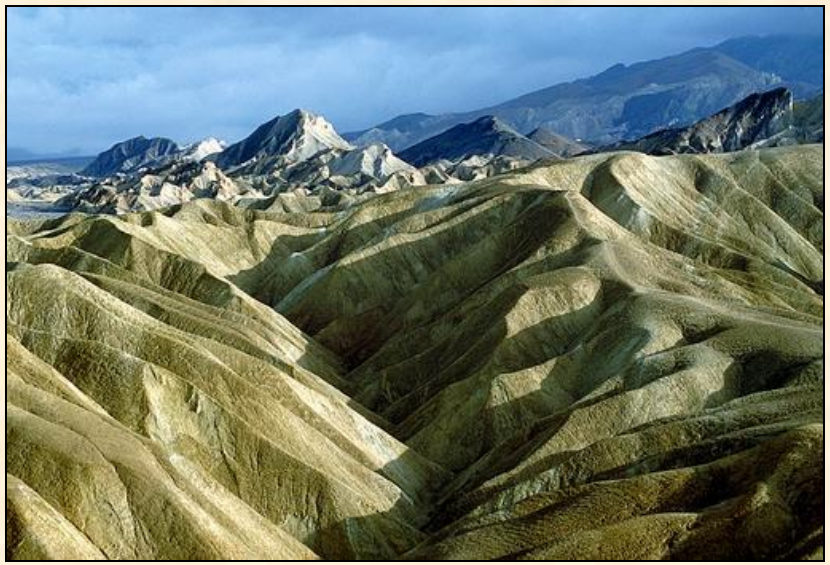
- **Gravity** facilitates the down slope transportation of loosened, weathered materials and enables them to move without the aid of water, wind, or ice. **Gravity related erosion is a major component of mass-wasting events.**

- **fluvial erosion (water)**
- **aeolian (wind) erosion**
- **rocks falls or landslides (mass-wasting) erosion**

Erosion: Water (Fluvial)

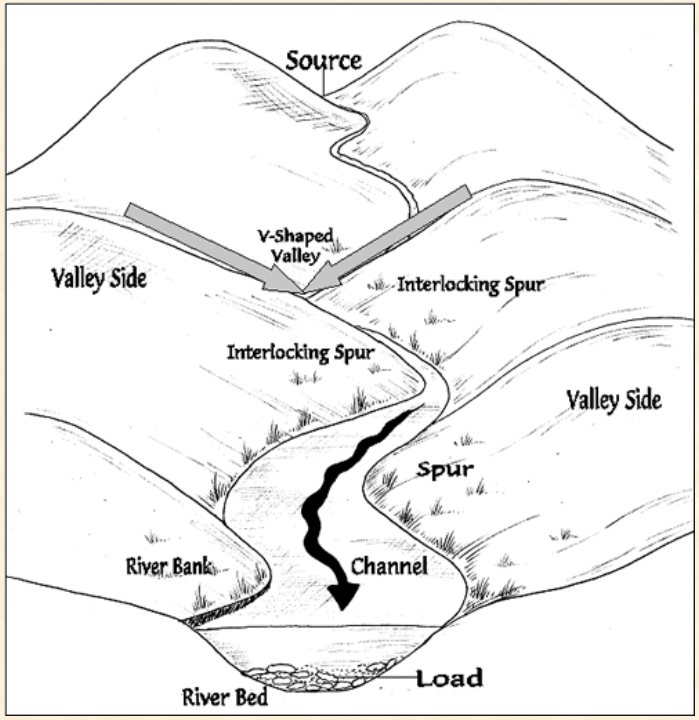
- 3 distinct categories:
  - **Rain splash erosion** occurs when the impact of a rain drop loosens and mobilizes particles.
  - **Sheet erosion** is a process where particles loosened buy rain-splash erosion are transported by runoff water down the slope of a surface.
  - **Rill erosion** occurs when water concentrates during sheet erosion and erodes small rills or gullys into the surface that channel flow down slope.





Erosion: Water (Fluvial)

- Rainfall events, melt-water runoff, or ground water percolation.
- Transported as **suspended load**, **bed load** (rolling along the bottom), or bounced by **saltation**.
- The accumulation of fluvial erosion and associated processes over a large area forms pathways for surface and groundwater flow and carves **v-shaped river valleys** that continue to erode, transport, and deposit weathered sediments across the landscape.

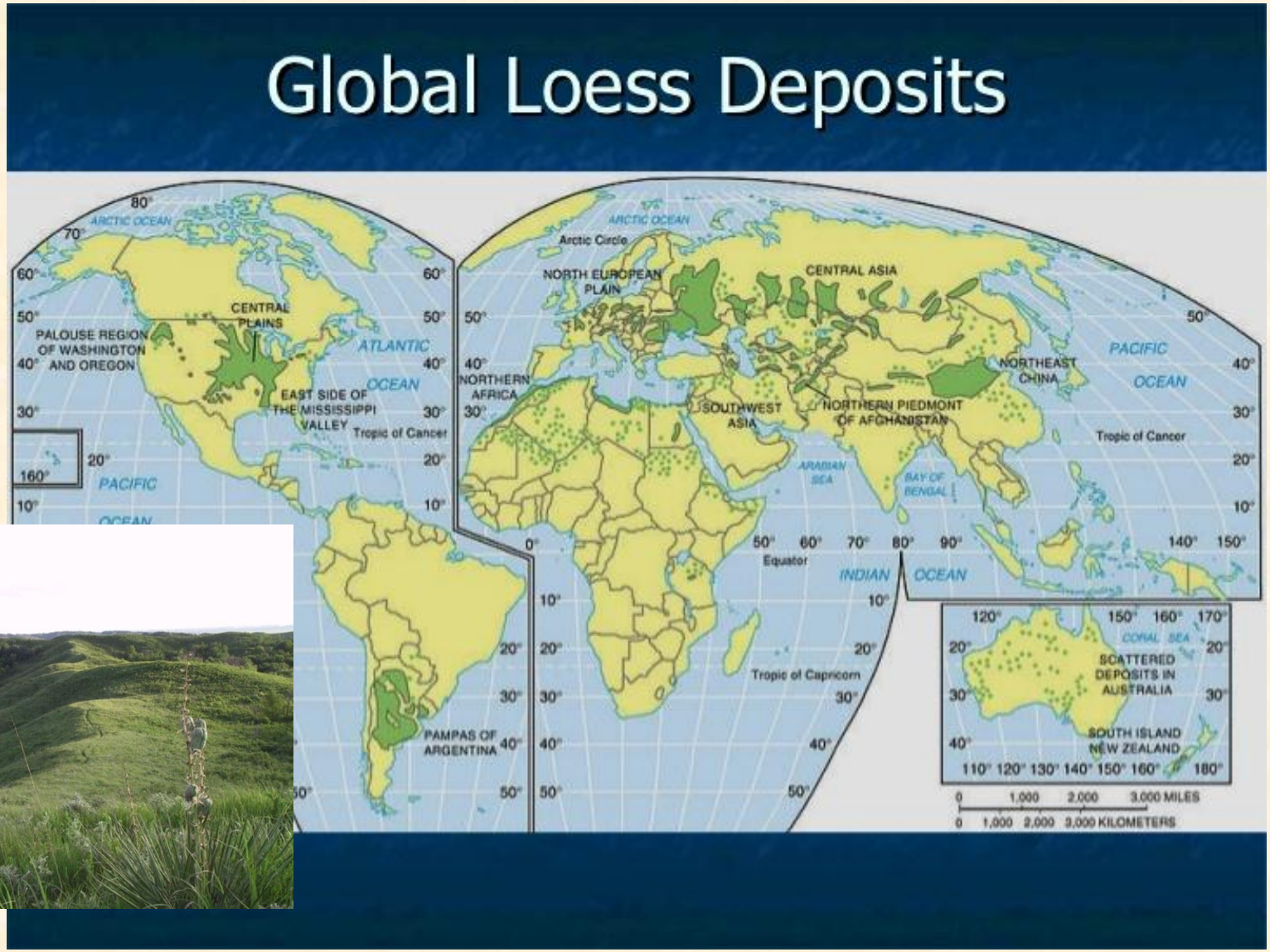


Erosion: Wind (Aeolian)

- **Deflation** is the movement or transport of particles through the air or along the ground
- **Abrasion** is the process that occurs when wind-transported particles sculpt features in the landscape through a "sand-blasting" like process
- Aeolian erosion and deposition processes create a diversity of landforms including sand dunes, loess deposits, and yardangs.

Courtesy Modis, Nasa

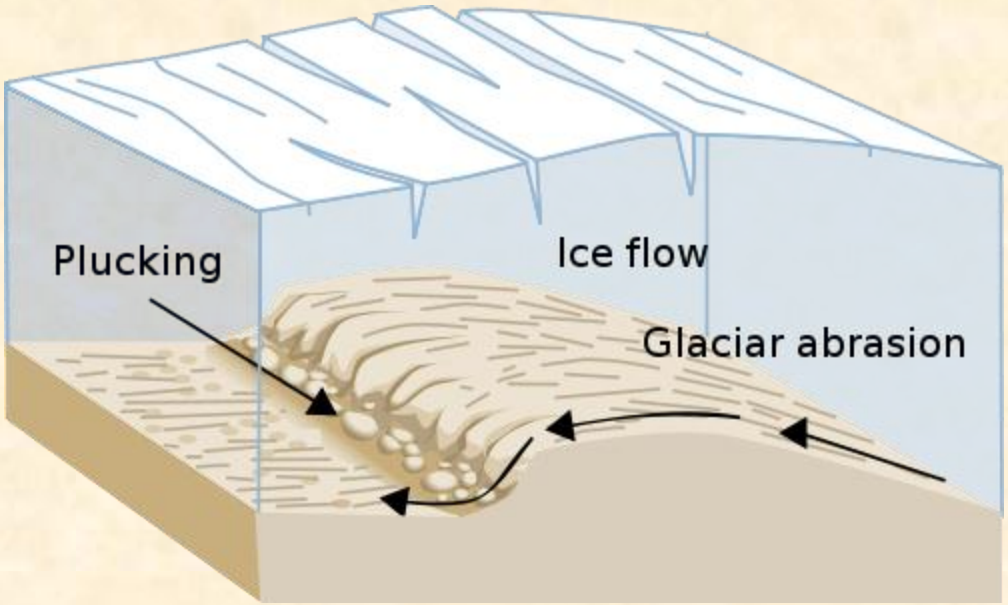
Loess: is a clastic, predominantly silt-sized sediment that is formed by the accumulation of wind-blown dust. Loess deposits cover about 10% of the Earth's surface.



Erosion: Ice (Periglacial and Glacial)

- Ice erosion occurs in combination with **periglacial** (significant freeze/thaw cycle processes) and **glacial processes**

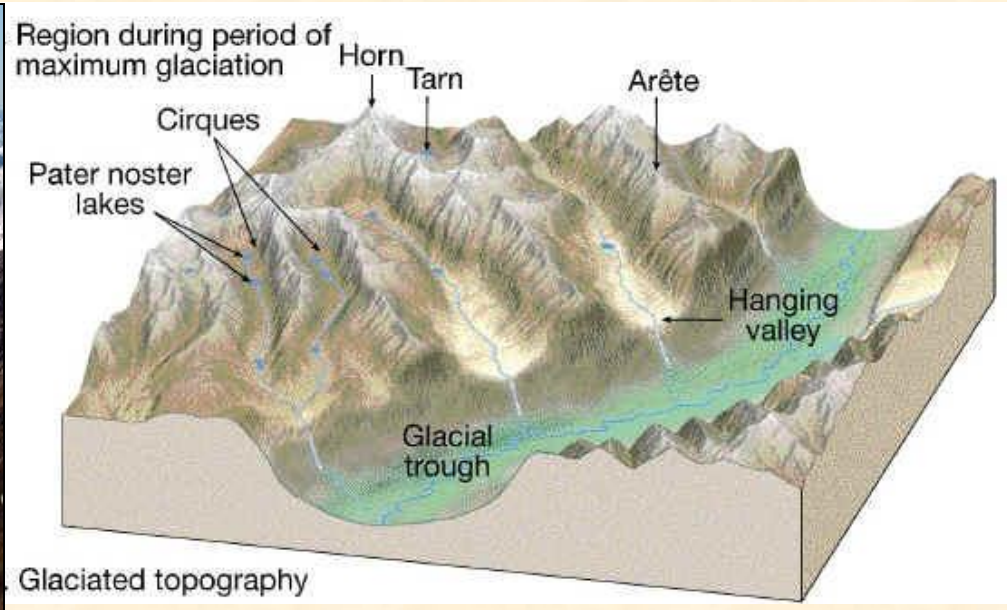
- Glacial erosion occurs when particles are incorporated into the glacial ice through a process referred to as **plucking**, and they are transported downslope within the glacier.



Erosion: Ice (Periglacial and Glacial)

- The friction and abrasion of the ice and rock moving across the bedrock, erodes the surface of the bedrock and often leaves scrapes, grooves, striations, or polished rock surfaces.

- The cumulative effects of glacial erosion on a mountainous landscape can produce distinct u-shaped valleys which are a common glacial landform.



Erosion: Gravity

- Does not require the aid of water, wind, or ice (**catalysts**)
- Movements may be slow or very abrupt.
- **Coherent** refers to the erosion of a consolidated mass of materials that erode or move as a single unit
- **Incoherent** refers to the erosion or movement of a mass of unconsolidated individual fragments of materials.
- Unconsolidated materials stabilize near an angle of 35° (**angle of repose**)



Photo: wikimedia commons

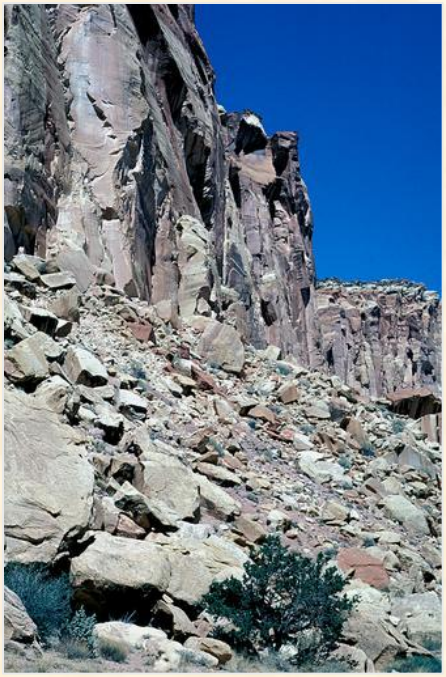
Mass Wasting

Mass wasting is a rapid form of erosion that works primarily under the influence of gravity in combination with other erosional agents.

Can result in small or large scale changes to the landscape depending on the type of event.

- Rock Falls
- Landslides
- Debris / Mud Flows
- Slumps
- Creep

Rock Fall



Landslide

Photo source: SCGS

Mass Wasting

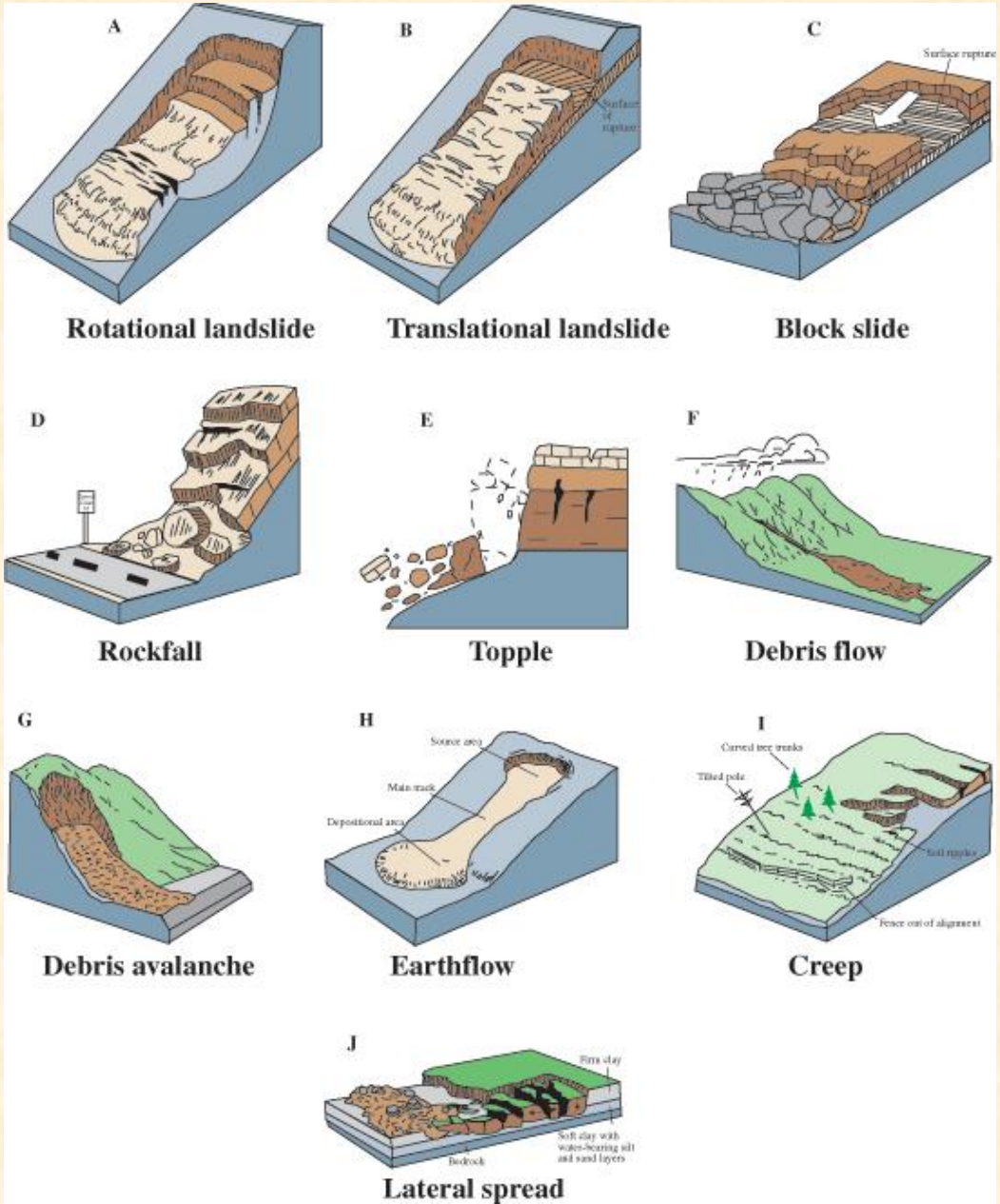
Flows, Slides, and Falls

- Type of material, the kind of motion, and the velocity of movement dictate kind of mass movement
- Falls involve the free-fall of debris or rock
- Slides occur when the material remains coherent and moves along a well-defined surface
- Flow occurs when material moves down slope as a viscous fluid (liquidy)

Mass Wasting

Characteristics to Consider:

- **water content**
- **internal structure**
- **distance traveled**
- **material involved**
- **formation mechanism**
- **geographic extent**

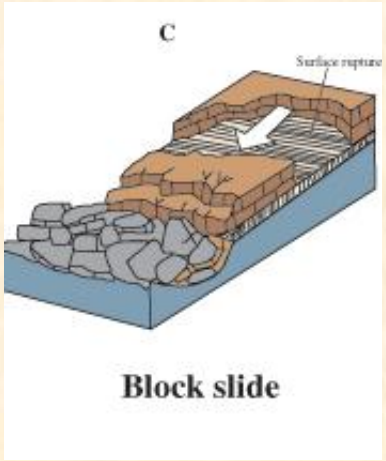


Rock Falls

- Rock falls occur when rocks (individual blocks) become dislodged
- Potential energy is converted to kinetic energy as the rock fragment falls
- Rocks fall, roll, bounce downhill eventually achieving a new equilibrium.
- Recent rainfall or snow melt-water events facilitate the movement.

Rock Falls

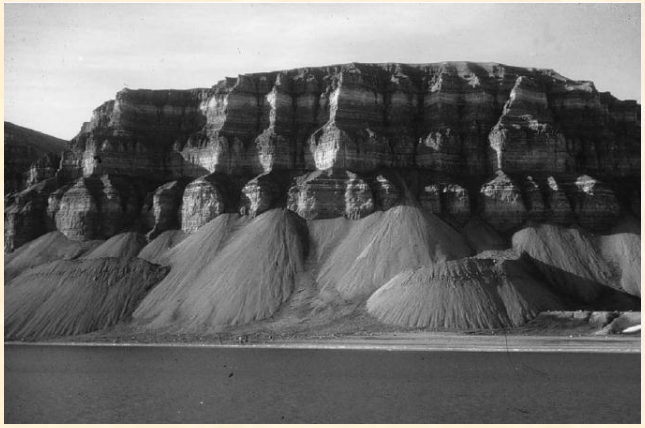
- **Rock Slide/Block Slide**: model of formation involves a mass of rock sliding along a bedding plane or zone of failure
- Rock mass stays more or less in tact.
- Exfoliation Domes



Rock Falls

- Rock falls often form piles of loose rock below their source and are sometimes referred to as **talus** or **scree**.

- Large volumes of talus may form a **talus slope**, **talus apron**, or **talus cone** depending on its shape. Talus tends to stabilize near the **angle of repose**, or the steepest angle maintained before changes in energy lead to gravitational erosion.

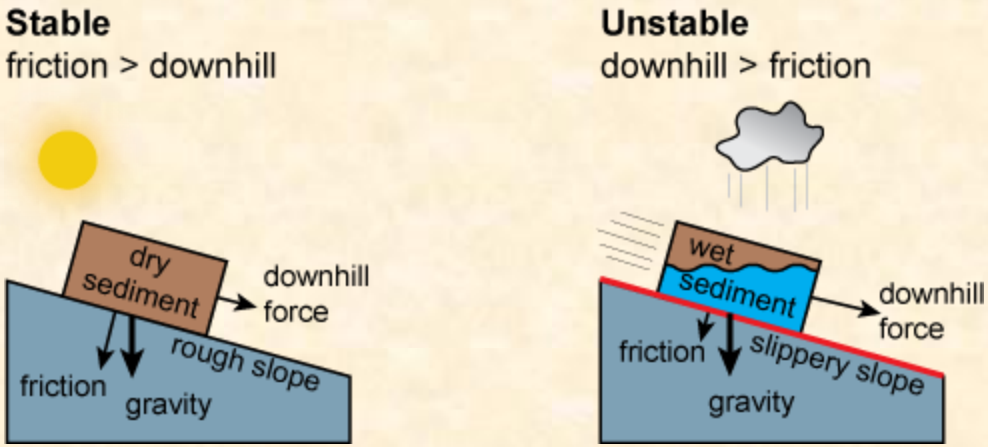


Landslides

- Landslides are mass-wasting events where large amounts of weathered rock material slide down a hillslope or mountain side primarily by gravity related erosion.
- Landslides occur very quickly and move with incredible speed and destruction, often removing or covering everything in their path.
- Nearly all landslides are triggered by an **earthquake**, or **lubricant agent** such as rainfall, or a snow or ice melt-water event.

This landslide event occurred in Jones Gap State Park in the Mountain Bridge Wilderness Area of South Carolina. Boulders, trees, soil, and other weathered material tumbled down this hill-slope after 8" of heavy rain fell over 2-days.

Photo source: SCGS



Landslides

- During intensive rainfall, soil and weathered rock material become unstable and loosened from the **saturated conditions** that separate the individual grains and other material fragments.

- **Increased fluid pressures** coupled with the loosened materials succumbs to gravity related erosion and the weathered materials plunge downhill as a powerful landslide.

Landslides: Geomorphology

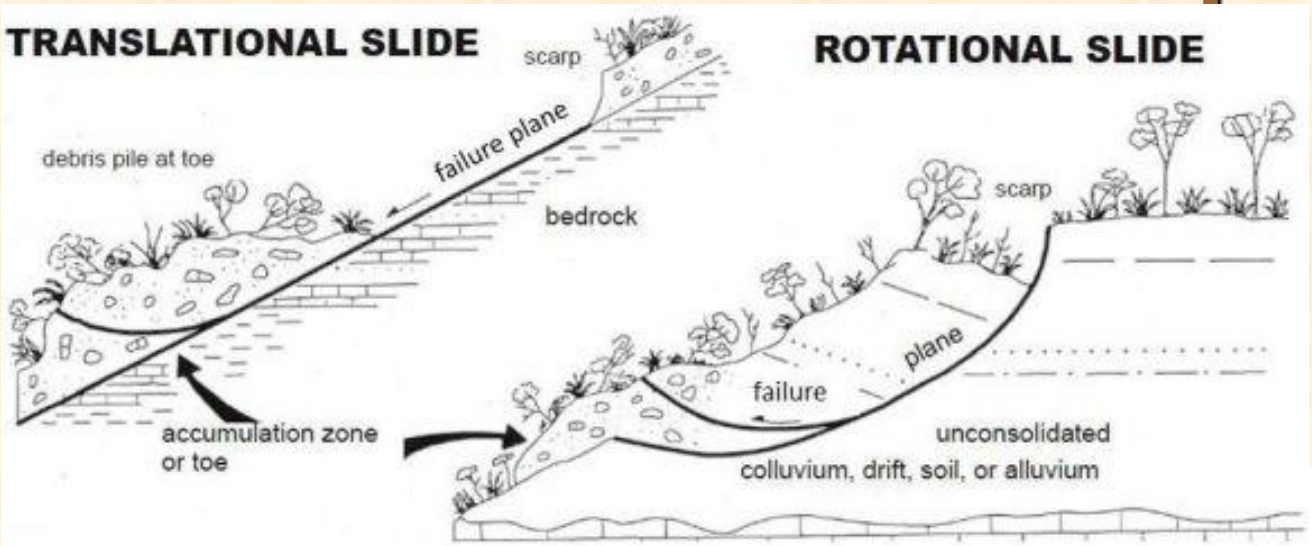
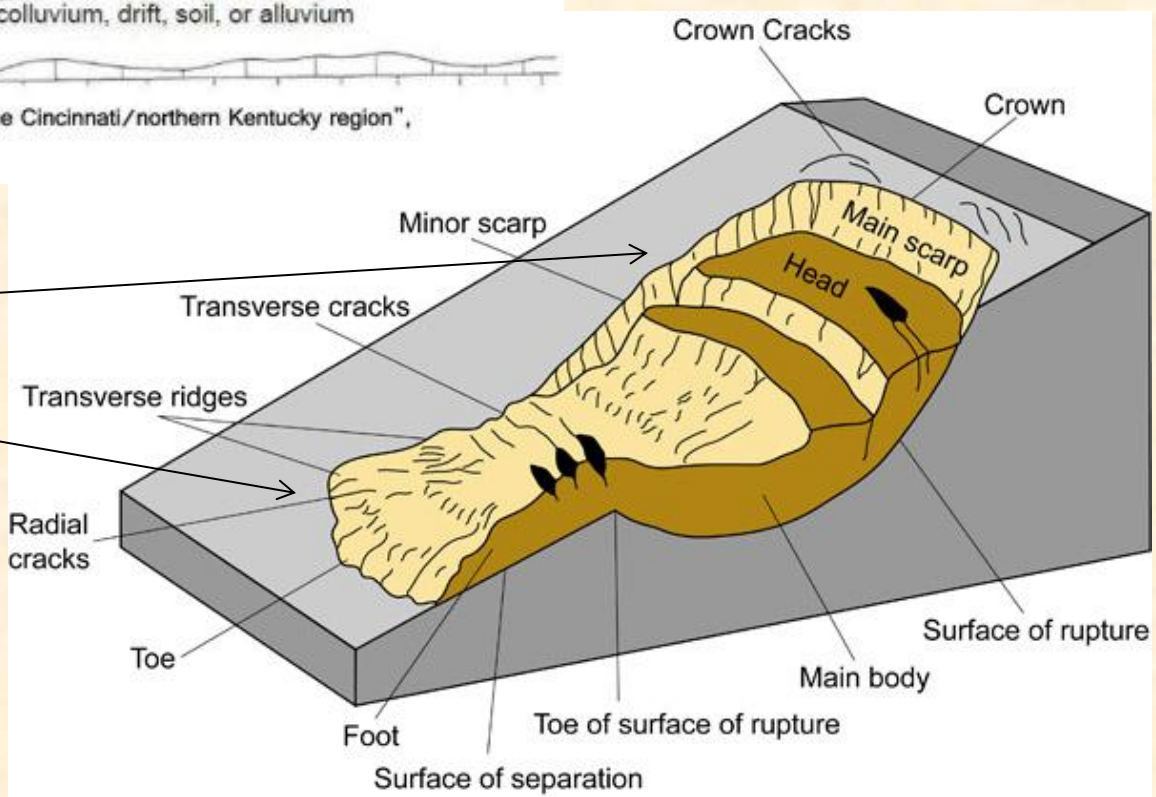


Diagram modified from Potter, P.E., 2007, "Exploring the geology of the Cincinnati/northern Kentucky region", Kentucky Geological Survey, Special Publication 8, 128 p.

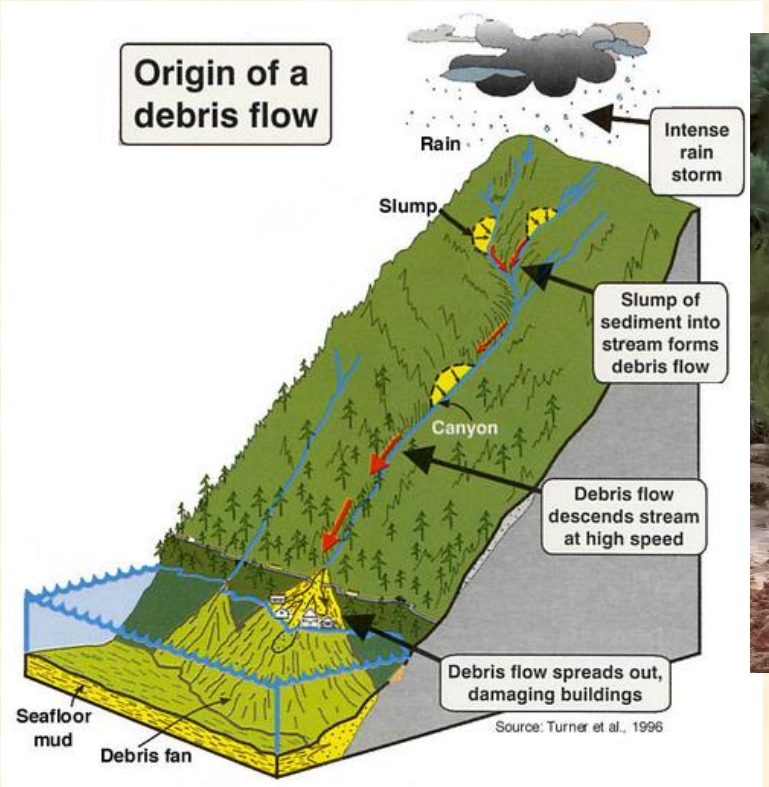
Zone of depletion

Zone of accumulation



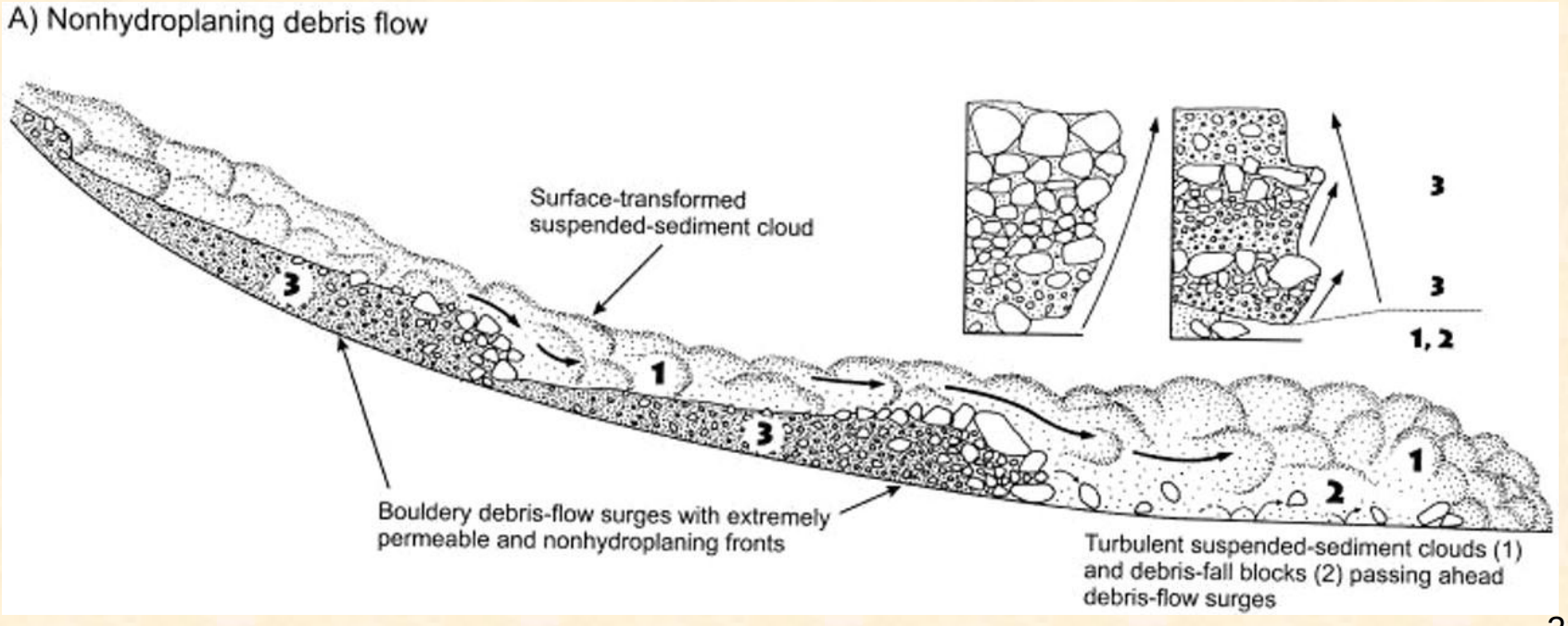
Debris and Mud Flows

- Heavy rainfalls produce large amounts of runoff that transport eroded soils, sediments, and plant debris down slope.
- Debris aprons, fan deposits or lobes are generated where the flow spreads out across valley bottoms.
- Follow existing drainage paths or carve out new paths as they flow downhill



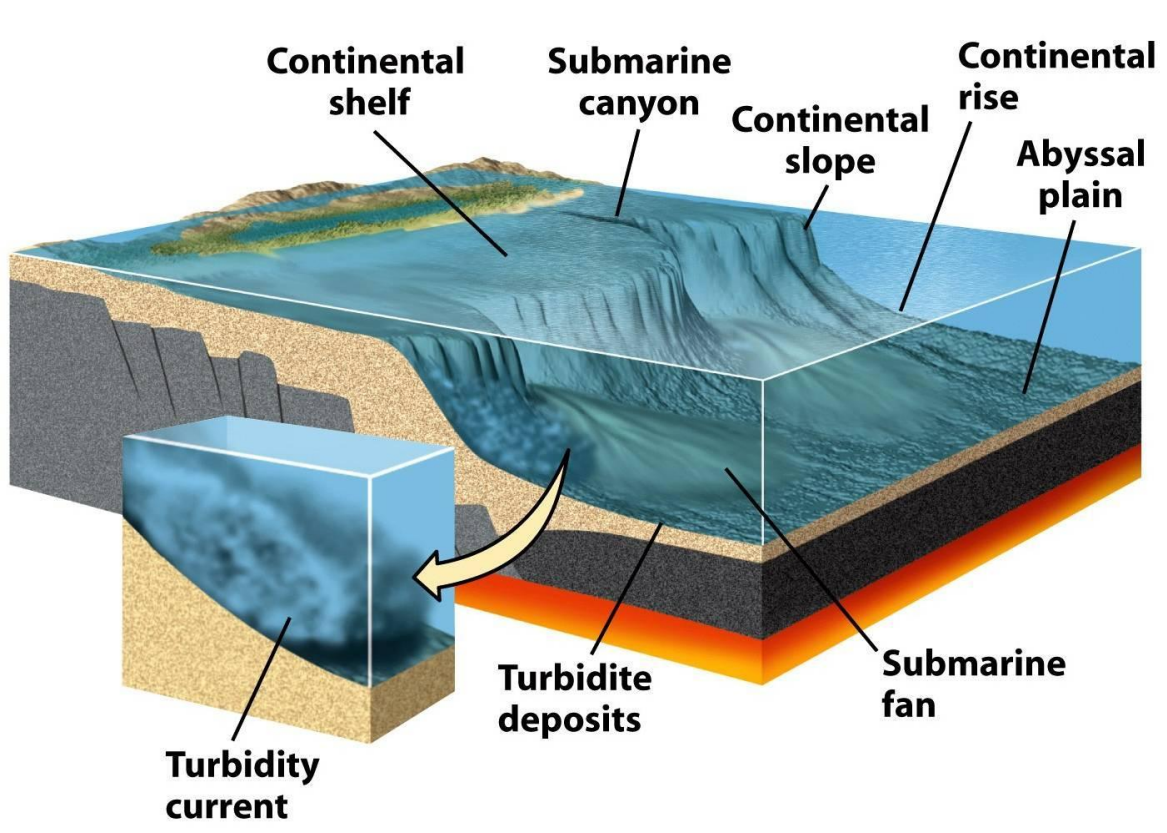
Debris and Mud Flows

- Range of sizes from clays (mud) to large debris and boulders
- **Debris flows** = **coarse-grained** materials
- **Mudflows** = **fine-grained** materials
- Slurry consistency = depends on material mobilized, thick, more dense then surrounding fluid
- **Turbidity Currents**: continental margin



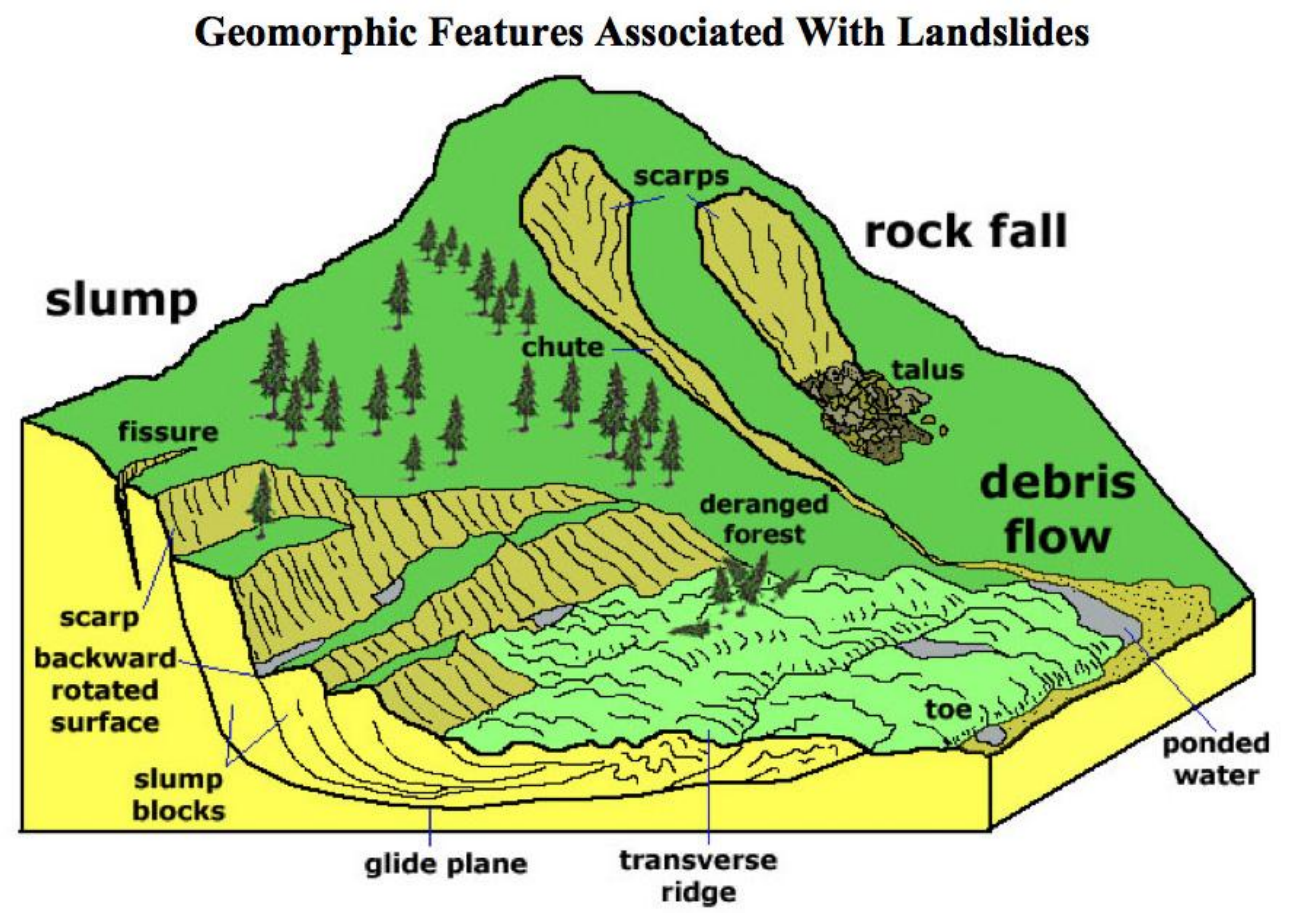
Debris and Mud Flows

- **Turbidity Currents**: triggered by surface gravity waves, internal waves, shelf currents, storms etc..
- Transport sediment from the **shelf**/**slope** to the **abyssal plain**
- Incising of the slope creates **marine canyons**
- Fan deposits accumulate forming the continental **rise**



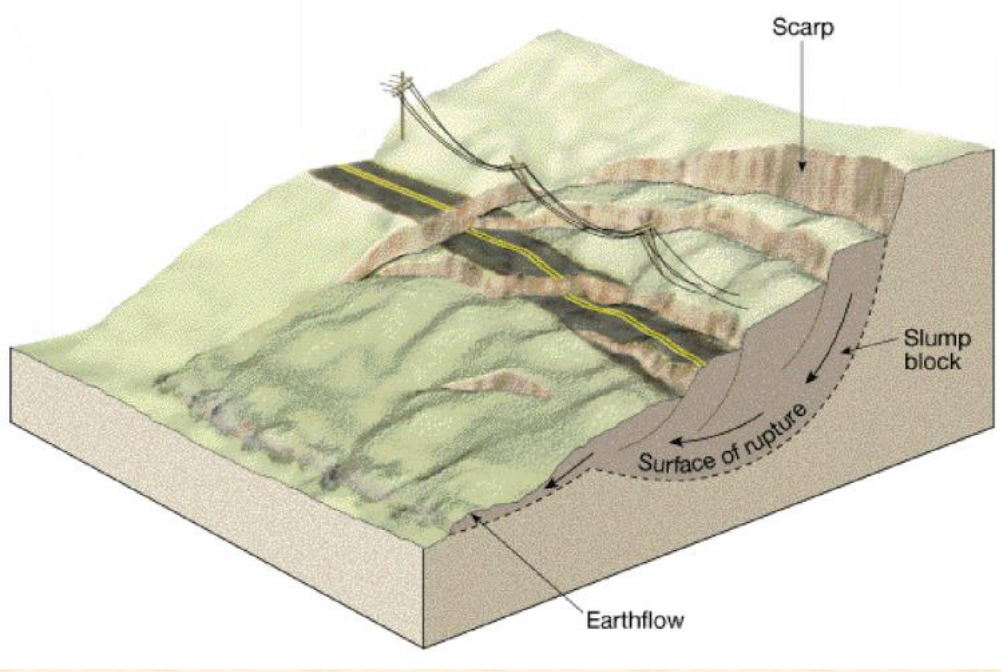
Slump

- Rock or soil collapses, breaks off from the hill slope, possible rotation, moves short distance downhill.
- **Coherent**: large consolidated mass of materials
- **Incoherent**: mass of unconsolidated materials or sediments



Slump

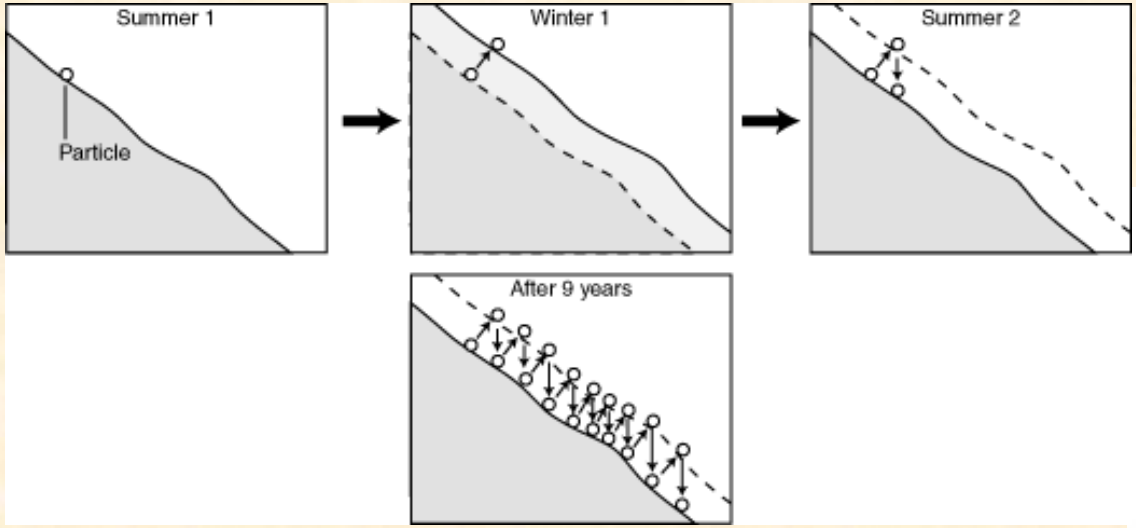
- **Translational Slumps**: fail along planar surfaces, joints, bedding planes, block slumps
- **Rotational Slumps**: generate scarps and secondary Slump Blocks as the mass moves along a concave upward slip surface
- **Hummocky Ridges**: coherency decreases toward the toe of the slump, pressure ridges may develop
- Transition to more of an **earthflow** (between mudflow and creep, internal structure and cohesion lost, soil liquefaction, clay, fine sand, silt)

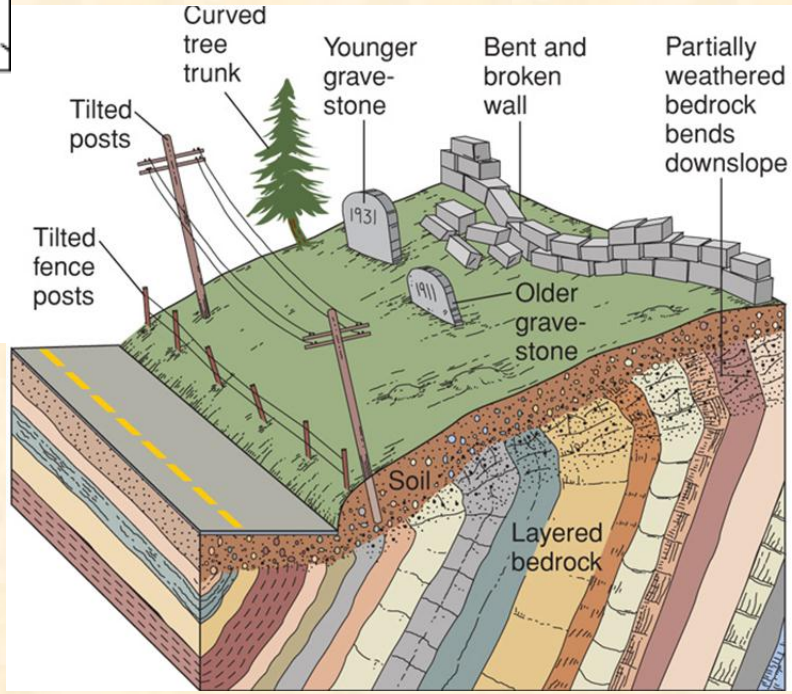


Slump

Creep

- Creep is the slowest mass-wasting process
- Gradual downhill movement of soil, bedrock, and weathered material.
- Usually, the entire slope moves as a complete unit.
- Creep processes occur on nearly every hillslope because of gravity.



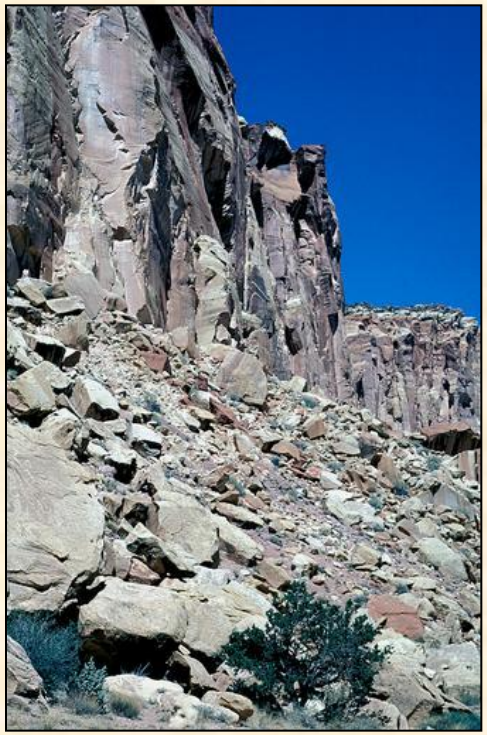


Creep

- Bent or extended tree trunks, tilted grave stones, poles etc..
- Freeze-thaw cycles and saturated conditions accelerate creep processes
- Solifluction: frozen tundra soils thaw out and gently 'flow' or sag downslope

Deposition

- Constructive processes that place weathered and eroded materials in a location that is different from their source.
- Deposition is not specific to a single weathering, erosion, or mass wasting event
- Applies to any consolidated or unconsolidated materials that have accumulated as a result of some natural process or agent.



Colluvium: all weathered and eroded rocks, soil, and sediments deposited at the base of a hill slope or cliff by the force of gravity and mass wasting.

Alluvium: materials deposited by running water.

Deposition

- Deposits can result from mechanical, chemical, or biological weathering, and water, wind, ice, or gravity-related erosional processes.
- The accumulation of deposited materials alters the landscapes and builds various landform features.
- **Floodplains** (fluvial deposits), **Sand dunes** (aeolian deposits), **Moraines** (glacial deposits), **Barrier Islands** etc..