Weathering, Mass Wasting, and Erosion

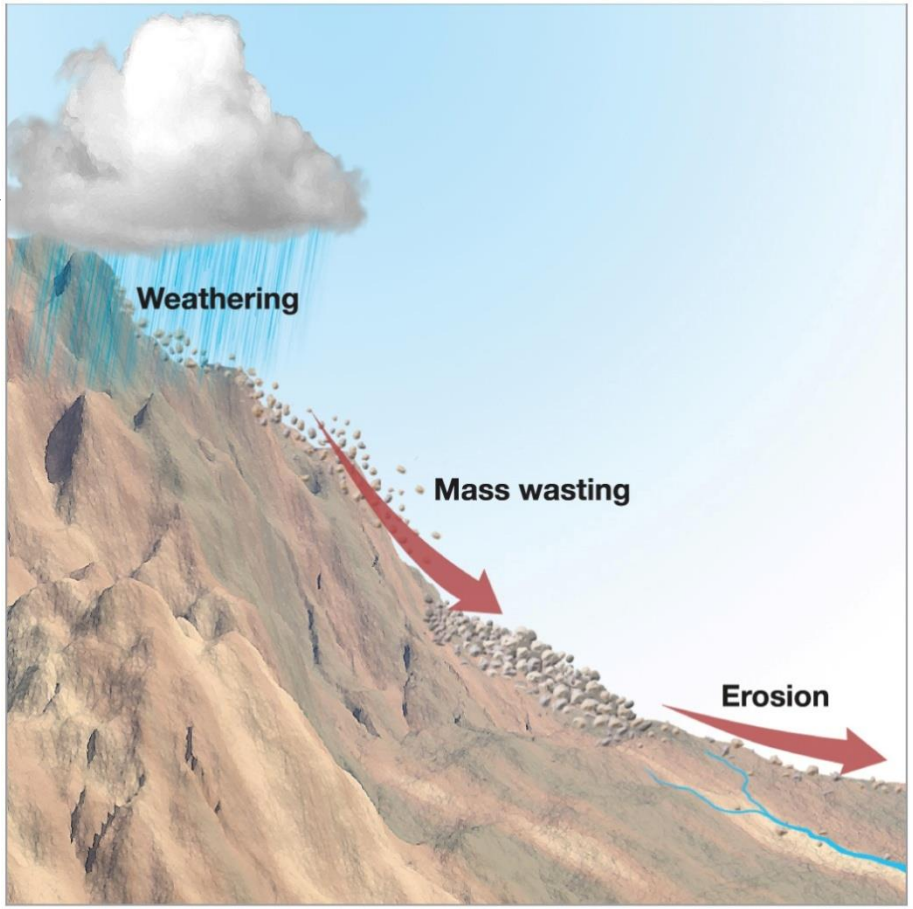
Denudation

The overall effect of disintegration, wearing away, and removal of rock material

- The term implies lowering of the surface of the continents.

Accomplished by three activities:

1. Weathering
2. Mass wasting
3. Erosion



The Impact of Weathering and Mass Wasting on the Landscape

External processes capable of wearing down anything the internal forces can build.

- Gravity, water, wind, and ice are molding the configuration of peaks, slopes, valleys, and plains.

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

Weathering

The mechanical and/or chemical disintegration of rock that is exposed to the weather (by atmospheric or biotic agencies).

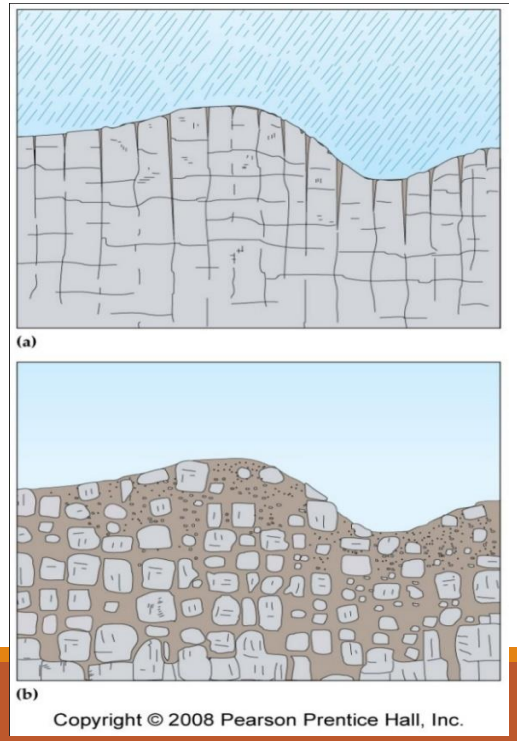
Weathering vs erosion

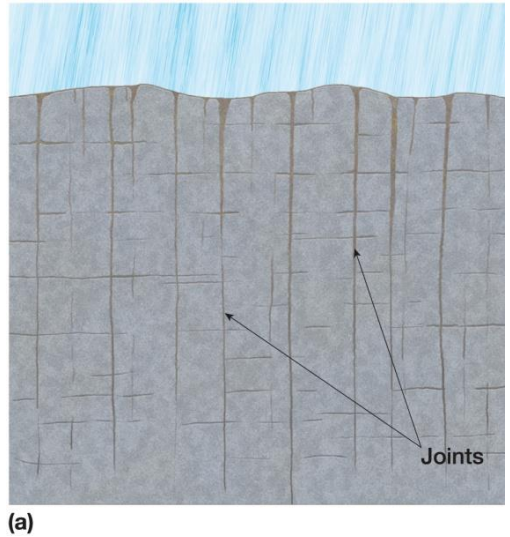
Weathering destroys bedrock and fragments it into smaller components – whenever bedrock is exposed, it weathers.

A. Weathering agents include water, air, and plant roots.

B. Exposure depends on **openings** in rocks.

Opening are typically microscopic





Five types of openings in rocks are common

1. **Microscopic openings**—profuse, so can be responsible for extensive weathering despite size.
   - Includes spaces between crystals of igneous and metamorphic rocks, pores between grains of sedimentary rocks, or minute fractures within or alongside mineral grains in any kind of rock.
2. **Joints**—cracks that develop in bedrock due to **stress**, but in which there is no appreciable movement parallel to the walls of the joint.
   - Most common structural features of the rocks of the lithosphere.
   - Because of their ubiquity, joints are most important of all rock openings in facilitating weathering

Five types of openings in rocks are common

3. **Faults**—a fracture or zone of fracture where the rock is forcefully broken with an accompanying displacement, (i.e., an actual movement of the crust on one or both sides of the break). The movement can be horizontal or vertical, or a combination of both.
   - Allows easy penetration of weathering agents into subsurface areas
4. **Lava vesicles**—holes of various size, small, that develop in cooling lava.
5. **Solution cavities**—holes formed in calcareous rocks (primarily limestone) as the soluble minerals are dissolved and carried away.

Weathering Agents

Most weathering agents are atmospheric:

- Oxygen, carbon dioxide, and water vapor are the three most influential atmospheric components.

Water is the most influential weathering agent.

Temperature changes are second important weathering agent.

Biotic agents also contribute, such as burrowing activities of animals and rooting effects of plants.

- Most important is the production of chemical substances that attack rock.

Three principal categories of weathering (mechanical (Physical), chemical, and biotic) usually act in concert.

1. Mechanical weathering (Physical)

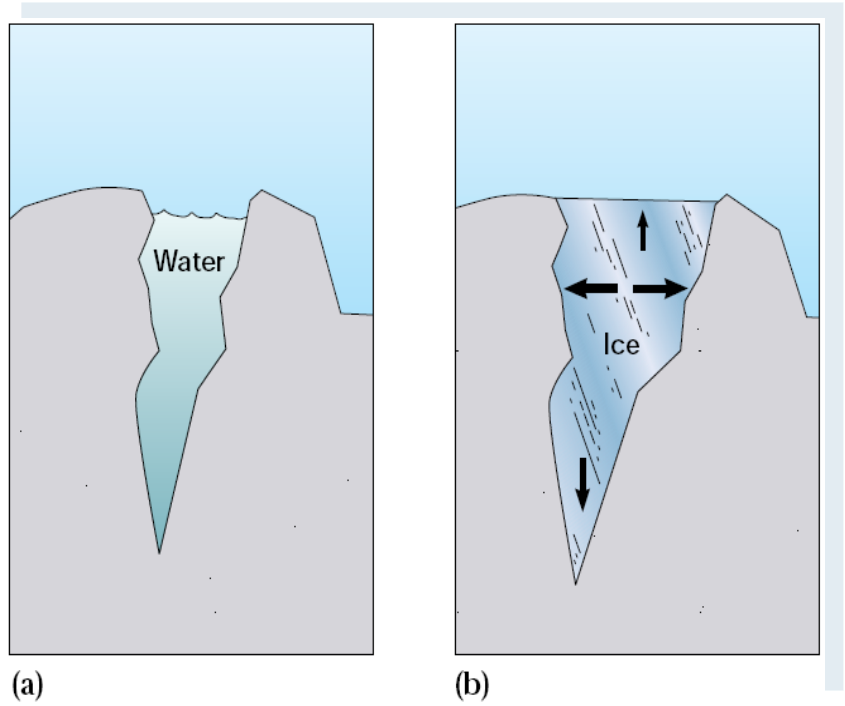
Mechanical weathering—the physical disintegration of rock material without any change in chemical composition.

Freeze–thaw action of water is probably most important single agent of mechanical weathering.

Frost wedging (frost shattering)—fragmentation of rock due to expansion of water that freezes in rock openings.

- Produces large boulders when occurs in large opening, while in small openings can granulate the rock into sand and dust.
- Produces gravel or coarse sand in a process called *granular disintegration*.

Physical characteristics of rocks are important determinants in rate and magnitude of mechanical weathering (along with temperature and moisture variations).



1. Mechanical weathering (Physical)

Salt wedging (salt-crystal growth)—rock disintegration caused by the crystallization of salts from evaporating water (less significant influence than frost wedging).

- Water brought up through rocks by capillary action carry dissolved salts
- Water evaporates, leaving salts behind as tiny crystals. With time, crystals grow, prying apart the rock grain by grain, similar to how freezing water does, although less intensely
- Halite (sodium chloride), calcite (calcium carbonate) or gypsum (calcium sulfate)
- Rocks at the base of rocks are more susceptible

1. Mechanical weathering (Physical)

Temperature changes (thermal action)

- Most rock-forming crystals expand when heated and contract when cool, process called thermal action
- Because different minerals expand at different rates, internal stresses can crack rock between mineral crystals, by causing minute changes in volume of mineral particles, which in turn weakens the coherence of the mineral grains and breaks them down.

Other Mechanical Weathering Processes

Chemical and biotic activities also contribute to mechanical weathering.

Chemical changes include increases in volume of mineral grains, which affects their coherence.

Biotic activities include plant roots widening rock openings.

- Burrowing animals
- Chemical alteration

Weathering

2. Chemical weathering: the decomposition of rocks by the alteration of rock-forming minerals

Almost all minerals are susceptible to chemical change (when exposed to atmospheric and biotic agents), but some, such as quartz, are more resistant than others.

Moisture is required for almost all chemical weathering.

Principal reacting agents are **oxygen, water, and carbon dioxide**.

Most significant processes are oxidation, hydrolysis, and carbonation.

Chemical weathering

Oxidation—the chemical union of oxygen atoms with atoms from various metallic elements to form new products, which are usually more voluminous, softer, and more easily eroded than the original compounds.

- For example, when iron-bearing minerals react with oxygen, they produce iron oxide (Fe_2O_3)

Hydrolysis—a chemical union of water with another substance to produce a new compound that is nearly always softer and weaker than the original.

- Invariably increases volume of mineral, and this increase contributes to mechanical disintegration.

Carbonation (Acid Action)—a process in which carbon dioxide in water reacts with carbonate rocks to produce a very soluble product (calcium bicarbonate), which can readily be removed by runoff or percolation, and which can also be deposited in crystalline form if the water is evaporated.

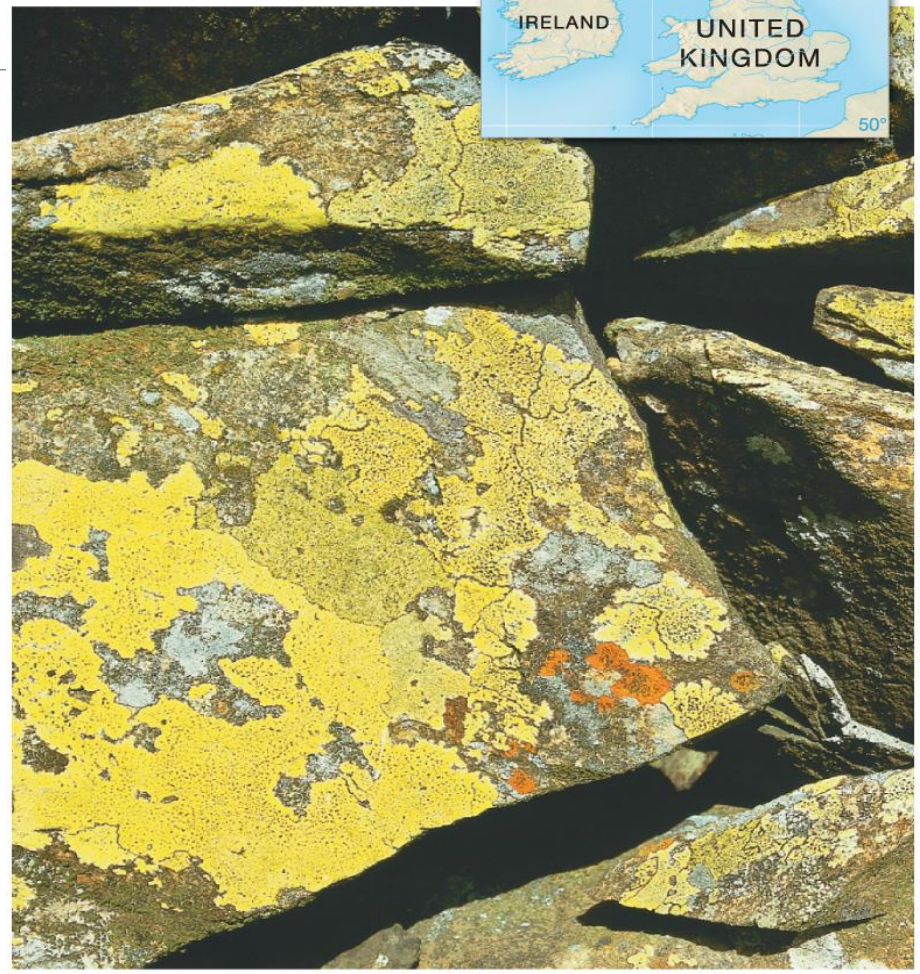
3.Biological weathering

refers to weathering processes involving living organisms.

- Penetration of roots into cracks and crevices are most notable.
- Lichens leach minerals and weaken the rock.
- Burrowing of animals.
- Subsequent chemical weathering obscures affect of biological weathering.

Climate and Weathering

- Weathering, particularly chemical weathering, is enhanced by a combination of high temperatures and abundant precipitation.
  - Precipitation is usually most important.



Mass Wasting

Process by which weathered materials are moved short distances by gravity

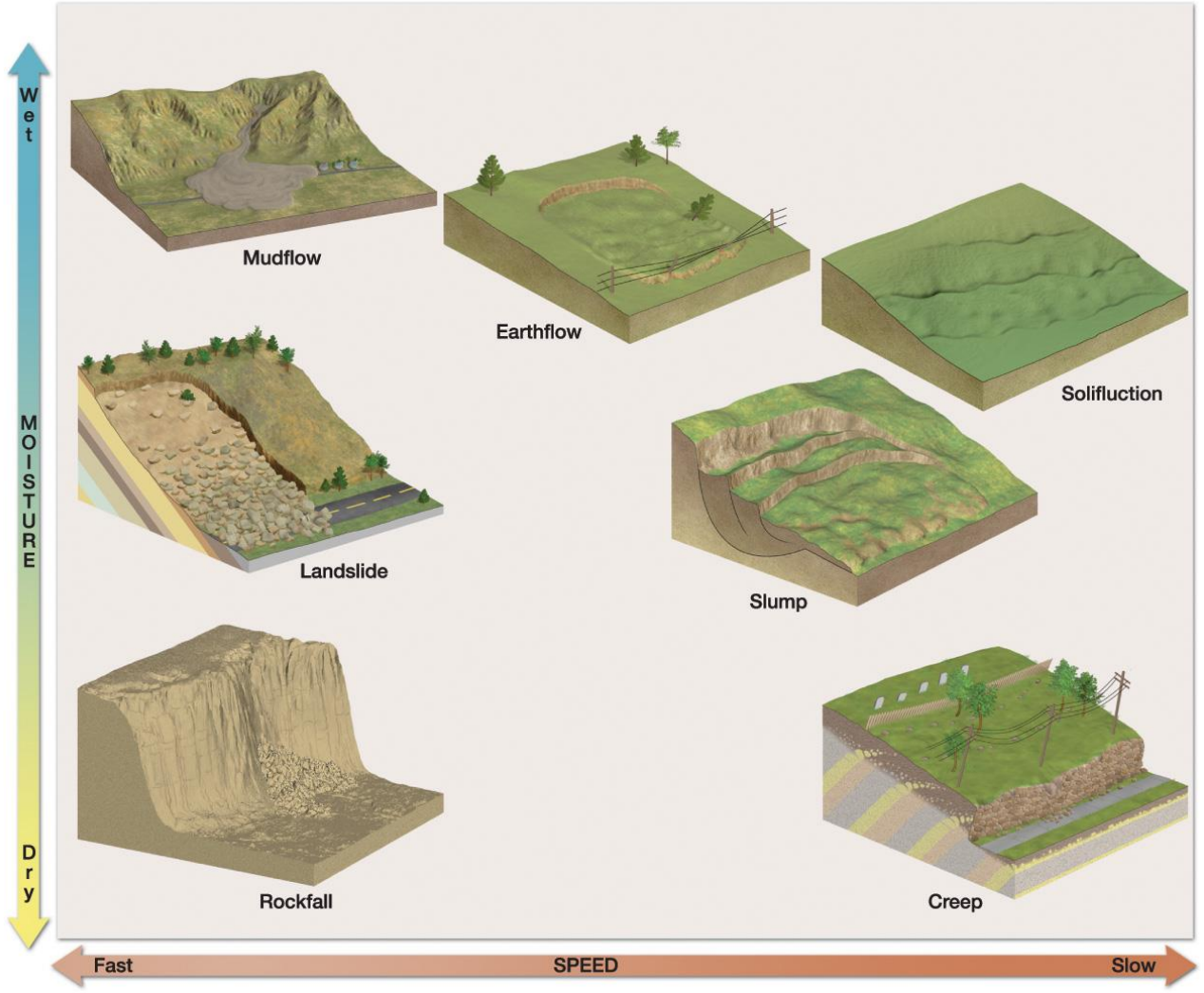
Factors influencing mass wasting:

- **Angle of repose** – steeper slopes lead to faster movement of weathered materials
- **Impact of water on lubrication of rock material** – rainfall, snowmelt, or subsurface flow- increases the mobility of rock fragments by diminishing friction between particles so they can slide past one another more readily.

  Water also adds to the buoyancy and weight of the weathered material, which makes for a lower angle of repose and adds momentum once movement is under way.
- **Clay–water mixture** very slick and mobile substance – clay absorb water readily, making them slippery and mobile
- Quick clays – materials resting on clay can be set in motion by rainfall or earthquake shock – hence the term quick clays—because they spontaneously change from solid to near-liquid due to disturbance or shock
- Subarctic mass wasting – in subarctic regions and at high latitudes, mass wasting is often initiated by the heaving action of frozen ground water.

Mass Wasting

Types of mass wasting

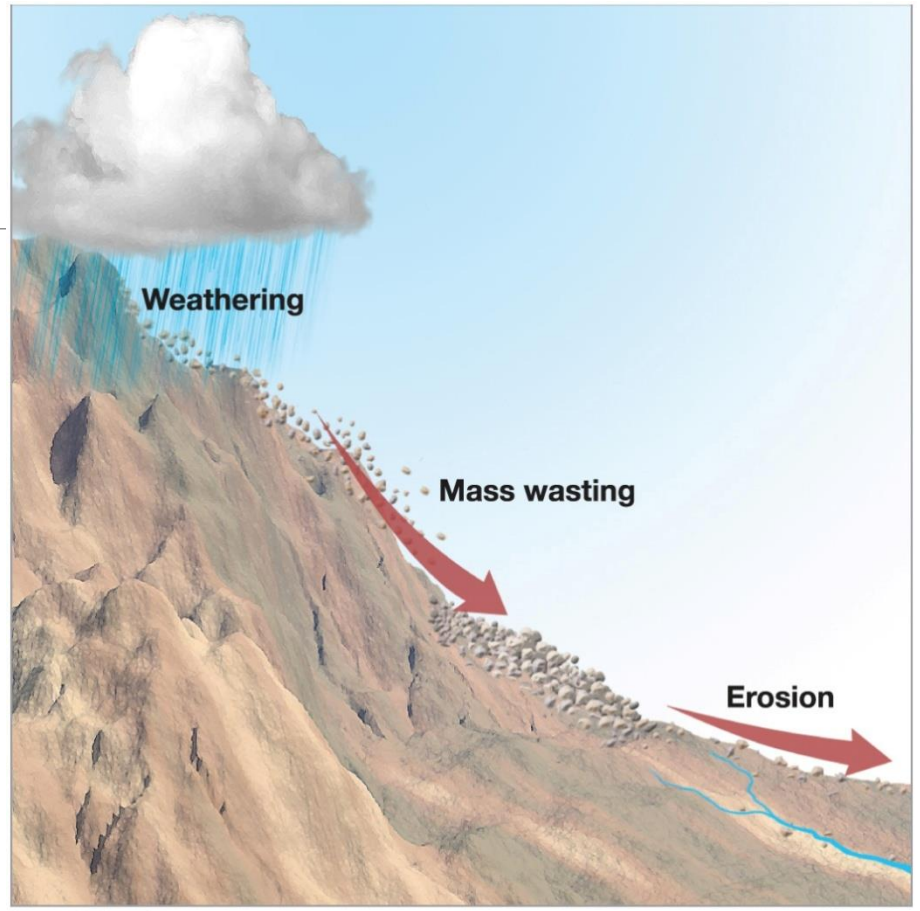


Mass Wasting

Recall: Mass Wasting is the second of these three processes:

1. Weathering
2. Mass wasting
3. Erosion

From fastest to slowest: **fall, slide, flow, creep**.



1. Fall

- **Fall**—simplest, most obvious, and fastest form of mass wasting, the falling of pieces of rock downslope.
- Often rocks do not fall far before becoming lodged, though this lodging can be unstable and temporary.
  - **Talus** (scree)—pieces of rock, of whatever size, that fall directly downslope.
  - **Talus slope (talus apron)**—the fragments of rocks (talus) that can accumulate relatively uniformly along the base of the slope.
  - **Talus cone**—sloping, cone-shaped heaps of dislodged talus (more characteristic than talus slope).
  - **Rock glaciers**—extremely slow flows of talus down slope caused by the pull of gravity and the freeze-thaw temperature changes that occur in mountain regions.

Rock Fall

Yosemite National Pk
@YosemiteNPS
Follow

Series of 7 rockfalls occurred on southeast face of El Capitan on Sept. 27, resulting in one fatality & one injury: go.nps.gov/1b9121.

7:23 PM - Sep 28, 2017

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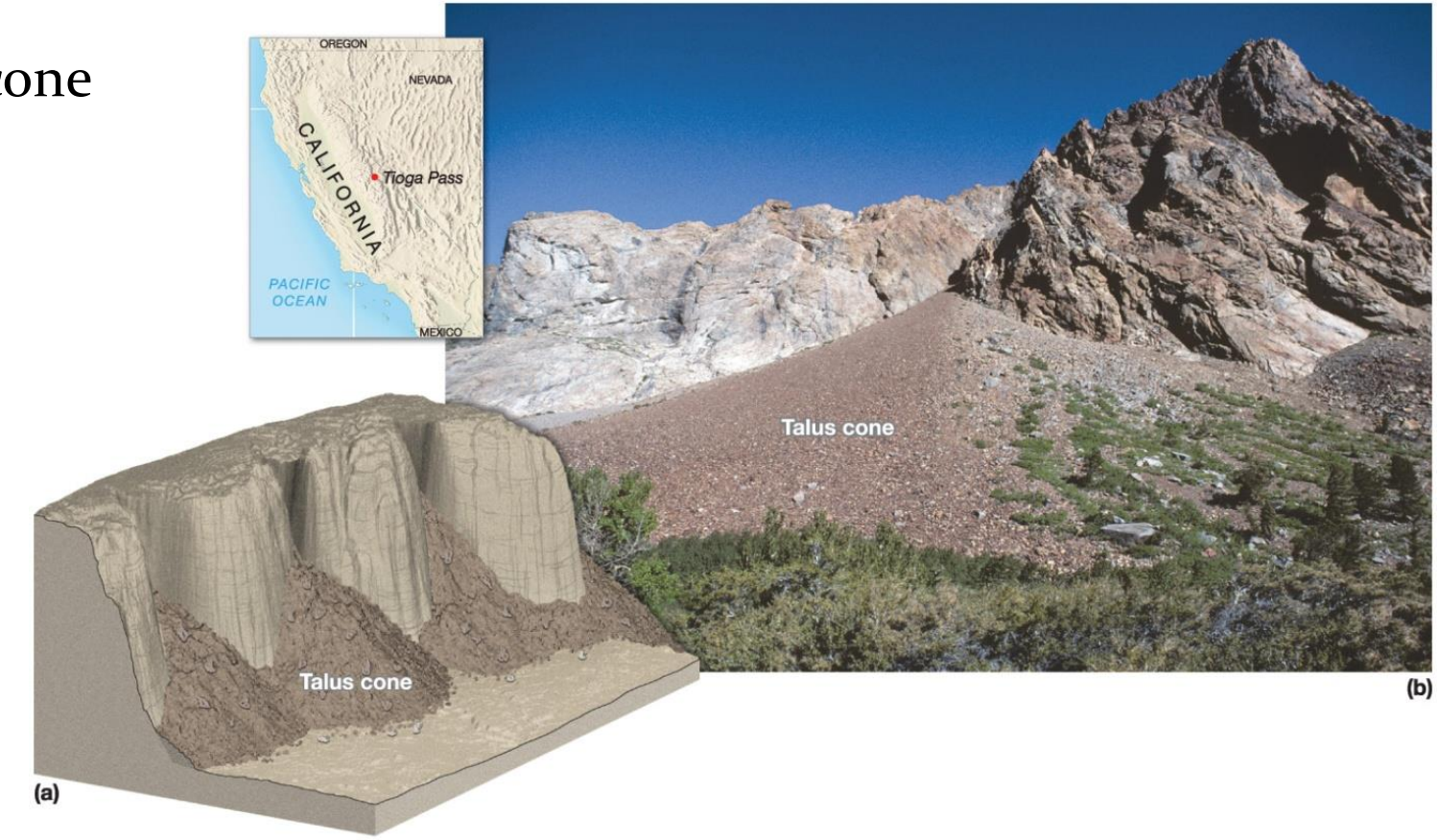
Report

Mass Wasting

Fall

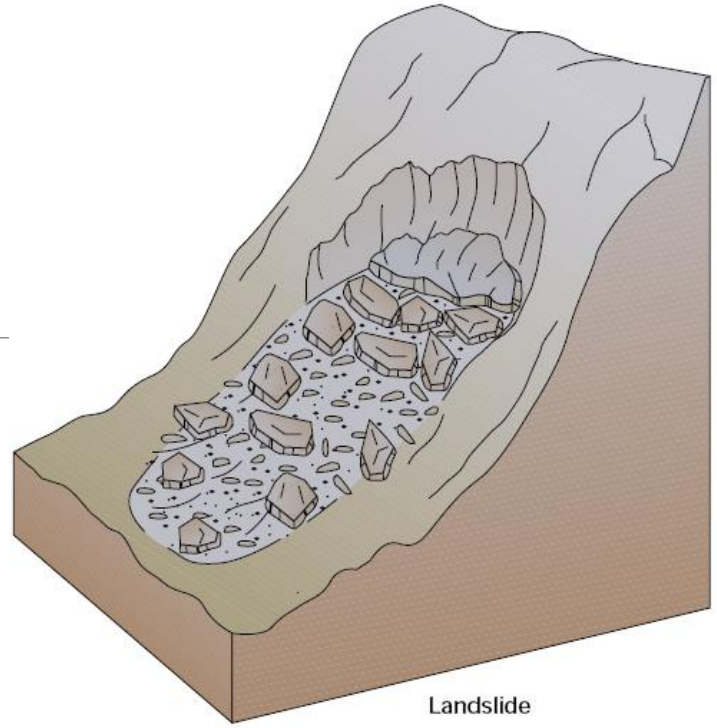
- Material tends to collect in cone shaped heaps – talus cones
- Talus cones grow up the mountain



2. Slide

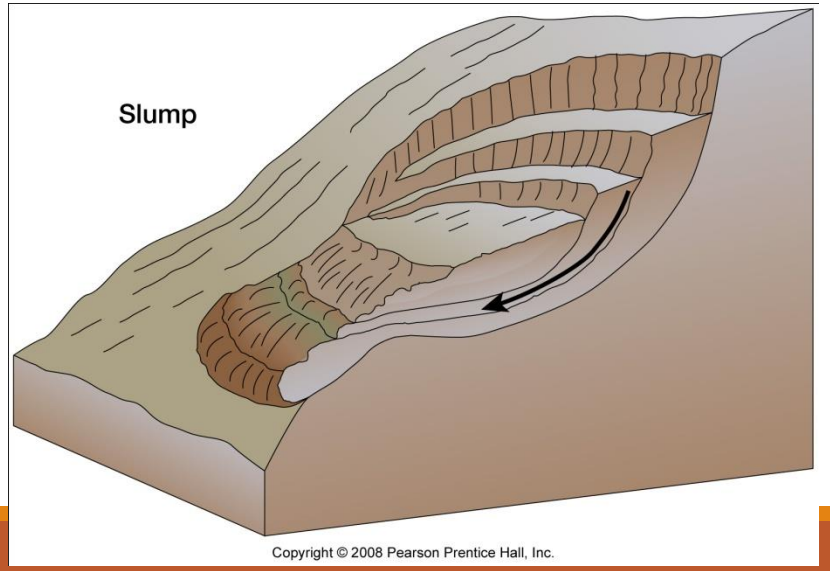
Landslide—an abrupt, rapid, and often catastrophic event in which a large mass of rock and earth slides bodily downslope in only a few seconds or minutes. An instantaneous collapse of a slope.

- Many triggered by rains.
- A pile of debris at valley bottom, and perhaps a lake on the up-valley side of the debris.



Slump—a slope collapse in which the rock or regolith moves downward and also rotates outward along a curved surface that has its concave side facing upward.

An extremely common form of mass wasting.



3. Flow

Flows are not as spectacular as falls and slides, but very conspicuous; they involve the material slipping gently downhill.

- Flow can be rapid, but it is normally gradual and sluggish.
- Characteristically cover several tens or hundreds of acres.

Earthflow—most common flow movement, where a portion of a water-saturated slope moves a limited distance downhill, usually with a heavy rain.

Mudflow—downslope movement of a thick mixture of soil and water that originates on slopes in arid and semiarid country.

- Heavy rain following a long dry spell makes for too much runoff to be absorbed by soil; instead the soil is picked up by the runoff and creates a viscous mass.

Debris flow—occurs when a mudflow has many large pieces of sediments (including rocks and boulders).

Rock glacier—an accumulated talus mass that moves slowly but distinctly downslope under its own weight.

4. Creep

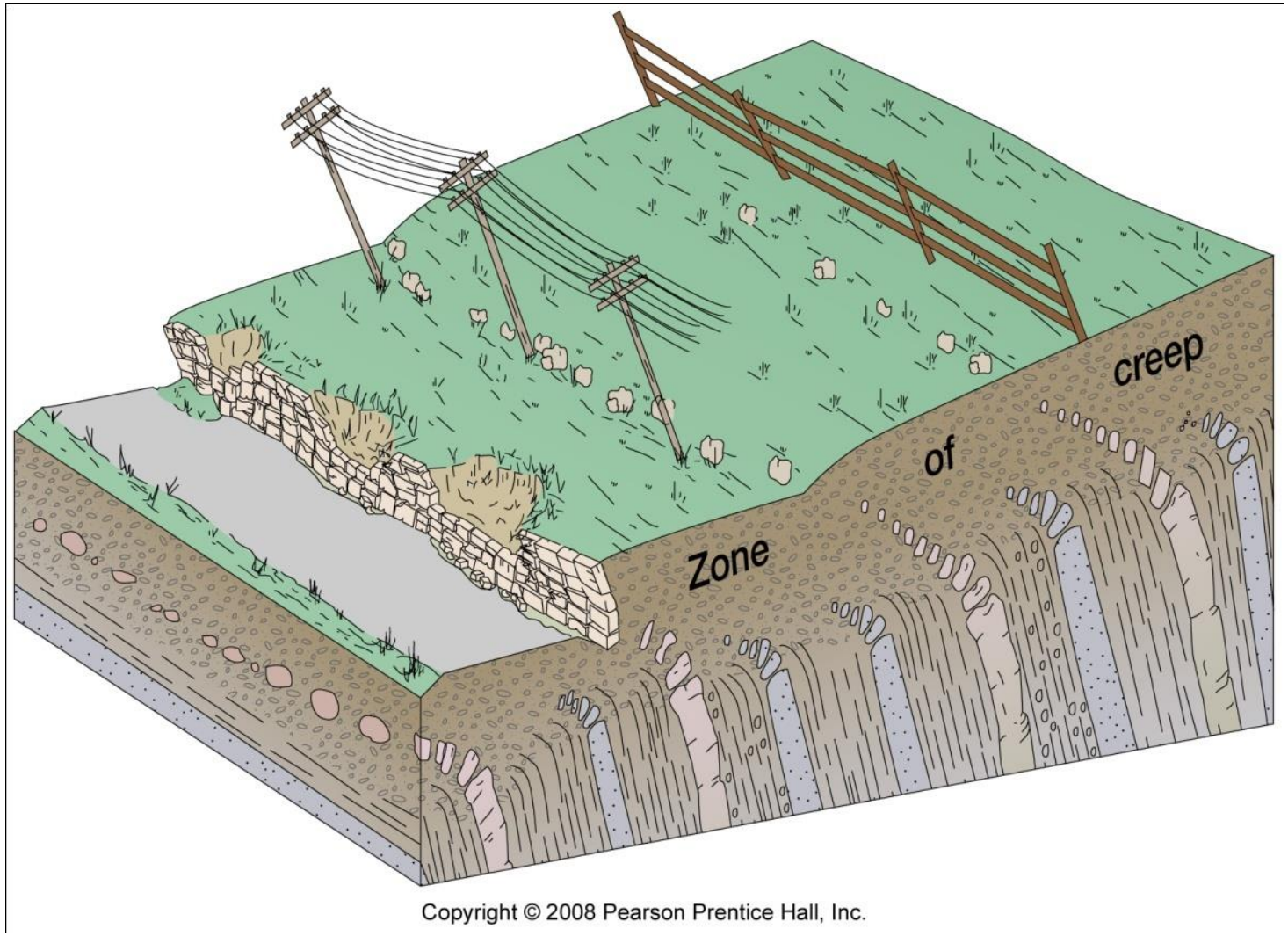
Creep (**soil creep**)—the slowest and least perceptible form of mass wasting, which consists of very gradual downhill movement of soil and regolith.

Occurs all over the world on slopes:

- Caused by various factors, most significantly freeze–thaw and wet–dry conditions.
- Gravity, burrowing animals, plant roots, earthquakes, and even thunder affect.

Very slow, but faster on water-saturated slopes.

Results usually only recognized by displacement of human-built structures.



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

Creep

Terracette—a complicated terracing effect, resembling a network of faint trails, which is produced by a creep, usually on steep grassy slopes, and grazing animals accentuate.

Solifluction—a special form of creep in tundra areas that produces a distinctive surface appearance. During the summer the near-surface portion of the ground thaws, but the meltwater cannot percolate deeper because of the permafrost below. The spaces between the soil particles become saturated, and the heavy surface material sags slowly downslope.

Solifluction

Terracette

Important Dates

August 1st, 2021: Exam 3 Due (will be given on July 28th, 2021)

August 2nd, 2021 : Due date for all blogs

August 4th, 2021: Project Presentations (start @ 10:00 AM); Attendance is required.

Quizzes: 15 best quizzes will be choosen.