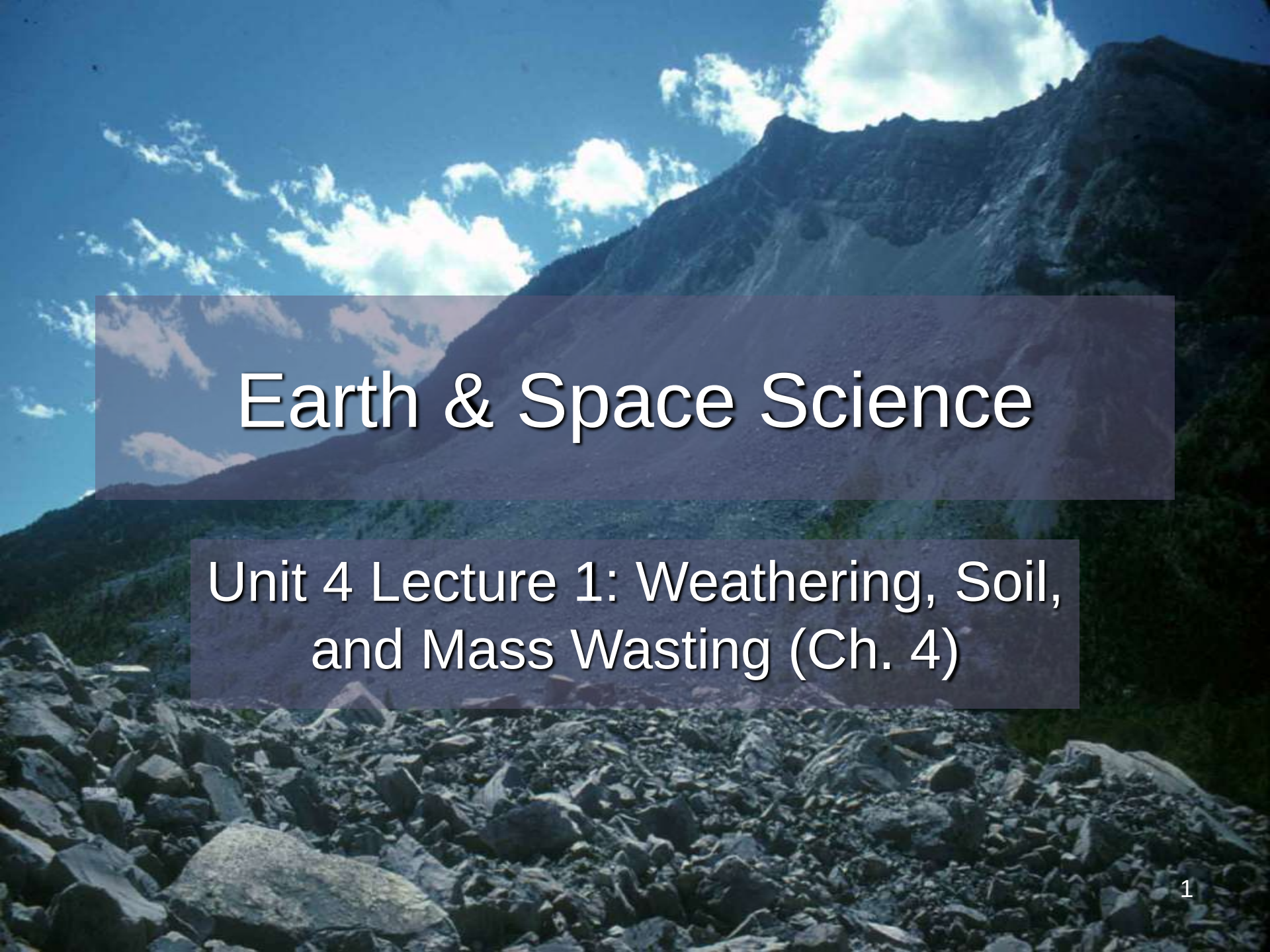


Earth & Space Science

Unit 4 Lecture 1: Weathering, Soil, and Mass Wasting (Ch. 4)

Earth's External Process

- Called external because they occur at or near Earth's surface
- Three types:
  - Weathering
  - Mass Wasting
  - Erosion

Weathering

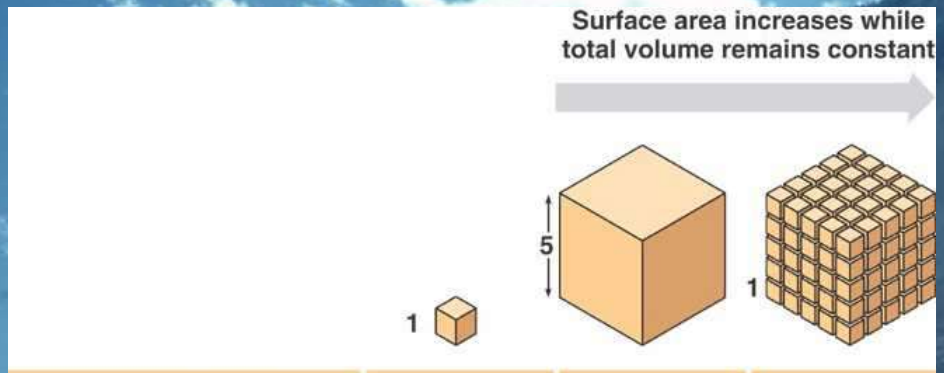
- Two kinds of weathering

1. Mechanical weathering
2. Chemical Weathering

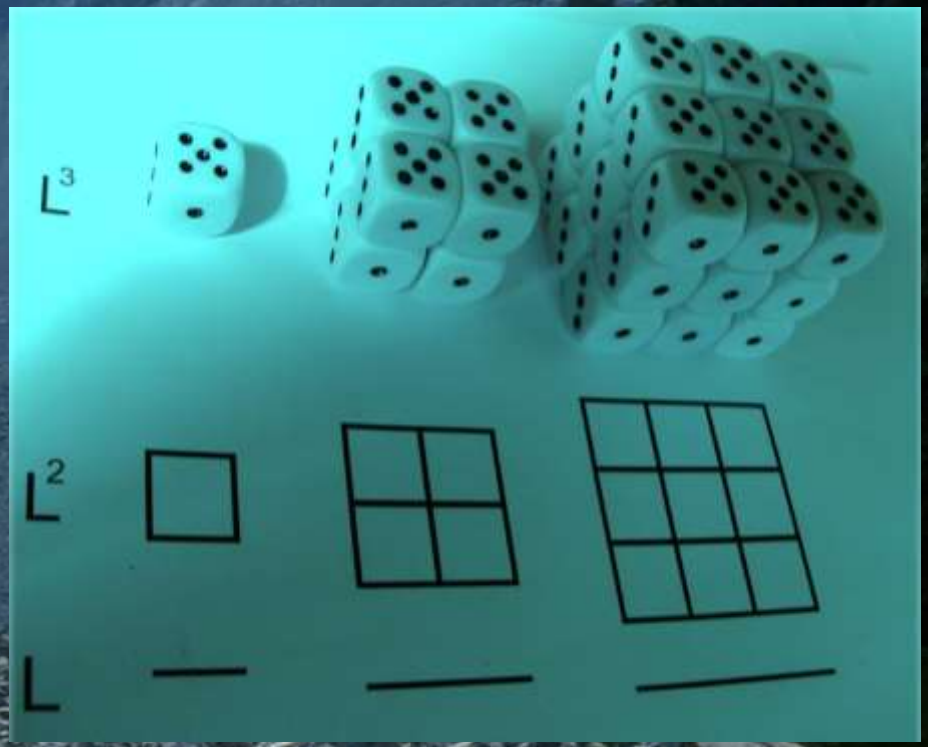
Mechanical Weathering

- Breaking of rocks into smaller pieces
- Four Processes
  - Frost wedging
  - Unloading
  - Thermal expansion
  - Biological activity

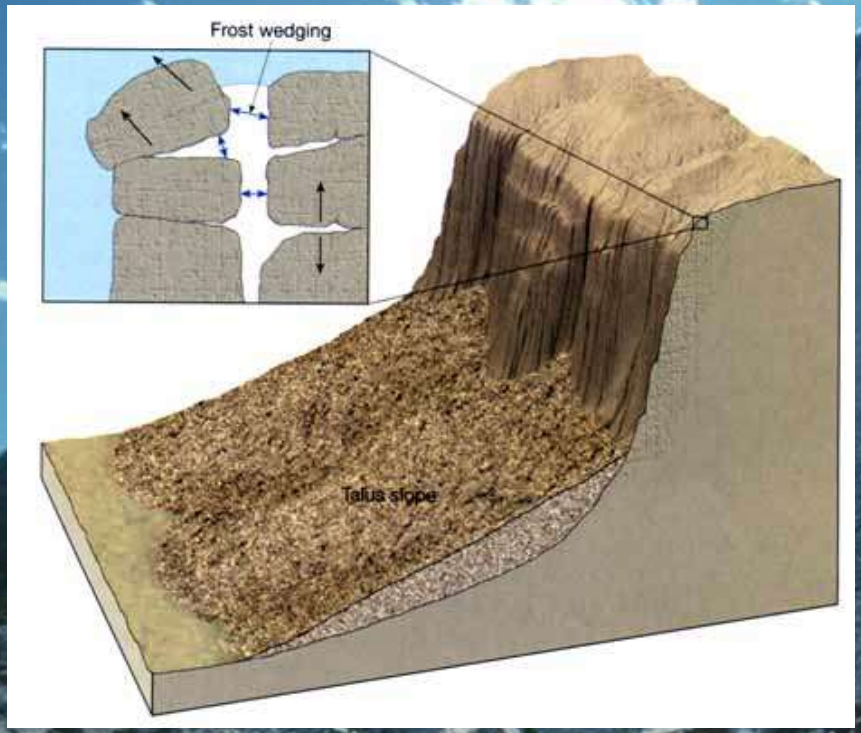
Mechanical Weathering (cont.)



Total surface area (height × width × number of sides × number of boxes)	6	150	750
Total volume (height × width × length × number of boxes)	1	125	125
Surface-to-volume ratio (surface area / volume)	6	1.2	6



Frost Wedging



1. Frost wedging on a talus slope
2. Picture of a real talus slope (on next slide)

Unloading

1. Half Dome, Yosemite National Park
2. Exfoliation of granite by unloading

Thermal Expansion

- Theory that the changes in temperature, over time, would stress the rock to the point of breaking
  - Deserts have the biggest change from day to night 30°C (54°F)
- Experimental data doesn't back up the theory
- But pebbles found in deserts show evidence of shattering from temperature changes.

Biological Activity

- Root Wedging – roots of plants seek the water found in the fractures between rocks, this leads to further breaks because of plant growth

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 (H_2CO_3) and alters the material

Weathering (cont.)

- Rates of weathering
  - Advanced mechanical weathering aids chemical weathering by increasing the surface area
  - Other important factors are
    - Mineral makeup
      - Marble (calcite) readily dissolves in weakly acidic solutions
      - Silicate minerals weather in the same order as their order of crystallization
    - Climate
      - Temperature and moisture are the most crucial factors
      - Chemical weathering is most effective in areas of warm temperatures and abundant moisture

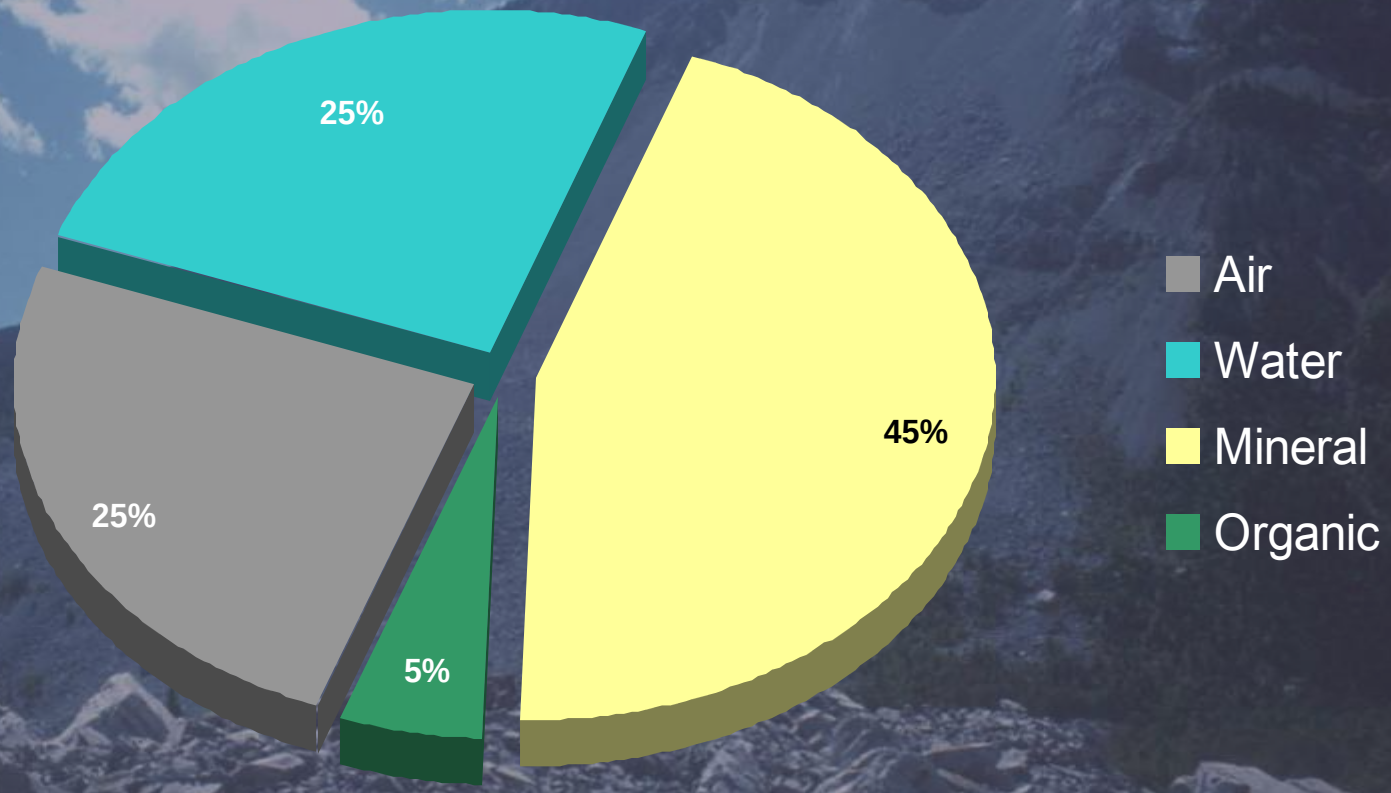
Soil

Science, in recent years, has focused more and more on the Earth as a planet, one that for all we know is unique – where a thin blanket of air, a thinner film of water, and the thinnest veneer of soil combine to support a web of life of wondrous diversity in continuous change.

What is Soil?

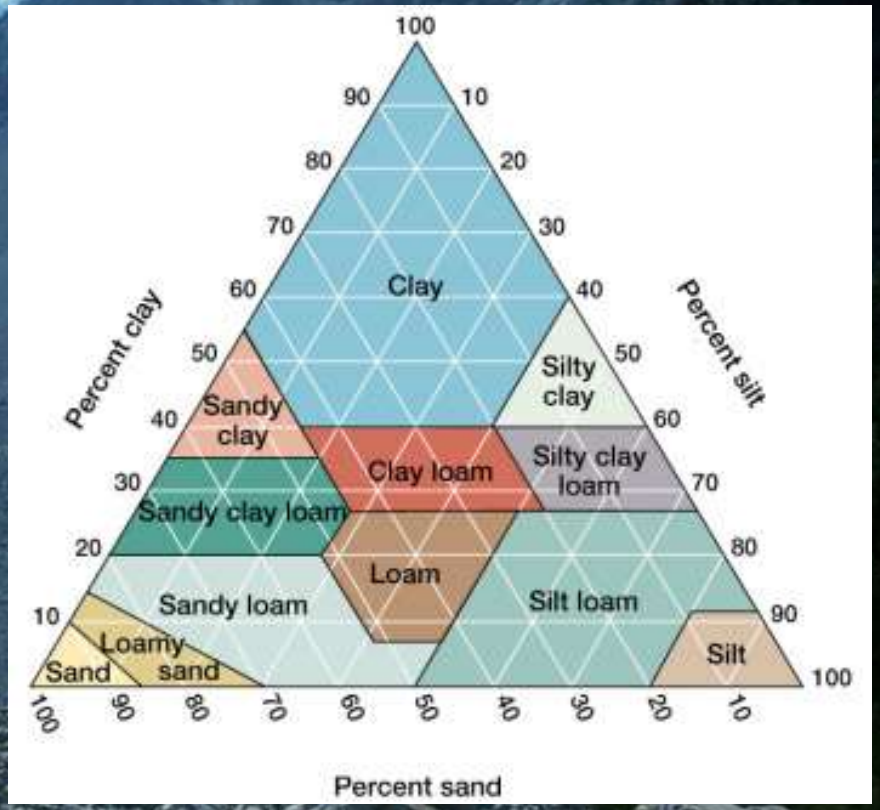
- Regolith vs. Soil
  - Regolith is the layer of rock and mineral fragments produced by weathering
  - Soil is a combination of mineral and organic matter, water, and air; Soil is the portion of regolith that supports the growth of plants.

Soil Breakdown (by Volume)



Soil Texture and Structure

- Texture
  - Refers to the proportions of different particle sizes
    - Sand (large size)
    - Silt
    - Clay (small size)
  - Loam is best suited for plant life



Soil Texture and Structure (cont.)

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

Controls of Soil Formation [5]

- Parent material
  - Residual soil – parent material is the bedrock
  - Transported soil – parent material has been carried from elsewhere and deposited
  - Influences Soils in two ways:
    - Affects the rate of weathering, thus the rate of soil formation
    - Chemical makeup of affects the soil's fertility

Controls of Soil Formation (cont.)

- Time
  - Important in all geologic processes
  - Amount of time to evolve varies for different soils
- Climate

Controls of Soil Formation (cont.)

- Plants and animals
  - Organisms influence the soil's physical and chemical properties
  - Furnished organic matter to soil
- Slope
  - Steep slope – often poor soils
  - Optimum is a flat-to-undulating upland surface
  - Slope orientation can affect the type of soil

Soil Profile

- Soil forming processes operate from the surface downward
- Horizons – zones or layers of soil

Soil Profile (cont.)

- Horizons in temperature regions
  - O – organic matter
  - A – organic and mineral matter
  - E – little organic matter
  - 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"

Soil Types

- Hundreds of soil types worldwide
- Three very generic types
  - Pedalfer
    - Accumulation of iron oxides and Aluminum-rich clays in the B horizon
    - Best developed under forest vegetation
  - Pedocal
    - Accumulate calcium carbonate
    - Associated with drier grasslands
  - Laterite
    - Hot, wet, tropical climates
    - Intense chemical weathering

Soil Erosion

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

Weathering creates ore deposits

- Process called secondary enrichment
  - Concentrates metals into economical deposits
  - Two ways of enrichment
    - Removing undesired material from the decomposing rock, leaving the desired elements behind
    - Desired elements are carried to lower zones and deposited
- Examples
  - Bauxite, the principal ore of aluminum
  - Many copper and silver deposits

Mass Wasting

- The downslope movement of rock, regolith, and soil under the direct influence of gravity
- Gravity is the controlling force
- Mass wasting is distinct because it does not require a transporting medium

Controls and Triggers of Mass Wasting

- Important triggering factors are
  - Saturation of the material with water
    - Destroys particle cohesion
    - Water adds weight
  - Oversteepening of slopes
    - Stable slope angle is different for various materials **angle of repose.**
    - Oversteepened slopes are unstable
  - Removal of anchoring vegetation
  - Ground vibrations from earthquakes

Types of Mass Wasting

- Generally each type is defined by three things:
  - The material involved
    - Debris
    - Mud
    - Earth
    - Rock
  - The movement of material
    - Fall (free-fall of pieces)
    - Flow (material moves as a viscous fluid)
    - Slide (material moves along a surface)
  - The velocity of the movement
    - Fast
    - Slow

Rock Avalanches

- Rock and debris can hurtle downslope at speeds exceeding 200 kilometers per hour (125 mph).
- Many researchers believe that rock avalanches “float on air”

WARNING

- **Landslide** – has no specific definition in geology; should be considered a popular nontechnical term to describe all relatively rapid forms of mass wasting, including those in which sliding does not occur.

Forms of Mass Wasting

- Slum
  - Rapid
  - Movement along a curved surface
  - Along oversteepened slopes

Forms of Mass Wasting (cont.)

- Rockslide
  - Rapid
  - Blocks of bedrock move down a slope

Forms of Mass Wasting (cont.)

- Mudflow
  - Rapid
  - Flow of debris with water
  - Often confined to channels
  - Serious problem in dry areas with heavy rains
  - Mudflows on the slopes of volcanoes are called lahars

Forms of Mass Wasting (cont.)

- Earthflow
  - Rapid
  - On hillsides in humid regions
  - Water saturates the soil

Slow Movements

- **Creep** – the slow movement of soil and regolith downhill

Slow Movements (cont.)

- Solifluction
  - Slow
  - In areas underlain by permafrost