1

2 **The Importance of Mass Wasting**
- Slopes are the most common elements in our physical landscape
  - Slopes may appear to be stable, but all are under the influence of gravity
  - At one extreme movement may be gradual and practically imperceptible
  - At the other, it may consist of a roaring debris flow or thundering rock avalanche

3 **The Importance of Mass Wasting**
- Landslides as Geologic Hazards
  - A landslide is a sudden event where large quantities of rock and soil move down steep slopes
    - When people and communities are in the way, a natural disaster may result
    - The term *landslide* has no specific definition in geology
  - Mass wasting refers to the downslope movement of rock, regolith, and soil under the direct influence of gravity

4 **The Importance of Mass Wasting**
- The Role of Mass Wasting in Landform Development
  - Mass wasting is the geologic process that often follows weathering
    - Sediment is ultimately transported to the sea
  - *Combined effects* of mass wasting and running water produce stream valleys
    - The most common and conspicuous of Earth's landforms

5 **Excavating the Colorado Plateau**

6 **Excavating the Colorado Plateau**

7 **The Importance of Mass Wasting**
- Slopes Change Through Time
  - Most rapid and spectacular mass-wasting events occur in areas of rugged, geologically young mountains
  - Mass wasting and erosional processes slowly change these rugged mountains to more subdued terrain
  - If dynamic internal processes did not continually produce regions having higher elevations, the system that moves debris to lower elevations would eventually cease
  - Gravity is the controlling force of mass wasting, but several other factors play important roles

8 **Controls and Triggers of Mass Wasting**
- The Role of Water
  - When sediment pores fill with water, cohesion among particles are destroyed
  - Water can lubricate materials
  - Water adds weight to a mass of material
    - Example: Colorado Front Range

9 **Saturation Reduces Friction**

10 **Heavy Rains Trigger Debris Flow**

11 **Controls and Triggers of Mass Wasting**
- Oversteepened Slopes
  - Many situations where oversteepening takes place
    - Examples: stream valleys and human activities
  - Unconsolidated granular particles assume a stable slope at the angle of repose
    - The steepest angle at which a material can remain stable
    - Different for various materials
  - Oversteepened slopes are unstable and can trigger mass wasting

12 **Angle of Repose**

13 **Unstable Slopes**

14 **Controls and Triggers of Mass Wasting**
- Removal of Vegetation

- Plants protect against erosions by binding soil and regolith together
  - Plants also shield the soil surface from raindrop impacts
- Vegetation is removed by forest fire or by humans (timber, farming, development)
  - Wildfires are inevitable in the western United States
  - Fast-moving destructive debris flows triggered by intense rainfalls are some of the most dangerous post-fire hazards

15 **Fire**

16 **Controls and Triggers of Mass Wasting**

- Earthquakes as Triggers
  - Earthquakes and aftershocks can dislodge rocks and unconsolidated materials
  - Examples from California and China
    - 1994 Northridge earthquake in California triggered 11,000 landslides
    - 2008 earthquake in China caused landslides which created temporary dams and "earthquake-created" lakes
  - Liquefaction
    - During periods of ground shaking, water-saturated surface materials behave as fluid-like masses that flow

17 **Earthquakes as Triggers**

18 **Controls and Triggers of Mass Wasting**

- Landslides Without Triggers?
  - Many rapid mass wasting events occur without a discernible trigger
  - Slope materials gradually weaken over time—eventually if the strength falls below what is necessary to maintain slope stability, a landslide will occur
    - Timing of these events is random
    - Accurate prediction is impossible

19 **Classification of Mass-Wasting Processes**

- Two things to consider for classifying mass-wasting processes:
- Type of Material
  - *Debris*, *mud*, and *earth* are used if soil and regolith move
  - "Rock" is used if bedrock moves
- Type of Motion
  - Fall
    - The free fall of detached pieces is called a fall
    - Talus slopes are built by rock falls

20 **Talus Slopes**

21 **Classification of Mass-Wasting Processes**

- Type of Motion
  - Slide
    - A slide occurs when there is a distinct zone of weakness separating the slide material from the underlying material
      - Rotational slide—surface of rupture is concave up
      - Translational slide—material moves along a flat surface
  - Flow
    - Flow occurs when material moves downslope as a viscous fluid
      - Most are saturated with water

22 **Classification of Mass-Wasting Processes**

- Rate of Movement
  - Fast
    - A rock avalanche is the most rapid type of mass wasting
      - Rocks float on air as they move downslope
  - Slow

- Creep moves particles a few millimeters per year
- A wide range of rates exists between these two extremes

23 **Watch Out for Falling Rock!**

24 **Blackhawk Rock Avalanche**

25 **Rapid Forms of Mass Wasting**

- Slump
  - A slump is the movement of a mass of rock or unconsolidated material as a unit along a curved surface (rotational slide)
    - Can involve a single mass or multiple blocks
  - Occurs along oversteepened slopes

26 **Slump**

27 **Slump at Point Fermia, California**

28 **Rapid Forms of Mass Wasting**

- Rockslide
  - A rockslide occurs when blocks of bedrock slide down a slope
    - A debris slide occurs when unconsolidated material slides down a slope
  - Generally very fast and destructive
  - Sometimes triggered by melting snow or rain
    - Most common during the spring
  - Sometimes triggered by earthquakes
    - New Madrid, Yellowstone, Gros Ventre

29 **Rockslide**

30 **Gros Ventre**

31 **Rapid Forms of Mass Wasting**

- Debris Flow
  - A debris flow is a rapid form of mass wasting that involves the flow of soil and regolith with water (mudflow if the material is fine grained)
  - Tend to occur more frequently in semi-arid mountainous regions
    - Sudden rainfall or snowmelt washes large quantities of sediment into rivers
      - Lack of vegetation to anchor soil
  - Often confined to channels and canyons

32 **Debris Flow**

33 **Rapid Forms of Mass Wasting**

- Lahar
  - Debris flows composed mostly of volcanic materials
    - Example: Mount St. Helens
  - Historically some of the most deadly volcanic hazards
    - Can occur during a volcanic eruption or when a volcano is quiet
    - Take place when highly unstable layers of ash and debris become saturated with water
    - Generally follow stream channels

34 **Lahars at Redoubt Volcano and Mount St. Helens**

35 **Lahars at Redoubt Volcano and Mount St. Helens**

36 **Rapid Forms of Mass Wasting**

- Earthflow
  - Earthflows form on hillsides in humid regions during heavy precipitation or snowmelt
    - Water saturates the soil and regolith
  - Commonly involve materials rich in clay and silt
    - Very viscous, move at slower rates than more fluid debris flows
  - Range in size from a few meters to more than a kilometer long and several hundred meters wide!

37 **Earthflow**

38 **Slow Movements**

- Creep
  - Creep is the *gradual* movement of soil and regolith downhill
    - Imperceptibly slow!
    - Aided by the alternate expansion and contraction of the surface material
    - Caused by freezing and thawing or wetting and drying
  - Causes fences and utility walls to tilt

39 **Creep**

40 **Effects of Creep**

41 **Slow Movements**

- Solifluction
  - Solifluction is the downslope movement of water logged soils
    - Literally: “soil flow”
    - Promoted by a deeper dense clay hardpan or impermeable bedrock layer
    - Common in regions underlain by permafrost
      - Occurs in the active layer, the zone above the permafrost

42 **Solifluction Lobes Near the Arctic Circle in Alaska**

43 **Slow Movements**

- The Sensitive Permafrost Landscape
  - Permafrost is permanently frozen ground
    - Summers are too short and cool to melt ice below the shallow surface
    - Deeper ground remains below 0°C (32°F) throughout the year
  - Extensive around the Arctic Ocean
    - Land use is regulated to prevent the permafrost from melting

44 **Distribution of Permafrost**

45 **When Permafrost Thaws**

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End of Chapter 15