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- 2  **Chapter 15 – Mass Wasting**
- 3  **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
- 4  **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
- 5  **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
- 6  **Excavating the Colorado Plateau**
- 7  **Excavating the Colorado Plateau**
- 8  **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
- 9  **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
- 10  **Saturation Reduces Friction**
- 11  **Heavy Rains Trigger Debris Flow**
- 12  **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
- 13  **Angle of Repose**
- 14  **Unstable Slopes**
- 15  **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
- 16  **Fire**
- 17  **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
- 18  **Earthquakes as Triggers**
- 19  **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
- 20  **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
- 21  **Talus Slopes**
- 22  **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
- 23  **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

24  **Watch Out for Falling Rock!**

25  **Blackhawk Rock Avalanche**

26  **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


27  **Slump**


28  **Slump at Point Fermia, California**

29  **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

30  **Rockslide**

31  **Gros Ventre**


32  **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

33  **Debris Flow**

34  **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

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

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

37  **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!

38  **Earthflow**

39  **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

40  **Creep**

41  **Effects of Creep**

42  **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

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

44  **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

45  **Distribution of Permafrost**

46  **When Permafrost Thaws**

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End of Chapter 15