

1  **Mass Wasting:
The Work of Gravity**

Earth – Chapter 15

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  **8 Oct 06, Kashmir**

7  **Feb 06, Leyte, P.I.**

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10  **Excavating the Colorado Plateau**

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12  **Excavating the Colorado Plateau**

13  **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

14  **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

15  **Saturation Reduces Friction**

16  **Heavy Rains Trigger Debris Flow**

17  **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

18  **Angle of Repose**

19  **Unstable Slopes**

20  **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

21  **Fire**

22  **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

23  **Earthquakes as Triggers**

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26  **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

27  **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

28  **Talus Slopes**

29  **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

30 **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

31 **Watch Out for Falling Rock!**

32 **Blackhawk Rock Avalanche (California)**

33 **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

34 **Slump**

35 ***La Jolla***

Soledad Mtn. Rd.

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37 ***What happened in 2006
(photos are one hour apart)***

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39 ***Classic slump characteristics***

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41 **Slump at Point Fermia, California**

42 **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

43 **Rockslide**

44 **Gros Ventre**

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47 **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

48 **Debris Flow**

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54 **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

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

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

57 **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!

58 **Earthflow**

59 **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

60 **Creep**

61 **Effects of Creep**

62 **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

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

64 **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

65  **Distribution of Permafrost**

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67  **When Permafrost Thaws**

68  **Submarine landslides**

- Submarine landslides are common and widespread in occurrence
- The most spectacular underwater landslides occur on the flanks of submarine volcanoes (called seamounts)

69  **Submarine landslides**

- Large slumps and debris flows scar the continental slopes along the margins of the United States
 - Triggered by the rapid buildup of unstable sediments, or by forces such as storm waves and earthquakes
 - Especially active near deltas

70  **End of Chapter**