EENS 204	Natural Disasters
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Mass-Wasting and Mass-Wasting Processes

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Mass-Wasting and its Human Impacts

Mass-Wasting is defined as the down slope movement of rock and regolith near the Earth's surface mainly due to the force of gravity. Mass-wasting is an important part of the erosional process, as it moves material from higher elevations to lower elevations where transporting agents like streams and glaciers can then pick up the material and move it to even lower elevations. Mass-wasting processes are occurring continuously on all slopes; some act very slowly, others occur very suddenly, often with disastrous results. Any perceptible down slope movement of rock or regolith is often referred to in general terms as a ***landslide***. Landslides, however, can be classified in a much more detailed way that reflects the mechanisms responsible for the movement and the velocity at which the movement occurs.

As human populations expand and occupy more and more of the land surface, mass-wasting processes become more likely to affect humans. The table below shows the impact of mass-wasting processes on human life over the last century.

Year	Location	Type	Fatalities
1916	Italy, Austria	Landslide	10,000
1920	China	Earthquake triggered landslide	200,000
1945	Japan	Flood triggered landslide	1,200
1949	USSR	Earthquake triggered landslide	12,000-20,000
1954	Austria	Landslide	200
1962	Peru	Landslide	4,000-5,000
1963	Italy	Landslide	2,000
1970	Peru	Earthquake related debris avalanche	70,000
1985	Columbia	Mudflow related to volcanic eruption	23,000
1987	Ecuador	Earthquake related landslide	1,000
1998	Nicaragua	Debris avalanche and mudflow tirggered by heavy rains during Hurricane Mitch	~2,000
2001	El Salvador	Earthquake-induced landslide	585
2006	Philippines	Rain triggered debris avalanche	>1100

In a typical year in the United States, landslides cause over $2 billion in damages and 25 to 50 deaths. In other countries, especially less developed countries, the loss is usually higher because of higher population densities, lack of zoning laws, lack of information about mass-wasting hazards, and lack of emergency preparedness. Between 1969 and 1993, worldwide, landslides caused an average of about 1550 deaths per year.

Knowledge about the relationships between local geology and mass-wasting processes can lead to better planning that can reduce vulnerability to such hazards. Thus, we will look at the various types of mass-wasting processes, their underlying causes, factors that affect slope stability, and what humans can do to reduce vulnerability and risk due to mass-wasting hazards.

Types of Mass-Wasting Processes

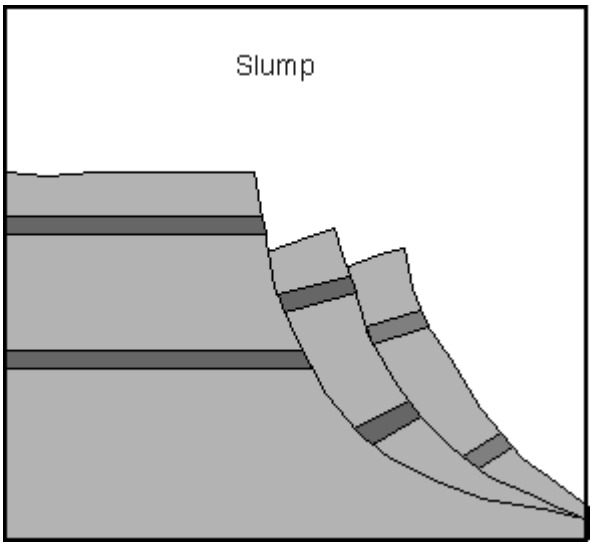
The down-slope movement of material, whether it be bedrock, regolith, or a mixture of these, is commonly referred to as a ***landslide***. All of these processes generally grade into one another, so classification of such processes is somewhat difficult. We will use a classification that divides mass-wasting processes into two broad categories (note that this classification is somewhat different than that used by your textbook).

1. ***Slope Failures*** - a sudden failure of the slope resulting in transport of debris down hill by sliding, rolling, falling, or slumping.

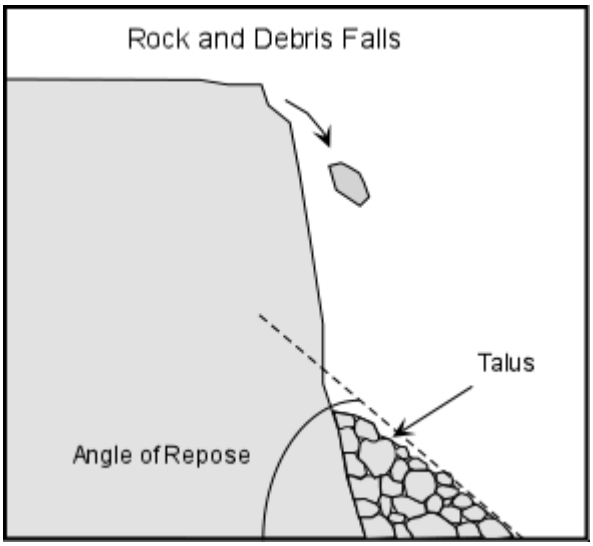
2. ***Sediment Flows*** - debris flows down hill mixed with water or air.

Slope Failures

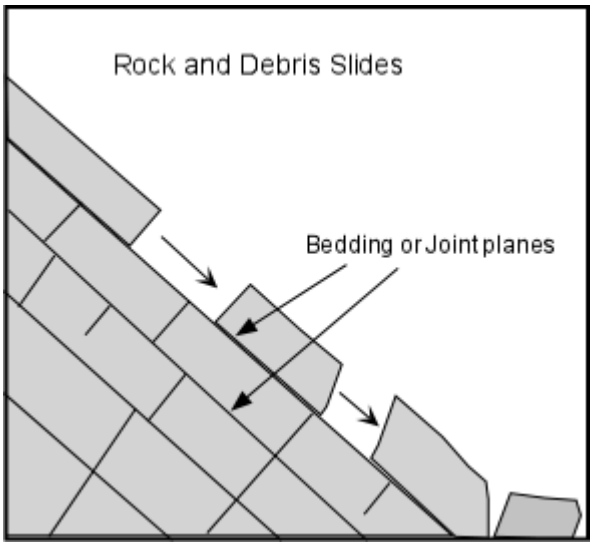
- ***Slumps*** - types of slides wherein downward rotation of rock or regolith occurs along a concave-upward curved surface (rotational slides). The upper surface of each slump block remains relatively undisturbed, as do the individual blocks. Slumps leave arcuate scars or depressions on the hill slope. Slumps can be isolated or may occur in large complexes covering thousands of square meters. They often form as a result of human activities, and thus are common along roads where slopes have been oversteepened during construction. They are also common along river banks and sea coasts, where erosion has under-cut the slopes. Heavy rains and earthquakes can also trigger slumps.



- ***Falls - Rock falls*** occur when a piece of rock on a steep slope becomes dislodged and falls down the slope. ***Debris falls*** are similar, except they involve a mixture of soil, regolith, vegetation, and rocks. A rock fall may be a single rock or a mass of rocks, and the falling rocks can dislodge other rocks as they collide with the cliff. Because this process involves the free fall of material, falls commonly occur where there are steep cliffs. At the base of most cliffs is an accumulation of fallen material termed ***talus.***



- ***Slides*** - Rock slides and debris slides result when rocks or debris slide down a pre-existing surface, such as a bedding plane, foliation surface, or joint surface (joints are regularly spaced fractures in rock that result from expansion during cooling or uplift of the rock mass). Piles of talus are common at the base of a rock slide or debris slide. Slides differ from slumps in that there is no rotation of the sliding rock mass along a curved surface.

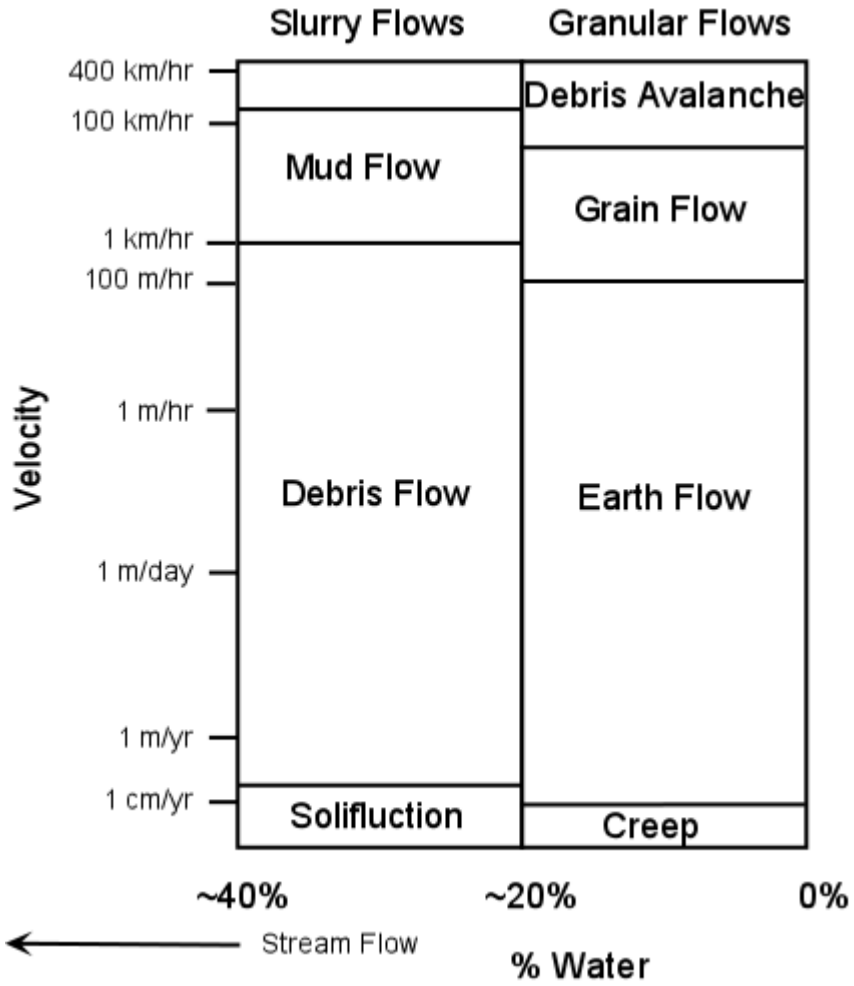


Sediment Flows

Sediment flows occur when sufficient force is applied to rocks and regolith that they begin to **flow** down slope. A sediment flow is a mixture of rock, and/or regolith with some water or air. They can be broken into two types depending on the amount of water present.

1. ***Slurry Flows***- are sediment flows that contain between about 20 and 40% water. As the water content increases above about 40% slurry flows grade into streams. Slurry flows are considered water-saturated flows.

2. ***Granular Flows*** - are sediment flows that contain between 0 and 20% water. Note that granular flows are possible with little or no water. Fluid-like behavior is given these flows by mixing with air. Granular flows are not saturated with water.



Each of these classes of sediment flows can be further subdivided on the basis of the velocity at which flowage occurs.

- ***Slurry Flows***

    - ***Solifluction*** -flowage at rates measured on the order of centimeters per year of regolith containing water. Solifluction produces distinctive lobes on hill slopes. These occur in areas where the soil remains saturated with water for long periods of time.

    - ***Debris Flows*** - these occur at higher velocities than solifluction, with velocities between 1 meter/yr and 100 meters/hr and often result from heavy rains causing saturation of the soil and regolith with water. They sometimes start with slumps and then flow down hill forming lobes with an irregular surface consisting of ridges and furrows.

    - ***Mudflows*** - these are a highly fluid, high velocity mixture of sediment and water that has a consistency ranging between soup-like and wet concrete. They move at velocities greater than 1 km/hr and tend to travel along valley floors. These usually result from heavy rains in areas where there is an abundance of unconsolidated sediment that can be picked up by streams. Thus after a heavy rain streams can turn into mudflows as they pick up more and more loose sediment.

Mudflows can travel for long distances over gently sloping stream beds. Because of their high velocity and long distance of travel they are potentially very dangerous. As we have seen, mudflows can also result from volcanic eruptions that cause melting of snow or ice on the slopes of volcanoes, or draining of crater lakes on volcanoes. Volcanic mudflows are often referred to as ***lahars***. Some lahars can be quite hot, if they are generated as a result of eruptions of hot tephra.

- ***Granular Flows***

    - ***Creep*** - the very slow, usually continuous movement of regolith down slope. Creep occurs on almost all slopes, but the rates vary. Evidence for creep is often seen in bent trees, offsets in roads and fences, and inclined utility poles (see figure 10.4 in your text).

    - ***Earthflows*** - are usually associated with heavy rains and move at velocities between several cm/yr and 100s of m/day. They usually remain active for long periods of time. They generally tend to be narrow tongue-like features that begin at a scarp or small cliff.

    - ***Grain Flows*** - usually form in relatively dry material, such as a sand dune, on a steep slope. A small disturbance sends the dry unconsolidated grains moving rapidly down slope.

    - ***Debris Avalanches*** - These are very high velocity flows of large volume mixtures of rock and regolith that result from complete collapse of a mountainous slope. They move down slope and then can travel for considerable distances along relatively gentle slopes. They are often triggered by earthquakes and volcanic eruptions.

Mass-Wasting in Cold Climates

Mass-wasting in cold climates is governed by the fact that water is frozen as ice during long periods of the year. Ice, although it is solid, does have the ability to flow, and freezing and thawing cycles can also contribute to movement.

- *Frost Heaving* - this process is large contributor to creep in cold climates. When water saturated soils freeze, they expand, pushing rocks and boulders on the surface upward perpendicular to the slope. When the soil thaws, the boulders move down vertically resulting in a net down slope movement.

- *Gelifluction* - Similar to solifluction, this process occurs when the upper layers of soil thaw during the warmer months resulting in water saturated soil that moves down slope.

- *Rock Glaciers* - a lobe of ice-cemented rock debris (mostly rocks with ice between the blocks) that slowly moves downhill.

Subaqueous Mass-Wasting

Mass wasting processes also occur on steep slopes in the ocean basins. A slope failure can

occur due to over-accumulation of sediment on slope or in a submarine canyon, or could occur as a result of a shock like an earthquake. Slumps, debris flows, and landslides are common.

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