EENS 3050	Natural Disasters
Tulane University	Prof. Stephen A. Nelson

Mass Movements and Mass Movement Processes

This page last updated on 23-Mar-2018

Mass Movements and Their Human Impacts

Mass Movement is defined as the down slope movement of rock and regolith near the Earth's surface mainly due to the force of gravity. Mass movements are 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 movement 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 movement processes become more likely to affect humans. The table below shows some of the most deadly movement processes since 1900.

Year	Location	Type	Fatalities
1916	Italy, Austria	Landslide	10,000
1919	Kelud Indonesia	Lahar	5,110
1920	China	Earthquake triggered landslide	200,000
1933	Sichuan. China	Earthquake triggered landslide	3100
1945	Japan	Flood triggered landslide	1,200
1949	USSR	Earthquake triggered landslide	12,000-20,000
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
1999	Vargas, Venezuela	debris flows triggered by heavy rain	30,000
2001	El Salvador	Earthquake-induced landslide	585
2006	Philippines	Rain triggered debris avalanche	1126
2009	Taiwan	Typhoon Marakot triggered landslide	~600
2010	Gansu, China	Rain triggered mud flows	1287
2013	Northern India	Heavy rain triggered landslides	5700
2017	Sierra Leone	mudlows	>1140

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 movement hazards, and lack of emergency preparedness. Between 2004 and 2010, worldwide, landslides caused an average of about 5330 deaths per year.

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

Types of Mass Movement Processes

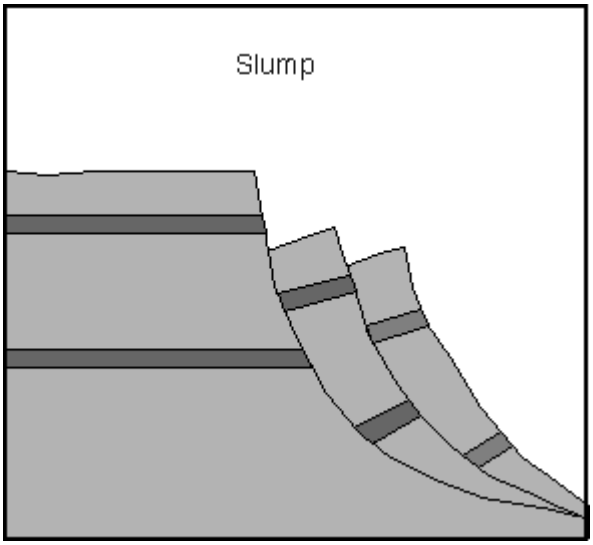
The down-slope movement of material, whether it be bedrock, regolith, or a mixture of these, is commonly referred to as a ***landslide***. All of these processes generally grade into one another, so classification of such processes is somewhat difficult. We will use a classification that divides mass movement 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.

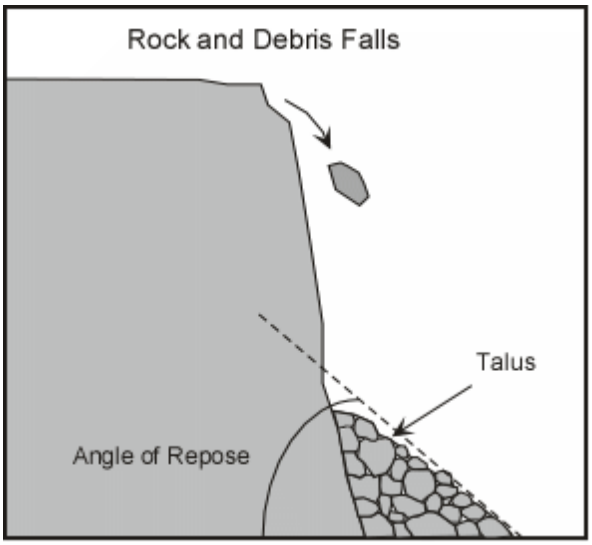
2. ***Sediment Flows*** - debris flows down hill mixed with water or air.

Slope Failures

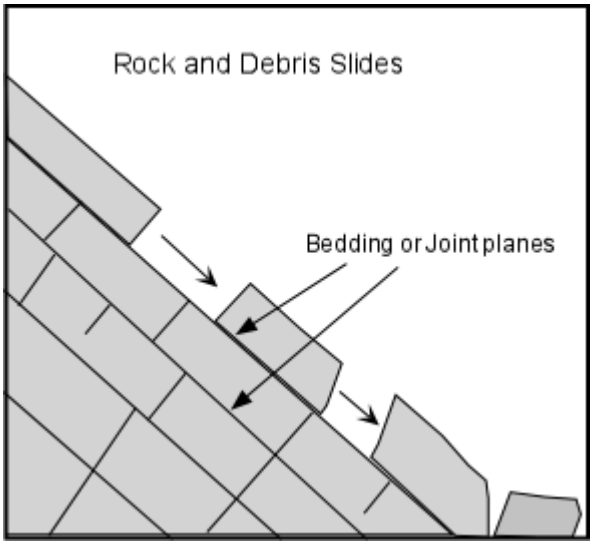
- ***Slumps (also called Rotational Slides)-*** types of slides wherein downward rotation of rock or regolith occurs along a concave-upward curved surface (rotational slides). The upper surface of each slump block remains relatively undisturbed, as do the individual blocks. Slumps leave arcuate scars 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 (also called Translational 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.



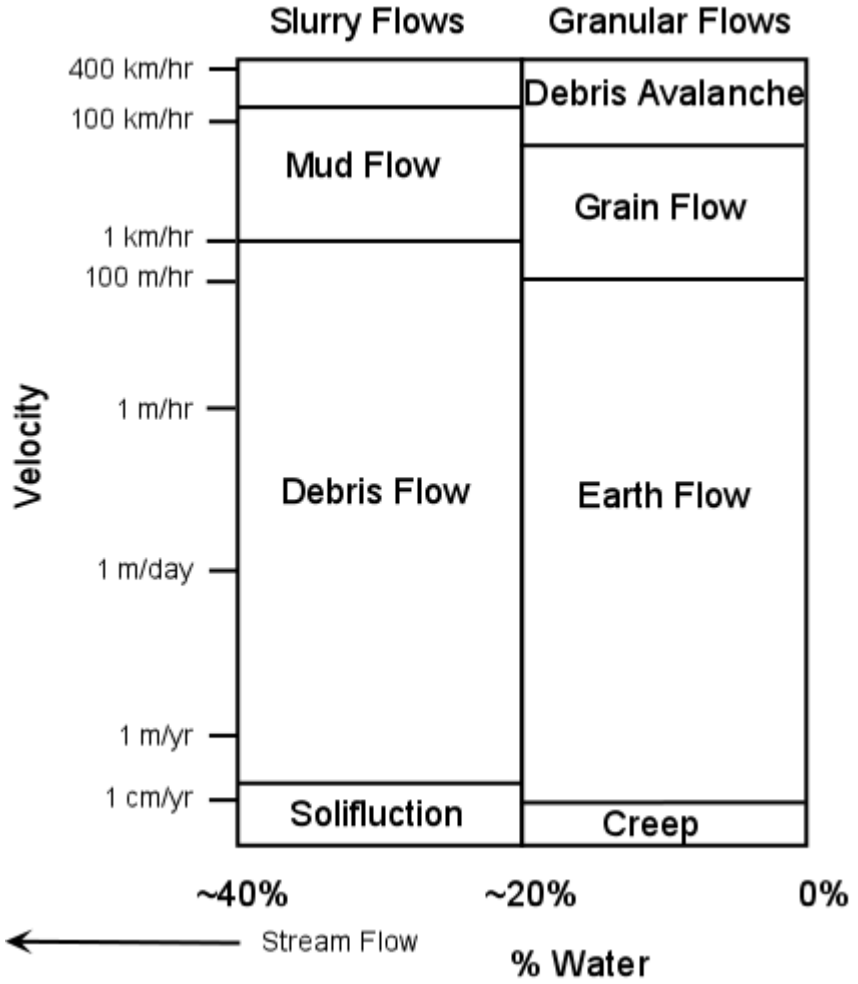
Sediment Flows

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.

Note that the media often refers to mudflows (and sometimes debris flows) as mudslides. This is inaccurate because mud flows rather than slides down a slope. Thus, in this course the word "mudslide" is an **illegal word** - one that you should never use.

- **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.
  - *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.
  - *Snow Avalanches* are similar to debris avalanches, but involve only snow, and are much more common than debris avalanches. Snow avalanches usually cause hundreds of deaths worldwide each year.

Mass Movements in Cold Climates

Mass movement 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.

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

Subaqueous Mass Movements

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.

3 types – of mass movements are common, based on degree of disintegration of the material during movcement:

1. Submarine slumps – Coherent blocks break and slip.
2. Submarine debris flows – Moving material breaks apart.
3. Turbidity currents –Sediment moves as a turbulent cloud, called a ***turbidity current***.

Examples of questions on this material that could be asked on an exam

1. What are the three types of slope failure?
2. How do sediment flows differ from slope failures and how are sediment flows classified?
3. What are fastest types of sediment flows and the slowest types of sediment flows?
4. Why is the word "mudslide", commonly used by the media, an illegal word in this course?

Return to EENS 3050 Homepage