

EENS 1110	Physical Geology
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<b>Mass Movements</b>	

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Mass movements (also called mass-wasting) is the down-slope movement of *Regolith* (loose uncemented mixture of soil and rock particles that covers the Earth's surface) by the force of gravity without the aid of a transporting medium such as water, ice, or wind. Still, as we shall see, water plays a key role.

Mass movements are part of a continuum of erosional processes between weathering and stream transport. Mass movement causes regolith and rock to move down-slope where sooner or later the loose particles will be picked up by another transporting agent and eventually moved to a site of deposition such as an ocean basin or lake bed.

Mass movement processes are occurring continuously on all slopes; some act very slowly, others occur very suddenly, often with disastrous results.

In this discussion, we hope to answer the following questions:

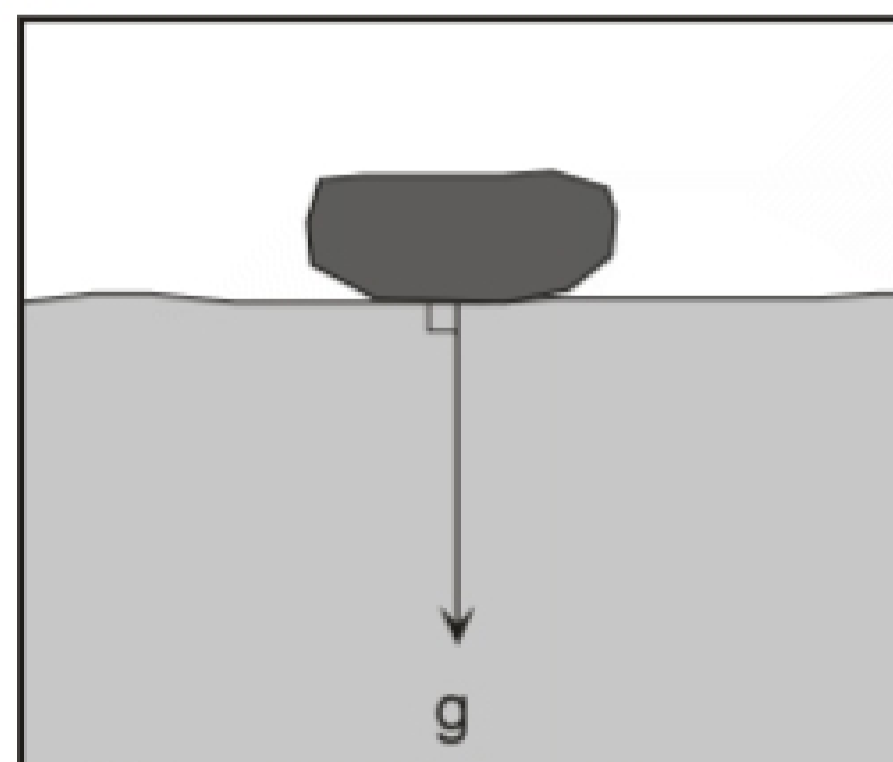
1. What determines whether or not a slope is stable or unstable?
2. How are the different mass movement processes classified?
3. How are mass movement events triggered?
4. What observations might suggest that the area is unstable and may start to move?
5. How can we mitigate against mass movement hazards?

We start with a discussion of the forces acting at the surface that cause mass movements.

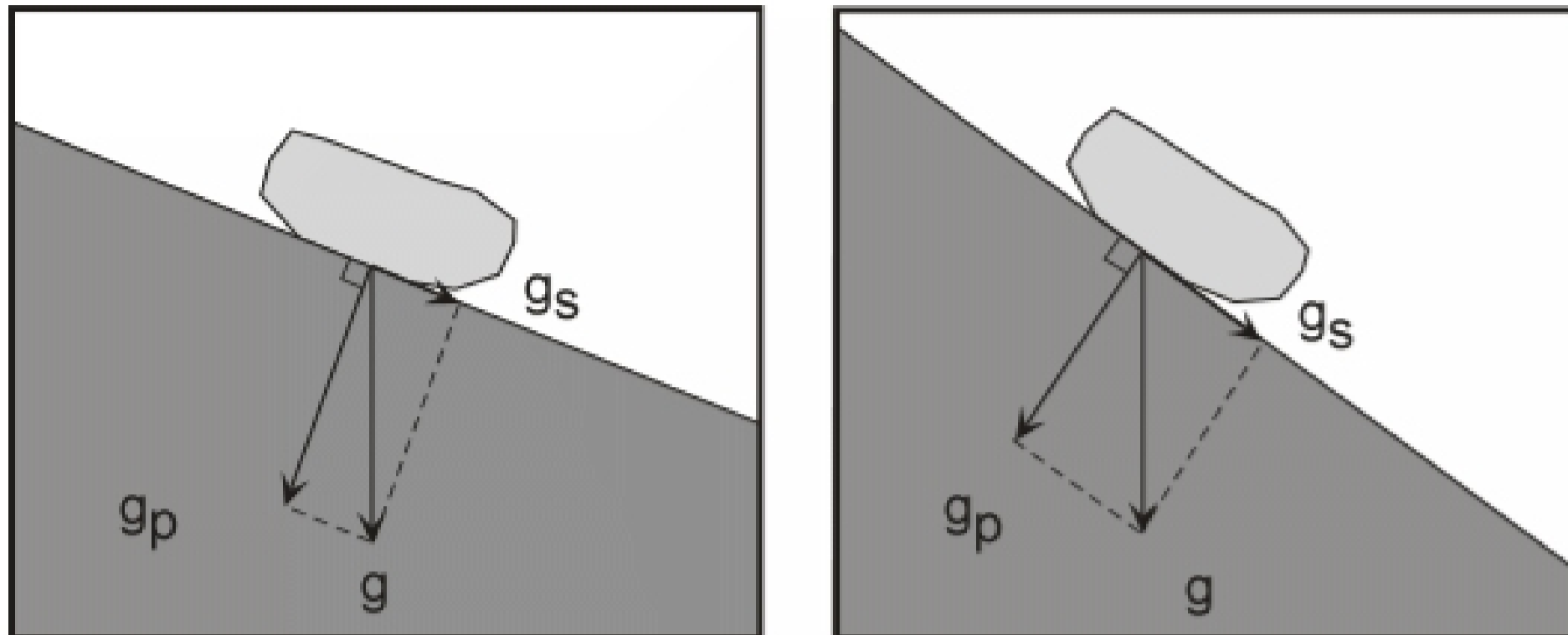
## Gravity

Gravity is the main force responsible for mass movements.

Gravity is a force that acts everywhere on the Earth's surface, pulling everything in a direction toward the center of the Earth. On a flat surface, parallel to the Earth's surface, the force of gravity acts downward. So long as the material remains on the flat surface it will not move under the force of gravity. Of course if the material forming the flat surface becomes weak or fails, then the unsupported support mass will move downward.



On a slope, the force of gravity can be resolved into two components: a component acting perpendicular to the slope, and a component acting parallel to the slope.



- The perpendicular component of gravity,  $g_p$ , helps to hold the object in place on the slope.
- The component of gravity acting parallel to the slope,  $g_s$ , causes a shear stress parallel to the slope and helps to move the object in the down-slope direction.
- On a steeper slope, the shear stress component of gravity,  $g_s$ , increases, and the perpendicular component of gravity,  $g_p$ , decreases.
- Another force resisting movement down the slope is grouped under the term *shear strength* and includes frictional resistance and cohesion among the particles that make up the object.
- When the shear stress becomes greater than the combination of forces holding the object on the slope, the object will move down-slope.
- Thus, down-slope movement is favored by steeper slope angles (increasing the shear stress) and anything that reduces the shear strength (such as lowering the cohesion among the particles or lowering the frictional resistance).
- For unconsolidated material, the angle that forms a stable slope is called the *angle of repose*.

### The Role of Water

Although water is not always directly involved as the transporting medium in mass movement processes, it does play an important role.

Addition of water from rainfall or snow melt adds weight to the slope. Water can seep into the soil or rock and replace the air in the pore space or fractures. Since water is heavier than air, this increases the weight of the soil.

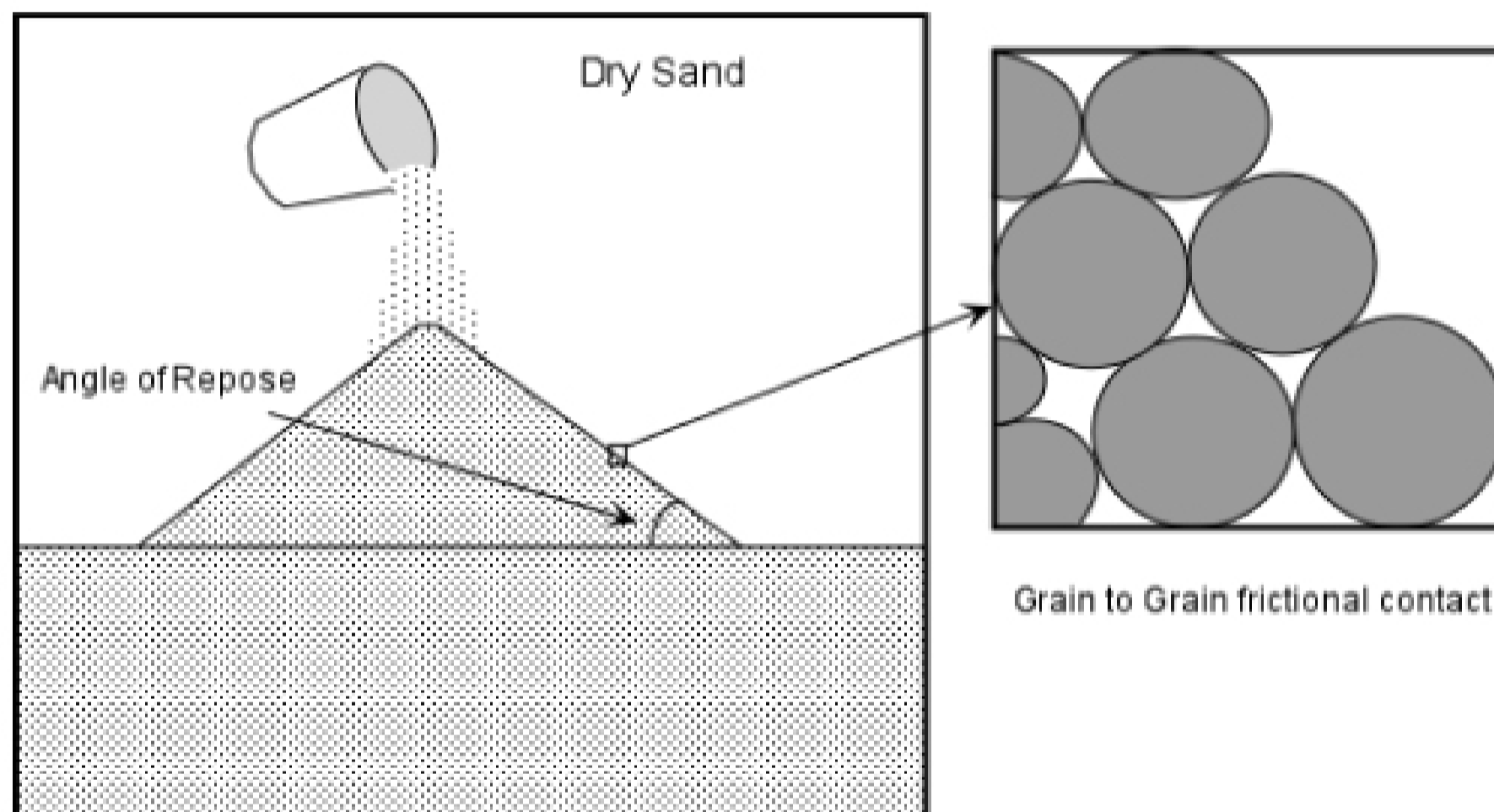
If the material becomes saturated with water, vibrations could cause liquifaction to occur, just like often happens during earthquakes.

Water can reduce the friction along a sliding surface.

Water has the ability to change the angle of repose (the slope angle which is the stable angle for the slope).

Think about building a sand castle on the beach. If the sand is totally dry, it is impossible to build a pile of sand with a steep face like a castle wall. If the sand is somewhat wet, however, one can build a vertical wall. If the sand is too wet, then it flows like a fluid and cannot remain in position as a wall.

- Dry unconsolidated grains will form a pile with a slope angle determined by the *angle of repose*. The angle of repose is the steepest angle at which a pile of unconsolidated grains remains stable, and is controlled by the frictional contact between the grains. In general, for dry materials the angle of repose increases with increasing grain size, but usually lies between about 30 and 45 °. Coarser grained and angular particles have a steeper angle of repose than fine grained and rounded particles.



- Slightly wet unconsolidated materials exhibit a very high angle of repose because surface tension between the water and the grains tends to hold the grains in place.

