GRAVITY & MASS MOVEMENT – Tutorial Script

All the landforms on planet Earth are formed through a combination of tectonic forces that push the land up, erosional forces that work to tear it down, and rocks of varying character and resistance that impact the location of erosion.

To review, the term **erosion** means the physical removal of rock fragments from one location and transport of them to another location. The breaking down of the rock chemically or physically is called **weathering**. The dropping of the rock into a new location is called **deposition**. In the next few video tutorials, we will focus on various agents of erosion such as gravity, running water, waves, glaciers, and humans. For this video tutorial, we discuss the erosional agent of gravity.

Gravity is a force that pulls material downhill towards the center of the Earth. Any object sitting loosely on Earth's surface will feel the pull of gravity and, unimpeded, will simply roll or side downhill. The heavier the object, the greater the force of gravity. **Friction** is the force that sticks loose material to a surface and needs to be overcome by the force of gravity before objects can move. Friction depends on the materials involved and the angle of the slope. Rough material has more frictional stickiness. Smooth material, less so. When my hands are smooth, they slide by each other easily. If I cover them in rough gloves, it gets harder to slide them. When I bend my hands, or let my fingers interfere, it's harder to slide them past each other. All of these are ways to increase the friction and keep objects from moving downhill. The weight of an object pushing against a surface will also contribute to friction. When I push my hands together tightly, it's harder to slide them.

This box, which is sitting on a hillside, is pulled toward the center of the Earth by the force of gravity, which is its weight. If the box is not moving, the component of its weight that moves along the surface of the hill is matched by an equal but opposite force of friction. Notice what happens to the force of its weight along the surface as the hillside steepens, the arrow gets longer, meaning this surface component of the force is getting greater. Once we get the hillside steep enough that the weight component along the surface is greater than the frictional force, the object will move downhill.

We call downhill movements of weathered rock material on Earth's surface **mass movement**, and we can classify the movement into a variety of types based on the type of material and the way it moves.

The slowest type of mass movement is called **creep** and refers to the top soil or sediment slowly moving downhill on a day-to-day basis as it alternately expands and contracts through daily heating and cooling cycles. That motion, while happening over distances of less than a millimeter, will overcome small frictional forces and allow a very small downhill movement each daily cycle. Cumulatively over many years, we see the top soil or sediment layer creeping its way downhill. Evidence that creep is occurring is visible when we see trees or fences on a slope bending downhill.

The fastest type of mass movement happens during a **rock fall**, which happens when cracks form on rock cliffs and eventually break off chunks of rock, which fall and collect at the base of the cliff in a pile known as a talus slope. These cracks can form through a number of processes, such as frost wedging and exfoliation. For more information on the physical weathering processes, watch the video tutorial on Weathering.

If a large number of rocks fall at the same time they can trap and ride atop a layer of air, which greatly reduces friction and allows them to move at speeds over 200 miles an hour. We call these movements **rock avalanches**, and because of their great speed, they can travel great distances, even up and over ridges. Rock falls and rock avalanches pose a considerable threat to communities that live in the mountains.

When a layer of rocks slides downhill along a planar surface, usually a rock bedding contact, fault, or foliation plane, it's called a **slide**. Slides can be triggered when water runs down along the bedding planes, reducing friction between them or when the base of the rock bed above the plane is excavated and thus is no longer supported.

When material on the hillside moves downhill along a curved surface, it's called a **slump** – think about what happens when you slump down in a chair.

Water can increase the likelihood of all these types of mass movement because it both reduces friction and adds weight. The more weight, the greater the force of gravity on the hillside. A little bit of water causes small particles to stick together, much like when you build sand castles on a beach. Too much, however, and it pushes them apart. When water content increases enough, it can cause the surface material to liquefy and flow. These type of mass movements where water content is high are called **flows**.

Given enough time, all hillsides will eventually fail and be eroded. What makes a particular hillside more likely than others to fail? What are some things you can look at for example if you're looking to buy property and want to know its stability? First look at the steepness of the hillside. The gentler the slope, the better. Then look at the rocks and material that make up the slope. The more solid the rock, the better. Loose, unconsolidated sediments or soils will be most likely to slump or slide. Then look at the geologic structure of the hillside. If there are bedding, foliation, or fault planes, are they parallel to the hillside? If so, they're more likely to fail than those that are perpendicular to the hillside. Is there a way for water that penetrates the hillside to easily flow out? Does it sit atop any ponds? Are there any springs? Water adds weight, so the more easily water can hit the surface and safely run off, the better. Finally, look at the vegetation. Plants with roots can help keep soils more compacted and connected, especially if the roots are deep.

What are some triggers that could start mass movement on a susceptible hillside? When the base of a rock bed is excavated, it loses its support. Excavation can happen during building of roads or highways or houses, or when rivers flood. Weight added to the top of a hillside will increase the force pushing downhill. Weight is added when houses are built on the top of the hill or when excavated sediment is piled up on the top of the hillside. Heavy rains or water leaks from reservoirs or homes at the top of a hillside can reduce friction and add weight to the hillside. A common trigger for mass movement in California is what happens when heavy rains first appear in an area that experienced a fire in the previous year and had its vegetation removed. Finally, a large shaking of the ground, like in an earthquake or explosion or through heavy foot traffic crossing a hillside, can trigger a mass movement.

In the state of California, mass movements cause the greatest financial and human impact of any natural disaster. It's a good idea to pay attention to the stability of hillsides when building structures, communities, and hiking trails.

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