

action brought on by changes in temperature (expansion and shrinkage), the freeze-thaw cycle, and the burrowing activity of animals.

Earthquakes

Earthquakes not only trigger landslides, but, over time, the tectonic activity causing them can create steep and potentially unstable slopes.

Rapid sedimentation

Rivers supply very large amounts of sediment to deltas in lakes and coastal areas. The rapidly deposited sediments are frequently underconsolidated, and have excess pore-water pressures and low strengths. Such deltaic sediments are often prone to underwater delta-front landsliding, especially where the sediments are rich in clay and/or contain gas from organic decomposition.

Wind-generated waves

Storm waves in coastal areas are known to trigger underwater landsliding in deltas by cyclically loading weak bottom sediments.

Tidal or river drawdown

Rapid lowering of water level in coastal areas or along river banks due to tides or river discharge fluctuations can cause underwater landsliding. The process in which weak river bank or deltaic sediments are left unsupported as the water level drops is known as "drawdown."

Types of Landslides

The most common types of landslides are described below. These definitions are based mainly on the work of Varnes (1978).

Falls

Falls are abrupt movements of masses of geologic materials that become detached from steep slopes or cliffs (Figures 8a, b). Movement occurs by free-fall, bouncing, and rolling. Depending on the type of earth materials involved, the result is a rockfall, soilfall, debris fall, earth fall, boulder fall, and so on. All types of falls are promoted by undercutting, differential weathering, excavation, or stream erosion.

Topple

A topple is a block of rock that tilts or rotates forward on a pivot or hinge point and then

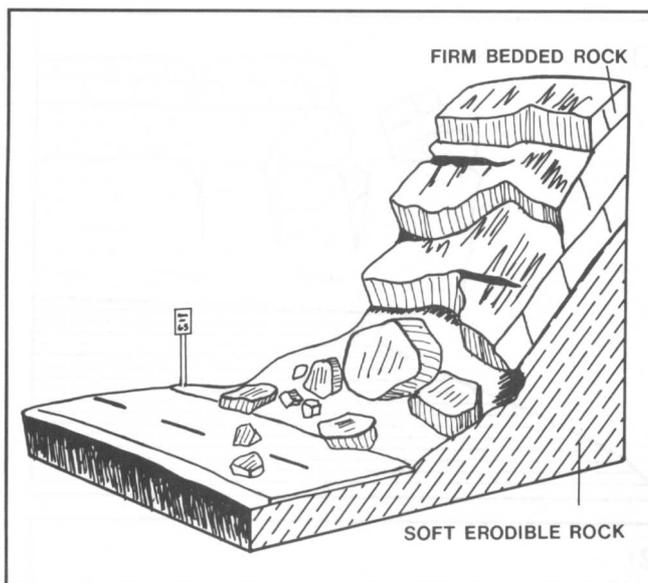


Figure 8a. Rockfall (Colorado Geological Survey et al., 1988).

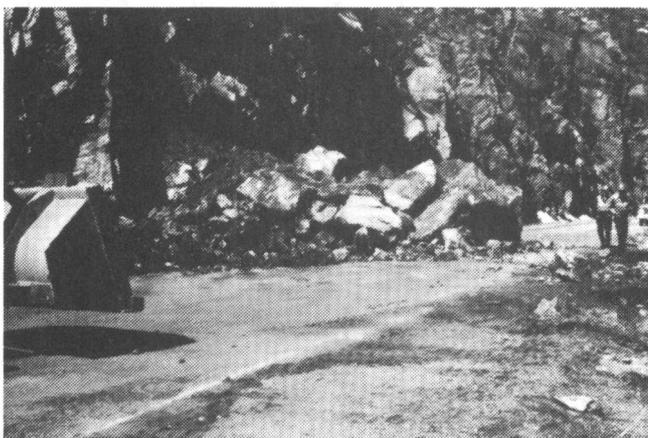


Figure 8b. Rockfall on U.S. Highway 6, Colorado (photograph by Colorado Geological Survey).

separates from the main mass, falling to the slope below, and subsequently bouncing or rolling down the slope (Figures 9a, b).

Slides

Although many types of mass movement are included in the general term "landslide," the more restrictive use of the term refers to movements of soil or rock along a distinct surface of rupture which separates the slide material from more stable underlying material. The two major types of landslides are rotational slides and translational slides.

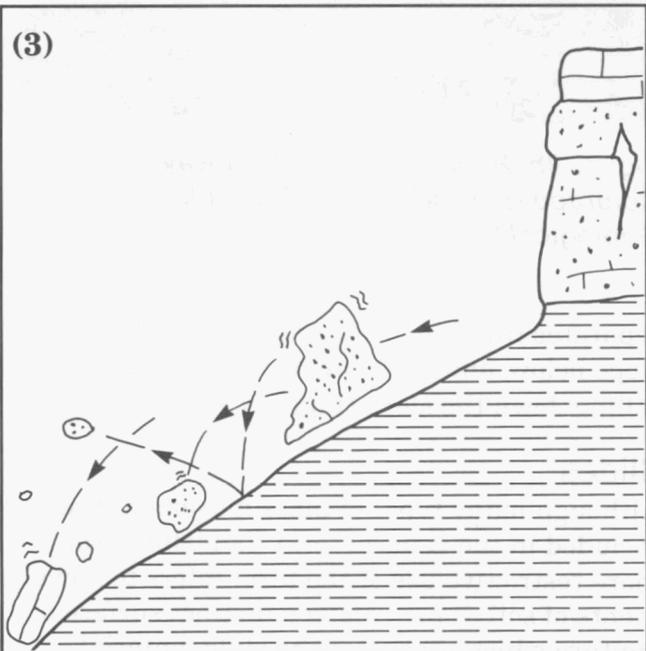
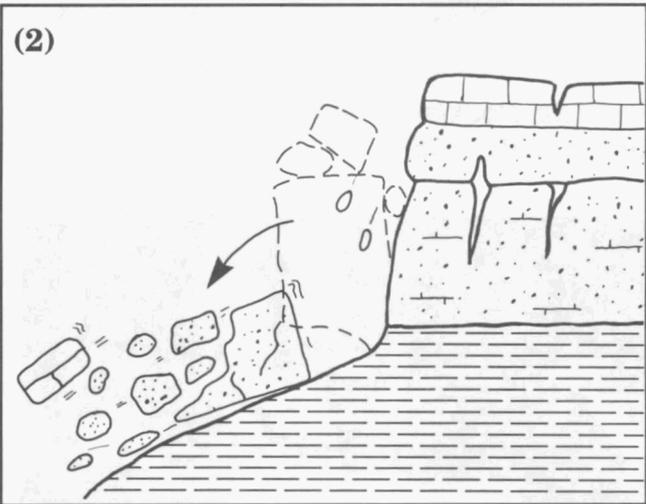
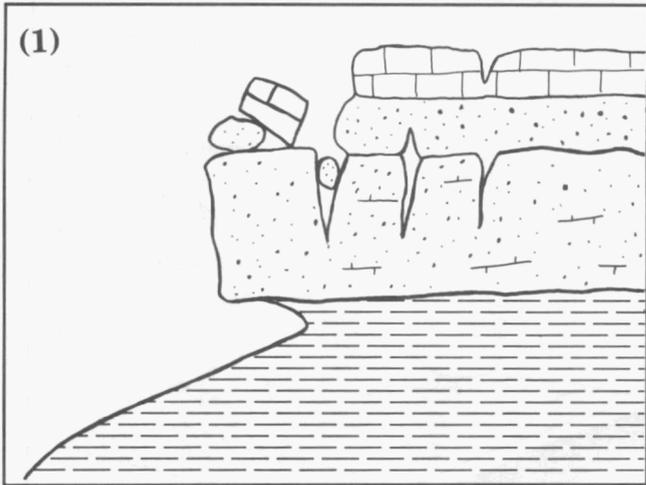


Figure 9a. Topple (Colorado Geological Survey et al., 1988).



Figure 9b. Topple, western Colorado (photograph by Colorado Geological Survey).

Rotational slide

A rotational slide is one in which the surface of rupture is curved concavely upward (spoon shaped) and the slide movement is more or less rotational about an axis that is parallel to the contour of the slope (Figures 10a, b). A "slump" is an example of a small rotational slide.

Translational slide

In a translational slide, the mass moves out, or down and outward along a relatively planar surface and has little rotational movement or backward tilting (Figure 11). The mass commonly slides out on top of the original ground surface. Such a slide may progress over great

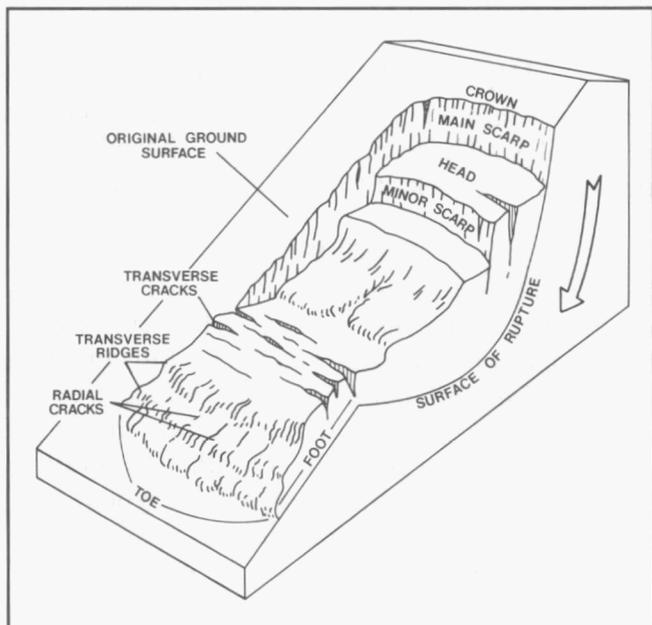


Figure 10a. Rotational landslide (modified from Varnes, 1978).