Earthflow

Earthflows have a characteristic "hourglass" shape (Figures 16a, b). A bowl or depression forms at the head where the unstable material collects and flows out. The central area is narrow and usually becomes wider as it reaches the valley floor. Flows generally occur in fine-grained materials or clay-bearing rocks on moderate slopes and with saturated conditions. However, dry flows of granular material are also possible.

Mudflow

A mudflow is an earthflow that consists of material that is wet enough to flow rapidly and that contains at least 50 percent sand-, silt-, and clay-sized particles.

Lahar

A lahar is a mudflow or debris flow that originates on the slope of a volcano. Lahars are usually triggered by such things as heavy rainfall eroding volcanic deposits; sudden melting of snow and ice due to heat from volcanic vents; or by the breakout of water from glaciers, crater lakes, or lakes dammed by volcanic eruptions.

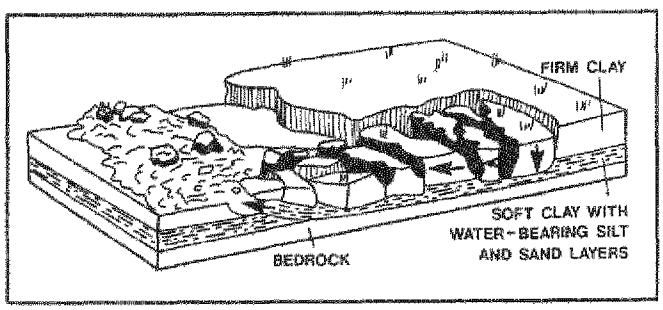

Figure 13a. Lateral spread (Colorado Geological Survey et al., 1988).

Figure 13b. Lateral spread, Cortez, Colorado. (Photograph by Colorado Geological Survey).

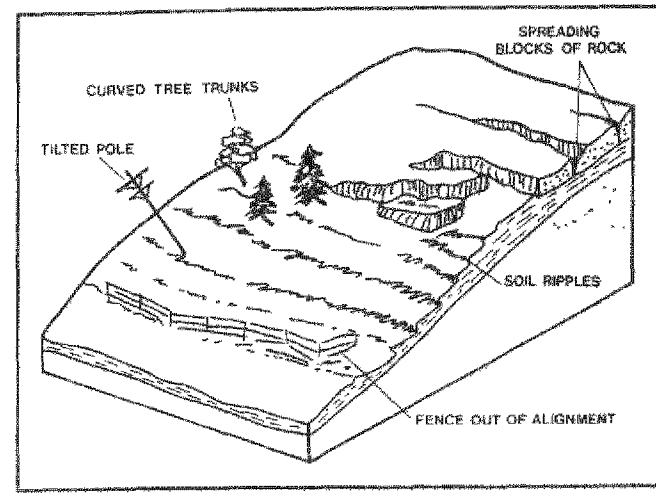

Figure 14a. Creep (Colorado Geological Survey et al., 1988).

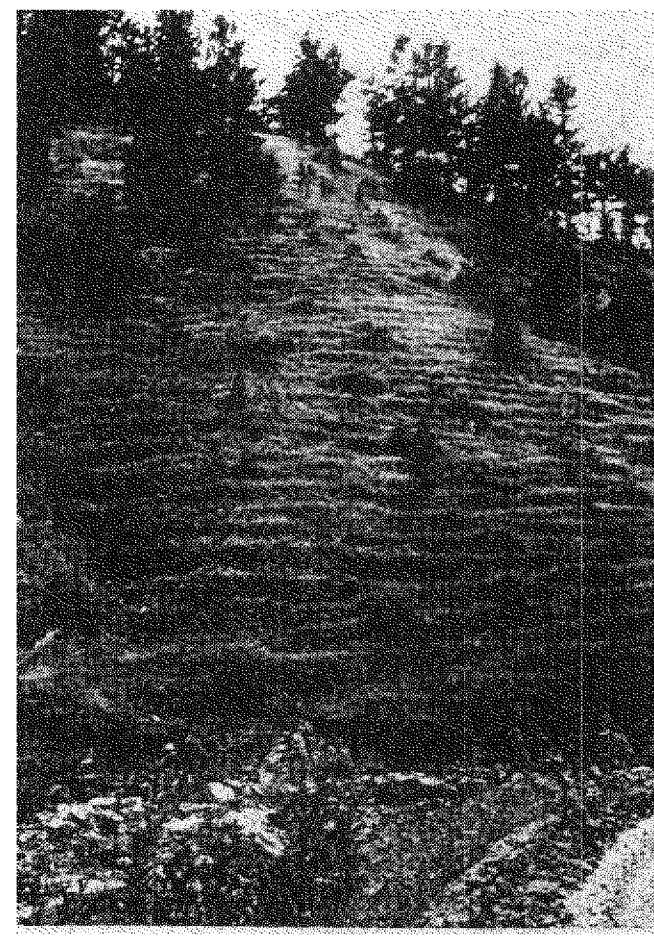

Figure 14b. Creep, vicinity of Mt. Vernon Canyon, Jefferson County, Colorado (photograph by Colorado Geological Survey).

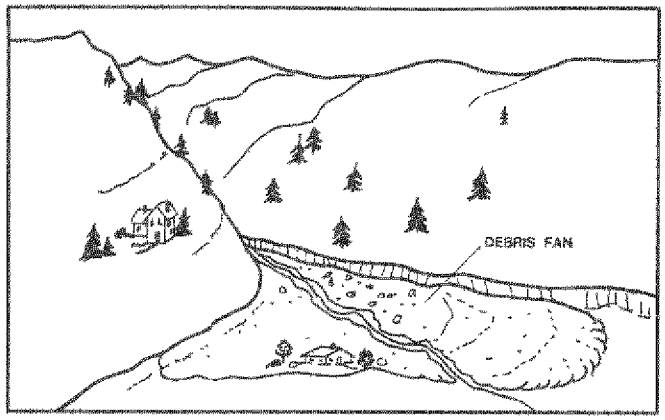

Figure 15. Debris fan formed by debris flows (Colorado Geological Survey et al., 1988).

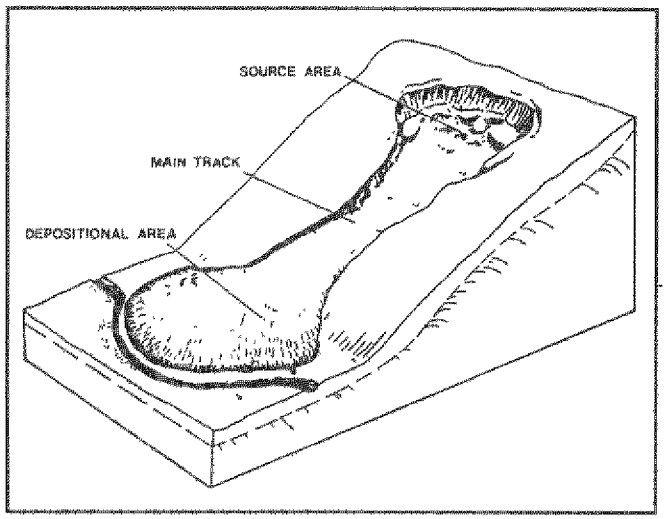

Figure 16a. Earthflow (modified from Varnes, 1978).

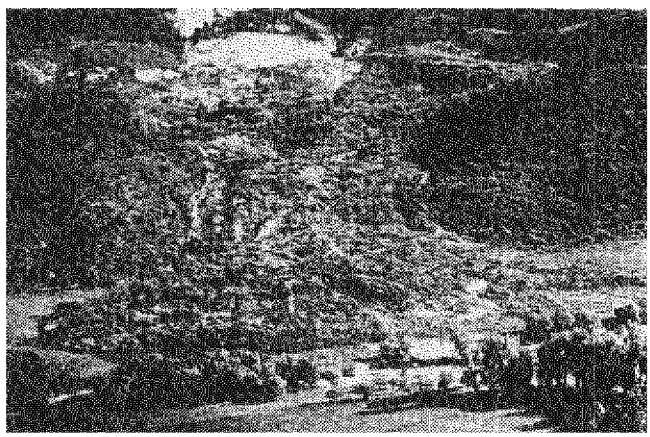

Figure 16b. Roan Creek earthflow near DeBeque, Colorado, 1985 (photograph by Colorado Geological Survey).

Subaqueous landslide *

Landslides which take place principally or totally underwater in lakes, along river banks, or in coastal and offshore marine areas are called subaqueous landslides. The failure of subaqueous slopes may result from a variety of factors acting singly or together, including rapid lacustrine or marine sedimentation, biogenic methane gas in sediments, surface water storm waves, current scour, water level drawdown, depositional oversteeping, or earthquake stresses. Many different types of subaqueous landslides have been identified in different locations, including rotational and translational slides, debris flows and mudflows, sand and silt liquefaction flows. There is also evidence that, in some circumstances, subaqueous landslides evolve into or initiate turbidity currents, which may flow underwater at high speeds for long distances. Subaqueous landslides pose problems for offshore and river engineering, particularly for the construction and maintenance of jetties, piers, levees, offshore platforms and facilities, and for sea-bed installations such as pipelines and telecommunications cables.

Interrelationship of Landsliding with Other Natural Hazards (The Multiple Hazard Concept)

Natural hazards often occur simultaneously or, in some cases, one hazard triggers another. For example, an earthquake may trigger a landslide, which in turn may block a valley causing upstream flooding. Different hazards may also occur at the same time as the result of a common cause. For example, heavy precipitation or rapid snowmelt can cause debris flows and flooding in the same area.

The simultaneous or sequential occurrence of interactive hazards may produce cumulative effects that differ significantly from those expected from any one of the component hazards.

Landsliding and Dam Safety

The safety of a dam can be severely compromised by landsliding upstream from the dam or on slopes bordering the dam's reservoir or abutments. Possible impacts include (1) the forma-

*Discussion by D.B. Prior