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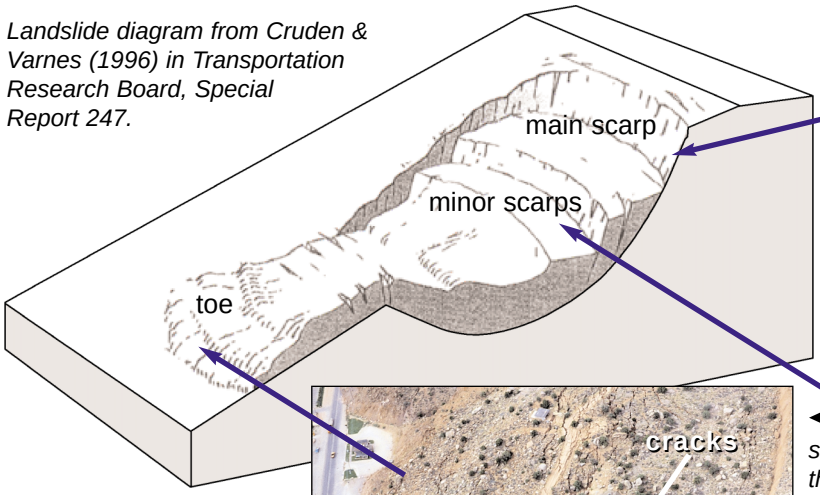
Landslides: What they are, why they occur

by William F. Case

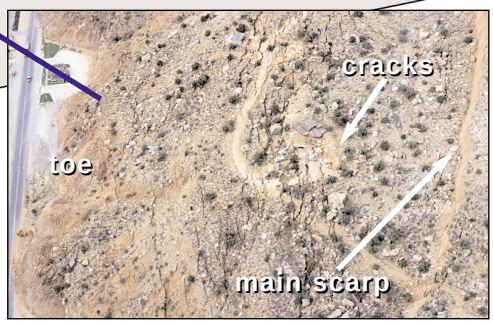
What is a slide?

Landslides occur as gravitational forces exceed the strength of material in a slope. Rock slides, debris slides, and slumps "slide" on a weak, fractured, slick, clayey, or water-saturated planar or curved (spoon-shaped) slip surface. As a landslide moves downslope, the ground surface cracks, tilts, and drops.

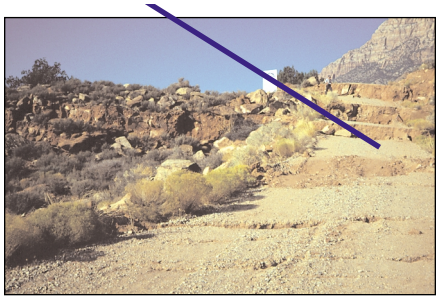
Landslide diagram from Cruden & Varnes (1996) in Transportation Research Board, Special Report 247.



The main landslide scarp is almost 40 feet high. Grooves were produced by grinding of rocks when the slide moved.



◀ *Aerial view of the toe, cracks, and main scarp. Note that the landslide moved onto the highway (lower left of photograph).*



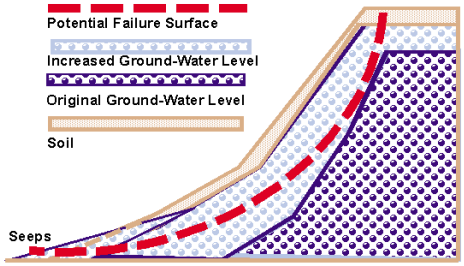
Minor internal landslide scarps in a subdivision road.

Anatomy of a landslide: Springdale landslide, Washington County

The Springdale landslide was triggered by a magnitude 5.8 earthquake that occurred near St. George on September 2, 1992. Eighteen million cubic yards of landslide material moved downslope destroying two water tanks and three houses.

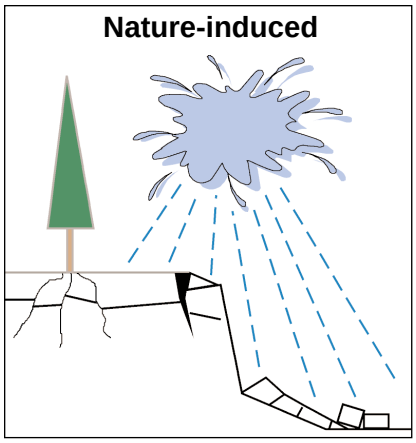
Why do landslides occur?

Landslides most often occur as ground water builds up in a slope due to rain, snowmelt, or landscape irrigation. This water increases the weight of the material in the slope, increases the pore pressure, hydrates and expands clay minerals, dissolves minerals that may hold particles together, and decreases the strength of the material, all of which weaken the slope.

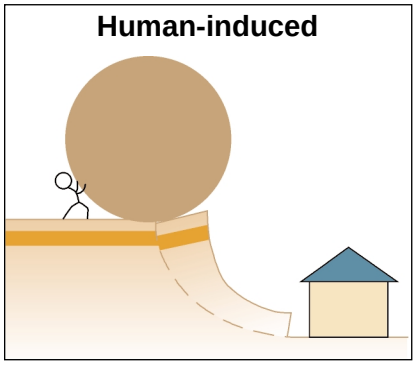


The potential for landsliding increases when groundwater levels rise due to rain, snowmelt, or landscape irrigation.

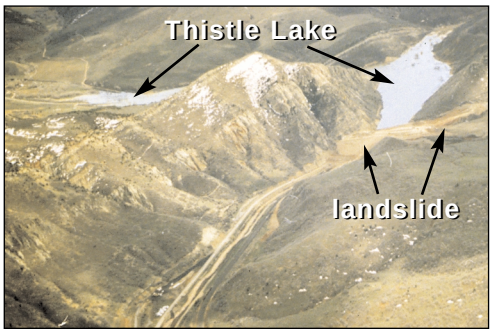
Steepening of a slope or removal of support at the toe by stream erosion or excavation also decreases slope stability. Stress increas-



Over time, ice, rain, and biological action weather rock and soil, lowering their strength.

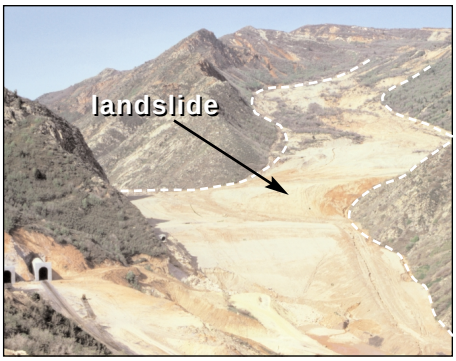


Loading the crest or excavating the toe of a slope can produce a landslide.



Aerial view looking southeast of Thistle landslide, 1983, Spanish Fork Canyon, Utah County. The landslide dammed the Spanish Fork River drowning the town of Thistle with the 200-foot-deep temporary Thistle lake. The landslide is still active; significant movement occurred in 1998.

In 1983, the wettest year ever recorded in Utah, the Thistle landslide slid into history as the most expensive landslide ever in the United States. When it finally stopped and abutted against the opposite canyon wall in Spanish Fork Canyon, Utah County, it dammed the Spanish Fork River; the resulting "Thistle Lake" submerged the town of Thistle. The landside also severed a major federal highway and an important railroad line. The 1983 Thistle landslide resulted in the first U.S. Presidential Disaster Declaration in Utah since statehood. The total cost of the landslide damage, including re-routing the highway and railroad, was several hundred million dollars.



Thistle landslide, May 14, 1984. new railroad tunnels and tracks visible on the left bypass the landslide. Photograph by Robert L. Schuster, U.S. Geological Survey.

es in a slope that is loaded with embankments, fills, buildings, or waste dumps, particularly when loads are near the top of the slope. Also, the pore pressure from ground water in a slope increases during vibration of large machines or earthquakes. Rapid changes of water level in reservoirs or streams also may trigger landslides along shorelines or stream banks. Landslides that have not moved for years commonly reactivate if ground-water levels change dramatically, particularly when water penetrates old ground cracks, or construction activity creates slope modification that reduces stability.

How can the slide risk be reduced?

The risk may be reduced by avoiding construction on steep slopes and existing landslides, or by stabilizing the slope. Stability increases when ground water is prevented from rising in the slide mass by (1) covering the landslide with an impermeable membrane, (2) directing surface water away from the landslide, (3) draining ground water away from the landslide to reduce the potential for a rise in ground-water level, and/or (4) minimizing surface irrigation. Slope stability is also increased when weight or retaining structures are placed at the toe of the landslide or when mass is removed from the top of the slope.

To find out more about landslides near you or on your property contact:

The home office of the Utah Geological Survey (UGS) at PO Box 146100, Salt Lake City, UT 84114-6100, phone 801-537-3300, FAX 801-537-3400, www.ugs.state.us. The office is at 1594 West North Temple, Salt Lake City. The Southern Utah Regional Office of the UGS: Electronic Learning Center, Room 103, Southern Utah University, Box 9053, Cedar City, UT 84720, phone 435-865-8126, lund@suu.edu. Also contact your city, county, or regional planning departments, or "geologists, geotechnical engineers" in the phone book.