Figure 18. Jackson Springs landslide on the Spokane arm of Franklin D. Roosevelt Lake, Washington, 1969. This landslide was triggered by extreme drawdown of the lake (photograph by the U.S. Bureau of Reclamation).

monitoring instruments were set up on the slope.In August and September of 1963, precipitation in the Piave Valley was three times higher than normal and infiltration of the precipitation into the slope probably contributed to its eventual failure. The day before the catastrophic slope failure creep rates of 40cm/day were registered.

On October 9–10, 1963, in the night, a large slab of the unstable slope failed and slipped into the reservoir. The volume of material was estimated to be 250 x 10^6 m^3 (a slab 250 m thick). A wall of water 250 m high surged up the opposite side of the valley, then turned and overtopped the dam. The concrete dam held, and the wall of water (30 x 10^6 m^3) dropped into the narrow gorge below, scouring loose debris as it went and destroying several communities below the dam. At least 1,900 people were killed.

The site of the dam has been left as it remained after the disaster, as a monument.

Landsliding and Flooding

Landsliding and flooding are closely allied because both are related to precipitation, runoff, and ground saturation. In addition, debris flows usually occur in small, steep stream channels and often are mistaken for floods. In fact, these events frequently occur simultaneously in the same area, and there is no distinct line differentiating the two phenomena.

Landslides and debris flows can cause flooding by forming landslide dams that block valleys and stream channels, allowing large amounts of water to back-up (Figure 19). This causes backwater flooding and, if the dam breaks, subsequent downstream flooding. Also, soil and debris from landslides can "bulk" or add volume to otherwise normal stream flow or cause channel blockages and diversions creating flood conditions or localized erosion. Finally, large landslides can negate the protective functions of a dam by reducing reservoir capacity or creating surge waves that can overtop a dam, resulting in downstream flooding (as described above).

In turn, flooding can cause landsliding. Erosion, due to rapidly moving flood waters, often undercuts slopes or cliffs. Once support is removed from the base of saturated slopes, landsliding often ensues.

Landsliding and Seismic Activity

Most of the mountainous areas that are vulnerable to landslides have also experienced at least moderate seismicity in historic times. The occurrence of earthquakes in steep landslide-prone areas greatly increases the likelihood that landslides will occur and increases the risk of serious damage far beyond that posed individually by the two processes. Landslide materials can be dilated by seismic activity and thus be subject to rapid infiltration during rainfall and snowmelt. Some areas of high seismic potential such as the New Madrid Seismic Zone of the lower Mississippi River valley may be subject to liquefaction and related ground failure.The Great Alaska Earthquake of March 27, 1964 caused an estimated $300 million in damages. As mentioned eariler, 60 percent of this was due to ground failure. Five landslides caused about $50 million damage in the city of Anchorage. Lateral spread failures damaged highways, railroads, and bridges, costing another $50 million. Flow failures in three Alaskan ports carried away docks, warehouses, and adjacent transportation facilities accounting for another $15

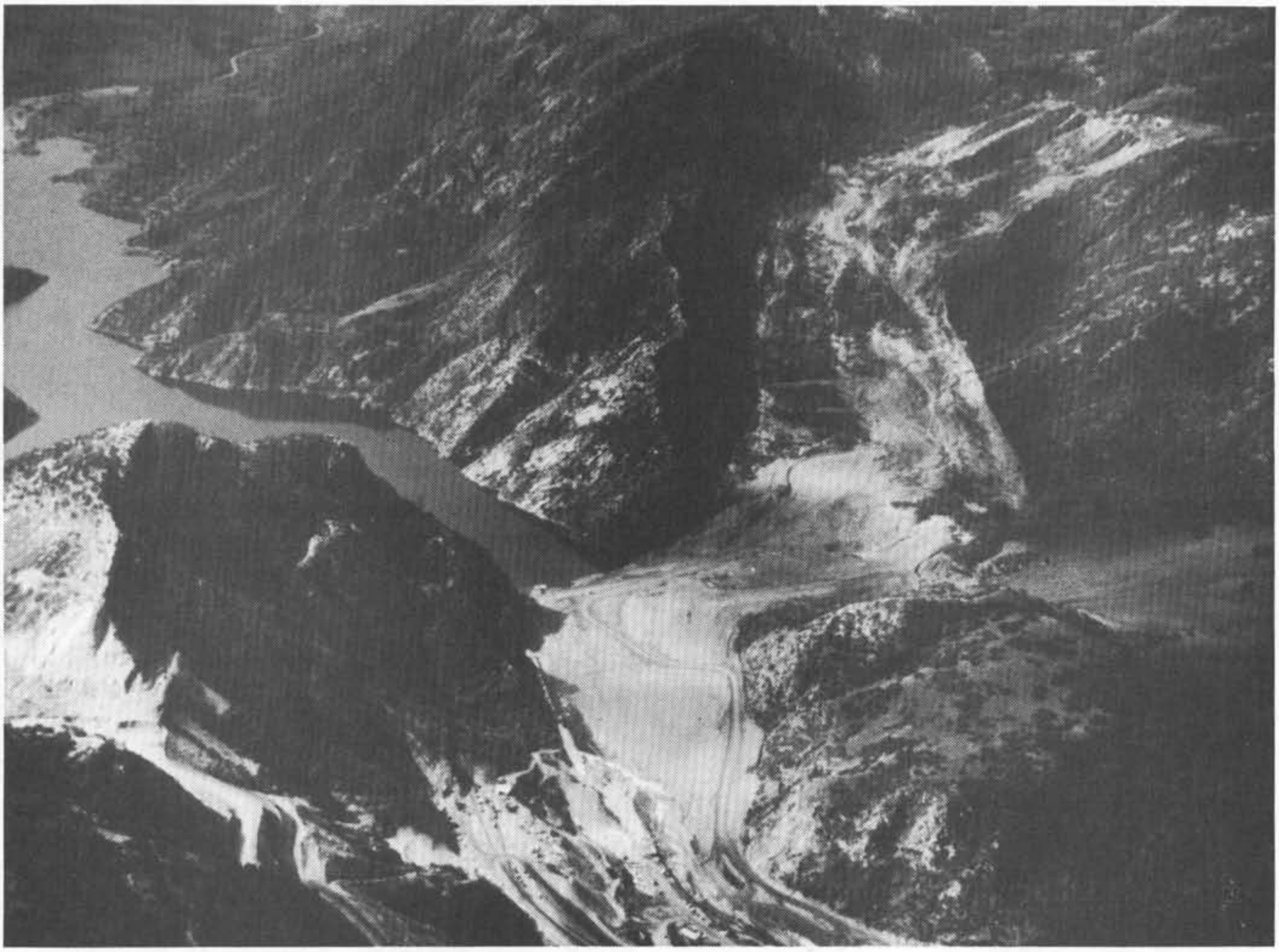

Figure 19. Aerial view of the Thistle landslide, Utah, 1983. This landslide dammed the Spanish Fork River creating a lake which inundated the town of Thistle and severed three major transportation arteries (photograph by Robert L. Schuster, U.S. Geological Survey).

million. Much of the landsliding was a direct result of the effect of the severe ground shaking on the Bootlegger Cove Formation. The shaking caused loss of strength in clays and liquefaction in sand and silt lenses (U.S. Geological Survey, 1981a).

Landsliding and Volcanic Activity

The May 18, 1980 eruption of Mount St. Helens in Washington state triggered a massive landslide on the north flank of the mountain. The volume of material moved was estimated to be 2.73 km^3. The landslide effectively depressurized the interior of the volcano; superheated waters turned into steam and magmatic gases also expanded, resulting in a giant explosion (U.S. Geological Survey, 1981b).

Because human activity had been restricted in the Mount St. Helens area due to predictions of an eruption, loss of life was minimized. However, the eruption devastated land as far as 29 km from the volcano. The resulting lateral blast, landslides, debris avalanches, debris flows, and flooding took 57 lives and caused an estimated $860 million in damage (Advisory Committee on the International Decade for Natural Hazard Reduction, 1987). ❑