VOLCANO HAZARDS

A public awareness information sheet

U.S. DEPARTMENT OF THE INTERIOR
U.S. Geological Survey

HISTORY OF LANDSLIDES AND DEBRIS FLOWS AT MOUNT RAINIER

Many landslides and debris flows have originated from Mount Rainier since the retreat of glaciers from Puget Sound about 10,000 years ago. The recurrent instability is due to several factors—height of the steep-sided volcanic cone, frequent volcanic activity, continuous weakening of rock by steam and hot, chemical-laden water, and exposure of unstable areas as the mountain's glaciers have receded. The landslide scars and deposits tell a fascinating story of the changing shape of the volcano (fig.1).

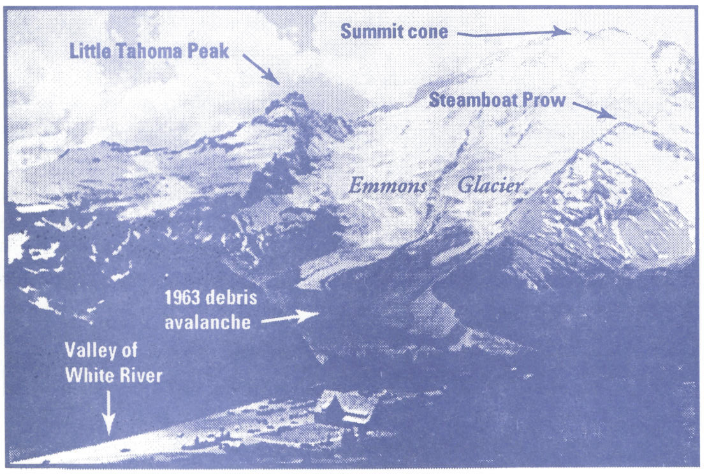

Fig. 1 - View of east side of Mount Rainier, showing area of failure of the Osceola Mudflow. The crater left by the flow was later filled by volcanic formation of the snow-clad summit cone. The Osceola Mudflow overran Steamboat Prow and split into branches down the White River and West Fork White River (right of photo). Landslide from Little Tahoma Peak in 1963 formed dark material on lower Emmons Glacier.

Landslides occur when part of the volcano "collapses" or fails and slides away from the rest of the volcano. The failed mass rapidly breaks up into a jumble of disaggregated pieces that flow at high velocity like a fluid. Clay and water in the debris cause further change to a liquid slurry known as a debris flow or mudflow. Volcanic debris flows are also widely known by the Indonesian term "lahar." Although the largest debris flows at Rainier form from landslides, many smaller flows are caused by volcanic eruptions, intense rainfall, and glacial-outburst floods.

Debris flows look and act like wet, flowing concrete—they are about 30 percent water. Velocities of large debris flows can reach more than 50 meters per second (110 miles per hour) on the volcano's steep flanks. Velocities of small flows like those in Tahoma Creek (fig.2) are commonly in the range of 5 to 10 meters per second (10 to 20 miles per hour).

Landslides on the volcano leave arcuate scars like the Sunset Amphitheater. The landslide producing the huge Osceola Mudflow removed the top 600 meters (2,000 feet) of Mount Rainier, leaving a summit crater. Subsequent volcanic eruptions created the modern summit cone within the crater (fig.1).

The largest debris flows that formed from landslides have extended as far from Mount Rainier as Puget Sound, flowing through now-populated areas. Large debris flows have occurred frequently enough (averaging every 500 to 1,000 years) so that planners are concerned about unlimited growth and the locations of long-lasting structures like power plants and water-storage reservoirs in valley bottoms.

Deposits of debris flows can be seen in roadcuts and river banks in valley bottoms around the volcano. They consist of a concrete-like mixture of pebbles and larger rocks dispersed in finer-grained sandy and muddy material. Deposits may contain large chunks of a landslide that did not break up into a debris flow; these blocks form mounds up to 10 meters (33 feet) high on the deposit surface.

Debris flows may be grouped in three size categories, each with a generally distinctive origin:

SMALL, FREQUENT FLOWS—Best known are the debris flows that formed from surges of water originating from glaciers and associated with either rainfall or glacier meltwater. These water surges rapidly erode loose sediment to form a debris flow. Examples occur annually in Tahoma Creek, where boulder-rich deposits can be seen along the West Side Road. By the time

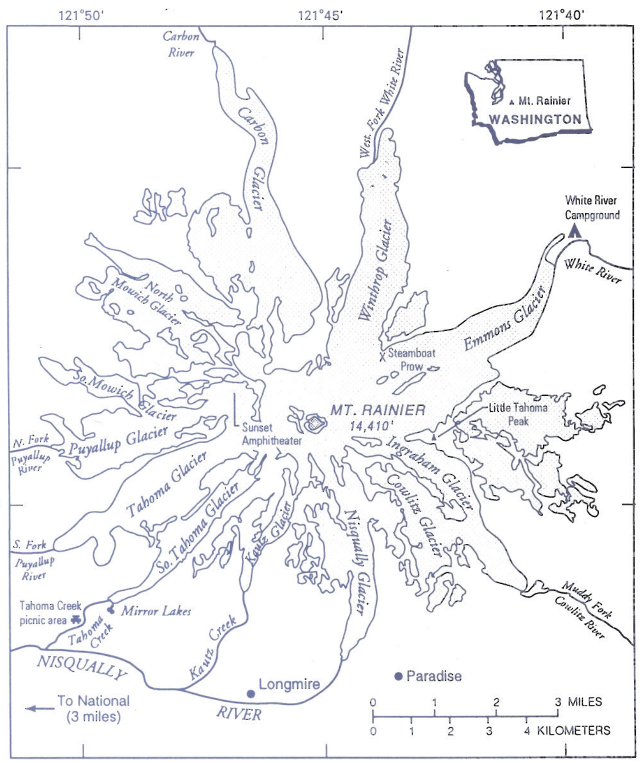

Fig. 2 - Topographic features on Mount Rainier.

these flows reach the main park highway, most coarse sediment has been deposited. See the companion Water Fact Sheet (Driedger and Walder, 1991) for descriptions of these flows.

Some small, frequent flows are derived from shallow landslides. Because hot, acid-rich fluids percolate throughout the interior of the volcano, rock deep beneath the surface is more highly altered than surficial material; therefore, shallow landslides generally will contain less water and clay (formed by alteration) and thus will be less likely to form debris flows than large landslides that deeply penetrate the volcano. The large landslides contain much water and clay and generally will readily mobilize to debris flows.

An easily viewed example of a small landslide that did not completely change to a debris flow is present on and below the end of the Emmons Glacier in the White River (fig.1). That flow occurred in December, 1963 from Little Tahoma Peak and traveled to within 1.0 kilometer (0.6 mile) of the White River Campground. An easy trail leads to the edge of the landslide debris where we can see the variation in rock type, from blocks of hard, unaltered lava to soft, highly altered rock. Structures preserved in the blocks range from intricate banding recording the flow of lavas to layers of explosively created fragments.

FLOWS INTERMEDIATE IN SIZE AND FREQUENCY—Modern examples are the series of flows in Kautz Creek on October 2-3, 1947. A "ghost forest" of trees killed by flows can be seen where the park road was buried for a distance of 0.9 kilometer (0.5 mile). At the bridge, the previous channel was buried by 9 meters (28 feet) of boulder gravel. This flow series began as water surges originating by collapse, during heavy rain, of the terminal 1.0 kilometer (0.6 mile) of the Kautz glacier. The largest 1947 flow continued in the Nisqually River to the park boundary, 15 kilometers (9 miles) downstream from the glacier.

The largest flows in this category also began as surges of water, but in these cases surges of water formed from melting of snow and ice by volcanic activity. Although flows of this type have occurred throughout history of Mount Rainier, they were especially common during the period of volcanism that formed the summit cone (fig.1) from about 2,200 to 700 years ago. The National Lahar is a large, distinctive example with yellow, sandy deposits that are best seen in roadcuts along the Nisqually River outside the park. The flow can be traced 95 kilometers (59 miles) to Puget Sound.

LARGE BUT INFREQUENT FLOWS—Debris flows are distributed over time like floods. The largest ones are also the rarest. Although the largest flows recur with the lowest frequency, planners may consider their potential for widespread impact to impose too high a level of risk for certain types of structures and development in some downstream areas.

By far the largest flow in the history of Mount Rainier is the Osceola Mudflow (fig.3). About 5,000 years ago, a huge landslide removed 3 cubic kilometers (0.7 cubic miles) from the summit of Mount Rainier. The landslide penetrated highly altered rock in the core of the volcano, and the huge clay-rich mass mobilized almost immediately to a debris flow. Large blocks of the landslide form numerous mounds in lateral deposits along the White River valley before spreading of the flow over a wide area of the Puget Sound Lowland (fig.3). Osceola deposits occur along trails near the White River Campground.

As you hike the trails around Paradise, look for widespread surficial deposits of a debris flow with scattered yellowish boulders. The Paradise Lahar overran much of the area around the visitor center, and was nearly 300 meters (980 feet) deep in surrounding valleys. The flow probably occurred at the same time as the Osceola Mudflow.

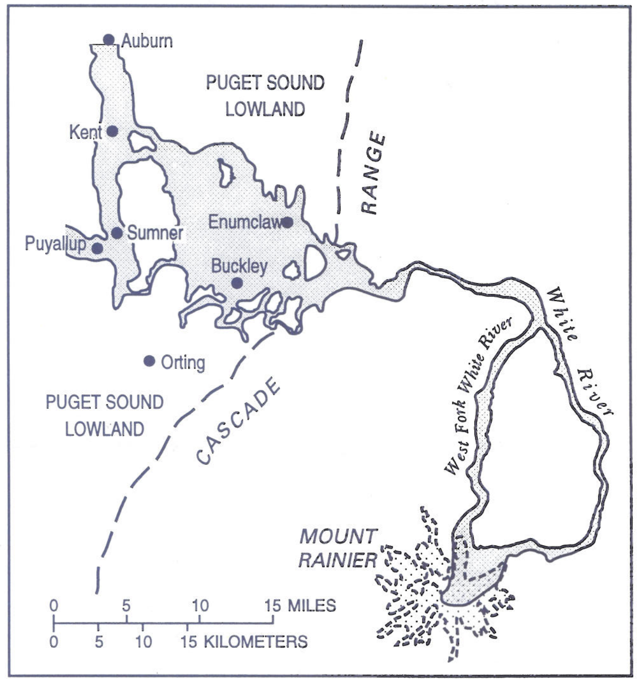

Fig. 3 – Osceola Mudflow

Several large flows in the Puyallup River drainage originated from the Sunset Amphitheater. The most typical example is the Electron Mudflow. Deposits of that flow, which occurred about 500 years ago, form the valley surface around Orting.

Large, generally clay-rich debris flows that originated as landslides have occurred, on average, every 500 to 1,000 years during the last 6,000 years at Mount Rainier. Because most Rainier landslides in the past have not been clearly associated with eruptions, it is unlikely that precursory volcanic activity will provide a warning of future flows Most potential landslide triggers, including large earthquakes in the Pacific Northwest, can occur without warning.

PRECAUTIONS FOR VISITORS—Observe warning signs and instructions posted by the National Park Service. Avoid camping in valley bottoms on the flanks of the volcano, unless in a designated campground. Follow the advice in the companion water-fact sheet by Driedger and Walder (1991).

FURTHER READING

Crandell, D.R., 1971, Postglacial lahars from Mount Rainier volcano, Washington: U.S.Geological Survey Professional Paper 677, 75 p.

Crandell, D.R., and Fahnestock, R. K., 1965, Rockfalls and avalanches from Little Tahoma Peak on Mount Rainier, Washington: U.S. Geological Survey Bulletin 1221-A,30 p.

Driedger, C. L., and Walder, J. S., 1991, Recent debris flows at Mount Rainier: U.S. Geological Survey Open-File Report 91-242, 2 p.

Scott, K. M., Pringle, P. T., and Vallance, J. W., 1992, Sedimentology, behavior, and hazards of debris flows at Mount Rainier, Washington: U.S. Geological Survey Open-File Report 90-385, 106 p.

—K.M. Scott and J.W. Vallance

For additional information, contact:
U.S. Geological Survey
Cascades Volcano Observatory
5400 MacArthur Boulevard
Vancouver, Washington 98661
Telephone (360) 696-7693 FAX (360) 696-7866