# Teacher Background

### *Glaciers and Mount Rainier co-exist as a dynamic system*

Mount Rainier distinguishes itself among other Cascade ***volcanoes*** because of its widespread high-altitude slopes and extensive snow and ice cover. About 88 square kilometers (34 square miles) of snow and ice cover the mountain at summer's end. ***Glaciers*** have covered Mount Rainier over much of the volcano's 500,000-year lifespan, creating a dynamic system. The volcano provides high-elevation slopes that are conducive to glacier formation and glacial ***erosion***. ***Volcanic eruptions*** can melt snow and ice, even while glaciers influence the movement of ***lava flows***. A general list of mechanisms of influence between glaciers and volcanoes is shown in the sidebar. This information is depicted in graphics ***"Glaciers on Mount Rainier," "Columbia Crest Summit,"*** and ***"Glacier-Volcano Interactions."***

## Sidebar 1 Mechanisms of Influence-Glaciers and Volcanoes

| *A Volcano's Influences upon its Glaciers* | *A Glacier's Influence upon its Volcano* |
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| Mount Rainier is an obstacle to moisture-laden air from the Pacific Ocean. The air is forced to rise, cool, and drop its moisture. | Rock debris embedded in ice at the bottom and margins of a glacier mechanically erodes surrounding rocks. |
| Frequent cold temperatures on high-altitude slopes provide an ideal environment for snow retention and transformation to glacier ice. | Glacial meltwater streams remove and transport loose rock from the mountain. |
| Extensive slopes of rugged volcanic terrain trap blowing snow and contribute to snow retention and glacier formation. | Glaciers can influence the distribution of lava flows. |
| Volcanic eruptions melt snow and ice. | Glaciers provide meltwater for formation of debris flows and lahars, which alter the volcano's landscape. |

### *Ice-age glaciers envelop Mount Rainier*

To understand the extent to which hot volcanic rocks have interacted with surrounding glaciers, we need to put on our “glacier glasses” and envision landscapes largely buried by ice. During ***ice ages*** that occurred repeatedly between approximately 1.8 million and 11,000 years ago, large ice sheets covered northern Europe and much of Canada and the northern United States, including the Puget Sound area. Mountain ranges in the western United States, including the Cascades were mantled by extensive glaciers. Some of the glaciers on Mount Rainier were hundreds of meters (1,000 feet or more) thick on the flanks of the volcano and almost 1,000 meters (3,000 feet) thick in valleys at the base of the cone. Mountain glaciers coalesced and flowed for one hundred kilometers (sixty miles). Glacier ice covered the locations of the present day communities of Ashford, Alder, Greenwater, and Carbonado. Around 15,000 years ago, these enormous glaciers began to thin and recede into existing valleys. Their descendents cover much of Mount Rainier today. View the extents of glaciers then and now in the graphic ***“ Maximum Extent of Glaciers on Mount Rainier During the Ice Ages.”***

### *Mount Rainier erupted repeatedly while buried by ice-age glaciers*

Mount Rainier erupted repeatedly during past ice ages. The co-existence of volcanic and glacial processes led to a variety of interactions that shaped the mountain in a unique way. The origins of these features can be understood only when the interactions of the glaciers and volcanic forces are recognized.

### *When lava meets ice*

During times of extensive glaciation, ***lava*** poured repeatedly from the summit ***vent*** of Mount Rainier and encountered glaciers. In the contest between lava flows, rock, and ice, glaciers at first appear to be less durable. In theory, a lava flow can melt about ten times its volume of ice, though it rarely does so. We commonly think of lava flows as bullish, relentless, and unstoppable. However, observations at ice-clad volcanoes around the world prove that glaciers can survive the onslaught of heat from lava flows. In some situations, glaciers can exert some control over the movement of lava flows, and as such are the architects of Mount Rainier. Consider these mechanisms.

- ***Lava flows tumble and disintegrate on steep slopes*** – Lava that flows over steep slopes often breaks apart and plunges onto the glacier, where it cools as rock debris. Sometimes the fragmenting lava flow forms a turbulent avalanche of scorching hot rock and gas called a ***pyroclastic flow***, which can sweep across the snow and ice. Incorporation of snow and ice into the pyroclastic flow can cause the flow to transform into a volcanic mudflow ***(lahar)***. Lahar layers are found in river valleys that extend from Mount Rainier.

- ***Ice-age glaciers act as physical and thermal barriers to lava flows*** – An advancing lava flow melts downward through thick ice until it contacts bedrock, where it chills and hardens, confined within the glacier. After the eruption, glacier ice often flows across the hardened lava flow. By this mechanism, Mount Rainier gains volume, and retains its glacier cover. Some of these lava flows, now partially eroded, are visible as ledges on the flanks of Mount Rainier.

- ***Thin ice and ice-free regions allow lava flows to travel far*** – Lava encounters less resistance in the thin ice and ice-free ridges between thick valley glaciers. The lava flow's outer skin cools and hardens, while the interior of the flow remains fluid and travels many kilometers (miles) from the base of the volcano. Over time, successive stacks of elongated lava flows have built ridges—from the bottom up—in a pattern that radiates from the cone of Mount Rainier. Paradise Ridge, Mazama Ridge, Rampart Ridge, and Emerald Ridge are some examples of this phenomenon. This interaction is depicted in the graphic ***"How Lava Ridges are Made."*** The phenomenon can happen only when glaciers envelop Mount Rainier, such as during an ice age.

### *More about glaciers*

A glacier is a large mass of flowing ice formed by the compaction and recrystallization of snow that has accumulated over a period of years. When snow crystals land atop one another their fragile edges snap and break. Pressure from overlying snowpack settles the crystals, squeezes out adjacent air pockets, forces them to liquify and then recrystallize as ice. By these processes, delicate snow crystals transform into a strong lattice of ice crystals that has sufficient strength to transform the landscape.

### *Glaciers as sculptors*

Glaciers are well known as sculptors of the landscape, but the true artist is rock debris encased within the ice. Landslides and rock fall produce rock debris that drops onto the glacier surface. Winter snow falls bury the rock debris. Snow surrounding this rock debris transforms to ice. Eventually some of the entrapped rocks touch the valley floor and walls where they scrape and polish, as with grit in a gem polishing machine. Millennia of erosion by glaciers are responsible in part for the characteristic U-shaped valleys. See glacial scratches (***striations***) depicted in the graphic ***"Glacial Scratches (Striations) on Lava Rock at Mount Rainier."***

### *Present-day glaciers at Mount Rainier*

While Ice-Age glaciers have thinned and receded dramatically over the last 15, 000 years, Mount Rainier still hosts one of North America's largest single peak glacier systems. The present glaciers consist of approximately 4.4 cubic kilometers (one cubic mile). For scale, imagine an ice cream scoop the size of Seattle's Safeco Field sports stadium. Removing all the perennial (long-lasting) snow and glacier ice from Mount Rainier would require 2,600 stadium-sized scoops! Envision this also as an ice cube one mile on a side. The volume of perennial snow and glacier ice on Mount Rainier is equivalent to the amount of ice on all the other Cascade volcanoes combined.