Center for Mathematics and Science Education

Teacher Resource Bulletin

These circulars are prepared by the students, faculty, and staff of California State University, Chico, as a service to teachers of northeastern California. The goals are to help teachers keep informed about current issues and to utilize local features and topics in their classrooms.

Glaciers of Mount Shasta

by Frances Biles

INTRODUCTION

Mount Shasta, located about 40 miles south of the Oregon border in north central California, is one of the major peaks in the Cascade Range (figure 1). Rising 14,162 feet above the sea and visible for more than 100 miles, the mountain is indeed a majestic sight. Mount Shasta is one of the largest stratovolcanoes in the world—not because of its height, but because of its massive 83 cubic-mile volume (see the regional information circular *Volcanic Mountains of Northeastern California*). One of Mount Shasta's outstanding features is its glaciers.

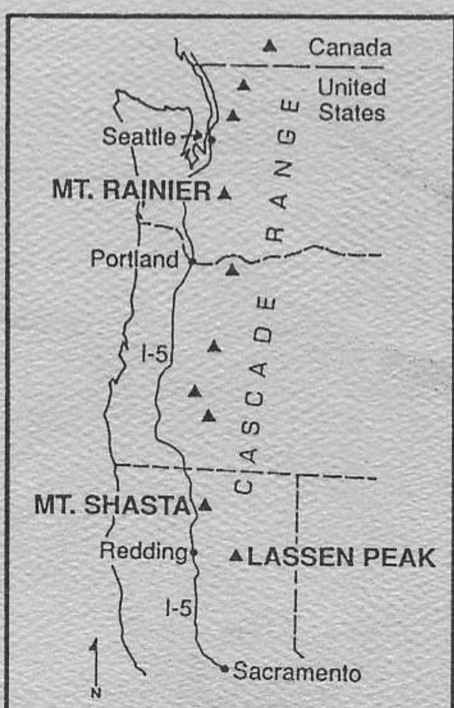

Figure 1. Mt. Shasta and the Cascade Volcanoes.

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BACKGROUND INFORMATION

Glaciers in the United States

Diverse California, land of sunshine and beaches, has approximately 80 glaciers, which are located in the Sierra Nevada and the Trinity Alps, as well as on Mount Shasta. Oregon, Washington, Wyoming, Montana, and Colorado also have glaciers, and patches of ice in Idaho, Utah, and Nevada may or may not be considered glaciers at the present time. Altogether, there are approximately 1,100 glaciers in the western states and 5,000 or so glaciers in Alaska; these are the only places where glaciers are found in the United States (figure 2).

Figure 2. Location of Glaciers in the United States, excluding Alaska.

Mount Shasta's glaciers, as well as the rest of the glaciers in California, are very small compared to those found in Alaska. For example, Alaska's (and the nation's) largest glacier, the Bering glacier, is 127 miles long and covers an area of 2,250 square miles. The longest glacier in California, the Whitney glacier on Mount Shasta, is about 2 miles long with an area of 0.5 square miles.

Most of California's glaciers are less than a mile in length and are considered ***cirque*** glaciers. A cirque glacier is a small mass of ice that sits in a spoon-shaped depression carved out by the ice itself at a valley head. A cirque usually represents the beginning of a longer glacial valley.

The Whitney glacier is Mount Shasta's only distinct valley (or alpine) glacier. In contrast to a cirque glacier, a ***valley*** glacier is longer and occupies both the cirque and the glacial valley below it. Valley glaciers occur in former stream valleys, which account for the glaciers' distinctive shape (see figure 3).

What Is a Glacier?

A glacier is much more than a big chunk of ice. It is a large year-round mass of snow and ice on land; the ice is not considered a glacier unless it shows evidence of either past or present movement. This movement is caused by the force of gravity acting on the accumulated ice and snow, making it flow slowly downhill. The ice and snow must be at least 150 feet thick for flow to occur. The glacier moves outward or downhill, eroding the land as it goes and producing distinctive landforms in the process. Glaciers are powerful tools for carving out features in the landscape. Yosemite Valley, for example, owes its presence to the movement of glaciers. The largest valley on Mount Shasta, Avalanche Gulch, is one of several glacier-carved valleys.

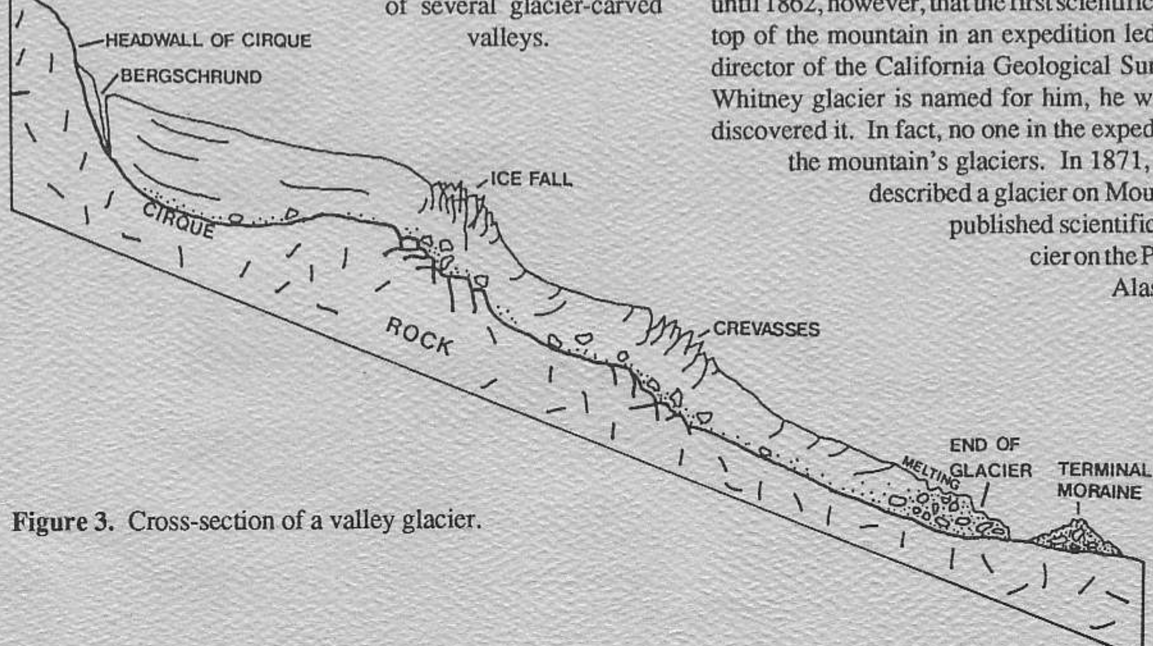

Figure 3. Cross-section of a valley glacier.

How Glaciers Form

The formation of glacial ice begins with light and delicate snowflakes, which have a density one-tenth that of water. Year by year, accumulating snow becomes denser and more like ice. After years of compaction caused by surface melting, refreezing, and compression from new layers of ice and snow collecting on top, a granular ice called ***firn*** forms. Firn, much denser and stronger than the original snow, is the material that eventually makes up the glacier. After hundreds of years of compression and compaction, melting and refreezing, the firn becomes glacial ice, with a density nine-tenths that of water. Through this process, the original delicate snowflakes become dense crystals of ice up to 10 inches long and increase in strength 500 times.

The process of turning fresh snow into glacial ice occurs only under favorable climatic conditions, that is, when each year's amount of accumulated snowfall exceeds the amount lost to melting and evaporation. The amount of snowfall a glacier receives each year is an important factor in determining whether a glacier will grow or shrink over the years. One reason Mount Shasta has been able to maintain its glaciers is because of the large amount of snowfall the mountain receives. In fact, records show that Mount Shasta received 189 inches of snow during one storm—more snowfall during a single storm than anywhere else in the United States.

GLACIERS ON MOUNT SHASTA

Discovery of the Glaciers

The first news of Mount Shasta's existence was spread to the east by Peter Skene Ogden, a Hudson Bay Company fur trapper. A February 1827 entry in his diary notes that he named the mountain "Sastice," after the local Indian tribe. It was not until 1862, however, that the first scientific party climbed to the top of the mountain in an expedition led by J. D. Whitney, director of the California Geological Survey. Although the Whitney glacier is named for him, he was not the one who discovered it. In fact, no one in the expedition noticed any of the mountain's glaciers. In 1871, Clarence King first described a glacier on Mount Shasta in the first published scientific account of any glacier on the Pacific slope south of Alaska.

Number of Glaciers

Mount Shasta has five, seven, or ten glaciers, depending on who does the counting. It has long been accepted that Mount Shasta has at least five glaciers. In 1986, the U.S. Geological Survey added two more glaciers to their Provisional Mount Shasta topographic map (making a total of seven). Philip T. Rhodes, in an article in *California Geology* (September 1987, p. 205), makes a case for the existence of ten glaciers on Mount Shasta. The uncertainty about the number of glaciers stems from the definition of a glacier: if a permanent mass of ice and snow does not move, it is considered a perennial snowbank; if it moves, it is a glacier. Rhodes cites evidence that ten separate masses of ice and snow show either "present or former movement," and hence are glaciers. Even if only five actual glaciers exist on Mount Shasta, the mountain still contains the largest number of glaciers on one peak in California.

Age of the Glaciers

The glaciers of Mount Shasta, like the others in California, are not leftovers from the large glaciers that existed in California during the Pleistocine Epoch (11,000 to 3,000,000 years ago) when huge ice sheets also advanced to cover much of the northern and eastern United States. The present glaciers were formed within the last 1,000 years, during a period of worldwide cooling called the Little Ice Age. Shasta's current glaciers cover an area of only about 3 square miles, in contrast to the Great Ice Age glaciers, which blanketed the entire peak.

Glacial Features

Glacial features that can be seen and photographed on Mount Shasta include the following (see figure 3):

Cirques All glaciers on Mount Shasta originate from cirques.

Crevasses Crevasses are deep fractures in the ice that occur when glacial flow accelerates over a steep slope. They can be up to 100 feet deep on Mount Shasta and are hazardous to climbers.

Ice falls An ice fall is a jumbled, chaotic mass of cliffs, spires, and steps formed in the ice when a glacier flows over a steep cliff. It is the ice equivalent of a waterfall.

Bergschrunds A bergschrund is a large crevasse that separates the beginning (flowing) part of the ice from the headwall of the cirque and the inactive snowfield above it.

Moraines As a glacier erodes its way through the landscape, it transports loose rocks and boulders called glacial till. A moraine is a hill, ridge, or pile of till deposited by a glacier. ***Terminal*** moraines form at the end of glaciers where melting occurs; they mark a glacier's advances and retreats. A ***medial*** moraine forms where two glaciers join. The rock debris along the glacier's sides piles up and is carried on top of the ice between two glaciers. ***Lateral*** moraines occur where till is deposited between the side of a glacier and the adjacent valley wall.

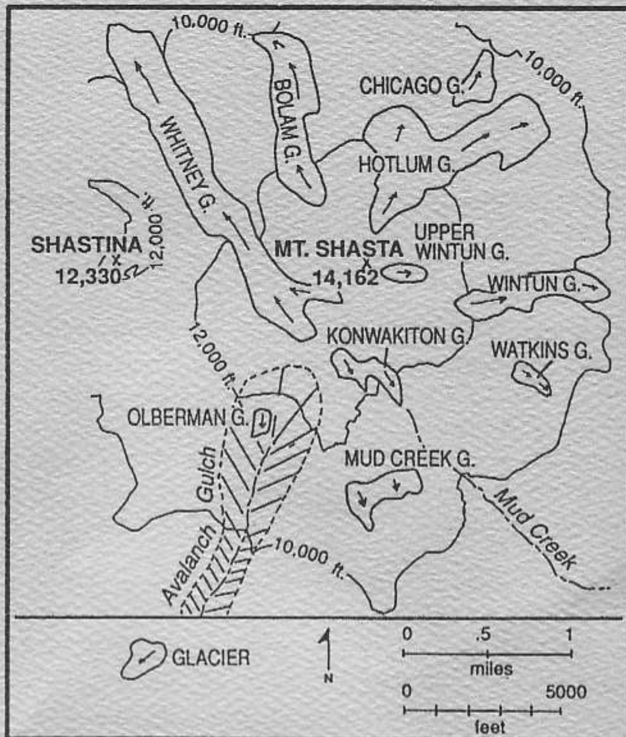

Figure 4. Location of glaciers on Mt. Shasta.

The Individual Glaciers

Figure 4 shows the location of the ten glaciers on Mount Shasta. Here are some comments on each:

Whitney The longest and only well-defined valley glacier in California, it has been growing since 1940.

Hotlum The largest glacier on Mount Shasta (about 0.6 square miles), it is considered by some to be the most beautiful of Shasta's glaciers. Hotlum has the only well-defined medial moraine on a California glacier and can move up to 7 inches in 24 hours.

Bolam The most stable of Shasta's glaciers, its size has not changed much in the last 50 years.

Wintun Some researchers think that the Wintun glacier is actually made up of two separate glaciers.

Konwakiton Konwakiton means "the muddy one." It is one of only two glaciers in California with a southeasterly slope direction. This glacier has left a prominent record of changes in its size. It is currently about 0.5 miles long, but it was 5 miles in length and occupied an area of 7 spare miles during the Pleistocene Ice Age.

Mud Creek Mud Creek also has a southeasterly slope direction and was once considered part of the Konwakiton glacier. The U.S. Geological Survey recognized Mud Creek as a separate glacier on its 1986 Provisional Mount Shasta topographic map.

Watkins This glacier was named for R. H. Watkins, Jr., who spent over 20 years trying to get it officially recognized. The Watkins glacier has finally been recognized as a true glacier by the U.S. Geological Survey on its 1986 Provisional Mount Shasta topographic map.

Chicago Some researchers consider the Chicago glacier to be part of the Hotlum glacier because it was connected to Hotlum in the past. It has been self-contained, however, for the last 50 to 60 years. The name is proposed by Rhodes in recognition of the research on Shasta's glaciers by the University of Chicago.

Upper Wintun This glacier is difficult to identify because it is almost always covered with snow. It probably has not been connected to the main Wintun glacier for hundreds or thousands of years.

Olberman This glacier appears to be active only following periods of heavy snowfall. Of all the glaciers on Shasta, Olberman is the only one that may lack the necessary characteristics to be called a glacier. The name is proposed by Rhodes in memory of J. M. Olberman, a well-known person in the Mount Shasta area who, in 1924, was the first to notice the presence of the ice.

Glacial Hazards

While Mount Shasta's glaciers may be beautiful to look at and exciting to climb, they also present potential hazards. One of the most devastating hazards is posed by a ***jokulhlaup***. Jokulhlaup (pronounced yo-kool-loup) is an Icelandic term for "glacial outburst flood." (Jokulhlaups are also referred to as mudflows.) The flood occurs in one of two ways: 1. the glacial ice melts rapidly, or 2. the channel of a glacier becomes plugged and the "dam" breaks, releasing the water suddenly. The flood water mixes with rock debris and dirt and pours down the mountain, overspilling its channel. These floods can be quite devastating; for example, a 1922 jokulhlaup in Iceland, produced by the melting ice from a volcano eruption, had a discharge rate 10 times that of the Mississippi River.

Rapid melting of snow and glacial ice as a result of periods of unusually warm temperatures or a volcanic eruption would likely trigger a jokulhlaup on Mount Shasta. Such a mudflow might be hazardous to the nearby towns of McCloud, Mt. Shasta, Dunsmuir, and Weed. McCloud, Mt. Shasta, and Dunsmuir are built on ancient mudflows from Mount Shasta, so history could easily repeat itself.

A series of mudflows caused by warm temperatures have occurred on Mount Shasta in the recent past; jokulhlaups occurred in 1920, 1924, 1926, and 1931. The larger flows originated from the Konwakiton and Mud Creek glaciers located in the Mud Creek drainage area (see figure 4). The 1924 jokulhlaup was particularly devastating: The mudflow, which started August 4 and continued in spurts until September 8, was 10 feet deep and covered an area 5 miles long and 1 mile wide. The flood caused the town of McCloud to lose its water supply and blocked roads, damaged property, and threatened fisheries.

Large mudflows also have occured on Mount Shasta as a result of volcanic eruptions. Geologic history indicates that the mountain averages one eruption every 250 to 300 years. Shasta last erupted about 200 years ago, and, although there is no way to predict exactly when the next eruption will occur, it is almost certain that Mount Shasta will continue to erupt in the future as it has in the past.

RECOMMENDED READINGS

For additional information on Mount Shasta's glaciers or glaciers in general, the following readings are recommended:

"A California Jokulhlaup" by Mary Hill and Elisabeth L. Egenhoff in *California Geology*, July 1976, p. 154.

"Historic Glacier Fluctuations at Mt. Shasta" by Philip T. Rhodes in *California Geology*, September 1987, p. 205.

Principles of Geomorphology by William D. Thornbury, 1969, pp. 345-375.

For information on climbing Shasta's glaciers, a pamphlet including a map, weather data, climbing routes, and other related information can be purchased from The Fifth Season, 426 North Mt. Shasta Blvd., Mt. Shasta City, 96067, (916) 926-3606.

Frances Biles was a senior in geography from Eureka, California when this bulletin was written.

Publication and distribution of this circular was made possible by the Center for Mathematics and Science Education at California State University, Chico. One of the goals of the Center is to improve the teaching and learning of science and mathematics at all levels. Preparation of this circular was supervised by Bill Guyton, Professor of Geosciences, and graduate student Lois Hicks helped in editing and production.

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