Lassen Geology

Lassen Volcanic National Park lies at the southern extremity of the Cascade Range, which extends northward some 500 miles through Oregon and Washington and into British Columbia. Lassen Peak and the 16 other major volcanoes of the Cascades are a segment of a ring of volcanoes that circle the Pacific Ocean, known collectively as "The Pacific Circle of Fire."

Northwest of the park lies the Klamath Mountains (a collective term for the Siskiyou, Trinity, Salmon and Marble Mountains). To the west lies the Sacramento Valley. Just south of the park begins the Sierra Nevada Mountains and to the east lies the Modoc Plateau and then the Great Basin.

Early History

All rock now exposed in the park is volcanic, but this has not always been the case. For hundreds of millions of years, the Lassen region had undergone repeated uplifting to form mountains, only to have them worn down and submerged under encroaching seas. During the periods of submersion, sands, muds and limestones would be deposited and occasionally volcanic activity was associated with the mountain building.

About 70 million years ago, the area where the Cascade Range is now situated was under the most recent encroachment by the Pacific Ocean. The Sierra Nevadas and the Klamath Mountains (which are probably an extension of the Sierras) were already in existence. The broad depression between them, "The Lassen Strait", was a seaway connecting the marine basin in California with that in east central Oregon.

At this time, the entire western portion of this continent became subject to profound earth movements. Gradually during millions of years, the rocks of the crusts were folded and fractured and the seas were driven away. This same bending and breaking of rocks relieved pressure on the hot material beneath the earth's crust and permitted lava to rise to the surface. From Washington southward along the Cascades and the Sierra Nevada volcanoes burst into activity. This activity continued until approximately 11 or 12 million years ago, piling lavas and ashes on each other until in places their thickness approached 10,000 feet, forming what is now known as the western Cascades. Erosion has changed these once jagged peaks into rolling hills.

Meanwhile, toward the end of this activity, eruptions of a different kind took place on an unprecedented scale in eastern Oregon and Washington. From innumerable cracks, floods of highly fluid basaltic lava spread to cover an area of over 200,000 square miles. Known as the Columbian Plateau, this great lava bed covers much of Oregon, Washington and even parts of Idaho. California's Modoc Plateau is a thinner basaltic flow which some associate with the Columbia Plateau, but there are technical objections to this. This activity also continued until 11 or 12 million years ago when the High Cascades took shape as a distinct mountain belt as a result of the upheaval and bending of the thick blanket of volcanic rocks. As a result of this upheaval, many features opened near the crust, and during the next 10 million years, a series of new basaltic volcanic cones similar to those now found in Hawaii were built.

Great Ice Age

One to two million years ago, the Great Ice Age (the last of a series of ice ages) entered and lasted until approximately 10,000 years ago. During this period, many of the great volcanoes for which the Cascade Range is known were built. The story of the exposed volcanic rocks in the Lassen region started between two and three million years ago, when the creation of the Tuscan Formation began. For one million years, a series of volcanic mudflows from three major source areas contributed debris covering almost 2,000 square miles to form the oldest distinctive formation of the High Cascades. Probably the oldest major source of the formation was Mt. Yana (centered a few miles southwest of Butt Mountain and south of the park). Mt. Yana had probably reached its full size, 10,000 feet in elevation and 15 miles in diameter, before Mt. Maidu, the second source, had acquired half its growth. Mt. Maidu, which eventually surpassed Mt. Yana in size, was centered over the town of Mineral. A third source situated north of Latour Butte made a lesser contribution to the formation. Other minor sources included an area near Hatchet Mountain Pass (northwest of Burney Mountain), dikes south and southwest of Inskip Hill and possibly Campbell Mound (north of Chico).

Meanwhile, within the park boundary other volcanic events were taking place. In the southwestern portion of the park, basaltic lavas poured forth in the vicinity of Willow Lake. These were followed by andesitic lavas which erupted near Juniper Lake and flowed westward about four miles. At about the same time, other andesitic lavas poured from several vents on the central plateau to cover an area of at least 30 square miles. Apparently, the vents of these lavas renewed activity at a much later date to form three cinder cones: Hat Mountain, Crater Butte and Fairfield Peak.

Sometime later, andesitic lavas poured out from what is now Reading Peak, flowing chiefly to the south and east, reaching the head of Warner Valley. By this time, the park's eastern portion had been transformed into a relatively flat plain.

This activity was followed by an eruption of basalts from volcanoes east of the park. These thick flows have been subsequently eroded to produce the rugged hills that limit the park on the east.

Mt. Tehama/Brokeoff Volcano

While all the events described above were taking place, an enormous strato-volcano, Mt. Tehama, had been building in the southwest corner of the park. Starting its activity after Mt. Yana but before Mt. Maidu started its, Mt. Tehama had by now reached an elevation of 11,000 feet. Its principal vent lay in the neighborhood of what is now the Sulphur Works, but a second vent from which no lavas issued lay on the eastern flank of Little Hot Springs Valley. Contrary to popular opinion, Bumpass Hell is not one of Tehama's main vents since it is located outside the caldera.

During Mt. Tehama's later history, four shield volcanoes, Raker and Prospect Peaks, Sifford Mountain and Mount Harkness, were being built at the corners of the central plateau. Raker Peak erupted andesite lavas while basalt issued from the others. During their last stages of eruption, each of these volcanoes developed a cinder cone on its summit.

Later, a mass of Rhyolite was forced through the north flank of Sifford Mountain and a plug of dacite was pushed up through the west flank of Raker Peak.

About this time, a new vent opened up on the northeastern slope of Mt. Tehama, probably close to where Lassen Peak now stands. From this new crater streams of fluid dacite flowed radically, but chiefly toward the north, piling up lava to a thickness of 1,500 feet. These are the black, glossy, columnar lavas that now encircle Lassen Peak--the pre-Lassen dacites.

Lassen Peak Formation

Approximately 27,000 years ago, Lassen Peak, a Pelean type plug dome volcano, was pushed up from this same vent. As its partly solid and partly viscous dacite lavas rose, its margins abraded and polished against the vent walls, and the surface of the growing pile crumbled continually, forming enormous banks of talus. A series of smaller domes also rose near Lassen Peak, but they have not been precisely dated. Crescent Crater, which at first glance appears as a parasite on Lassen's northeast flank, has been more heavily glaciated and thus is older. Other dacite domes which rose on Tehama's flanks are Bumpass Mountain, Helen Ridge, Eagle Peak, Vulcan's Castle and Reading Peak which was upheaved through vents from which the Flatiron andesites had long before erupted. An upper limit of 10,000 years has been set for the domes next to Lost Creek (north domes). All of these domes must have risen with great rapidity.

The destruction of the Tehama volcano probably began about this time. It is possible that Tehama collapsed along a series of fault lines which criss-crossed it--a collapse which may have been brought about by the extrusion of extensive amounts of lava necessary to form the dacite domes on its flank.

Chaos Crags

Subsequent to the rise of Lassen Peak, several dacitic pumice cones developed in a line extending northwest from the base of Lassen Peak. Then about 1,100 years ago, several dacitic domes, the Chaos Crags, protruded through these cones, obliterating all but half of the southernmost cone. A series of large avalanches possibly triggered by steam explosions have occurred on the north side of the Crags at least 300 years ago. These avalanches were of the "air cushion" type and developed speeds exceeding 100 miles per hour to form a wilderness of debris, the Chaos Jumbles, which covers an area of 2 1/2 square miles. Manzanita Lake was formed as a result of Manzanita Creek being dammed by the debris. Reflection Lake and Lily Pond are depressions in this debris.

Cinder Cone

About the mid 1700s a series of eruptions produced the Cinder Cone in the northeast corner of the park, mantling an area of 30 square miles with ejecta in the process. In the meantime, ashes falling on the streams of lava pouring from the cone's east flank formed the Painted Dunes. At the same time another lava flow poured from the Cinder Cone and entered Butte Lake and damned the drainage into Butte Lake to form a new lake--Snag Lake. In the late 1700s Cinder Cone had its most recent eruption and lava flow.

Lassen Peak Eruption

Steam rose from the domes of Chaos Crags until 1857, but no important eruptions occurred again until Lassen Peak burst into activity in 1914.

For one year, explosions recurred at irregular intervals. Then, on May 19, 1915, a mass of lava rose in the summit crater and spilled over the southwestern and northeastern sides. On the southwestern slope glowing lava descended 1,000 feet toward the Sacramento Valley, then cooled and hardened. Extensive mudflows were created on the northeastern side as snowbanks were melted. The resulting debris swept down the slope. Divided by Raker Peak, part of this mudflow raced down Lost Creek; the remaining flow passed over the 100 foot rise east of the park road and rushed down Hat Creek. A wide barren swath was brutally torn through the forest.

Three days later, May 22, 1915, a great explosion blasted out a new crater. A volcanic cloud rose 40,000 feet, but a portion of the explosive force was deflected downward. The resulting Hot Blast (nuee ardente) roared down the same path taken by the mudflow, resulting in further damage along the headwaters of Hat and Lost Creeks. Thereafter, activity declined, finally ending in 1921. Since then, the volcano has lain dormant, although a little steam still rises from small vents in its summit and on its flanks. Pumice ejected during the 1915 eruption of Lassen Peak is conspicuously banded with light streaks of dacite and dark ones of andesite, which appears to represent two distinct magmas imperfectly mixed during the eruption.

Hydrothermal Areas

Several groups of hot springs and fumaroles, remnants of former volcanic activity, exist in the park. Most of these lie in or are closely adjacent to Mt. Tehama's caldera. Bumpass Hell is the most spectacular of these, but others of importance are Sulphur Works, Little Hot Springs Valley, Cold Boiling Lake and Devil's Kitchen in Warner Valley. In each thermal area, the highest temperature of water generally is close to the boiling temperature at the altitude of the particular spring or fumarole--198°F at Bumpass Hell and 191°F on the northwest flanks of Lassen Peak. Temperatures as high as 230°F have been recorded in the park.

Spring activity varies with water supply. Abundant water results in clear springs during early summer, but as the season progresses and the water supply decreases, springs change successively to turbid, warm pools, spattering mudpots, and finally steaming fumaroles. There are no true geysers within Lassen Volcanic National Park.

Gases from hot springs are composed mostly of steam and carbon dioxide, with minor amounts of other gases. These react with the rocks around the springs to ultimately form opal if temperature and acidity are high, and kaolin if they are low. Deposits of sulphur, iron pyrite (fool's gold), quartz and other substances are also found around the springs and in their drainage channels.

Solfataric alternation within the caldera of Mt. Tehama covers about five square miles, much more extensive than the present hot springs basins--indicative of its former extent, and suggestive of its waning activity. It is the altered materials in the caldera which yielded most readily to the forces of erosion. Diamond Peak is a body of unaltered rock which still remains because it is more resistant.

Glaciation

Glaciation has played an important but incompletely understood role in the park. Glaciers existed throughout the park during most of the Great Ice Age with smaller ones persisting at higher elevations until comparatively recent times. Lassen Peak is situated at a center from which many of these glaciers originated. Ice that glaciated the valley of Mill Creek (whose canyon is mostly post-glacial), Blue Lake Canyon, Kings Creek Meadows, Flatiron Ridge, Warner Valley and the valley of Manzanita, Hat and Lost Creeks originated from there. Indeed, Lassen Peak appears to be sitting in the depression carved by the Lost Creek Glacier.

Reading Peak is situated at a second center from which ice moved north into Hat Creek and Summit Creek. Ice moving southward united with some of the above glaciers and emptied into Warner Valley.

On the central plateau, the ridge connecting Hat Mountain with Crater Butte served as a divide between ice flowing northward to Badger Flat and Hat Creek and that moving southward to Corral Meadows, Kings Creek and Warner Valley. Ice from Mt. Harkness and Sifford Mountain also wound up in Warner Valley.

The crest of Saddle Mountain served as a divide with ice north of it moving into the depression containing Snag and Butte Lakes, while those to the south entered Warner Valley. The ice varied from a thickness of 1,600 feet in Warner Valley to much thinner sheets in the higher mountains. By carving beautiful cirques, canyons and most of Lassen's lakes, glaciers have contributed much to the beauty of Lassen's landscape.

Lava

Four types of lava are found in the park. Rhyolite and dacite are light-colored acid lavas which remain stiff and viscous at high temperatures. Basalt is a dark-colored basic lava which is fluid at high temperatures. Andesite is intermediate in these characteristics.

References

The major sources for the above outline are Williams' Crater Lake, 1941; Williams' Geology of Lassen Volcanic National Park, 1932; Geology of Northern California, Bulletin 190, California Division of Mines and Geology, 1966; and Lydon's Geology and Lahars of the Tuscan Formation, Northern California, as well as verbal comments by Drs. Dwight Crandell and Don Mullineaux, U.S. Geological Survey.