Geology of Lava Beds National Monument

Compilation of this material sponsored by the Geological Society of America's GeoCorps Program in partnership with the National Park Service

In this section you will learn:

- Why geology is important at LABE
- Tectonic and volcanic setting of the monument
- Geologic history of the region: oldest and youngest rocks in LABE
- Important rock units: Mammoth Crater flow, Devil's Homestead flow, Valentine Cave flow, Schonchin Butte and its lava flow
- Origin of Petroglyph Point
- Volcanic hazards in LABE
- Prominent geologic features in the monument
- Common rock types in LABE

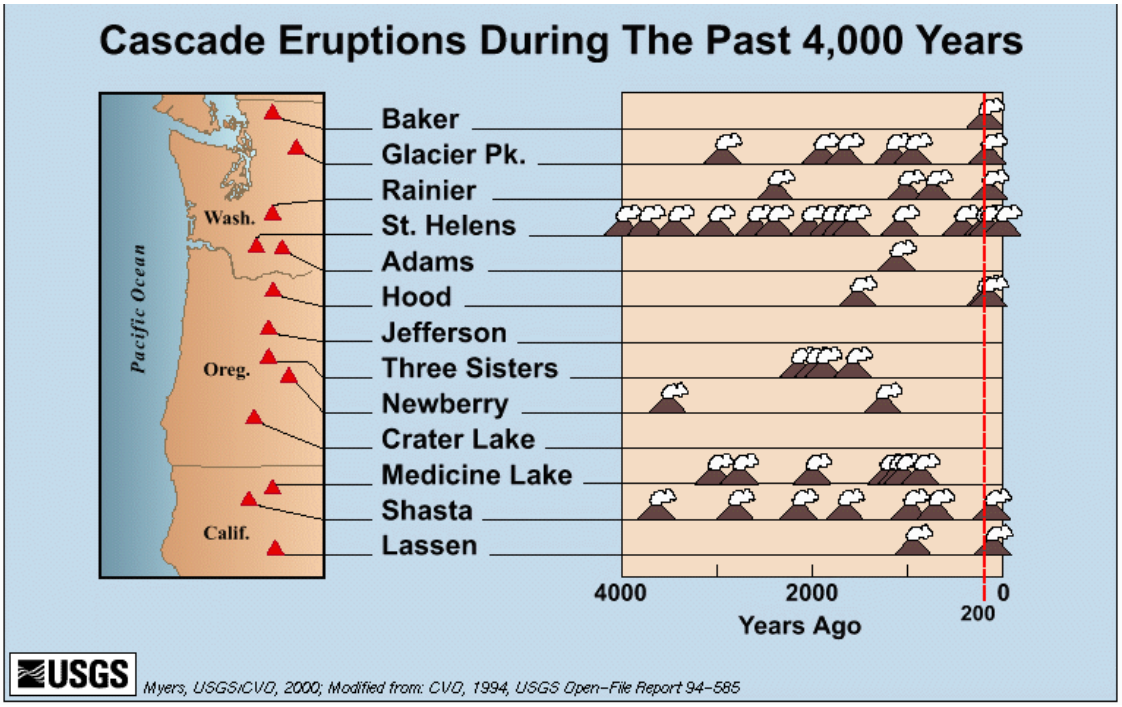
Importance of geology at Lava Beds National Monument (LABE)

It is, after all, LAVA BEDS National Monument. The geology is critical to everything else in the monument including vegetation, wildlife, and people. Native American history in the monument depends crucially on lava flow morphology as illustrated by the events of the Modoc War at Captain Jack's Stronghold. Climate change in the form of glaciation has also been important to vegetation patterns. Soil development is aided by transport of dust by wind from dry lake beds, and deposition of glacial till.

As the name implies, we are located in an area of volcanic activity. LABE is situated on the north flank of a large shield volcano: Medicine Lake volcano (MLV). The Medicine Lake shield volcano rises about 3900 feet above the Modoc Plateau to an elevation of nearly 8000 feet. Lavas from MLV cover over 770 square miles, and their volume is estimated to be at least 145 cubic miles, making it the largest volcano by volume in the Cascade Range.

Medicine Lake volcano viewed from the northern end of the monument. The volcano covers the entire skyline (and more outside the frame). Cinder cones dot its flanks.

Medicine Lake volcano is considered to be a **dormant** volcano. It has erupted before and is likely to erupt again, but it is not currently active. Active volcanoes are those that are currently erupting or have erupted within the last few hundred years (within historical times). A volcano can be considered to be extinct if it hasn't erupted in over a million years. Most of the Cascade volcanoes are still considered to be active and several have erupted in the past few hundred years, as illustrated in the figure below. The two most recent eruptions were Mt. St. Helens (large eruption in 1980 and dome building over the last 2 years) and Lassen Peak (erupted intermittently between 1914 and 1921).

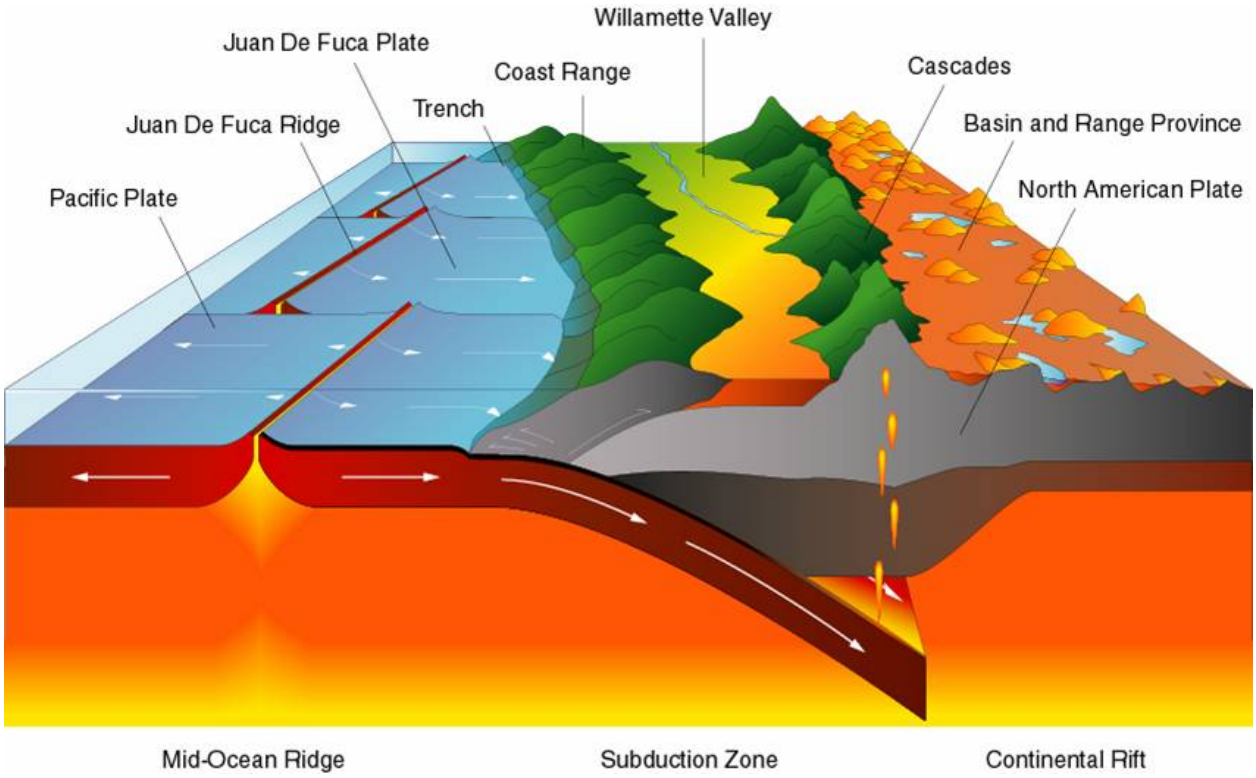


Hydrothermal activity, such as hot springs and fumaroles, are indicators that a volcano is not yet extinct; hot rock or magma must still be residing beneath the volcano to heat the groundwater. Several "hot spots" and steam vents can be found in the Medicine Lake highlands.

Tectonic Setting

Medicine Lake volcano is located between the subduction zone off the coast to the west and the Basin and Range extensional province to the east, as shown in the diagram below. The Juan de Fuca oceanic plate is subducting beneath the North American continental plate. The Cascade Range consists of the volcanoes resulting from the subduction (called a volcanic arc). Medicine Lake volcano is considered part of the Cascade Range, but its location east of the main Cascade crest and its features are influenced by the nearby extension of the Basin and Range. The volcano is located over the westernmost N-S oriented normal faults of the Basin and Range extensional province. Faults provide a weak zone in the crust allowing magmas to rise more easily. Thus, more basalt is erupted since magma can spend less time migrating towards the surface (less incorporation of silica-rich continental crust and less magma differentiation) resulting in a broad basaltic shield rather than a stratovolcano. Gillem Fault (exposed along

Gillem Bluff) is a normal fault along which the block on the east side has moved down relative to the west block; vents of Glass Mountain on Medicine Lake volcano may follow the extension of this fault to the south.



Abbreviated Geologic History of Medicine Lake Volcano and LABE

Medicine Lake volcano began to grow about half a million years ago as large eruptions of basalt began to pile up. Between about 500,000 and 300,000 years ago numerous domes and flows of silica-rich lava were produced. Some basaltic flows also occurred during this time including the flow that produced the basalt of Hovey Point (about 450,000 years old) which is crossed on the road to Captain Jack's Stronghold. Basaltic-Andesitic volcanism has been dominant since then.

The Mammoth Crater basalt flow (about 36,000 years old) covers ~70% of the surface of LABE and contains most of the large lava tube caves including Skull Cave and the caves along Cave Loop. Eight eruptions have occurred over the last ~3000 years. The youngest flow in LABE is Callahan Flow, a basaltic andesite a'a and block flow that erupted 1,100 years ago from vents at the base of Cinder Butte just south of the monument border. The most recent eruption on MLV is the rhyolite and dacite eruption of Glass Mountain 885 years ago. White pumice from recent (<1000 years ago) explosive silica-rich eruptions dusts all rock units in LABE.

Recent flows that make up the vast bulk of the surface of LABE include (see **Surface Geology Map of LABE** for more detail):

- Tuff deposits of Juniper Butte and Petroglyph Point: about 275,000 years old. Juniper Butte and Petroglyph Point are tuff cones that formed when basaltic magma interacted violently with water of ancient Tule Lake.
- Basaltic Andesite of Semi Crater: older than Hippo Butte flow. Trail to Thomas-Wright Battlefield crosses this flow.
- Basaltic Andesite of Hippo Butte: older than Andesite of Schonchin Butte. Road between Visitor Center and Skull Cave turnoff as well as about half of Bunchgrass Trail crosses this flow.
- Andesite of Schonchin Butte: approximately 65,000 years old. Lava did not flow from the top of the butte but was erupted from vents at its base. Butte is a cinder cone that formed from andesitic tephra launched upwards from the vent.
- Andesite of Whitney Butte: older than Mammoth Crater flow. Butte is a cinder cone formed at same time as the lava flow (flow emerged from base of cinder cone – typical for this type of eruption).
- Basaltic Andesite of Three Sisters: also older than Mammoth Crater flow. Buttes are cinder cones created at the same time as the lava flow and are partially buried by the lava.
- Basalt of Mammoth Crater: dated at about 36,000 years old. Covers ~70% of the monument area and contains most of the large lava tube caves including Skull Cave and the caves along Cave Loop.
- Basalt of The Castles: younger than Mammoth Crater flow, older than Black Crater and Ross Chimneys flow.
- Basaltic Andesite of Valentine Cave: dated at 10,850 years old. Erupted from spatter cones located ~1 km south of LABE.
- Basalt of Devil's Homestead: about 10,500 years old. Flow starts out as pahoehoe at the Fleener Chimneys spatter vents and changes to a'a.
- Basalt of Black Crater and Ross Chimneys: dated at 3,025 years old. Pahoehoe flow erupted from series of spatter cones aligned along a fissure.
- Basaltic Andesite of Callahan Flow: dated at 1,100 years old. Youngest flow in the monument; a'a and blocky flow erupted from vent at base of Cinder Butte just south of LABE.

Older rocks 1-2 million years old are exposed on the fault scarp of Gillem Bluff (includes basalt, andesite, and tuff). These rocks predate the birth of Medicine Lake volcano and the locations of their vents are unknown (buried under more recent flows). Some of the lava erupted beneath the waters of an ancient, deeper Tule Lake producing pillow lavas that can be seen along the Gillem Bluff trail.

Glaciation: Several episodes of glaciation have occurred at MLV over the last 500,000 years. Ice probably extended down to ~6000 feet in elevation. Valentine Cave basalt flow erupted after the last glacial episode and has covered much of the glacial outwash deposits. Within LABE are two areas where glacial deposits can still be found (both near the southern edge of the monument): at the bottom of Hidden Valley and in a former quarry east of Caldwell Butte. Higher up on MLV glacial striations can be found on some rock surfaces where the rock fragments carried by the ice were dragged over the surface below leaving long grooves or scratches.

Volcanic Hazards at MLV and LABE

Rhyolite-dacite eruptions dominate the upper portions of MLV around the caldera rim, however these eruptions are relatively small, therefore the risk of pyroclastic flow is minimal and restricted to areas immediately around the eruptive vent. Ash and tephra fall may extend to a larger area with quantities depending on distance from the eruption (many feet right at the vent to a few inches miles away). Basalt-andesite eruptions are common on the volcano flanks (including LABE). Lava flow with accompanying fire would be the primary hazard. If eruption occurred when snow cover is heavy, minor lahars may be produced. Rock ejecta and ground deformation may affect areas close to the vent. The distance from the most recent eruption vents to modern day Tule Lake makes tsunami there unlikely (plus the lake is very shallow). An eruption could affect Medicine Lake and the cabins and campgrounds surrounding it. Earthquakes accompanying an eruption could be as large as magnitude 5. Tectonic earthquakes (not related to an eruption) could be larger.

Oceanic island shield volcanoes do undergo flank and sector collapse. On Hawaii and other volcanic ocean islands there is evidence of huge submarine landslides off the flanks of the volcanoes. However, continental shield volcanoes are not as prone to collapse due to the lack of wave erosion. At MLV there is no reported evidence of prior large landslides.

A large eruption at Mt. Shasta could dump significant quantities of ash over the region depending on the prevailing wind patterns.

Volcanic Features in LABE

Below is a list plus a few photos of the major volcanic features in the monument that are easily viewed from visitor sites and popular trails. Additional photos and explanations of features are included in the **LABE Geology Photobook** section (organized by location).

A'a flows: Devil's Homestead, Callahan flow.

Devil's Homestead flow viewed from the Devil's Homestead overlook.

Pahoehoe flows: Fleener Chimneys picnic area, Black Crater, Captain Jacks Stronghold.

Black Crater flow.

Ropy pahoehoe surface at Captain Jack's Stronghold.

Block flow: Callahan flow, Schonchin Butte flow.

Spatter cones: Fleener Chimneys, Black Crater.

Fleener Chimneys spatter cones.

Cinder cones: Schonchin Butte, Hippo Butte, Caldwell Butte, Whitney Butte.

Craters: Mammoth Crater.

Tuff cones: Petroglyph Point, Juniper Butte.

Petroglyph Point tuff cone. The cone has been heavily eroded by wave action from ancient Tule Lake resulting in the cliffs that are a popular nesting site for many different bird species.

Lava tube caves: (numerous) Mushpot, Skull, Valentine, Catacombs, Hercules leg, Merril, etc. Features include (can be viewed in numerous caves in the monument):

- **breakdown**: pieces of lava tube ceiling or wall that have broken off and fallen to the floor. Much of this breakage occurs during the cooling phase, as shrinkage of the tube's lining occurs and contraction cracks form.

- **skylight**: an opening to the surface formed where a portion of a lava tube's ceiling has collapsed.
- **tube in tube**: as a lava stream moves along the floor of an existing tube, it may form an insulating crust, just as occurs on the surface to form lava tubes.
- **pillar**: column of hardened lava that forms around an obstacle in the flow (tree, rock); flow is divided by the obstacle and rejoins beyond it.
- **contraction cracks**: as the lining inside a tube cools, shrinkage occurs and cracks form in the walls and floors.
- **dripstone**: coating over cave wall where hot lava dripped down the wall.
- **pull outs**: section of wall where still-hot lava peeled away exposing older linings of harder lava.
- **lavacicles or lava stalactites**: pointed, drip-shaped pendulums of hardened lava on cave ceiling formed by lava dripping off of hot molten ceiling or by splashing up of lava from flow below.
- **drip stalagmite**: roughly conical pile of lava dripped from ceiling above.
- **benches**: ledges of hardened lava along cave walls marking the top of prior flows.
- **balcony**: section of benches that span the entire width of the cave leaving a passage below.
- **cave coral** and **secondary mineralization**: minerals deposited by percolating groundwater on cave roof and walls form a thin layer of white or yellowish crystals sometimes developing delicate and intricate shapes called cave coral.

Tree mold: along Thomas-Wright Battlefield trail.

Tumulus or **schollendome, pressure ridge**: numerous places throughout the monument.

Tumulus at Captain Jack's Stronghold.

Pillow basalts: can be seen in some areas along fault scarp of Gillem Bluff where these old lavas flowed into an ancient more extensive lake.

Littoral cone: Hospital Rock where lava tube emptied into ancient Tule Lake during the Mammoth Crater eruptions.

Hospital Rock.

Common Rock Types in LABE

Basalt, andesite, and basaltic andesite make up the lava flows within LABE (see **Surface Geology Map of LABE** for more details). At Medicine Lake volcano, these three rock types look extremely similar to each other; all are dark colored and the andesite is commonly black (actually darker than many of the basalt rock units). Geologists determined the rock types by taking samples to a laboratory to determine their silica content. Basalt is the most common rock in the monument and covers most of the land area. Basaltic andesite can be found around Hippo Butte and the Three Sisters. Schonchin Butte and Whitney Butte are formed of andesitic tephra. Andesite lava flows extend northward from each of these two cinder cones.

Pumice and obsidian from Glass Mountain can be found throughout the monument, especially towards the southern end, closer to Glass Mountain.

Glacial deposits (gravel) can only be found in two locations in LABE: at the bottom of Hidden Valley, and in the former quarry east of Caldwell Butte. Neither location is easily accessible to visitors.

Tuff makes up the tuff cones of Juniper Butte and Petroglyph Point. Tuff can also be found along the Gillem Bluff trail and on top of the bluff.