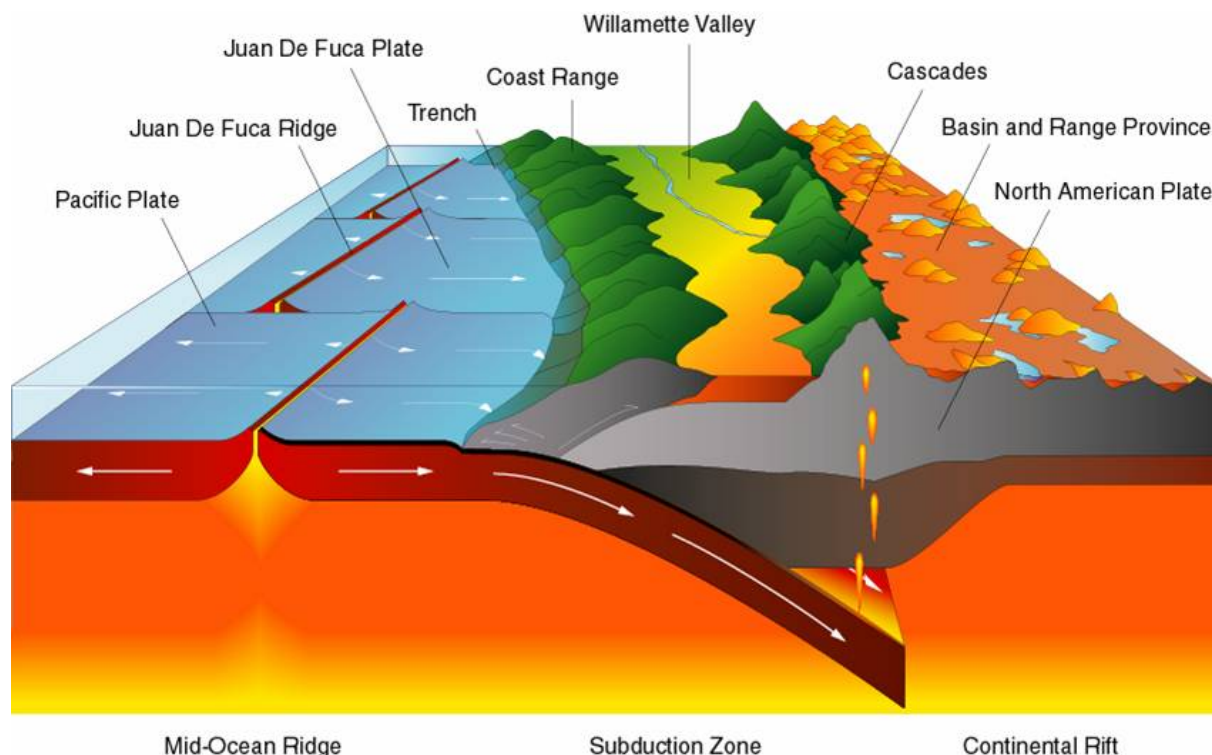


Lava Beds National Monument – Geology FAQ

This is a collection of common questions that visitors may have about the geology of the monument. Compilation of this material sponsored by the Geological Society of America's GeoCorps Program in partnership with the National Park Service.

Why is there a volcano here?

Medicine Lake volcano is considered to be part of the Cascade Range. The Cascade Range is a band of volcanoes extending from Lassen Peak in northern California to Mt. Baker in northern Washington. The volcanoes are a result of the subduction of the Juan de Fuca plate beneath the North American plate, as shown in diagram below. These plates are part of the earth's outer layer which is broken into pieces that move slowly across the surface, interacting with each other at their boundaries. When a continental plate and oceanic plate are moving towards each other one sinks beneath the other in a "subduction zone." The plate that sinks will be the oceanic plate because oceanic plates are thinner and denser than continental plates. Volcanoes form on the overriding plate due to melting in the wedge of mantle above the downgoing plate. Water escaping from the downgoing plate migrates up into the mantle wedge and infiltrates the solid rock. The now "wet" rock can begin to melt because the combination with water results in a decrease in the melting temperature (similar to how ice will melt when you throw salt on it). The melted rock is less dense than the solid rock around it so it can rise up into the crust and erupt to form volcanoes. Medicine Lake volcano is also influenced by the stretching and thinning of the crust occurring in the Basin and Range province to the east. Faults develop in the crust when it is stretched and these faults can provide conduits for magma. Medicine Lake volcano is sitting on some of the westernmost of these extensional faults. The extension of the crust combined with the melting of mantle material associated with subduction has resulted in the eruption of a lot of basaltic lava which has built up Medicine Lake volcano over the last 500,000 years.



When will this volcano blow up? [Is this volcano active/extinct? Is this volcano dangerous?]

Medicine Lake volcano, pictured below, last erupted about 885 years ago to form Glass Mountain. This makes it a “dormant” volcano, defined as a volcano that has erupted before but not within historical times (the last few hundred years) and which is considered to be capable of erupting again in the future. Medicine Lake volcano will almost surely erupt again someday, but currently there are no signs that it is getting ready to erupt soon. Seismic activity (a common precursor to eruptions) is low and the top of the volcano is actually subsiding. Usually, when fresh magma intrudes beneath a volcano in preparation for an eruption the volcano will bulge upward slightly. Since Medicine Lake volcano is instead sinking downwards, it is very unlikely that any new magma is being injected into the volcano’s plumbing system. Thus, the likelihood of an eruption occurring anytime soon is very low.



When was the last/most recent eruption on the volcano?

The most recent eruption on Medicine Lake volcano was the eruption of Glass Mountain about 885 years ago. This was an explosive eruption that distributed ash and pumice over a wide area. Glass Mountain (pictured here) is formed from a thick flow of silica-rich lava that cooled rapidly to form lots of obsidian (volcanic glass).

Why did the lava here make lava tubes, cinder cones, etc., and not explode like Mount St. Helens?

Mount St. Helens (and other Cascade composite or stratovolcanoes like Mt. Shasta, Mt. Hood, and Mt. Rainier) erupted lava which was very viscous and gooey (like cold oatmeal) whereas most of the lava that erupted from Medicine Lake volcano was fluid and runny (like maple syrup). The difference in viscosity or fluidity of the lava is due to the amount of silica in the lava. High silica lava is gooey, low silica lava is runny. Beneath the surface, magma is under great pressure from the weight of rock above and from its own internal pressure, like soda in a bottle. Magma also has gases dissolved in the melt, like the carbon dioxide in soda. When the pressure is released (opening the bottle) the gases bubble out of the magma. Gooey high silica magma does not allow gases to easily escape, plus the sticky magma will not flow easily up out of a vent. Instead, the vent becomes blocked and pressure builds up until it finally overcomes the strength of the rock and magma is able to burst out of the volcano driven by the rapid expansion of the dissolved gases. The result is an explosive eruption. Runny low silica magma, on the other hand, does not tend to clog the vent and gases can more easily escape. Lava is launched high out of the vent forming a lava fountain or building a cinder cone when gases are suddenly allowed to escape. Fluid low silica lava can also pour quietly from a vent forming pahoehoe and a'a flows. Eruptions of low silica lava are called effusive because of the tendency of the lava to flow easily out of the vent.



Effusive eruption (Puu Oo, Hawaii).



Explosive eruption (Mt. St. Helens).

Why does this volcano not look like Mt. Shasta?

Mt. Shasta is a stratovolcano (or composite volcano). It is made of layers of ash and thick silica-rich lava flows which give it a steep-sided conical shape. Medicine Lake volcano is a shield volcano. Shield volcanoes are built of numerous thin basalt flows. Basaltic lava is low in silica and thus is more fluid than the type of lava that composes Mt. Shasta. The fluidity of the basaltic lava allows it to flow a long distance from the eruptive vent (especially when lava tubes form) resulting in a volcano with a broad low slope.



How do lava tubes form?

Lava tubes form in smooth flows of basaltic lava called pahoehoe flows. Lava on the surface of the flow cools quickly because it is exposed to the air. A channel of flowing lava will develop a roof by the coalescence of chunks of cooled lava on the surface of the flow. The solid roof insulates the hot lava inside allowing it to flow a long distance from the vent. When the eruption ends or lava is diverted elsewhere an empty tube is left behind. Collapsed portions of the tube roof can later allow access to the lava tube cave.

Lava tube caves are usually formed close to the surface, but later flows can bury tubes beneath tens of feet of lava. These buried tubes are less likely to maintain a connection to the surface (though a skylight or breakdown) although younger tubes above may break through to deeper tubes. Skull cave is an example of a cave with at least three different levels of tubes stacked one on top of another. The photo above shows an active lava tube on Kilauea volcano in Hawaii.



Is there any hot lava here?

There are no current ongoing eruptions on Medicine Lake volcano today, so there is no hot molten lava to be found. What we can see instead are the frozen forms of lava that cooled a thousand years or more ago. Cinder cones (Schonchin Butte, Three Sisters, Crescent Butte, Hippo Butte, Caldwell Butte, Eagle Nest Butte, Island Butte) formed as piles of frothy lava chunks that were launched up into the air by expanding gases in the lava much like droplets of liquid ejected into the air above a frothing glass of soda. Spatter cones (Fleener Chimneys, Black Crater) formed when the lava contained less gas; blobs of lava were spat out of the vent and piled up around it as lava flowed from the vent. Pahoehoe, a`a, and blocky lava flows formed as lava oozed from vents. The hottest and most fluid lava formed pahoehoe flows with smooth, ropy or hummocky surfaces. Cooler and more viscous lava formed jumbled a`a flows. Blocky flows formed from the coolest and most gooey lava erupted in the monument as the cool lava near the surface of the flow fractured into irregular blocks.

Why is some of the lava smooth (pahoehoe) and some rough (a`a)? [What causes a flow to be either pahoehoe or a`a?]

The critical factor that determines whether pahoehoe or a`a forms is the relationship between the viscosity of the lava (resistance to flow) and the amount of internal disturbance or shear that occurs as lava spreads from a vent down-slope. Generally, if lava viscosity is high (relatively cool pasty lava), a low rate of shear or disturbance will likely cause a`a to form. For example, a slow-moving pahoehoe flow that has cooled sufficiently may transform into a`a as the flow continues to advance. If lava viscosity is low (relatively hot fluid lava), a high rate of shear or disturbance is required for the transition from pahoehoe to a`a. For example, when a fluid pahoehoe flow pours over a steep slope, it increases its speed and creates conditions favorable for a`a to form. Any factor that increases the viscosity of pahoehoe, such as cooling, loss of gas, or crystallization will favor the transition of pahoehoe to a`a. [After the USGS Photo Glossary of Volcanic Terms: <http://volcanoes.usgs.gov/Products/Pglossary/pglossary.html>]



A`a flow (left) and pahoehoe flow (right) moving down slope. The viscosity (dependent on temperature, gas content, and crystal content) determines whether disturbances in a lava flow, such as an increase in slope, will allow it to continue as smooth pahoehoe or change to chunky a`a. The flow on the right has a higher temperature and thus lower viscosity (runny) so it remains as pahoehoe over the slope changes. The flow on the left is cooler and more viscous (gooey) so it has converted to a`a when the slope increased (outside the view of the photo).

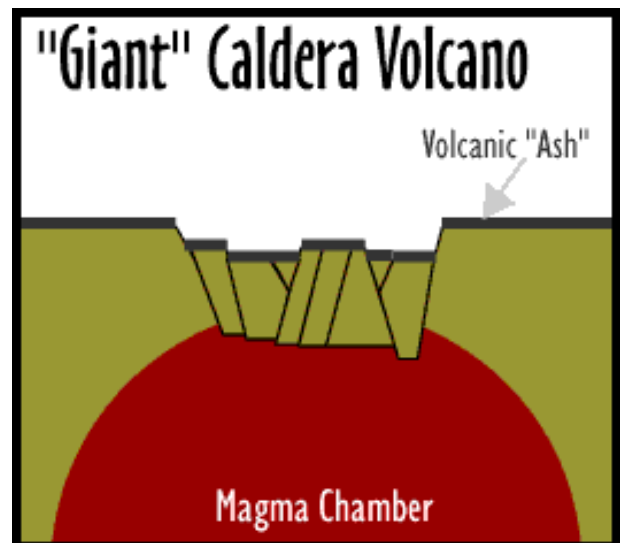


What happens when lava reaches the lake?

When hot lava enters a body of water, the water quickly chills the lava causing it to shatter. At the same time, the water converts abruptly to steam. Chunks of shattered lava are launched upwards by the force of the shattering and expansion of water into steam, as shown in the photo from Hawaii on the left. The chunks collect in a roughly conical pile on the shoreline which is called a littoral cone. If lava erupts under water it forms what are called pillow lavas or pillow basalts. First, the outer surface of the lava is quenched by the water forming a flexible crust around the expanded lava pillow. Then the pressure builds until the crust breaks and new basalt extrudes like toothpaste, forming another pillow. As this process continues the pillows build on top of each other forming a thick layer.

What's the difference between a crater and a caldera?

Generally speaking, craters are small features resulting from eruption of lava or pyroclastic material (ash, pieces of lava, rock, and crystals blasted from a volcano during an explosive eruption) while calderas are much larger features (>1 mile across) resulting from collapse of the ground above a partially emptied magma chamber after a very large explosive eruption, as shown in the diagram to the right. For example, Crater Lake is actually a large collapse feature and should perhaps be called "Caldera Lake" for the sake of accurate terminology.





White pumice gravel covers the ground near Valentine Cave.

What/where are the youngest rocks in Lava Beds?

The Callahan Flow in the southwestern corner of the monument is the youngest lava flow in Lava Beds (1,100 years old). However, the youngest rocks are the white-yellowish pumice pieces and dark obsidian shards scattered throughout the monument. When the eruption that formed Glass Mountain occurred, pumice bits were blasted out of the vent and distributed over a wide area. This eruption occurred about 885 years ago.

What/where are the oldest rocks in Lava Beds?

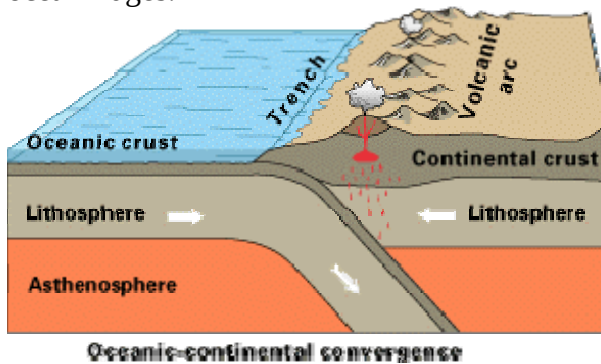
The oldest rocks in the monument are exposed in Gillem Bluff (pictured below). The bluff is actually a fault scarp. The land to the east of the scarp has moved downwards relative to the land to the west of the scarp. The volcanic rocks exposed by the fault in the cliff walls are more than 2 million years old and actually predate the birth of Medicine Lake volcano (roughly 500,000 years ago). The oldest rock in the monument that erupted from Medicine Lake volcano is the basalt of Hovey Point located at the northern edge of the monument (about 450,000 years old). The road between Canby's Cross and Captain Jack's Stronghold crosses this flow.



Where does the magma come from? [Where did the lava come from?]

Magma comes from the mantle, but the mantle is not a sea of molten rock; it is solid. Magma is generated when mantle material undergoes partial melting (some constituents in the rock melt while others with higher melting temperatures remain solid). Rock in the mantle is under very high pressure from the weight of miles of rock above and this keeps the rock from melting under normal circumstances, even though it is also very hot. So how do we melt the mantle to get magma? There are three ways to melt a portion of the mantle: (1) raise its temperature by adding heat, (2) reduce the pressure, thereby allowing it to melt, (3) add water, thereby lowering the melting temperature.

At divergent plate boundaries, mantle material rises up to fill the gap between the separating plates. As it rises, it can maintain most of its heat (temperature remains the same) but the pressure on the rock decreases as it rises. At some depth the pressure will have decreased enough that the rock can expand and begin to melt. This is how magma is produced at mid-ocean ridges.

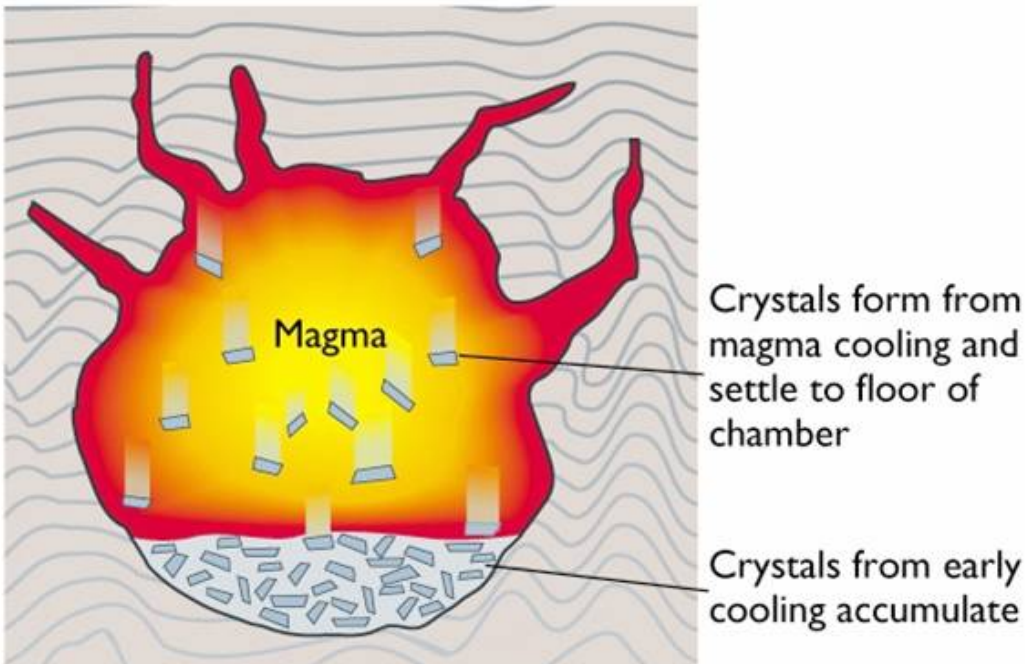


Melting of mantle material at a subduction zone (shown in the diagram on the left) occurs due to the addition of water to the rock. The effect is similar to causing ice to melt by throwing salt on it. The temperature and pressure of the rock are not changed, but the composition of the rock is altered by the addition of water. “Wet” rock has a lower melting temperature than “dry” rock, so simply adding water to hot rock can allow it melt. The less dense melt can then

rise up through the crust and eventually erupt at a volcano. But where does the water come from? It comes from the subducting (downgoing) oceanic plate. The oceanic crust carries water with it in layers of sediment, in cracks, and within some of the minerals precipitated at hydrothermal vents. As the plate heads down into the mantle it slowly heats up. Once it reaches a depth of about 90 miles it is hot enough for the water to escape from the plate and rise into the mantle above it. This water then seeps into the mantle rock converting it to “wet” rock and allowing it melt.

How do you get different lavas at one volcano?

Magma that is created when mantle rocks undergo partial melting has a chemical composition that is like basalt (silica-poor and rich in iron and magnesium). If this magma can get to the surface and erupt quickly (perhaps by following a preexisting fracture in the crust) the resulting volcanic rock will be basalt. But often magma cannot go directly from the mantle to the surface. Magma ascends due to the density difference between the hot molten rock and cool dense solid rock around it, similar to the way a cork will rise through water because it is less dense than the water. As the magma makes its way up through the crust, it may reach a point at which it cannot rise any farther. A body of magma may then be maintained below the volcano for a long time. As it sits there it begins to cool. Igneous rocks are made of different silica-rich and silica-poor minerals. As the magma slowly cools it will reach the temperature at which certain minerals can begin to crystallize. As these minerals crystallize the chemical elements that make up the minerals are removed from the melt. Silica-poor minerals tend to be dense (due to the higher iron content) so crystals of silica-poor minerals that form early at relatively high temperatures will sink to the bottom of the magma chamber as shown in the diagram below. The melt above will then have a more silica-rich composition. If that melt can now erupt, the resulting lava will be andesitic or rhyolitic in composition.



Another thing that can happen to magma as it makes its way upward is that pieces of the surrounding crustal rock can be incorporated into the magma. If the magma is traveling through continental crust (which is high in silica) the composition of the magma will then become more silica-rich. A fresh injection of basaltic magma from below can cause mixing within the magma body and eruption of more silica-poor lavas. Alternatively, basalt can be erupted from a new magma body that does not connect to our magma chamber but instead vents elsewhere (perhaps on the flank of the volcano, e.g. Fleener Chimneys).