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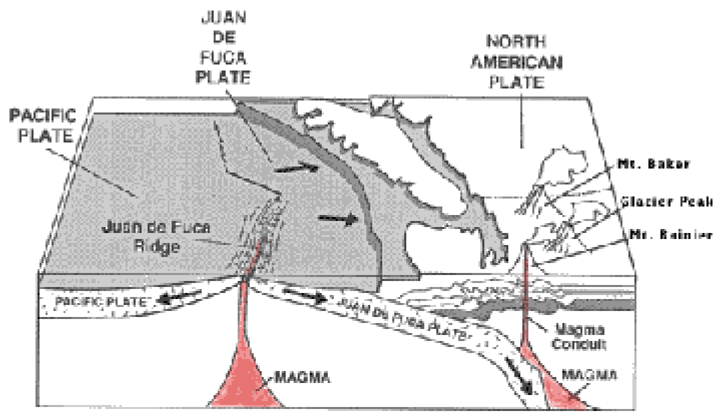
Geology 190

The Eruption that created the Bishop Tuff and Other Landforms in the Eastern Sierra Landscape

“The climatic (eruption of Bishop Tuff) occurred about 700,00 years ago when the silica-rich, gas-charged rhyolitic magma rose to the surface through a series of circular fractures in the crust” (Harris, 48). However, studying this eruption is a difficult task, as well as trying to figure out what the landforms looked like before the eruption. The method commonly used to study old volcanic eruptions is with core samples taken by drilling into the earth’s crust a few meters. Therefore, the scientists can see the layers and know what came first. By studying the cause for this eruption, by figuring out what occurred during the eruption, and by understanding the results of the eruption, scientists can learn new things about present and future volcanic activity.

To understand the eruption of Bishop Tuff, one must address the cause of the eruption. Many of the landforms in the basin and range were and still are being created by an oceanic plate and a continental plate converging, and the oceanic plate subducting under the continental plate. 100

million years ago the Farallon plate, an oceanic plate, subducted under the North American plate, a continental plate. A present day example is the Juan de Fuca plate subducting underneath the North American plate as shown in the picture below.



The effects of the Juan de Fuca plate subducting under the North American plate.

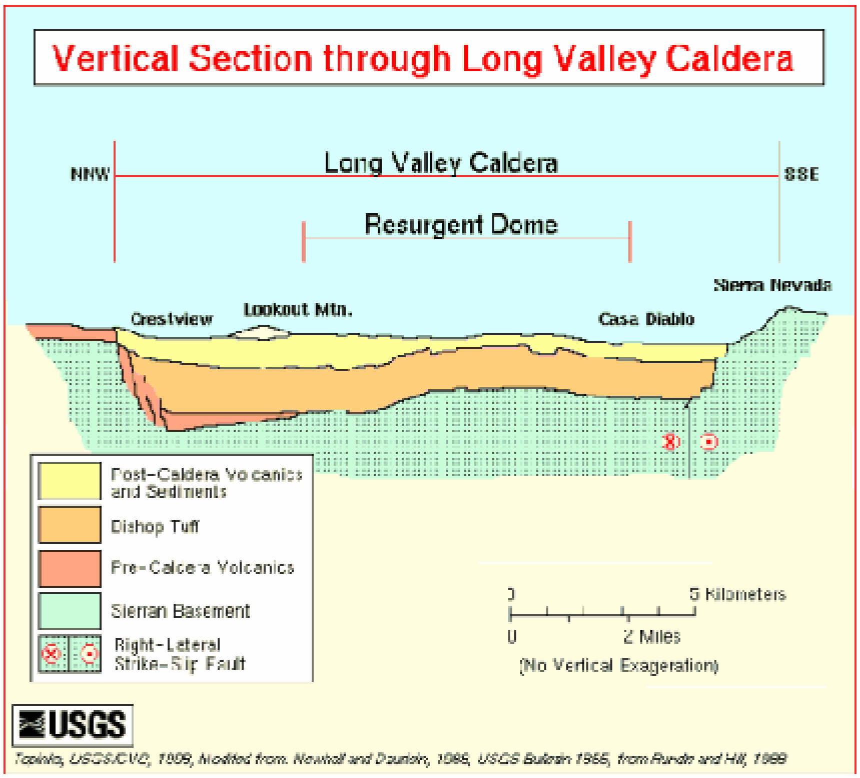
http://pubs.usgs.gov/gip/volcus/page37.html

During subduction, once the oceanic plate "reaches a depth of about 100 kilometers, partial melting of the water-rich oceanic crust and some of the overlying mantle takes place" (Tarbucks and Lutgens, 192). After this partial melting, the magma becomes less dense and slowly begins to proceed its way up until it reaches equilibrium with the surrounding matter, or it can erupt.

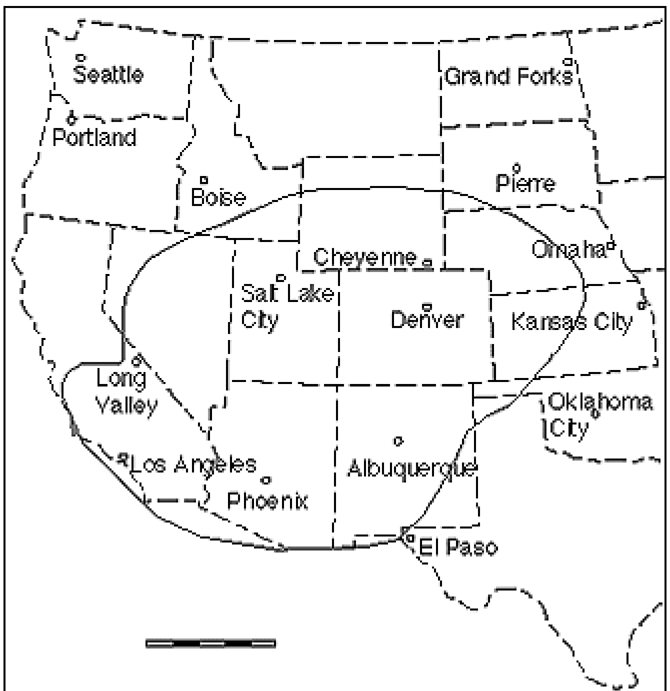
However the magma in the cataclysmic eruption went through a process called fractional crystallization before it erupted. As the molten rock starts to cool, the mafic materials in the magma will cool first. These solidified materials will begin to settle out of the magma, making the magma be more silica rich (Marshak, 145). Next, the magma does two things. One, depending on how silic the material becomes the basaltic magma will become either rhyolitic or andesitic. The magma in the eruption 700,000 years ago was rhyolitic. The second thing that happens when magma becomes more silica rich is that it starts to rise. The magma is lighter and becomes buoyant due to the silica. From here it can either erupt or rise until it reaches equilibrium once again.

The main reason for the eruption obviously is the subduction of the 2 oceanic plates, Farallon and Juan de Fuca, under the continental plate, North American. This created the volcanoes that erupted that created the vast Bishop Tuff. As far as fractional crystallization, the magma did not necessarily go through that process. It is just a possibility since the eruption produced a vast amount of rhyolite. The other possibility is that the magma was always rhyolitic. The first possibility makes more sense as the cause for the eruption.

After comprehending some possible ideas as to why the volcano erupted, the next thing is to reconstruct what happened during the eruption. By drilling through the Earth’s crust a few kilometers, one can study the exposed layers of the core sample and figure out what happened in sequential order. After taking a core sample from the Long Valley Caldera and one from outside the caldera, the USGS (United States Geological Survey) was able to make a schematic like the one picture below.



Before the volcano could erupt, gas needed to be released. However, “all confining pressure of the overlaying rock” had to be removed (Harris, 48). This gas was having difficulty trying to make its way through the viscous magma. Finally, when the volcano blew its top and the gas was let go of, the magma, ash fall, and ash flow were loose. It was so explosive that the ash fall ejected from the volcano reached Nebraska. Soon to follow was the incredibly fast and extremely hot pyroclastic flow. Pyroclastic flow when translated word for word means broken fire. It can reach speeds as fast as 150 miles per hour and its heat can range anywhere from 600 to 800 degrees Celsius. Therefore, it kills anything and everything in its path. The ash fall an ash flow put together make up the Bishop Tuff that extends as far as Nebraska like the picture shows below.



Distribution of Bishop ash beds from eruption at Long Valley caldera. From Izett and others (1982).

http://volcano.und.nodak.edu/vwdocs/volc_images/north_america/California/long_valley.html

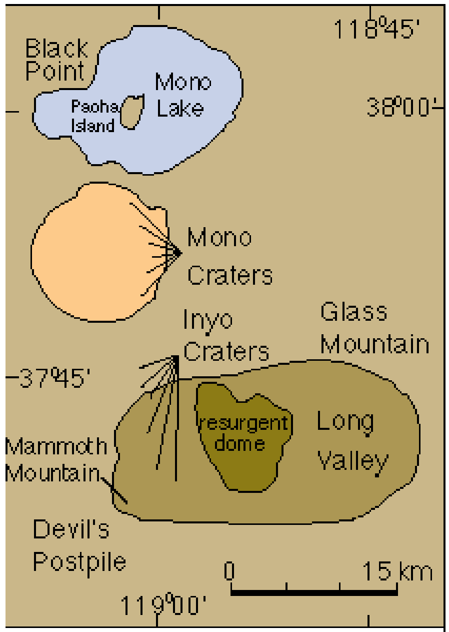
Not long after the falls and flows of ash, too much magma left the magma chamber causing it to collapse. This is called a caldera which is basically “a large, roughly circular depression commonly formed by the explosion or collapse of a volcanic peak” (Ritchie, 25). This caldera is known as the Long Valley Caldera and is 17 by 32 kilometers. The most recent measurement of the caldera's walls states that the walls “rise steeply to elevations of 3000 to 3500 meters on most sides” (Hamburger, Rupp, Brandy). Since this Long Valley Caldera formed after the eruption of the ash fall and flow, it makes sense that in the picture that post-caldera lavas and fill have covered the tuff. Yet, the tuff can still be seen right outside the walls of the caldera. More will be covered over the lava fill further on.

After the formation of the caldera, the land was still in the process of changing. About 100,000 years later, which is a short time geologically speaking, a resurgent done began to form. Pressure increased within the collapsed magma chamber and forced overlying rocks upward, thus creating this resurgent dome. While the resurgent dome was still forming, the caldera was filled with a large lake making the resurgent dome look like an island. This water drained eventually into the Owens River Gorge (Jensen).

The next things to form in the Long Valley Caldera region were the Mono-Inyo craters as shown below.

http://volcano.und.nodak.edu/vwdocs/volc_images/north_america/California/long_valley.html

These craters are at least 400,000 years old, since only eruptions are dated back to 400,000 years old. To understand in a better way as to when these craters were formed is by identifying it with the late-Pleistocene to Holocene period. The youngest of the craters is Paoha Island, located in Mono Lake. All of these craters have periodically been erupting ever since the cataclysmic eruption 700,000 years ago. The main cause for their eruptions could be because the Mono-Inyo Craters are situated along volcanic vents between Mono Lake and the Long Valley Caldera (Jensen). Also, it is the lava from these eruptions that have added to the layer of lava fill in the Long Valley Caldera. To get a better understanding of how these craters are positioned in relation to the Long Valley Caldera, the below picture should help. The last eruption from these craters was about 500 years ago, so it hasn’t been a long time since the last eruption, geologically speaking.



Location of main features of the Long Valley and Mono-Inyo Craters Volcanic Field. Based on Bailey (1983 and 1989).

http://volcano.und.nodak.edu/vwdocs/volc_images/north_america/California/long_valley.html

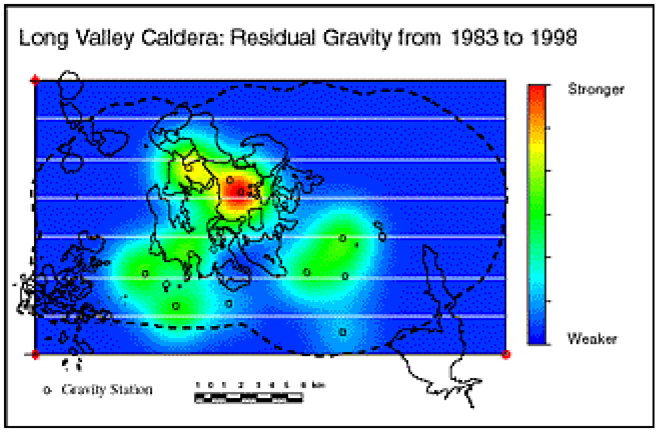
This leads on to the present day with the eruption from 700,000 years ago. It was not until 1978 that a succession of earthquakes created much interest among people. Most of this interest was aroused due to the possibility to another volcanic eruption occurring soon. Geologist states that the root of these earthquakes is “movement along a fault and by the pressure of magma rising beneath the Earth’s crust” (USGS). In 1980, the biggest earthquakes hit the southern part of the caldera. These intense earthquakes led the USGS to examine them closer.

Upon close examination, the USGS discovered that the resurgent dome in the Long Valley Caldera rose almost an entire foot since the last measurement in the summer of

1979. To date, the resurgent dome has risen nearly two feet. This was the first piece of evidence that suggested that there might be a possible eruption in the Long Valley region.

In 1990, another clue showed up; numbers of trees began dieing on Mammoth Mountain, located on the southwest side of the caldera. It was discovered that these trees were killed off by large amounts of gas coming up from the ground from magma. These carbon dioxide emissions make their way into the soil and kill the roots since the “roots need to absorb oxygen directly” (USGS). According to the USGS, gas emissions and earthquake swarms are common before volcanic eruptions. This period of unrest can last from a few weeks to several decades.

A new piece of evidence from Stanford University states that there is “an increase in the strength of the gravity in the central part of the caldera, in an actively uplifting region known as the resurgent dome” (Cole). This coincides with the notion that the magma body is rising. This new gravity data helps when discussing the possibilities of future eruptions. The results of the study on the gravitational strength can be seen below.



http://www.standford.edu/dept/news/report/news/january6/magma16.html

However, even with this new piece of evidence, scientists are still unsure as to whether or not that this recent unrest will lead to volcanic activity. It almost seems to be obvious that an eruption is due. The Long Valley Caldera has never been dormant, and it will not stop now, especially with all this unrest. Scientists themselves have said that some signs of a volcano erupting also occurred with other eruptions. So should not the evident answer be that there will be an eruption? Apparently that question is still in great discussion.

By following a volcano from its birth to its death, one can learn a great deal about volcanoes in general and use that knowledge to help even one day predict when a volcano will erupt. In studying the huge eruption of Bishop Tuff of about 700,000 years ago, one can understand what actually goes on with a volcano. For example, with scientists knowing signs that occur before a volcano erupts, they are using that knowledge to help figure out if the unrest in the caldera actually means there will be an eruption in the future. Knowing a volcano in and out also gives clues to the future. As the saying goes, the past holds the key to the future.

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