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Final Paper

From Punchbowl to Panum:

Long Valley Volcanism and the Mono-Inyo Crater Chain

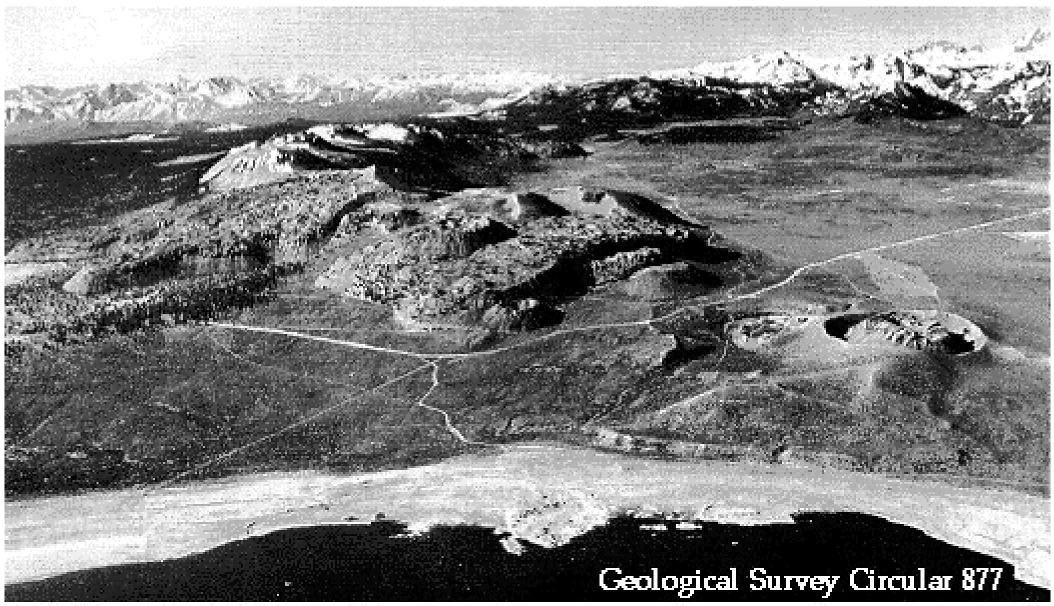


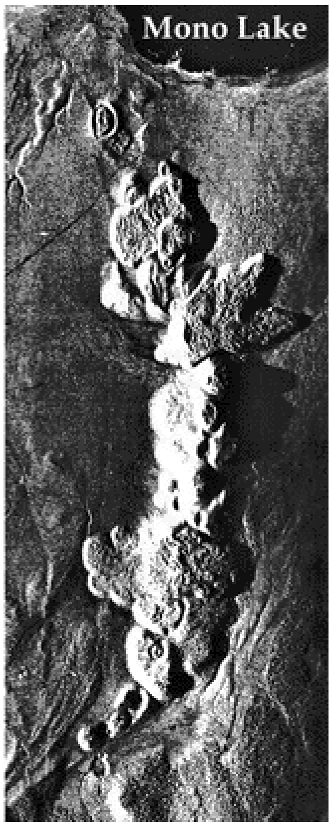
Figure 1.

After a sequence of earthquakes during the late 1970's to the early 1980's a great deal of interest was generated towards the Long Valley caldera and Mono-Inyo Crater chain. The observation of earthquakes, ground deformation, and groundwater changing to steam were interpreted as indicators of rising magma beneath the caldera. Rising magma could lead to a volcanic eruption so the United States Geological Survey (U.S.G.S.) created risk assessments for the possibility of future eruptions and has vigorously monitored the area to this date[2]. Continuing studies have found that the caldera has continued to rise on the scale of millimeters per year and carbon dioxide concentrations in the soil have been measured between 30-96%, both indicators for the possibility of large-scale magma intrusion[2]. The Mono Craters are a young volcanic chain associated with the Long Valley caldera that is located in Eastern-central California. Long Valley caldera is at the boundary between the Sierra Nevada and the Basin and Range province. Indicators of rising magma, and the region's checkered and unpredictable volcanic eruptions all combine to create a complex and dangerous game of watching and waiting.

The Long Valley caldera was produced by a catastrophic eruption about 730,000 years ago. The roof above the magma chamber collapsed and forced 150 cubic miles of rhyolitic magma to the surface in the form of Plinian ash columns and associated air falls and ash flows[2]. The caldera is a ten by twenty mile ellipse. The caldera floor has an elevation of two thousand meters in the east, rising to two thousand six hundred meters in the west. The caldera walls are at elevations from 3000-3500 meters except for a portion in the east where it is only 2300 meters [2]. This region is known to be one of the largest Quaternary rhyolitic volcanic centers in North America and is also associated with extensional tectonics (where the land is slowly stretching apart)[4]. The Mono Crater chain that will be the focus of this paper is just outside the caldera and is a part of a larger structure that forms a 40km chain of craters, domes, and flows dated to the late Pleistocene and Holocene era[4]. This chain includes the Inyo Craters and Mono Lake volcanoes. Rhyolitic volcanism began on the Mono Craters chain northwest of the caldera about 35,000 years ago. The youngest feature, Negit Island is only 600 years old[5].

Volcanic activity in the region that allowed the formation of the Mono Craters is a result of "an old circular fracture in the Earth's crust that is providing magma deep within the Earth a path to the surface."[5] Stepping back to examine the Long Valley region as a whole, the Sierra Nevada mountain range is to the East of the crater chain. The fracture mentioned was created around the margins of an earlier body of Sierran granitic magma that rose to the surface approximately 70 million years ago[8].

The Mono Craters should not be thought of as craters in the classic sense meaning a depression or pit[6]. The Mono Craters are a range of 30 or more overlapping domes and craters evident in Figure 2[4].



These craters are composed of a rhyolitic magma. Rhyolite is a volcanic rock with a very high silica content. Silica is a mineral commonly found in the form of sand and plays an important role in the composition and behavior of magmas. As magma rises to the surface, the pressure decreases which allows the gas contained within the molten magma to expand. A magma rising quickly containing expanding gases will erupt explosively as the gas pushes to escape. A viscous magma rising and cooling more slowly will result in a slow oozing out of magma that when exposed to the air freezes and stops moving. This black volcanic glass that is formed is called obsidian[5].

Figure 2.

The Basin and Range province caused a great deal of stretching to the Earth's crust. The fractures and faulting around the Mono Basin area were at one time moved as a response to the extension of the southern part of the Basin. The voids left as a result of this stretching are being filled by intruding magma. The magma chamber beneath the Mono Craters is believed to be similar in composition and size to the magma chamber that created the Long Valley eruption. The Mono Craters have in general erupted in three distinct phases as a result of the build up and release of gas[5]. Figure 3 depicts these three phases[6].

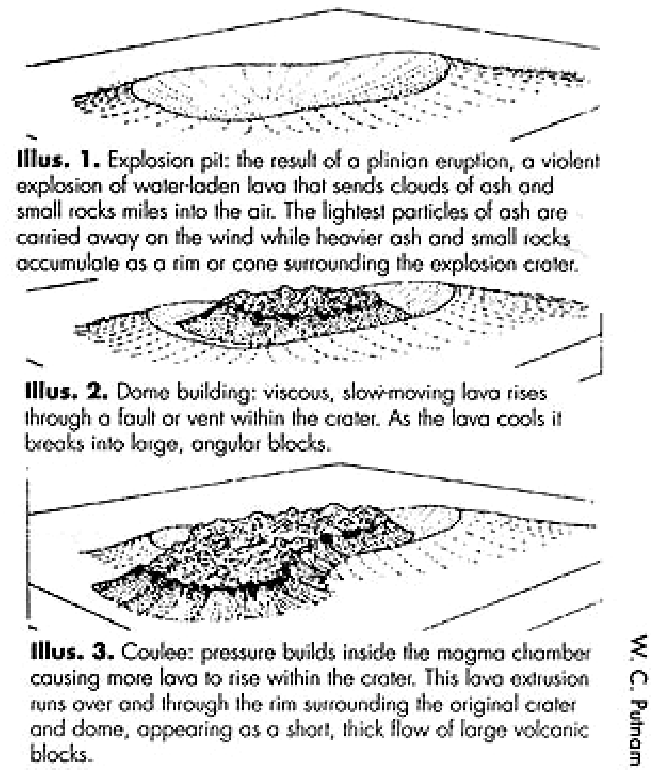


Figure 3.

Phase one of eruption involves an explosion caused by the release of gas trapped within the magma at high pressure. The result of this is an explosion crater with a visible debris ring. A large percentage of the magma volume is erupted during this phase as a blast of ash. This ash is also referred to as tephra.

Eruption phase two involves the extrusion of lava. This lava is characteristically very viscous and rises slowly in a close to solid form. The viscous lava creates a dome inside the debris ring sealing off the vent or fissure source. Since the first phase of eruption releases the majority of the gases the remaining eruptions will be smaller and occur slowly.

The formation of coulee occurs in the third phase of eruption. The lava continues to be extrude to the point where it overruns some or all of the surrounding debris ring that formed during phase one[5].

During the past 35,000 years, volcanic activity in the Long Valley area has been confined to the Mono-Inyo Craters volcanic chain[4]. About 20 small to moderate eruptions have occurred somewhere along the chain in the last 5,000 years as Figure 4 indicates. Some of the eruptions occurred at about the same time and in close proximity. For example, the Inyo eruptions 550-600 years and the eruptions from the north end of the Mono Craters about 600 years ago. The intervals between eruptions or eruption clusters ranged from 250 to 750 years. The diagram in Figure 4 below shows events on the Mono-Inyo Crater chain in relation to one another.

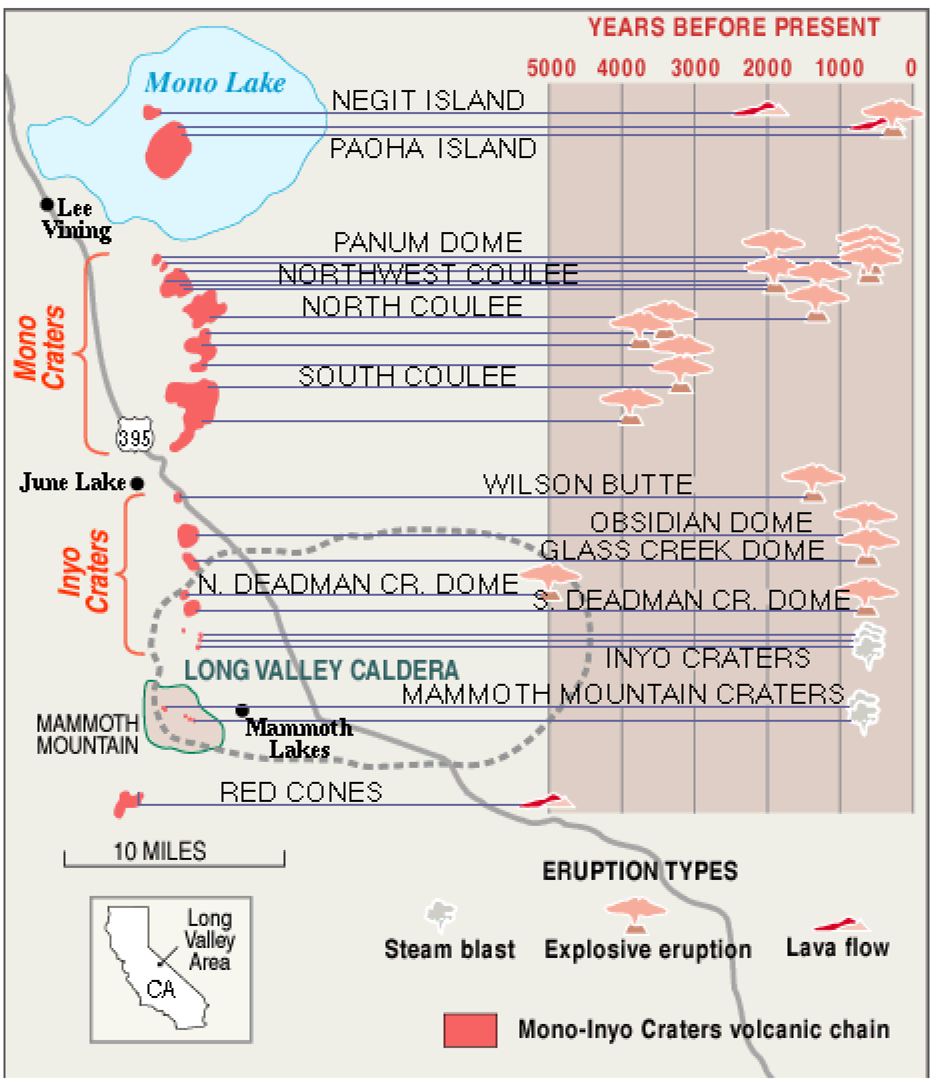


Figure 4

As theorized, rising magma preceded all of the major eruptions. Ground cracking formed what are now familiar features; lava flows, craters, layers of pumice and ash, and cracks near Mammoth Mountain. Volcanic activity occurred during an extremely short period of time. The sequence of these eruptions can help us to anticipate the type of activity that is likely to occur again, and to recognize the events that will almost certainly precede future eruptions[1].

However, the Mono Craters are not active at this time. Using dendrochronology to date trees found growing upon deposits from the eruption to 1369AD, the last eruption in the Mono Crater chain occurred approximately 630 years ago, an extremely short period of time between the last eruption and today's concerns over the current activity in the Mono-Inyo crater chain[5]. An even more current eruption is said to have occurred on Paoha Island in Mono Lake is said to have erupted only 250 years ago. Concern over whether or not the Mono Craters pose a risk of erupting again anytime soon is a topic of much debate. When the Los Angeles Department of Water and Power drilled through the Mono Craters during the 1930's aqueduct construction they found possible evidence of rising magma. Extremely hot groundwater, the presence of carbon dioxide gas and steam all indicate activity within the craters[6].

The USGS stated that, "If future monitoring of the Long Valley volcanic unrest suggests magma is moving beneath the Mono-Inyo chain, it may not be possible for scientists to anticipate the exact location of one or more eruptive vents. For example, about 600 years ago eruptions from both the northern and southern parts of the chain occurred from vents along zones 6-11km in length. Thus, scientists will probably not be able to define the pyroclastic-flow and surge zone more precisely when an eruption is expected."[7]

With continued monitoring of the changes beneath the surface of Long Valley scientists will be able to alert the public to changes that indicate an increased likelihood for earthquake or volcanic eruption. The Mono Craters are special because they are towards the end of the line in the Mono-Inyo Crater chain and exist as examples of very young volcanic activity. The Mono Craters are well preserved and play a role in better understanding the formation, intrusion and movement of a magma body in relation to the extremely complicated tectonics of the Long Valley region. As with all seismically active regions there is not one single set of warning signs for eruption or type of eruption. The combination of knowledge about how the volcanoes act after eruption and before eruption adds insight into being able to predict future eruptions and broadening the understanding of past eruptions.

Works Cited

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