USGS
science for a changing world

Frequency of Volcanic Eruptions in the Mammoth Lakes Sierra

Geologists recognize lavas and ash deposits from about 60 past eruptions in the area around Mammoth Mountain and Devils Postpile, California. This raises the unanswerable question, "When will it erupt again?" An alternative, answerable, and informative question is, "How often has it erupted?"

In the Mammoth Lakes Sierra, geologists have mapped in great detail all the lavas and ash deposits produced by those 60 eruptions. They have dated almost all of them by laboratory methods, showing that eruptions have been repetitive and persistent, though not quite regular, over the last quarter-million years. For few volcanoes in the world is the long-term eruptive frequency so well calibrated as in the Mammoth Lakes Sierra.

Rising Magma and Volcanic Eruptions

Beneath active volcanic regions, molten magma is held in chambers and conduits at many depths—from a few miles to more than 100. But its ascent to the surface to produce lava flows or to effervesce its dissolved gas to produce explosions can seldom be predicted long in advance. Not until telltale signs of ascending magma (earthquakes, ground uplift, and gas clouds) are recorded by monitoring instruments, typically only weeks before an outburst, can geologists consider an impending eruption likely.

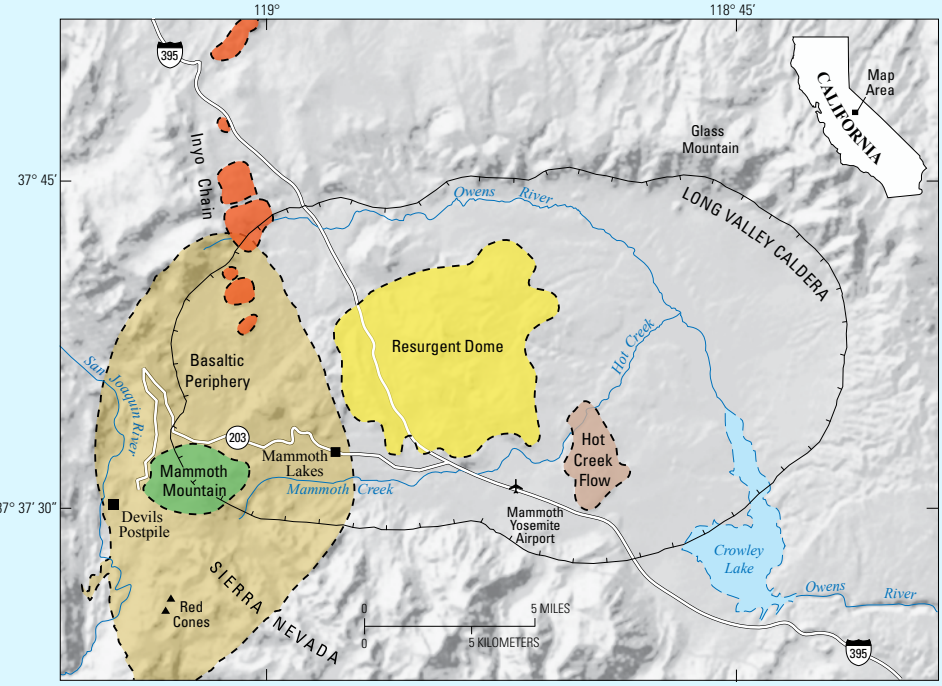
A few volcanoes (Kīlauea, Hawaii; Stromboli, Italy; Sakurajima, Japan) erupt persistently for many years. Others tend to erupt every few years and still others erupt every few decades. But many volcanoes come back to life after lying dormant for centuries or even thousands of years. How do we deal with volcanoes that have never erupted in recorded history but certainly could?

For long-dormant but potentially threatening volcanoes, geologists do labor-intensive field mapping, sampling, and dating of deposits from all past eruptions to build detailed records of the magnitude, style, and frequency of prehistoric activity. Such records are useful indicators of what to anticipate when a volcano again becomes restless. Studies of eruptive histories are now fairly detailed for several volcanoes in the Cascade Range, as is the record for the Mammoth Mountain volcanic field of California.

Mammoth Mountain Volcanology

Mammoth Mountain, site of a major regional ski area, rises 3,000 feet above the Town of Mammoth Lakes. Geologists have mapped the deposits of 25 separate eruptions that incrementally built the edifice from 100,000 to 50,000 years ago. Nearly all eruptions were extrusions of viscous lava that solidified as knobby domes and thick lava flows. Only one deposit represents an explosive eruption that spread a cloud of pumice and ash eastward across Long Valley. Surrounding Mammoth Mountain, about 35 scattered vents, mostly basaltic and andesitic cinder cones, bring the total number of eruptions to about 60.

Thick viscous magmas (andesite, dacite, and rhyolite) are products of cooling and crystallizing in magma chambers and plumbing conduits within the Earth's crust, mostly at depths between 2 and 15 miles. However, almost all magmatic activity is initiated by the rise of hotter, more fluid basaltic magma that is produced by melting of the Earth's mantle at more than 20 miles deep. Batches of molten basalt sometimes rise right through



Map of Mammoth Mountain and the vicinity.

Banner: Devils Postpile basalt, eroded colonnade 3 miles west of Mammoth Mountain.

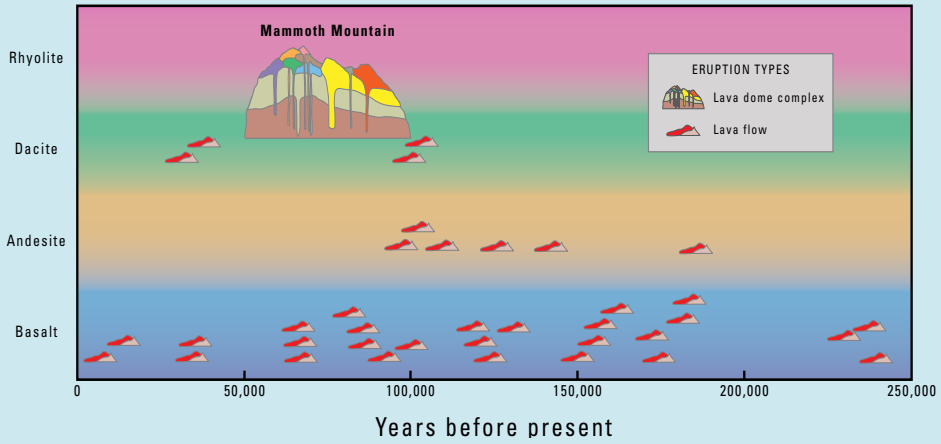
Mammoth Mountain rises above the Town of Mammoth Lakes, California.

the crust and erupt as basaltic lava flows and cinder cones. Devils Postpile is an example of basaltic lava that flowed out of a vent and ponded thickly on a canyon floor. Other batches of rising basalt fail to erupt, and they stall within the crust, melting the surrounding crustal rocks with their greater heat. Cooling, crystallization, and mixing of mantle and crustal melts with different temperatures, water contents, and viscosities can lead to a wide range of erupting compositions. Progressively lower temperature magmas, from basalt to andesite to dacite to rhyolite, are increasingly more viscous, contain more water, and erupt more explosively.

The viscous dacite lavas of Mammoth Mountain oozed out and piled up above a crustal magma chamber that lay near the middle of a scattered field of about 35 basaltic and andesitic vents. Geologists infer that heating by the many surrounding basalts had focused the crustal dacite chamber where the basaltic injections were most concentrated. The mass and heat of the basalts are fundamental to producing the dacites at the center of the volcanic field.

Determining the Ages of Mammoth Eruptions

Most of the 60 magma batches, which erupted lavas of many kinds, have been dated by argon radioisotopic methods in U.S. Geological Survey (USGS) laboratories. Basalts began erupting in the Mammoth Mountain area about 235,000 years ago and have been fairly persistent ever since. Between 140,000 and 100,000 years ago, cooling of basalts within the crust led to eruption of several batches of andesite. Continued cooling, magma mixing, and partial crystallization produced dacite melt that culminated in 29 dacite eruptions during a 50,000-year-long episode; 25 of these eruptions built Mammoth Mountain in the center of the volcanic field. Dacite eruptions eventually ceased, but a few basaltic eruptions have continued during postglacial time—the past 16,000 years. The most recent eruption of all was the basalt of Red Cones, a lava-flow apron and two cinder cones that erupted 8,000 years ago, just 3 miles southwest of the summit of Mammoth Mountain. Since 1990, batches of basalt that failed to erupt, but instead stalled in the crust, have been releasing enough carbon dioxide gas to kill the forest at 10 sites that hug the base of Mammoth Mountain (see USGS Fact Sheet 172–96, cited below).



Eruptive timeline showing the age and composition of 60 eruptions on and around Mammoth Mountain.

How Frequently Has Mammoth Mountain Erupted?

Looking at the eruptive timeline, there has been at least one eruption every 10,000 years or so for the past 250,000 years, and the last eruption was 8,000 years ago. Time gaps between eruptions are variable, and we never expect eruption frequency to be strictly regular. We cannot predict exactly when the next eruption will take place, but the USGS California Volcano Observatory has a network of seismometers, ground deformation detectors, and gas sensors in place that give us real-time alerts about unrest beneath the volcanic field.

One of the twin basaltic cinder cones, called Red Cones, 3 miles southwest of Mammoth Mountain.

Wes Hildreth, Andrew Calvert, Judy Fierstein, and Mae Marcaida

Edited by Katherine Jacques

Layout by Geraldine Dang

For Additional Information:

https://volcanoes.usgs.gov/observatories/calvo/

Invisible CO_2 gas killing trees at Mammoth Mountain, California (USGS Fact Sheet 172–96); California's restless giant—the Long Valley Caldera (USGS Fact Sheet 2014–3056); The California Volcano Observatory—Monitoring the State's restless volcanoes (USGS Fact Sheet 2014–3120); U.S. Geological Survey's alert-notification system for volcanic activity (USGS Fact Sheet 2006–3139).

ISSN 2327-6916 (print)
ISSN 2327-6932 (online)
https://doi.org/10.3133/fs20183059