

The California Volcano Observatory—Monitoring the State’s Restless Volcanoes

Volcanic eruptions happen in the State of California about as frequently as the largest earthquakes on the San Andreas Fault Zone. At least 10 eruptions have taken place in California in the past 1,000 years—most recently at Lassen Peak in Lassen Volcanic National Park (1914 to 1917) in the northern part of the State—and future volcanic eruptions are inevitable. The U.S. Geological Survey California Volcano Observatory monitors the State’s potentially hazardous volcanoes.

More than 50 volcanoes in the United States have erupted one or more times in the past 200 years. The most volcanically active regions are in Hawaii, Alaska, Washington, Oregon, and California. California’s volcanoes are dispersed throughout the State—from near its northern border with Oregon to its southern border with Mexico. The U.S. Geological Survey California Volcano Observatory (USGS CalVO) in Menlo Park watches over California’s potentially hazardous volcanoes to help communities prepare for, and respond to, volcanic activity.

Some California Volcanoes are More Hazardous Than Others

The USGS has ranked the volcanic threat at all U.S. volcanoes using volcano age, types of potential hazards, and estimates of the societal exposure to those hazards. Sixteen volcanoes are on California’s watch list to monitor. Research suggests that partially molten rock (magma) lies beneath seven of these volcanoes—Medicine Lake Volcano, Mount Shasta, Lassen Volcanic Center, Clear Lake Volcanic Field, the Long Valley Volcanic Region, Coso Volcanic Field, and Salton Buttes. At these volcanoes, earthquakes (seismicity), hot springs, volcanic gas emissions, and (or) ground movement (deformation) attest to their restless nature.




As a part of the U.S. Geological Survey’s Volcano Hazards Program, the California Volcano Observatory aims to advance scientific understanding of volcanic processes and lessen the harmful impacts of volcanic activity in the volcanically active areas of California.

Volcanoes of very high to low threat are scattered throughout California, from the Oregon border (north) to Mexico (south). Other older volcanoes in California are of less concern. California’s volcano watch list is subject to change as new data on past eruptive activity are collected, as volcanic unrest changes, and as populations in threatened areas grow or decline.

This type of low-level volcanic unrest can persist for decades or even hundreds of years without an eruption. Although steady, low-level unrest is normal for many young volcanoes, rapidly accelerating unrest is cause for concern. At California’s most threatening volcanoes, monitoring sensors are in place to continuously track levels of unrest. Such monitoring is necessary to determine the baseline, or background level, of activity at a volcano to help volcanologists know what is normal. An uptick in unrest may be a sign of increased volcanic threat.

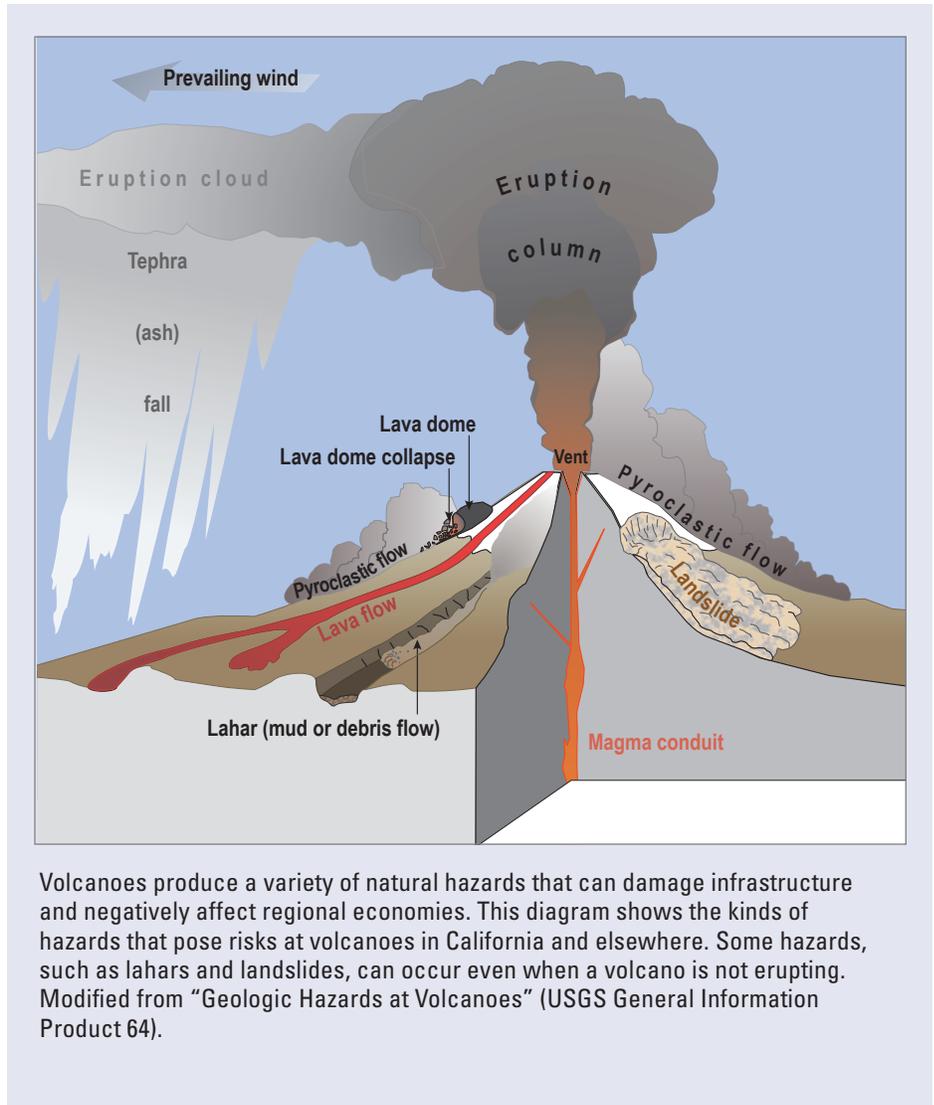
California Volcanoes Erupt in Various Styles and Produce Diverse Hazards

Explosive eruptions blast lava fragments (**tephra**) and gas into the air with tremendous force. The finest particles (**ash**) billow upward, forming an **eruption column** that can attain stratospheric heights in minutes. Simultaneously, searing volcanic gas laden with ash and coarse chunks of lava may sweep down the flanks of the volcano as a **pyroclastic flow**. Ash in the **eruption cloud**, carried by the prevailing winds, is an aviation hazard and may remain suspended for

hundreds of miles before settling to the ground as **ash fall**. During less energetic effusive eruptions, hot, fluid lava may issue from the volcano as **lava flows** that can cover many miles in a single day. Alternatively, a sluggish plug of cooler, partially solidified lava may push up at the vent during an effusive eruption, creating a **lava dome**. A growing lava dome may become so steep that it collapses, violently releasing pyroclastic flows potentially as hazardous as those produced during explosive eruptions.

During and after an explosive or effusive eruption, loose volcanic debris on the flanks of the volcano can be mobilized by heavy rainfall or melting snow and ice, forming powerful floods of mud and rock (**lahars**) resembling rivers of wet concrete. These can rush down valleys and stream channels as one of the most destructive types of volcano hazards.

When a dormant volcano reawakens, a series of events commonly unfolds—the energy of eruptive activity increases, peaks, and then gradually subsides as the volcano returns to a state of rest. The 1914 to 1917 eruptions of Lassen Peak produced a yearlong series of minor steam blasts before a major explosion sent an eruption column 30,000 feet high and unleashed devastating pyroclastic flows and lahars. Windborne ash drifted 275 miles eastward and fell as far away as Elko, Nevada. The climactic phase of the eruption was over in a matter of days, but recurring steam blasts and lahars created hazardous conditions for several years afterwards. Unlike other natural disasters, volcanic eruptions and their associated hazards can persist for months, years, or even decades before an “all clear” can be sounded.



High to very high threat volcanoes. Several of California’s young volcanoes are less than 100 miles from major population centers. The inherent beauty of the State’s volcanic regions draws thousands of visitors each year, while their potential for geothermal energy has attracted industrial developers.



Medicine Lake Volcano

High threat

Lava Beds National Monument, about 30 miles south of Klamath Falls, Oregon, is located on the lower northern flank of the shield-shaped Medicine Lake Volcano and contains the highest concentration of lava-tube caves in North America.



Mount Shasta

Very high threat

This 14,162-foot-high volcano holds the headwaters of the upper Sacramento River and is adjacent to several towns and major highway, rail, and air transportation corridors.



Lassen Volcanic Center

Very high threat

Lassen Volcanic National Park, located about 50 miles east of Redding, showcases the dynamic history of this area and draws more than 350,000 visitors each year. Lassen Peak erupted violently in the early twentieth century.

The California Volcano Observatory uses several modern instrumental methods to monitor volcanoes. Three key techniques measure earthquakes (seismicity), movement of the ground surface (deformation), and the types and amounts of gases released from a volcano (gas geochemistry).



Left: Sophisticated sensors like this Global Positioning System (GPS) receiver and seismometer in the Long Valley Volcanic Region can detect ground deformation and seismicity that occur as magma or volcanic gas rises toward the Earth's surface in the weeks to months prior to an eruption. Data are telemetered from sensors in the field to USGS offices in Menlo Park, California, for processing and interpretation. Early detection of eruption precursors via a reliable volcano monitoring network is essential to hazard mitigation. Mammoth Mountain, a volcano made up of overlapping lava domes and flows, is visible behind the monitoring equipment. **Right:** Volcanic-gas "sniffer" at Mammoth Mountain continuously measures temperature plus carbon dioxide and other gas concentrations at a steaming vent.

Volcano Hazard Zones Identify Threatened Areas.

Maps of volcano hazard zones convey the types of hazards that may occur during a future eruption and the areas of likely impact. The specific hazards to people and property depend on the eruption style (effusive or explosive), the volume of lava erupted, the location of the vent, the eruption duration, and local water-flow and precipitation conditions. Low-energy effusive eruptions are destructive, but generally not life threatening. High-energy explosive eruptions are destructive and life threatening.

Statewide, California's volcano hazard zones encompass more than 24,000 square miles, of which about half is privately owned and about half is public land that is managed by the U.S. Forest Service, National Park Service, or Bureau of Land Management. Within these zones are natural resources and infrastructure essential to California's water, power, and transportation systems. Although less than 1 percent of California's population lives within a designated hazard zone, more than 20 million recreational visitors are attracted annually to the dramatic landscapes they afford.

CalVO Provides Timely Forecasting of Volcano Hazards

The mission of the California Volcano Observatory is to enhance public safety and minimize societal disruption in the event of volcanic unrest through delivery of effective forecasts of volcanic activity derived from monitoring and rigorous scientific research. Whereas USGS maps of volcano hazard zones provide long-term perspectives on future volcanic activity, short-term forecasts give warning of likely outcomes under rapidly changing conditions during volcanic unrest and eruption.

An eruption at any one of the six volcanoes shown here may result in volcanic hazards that could impact vulnerable infrastructure and resources. In an explosive eruption, airborne ash could travel for hundreds of miles—so the volcano closest to your home may not be the one that affects you the most.



Clear Lake Volcanic Field

High threat

Located about 90 miles north of San Francisco, the Clear Lake Volcanic Field provides the heat for The Geysers, the largest complex of geothermal power plants in the world.



Long Valley Volcanic Region

High to very high threat

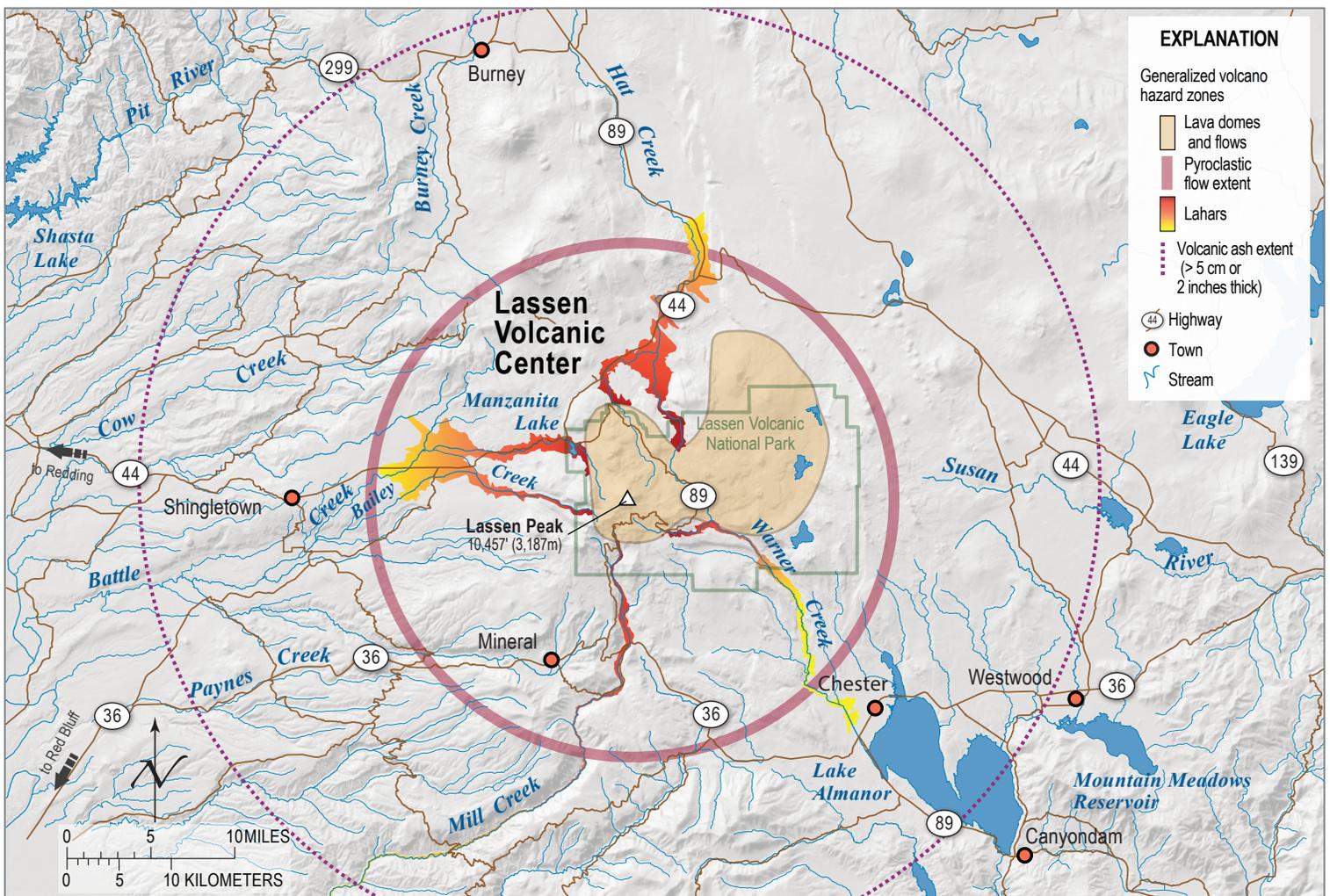
A cataclysmic "supervolcano" eruption about 760,000 years ago left behind a depression 20 miles long and 10 miles wide known as Long Valley Caldera, located about 30 miles southeast of Yosemite National Park.



Salton Buttes

High threat

The Salton Buttes are volcanic domes that lie within the Salton Sea Geothermal Field located about 90 miles southeast of Palm Springs.



U.S. Geological Survey geologists produce volcano hazard maps, like this generalized hazards map of Lassen Volcanic Center in northern California, to estimate potential impact areas for ground-based and ash-fall hazards during a volcanic eruption. Pyroclastic flows generally travel down drainages and in this area have been found in valleys as much as 15 miles from Lassen Peak. Ash-fall hazards could affect other, more distant areas downwind, depending on wind directions and strengths during an ash-producing eruption.

“Real-time” forecasts are released as USGS Volcano Alert Notifications (VANs) and Volcano Observatory Notices for Aviation (VONAs), both of which use four-tiered threat level systems. VANs use Normal-Advisory-Watch-Warning to specify increasing threat on the ground, and VONAs use Green-Yellow-Orange-Red to specify increasing threat to aviation. An email-based Volcano Notification Service (VNS) automatically delivers VANs, VONAs, and other volcano information to all subscribers who register online at <http://volcanoes.usgs.gov/vns>.

USGS Volcano Hazards Program Promotes Community Resilience

Volcano research, monitoring, and hazard notification by CalVO is only one part of the larger USGS Volcano Hazards Program’s effort to identify and mitigate volcanic hazards in the

United States and abroad. The USGS operates four volcano observatories in addition to CalVO—the Cascades Volcano Observatory (covering Oreg., Wash., Idaho); Yellowstone Volcano Observatory (Mont., Wyo., Colo., Utah, N. Mex., and Ariz.); Hawaiian Volcano Observatory (Hawai‘i); and Alaska Volcano Observatory (Alaska., Northern Mariana Islands). Key to their ongoing success is continued implementation of the National Volcano Early Warning System (NVEWS) to modernize the Nation’s monitoring infrastructure and to improve the detection and forecasting of volcanic activity. Additionally, with the support of the U.S. Office of Foreign Disaster Assistance, the USGS Volcano Disaster Assistance Program (VDAP) responds to volcano crises abroad and helps build volcano hazard response capabilities in other nations.

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<http://volcanoes.usgs.gov/observatories/calvo/>

This fact sheet and any updates to it are available online at <http://pubs.usgs.gov/fs/2014/3120/>

See also *What are Volcano Hazards?* (USGS Fact Sheet 002–97); *Volcano Hazards—A National Threat* (USGS Fact Sheet 2006–3014), *U.S. Geological Survey’s Alert-Notification System for Volcanic Activity* (USGS Fact Sheet 2006–3139); *A Sight “Fearfully Grand”—Eruptions of Lassen Peak, California, 1914 to 1917* (USGS Fact Sheet 2014–3119); and *Geologic Hazards at Volcanoes* (USGS General Information Product 64)