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Volcanic Hazards and Risks Associated With Possible Eruptions in the Vicinity of the Long Valley Caldera

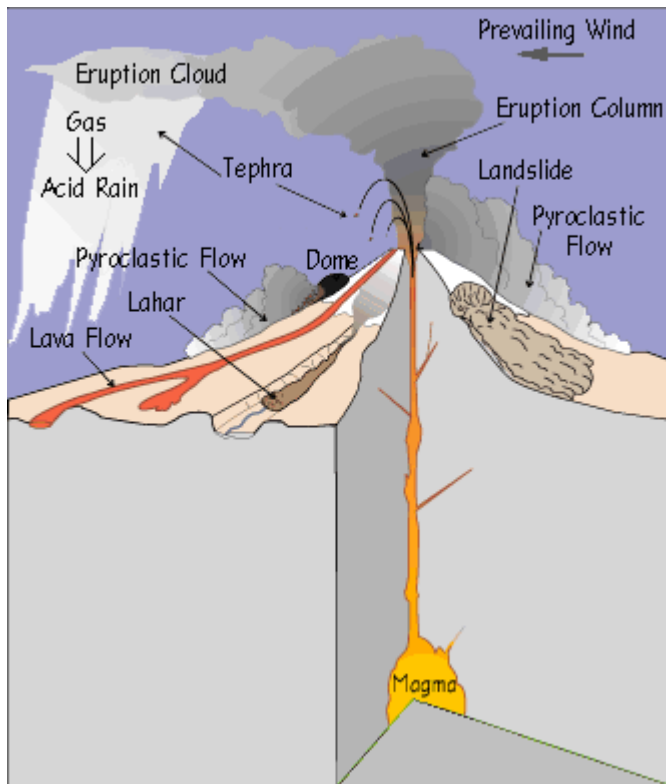
What is a volcanic hazard?

A volcanic hazard is the probability of a certain area being affected by particular volcanic phenomenon.

What is a volcanic risk?

A volcanic risk is the probability of effect on human society.

What kinds of volcanic hazards are there, and how will they affect human life in the Long Valley area?



USGS Volcanic Hazards Diagram

The primary volcanic hazards are: lava flows, ash fall, pyroclastic flows, lahars, landslides and gas emissions.



(S.R. Brantley 7/29/98 Long Valley)

Lava Flows:

There are three factors that determine how much area is affected by lava flow: the rate of effusion, the slope of the surface onto which it is erupted, and the viscosity of the lava. The rate of effusion is the most important factor. In the most exceptional case, basalt flows have discharged at such a rate to cover tens of thousands of square kilometers. Dacitic and rhyolitic lavas, which are more viscous, erupt at lower rates, often forming volcanic domes close to the vent.(Scott, 1989)

Lava flows bury, crush or burn everything in their paths. They start fires and melt snow and ice that can produce floods and debris flows. Because they follow valleys, lava flows can dam tributaries and form lakes, which can cause flooding if the dams fail. According to the USGS, future lava flows in Long Valley will be either basaltic (relatively fluid) or dacitic or rhyolitic, (viscous) as past lava flows have been both. Basaltic flows may reach as far as thirty miles from the vent. Dacitic and rhyolitic flows seldom reach beyond three miles from the vent, but often form domes, which create pyroclastic flow hazards when their steep, unstable sides collapse. (Scott,1989 and

lvo.wr.usgs.gov)



(D.E. Wieprecht, ash fall from Randle, Washington)

Ash Fall:

Ash is a form of tephra which consists of fragments of rock and lava ejected from an erupting volcano. Tephra fall is the widest ranging direct volcanic hazard. Ash is tephra less than two millimeters in size. Fine ash can be carried by the wind and cover an entire continent. Tephra falls are a hazard to life by burial and the suspension of fine grained particles in the air. If tephra builds up on the roof of a building, it can cause collapse, as well as break power and phone lines. Wet, compacted tephra has a greater density than that of dry tephra, so rainfall poses an added threat.

The suspension of ash in the air affects visibility and health. Internal combustion engines are especially at risk for damage, affecting air, rail and highway traffic. Fine grained particles can be suspended in the air by wind, especially in dry climates, and prolong many of these problems. Even thin ash falls can damage hospitals, electric plants, pumping plants, storm sewers, surface draining systems and water and sewage treatment facilities. Eruption clouds can disrupt air travel by causing flights to have to be diverted, delayed and canceled.

Tephra falls can cause fire by the lightning generated in eruption clouds and by hot fragments. Once dispersed over a drainage basin, tephra can greatly change rainfall/runoff relationships. Low permeability of fine ash deposits lead to increased runoff accumulation, erosion, and stream and channel adjustment. (Scott, p.19)

According to the USGS, in a typical eruption of a Mono-Inyo vent, tephra may accumulate to a thickness of ten meters near the vent. Areas downwind could be covered with ash and pumice eight inches thick twenty two miles away, and five inches fifty three miles away. (Scott 1989 and USGS website and Wheeler p.42)



(Bishop Tuff, unknown)



(C. Newhall, 9/15/84 Mayon Volcano, Phillipines)

Pyroclastic Flows:

Pyroclastic flows are masses of hot debris and gases that move rapidly along the ground surface. A flow is usually composed of two parts:(1) a dense, basal flow that remains close to the ground, called the pyroclastic flow proper, and (2) a turbulent ash cloud preceding or overriding the flow. Pyroclastic flows are common at silicic calderas like Long Valley. These flows pose hazards from asphyxiation, burial, incineration and impact. They can also mix with surface water and melt snow and ice to create lahars and floods. Pyroclastic flows can start fires and because they have great mass and speed, they can travel over topographic barriers, affecting larger areas.

Based on the distances that Pyroclastic flows are known to have traveled in the past few thousands of years, areas ten miles from a Mono-Inyo vent could be swept by a flow. Flows from vents on Mammoth Mountain could travel even farther because of the momentum it would gain traveling down Mammoth's steep sides.



(R. Janda 12/18/85 Guali River Valley)

Lahars:

Lahars are created when a large volume of volcanic ash and debris become saturated with water and suddenly move down slope. Lahars can be divided into two

categories: debris flows and mudflows. In debris flows, fifty percent of particles are coarser than sand and has the general consistency of wet concrete. Mudflows can travel very, very quickly with little or no warning. Lahars can destroy virtually anything in their path, even large structures such as bridges. They can bury crops and houses. The areas of Long Valley likely to be affected by lahars is approximately the same as those estimated to be affected by pyroclastic flow. (Scott 1989 and USGS)



(J. Marso 11/85 Rio Lagunillas)

Gas Emissions:

Expansion of volcanic gases is what causes many eruptions to be so explosive. Gases spread from an erupting volcano as acid aerosols attached to tephra particles. These corrosive gases can damage commercial jet airplanes when the gases invade cruising altitude atmosphere. Water vapor, carbon dioxide and sulfur dioxide are the most abundant gases released from a volcano respectively. Hydrogen sulfide, hydrogen, carbon monoxide, hydrogen chloride, hydrogen fluoride and helium are also released in smaller quantities. Sulfur dioxide, carbon dioxide and hydrogen fluoride pose the greatest hazards to humans. Sulfur dioxide can lead to acid rain and air pollution. Carbon dioxide, heavier than air, sinks into low lying areas and collects in the soil, killing people, animals and

vegetation. Exposure to hydrogen fluoride can cause skin and eye irritation and bone degeneration. Animals that eat grass coated in this gas will be poisoned. It also promotes acid rain.



(John Rogie)

The Horseshoe Lake area near Mammoth Mountain is well known for the trees that have been killed by the high (80%) concentrations of carbon dioxide in the soil. The gas is coming up through the ground from magma underlying the area, and chokes off the necessary oxygen for the trees to survive. One skier has died near Horseshoe lake when he fell through the snow into a pit, and asphyxiated. (USGS)

Landslides:

Landslides often originate as rockslides which break up into fragments as they move down. A landslide in the Long Valley area is most likely to occur on Mammoth Mountain because it is steep and more likely to be weakened by the rise and eruption of molten rock. The intrusion of magma into a volcano, explosive eruptions, earthquakes and large amounts of rainfall that saturates tephra covered slope scare likely to cause landslides. A landslide will destroy everything in its path, and may cause explosive eruptions, bury river valleys, generate lahars, trigger tsunamis or create deep craters.



(USGS)

(volcanoes.usgs.gov)

Earthquakes:

Earthquakes are another hazard associated with the Long Valley Caldera. As magma chambers fill with magma, rocks shift to make room and earthquakes occur. Earthquakes have been occurring in swarms every day in the caldera. Most of these occur deep within the earth and aren't felt at the surface. In 1997, more than a thousand earthquakes occurred in forty eight hours, at a highest magnitude of 4.8. In 1980, four magnitude 6.0 earthquakes occurred in forty eight hours. These earthquakes were strong enough to cause some structural damage and scare many vacationing Memorial Day travelers from the area. (Wheeler p.45)

What is the role of the USGS in warning people of these hazards?

Mammoth Mountain and the surrounding area rely heavily on tourist dollars to keep their economy going. Prior to 1980, most residents had no idea they were living in a volcanically active area. Officials had issued a low level volcanic alert, a situation which was aggravated by the intervention of outside media. Then, nothing happened. No more earthquakes and no eruption. Tourists stopped coming and real estate prices went down. People were losing money they depended on to survive, and much animosity was directed at the USGS.

So the question is what should the USGS do should more intense quakes start happening or should the resurgent dome begin rising rapidly? If a warning is sent out

tourists will likely again flee, and if nothing happens, the USGS will again be in the hot seat. People may begin to ignore warnings, thinking that the warning is only a cry of “wolf.” If a warning is not issued at all or in time and people are killed, the USGS will still be blamed. Pyroclastic flows and lahars can not be outrun.

This answer to this question is not black and white. The USGS has a responsibility to citizens, to let them know when they are in danger. They have also developed a volcano emergency plan. But if the people aren't willing to accept the fact that there is a risk involved in living in this area, and accept responsibility for the fact that they are, to some extent, choosing to live there, then no compromise can be reached.

Tsunamis:

Tsunamis are another volcanic hazard worth mentioning, although not likely to affect the Long Valley area since it is far from the coast. Tsunamis are long sea waves that travel at great speed, and build to great height as they reach shallow water. Most tsunamis are caused by earthquakes, however many historic tsunamis were of volcanic origin. Volcanic explosions and collapses as well as landslides lahars and pyroclastic flows entering bodies of water have caused tsunamis. Tsunamis crush buildings with the force of the water and drown people and animals.

Atmospheric shock waves:

Rapidly moving volcanic ejections from historically explosive eruptions have caused atmospheric shock waves. Windows in Tambora, Indonesia were broken 400 km from the source in 1815. Mount St. Helens also produced shock waves, but did not damage any buildings. (Scott, p.20) Volcanoes are a natural phenomenon of

unimaginable force and affect on the world around them. As humans, we can't hope to ever control these forces, only to understand them. We must adapt our lives to live in harmony with the volcano. (Scott 1989)

References:

1. Keller, Edward A. Environmental Geology.(eighth edition)
2. USGS website: volcanoes.usgs.gov
- 3.Scott, William E. Volcanic and Related Hazards. 1989, US Geological Survey
4. Wheeler, Mark. “When Magma’s on the Move” from Smithsonian magazine.