DANTE'S PEAK FAQ'S (frequently asked questions)

U.S. Geological Survey
Volcano Hazards Program
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Dante's Peak, a new volcano-disaster thriller from Universal Studios, dramatizes some real-world concerns faced by communities located near active volcanoes in the United States. Set in the northern Cascade Range of Washington State, the movie portrays the roles of U.S. Geological Survey (USGS) scientists and local public officials during the re-awakening and eruption of a fictional volcano – one that resembles dozens of real volcanoes in Alaska, British Columbia, Washington, Oregon, and northern California. To separate fact from fiction, here are answers to some frequently asked questions about the movie and the USGS mission to reduce the risk from dangerous volcanoes.

GENERAL QUESTIONS ABOUT VOLCANOES AND VOLCANOLOGISTS

Q: Can scientists really anticipate volcanic eruptions?

A: Yes, in many cases, but most reliably only for volcanoes that have been studied geologically. By studying deposits of rock and ash formed by past events, volcanologists can re-construct the history of a volcano in considerable detail. This allows them to make general forecasts about future activity, because the past is often, though not always, a good guide to the future. For example, USGS scientists who studied Mount St. Helens during the 1970's recognized that, for thousands of years, it had been the most active and explosive volcano in the entire Cascade Range. On that basis, they forecast that Mount St. Helens might be the next Cascade volcano to erupt, possibly before the year 2000. In 1980, their detective work paid off when the volcano erupted for the first time in 123 years.

Q: Are specific predictions of an eruption's time, place, and character possible?

A: In some cases the answer is yes, but specific predictions require more and different kinds of information. Using seismometers and other sensitive monitoring instruments, USGS scientists are keeping an eye on more than three dozen dangerous volcanoes in the western United States. At the first sign of trouble they'll intensify their monitoring efforts, as depicted in the movie. Taking the pulse of a restless volcano in this way allows scientists to refine their assessment of hazards and make increasingly specific statements about future activity, including the time, location, and type of activity expected.

For example, USGS scientists correctly predicted days in advance more than a dozen dome-building eruptions at Mount St. Helens during 1980-1986. In 1991, an accurate prediction of the largest eruption on Earth in almost 80 years saved thousands of lives and millions of dollars worth of property near Mount Pinatubo in the Philippines.

Q: Is there really a U.S. Geological Survey and does it provide eruption warnings?

A: Yes, the United States Geological Survey was established by Congress in 1879 and continues to provide biologic, geologic, hydrologic, and topographic information to the Nation. The USGS is mandated by Congress to provide timely warnings about geologic hazards, including volcano hazards, to U.S. citizens and public officials. This mission is accomplished mainly through the USGS Volcano Hazards Program, which operates volcano observatories in Washington, Alaska, Hawaii, and California, and supports research on volcanoes and volcanic processes at other locations in the U.S.

Q: How does the USGS provide eruption warnings?

A: The USGS warning system varies depending on the nature and proximity of volcanic hazards to surrounding communities or aircraft. Before a crisis starts, we provide hazards-zonation maps and other information about the frequency of eruptions and extent of specific hazards to public officials, land-use planners, and emergency-management agencies. The USGS works with the Federal Aviation Administration and National Weather Service to provide airline pilots with timely information about hazardous volcanic ash clouds.

When communities are at risk, scientists give hazards information directly to public officials to help them make decisions about land-use or evacuations. Unlike the movie, warnings are delivered only after a thorough analysis of all existing information and careful consultation among members of the USGS response team. Our goal is always to keep natural processes from becoming natural disasters.

Q: How many active volcanoes are there in the United States?

A: There are about 65 volcanoes in the U.S. that scientists consider active. Most of these are located in Alaska, where eruptions occur virtually every year. The others are located in the Cascade Range (Washington, Oregon, northern California), or in Hawaii on the islands of Hawaii and Maui. Kilauea volcano in Hawaii is one of the most active volcanoes on Earth. It has been erupting almost continuously since 1983!

Q: How many active volcanoes are there on Earth?

A: There are about 1500 potentially active volcanoes worldwide, aside from the continuous belt of volcanoes on the ocean floor. About 500 of these have erupted in historical time. Many of these are located along the Pacific Rim in what is known as the "Ring of Fire." In the U.S., volcanoes in the Cascade Range and Alaska (Aleutian volcanic chain) are part of the Ring, while Hawaiian volcanoes form over a "hot spot" near the center of the Ring.

Q: What are the major volcanoes in the Cascade Range?

A: Mount Baker, Glacier Peak, Mount Rainier, Mount St. Helens, and Mount Adams in Washington; Mount Hood, Mount Jefferson, Three Sisters, Newberry Volcano, Crater Lake, and McLoughlin in Oregon; and Medicine Lake Volcano, Mount Shasta, and the Lassen volcanic field in northern California.

Q: Which Cascade volcano will erupt next?

A: No one knows for sure, but seven of them have erupted in just the past 200 years: Mount St. Helens (1800-1857 and 1980-1986), Lassen Peak (1914-1917), Mount Baker, Glacier Peak, Mount Rainier, Mount Hood, and Mount Shasta. Any of these could be the next to erupt, though the odds are highest at Mount St. Helens. Or the next eruption could come from a new vent entirely. During the past few thousand years, there have been dozens of eruptions in areas between the known volcanoes from vents scattered throughout the Cascade Range.

MOVIE FACT OR FICTION?

Q: Is the eruption depicted in Dante's Peak realistic?

A: In many but not all respects, the movie's depiction of eruptive hazards hits close to the mark, especially as regards the enormous power unleashed during an eruption. Stratovolcanoes in the Cascade Range and Alaska erupt explosively and produce pyroclastic flows, clouds of volcanic ash, and debris flows (lahars) that behave much as shown in the movie. Lava flows at these volcanoes, though, are usually thick and slow moving, unlike the fluid flows in the movie. Fast-flowing flows of basalt lava are common in Hawaii, though. Real eruptions may be considerably larger or smaller, and affect larger or smaller areas, than those shown in the film.

Q: Can eruptions really threaten helicopters, as in the movie, and other aircraft?

A: Yes. Encounters between aircraft and clouds of volcanic ash are a serious concern. Jet

engines and other aircraft components are vulnerable to damage by fine, abrasive volcanic ash, which can drift in dangerous concentrations hundreds of miles downwind from an erupting volcano.

During the past 15 years, at least 80 aircraft have accidentally encountered volcanic ash clouds, and in 6 cases jet engines temporarily lost power. An international consortium of government agencies, including the U.S. Geological Survey, Federal Aviation Administration, and National Weather Service, is now monitoring ash-producing volcanoes and tracking volcanic ash clouds to reduce the likelihood of future encounters.

Q: Can the temperature of hot springs near a restless volcano change quickly enough to injure bathers?

A: Temperature changes can and do occur, but usually more slowly than shown in the movie. In fact, the temperature of hot springs may increase, decrease, or stay the same during volcanic unrest. Increases in water temperature, when they do occur, usually take days or weeks to develop, rather than a few seconds as shown in the movie.

In rare cases, earthquakes can suddenly disrupt a volcano's hot groundwater system, changing its temperature. And earthquakes have been known to temporarily increase the flow of water from hot springs, sometimes causing geyser-like activity that could threaten bathers.

Q: Do earthquakes large enough to collapse buildings and roads accompany volcanic eruptions?

A: Not usually. Earthquakes associated with eruptions rarely exceed magnitude 5, and these moderate earthquakes are not big enough to destroy the kinds of buildings, houses, and roads that were demolished in the movie. The largest earthquakes at Mount St. Helens in 1980 were magnitude 5, large enough to sway trees and damage buildings, but not destroy them. During the huge eruption of Mount Pinatubo in the Philippines in 1991, dozens of light to moderate earthquakes (magnitude 3 to 5) were felt by several hundred thousand people. Many houses collapsed, but not primarily because of the shaking. Heavy, wet ash from the eruption and a hurricane accumulated on roofs and crushed them.

Stronger earthquakes sometimes DO occur near volcanoes as a result of tectonic faulting. For example, four magnitude 6 earthquakes struck Long Valley caldera, California, in 1980, and a magnitude 7.2 earthquake struck Kilauea Volcano, Hawaii, in 1975. Both volcanoes were quiet at the time. The Hawaii earthquake triggered a small eruption at the summit of Kilauea. No eruption has yet occurred at Long Valley, but the area has been restless since the 1980 earthquakes.

Q: Can a town's water supply become contaminated when a volcano is restless?

A: Yes, but probably not as quickly as shown in the movie. If a town's water supply originates directly from a volcano's groundwater system or from a stream that has been covered with volcanic ash, the water could become contaminated with foul-smelling gases or fine ash and other sediment. Some volcanic gases such as sulfur dioxide dissolve in groundwater, making the water acidic. Sulfurous odors, however, are caused by hydrogen sulfide gas, which smells like rotten eggs.

Q: Do scientists drive across moving lava flows?

A: No. Any attempt to drive across an active lava flow, even one that has partly solidified to form a thin crust, is likely to lead to disaster. With a temperature of 1,700 degrees Fahrenheit or higher, fresh lava will quickly melt rubber tires and ignite gas tanks. And if a vehicle gets stuck in moving lava, well, you know the rest of the story.

Q: Can carbon dioxide gas from volcanoes kill trees and wildlife?

A: Yes. At several volcanoes around the world, carbon dioxide gas released from magma has accumulated in the soil in sufficient concentrations to kill vegetation or has collected in low areas and suffocated animals. At Mammoth Mountain in California, carbon dioxide has killed about 100 acres of trees since 1989, and visitors to this area have occasionally suffered symptoms of asphyxiation when entering cabins or below-ground excavations. USGS scientists have concluded that the gas is escaping from a magma body beneath Mammoth Mountain. The magma itself is not currently moving toward the surface, but the USGS is monitoring the situation carefully.

Q: Can volcanoes suddenly become restless and erupt within one week of the first signs of activity?

A: Yes. The first steam eruption at Mount St. Helens on March 27, 1980, was preceded by only 7 days of intense earthquake activity. The climactic eruption, on May 18, followed seven weeks later. An eruption of Redoubt Volcano in Alaska on December 13, 1989, was preceded by only 24 hours of intense earthquake activity. But other volcanoes have been restless for months or years before an eruption occurred, and sometimes a period of unrest doesn't produce an eruption at all.

Q: Are robots used by the USGS to monitor volcanoes?

A: No. We rely on observations and measurements made by experienced scientists and on critical data sent by radio or satellite relay from monitoring instruments installed around a volcano. These instruments include seismometers, tiltmeters, Global Positioning System (GPS) receivers, gas sensors, mudflow (lahar or debris flow) sensors, and temperature probes.

NASA has tested a robot named Dante at Mount Erebus volcano in Antarctica and Mount Spurr volcano in Alaska. The USGS believes that, on Earth, experienced volcanologists are a better and more cost-effective alternative for monitoring dangerous volcanoes.

Q: Can volcanoes produce large explosive eruptions and rivers of fluid lava at the same time?

A: Not usually. During a single eruption, a volcano CAN produce both lava flows and ash, sometimes simultaneously. The red, glowing lava fountains and lava flows in Dante's Peak (including the active flow across which Harry Dalton drives) are characteristic of a fluid magma, called basalt. In contrast, explosive gray ash columns and pyroclastic flows shown in other scenes are characteristic of more viscous magmas, called andesite, dacite, or rhyolite. It's uncommon for a volcano to erupt magmas of widely different composition at the same time.

Q: Can lakes near volcanoes become acidic enough to be dangerous to people?

A: Yes. Crater lakes atop volcanoes are typically the most acid, with pH values as low as 0.1 (very strong acid). Normal lake waters, in contrast, have relatively neutral pH values near 7.0. The crater lake at El Chichon volcano in Mexico had a pH of 0.5 in 1983 and Mount Pinatubo's crater lake had a pH of 1.9 in 1992. The acid waters of these lakes are capable of causing burns to human skin but are unlikely to dissolve metal quickly. Gases from magma that dissolve in lake water to form such acidic brews include carbon dioxide, sulfur dioxide, hydrogen sulfide, hydrogen chloride, and hydrogen fluoride. However, the movie's rapidly formed acidic lake capable of dissolving an aluminum boat in a matter of minutes is unrealistic.

QUESTIONS ABOUT ERUPTION PRECURSORS

Before a volcano erupts, magma must force its way upward through solid rock beneath a restless volcano. This process causes the ground above to heave and shake as rock is shoved aside or broken. At the same time, gases are released from the magma as it rises to shallower levels where the pressure is lower. These phenomena - ground movements, earthquakes, and changes in volcanic gases - provide the clues that scientists use to recognize a restless volcano and anticipate what might happen next.

Q: What kinds of unusual activity might be noticed before an eruption?

A: Common symptoms of volcanic unrest include an increase in the frequency or intensity of earthquakes beneath a volcano; the occurrence of volcanic tremor; swelling, subsidence, or cracking of the ground; increased steam emission or small steam explosions; melting snow or ice; changes in existing fumaroles or hot springs, or the appearance of new ones; and increased discharge of magmatic gases. Volcanologists assess the significance of volcanic unrest partly by monitoring the pace and intensity of such activity.

Q: What is volcanic tremor, and how does it differ from earthquakes?

A: Tremor is a seismic vibration, similar to a volcanic earthquake, but of longer duration and more continuous than earthquakes of the same amplitude. Volcanic tremor can last from minutes to days. It may be caused by magma moving through narrow cracks, boiling and pulsation of pressurized fluids within the volcano, or escape of pressurized steam and gases from fumaroles.

Q: Do volcanoes produce different kinds of earthquakes?

A: Yes. A variety of earthquake types can occur at a volcano that is getting ready to erupt. These include earthquakes caused by rocks breaking along faults or fractures, termed tectonic-type earthquakes. Another common type a long-period or volcanic earthquake. These can occur when bubble-filled magma is on the move beneath a volcano. In Dante's Peak, Harry Dalton states in one scene that he has felt some volcanic earthquakes. In fact, the differences between tectonic-type and volcanic-type earthquakes are so subtle that they can be distinguished only by using seismometers.

Q: What kind of gases escape from volcanoes?

A: The fumes escaping from a volcano consist mostly of water vapor (steam). Steam may be emitted from the hot interiors of volcanoes even when they are dormant. But steaming usually increases dramatically as magma intrudes and heats groundwater beneath a volcano. Magma gives off carbon dioxide (CO_2) and hydrogen sulfide (H_2S, rotten egg gas) that do not totally dissolve in groundwater and can therefore show up at the surface. As water inside the volcano boils away, other more water-soluble volcanic gases can reach the surface, signaling an increasingly grave situation. These gases include sulfur dioxide (SO_2) and common halogen gases such as hydrogen chloride (HCl), and hydrogen fluoride (HF).

Q: Are there any restless volcanoes in the U.S. today?

A: Several. After a persistent swarm of earthquakes beneath Mammoth Mountain, California, in 1989, large volumes of carbon dioxide began seeping from beneath this volcano. The CO_2 is killing trees and has become a hazard in some campgrounds near the volcano. The USGS is working with the U.S. Forest Service to monitor the CO_2 emissions and earthquake activity at Mammoth Mountain and to keep the public informed of the hazards.

An increase in earthquake activity has been observed at Iliamna Volcano in the Cook Inlet region of Alaska since May, 1996. Airborne surveys in August and October 1996 showed increased CO_2 emissions from the volcano. Modest increases in sulfur dioxide were also observed. The USGS is continuing to monitor Iliamna's activity with the University of Alaska Fairbanks Geophysical Institute and the Alaska Division of Geological and

Geophysical Surveys in a cooperative program at the Alaska Volcano Observatory.

Also in Alaska, the Katmai region, which produced the Valley of Ten Thousand Smokes during a colossal eruption in 1912, has experienced swarms of small earthquakes in recent years. And Pavlof volcano has been erupting sporadically since September 1996 and remains restless.

In Hawaii, the largest volcanic edifice on Earth, Mauna Loa, has been slowly swelling and producing earthquakes since its last eruption in 1984.

At Yellowstone in northwest Wyoming, one of the largest active volcanic systems on Earth, spectacular hydrothermal activity (geysers, hot springs, mud volcanoes), frequent earthquakes, and large ground movements remind us constantly that future eruptions are likely. The likelihood of an eruption at Yellowstone anytime soon, though, is much lower than at many other volcanoes in the western U.S.

QUESTIONS ABOUT VOLCANO MONITORING

To anticipate the awakening or reawakening of a volcano, volcanologists watch for changes caused by moving or pressurizing magma and associated changes in the hydrothermal system surrounding the magma. Much as depicted in Dante's Peak, magma moving toward the surface can cause swarms of earthquakes; swelling, subsidence, or cracking of the volcano's flanks; and changes in the amount or types of gases that are emitted from a volcano. The USGS continuously monitors many volcanoes in the states of Washington, Oregon, California, Hawaii, Alaska and Wyoming (Yellowstone) to detect unusual activity.

Q: Does the USGS have a team of volcanologists that can respond to volcanic unrest on short notice?

A: Yes. The USGS Volcano Hazards Team includes experts in all aspects of volcano hazard assessment, monitoring, information dissemination, and volcano-emergency response. As depicted in the movie, a group of USGS scientists will respond to any potentially hazardous volcanic activity in the United States.

Q: Does the USGS have a team for rapid response to volcano emergencies abroad?

A: Yes. Such a team is operated by the U.S. Geological Survey as part of the Volcano Disaster Assistance Program (VDAP). The team was formed in cooperation with the U.S. Office of Foreign Disaster Assistance (OFDA) of the U.S. State Department following the 1985 eruption of Nevado del Ruiz Volcano, Colombia, in which over 23,000 people lost their lives. At the request of host countries and working through OFDA, VDAP scientists quickly determine the nature of volcanic unrest and assess its possible consequences.

VDAP has responded to volcano emergencies in more than a dozen countries during the past decade.

In addition to helping people in other countries to get out of harm's way, VDAP's international work directly benefits volcano-hazard mitigation in the United States. Through VDAP, we gain experience at active volcanoes that will help during future crises in the western U.S., and we collect important scientific data on eruption precursors that are used to better understand how U.S. volcanoes work.

Q: How does the USGS monitor volcanoes in the United States?

A: One of the earliest signs of an impending eruption is often a subtle change in seismic activity beneath a volcano. In cooperation with universities and state agencies, the USGS monitors seismic activity near volcanoes using networks of seismometers. When unusual activity is detected, more seismometers and other instruments may be installed by a response team to better determine if an eruption is likely.

Q: How are earthquakes monitored?

A: By installing seismometers which send information continuously via radio to a central recording site (observatory), scientists can determine the sizes and locations of earthquakes near a volcano. They look for specific types of earthquakes that are often associated with volcanic activity, including long-period volcanic earthquakes and volcanic tremor. An increase in the number or size of earthquakes beneath a volcano usually means that an eruption is more likely.

Q: How are ground movements measured?

A: Ground deformation (swelling, subsidence, or cracking) is measured with a variety of techniques, including Electronic Distance Meters (EDM), the Global Positioning System (GPS), precise leveling surveys, strainmeters, and tiltmeters. EDM's use lasers to accurately measure changes in distance between benchmarks (fixed points) with repeated measurements. GPS makes use of satellites orbiting the Earth to determine and track the locations of points. Strainmeters and tiltmeters are used to monitor subtle changes in shape of the ground surface.

Q: How are volcanic gases measured?

A: Instruments to measure sulfur dioxide and carbon dioxide can be mounted in aircraft to determine the quantity of gas being emitted on a daily basis. Such instruments can also be used in a ground-based mode. In Dante's Peak, a correlation spectrometer (COSPEC) was mounted in a helicopter to monitor sulfur dioxide emissions from the volcano. The instrument that detects carbon dioxide can be installed on a volcano and configured to send data continuously via radio to an observatory. Sulfur dioxide in volcanic clouds can also be measured from space with instruments aboard satellites.

Q: Can mudflows be monitored?

A: The torrents of mud, rocks, logs and other debris depicted in Dante's Peak are collectively called mudflows, debris flows, or lahars, an Indonesian term for volcanic mudflows. An instrument called an acoustic flow monitor can be installed near river valleys leading away from a volcano to help provide warnings of approaching flows. The system senses vibrations caused by the mudflows and sends alerts via radio to the volcano observatory.

Q: What else do scientists measure at volcanoes?

A: Field observations by experienced volcanologists go hand in hand with more sophisticated equipment and techniques to form a complete system for monitoring volcanoes. Field observations may include water temperature and pH (acidity) measurements, as shown in Dante's Peak, or observations of ground cracking, new areas of avalanching rocks, etc. An experienced observer can integrate many different types of data on the spot and design simple measurements to further assess the significance of volcanic unrest. There is there is no substitute for well trained, experienced observers when trying to figure out how a volcano will behave.

QUESTIONS ABOUT VOLCANO HAZARDS

In Dante's Peak, a restless volcano endangers nearby residents with clouds of ash, falling blocks of rock, pyroclastic flows or ash hurricanes, lava flows, and floods of debris or lahars. These hazards are typical of snow- and ice-covered stratovolcanoes like those in the Pacific Northwest and Alaska. Since 1980, volcanic activity has killed more than 29,000 people worldwide. Most of the deaths were caused by lahars and pyroclastic flows; a few hundred people were killed by ash falls, which collapsed the roofs of buildings.

Q: What kinds of hazards were depicted in the movie, and what part have they played in real volcanic eruptions?

A: *Debris flows, or lahars*, are slurries of muddy debris and water like the one that carried away Paul Dreyfuss in Dante's Peak. They are caused by mixing of solid debris with water, melted snow, or ice. Lahars destroyed houses, bridges, and logging trucks during the May 1980 eruption of Mount St. Helens, and have inundated other valleys around Cascade volcanoes during prehistoric eruptions. Lahars at Nevado del Ruiz volcano, Colombia, in 1985, killed more than 23,000 people. At Mount Rainier, lahars have also been produced by major landslides that apparently were neither triggered nor accompanied by eruptive activity. Lahars can travel many tens of miles in a period of hours, destroying everything in their paths.

Tephra (ash and coarser debris), like that which buried the town of Dante's Peak, is composed of fragments of magma or rock blown apart by gas expansion. Tephra can cause roofs to collapse, endanger people with respiratory problems, and damage machinery. Tephra can clog machinery, severely damage aircraft, cause respiratory

problems, and short out power lines up to hundreds of miles downwind of eruptions. Explosions may also throw large rocks up to a few miles. As in Dante's Peak, falling blocks killed people at Galeras Volcano in Colombia in 1992, and at Mount Etna, Italy, in 1979.

Pyroclastic surges and flows, called "pyroclastic clouds" by Harry Dalton in Dante's Peak, are hot, turbulent clouds of tephra (known as surges), or dense, turbulent mixtures of tephra and gas (known as flows). Pyroclastic flows and surges can travel more than a hundred miles per hour and incinerate or crush most objects in their path. Though most extend only a few miles, a pyroclastic surge at Mount St. Helens in 1980 extended 18 miles (28 km) and killed 57 people. Pyroclastic surges at El Chichon Volcano in Mexico in 1982 killed 2000 people, and pyroclastic flows at Mount Unzen, Japan, in June, 1991, killed 43 people. Contrary to the movie, speeding vehicles cannot outrun a pyroclastic flow or surge.

Lava flows erupted at explosive stratovolcanoes like those in the Pacific Northwest and Alaska are typically slow-moving, thick, viscous flows. Kilauea Volcano on the island of Hawaii has produced thin, fluid lava flows like those depicted in Dante's Peak throughout its history, and almost continuously since 1983. Lava flows destroyed a visitor center at Kilauea in 1989 and overran the village of Kalapana on the volcano's southeast flank in 1991.

Q: Can volcanoes be dangerous even when they don't erupt?

A: Definitely. Many stratovolcanoes have a plumbing system of hot acid water that progressively breaks down hard rock to soft, clay-rich material. The volcano is gradually weakened, and large parts may suddenly fail. Resulting water-rich landslides are especially dangerous because they can occur without any volcanic or seismic warning.

The risk of mudflows formed this way is especially high along rivers downstream from Mount Rainier, because of the large population on floodplains, the huge weakened edifice of the volcano, and a long history of large flows that occurred when the volcano was otherwise dormant.

Q: How can residents who live near volcanoes prepare for future eruptions?

A: Residents can obtain copies of USGS volcano-hazard reports to determine whether they live or work in areas at risk from volcanic activity. Everyone should plan how they and their family will respond to a natural disaster, including unrest or eruptive activity at nearby volcanoes. Preparation might include knowing where to go when family members are separated, where to go for emergency housing, what emergency supplies to keep on hand, and how to be self sufficient for several days, as recommended by local emergency management agencies. Residents who live within 100 miles of a volcano should also find out what their local officials are doing to prepare their community for the possibility of renewed volcanic activity. Lastly, enjoy the scenic, recreational, and inspirational benefits of living near an active volcano!