2

The Kīlauea Volcano: Be a Volcanologist

Monitoring Kīlauea

Learning IN MOTION®

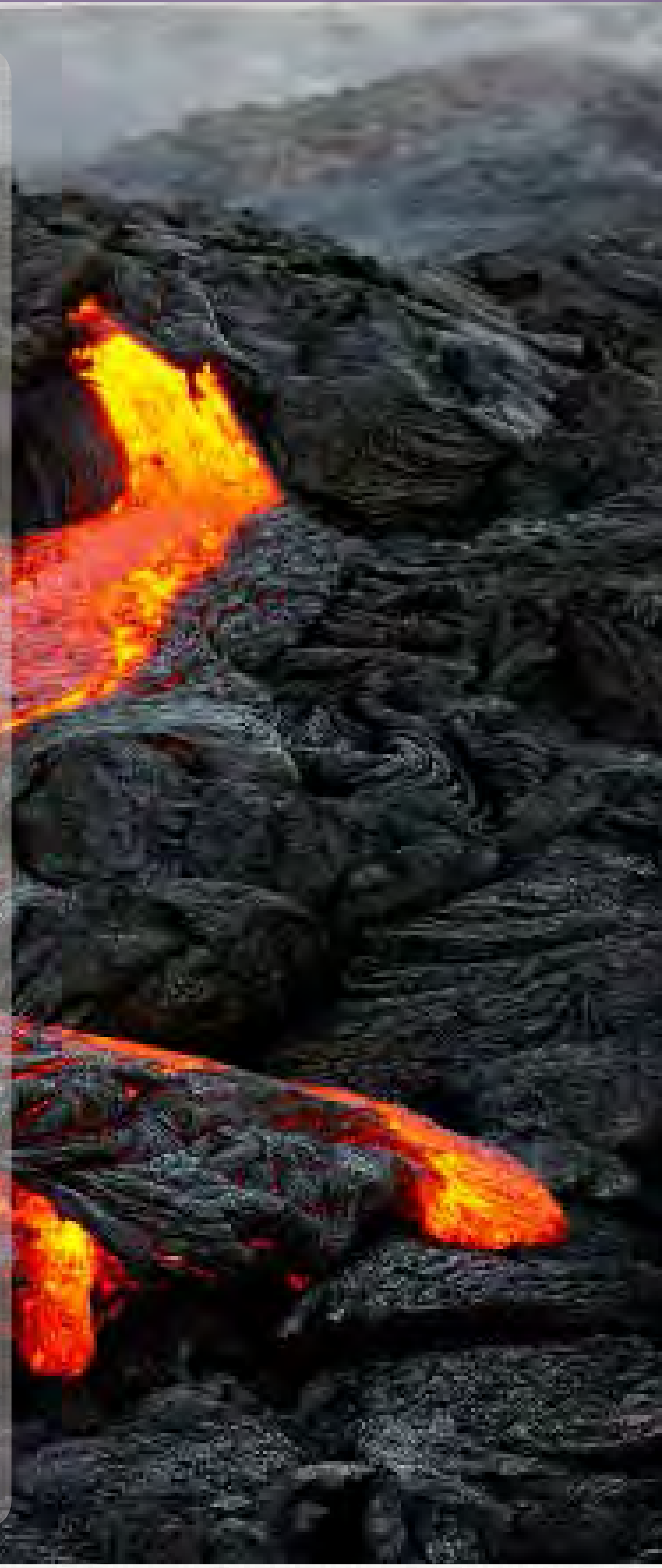
2 Monitoring Kīlauea

Students continue playing the role of volcanologists on the island of Hawai‘i. They analyze new geologic data (including maps, photos, and graphs) from the first few days of the May 2018 eruption of Kīlauea in order to predict the occurrence and effects of volcanic hazards and make safety recommendations to the public.

GUIDING QUESTION

How do scientists monitor volcanoes in order to predict hazards and keep the public safe?

Lesson 2: Monitoring Kīlauea



MATERIALS

Teacher Materials

- **Monitoring Kīlauea** visuals
    - **May 2, 2018 Map** visual
    - **Eruption in Leilani Estates** photograph
    - **Hawai'i Volcano Hazard Update** visual
    - **Evacuation and Road Closure Map** visual

Student Materials

- **Monitoring Kīlauea Data** handout (online or print) (1 per pair or team of 4)
- **Volcanology** handout (from previous lessons) (1 per student)
- **Observation Journal** handout (1 per student)
- Optional: Computer or tablet with Internet access (1 device per team)

RESOURCES

Websites

Hawai'i County Civil Defense Alert Archive website (for Extension)

FEMA.gov Kīlauea Eruption web page (for Extension)

PREPARATION

Prepare Lesson Materials

1. Determine which lesson handouts you will need hard copies of, and print enough for your class. Note that the **Monitoring Kīlauea Data** handout can be accessed online. It is recommended that students work in groups of four if using hard copies and in pairs if using computers. If using hard copies, printing in color is highly recommended to support student analysis of data represented in maps and photos.

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- The **Volcanology** and **Monitoring Kīlauea Data** handouts can be laminated for re-use.

2. Students should continue using the **Observation Journal** that they started in Lesson 1. Prepare a class chart based on the table in the **Observation Journal** handout for use in the discussion part of the lesson (see page 41).

Prepare the Activity Approach

1. Determine how you will structure the Activity section of the lesson. Depending on the needs of your class, you may opt to conduct the activity with an open-ended approach or with more structured guidance. For example:
   - Have teams self-direct their pacing and decide for themselves which data to analyze first.
   - Give students more structured guidance. Encourage the class to start with the maps and images and then progress to the graph.
   - You might also assign team roles and/or designate different students within the teams to lead the team's analysis of different pieces of data.
2. For a self-directed approach, be prepared to monitor teams as they determine their own allocation of tasks, pacing, and process for recording data.

Lesson 2: Monitoring Kīlauea

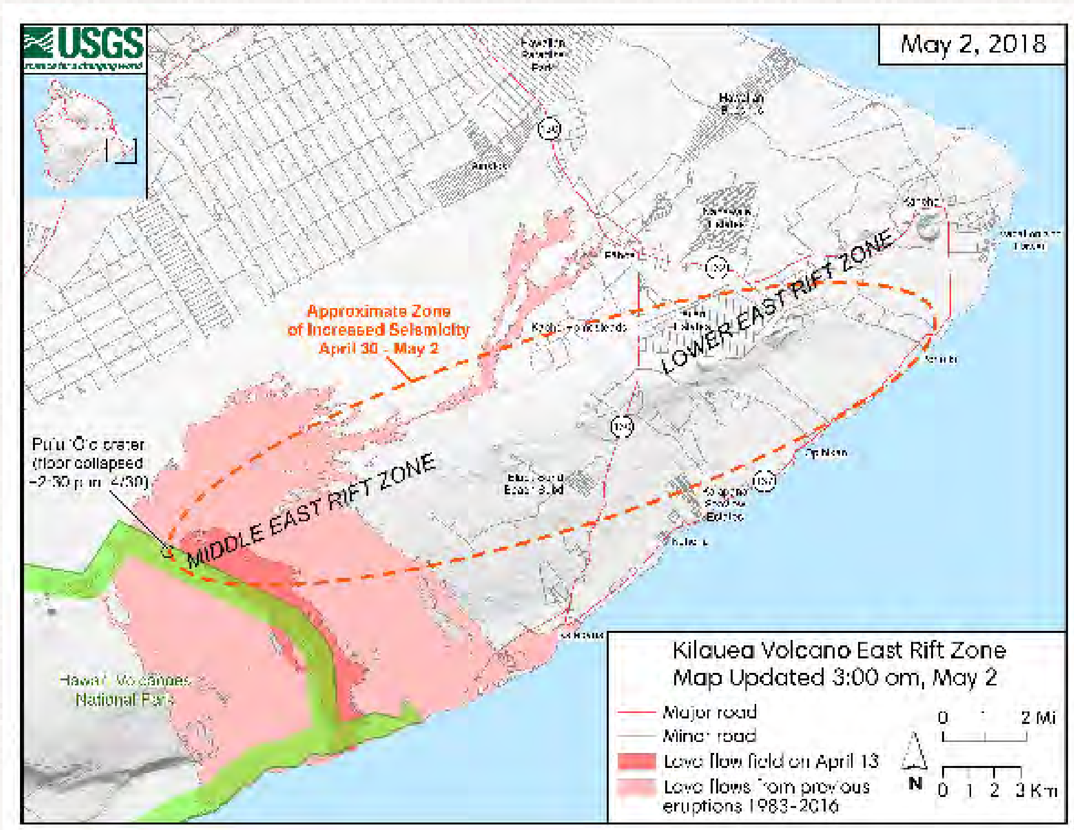
OPENING

Review Lesson 1 Key Ideas

1. Remind students that in the previous lesson they began working as volcanologists on the island of Hawaiʻi to help determine ways to keep the public safe from volcanic hazards. Have a few students share the predictions that they made and the course(s) of action that the class recommended (monitoring, issuing an alert, and/or evacuating areas around one or more of the island's volcanoes).
2. Next, reveal that United States Geological Survey (USGS) scientists working on the island of Hawaiʻi responded by closely monitoring the Kīlauea area. As a result, an alert was issued in anticipation of a possible eruption. Areas of Hawaiʻi Volcanoes National Park around Kīlauea were closed due to potential volcanic hazards. Point out that the scientists also continued to monitor the other active volcanoes on the island, although less closely than Kīlauea.

Discuss Interpreting Data from Photos and Maps

1. Show the first image in the **Monitoring Kīlauea** visuals, which is the **May 2, 2018 Map** visual. This is a USGS map of the southeastern portion of the island of Hawaiʻi.



May 2, 2018 Map visual

Source: U.S. Geological Survey

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2. Have a couple students point out something they notice. For example, you may have students locate:
   - The area of increased earthquake activity recorded from April 30 to May 2, 2018 (marked by a dotted oval and the label "Approximate Zone of Increased Seismicity April 30 - May 2")
   - Middle East and Lower East Rift Zones (the elevated ridge of land that runs along the southeastern coast, a few kilometers inland from the ocean)
   - Neighborhoods where people live, such as Black Sand Beach Subd., Leilani Estates, and Kaohe Homesteads
   - Pu'u' Ō'ō crater (at the edge of Hawai'i Volcanoes National Park on the west end of the Middle East Rift Zone)
   - Areas marked in light pink and in dark pink, which represent previous lava flows (in the Middle East Rift Zone, starting near Pu'u' Ō'ō crater)
3. Review that the class's previous observations were of activity that took place during March, April, and early May 2018.
4. Display the **Eruption in Leilani Estates** photograph, which shows the Kīlauea Volcano eruption on May 3, 2018. While displaying the image, read aloud the description, which provides an overview from the U.S. Geological Survey of news about the eruption:

   On May 3, 2018, a new eruption of Kīlauea Volcano began in the Leilani Estates neighborhood located in the lower East Rift Zone. Lava, hot water vapor, and gas fumes started spewing into the air from a newly-opened crack in the earth, and lava flowed slowly outward about 10 meters from this fissure.

Eruption in Leilani Estates photograph Source: U.S. Geological Survey

Introduce Today's Goal

1. Remind students of the unit Guiding Question:

   How do scientists monitor volcanoes in order to predict hazards and keep the public safe?

2. Explain that students will work in their teams from the previous lesson to investigate and interpret data from maps, photos, and a graph. As in Lesson 1, they will organize their notes in their **Observation Journal**.
3. Explain that students should use the **Observation Journal** to:
   - Describe and predict volcanic hazards.
   - Make recommendations to keep the public safe.
4. You may want to record these tasks on the board or somewhere else easily visible to students for reference.

Observation Journal handout

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ACTIVITY

Introduce the Activity

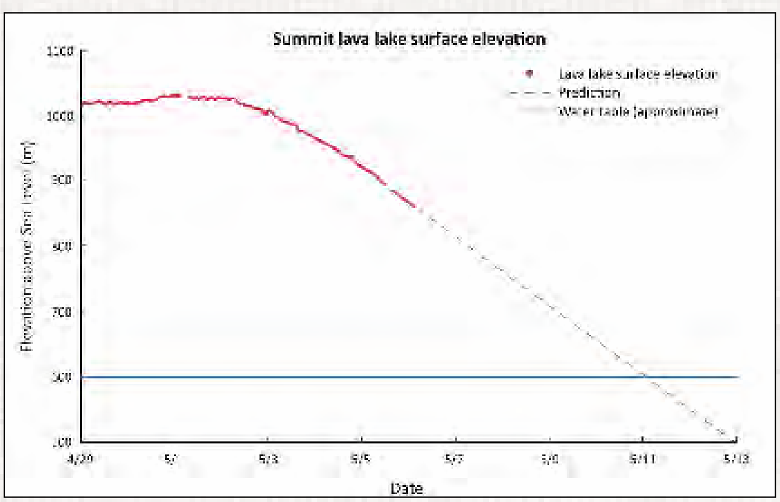
1. Ensure students have their **Observation Journal** handout from the previous lesson. Tell students to gather in their pairs or teams of four.

2. Ensure that each team has a copy of the **Volcanology** handout (from Lessons 0 and 1). These handouts provide information that teams can reference as needed to help them make sense of and analyze the volcano data. Point out the Lesson 2 section and review the topic question on each page:

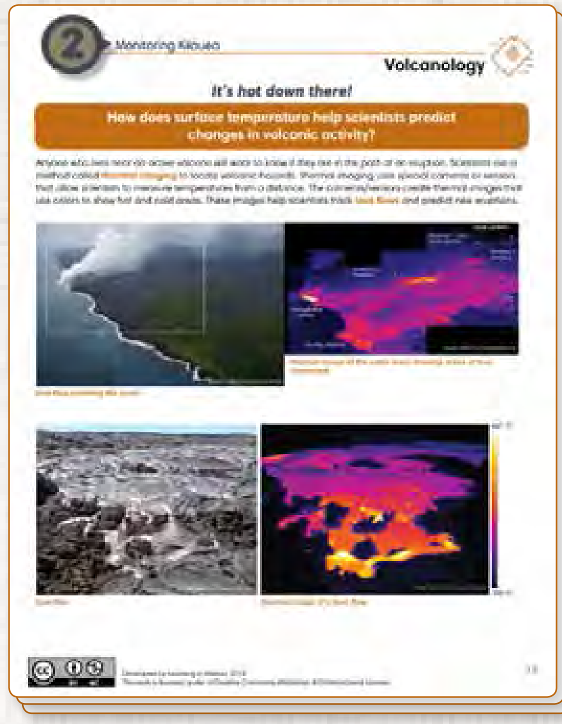
   - *How does surface temperature help scientists predict changes in volcanic activity?*
   - *How can scientists predict where lava will flow?*
   - *How can the lava lake provide clues about an eruption?*

3. Provide each team with a copy of the **Monitoring Kīlauea Data** handout (print or online), which includes:

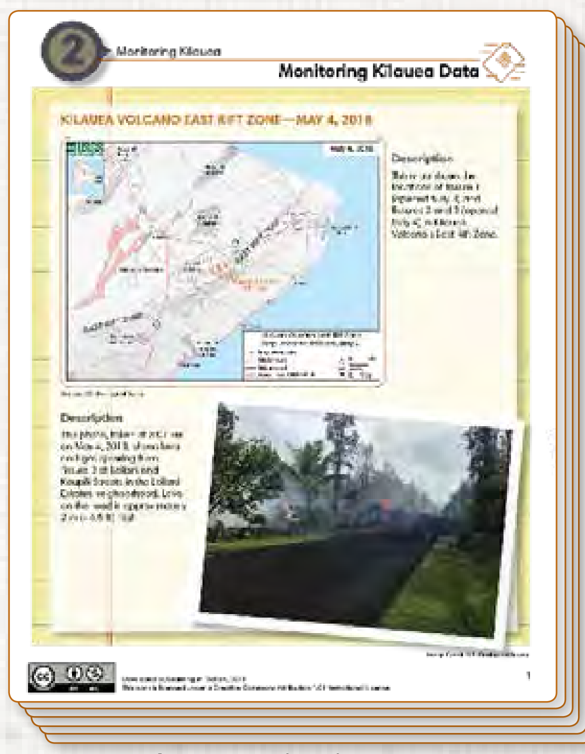
   - Photos and maps (including thermal maps) of the Lower East Rift Zone of Kīlauea Volcano from May 4–9, 2018
   - Graph of Kīlauea Volcano summit lava lake levels, with data from April 29–May 6, 2018, and predictions through May 13, 2018



Source: U.S. Geological Survey



Volcanology handout



Monitoring Kīlauea Data handout

Lesson 2: Monitoring Kīlauea

4. Remind students that if they come across unfamiliar concepts or vocabulary terms, they can refer to the **Volcanology** handout.
5. You may want to conduct a quick class brainstorm regarding possible ways to organize the data in students' **Observation Journal**—for example, by:
   - Date
   - Type of hazard (e.g., fissures, lava flows, toxic gases, explosions)
   - Location/area (e.g., volcano summit, East Rift Zone)
6. Encourage students to work together with their team to share information and discuss their ideas. Remind students to record their observations, analysis, and recommendations in the table in their **Observation Journal**.
7. If you feel that students need additional guidance, provide some guiding questions such as the following to help teams analyze the data:
   - *What can you understand from looking at each map, graph, or image? What information can help you interpret the data?*
   - *What hazards are currently present? What types of damage are they causing?*
   - *Where are the hazards located?*
   - *How would you describe the severity of the hazards you observed?*
   - *How do the locations or severity of the hazards change over time?*
   - *What patterns do you notice in the data?*
   - *What new or future hazards do you predict, and why?*

Organize, Analyze, and Interpret Data

1. As teams work, circulate to monitor progress and support students in interpreting the data. As necessary, remind them to refer to the **Volcanology** handout to help them make sense of new terms and concepts; also remind them to record their observations, analysis, and recommendations in their **Observation Journal**.
2. Engage with teams and monitor their understanding by posing further probing questions, such as:
   - *What are some volcano hazards that you notice in this [map, photo]?*
   - *What do you notice about the progression of fissures from May 4 to later dates?*
   - *What information have you found that can help you predict what might happen next with this Kīlauea volcano eruption?*
   - *What can you understand from looking at the graph of the lava lake level? Where can you find information to help you interpret the graph?*
   - *Based on the data your team has looked at, what areas do you think are at risk for volcanic hazards or eruptions? Why?*

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3. As you monitor the investigation, take notes about students' work in order to prepare for class discussion. For example, make note of unique and/or pervasive:
    - Ways teams organize their data
    - Observations about the maps, photos, or graph
    - Insights about the meaning of the data
    - Recommendations for keeping the public safe

Discuss Data Analysis and Recommendations

1. Have students reconvene for a whole-class discussion. As students share ideas that they recorded in their **Observation Journal**, encourage other teams to ask clarifying questions. If audience members disagree with some aspect of the presenters' interpretation, have them provide an argument explaining their alternate explanation.
2. Complete a class chart to record students' ideas. A completed class chart might resemble the following.

Our Observations	Our Analysis	Our Recommendations
Lava flow • New fissures are appearing in the Leilani Estates area of the East Rift Zone. • Thermal maps show hot areas spreading from around Fissure 8 on May 6 and around Fissure 15 on May 9. • The lava is covering and burning the areas near the fissures. • There are cracks in some of the roads such as Pohoiki Road. • The fissures are spreading in a line toward the northeast and southwest.	• Lava flows are a hazard to people living nearby and downhill. • More fissures might continue to appear in the same directions. • New fissures or lava flows might happen near the cracks.	• People who live in Leilani Estates and areas downhill should evacuate. • Roads in Leilani Estates should be closed. • People who live in areas to the northeast and southwest should be alerted. • Areas in the East Rift Zone and down the lines of steepest descent should be monitored or closed in those directions.
Summit lava lake • The lava lake level is dropping.	• The lava lake level might continue to drop. If it goes below the water table, there could be an explosive eruption. It is predicted to happen around May 11. • The drop in the lava lake level might mean more magma is moving down the rift zone.	• The area around the lava lake should be closed to the public.

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REFLECTION

Summarize

1. After completing the class chart, review some of the main points that students made. For example, you might say:
   - We noticed a series of fissures opening up in the Leilani Estates area and spreading in a line to the northeast and the southwest. The East Rift Zone area should continue to be monitored for new fissures. We recommended that the Leilani Estates area and other places downhill from that area be closed and evacuated because they are at risk of being burned and damaged by lava flows. We also noticed that the lava lake level at the summit is dropping and it might go below the water table. We predicted that this could cause an explosive eruption, so people should stay away from that area.
2. Review some of the technologies and methods—thermal imaging, seismographs, GPS stations—that scientists use to monitor volcanic activity. Discuss how this information helps them make predictions, based on which the public can be advised about how to stay safe. Explain that the class will now look at an alert and evacuation plan that scientists and officials created in response to the Kīlauea eruption.

Image Credit: U.S. Geological Survey

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View Hazard Documentation

1. Project the **Hawai'i Volcano Hazard Update** visual (adapted from the official daily updates produced by the USGS Hawaiian Volcano Observatory for May 4 to May 9, 2018). Read the update aloud, or have a student do so. As you read, have students consider how the information in the update compares to their own data analysis.

HAWAI'I VOLCANO HAZARD UPDATE
May 9, 2018

KĪLAUEA VOLCANO
19.42° N, 155.29° W, Summit Elevation 4091 ft (1247 m)
Current Volcano Alert Level: WARNING

An eruption is in progress along Kilauea Volcano's lower East Rift Zone. Small fissure vents have opened in Leilani Estates subdivision. Additional fissure outbreaks producing spatter and lava flows are likely. Locations cannot be predicted with certainty, but new outbreaks so far have been preceded by ground cracking, then strong steam and volcanic gas release. High levels of volcanic gas including sulfur dioxide are being released from the fissure vents. Areas further along the rift from the current fissure zone are the most likely to see further outbreaks. Areas downslope of an erupting fissure or vent are at risk of being covered by lava. The general area of the Leilani subdivision remains at greatest risk. However, as the eruption progresses, other areas of the lower East Rift Zone may also be at risk. As the lava lake level inside the summit crater drops, rockfalls from the crater walls may increase, causing explosions from the lake onto the nearby crater rim. Residents of the area should remain alert, review emergency plans, heed closures and evacuations, and watch for further information about the status of the volcano.

Hawai'i Volcano Hazard Update visual

Source: Adapted from U.S. Geological Survey

2. Then show the **Evacuation and Road Closure Map** visual.

Evacuation and Road Closure Map visual

Source: Adapted from County of Hawai'i

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Explain that the County of Hawai‘i maintains an alert page on its website; information on this page includes civil defense messages and maps of hazards and evacuations. The website helps to provide important safety information to the public. The **Evacuation and Road Closure Map** is a reproduction of the 2018 Lava Information Map from the county website in mid May 2018. Have students identify the areas of mandatory evacuation, road closures, and other map features. Note that the pink areas represent all lava flows since the eruption began, including those that are no longer active.

Formative Assessment

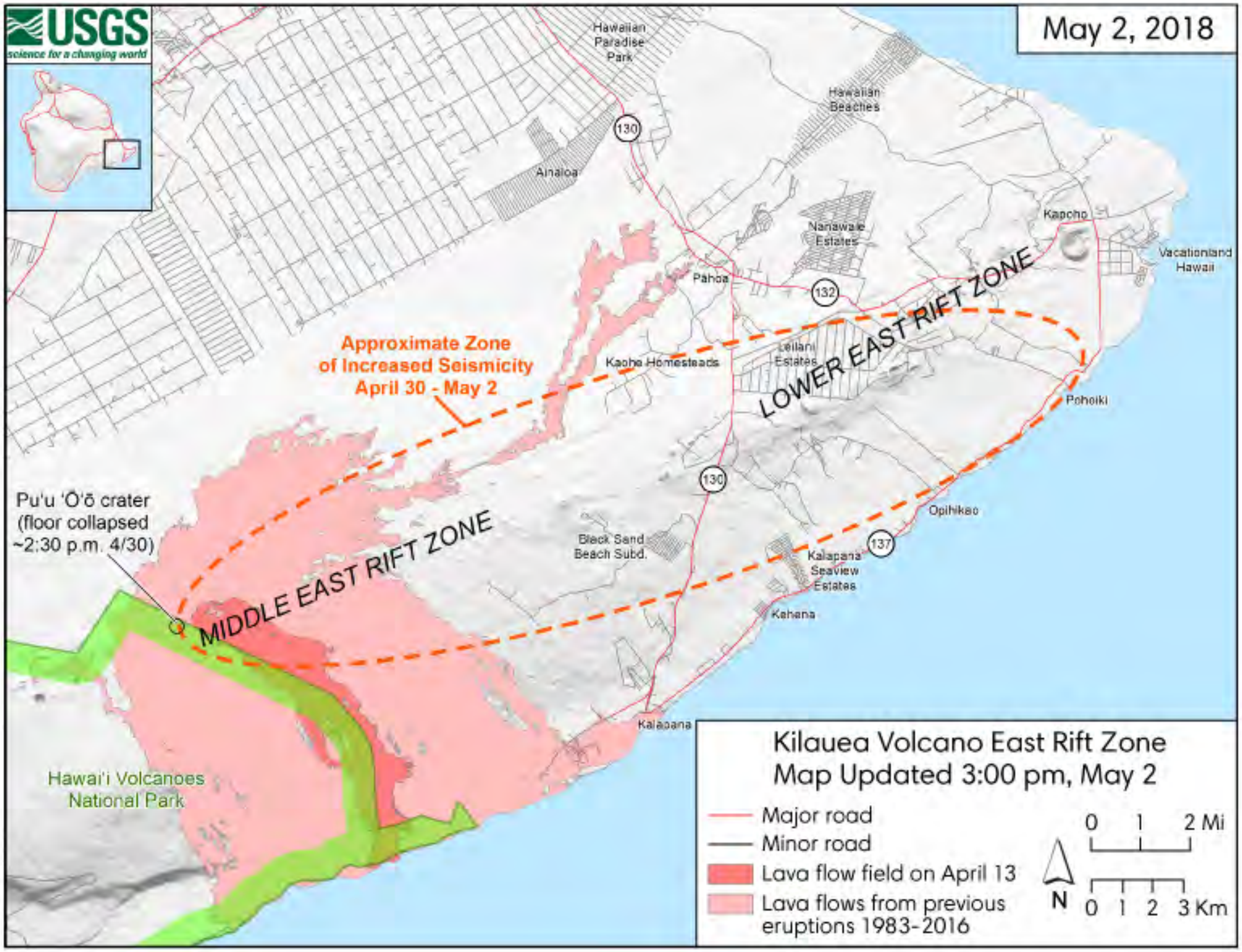
1. Ask students to record responses to the following:
    - ***How does technology help scientists keep the public safe and informed about hazards? Describe at least two ways.***
2. You may ask students to record their reflections on a separate piece of paper to turn in or in another location, such as a science journal, according to your class routines.

EXTENSION

Explore Additional Emergency Resources

1. Show students the **Hawai‘i County Civil Defense Alert Archive** website. Choose an alert to read together and ask students to listen for:
    - Data and observations from scientific monitoring (such as sulfur dioxide levels, earthquake occurrences)
    - Decisions or advisories that were made based on the data (such as evacuations)
2. Show students the **FEMA.gov** web page about the Kīlauea eruption. Point out the features and services offered, such as:
    - Assistance for residents to access disaster recovery centers
    - News releases
    - Links to county alerts, healthcare resources, etc.

May 2, 2018 Map



This map shows the area of increased earthquake activity along the East Rift Zone of the Kīlauea Volcano from April 30 to May 2, 2018.
Source: U.S. Geological Survey

Eruption in Leilani Estates

On May 3, 2018, a new eruption of Kīlauea Volcano began in the Leilani Estates neighborhood located in the lower East Rift Zone. Lava, hot water vapor, and gas fumes started spewing into the air from a newly-opened crack in the earth, and lava flowed slowly outward about 10 m from this volcanic fissure.

Image Credit: U.S. Geological Survey

Observation Journal

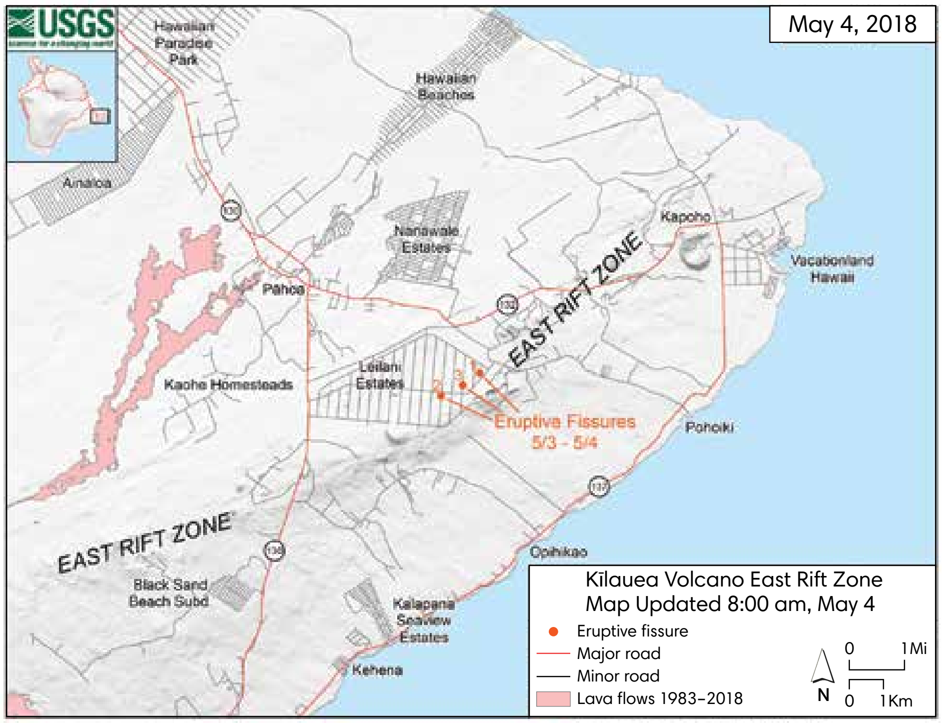
Date(s)	Observations	Analysis (What are the hazards? What do you predict next?)	Recommendations

Observation Journal

Date(s)	Observations	Analysis (What are the hazards? What do you predict next?)	Recommendations

Monitoring Kīlauea Data

KĪLAUEA VOLCANO EAST RIFT ZONE—MAY 4, 2018



Source: U.S. Geological Survey

Description

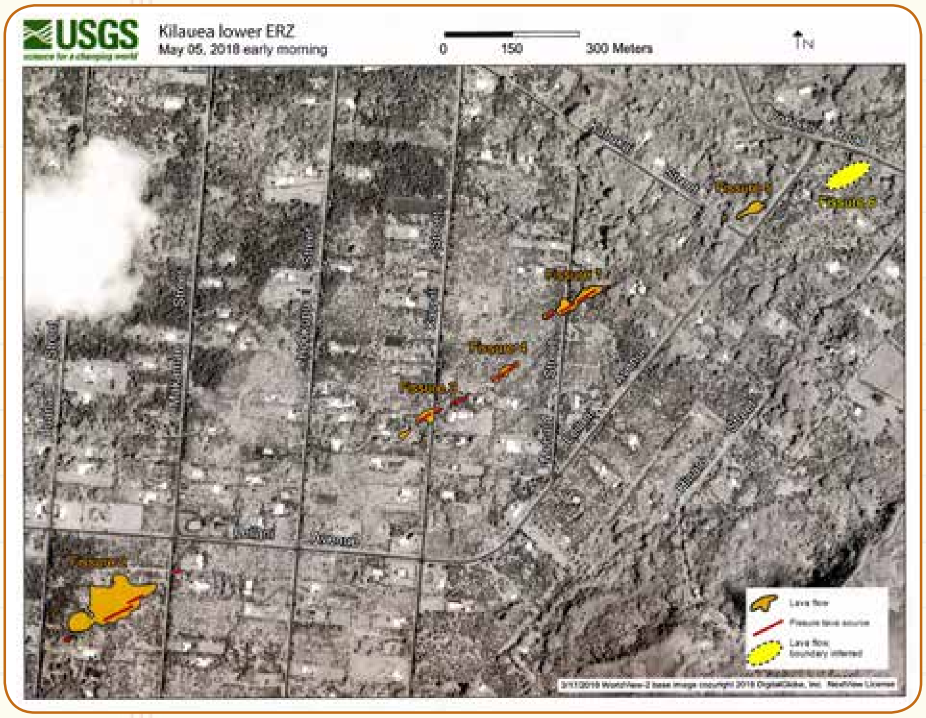
This map shows the locations of fissure 1 (opened May 3) and fissures 2 and 3 (opened May 4) in Kīlauea Volcano's East Rift Zone.

Description

This photo, taken at 8:07 AM on May 4, 2018, shows lava and gas spewing from fissure 3 at Leilani and Kaupili Streets in the Leilani Estates neighborhood. Lava on the road is approximately 2 m (~6.5 ft) high.

Image Credit: U.S. Geological Survey

KĪLAUEA VOLCANO EAST RIFT ZONE—MAY 5, 2018



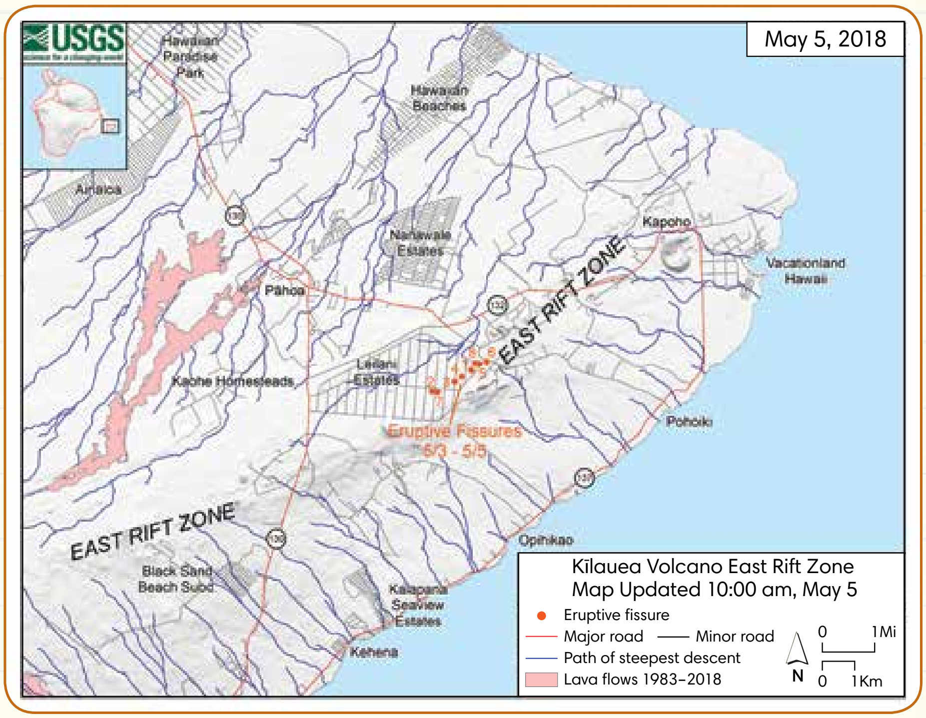
Source: U.S. Geological Survey
Satellite image ©2018 DigitalGlobe,
a Maxar company

Description

This satellite image shows fissures 1–5 and lava-covered areas of Leilani Estates in Kīlauea Volcano's East Rift Zone on May 5, 2018.

Description

This map shows the locations of fissures 7–8 (opened May 5), along with previously-opened fissures 1–6. The blue lines show the paths of steepest descent.



Source: U.S. Geological Survey

Description

This photo shows a newly opened crack on Pohoiki road in Leilani Estates on May 5, 2018.

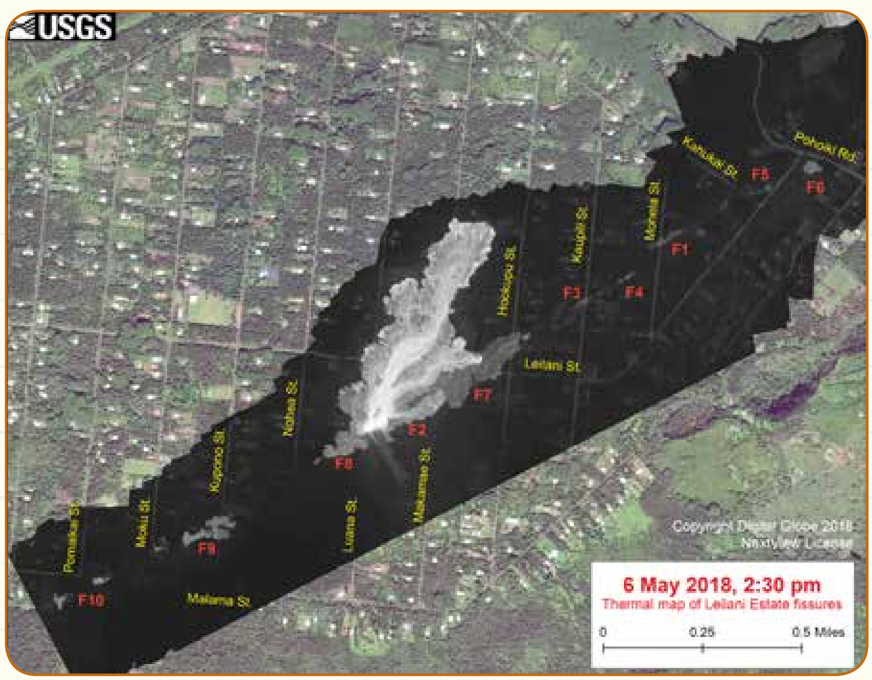
Image Credit: U.S. Geological Survey

KĪLAUEA VOLCANO EAST RIFT ZONE—MAY 6, 2018

Description

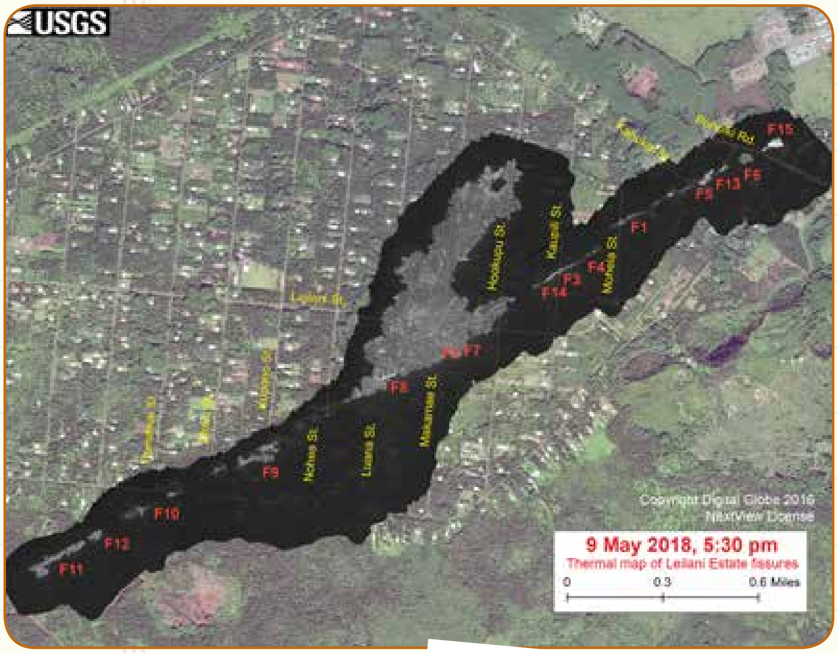
This thermal map, created at 2:30 PM on May 6, 2018, shows fissures 9–10 (opened May 6) along with previously-opened fissures 1–8 in Kīlauea Volcano's East Rift Zone.

The thermal image is the black portion at the center. It is shown over a color satellite image of the area. Lava flow is shown in grey and white. The hottest temperatures appear as the brightest white areas.



Source: U.S. Geological Survey
Satellite image ©2018 DigitalGlobe, a Maxar company

KĪLAUEA VOLCANO EAST RIFT ZONE—MAY 9, 2018



Description

This thermal map, created at 5:30 PM on May 9, 2018, shows fissures 1-15 in Kīlauea Volcano's East Rift Zone. Fissures 11-12 opened May 7, fissures 13-14 opened May 8, and fissure 15 opened May 9.

The thermal image is the black portion at the center. It is shown over a color satellite image of the area. Lava flow is shown in grey and white. The hottest temperatures appear as the brightest white areas.

Source: U.S. Geological Survey
Satellite image ©2018 DigitalGlobe, a Maxar company

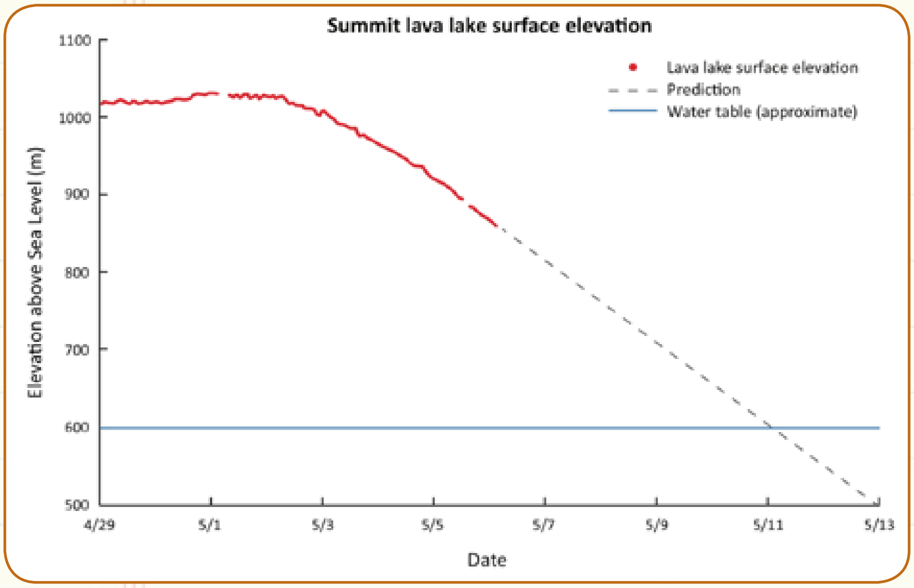
Description

This photo shows a geologist from the Hawaiian Volcano Observatory (HVO) measuring the temperature at cracks in Nohea Street in Leilani Estates at 11:47 AM on May 9, 2018. The temperature reading was 103°C (218° F).

This photo shows deep cracks, burned trees, and gas around fissure 14.

Image Credit: U.S. Geological Survey

KĪLAUEA VOLCANO SUMMIT CALDERA—MAY 6, 2018



Description

This is a graph of the lava lake level at the Kīlauea Volcano summit caldera. Data marked in red shows the lava lake level from April 29 to May 6, 2018. The dotted line shows predicted levels.

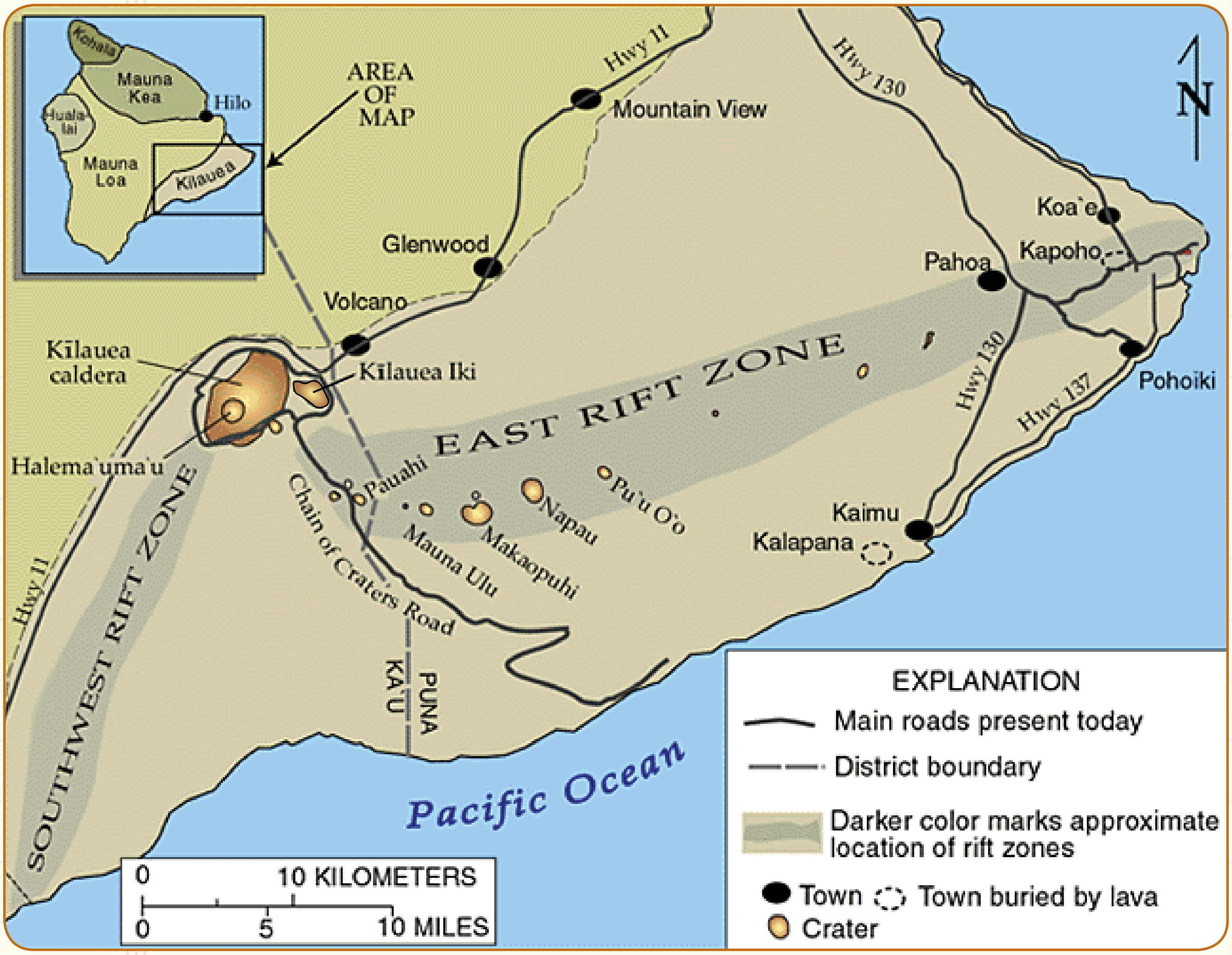
Source: Adapted from U.S. Geological Survey

Description

This photo shows the Kīlauea Volcano's summit crater. The level of the lava lake dropped significantly below the crater rim.

Source: U.S. Geological Survey

KĪLAUEA VOLCANO MAP



Source: U.S. Geological Survey

Description

This map of Kīlauea Volcano shows the summit caldera as well as rift zones and craters downhill from the summit.

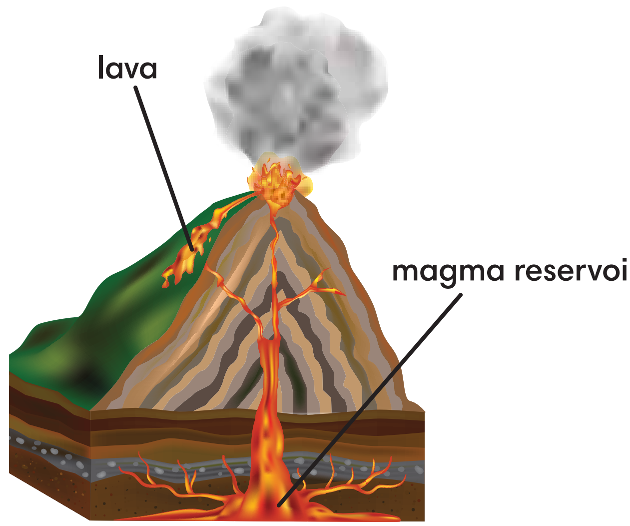
IMPORTANT TERMS

magma Rock that is molten (in liquid form due to heating). When magma reaches the surface, it is called *lava*.

magma reservoir An underground pool that is filled with molten rock (magma); also known as a **magma chamber**.

lava Magma (molten rock) that is erupting/has erupted above ground. Lava is hot! Hawaiian lava has an average temperature of about 1100°C (2012°F).

- **lava flow** Lava moving along the ground (or underwater).
- **lava lake** A pool of lava that forms in a volcanic crater or caldera.



magma reservoir and lava


lava


lava lake

eruption (volcanic) Occurs when gases, ash, rocks, and/or lava break out of Earth's surface.

- **explosive eruption** An eruption in which trapped gases blast apart sticky lava. This creates debris and causes ash clouds that can reach high into the sky.
- **effusive eruption** An eruption in which runny lava flows steadily and often slowly downhill.
- **flank eruption** An eruption from the side (flank) of a volcano rather than from the summit. Flank eruptions are common in the rift zones of shield volcanoes.


explosive eruptions

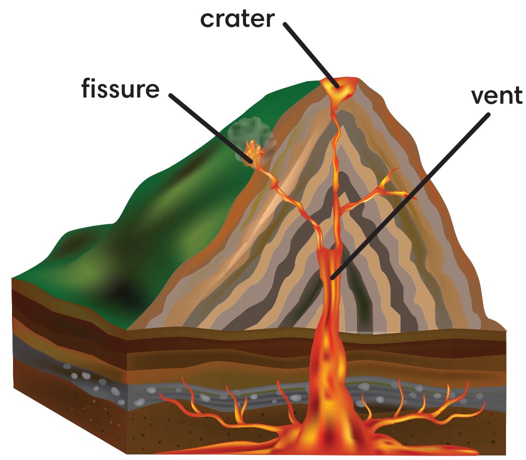
effusive eruption

flank eruption (effusive)

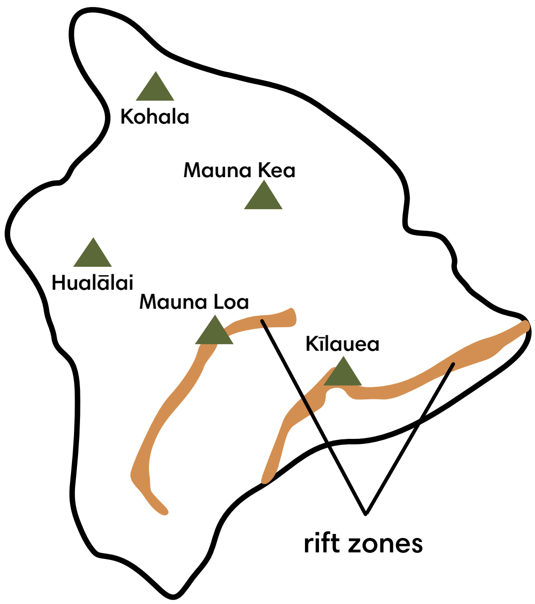
fissure A long crack or break in the ground from which volcanic gases, ash, rocks, and/or lava erupts.

rift zone An area along the side of a volcano where the land is splitting apart. Fissures often form in these areas. Rift zones are common in shield volcanoes.

vent An opening in a volcano that carries magma up to the summit crater or to a fissure.



vent, fissure, and crater



rift zones


fissure

caldera A large, steep-sided pit on a volcano. It is formed when the summit (highest point) collapses because magma has drained away or lava has erupted from it. Calderas are found on many dormant volcanoes. Sometimes, however, a caldera can have an active crater inside it.

crater A pit with openings for volcanic activities like lava flow and eruption of ashes. Craters are smaller than calderas and are generally circular.


caldera

crater within a caldera

tephra Ash and lava fragments that are thrown into the air during a volcanic eruption.

- **volcanic bomb** (or **projectile**) A piece of tephra that measures over 64 mm.
- **volcanic ash** A piece of tephra that measures less than 2 mm.


eruption of tephra

volcanic bomb

volcanic ash

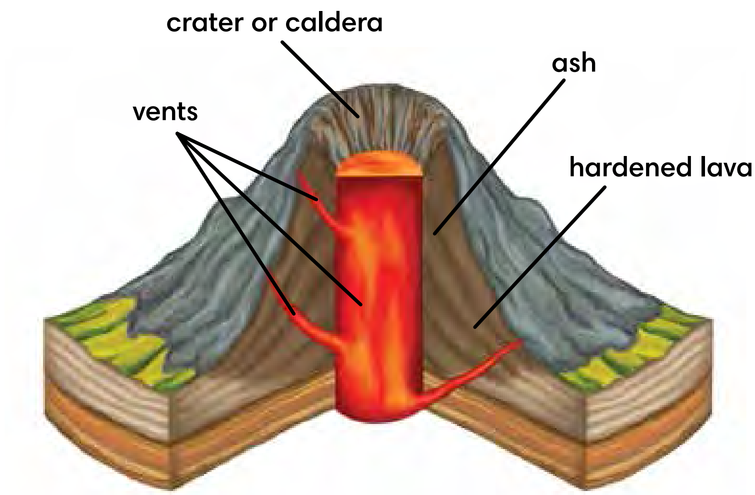
WHAT IS A COMPOSITE VOLCANO?

A **composite volcano** is the tallest and steepest type of volcano. It has the shape and size of a mountain.

On a composite volcano, thick and sticky lava erupts from a central vent. The eruptions are often explosive. Flank eruptions can also occur.

Composite volcanoes are formed of layers of hardened lava and ash. Most have a summit crater, which can become a caldera after a large explosion and collapse.

Another word for a composite volcano is **stratovolcano**.



structure of a composite volcano

Mount Fuji, Japan

Volcán Arenal, Costa Rica

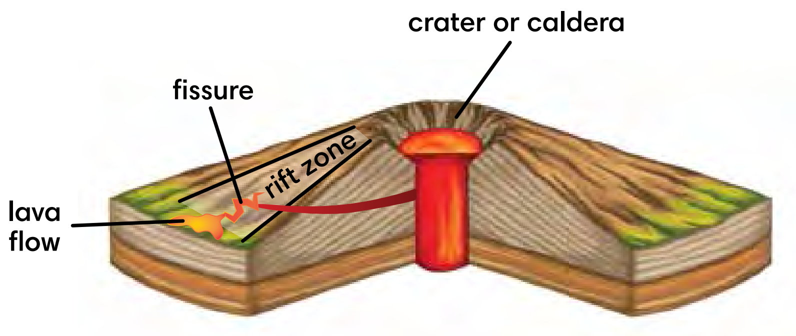
WHAT IS A SHIELD VOLCANO?

A **shield volcano** is the largest and widest type of volcano. It is less steep than other volcanoes. The name "shield" comes from the broad shape, which looks like a warrior's shield.

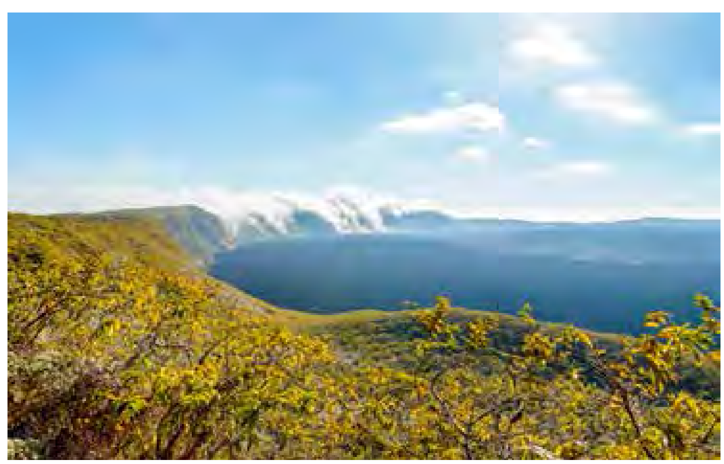
A shield volcano often has effusive eruptions of runny lava. However, explosive eruptions can also occur. Eruptions often occur from fissures in rift zones.

Shield volcanoes build up over time from lava flows that pour in all directions. When this occurs in the ocean, the hardened lava can form an island.

A large eruption on a shield volcano can form a caldera.



structure of a shield volcano



Galápagos Islands, Ecuador

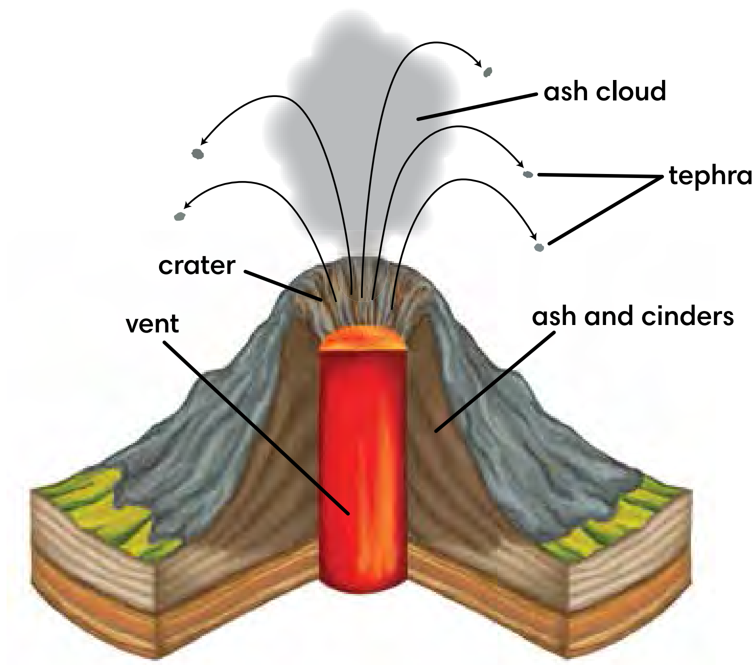
WHAT IS A CINDER CONE VOLCANO?

A **cinder cone volcano** is the simplest form of volcano.

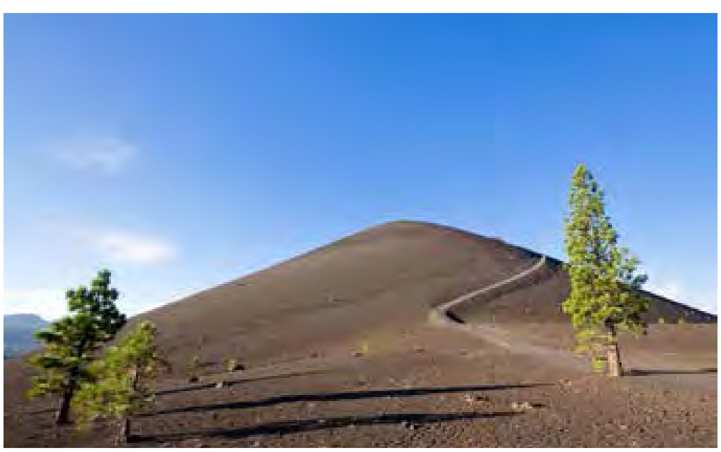
Cinder cones are relatively small. They rarely rise more than 300 m above their surroundings.

Cinder cones have explosive eruptions of gas, lava, and ash from a single vent. These lumps of lava cool into cinders and pile up with ash to create a cone shape with a crater at the top.

Cinder cones often form on or near larger volcanoes (shield or composite volcanoes).



structure of a cinder cone volcano



cinder cone, Lassen Volcanic National Park, CA

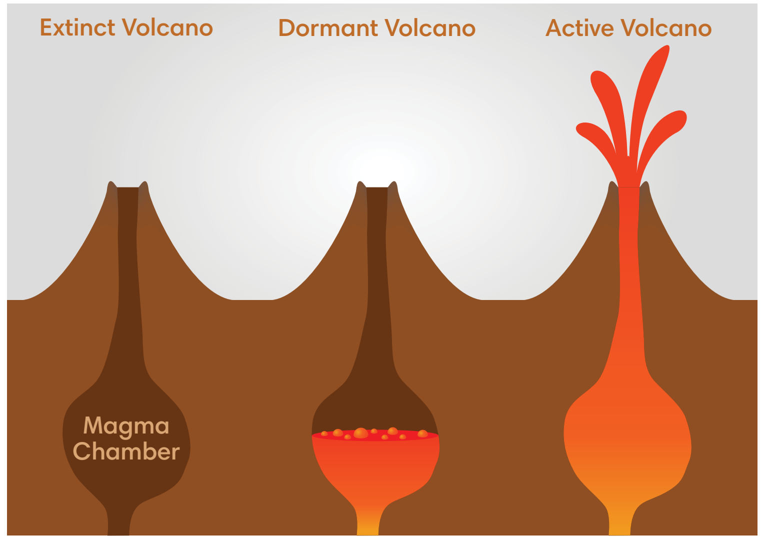
cinder cones within Haleakalā National Park, Hawai‘i

HOW CAN YOU TELL WHETHER A VOLCANO IS ACTIVE, DORMANT, OR EXTINCT?

Most scientists call a volcano **active** if it has erupted in the last 10,000 years.

If a volcano has not erupted very recently but is expected to erupt again, then it is called **dormant**. A dormant volcano is a kind of active volcano. It still holds magma beneath it.

A volcano is called **extinct** if scientists think it will never erupt again. Most extinct volcanoes show no evidence of an eruption within the last 10,000 years. An extinct volcano is cut off from any supply of magma.



extinct, dormant, and active volcanoes

Glass House Mountains, Australia: extinct volcanoes

Kibo peak, Kilimanjaro, Tanzania: a dormant volcano

Mayon, Philippines: an active volcano

The ground is swelling!

How and why do scientists monitor deformation at volcanoes?

Deformation refers to changes to the ground surface on a volcano. These changes are caused by magma moving underground. The changes may appear as swelling (inflation) or sinking (deflation).

Inflation occurs when a magma reservoir fills. The reservoir swells and pushes the ground above it up and out, tilting the ground away. This often happens before an eruption. **Deflation** happens after magma erupts or as it moves away underground. This causes the ground to sink down.

These changes can usually only be measured with sensitive instruments. A Global Positioning System (GPS) receiver is an instrument that uses satellite signals to determine its location. Scientists set up GPS stations with receivers on volcanoes and measure the changes in their locations. They also measure changes in the distances between stations. An increase in distance between these GPS stations can mean that inflation is occurring.

Scientists monitor deformation because these changes can offer signs that a volcano may erupt soon.

inflation on Mount Saint Helens prior to an eruption in 1980

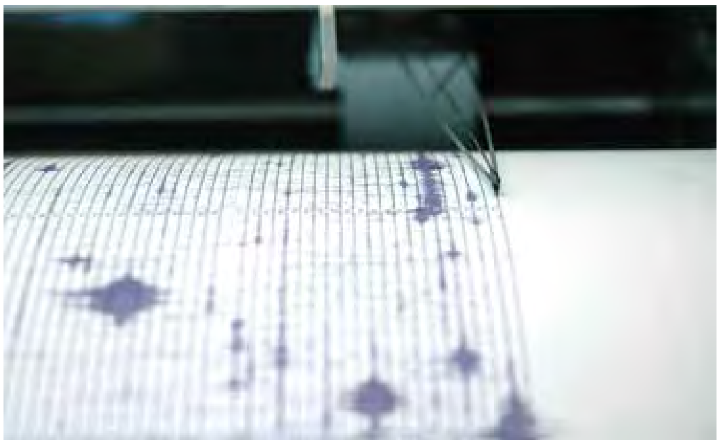
setting up a portable GPS receiver on a Hawaiian volcano

GPS receiver at North Rim Station, Newberry Volcano, Oregon

The ground is shaking!

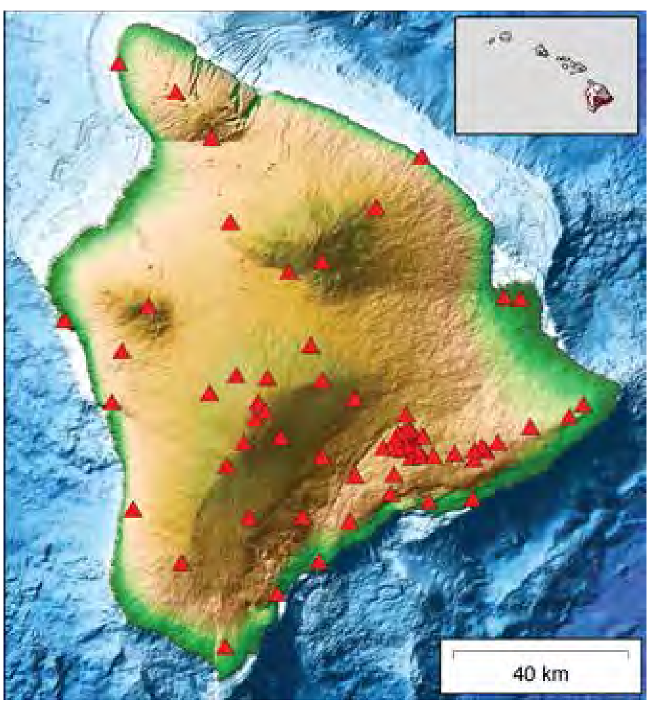
How and why do scientists monitor earthquakes around volcanoes?

Volcanic activity can sometimes cause earthquakes. Most of these earthquakes are too small for people to feel directly. However, scientists can use instruments called **seismographs** to detect them. Lots of small earthquakes near a volcano can provide warning signs that magma is cracking rocks and rising up through the cracks. When the magma is closer to the ground surface, the volcano may erupt soon.



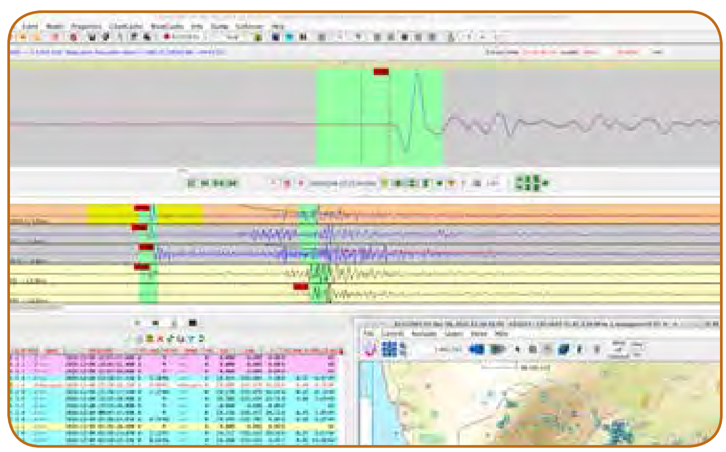
seismograph recording

earthquake monitoring station on Vesuvius



earthquake monitoring stations (red triangles) on the island of Hawaiʻi and across the state of Hawaii (inset)

Source: U.S. Geological Survey



screenshot from Hawaiʻi Volcano Observatory's earthquake monitoring software

Source: U.S. Geological Survey

Eew, that smell!

How and why do scientists measure sulfur dioxide concentrations around volcanoes?

Sulfur dioxide is a colorless gas with a nasty, sharp smell. It is produced by active volcanoes. Scientists use instruments called **spectrometers** to measure and monitor the amount of sulfur dioxide released by a volcano.

Changes in the amount of gases released can help scientists predict an upcoming eruption. These changes can also give clues about the amount of magma supplying an eruption. Volcanoes release more sulfur dioxide when magma comes near the surface.

Sulfur dioxide is toxic if it is inhaled. It can cause irritation of the nose and throat, as well as coughing and shortness of breath. Wind can carry the gas from its source to other areas nearby.

Scientists and public health officials recommend that people stay indoors and avoid exercise when levels of sulfur dioxide are high. Anyone with breathing or heart problems should leave the area.

measuring volcanic gases with a spectrometer at Kīlauea Volcano, Hawaiʻi

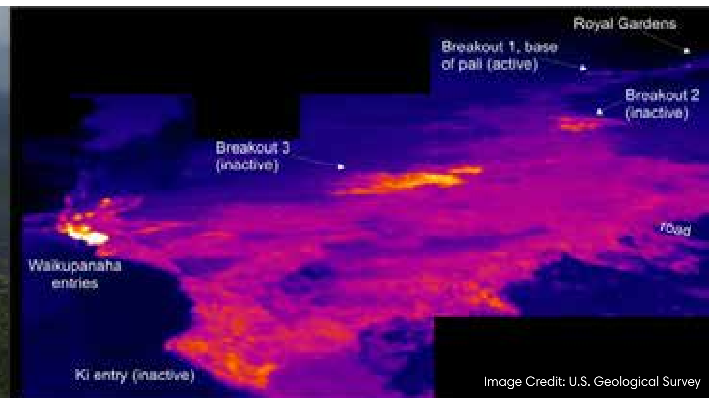
sampling gases at Augustine Volcano, Alaska

It's hot down there!

How does surface temperature help scientists predict changes in volcanic activity?

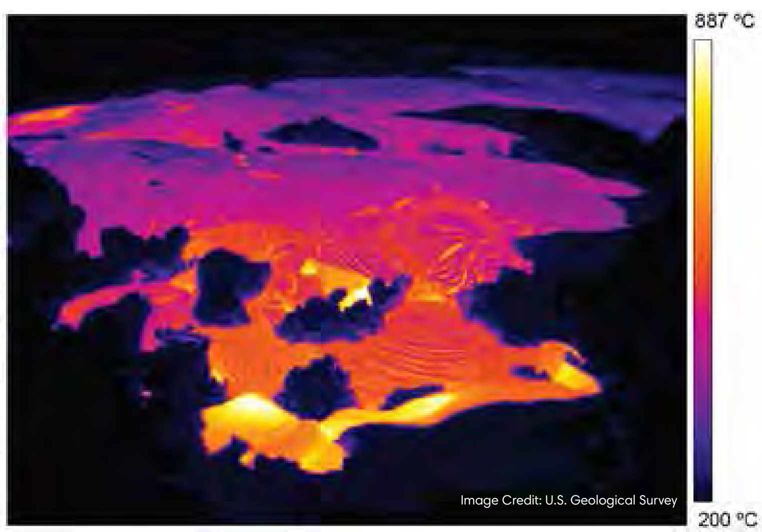
Anyone who lives near an active volcano will want to know if they are in the path of an eruption. Scientists use a method called **thermal imaging** to locate volcanic hazards. Thermal imaging uses special cameras or sensors that allow scientists to measure temperatures from a distance. The cameras/sensors create thermal images that use colors to show hot and cold areas. These images help scientists track **lava flows** and predict new eruptions.

lava flow reaching the coast



thermal image of the same area, showing areas of lava movement

lava flow



thermal image of a lava flow

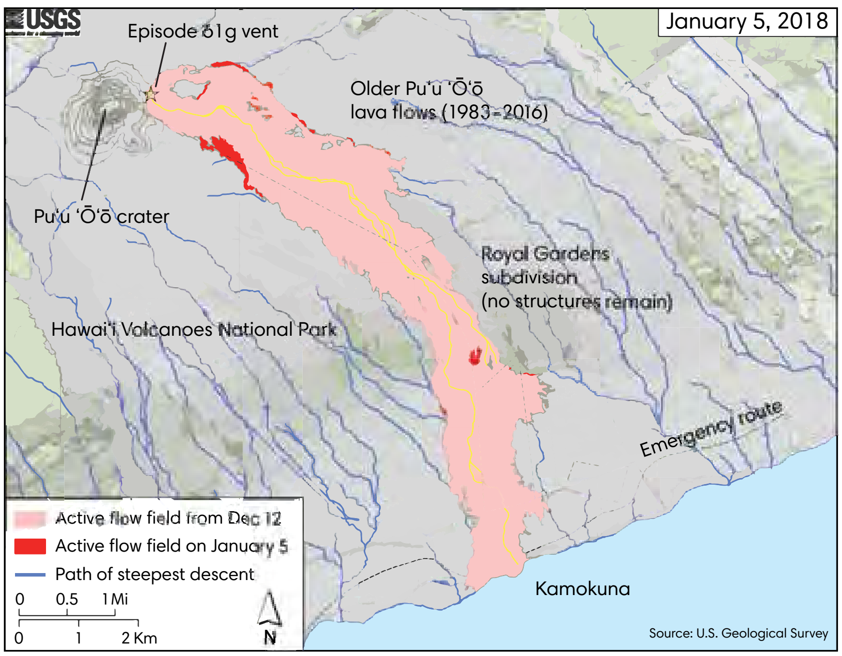
Get out of the way!

How can scientists predict where lava will flow?

When **magma** rises to the surface above a volcano, the hot, molten rock is called **lava**. In order to warn people where they might be in danger, scientists work to predict where the lava will flow.

Lava can sometimes flow from long **fissures**, or cracks in the ground, on a volcano's flanks. When lava erupts along a fissure, it may produce "curtains of fire." These rows of lava fountains often reach a few tens of meters in height and dwindle down after a few days.

Lava that spills from a **crater** or fissure will flow downhill. **Lava flows** are likely to follow the paths of steepest descent (where the ground slopes down the steepest). Once lava begins to flow, anyone living on the downhill side of its path will be alerted and evacuated. Roads, parks, and nearby areas at risk will be closed to the public.



map of lava flows and paths of steepest descent from Kīlauea's East Rift Zone in January 2018

area closure signs near a lava flow

a lava flow pours downhill from a fissure

It's gonna explode!

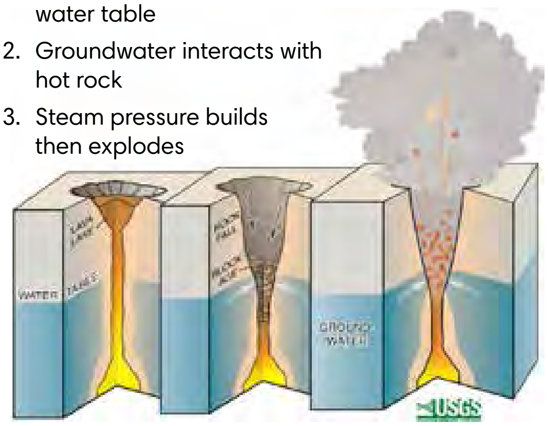
How can the lava lake provide clues about an eruption?

There are different types of volcanic eruptions. When a shield volcano erupts, the lava usually oozes slowly downhill. However, explosions can also occur. This can happen when a **lava lake** drops down below the water table underground. The water turns into steam, which builds up pressure until the rocks around it explode. Scientists monitor the levels of magma and groundwater in order to predict explosive eruptions.

Explosive eruptions blast **tephra**, or ash and lava fragments, into the air. Falling rocks called **volcanic bombs** can pose dangers to people close by. Ash can damage buildings, crops, and vehicles. It can endanger airplane flights and cause health problems when breathed in. Scientists try to predict eruptions to help people avoid these dangers.

Explosive eruptions can occur when:

1. Magma column drops below water table
2. Groundwater interacts with hot rock
3. Steam pressure builds then explodes



explosive eruption process

Source: U.S. Geological Survey

volcanic bombs from explosive eruptions littering the area near a volcanic crater

houses covered in ash from a volcanic eruption

A drop in the level of the lava lake can give scientists another clue. It may mean that magma is moving somewhere else underground. Another eruption might happen nearby.

Hawai‘i Volcano Hazard Update

HAWAI‘I VOLCANO HAZARD UPDATE
May 9, 2018

KĪLAUEA VOLCANO
19.42° N, 155.29° W, Summit Elevation 4091 ft (1247 m)
Current Volcano Alert Level: WARNING

An eruption is in progress along Kīlauea Volcano's lower East Rift Zone. Small fissure vents have opened in Leilani Estates subdivision. Additional fissure outbreaks producing spatter and lava flows are likely. Locations cannot be predicted with certainty, but new outbreaks so far have been preceded by ground cracking, then strong steam and volcanic gas release. High levels of volcanic gas including sulfur dioxide are being released from the fissure vents. Areas further along the rift from the current fissure zone are the most likely to see further outbreaks. Areas downslope of an erupting fissure or vent are at risk of being covered by lava. The general area of the Leilani subdivision remains at greatest risk. However, as the eruption progresses, other areas of the lower East Rift Zone may also be at risk. As the lava lake level inside the summit crater drops, rockfalls from the crater walls may increase, causing explosions from the lake onto the nearby crater rim. Residents of the area should remain alert, review emergency plans, heed closures and evacuations, and watch for further information about the status of the volcano.

Evacuation and Road Closure Map

This map shows roadblocks, road closures, and mandatory evacuation areas along Kīlauea Volcano's East Rift Zone in mid May, 2018.