Image Credit: Iswanto Arif / Unsplash

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The Kīlauea Volcano: Be a Volcanologist

About Volcanoes

Learning IN MOTION®

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About Volcanoes

Students explore background information about volcanoes in order to ensure they have the understandings necessary to participate in the following series of lessons. Students work with a team to sort a set of volcanoes into categories of their own choosing based on images and data. They read about categories commonly used to classify volcanoes by type (composite, shield, and cinder cone) and status (active, dormant, and extinct), and classify the set of volcanoes into these categories.

GUIDING QUESTION

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

Lesson 0: About Volcanoes

MATERIALS

Teacher Materials

- **About Volcanoes** visual
  - **Volcano** photographs

Student Materials

- **Volcano Card Sort Data** handout (online or print) (1 per team of 4)
- **Volcanology** handout (1 per student)

LESSON PREPARATION

- Decide whether to use hard copies of the handouts or have students access the online version.
  - If students will use hard copies, prior to class, ask a student to cut apart the volcano profile cards in each **Volcano Card Sort Data** handout, so the teams can sort them. If desired, the cards can be laminated for re-use. Keep the graphic organizer from each handout to provide to the team.
- Print a copy of the **Volcanology** handout for each student. Students will use the pages in this handout throughout the unit. If desired, the pages can be laminated for re-use.
- Designate 4 stations around the classroom for students to read about their volcano topic:
  - Station 1: composite volcanoes (page 5)
  - Station 2: shield volcanoes (page 6)
  - Station 3: cinder cone volcanoes (page 7)
  - Station 4: active, dormant, and extinct volcanoes (page 8)

Image Credit: Gary Saldana / Unsplash

Lesson 0: About Volcanoes

OPENING

Elicit Prior Knowledge

1. Show students the **Volcano** photographs. Ask students questions such as the following to engage their prior knowledge of volcanoes:
    - *What is a volcano?*
    - *Have you ever visited a volcano? What did you observe?*
    - *Why do you think it is important to study volcanoes?*
    - *How might volcanoes affect humans?*

2. Ask students to consider the following set of statements and decide whether they think each statement is true or false. You can have students raise their hand to indicate their choice or raise one finger for "true" and two fingers for "false."
    - A volcano can grow or change shape over time. *(true)*
    - A volcano that hasn't erupted in thousands of years can still erupt again in the future. *(true)*
    - All volcanoes are shaped like tall, steep cones. *(false)*
    - All volcanoes have a crater at the top with a lake of hot lava inside. *(false)*
    - Any volcano in the world might erupt at any time, and there is no way to predict it. *(false)*
    - Not all volcanic eruptions are fast and explosive. Some happen very slowly. *(true)*

Volcano photographs

Lesson 0: About Volcanoes

Introduce the Guiding Question

1. Introduce the unit Guiding Question:

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

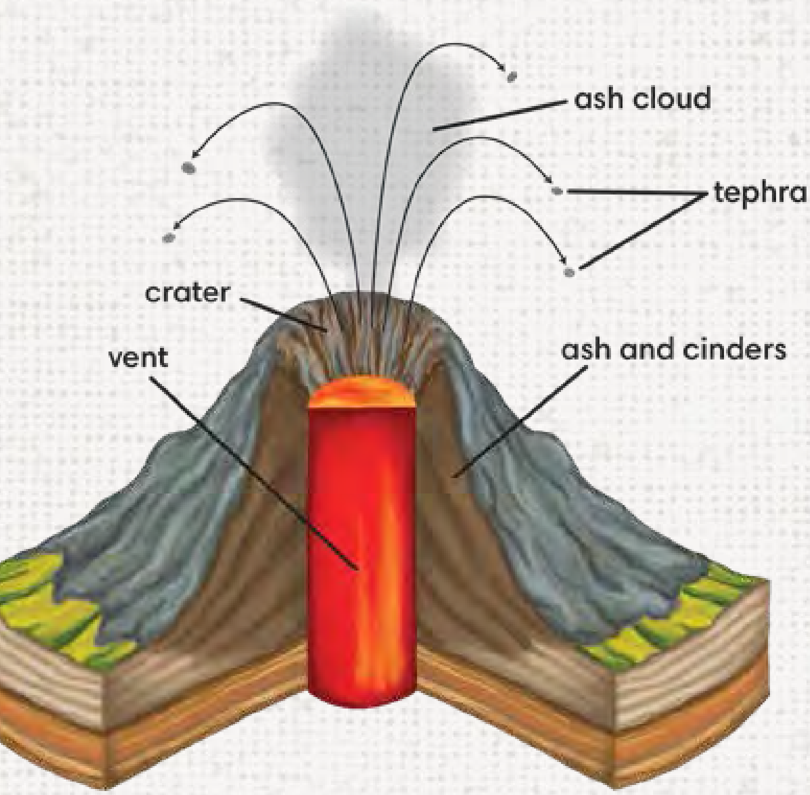
2. Let students know that over the next series of lessons, they will work as volcanologists, or scientists who study volcanoes. Explain:

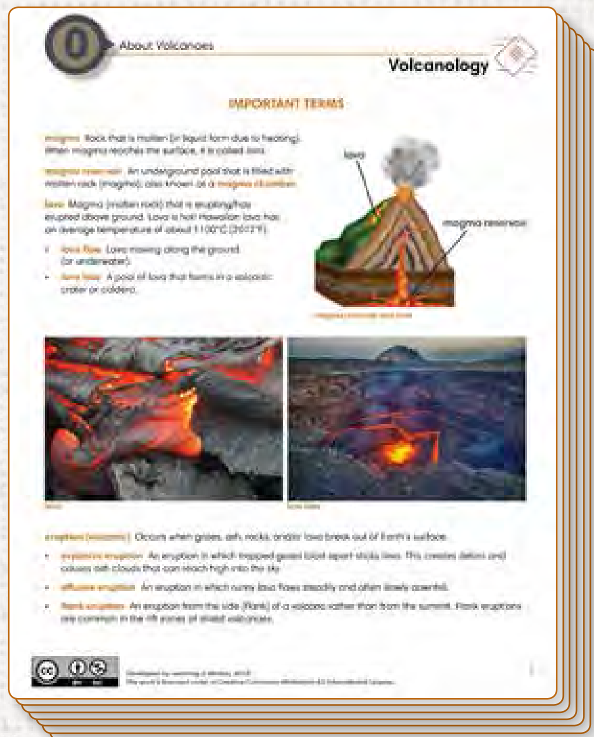
   - Their task will be to analyze data about volcanic activity in order to keep the public safe.
   - Before they start analyzing data (in the next lesson), it is important that they understand the basics about volcanoes and volcanic eruptions. Today they will prepare for their role as volcanologists by exploring different types of volcanoes and their characteristics.

ACTIVITY

Try Sorting Volcanoes

1. Provide each student with a **Volcanology** handout, and explain that it contains information that they can reference throughout the unit as they work as volcanologists. Point out the sections that they will need today on pages 1–8.





Volcanology handout

Lesson 0: About Volcanoes

2. Have students meet with teams of four. Provide each team with a **Volcano Card Sort Data** handout (either the **Volcano Card Sort Online Data** handout or the printed **Volcano Card Sort Data** handout with the cards cut out).

3. Point out that the **Volcano Card Sort Data** handout contains information about 11 different volcanoes. Explain that students will work with their team to take a few moments to sort the volcanoes into groups based on the photos and information provided. Students can use any criteria of their choosing to sort the volcanoes.

    - **Print version:** Students should sort the cards into piles. They can create labels for their piles using pieces of scrap paper.
    - **Online version:** Students should access the Sort tab of Lesson 0. They can drag and drop the volcanoes to sort them into groups and add labels for their categories using text boxes.
    - As students sort the volcanoes, they should refer to the **Volcanology** handout for help understanding unfamiliar terms.

Volcano Card Sort Data handout

4. Allow a few teams to share the criteria they sorted their volcanoes by. For example, they might sort them based on shape, size, appearance, date of last eruption, or any other characteristic that they notice.

Gather Information

1. Explain that as volcanologists, students will learn a few categories commonly used to classify volcanoes. Each student in a team will be assigned a different topic. They will read an information sheet about their topic and be responsible for helping their team sort the volcanoes based on that information.

2. Review the four topics in the **Volcanology** handout (pages 5–8) with the class:
    - *What is a composite volcano?*
    - *What is a shield volcano?*
    - *What is a cinder cone volcano?*
    - *How can you tell if a volcano is active, dormant, or extinct?*

3. Have teams determine which student will read each of the four topics. Instruct students to find their assigned topic in the **Volcanology** handout (pages 5–8).

4. Have each team member go to their designated reading station and find a partner who has the same topic (see Lesson Preparation). Allow students time to read their assigned info sheet with their partner.

Lesson 0: About Volcanoes

Classify Volcanoes

1. Signal for students to meet back with their home team. Tell students that they need to work together with their team to classify each volcano as a composite volcano, shield volcano, or cinder cone volcano, and as active, dormant, or extinct.
   - As the team looks at each volcano together, each student should consider the information that they read in their info sheet and share any key ideas with their team that will help the team classify the volcano.
   - Students can also ask other team members questions about their topics.
   - **Print version:** Students should record the name of each volcano in the appropriate space in the graphic organizer.
   - **Online version:** Students should select the appropriate categories from the two drop-down menus next to each volcano profile in the Classify tab. You may also choose to provide the printed graphic organizer for students working online.
   - Emphasize that students should be prepared to justify their decisions about volcano classifications to the class during discussion.
   - Students should classify as many of the volcanoes as they can within the time limits of the activity.

Discuss

1. After students have classified the volcanoes, bring the class together for discussion.
2. Draw a copy of the graphic organizer on the board. Ask for student input about how they classified the volcanoes. Ensure that students provide reasoning for each classification. A completed graphic organizer and example student responses are shown below. Students might say:
   - **We classified Stromboli as an active composite volcano because it has a tall mountainous shape with a summit crater, and it has been explosively erupting recently.**

Stromboli

Lesson 0: About Volcanoes


Gunung Agung

- We classified Ngauruhoe as an active composite volcano because is really tall and mountainous like most composite volcanoes, and it has erupted recently. Some of the eruptions were explosive.
- We classified Gunung Agung as an active composite volcano because it has the size, shape, and appearance of a composite volcano, and it has erupted explosively recently.
- We classified Erta Ale as an active volcano because it has erupted recently, and it has continuous lava lakes. It is a shield volcano because it has a broad shape and because it has eruptions from fissures on its flanks, which are common in shield volcanoes.
- We classified La Cumbre as an active shield volcano because effusive eruptions occur from fissures on the flanks, and they have been happening since 2009. It also has a broad shape and isn't steep like a composite volcano.
- We classified Cerro Negro as an active cinder cone volcano because it is a young volcano so it has erupted recently, and it erupts a lot of ash and volcanic debris.
- We classified Mount Edgecumbe as a dormant composite volcano because it hasn't erupted in thousands of years, but some of the eruptions were less than 10,000 years ago.
- We classified Mauna Kea as a dormant shield volcano because it has effusive eruptions, was built up by lava flows, and may erupt again.


Mauna Kea

Lesson 0: About Volcanoes

- We classified Lava Butte as dormant because it hasn't erupted in a long time, but it was still less than 10,000 years ago. It is a cinder cone because the cone shape was formed by hot ash and cinders, and it formed on a larger volcano.
- We classified Mount Shari as an extinct composite volcano because it hasn't erupted in hundreds of thousands of years, and it's made of layers of hardened lava and ash, which is how composite volcanoes are formed.
- We classified Kīlauea as an active shield volcano because it has been erupting effusively and because it has rift zones, which shield volcanoes often have.

	Composite	Shield	Cinder Cone
Active	Stromboli Ngauruhoe Gunung Agung	Erta Ale La Cumbre Kīlauea	Cerro Negro
Dormant	Mount Edgecumbe	Mauna Kea	Lava Butte
Extinct	Mount Shari		

3. Ask students to share any other interesting observations or questions from the activity. For example, students might notice:

- Some of the active volcanoes have ash or gas clouds in the pictures, but not all of them. You can't always tell by looking at the volcano whether it is active or not.
- I noticed that a volcano can have snow around the top.
- Some of the volcanoes look different than I expected. I didn't know that they could be flat-looking like Erta Ale or Kīlauea.


Image Credit: David Wollschlegel / Unsplash

Lesson 0: About Volcanoes

REFLECTION

Summarize

1. Summarize that today students discovered patterns in the features and eruption histories of different volcanoes. They used these patterns to sort and classify the volcanoes. Classifications such as these can provide useful information to scientists and make it easy to communicate. For example, the classification "active shield volcano" can tell a scientist a lot about a volcano.
2. Remind students that they will continue to apply their understandings about volcanoes in the lessons that follow, when they will analyze data in order to make predictions about volcanoes and keep the public safe.

Reflect

1. Ask students to write the following:
   - *1 way that volcanoes interact with Earth's water or air*
   - *1 way that volcanoes can change landscapes*
   - *1 thing they still want to know about volcanoes*
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.

Image Credit: ibrahim kusuma / Unsplash

About Volcanoes

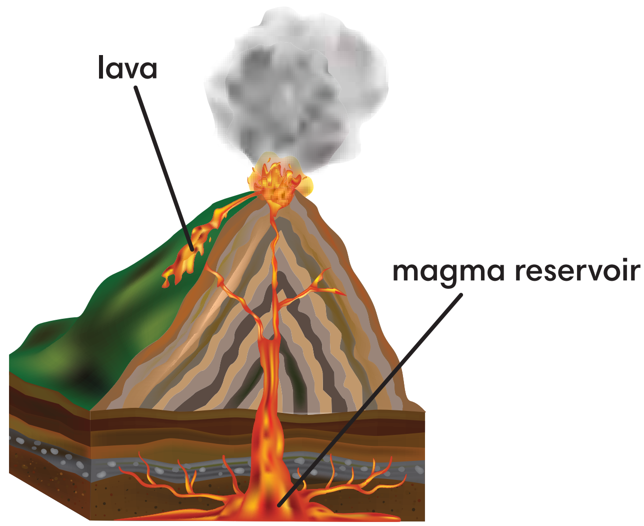
IMPORTANT TERMS

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

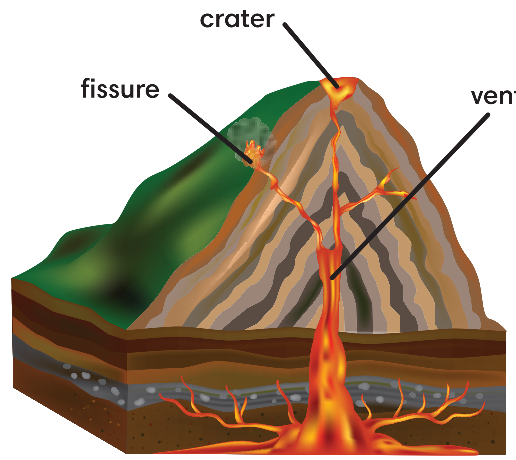

effusive eruption


flank eruption (effusive)

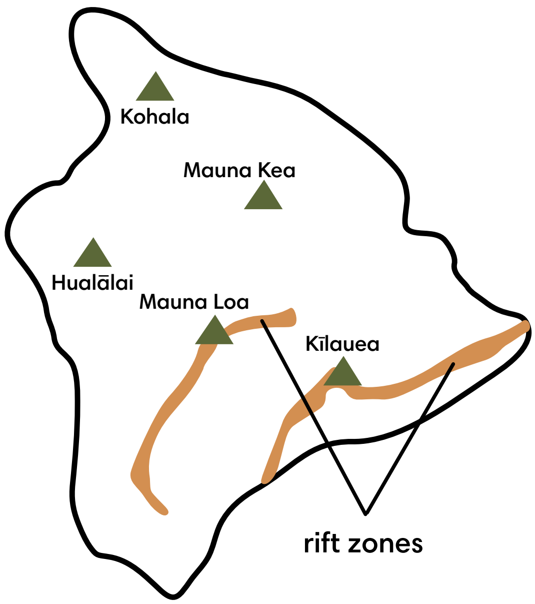
fissure A long crack or break in the ground from which volcanic gases, ash, rocks, and/or lava erupts.

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

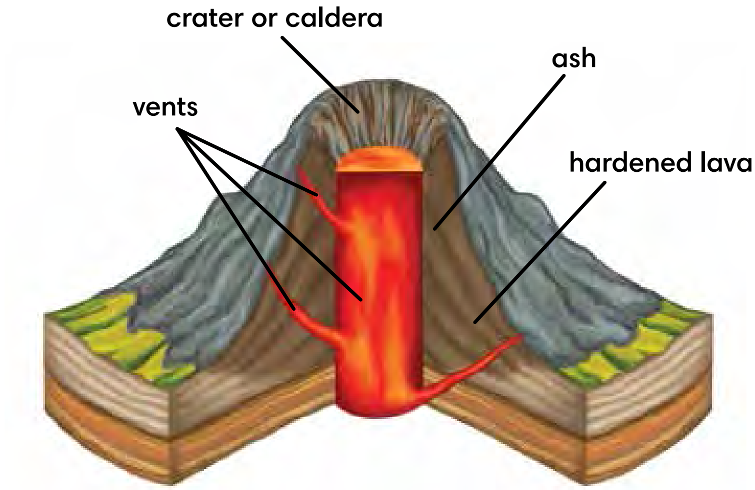
WHAT IS A COMPOSITE VOLCANO?

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

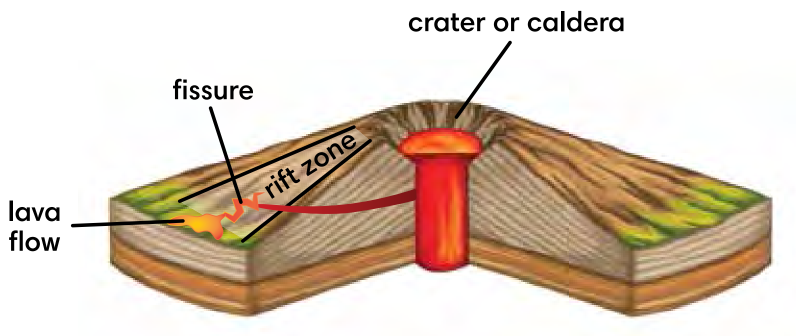
WHAT IS A SHIELD VOLCANO?

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.

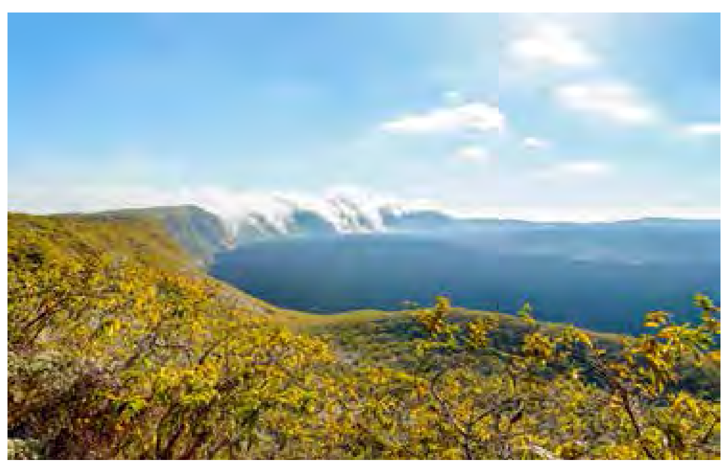
A shield volcano often has effusive eruptions of runny lava. However, explosive eruptions can also occur. Eruptions often occur from fissures in rift zones.

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

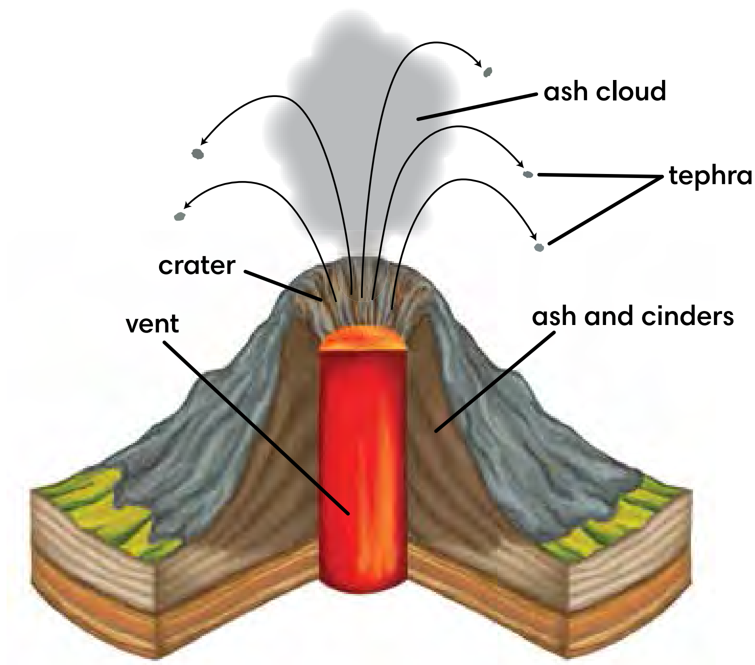
WHAT IS A CINDER CONE VOLCANO?

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

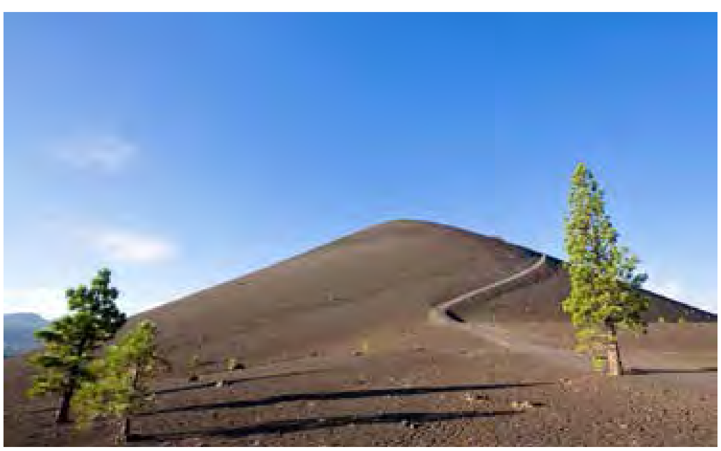
Cinder cones are relatively small. They rarely rise more than 300 m above their surroundings.

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

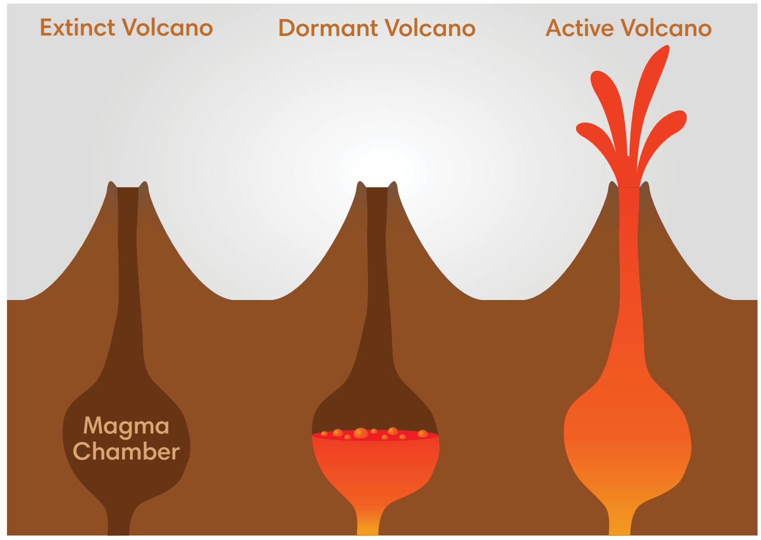
cinder cones within Haleakalā National Park, Hawai‘i

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

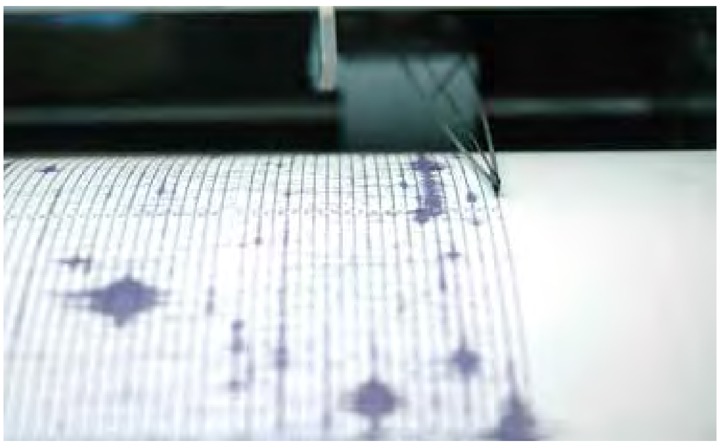
setting up a portable GPS receiver on a Hawaiian volcano

GPS receiver at North Rim Station, Newberry Volcano, Oregon

The ground is shaking!

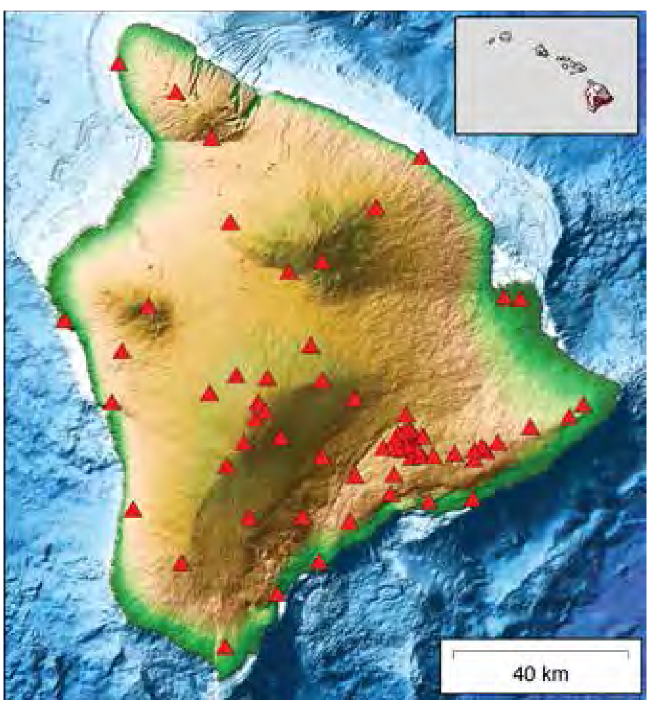
How and why do scientists monitor earthquakes around volcanoes?

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.



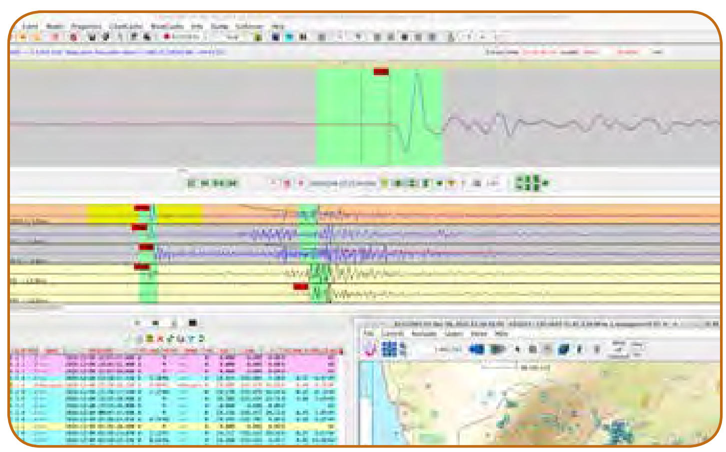
seismograph recording

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

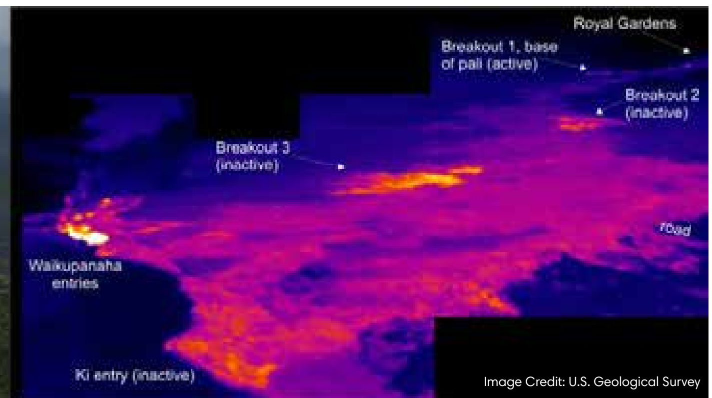
sampling gases at Augustine Volcano, Alaska

It's hot down there!

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

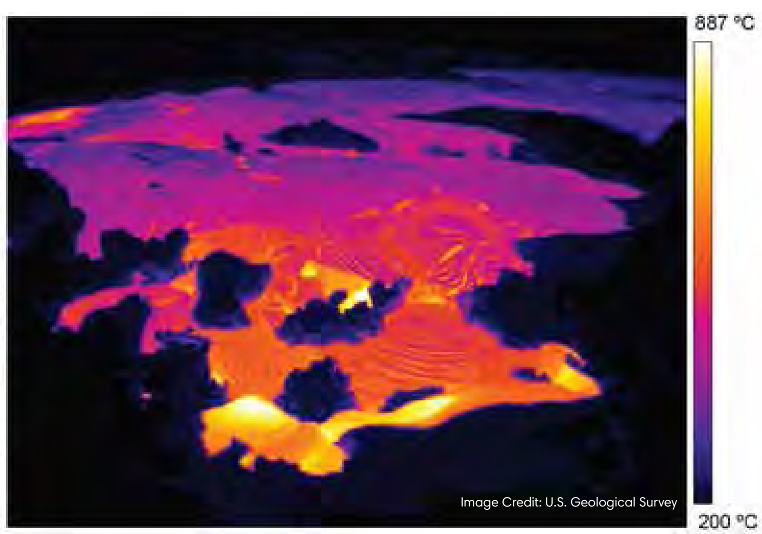
Anyone who lives near an active volcano will want to know if they are in the path of an eruption. Scientists use a method called **thermal imaging** to locate volcanic hazards. Thermal imaging uses special cameras or sensors that allow scientists to measure temperatures from a distance. The cameras/sensors 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

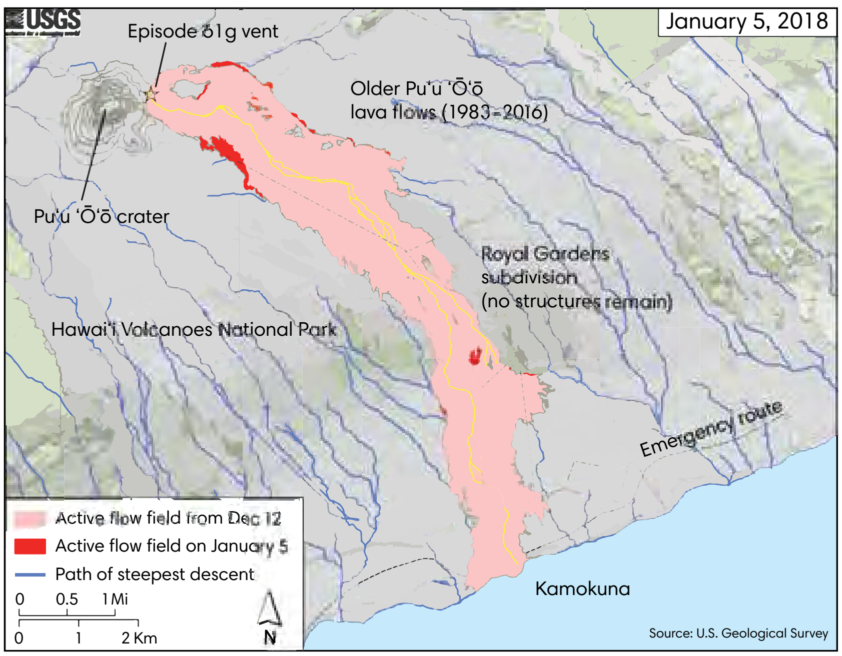
Get out of the way!

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!

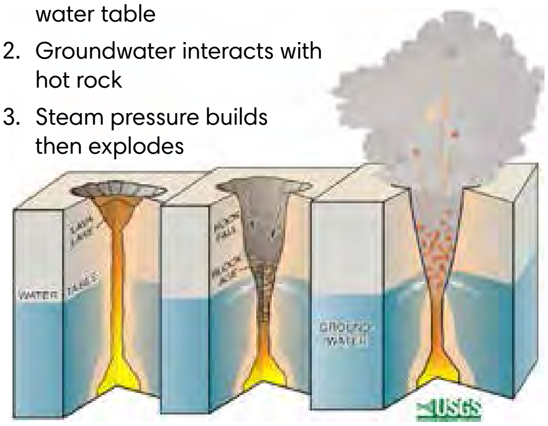
How can the lava lake provide clues about an eruption?

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.

Volcano Card Sort Data


Image Credit: filippo_jean, CC BY-SA 2.0


Image Credit: © A.Savin, Wikimedia Commons

Name: **Erta Ale**

Location: Afar Region, Ethiopia

Data:

- The name means "smoking mountain" in the local Afar language.
- It has almost continuously had a **lava lake**, which sometimes overflows on the south side of the volcano.
- A major **eruption** in 2005 killed 250 livestock and caused many people to flee.
- Another eruption occurred in 2017.
- **Fissure** eruptions have occurred recently on the volcano's flanks.
- It has a very broad shape—it is about 600 m tall and 50 km wide.

Name: **Stromboli**

Location: Mediterranean Sea north of Sicily, Italy

Data:

- It has been in almost continuous **eruption** for the past 2,000 years. The most recent eruption was in 2013–2014.
- **Explosive eruptions** occur at the summit **crater**.
- It forms an island 2 km wide. Its base begins over 1,000 m below the sea and rises over 900 m above sea level.
- The name of the volcano comes from the term *Strombolian eruptions*, which are short, quick blasts of lava.

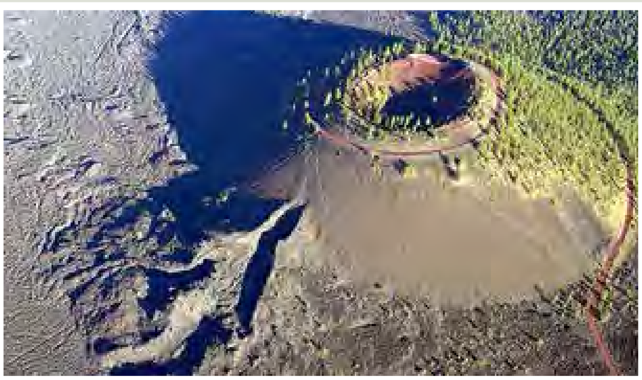
Volcano Card Sort Data

Name: La Cumbre (Fernandina Island)

Location: Galápagos Islands, Ecuador

Data:

- It has been erupting since 2009.
- **Effusive eruptions** occur from the summit **caldera** area and from **fissures** along the flanks. Lava flows reach the ocean.
- **Explosive eruptions** have also occurred, causing the **caldera** floor to collapse.
- It forms an island 6.5 km wide and rises nearly 1,500 m from the ocean surface.



Name: Lava Butte

Location: Oregon, United States

Data:

- It has erupted only once, about 7,000 years ago.
- The eruption spewed hot ash and cinder to form the cone shape.
- It is part of the larger Newberry Volcano (a shield volcano).
- It stands about 155 m tall, with a summit **crater** from 20 m to 50 m deep.

Volcano Card Sort Data

Name: Ngauruhoe

Location: North Island, New Zealand

Data:

- It is the highest peak in a group of volcanoes called Tongariro volcanic complex.
- It first erupted about 2,500 years ago.
- **Explosive eruptions** and lava flows have occurred several dozen times since the 1800s. The most recent eruption was in 1977.
- Fun fact: It was used to portray Mount Doom in the *Lord of the Rings* movies.

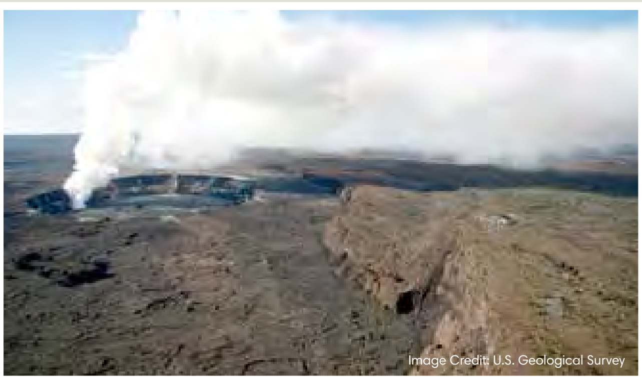


Image Credit: U.S. Geological Survey

Name: Kīlauea

Location: Island of Hawai'i, United States

Data:

- It has had ongoing **effusive eruptions** since 1983.
- **Lava flows** have covered hundreds of square kilometers and added new land to the coastline of Hawai'i.
- It has a **summit caldera** that contains a **crater** with a **lava lake**.
- It has two **rift zones** (East Rift Zone and Southwest Rift Zone) between the summit and the ocean.
- It is considered to be the home of the goddess Pele from Hawaiian legends.

Name: **Mount Edgecumbe**

Location: Alaska, United States

Data:

- It last erupted around 2200 BC.
- A series of **explosive eruptions** occurred about 9,000–13,000 years ago.
- It stands 970 m tall, with a well-defined **crater**.

Name: **Mount Shari**

Location: Hokkaido, Japan

Data:

- It was last active about 300,000 years ago.
- It is formed of alternate layers of hardened lava and ash.
- It stands 1,070 m tall.
- It is one of Japan's 100 most famous mountains.

Volcano Card Sort Data

Name: Mauna Kea

Location: Island of Hawai'i, United States

Data:

- The last **eruption** was around 4,500 years ago.
- **Effusive eruptions** from this and nearby volcanoes have built up the island of Hawai'i over many years.
- It rises 4,207 m and spreads broadly at its base.
- It may reawaken; its history shows long breaks in activity between past eruptions.
- Scientists built an observatory at the summit.

Name: Gunung Agung

Location: Bali, Indonesia

Data:

- It **erupted** in 2017 and was still erupting as of August, 2018. Thousands of people fled the area and flights were suspended.
- **Explosive eruptions** send up huge ash clouds.
- It rises over 3,000 m high and forms the tallest peak on the island of Bali.
- It is the site of an important temple for the Balinese people.

Volcano Card Sort Data

Name: Cerro Negro

Location: León, Nicaragua

Data:

- It is one of the youngest volcanoes in Central America.
- It first appeared in 1850.
- **Explosive eruptions** of ash and volcanic debris have occurred every few years to every few decades.
- Falling ash sometimes damages towns and crop fields nearby.
- Frequent eruptions have changed the volcano's shape and size.

	Composite	Shield	Cinder Cone
Active			
Dormant			
Extinct			