

# Volcanoes

## ESSENTIAL QUESTION

**How do volcanoes change Earth's surface?**

By the end of this lesson, you should be able to describe what the various kinds of volcanoes and eruptions are, where they occur, how they form, and how they change Earth's surface.

The Arenal volcano in Costa Rica has been active since 1968. The volcano has erupted on and off for over 7,000 years.

## Lesson Labs

### Quick Labs

- Modeling an Explosive Eruption
- Volcano Mapping

### Exploration Lab

- Modeling Lava Viscosity

## Engage Your Brain

**1 Predict** Check T or F to show whether you think each statement is true or false.

- | T                        | F                        |  |
|--------------------------|--------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | Volcanoes create new landforms such as mountains.                      |
| <input type="checkbox"/> | <input type="checkbox"/> | Tectonic plate boundaries are the only locations where volcanoes form. |
| <input type="checkbox"/> | <input type="checkbox"/> | Volcanic eruptions are often accompanied by earthquakes.               |
| <input type="checkbox"/> | <input type="checkbox"/> | Volcanoes form new rocks and minerals.                                 |

**2 Hypothesize** You are a news reporter assigned to cover a story about the roadway in the image below. Describe what you think happened in this photo.



## Active Reading

**3 Synthesize** You can often define an unknown word if you know the meaning of its word parts. Use the word parts and sentence below to make an educated guess about the meaning of the word *pyroclastic*.

Word part	Meaning
pyro-	heat or fire
-clastic	pieces

### Example sentence

Pyroclastic material was ejected into the atmosphere with explosive force during the eruption of the volcano.

**pyroclastic:**

## Vocabulary Terms

- |           |                  |
|-----------|------------------|
| • volcano | • vent           |
| • magma   | • tectonic plate |
| • lava    | • hot spot       |

**4 Apply** As you learn the definition of each vocabulary term in this lesson, create your own definition or sketch to help you remember the meaning of the term.



# Magma MAGIC

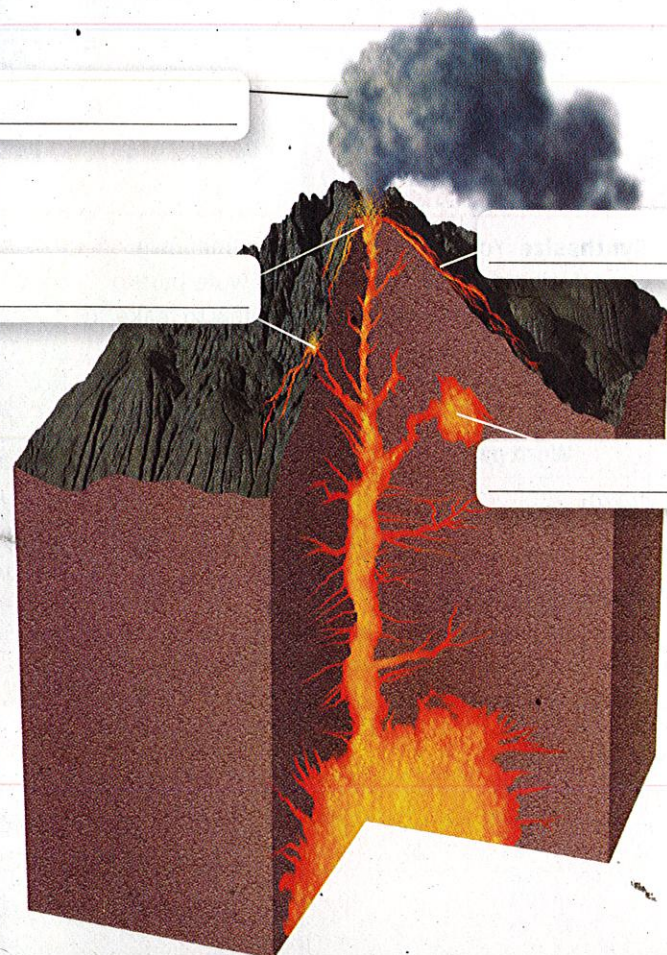
## What is a volcano?

What do volcanoes look like? Most people think of a steep mountain with smoke coming out of the top. In fact, a **volcano** is any place where gas, ash, or melted rock come out of the ground. A volcano can be a tall mountain, as shown below, or a small crack in the ground. Volcanoes occur on land and underwater. There are even volcanoes on other planets. Not all volcanoes actively erupt. Many are *dormant*, meaning an eruption has not occurred in a long period of time.

Volcanoes form as rock below the surface of Earth melts. The melted rock, or **magma**, is less dense than solid rock, so it rises toward the surface. **Lava** is magma that has reached Earth's surface. Lava and clouds of ash can erupt from a **vent**, or opening of a volcano.



**5 Identify** Label the parts of the volcano. Include the following terms: *magma*, *lava*, *vent*, *ash cloud*.



Lava can reach temperatures of more than 1,200 °C.

## What are the kinds of volcanic landforms?

The location of a volcano and the composition of magma determine the type of volcanic landforms created. Shield volcanoes, cinder cones, composite volcanoes, lava plateaus, craters, and calderas are all types of volcanic landforms.

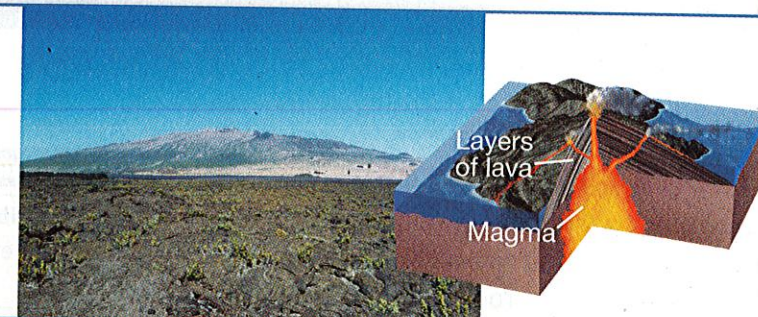
### Volcanic Mountains

Materials ejected from a volcano may build up around a vent to create volcanic mountains. *Viscosity* (vyz•SKAHZ•ih•tee) is the resistance of a liquid material, such as lava, to flow. The viscosity of lava determines the explosiveness of an eruption and the shape of the resulting volcanic mountain. Low-viscosity lava flows easily, forms low slopes, and erupts without large explosions. High-viscosity lava does not flow easily, forms steep slopes, and can erupt explosively. *Pyroclastic materials* (py•roh•KLAHZ•tyk), or hot ash and bits of rock, may also be ejected into the atmosphere.

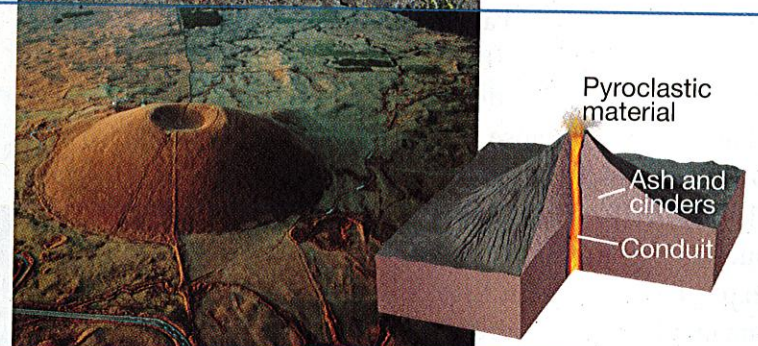


**7 Identify** As you read, underline the main features of each type of volcanic mountain.

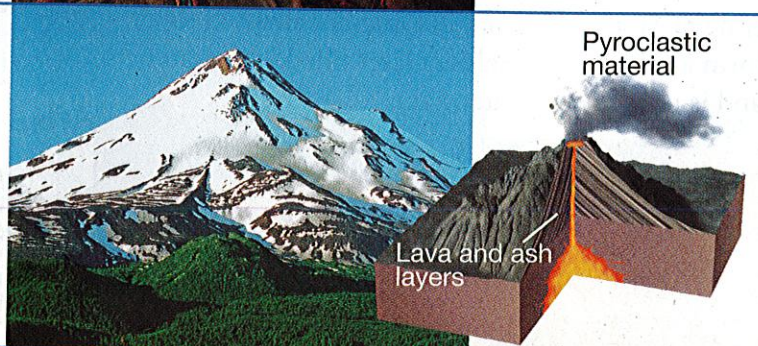
• **Shield Volcanoes** Volcanoes with a broad base and gently sloping sides are *shield volcanoes*. Shield volcanoes cover a wide area and generally form from mild eruptions. Layers of lava flow out from the vent, harden, and slowly build up to form the cone. The Hawaiian Islands are shield volcanoes.



• **Cinder Cones** Sometimes, ash and pieces of lava harden in the air and can fall to the ground around a small vent. The hardened pieces of lava are called cinders. The cinders and ash build up around the vent and form a steep volcano called a *cinder cone*. A cinder cone can also form at a side vent on other volcanic mountains, such as on shield or composite volcanoes.



• **Composite Volcanoes** Alternating layers of hardened lava flows and pyroclastic material create *composite volcanoes* (kuhm•PAHZ•iht). During a mild eruption, lava flows cover the sides of the cone. During an explosive eruption, pyroclastic material is deposited around the vent. Composite volcanoes commonly develop into large and steep volcanic mountains.



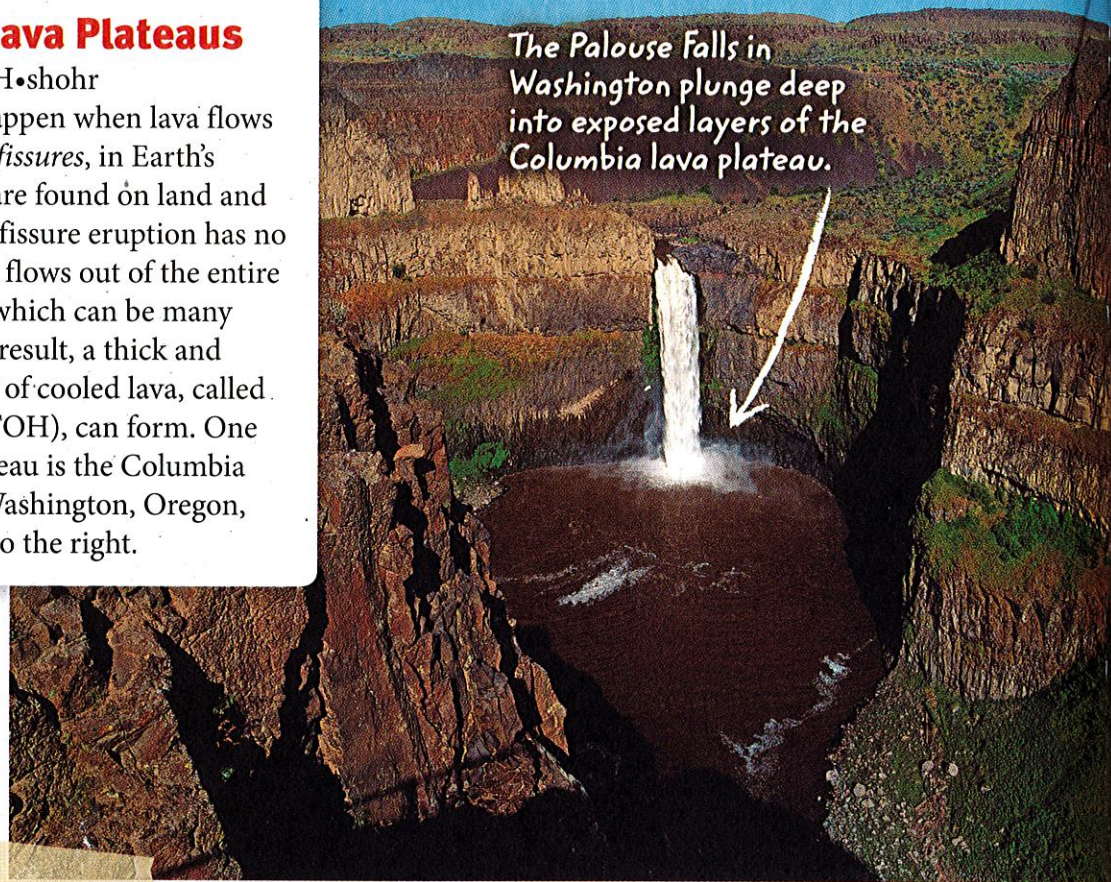
## Think Outside the Book Inquiry

**6 Apply** Small fragments of rock material that are ejected from a volcano are known as *volcanic ash*. Volcanic ash is a form of pyroclastic material. The material does not dissolve in water and is very abrasive, meaning it can scratch surfaces. Ash can build up to great depths in locations around a volcano. Write a cleanup plan for a town that explains how you might safely remove and dispose of volcanic ash.



## Fissures and Lava Plateaus

Fissure eruptions (FIH•shohr ee•RUHP•shuhnz) happen when lava flows from giant cracks, or *fissures*, in Earth's surface. The fissures are found on land and on the ocean floor. A fissure eruption has no central opening. Lava flows out of the entire length of the fissure, which can be many kilometers long. As a result, a thick and mostly flattened layer of cooled lava, called a *lava plateau* (plah•TOH), can form. One example of a lava plateau is the Columbia Plateau Province in Washington, Oregon, and Idaho, as shown to the right.



The Palouse Falls in Washington plunge deep into exposed layers of the Columbia lava plateau.

## Craters and Calderas

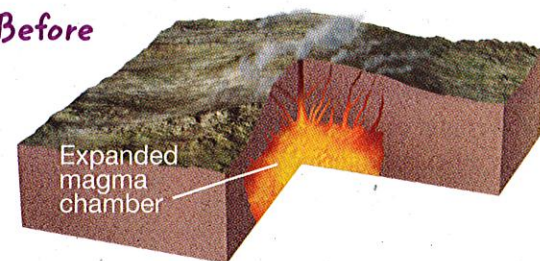
A *volcanic crater* is an opening or depression at the top of a volcano caused by eruptions. Inside the volcano, molten rock can form an expanded area of magma called a *magma chamber*, as shown to the right. When the magma chamber below a volcano empties, the roof of the magma chamber may collapse and leave an even larger, basin-shaped depression called a *caldera* (kahl•DAHR•uh). Calderas can form from the sudden drain of a magma chamber during an explosive eruption or from a slowly emptied magma chamber. More than 7,000 years ago, the cone of Mount Mazama in Oregon collapsed to form a caldera. The caldera later filled with water and is now called Crater Lake.

A caldera can be more than 100 km in diameter.

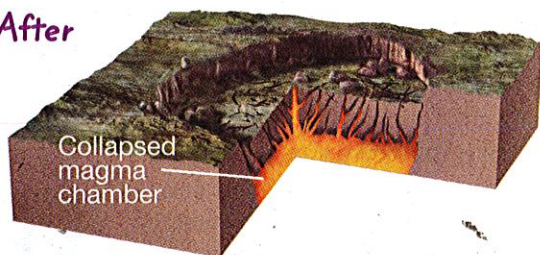
### Visualize It!

**8 Describe** How does the appearance of land surfaces change before and after a caldera forms?

Before



After



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# ERUPTION!

## Where do volcanoes form?

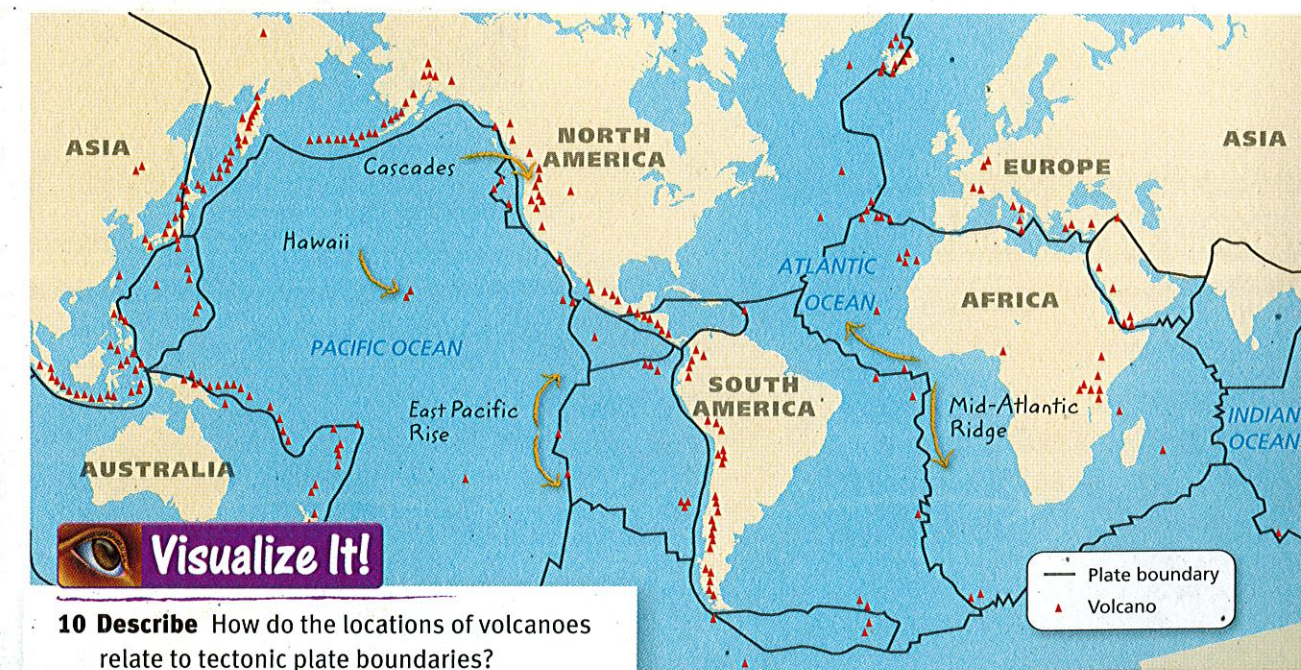
Volcanoes can form at plate boundaries or within the middle of a plate. Recall that **tectonic plates** are giant sections of lithosphere on Earth's surface. Volcanoes can form at *divergent plate boundaries* where two plates are moving away from each other. Most fissure eruptions occur at divergent boundaries. Shield volcanoes, fissure eruptions, and cinder cones can also occur away from plate boundaries within a plate at *hot spots*. The type of lava normally associated with these volcanoes has a relatively low viscosity, few trapped gases, and is usually not explosive.

Composite volcanoes are most common along *convergent plate boundaries* where oceanic plates subduct. In order for the rock to melt, it must be hot and the pressure on it must drop, or water and other fluids must be added to it. Extra fluids from ocean water form magma of higher viscosity with more trapped gases. Thus, composite volcanoes produce the most violent eruptions. The *Ring of Fire* is a name used to describe the numerous explosive volcanoes that form on convergent plate boundaries surrounding the Pacific Ocean.

### Active Reading

**9 Identify** As you read, underline three locations where volcanoes can form.

## Plate Tectonic Boundaries and Volcano Locations Worldwide



### Visualize It!

**10 Describe** How do the locations of volcanoes relate to tectonic plate boundaries?



## At Divergent Boundaries

At divergent boundaries, plates move away from each other. The lithosphere stretches and gets thinner, so the pressure on the mantle rock below decreases. As a result, the asthenosphere bulges upward and magma forms. This magma rises through fissures in the lithosphere, out onto the land or the ocean floor.

Most divergent boundaries are on the ocean floor. When eruptions occur in these areas, undersea volcanoes develop. These volcanoes and other processes lead to the formation of a long, underwater mountain range known as a *mid-ocean ridge*. Two examples of mid-ocean ridges are the East Pacific Rise in the Pacific Ocean and the Mid-Atlantic Ridge in the Atlantic Ocean. The youngest rocks in the ocean are located at mid-ocean ridges.

Shield volcanoes and cinder cones are common in Iceland, where the Mid-Atlantic Ridge runs through the country. As the plates move away from each other, new crust forms. When a divergent boundary is located in the middle of a continent, the crust stretches until a rift valley is formed, as shown below.

**Active Reading 11 Identify** What types of volcanic landforms occur at divergent plate boundaries?

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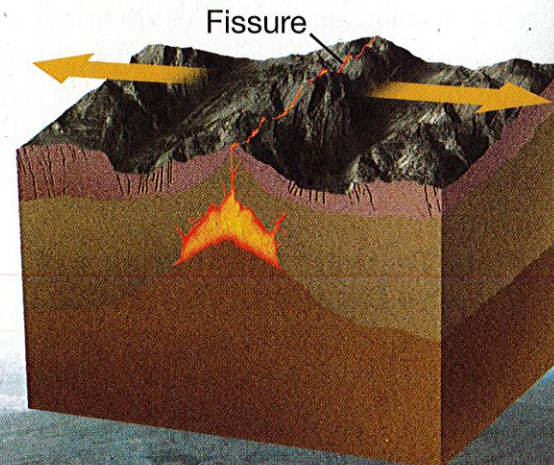


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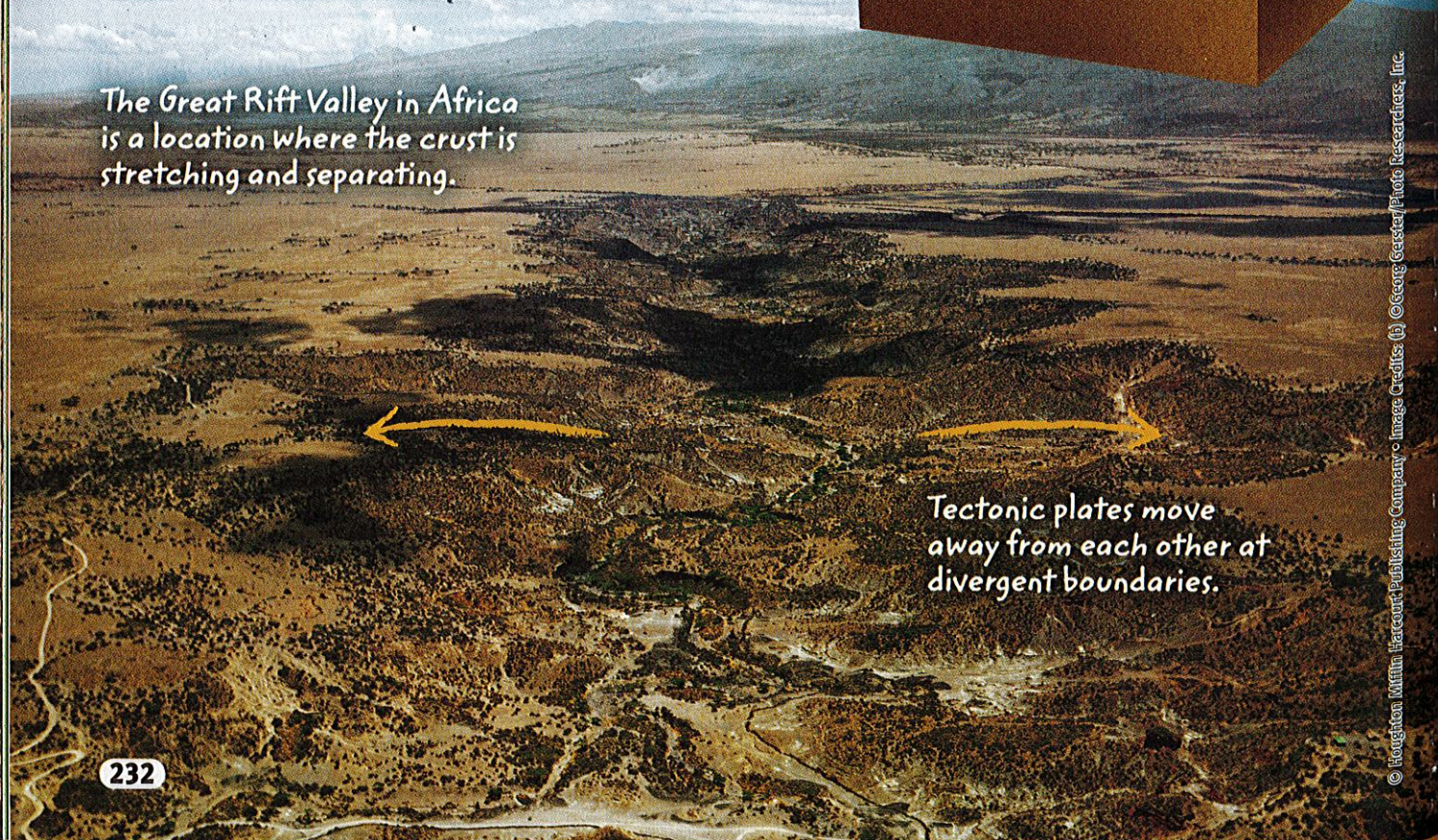


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Divergent plate boundaries create fissure eruptions and shield volcanoes.



The Great Rift Valley in Africa is a location where the crust is stretching and separating.



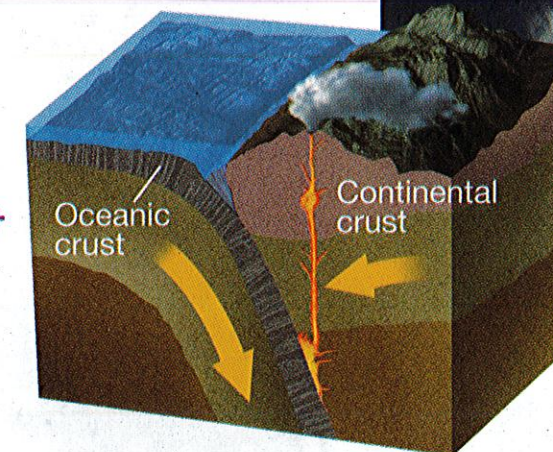
Tectonic plates move away from each other at divergent boundaries.

## At Convergent Boundaries

At convergent boundaries, two plates move toward each other. In most cases, one plate sinks beneath the other plate. As the sinking plate dives into the mantle, fluids in the sinking plate become super heated and escape. These escaping fluids cause the rock above the sinking plate to melt and form magma. This magma rises to the surface and erupts to form volcanoes.

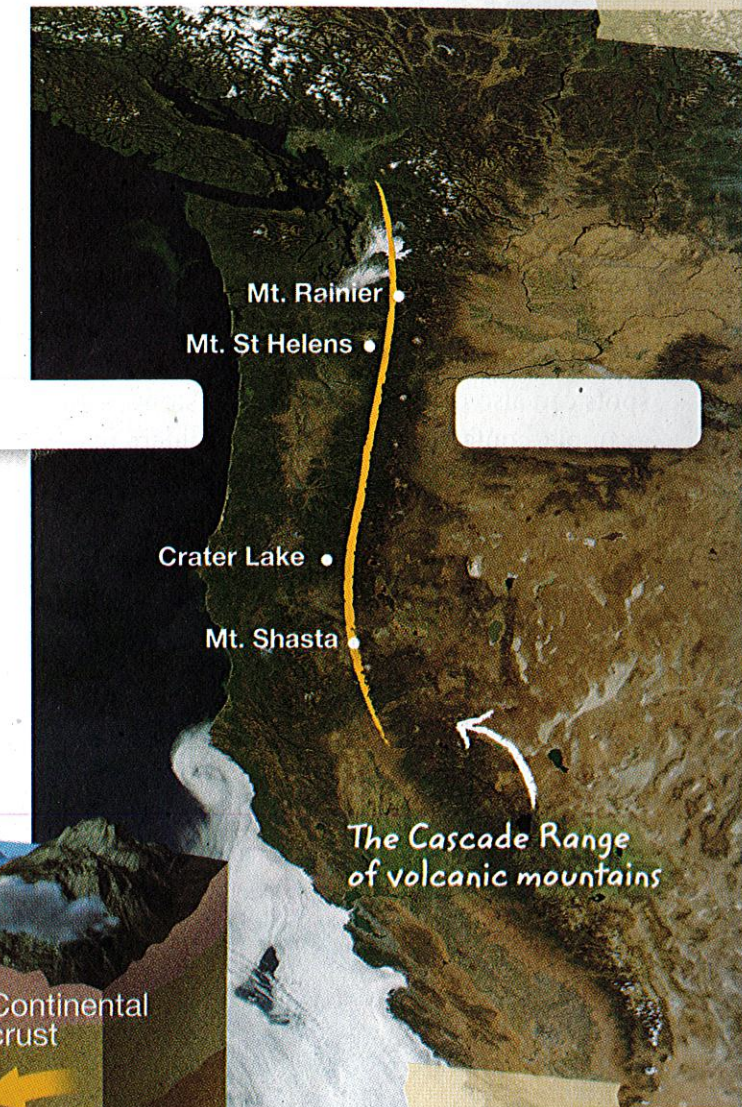
The magma that forms at convergent boundaries has a high concentration of fluids. As the magma rises, decreasing pressure causes the fluid trapped in the magma to form gas bubbles. But, because the magma has a high viscosity, these bubbles cannot escape easily. As the bubbles expand, the magma rises faster. Eventually, the magma can erupt explosively, forming calderas or composite volcanoes. Gas, ash, and large chunks of rock can be blown out of the volcanoes. The Cascade Range is a chain of active composite volcanoes in the northwestern United States, as shown to the right. In 1980, Mt. St. Helens erupted so violently that the entire top of the mountain was blown away.

Tectonic plates move toward each other at convergent boundaries.



## Visualize It!

**12 Identify** Draw two arrows in the white boxes to indicate the direction of motion of the plates that formed the Cascade volcanoes.



**13 Summarize** List the characteristics of divergent-boundary volcanoes and convergent-boundary volcanoes below.

Volcanoes at divergent boundaries	Volcanoes at convergent boundaries



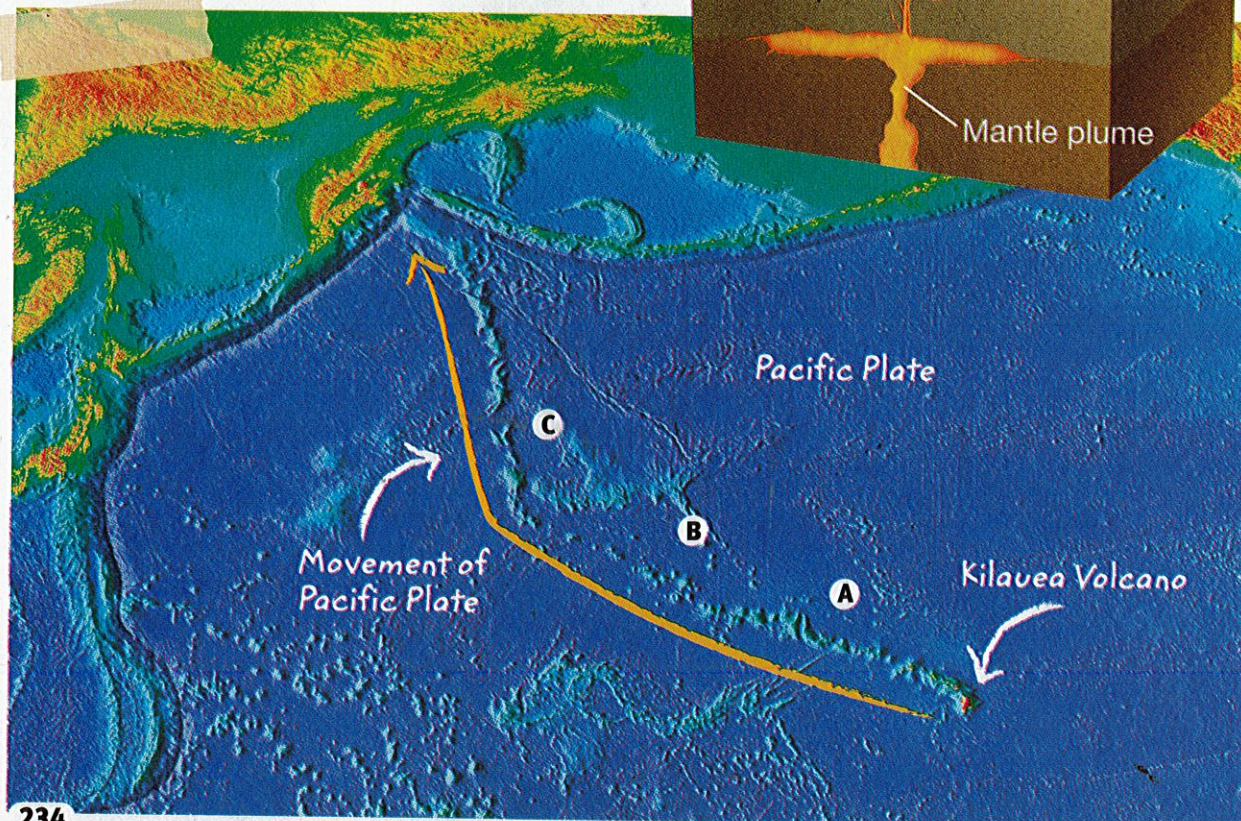
## At Hot Spots

Volcanoes can form within a plate, away from the plate boundaries. A **hot spot** is a location where a column of extremely hot mantle rock, called a *mantle plume*, rises through the asthenosphere. As the hot rock reaches the base of the lithosphere, it melts partially to form magma that can rise to the surface and form a volcano. Eruptions at a hot spot commonly form shield volcanoes. As tectonic plates move over a mantle plume, chains of volcanic mountains can form, as shown below.

The youngest Hawaiian island, the Big Island, is home to Kilauea (kih•loh•AY•uh). The Kilauea volcano is an active shield volcano located over a mantle plume. To the north and west of Kilauea is a chain of progressively-older shield volcanoes. These volcanoes were once located over the same mantle plume. Hot spots can also occur on land. Yellowstone National Park, for example, contains a huge volcanic caldera that was formed by the same mantle plume that created the Columbia Plateau.

### Visualize It!

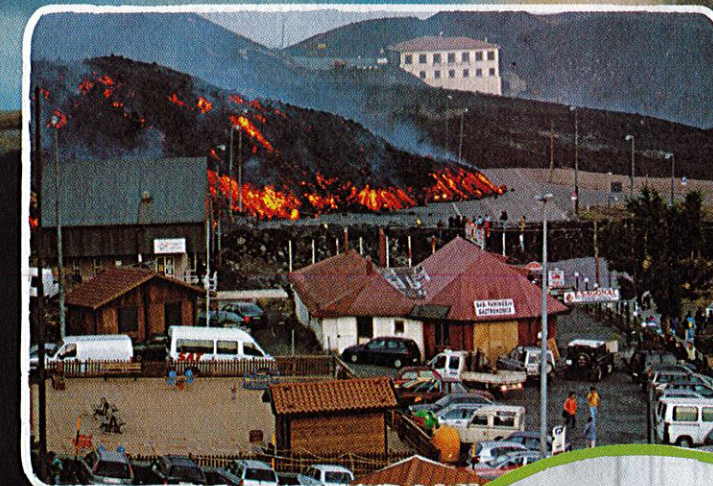
**14 Analyze** Which location, A, B, or C, do you think is the oldest volcano? How do you know?



## Why It Matters

# Living Near a Volcano

Volcanoes occur around the world. Many people live near volcanoes because the soils around a volcano can be very rich with essential minerals. These minerals make the soils fertile for growing a variety of crops. Living near a volcano also has its hazards. Sudden and unexpected eruptions can cause people to lose their homes and their lives.



### Destruction

Earthquakes, fires, ash, and lava flows during an eruption can destroy entire cities.



### Ash in the Air

Volcanic ash can cause breathing problems, bury crops, and damage engines. The weight of falling ash can cause buildings to collapse.

### Not All Bad

Volcanic rocks are used in jewelry, in making concrete, and in water filtration systems. Even cat litter and facial scrubs can contain volcanic rock.

### Extend

**15 Identify** Are all characteristics of volcanoes dangerous?

**16 Apply** Research the eruption of a specific volcano of your choice. Describe how the volcano affected the environment and the people near the volcano.

**17 Design** Create a poster that outlines a school safety plan for events that can occur before, during, and after a volcanic eruption.

### Inquiry



# Visual Summary

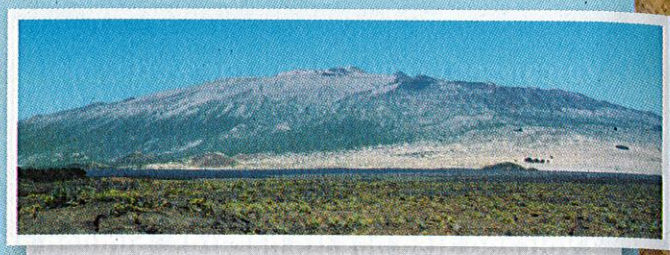
To complete this summary, check the box that indicates true or false. Then, use the key below to check your answers. You can use this page to review the main concepts of the lesson.

Lava and magma are different.



T F  
18 ☐ ☐ Lava is inside Earth's crust and may contain trapped gases.

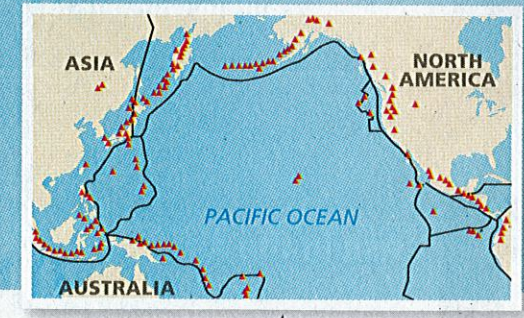
The three types of volcanic mountains are shield volcanoes, cinder cones, and composite volcanoes.



T F  
19 ☐ ☐ The type of volcano shown is a shield volcano.

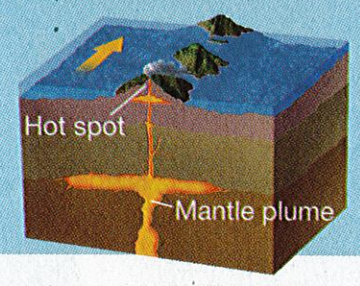
## Volcanoes

Volcanoes can form at tectonic plate boundaries.



T F  
20 ☐ ☐ At divergent plate boundaries, plates move toward each other.

Volcanoes can form at hot spots.



T F  
21 ☐ ☐ Hot spots are restricted to tectonic plate boundaries.

Answers: 18 False; 19 True; 20 False; 21 False

22 Explain How do volcanoes contribute to the formation of new landforms?

# Lesson Review

## Vocabulary

Write 1 or 2 sentences that describe the differences between the two terms.

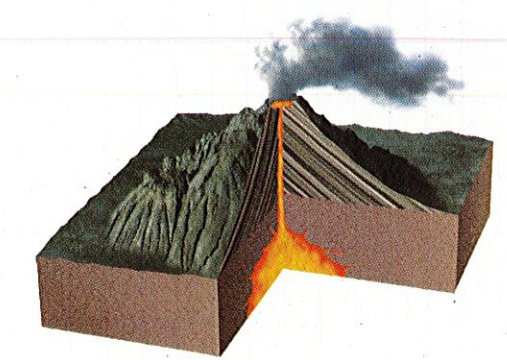
1 magma lava  
\_\_\_\_\_  
\_\_\_\_\_

2 volcano vent  
\_\_\_\_\_  
\_\_\_\_\_

3 tectonic plate hot spot  
\_\_\_\_\_  
\_\_\_\_\_

## Key Concepts

Use the image to answer the following question.



4 Identify How did the composite volcano in the image get its layered interior?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

5 Analyze Is pyroclastic material likely to form from low-viscosity lava or high-viscosity lava? Explain.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Describe the location and characteristics of the types of volcanic landforms in the table below.

Volcanic landform	Description
6 Hot-spot volcanoes	
7 Cinder cones	
8 Calderas	

## Critical Thinking

9 Hypothesize In Iceland, the Mid-Atlantic Ridge runs through the center of the country. What can you conclude about the appearance of Iceland many thousands of years from now?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

10 Analyze Why do you think the location surrounding the Pacific Ocean is known as the Ring of Fire?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_