

# Causes of Volcanic Eruptions

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How does magma form?
- Where do volcanoes form?
- How can geologists predict volcanic eruptions?

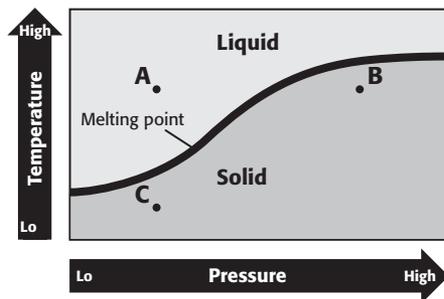
**National Science Education Standards**  
ES 1b, 1c

## How Does Magma Form?

Magma forms deep in the Earth’s crust and in the upper parts of the mantle. In these areas, the temperature and pressure are very high. Changes in pressure and temperature can cause magma to form.

Part of the upper mantle is made of very hot, solid rock. The rock is so hot that it can flow, like soft chewing gum, even though it is solid. If rock of this temperature were found at the Earth’s surface, it would be *molten*, or melted. The rock in the mantle does not melt because it is under high pressure. This pressure is produced by the weight of the rock above the mantle. ✓

In the figure below, the curved line shows the melting point of a rock. The *melting point* is the temperature at which the rock melts for a certain pressure.



The curved line shows the melting point of the rock. Rock with the temperature and pressure of point A is liquid. Rock at the same temperature but higher pressure (B) is solid. Rock at the same pressure but lower temperature (C) is also solid.

## STUDY TIP

**Describe** After you read this section, make flowcharts showing how magma forms at divergent boundaries and at convergent boundaries.

## READING CHECK

**1. Explain** Why doesn’t the hot rock in the mantle melt?

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## Math Focus

**2. Describe** A rock starts out at point C. Then, its temperature increases. What will happen to the rock if its temperature continues to rise?

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## MAGMA FORMATION IN THE MANTLE

The temperature of the mantle is fairly constant. Magma usually forms because of a decrease in pressure. Therefore, a lot of magma forms at the boundary between separating tectonic plates, where pressure decreases. Magma is less dense than the solid rock it forms from. Therefore, it rises toward the surface and erupts.

**SECTION 3** Causes of Volcanic Eruptions *continued*

## Where Do Volcanoes Form?

The locations of volcanoes give clues about how volcanoes form. The figure below shows the locations of some of the world’s major active volcanoes. The map also shows the boundaries between tectonic plates. Most volcanoes are found at tectonic plate boundaries. For example, there are many volcanoes on the plate boundaries surrounding the Pacific Ocean. Therefore, the area is sometimes called the *Ring of Fire*.

Remember that tectonic plate boundaries are areas where plates collide, separate, or slide past one another. Most volcanoes are found where plates move together or apart. About 15% of active volcanoes on land form where plates separate, and about 80% form where plates collide. The remaining few volcanoes on land are found far from tectonic plate boundaries.

**STANDARDS CHECK**

**ES 1b** Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building result from these plate motions.

**Word Help: response**  
an action brought on by another action; a reaction

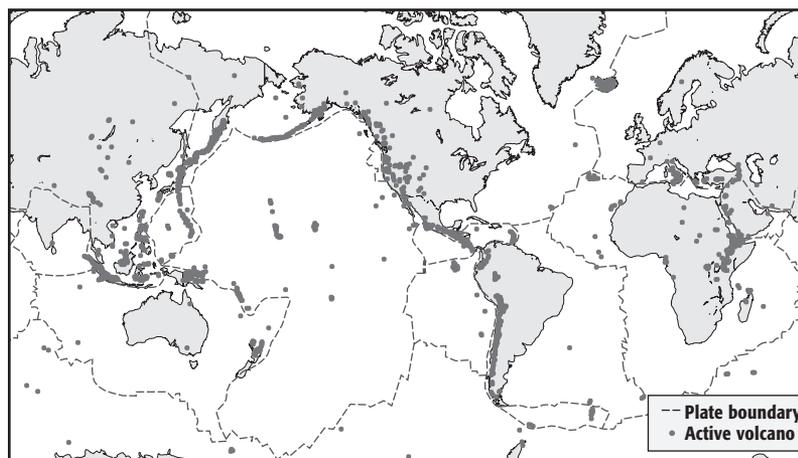
**Word Help: major**  
of great importance or large scale

**3. Describe** Where are most volcanoes found?

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### Volcanoes and Tectonic Plate Boundaries



### WHERE PLATES MOVE APART

At a *divergent boundary*, tectonic plates move away from each other. A set of deep cracks called a **rift zone** forms between the plates. Mantle rock moves upward to fill in the gap. When the mantle rock gets close to the surface, the pressure decreases. The decrease in pressure causes the mantle rock to melt, forming magma. The magma rises through the rift zones and erupts. ✓

Most divergent boundaries are on the ocean floor. Lava that flows from undersea rift zones produces volcanoes and mountain chains. These volcanoes and mountain chains are called *mid-ocean ridges*. The mid-ocean ridges circle the ocean floor.

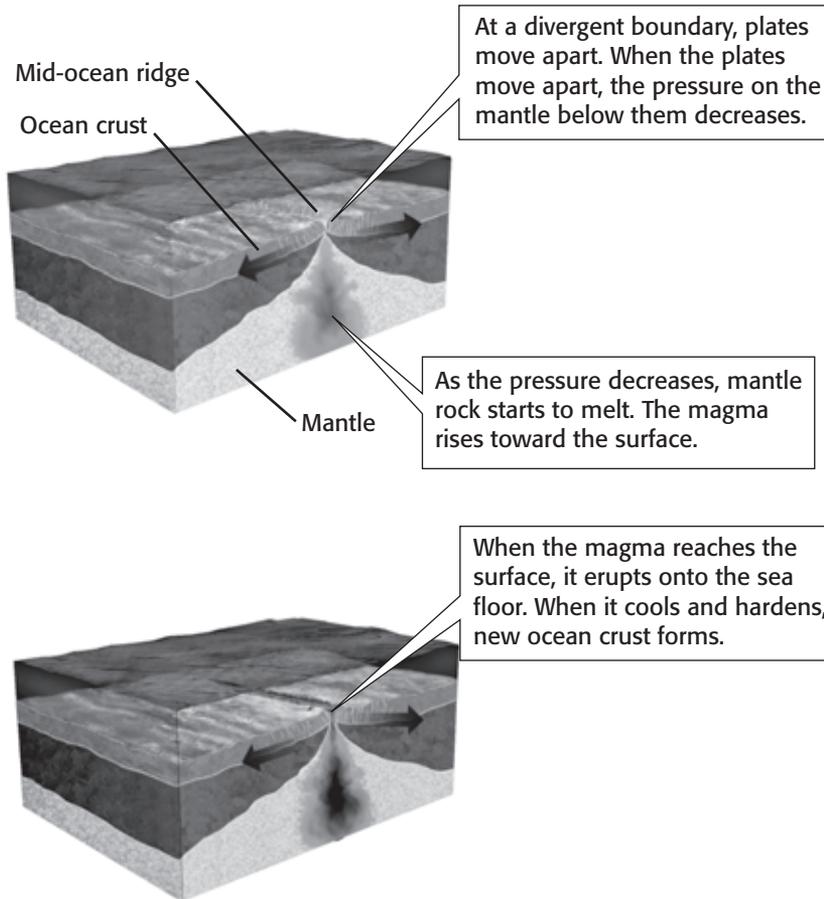
**READING CHECK**

**4. Identify** What causes magma to melt at divergent boundaries?

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**SECTION 3** Causes of Volcanic Eruptions *continued*

**How Magma Forms at a Divergent Boundary**



**TAKE A LOOK**

**5. Explain** How does new ocean crust form?

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**WHERE PLATES MOVE TOGETHER**

At a *convergent boundary*, the tectonic plates collide. When an oceanic plate collides with a continental plate, the oceanic plate slides under the continental plate. This is called *subduction*. The oceanic crust sinks into the mantle because it is more dense than the continental crust. ✓

As the ocean crust sinks, the temperature and pressure on it increase. Because the ocean crust forms below the ocean, the rock contains a lot of water. The heat and pressure on the ocean crust cause this water to be released.

The water mixes with the mantle rock above the oceanic plate. When the mantle rock mixes with water, it can melt at a lower temperature. The mantle rock begins to melt at the subduction zone. The magma rises to the surface and erupts as a volcano.

**READING CHECK**

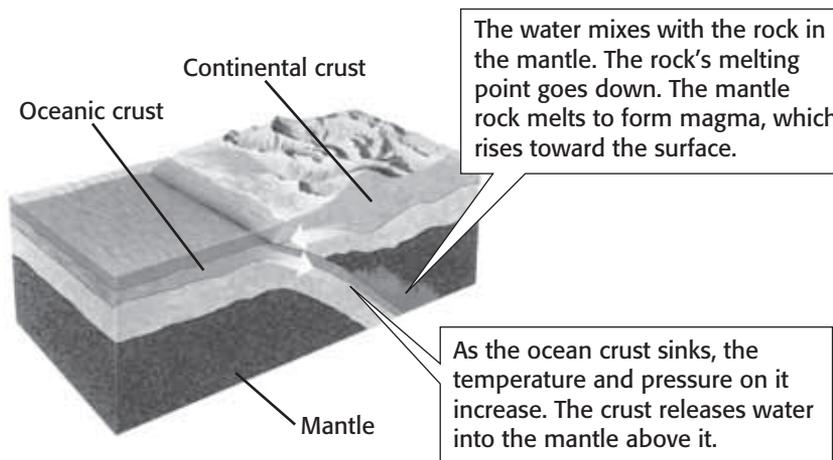
**6. Explain** Why does oceanic crust sink below continental crust?

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**SECTION 3** Causes of Volcanic Eruptions *continued*

**How Magma Forms at a Convergent Boundary**



**TAKE A LOOK**

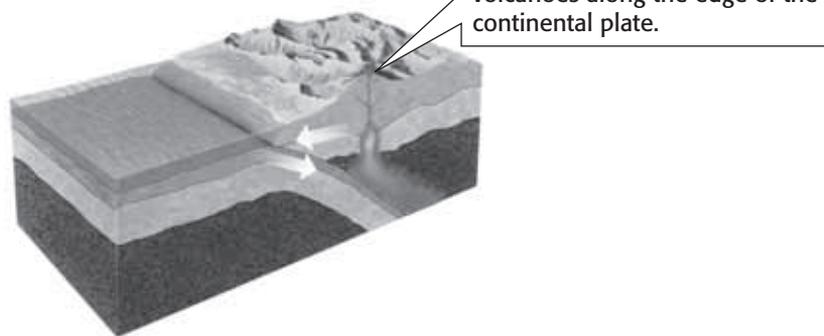
**7. Explain** How does subduction produce magma?

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**IN THE MIDDLE OF PLATES**

Although most volcanoes form at plate boundaries, not all volcanoes form there. Some volcanoes, such as the Hawaiian Islands, form at hot spots. **Hot spots** are places on the Earth's surface where volcanoes form far from plate boundaries. Most scientists think that hot spots form above hot columns of mantle rock called *mantle plumes*. Some scientists think that hot spots form where magma rises through cracks in the Earth's crust. ✓

**READING CHECK**

**8. Define** What is a hot spot?

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Long chains of volcanoes are common at hot spots. One theory to explain this is that a mantle plume stays in one place while the plate moves over it. Another theory states that hot-spot volcanoes occur in long chains because they form along cracks in the Earth's crust. Scientists are not sure which of these theories is correct. It is possible that some hot spots form over plumes, but others form over cracks.

**SECTION 3** Causes of Volcanic Eruptions *continued*

**How Can We Predict Volcanic Eruptions?**

Scientists cannot always predict when and where a volcano will erupt. However, by studying ancient and modern volcanoes, scientists have been able to identify some signs that an eruption may happen.

One feature that scientists use to predict whether an eruption will happen is the state of the volcano. Geologists put volcanoes into three groups based on how active they are.

- *Extinct* volcanoes have not erupted in recorded history and probably will not erupt again.
- *Dormant* volcanoes are currently not erupting, but they may erupt again.
- *Active* volcanoes are currently erupting or show signs of erupting in the near future.

**SMALL QUAKES AND VOLCANIC GASES**

Most active volcanoes produce small earthquakes as the magma within them moves upward. This happens because the magma pushes on the rocks as it rises. In many cases, the number and strength of these earthquakes increases before a volcanic eruption. Therefore, monitoring earthquakes is one of the best ways to predict an eruption.

Scientists also study the volume and composition of gases given off by the volcano. Just before an eruption, many volcanoes give off more gas. The composition of the gas may also change before an eruption. By monitoring the gases, scientists can predict when an eruption may happen.

**MEASURING SLOPE AND TEMPERATURE**

As magma rises before an eruption, it can cause the Earth’s surface to swell. The side of a volcano may even bulge. Scientists can use an instrument called a *tiltmeter* to measure the slope of the volcano’s sides. Changes in the slope can indicate that an eruption is likely. ✓

One of the newest methods for predicting volcanic eruptions involves using satellite images. Satellites can record the surface temperatures at and around volcanoes. As magma rises, the surface temperature of the volcano may increase. Therefore, an increase in surface temperature can indicate that an eruption is likely.

*Critical Thinking*

**9. Compare** What is the difference between dormant volcanoes and extinct volcanoes?

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*Critical Thinking*

**10. Infer** Why may a volcano that is about to erupt give off more gas?  
(Hint: Why are some eruptions explosive?)

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 **READING CHECK**

**11. Explain** Why may the Earth’s surface swell before an eruption?

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# Section 3 Review

NSES ES 1b, 1c

## SECTION VOCABULARY

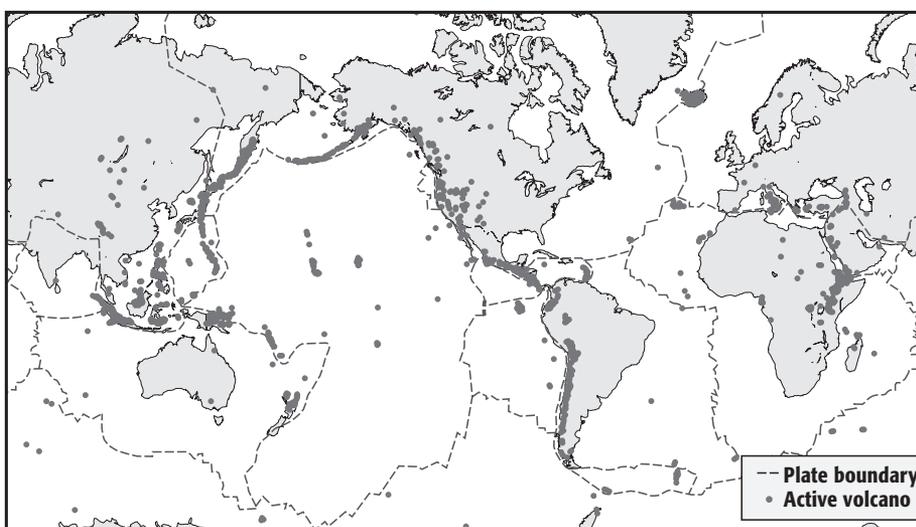
**hot spot** a volcanically active area of Earth's surface, commonly far from a tectonic plate boundary

**rift zone** an area of deep cracks that forms between two tectonic plates that are pulling away from each other

1. **Identify** Where do rift zones form?

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2. **Apply Concepts** The map below shows the locations of many volcanoes. On the map, circle three volcanoes that are probably found at hot spots.



3. **Identify** What is the most common cause of magma formation in the mantle?

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4. **Describe** How does magma form at divergent boundaries?

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5. **List** Give four signs that a volcanic eruption is likely.

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