

## Section 1

# Why Volcanoes Form

**Key Concept** Volcanoes occur at tectonic plate boundaries and at hot spots, where molten rock, or magma, forms and rises to the surface.

### What You Will Learn

- Most volcanoes are located at or near tectonic plate boundaries.
- Volcanoes form at divergent boundaries, convergent boundaries, and hot spots.
- The temperature, pressure, and fluid content of rock play roles in the formation of magma.

### Why It Matters

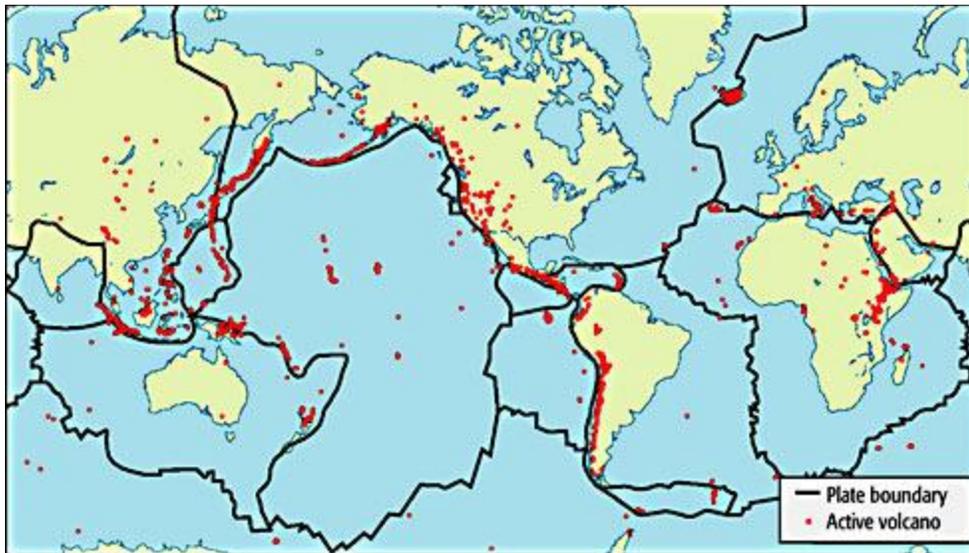
If molten, gas-charged magma rises to Earth's surface, a variety of volcanic phenomena can take place.

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A **volcano** is a vent or fissure in Earth's surface through which melted rock and gases pass. An estimated 1,500 volcanoes have been active above sea level during the past 10,000 years of Earth's history. Many more have been active beneath the ocean.

### Where Volcanoes Form

The locations of volcanoes are clues that help explain how volcanoes form. The map in **Figure 1** shows the locations of some of the world's major active volcanoes. The map also shows the boundaries between tectonic plates. Tectonic plate boundaries are areas where tectonic plates collide, pull away from one another, or move past one another horizontally. A large number of volcanoes lie directly on tectonic plate boundaries. In fact, the plate boundaries that surround the Pacific Ocean have so many volcanoes that the area is called the *Ring of Fire*.



**Figure 1** This map shows the locations of tectonic plate boundaries and many of Earth's active volcanoes. **How are the locations of volcanoes and plate boundaries related?**

At tectonic plate boundaries, several processes cause rock to melt at lower-crustal or upper-mantle depths. The molten rock is called **magma**. Because magma is less dense than the solid rock surrounding it, magma travels up toward the surface. When it reaches the surface, magma erupts to form a volcano.

**Standards Check** Where are most volcanoes located?

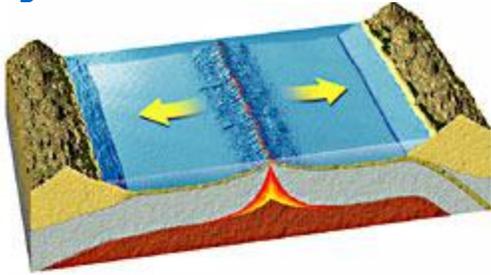


### **Divergent Boundaries**

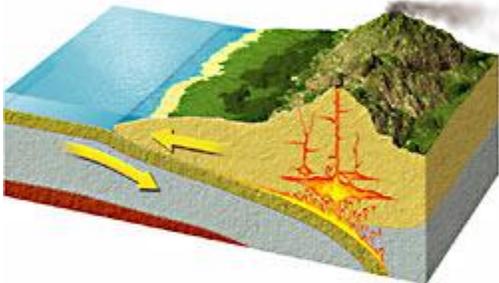
The boundary between two tectonic plates that are pulling away from one another is called a *divergent boundary*. As tectonic plates pull away from one another, a set of deep vertical fractures called *fissures* form. Molten rock flows through these fissures onto the ocean floor. The molten rock also forms submarine volcanoes. At divergent boundaries, underwater mountain chains known as *mid-ocean ridges* are common. A mid-ocean ridge is shown in **Figure 2**. In fact, most volcanic activity on Earth happens at mid-

ocean ridges.

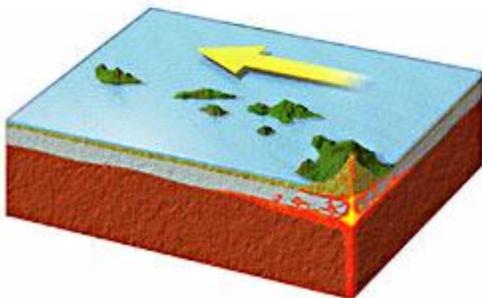
## Figure 2 Locations Where Volcanoes Form



As tectonic plates pull away from one another, magma flows through fractures in the sea floor at mid-ocean ridges.



At a convergent boundary, a plate made of dense lithosphere moves beneath another plate.



As a tectonic plate moves over a mantle plume, rising magma may cause a chain of volcanoes to form.

Most divergent boundaries are underwater. However, Iceland is an island that is being pulled apart by a mid-ocean ridge.

### Convergent Boundaries

The boundary where two tectonic plates collide is called a

*convergent boundary*. As two plates collide, the denser plate slides under the other plate. As the denser plate bends, a deep depression known as a *trench* forms. At a trench, one plate moves downward into the mantle. This process, in which one plate moves beneath another plate, is called *subduction*. It is shown in **Figure 2**. As the plate moves farther downward into Earth's mantle, the rock is subjected to greater heat and pressure. As a result, the plate releases fluids, which causes surrounding rock to melt.

### Hot Spots

Volcanically active places that are not located at tectonic plate boundaries are called *hot spots*. Hot spots are thought to lie directly above columns of hot rock that rise through Earth's mantle. These columns are called *mantle plumes*. Mantle plumes are stationary. Therefore, as a tectonic plate moves over a mantle plume, rising magma causes a chain of volcanic islands to form. The Hawaiian Islands, shown in **Figure 2**, have formed as the Pacific plate passes over a mantle plume.

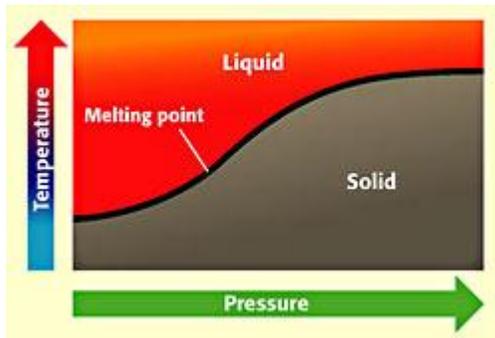
**Standards Check** How do hot-spot volcanoes differ from other volcanoes?

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### How Magma Forms

Understanding why volcanoes erupt requires an understanding of how magma forms. Magma forms in the deeper parts of Earth's crust and in the uppermost parts of the mantle. In these locations, temperature and pressure are very high. Changes in pressure and temperature cause magma to form. As **Figure 3** shows, rock melts when its temperature increases or when the pressure on the rock decreases. In addition, water can lower the melting temperature of rock and cause the rock to melt.



**Figure 3** The curved line indicates the melting point of a rock. As pressure decreases and temperature increases, the rock begins to melt.

### Increasing Temperature

As a tectonic plate moves downward into the mantle, the plate is exposed to greater temperatures at depth. This increase in temperature may cause the minerals in the rock to melt. But minerals in a rock have different melting temperatures. So, not all of the minerals in the rock melt at the same time. Minerals that have low melting temperatures melt before minerals that have high melting temperatures.

### Decreasing Pressure

Magma can also form when the pressure on a rock decreases. In Earth's mantle, the pressure on rock is so great that the rock cannot expand. Expansion of rock is important in the formation of magma, because magma takes up more space than solid rock does. At divergent boundaries and hot spots, hot mantle rock rises to a shallow depth, where the pressure on the rock decreases. The decrease in pressure allows the hot rock to expand and to melt.

### Adding Fluids

Oceanic lithosphere is made up of sediments and volcanic rocks

that contain water and other fluids. When oceanic lithosphere moves downward into the mantle at a convergent boundary, the fluids contact the surrounding rock. When the fluids enter the already hot mantle rock, the melting temperature of the hot rock decreases. As a result, the rock begins to melt.

**Standards Check** How does adding fluids to hot rock cause magma to form?



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## Section Summary

- A volcano is a vent or fissure in Earth's surface through which magma and gases pass.
- Most volcanoes are located at tectonic plate boundaries.
- Volcanic activity occurs at divergent plate boundaries, convergent plate boundaries, and hot spots.
- Magma forms when the temperature of a rock increases, when the pressure on a rock decreases, or when water lowers the melting temperature of a rock.

