Section 2
Types of Volcanoes

Key Concept Tectonic plate motions can result in volcanic activity at plate boundaries.

What You Will Learn
- Nonexplosive eruptions of basaltic magma occur at divergent boundaries.
- Shield volcanoes that form from enormous volumes of basaltic magma occur at hot spots.
- Explosive eruptions of silica-rich magma occur at convergent boundaries.

Why It Matters
Knowing the tectonic setting of a volcano helps scientists predict the type of eruption that the volcano may produce.

The process of magma formation is different at each type of plate boundary, where the tectonic setting is unique. Therefore, the composition of magma differs in each of these settings. As a result, tectonic settings determine the types of volcanoes that form and the types of eruptions that take place.

Volcanoes at Divergent Boundaries
At divergent boundaries, plates move away from each other. As the two plates pull away from one another, the lithosphere becomes thinner. A set of deep cracks form in an area called a *rift zone*. Hot mantle rock rises to fill these cracks. As the rock rises, a decrease in pressure causes hot mantle rock to melt and form magma. When the magma reaches Earth's surface, the magma is called **lava.**

Lava at Divergent Boundaries

Lava that flows at divergent boundaries forms from melted mantle rock. As a result, this lava is rich in the elements iron and magnesium and relatively poor in silica. Because of its composition, lava from mantle rock cools to form dark-colored rock. The term **mafic** describes magma, lava, and rocks—such as dark-colored basalt, shown in **Figure 1**—that are rich in iron and magnesium. Because it is low in silica, mafic lava is runny and not sticky. Thus, this type of lava generally produces nonexplosive eruptions. Teide volcano, shown in **Figure 1,** is made largely of basalt.

Figure 1 Teide, located in the Canary Islands, is the third-largest volcano on Earth.

Standards Check Describe the lava that forms at divergent plate boundaries.

Volcanoes at Hot Spots

A hot spot is a volcanically active area that is located far from a tectonic plate boundary. A hot spot forms in a tectonic plate over a mantle plume. Mantle plumes are columns of hot, solid rock that rise through the mantle by convection. They are thought to originate at the boundary between the mantle and the outer core.

When the top of a mantle plume reaches the base of the lithosphere, the mantle rock spreads out and "pools" under the lithosphere. Because pressure on the rock in the plume is low at this shallow depth, the rock melts. Large volumes of magma are released onto the ocean floor. Continuous eruptions may produce a volcanic cone. As the plate continues to move over the mantle plume, a chain of volcanoes may form.

Standards Check Explain how mantle plumes generate volcanic activity at hot spots.

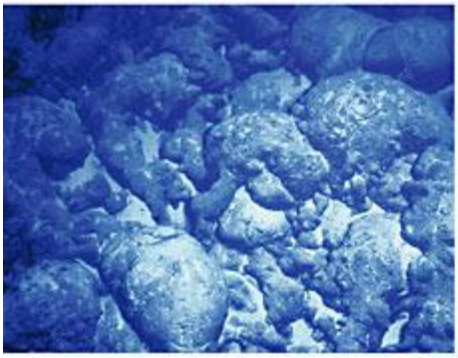
Lava at Hot Spots

Because lava at hot spots comes from the mantle, the lava is mafic and fluid. As a result, most eruptions at hot spots are non-explosive. The type of rock that forms from this lava depends on the temperature, gas content, flow rate, and slope of the lava flow. Four types of mafic lava are shown in **Figure 4.**

Figure 4 Four Types of Lava

Aa is lava that forms a thick, brittle crust. The crust is torn into jagged pieces as molten lava continues to flow underneath.

Pahoehoe is lava that forms a thin crust. The crust wrinkles as it is moved by molten lava that continues to flow underneath.



Pillow lava forms when lava erupts underwater. This lava forms rounded lumps that are the shape of pillows.

Blocky lava is cool, stiff lava that does not travel far from the eruption site. Blocky lava usually oozes from a volcano and forms jumbled heaps of sharp-edged chunks.

Shield Volcanoes

Shield volcanoes usually form at hot spots. Shield vol canoes form from layers of lava left by many nonexplosive eruptions. The lava is very runny, so it spreads out over a wide area. Over time, the layers of lava create a volcanic moun tain that has gently sloping sides. The sides of shield volcanoes are not very steep, but the volcanoes can be very large. The base of a large shield volcano can be more than 100 km in diameter. Mauna Kea, the Hawaiian shield volcano shown in **Figure 5,** is the tallest mountain on Earth. Measured from its base on the sea floor, Mauna Kea is taller than Mount Everest.

Figure 5 From sea floor to summit, the Hawaiian shield volcano Mauna Kea is around 10 km tall.

Parts of a Volcano

Most volcanoes share a specific set of features, such as the features shown in **Figure 6.** The magma that feeds the eruptions pools deep underground in a structure called a *magma chamber*. Before erupting as lava from a volcano, magma rises from the magma chamber to Earth's surface through cracks in the crust. This movement of magma through rock causes small earthquakes that can be used to predict an eruption.

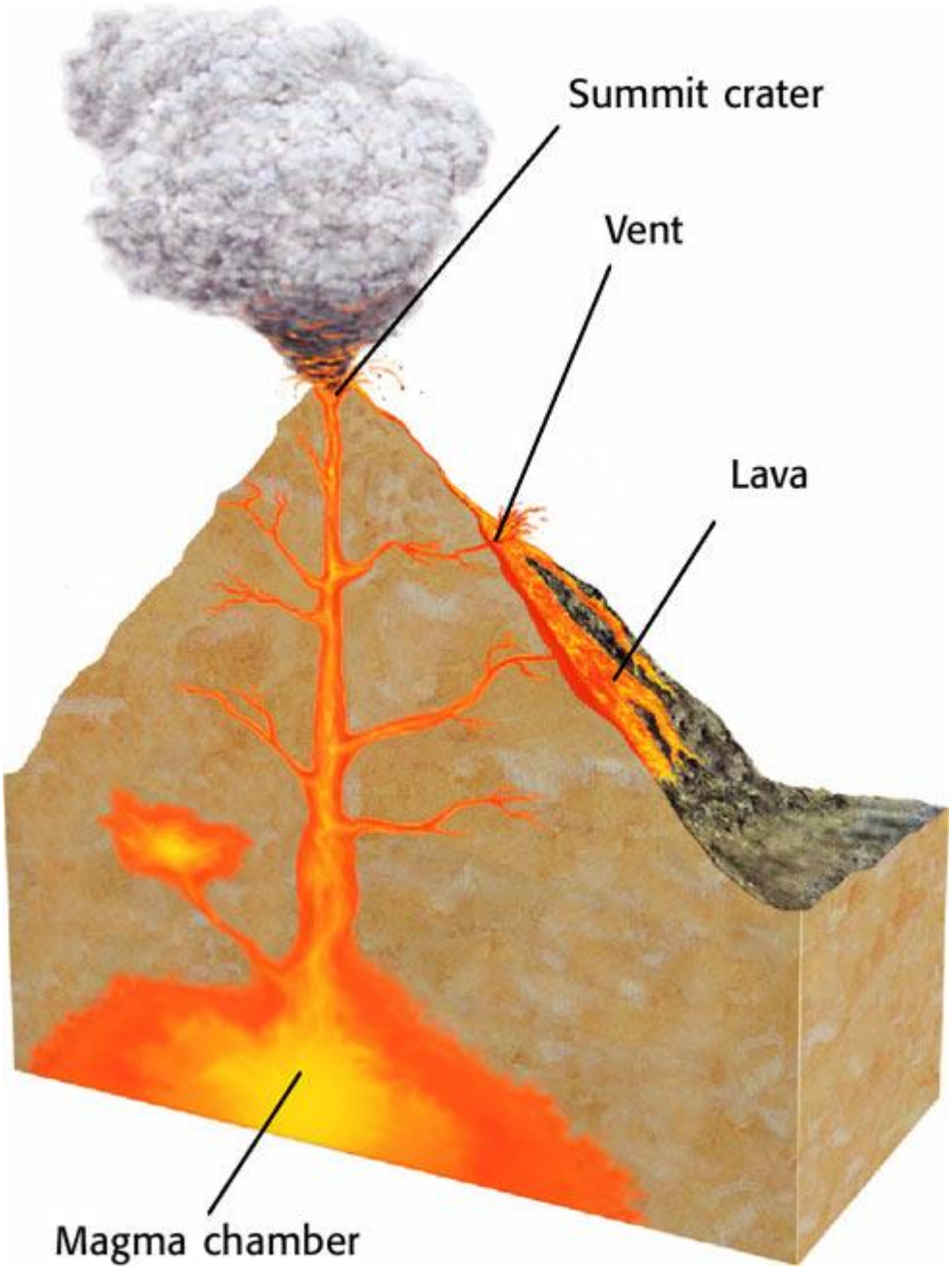


Figure 6 When magma from a magma chamber erupts as lava from a vent, the lava may harden to form a volcanic mountain.

At Earth's surface, lava is released through openings called *vents*. Lava may erupt from a central summit crater of a shield volcano. Lava may also erupt from fissures along the sides of a shield volcano. After erupting from a vent, the fluid lavas move downslope in lava flows, long rivers of molten rock. Often, the flow will cool and solidify

on top while the interior continues to travel through long, pipelike structures known as *lava tubes*.

Standards Check Describe how earthquakes are related to volcanic eruptions.

Volcanoes at Convergent Boundaries

At a convergent boundary, a plate that contains oceanic lithosphere may descend into the mantle beneath another plate. The descending lithosphere contains water. As the lithosphere descends into the mantle, temperature and pressure increase. As a result, the subducting lithosphere releases water into the surrounding mantle and the overlying crust. The water lowers the melting temperature of the rock, and the rock melts. The magma that forms rises through the crust and erupts. These eruptions form a chain of volcanoes parallel to the plate boundary.

Lava at Convergent Boundaries

Magmas at convergent boundaries are melted mantle rock and melted crustal rock. So, fluid mafic lava and lava rich in silica and feldspar minerals form at these boundaries. Lavas rich in silica and feldspar cool to form light-colored rocks. The term **felsic** is used to describe magma, lava, and rocks that are rich in silica and feldspars. Silica-rich magma tends to trap water and gas bubbles, which causes enormous gas pressure to develop within the magma. As the gas-filled magma rises to Earth's surface, pressure is rapidly released. This change results in a powerful explosive eruption.

Standards Check What is the relationship between high silica content in magma and an explosive eruption?

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silica-rich magma tends to trap

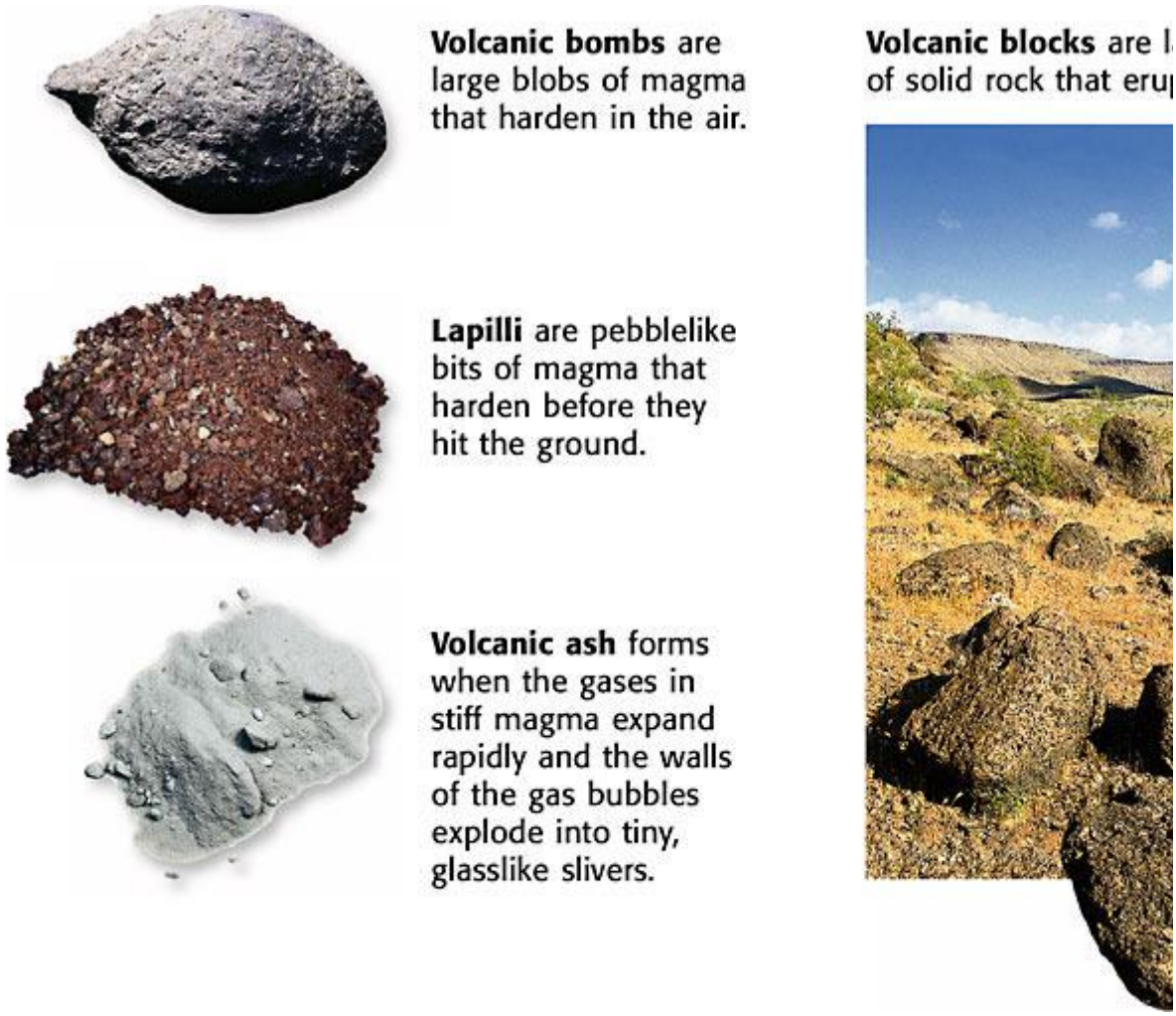

Figure 7 Types of Pyroclastic Material

Types of Pyroclastic Material

Pyroclastic material is particles of lava that form when magma explodes from a volcano and solidifies in the air. Pyroclastic material also forms when powerful eruptions shatter existing rock. **Figure 7** shows four types of pyroclastic material.

Pyroclastic Flows

Pyroclastic flows, such as the one shown in **Figure 8,** are produced when a volcano ejects enormous amounts of hot ash, dust, and toxic gases. This glowing cloud of pyroclastic material can race down the slope of a volcano at speeds of more than 200 km/h. This speed is faster than the speed of most hurricane-force winds! The temperature at the center of a pyroclastic flow can exceed 700ºC. At this high temperature, a pyroclastic flow burns everything in its path. These extremes make pyroclastic flows the most dangerous of all volcanic phenomena.

Figure 8 Pyroclastic flows associated with the 1991 eruption of Mount Pinatubo in the Philippines had temperatures that reached 750ºC.

Cinder Cone Volcanoes

Cinder cone volcanoes are the smallest type of volcano. They generally reach heights of no more than 300 m. They are also the most common type of volcano. Cinder cone volcanoes are made of pyroclastic material and most often form from moderately explosive eruptions. As **Figure 9** shows, cinder cone volcanoes have steep sides. They also have a wide summit crater. Unlike other types of volcanoes, cinder cone volcanoes usually erupt only once in their lifetime.

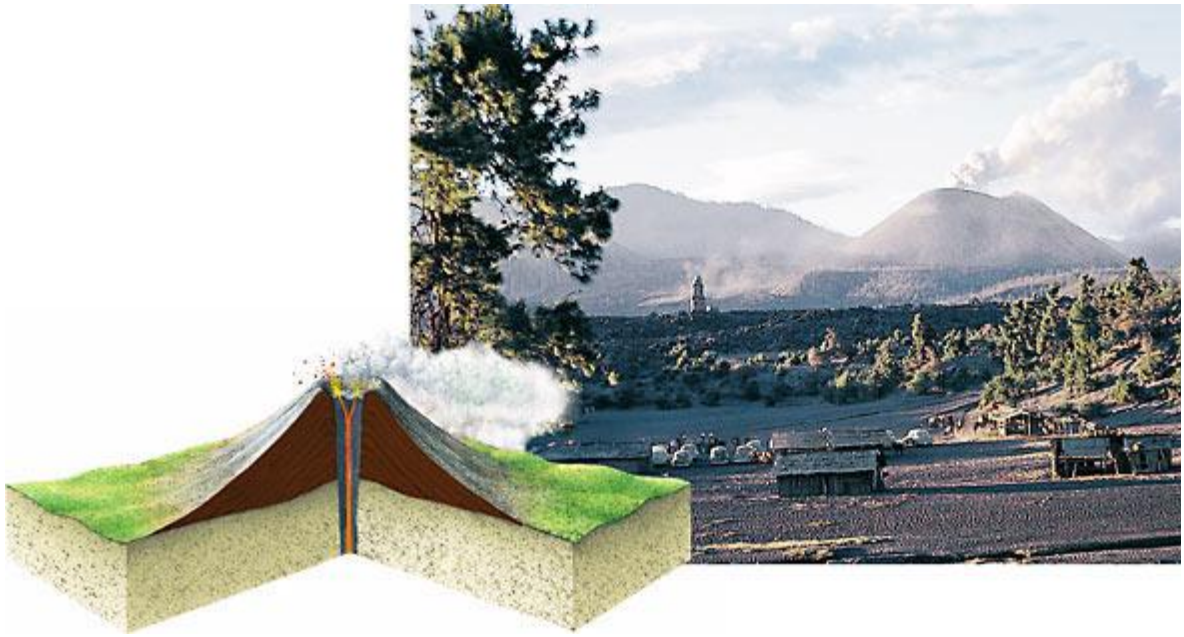

Figure 9 Parícutin, a cinder cone volcano in Mexico, appeared in a farmer's cornfield in 1943. The volcano erupted for nine years. When Parícutin stopped erupting, its height was 400 m.

Composite Volcanoes

Composite volcanoes, also called *stratovolcanoes,* are the most recognizable of all volcanoes. Composite volcanoes form from both explosive eruptions of pyroclastic ma terial and quieter flows of lava. The combination of both types of eruptions forms alternating layers of pyroclastic material and lava. Composite volcanoes—such as Mount Fuji, shown in **Figure 10**—have a broad base and have sides that get steeper toward the summit crater. Composite volcanoes may generate many eruptions. However, these eruptions may occur at intervals of hundreds of years or more.

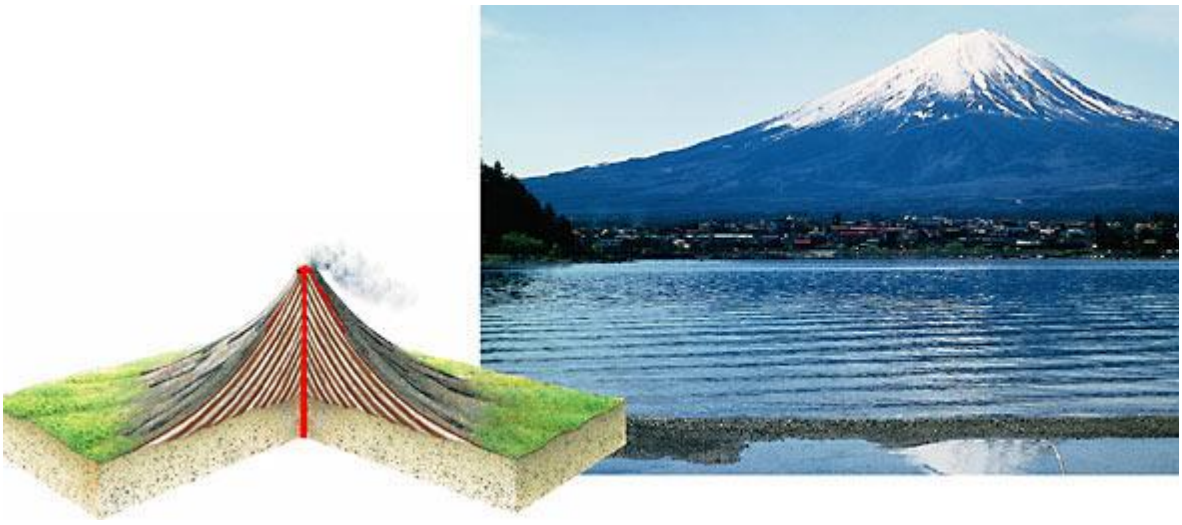

Figure 10 Mount Fuji, located in Japan, is a famous composite volcano. Its lower slopes are broad and gentle, but its upper slopes steepen toward the summit crater.

Standards Check How do cinder cone volcanoes differ from composite volcanoes?

Section Summary

- Mafic lava erupts quietly through cracks, or fissures, in the lithosphere at divergent boundaries.
- At hot spots, continuous eruptions of mafic magma form chains of volcanoes above mantle plumes.
- Shield volcanoes form from the mafic lava erupted at hot spots.
- At convergent boundaries, eruptions of

silicarich magma are often explosive.

- Composite volcanoes form from the felsic lava erupted at convergent boundaries.

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