Section 17.3

Objectives

- **Describe** how Earth's tectonic plates result in many geologic features.
- **Compare and contrast** the three types of plate boundaries and the features associated with each.
- **Generalize** the processes associated with subduction zones.

Review Vocabulary

mid-ocean ridge: a major feature along the ocean floor consisting of an elevated region with a central valley

New Vocabulary

tectonic plate
divergent boundary
rift valley
convergent boundary
subduction
transform boundary

Plate Boundaries

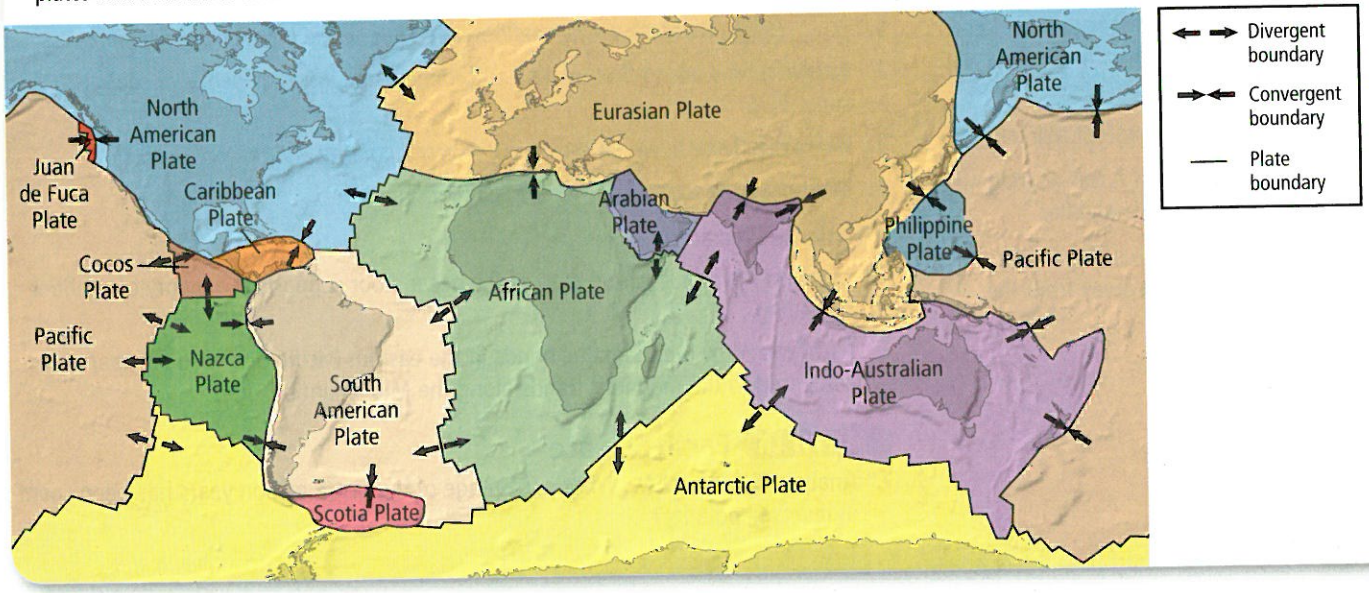
MAIN Idea **Volcanoes, mountains, and deep-sea trenches form at the boundaries between the plates.**

Real-World Reading Link Imagine a pot of soup that has been allowed to cool in a refrigerator. Fats in the soup have solidified into a hard surface, but if you tilt the pot back and forth, you will see the rigid surface bending and cracking. This is similar to the relationship between different layers of Earth.

Theory of Plate Tectonics

The evidence for seafloor spreading suggested that continental and oceanic crust move as enormous slabs, which geologists describe as tectonic plates. **Tectonic plates** are huge pieces of crust and rigid upper mantle that fit together at their edges to cover Earth's surface. As illustrated in **Figure 17.16,** there are about 12 major plates and several smaller ones. These plates move very slowly—only a few centimeters each year—which is similar to the rate at which fingernails grow. Plate tectonics is the theory that describes how tectonic plates move and shape Earth's surface. They move in different directions and at different rates relative to one another and they interact with one another at their boundaries. Each type of boundary has certain geologic characteristics and processes associated with it. A divergent boundary occurs where tectonic plates move away from each other. A convergent boundary occurs where tectonic plates move toward each other. A transform boundary occurs where tectonic plates move horizontally past each other.

Figure 17.16 Earth's crust and rigid upper mantle are broken into enormous slabs called tectonic plates that interact at their boundaries.



Divergent boundaries Regions where two tectonic plates are moving apart are called **divergent boundaries.** Most divergent boundaries are found along the seafloor in rift valleys. It is in this central rift that the process of seafloor spreading begins. Magma rising through the rift's faults forms a mid-ocean ridge. The mid-ocean ridge appears as a continuous mountain chain on the ocean floor. The formation of new ocean crust at most divergent boundaries accounts for the high heat flow, volcanism, and earthquakes associated with these boundaries.

Reading Check **Identify** the cause of volcanism and earthquakes associated with mid-ocean ridges.

Throughout millions of years, the process of seafloor spreading along a divergent boundary can cause an ocean basin to grow wider. Although most divergent boundaries form ridges on the ocean floor, some divergent boundaries form on continents. When continental crust begins to separate, the stretched crust forms a long, narrow depression called a **rift valley.** **Figure 17.17** shows the rift valley that is currently forming in East Africa. The rifting might eventually lead to the formation of a new ocean basin.

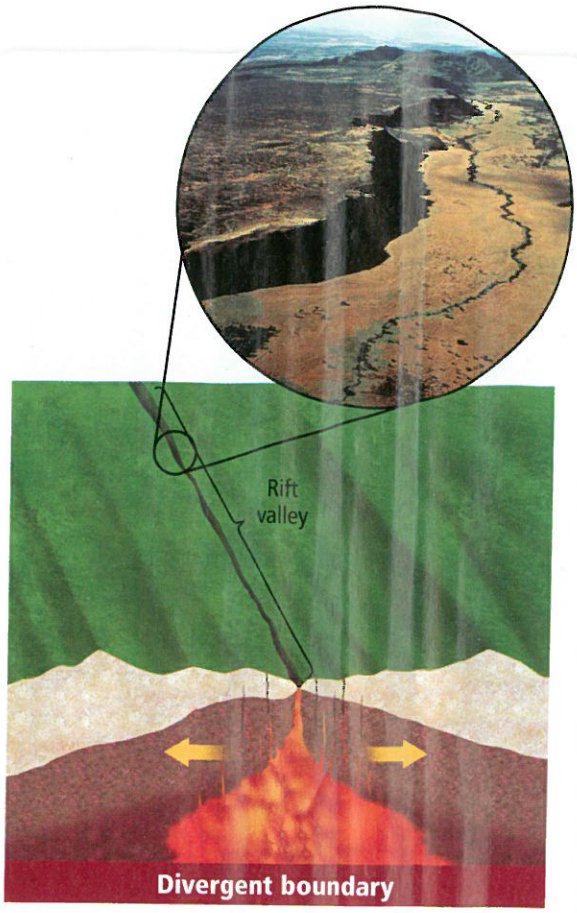


Figure 17.17 Divergent boundaries are places where plates separate. An ocean ridge is a divergent boundary on the ocean floor. In East Africa, a divergent boundary has also created a rift valley.

MiniLab

Model Ocean-Basin Formation

How did a divergent boundary form the South Atlantic Ocean? Around 150 mya, a divergent boundary split an ancient continent. Over time, new crust was added along the boundary, widening the rift between Africa and South America.

Procedure

1. Read and complete the lab safety form.
2. Use a **world map** to create **paper templates** of South America and Africa.
3. Place the two continental templates in the center of a **large piece of paper,** and fit them together along their Atlantic coastlines.
4. Carefully trace around the templates with a **pencil.** Remove the templates and label the diagram *150 mya.*
5. Use an average spreading rate of 4 cm/y and a map scale of 1 cm = 500 km to create six maps that show the development of the Atlantic Ocean at 30-million-year intervals, beginning 150 mya.

Analysis

1. **Compare** your last map with a world map. Is the actual width of the South Atlantic Ocean the same on both maps?
2. **Consider** why there might be differences between the width in your model and the actual width of the present South Atlantic Ocean.

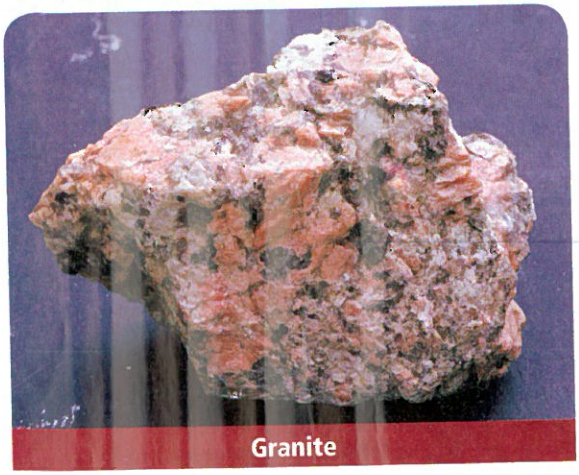


Figure 17.18 Oceanic plates are mostly basalt. Continental plates are mostly granite with a thin cover of sedimentary rock, both of which are less dense than basalt.

Convergent boundaries At **convergent boundaries,** two tectonic plates are moving toward each other. When two plates collide, the denser plate eventually descends below the other, less-dense plate in a process called **subduction.** There are three types of convergent boundaries, classified according to the type of crust involved. Recall from Chapter 1 that oceanic crust is made mostly of minerals that are high in iron and magnesium, which form dense, dark-colored basaltic rocks, such as the basalt shown in **Figure 17.18.** Continental crust is composed mostly of minerals such as feldspar and quartz, which form less-dense, lighter-colored granitic rocks. The differences in density of the crustal material affects how they converge. The three types of tectonic boundaries and their associated landforms are shown in **Table 17.1.**

Oceanic-oceanic In the oceanic-oceanic convergent boundary shown in **Table 17.1,** a subduction zone is formed when one oceanic plate, which is denser as a result of cooling, descends below another oceanic plate. The process of subduction creates an ocean trench. The subducted plate descends into the mantle, thereby recycling oceanic crust formed at the ridge. Water carried into Earth by the subducting plate lowers the melting temperature of the plate, causing it to melt at shallower depths. The molten material, called magma, is less dense, so it rises back to the surface where it often erupts and forms an arc of volcanic islands that parallel the trench. Some examples of trenches and island arcs are the Marianas Trench and Marianas Islands in the West Pacific Ocean and the Aleutian Trench and Aleutian Islands in the North Pacific Ocean. A volcanic peak in the Aleutian Island arc is shown in **Table 17.1.**

Oceanic-continental Subduction zones are also found where an oceanic plate converges with a continental plate, as shown in **Table 17.1.** Note that it is the denser oceanic plate that is subducted. Oceanic-continental convergence also produces a trench and volcanic arc. However, instead of forming an arc of volcanic islands, oceanic-continental convergence results in a chain of volcanoes along the edge of the continental plate. The result of this type of subduction is a mountain range with many volcanoes. The Peru-Chile Trench and the Andes mountain range, which are located along the western coast of South America, formed in this way.

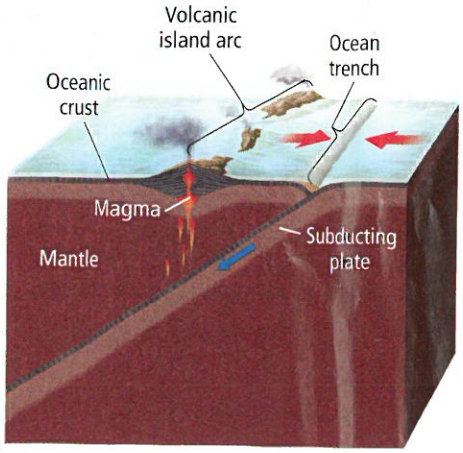
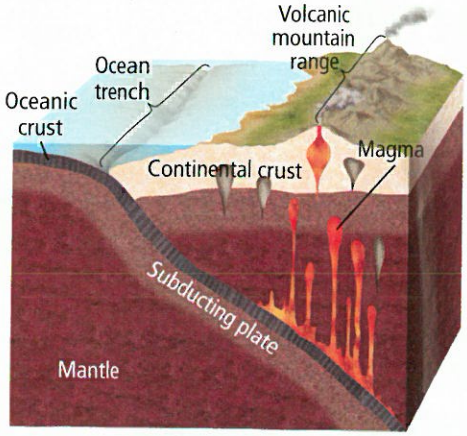
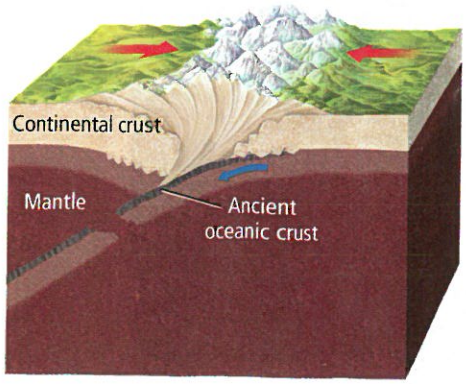
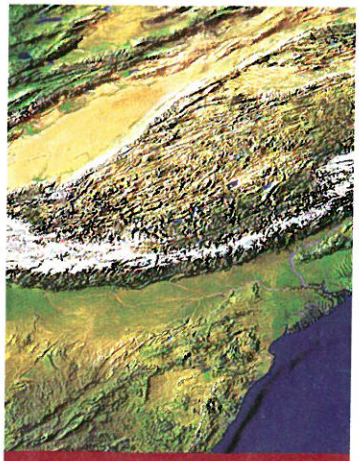
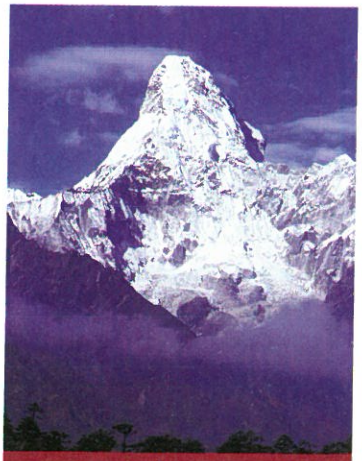
VOCABULARY

ACADEMIC VOCABULARY

Parallel (PAIR uh lel)
extending in the same direction, everywhere equidistant, and not meeting
The commuter train runs parallel to the freeway for many kilometers.

Table 17.1 Summary of Convergent Boundaries

Concepts In Motion
Interactive Table To explore more about convergent boundaries, visit glencoe.com.

Type of Convergent Boundary	Example of Region Affected by Boundary	Example of Landform Produced
Oceanic-oceanic 	 Aleutian Islands	 Chagulak Island, Alaska
Oceanic-continental 	 Andes mountain range	 Osorno Volcano, Chile
Continental-continental 	 Himalayas	 Ama Dablan, Nepal

Continental-continental The third type of convergent boundary forms when two continental plates collide. Continental-continental boundaries form long after an oceanic plate has converged with a continental plate. Recall that continents are often carried along attached to oceanic crust. Over time, an oceanic plate can be completely subducted, dragging an attached continent behind it toward the subduction zone. As a result of its denser composition, oceanic crust descends beneath the continental crust at the subduction zone. The continental crust that it pulls behind it cannot descend because continental rocks are less dense, and will not sink into the mantle. As a result, the edges of both continents collide, and become crumpled, folded, and uplifted. This forms a vast mountain range, such as the Himalayas, as shown in **Table 17.1.**

FOLDABLES
Incorporate information from this section into your Foldable.

Transform boundaries A region where two plates slide horizontally past each other is a **transform boundary,** as shown in **Figure 17.19.** Transform boundaries are characterized by long faults, sometimes hundreds of kilometers in length, and by shallow earthquakes. Transform boundaries were named for the way Earth's crust changes, or transforms, its relative direction and velocity from one side of the boundary to the other. Recall that new crust is formed at divergent boundaries and destroyed at convergent boundaries. Crust is only deformed or fractured somewhat along transform boundaries.

PROBLEM-SOLVING LAB

Interpret Scientific Illustrations

How does plate motion change along a transform boundary? The figure at the right shows the Gibbs Fracture Zone, which is a segment of the Mid-Atlantic Ridge located south of Iceland and west of the British Isles. Copy this figure.

Analysis

1. **Draw** arrows on your copy to indicate the direction of seafloor movement at locations A, B, C, D, E, and F.
2. **Compare** the direction of motion for the following pairs of locations: A and D, B and E, and C and F.

Think Critically

3. **Differentiate** Which three locations are on the North American Plate?
4. **Indicate** the portion of the fracture zone that is the boundary between North America and Europe.
5. **Assess** Which two locations represent the oldest crust?

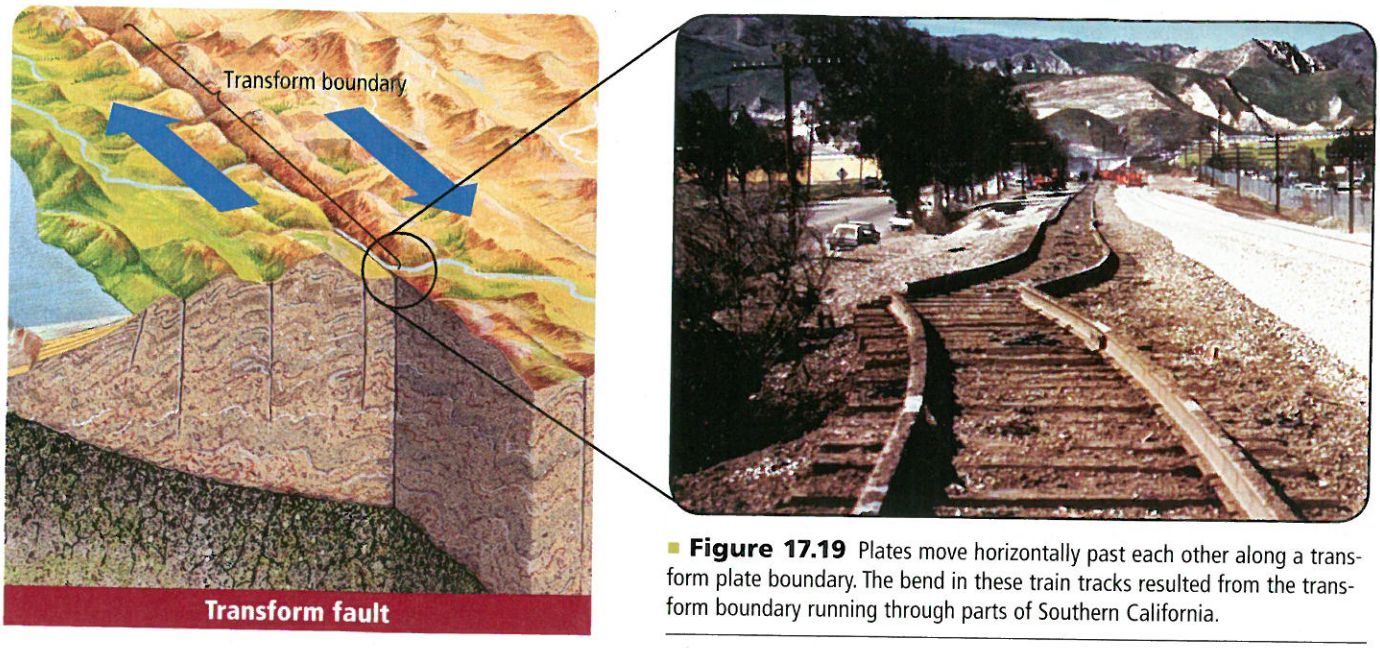


Figure 17.19 Plates move horizontally past each other along a transform plate boundary. The bend in these train tracks resulted from the transform boundary running through parts of Southern California.

Most transform boundaries offset sections of ocean ridges, as you observed in the Problem-Solving Lab. Sometimes transform boundaries occur on continents. The San Andreas Fault is probably the best-known example. Recall from the Launch Lab at the beginning of this chapter that the San Andreas Fault system is part of a transform boundary that separates southwestern California from the rest of the state. Movements along this transform boundary create situations like the one shown in **Figure 17.19** and are responsible for most of the earthquakes that strike California every year.

Section 17.3 Assessment

Section Summary

- Earth's crust and rigid upper mantle are broken into large slabs of rock called tectonic plates.
- Plates move in different directions and at different rates over Earth's surface.
- At divergent plate boundaries, plates move apart. At convergent boundaries, plates come together. At transform boundaries, plates slide horizontally past each other.
- Each type of boundary is characterized by certain geologic features.

Understand Main Ideas

1. MAIN Idea **Describe** how plate tectonics results in the development of Earth's major geologic features.
2. **Summarize** the processes of convergence that formed the Himalayan mountains.
3. **List** the geologic features associated with each type of convergent boundary.
4. **Identify** the type of location where transform boundaries most commonly occur.

Think Critically

5. **Choose** three plate boundaries in **Figure 17.16,** and predict what will happen over time at each boundary.
6. **Describe** how two portions of newly formed crust move between parts of a ridge that are offset by a transform boundary.

WRITING in Earth Science

7. Write a news report on the tectonic activity that is occurring at the Aleutian Islands in Alaska.