

Section 2

The Theory of Plate Tectonics

Key Concept Tectonic plates the size of continents and oceans move at rates of a few centimeters per year in response to movements in the mantle.

What You Will Learn

- Earth's lithosphere is broken into pieces called *tectonic plates*.
- Heat from Earth's interior causes convection in the mantle.
- Tectonic plates move at an average rate of a few centimeters per year.

Why It Matters

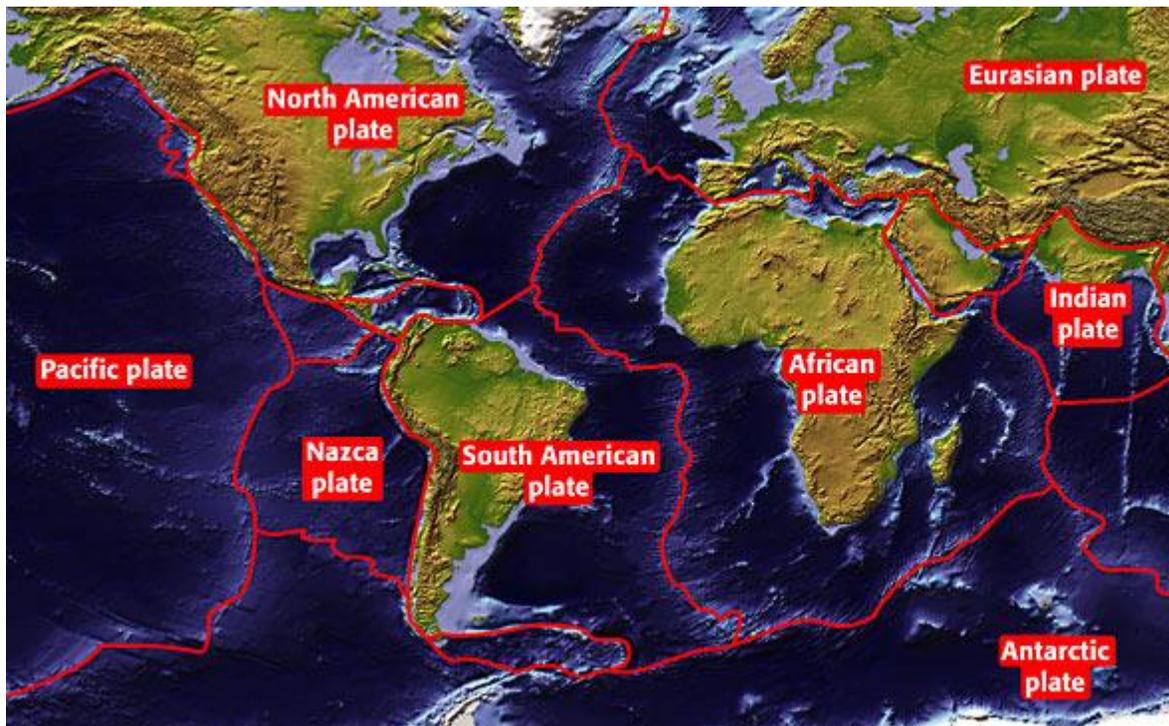
The theory of plate tectonics is a cornerstone of Earth science. Understanding plate tectonics will help you understand other topics of Earth science.

How much force does it take to move a continent? Where could all of the energy for such force possibly come from? As scientists' understanding of mid-ocean ridges and magnetic reversals grew, scientists formed a theory to explain how continents move. **Plate tectonics** is the theory that Earth's lithosphere is divided into tectonic plates that move around on top of the asthenosphere. In this section, you will learn what causes tectonic plates to move.

Tectonic Plates

Pieces of the lithosphere that move around on top of the asthenosphere are called **tectonic plates**. Earth's major tectonic plates are shown on the map in **Figure 1**. Note that tectonic plates differ in size. Some tectonic plates contain both continental and oceanic crust. Also note that some tectonic plates contain mostly oceanic crust, whereas others contain mostly continental crust.

Figure 1 Earth's Major Tectonic Plates



A Tectonic Plate Close-Up

Earth's lithosphere is like a giant jigsaw puzzle, and tectonic plates are like the pieces of the jigsaw puzzle. What would a tectonic plate look like if you could lift it out of this rocky jigsaw puzzle? **Figure 2** shows what the South American plate might look like. Notice that this tectonic plate consists of not only the upper part of the mantle but also both oceanic crust and continental crust. The thickest part of the South American plate is the part underneath the thick continental crust of the Andes Mountains. The thinnest part of this plate is located at the mid-ocean ridge in the Atlantic Ocean.

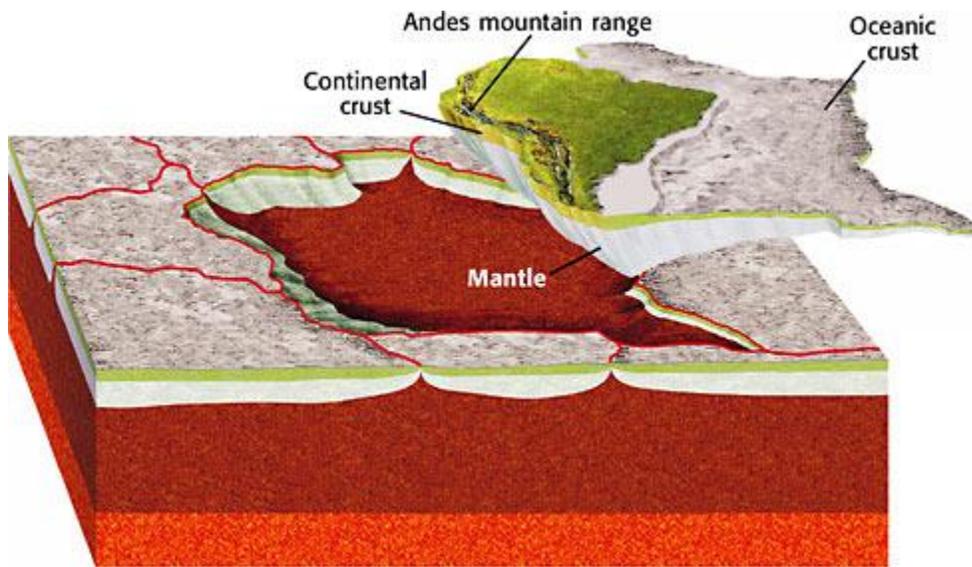


Figure 2 This image shows what you might see if you could lift the South American plate out of its position between other tectonic plates.

Like Ice Cubes in a Bowl of Punch

Think about ice cubes floating in a bowl of punch. If there are enough cubes, they will cover the surface of the punch and bump into one another. Parts of the ice cubes are below the surface of the punch and displace the punch. Large pieces of ice displace more punch than small pieces of ice do. Tectonic plates “float” on the asthenosphere in a similar way. The plates cover the surface of the asthenosphere, and they touch one another and move around. The lithosphere displaces the asthenosphere. Thick tectonic plates, such as those made of continental lithosphere, displace more asthenosphere than do thin plates, such as those made of oceanic lithosphere.

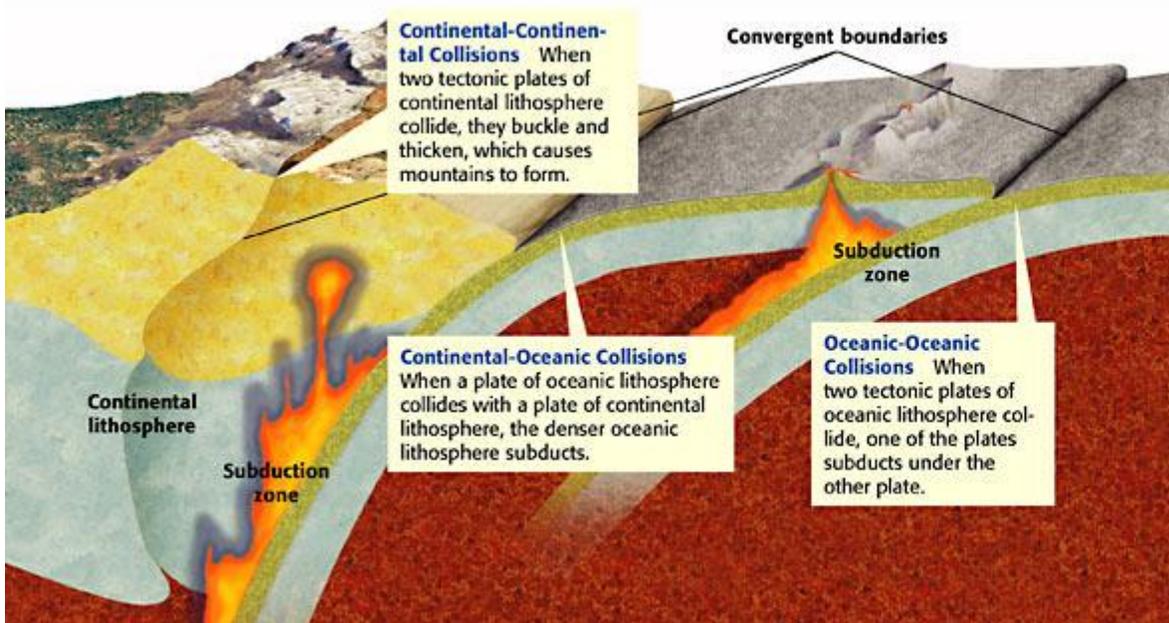
Standards Check Why do tectonic plates made of continental lithosphere displace more asthenosphere than tectonic plates made of oceanic lithosphere do?



Tectonic Plate Boundaries

A boundary is a place where tectonic plates meet. Tectonic plate boundaries are located by studying the locations of earthquakes, volcanoes, and landforms such as mid-ocean ridges and ocean trenches. Plate boundaries are divided into three types based on how the tectonic plates move relative to one another. **Figure 3** shows examples of tectonic plate boundaries.

Figure 3 Tectonic Plate Boundaries



Convergent Boundaries

The boundary at which two tectonic plates collide is a *convergent boundary*. At a convergent boundary, three types of collisions may happen. The three types of collisions and their results are outlined in the following list:

- Two plates made of continental lithosphere may collide. This collision may form a high mountain range, which develops over a period of millions of years.
- A plate of oceanic lithosphere may collide with a plate of continental lithosphere. The denser oceanic crust sinks, or subducts, beneath the less-dense continental crust. This process is called *subduction*. Subduction may cause a chain of volcanoes to form parallel to the plate boundary.
- If two plates of oceanic lithosphere collide, the denser of the two plates will subduct. A series of volcanic islands, called an *island arc*, may form parallel to the plate boundary.

Divergent Boundaries

The boundary at which two tectonic plates separate is a *divergent boundary*. Some divergent boundaries appear on land, such as in Iceland and eastern Africa. However, most divergent boundaries happen on the sea floor. These boundaries are characterized by mid-ocean ridges. As the plates pull away from each other, fractures form in the oceanic lithosphere. Magma rises through these fractures to the ocean floor. There, the magma solidifies to form new lithosphere.

Transform Boundaries

The boundary at which two tectonic plates slide past one another horizontally is a *transform boundary*. Most transform boundaries occur in the sea floor at mid-ocean ridges. At these locations, transform boundaries run perpendicular to the ridge where plates are pulling apart. The transform boundaries cause offsets between shorter segments of the ridge. These offsets give mid-ocean ridges the zigzag patterns that are seen on maps of the sea floor.

A well-known example of a transform boundary that occurs both on the sea floor and on land is the San Andreas fault system in California. The fault system is located where the Pacific and North American plates are sliding past each other.

Standards Check Compare the three types of plate boundaries.

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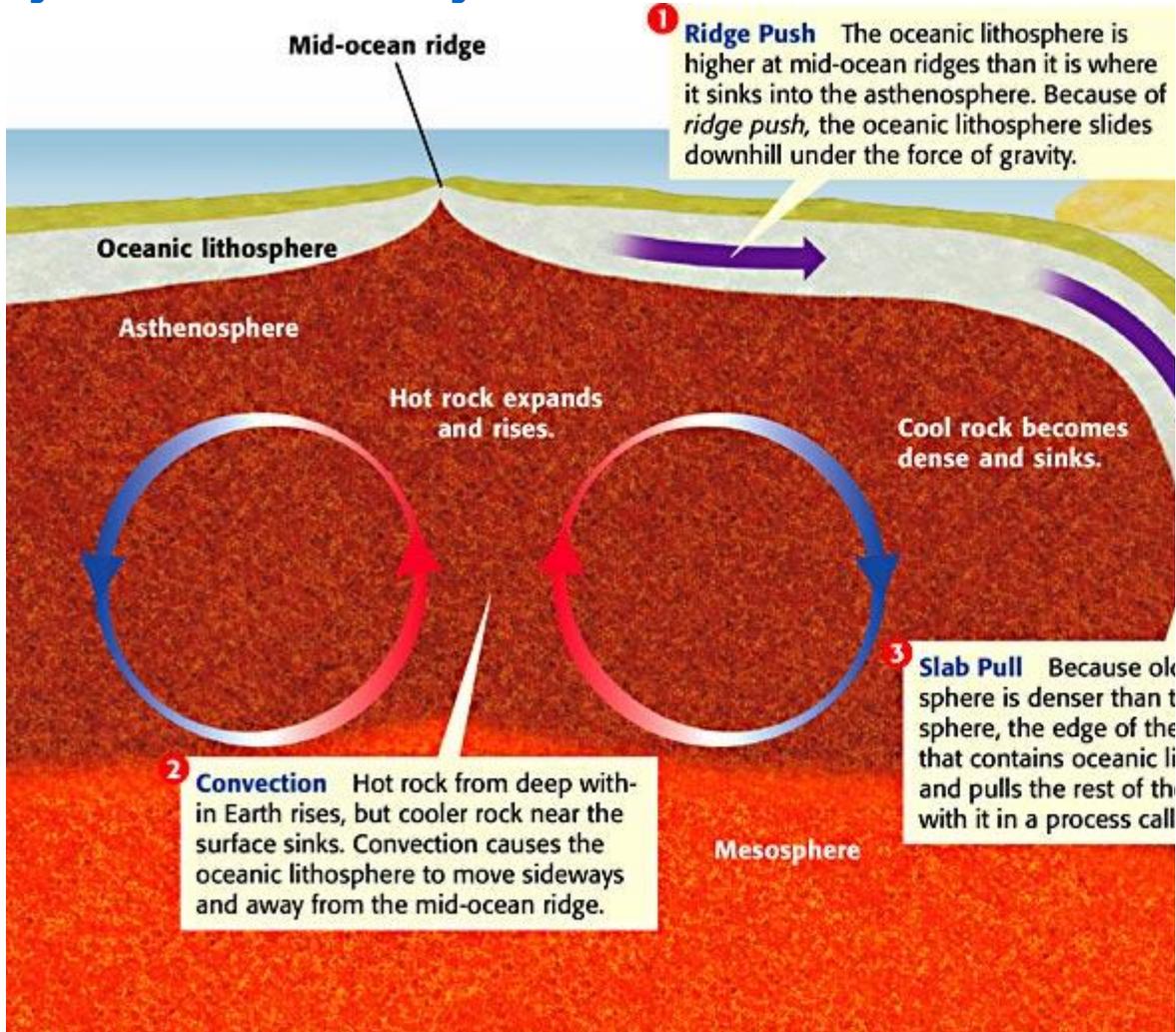
Causes of Tectonic Plate Motion

What causes the motion of tectonic plates? Tectonic plate motion is the result of density differences that are caused by the flow of heat within Earth. Earth's core and mantle are very hot because they contain minerals that have radioactive atoms. These atoms release heat as they decay. Heat always flows from a warmer area to a colder

area. Thus, heat from Earth's center flows toward the surface. However, rock is a poor conductor of heat. Therefore, most of the transfer of heat happens through convection.

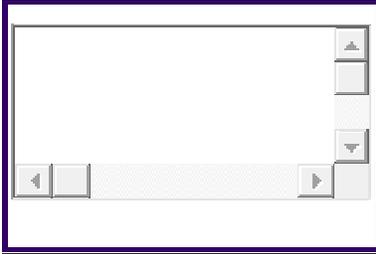
When rock is heated, it expands, becomes less dense, and rises toward the surface of Earth. At the surface, cold, dense rock of the lithosphere tends to sink during subduction. This process causes *convection currents* in the mantle. **Figure 4** shows three mechanisms of convection that drive tectonic plate motion.

Figure 4 Three Possible Driving Forces of Plate Tectonics



Standards Check How does mantle convection cause plate motion?

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Reading Help

Tracking Tectonic Plate Motion

Tectonic plate movement is so gradual that it is measured in centimeters per year. The average rate of movement for different plates ranges between 2.5 cm/year and 15 cm/year. To measure the rate of tectonic plate movement on continents, scientists use GPS. Radio signals are continuously beamed from satellites to GPS ground stations, which record the exact distance between the satellites and the ground station. Over time, these distances change slightly. Scientists use these distances to measure rates of plate motion. However, scientists use sea-floor spreading to measure the rate of movement of oceanic plates.

Standards Check How fast do tectonic plates move?



Section Summary

- Plate tectonics is the theory that explains how pieces of Earth's lithosphere move and change shape.
- Tectonic plates are large pieces of the lithosphere that move around on top of the asthenosphere.
- Boundaries between tectonic plates are classified as convergent, divergent, or transform.
- Convection is the main driving force of plate tectonics.
- Tectonic plates move a few centimeters per year. Scientists measure this rate by using GPS or by using seafloor spreading.

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