Section 17.4

Objectives

- **Explain** the process of convection.
- **Summarize** how convection in the mantle is related to the movements of tectonic plates.
- **Compare and contrast** the processes of ridge push and slab pull.

Review Vocabulary

convection: the circulatory motion that occurs in a fluid at a nonuniform temperature owing to the variation of its density and the action of gravity

New Vocabulary

ridge push
slab pull

Causes of Plate Motions

MAIN Idea **Convection currents in the mantle cause plate motions.**

Real-World Reading Link You probably know a lava lamp does not contain real lava, but the materials inside a lava lamp behave much like the molten rock within Earth.

Convection

One of the main questions about the theory of plate tectonics has remained unanswered since Alfred Wegener first proposed continental drift. What force or forces cause tectonic plates to move? Many scientists now think that large-scale motion in the mantle—Earth's interior between the crust and the core—is the mechanism that drives the movement of tectonic plates.

Convection currents Recall from Chapter 11 that convection is the transfer of thermal energy by the movement of heated material from one place to another. As in a lava lamp, the cooling of matter causes it to contract slightly and increase in density. The cooled matter then sinks as a result of gravity. Warmed matter is then displaced and forced to rise. This up-and-down flow produces a pattern of motion called a convection current. Convection currents aid in the transfer of thermal energy from warmer regions of matter to cooler regions. A convection current can be observed in the series of photographs shown in **Figure 17.20.** Earth's mantle is composed of partially molten material that is heated unevenly by radioactive decay from both the mantle itself and the core beneath it. Radioactive decay heats up the molten material in the mantle and causes enormous convection currents to move material throughout the mantle.

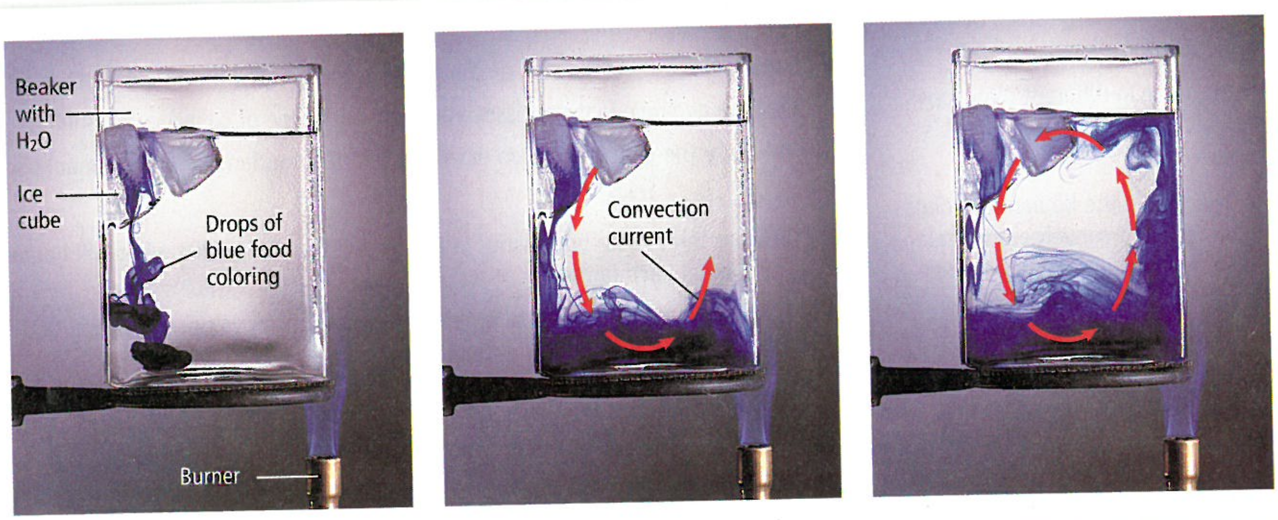


Figure 17.20 Water cooled by the ice cube sinks to the bottom where it is warmed by the burner and rises. The process continues as the ice cube cools the water again.
Infer *what will happen to the ice cube due to convection currents.*

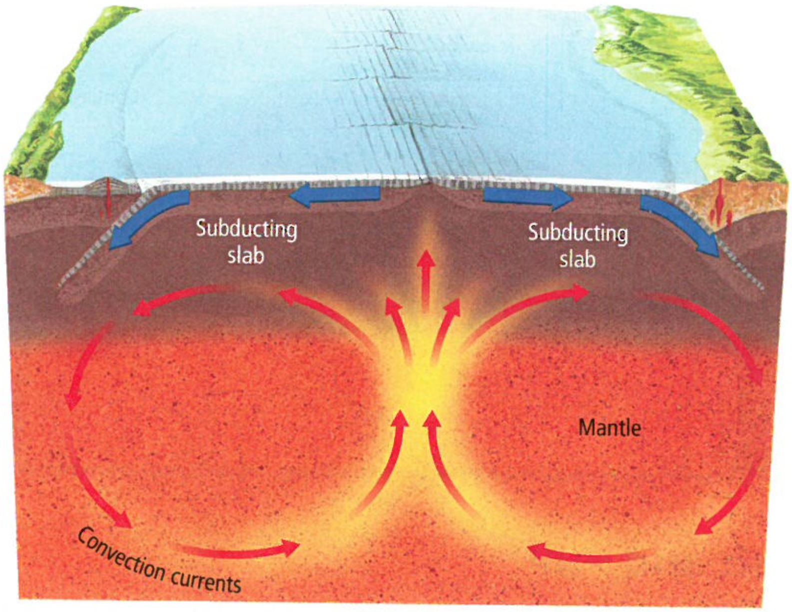


Figure 17.21 Convection currents develop in the mantle, moving the crust and outermost part of the mantle, and transferring thermal energy from the Earth's interior to its exterior.

Convection in the mantle Convection currents in the mantle, illustrated in **Figure 17.21,** are thought to be the driving mechanism of plate movements. Recall that even though the mantle is a solid, much of it moves like a soft, pliable plastic. The part of the mantle that is too cold and stiff to flow lies beneath the crust and is attached to it, moving as a part of tectonic plates. In the convection currents of the mantle, cooler mantle material is denser than hot mantle material. Mantle that has cooled at the base of tectonic plates slowly sinks downward toward the center of Earth. Heated mantle material near the core is then displaced, and like the wax warmed in a lava lamp, it rises. Convection currents in the mantle are sustained by this rise and fall of material which results in a transfer of energy between Earth's hot interior and its cooler exterior. Although convection currents can be thousands of kilometers across, they flow at rates of only a few centimeters per year. Scientists think that these convection currents are set in motion by subducting slabs.

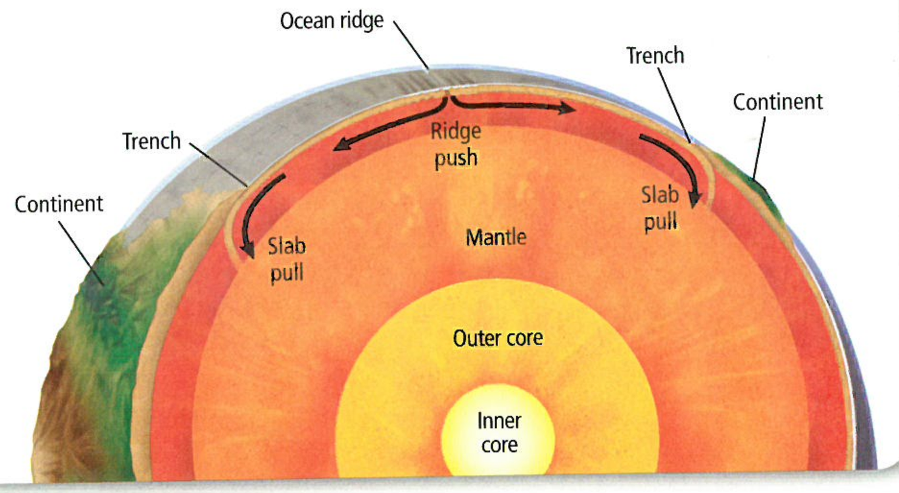
Reading Check **Discuss** Which causes a convection current to flow: the rising of hot material, or the sinking of cold material?

Plate movement How are convergent and divergent movements of tectonic plates related to mantle convection? The rising material in the convection current spreads out as it reaches the upper mantle and causes both upward and sideways forces. These forces lift and split the lithosphere at divergent plate boundaries. As the plates separate, material rising from the mantle supplies the magma that hardens to form new ocean crust. The downward part of a convection current occurs where a sinking force pulls tectonic plates downward at convergent boundaries.

■ **Figure 17.22** Ridge push and slab pull are two of the processes that move tectonic plates over the surface of Earth.

Concepts In Motion

Interactive Figure To see an animation of ridge push and slab pull, visit glencoe.com.



Push and Pull

Scientists hypothesize that there are several processes that determine how mantle convection affects the movement of tectonic plates. Study **Figure 17.22.** As oceanic crust cools and moves away from a divergent boundary, it becomes denser and sinks compared to the newer, less-dense oceanic crust. As the older portion of the seafloor sinks, the weight of the uplifted ridge is thought to push the oceanic plate toward the trench formed at the subduction zone in a process called **ridge push.**

A second and possibly more significant process that determines the movement of tectonic plates is called slab pull. In **slab pull,** the weight of a subducting plate pulls the trailing slab into the subduction zone much like a tablecloth slipping off the table can pull articles off with it. It is likely that combination of mechanisms such as these are involved in plate motions at subduction zones.

Section 17.4 Assessment

Section Summary

- Convection is the transfer of energy via the movement of heated matter.
- Convection currents in the mantle result in an energy transfer between Earth's hot interior and cooler exterior.
- Plate movement results from the processes called ridge push and slab pull.

Understand Main Ideas

1. MAIN Idea **Draw** a diagram comparing convection in a pot of water with convection in Earth's mantle. Relate the process of convection to plate movement.
2. **Restate** the relationships among mantle convection, ocean ridges, and subduction zones.
3. **Make** a model that illustrates the tectonic processes of ridge push and slab pull.

Think Critically

4. **Evaluate** this statement: Convection currents only move oceanic crust.
5. **Summarize** how convection is responsible for the arrangement of continents on Earth's surface.

WRITING in Earth Science

6. Write dictionary definitions for *ridge push* and *slab pull* without using those terms.

Earth Science Online **Self-Check Quiz** glencoe.com

Earth Science and the Environment

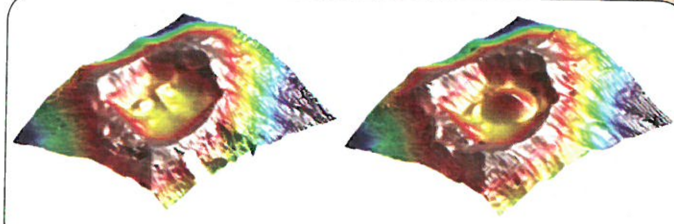
Vailulu'u Seamount

The American Samoan Islands are part of an island chain in the South Pacific Ocean. Recent exploration at the edge of the island chain has revealed how tectonic processes can result in new and completely unique environments.

Discovery of a volcano In 1999, Vailulu'u (vah EEL ool oo oo), an active volcanic seamount, was discovered when oceanographers first mapped the area using remote sonar methods. The map revealed the outline of a massive volcano hollowed by a caldera. The ocean is about 5 km deep, and the ringlike ridges of the caldera come within 600 m from the ocean surface. The 1999 map showed that the caldera floor was generally flat—about 1 km below sea level. Scientists knew that the volcano was produced from a hot spot, a region of heated magma in the mantle below.

Vailulu'u revisited In 2005, a team of scientists returned to study Vailulu'u using deep-sea submersibles. Before diving, they remapped the seamount, and discovered that the floor of the caldera had changed dramatically. Sometime in the past six years, volcanic activity had developed a lava cone 300 m high, roughly the height of the Empire State Building. The cone was soon named Nafanua (nah fah NOO ah), after the Samoan goddess of war. The scientists made several trips in the submersible and discovered how tectonic activity had caused completely new ecosystems to develop.

Eel City At the top of Nafanua, they encountered 30-cm-long eels so numerous that they nicknamed the area *Eel City.* The top of the cone is too deep for sunlight to permit the growth of plants, so the scientists were puzzled about the eels' food source. Investigations revealed that the seamount had changed the local currents, depositing waves of shrimp above Nafanua.



When you compare the two images, you can see the appearance of the Nafanua cone in the center of the caldera.

Moat of death Hydrothermal vents on the floor of the caldera emitted toxic chemicals, including clouds of a murky oil-like liquid containing carbon dioxide. Some of the vents released water that was a scalding 85°C. The same currents that brought shrimp to the eels were carrying fish down into the toxic environment of the caldera, which was nicknamed *the moat of death.* Yet, some life-forms were thriving. Much of the caldera floor was covered by a 1-m-thick mat of microbes, and bright red bristleworms abounded around the fish carcasses.

Birth of an island Nafanua is expected to continue growing. At its present rate, it will reach the ocean surface within a few decades and become the newest island in the Samoan chain. Earth scientists will continue to monitor the growth of Nafanua, and learn how tectonic events can help shape entire ecosystems.

WRITING in Earth Science

Investigate the biological activity and unique habitats discovered on Vailulu'u seamount. Write a newspaper article that describes the organisms and conditions on the seamount. To learn more about the Vailulu'u seamount, visit glencoe.com.