

9.5 Mechanisms of Plate Motion



Section 9.5

1 FOCUS

Section Objectives

- 9.13** Compare the mechanisms of slab-pull and ridge-push as contributing to plate motion.
- 9.14** Relate the unequal distribution of heat in Earth and the mechanism of mantle convection to the movement of tectonic plates.

Reading Focus

Key Concepts

- ➡ What are the mechanisms of plate motion?
- ➡ What causes plate motion?

Vocabulary

- ◆ convective flow
- ◆ slab-pull
- ◆ ridge-push
- ◆ mantle plume

Reading Strategy

Identifying Main Ideas Copy the table. As you read, write the main ideas for each topic.

Topic	Main Idea
Slab-pull	a. _____ ?
Ridge-push	b. _____ ?
Mantle convection	c. _____ ?

Reading Focus

Build Vocabulary L2

Paraphrase Have students explain, in their own words, the meaning of the new vocabulary terms in this section. Since each term contains an “action-type” word (*pull, push, plume, convection*), students should be able to form mental images to help with their explanations.

Reading Strategy L2

- a. mechanism of plate motion in which the descending slab pulls on the plate
- b. mechanism of plate motion in which the force of new crust formed at the high ridges pushes on the plate
- c. the major mechanism of plate motion as the upward flow of hot, less dense mantle material and the downward flow of cold, dense material drives plate tectonics

2 INSTRUCT

Causes of Plate Motion

Build Science Skills L2

Using Models Challenge students to use their hands, phone books, or other objects to model slab-pull and ridge-push. Have them explain the processes as they manipulate the model.

Verbal, Kinesthetic

Causes of Plate Motion

➡ Scientists generally agree that convection occurring in the mantle is the basic driving force for plate movement. During convection, warm, less dense material rises and cooler, denser material sinks. The motion of matter resulting from convection is called **convective flow**. The slow movements of the plates and mantle are driven by the unequal distribution of Earth’s heat. The heat is generated by the radioactive decay of elements, such as uranium, found within Earth’s mantle and crust.

Slab-Pull and Ridge-Push Several mechanisms produce forces that cause plate motion. One mechanism, called **slab-pull**, occurs because old oceanic crust, which is relatively cool and dense, sinks into the asthenosphere and “pulls” the trailing lithosphere along. ➡ **Slab-pull is thought to be the primary downward arm of convective flow in the mantle.** By contrast, **ridge-push** results from the elevated position of the oceanic ridge system. ➡ **Ridge-push causes oceanic lithosphere to slide down the sides of the oceanic ridge.** The downward slide is the result of gravity acting on the oceanic lithosphere. Ridge-push, although active in some spreading centers, is probably less important than slab-pull.

Mantle Convection Most models suggest that hot plumes of rock are the upward flowing arms in mantle convection. These rising **mantle plumes** sometimes show themselves on Earth’s surface as hot spots and volcanoes.

Section 9.5 (continued)

Use Visuals

L1

Figure 20 Have students study the figure. Ask: **At what type of boundary does upward convective movement occur?** (*divergent*) **At what type of boundary does downward convective movement occur?** (*convergent*)

ASSESS

Evaluate Understanding

L2

To assess students' knowledge of section content, have them write a short paragraph explaining convection. Paragraphs should include the cause of convection currents and the movements that occur.

Reteach

L1

Demonstrate convection as follows: Heat a beaker of water on a hot plate. When the water is hot, add an ice cube to the water near the edge of the beaker. Drop a few drops of food coloring next to the ice cube. Students will be able to watch the food coloring move through the water by convection.

Connecting Concepts

It would provide the missing mechanism that causes the continents to move.

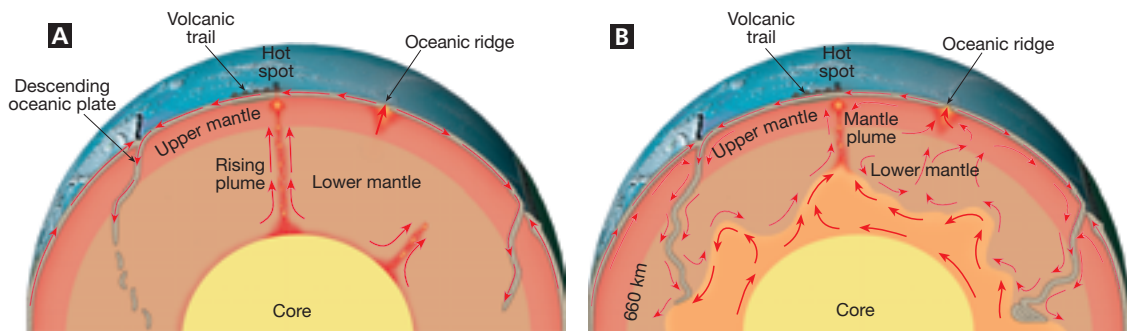


Figure 20 Mantle Convection Models **A** In the whole-mantle convection model, cold oceanic lithosphere descends into the mantle. Hot mantle plumes transport heat toward the surface. **B** The deep-layer model suggests that Earth's heat causes these layers of convection to slowly swell and shrink in complex patterns. Some material from the lower layer flows upward as mantle plumes.

One recent model is called whole-mantle convection. In this model, slabs of cold oceanic lithosphere descend into the lower mantle. This process provides the downward arm of convective flow, as shown in Figure 20A. At the same time, hot mantle plumes originating near the mantle-core boundary move heat toward the surface. Another model is the deep-layer model. You might compare this model to a lava lamp on a low setting. As shown in Figure 20B, the lower mantle is like the colored fluid in the bottom layer of a lava lamp. Like a lava lamp, heat from Earth's interior causes the two layers to slowly swell and shrink in complex patterns without much mixing. A small amount of material from the lower layer flows upward as mantle plumes, creating hot-spot volcanism at the surface.

There is still much to be learned about the mechanisms that cause plates to move. But one thing is clear. 🌍 **The unequal distribution of heat within Earth causes the thermal convection in the mantle that ultimately drives plate motion.** Exactly how this convection operates is still being debated.

Section 9.5 Assessment

Reviewing Concepts

1. 🌍 Describe the mechanisms of plate motion.
2. 🌍 What drives the slow movement of the plates and the convection in the mantle?
3. What is the main source of heat in Earth's interior?

Critical Thinking

4. **Relating Cause and Effect** How is the theory of plate tectonics related to the radioactive decay of elements within Earth's interior?

5. **Calculating** If Africa and Australia are moving apart at a rate of 4.4 centimeters per year, approximately how long will it take for the ocean between the two continents to increase by 1000 kilometers?

Connecting Concepts

Heat Flow Review Section 9.1. How would the flow of heat generated by radioactive decay benefit the theory of continental drift?

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Section 9.5 Assessment

1. slab-pull: force where the descending slab pulls on the plate; ridge-push: force of gravity causing the cold lithosphere to move away from the ridge by sliding down over the asthenosphere, which gets more elevated toward the ridge; mantle convection: motion caused by flow of hot, less-dense material upwards and cold, more-dense material downward
2. the unequal distribution of heat within Earth's interior drives plate motions
3. heat generated by radioactive decay of elements in Earth's interior
4. If radioactive decay stopped, no additional heat would be generated within Earth's interior. This heat drives the mantle convection that is the driving mechanism for plate tectonics, so plate motion would gradually stop.
5. approximately 23 million years

Plate Tectonics into the Future

Two geologists, Robert Dietz and John Holden, used present-day plate movements to predict the locations of landmasses in the future. The map below

shows where they predict Earth's landmasses will be 50 million years from now if plate movements remain at their present rates.

Future Continent Positions



MAP MASTER™
Skills Activity

Figure 21

Location The world may look like this 50 million years from now.

Identify Effects What could happen to Los Angeles and San Francisco if this proposed movement occurs?

L.A. on the Move

In North America, the Baja Peninsula and the portion of southern California that lies west of the San Andreas Fault will have slid past the North American plate. If this northward motion takes place, Los Angeles and San Francisco will pass each other in about 10 million years. In about 60 million years Los Angeles will begin to descend into the Aleutian trench.

New Sea in Africa

Major changes are seen in Africa, where a new sea emerges as East Africa is ripped away from the mainland. In addition, Africa will have moved slowly into Europe, perhaps creating the next major mountain-building stage on Earth. Meanwhile, the Arabian Peninsula continues to move away from Africa, allowing the Red Sea to widen and close the Persian Gulf.

Atlantic Ocean Grows

In other parts of the world, Australia will be located across the equator and, along with New Guinea, will be on a collision course with Asia. Meanwhile, North and South America will begin to separate, while the Atlantic and Indian oceans will continue to grow as the Pacific Ocean shrinks.

These projections into the future, although interesting, must be viewed with caution because many assumptions must be correct for these events to occur. We can be sure that large changes in the shapes and positions of continents will occur for millions of years to come.

Plate Tectonics into the Future

L2

MAP MASTER™
Skills Activity

Answer

Identify Effects The cities could have a change in climate as they move north. They may also undergo damage from earthquakes associated with the movement.

Background

Robert Dietz began his career as a marine geologist. He was an early proponent of continental drift and of seafloor spreading, which he named. Much of his early work was conducted in submersibles off the coast of California. John Holden was Dietz's colleague and his illustrator.

Teaching Tip

Have students cut out outlines of the continents and place them on a piece of white poster paper in their current locations. As students read each paragraph of the feature, they should move the continents to their predicted location. When they finish reading the feature, ask students to write a short paragraph describing how plant and animal life would be different on the continents in their new positions. For example, tropical vegetation in southern California would be replaced with plant life that could exist in an Arctic climate.

Verbal, Kinesthetic