

# Sea-Floor Spreading

## Reading Preview

### Key Concepts

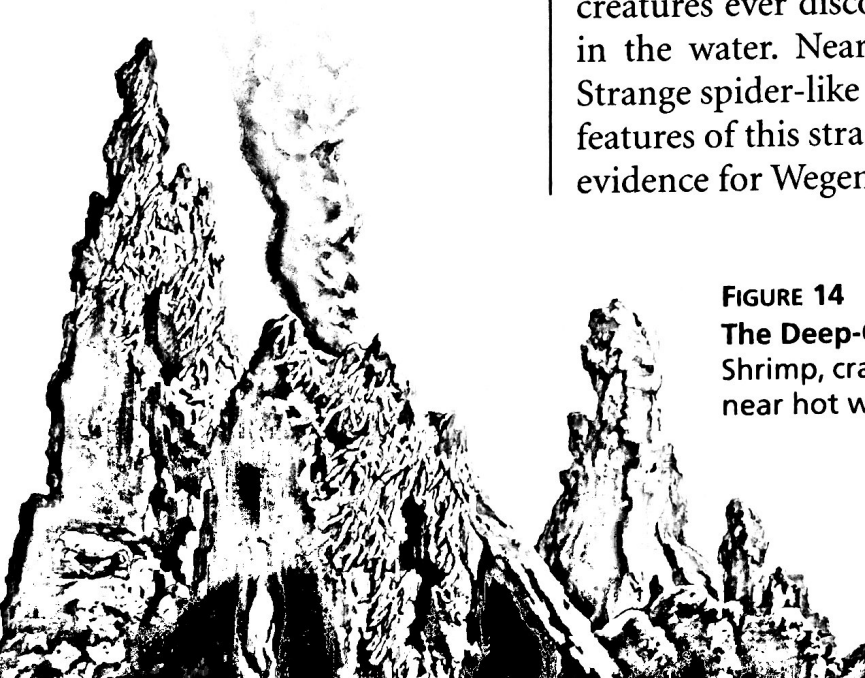
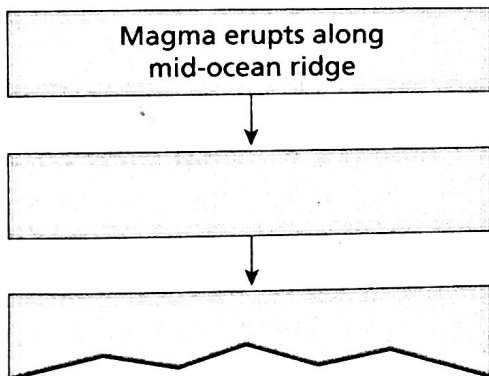
- What is the process of sea-floor spreading?
- What is the evidence for sea-floor spreading?
- What happens at deep-ocean trenches?

### Key Terms

- mid-ocean ridge • sonar
- sea-floor spreading
- deep-ocean trench
- subduction

## Target Reading Skill

**Sequencing** Make a flowchart to show the process of sea-floor spreading.



Lab  
zone

## Discover Activity

### What Is the Effect of a Change in Density?

1. Partially fill a sink or dishpan with water.
2. Open up a dry washcloth in your hand. Does the washcloth feel light or heavy?
3. Moisten one edge of the washcloth in the water. Then gently place the washcloth so that it floats on the water's surface. Observe the washcloth carefully (especially at its edges) as it starts to sink.
4. Remove the washcloth from the water and open it up in your hand. Is the mass of the washcloth the same as, less than, or greater than when it was dry?

### Think It Over

**Observing** How did the washcloth's density change? What effect did this change in density have on the washcloth?

Deep in the ocean, the temperature is near freezing. There is no light, and living things are generally scarce. Yet some areas of the deep-ocean floor are teeming with life. One of these areas is the East Pacific Rise. This area forms part of the Pacific Ocean floor off the coasts of Mexico and South America. Here, ocean water sinks through cracks, or vents, in the crust. The water is heated by contact with hot material from the mantle. The hot water then spurts back into the ocean.

Around these hot-water vents live some of the most bizarre creatures ever discovered. Giant, red-tipped tube worms sway in the water. Nearby sit giant clams nearly a meter across. Strange spider-like crabs scuttle by. Surprisingly, the geological features of this strange environment provided some of the best evidence for Wegener's hypothesis of continental drift.

FIGURE 14

### The Deep-Ocean Floor

Shrimp, crabs, and other organisms cluster near hot water vents in the ocean floor.

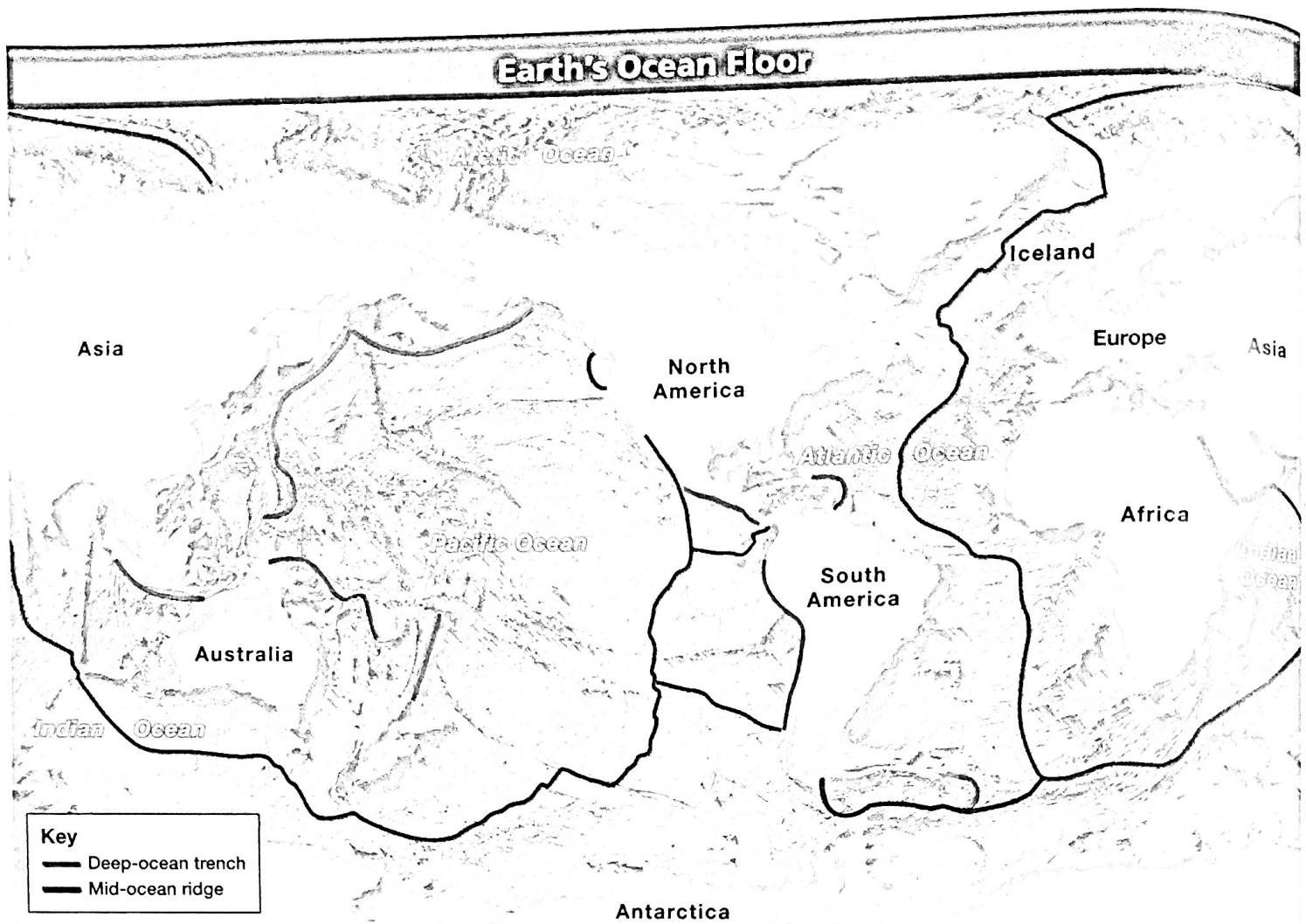


FIGURE 15

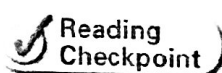
The mid-ocean ridge system is more than 50,000 kilometers long. Interpreting Maps *What is unusual about Iceland?*

## Mid-Ocean Ridges

The East Pacific Rise is just one of many **mid-ocean ridges** that wind beneath Earth's oceans. In the mid-1900s, scientists mapped the mid-ocean ridges using sonar. **Sonar** is a device that bounces sound waves off underwater objects and then records the echoes of these sound waves. The time it takes for the echo to arrive indicates the distance to the object.

Mid-ocean ridges curve like the seam of a baseball along the sea floor. They extend into all of Earth's oceans. Figure 15 shows the location of these ridges. Most of the mountains in the mid-ocean ridge system lie hidden under hundreds of meters of water. But in a few places the ridge pokes above the surface. For example, the island of Iceland is a part of the mid-ocean ridge that rises above the surface in the North Atlantic Ocean. A steep-sided valley splits the top of some mid-ocean ridges.

The mapping of mid-ocean ridges made scientists curious to know more about them. What are the ridges? How do they form?



Reading  
Checkpoint

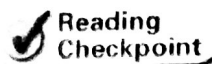
What device is used to map the ocean floor?

# What Is Sea-Floor Spreading?

Harry Hess, an American geologist, was one of the scientists who studied mid-ocean ridges. Hess carefully examined maps of the mid-ocean ridge system. Then he began to think about the ocean floor in relation to the problem of continental drift. Finally, he reached a startling conclusion: Maybe Wegener was right! Perhaps the continents do move.

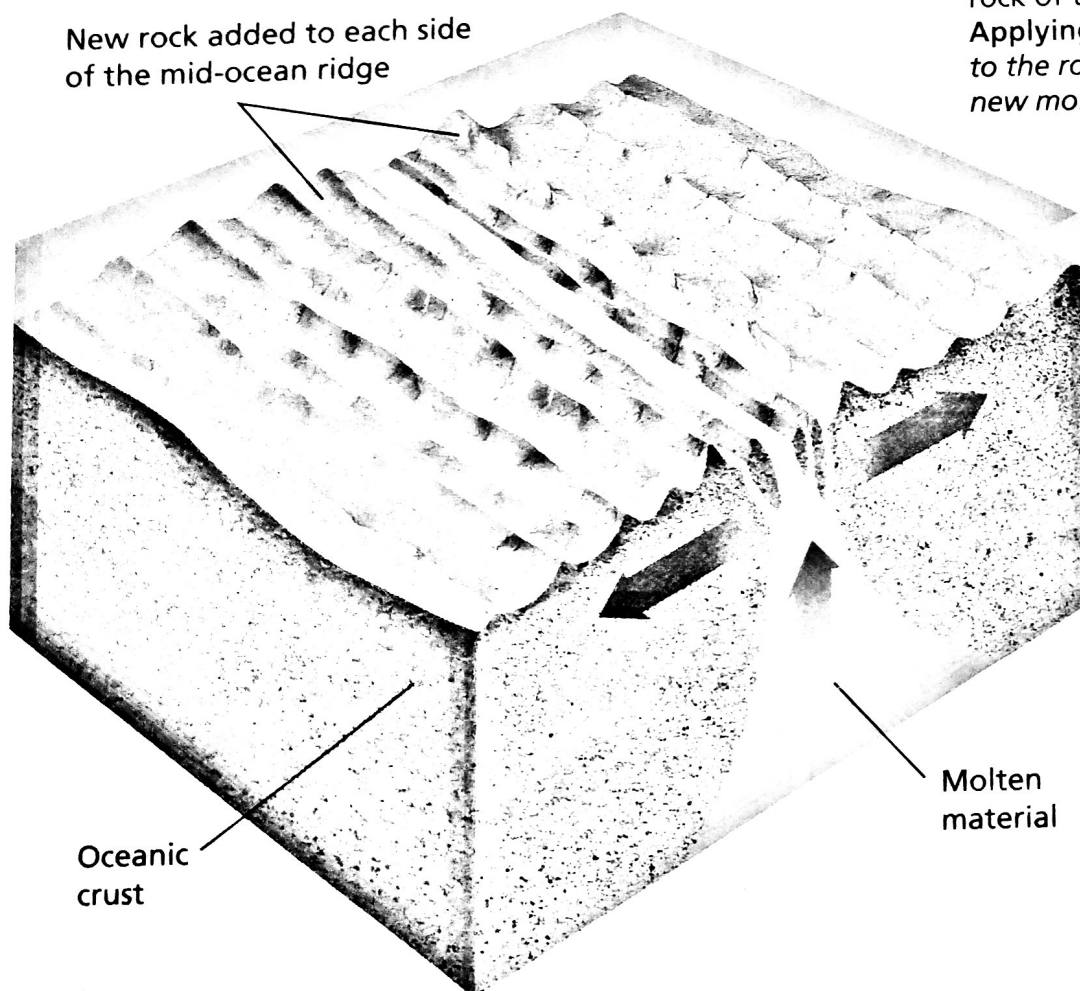
In 1960, Hess proposed a radical idea. He suggested that a process he called **sea-floor spreading** continually adds new material to the ocean floor. **In sea-floor spreading, the sea floor spreads apart along both sides of a mid-ocean ridge as new crust is added. As a result, the ocean floors move like conveyor belts, carrying the continents along with them.** Look at Figure 16 to see the process of sea-floor spreading.

Sea-floor spreading begins at a mid-ocean ridge, which forms along a crack in the oceanic crust. Along the ridge, molten material that forms several kilometers beneath the surface rises and erupts. At the same time, older rock moves outward on both sides of the ridge. As the molten material cools, it forms a strip of solid rock in the center of the ridge. When more molten material flows into the crack, it forms a new strip of rock.



Reading  
Checkpoint

How does new oceanic crust form?



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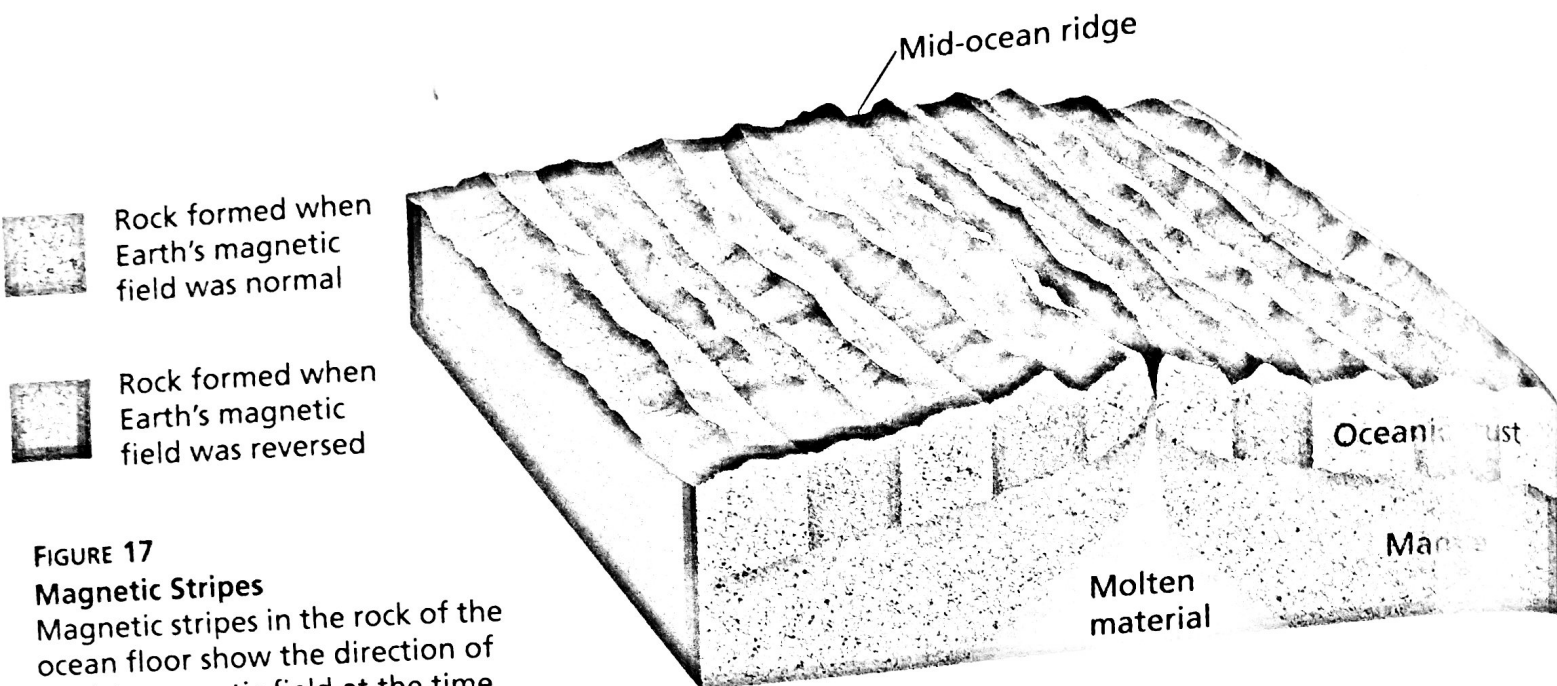
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FIGURE 16

## Sea-Floor Spreading

Molten material erupts through the valley that runs along the center of some mid-ocean ridges. This material hardens to form the rock of the ocean floor.

**Applying Concepts** *What happens to the rock along the ridge when new molten material erupts?*



**FIGURE 17**  
**Magnetic Stripes**  
 Magnetic stripes in the rock of the ocean floor show the direction of Earth's magnetic field at the time the rock hardened.  
 Interpreting Diagrams How are these matching stripes evidence of sea-floor spreading?

## Evidence for Sea-Floor Spreading

Several types of evidence supported Hess's theory of sea-floor spreading: eruptions of molten material, magnetic stripes in the rock of the ocean floor, and the ages of the rocks themselves. This evidence led scientists to look again at Wegener's hypothesis of continental drift.

**Evidence From Molten Material** In the 1960s, scientists found evidence that new material is indeed erupting along mid-ocean ridges. The scientists dived to the ocean floor in *Alvin*, a small submarine built to withstand the crushing pressures four kilometers down in the ocean. In a ridge's central valley, *Alvin*'s crew found strange rocks shaped like pillows or like toothpaste squeezed from a tube. Such rocks form only when molten material hardens quickly after erupting under water. These rocks showed that molten material has erupted again and again along the mid-ocean ridge.

**Evidence From Magnetic Stripes** When scientists studied patterns in the rocks of the ocean floor, they found more support for sea-floor spreading. You read earlier that Earth behaves like a giant magnet, with a north pole and a south pole. Surprisingly, Earth's magnetic poles have reversed themselves many times during Earth's history. The last reversal happened 780,000 years ago. If the magnetic poles suddenly reversed themselves today, you would find that your compass needle points south.

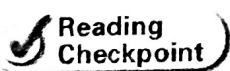


Scientists discovered that the rock that makes up the ocean floor lies in a pattern of magnetized “stripes.” These stripes hold a record of reversals in Earth’s magnetic field. The rock of the ocean floor contains iron. The rock began as molten material that cooled and hardened. As the rock cooled, the iron bits inside lined up in the direction of Earth’s magnetic poles. This locked the iron bits in place, giving the rocks a permanent “magnetic memory.”

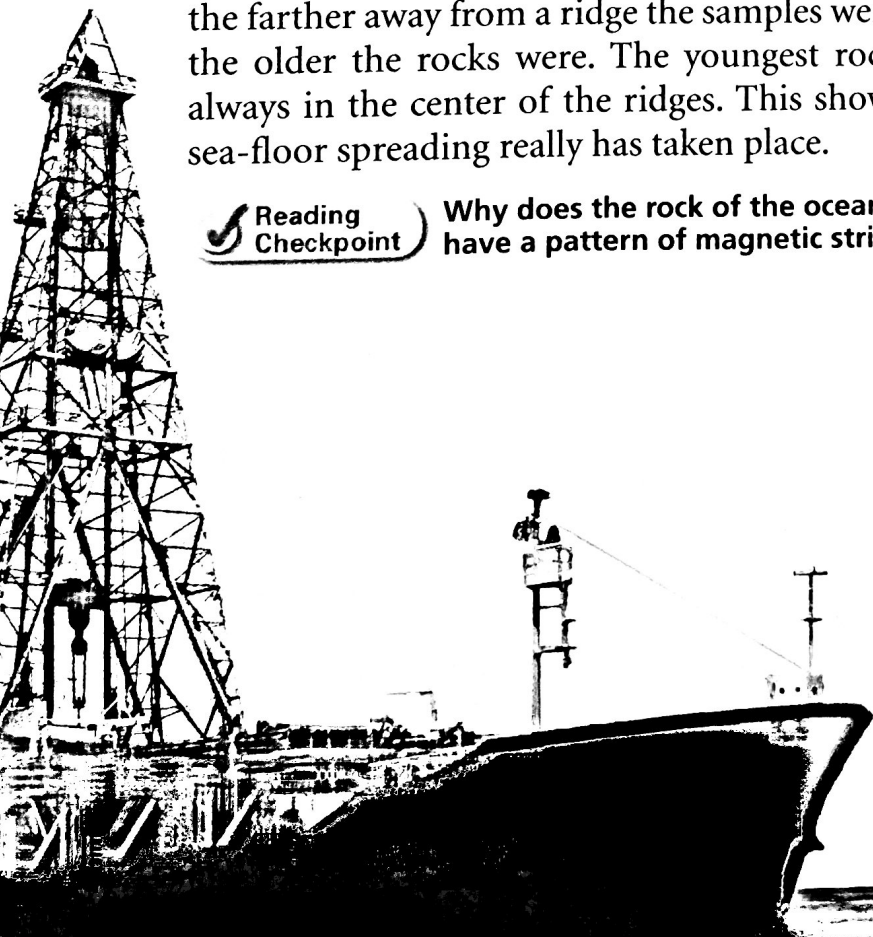
Using sensitive instruments, scientists recorded the magnetic memory of rocks on both sides of a mid-ocean ridge. They found that stripes of rock that formed when Earth’s magnetic field pointed north alternate with stripes of rock that formed when the magnetic field pointed south. As shown in Figure 17, the pattern is the same on both sides of the ridge.

**Evidence From Drilling Samples** The final proof of sea-floor spreading came from rock samples obtained by drilling into the ocean floor. The *Glomar Challenger*, a drilling ship built in 1968, gathered the samples. The *Glomar Challenger* sent drilling pipes through water six kilometers deep to drill holes in the ocean floor. This feat has been compared to using a sharp-ended wire to dig a hole into a sidewalk from the top of the Empire State Building.

Samples from the sea floor were brought up through the pipes. Then the scientists determined the age of the rocks in the samples. They found that the farther away from a ridge the samples were taken, the older the rocks were. The youngest rocks were always in the center of the ridges. This showed that sea-floor spreading really has taken place.



**Why does the rock of the ocean floor have a pattern of magnetic stripes?**



### Reversing Poles

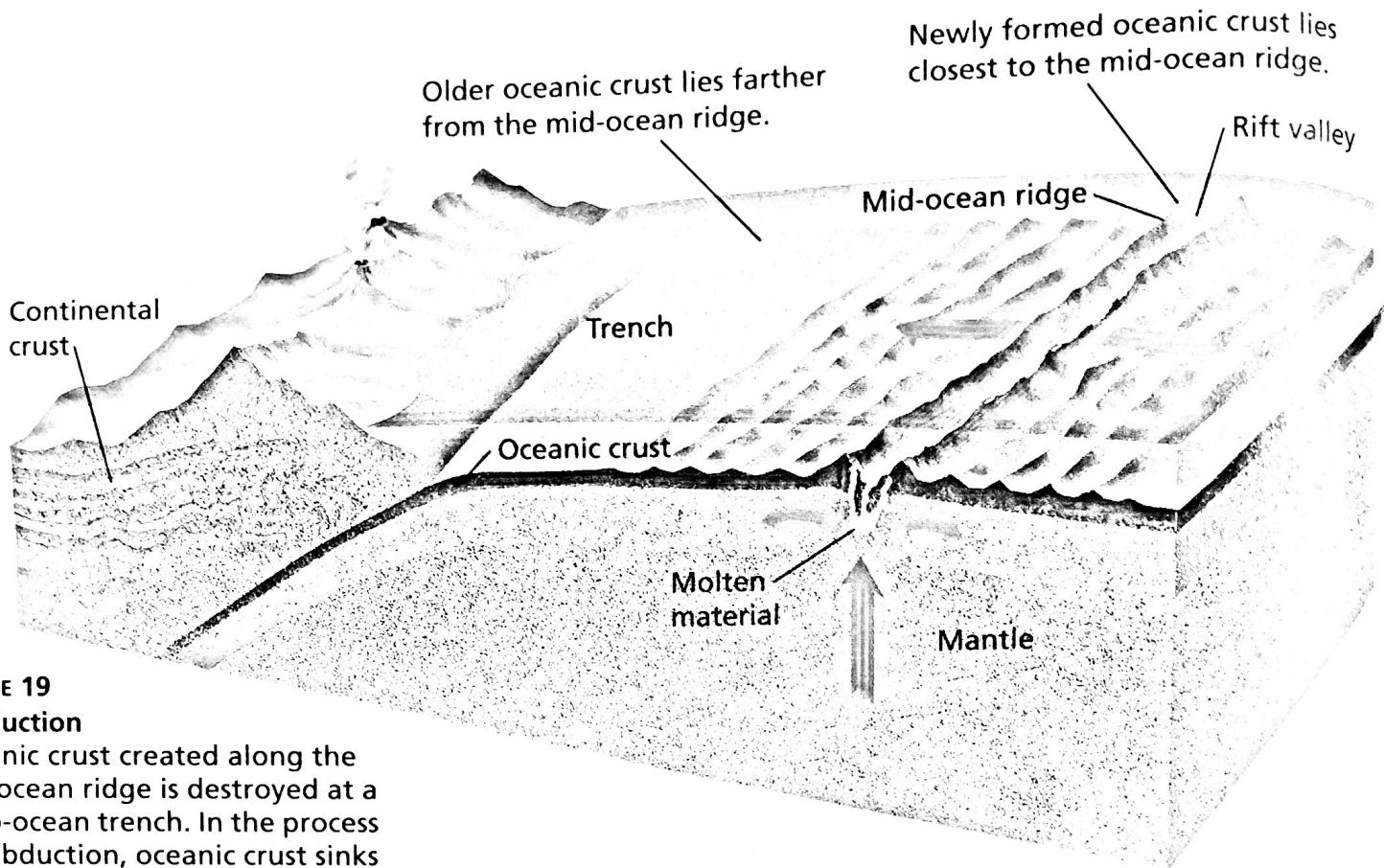
1. Cut six short pieces, each about 2.5 cm long, from a length of audiotape.
2. Tape one end of each piece of audiotape to a flat surface. The pieces should be spaced 1 cm apart and lined up lengthwise in a single row.
3. Touch a bar magnet’s north pole to the first piece of audiotape. Then reverse the magnet and touch its south pole to the next piece.
4. Repeat Step 3 until you have applied the magnet to each piece of audiotape.
5. Sweep one end of the magnet about 1 cm above the line of audiotape pieces. Observe what happens.

**Making Models** What characteristic of the ocean floor did you observe as you swept the magnet along the line of audiotape pieces?

**FIGURE 18**

#### Sea-Floor Drilling

The *Glomar Challenger* was the first research ship designed to drill samples of rock from the deep-ocean floor.



**FIGURE 19**  
**Subduction**

Oceanic crust created along the mid-ocean ridge is destroyed at a deep-ocean trench. In the process of subduction, oceanic crust sinks down beneath the trench into the mantle.

**Drawing Conclusions** *Where would the densest oceanic crust be found?*



## Subduction at Trenches

How can the ocean floor keep getting wider and wider? The answer is that the ocean floor generally does not just keep spreading. Instead, the ocean floor plunges into deep underwater canyons called **deep-ocean trenches**. At a deep-ocean trench, the oceanic crust bends downward. What occurs at trenches? **In a process taking tens of millions of years, part of the ocean floor sinks back into the mantle at deep-ocean trenches.**

**The Process of Subduction** The process by which ocean floor sinks beneath a deep-ocean trench and back into the mantle is called **subduction** (sub DUK shun). As subduction occurs, crust closer to a mid-ocean ridge moves away from the ridge and toward a deep-ocean trench. Sea-floor spreading and subduction work together. They move the ocean floor as if it were on a giant conveyor belt.

New oceanic crust is hot. But as it moves away from the mid-ocean ridge, it cools and becomes more dense. Eventually, as shown in Figure 19, gravity pulls this older, denser oceanic crust down beneath the trench. The sinking crust is like the washcloth in the Discover activity at the beginning of this section. As the dry washcloth floating on the water gets wet, its density increases and it begins to sink.

**Subduction and Earth's Oceans** The processes of subduction and sea-floor spreading can change the size and shape of the oceans. Because of these processes, the ocean floor is renewed about every 200 million years. That is the time it takes for new rock to form at the mid-ocean ridge, move across the ocean, and sink into a trench.

The vast Pacific Ocean covers almost one third of the planet. And yet it is shrinking. How can that be? Sometimes a deep ocean trench swallows more oceanic crust than a mid-ocean ridge can produce. Then, if the ridge does not add new crust fast enough, the width of the ocean will shrink. In the Pacific Ocean, subduction through the many trenches that ring the ocean is occurring faster than new crust can be added.

On the other hand, the Atlantic Ocean is expanding. Unlike the Pacific Ocean, the Atlantic Ocean has only a few short trenches. As a result, the spreading ocean floor has virtually nowhere to go. In most places, the oceanic crust of the Atlantic Ocean floor is attached to the continental crust of the continents around the ocean. So as the Atlantic's ocean floor spreads, the continents along its edges also move. Over time, the whole ocean gets wider.



**FIGURE 20**

#### Growing an Ocean

Because of sea-floor spreading, the distance between Europe and North America is increasing by a few centimeters per year.



**Why is the Pacific Ocean shrinking?**

## Section 4 Assessment

**Target Reading Skill Sequencing** Refer to your flowchart on sea-floor spreading as you answer the questions below.

### Reviewing Key Concepts

1. **a. Naming** What scientist helped to discover the process of sea-floor spreading?
- b. Identifying** Along what feature of the ocean floor does sea-floor spreading begin?
- c. Sequencing** What are the steps in the process of sea-floor spreading?
2. **a. Reviewing** What three types of evidence provided support for the theory of sea-floor spreading?
- b. Applying Concepts** How do rocks along the central valley of the mid-ocean ridge provide evidence of sea-floor spreading?
- c. Predicting** Where would you expect to find the oldest rock on the ocean floor?

3. **a. Defining** What is a deep-ocean trench?
- b. Relating Cause and Effect** What happens to oceanic crust at a deep-ocean trench?

### Writing in Science

**Description** Write a description of what you might see if you could explore a mid-ocean ridge in a vessel like the *Alvin*. In your description, be sure to include the main features of the ocean floor along and near the ridge.