LESSON 2

Seafloor Spreading

Science Content Standards

1.a Students know evidence of plate tectonics is derived from the fit of the continents; the location of earthquakes, volcanoes, and mid-ocean ridges; and the distribution of fossils, rock types, and ancient climatic zones.

7.g Interpret events by sequence and time from natural phenomena (e.g., the relative ages of rocks and intrusions).

Reading Guide

What *You'll Learn*

- **Describe** new discoveries that led to the seafloor spreading hypothesis.
- **Explain** how seafloor spreading works.
- **Compare and contrast** evidence for seafloor spreading with evidence for continental drift.

Why *It's Important*

The seafloor spreading hypothesis explained continental drift.

Vocabulary

mid-ocean ridge
seafloor spreading

Review Vocabulary

magma: molten, liquid rock material found underground (p. 96)

Main Idea New discoveries led to seafloor spreading as an explanation for continental drift.

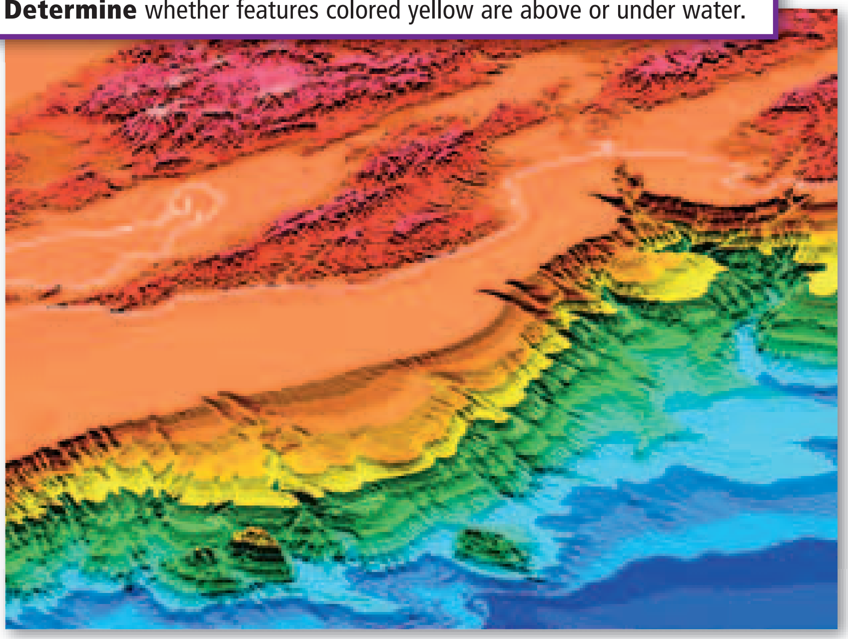
Real-World Reading Connection Do you know how to do a magic trick? When you first see a good trick, it seems impossible. Then, when you learn how the trick works, it doesn't seem impossible any more. In the decades after continental drift was rejected, scientists discovered new technology that helped explain how continents could move.

Investigating the Seafloor

Wegener collected most of his evidence for continental drift at Earth's surface. But, there is also evidence on the seafloor. Scientists began investigating the seafloor by collecting samples of rocks. They knew that most rocks on the seafloor are made of basalt. Recall from Chapter 2 that basalt is an igneous rock that is made of highly dense minerals such as olivine and magnetite.

Scientists wondered why rocks on the seafloor were so different from rocks on land. By the 1950s, new technologies were being developed to explore the seafloor. An example of this technology is shown in **Figure 6.**

Figure 6 The bottom of the ocean is complicated. In this colorized image of the seafloor off the central California coast, the coastline is outlined in white.
Determine whether features colored yellow are above or under water.



United States Geological Society

Mapping the Seafloor

During World War II, a new method was developed for mapping the seafloor. This new method used technology called sonar. **Figure 7** shows how sonar works. Scientists emit sound waves from a boat. The sound waves bounce off the seafloor. Then, a receiver records the time it takes for the waves to return. Because scientists know the speed of sound waves in water, they can use the data to calculate the depth of water. With this new technology, the topography of the seafloor was mapped.

Mid-Ocean Ridges

Figure 8 shows what scientists discovered when they mapped the topography of the seafloor. Hidden under ocean waters are the longest mountain ranges on Earth. These mountain ranges, in the middle of the seafloor, are called **mid-ocean ridges.** The mountains wrap around Earth much like seams wrap around a baseball.

Maps of the seafloor made scientists want to learn even more about it. They studied temperatures on the seafloor. They discovered that there is more heat escaping from Earth at the mid-ocean ridges than at other locations in the oceans. The closer you move toward a mid-ocean ridge, the more heat flows from the mantle, as shown in **Figure 9.**

Figure 7 **Seafloor Mapping** Sonar uses sound waves bounced off the seafloor to measure ocean depths.

Name an animal that uses sound waves to navigate.

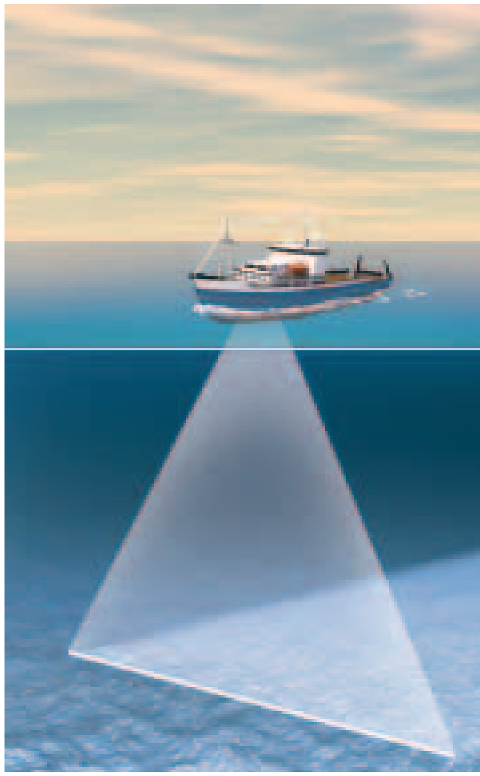
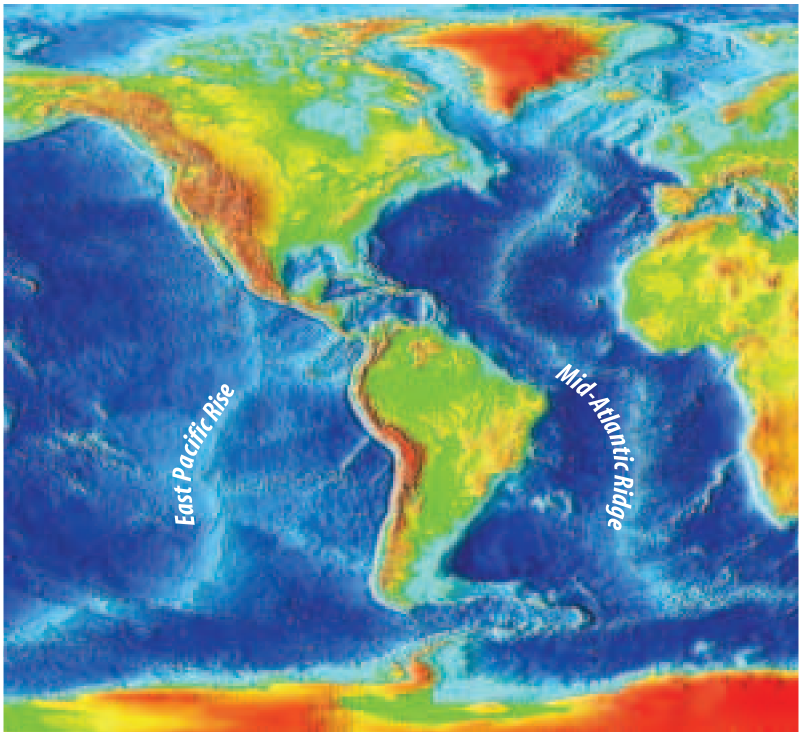


Figure 8 **Depth Changes** The light-blue color on the map shows locations with shallow water.



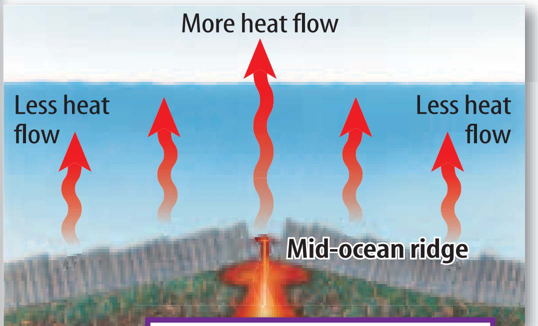


Figure 9 The flow of heat from the mantle increases the closer you get to a mid-ocean ridge.

The Seafloor Moves

Harry Hess was an American geologist. He studied the seafloor, trying to understand how mid-ocean ridges were formed. He proposed it was hot beneath the mid-ocean ridges because lava erupted there and made new seafloor. Hess suggested a new **hypothesis** describing this process.

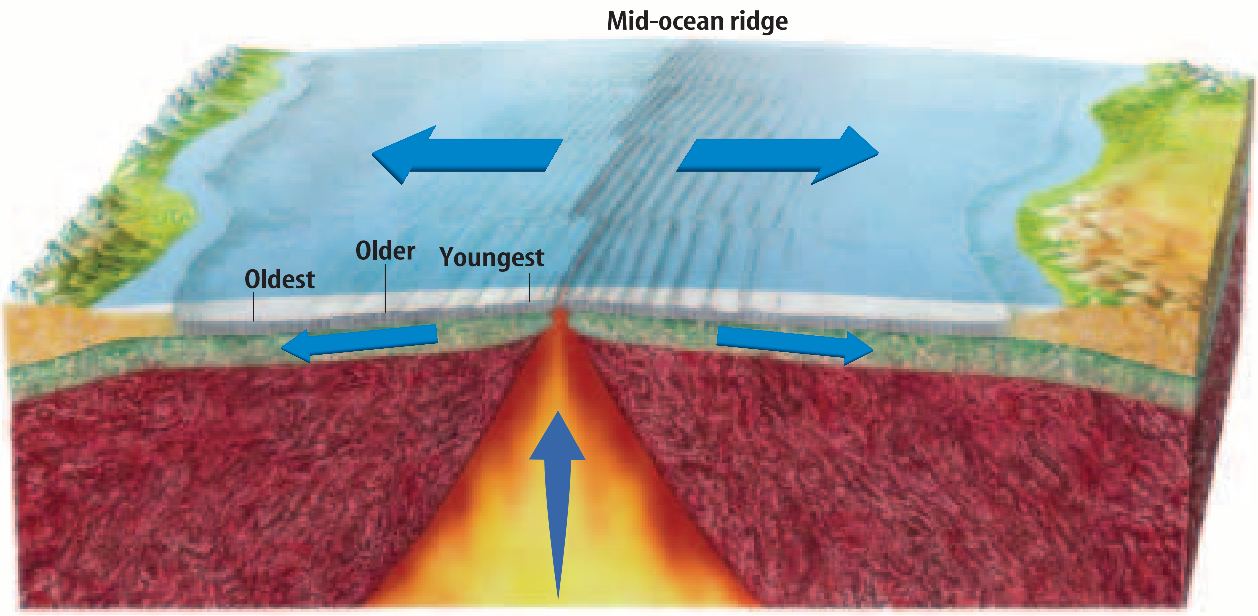
ACADEMIC VOCABULARY
hypothesis (hi PAH thuh sus)
(noun) a tentative explanation that can be tested with a scientific investigation
Michael made a hypothesis that he would have no cavities because he did a good job of brushing and flossing his teeth.

Seafloor spreading is the process by which new seafloor is continuously made at the mid-ocean ridges. Convection brings hot material in the mantle toward the surface, causing magma to form. The magma flows out as lava through cracks along the ridge. When the lava cools, it forms new seafloor. Then, the seafloor moves sideways, away from the center of the mid-ocean ridge.

Where does new seafloor form?

Seafloor spreading seemed to explain continental drift. **Figure 10** shows seafloor moving away from the mid-ocean ridge as new oceanic crust is formed. Notice how the seafloor becomes older as the distance from the mid-ocean ridge increases. Adding new seafloor makes the ocean wider. As a result, continents drift apart as the ocean grows. Scientists looked for evidence that could test the new seafloor spreading hypothesis. Studies of mid-ocean ridges continue today, as shown in **Figure 11.**

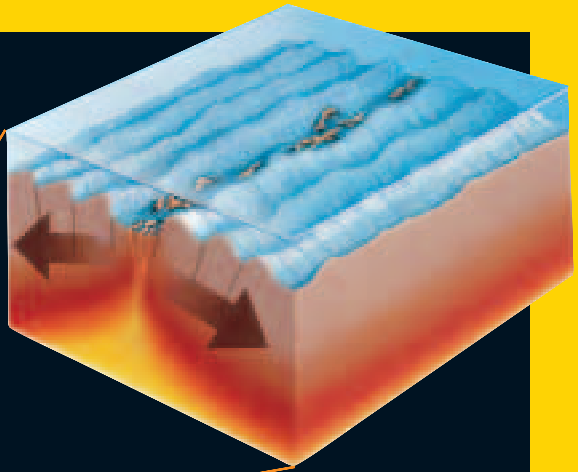
Figure 10 Seafloor spreading forms new oceanic crust. The older oceanic crust moves away from the ridge as new oceanic crust forms.



Visualizing Mid-Ocean Ridges

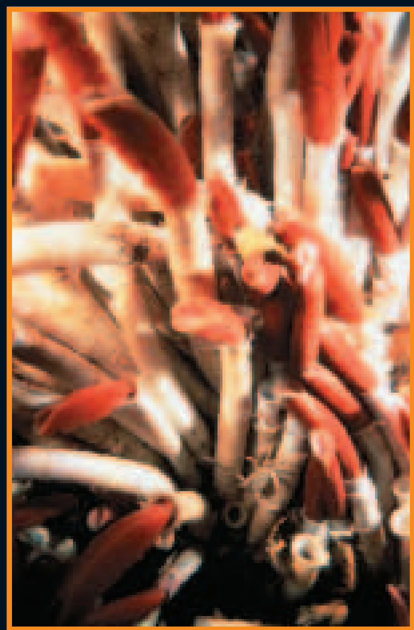
Figure 11

Mid-ocean ridges are vast, underwater mountains that form the longest continuous mountain ranges on Earth. Earthquakes and volcanoes commonly occur along the ridges. An example of a mid-ocean ridge is the Mid-Atlantic Ridge. The Mid-Atlantic Ridge was formed when the North and South American Plates pulled apart from the Eurasian and African Plates.



▲ New oceanic crust is formed as seafloor moves away from the mid-ocean ridge. The seafloor becomes older as the distance from the mid-ocean ridge increases.

▼ Scientists have made many new discoveries on the seafloor. Hydrothermal vents, also known as black smokers, form along mid-ocean ridges. The "smoke" that rises from the hydrothermal vent is actually a hot fluid that is rich in metals.

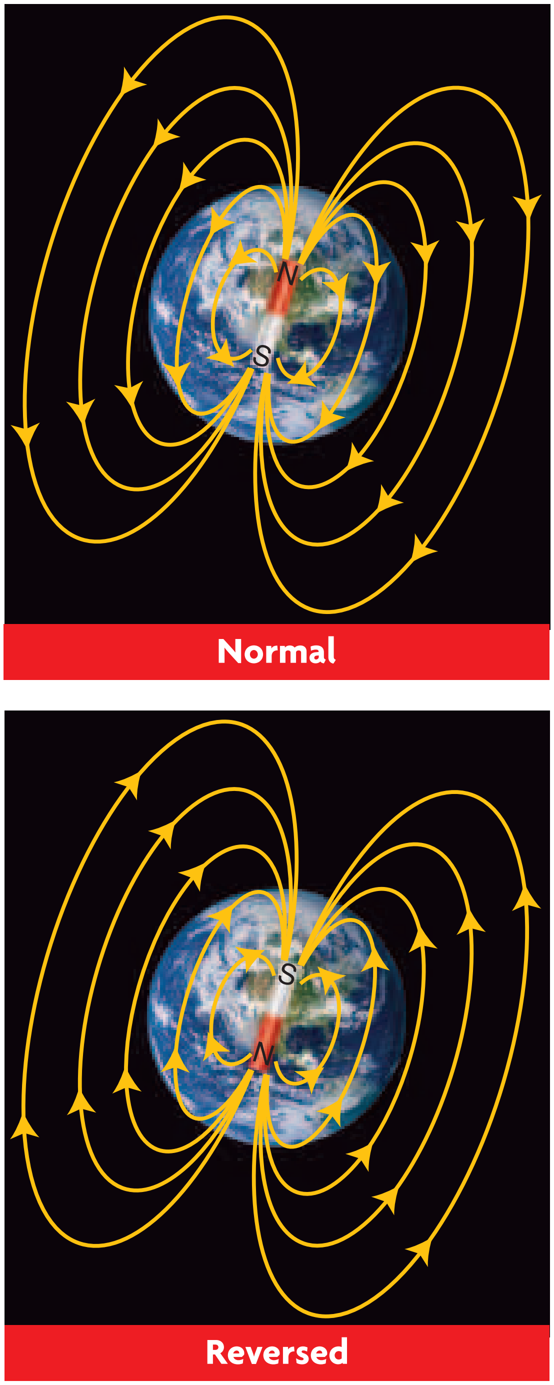


Some species, such as these giant tube worms, live next to the hydrothermal vents. The heat and minerals allow them to survive without sunlight. ▲

Contributed by National Geographic

(l r)Ralph White/CORBIS, (c)Davis Meltzer

Figure 12A Earth's magnetic poles have reversed many times over many millions of years.



Evidence for Spreading

New evidence connected the ages of seafloor rocks to how Earth's magnetic field was oriented at those times.

Magnetic Polarity Reversals

Whenever you use a compass, the north-seeking end of the needle points to Earth's magnetic north pole. But, Earth's magnetic field has not always had the same orientation. Sometimes the magnetic poles reverse. If you happened to be living at a time after the magnetic poles switched, your compass needle would point south instead of north.

Orientation The top diagram of **Figure 12A** shows the orientation of the magnetic field the way it is today. This is called *normal.* When it points in the opposite direction, it is called *reversed.* Scientists learned the ages of each of these reversals. They used this information to produce a magnetic time scale, which is like a calendar for part of Earth's history.

Recording Reversals Igneous rocks can record these reversals, as illustrated below in **Figure 12B.** This happens along a mid-ocean ridge as oceanic crust forms from lava and cools. Tiny crystals record the magnetic field orientation that existed when the crust cooled.

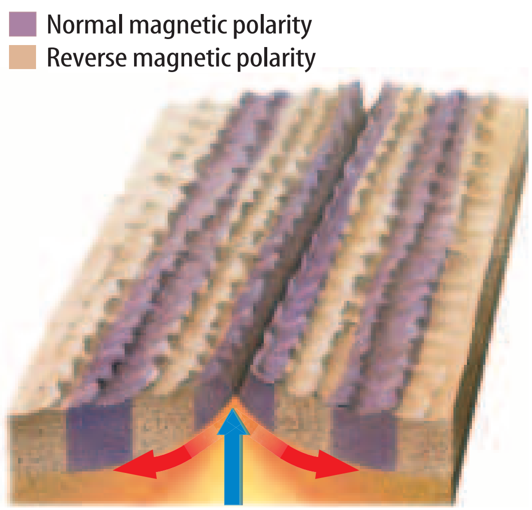


Figure 12B Igneous rocks that form on both sides of mid-ocean ridges can preserve changes in Earth's magnetic field.
Explain why magnetic polarity reversals are evidence of seafloor spreading.

Magnetic Stripes on the Seafloor

As shown in **Figure 13,** scientists can measure Earth's magnetic field with instruments called magnetometers. These instruments can travel over large areas of Earth's surface by ship, plane, and satellite. As they move over the ocean, they measure the strength of the magnetic field. The oceanic crust makes a striped pattern when graphed because it contains alternating strips of rock with normal and reversed polarity.

These magnetic stripes are shown in **Figure 12.** Just as Hess hypothesized, the seafloor is youngest at the mid-ocean ridge. By measuring the distance of a stripe of rock from the mid-ocean ridge and determining its age, scientists can calculate the velocity of seafloor movement.

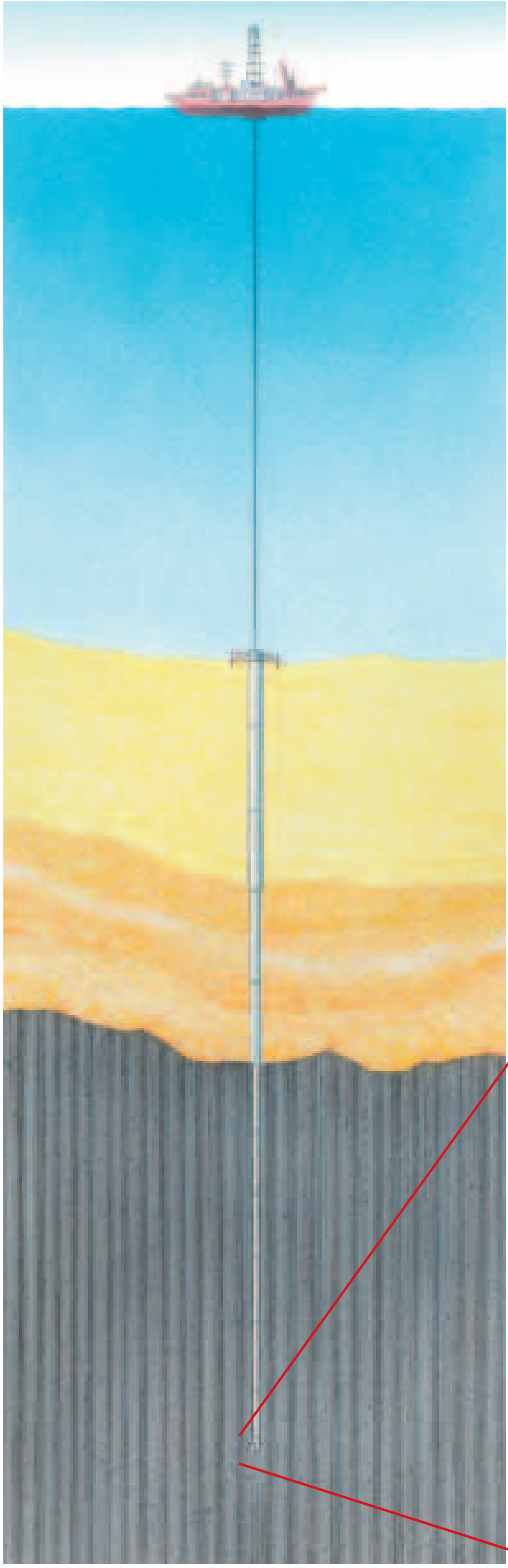
Reading Check How is the velocity of seafloor movement calculated using magnetic polarity reversals?

The seafloor and continents move slowly, only centimeters per year. Learning about seafloor spreading was like learning how a magic trick is done. Scientists finally understood how the continents could move and accepted Wegener's continental drift hypothesis.

Figure 13 Scientists use magnetometers to collect data about Earth's magnetic field.

Astrium

Figure 14 Drill pipes up to 6 km long are used by scientists in order to reach the seafloor in the deep ocean.



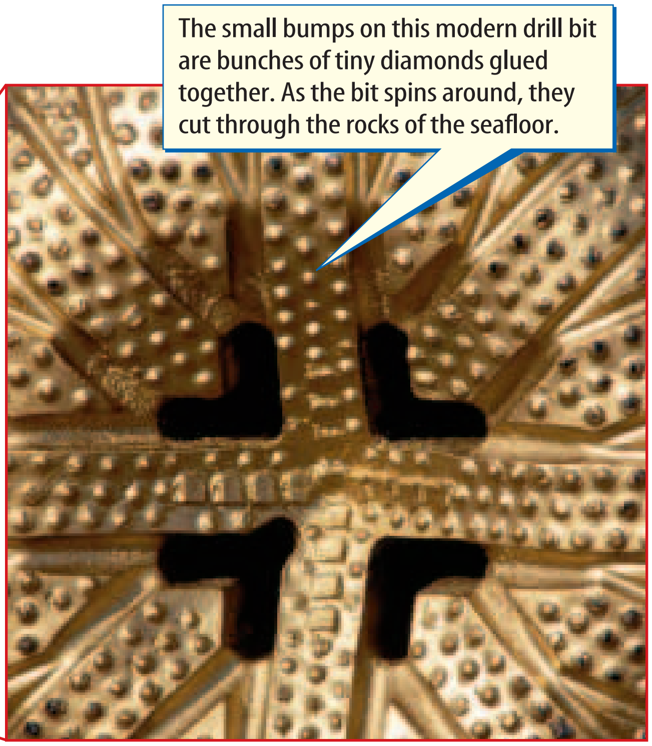
Seafloor Drilling

Not long after scientists learned how to determine the age of the seafloor, they developed deep-sea drilling. They designed a boat that could drill and collect samples from the seafloor. This boat, named the *Glomar Challenger*, made its first voyage in 1968.

Scientists used drill pipes several kilometers long to cut through rock at the bottom of the sea and bring up samples. **Figure 14** shows how the drill pipe extended all the way from the ship to the seafloor. The photo in **Figure 14** shows how the drill bit, with diamonds glued in it, was attached to the bottom of the drill pipe. Recall from Chapter 2 that diamond is the hardest mineral. A diamond-tipped drill can cut through the hardest rock.

Reading Check Why are diamonds used in drill bits?

The ages of the samples showed that the oldest rocks were farthest from the mid-ocean ridge. And, the youngest rocks are found in the center of the mid-ocean ridge. This seafloor drilling supported the seafloor-spreading hypothesis.



Lowell Georgia/CORBIS

Seafloor Spreading Hypothesis

By the 1950s, new methods and technologies, such as sonar, were being developed to map and explore the seafloor. When scientists mapped the topography of the seafloor they discovered underwater mountain ranges known as mid-ocean ridges. Harry Hess studied the seafloor trying to understand how mid-ocean ridges were formed. He proposed the seafloor spreading hypothesis, which is the process by which new seafloor is continuously made at the mid-ocean ridges. New evidence from around the world showed that the seafloor was spreading, as Hess had thought. Seafloor spreading seemed to explain continental drift. Studies of mid-ocean ridges continue today.

LESSON 2 Review

Summarize

Create your own lesson summary as you organize an **outline.**

1. **Scan** the lesson. Find and list the first **red** main heading.
2. **Review** the text after the heading and list 2–3 details about the heading.
3. **Find** and list each **blue** subheading that follows the **red** main heading.
4. **List** 2–3 details, key terms, and definitions under each **blue** subheading.
5. **Review** additional **red** main headings and their supporting **blue** subheadings. List 2–3 details about each.

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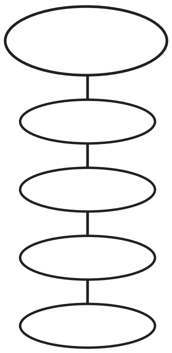
Standards Check

Using Vocabulary

1. Use the terms *mid-ocean ridge* and *seafloor spreading* in the same sentence. 1.a
2. Write a definition for the term *mid-ocean ridge* in your own words. 1.a

Understanding Main Ideas

3. **Sequence** Draw a diagram like the one below. List the process of seafloor spreading beginning with convection brining hot material in the mantle toward the surface. 1.a



4. **Illustrate** the symmetry of magnetic polarity stripes on the seafloor. 1.a
5. **Assess** how new data supported the seafloor spreading hypothesis. 1.a

Applying Science

6. **Suggest** what scientists' reactions to the continental drift hypothesis might have been if data from the seafloor were available in the 1910s. 1.a
7. **Interpret** the high temperatures measured at mid-ocean ridges to formation of basalt at the ridges. 1.a

Science Online
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