Section 17.2

Objectives

- **Summarize** the evidence that led to the discovery of seafloor spreading.
- **Explain** the significance of magnetic patterns on the seafloor.
- **Explain** the process of seafloor spreading.

Review Vocabulary

basalt: a dark-gray to black fine-grained igneous rock

New Vocabulary

magnetometer
magnetic reversal
paleomagnetism
isochron
seafloor spreading

Seafloor Spreading

MAIN Idea **Oceanic crust forms at ocean ridges and becomes part of the seafloor.**

Real-World Reading Link Have you ever counted the rings on a tree stump to find the age of the tree? Scientists can study similar patterns on the ocean floor to determine its age.

Mapping the Ocean Floor

Until the mid-1900s, most people, including many scientists, thought that the ocean floors were essentially flat. Many people also had misconceptions that oceanic crust was unchanging and was much older than continental crust. However, advances in technology during the 1940s and 1950s showed that all of these widely accepted ideas were incorrect.

One technological advance that was used to study the ocean floor was the magnetometer. A **magnetometer** (mag nuh TAH muh tur), such as the one shown in **Figure 17.7,** is a device that can detect small changes in magnetic fields. Towed behind a ship, it can record the magnetic field generated by ocean floor rocks. You will learn more about magnetism and how it supports continental drift later in this section.

Another advancement that allowed scientists to study the ocean floor in great detail was the development of echo-sounding methods. One type of echo sounding is sonar. Recall from Chapter 15 that sonar uses sound waves to measure distance by measuring the time it takes for sound waves sent from the ship to bounce off the seafloor and return to the ship. Developments in sonar technology enabled scientists to measure water depth and map the topography of the ocean floor.

Figure 17.7 Magnetometers are devices that can detect small changes in magnetic fields. The data collected using magnetometers lowered into the ocean furthered scientists' understanding of rocks underlying the ocean floor.

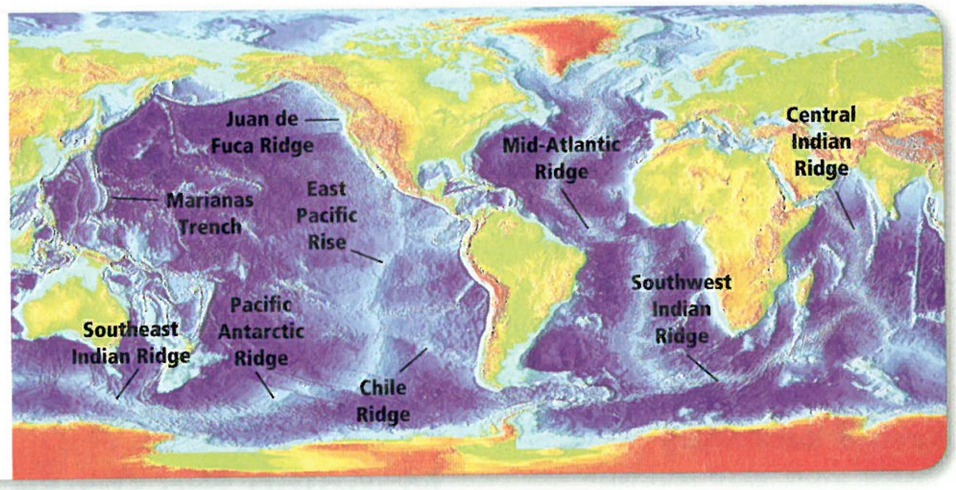


Figure 17.8 Sonar data revealed ocean ridges and deep-sea trenches. Earthquakes and volcanism are common along ridges and trenches.

Ocean-Floor Topography

The maps made from data collected by sonar and magnetometers surprised many scientists. They discovered that vast, underwater mountain chains called ocean ridges run along the ocean floors around Earth much like seams on a baseball. These ocean floor features, shown in **Figure 17.8,** form the longest continuous mountain range on Earth. When they were first discovered, ocean ridges generated much discussion because of their enormous length and height—they are more than 80,000 km long and up to 3 km above the ocean floor. Later, scientists discovered that earthquakes and volcanism are common along the ridges.

Reading Check **Describe** Where are the longest continuous mountain ranges on Earth?

Maps generated with sonar data also revealed that underwater mountain chains had counterparts called deep-sea trenches, which are also shown on the map in **Figure 17.8.** Recall from Chapter 16 that a deep-sea trench is a narrow, elongated depression in the seafloor. Trenches can be thousands of kilometers long and many kilometers deep. The deepest trench, called the Marianas Trench, is in the Pacific Ocean and is more than 11 km deep. Mount Everest, the world's tallest mountain, stands at 9 km above sea level, and could fit inside the Marianas Trench with six Empire State buildings stacked on top.

These two topographic features of the ocean floor—ocean ridges and deep-sea trenches—puzzled geologists for more than a decade after their discovery. What could have formed an underwater mountain range that extended around Earth? What is the source of the volcanism associated with these mountains? What forces could depress Earth's crust enough to create trenches nearly 6 times as deep as the Grand Canyon? You will find out the answers to these questions later in this chapter.

VOCABULARY
SCIENCE USAGE V. COMMON USAGE

Depress

Science usage: to cause to sink to a lower position

Common usage: to sadden or discourage

Ocean Rocks and Sediments

In addition to making maps, scientists collected samples of deep-sea sediments and the underlying oceanic crust. Analysis of the rocks and sediments led to two important discoveries. First, the ages of the rocks that make up the seafloor varies across the ocean floor, and these variations are predictable. Rock samples taken from areas near ocean ridges were found to be younger than samples taken from areas near deep-sea trenches. The samples showed that the age of oceanic crust consistently increases with distance from a ridge, as shown in **Figure 17.9.** This trend was symmetric across the ocean ridges. Scientists also discovered from the rock samples that even the oldest parts of the seafloor are geologically young—about 180 million years old. Why are ocean-floor rocks so young compared to continental rocks, some of which are at least 3.8 billion years old? Geologists knew that oceans had existed for more than 180 million years so they wondered why there was no trace of older oceanic crust.

The second discovery involved the sediments on the ocean floor. Measurements showed that ocean-floor sediments are typically a few hundred meters thick. Large areas of continents, on the other hand, are blanketed with sedimentary rocks that are as much as 20 km thick. Scientists knew that erosion and deposition occur in Earth's oceans but did not understand why seafloor sediments were not as thick as their continental counterparts. Scientists hypothesized that the relatively thin layer of ocean sediments was related to the age of the ocean crust. Observations of ocean-floor sediments revealed that the thickness of the sediments increases with distance from an ocean ridge, as shown in **Figure 17.9.** The pattern of thickness across the ocean floor was symmetrical across the ocean ridges.

CAREERS IN EARTH SCIENCE

Marine geologist Earth scientists who study the ocean floor to understand geologic processes such as plate tectonics are marine geologists. To learn more about Earth science careers, visit glencoe.com.

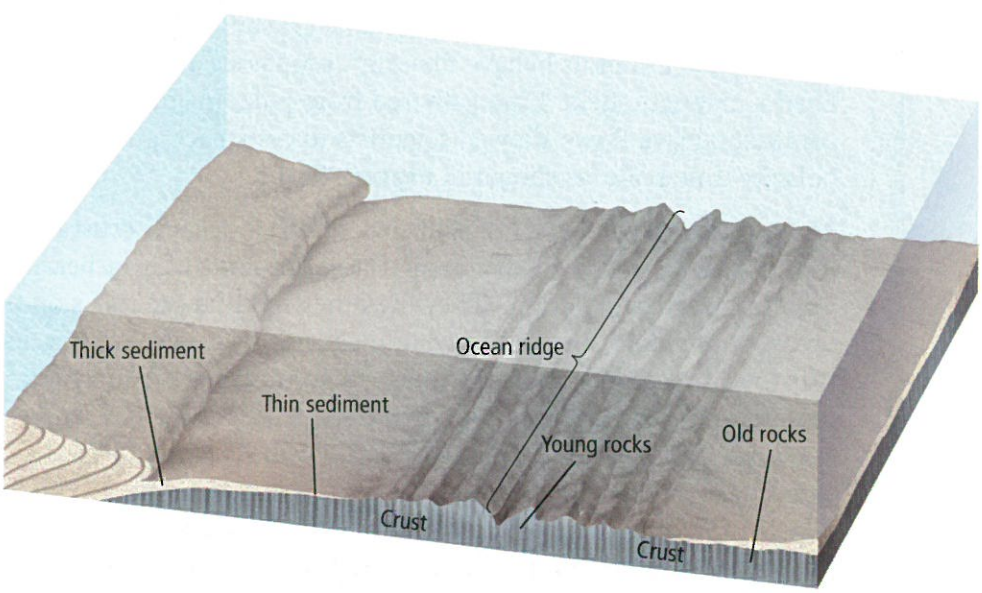


Figure 17.9 The ages of ocean crust and the thicknesses of ocean-floor sediments increase with distance from the ridge.

Figure 17.10 Earth's magnetic field is generated by the flow of molten iron in the liquid outer core. The polarity of the field changes over time from normal to reversed.

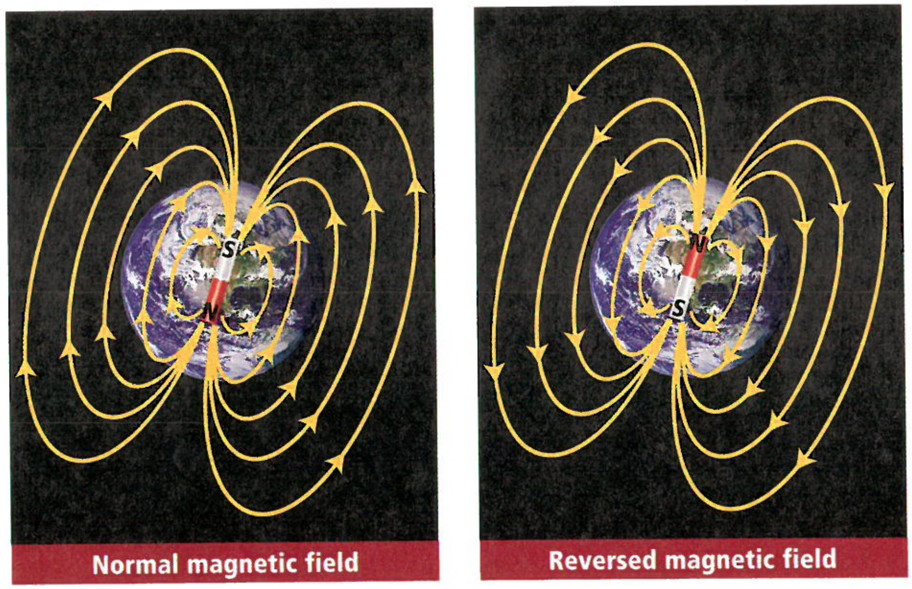
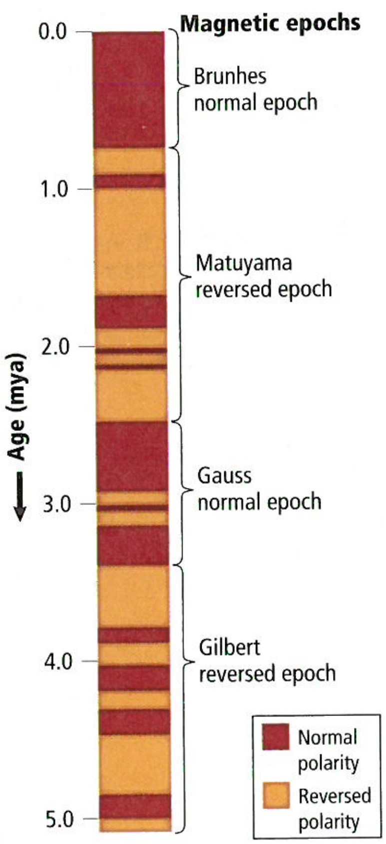


Figure 17.11 Periods of normal polarity alternate with periods of reversed polarity. Long-term changes in Earth's magnetic field, called epochs, are named as shown here. Short-term changes are called events.



Magnetism

Earth has a magnetic field generated by the flow of molten iron in the outer core. This field is what causes a compass needle to point to the North. A **magnetic reversal** happens when the flow in the outer core changes, and Earth's magnetic field changes direction. This would cause compasses to point to the South. Magnetic reversals have occurred many times in Earth's history. As shown in **Figure 17.10,** a magnetic field that has the same orientation as Earth's present field is said to have normal polarity. A magnetic field that is opposite to the present field has reversed polarity.

Magnetic polarity time scale **Paleomagnetism** is the study of the history of Earth's magnetic field. When lava solidifies, iron-bearing minerals such as magnetite crystallize. As they crystallize, these minerals behave like tiny compasses and align with Earth's magnetic field. Data gathered from paleomagnetic studies of continental lava flows allowed scientists to construct a magnetic polarity time scale, as shown in **Figure 17.11.**

Magnetic symmetry Scientists knew that oceanic crust is mostly basaltic rock, which contains large amounts of iron-bearing minerals of volcanic origin. They hypothesized that the rocks on the ocean floor would show a record of magnetic reversals. When scientists towed magnetometers behind ships to measure the magnetic orientation of the rocks of the ocean floor, a surprising pattern emerged. The regions with normal and reverse polarity formed a series of stripes across the floor parallel to the ocean ridges. The scientists were doubly surprised to discover that the ages and widths of the stripes matched from one side of the ridges to the other. Compare the magnetic pattern on opposite sides of the ocean ridge shown in **Figure 17.12.**

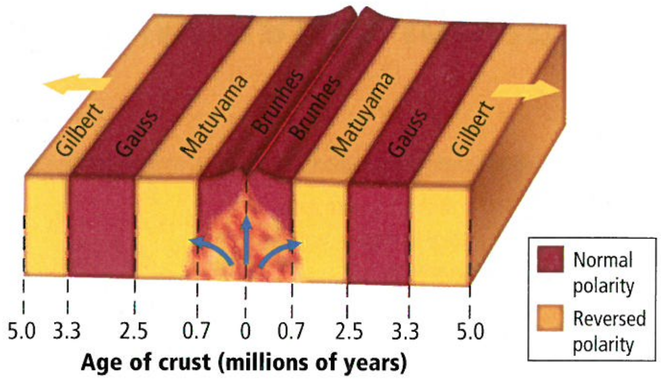
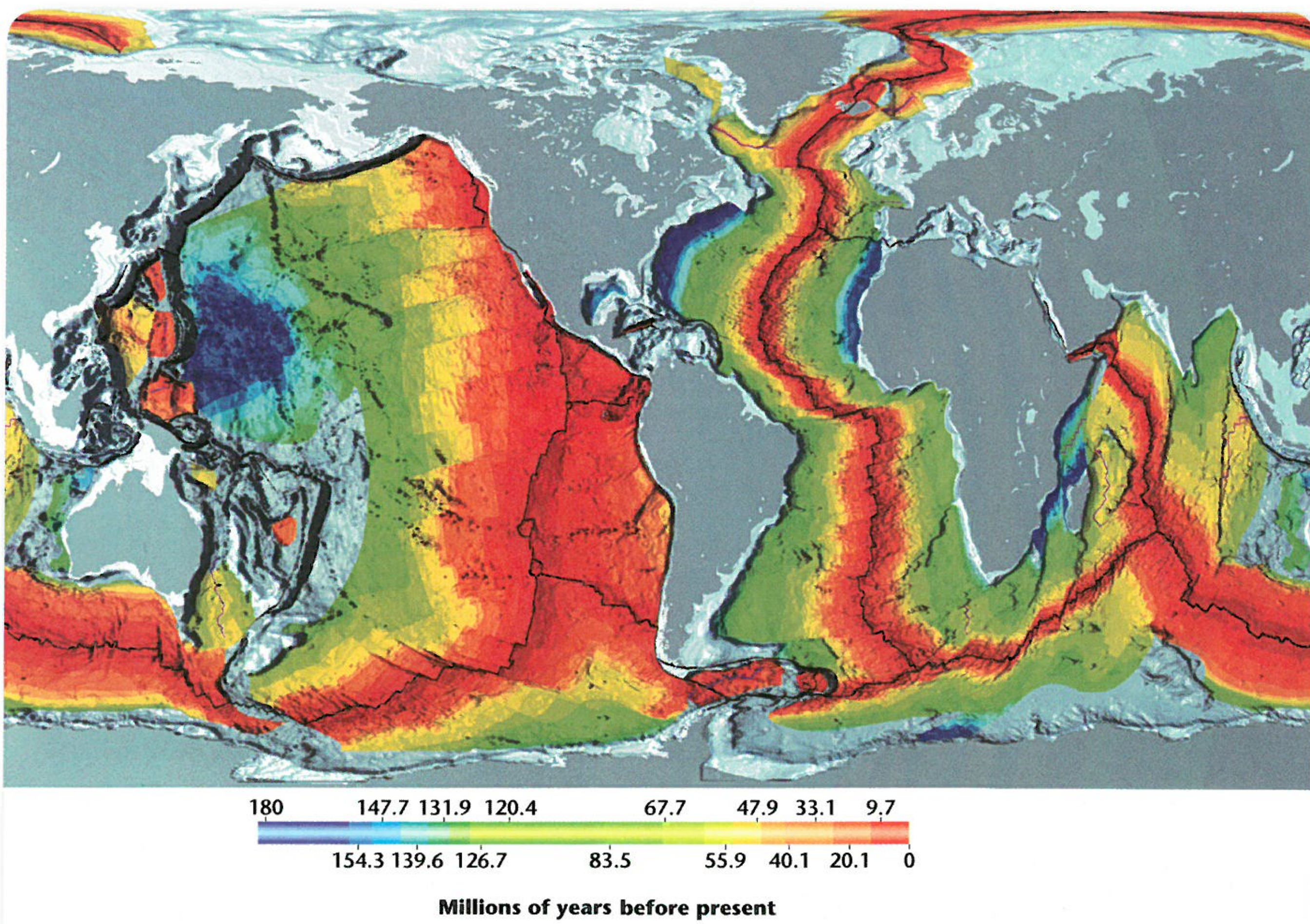


Figure 17.12 Reversals in the polarity of Earth's magnetic field are recorded in the rocks that make up the ocean floor.
Identify ***the polarity of the most recently produced basalt at the ocean ridge.***

By matching the patterns on the seafloor with the known pattern of reversals on land, scientists were able to determine the age of the ocean floor from magnetic recording. This method enabled scientists to quickly create isochron (I suh krahn) maps of the ocean floor. An **isochron** is an imaginary line on a map that shows points that have the same age—that is, they formed at the same time. In the isochron map shown in **Figure 17.13,** note that relatively young ocean-floor crust is near ocean ridges, while older ocean crust is found along deep-sea trenches.

Figure 17.13 Each colored band on this isochron map of the ocean floor represents the age of that strip of the crust.
Observe ***What pattern do you observe?***

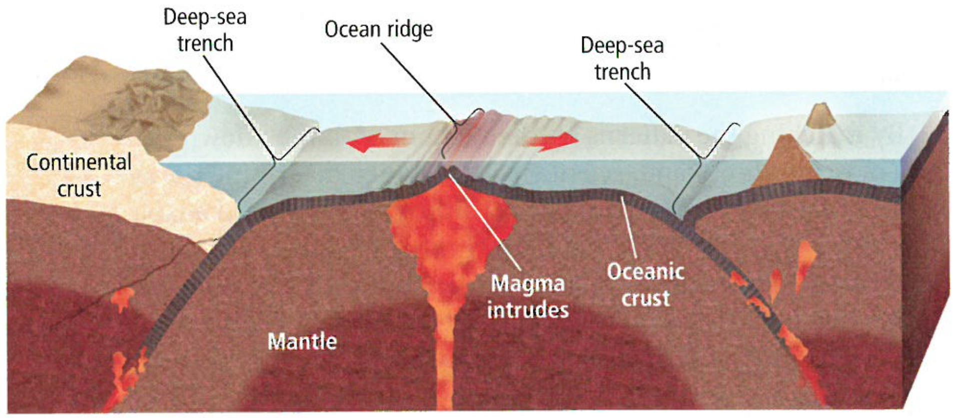


NATIONAL GEOGRAPHIC

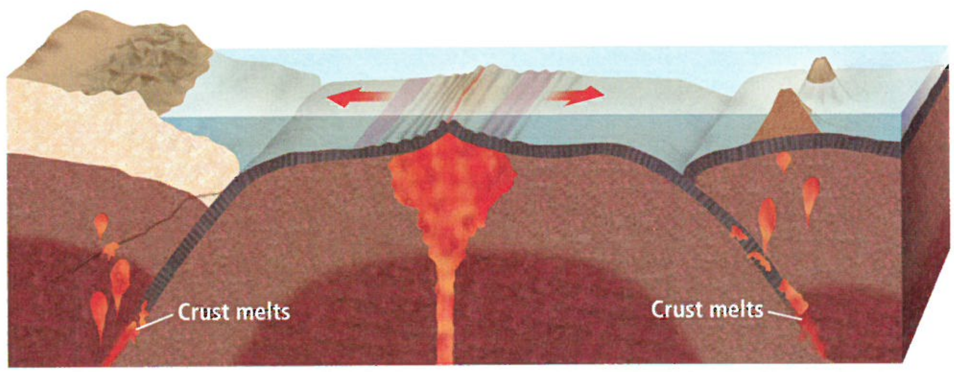
Visualizing Seafloor Spreading

Figure 17.14 Data from topographic, sedimentary, and paleomagnetic research led scientists to propose seafloor spreading. Seafloor spreading is the process by which new oceanic crust forms at ocean ridges, and slowly moves away from the spreading center until it is subducted and recycled at deep-sea trenches.

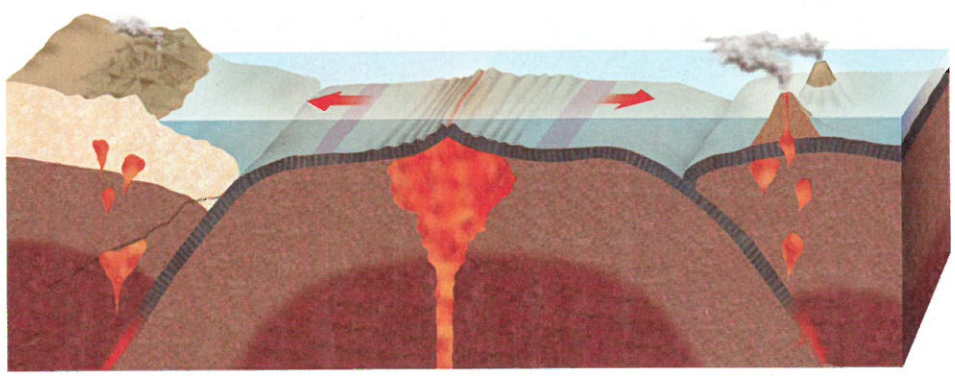
Magma intrudes into the ocean floor along a ridge and fills the gap that is created. When the molten material solidifies, it becomes new oceanic crust.



The continuous spreading and intrusion of magma result in the addition of new oceanic crust. Two halves of the oceanic crust spread apart slowly, and move apart like a conveyor belt.



The far edges of the oceanic crust sink beneath continental crust. As it descends, water in the minerals causes the oceanic crust to melt, forming magma. The magma rises and forms part of the continental crust.



Concepts In Motion To explore more about seafloor spreading, visit glencoe.com.

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Seafloor Spreading

Using all the topographic, sedimentary, and paleomagnetic data from the seafloor, seafloor spreading was proposed. **Seafloor spreading** is the theory that explains how new ocean crust is formed at ocean ridges and destroyed at deep-sea trenches. **Figure 17.14** illustrates how seafloor spreading occurs.

During seafloor spreading, magma, which is hotter and less dense than surrounding mantle material, is forced toward the surface of the crust along an ocean ridge. As the two sides of the ridge spread apart, the rising magma fills the gap that is created. When the magma solidifies, a small amount of new ocean floor is added to Earth's surface. As spreading along a ridge continues, more magma is forced upward and solidifies. This cycle of spreading and the intrusion of magma continues the formation of ocean floor, which slowly moves away from the ridge. Of course, seafloor spreading mostly happens under the sea, but in Iceland, a portion of the Mid-Atlantic Ridge rises above sea level. **Figure 17.15** shows lava erupting along the ridge.

Recall that while Wegener collected many data to support the idea that the continents are drifting across Earth's surface, he could not explain what caused the landmasses to move or how they moved. Seafloor spreading was the missing link that Wegener needed to complete his model of continental drift. Continents are not pushing through ocean crust, as Wegener proposed. In fact, continents are more like passengers that ride along while ocean crust slowly moves away from ocean ridges. Seafloor spreading led to a new understanding of how Earth's crust and rigid upper mantle move. This will be explored in the next sections.

Figure 17.15 The entire island of Iceland lies on the Mid-Atlantic ocean spreading center. Because the seafloor is spreading, Iceland is growing larger. In 1783, more than 12 km^3 of lava erupted—enough to pave the entire U.S. interstate freeway system to a depth of 10 m.

Section 17.2 Assessment

Section Summary

- Studies of the seafloor provided evidence that the ocean floor is not flat and unchanging.
- Oceanic crust is geologically young.
- New oceanic crust forms as magma rises at ridges and solidifies.
- As new oceanic crust forms, the older crust moves away from the ridges.

Understand Main Ideas

1. MAIN Idea **Describe** why seafloor spreading is like a moving conveyor belt.
2. **Explain** how ocean-floor rocks and sediments provided evidence of seafloor spreading.
3. **Differentiate** between the terms *reversed polarity* and *normal polarity.*
4. **Describe** the topography of the seafloor.

Think Critically

5. **Explain** how an isochron map of the ocean floor supports the theory of seafloor spreading.
6. **Analyze** Why are magnetic bands in the eastern Pacific Ocean so far apart compared to the magnetic bands along the Mid-Atlantic Ridge?

MATH in Earth Science

7. Analyze **Figure 17.11.** What percentage of the last 5 million years has been spent in reversed polarity?

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