Plate Tectonics

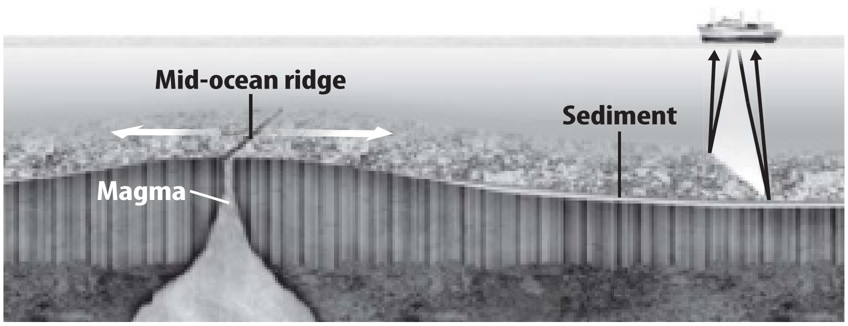
Development of a Theory

Read to Learn

Mapping the Ocean Floor

Scientists began exploring the seafloor in greater detail during the late 1940s. They used a device called an echo sounder to measure the depths of the ocean floor. An echo sounder produces sound waves that travel from a ship to the seafloor. The waves echo, or bounce, off the seafloor and back to the ship. The echo sounder records the time it takes the echo to return. When the ocean is deeper, the time it takes for the sound waves to bounce back is longer. Scientists calculated ocean depths and used these data to create topographic maps of the seafloor.

These new topographic maps showed large mountain ranges that stretched for many miles along the seafloor. *The mountain ranges in the middle of the oceans are called* **mid-ocean ridges.** Mid-ocean ridges, shown in the figure below, are much longer than any mountain range on land.



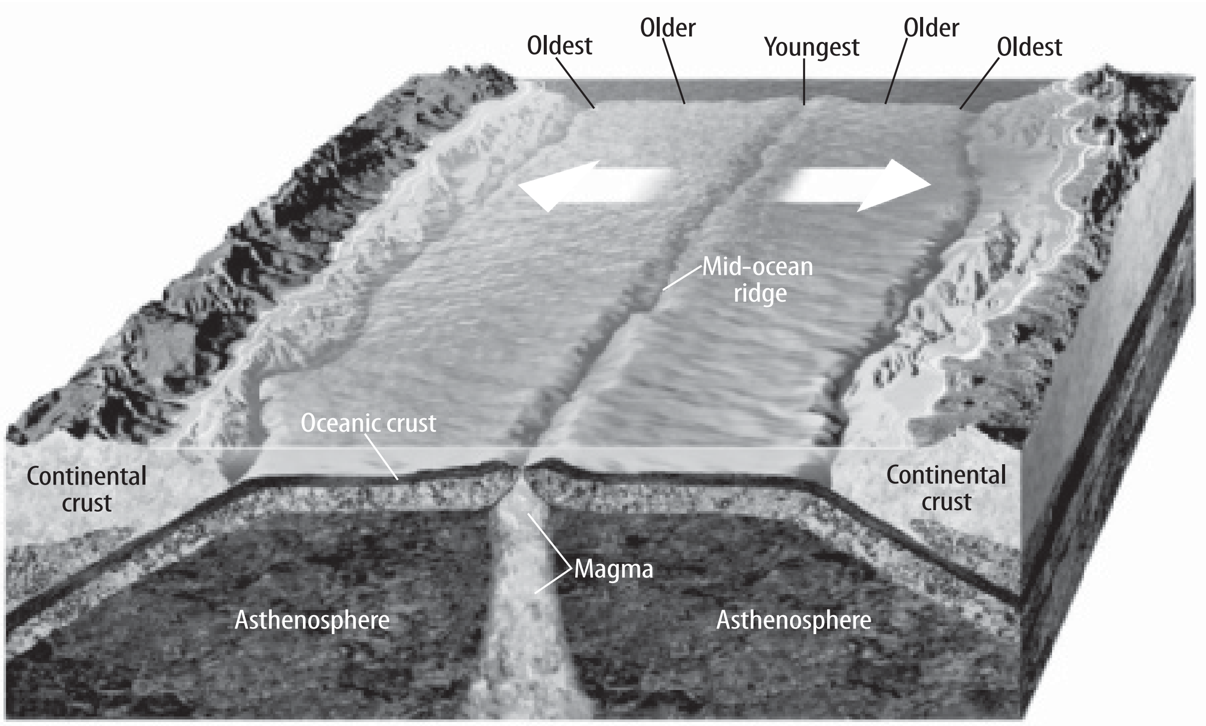
Seafloor Spreading

By the 1960s, scientists had discovered a new process to help explain continental drift. This process is called seafloor spreading. **Seafloor spreading** *is the process by which new oceanic crust forms along a mid-ocean ridge and older oceanic crust moves away from the ridge.*

When the seafloor spreads, Earth's mantle melts and forms magma. The liquid magma is less dense than the solid mantle. The magma rises through cracks in the crust along the mid-ocean ridge. When magma reaches Earth's surface, it is called lava.

As the lava cools and crystallizes on the seafloor, it forms a type of rock called basalt. Oceanic crust is mostly basalt. Because the lava erupts into water, it cools rapidly. The rapidly cooling lava forms rounded structures called pillow lava.

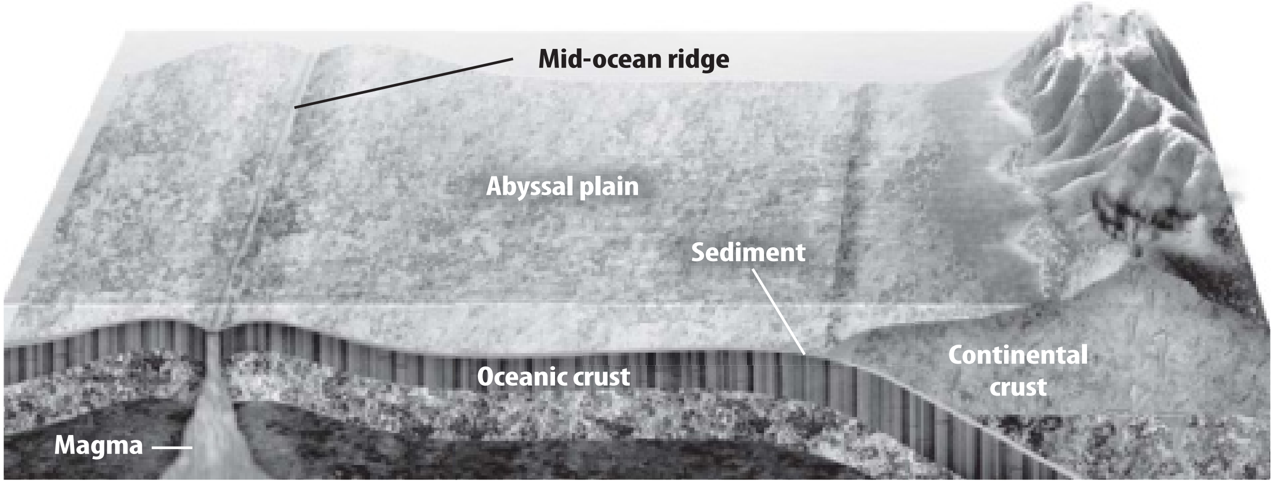
As the seafloor spreads apart, new crust that is forming pushes the older crust away from the mid-ocean ridge. The mid-ocean ridge, at the center of this formation, is shown below. The closer the crust is to a mid-ocean ridge, the younger the oceanic crust is. Scientists concluded that as the seafloor spreads, the continents must be moving. Seafloor spreading is the mechanism that explains Wegener's hypothesis of continental drift.



Topography of the Seafloor

What determines the topography of the ocean floor? One factor is seafloor spreading. The rugged mountains that make up the mid-ocean ridge system can form in two different ways. Some form as large amounts of lava erupt from the center of the ridge. That lava cools and builds up around the ridge. Others form as the lava cools and forms new crust that cracks. The rocks move up or down along these cracks and form jagged mountains.

Sediment also determines the topography of the ocean floor. Close to a mid-ocean ridge, the crust is young, and there is not much sediment. However, farther from the ridge, sediment becomes thick enough to make the seafloor smooth. This deep, smooth part of the ocean floor, shown below, is called the abyssal (uh BIH sul) plain.



Moving Continents Around

The theory of seafloor spreading provides a way to explain how continents move. Continents do not move through the solid mantle or the seafloor. However, seafloor spreading suggests that continents move as the seafloor spreads along a mid-ocean ridge.

Development of a Theory

Just as evidence was needed to support continental drift, evidence was needed to support seafloor spreading. Some of the evidence to support seafloor spreading came from rocks on the ocean floor that were not covered with sediment. Scientists studied the magnetic signatures of minerals in these rocks. They discovered two important things. First, Earth's magnetic field changes. Second, these changes appear in rocks that make up the ocean floor.

Magnetic Reversals

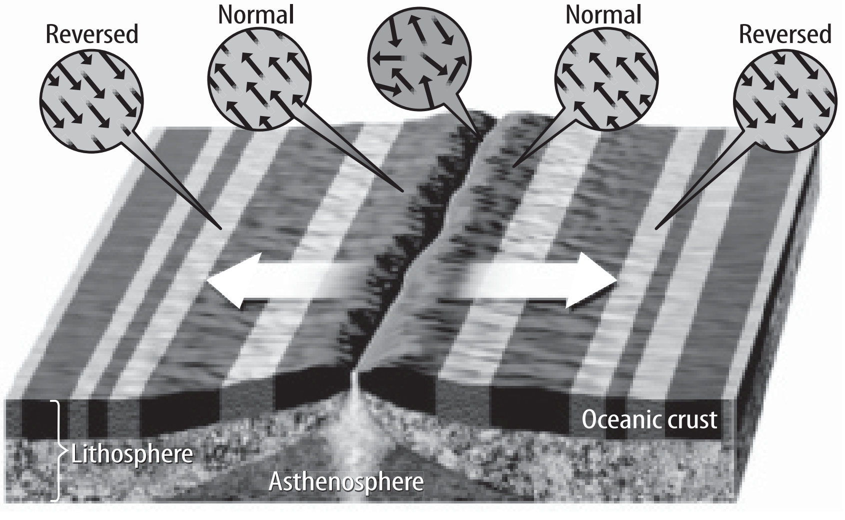
Earth's iron-rich, liquid outer core is like a giant magnet that creates Earth's magnetic field. The direction of this magnetic field is not always the same. Today's magnetic field is described as having normal polarity. **Normal polarity** *is a state in which magnetized objects, such as compass needles, will orient themselves to point north.*

Sometimes a **magnetic reversal** *occurs and the magnetic field reverses direction.* The opposite of normal polarity is reversed polarity. **Reversed polarity** *is a state in which magnetized objects reverse direction and orient themselves to point south.*

Magnetic reversals have occurred hundreds of times in Earth's past. They occur every few hundred thousand to every few million years.

Rocks Reveal Magnetic Signature

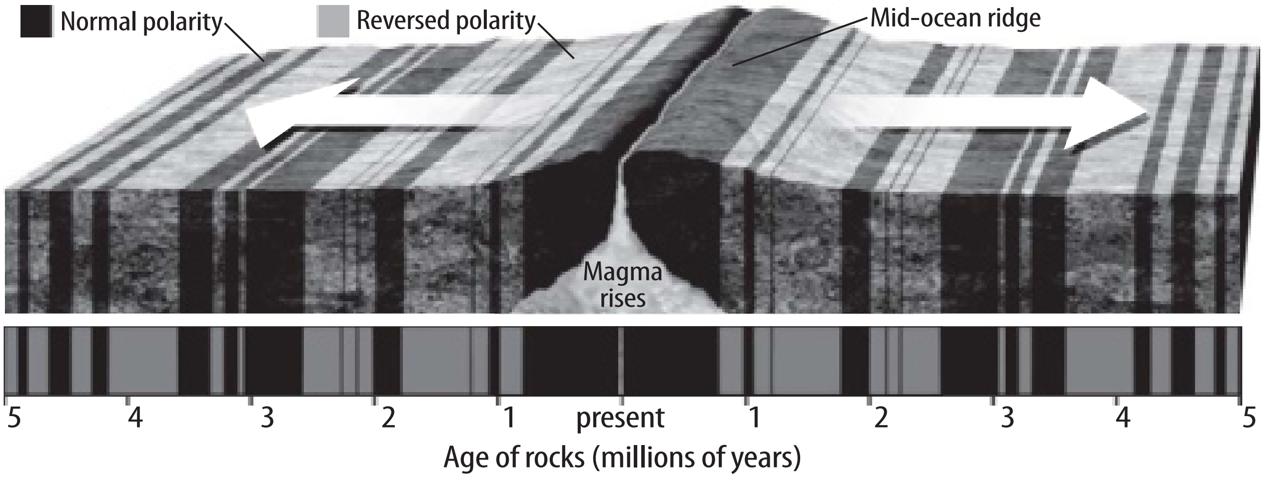
Ocean crust contains large amounts of basalt. Basalt contains iron-rich minerals that are magnetic. Each mineral acts like a small magnet. The figure below shows how magnetic minerals align themselves with Earth's magnetic field. When lava erupts along a mid-ocean ridge, it cools, crystallizes, and permanently records the direction of Earth's magnetic field at the time of the eruption. Scientists have discovered parallel patterns in the magnetic signature of rocks on either side of mid-ocean ridges. For example, in the figure below, notice the normal pattern exists closest to either side of the mid-ocean ridge. Likewise, the reversed polarity pattern exists at about the same distance on either side of the mid-ocean ridge.



Evidence to Support the Theory

To support the theory of seafloor spreading, scientists collected data about the magnetic minerals in rocks from the seafloor. They used a magnetometer (mag nuh TAH muh tur) to measure and record the magnetic signature of these rocks. The data collected showed parallel magnetic stripes on either side of the mid-ocean ridge, as shown below. What do these stripes mean?

Each pair of magnetic stripes is similar in composition, age, and magnetic character. Each stripe also records whether Earth's magnetic field was in a period of normal or reversed polarity when the crust formed. Notice that the stripes on either side of the ridge are the same. This pattern supports the idea that ocean crust forms along mid-ocean ridges and is carried away from the center of the ridges.



Other measurements made on the seafloor confirm seafloor spreading. Scientists drilled holes in the seafloor and measured the temperature below the surface. These temperatures show how much thermal energy leaves Earth. Scientists discovered that more thermal energy leaves Earth near mid-ocean ridges than is released from beneath abyssal plains. In addition, studies of sediment show that sediment closest to a mid-ocean ridge is younger and thinner than sediment farther away from the ridge.