11.2 Sea-floor Spreading

In Wegener's time, the world's ocean floors were largely unexplored. Mapping the sea floor provided more important evidence for the theory of plate tectonics.

Undersea mountains discovered

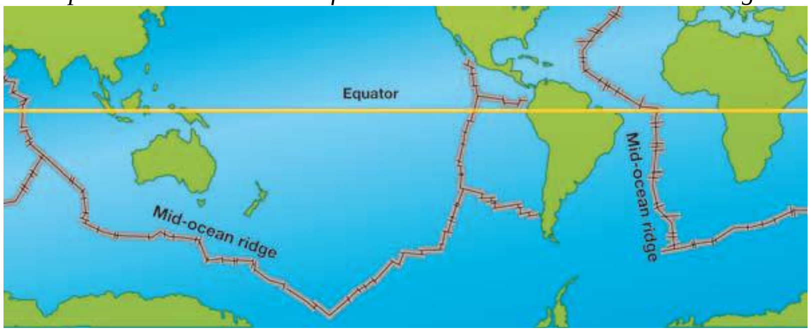
A map of the ocean floor

During World War II, the United States Navy needed to locate enemy submarines hiding on the bottom of shallow seas. Because of this, large areas of the ocean floor were mapped for the first time. American geophysicist and naval officer Harry Hess did some of the mapping. His work helped develop the theory of plate tectonics.

Mid-ocean ridges

The naval maps showed huge mountain ranges that formed a continuous chain down the centers of the ocean floors. These mountain ranges are called **mid-ocean ridges**. Hess wondered if it was possible that new ocean floor was created at mid-ocean ridges. If new ocean floor formed at a ridge, then continents on either side would get pushed apart during the process (Figure 11.4).

Figure 11.4: *Harry Hess wondered if it was possible that new ocean floor was created at the mid-ocean ridges.*



The sea-floor spreading hypothesis

A hypothesis is born

Hess thought that Wegener was partly right. The continents *had* separated from a supercontinent, but not by plowing through the sea floor. Instead, continents moved along as part of the growing sea floor! Hess called his hypothesis **sea-floor spreading**.

A good idea needs more evidence

Sea-floor spreading was an intriguing hypothesis. But for many years scientists had viewed the continents as permanently fixed in place. Sea-floor spreading would need strong evidence to support it before it would ever be more than just a hypothesis.

Rapid scientific progress

A time of tremendously rapid scientific progress followed Hess' sea-floor spreading hypothesis. Many scientists added to each other's work and found the evidence needed to explain sea-floor spreading.

Magnetic patterns and the age of rocks

The discovery of *magnetic reversal patterns* in the rocks on both sides of the mid-ocean ridges was a key piece of evidence. These striped patterns are formed as magnetic minerals found within newly formed rock align to Earth's magnetic field as the rock cools. Scientists noticed that the magnetic patterns matched on either side of a ridge (Figure 11.5). They also noticed that the oldest rocks were furthest from the ridge. These observations showed that sea-floor spreading was occurring—the new ocean floor that forms at mid-ocean ridges moves away from the ridges as time passes.

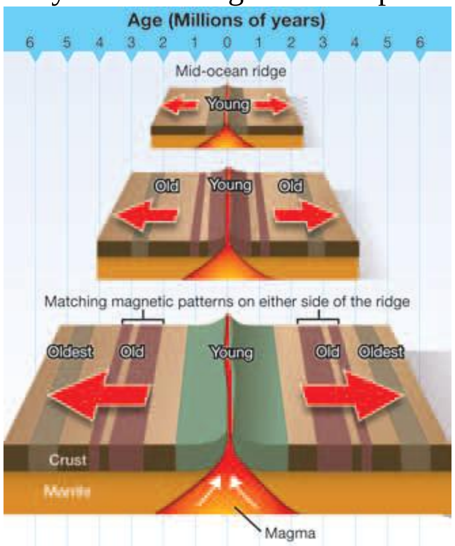


Figure 11.5: *Matching magnetic reversal patterns and the age of rocks on either side of mid-ocean ridges provided strong evidence for sea-floor spreading.*

Moving pieces of the lithosphere

After a breakthrough

After the breakthrough discovery of magnetic patterns was understood, there was a lot of interest in the idea of sea-floor spreading. Scientists realized that large pieces of Earth's surface moved about like rafts on a river. Today we know these "rafts" are pieces of lithosphere called **lithospheric plates** that move over the asthenosphere. Plate tectonics is the study of these lithospheric plates. There are two kinds of lithospheric plates: **oceanic plates** and **continental plates**. Oceanic plates form the floor of the ocean. They are thin and mostly made of dense basalt. Continental plates are thicker and less dense than oceanic plates. Continental plates are made of andesite and granite.

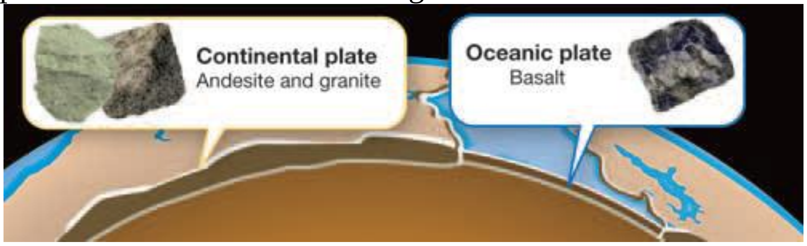


Plate tectonics answers other questions

Science is a process that builds on itself. Early discoveries provide a better understanding that leads to more discoveries. The evidence that Alfred Wegener collected to support an ancient supercontinent is valid today. And our understanding of plate tectonics has allowed us to answer other questions such as:

- Why are volcanoes and earthquakes located where they are?
- Where can we find oil, gas, gold, and other important resources?

What drives lithospheric plates?

Convection cells

Convection cells in Earth's lower mantle drive the lithospheric plates on the surface. Earth's core heats the rock material of the lower mantle. As it is heated, it expands and becomes less dense.

What happens at mid-ocean ridges?

The lower mantle rock material rises toward Earth's surface. Lithospheric plates move apart over the rising part of a convection cell. Basaltic lava is extruded between the plates along the midocean ridge. The basaltic lava adds to the plates so that they grow in size. Over time, as newly formed plate material moves away from the mid-ocean ridge, it ages, cools, and becomes denser.

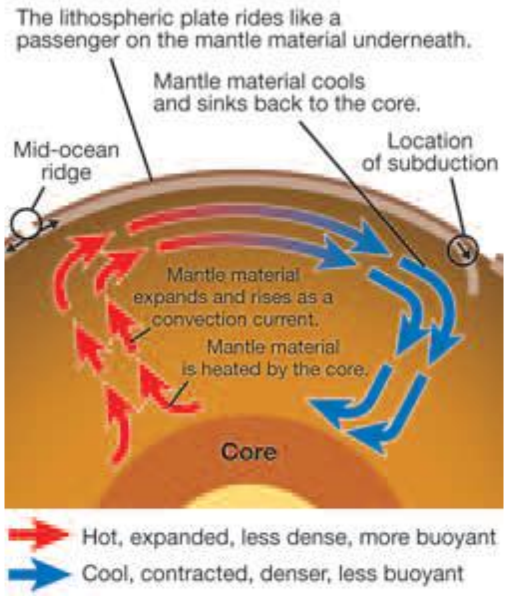


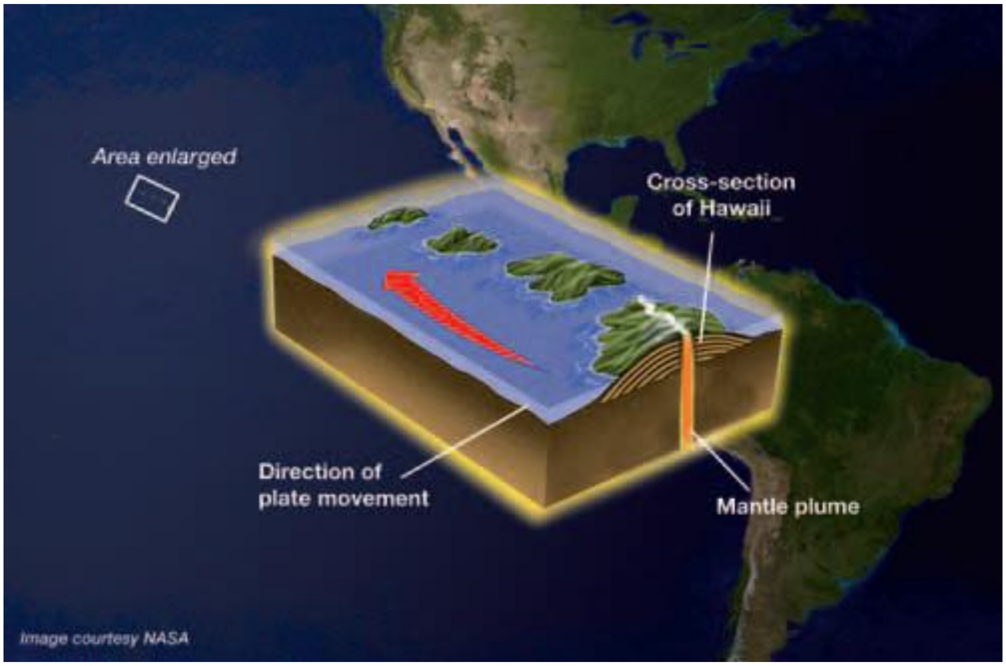
Figure 11.6: *A convection cell in the lower mantle.*

Subduction

The cooler, denser edge of a lithospheric plate eventually sinks below another lithospheric plate and enters the mantle (Figure 11.6). This sinking process is called **subduction**. As the subducting plate enters the mantle, it cools the adjacent mantle material. Cooling makes the nearby material denser and it sinks deeper into the mantle. This sinking completes the mantle convection cell. Subduction also happens when a denser oceanic plate encounters a continental plate. The oceanic plate subducts under the continental plate.

Hot spots and island chains

Volcanic activity can be found on mid-ocean ridges. Sometimes a single, hot, rising **mantle plume** causes a volcanic eruption in the plate above it. If the eruption is strong and lasts long enough, the volcanic eruption may form an island on the plate. After the island forms, the movement of the plate carries it away from the mantle plume. Without the heat from the mantle plume underneath, the volcano that formed the island becomes dormant. In the meantime, a new volcano begins to form on the part of the plate that is now over the mantle plume. This process can repeat over and over, forming a chain of islands. The first island formed in the chain is made of old dormant volcanoes, while the most recent island in the chain generally has active volcanoes. Scientists determine the direction and speed of plate movement by measuring these island chains. The speed of moving plates ranges from 1 to 10 centimeters each year. The Hawaiian Islands are a good example of an island chain formed by a mantle plume hot spot.



11.2 Section Review

1. Explain why magnetic patterns are important evidence for plate tectonics.

2. How were mid-ocean ridges discovered?

3. What was Harry Hess' hypothesis regarding the ocean floor and how it was made?

4. What two discoveries supported Hess' hypothesis?

5. What is the study of lithospheric plates called?

6. Over what surface do lithospheric plates move?
a. lower mantle b. outer core
c. inner core d. asthenosphere

7. Name the two types of lithospheric plates and describe them.

8. What are some questions that are answered by plate tectonics?

9. What is the source of energy that drives the movement of the lithospheric plates?

10. Do lithospheric plates move quickly or slowly? Explain your answer.

11. Describe the process of subduction in your own words. What causes subduction to happen?

12. Name an example of an island chain formed by a mantle plume hot spot. Describe/draw the process of how it formed.