Evidence for Continental Drift

The map of the world is a common sight on classroom walls. Look at Figure 5.36. Can you see where the bulge of South America could fit into the indented side of Africa? Are there other continents that might fit together?

The fit of the continents was a mystery to scientists for a long time. If the continents were fixed in place, why did they look as though they had once been joined? One scientist who wondered about the fit of the continents was Alfred Wegener (1880–1930).

Figure 5.36 The map above shows the location of three kinds of fossils that have been found on many different continents. Notice that fossils of *Glossopteris* have been found on Antarctica, which is totally covered with ice now.

Biological Evidence

In his research, Wegener noticed that several fossils of similar plants and animals (like those in Figure 5.36) had been found on different continents. *Mesosaurus* lived in freshwater lakes, and its fossils have been found in eastern South America and southern Africa. If it was able to swim in salt water, why did it not swim to more locations?

Lystrosaurus could not swim at all, but travelled from South America to Africa. It must have travelled by some sort of land connection.

Several explanations were offered for this biological evidence (evidence from plants and animals). Perhaps a bridge of land between the continents had existed, then disappeared. Maybe trees had fallen into the water, enabling animals to cross the ocean. At one time the ocean might have been lower and islands had existed close enough together to allow the animals to cross.

Wegener studied the fossil evidence and the interlocking shapes of the continents. He concluded the continents had been joined together when the fossil animals and plants had been alive. Over thousands, maybe millions, of years, the continents had gradually moved to their present locations. Wegener called his explanation **continental drift**.

Evidence from Rocks

Wegener continued his research. He examined the observations of other scientists to see if there might be more evidence to support the idea of continental movement. He discovered that geologists had found similarities in rocks on both sides of the Atlantic Ocean. A mountain range, called the Appalachians, in eastern North America was made of the same kind and ages of rock as the mountain range that ran through Britain and Norway (see Figure 5.37).

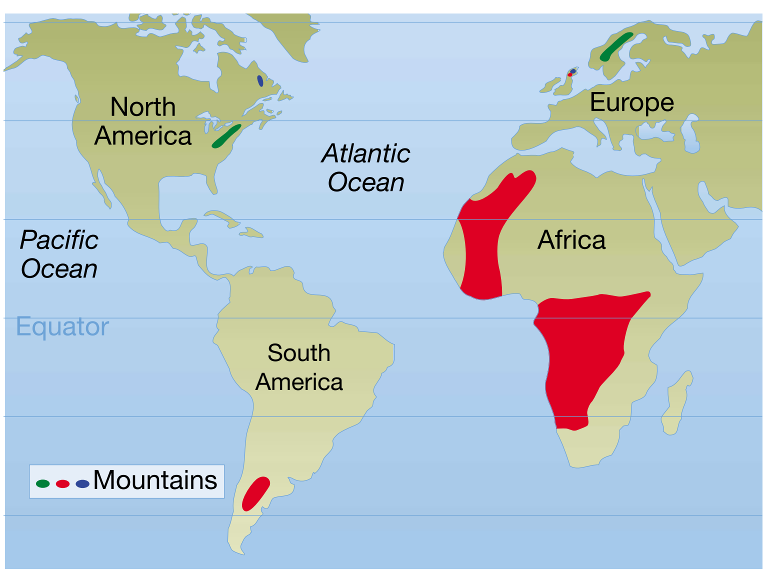
A further clue came from fossils of trilobites found high up on the Himalayan Mountains in India. These trilobites roamed the ancient seas 250 to 500 million years ago. How did trilobites end up on the "roof" of the world? The evidence suggested that India was once a separate piece of land. Many millions of years ago, India drifted into Eurasia. The collision pushed rocks containing fossils from the bottom of the sea up to the top of the Himalayan mountains (see Figure 5.38).

Geological Evidence of Climate

Coal provided further important information about Earth's history. In order for coal to form, there has to be rich, luxurious plant life in a tropical, swampy environment. The coal beds that exist in North America, Europe, and Antarctica are now in moderate to cold climates. How did tropical plants grow there in the past? Why has the climate changed in so many places?

For Wegener, the clues provided by geological evidence of climatic change raised questions that had no easy answers. Since Wegener was trained as a meteorologist, he was especially interested in these clues. He found evidence of even greater climatic changes in places that had probably been covered by glaciers.

Figure 5.37 How could mountains formed from the same type of rock occur thousands of kilometres from each other across an ocean?



Ancient glacial deposits (200 to 300 million years old) were found spread over the southern hemisphere. Layers of deposits left behind by glaciers were found in southern Africa, South America, India, and Australia. Under the deposits in some places, there were grooves in the bedrock showing the direction in which the glaciers had moved. All of these locations now had very warm climates, much too warm for glaciers. Was the whole world cold, or had these land masses moved to their present warm locations from a place nearer to the South Pole?

INTERNET CONNECT

www.mcgrawhill.ca/links/sciencefocus7

Find out more about Wegener by going to the web site above. Click on **Web Links** to find out where to go next. See if you can locate any drawings from Wegener's book. Find some information about him that you did not learn in this text, and use it to prepare a brief biography.

Response to Wegener

In 1915 Wegener published his findings in a book, written in German, called *The Origin of Continents and Oceans*. In the book, he stated that all of Earth's continents had been joined together in a giant supercontinent called Pangaea. Pangaea started breaking up about 200 million years ago, and the pieces began moving or drifting into their present locations. Wegener wrote, "It is just as if we were to refit the torn pieces of a newspaper by matching their edges and then check whether the lines of print run smoothly across. If they do, there is nothing left but to conclude that the pieces were in fact joined in this way."

To support his hypothesis about drifting continents, Wegener thought about what forces might be causing the movement. He proposed that the Moon might be responsible, but other scientists disagreed with him. Because Wegener could not satisfactorily explain the origin of the force that was moving the continents, the scientific community rejected his ideas on continental drift.

Wegener died in Greenland in 1930, still searching for evidence to support his theory of continental drift. Years later, advances in technology and the work of a Canadian scientist led to a new theory that explained Wegener's observations.

Figure 5.38 Earth may have looked like this 180 million years ago. Try to name the seven biggest land masses on the maps. Can you find India on the map?

Advances in Technology

Important and surprising clues about Earth's crust have been collected from the sea floor using **sonar** (sound wave technology), as shown in Figure 5.39A.

When many sonar tests from Earth's oceans were studied, the results amazed everyone. It was obvious that there were mountains on the sea floor. Moreover, there were long mountain ranges or ridges in some places, just like the mountain ranges that existed on land. Scientists identified a mountain ridge that stretched from north to south along the middle of the Atlantic Ocean. They called this ridge the Mid-Atlantic Ridge (see Figure 5.40).

The features found on the sea floor were similar to the features found on land. What was causing these mountains to form? The answer would come from another technology.

Cool Tools

Sonar stands for **So**und **N**avigation **a**nd **R**anging. This technology is used in nature by bats to navigate around objects in the dark. Sonar works by sending out a sound and then recording the time that the sound takes to bounce back. For example, scientists can bounce a sound off the ocean floor and measure the time that it takes to bounce back. Since they know how fast the sound travels, they can calculate the distance to the bottom of the ocean.

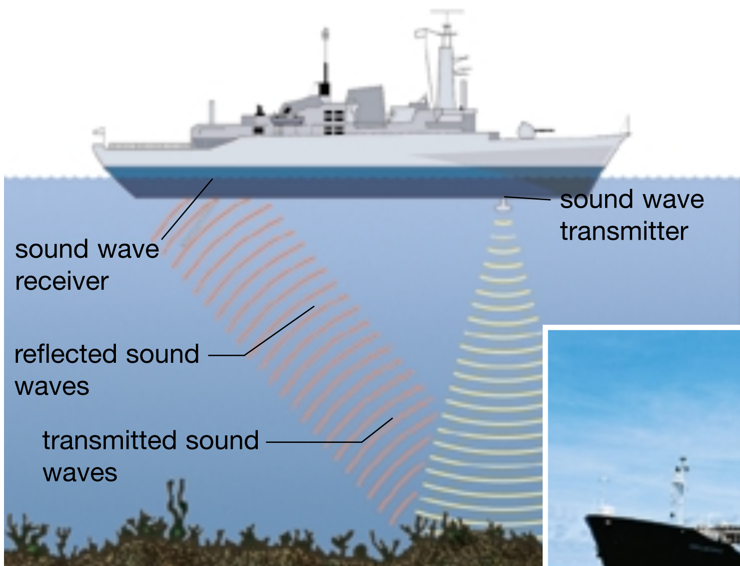


Figure 5.39A Sonar revealed that the ocean floor was not flat, as was previously believed.

Figure 5.39B The *Glomar Challenger* used oil-drilling technology to help scientists explore beneath the ocean floor.

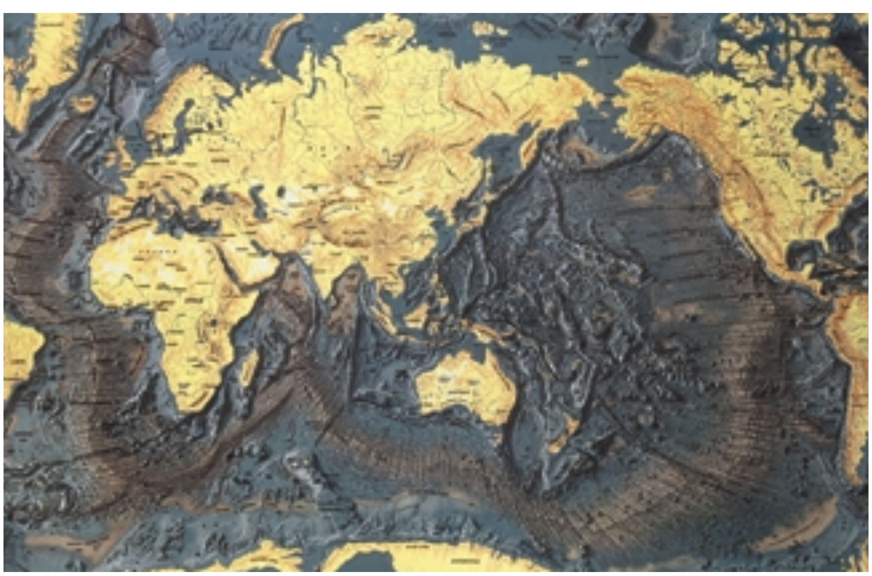
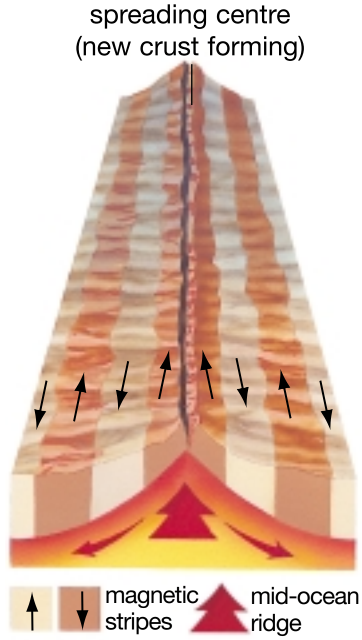


Figure 5.40 This map shows the mid-ocean ridges and the trenches. The long, ridged structures are the mid-ocean ridges.

Figure 5.41 The pattern of magnetic reversals on the sea floor led scientists to the theory of sea floor spreading. As new crust forms, it takes on the magnetic polarity of Earth at the time of formation.



Magnetometers are electronic instruments that can detect the direction and strength of a magnetic field. They usually record a magnetic field that points north. However, as the ships that carried them moved across the Atlantic Ocean, sometimes the magnetometers recorded a magnetic field that pointed south. A pattern of magnetic reversals was found travelling parallel to the Mid-Atlantic Ridge. The width and direction of the stripes on both sides of the Ridge were similar (see Figure 5.41). What was causing the reversals?

Igneous rock provided a clue. The magma that forms igneous rock contains iron-bearing minerals such as magnetite. These minerals line themselves up with Earth's magnetic field. As the molten rock hardens at Earth's surface, the mineral particles stay in line with the magnetic field. So the magnetic reversal stripes must have formed at a different time — a time when Earth experienced a reversal of its magnetic field. If the stripes lined up with the ridges, it could mean that the sea floor was spreading. It also meant that new rock was being formed at the mid-ocean ridges. The theory of **sea floor spreading** was formulated.

Ask an Expert

Turn to page 434 to find out how Charlotte Keen studies rock many kilometres below Earth's surface.

Find Out ACTIVITY

What Do the Rocks Tell Us?

What information can rocks provide about the ocean floor?

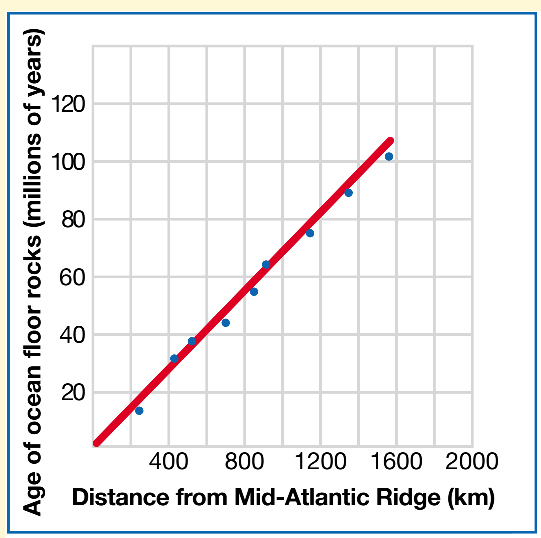
Procedure — Analyzing and Interpreting

The graph on the right is a "best fit" graph. The small dots represent samples of rock taken from the magnetic stripes at the bottom of the Atlantic Ocean. Each dot represents a sample of rock.

1. Find the age of the oldest rock and the youngest rock on the graph.
2. State the distance of the oldest rock and the youngest rock from the Mid-Atlantic Ridge.
3. Infer or predict some additional data for the graph.

What Did You Find Out?

What does this evidence suggest was happening to the sea floor? Explain your answer.



Find Out ACTIVITY

The Spreading Sea Floor

When magma rises from the mid-ocean ridge, it produces a new crust which pushes the plates apart. How can you create a model of this process?

Materials

sheet of paper (21 cm × 28 cm)

paints, markers, or coloured pencils

scissors

tape

Procedure

1. Cut the paper in half lengthwise. Tape the ends together to make one long strip.
2. Push two desks or tables together. Fold the long strip of paper in half. Hold the paper vertically under the crack between the desks. Push the open ends of the folded paper upward until the ends are about 5 cm above the desk.
3. Fold the ends and colour a pattern on them.
4. Push up another 5 cm and colour a different pattern.
5. Repeat until all the paper is at the surface.

What Did You Find Out?

1. What does the paper represent in your model?
2. What does the crack between the desks represent?
3. Which pattern on your strip represents the oldest rock? the youngest rock?

Deep Sea Drilling

Scientists confirmed the theory of sea floor spreading when they were able to bring up samples of rock for testing. The ship *Glomar Challenger* (see Figure 5.39B) carried equipment that could drill deep holes into the sea floor. Rock from the holes was brought onto the ship for testing by scientists. Can you imagine the excitement of the scientists who first examined these rock samples, knowing that they were the first people in the history of the world to do so! Tests of the rock samples showed that younger rock was closer to the Mid-Atlantic Ridge and older rock was closer to the continents. Scientists found that the Atlantic Ocean is getting wider by about 2 cm every year — about the same speed that your fingernails grow!

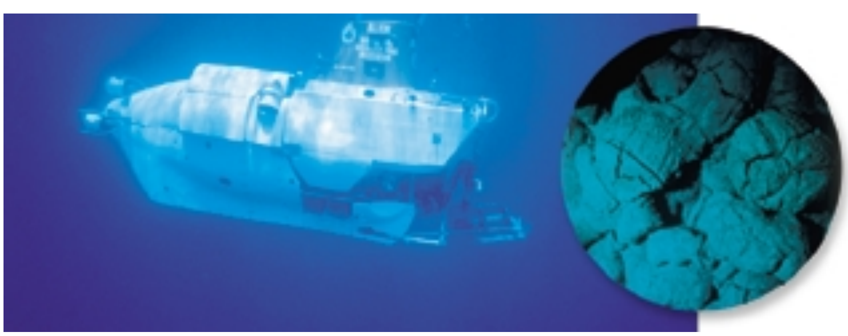


Figure 5.42 Advances in Canadian fibre technology have allowed submersibles to travel even deeper in the ocean. Submersibles like *Alvin* have made it possible for us to see lava coming out of cracks in the sea floor. The lava cools so quickly in the cold water that it is called "pillow lava." Why might it have been given this name?

Cool Tools

Even with scuba (**s**elf-**c**ontained **u**nderwater **b**reathing **a**pparatus) gear, deep-sea divers can go only a few hundred metres down into the ocean because of the tremendous pressure of the water on their bodies. Submersibles allow people to travel deeper into the ocean by protecting them from the pressure of the water. Submersibles are equipped with an air supply and powerful lights.

The Theory of Plate Tectonics

The evidence collected by advanced technology indicated that Earth's crust was moving. The crust was not fixed in place, as most people believed.

A Canadian scientist helped form a new theory to explain how the crust moves. The new theory stated that Earth's crust is broken up into pieces, called **plates**. These plates are always moving on Earth's mantle. Scientists called the new theory **the theory of plate tectonics.**

In Figure 5.43, the major plates are labelled. Can you see that most of the plates are named for the continent that is on the plate? Two plates pushing together are called **converging plates**. Two plates pulling apart are called **diverging plates**.

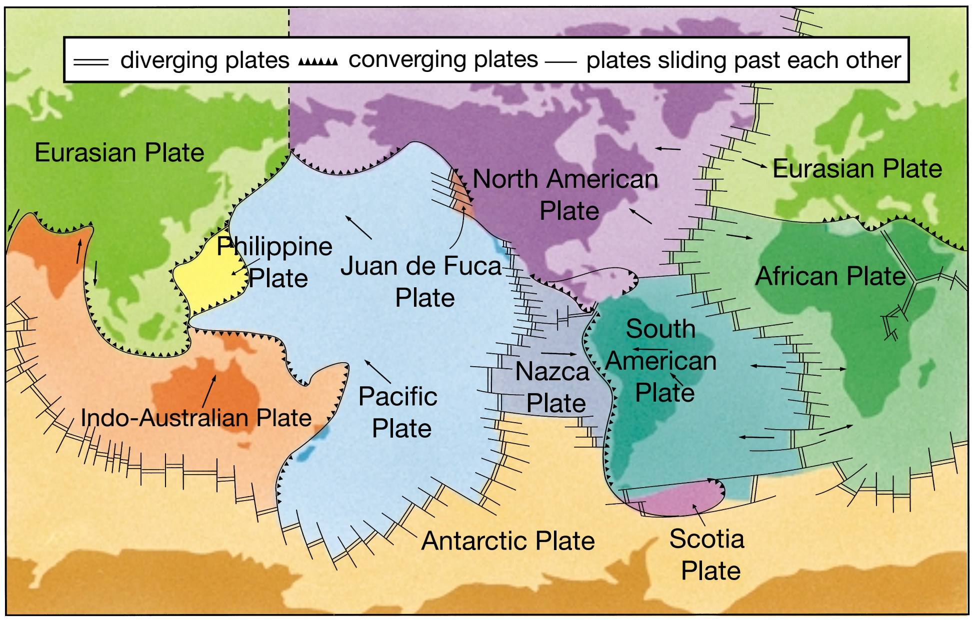


Figure 5.43 This diagram shows the major plates, their direction of movement, and the type of boundary between them. What is happening to the Juan de Fuca Plate where it meets the North American Plate?

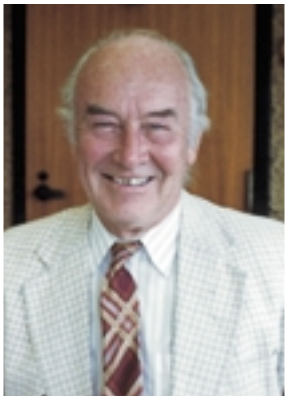


Figure 5.44 Tuzo Wilson (1908–1993)

J. Tuzo Wilson, a Canadian scientist, is one of the long line of scientists who have contributed to our understanding of Earth's crust (see Figure 5.44). He made an important addition to scientific observation when he developed the concept of a third kind of movement along plate boundaries. Instead of pushing together or pulling apart, he hypothesized that plates were sliding past each other.

Wilson's idea of sliding plates brought about a rethinking of Earth's crust movement.