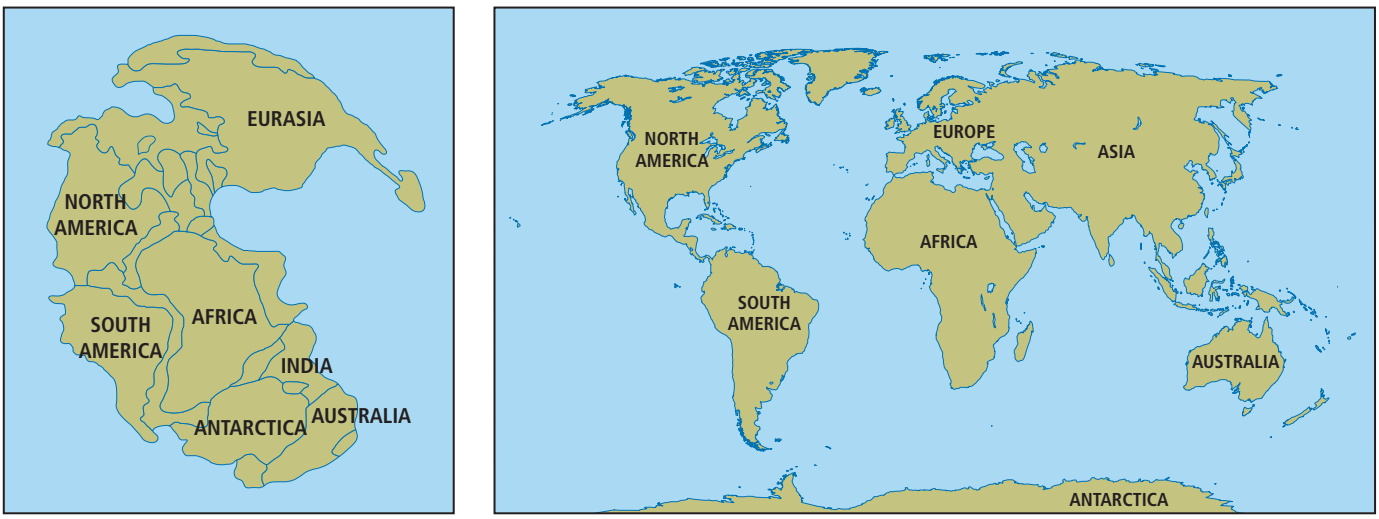
17.2 Evidence of a Dynamic Earth

Today we know that the surface of Earth moves constantly. New sections of lithosphere are produced and older sections are recycled. The lithosphere is divided up into **tectonic plates**, both large and small pieces that float on the denser asthenosphere. Plate tectonics is the theory that explains this plate movement and its consequences. As the plates move past, over, and under each other, they cause volcanoes, earthquakes, and faults. As the plates spread apart or collide, they form mountains, rift valleys, and a global network of ocean-floor ridges. This theory took a long time to develop and involved many scientists from different fields of study. It also required new technology such as sonar to gather supporting evidence.

Continental Drift

When people began drawing fairly accurate maps of the world, they were intrigued by the apparent fit of the continents. It looked as if they were puzzle pieces that had been pulled apart (Figure 1). In 1912, German meteorologist Alfred Wegener was also intrigued by this. He knew other scientists had gathered evidence of several more geological peculiarities:

- the puzzle fit of the continents (mainly Africa and South America)
- match of geological features on distant coastlines (eastern Americas match western Europe and Africa)
- identical ancient fossils on distant coastlines (Africa, South America, Australia)
- the presence of coal deposits in non-tropical areas (Antarctica)
- evidence of glaciers near the equator (Africa)



(a) (b)

Figure 1 (a) Alfred Wegener suggested that about 270 million years ago, all of the continents formed a single landmass he called Pangaea. (b) The continents today.

Wegener proposed a radical idea to explain this evidence: **continental drift theory**. This theory argues that the continents have moved slowly since Earth formed and were once joined together in a land mass called Pangaea.

The Fossil Record

Jigsaw puzzle fit is not the only reason to think the continents have moved. Some rare plant and animal fossils are found in distant parts of the world (Figure 2). For example, *Mesosaurus* was an aquatic reptile that lived during the early Permian era, more than 250 million years ago. Its fossilized remains have only been found in two places: on the southwest coast of Africa, and the southeast coast of South America. *Mesosaurus* was a fresh-water animal, so it would not have been able to migrate across the Atlantic Ocean. Wegener asked, were the continents closer together, at one time, so the animals could travel between them? As ridiculous as that may sound, Wegener felt that it was no more ridiculous than the common belief that many species migrated via "land bridges" that might once have existed between the continents. There was no evidence of such bridges.

STUDY TIP

You can use a table to help you organize information for studying. Make a three-column table with the following headings: Fossil Record, Matching Mountains, and Ancient Glacial Evidence. Under the appropriate heading, record important information in point-form notes. Include the words in bold in your notes.

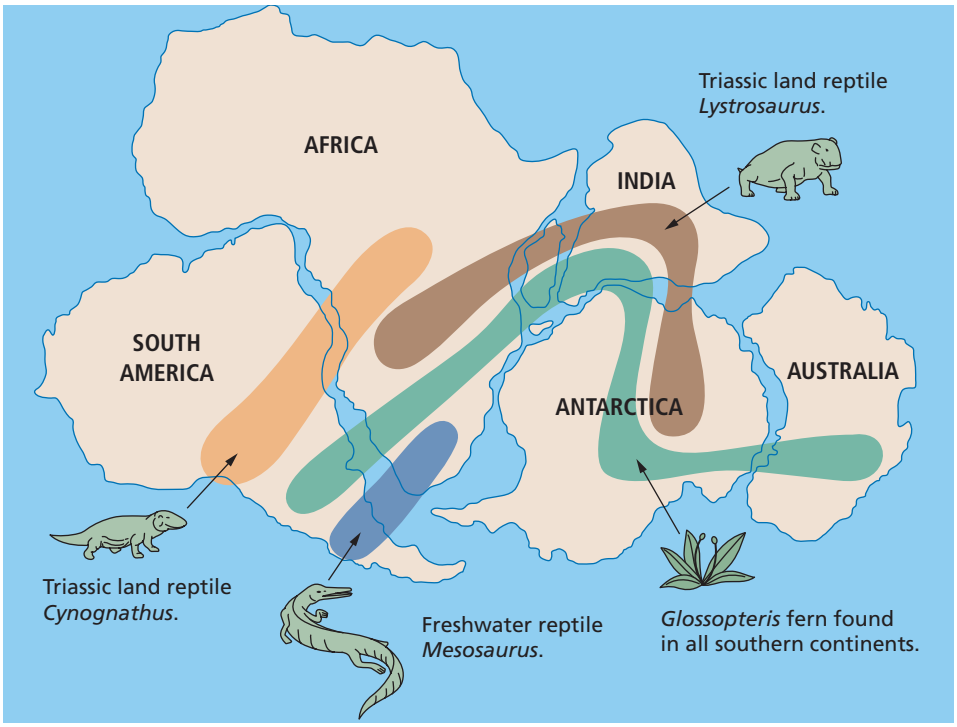


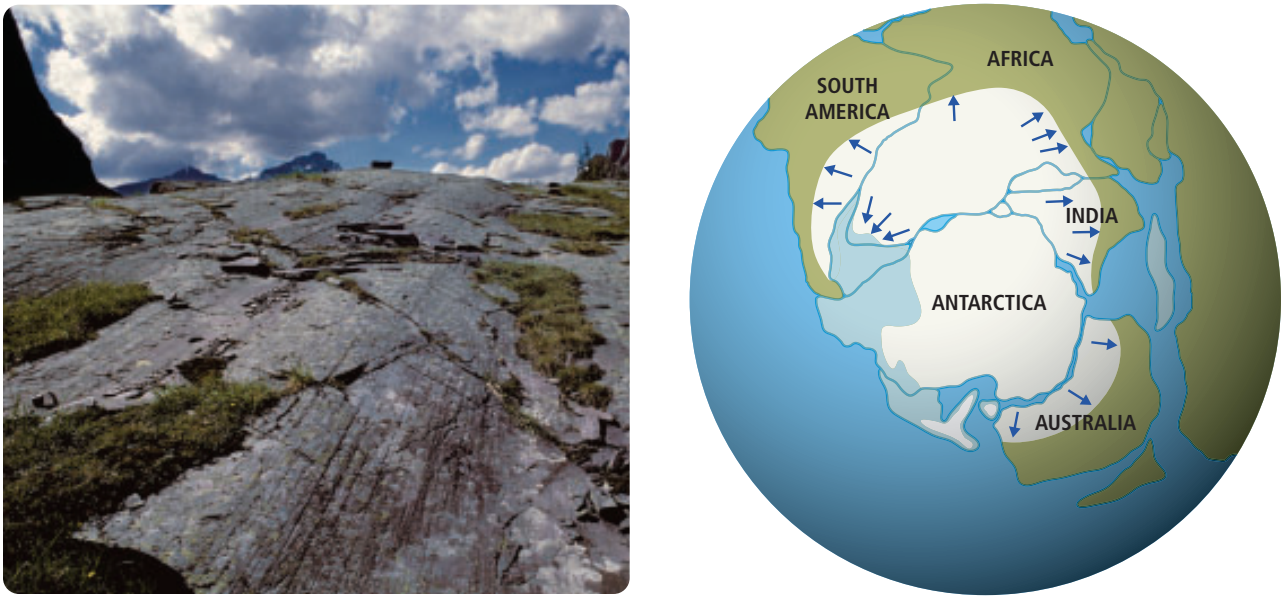
Figure 2 Certain land-animal fossil specimens like *Cynognathus* have been found only in small areas, but on both sides of the Atlantic ocean. *Glossopteris* was a giant fern that existed for only a short time. Even though it was a tropical plant, its fossils are found on every continent, including Antarctica.

Matching Mountains

Certain geological features like mountain chains and ancient lava flows line up across distant continents. Folded mountains such as the Appalachians in the northeast United States have very distinct patterns of rock layers. This same pattern can be found in Britain and Norway as well as in South America and Africa. Large coal deposits (formed from lush tropical forests 350 million years ago) have been found far from the tropics, in Antarctica. For Wegener, this provided strong evidence that the continents had changed position.

Ancient Glacial Evidence

Glaciers scour the rock in their path (Figure 3) providing evidence of **paleoglaciation**, the extensive periods in which glaciers covered most of the continents. Glaciers existed where they could not today, such as near the equator in southern India. Did Earth's axis change or did the continents move? Wegener felt that continental drift was the simpler explanation.



(a) (b)

Figure 3 (a) Glaciers scratch grooves into Earth's crust as they move, showing us their direction of movement. (b) Patterns gouged by glaciers more than 250 million years ago match up on Pangaea, as Wegener hypothesized.

Challenges to Continental Drift Theory

Wegener's ideas faced a lot of opposition from prominent geologists of the early 1900s. Many scientists supported his ideas (including those who made the discoveries mentioned above). However, it was hard to shake the belief in older theories. The age of Earth, for example, was a hot debate at the time. Estimates ranged wildly from 6000 years to 400 million years. Continental drift theory required a much longer time than that. It was not until the 1950s that radioactive dating of rocks supported the hypothesis that Earth is more than 4600 million years old.

More importantly though, Wegener could not provide strong evidence for how the continents were able to move over the surface of Earth. While important science groups were resistant to these new ideas, oil exploration geologists knew that understanding the kind of motions in Wegener's theory helped them find oil. In the next section, you'll learn about critical evidence from the sea floor gathered later, during the Second World War. This contributed to theories of how Earth's crust could move.

LEARNING TIP

Think back over Section 17.2. Ask yourself, "What evidence did Wegener propose to support his continental drift theory? What was considered by critics to be the weakness in his theory?"

17.2 CHECK YOUR Understanding

1. (a) Describe Wegener's continental drift theory.
   (b) List the evidence that Wegener used to support his theory.
2. Explain how the presence of coal deposits in Antarctica supports the theory of continental drift. Figure 4 shows a current world map.

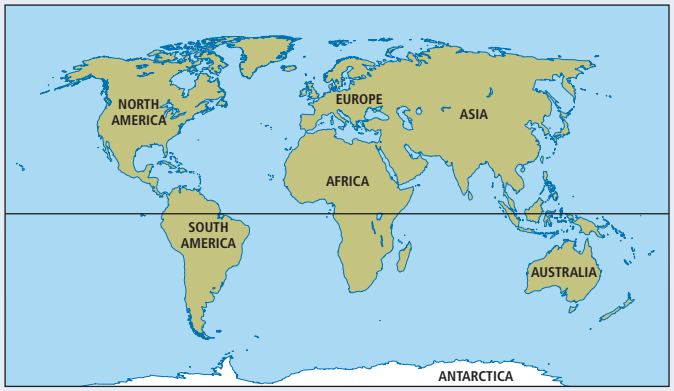


Figure 4

3. Wegener's critics argued that a much warmer climate in the past could explain the coal found in Antarctica. If Antarctica was once warm enough for coal-forming vegetation to thrive there, what do you think the equatorial regions would have been like?
4. (a) What kinds of evidence do glaciers leave behind?
   (b) Explain how the direction of motion of ancient glaciers can be determined.
   (c) What can explain evidence of ancient glaciers near the equator?
5. Explain why most geologists did not accept Wegener's continental drift theory at the time he proposed it.
6. (a) Name the landform in Figure 5.
   (b) How is this landform important to Wegener's theory?

Figure 5

7. (a) Pangaea can be used to explain the presence of similar fossils on opposite sides of the Atlantic Ocean. What other explanation was proposed?
   (b) Why did Wegener not accept this reason?
8. In Egypt, the Great Pyramids of Giza face slightly east of true north. Explain why the pyramids might not line up with true north as the builders likely intended. Assume that the builders 4500 years ago could determine directions accurately.