8.9A Plate Tectonic Theory

Have you ever looked at a world map and noticed the shapes of the continents? Have you ever noticed how some continents appear to fit together like the pieces of a jigsaw puzzle? Why do you think this is? Is it just a coincidence, or do you think it suggests something important about the history of our planet?

If you've ever noticed how the continents appear to fit together like a jigsaw puzzle, you're not alone. In the early 20th Century, a German scientist named Alfred Wegener noticed this phenomenon. Wegener hypothesized that at one or more points in Earth's history, the continents were connected.

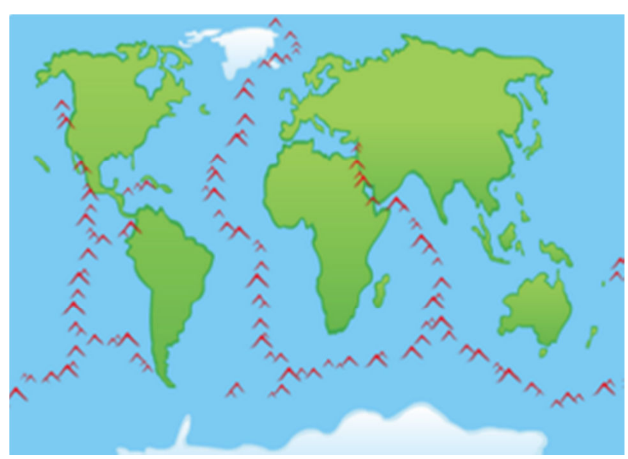
Wegener looked for further evidence that the continents may have once been connected. He looked for other connections between the matching coastlines. Where coastlines appeared to fit together, Wegener noticed that certain geologic formations also appeared to fit together. For example, a mountain range on one coastline appears to connect with a mountain chain on the opposite coastline. Several deposits of sediments left behind by glaciers also line up along the matching coastlines of continents.

Wegener concluded from his findings that the continents must move over time. He called this hypothesis continental displacement. (Later scientists gave the process its more familiar name, continental drift.) At least once in Earth's history, the continents were connected in large land masses. These large land masses are called supercontinents. 250 million years ago, all the continents were connected in one giant supercontinent. Wegener named this supercontinent Pangaea, which means "all Earth."

Despite the evidence Wegener collected, he could not provide a theory explaining how the continents moved over time. Partly for this reason, his hypothesis was initially rejected by the scientific community. Then in the 1940s, scientists discovered new evidence suggesting how continents drift. Unfortunately, Wegener did not live to see his work validated. He froze to death on an expedition across the Greenland ice cap trying to prove his hypothesis.

STUDYING THE OCEAN FLOOR

There were many advances in ocean exploration technology in the 1940s and 1950s. This led to new information about the ocean floor. Scientists began to realize the crust beneath oceans is not as old as the crust beneath continents. They also learned the ocean floor is not flat and barren. Instead, it contains many topographic features. In fact, one of the largest mountain ranges in the world is at the bottom of the ocean.



This mountain range, the mid-ocean ridge, is made up of two parallel mountain chains separated by a central valley. It is 50,000 kilometers long and an average of 4,500 meters tall. This map shows the different parts of the mid-ocean ridge.

Scientists discovered other information about the ocean floor as well. For example, sediments at the bottom of the ocean had been building up for a maximum of only 300 million years. If the ocean floor had not changed throughout Earth's history, these sediments would be about 4 billion years old. Similarly, the oldest fossils on the ocean floor are only about 180 million years old. Marine fossils buried in Earth's continents are thought to be much older. Scientists realized that some process must be destroying older sediments and fossils on the ocean floor. Because rocks and fossils on the continents are much older than those on the ocean floor, this process must affect oceanic crust differently than continental crust.

SCIENTISTS IN THE SPOTLIGHT: HARRY HESS AND SEAFLOOR SPREADING

Harry Hess was a geologist who served in the U.S. Navy during World War II. Hess used some of the Navy's ocean exploration technology to study the mid-ocean ridge and other ocean features. In the 1950s and early 1960s, Harry Hess used his research of the ocean floor to develop a hypothesis called seafloor spreading.

Seafloor spreading is a phenomenon by which magma from Earth's mantle—the layer beneath the crust—wells up between the central valley of the mid-ocean ridge.

When the magma pushes up through the center of the mid-ocean ridge, it forces the ocean floor apart. This breaking apart of the crust is called rifting. When the magma reaches the surface of the ocean crust, it cools and solidifies into igneous rock. This makes new oceanic crust in the center of the mid-ocean ridge. Hess also reasoned that older crust is destroyed as it sinks into deep ocean basins. Seafloor spreading explains why oceanic crust is younger than continental crust: oceanic crust is continually being recycled.

Hess had better luck than Wegener. He lived long enough to see his hypothesis validated by further scientific evidence and accepted by the scientific community. In the process, Hess finally provided the explanation that Wegener lacked for his continental drift hypothesis. Continents are dragged along Earth's surface by the motion of oceanic crust as it is recycled.

THE THEORY OF PLATE TECTONICS

By the 1970s, scientists had learned enough about how Earth's crust moves to develop a comprehensive theory. This theory, called plate tectonics, states that Earth's solid, rocky lithosphere is broken into pieces called tectonic plates (also known as lithospheric plates). Where tectonic plates consist of oceanic crust, they are denser. Where tectonic plates consist of continental crust, they are less dense.

As tectonic plates move, they rub against each other. These movements cause earthquakes. Tectonic plate movements also create openings in Earth's crust where magma can reach the planet's surface; we call these openings volcanoes. By mapping the locations of earthquakes and volcanoes, scientists have been able to locate the boundaries of Earth's tectonic plates.