The History of the Theory of Plate Tectonics

Think about a time before seafloor maps and satellite photos of Earth, even before accurate global land maps.

The idea that Earth's outer layer is made of moving plates was not widely accepted until the 1960s. The theory of plate tectonics was probably not included in your grandparents' science textbooks. The theory is built on centuries of data and scientific development.

Geologic Puzzles

The origins of the theory go back to the first world maps in the late 1500s. These maps included most of Earth. After seeing the shapes of Africa and South America, some people wondered if the two continents were once connected. But how could that have happened? It took 300 years for scientists to come up with some ideas for how continents move.

As explorers traveled to the far reaches of Earth, they asked, How did fossils of sea creatures get on top of tall mountains? Is there a relationship between volcanoes and earthquakes? Were the continents once close together, making one big landform?

Think about a time before seafloor maps and satellite photos of Earth, even before accurate global land maps.

The idea that Earth's outer layer is made of moving plates was not widely accepted until the 1960s. The theory of plate tectonics was probably not included in your grandparents' science textbooks. The theory is built on centuries of data and scientific development.

Geologic Puzzles

The origins of the theory go back to the first world maps in the late 1500s. These maps included most of Earth. After seeing the shapes of Africa and South America, some people wondered if the two continents were once connected. But how could that have happened? It took 300 years for scientists to come up with some ideas for how continents move.

As explorers traveled to the far reaches of Earth, they asked, How did fossils of sea creatures get on top of tall mountains? Is there a relationship between volcanoes and earthquakes? Were the continents once close together, making one big landform?
Explaining the Puzzle

There were two main explanations for the mountain top marine fossils. Some believed that global flooding raised the sea level above the highest peaks of the world. But otherwise, Earth's land had never changed. Others observed earthquakes and volcanic activity. They reasoned that processes inside Earth changed the surface, creating new hills and mountains.

James Hutton (1726–1797), a Scottish geologist, supported this second explanation. He observed that streams carried sediments away from his farm. So why had erosion not made the world into a perfectly round sphere? He decided that forces lifting sections of Earth's surface must balance out erosion.

Hutton's theory required large amounts of heat energy from inside Earth and extremely long periods of time. These were brilliant new ideas about Earth's history. But Hutton was a poor writer. Even the brightest scientific minds could not understand his written explanations.

After Hutton died, a close friend rewrote his book about geology. Eventually, scientists accepted Hutton's ideas of a changing planet. But understanding the evidence for plate tectonics was a long way off.

World maps in the 1550s began to give a more complete view of Earth. Some people began to wonder if South America and Africa had once been connected.
Putting the Pieces Together

The puzzle-like shapes of the continents intrigued Alfred Wegener (1880–1930), a German meteorologist. He was also interested in odd connections among fossils. For example, he found fossils of animals that once lived in tropical climates in areas that now have cold climates. He observed that the same plants and animals appeared as fossils in rocks of the same period on different sides of the ocean. The fossils included a freshwater reptile that was like a small crocodile found in Brazil and South Africa.

Can you imagine an entire community of reptiles traveling from Africa to South America? Neither could Wegener. Instead, he proposed a world where all the continents were connected as one huge continent. He called it Pangaea. He wrote of Pangaea as a land “where flora and fauna were able to mingle together before they were split apart.” In the early 1900s, he published his idea of drifting continents, a new way of viewing Earth’s history. But at the time, most scientists believed the continents were anchored in place. The continents might move up and down, but they certainly did not drift around the planet.

The color splashes show the possible patterns of fossil distribution before the continents split apart.

Earth’s Landmasses in Ancient Position

AFRICA

INDIA

SOUTH AMERICA

ANTARCTICA

AUSTRALIA

Fossil remains of Cynognathus, a Triassic land reptile approximately 3 m long.

Fossil remains of the freshwater reptile Mesosaurus.

Fossil evidence of the Triassic land reptile Lystrosaurus.

Fossils of the fern Glossopteris found in all of the southern continents, show that they were once joined.

Fossil remains of the freshwater reptile Mesosaurus.

Fossil remains of Glossopteris found in all of the southern continents, show that they were once joined.

The color splashes show the possible patterns of fossil distribution before the continents split apart.
Scientists dismissed Wegener’s ideas as physically impossible. In fact, Wegener could not explain what forces had moved large masses of solid rock over such great distances. How could it have happened? Wegener fought for his ideas of moving continents and a more dynamic planet until his death in 1930.

Scientists found it hard to ignore the fossil evidence for Wegener’s theory. To get around this problem, geologists imagined land bridges crossing the ocean. Fossils of an ancient horse were found in France and Florida. So a land bridge was drawn across the Atlantic Ocean. A lost continent was an attempt to explain connections that spanned the Indian Ocean. As evidence of underwater mountains, a lost continent was shown in the ocean near Indonesia, south of Sumatra. Evidently, land bridges disappeared when technology allowed us to map the seafloor.

The Missing Pieces

In the late 19th century, scientists used long ropes to measure the depth of the ocean. They found out that the seafloor is not as flat as people thought. Knowledge of the topography of the seafloor increased with the development of modern tools. In 1853, US Navy lieutenant Matthew Maury (1806–1873) published the first ocean-bottom chart. It showed evidence of underwater mountains in the central Atlantic Ocean. Survey ships laying the trans-Atlantic telegraph cable confirmed Maury’s findings.

This series of maps shows the probable positions of the continents following the breakup of the supercontinent Pangaea more than 200 million years ago.
The first sonar systems were developed during World War I (1914–1918) to help locate German submarines. These systems recorded the time it took for sound to travel from the ship to the seafloor and back again. The ocean depth was calculated from these times. The data collected from this early sonar confirmed the existence of the Mid-Atlantic Ridge.

Sonar can also measure the thickness of sediments, an important tool in the study of the seafloor. In 1947, seismologists on the US research ship *Atlantis* measured the sediment layer in the Atlantic. Scientists had believed that the ocean was at least 4 billion years old. If it was that old, the sediment layer on the ocean bottom should have become very thick. But evidence from sonar readings showed that the layer was relatively thin. Why was that?

### Seafloor Spreading

Harry Hammond Hess (1906–1969) was the geologist who finally came up with evidence that supported Wegener’s theory of drifting continents. During World War II (1939–1945), Hess was captain of a transport ship equipped with the newest form of sonar. He decided to use the equipment to gather data all the time. He noticed that the sediment layer was thinnest near the mid-ocean ridge. It got thicker as he traveled away from the ridge. The sediments nearest the ridge had been deposited over less time than those farther from it. From this evidence, Hess and other scientists inferred that the crust nearer to the ridge was younger. This difference in age suggests that the Atlantic seafloor is spreading. It is pushing Africa and South America apart by about 5 centimeters (cm) a year.

The Mid-Atlantic Ridge is part of the underwater mountain range that winds around the globe for about 70,000 km.
In seafloor spreading, new crust forms at the mid-ocean ridge and slowly moves sideways away from the ridge. Eventually, this crust plunges back into the mantle at trenches.

Today, we combine satellite images of underwater mountains with earthquake and volcano data to study the processes that shape Earth. These data are evidence that Earth’s crust is composed of solid tectonic plates that float on the fluid portion of the mantle. This evidence strongly supports the modern theory of moving crustal plates, called plate tectonics. It took courage and conviction for scientists like Wegener and Hess to defend and promote their unconventional ideas. Their new ideas changed the way everyone thinks about Earth.

Seafloor Spreading

The Mid-Atlantic Ridge—the boundary between the North American and Eurasian tectonic plates—slices through the center of Iceland. Rocky outcroppings mark where the plates are moving sideways away from the ridge.

Think Questions

1. What evidence caused Wegener to combine satellite images of underwater mountains with earthquake and volcano data to study the processes that shape Earth?
2. Why did most geologists disagree with Wegener’s ideas?
3. What are two pieces of evidence that scientists used to support the modern theory of plate tectonics?
4. Why do you think the mid-ocean ridge is composed of solid igneous rock?