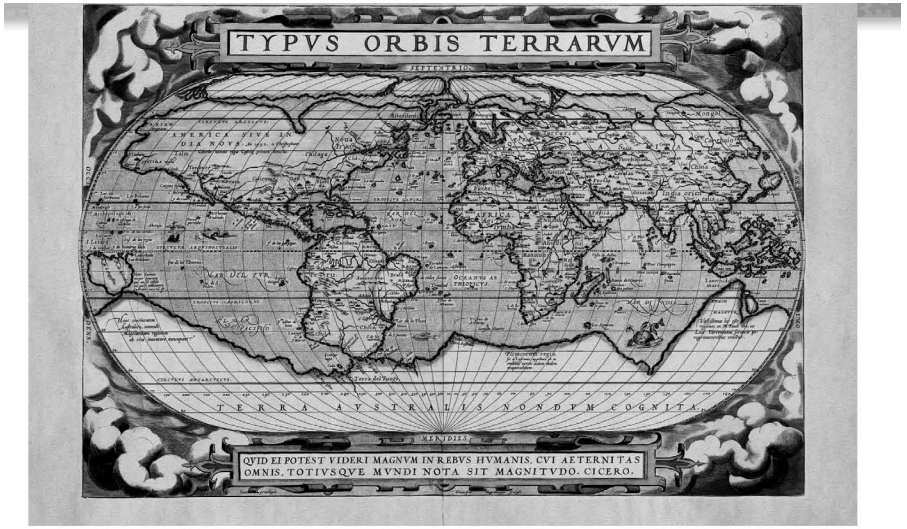


World maps in the late 1500's began to give a more complete view of Earth. Some people began to wonder if South America and Africa were once connected.

The Human Story of the Theory of Plate Tectonics

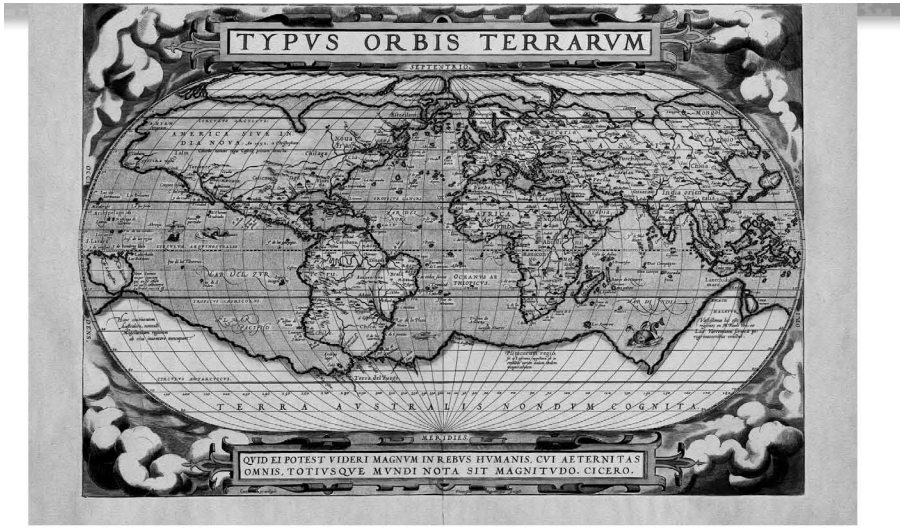
This is a story of how a theory was born. It is a story of denial and resistance to change that required the persistence of big thinkers collaborating and gathering evidence over centuries to conceive ideas beyond our imaginations.

The theory of Plate Tectonics is one of the most important scientific discoveries in modern times. But the idea that the Earth's outer layer is made of moving plates was not universally accepted until very recently. In fact, most likely it was not in your grandparents' science textbooks. It would take centuries of gathering data and sharing ideas before the scientific community would accept the evidence. World maps in the late 1500's began to give a more complete view of the Earth. From the shapes of Africa and South America, some people began to wonder if they were once connected.

The origins of the theory go back to the first world maps—and seeing the matching shapes of South America and Africa. It would be three hundred years more before creative people would suggest ideas for how continents could move. These people developed theories based in part on fossil evidence.

The Mystery of Deep-Sea Fossils

Since early global exploration, scientists have pondered the great mysteries of the



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Earth. This was a time before satellite photos of the Earth, before sea floor maps, and even before accurate global land maps. Still as they travelled, people asked: Did the continents fit together at one time? Is there meaning to the patterns of volcanoes and earthquakes? How did the great mountain ranges of the world form? And most mystifying, how did deep-sea fossils get on top of those enormous mountains?

There were two main groups of thought to explain the mountaintop marine fossils. Some believed that the land had not changed since the beginning of time, but that global flooding raised sea level above the highest peaks of the world. Others pointed out that the flood water seemed to have disappeared. Instead they observed active earthquakes and volcanoes and reasoned that uplifting processes created new hills and mountains.

James Hutton, a Scottish geologist, was a visionary of this second group. He observed how streams carried sediments away from his farm. He decided that there must be forces lifting sections of Earth's surface to counteract erosion. If there weren't these uplifting forces, he reasoned, erosion would have smoothed the world into a perfectly round sphere. His theory of uplift required large amounts of heat energy from inside Earth and extremely long periods of time. These were groundbreaking ideas that should have revolutionized the thinking about earth history. But Hutton was unfortunately a poor writer. Even the brightest scientific minds could not understand his written explanations. Had a close friend not rewritten his book after his death, Hutton's ideas may have been lost to the world entirely.

The scientific community ultimately accepted Hutton's ideas of a dynamic vertically changing planet, but we were still a long way from understanding evidence of continents fitting together.

Putting the Puzzle Pieces Together

The puzzle-like shapes of the continents intrigued Alfred Wegener, a German meteorologist. Although his career was to study the weather, as he explored the coasts he found many curious fossil connections that didn't seem to fit. For example, he found fossils of animals that once lived in tropical climates in areas that are now cold climates. In addition, he noticed fossils of the same plants and animals that existed at the same time across impassible oceans, like unique marsupials in South America and Australia or identical snails found only in Scandinavia and New England.

Can you imagine an entire community of animals like marsupials (koalas, kangaroos and all) traveling from Australia to South America? Neither could Wegener. Instead he envisioned a world where all the continents were connected into one mega-continent he called *Pangea* "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 and sparked a new way of viewing Earth's history. But at the time, the scientific community believed the continents were firmly anchored in place. The continents might move up and down but certainly did not drift around the planet.

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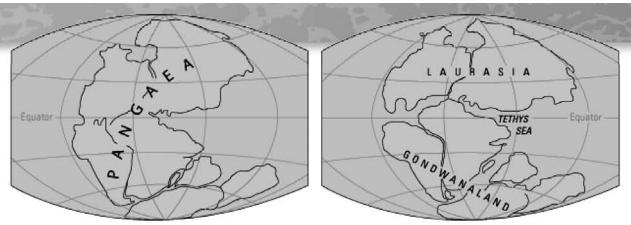
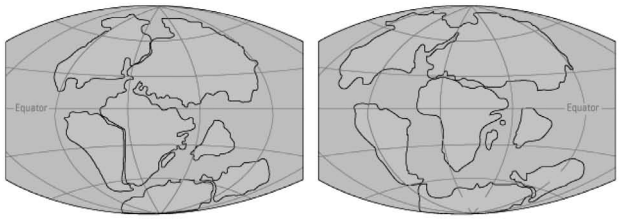


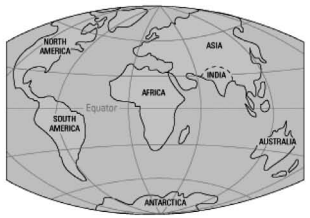
PERMIAN
225 million years ago

TRIASSIC
200 million years ago



JURASSIC
150 million years ago

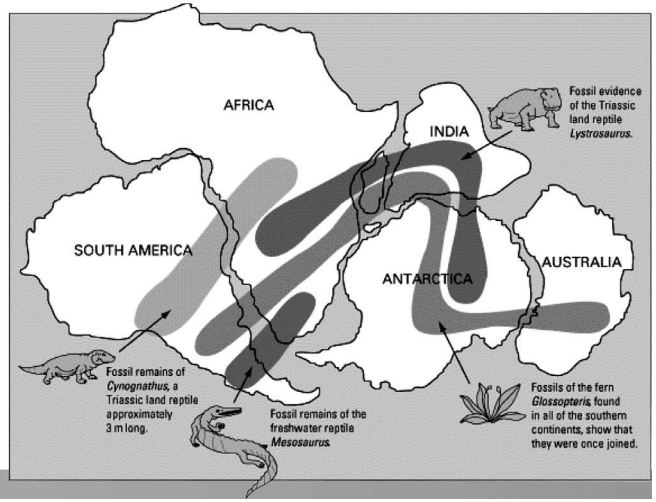
CRETACEOUS
65 million years ago



PRESENT DAY

These diagrams show the break up Panagaea and the spread of the continents to their current locations.

The colors on this map show the possible patterns of fossil distribution before the continents split apart.



PANGAEA
Equator
LAURASIA
TETHYS SEA
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Equator
PERMIAN
225 million years ago
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Equator
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NORTH AMERICA
ASIA
INDIA
AFRICA
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AFRICA
INDIA
SOUTH AMERICA
ANTARCTICA
AUSTRALIA
Fossil evidence of the Triassic land reptile *Lystrosaurus*.
Fossil remains of *Cynognathus*, a Triassic land reptile approximately 3 m long.
Fossil remains of the freshwater reptile *Mesosaurus*.
Fossils of the fern *Glossopteris*, found in all of the southern continents, show that they were once joined.
66

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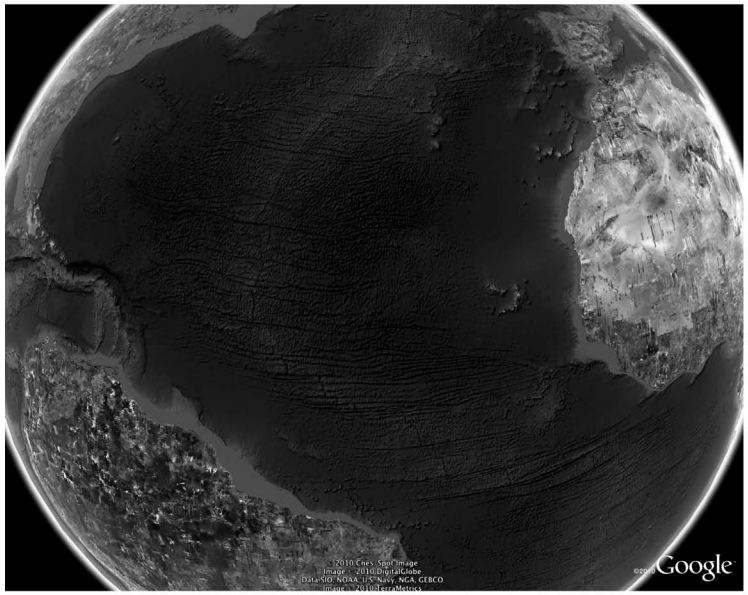
Resistance to Continental Drift

Scientists dismissed Wegener's ideas as the physically impossible musings of a meteorologist nosing into a field he didn't belong. In truth, a weakness in Wegener's theory was that he wasn't able to explain what forces could be capable of moving large masses of solid rock over such great distances. Wegener fought until his untimely death for the acceptance of his ideas of moving continents and a more dynamic planet.

The scientific community dismissed the idea of moving continents, but it was much harder to ignore the fossil evidence surfacing across the world. To get around this problem, skeptical geologists imagined "land bridges" crisscrossing the oceans. When an ancient horse was found to have lived in France and Florida, a land bridge was drawn across the Atlantic. One of the most famous was the lost continent of Lemuria that was imagined to explain the scattered locations of the same rock formations and similar species of Lemurs across the Indian Ocean. Of course, no remains were found for most of these land bridges once technology allowed us to map the mysterious ocean floor.



This is an image from Google™ Earth of the mid-Atlantic ridge as seen from space. This ridge is a mountain range running north to south in the middle of the Atlantic Ocean.

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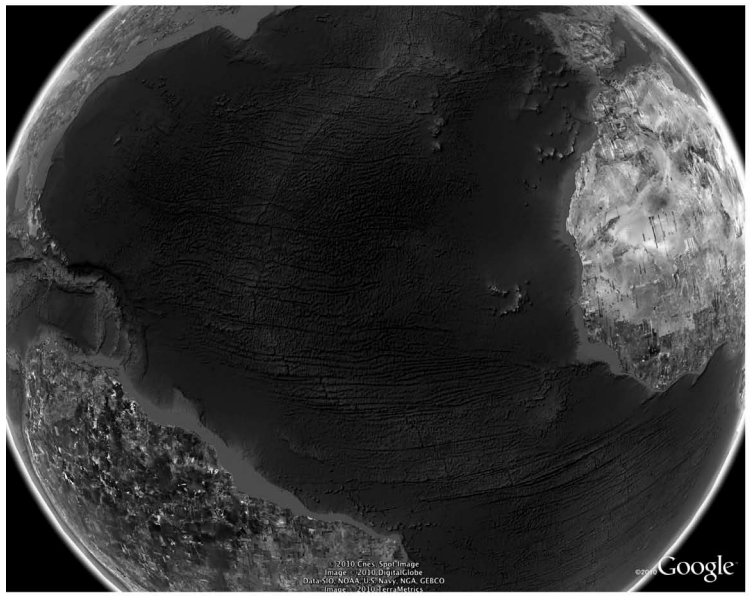

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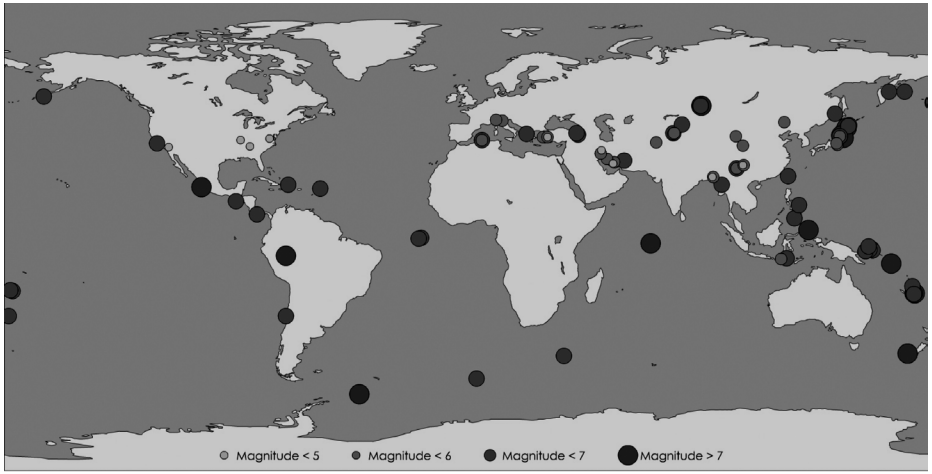


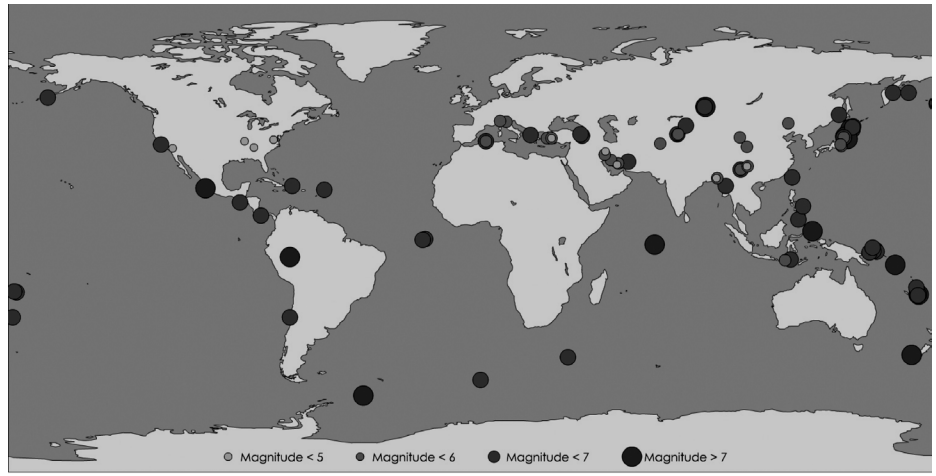
This map shows where earthquakes and volcanoes occur on Earth, just like you discovered in class.

The Missing Pieces: Mapping the Sea Floor

The scientific community had rejected Wegener's ideas because they could not fathom how the continents could move. However, after Wegener's death, insights into the seafloor offered new evidence to revive the debate. Until just recently, the world beneath the ocean surface was a complete mystery. Ocean depths used to be measured using deep-sea line "soundings," long lines lowered to the bottom!

Sonar technology, designed during WWI and WWII, helped sharpen the picture and interesting information started to accumulate. The data indicated that the greatest mountain ranges of the world were actually underwater, running along the middle of all the major oceans. Undeniable global patterns of earthquakes and volcanoes were mapped along these submarine mountain ranges and oceanic trenches. What was happening in the middle of the oceans, far under the surface of the water?

Harry Hammond Hess, a professor of geology at Princeton University, would finally offer key evidence of seafloor spreading that was missing from Wegener's drifting continents theory. During WW II, Hess was captain of a transport ship equipped with the newest form of sonar for navigating beach landings. Hess, decided to leave the equipment on to gather data even during battles. He noticed that the sea floor was youngest near the mid-ocean ridge and became older as you moved away on either



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Today we can look at satellite images of underwater mountains combined with earthquake and volcano data to study the processes that shape Earth. These data have led to evidence of Earth's crust being composed of solid plates floating on fluid magma beneath. This evidence strongly supports the modern theory of moving crustal plates, called plate tectonics. Looking back in history, we can now appreciate the courage and conviction it took scientists like Wegener and Hess to defend and promote their new ideas that were different from the accepted scientific thinking of the day. Their new ideas changed the way everyone would think about the planet we live on.

Think Questions

1. What will be the next exploration that will push the limits of the human imagination and shift popular thought?
2. Will it be the future of our global climate system?
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Investigation 6: Volcanoes and Earthquakes **69**

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