

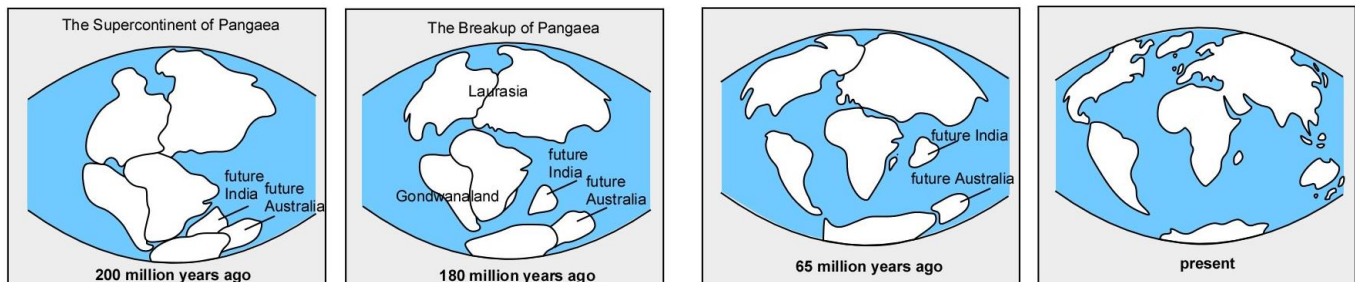
STAAR Science Tutorial 38 **TEK 8.9A: Plate Tectonic Theory Evidence**

TEK 8.9A: Describe the historical development of evidence that supports plate tectonic theory.

- Prior to the year 1900, most scientists that studied geology believed that the present position and shape of the Earth's continents changed very little over time. They understood that volcanoes created new mountains or volcanic islands, and erosion wore down older mountains, but believed that the continents themselves were fixed in their present position.
- Scientists in the 1800's had studied rock layers and fossils all over the earth, and had noticed some coincidences they could not explain. For example, similar sequences of sedimentary rock layers, and similar dinosaur fossils, could be found on the opposite sides of the Atlantic Ocean. The east coast of South America, and the west coast of Africa, also had a similar shape.

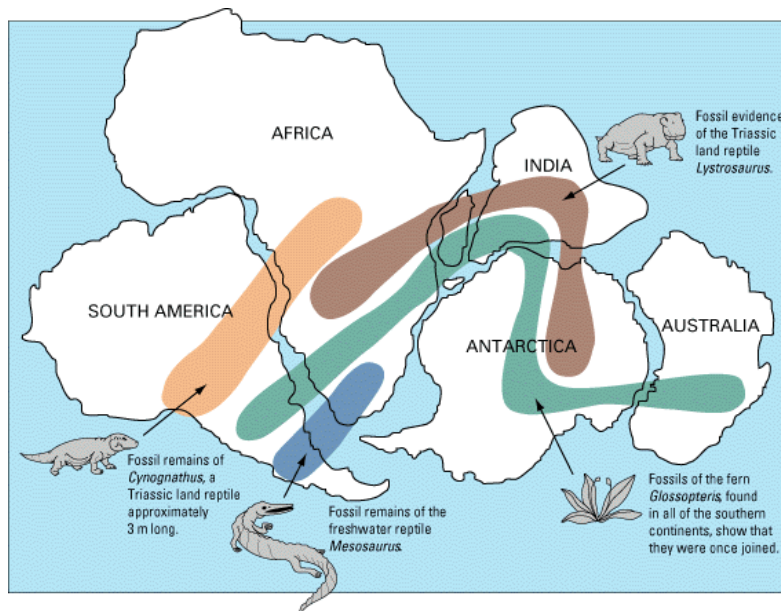
Wegener's Continental Drift Hypothesis

- A German scientist named **Alfred Wegener** noticed these and other geologic clues, and came to believe that there was a reason for these coincidences. Starting with the shapes of the continents, Wegener found that all of the continents could be fitted together like jigsaw puzzle pieces. He wondered if in fact all of the continents could have once been a single super-continent.
- Over a number of years in the early 1900's, Wegener assembled geologic evidence that he believed supported his "**continental drift hypothesis.**" His hypothesis stated that the continents drifted across the surface of Earth over time, and that about 200 million years ago all of the continents on Earth were assembled together as a single super-continent that he later called Pangaea. The maps below show his proposed sequence of continental drift over time. He first presented his hypothesis publicly in 1912, and published a book with his hypothesis in 1915.



- The evidence that Wegener assembled to support his Continental Drift Hypothesis included the following:

- Puzzle-Like Fit of Continents: If an outline of the continental shelf edges of the continents were cut from a map and slid together (as shown in the map on the next page), they formed a single continental landmass.
- Matching Sedimentary Rock Layers: Wegener studied the sequence of rock layers found on opposite sides of the Atlantic Ocean, on the present eastern shore of South America and western shore of Africa, and found that they matched very closely. In many cases, these matching rock layers also contained fossils, as shown in the map below, that further evidenced their prior connection.
- Matching Ranges of Fossils: Wegener assembled published fossil discoveries made across the continents, and found that the range where each fossil was found formed continuous bands, shown in the map below, that were evidence the animals once lived on a joined super-continent.

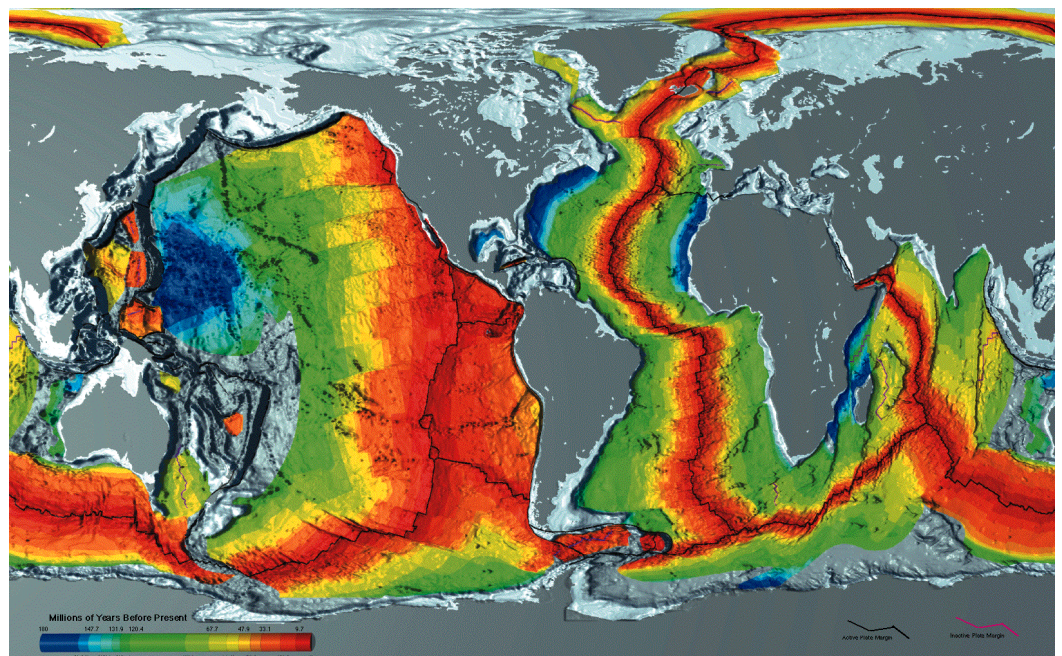


- Glacial Remains in Tropical Areas: Glaciers, moving sheets of ice created by accumulating and compacted snow, can only exist in cold climates. Evidence of past glacial activity has been found in present tropical areas, suggesting that the continent was once close to an arctic region (when the glacier was created) and later moved closer to the equator.
- Tropical Plant Fossils Found in Arctic Areas: Scientists have found fossils of tropical plants in Antarctica, suggesting that Antarctica was once located close to the equator.

- As extensive and varied as his evidence was, Wegener could not explain how continents could drift. The scientific community largely rejected his hypothesis, because they could not imagine how continents could move. Wegener died in 1930 with his continental drift hypothesis all but forgotten by scientists.

Hess' Seafloor Spreading Hypothesis

- The features of the Earth's ocean floor were almost completely unknown to science before the 1950's. While submarines existed in the early 1900's, they could only dive to shallow depths. Crude **sonar** systems, which used sound waves bouncing off of solid objects, were developed immediately after the sinking of the Titanic in 1912, but these became military secrets used for submarine warfare during the two world wars. Harry Hess, a geologist and U.S. Navy officer during World War II, first used military sonar in the Northern Pacific, and began to learn of submerged volcanoes and other mountain features there. Sonar systems that could reach the ocean floor and give accurate depth readings were not available to science until the 1950's. The Mid-Atlantic Ridge and other mid-ocean ridges were discovered in large-scale sonar studies during the late 1950's.
- **Harry Hess**, now a geologist at Princeton University, first proposed his **seafloor spreading hypothesis** in 1962. According to this hypothesis, new ocean crust was added at long ridges of volcanic vents, pushing away the older crust to either side of the ridge. In the Atlantic Ocean, the continents on either side of the ocean (Europe and North America in the northern hemisphere; South America and Africa in the southern hemisphere) slowly moved further apart over long spans of time.
- By 1968, significant additional evidence supporting both Wegener's continental drift hypothesis and Hess' seafloor spreading hypothesis was discovered. The age of the igneous rock on either side of the Mid-Atlantic Ridge was measured, from the North American to the European coasts. The rock at the ridge was very young, while the rock at the two continental coasts was about 200 million years old. The color image below (best viewed on the computer) shows the approximate age of rock in all ocean basins, with red the youngest and blue the oldest, clearly showing the history of seafloor spreading.



- Additional evidence supporting the seafloor spreading hypothesis includes the “magnetic striping” of the seafloor. The location of the Earth’s magnetic north shifts from near the geographic north pole to near the geographic south pole every half million to one million years. The orientation of magnetite crystals in seafloor rock points either north or south in alternate bands, like frozen compass needles showing the direction of magnetic north when that rock cooled and hardened.

The Plate Tectonics Theory

- It did not take scientists long to realize that Hess’ seafloor spreading hypothesis explained how Wegener’s continental drift could work. The two hypotheses were merged into what now is known as the **plate tectonics theory**. Scientists currently accept this theory as the best available explanation of the geologic processes that shape Earth’s crust.
- According to the plate tectonic theory, the lithosphere is broken into nine major and many smaller tectonic plates, which float on the denser semi-liquid asthenosphere. Convection currents of thick molten rock in the asthenosphere move the plates slowly over millions of years, opening up gaps that fill with lava, usually at the center of mid-ocean ridges in the middle of large ocean basins (for example, at the center of the Atlantic Ocean). Over time the plates on either side of the mid-ocean ridge get wider, pushing the attached continents further apart. At the other side of the continental plates, ocean crust (for example, at the edges of the Pacific Plate) is subducted (pulled under) the advancing edge of the continental plate. Compression and tension forces within the continental plates cause mountain formation. Magma from the melting of the subducting ocean plates slowly comes back to the surface as volcanic eruptions.
- Tutorial 39 gives a more detailed description of the plate tectonics theory and the formation of mountains and other crustal features.

Practice Questions

1. What scientist first formally proposed that the position of Earth’s continents change over time (the continental drift hypothesis)?

2. What name was given to the super-continent that was proposed in this hypothesis? _____
3. How long ago did this super-continent break apart, according to this hypothesis?

4. Was this hypothesis accepted by the scientific community when it was first proposed? _____ Why or why not? _____

5. What five categories of evidence were offered for the continental drift hypothesis? (1) _____ ;
(2) _____ ;
(3) _____ ;
(4) _____ ;
(5) _____ .
6. What advancement in technology allowed scientists to map the depth of the Earth's ocean floors? _____
7. When did scientists first discover the Mid-Atlantic Ridge? _____
8. What scientist first proposed the seafloor spreading hypothesis?

9. How was the movement of continents explained by the seafloor spreading hypothesis? _____

10. What two additional categories of evidence supported the original seafloor spreading hypothesis? (1) _____ ;

(2) _____ .

11. What is the name of the theory that combined the continental drift hypothesis and the seafloor spreading hypothesis? _____
