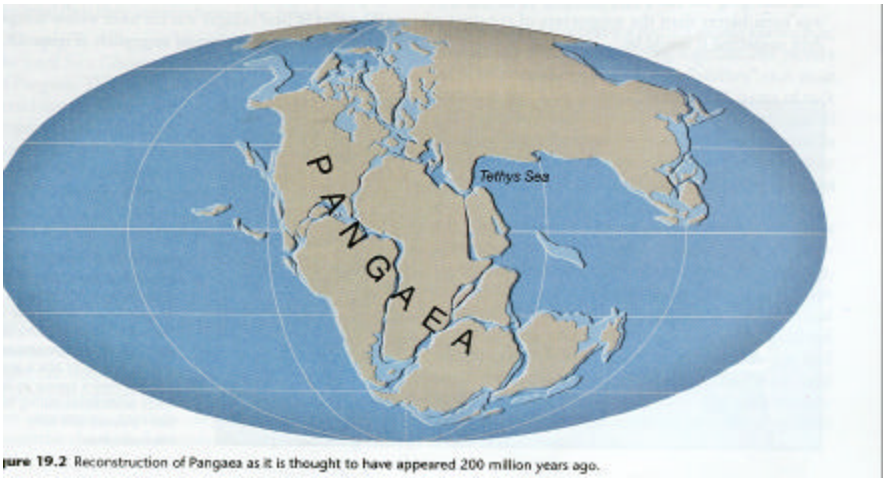
Plate Tectonics

Part 1-
The hypothesis of Continental Drift
Alfred Wegener

Wegener's Hypothesis- That all continents were once unified into a supercontinent called Pangea. That the continents have moved around the surface of the Earth



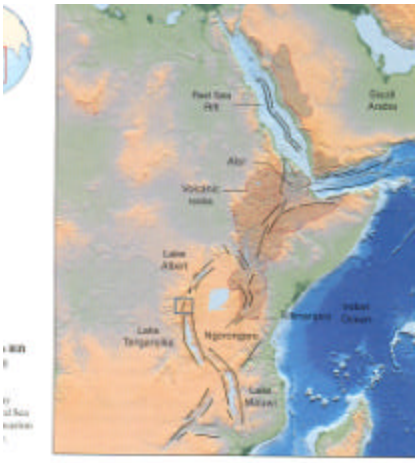
ure 19.2 Reconstruction of Pangaea as it is thought to have appeared 200 million years ago.

Evidence for Continental Drift

1) The fit of the continents, something like a jigsaw puzzle

Figure 19.3 This shows the best fit of South America and Africa along the continental slope at a depth of 500 fathoms (about 900 meters). The areas where continental blocks overlap appear in brown. (After A. G. Smith, "Continental Drift." In *Understanding the Earth*, edited by I. G. Gass. Courtesy of Artemis Press)

Saudi Arabian peninsula fits into the corner of East Africa



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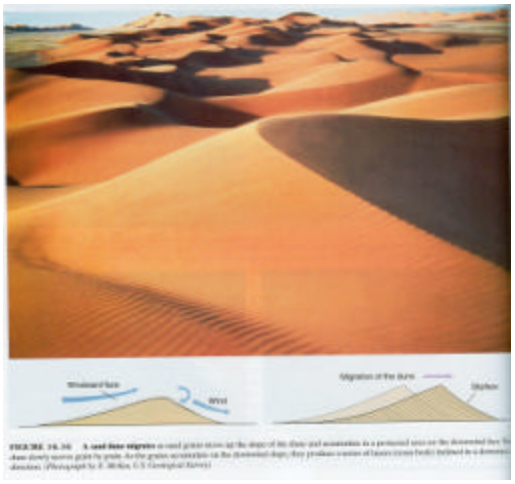
2. Paleoclimatic Evidence From Rocks-

rocks provide evidence of what past climates were like.

A. For instance sand dunes become distinctive looking rocks. As sand migrates over dune and falls down the opposite side, it builds up in layers that are inclined (see lower right part of diagram). These layers are preserved when the sand is cemented into rock (see next slide).



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Rocks that show this type of layering (see below) indicate a climate like that which occurs today are nearer the equator, such as the current Sahara Desert. We find these types of rocks in Antarctica.

GURE 16.17 **Cross-bedding** in the Navajo Sandstone in Zion National Park, Utah, is evidence that the rock formed in an ancient desert. The lination of the strata shows that the wind blew from north to south (from left to right, in the photograph) for most of the time during which this nation was being deposited.

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- The finding of evidence of ancient sand dune deposits in Antarctica was interpreted in two different ways. One explanation was that the climate of the Earth has changed radically over time and that at one time, desert conditions existed at the South Pole and caused the formation of the sand dunes there.

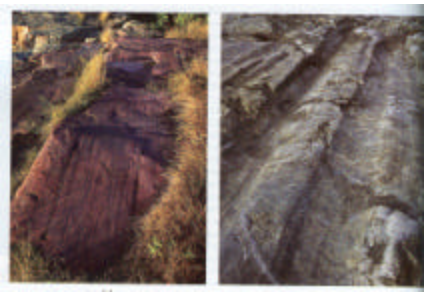
- The other explanation was that the climates of Earth have not changed so dramatically and that instead the continents have moved across Earth's surface and migrated from one climate zone to another. Thus, it was argued by Wegener that the polar regions have never been arid enough to form sand dunes. Instead the way to explain the sand dunes is that the continent of Antarctica was once located much further north, closer to the equator where the desert belts exist today.

b. Coal beds

- Another example of how rocks indicate what ancient climates were like is coal. Coal is made when large quantities of plant material is buried under other sediments.
- Coal beds indicate tropical climate where massive amounts of plant growth accumulate and form coal beds. The great amount of plant material needed to form coal seams requires tropical growing conditions.
- Today we find coal beds in places like Utah and Antarctica. How did coal form in places which today are far from the equator? Either the climate zones of the Earth have changed radically, or the continents have moved between climate zones.

c. Glacial deposits and evidence for ice transport occur in the currently warm climates of Brazil and India.

Glacial striations (left) and grooves (right and next slide) are where rocks embedded at the base of moving glaciers have been dragged across the solid rock of the Earth's surface and carved grooves into the bedrock surface. Today, we find this evidence of glaciation in tropical to subtropical climates. The grooves also show the direction of glacier movement.



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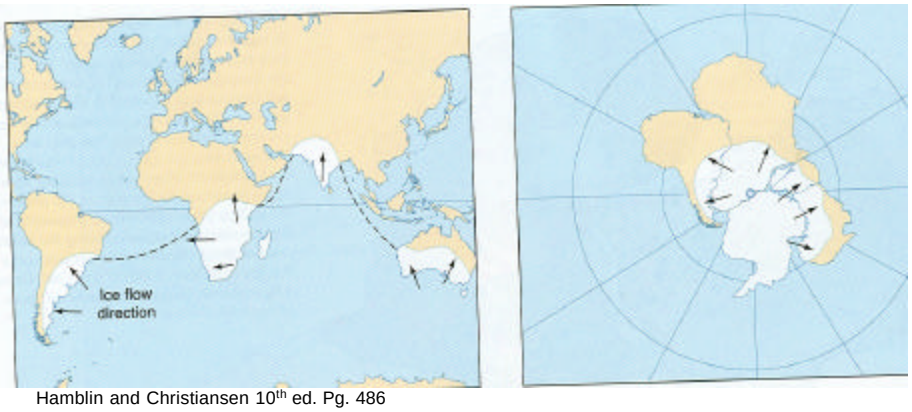
The grooves were created when a large block of ice-cemented boulders scraped across this bedrock. These are some of the distinctive features of glaciation. Grooves in bedrock tell us the ice was traveling in one of two directions (in this case either toward you or away from you). We can tell which direction it was by looking for distinctive deposits of sediment left at the lower end of glaciers, where it was melting. Fig. 14.1 pg 375 shows the piles of rocky debris left at the lower end of the glacier where melting occurs. These deposits are called moraines. The glacier moves away from the zone of accumulation towards the zone of melting and evaporation, where the moraines form. Thus we know the direction of ice flow from grooves and moraines left behind after the glacier is gone.

Glacial deposits that are all the same age (about 300 million years old) have been found in S. America, Africa, India, and Australia, and Antarctica (see left below). Today, most of these are places where glaciers are unlikely to occur, even in times of global cooling (e.g. equatorial Africa and tropical India).

An additional observation that puzzled geologists was how the evidence for the direction of glacier movement suggested that glaciers moved from the ocean toward the land (see left diagram below). Glaciers move by gravity - so it does not make sense that their flow directions should be from the ocean (at sea level) up onto the land's surface. But, if it is assumed the continents were all connected at the time of glaciation (see right below), then the directions of ice movement make sense.



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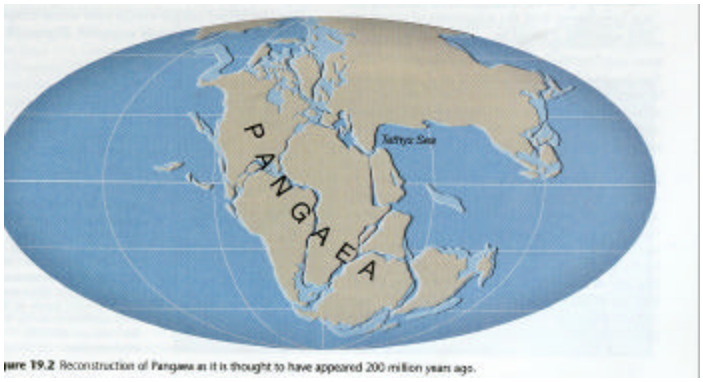
But, is it possible that the Earth could have gone through a cooling period cold enough to cause glaciation everywhere on the planet? Could this explain why there is evidence for glaciation in areas that are tropical today? Wegener thought not because there is evidence for large tropical swamps (vast coal beds, trees without seasonal rings, a ferns with large fronds) in N. Hemisphere continents (eastern U.S., Europe, Siberia) that are same age as the glaciation.

Wegener explained this by saying all southern continents were once connected together, so ice could cover all at same time, and that they were all located near South Pole. While at the same time, parts of North America, southern Europe, and Siberia were located nearer the equator where a tropical climate existed.

In the diagram below the "A" of Pangaea is on Antarctica, the continent just north of Antarctica is India and the continent just east of Antarctica is Austrailia.



ure 19.2 Reconstruction of Pangaea as it is thought to have appeared 200 million years ago.

Study Fig. 17.6, pg. 487 from Hamblin and Christiansen

It shows paleoclimatic evidence from rocks that are of all the same age. It was this evidence that Wegener used to prove that there was not a massive cooling of the Earth that would allow glaciers to exist where India is today. Instead he argued that the continents must have been in different locations at that time (the locations shown on the map)

- Wegener used evidence of past climates obtained from rocks (paleoclimatic evidence) to say that the continents have moved in and out of different climate zones over time.
- For example, we now believe that Utah was once located near the equator. We have coal beds that are about 100 million years old. These beds preserve fossils of trees without rings and large fronds. Both of the are features of tropical plants that don't undergo any seasonal changes and were growing year-round.

- Similarly, Wegener argued that all the continents have migrated between climate zones. Particularly the southern continents, where he argued that Antarctica was once located at mid-latitudes in a tropical zone and India was once located in a polar region. He felt he had evidence that disproved the idea that major climate change could happen that would shift the climate zones to the point of having glaciation in the tropics and tropical climates at the poles.

3. Fossil evidence

Fossils are evidence of past life. Wegener looked at the type of animal and the distribution of their fossils to support his idea the continents were once connected.

For example, he cited the findings of Mesosaurus , a freshwater crocodile-like animal, in rocks of same age on both S. America and Africa. Wegener asked, How is it possible that land animals and plants migrate across open water? This animal could not have swum the great distance of ocean that now separates the fossils. He concluded this was evidence the two continents were once connected.

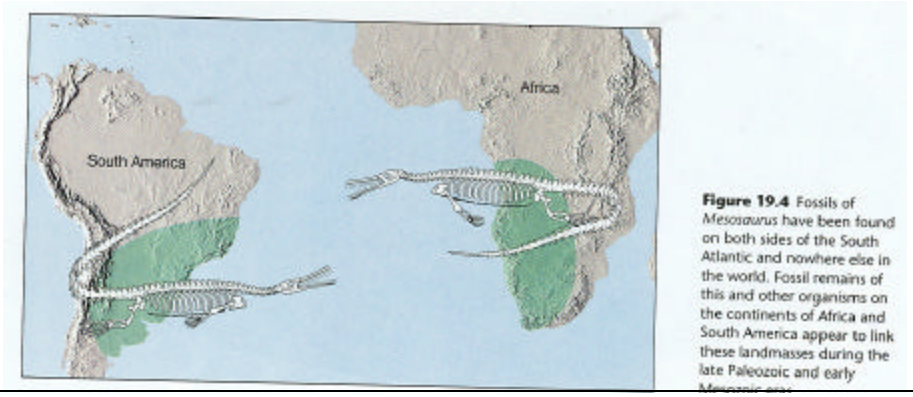


Figure 19.4 Fossils of *Mesosaurus* have been found on both sides of the South Atlantic and nowhere else in the world. Fossil remains of this and other organisms on the continents of Africa and South America appear to link these landmasses during the late Paleozoic and early

Wegener cited fossil evidence for other organisms as well. Fossil fern plant (Glossopteris)- had seeds too large to be wind blown between continents as they are arranged today. But if India, Australia, Antarctica, S. America, and Africa were once connected, the finding of these plant fossils on all these continents is explained. A similar argument was made for land reptiles whose fossils were also found on these continents.

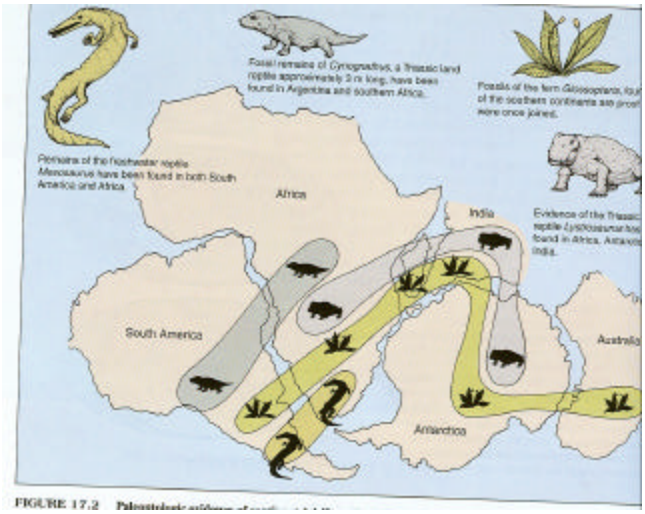


FIGURE 17.2

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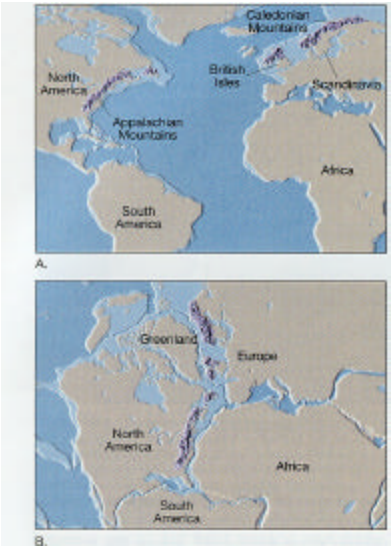
- Opponents argument was the land bridges once existed and are currently underwater. They pointed to the Bering Strait between Siberia and Alaska as an example. Since very little was known about ocean floors at this time, no one could really test this explanation. However, it was considered much more likely than the idea that the continents have moved in the time since the organisms were alive.

4.



Match of old mountain belts and other rock structures across oceans.

The Appalachian Mtns of eastern N. America and the Caledonian Mts of N. Europe are the same age and have the exact same internal structures and rock type. Wegener argued they had once been the same range, but the breaking up and movement of the original continent has caused the sections of the mountain range to be separated by Atlantic ocean

IGURE 17.4 When reconstructed, the ontinents fit together like a jigsaw puzzle or ieces of a torn newspaper. Not only do the outlines of the torn pieces fit together, but he printing on them (analogous to the ages and structural features of the continents) also matches across their edges.

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Wegener used several lines of evidence from different types of data to make his case that the continents were once organized into Pangea and have since moved.

His hypothesis was not accepted. He could not explain how something as massive as a continent could plow along through the rocks of the ocean floors.

The last paper Wegener wrote was in 1932, the idea died out until amazing new data came about as technology developed during World War 2 became available to scientists and a new idea, called Plate Tectonics, was developed from the hypothesis of Continental Drift.

With this new data, an explanation for how the continents move was developed. Now the concept of Plate Tectonics is considered a very well proven idea and has the status of a theory.