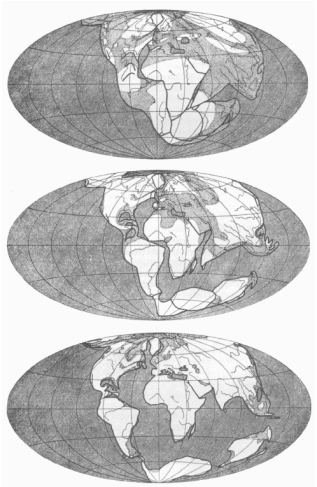
Plate TECTONICS

or

"I feel the Earth move under my feet. . ."

Alfred Wegener (1880-1930)

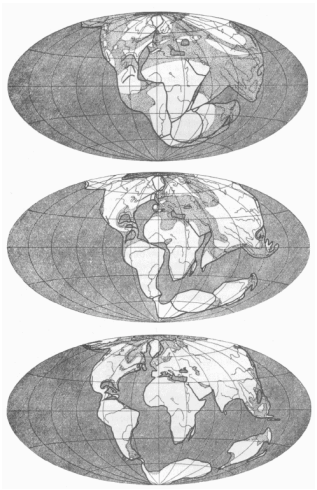
A German meteorologist and geophysicist, Wegener became interested in "continental drift" while reading about the distribution of certain animal and plant fossils in far-flung places on the Earth.



"the fundamental soundness of the idea seized my mind. . ."

Pangaea

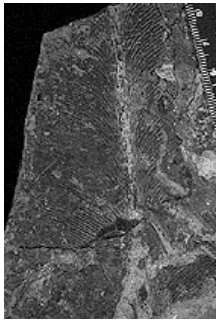
- **formed** about 250 million years ago (before that, continents were separate)
- began **breaking up** about 200 million years ago, forming:
  - a northern half, **Laurasia**
  - and a southern half, **Gondwana**
- Both halves then further fragmented to give rise to the continents we know today



Wegener's lines of evidence:

- Distribution of fossils that pre-dated the breakup of Pangaea
- Distribution of living organisms
- Apparent Polar Wander (no time to go into this—has to do with magnetic fields in older rocks)
- Distribution of geological features

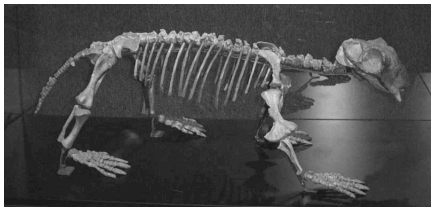
Some of Wegener's evidence came from the distribution of fossils that pre-dated the breakup of Pangaea. Consider the fernlike plant *Glossopteris* (290-255 million years old). . .

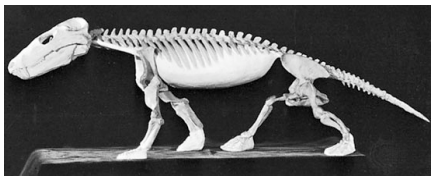


Antarctica

Australia

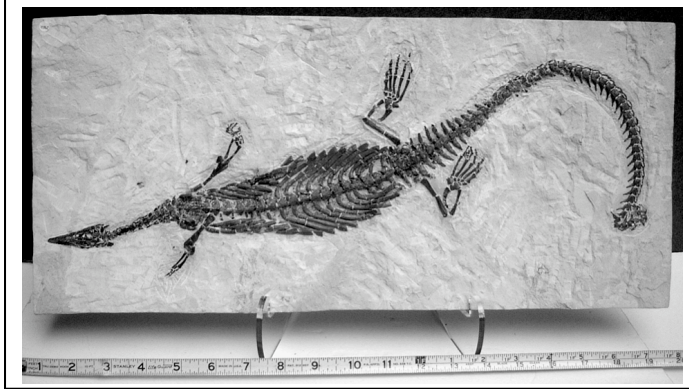
India





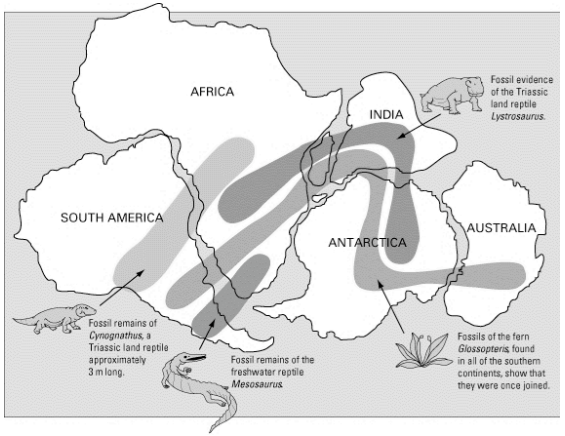
Or consider these *synapsids* (relatives and ancestors of mammals, although not fully mammalian) *Lystrosaurus* (top) and *Cynognathus* (bottom), from the same time frame as *Glossopteris*. . .

And consider *Mesosaurus*, an odd little reptile that was evidently adapted for aquatic life. . .



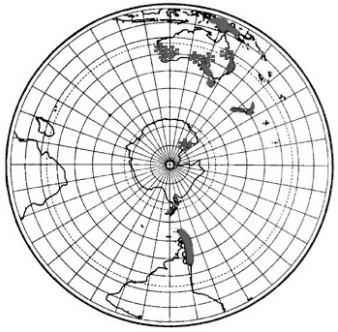
These and other fossils are important because:

- They lived during the time that Pangaea was breaking up
- They are found on landmasses that were once close together in Pangaea, and that stayed together when Pangaea split
- They have the same (or an overlapping) pattern of distribution



This map shows where these fossils have turned up, superimposed on a reconstruction of southern Pangaea

A number of living organisms are distributed in patterns that suggest that they were once unique to Laurentia or Gondwana.



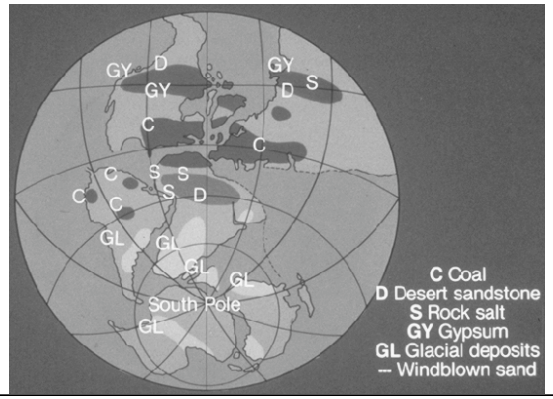
Nothofagus, the genus of "southern beech", and its distribution. Asterisks indicate where fossils have been found.

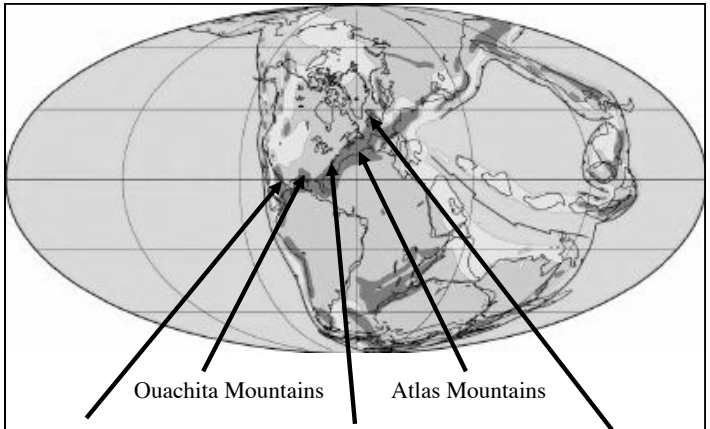
Lungfishes are another example of Gondwanan species.
(Left: African. Upper right: Australian. Lower right: South American.)

So is a family of flowering plants known as the Proteaceae.

(Top left: African *Protea cynaroides*. Bottom left: Australian *Telopea speciosissima*. Top right: South American *Embothrium coccineum*.)

Wegener also found geological features on separate continents that "matched up" if the continents were put back together. These included mountain ranges, layers of glacial deposits, and other rock types that seemed to correlate with climate zones. . . .





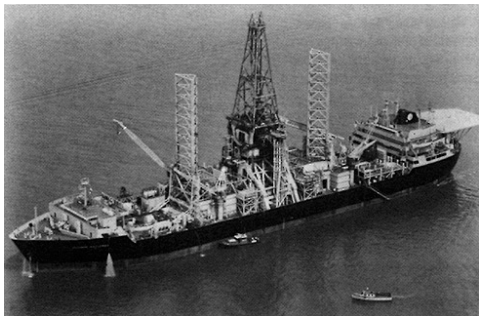
Notice how these mountain ranges, now separate, fit together into one range on this reconstruction of Pangaea.

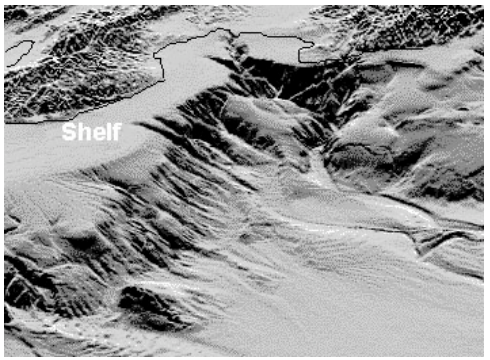
Wegener's ideas did not meet with much acceptance at the time. . .

The theory of Wegener is to me a beautiful dream, the dream of a great poet. One tries to embrace it and finds that he has in his arms but a little vapor or smoke; it is at the same time both alluring and intangible. -- H. Termier, French paleontologist

Whatever his own attitude may have been originally, in his book he is not seeking truth; he is advocating a cause and is blind to every fact and argument that tells against it. -- Philip Lake, American geologist

But increasing exploration of the ocean floor, by ships like *Glomar Challenger,* led to the formation of modern plate tectonic theory by 1965

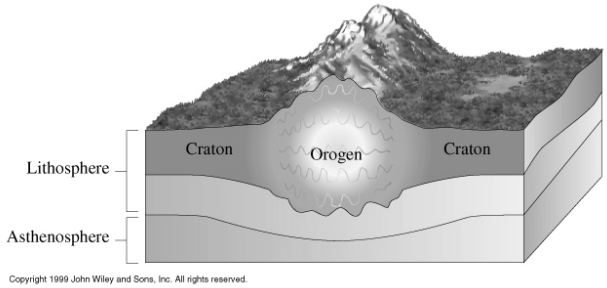




Structure of a continent: The *continental shelf* is a relatively flat region extending to the steeper *continental slope,* which marks the true edge of the continent.

Match up the outlines of the continental shelves, and you get an almost perfect fit. . .

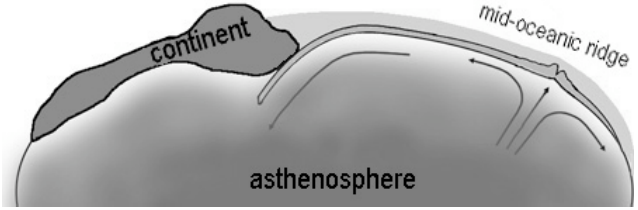
Cross-section of a continent: The lighter *continental crust* (density about 2.6-2.7 g/cm^3) lies above the *oceanic crust* (density about 2.8 g/cm^3). Both together make up *tectonic plates* that "float" on the extremely viscous *asthenosphere*.



A continent can be pushed down into the asthenosphere, and then rise back up if the pressure is released. This adjustment to retain buoyancy is called *isostasy*.

Thanks to *glacioisostatic rebound*, these ancient sea cliffs are now hundreds of feet from the waterline. Hudson Bay, Canada.

The modern picture of plate tectonics:



Continents don't "plow through" the oceanic crust, as Wegener thought. Instead, they are carried by the oceanic crust as if on a conveyor belt. The driving force is thought to be convection in the asthenosphere.

Both continental and oceanic crust form *tectonic plates*.

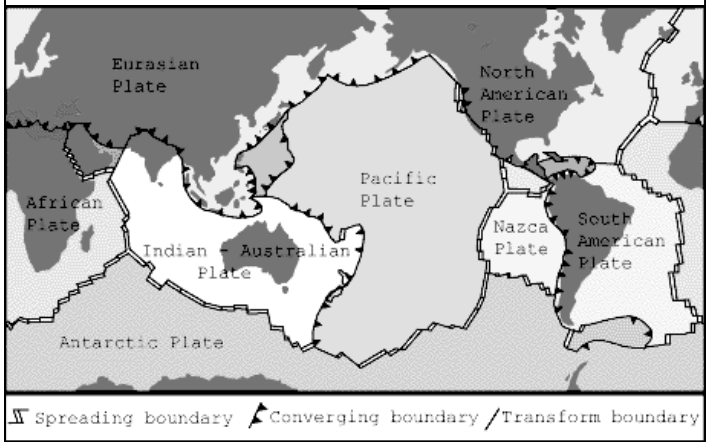
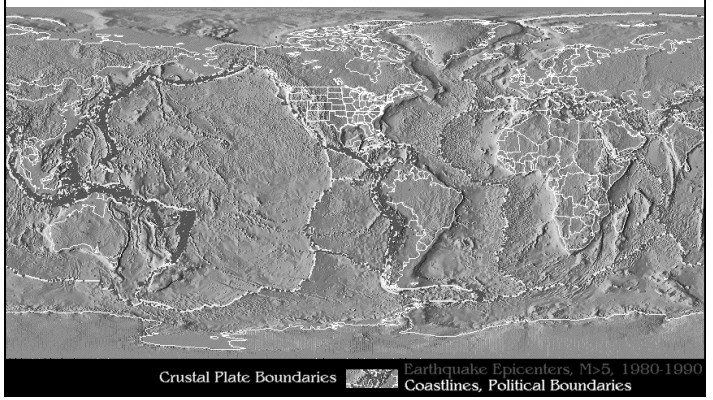
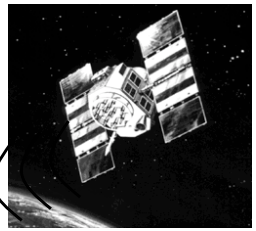
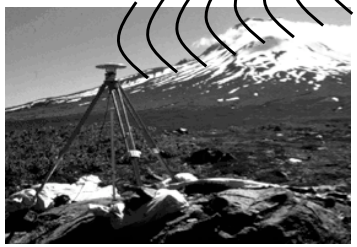


Plate margins are often associated with earthquakes (shown as red dots) and with volcanoes.



GPS (Global Positioning System) and other space-based technologies are now used to measure directly how fast tectonic plates are moving.





Plates today are moving at speeds of between 2 cm/year and 15 cm/year. This is in line with estimates from the geologic record of how fast they've moved over the past millions of years.