The Theory of Plate Tectonics, Pt. I

BI 201 Natural History of Guam
Class Presentation 05

I. Wegener's Continental Drift Hypothesis

- The concept of crustal movement had its beginnings with **Alfred Wegener**
  - Wegener was a German meteorologist who noted the apparent fit of continents

Alfred Wegener, 1880–1930

- He developed a hypothesis on movement of continents (“continental drift”) that he first presented at a symposium in 1912
- Wegener was not the first to remark on the apparent fit of the continents

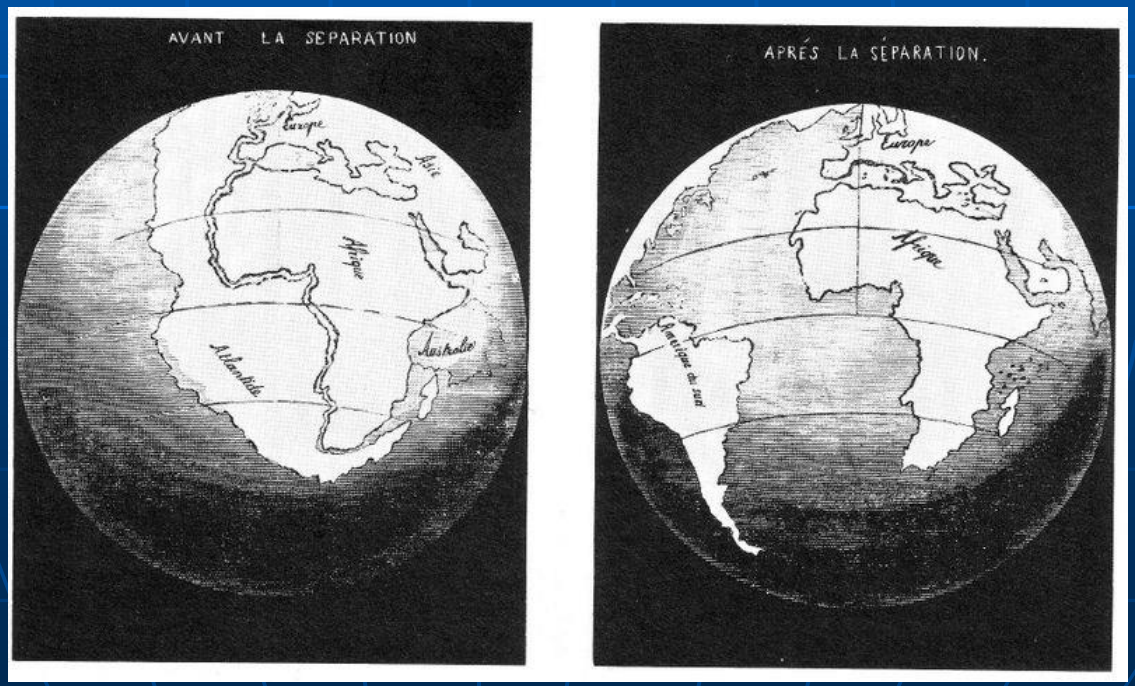
- **Abraham Ortelius**
  - Ortelius was a Dutch cartographer who published his *Thesaurus Geographicus* in 1596
  - He postulated that earthquakes and floods tore America from Africa and Europe
  - *"The vestiges of the rupture reveal themselves, if someone brings forward a map of the world and considers carefully the coasts of the three [continents]."*

Abraham Ortelius, 1527-1598

- **Francis Bacon**
  - Bacon pointed out the correspondence in the outlines of the continents bordering the Atlantic Ocean, particularly noting the fit between South America and Africa in his *Novum Organum* in 1620
  - He made no further attempt to explain his observation

Sir Francis Bacon, 1561-1626

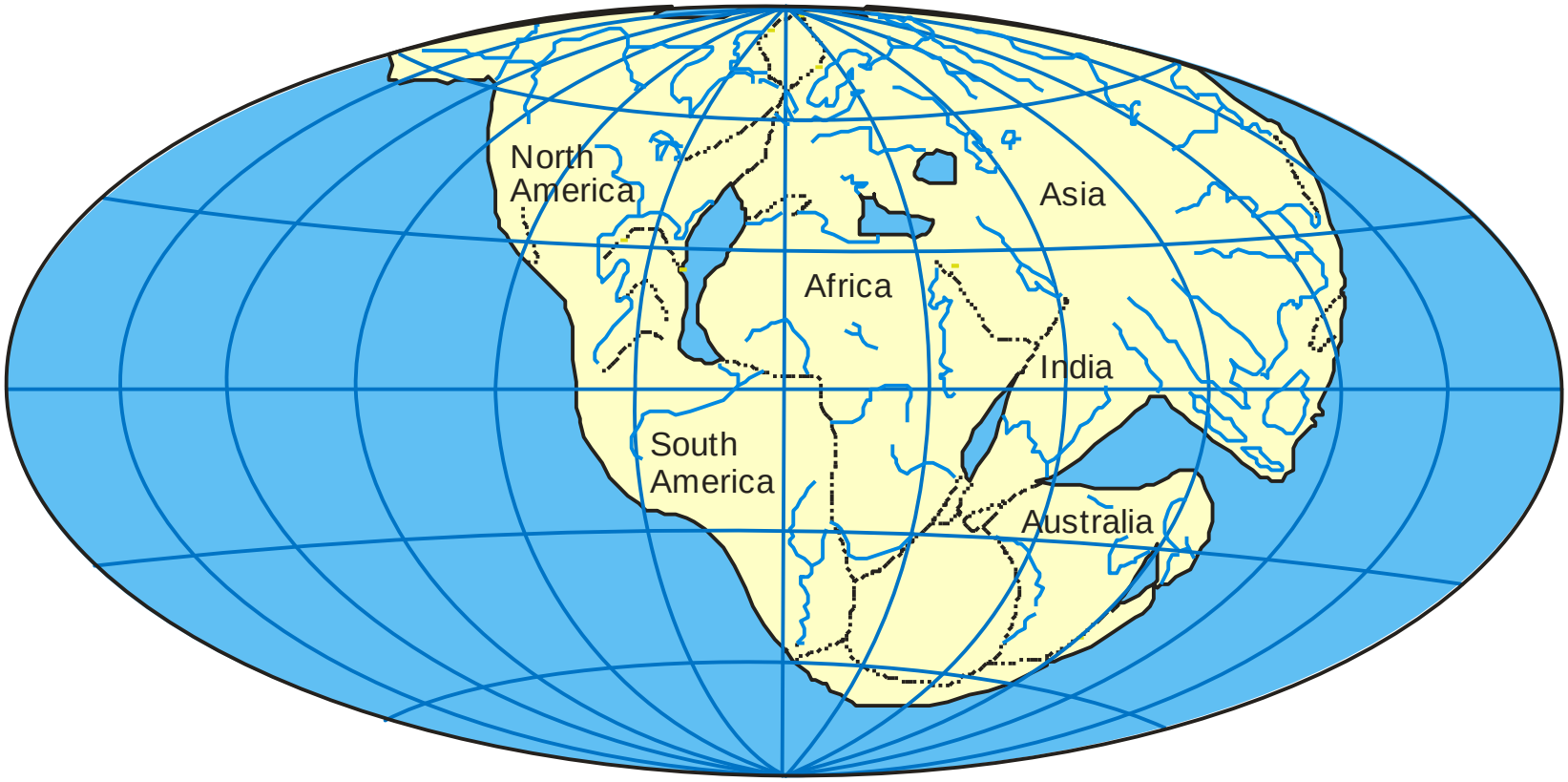
- **Antonio Snider-Pellegrini**
  - Snider was an advocate of *catastrophism* (i.e., the view that geologic history consists of a sequence of numerous violent catastrophic events)
  - He wrote of the apparent jigsaw puzzle fit of the U.S. Atlantic coast and west Africa
  - Snider ascribed the biblical flood to the former existence of a single continent that was torn apart to restore the balance of a lopsided Earth



- What made Wegener's hypothesis different?
  1. Wegener was the first to provide a detailed hypothesis of continental movement; AND
  2. He was the first to provide empirical data in support of his idea
- His ideas were first published in German in 1915 [*Die Entstehung der Kontinente und Oceane*, 94 p.]
- The first English translation was published in 1922

- The idea of continental movement was so controversial that Wegener continued to gather data in support of idea until his hypothesis was published in its final, 4th edition in 1929 as "*The Origin of Continents and Oceans*"

- Basic ideas of Wegener's "continental drift" hypothesis
  A. About 200 Mybp, the continents were all joined together in one massive supercontinent called **Pangaea**



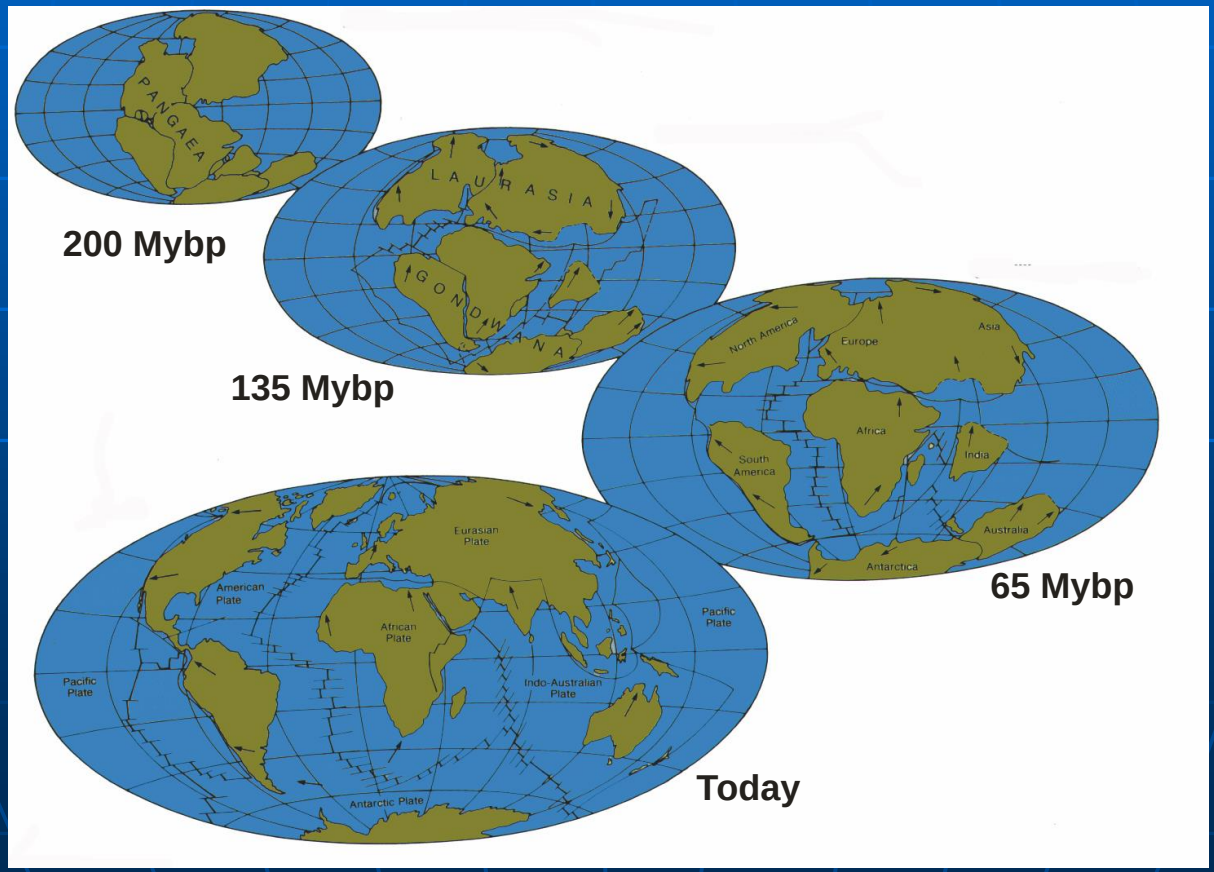
The supercontinent Pangaea. [Adapted from A. Wegener, 1928*The Origin of Continents and Oceans*]

B. About 185 Mybp, Pangaea began to break apart into two large land masses called

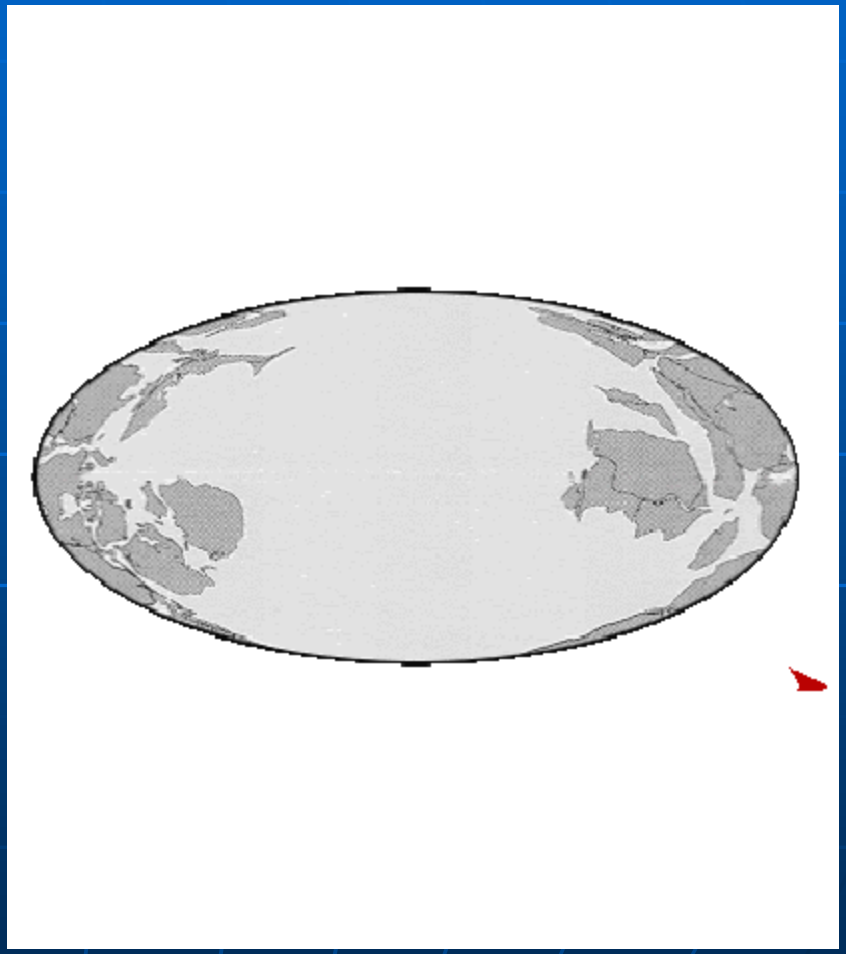
a) **Laurasia**—encompassing North America, Europe and Asia

b) **Gondwanaland**—encompassing South America, Africa, Antarctica, Australia, and India

C. About 135 Mybp, Laurasia and Gondwanaland further divided, creating the modern continental land masses by ca. 65 Mybp



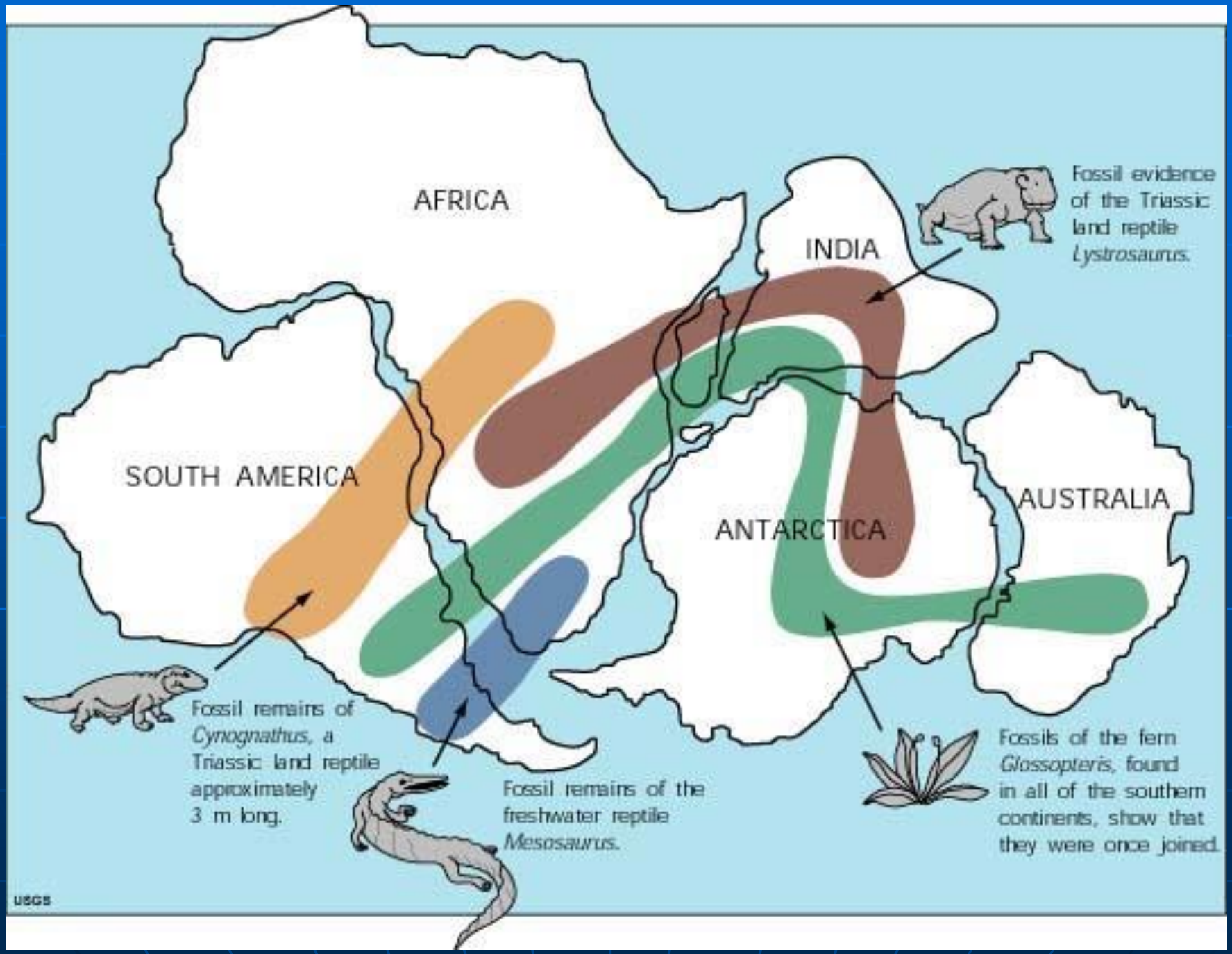
D. These continents have moved to their current positions over the last 65 My



- Wegener's continental drift hypothesis was very controversial
  - It opposed the two prevailing views
    - **Static Earth**
      - The Biblical story of creation
      - God created Earth, and it has remained the same ever since
    - **Shrinking Earth Hypothesis**
      - At one time, Earth was completely solid, and slowly cooled through time
      - As it cooled, the diameter of the planet decreased, producing faults and folds in topography at stress fields in Earth's crust

- Wegener began collecting data to test his hypothesis

1. **Fossil evidence**
   - Wegener demonstrated that fossils on several continents were very similar


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.
USGS

- In particular, Wegener noted the fossil plant *G*
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  Glossopteris evolved while the continents were joined

Modern ferns have reproductive structures called sori that realease airborne spores

Fossilized seeds of *Trigonocarpus* seed fern

Fossilized leaf of *Glossopteris*

2. Geological data

- Older rocks at locations where *Glossopteris* is found are similar in stratigraphy (i.e., rock sequence) in South America, Africa, India, Australia and Antarctica

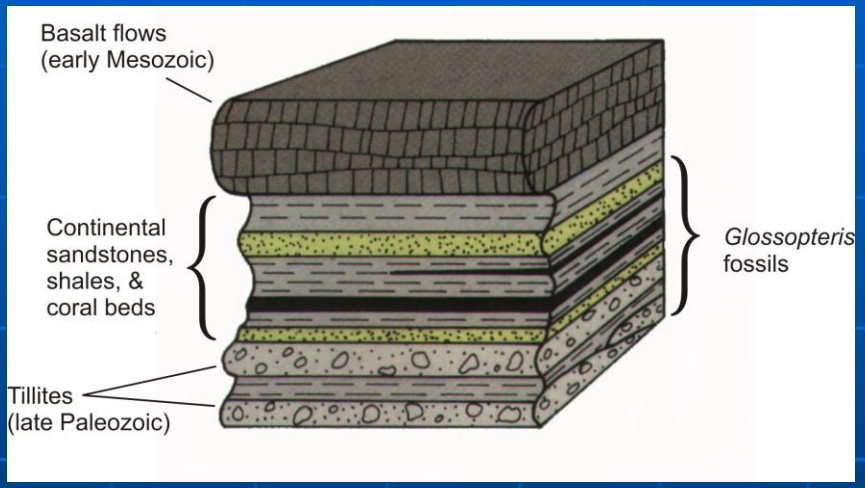

Africa
South America
Ice
Ice

- Stratigraphy of older rocks is
  - Paleozoic tillites [>245 Mybp] ,

    overlain by
  - thick continental sedimentary rocks (containing *Glossopteris*),

    overlain by
  - early Mesozoic lava flows [66–245 Mybp]
- However, younger rocks in these five locations are very dissimilar

- Wegener concluded that these data suggest that older rock sequences formed as single unit when continents were together in Pangaea, while younger rock sequences developed after Pangaea split during the Mesozoic (66–245 Mybp)



3. Paleoclimate data

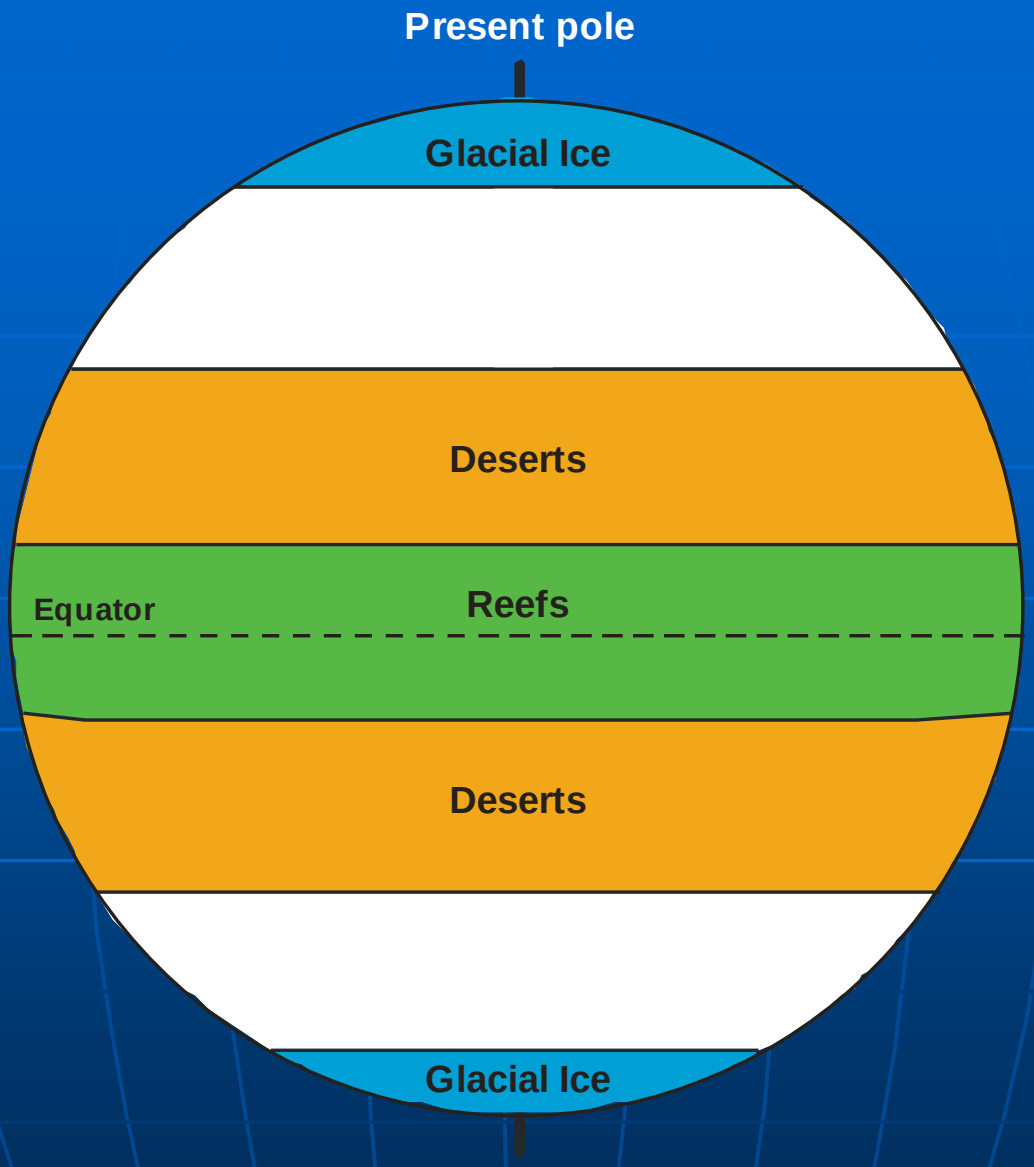
- Wegener also found evidence for glaciation on continents of the southern hemisphere in the late Paleozoic [>245 Mybp] that supported the idea of Pangaea
- At modern continental locations, glaciation of such extensive magnitude would **have** to prevail over almost the entire planet
- However, there is no evidence of widespread glaciation in the northern hemisphere during the Paleozoic Era [245–570 Mybp]
- In fact, coal deposits of North American and Europe were being laid down in warm, swampy conditions during the Paleozoic

Geographic range of apparent glaciation on continents of the southern hemisphere in the late Paleozoic [>245 Mybp]

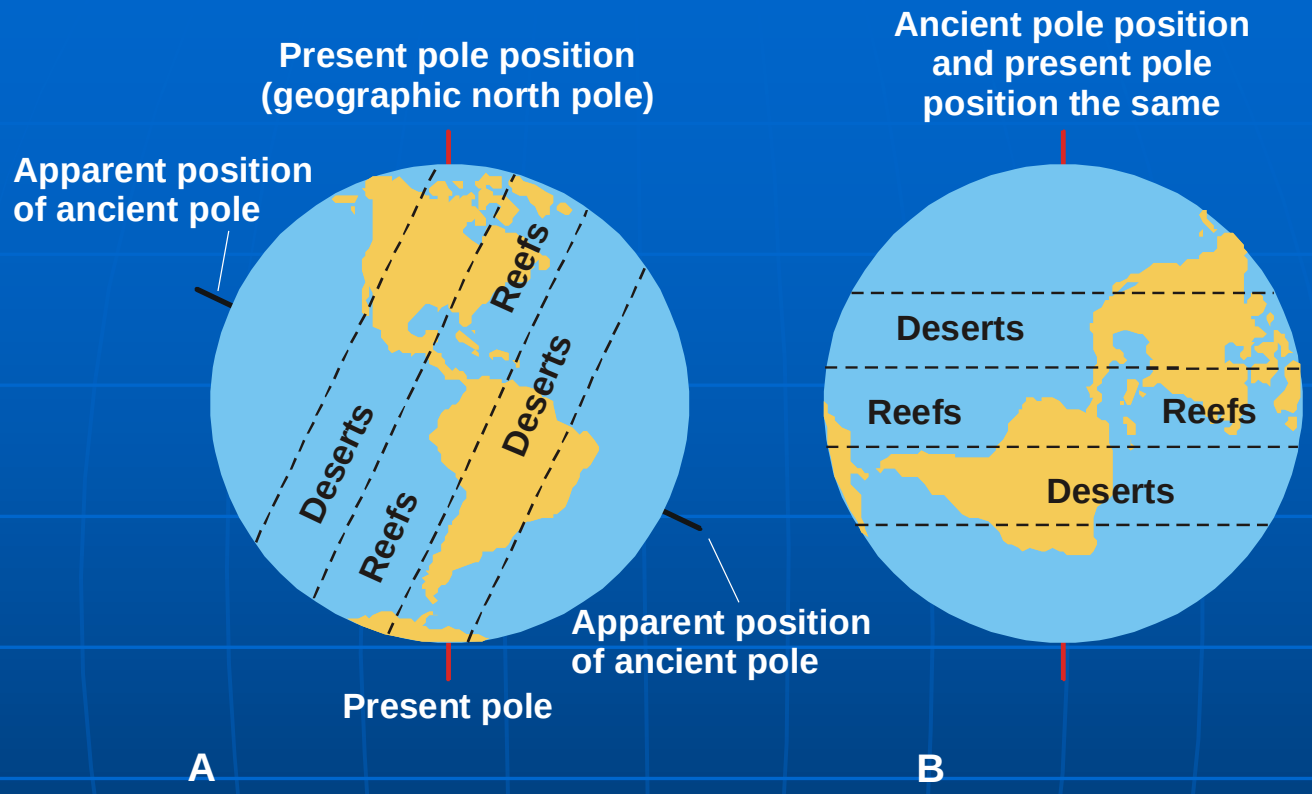
Wegener demonstrated that the glaciation would be localized if the five localities were joined in southern Pangaea

4. Apparent polar wandering

- Geological evidence indicates that there have been shifts in climate belts through Earth's history
- The idea of Earth's apparent polar wander is based on evidence indicating shifts in the paleoclimate belts



Generalized climate zone today produce belts of geological features, such as glaciers, deserts, and coral reefs. [Adapted from Plummer and McGeary, 1991].



Two ways of interpreting the distribution of ancient climate belts. (A) Continents fixed, poles wader. (B) Poles fixed, continents drift. For simplicity, the continents in B are shown having moved as a unit, without changing positions relative to one another. If continents move, they should change relative positions, complicating the pattern shown. [Adapted from Plummer and McCreary, 1991].

- The second explanation supported Wegener's hypothesis

- Despite the supporting evidence, Wegener's hypothesis remained controversial, primarily because of the mechanism Wegener chose to explain the cause of continental movements
  - The driving force that he considered for drift was unconvincing: he proposed that the westward tidal force exerted on the continents caused them to ***"plow through oceanic crust, perhaps crumpling up mountain ranges on the leading edges where they push against the sea floor"***
  - Opponents of Wegener's hypothesis were quick to point out that sea floor crust is denser (3.0 g/cm^3) than continental crust (2.7 g/cm^3)
    - Therefore, continents plowing through sea floor is not possible

- Wegener died in 1930 in Greenland, from exposure on glacial ice while making geophysical measurements bearing on drift
- He was lost in a blizzard on 1 November 1930, and his body was recovered the following May