Plate Tectonics

- Intro: Chemical and physical structure of Earth

1) The plate tectonic system
2) A theory is born
3) Early evidence for continental drift
4) Continental drift and paleomagnetism

Read Chapter 3!

PLATE TECTONICS 2) A theory is born

How do scientists work? The scientific method

Observations

↓

Hypotheses → Testing (Lab, field…)

=tentative explanations

results presented at meetings, research papers, scrutinized by peers...

If accepted...

Theory, Model

= accepted explanation of natural phenomenon, can be used as predictive tool

↓

Law *= verbal or mathematical statement of a well established explanation of a natural phenomenon (e.g. gravity)*

Scientists are working to make observations (working descriptively) or test hypotheses to explain observations. The process never ends: theories can be revoked any time if they are not in accordance with new observations (similarity of scientists and detectives..).

PLATE TECTONICS 2) A theory is born

1915
Alfred Wegener published hypothesis of
continental drift
(***'The origins of continents and oceans'***)

He hypothesized:

- existence of single "super-continent"
  Pangaea *("pan - G - uh")*
- ~ 200 million years ago Pangaea broke into smaller pieces, & "drifted" to present positions

200 million years ago

2) A theory is born

1924
Wegeners book translated to English

& met with hostile criticism

- **Main objection:** no way to explain continental drift.

3. Early evidence for continental drift

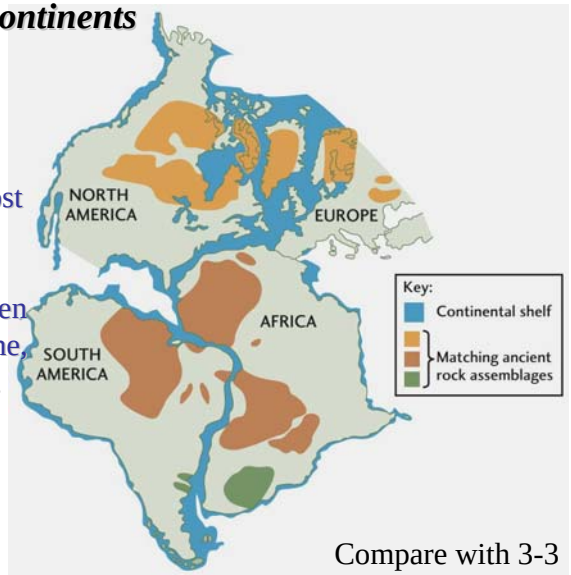
- ***Jigsaw puzzle of the continents***
- ***Fossil record***
- ***Rock types and structural similarities***
- ***Paleoclimate***

3. Early evidence for continental drift

- ***Jigsaw puzzle of the continents***

The fit of all continents around the Atlantic is almost perfect.

The best fit is achieved when taking the 1000 m depth line, the true edge of continents. (1960's by Sir Edward Bullard)

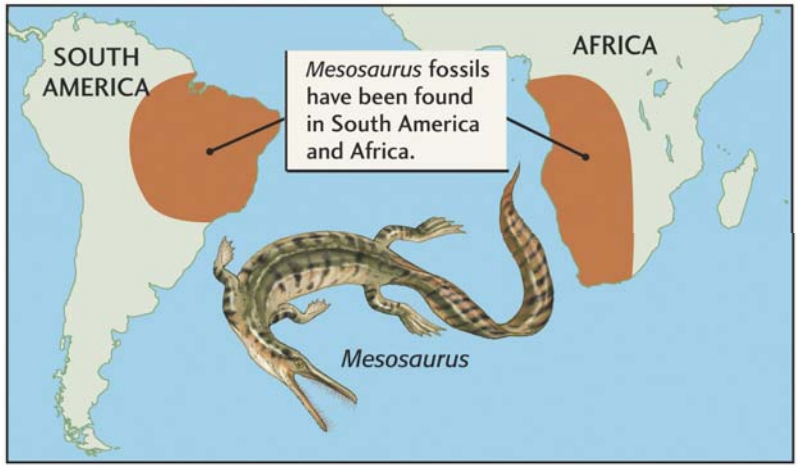


Compare with 3-3

3. Early evidence for continental drift

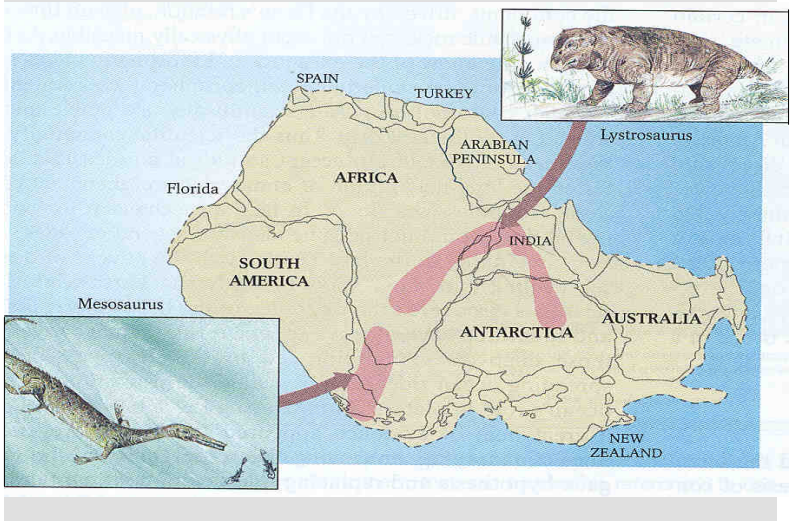
- ***Fossil evidence***

Several fossil organisms have been found in common on different continents



3. Early evidence for continental drift

- ***Fossil evidence***



3. Early evidence for continental drift

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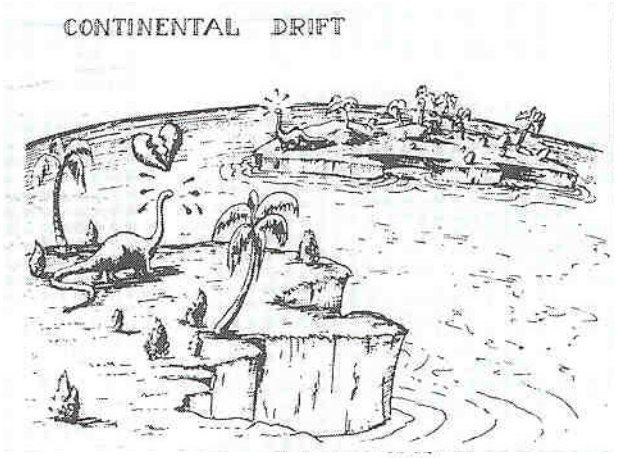


PLATE TECTONICS

3. Early evidence for continental drift

- ***Rock evidence***

Mountain belts on one continent match up with another.

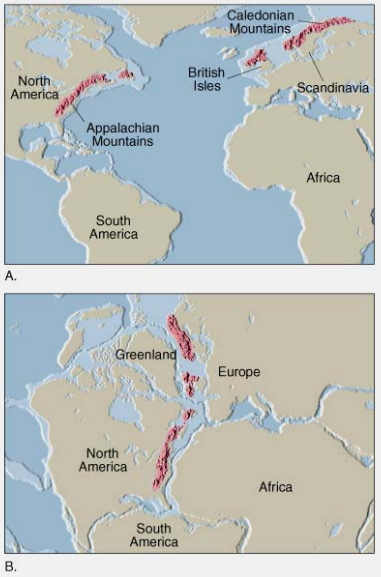
Similar rock structure and age:

- **Appalachians (eastern US)**
- **British Isles, Scandanavia**

3. Early evidence for continental drift

- ***Rock evidence***

Mountain belts on one continent match up with another.



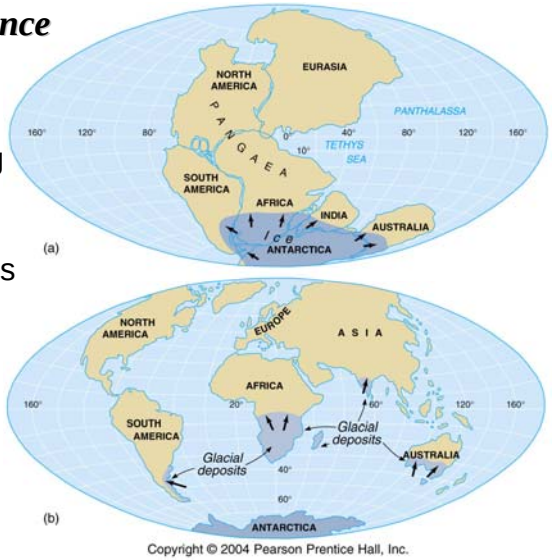
Compare with Fig. 3.4

PLATE TECTONICS 3. Early evidence for continental drift

- ***Paleoclimate evidence***

(ancient)

Ice sheets covered big areas of southern hemisphere
~ 220-300 million years ago



Compare with Fig. 3.5

PLATE TECTONICS 3. Early evidence for continental drift

- ***Paleoclimate evidence***

Ice sheets covered big areas of southern hemisphere
~ 220-300 million years ago

Glacial striations

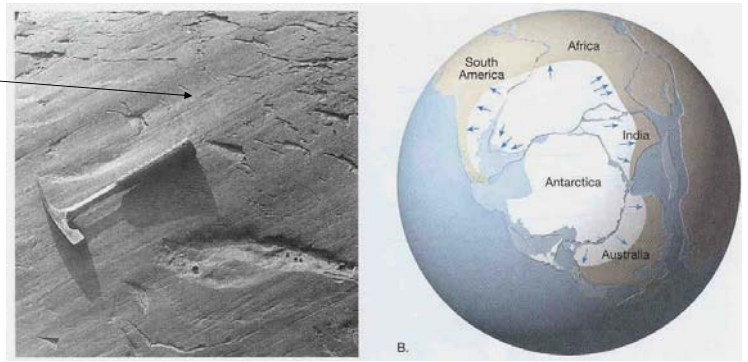


Plate Tectonics

PLATE TECTONICS 4) Continental drift and paleomagnetism

Wegener's idea died until 1950's.
Renewed interest from **rock magnetism**

- **Paleomagnetism:** ancient magnetic field of Earth recorded and frozen into rocks

How? Need to know about 2 things:

- Earth's magnetic field
- Magnetism in rocks

Rock magnetism

-Certain minerals are magnetic (e.g., magnetite, iron)
-They loose magnetization when heated above Curie point (580°C for iron)
-When cooled below Curie pt, magnetic grain aligns w/ Earth's magnetic field

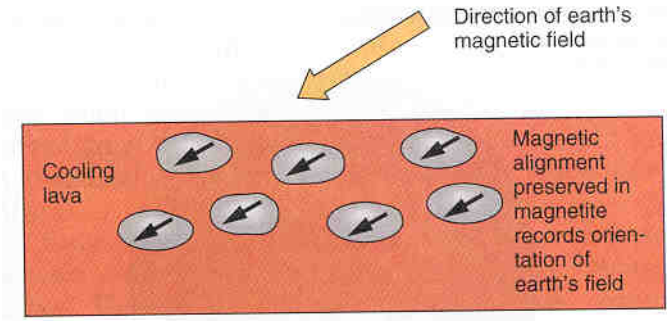


PLATE TECTONICS 4) Continental drift and paleomagnetism

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http://www.pbs.org/wgbh/nova/minutes/q_30

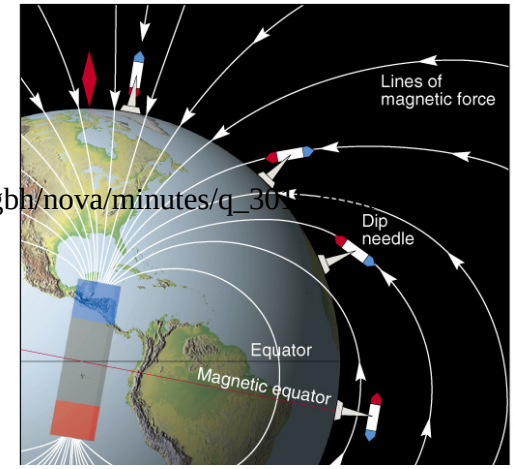
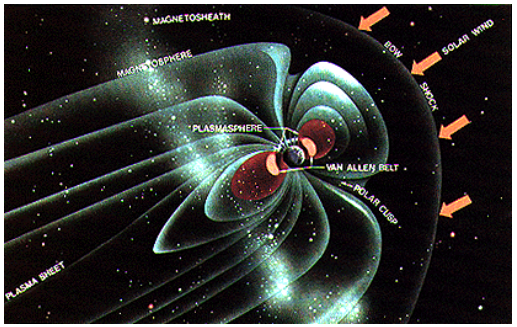


Fig. 3-7

Earth's magnetic field

In the simplest terms, Earth can be thought of as a dipole (2-pole) magnet. Magnetic field lines radiate between Earth's north and south magnetic poles just as they do between the poles of a bar magnet. Charged particles become trapped on these field lines (just as the iron filings are trapped), forming the **magnetosphere**.

- Earth's magnetic field protects us from sun's high energy radiation (solar flares).



http://liftoff.msfc.nasa.gov/academy/space/mag_field.html

PLATE TECTONICS 4) Continental drift and paleomagnetism

- Earth's magnetic field "reverses"
- recorded in lava flows

http://www.pbs.org/wgbh/nova/minutes/q_3016.html

And now: The Hollywood version…

Geomagnetic reversals

- Earth's magnetic field "reverses"
- recorded in lava flows

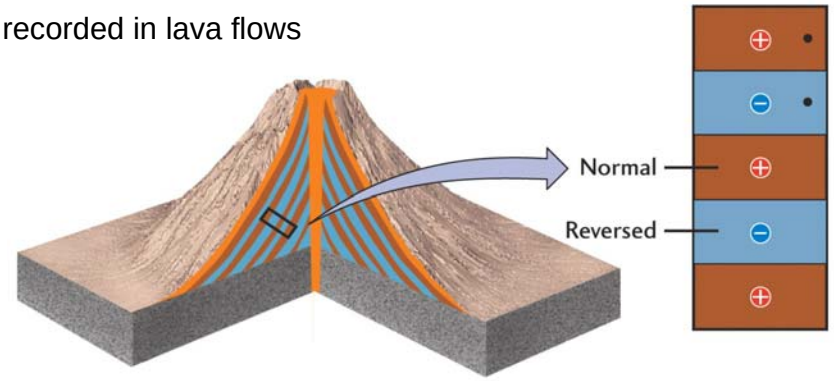
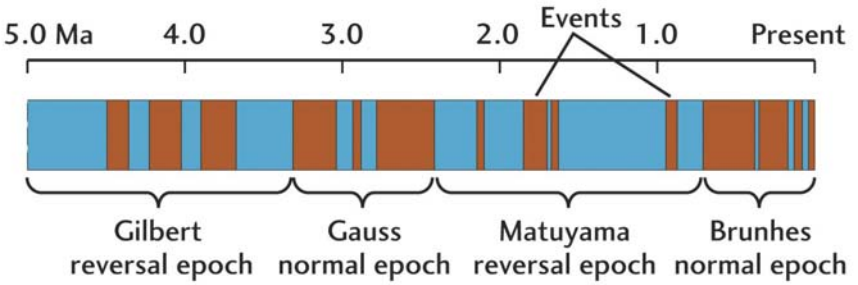


Fig 3-9

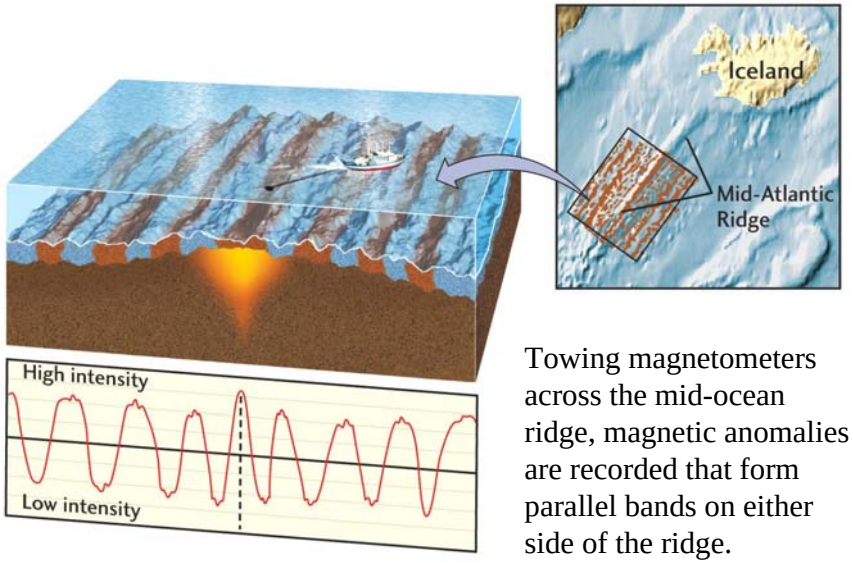
4) Continental drift and paleomagnetism



From dating reversals in the lava record in different continental lava flows, a magnetic time line can be established. There is a reversal about every 500,000 years (short reversal '**events**' may interrupt the longer magnetic '**epochs**').

See Fig. 3-13

4) Continental drift and paleomagnetism



Towing magnetometers across the mid-ocean ridge, magnetic anomalies are recorded that form parallel bands on either side of the ridge.

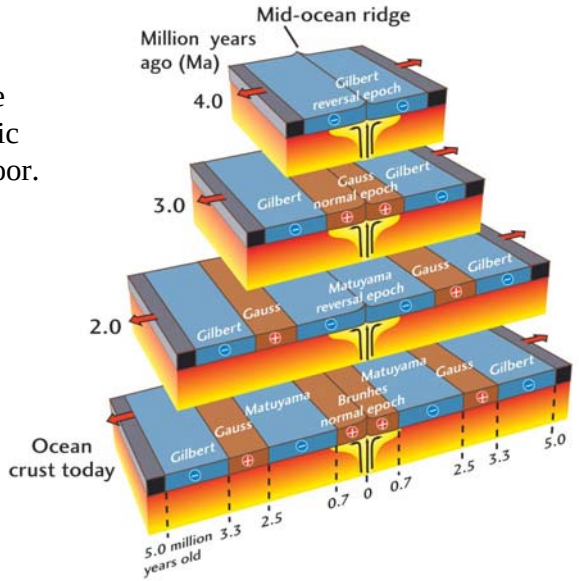
Movie: Seafloor Spreading

Movie

4) Continental drift and paleomagnetism

The reconstructed magnetic time-line were used to date the magnetic anomalies on the sea-floor.

Knowing the width of a band, and the time a magnetic epoch lasted you can come up with a value of seafloor spreading (speed=distance/time)



See Fig. 3-11

4) Continental drift and paleomagnetism

Seafloor magnetic stripes

- 1963, Vine & Matthews connected seafloor spreading & continental drift, from magnetic field reversals recorded in cooling lavas of new seafloor
- symmetric patterns ("stripes") on either side of spreading center (mid-ocean ridge)
- changes in width of a given stripe indicate changes in spreading rate.

4) Continental drift and paleomagnetism

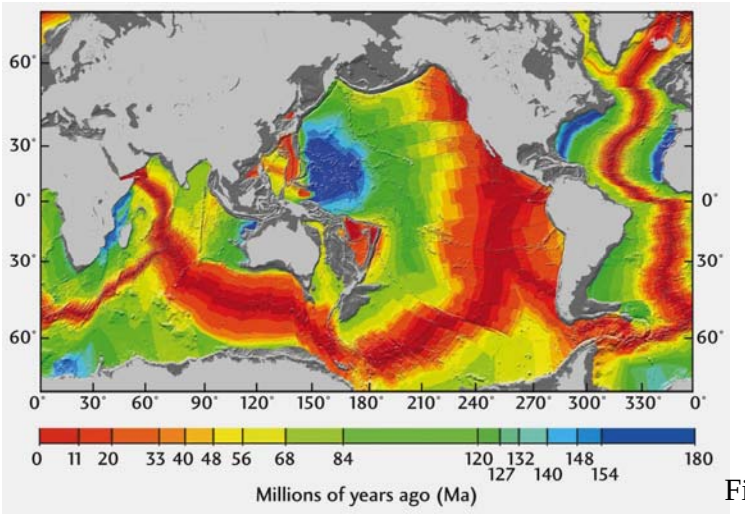


Fig. 3-12

Age of sea-floor measured from magnetic reversals and deep sea drilling.

Deep Sea Drilling Vessel JOIDES Resolution

Confirmed ocean floor age increases away from mid-ocean ridge.

4) Continental drift and paleomagnetism

- See history handout:

- The great synthesis: in 1965, Tuzo Wilson merged the concepts of continental drift and seafloor spreading into the theory of ‘Plate Tectonics’