

Bell Ringer

1. List the members in your poster group
2. Assign percentages for how much you think they participated in the poster.
3. Go to <https://goo.gl/yD14PX> and take the survey. Use your phone or borrow a neighbor's. Or grab a computer.

Posters



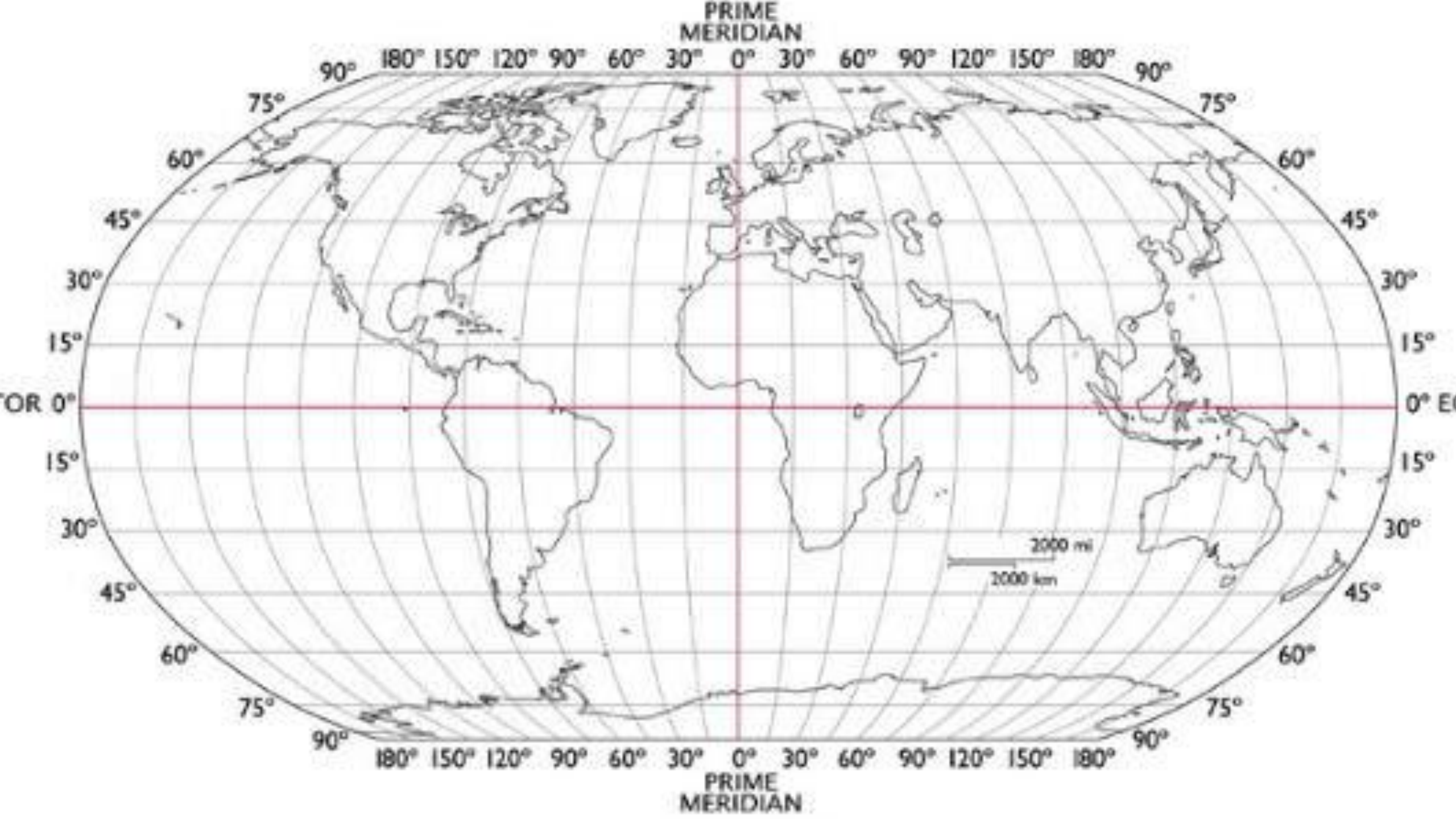
Quiz

- Go to Hammer Science > Earth Science
- Click on 'Earth Layers Quiz
- Take the Quiz
- Read something silently when you are done



Earthquake Mapping





Bell Ringer

1. Do earthquakes and volcanoes happen randomly, or are there specific places where they tend to occur?
2. What is one example of a volcano that exists not on a plate boundary?
3. What is the physical layer of the Earth that makes up all of the crust and some of the mantle?



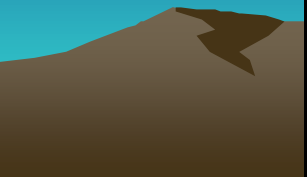
Goals for today

1. Understand the modern theory of plate tectonics
2. Understand 'Continental drift', our theory before plate tectonics.
3. Evidences for plate tectonics and continental drift.



Objective 2 - Plate Tectonics

- ***Continental Drift***
 - ***Alfred Wegner***
 - ***Structure & Glaciation***
 - ***Paleontology***
- ***Plate Tectonics***
 - ***Sea Floor Spreading (H.H. Hess)***
 - ***Ocean Floor***
 - ***Paleomagnetism***
 - ***Sediment***



Continental Drift

The Meteorologist Who Started a Revolution
Wegner (1880–1930)



The Origin of the
Continents and Oceans
(1915)

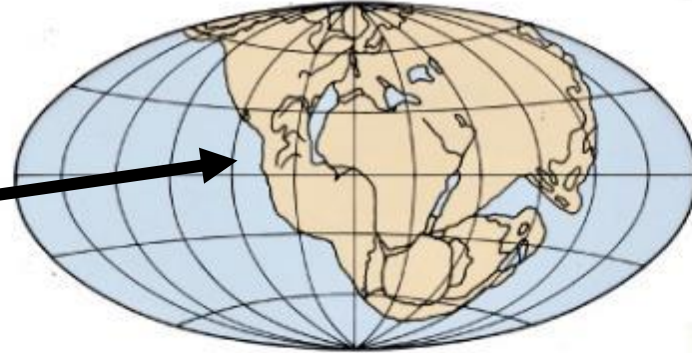
The predecessor to
modern plate tectonics

Similar shapes, fossils,
ancient climates

Similar Shapes of Continents

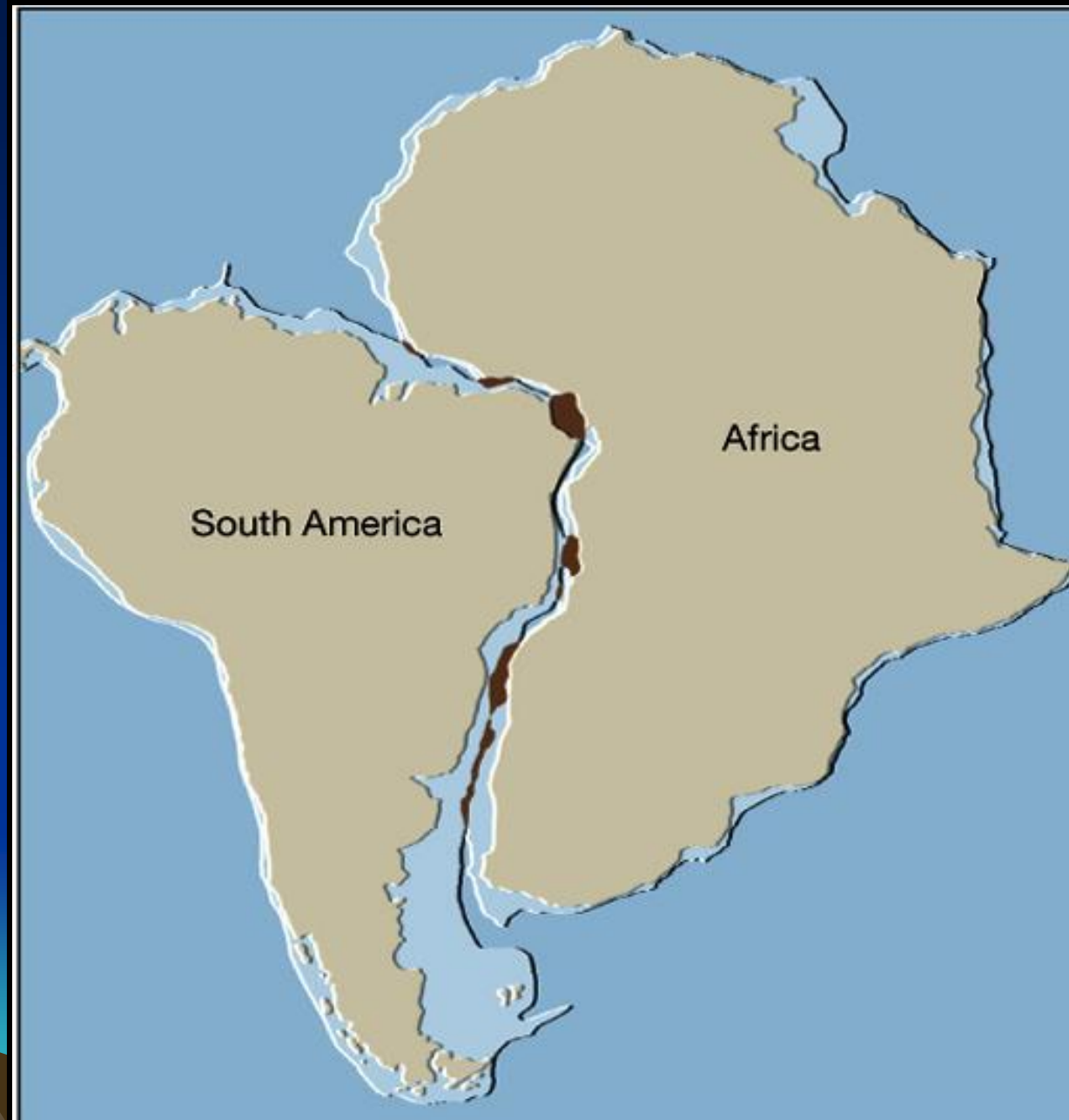
*Continental drift
maps by Wegner
(1915)
"not widely
accepted"*

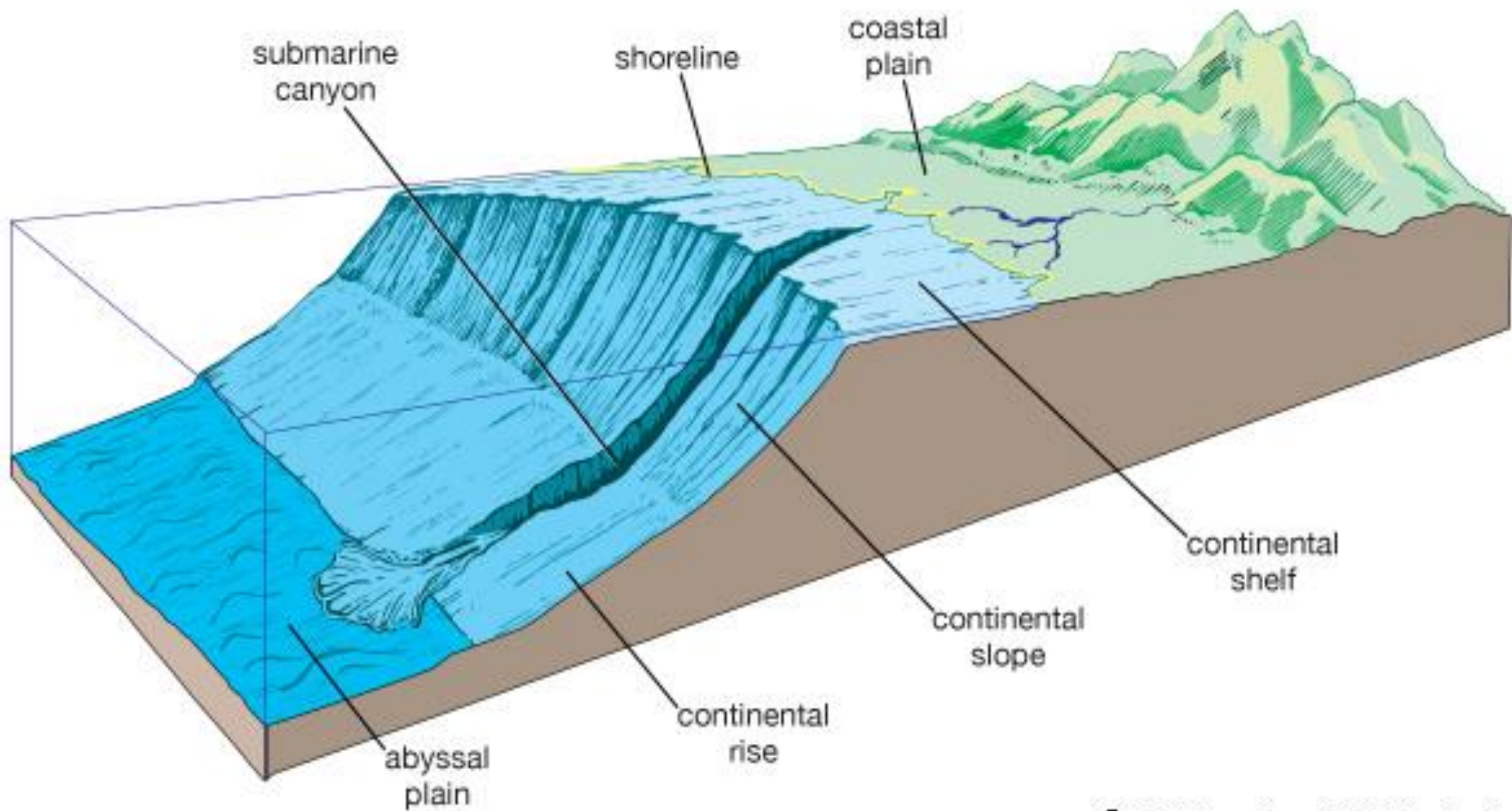
Pangea

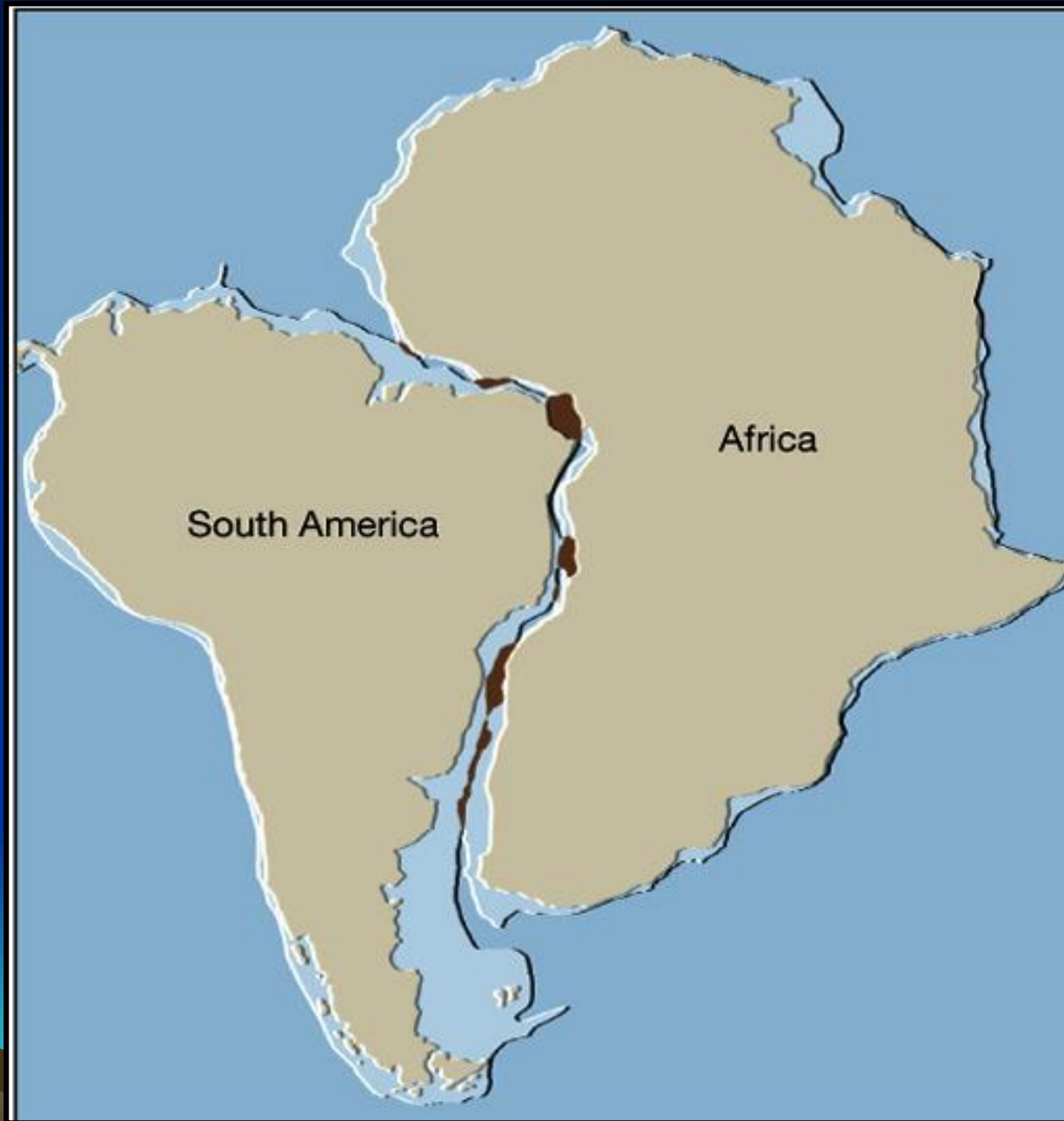


(B)

Fit is enhanced by fitting continental Shelf at the break, and not at the shore line







South America

Africa

Evidence for Continental Drift

- Paleoclimate
 - Evidence of extreme changes in climate as compared to the present
 - Coal deposits in Antarctica
 - Evidence from:
 - Evaporite's (Like salt)
 - Desert sand deposits
 - Coral reefs
 - Glaciation



Coal swamp



Desert sand



Salt deposits



Reef



Glaciated



Desert



Tropics

Evidence for Continental Drift

- Paleontological
 - Similar fossils on opposite sides of the Atlantic Ocean
 - Plants and animals
 - *Glossopteris* on all southern continents
 - No mechanism to transport across ocean

***Ancient
Mesosaurus
Habitat***





MESOSAURUS



Permian freshwater reptiles





Remains of the freshwater reptile *Mesosaurus* have been found in both South America and Africa.



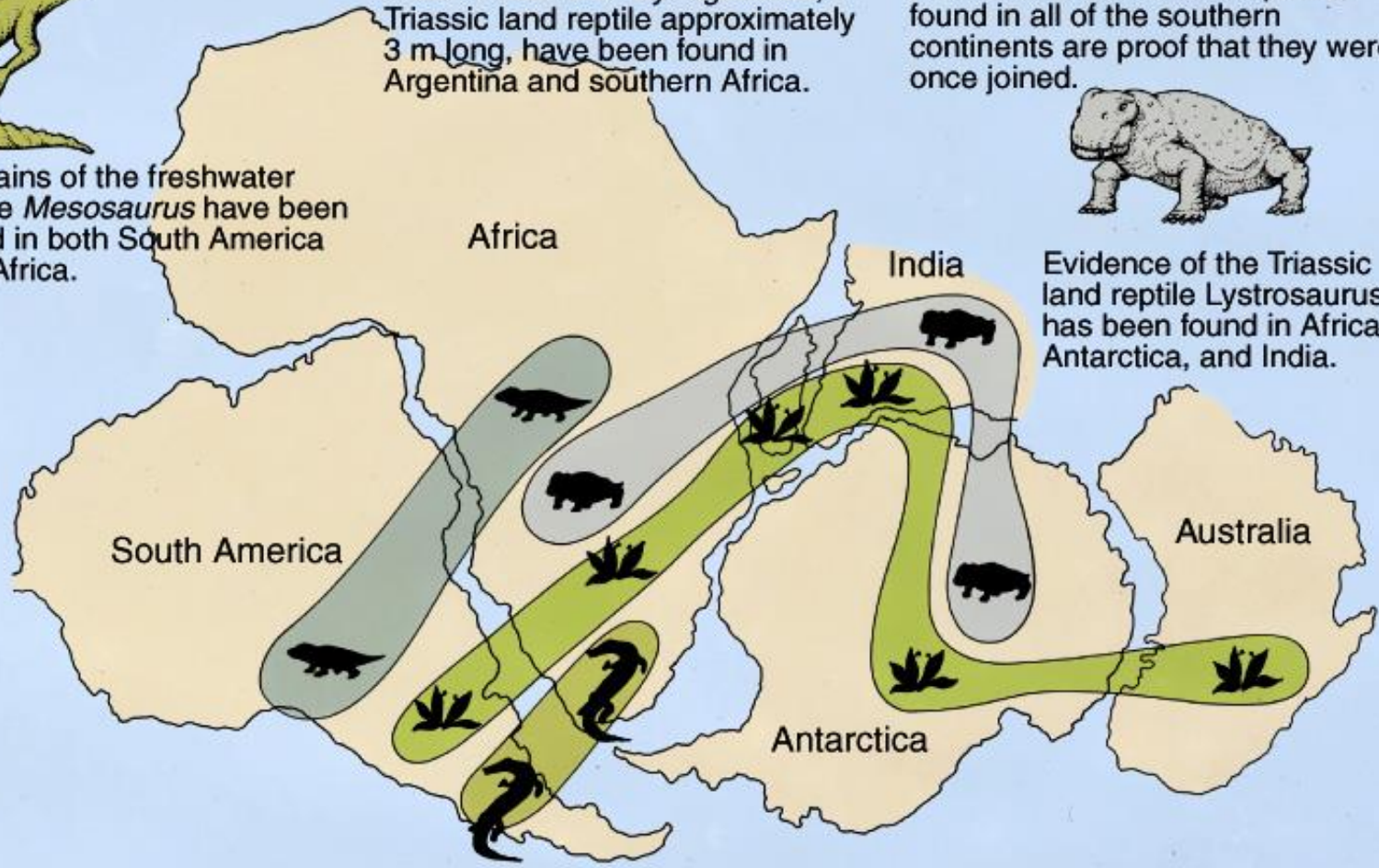
Fossil remains of *Cynognathus*, a Triassic land reptile approximately 3 m long, have been found in Argentina and southern Africa.



Fossils of the fern *Glossopteris*, found in all of the southern continents are proof that they were once joined.



Evidence of the Triassic land reptile *Lystrosaurus* has been found in Africa, Antarctica, and India.



Evidence for Continental Drift

- Rock type & structures
 - Distinct rocks on both sides of the Ocean
 - Cape fold belt and equivalent – S.Africa & Argentina
 - Appalachian Mtns and equivalent – U.S., Canada, Scotland & Norway
 - Only occur in rocks > 145 mya

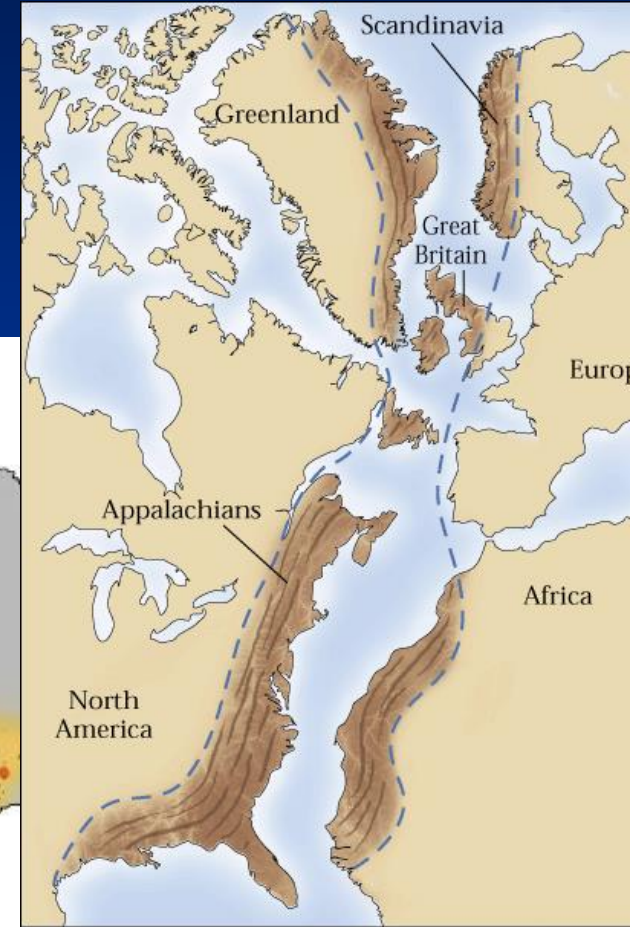
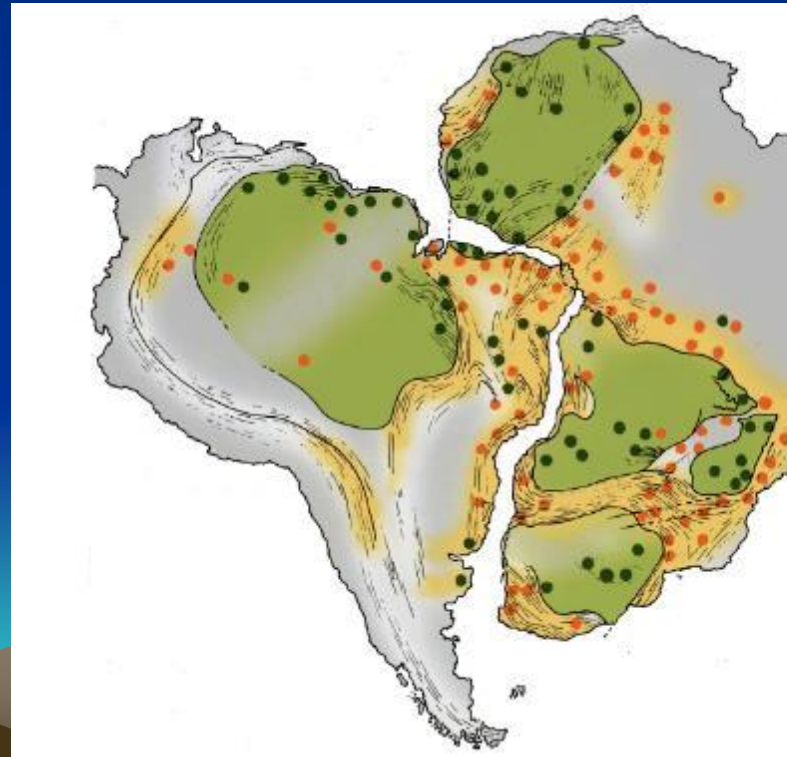


Plate tectonics puzzle



***Continents “Plow”
through ocean crust,
driven by forces related
to Earth’s rotation***



How was Wegener's Theory received?

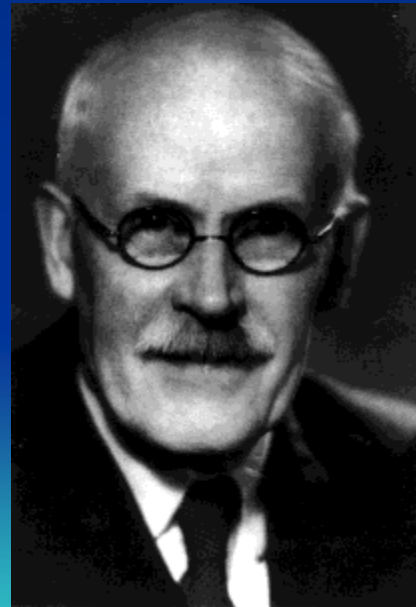
- Rollin T. Chamberlin (U of Chicago, 1928)
“Wegener's hypothesis in general is of the foot-loose type, in that it takes considerable liberty with our globe, and is less bound by restrictions or tied down by awkward, ugly facts than most of its rival theories. Its appeal seems to lie in the fact that it plays a game in which there are few restrictive rules and no sharply drawn code of conduct.”

- Bailey Willis (Stanford Univ., 1928)



“When we consider the manner in which the theory is presented, we find that the author offers no direct proof of its verity; that the indirect proofs assembled from geology, paleontology, and geophysics prove nothing in regard to drift...; that the fields of related sciences have been searched for arguments that would lend color to the adopted theory, whereas facts and principles opposed to it have been ignored. Thus the book leaves the impression that it has been written by an advocate rather than by an impartial investigator.

- Harold Jeffreys (Cambridge U., 1924)
“It is an impossible hypothesis! How can a small force not only produce indefinitely great movement, but overcome a force many times greater acting in the opposite direction at the same time?”

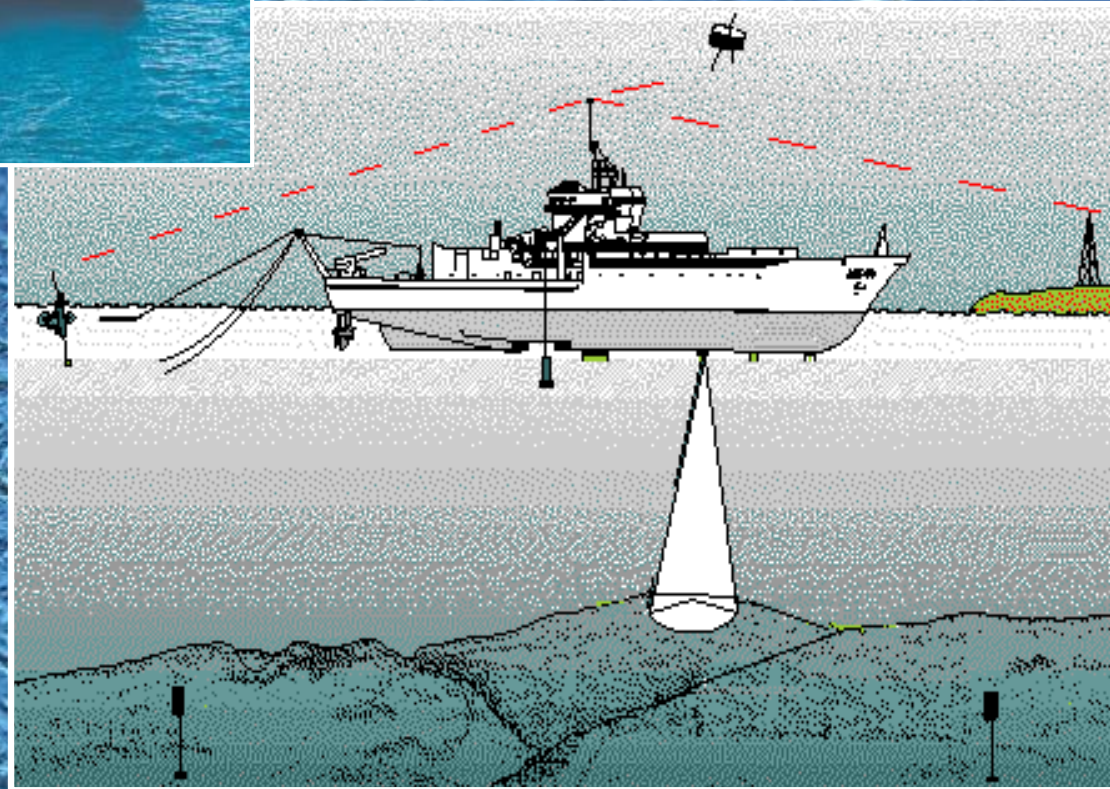


Development of Plate Tectonic Theory

- Original evidence for continental drift was from the continents
- Technological advances in the 1950's and 1960's allowed investigation of the sea floor
- Geophysics & paleomagnetism provided new data

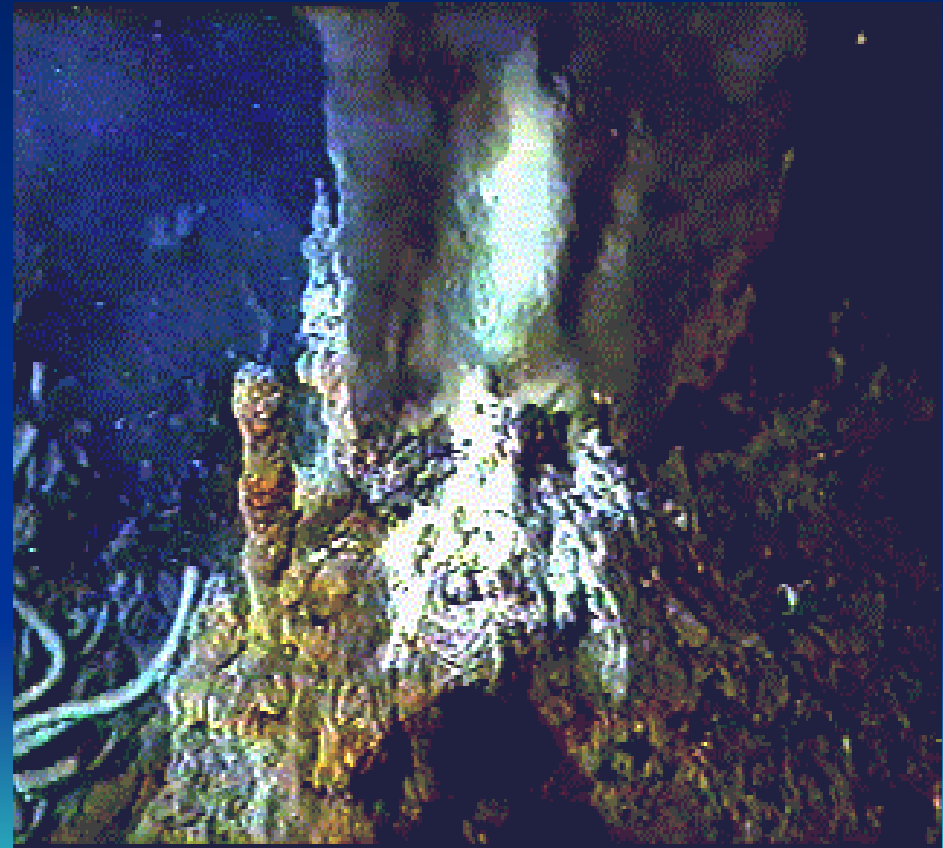


- **Seafloor spreading proposed (Hess-1962)**
 - **Considered new data on ocean floor**



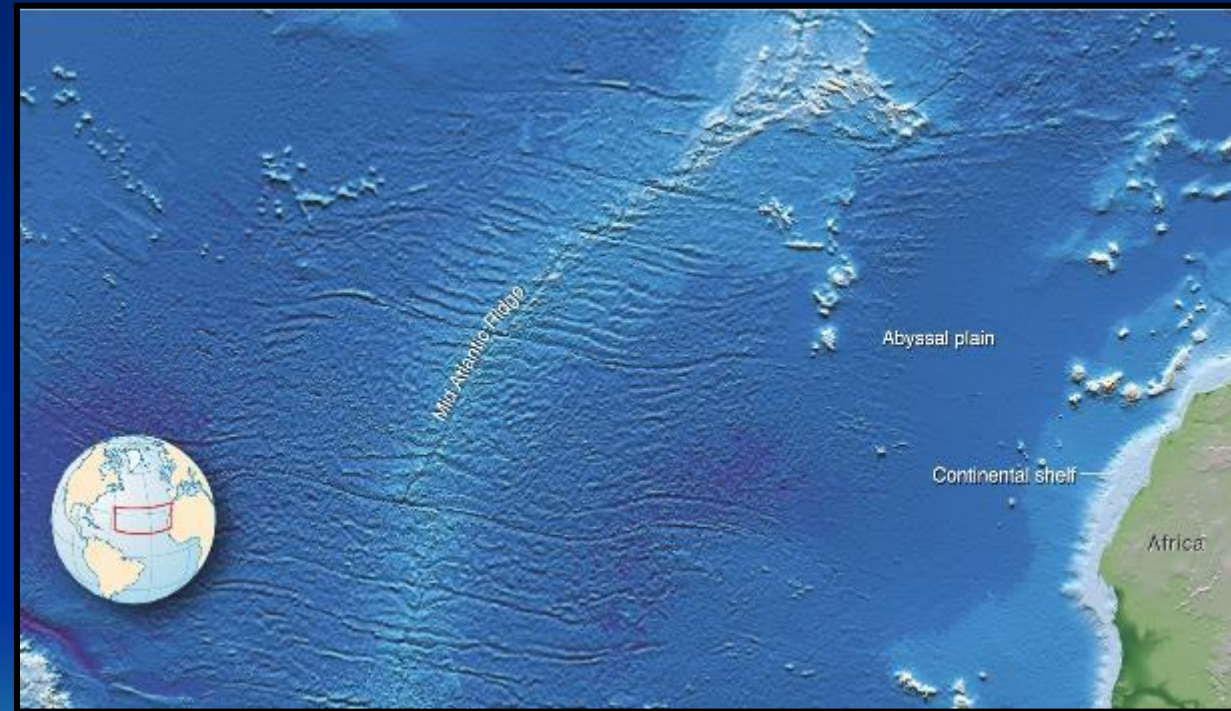
Geology of the Ocean Floor

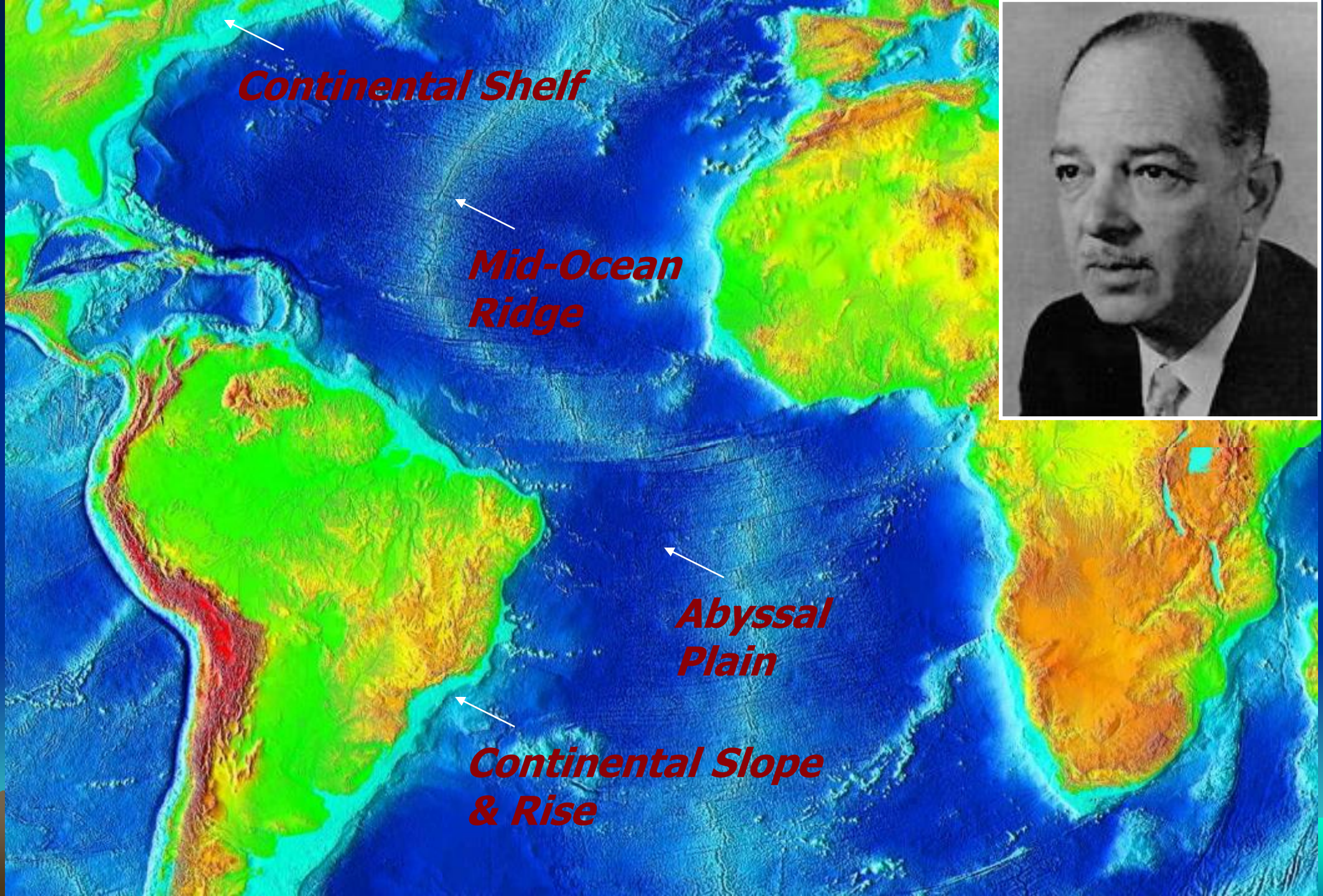
- Topography of the ocean basins
 - Basins are divided by a large ridge system
 - Ridge system is continuous around the entire globe
 - Central rift valley within the ridge



Geology of the Ocean Floor

- Physical properties
 - Composed of basalt
 - Younger and thinner than most continental rocks
 - No evidence of crustal deformation – unlike folded mountains



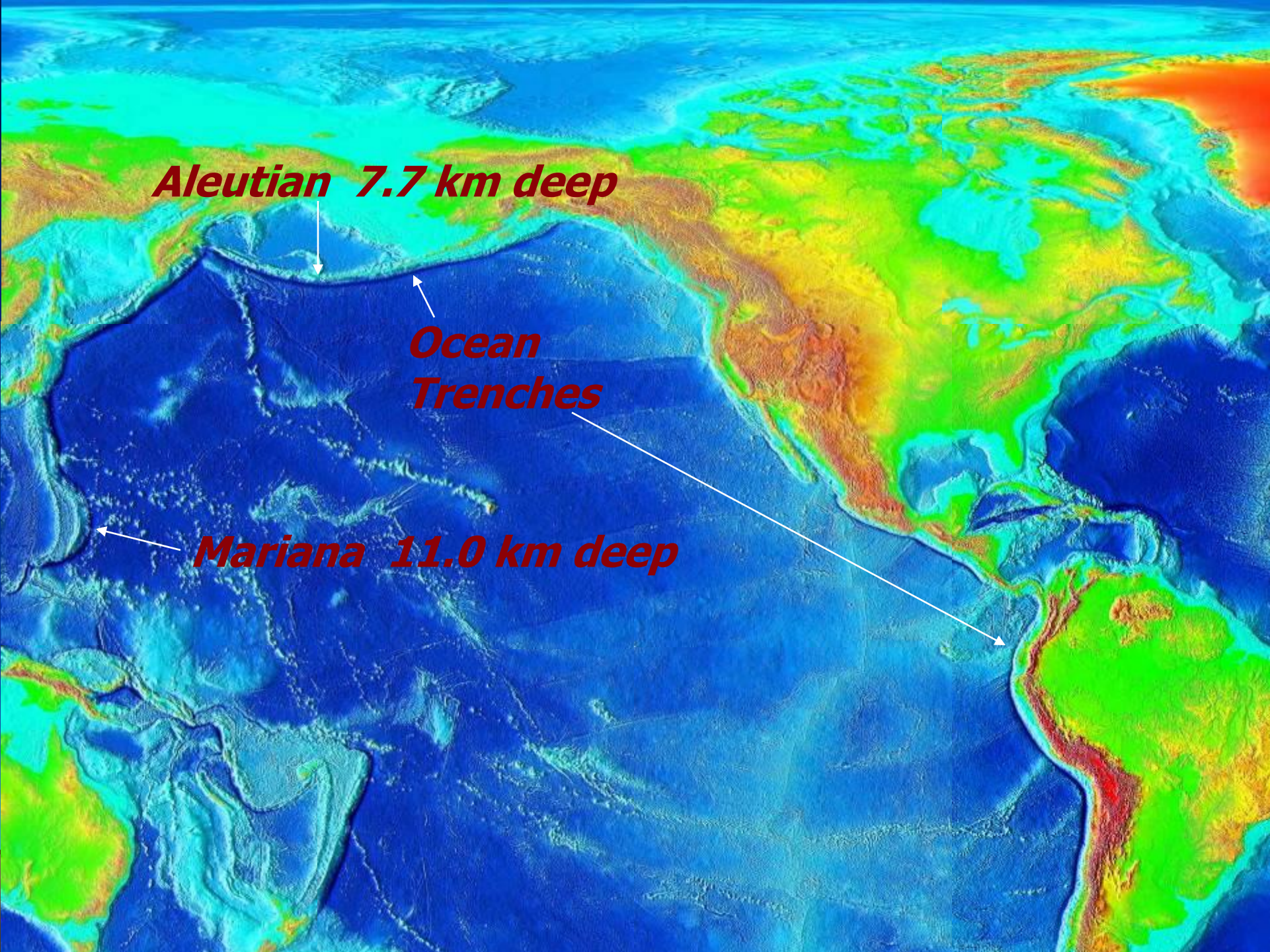


Continental Shelf

Mid-Ocean Ridge

Abyssal Plain

Continental Slope & Rise



Aleutian 7.7 km deep

***Ocean
Trenches***

Mariana 11.0 km deep

What fuels all of this? Where is the energy coming from?



Bell Ringer

1. What is one of the evidences Wegner had for his theory of Continental Drift?
2. Continental Drift came from evidences on the continents. Where did evidences for Plate Tectonics come from?
3. What did scientists expect to find on the bottom of the ocean. What did they actually find in the middle of the Atlantic?



Convection Activity

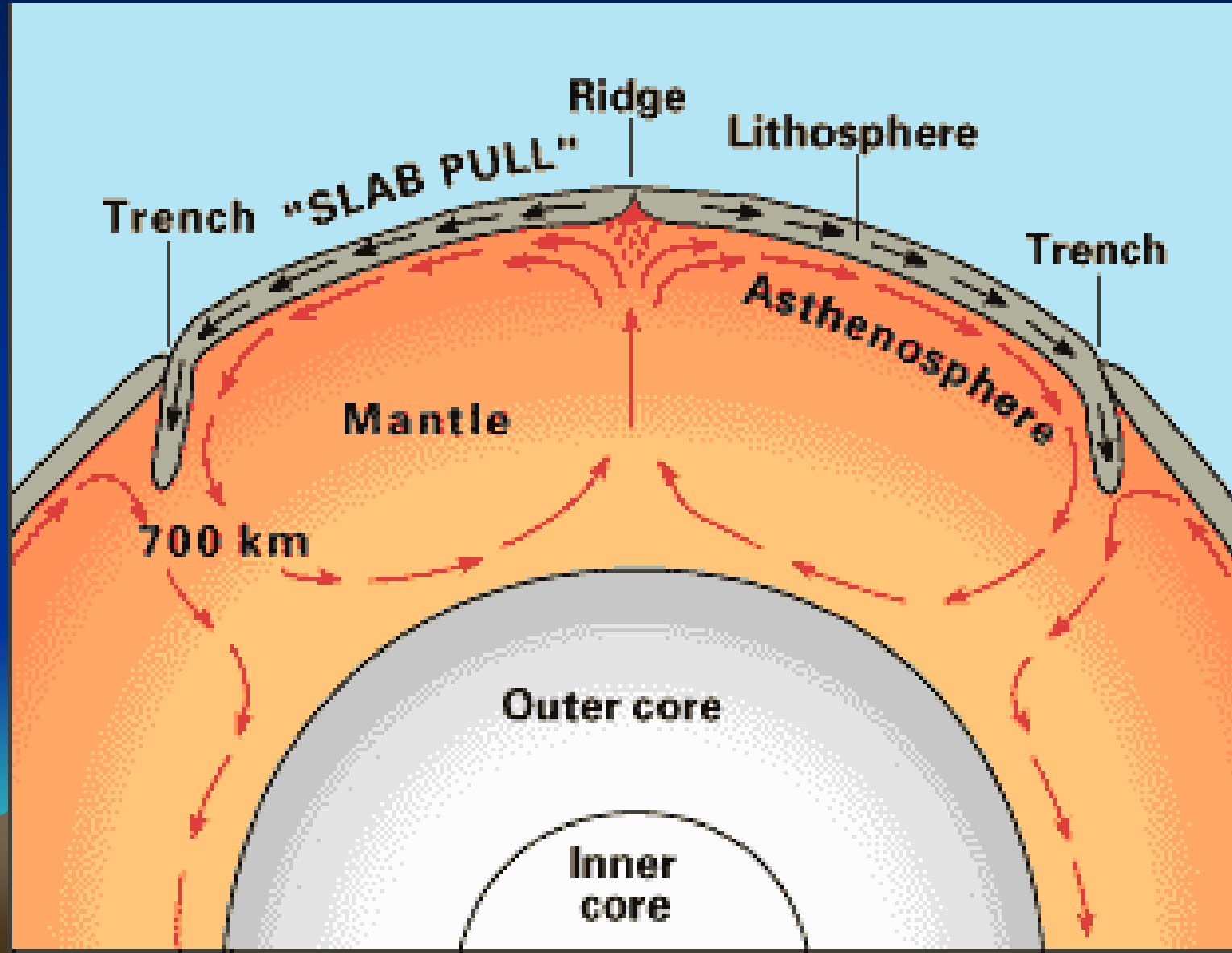


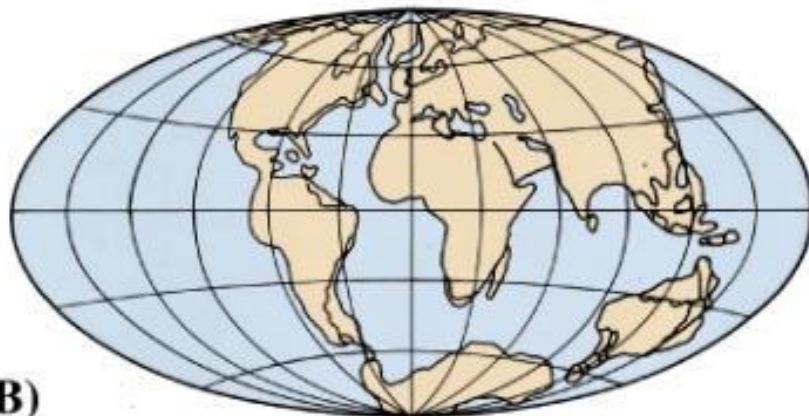
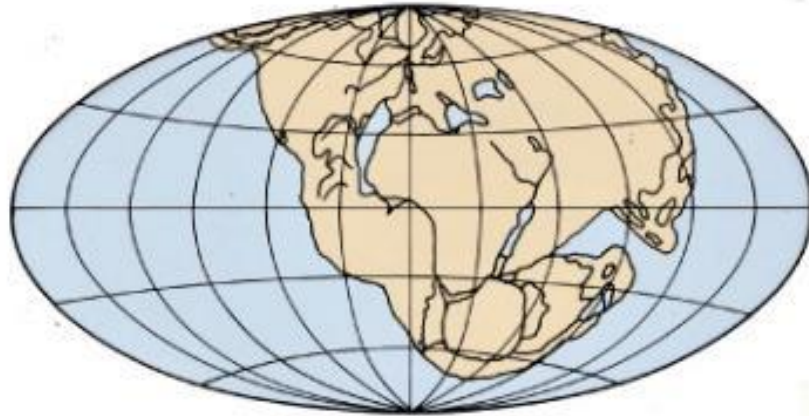
When lava meets water

- <https://www.youtube.com/watch?v=hmMIspNoZMs>
- <https://www.youtube.com/watch?v=ahZD95I1MvM>
- <https://www.youtube.com/watch?v=yvSmPqqZB3Q>



The interior of the earth is a busy place as both the outer core and the asthenosphere convect!

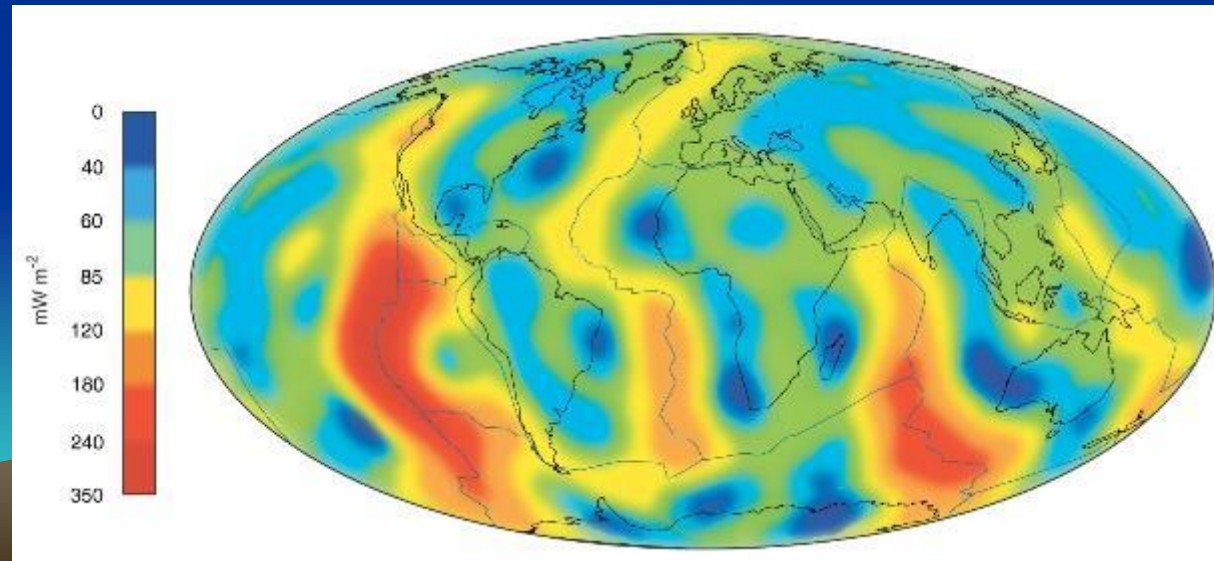




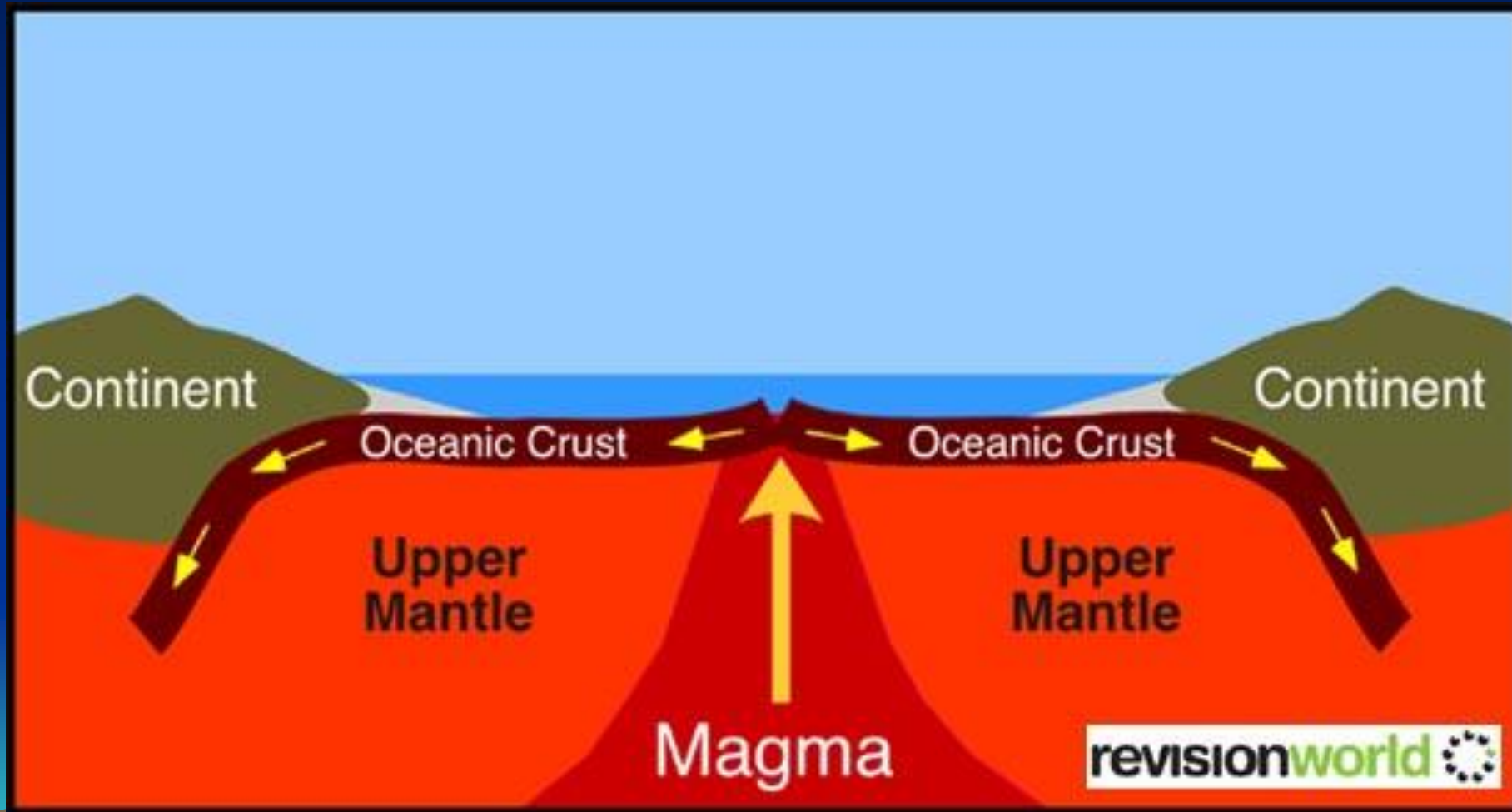
(B)

Geology of the Ocean Floor

- Seafloor spreading proposed (Hess-1960)
 - New data on ocean floor
 - Proposed mechanisms. ‘What’s causing it?’:
 - Mantle convection
 - Rifting and volcanism along ridge system
 - Continents pushed along w/ spreading seafloor
 - Recycling of oceanic crust by subduction



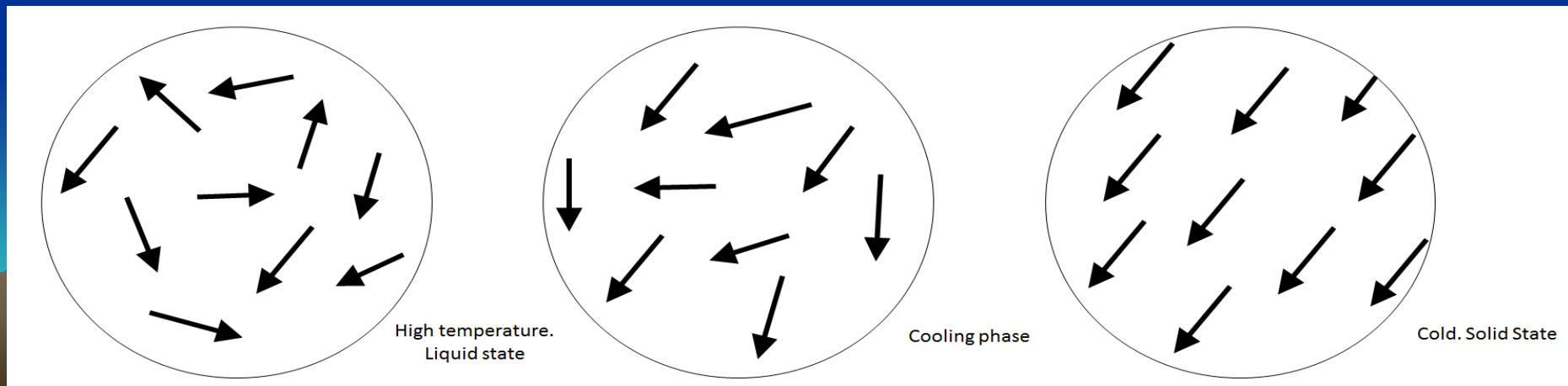
Oceanic crust cycle



Geology of the Ocean Floor

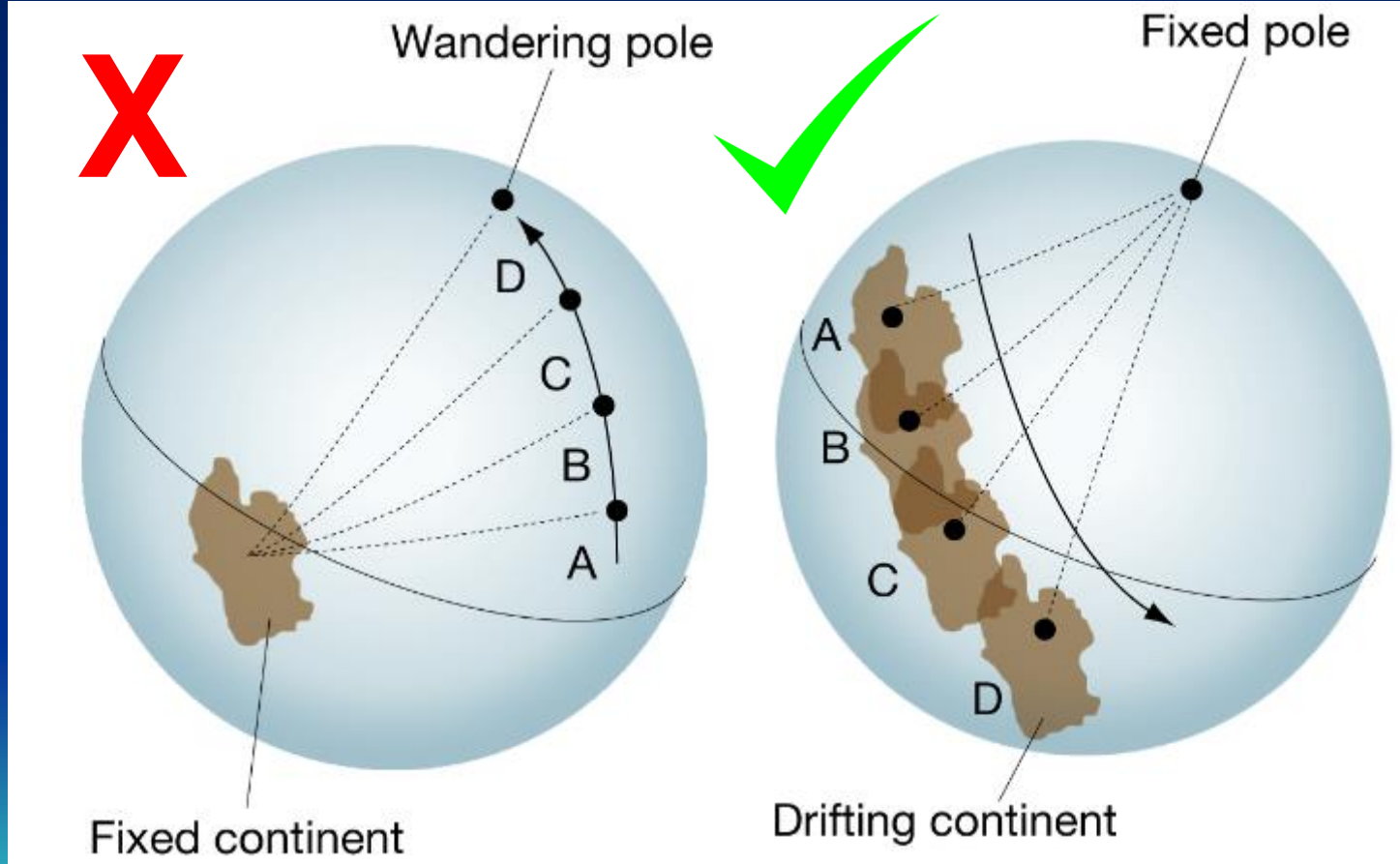
- Paleomagnetism

- Magma comes from the mantle and core.
- Iron rich magma erupts onto the surface.
- Iron rich rocks are weakly magnetized (oriented in every direction)
- All get oriented towards the North Pole
- Magma cools and orientation of magnetic field is preserved



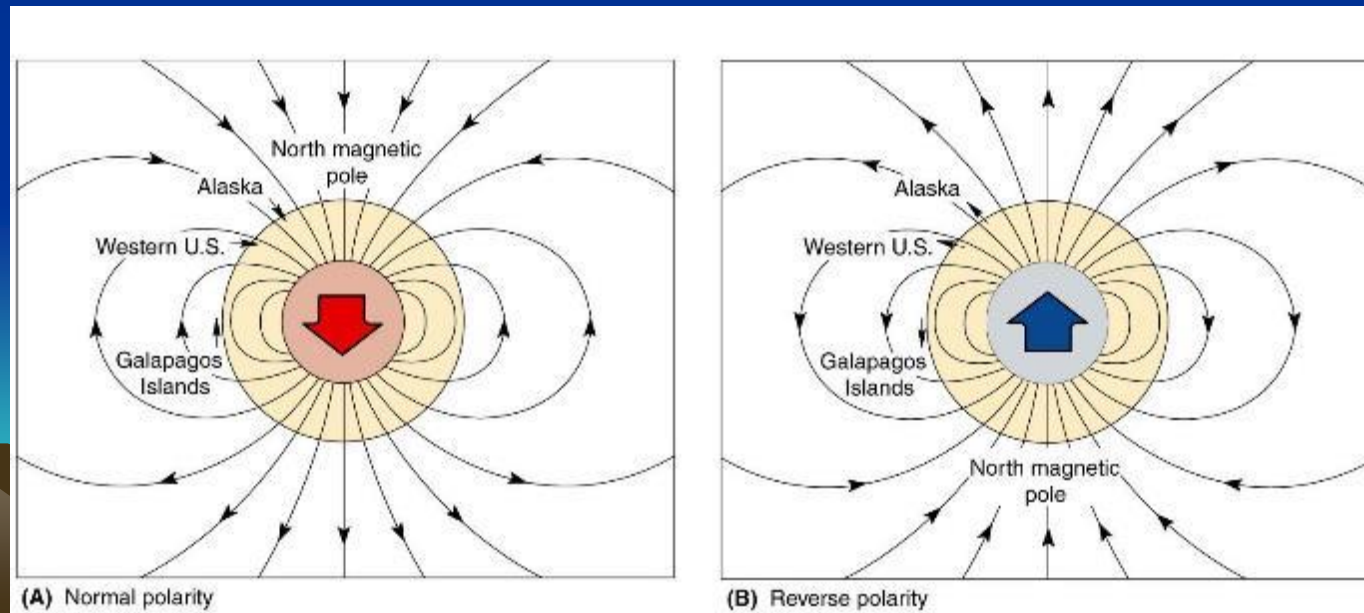
Polar Wandering

- Polar wandering
 - Look at ancient rocks.
 - Earth's north magnetic pole appeared to move over time based on different aged rocks.
 - Polar wandering paths varied by continent
 - This means the continents move, not the poles



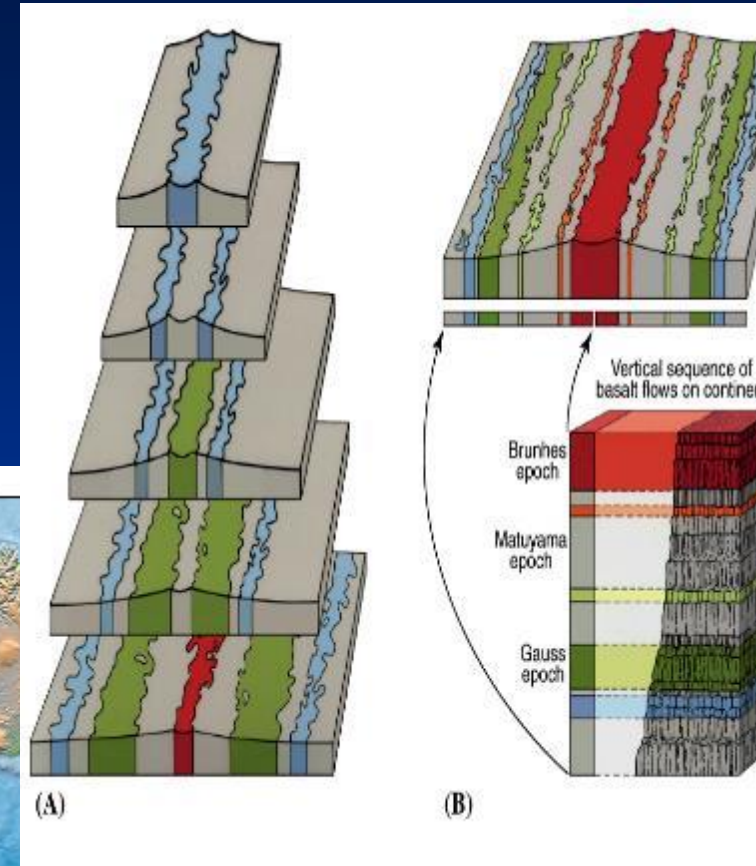
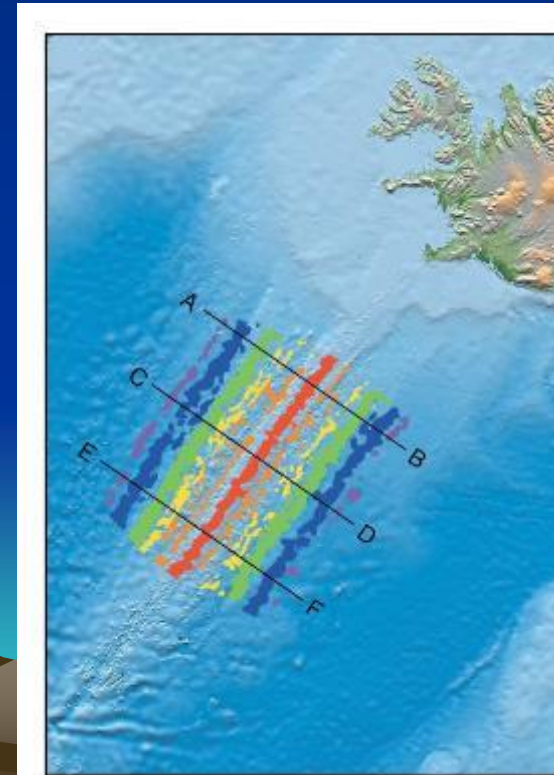
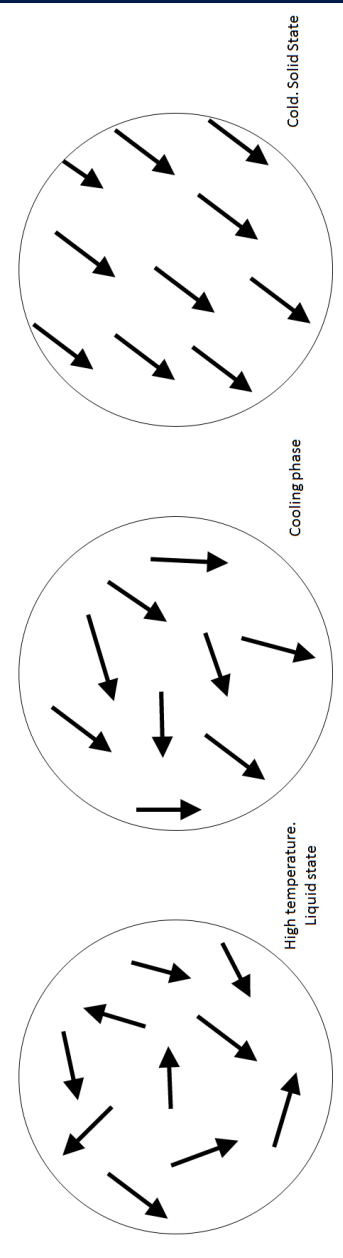
Geology of the Ocean Floor

- Magnetic reversals
 - Earth's magnetic field polarity has reversed throughout all time
 - Normal polarity – $N_{\text{magnetic}} = N_{\text{geographic}}$
 - Reversed polarity – $N_{\text{magnetic}} = S_{\text{geographic}}$
 - At least 12 reversals in last 4 my. About every 350 thousand years.



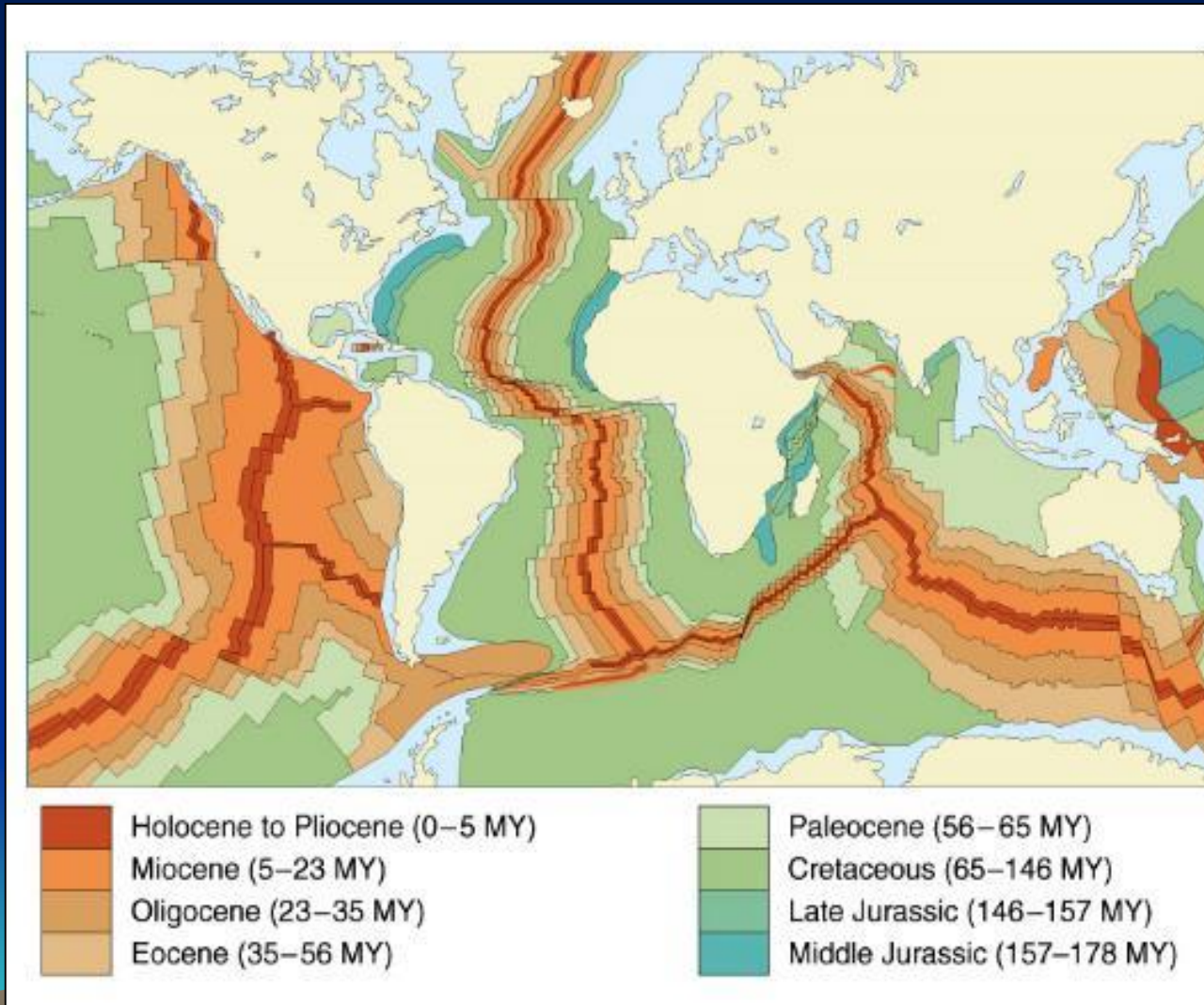
Geology of the Ocean Floor

- Testing Hess' hypothesis. Does the sea floor actually spread?
 - Magnetic properties recorded in ocean floor
 - Remember, Magma cools forming new crust
 - Polarity at time of cooling preserved



Observations

- Magnetic polarity stripes in ocean crust, parallel ridges
 - Symmetrical on either side of the ridge
 - Youngest sediments resting directly on basalt near the ridge
 - Sediment just above the basalt gets older
 - moving away from the ridge



Geology of the Ocean Floor

- Give age of seafloor

- Increases away from ridge

This means new magma is being created on the ridge.

- Rates of plate motion may be calculated

- Accumulation rates of $\sim 3 \text{ mm} / 1000 \text{ yr}$

