Theories of Geologic Processes

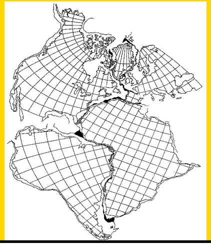
Continental Drift
Plate Tectonics

Geologic Processes

- Constant changes
- Driven by internal processes
  - Build up the planet's surface
  - Energy provided from heat in the interior
  - Causes the mantle to deform and flow

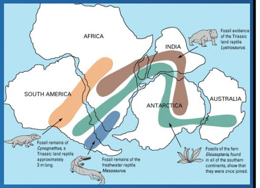
Early MapMakers

- Early mapmakers saw matching coastlines & suggested that Earth's continents had moved.
  - Ex. South America "fits with" Africa

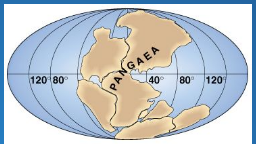


Continental Drift

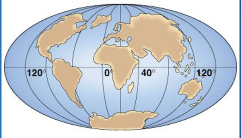
- Hypothesis proposed in 1912 by Alfred Wegener
- Initial Observations
  - Same fossils, landforms, glacial deposits, r types, & paleomagnetism across continents
  - Fit of continents
- Proposed that continents move very slowly over millions of years
- Rejected for failure to provide mechanism



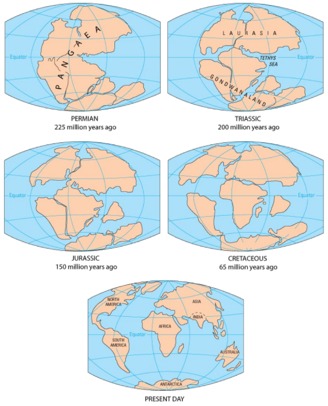
Pangea



225 million years ago



Present



Theory of Plate Tectonics

- Accepted in early 1960's
  - Mechanism identified by **Harry Hess**'s research on sea floor spreading
- **Movement** of tectonic/lithospheric plates
  - 60 miles thick
  - Made up of continental & oceanic crust
  - Different plates = different speeds
  - Move via mantle convection currents
  - Produces volcanoes, earthquakes, oceanic ridge system, & trenches
- Helps explain patterns of biological evolution

What Does the Ocean Floor Look Like?

- **Tools for Studying the Ocean Floor**
  - Sonar: uses sound waves to determine depth of ocean.
  - Magnetometer: can detect small changes in magnetic fields
- **Ocean Floor Topography**
  - Ocean Ridges: underwater mountain chains
  - Deep-Sea Trenches: narrow, elongated depression in sea floor with very steep sides.

Ocean Ridges & Deep-Sea Trenches

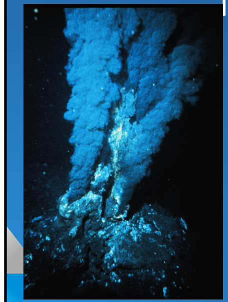
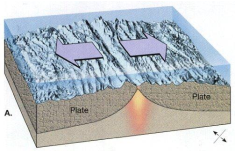


Figure 1.12
The sea floors of the world.
From World Ocean Floor by Bruce C. Heezen and Marie Tharp, 1977. © by Marie Tharp 1977. Reproduced by permission of Marie Tharp, 1 Washington Ave., South Nyack, NY 10960.

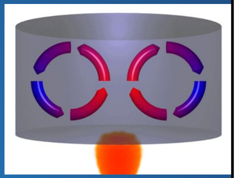
Conclusion: Sea Floor Spreading

- **Sea Floor Spreading:** new ocean crust is formed at ocean ridges and is destroyed at deep-sea trenches.
  - Hot, low-density magma rises from mantle into crust at ocean ridges.
  - **Explains HOW continental drift works.**



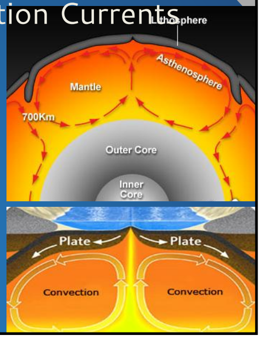
Why do Plates Move?

- **Convection**: transfer of thermal energy by the movement of warmed matter.
  - Warm matter rises, cool matter sinks.
- **Mantle Convection:** Warm (less dense) mantle rises. Cool mantle sinks. This creates convection currents.

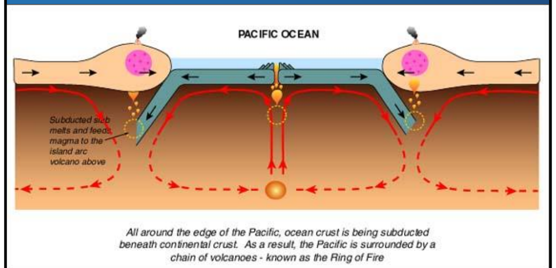


How the Plates Move: Mantle Convection Currents

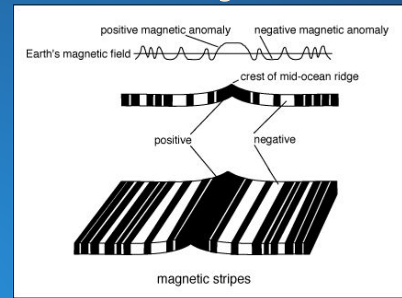
- Rigid lithospheric plates on top of semi-fluid asthenosphere
- Powered by heat from core
- Hot rises, cold sinks
- Plates surf on the resulting motion



How the Plates Move on Mantle Convection Currents



Paleomagnetism

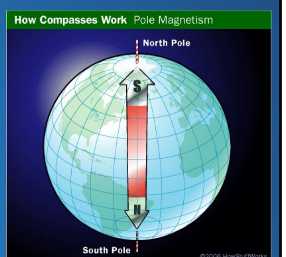


Magnetism & the Ocean Floor

Paleomagnetism: study of the magnetic record

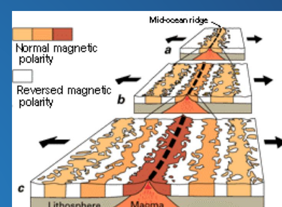
- *Ocean floor is made of basalt which contains minerals with iron. As basaltic lava cools, the iron minerals become oriented parallel to Earth's magnetic field (just like compass needles).*

Magnetic Reversal: a change in Earth's magnetic field



Paleomagnetism

Magnetometers found stripes parallel to ocean ridges with alternating magnetic orientation.

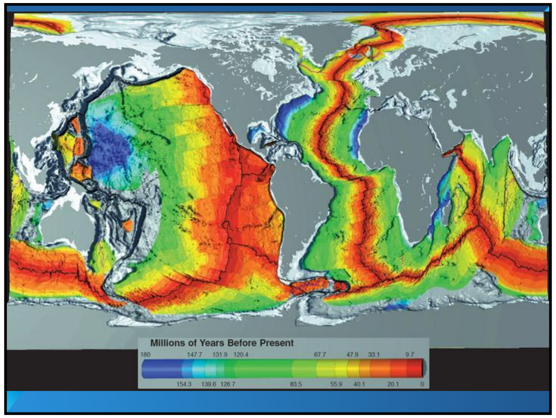


How Old are the Rocks in the Ocean Floor?

- *Rock samples near ocean ridges are young.*
- *Rock samples near deep-sea trenches are old.*
- *The oldest ocean floor rocks are only 180 million years old. [Continental rocks can be 3.8 billion years old!]*
- *The layer of ocean sediment is MUCH thinner than the continental sediment layer. [a few hundred meters thick vs. 2-20 km]*

Isochron Maps: lines on map connect points of the same age.

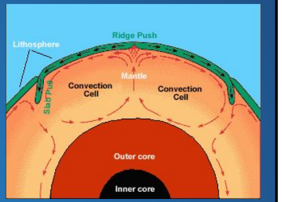
- *Similar to contour lines on a topographic map*

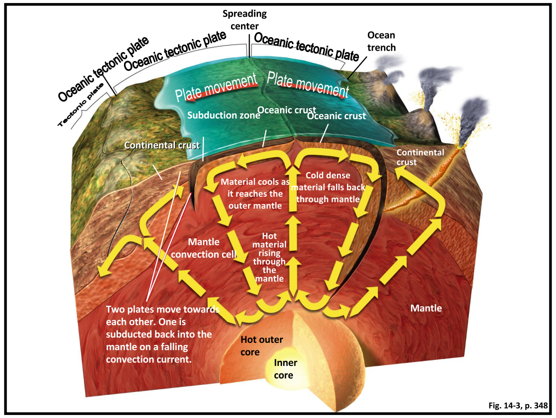


Why do Plates Move?

Slab Pull:
The weight of a subducting plate helps pull the trailing lithosphere into the subduction zone.

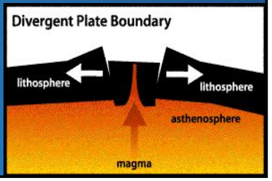
Ridge Push:
The weight of the uplifted ridge pushes an oceanic plate toward the trench formed at the subduction zone.





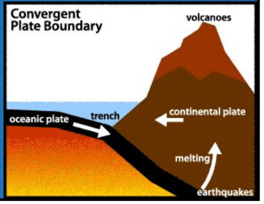
How the Plates Move: Ridge Push

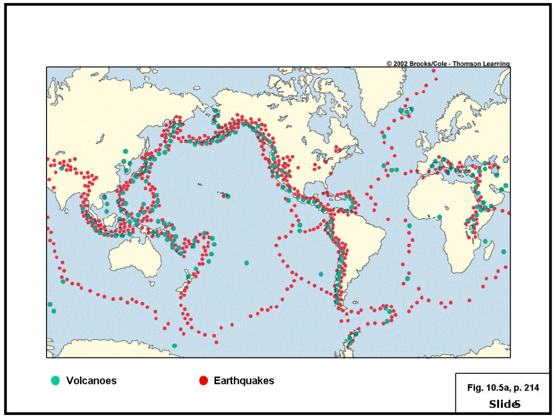
- **Divergent boundary**: rising edges of 2 convection cells push magma up at same location
- New crust pushes the older crust/lithospheric plates away from the area
- Produces
  - Mid-ocean ridges
  - New crust



How the Plates Move: Gravity/Slab Pull

- **Convergent boundary**: descending edges of 2 convection cells pull the denser crust (oceanic > continental) below the less dense crust
- Subducted plate melts into mantle
- Produces
  - Subduction zone
  - Trench
  - Volcanic Arc
    - Continental
    - Islandic
  - Earthquakes





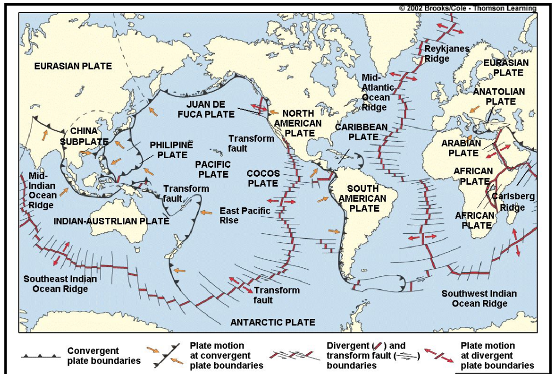
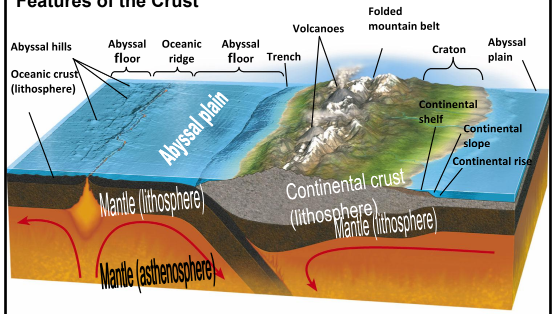


Plate system

Fig. 10.5b, p. 214
Slide 6

Features of the Crust

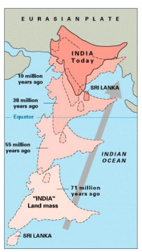


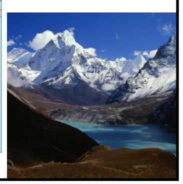
Convergent Boundaries

- **Oceanic-Continental**
  - subduction, trench, crust destroyed, volcanoes/mountains
  - Ex. Peru-Chile Trench & Andes Mountains

Convergent Boundaries

- **Continental-Continental**
  - mountains
  - Ex. Himalayas



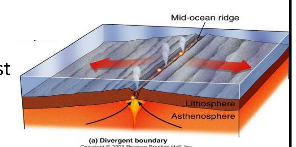


Convergent Bo

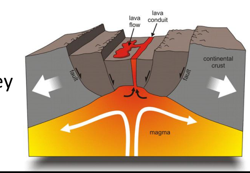
- **Oceanic-Oceanic** (
  cooler than the oth
  - Subduction, trench
    volcanic island arc
  - Ex. Mariana Islands, Aleutian Islands

Divergent Boundaries

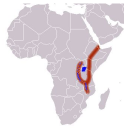
- **Oceanic-Oceanic**
  - rift, volcanoes, new crust
  - Ex. Mid Atlantic Ridge



- **Continental-Continental**
  - rift, volcanoes, new crust
  - Ex. Great African Rift Valley



Great African Rift Valley



Transform Boundary

- **Continental-Continental**
  - Ex. San Andreas Fault (California)