

The Theory of Plate Tectonics

Continental Drift
 Seafloor Spreading
 Hydrothermal Vents



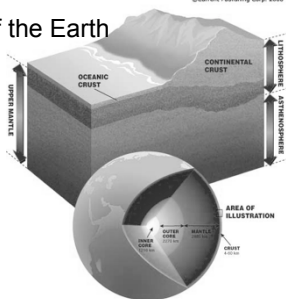
Photo by Richard A. Lutz

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➤ **Earth's interior is layered, and the layers are arranged by density. Each deeper layer is denser than the layer above.**

Four major layers of the Earth

- From the center of the Earth:
- Inner core
- Outer core
- Mantle
- Crust



Cross-section of the earth

Density and layering

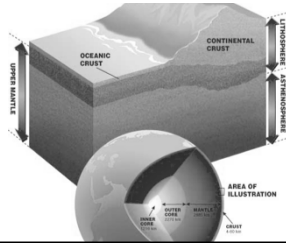
- Density is a key concept for understanding the structure of Earth [and oceans]
- Density measures the mass per unit volume of a substance.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

- Density is expressed as grams per cubic centimeter.
- [Pure] Water has a density of 1 g/cm³

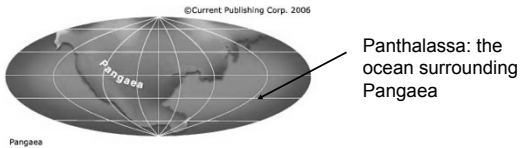
Two layers of the upper mantle:

- **Lithosphere** = uppermost rigid part of the upper mantle and the crust.
- **Asthenosphere** = top part of the upper mantle that flows very slowly over time (like old glass or tar)

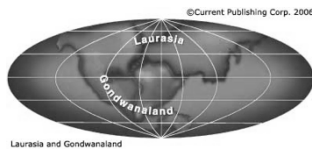


Theory of continental drift

- Alfred Wegner and Pangaea (single giant continent - *all the Earth*)

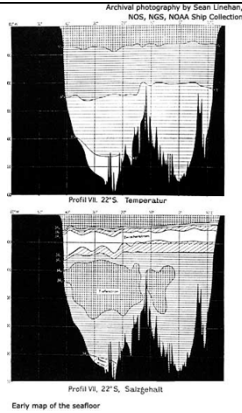


- The theory that all the continents were once a single landmass that drifted apart (and are still doing so) is the *theory of continental drift*.

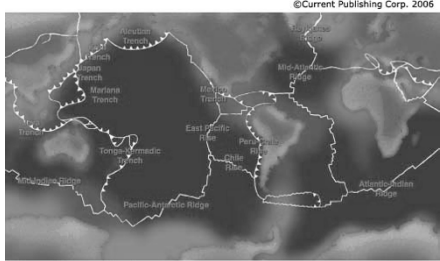


The theory of seafloor spreading

- The invention of SONAR (SOUND Navigation and Ranging) allowed ships to map the topography of the seafloor.



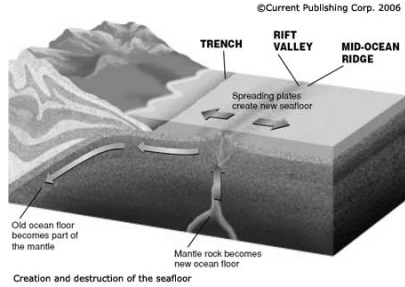
Map of ridges and trenches



Ridges and Trenches (continued)

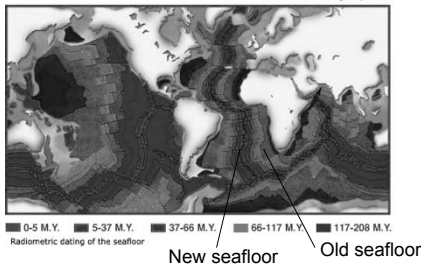
- Rift Valley: a valley running through the center of a **mid-ocean ridge** where the seafloor spreads and new seafloor originates.
- Trench: a deep ravine in the ocean floor where two tectonic plates meet and one is pushed under the other (subduction zone).

The creation and destruction of seafloor



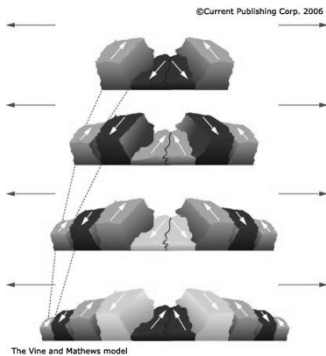
Age of the seafloor

Seafloor is younger near ridges where spreading occurs. Seafloor is older farther from ridges, shown here by age of rocks.



Evidence of seafloor age: reversal of Earth's magnetic fields

Location of Earth's magnetic poles changes periodically (over millions of years) as shown by orientation of magnetic particles.

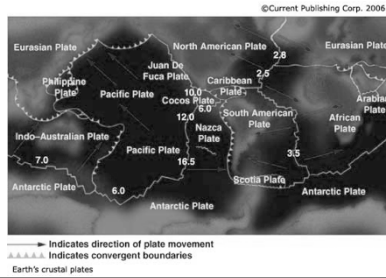


What is the theory of plate tectonics?

- **The Earth's lithosphere consists of more than a dozen separate plates. The plates are rigid and float on the asthenosphere.**

•The plates include oceanic and continental crust.

•Continents and oceans are formed and destroyed where plates collide, flex, and sink.



Boundaries and faults

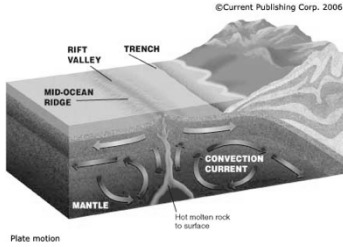
- **What are the 3 types of boundaries?**
- **Divergent:** is a boundary between 2 plates moving away from each other (rift valleys).
- **Convergent:** is a boundary between 2 colliding plates (mountains; trenches).
- **Transform:** is a boundary between 2 plates sliding against each other - often where earthquakes occur.

Earthquake zone: San Andreas Fault is an example of a transform boundary where the North American Plate and Pacific Plate meet.



Why do plates move?

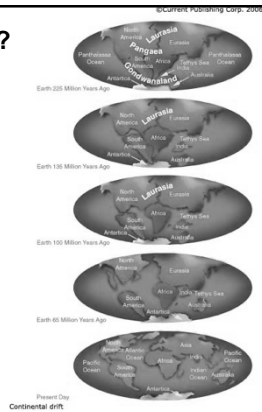
Convection is a primary force causing seafloor spreading and continental drift.



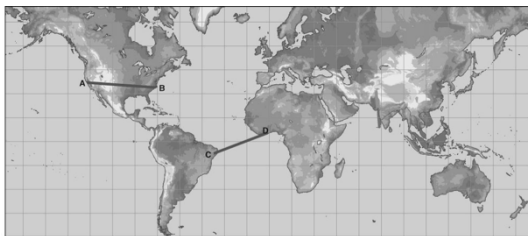
Plates are carried along as though on a conveyor belt.

What happens next?

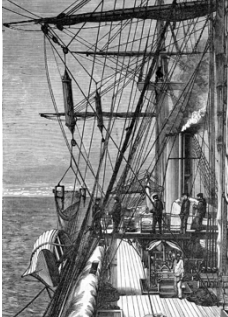
Theory is that over the next several million years:
 Atlantic and Indian Oceans will expand;
 Pacific Ocean will shrink;
 Mediterranean Sea will close as Africa moves northward.



Continental Margins and Ocean Basins (Garrison Chapter 4)



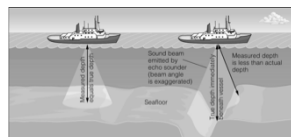
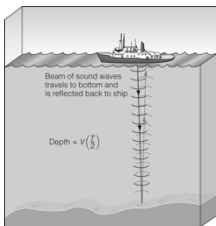
The Ocean Floor Is Mapped by Bathymetry



The discovery and study of ocean floor contours is called **Bathymetry**.

Early bathymetric studies used a weighted line to measure depth to the ocean floor.

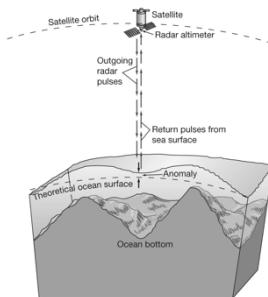
Echo Sounders Bounce Sound off the Seabed



Echo sounding is a method of measuring seafloor depth using powerful sound pulses

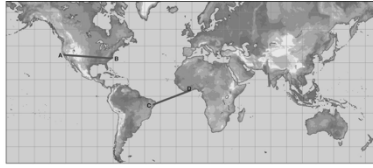
Sea Floor Mapping from Space

- Satellites image sea floor features based on gravitational bulges in sea surface
- Indirectly reveals bathymetry

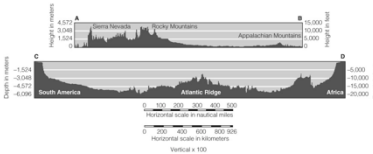


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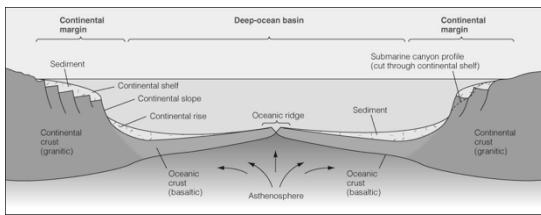
The Topography of Ocean Floors



Cross section of the Atlantic ocean basin and the continental United States

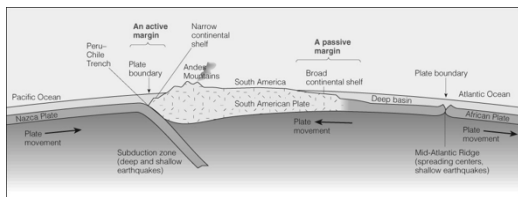


Ocean-Floor Topography Varies with Location



The submerged outer edge of a continent is called the *continental margin*.
The deep-sea floor beyond the continental margin is properly called the *ocean basin*.

Continental Margins May Be **Active** or **Passive**



Typical continental margins bordering the tectonically active (Pacific-type) and passive (Atlantic-type) edges of a moving continent.

Continental Margins

- Passive
 - Not close to any plate boundary
 - No major tectonic activity
- Active
 - Associated with convergent or transform plate boundaries
 - Much tectonic activity

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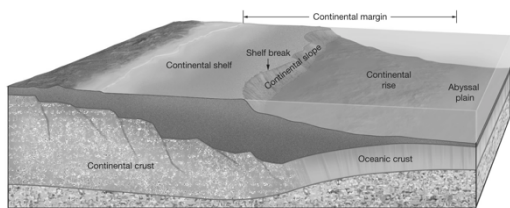
Active Continental Margins

- Convergent Active Margin
 - Narrow shelf
 - Offshore trench
 - Example: Western South America
- Transform Continental Margin
 - Transform plate boundaries
 - Example: Coastal California along San Andreas Fault

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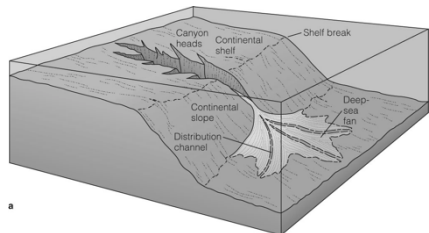
Continental Slope

- Where deep ocean basins begin
- Greater slope than continental shelf
- Marked by submarine canyons



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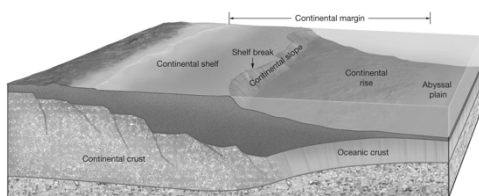
Submarine Canyons Form at the Junction between Continental Shelf and Continental Slope



Submarine canyons cut into the continental shelf and slope, often terminating on the deep-sea floor in a fan-shaped wedge of sediment.

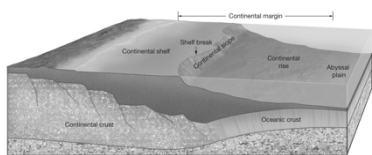
Continental Rise

- Transition between continental and oceanic crust
- Deposits generate deep-sea fans, or submarine fans



Abyssal Plains

- Deep, flat parts of Earth
- Well-developed in Atlantic and Indian Oceans
- Extend from base of continental rise



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Ocean Trenches

- Convergent (active) margins cause ocean trenches.
 - Deepest part of oceans
 - Most in Pacific Ocean
 - Deepest trench – Mariana Trench at 11,022 meters (36,161 feet)

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Trenches are depressions in the ocean floor caused by the **subduction** of a **converging** ocean plate. Most trenches are around the edges of the active Pacific.



Mid-Ocean Ridge

- Longest mountain chain
- On average, 2.5 km (1.5 miles) above surrounding sea floor
- Wholly volcanic
- Divergent plate boundary

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Hydrothermal Vents Are Hot Springs on Active Oceanic Ridges

- Sea floor hot springs
- Foster unusual deep-ocean ecosystems able to survive without sunlight
- **White smokers**
 - temps from 30–350°C (662°F)
- **Black smokers**
 - temps above 350°C

