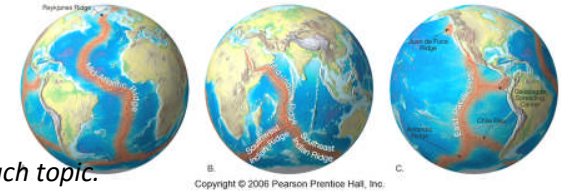
Chapter Outlines

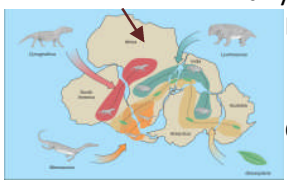


NOTE: This is intended to help students 'organize' their understanding of each topic.
It is not a comprehensive study guide for quizzes or midterms, i.e. study your text!

Plate Tectonics

Magma generation, igneous intrusions, metamorphism, volcanic action, earthquakes, faulting, folding, and mountain building are mostly the result of **plate tectonic** activity. The earth's lithosphere *(crust & uppermost mantle)* is divided into eight large pieces and over twenty smaller pieces. These **lithospheric plates** are composed of **Earth's crust** *(both oceanic and continental)* along with the rigid portion of the underlying upper mantle. Convection currents in the mantle are thought to create forces that push and pull these plates at the surface. Intense geologic activity occurs where plates move apart *(divergent boundaries),* collide *(convergent boundaries)* or slide past one another *(transform boundaries).* About 200 million years ago plate tectonic forces began to break a single continental land mass *(in a repeating, non-ending, process)* into pieces that then spread apart to form the continents as we know them today.

Correlation of fossil records



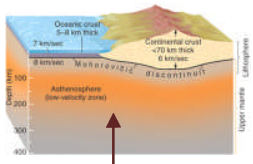
I. **Continental drift**: an idea before its time
- A. Early world map makers speculated on the matching coastlines of N & S America to Europe and Africa
- B. **Alfred Wegener**
  1. First proposed hypothesis, 1915
  2. Published '*The Origin of Continents and Oceans*'
- C. In Wegener's continental drift hypothesis:
  1. Supercontinent called **Pangaea** began breaking apart about 200 million years ago
  2. Continents 'drifted' to present positions
  3. Continents 'broke' through the ocean crust like an icebreaker
  4. Evidence used by Wegener
     - a. Fit of South America and Africa
     - b. Fossil matches across the seas
     - c. Ancient climates
     - d. Rock type and mountain structure matches
     - e. Matching records of glaciation
  5. Main objection to Wegener's proposal was inability to provide a mechanism

Fit of rock types and glacial evidence

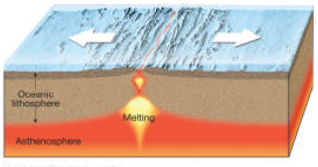
Record of glaciation

'Pangaea' the most recent super-continent

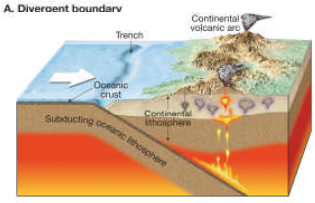
II. 'Drift' hypothesis evolves to the more encompassing **'Plate Tectonics'** in the 1960's
- A. Earth's rigid outer shell is called the **lithosphere**
- B. Earth's surface *(the lithosphere)* consists of several plates
  1. Plates are moving slowly, a rate of **5 to 9 centimeters per year** is the norm
  2. Largest plate is the Pacific plate
- C. **Asthenosphere…**
  exists beneath the lithosphere as a partially melted zone that allows for movement of lithosphere
- D. **Plate boundaries**
  1. All major interactions among plates *(and most 'interesting' geology)* occur along their boundaries
  2. Types of plate boundaries
     - a. **Divergent plate boundaries** *('spreading') where two plates move apart*
       1. Mantle material upwells to create new seafloor
       2. Oceanic ridges develop along well-developed divergent boundaries
          - a. Represent 20 percent of Earth's surface
          - b. Rift valleys may develop along the axis *(top of the ridge)*
       3. Continental rifts may form at spreading centers within a continent *(East Africa)*
     - b. **Convergent plate boundaries** *(destructive margins)*
       1. Plates collide, an **ocean trench** forms, and lithosphere is subducted into the mantle
       2. Types of convergence
          - a. **Oceanic–continental** convergence
            1. Denser oceanic plate sinks into the asthenosphere under the continent



Semi-liquid asthenosphere



A. Divergent boundary

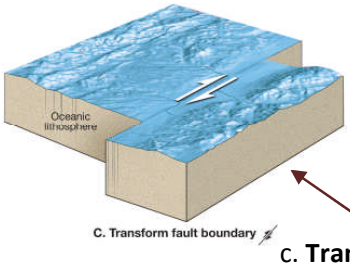


B. Convergent boundary

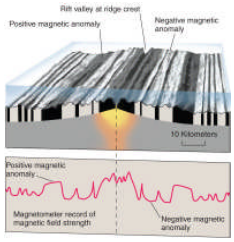
2. Pockets of magma develop and rise
3. **Continental volcanic arcs** form such as Andes, Cascades, and Sierra Nevada

b. **Oceanic–oceanic** convergence
1. Two oceanic plates converge and one descends beneath the other
2. Often forms volcanoes on the ocean floor
3. **Volcanic island arcs** form as volcanoes emerge from the sea - for example: Aleutian Islands, Mariana Islands, Tonga Islands

c. **Continental–continental** convergence
1. When subducting plates contain continental material, two continents collide
2. Can produce new mountain ranges such as the Himalayas

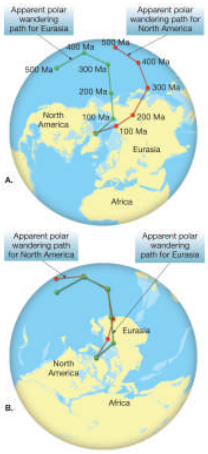


c. **Transform fault boundaries**
1. Plates slide past one another, no new crust is created and no crust is destroyed
2. Transform faults *(an example is California's San Andreas Fault)*
a. Most join two segments of a mid-ocean ridge
b. At the time of formation, they roughly parallel the direction of plate movement

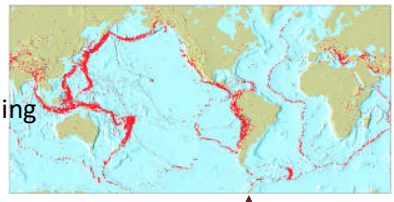


Record of magnetic reversals in new sea floor

E. Evidence for the plate tectonics model
1. **Paleomagnetism** – ancient magnetism preserved in rocks
a. Probably the most persuasive evidence
b. Paleomagnetic records show…
1. Polar wandering *(evidence that continents have moved over time)*
2. Earth's magnetic field reversals…
a. Recorded in rocks as they form at oceanic ridges
b. Record of reversals across ocean ridges confirms seafloor spreading



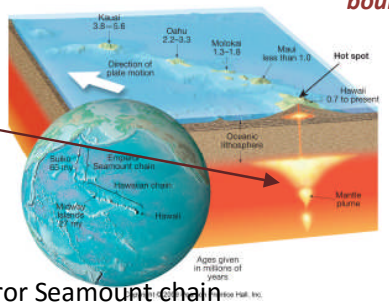
The 'apparent' wandering of the magnetic pole



Global earthquake patterns can define plate boundaries

2. Earthquake patterns
a. Associated with plate boundaries
b. **Deep-focus** earthquakes along trenches provide a method for tracking the plate's descent
3. Ocean drilling
a. Deep Sea Drilling Project *(including the Glomar Challenger)*
b. Age of deepest sediments are relatively young *(ocean basins are geologically young)*
1. Youngest sediments are near the ridges
2. Older are at a distance from the ridge
4. **Hot spots**
a. Rising plumes of mantle material
b. Volcanoes can form over them
1. Example - Hawaiian Island chain
2. These chains of volcanoes mark/record plate movement

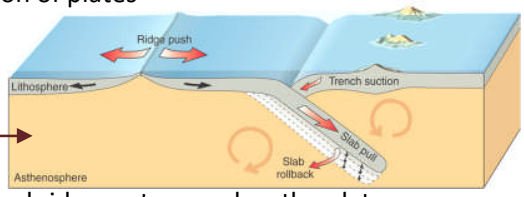
The 'hot spot' that formed the Hawaiian chain

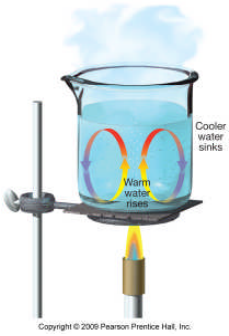


F. Measuring plate motion
1. By using hot spot 'tracks' like those of the Hawaiian Island–Emperor Seamount chain
2. Using GPS technology to directly measure the relative motion of plates

G. Driving mechanism of plate tectonics
1. No single model explains all facets of plate tectonics
2. Earth's heat is the driving force
3. Several models have been proposed
a. **Slab-pull** and **slab-push** model…
Descending oceanic crust pulls the plate, and the elevated ridge system pushes the plate
b. **Mantle convection**
1. **Mantle plumes** extend from mantle–core boundary and cause convection within the mantle and causing a drag on the underside of plates where it turns horizontal
2. Models
a. Layering at 660 kilometers
b. Whole-mantle convection

Some possible plate 'driving' mechanisms





Convection in heating water

A hypothetical illustration of mantle convection currents