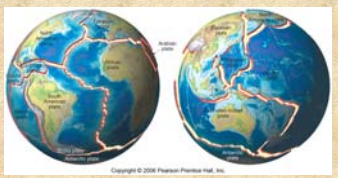
Plate Tectonics

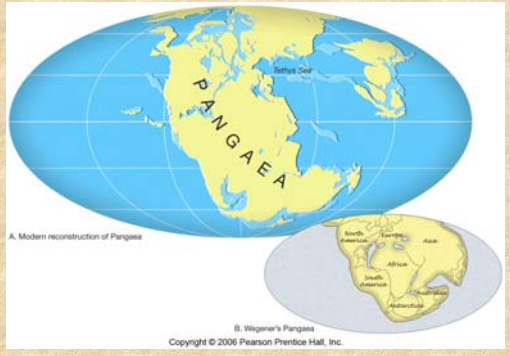
- Plate tectonics is the concept that the surface of the earth is composed of interlocking plates and that these plates move across the surface of the earth over time
- The evolution of this idea took place over several decades as the study of earthquakes increased and more and more of the earth's surface (namely the ocean basins) was explored



Continental Drift

- Plate tectonics originated as an idea called continental drift
- This idea was proposed by Alfred Wegener in 1915
- Wegener basically stated that all of the continents were at one time connected and formed a supercontinent called **Pangea**
- Over time, the continents moved away from each other and eventually arrived at their current positions

Pangea



Evidence for Continental Drift

- Wegener has compiled many pieces of evidence to support his hypothesis including
  - The fit of the continents
  - Similar fossils across continents
  - Similar rock type and structure across continents
  - Paleoclimatic evidence

Fit of the Continents

- By imaging South America and Africa floating toward each other, it is easy to see how they might fit together

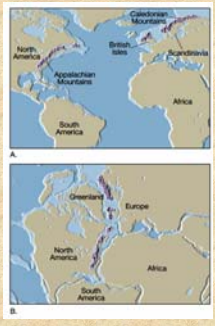
Fossil Evidence

- Fossils of a marine reptile, Mesosaurus, and a plant, Glossopteris, have been found only on the west coast of South America and the west coast of Africa

If Mesosaurus could swim across great oceans (as the fossil evidence suggests), then Mesosaurus fossils *should* be found in many more locations. But they are only found at these two places.

Rock and Structure Evidence

- The same type of rock sequence and structures (folds, faults, etc.) have been observed on two different continents
- This suggests that one sequence of rock type and structure once formed in the past then, as the continents migrated, the rock assemblage was cut I two



Paleoclimatic Evidence

- Evidence from ancient glacial advances can be interpreted from grooves found in certain rocks
- Grooves from past glacial advances have been found on the southern coasts of South America, Africa, Australia, and India

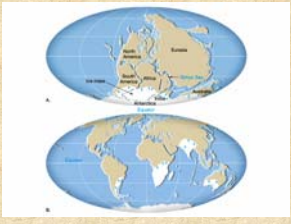
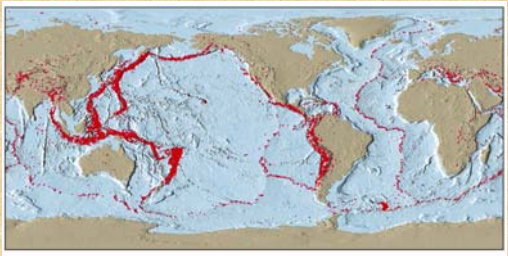


Plate Tectonics

- Continental drift was presented to many of the lead scientists in the early 20th century but was never taken seriously
- The idea of the continents actually moving across the surface of the earth just seemed too outrageous
- The hypothesis slowly faded from the minds of scientists until the beginning of World War II
- The war led to an increase in the research of the earth, particularly the ocean basins
- Additionally, advances in locating earthquakes led to an interesting observation

Distribution of Earthquakes

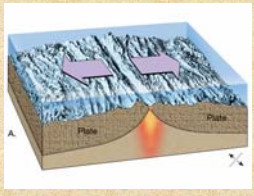


Plates and Plate Boundaries

- Research into the distribution of earthquakes and the increased study of the ocean floor led researchers to propose that the crust of the earth is composed of interlocking plates
- The plates are separated by plate boundaries, where significant tectonic activity occurs
- Three main types of plate boundaries have been identified
  - Divergent
  - Convergent
  - Transform

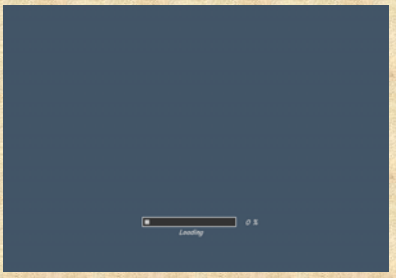
Divergent Plate Boundary

- Occurs where two plates move away from each other
- Molten rock arises from the interior of the earth, cools, and produces new oceanic crust - Basalt



Examples: Mid-Atlantic Ridge, Mid-Indian Ridge, East Pacific Rise

Divergent Plate Boundary

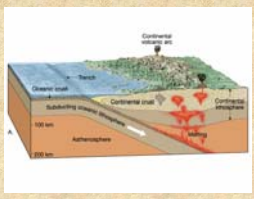


Convergent Plate Boundary

- Occurs where two plates move toward from each other
- This typically results in the destruction of oceanic crust
- Three types of convergent plate boundaries
  - Ocean-Continent
  - Ocean-Ocean
  - Continent-Continent

Ocean-Continent Convergence

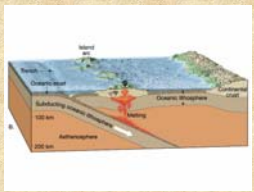
- Occurs where oceanic crust collides with continental crust
- The oceanic crust is subducted because it is more dense (mafic)
- The oceanic crust eventually melts and the magma rises to the surface to form a volcanic arc



Examples: Cascade Mountains, Andes Mountains

Ocean-Ocean Convergence

- Occurs where oceanic crust collides with oceanic crust
- The older crust is subducted because it is more dense (has had more time to cool at surface)
- The rock eventually melts and the magma rises to form an island arc

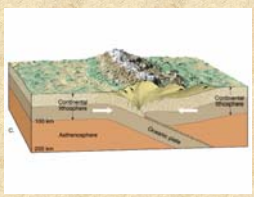


Examples: Japan, Philippines, Indonesia, Aleutian Islands

Convergent Plate Boundaries

Continent-Continent Convergence

- Occurs where continental crust collides with continental crust
- No subduction takes place; the two plates collide forming a large, highly deformed mountain chain



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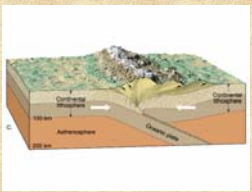
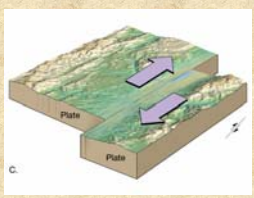


Examples: Himalayas, Appalachians (former)

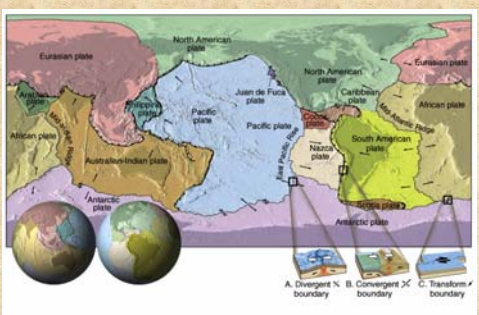
Transform Plate Boundaries

- Occurs where two plates slide past each other
- No subduction and no mountain building occur



Example: San Andreas Fault

Plate Boundary Locations



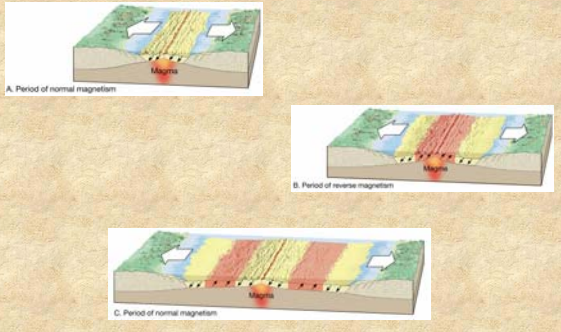
Other Evidence: Paleomagnetism

- Additional evidence to support the plate tectonics idea came from paleomagnetism
- As a magma that contains an abundance of iron begins to cool, the iron within the magma will orient itself toward the magnetic north pole
- Therefore, by studying the orientation of iron within a rock sample, geologists can infer the respective orientation between the rock sample and the magnetic north pole

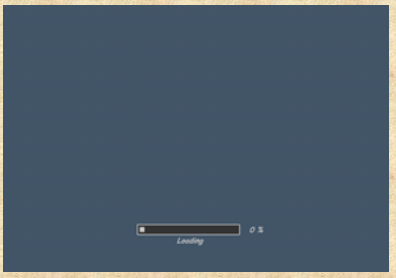
Sea-Floor Spreading

- Paleomagnetism has revealed an interesting trend in the orientation of iron in rocks on the sea floor
- The iron within the rock close to the ridge (younger) are oriented toward the current north pole but the iron in rocks further away from the ridge (older) are oriented toward the current south pole
- Moving from the Mid-Atlantic ridge to North America or Africa, the iron within the oceanic crust reverses itself periodically
- This suggests that the north and south poles have changed positions over time and the Atlantic ocean is growing

Sea-Floor Spreading



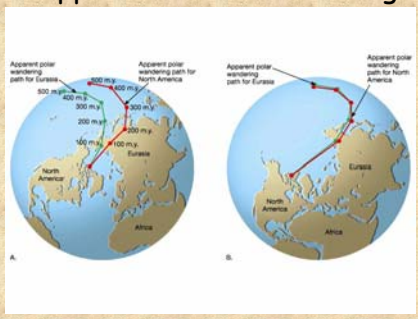
Sea-Floor Spreading



Apparent Polar Wandering

- By studying the orientation of iron in land-based rock units, geologists find that assuming the continents have not moved over time, then the magnetic north pole has wandered considerably across the northern hemisphere
- Because there is no known mechanism that would cause this effect, it suggests that the north pole doesn't move but the continents do

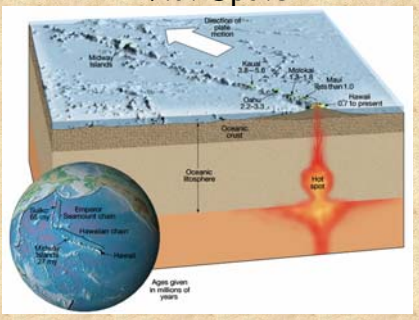
Apparent Polar Wandering



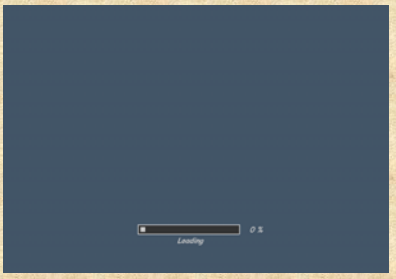
Hot Spots

- Hot spots are locations on the earth that experience volcanic activity but do not lie near a plate boundary
- Hawaii is an excellent example
- A weak zone in the crust allows magma to rise to the surface
- The magma extrudes onto the surface and builds a volcano
- However, because of the motion of the plate that Hawaii rests on, not just one volcano is created, rather a chain of volcanoes
- In time, the big island of Hawaii will move to the north and west (with the other Hawaiian Islands), and a new island will be created

Hot Spots



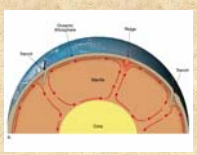
Hot Spots

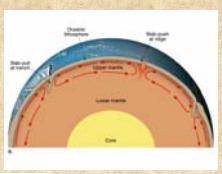


Mechanism

- The mechanism that drives plate tectonics is believed to be convection cells deep within the earth
- Hot magma rises to the surface and extrudes at the divergent plate boundaries
- The magma cools into igneous rock which eventually gets pushed to either side by hot magma rising below it
- The crust will eventually get subducted again at the convergent plate boundary

Convection Theories





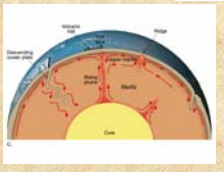
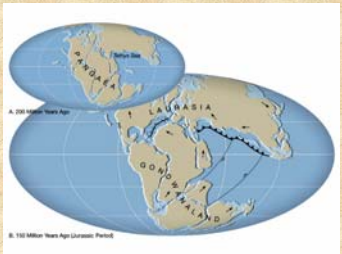


Plate Motion Through Time



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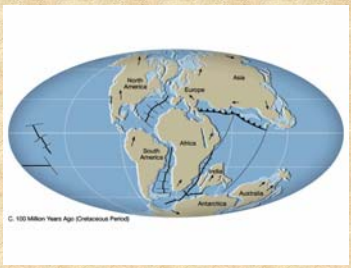

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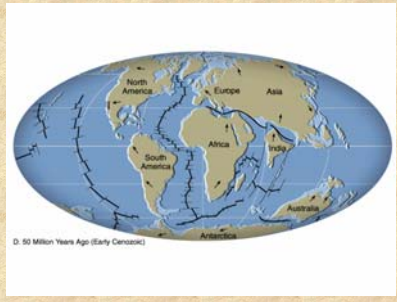

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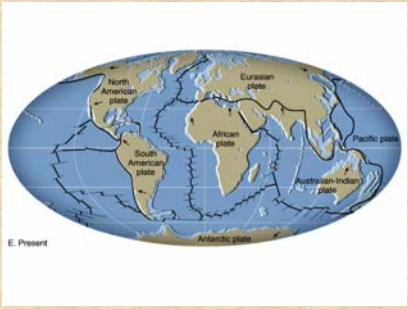

Plate Motion Through Time