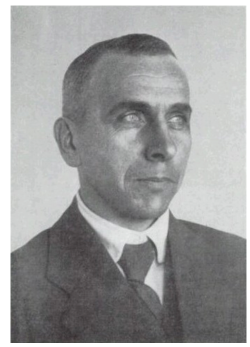
Chapter 11 Plate Tectonics

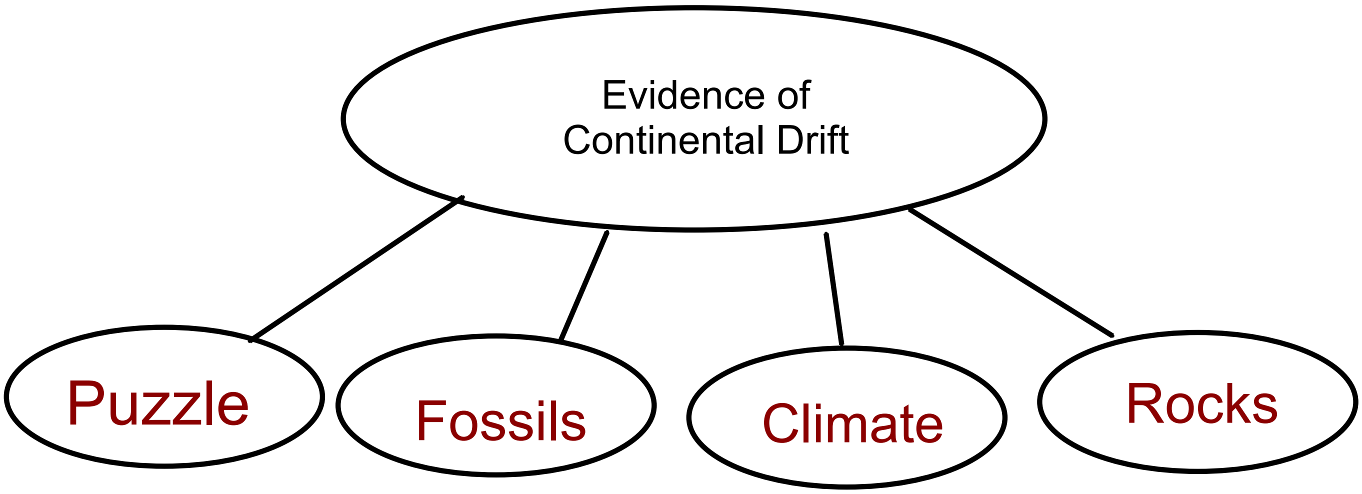
E3.p3A: Pangea
E3.2A: Earth's interior
E3.2d: Validate Earth Model
E3.2c: Diff btw Oceanic and Continental crust
E3.3A: Plate movement cause...
E3.3B: Why plates move
E3.r3e: Temp in lithosphere
E3.3c: Motion/rate of plates
E3.r3f: Plate move affect climate

Define Pangaea:



The name Alfred Wegner gave to the large landmass, made up of all continents that he believed existed before it broke apart to form the present continents.

Began to break up approximately 200 million years ago



Scientist use geologic, paleontological, and paleoclimatological evidence

Geology: Study of solid Earth, rocks, and changing rock process.
Paleontology: Study of prehistoric life.
Paleoclimatology: Study of changes in climate taken on the scale of the entire history of Earth.

Africa and South America were once a part of a single.
What evidence is there to prove this?

1. Continental coastlines are a puzzle like fit

2. Fossils of same animals (flaunal) found on each continent
Flaunal: Animals within a region

3. Similar climates were found in paleoclimatologial data.
Evidence was found in rocks, coral, sediments, and tree rings

4. Similar rock stuctures. Similar geography

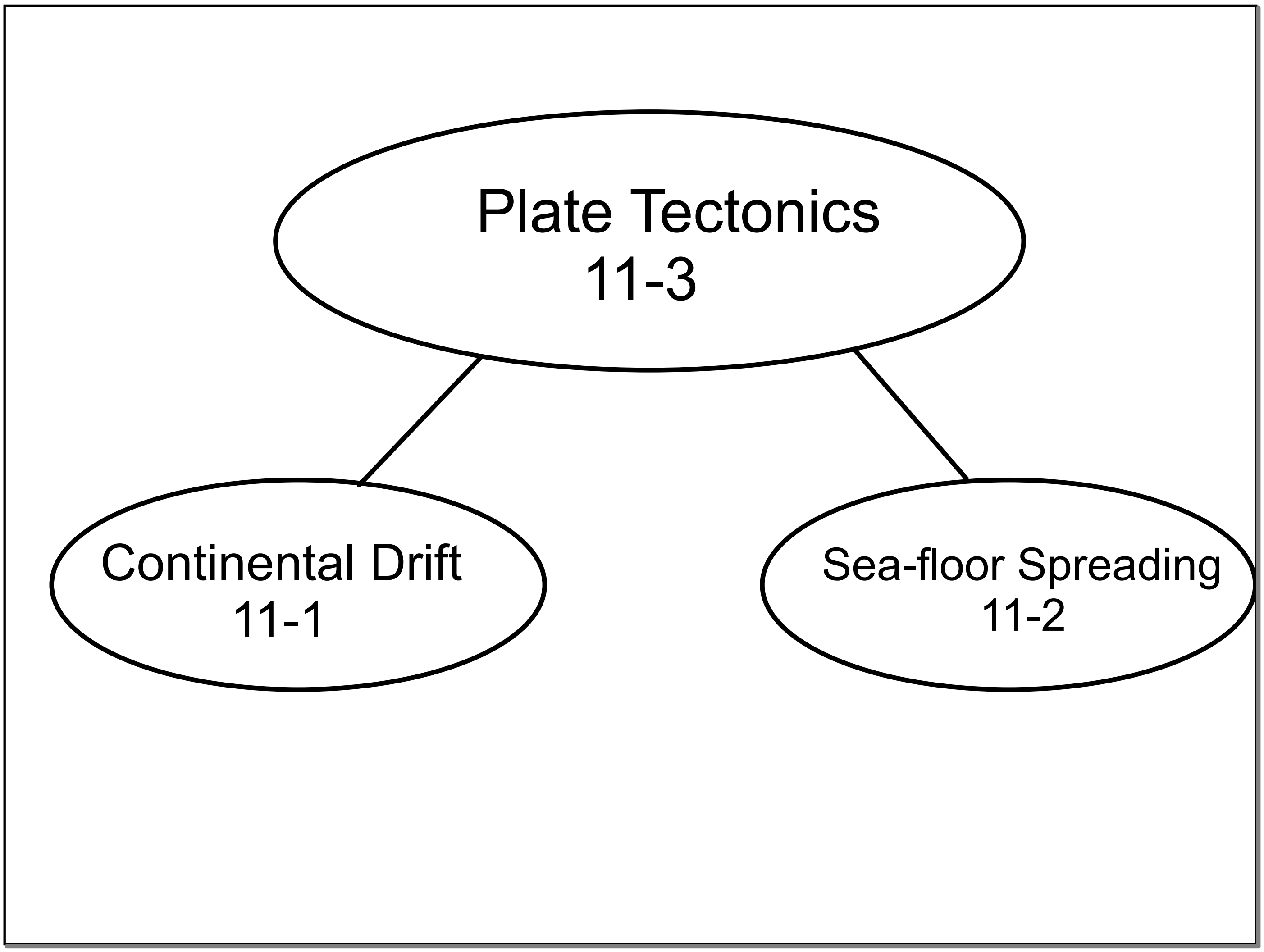


Plate Tectonics
11-3
Continental Drift
11-1
Sea-floor Spreading
11-2

Plate Tectonics: The theory that Earth's crust and upper mantle (lithosphere) are broken into sections, called plates, that slowly move around on the mantle.

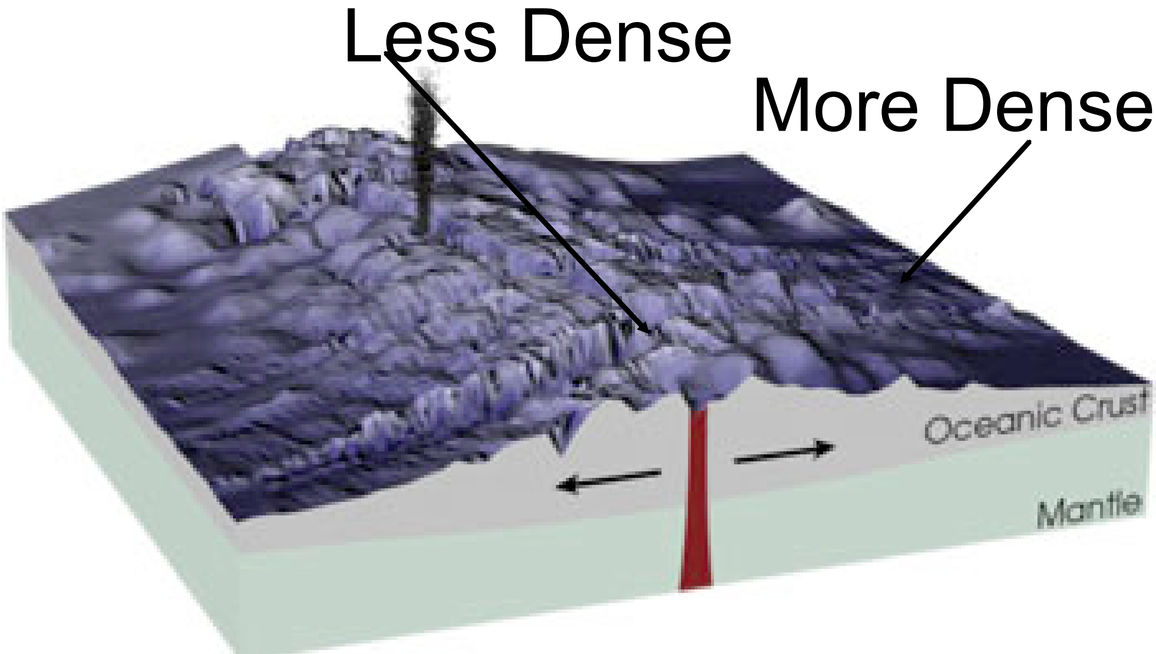
Continental Drift: A hypothesis proposed by Alfred Wegener which states that continents have moved horizontally around the globe over time to reach their current locations.

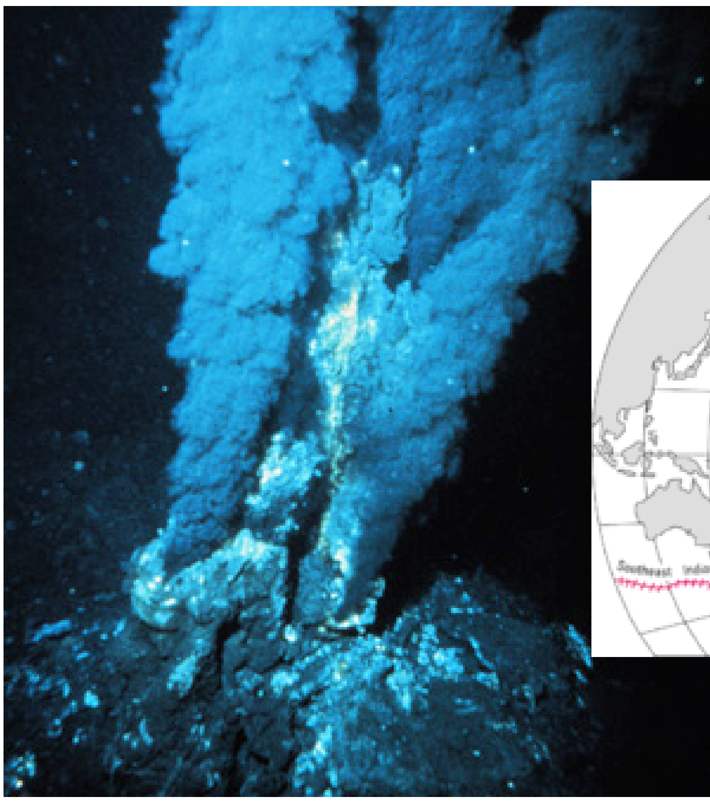
Seafloor Spreading: The theory that magma from the Earth's mantle rises to the surface at mid-ocean ridges and cools to form new seafloor, which new magma slowly pushed away from the ridge.

An example of Seafloor Spreading

Mid-Ocean Ridge

Boundary between two oceanic, divergent plates that produces an underwater mountain system. Has a valley or rift in the center. The rise in the mantle as magma emerges as lava, and creates a new crust when it cools.

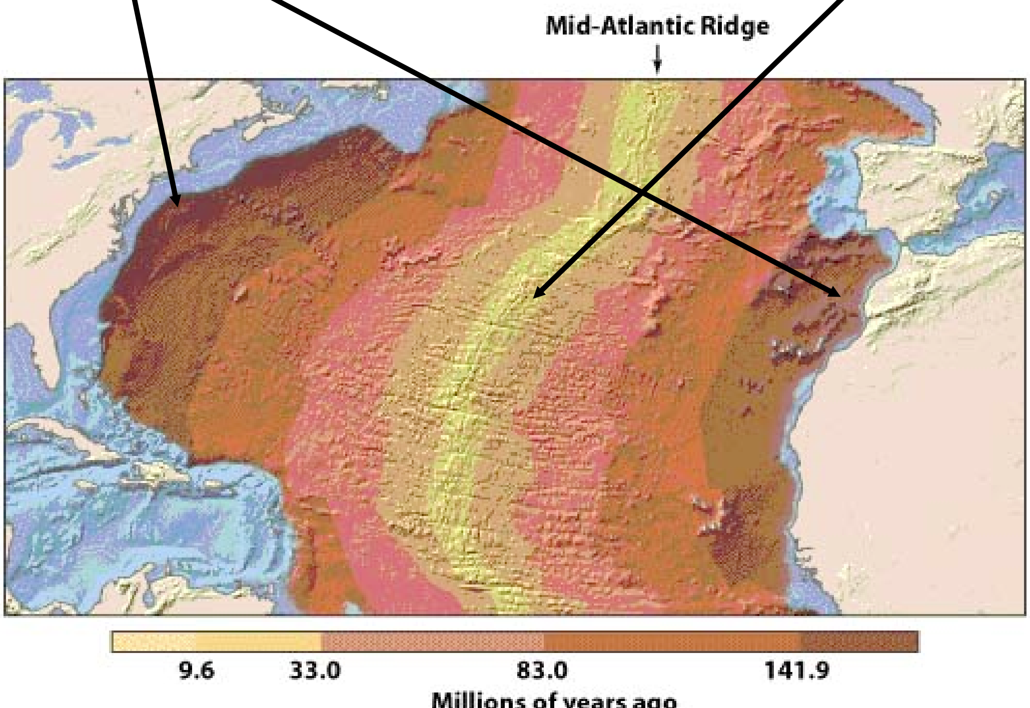





Juan de Fuca Ridge
Equator
Central Indian Ridge
Southeast Indian Ridge
Pacific Antarctic Ridge

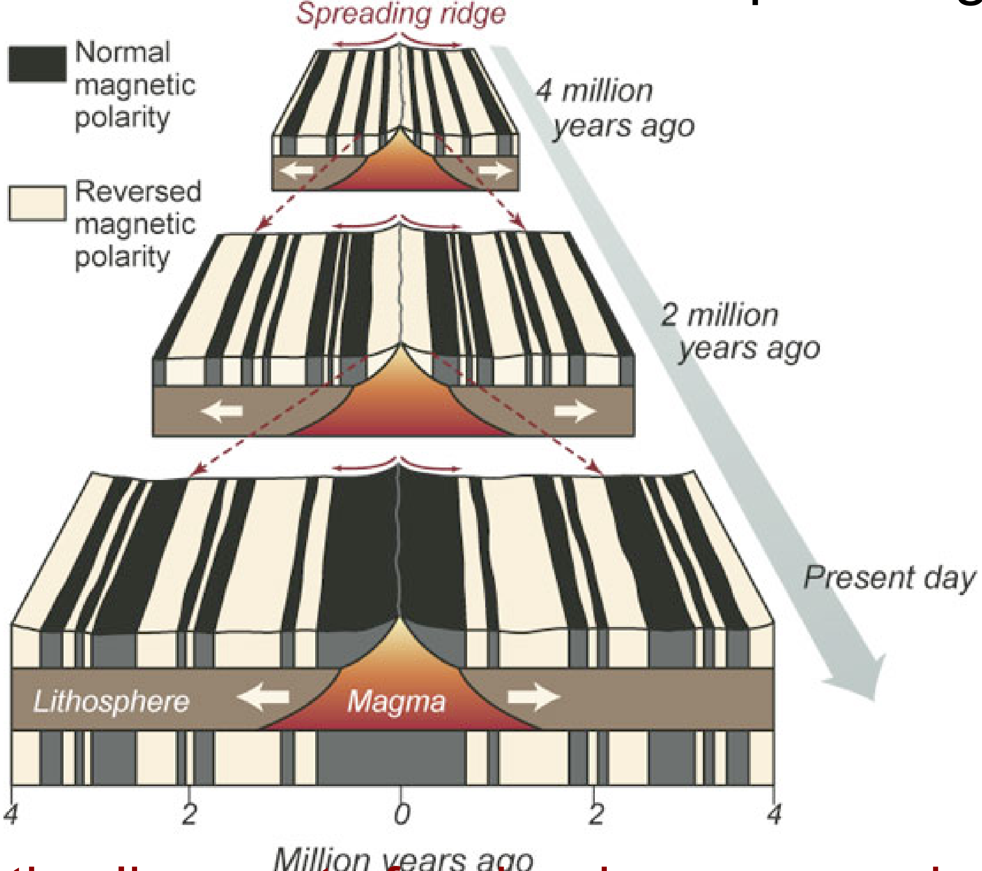
Older Rock

Younger Rock



Evidence from drilling from research ship, Glomar Challenger supports theory of seafloor spreading.

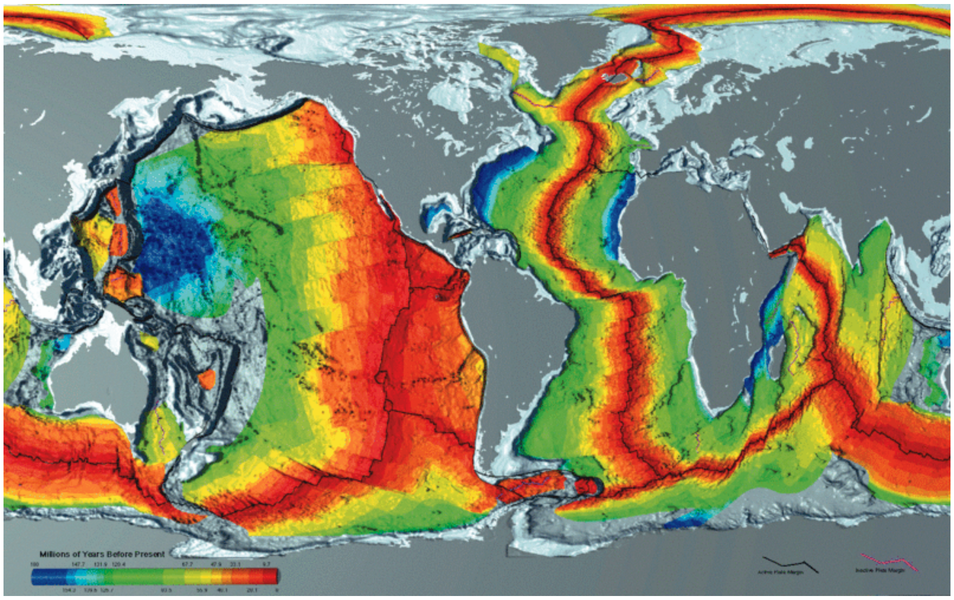
More evidence of Sea Floor spreading



Magnetic alignment of rocks show reverse back and forth. Last reversal 780,000 years ago

As the seafloor speads apart at a mid-ocean ridge, new seafloor is created.

The older sea floor moves away from the ridge in both directions.



Three types of plate boundaries

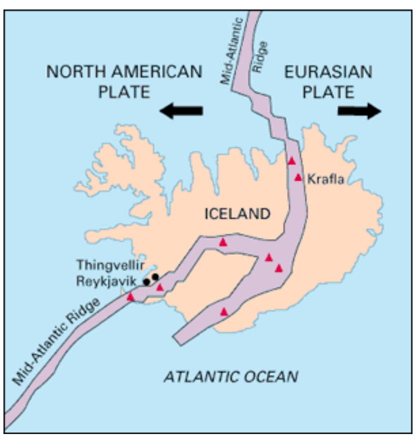
1. Divergent plate boundary (AKA: Constructive or Extensional)

Two tectonic plates that are moving away from each other.

Divergent plates:

Oceanic and Oceanic: Produces Mid-Oceanic ridges

Continental and Continental: Produces Rifts or Valleys



Iceland

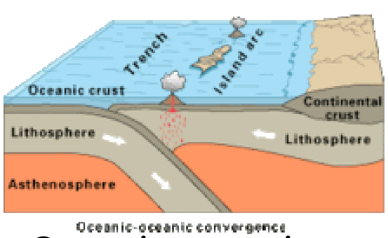
Three types of plate boundaries

2. Convergent plate boundary (AKA destructive)

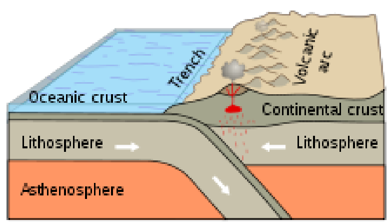
   Two or more tectonic plates move toward one another and collide. Subduction plates are a type of convergent plate.

   *Oceanic and Oceanic
   *Oceanic and Continental
   *Continental and Continental (Continental Collision)

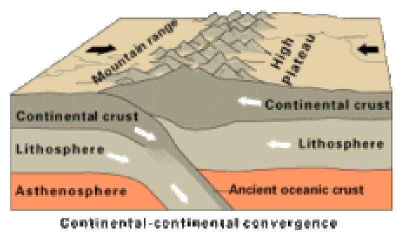
Earthquakes, volcanoes and mountain buildings are common near convergent boundaries



Oceanic-oceanic



Oceanic-continental



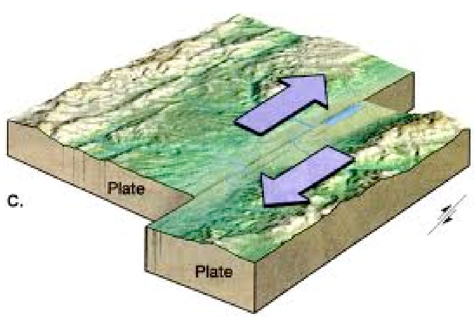
Continental-continental

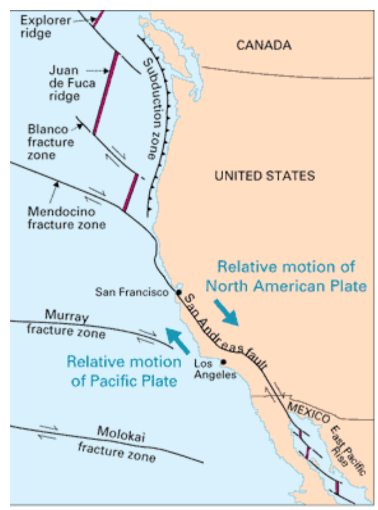
Three types of plate boundaries

3. Transform plate boundary, (AKA conservative or transform fault)

A boundary between two tectonic plates that are sliding horizontally past one another.

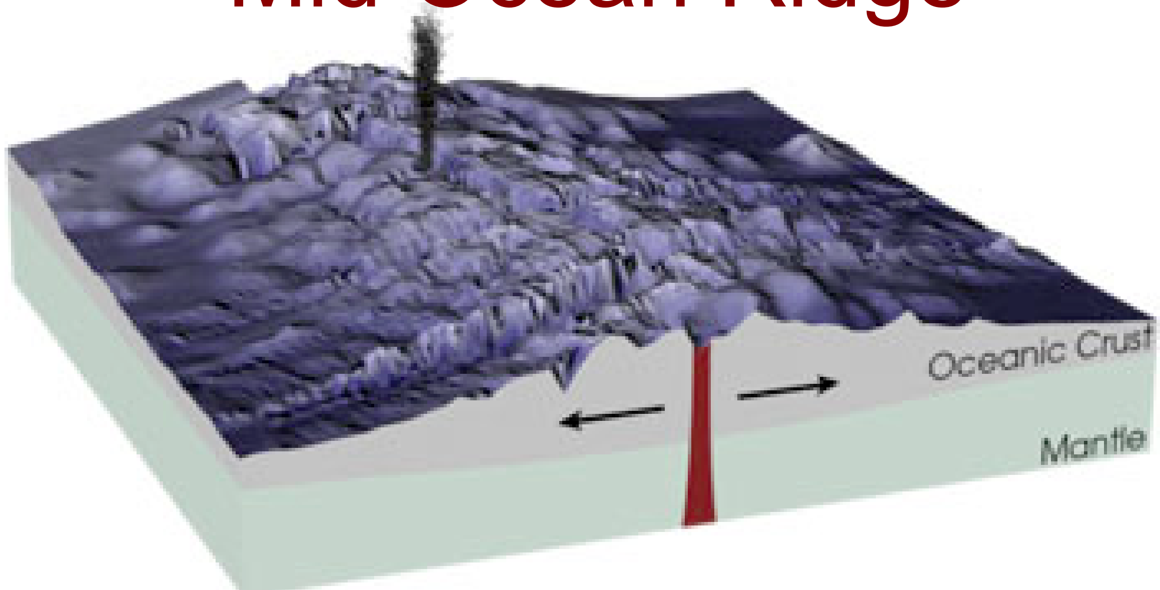
Neither creates nor destroys plates.





Geographic features associated with plate boundaries

Mid Ocean Ridge



Continental Rift

Boundary between two continental, divergent plates that produces a large rift or chasm in the center.

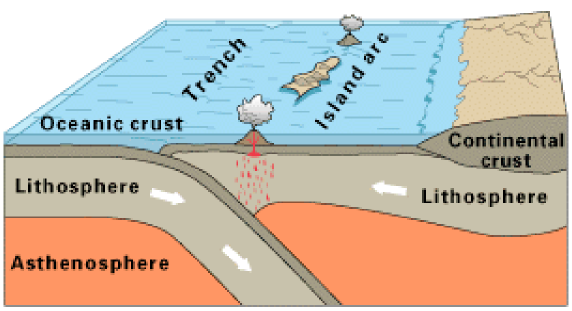
Similar to seafloor spreading, but on land and has no magma emerging as lava. An example is the Great Rift Valley in Africa.

Trench

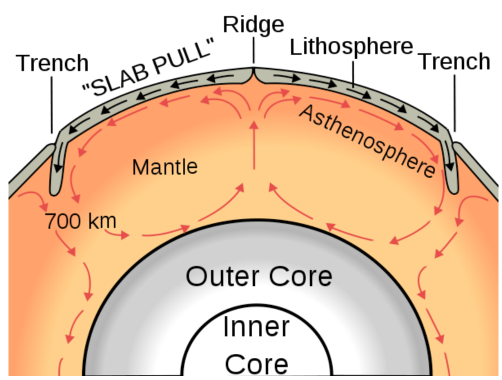
A long, narrow, steep-sided depression in the ocean floor formed where one crustal plate is forced beneath another.

Oceanic Trench

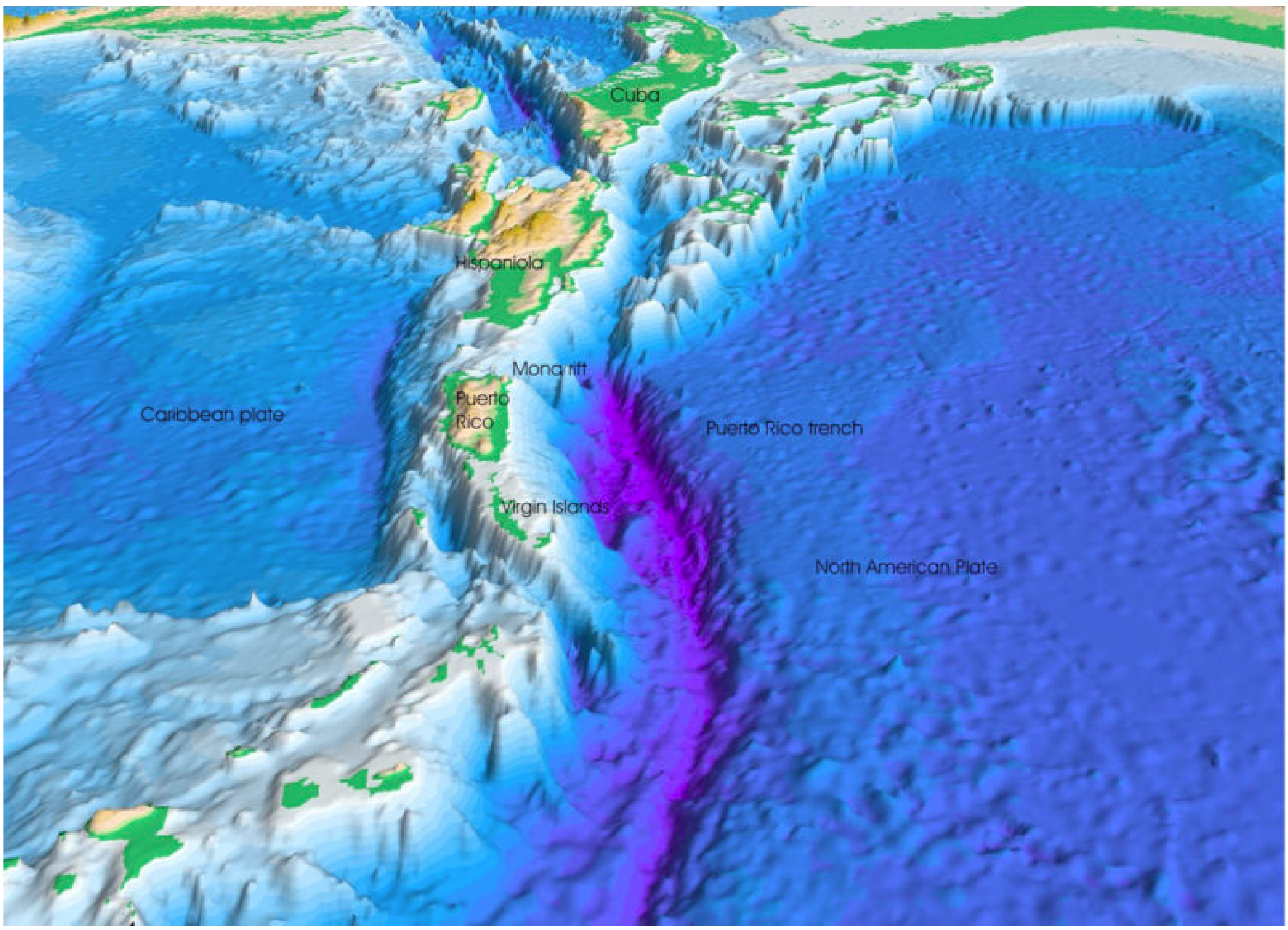
Occur at a subduction zone. Trenches are generally parallel to a volcanic island arcs. Oceanic trenches typically extend 3 to 4 km (1.9 to 2.5 mi) below the level of the oceanic floor.

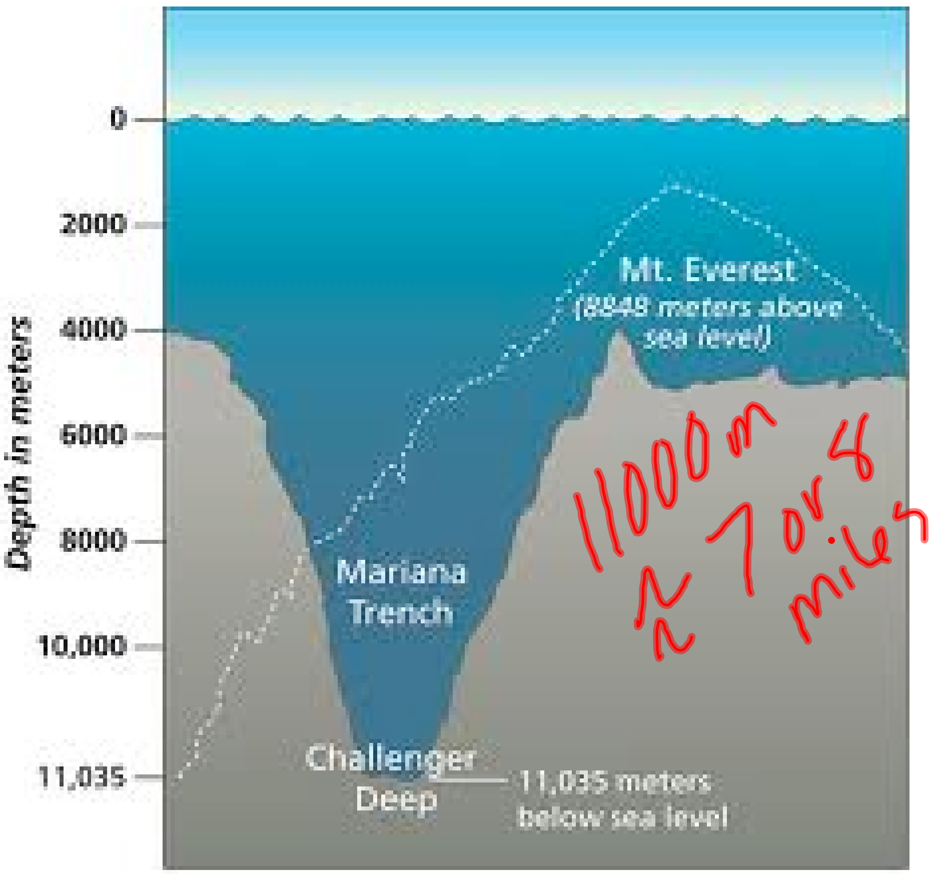


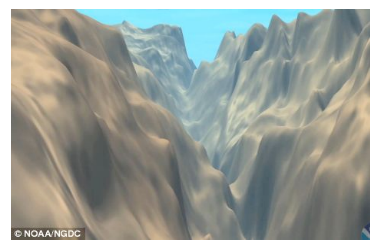
Oceanic-oceanic convergence



The Puerto Rico Trench is an oceanic trench located on the boundary between the Caribbean Sea and the Atlantic Ocean.

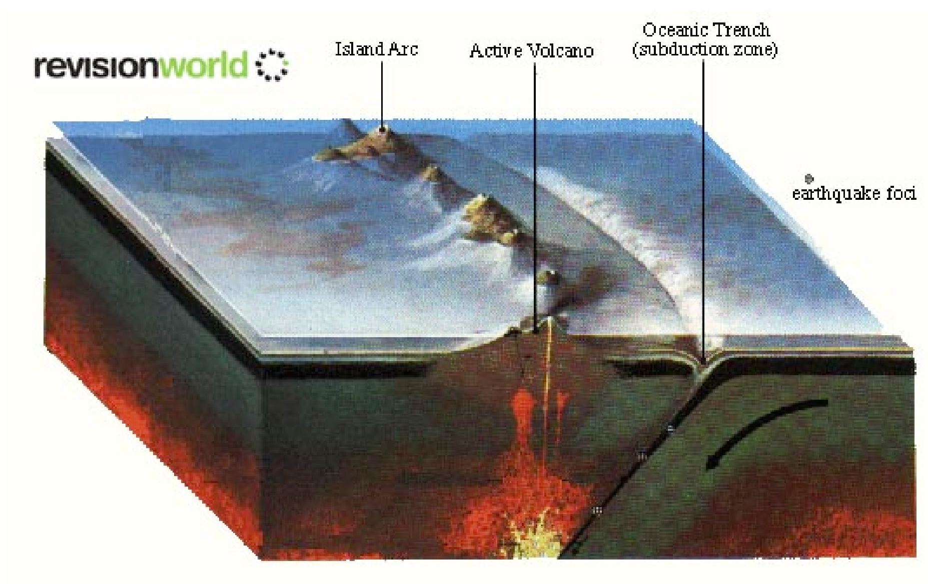



0
2000
4000
6000
8000
10,000
11,035
Depth in meters
Mt. Everest
(8848 meters above sea level)
Mariana Trench
Challenger Deep
11,035 meters below sea level
11000m
≈ 7 or 8 miles


© NOAA/NGDC

Volcanic Arc

A chain of volcanoes positioned in an arc shape. Occurs when volcanoes form islands as a results from subduction of an oceanic plate under another tectonic plate, often parallel to an oceanic trench.



There are two types of volcanic arcs:

- **Oceanic arcs** form when oceanic crust subducts beneath other oceanic crust on an adjacent plate, creating a volcanic island arc. (Not all island arcs are volcanic island arcs.)

Example: The Lesser Antilles

There are two types of volcanic arcs:

- **Continental arcs** form when oceanic crust subducts beneath continental crust on an adjacent plate, creating an arc-shaped mountain belt.
  (Not all mountain belts are formed this way.)

Example: The Andes Mountains

Difference between Continental plate and Oceanic plate

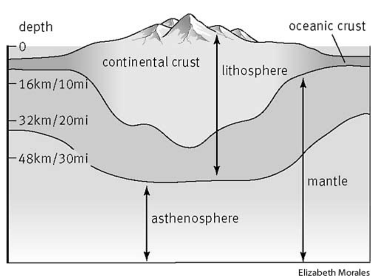
***Density: Ocean plate is more dense due to sinking and cooling of ocean plates. It is denser, but thinner.**

***Age: Oceanic Plate is younger than Continental Plate. Oldest material on Ocean floor is 160 million years old.**

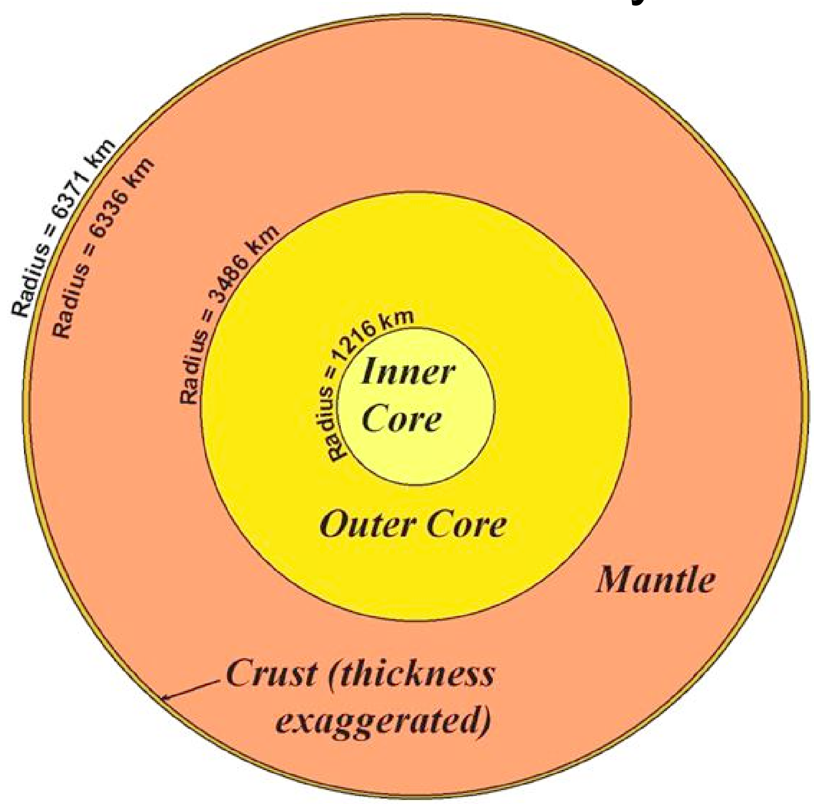
***Composition: oceanic plate is basaltic (made from lava from the divergent ridges). Continental is granitic (made from magma welling up from the convergent boundaries).**

What are tectonic plates?

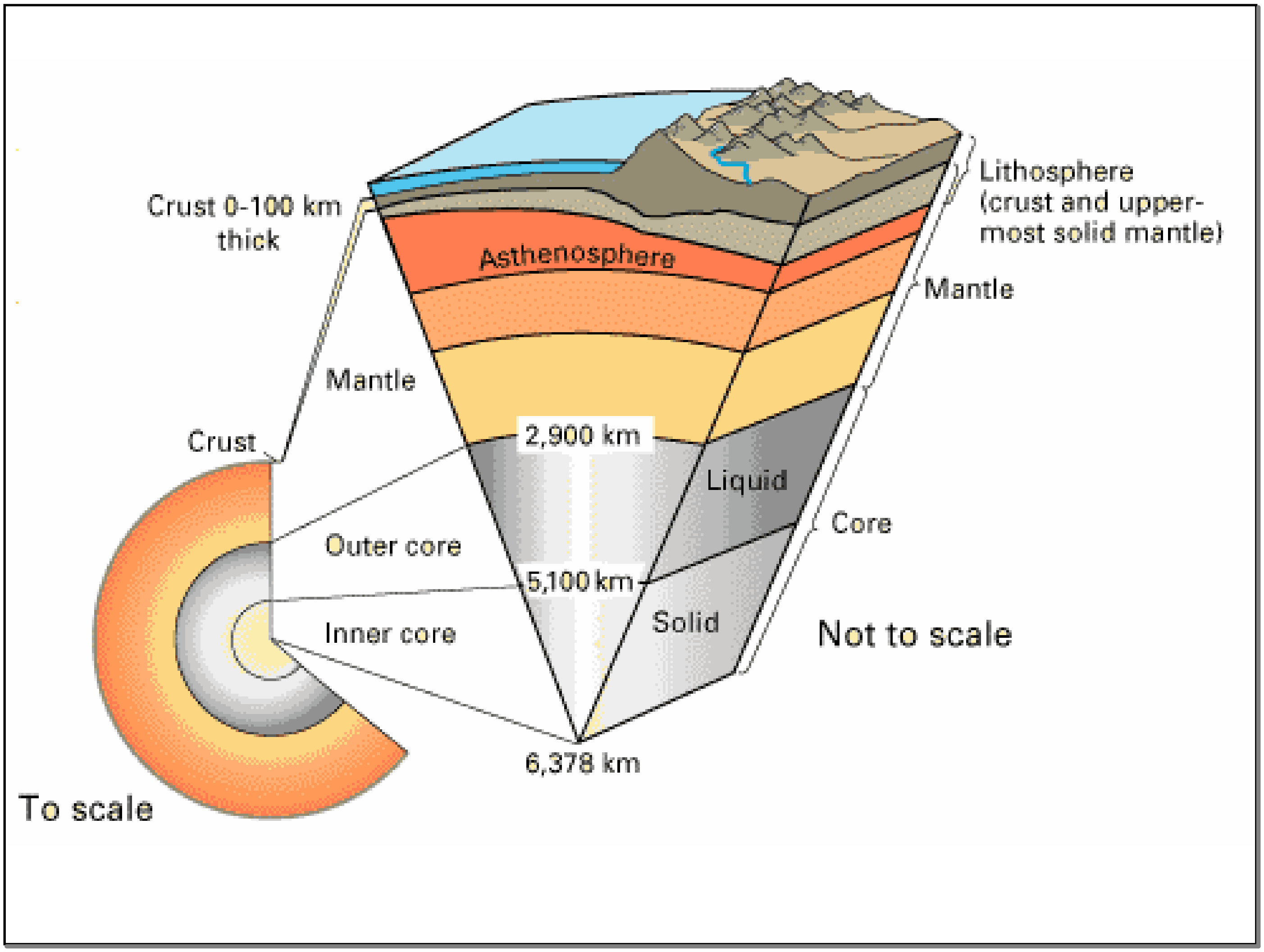
Tectonic plates are part of the lithosphere that are broken up. They float on the asthenosphere.



Model of Earth's Layers



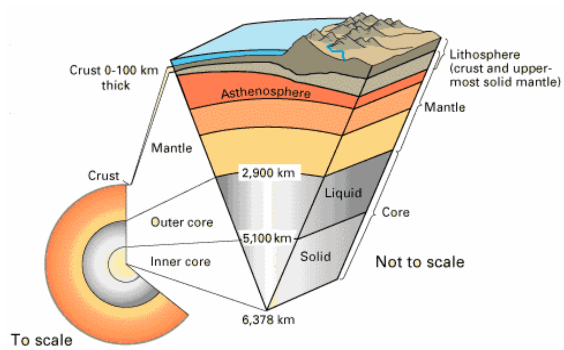
March 05, 2013



The asthenosphere is just below the lithosphere.

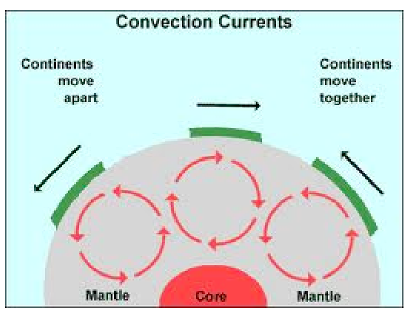
In spite of its high temperature, pressures keep it plastic, and it has a relatively low density.

In this zone, the rock making up the mantle behaves like both a liquid and a solid.



What causes the plates to move?

Convection heat through the mantle causes the plate to move. This outward flow of heat comes from the Earth's interior. This convection heat is the driving energy for plate tectonics.



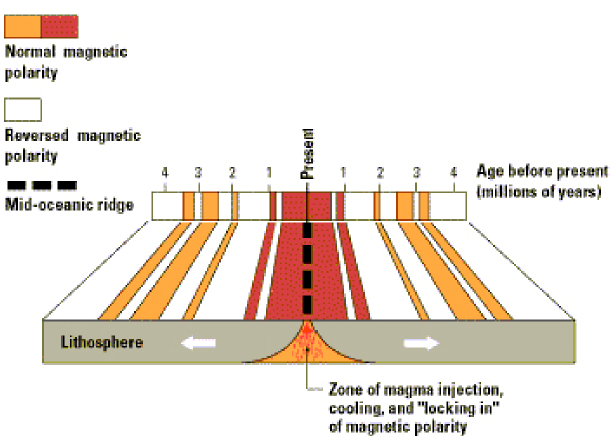
The average rates of plate movement can range widely. The Arctic Ridge has the slowest rate (less than 2.5 cm/yr), and the East Pacific Rise near Easter Island has the fastest rate (more than 15 cm/yr).

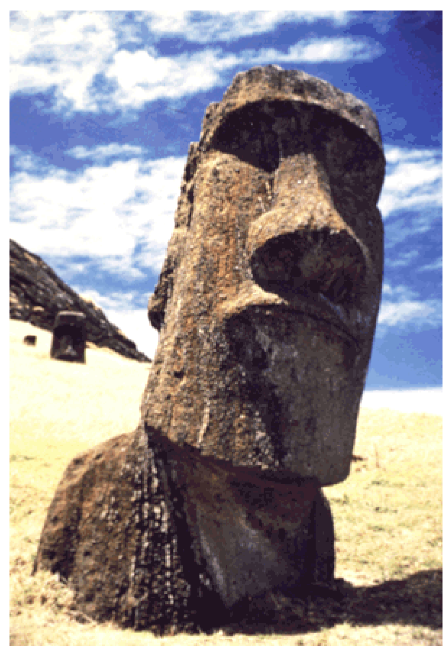
What is the rates of motion of tectonic plates?

$$\text{velocity} = \frac{\text{distance}}{\text{time}}$$

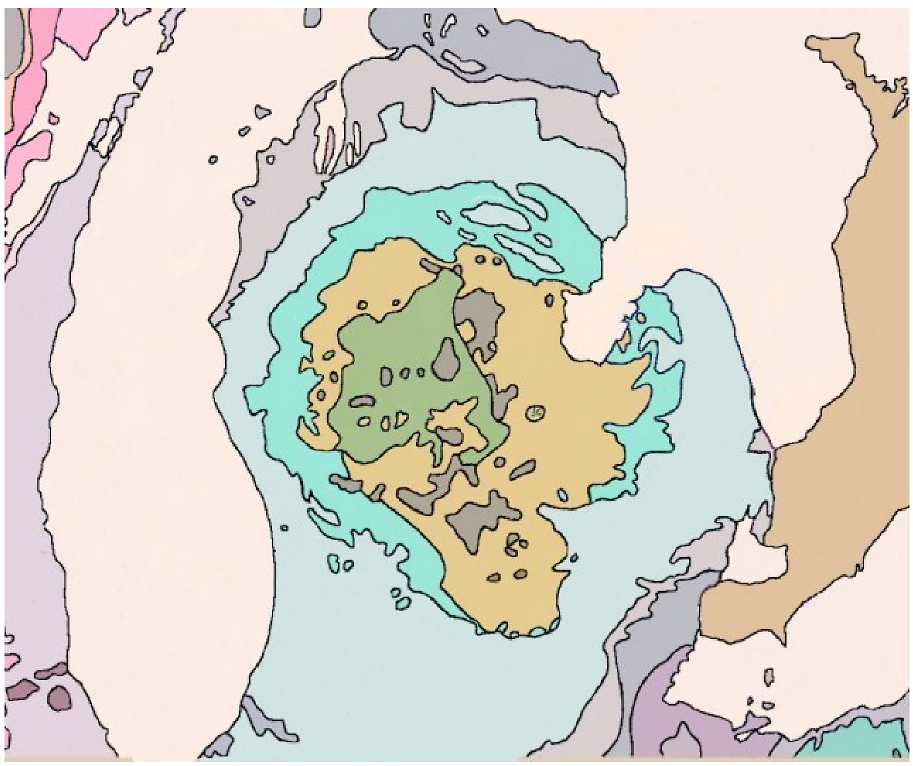
Plate	Absolute Velocity (cm/yr)*
Antarctic	~2.05
African	~2.15
Arabian	~4.65
Caribbean	~2.45
Cocos	~8.55
Eurasian	~0.95
Indian	~6.00
Nazca	~7.55
North American	~1.15
Pacific	~8.10
Philippine	~6.35
South American	~1.45

Ocean-floor magnetic striping records the reversal in the Earth's magnetic field. Evidence can also be obtained from geologic mapping studies. If a rock formation of known age can be matched with the same formation on the other side of the boundary, then measuring the distance that the formation has been offset can give an estimate.

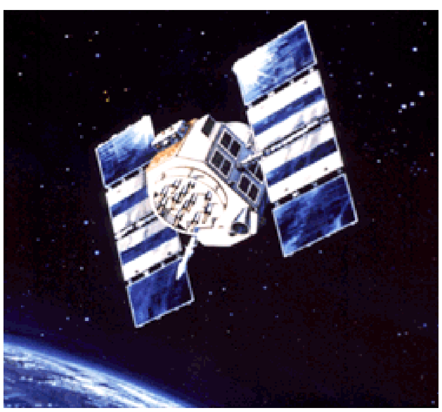




March 05, 2013



Current plate movement can be tracked directly by means of satellites or ground-based geodetic measurements.



How do Scientist know where the plate boundaries are locate?

Scientist use the volcanoes and earthquakes associated with the ring of fire to locate plate boundaries.

What is the Rates of motion of Tectonic plates

Scientist use the ocean-floor magnetic striping records. These strips flip-flops in the Earth's magnetic field, scientists, knowing the approximate duration of the reversal, can calculate the average rate of plate movement during a given time span. These average rates of plate separations can range widely. The Arctic Ridge has the slowest rate (less than 2.5 cm/yr), and the East Pacific Rise near Easter Island, in the South Pacific about 3,400 km west of Chile, has the fastest rate (more than 15 cm/yr).

The majority of the research showed that the plates moved at the average rates between approximately 0.60 cm/yr to 10 cm/yr. Some sources stated that in the North Atlantic, the rate of movement is only about 1 cm (about 0.4 in) per year, while in the Pacific it amounts to more than 4 cm (almost 2 in) annually, while two others said the plates, in general, traveled from 5 to 10 cm/yr.

or space-based geodetic measurements; geodesy is the science of the size and shape of the Earth. Ground-based measurements are taken with conventional but very precise ground-surveying techniques, using laser-electronic instruments. However, because plate motions are global in scale, they are best measured by satellite-based methods. The late 1970s witnessed the rapid growth of space geodesy, a term applied to space-based techniques for taking precise, repeated measurements of carefully chosen points on the Earth's surface separated by hundreds to thousands of kilometers. The three most commonly used space-geodetic techniques -- very long baseline interferometry (VLBI), satellite laser ranging (SLR), and the Global Positioning System (GPS) -- are based on technologies developed for military and aerospace research, notably radio astronomy and satellite tracking.

Among the three techniques, to date the GPS has been the most useful for studying the Earth's crustal movements. Twenty-one satellites are currently in orbit 20,000 km above the Earth as part of the NavStar system of the U.S. Department of Defense. These satellites continuously transmit radio signals back to Earth. To determine its precise position on Earth (longitude, latitude, elevation), each GPS ground site must simultaneously receive signals from at least four satellites, recording the exact time and location of each satellite when its signal was received. By repeatedly measuring distances between specific points, geologists can determine if there has been active movement along faults or between plates. The separations between GPS sites are already being measured regularly around the Pacific basin. By monitoring the interaction between the Pacific Plate and the surrounding, largely continental plates, scientists hope to learn more about the events building up to earthquakes and volcanic eruptions in the circum-Pacific Ring of Fire. Space-geodetic data have already confirme

Coolest website ever - can caculate rate of hawaii move

http://www.classzone.com/books/earth_science/terc/content/investigations/es0810/es0810page01.cfm

March 05, 2013