CONTINENTAL DRIFT

- The belief that continents have not always been fixed in their present positions was suspected long before the 20th century
- However, it was not until 1912 that the idea of moving continents was seriously considered as a full-blown scientific theory called *Continental Drift.*

The distribution of glacial features can be best explained if the continents were part of Pangaea.

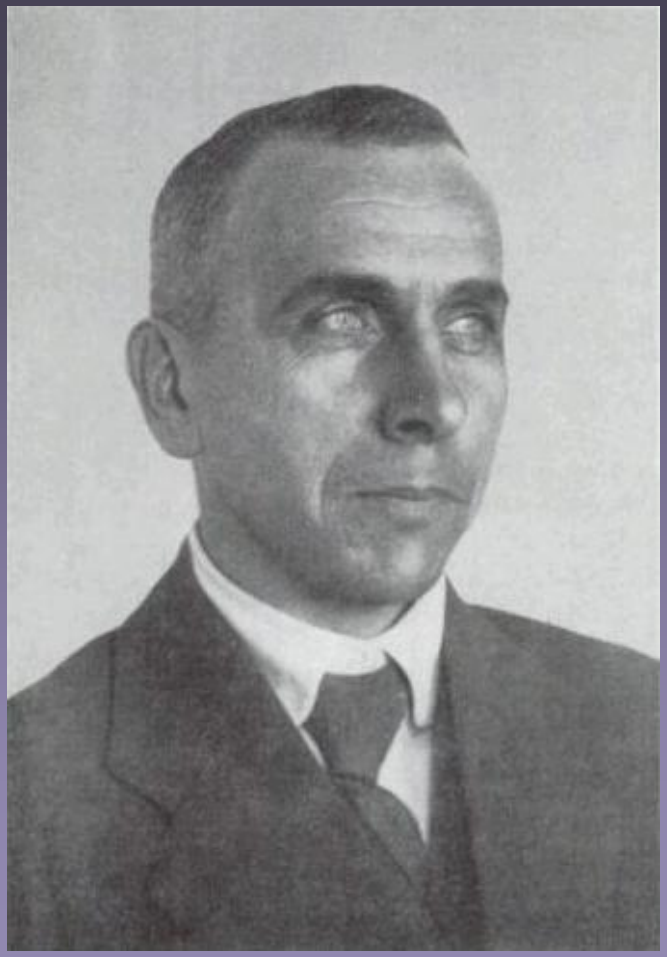
Continental Drift

End Of Slide

Chapter menu

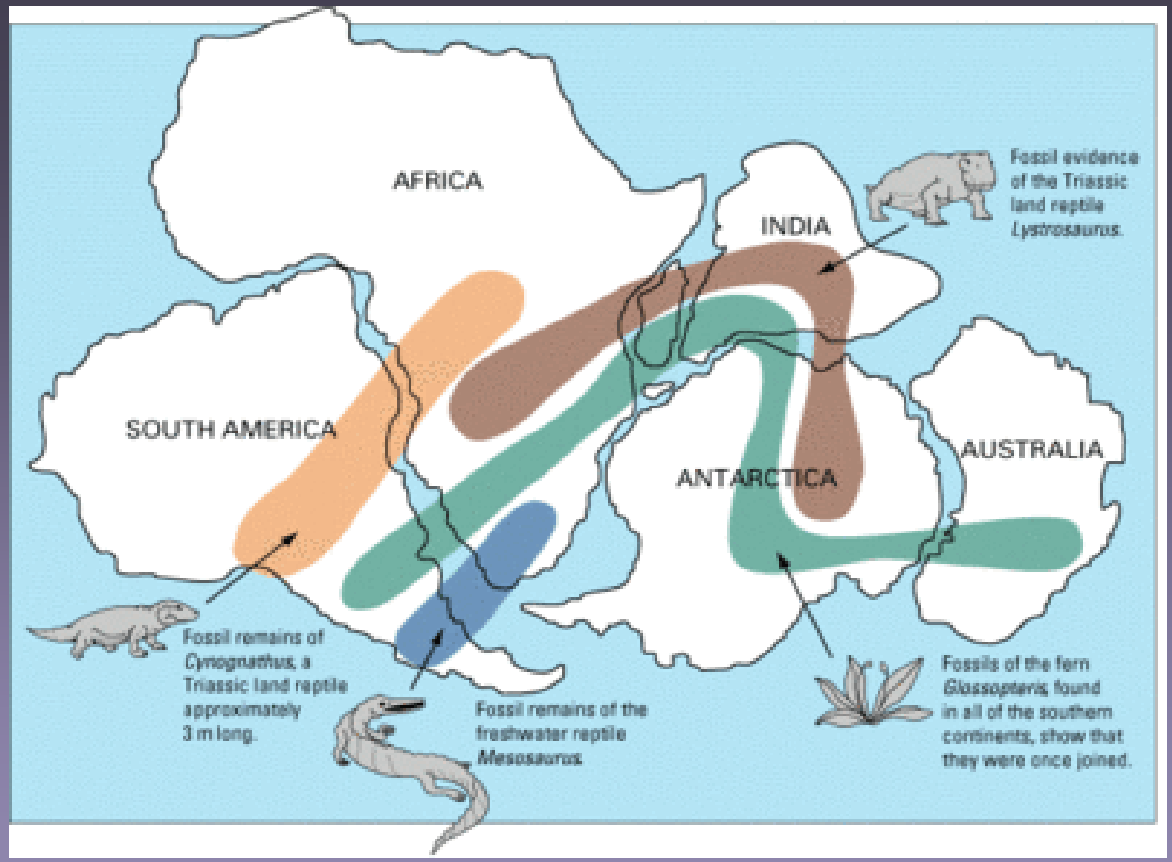
Resources

- Introduced in two articles published by a 32-year-old German meteorologist named Alfred Wegener.
- He proposed that, around 200 million years ago, the supercontinent Pangaea began to split apart.



Alfred Wegener

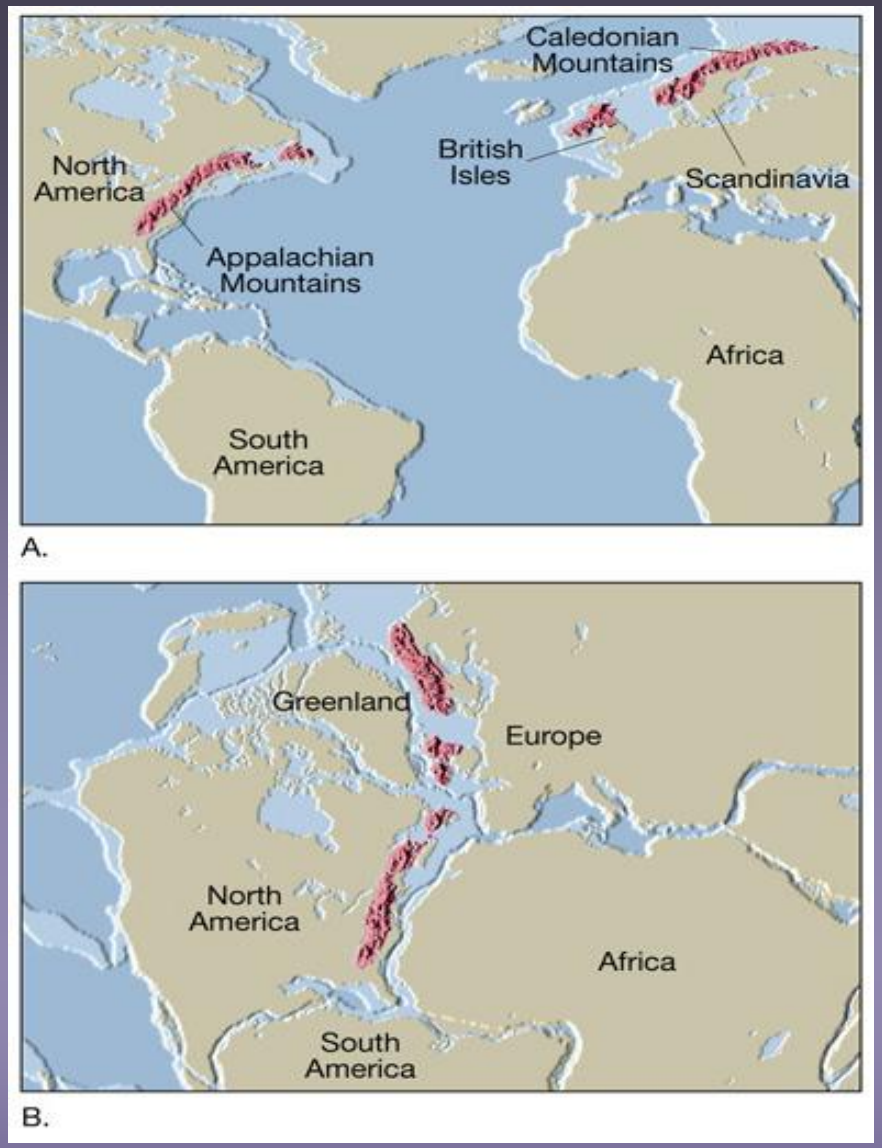
Alfred Wegener's Evidence



- His hypothesis was strongly supported by the physical evidence:
- (1) Rock Type and Geological Evidence, (2) Fossils, (3) Continental Jigsaw Puzzle, (4) Ancient Climates

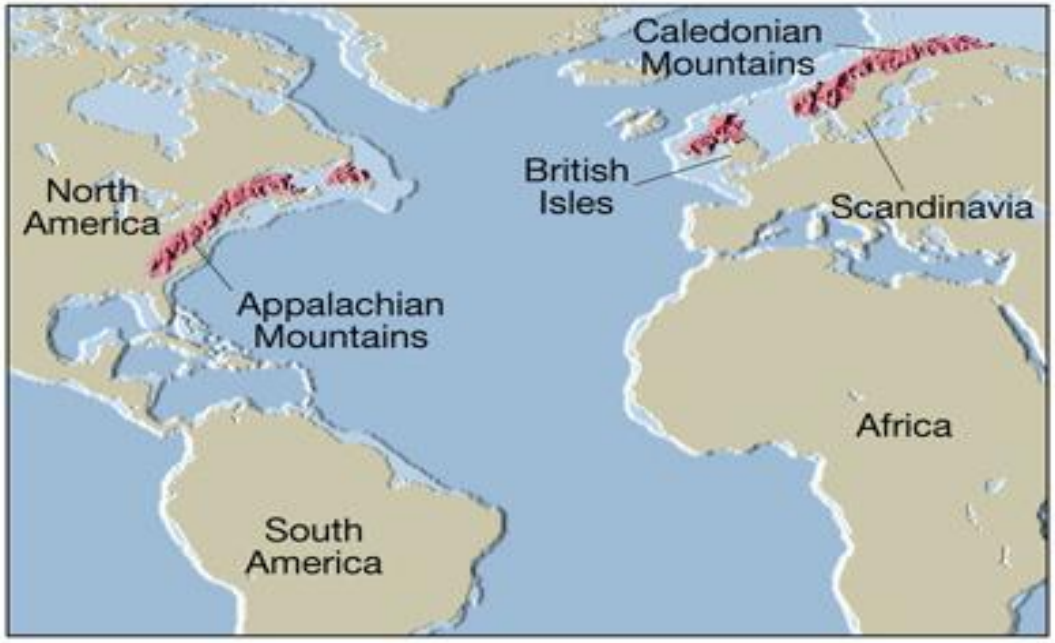
- Geologist have found the ages and types of rocks in the coastal regions of widely separated areas matched closely across the Atlantic ocean.

1. Rock Type and Geological Evidence



- Mountains like the Appalachian's became an obvious fit with the Caledonian on the other side of the Atlantic.

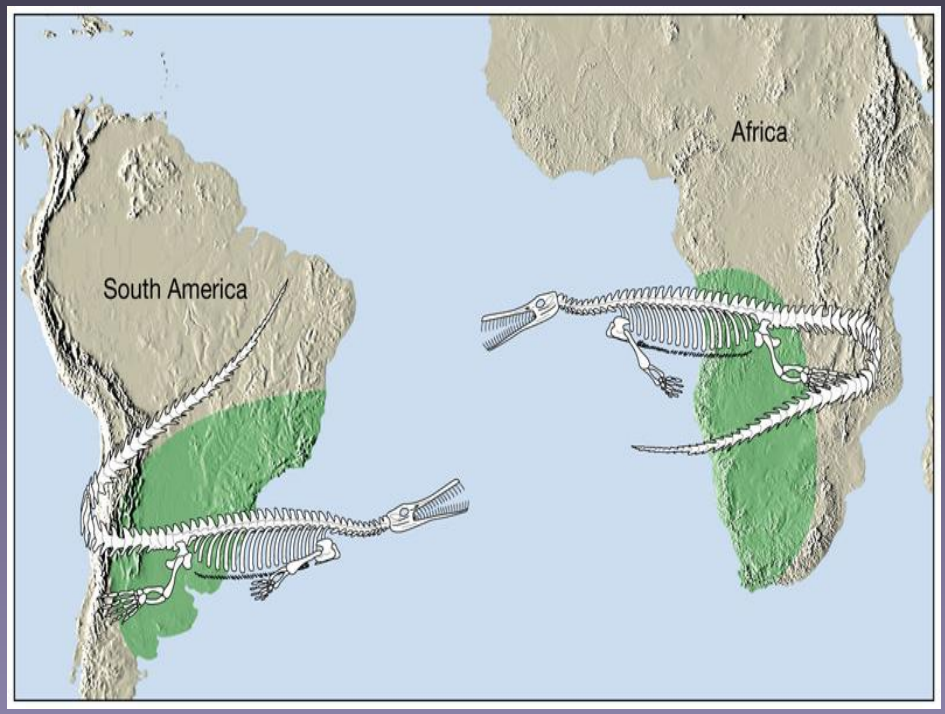
1. Rock Type and Geological Evidence



A.

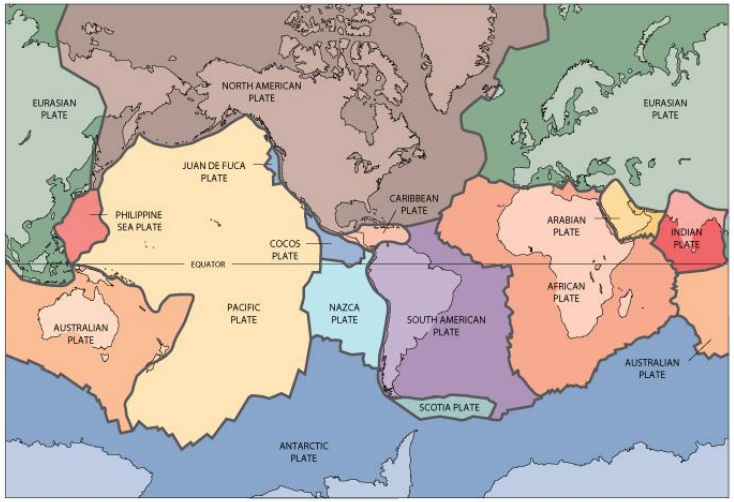
B.

- Fossils of the same plants and animals could be found in areas of continents that had once been connected.
- Fossils of small land reptiles, mites and even earthworms have been found on South Africa and South America, reinforcing Wegener's theory of continental drift.



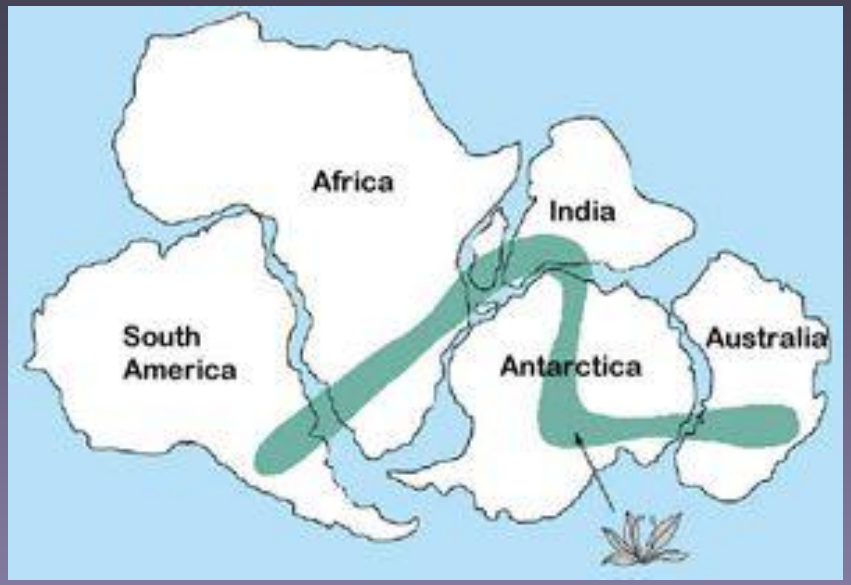
2. Fossil Evidence

- Objection: Erosion would have changed the continents' shapes
- Solution: There are continental shelves underwater- not as much erosion.



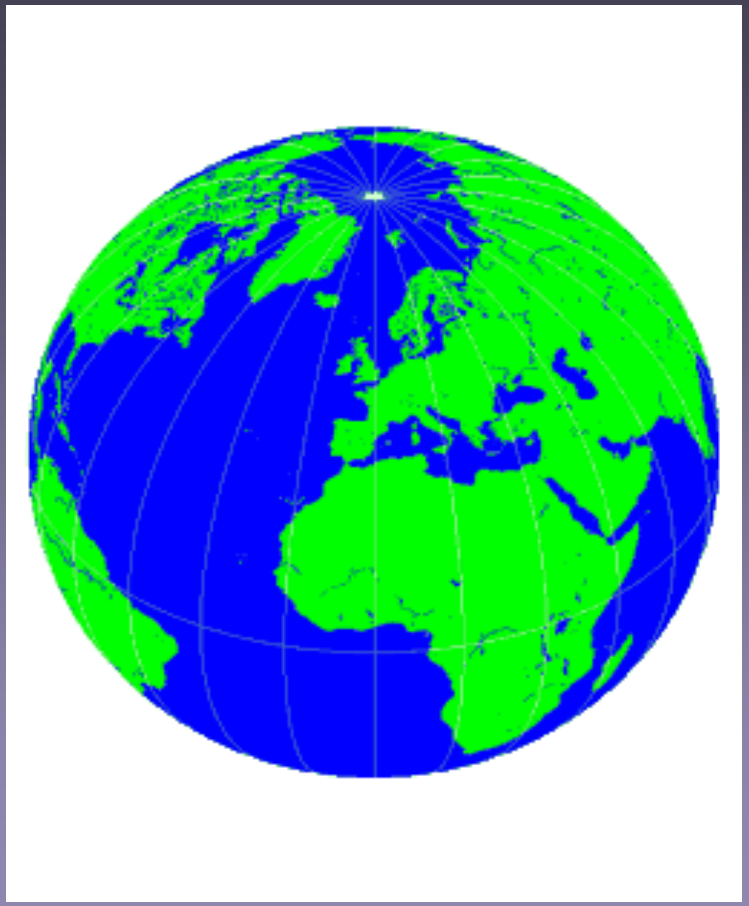
3. Continental Jigsaw Puzzle

- Evidence of glaciers was found in Africa, South America, India, Australia.
- Currently, they are near the equator



4. Ancient Climates

- In his work, Wegener presented a large amount of very strong evidence in support of continental drift, but the mechanism remained elusive.
- He eventually proposed that it was the rotation of the earth that moved the tectonic plates.

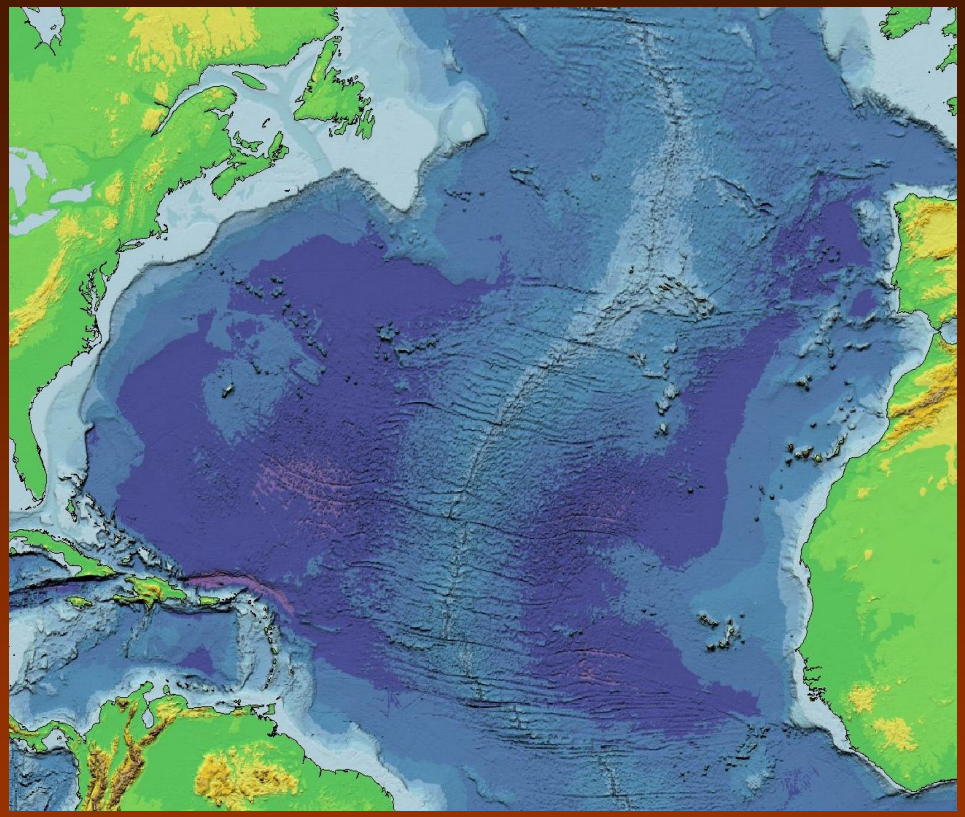


Wegener

Check for Understanding

What were four fundamental pieces of evidence Wegner used to support continental drift?

- Seeking to improve our knowledge of Earth, scientists used new war tested technologies like sonar and magnetometers.



Sea Floor Spreading

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Chapter menu

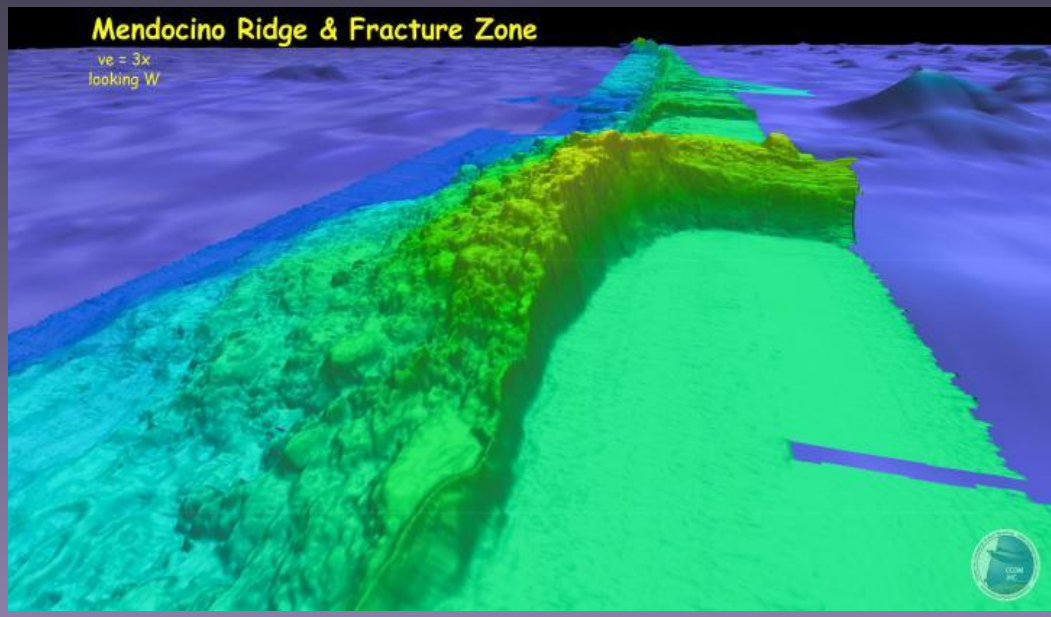
Resources

- Harry Hess, was a professor of geology at Princeton University and a Captain of the Navy.
- During the wartime Hess collected ocean floor profiles across the North Pacific Ocean, resulting in the
- (1) discovery of flat-topped submarine volcanoes.

Hess Introduces Sea-Floor Spreading

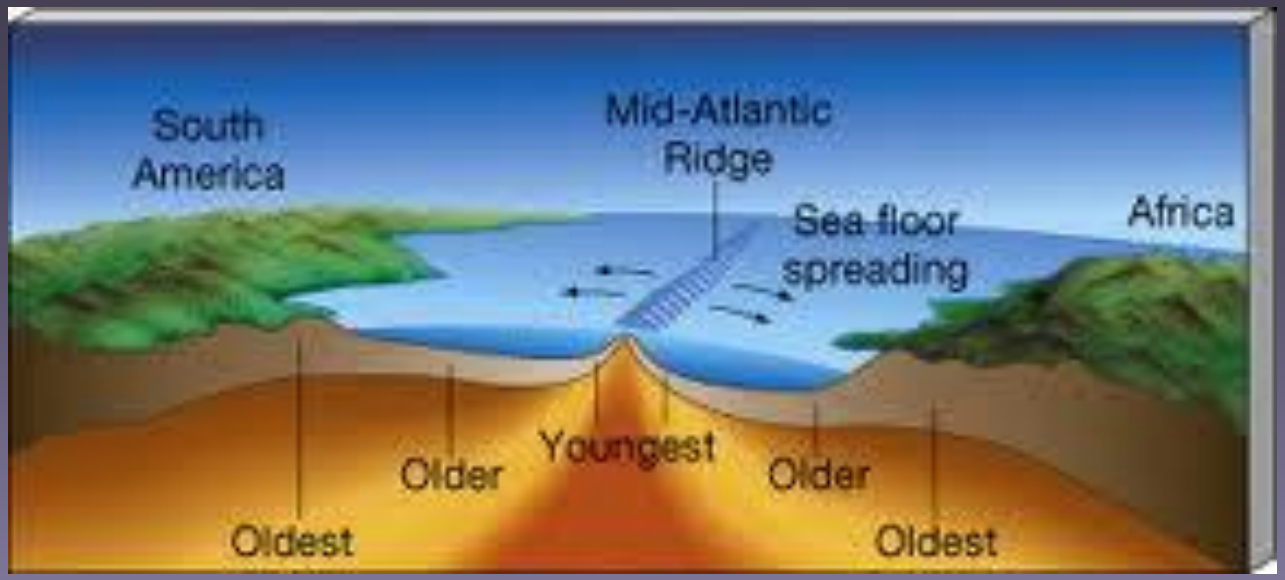
- It was widely assumed that the ocean was flat so Hess did more research and in the Atlantic Ocean he found that:

(2) The sediment that covers the sea floor is thinner closer to a ridge than it is farther from the ridge.



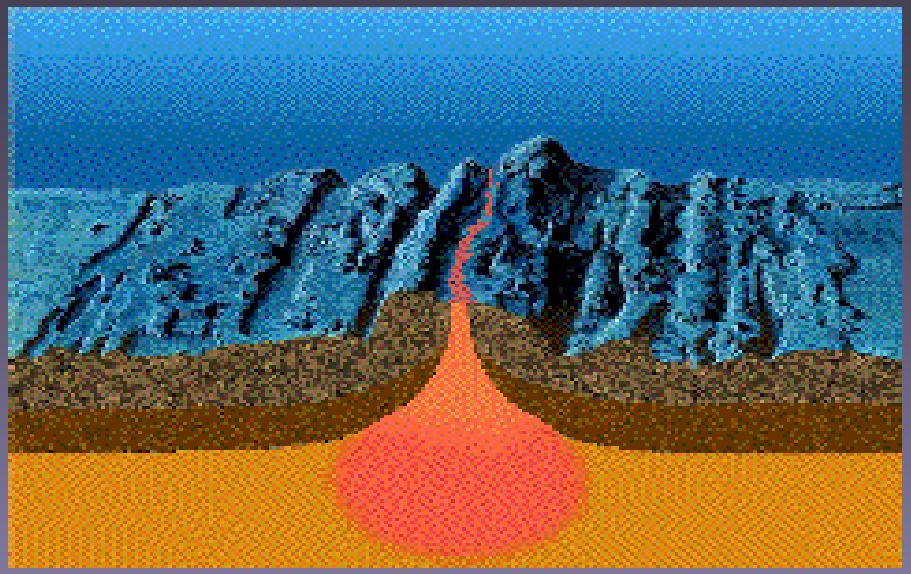
Hess Introduces Sea-Floor Spreading

Atlantic Ridge



- Using core samples Hess discovered the ocean floor is very young compared to continental rock.
- (3) He also noticed rock that was closer to the ridge was younger then rock away from the ridge.

- Using this data, he published a paper titled "History of Ocean Basins", in 1962.
- In it, he introduces the hypothesis that later would be called "S*eafloor Spreading".*
- He was convinced that the convection of the Earth's mantle was creating the mountains he found and creating the driving force to tectonic plates.



Mid-Ocean Ridges

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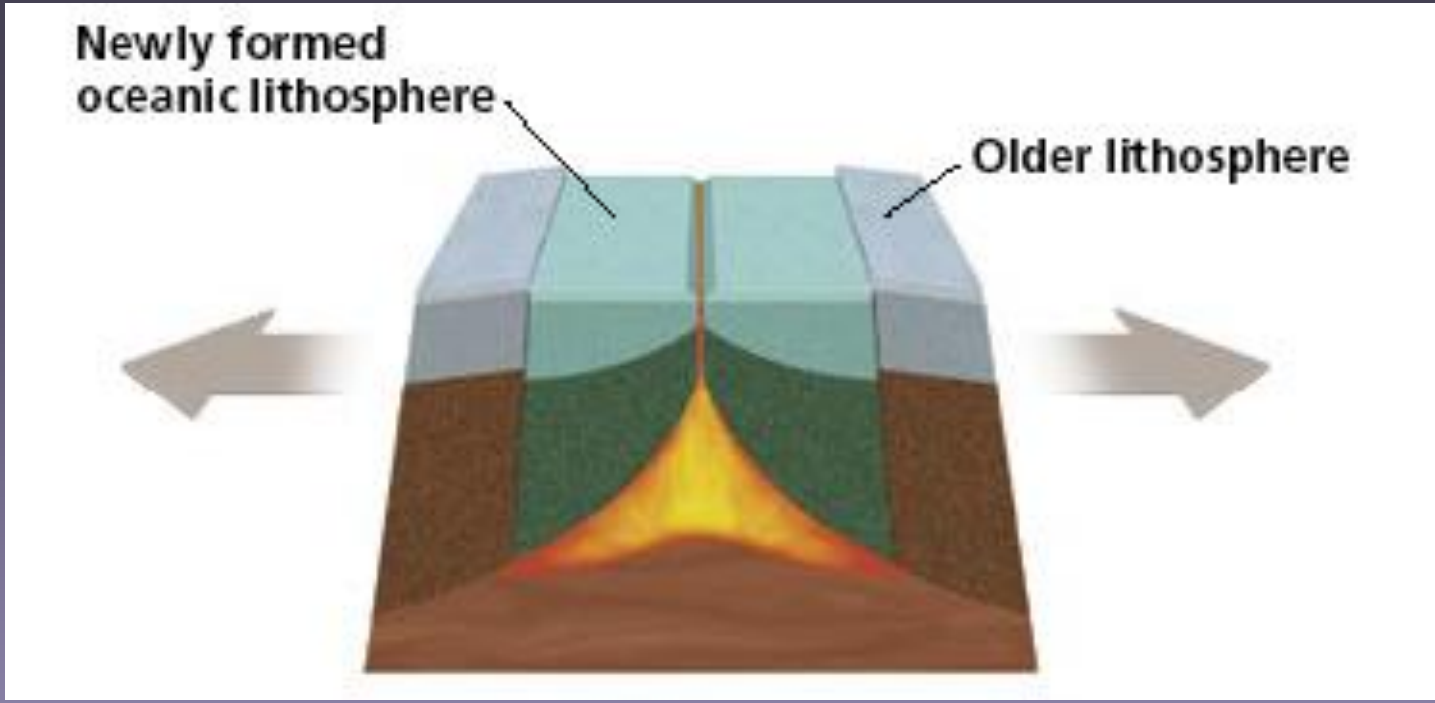
Chapter menu

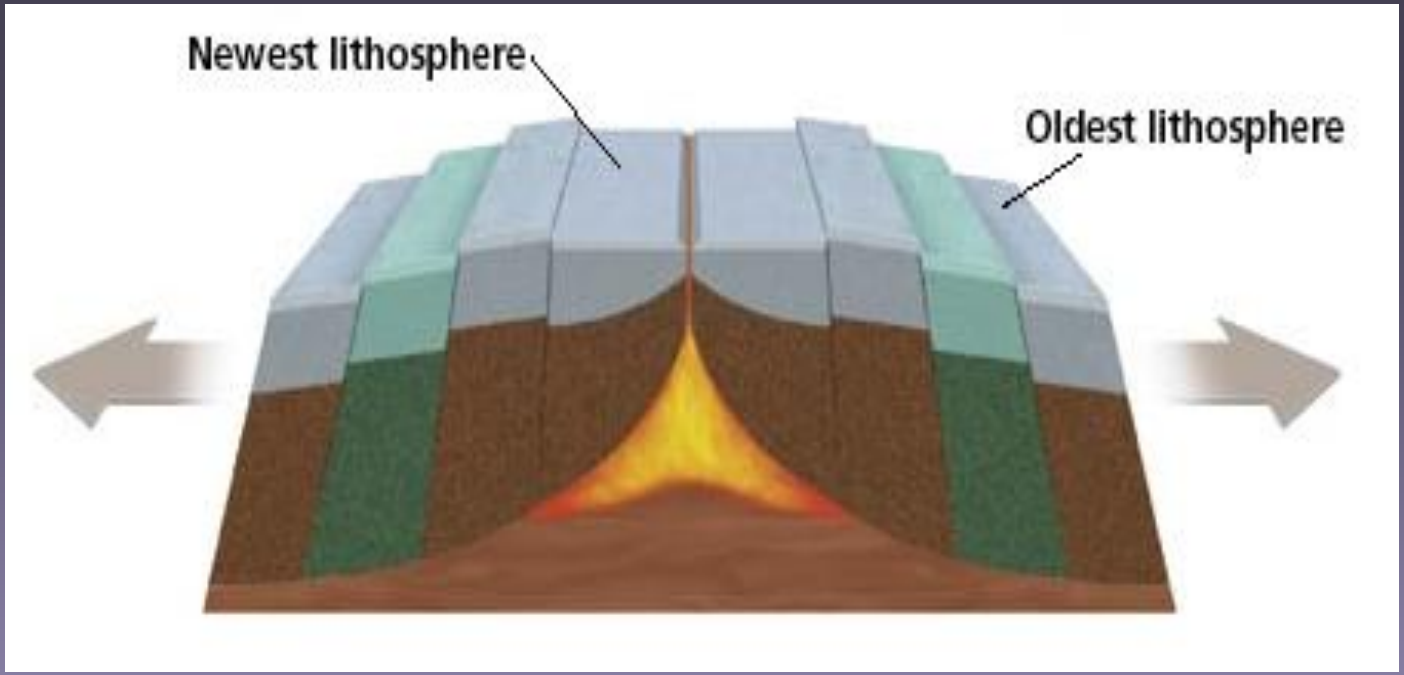
Resources

Sea-Floor Spreading



• Sea Floor spreading is the process by which new oceanic lithosphere forms as magma rises to Earth's surface and solidifies at a mid-ocean ridge (Mountain Chain).

Sea-Floor Spreading



- As this process continues the rock closest to the ridge slowly pushes the older rock further away from the ridge.
- A lot like old toothpaste or a mustard bottle.

Check for Understanding

1. What were the findings of Henry Hess?

2. Explain sea floor spreading.

- Using magnetometers, scientists in 1963 (Paleomagnetism) began recognizing odd magnetic variations across the ocean floor.

Paleomagnetism

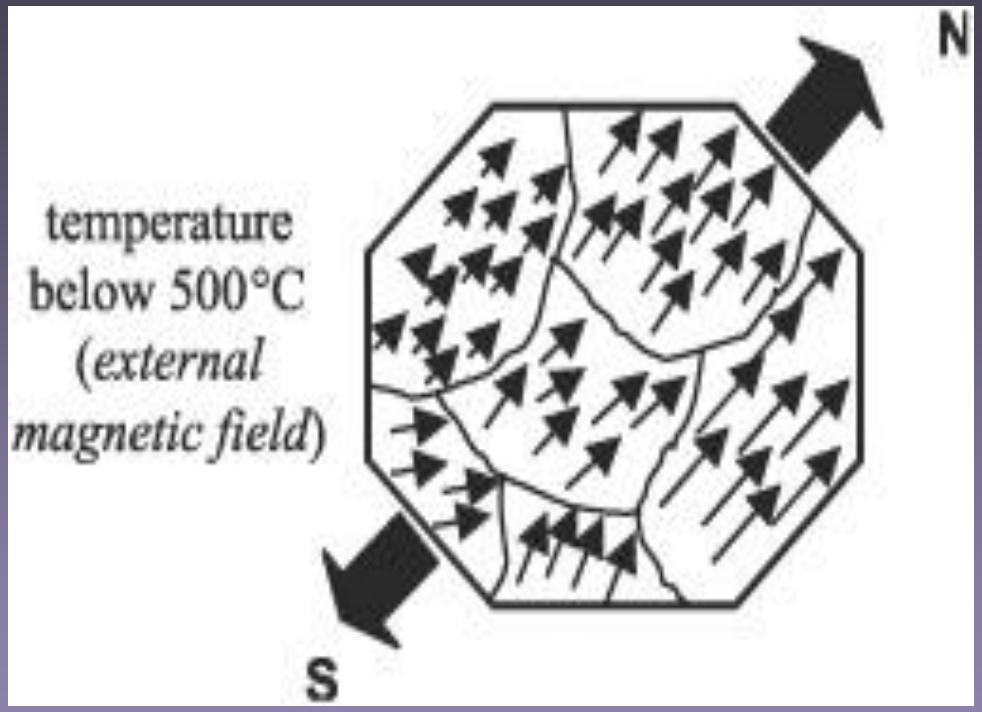
End Of Slide

Chapter menu

Resources

- Basalt is the iron-rich, volcanic rock making up the ocean floor--contains a strongly magnetic mineral known as *magnetite.*

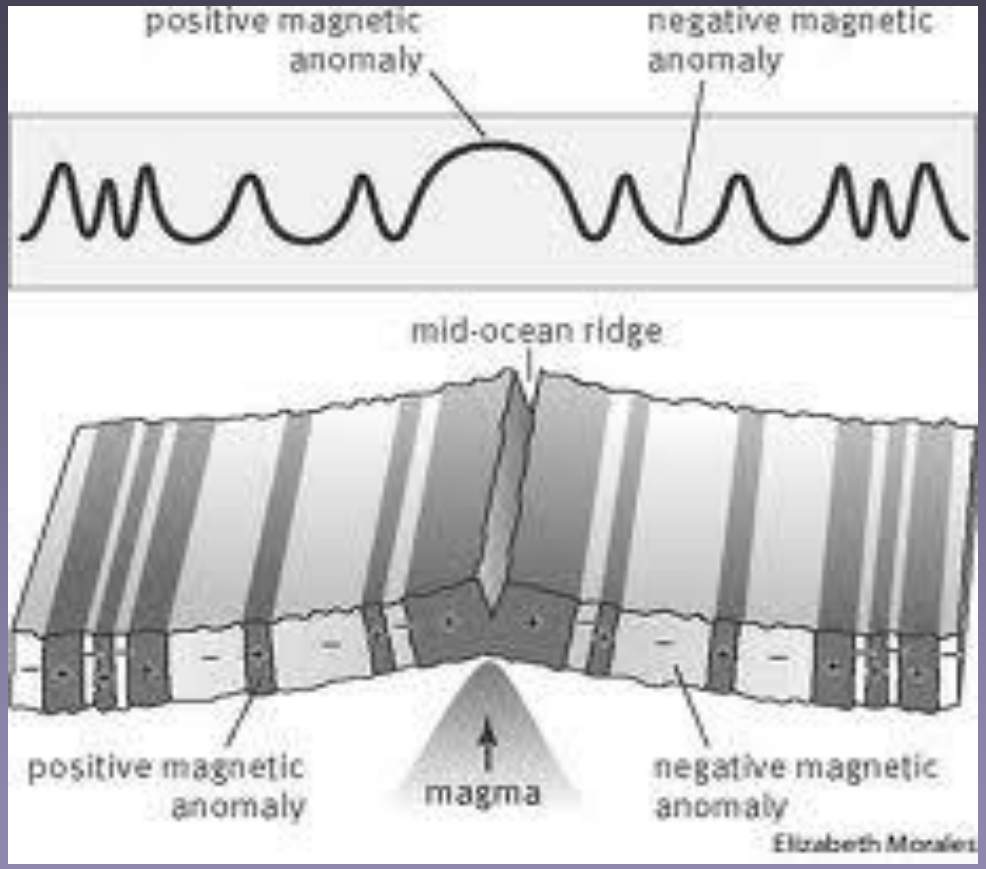
- When magma solidifies, the magnetite in the magma with Earth's magnetic field.



Paleomagnetism

• Geologist begin to date the basalt rocks and they notice something odd.

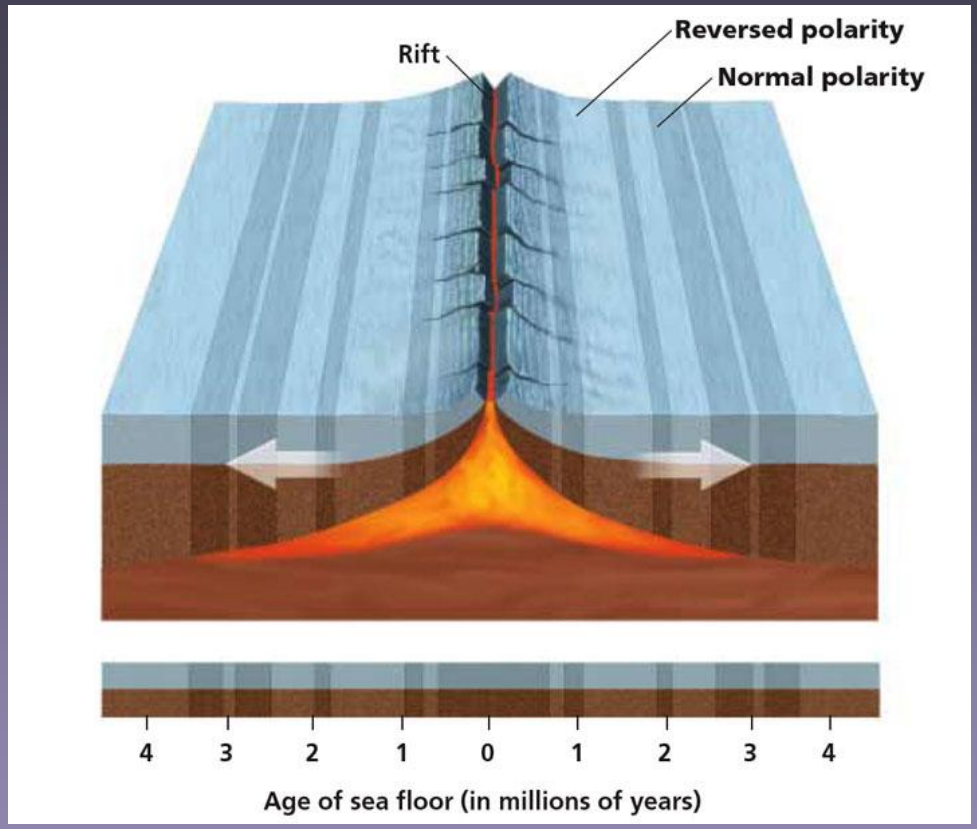
• Some rocks have magnetic fields that point north (normal polarity) while other rocks had magnetic fields that pointed south (reversed polarity).



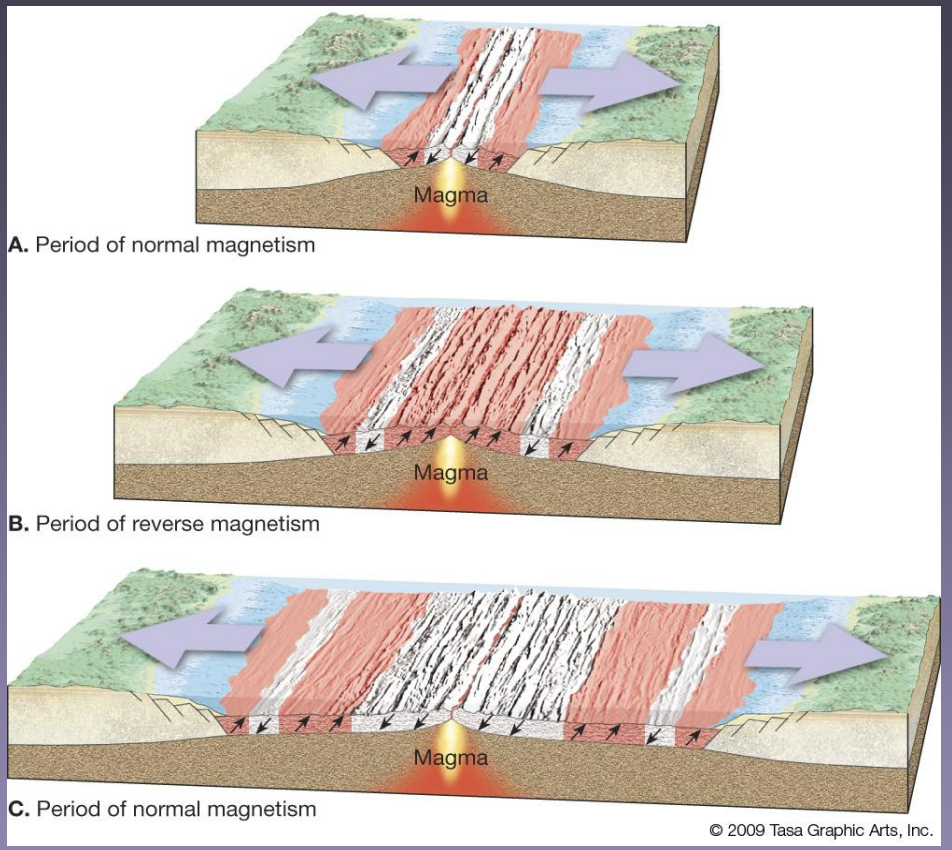
Magnetic reversals within Rock

Magnetic Reversals

- When scientists dated these rocks they realized that all rocks placed these periods of normal and reversed polarity in chronological order or a pattern.
- The current time scale contains 184 polarity intervals in the last 83 million years.

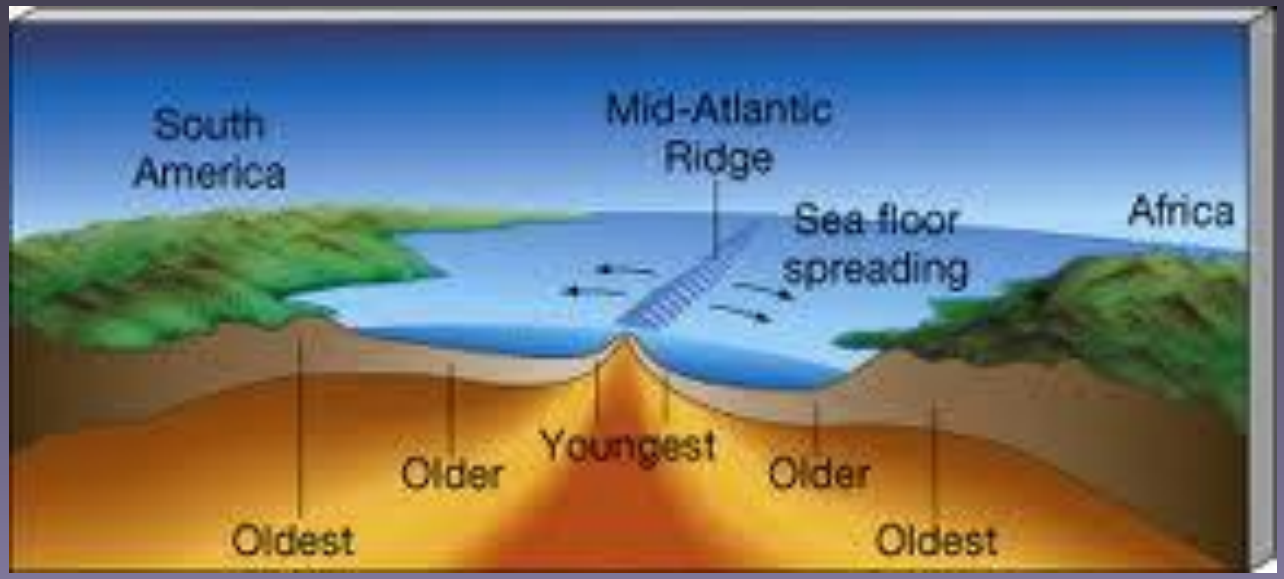


- Reversal patterns on the sea floor could also be found on land.
- The reversals in land rocks also matched the geomagnetic reversal time scale.



Continental Reversal Patterns

Atlantic Ridge



- Finally, improved seismic data confirmed that oceanic crust was indeed sinking into the trenches, fully proving Hess' hypothesis, which was based largely on intuitive geologic reasoning.
- This would also rescue Alfred Wegener’s namesake.

Check for Understanding

Complete Individually

1. What key piece of technology lead to Hess's discovery of sea floor spreading?
2. Explain why sea floor spreading creates a mirror image on either side of the ridge. Draw a picture and describe to explain.

- Plate tectonics the theory that explains how large pieces of the lithosphere, called plates, move and change shape.

How Continents Move

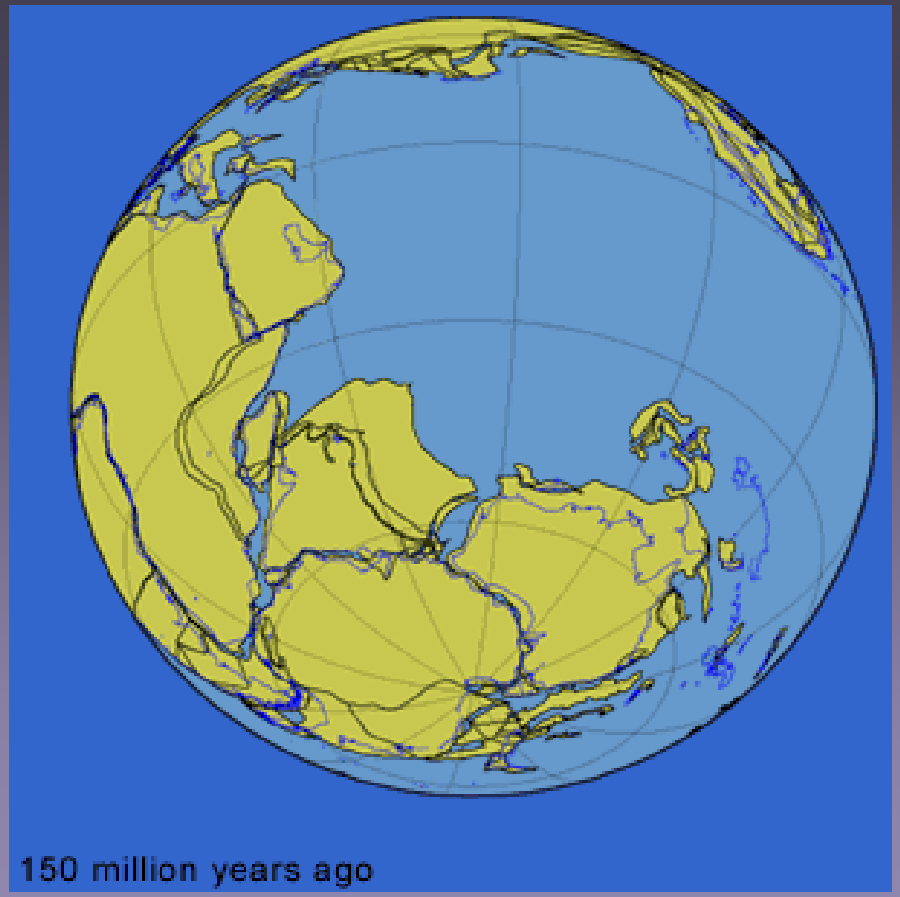
- The two layers of Earth that determine our plate tectonics are the
- (1) Lithosphere- outer layer
- (2) Asthenosphere the solid, plastic layer of the mantle beneath the lithosphere.

and…

3) Convection Cells move warmer material towards the surface and the cooler material back into the Earths interior.

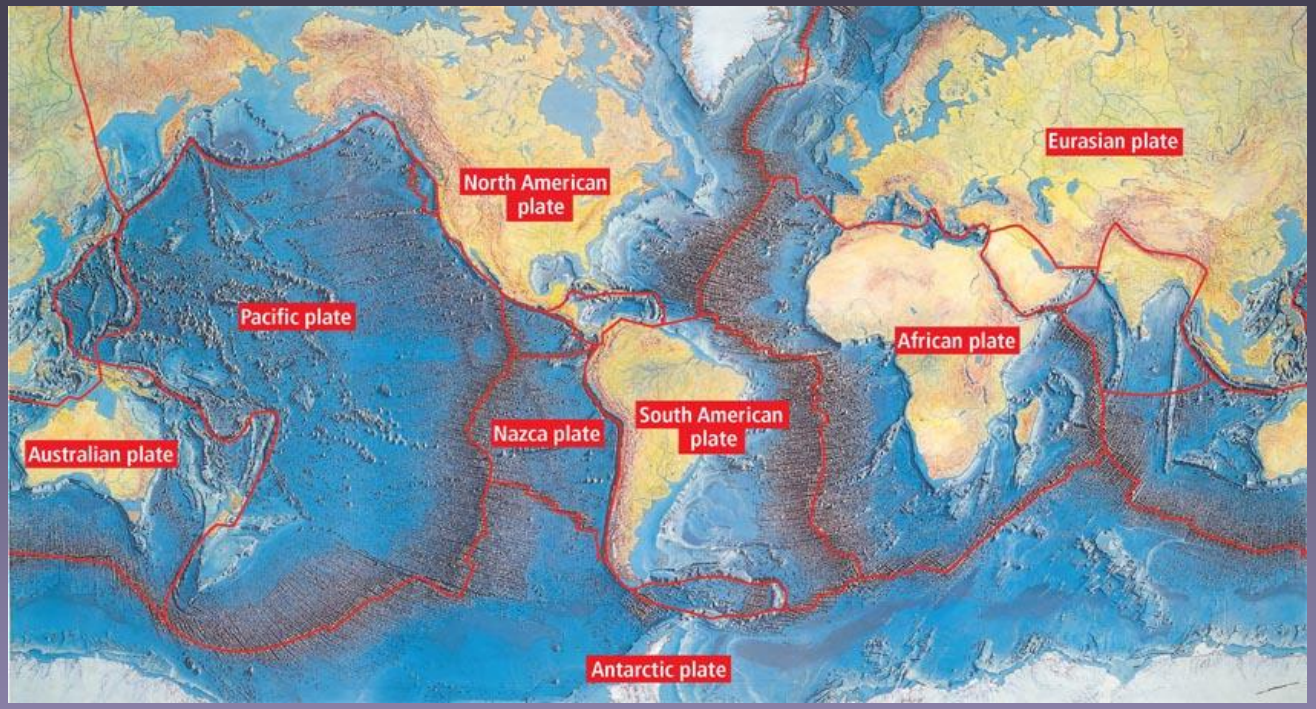
How Continents Move

- Tectonic plates can include continental crust, or oceanic crust.
- Continents and oceans are carried along on the moving tectonic plates in the same way that passengers are carried by a bus.



How Tectonic Plates Move

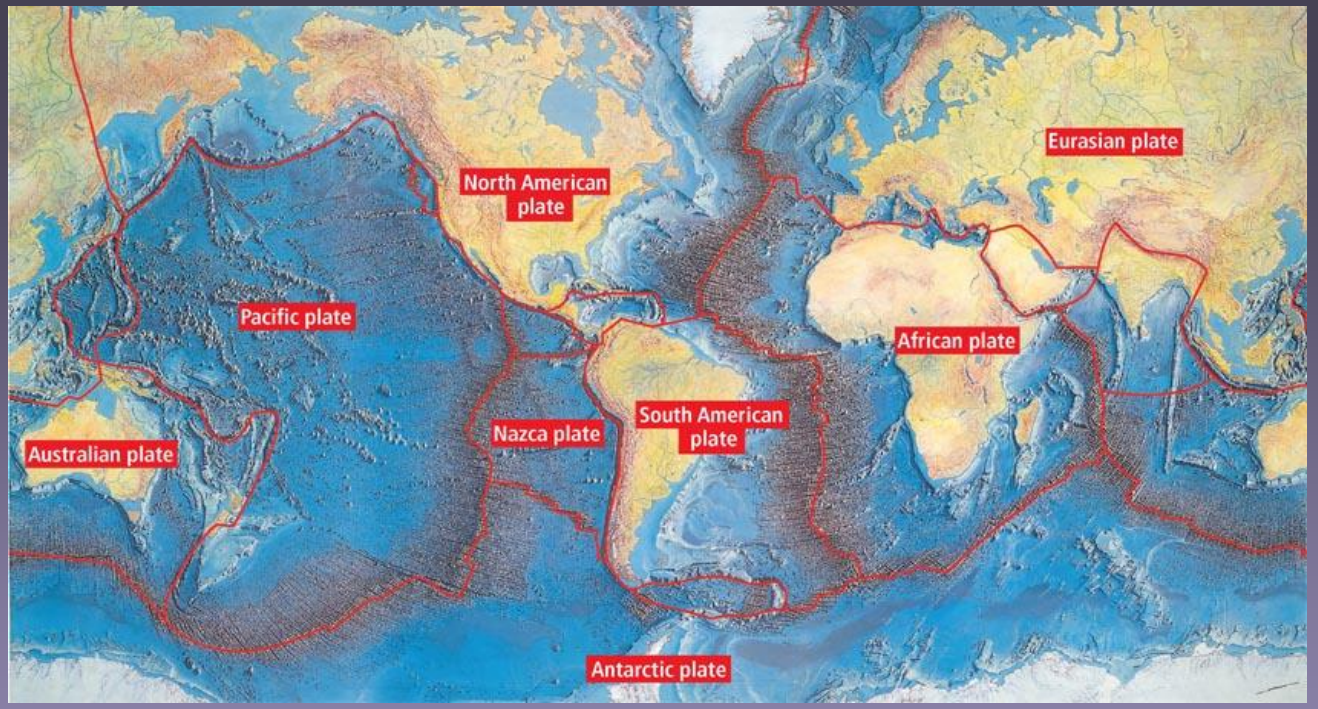
Tectonic Plate Boundaries



- Scientists have identified 15 major tectonic plates.
- These plate boundaries are defined by studying data from earthquakes.

Chapter menu
Resources

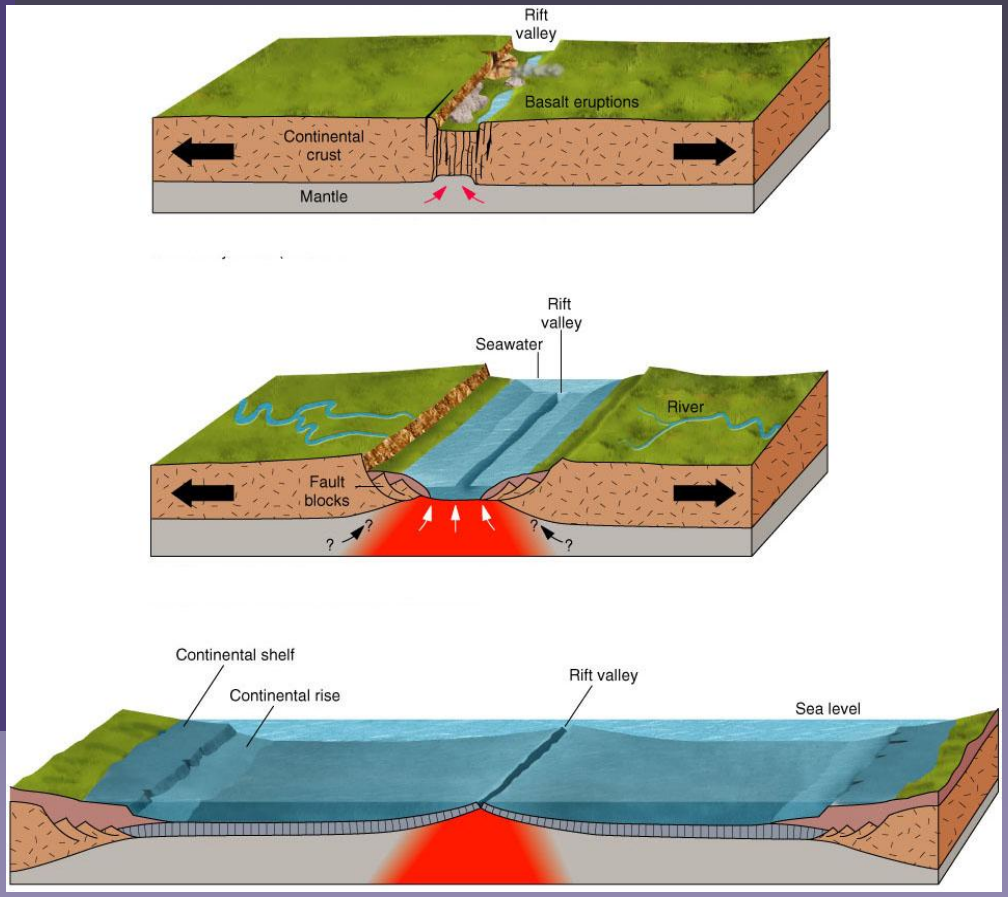
Tectonic Plates Boundaries



- Tectonic plate boundaries may be in the middle of the ocean floor, around the edges of continents, or even within continents.

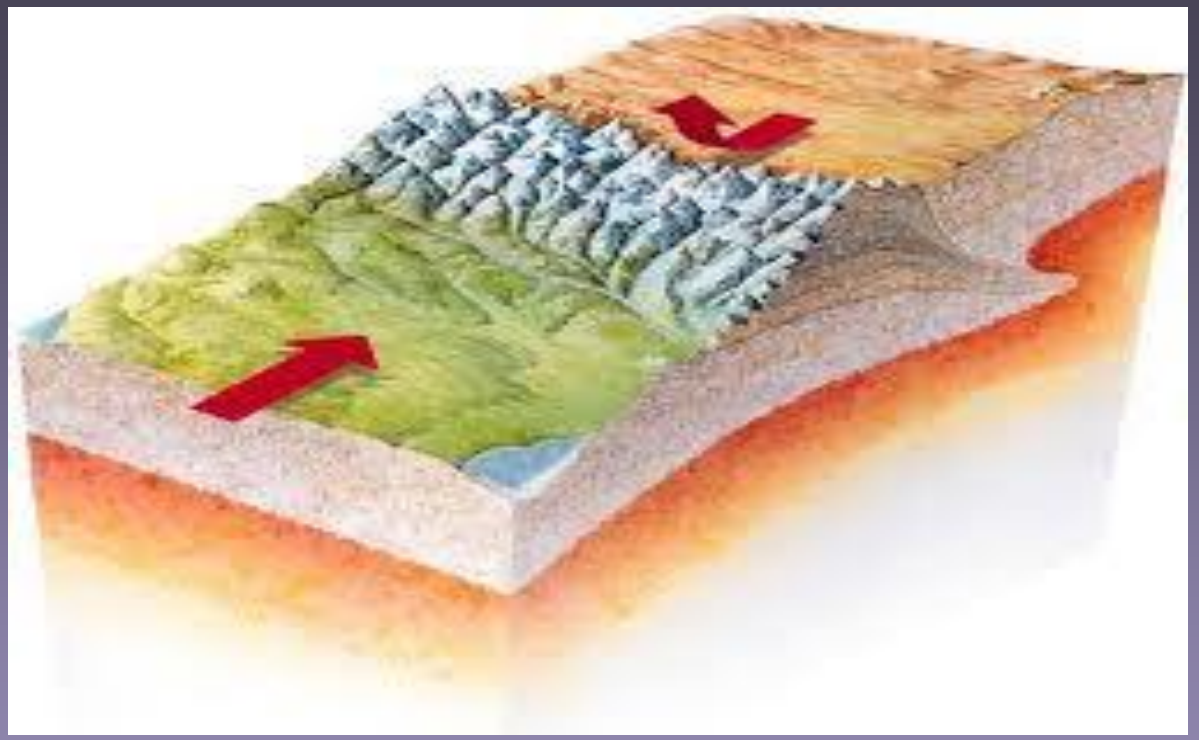
- **1. Divergent Boundaries** - In divergent boundaries plates move away from each other forming a rift in Earth's crust.

- Divergent boundaries occur on both sea and land.



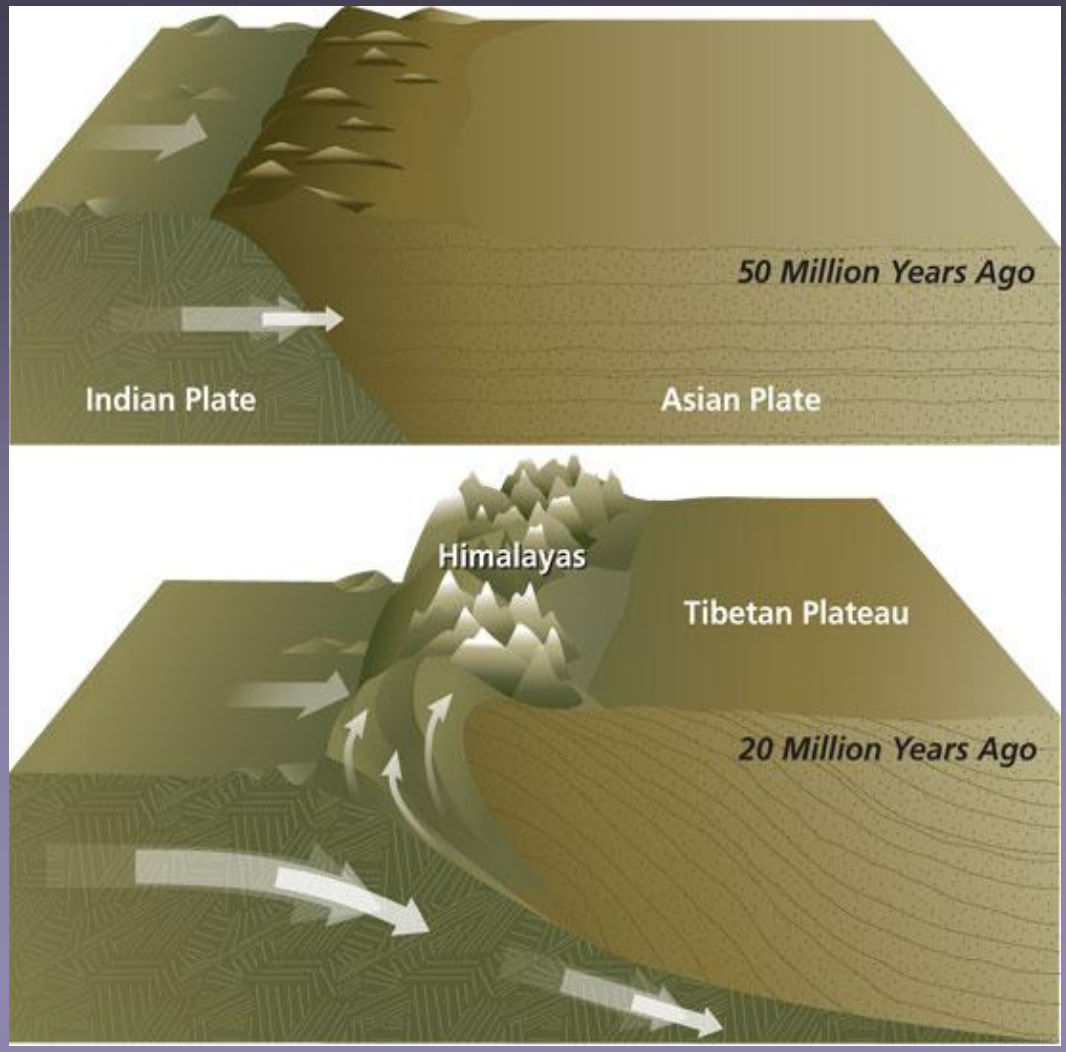
3 Major Types of Plate Boundaries

3 Major Types of Plate Boundaries

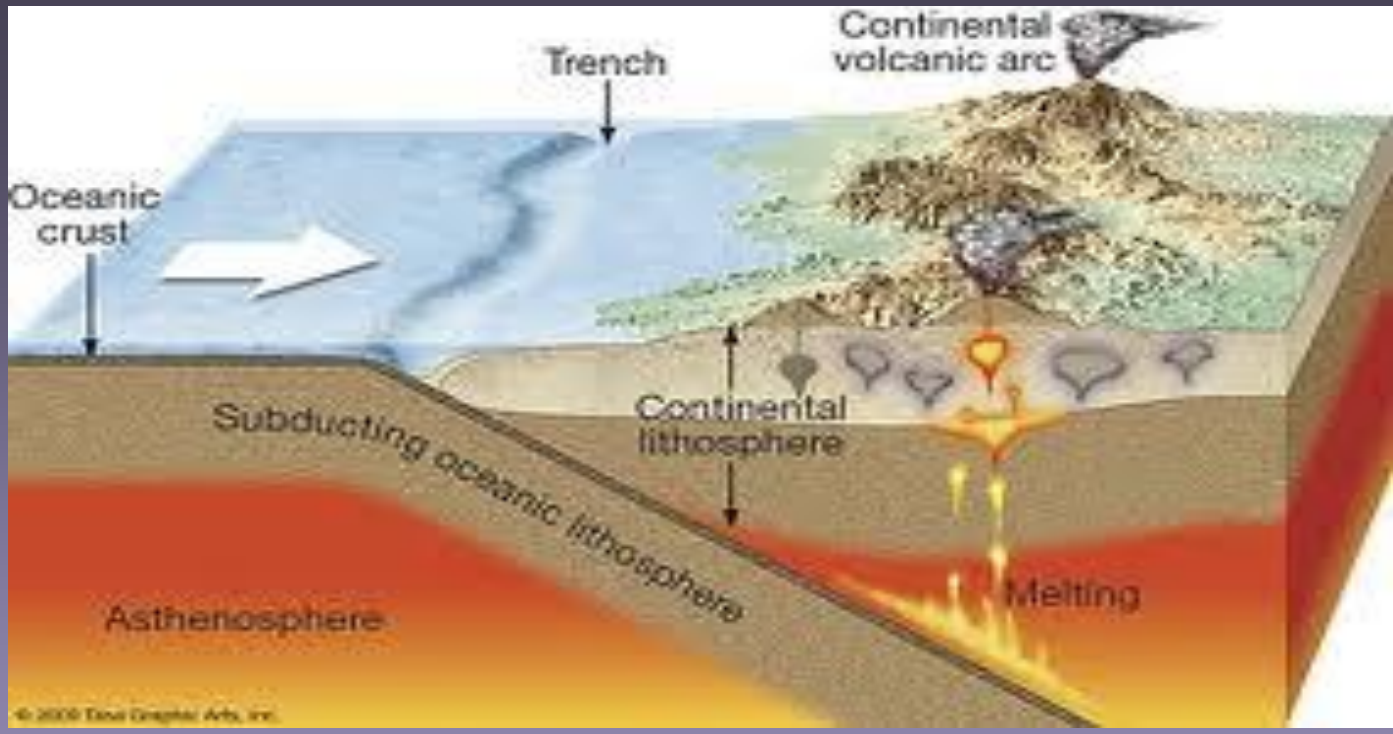


- **2. Convergent Boundaries** - In convergent boundaries the plates collide into each other, typically forming mountains and a subduction zone.

Himalayas

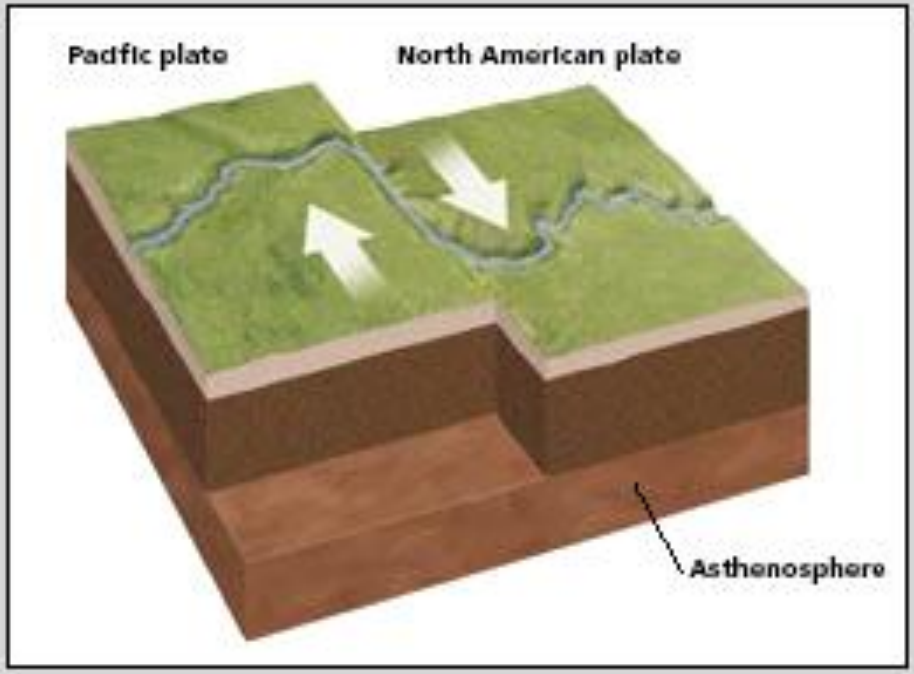


Convergent Boundaries



- Convergent boundaries can occur between two oceanic plates, two continental plates or occur between one oceanic plate and one continental plate.

Transform Boundary



- **3. Transform Boundaries -** In transform boundaries the plates slide past each other.

3 Major types of Plate Boundaries

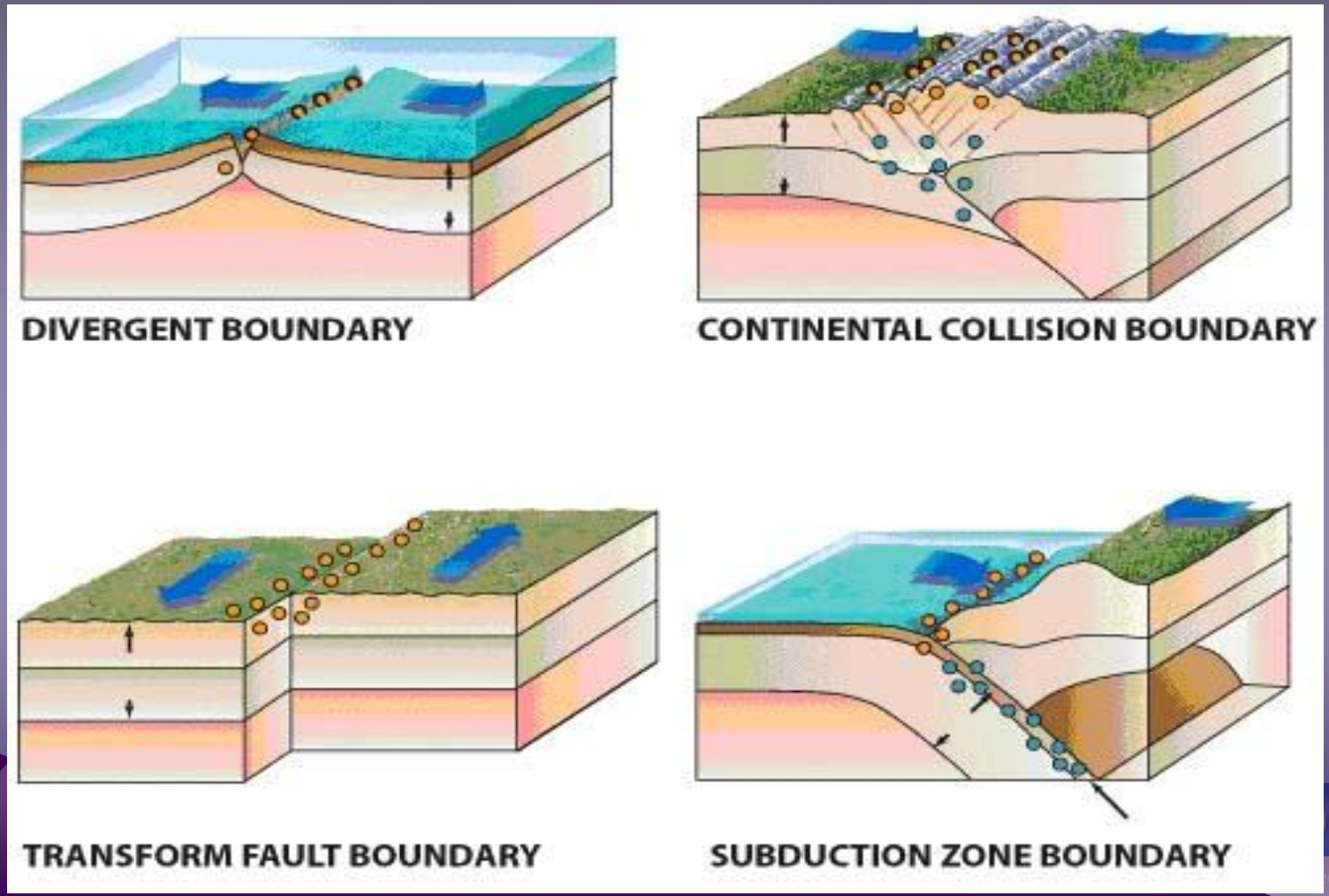
- Like our San Andreas fault.

3 Major types of Plate Boundaries

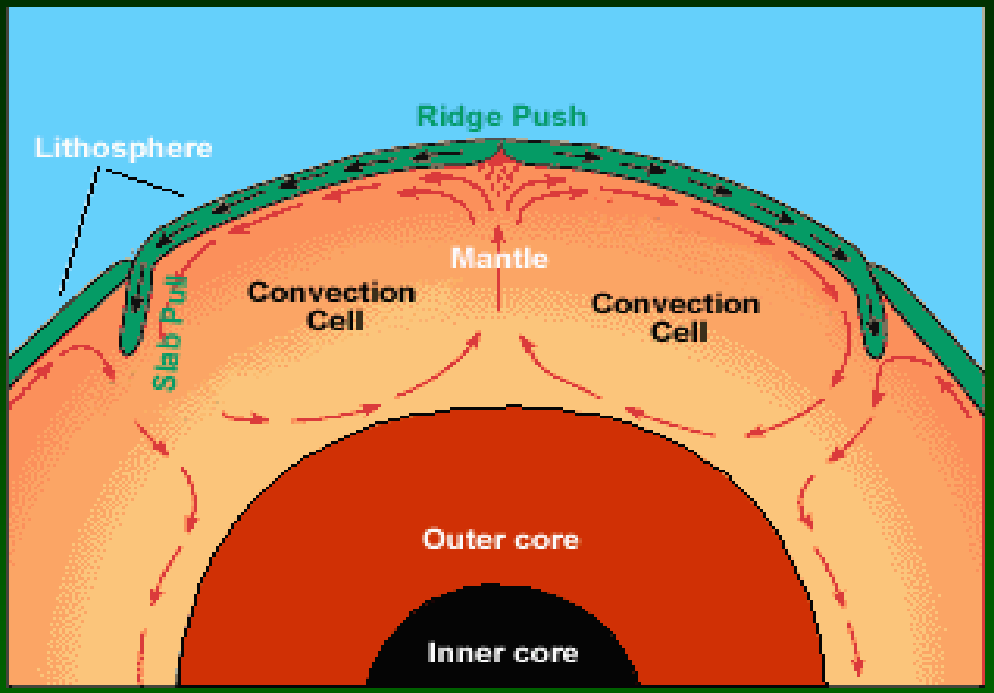
Check for Understanding

- Describe how the Himalayan mountains were formed.
  - Use the following words
    - Tectonic Plates
    - Convergent Boundary
    - Force

Draw these four types of plate boundaries and describe each one using complete sentences.

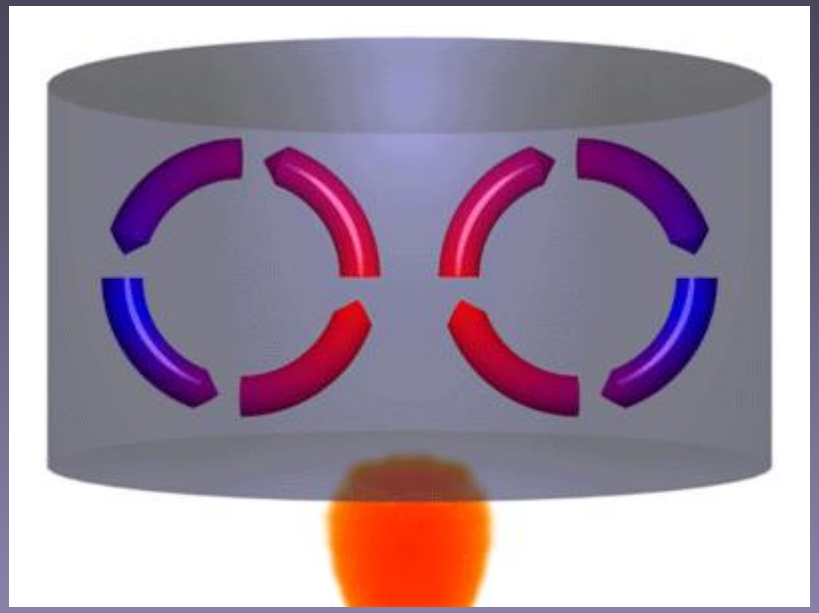


Causes of Plate Motion



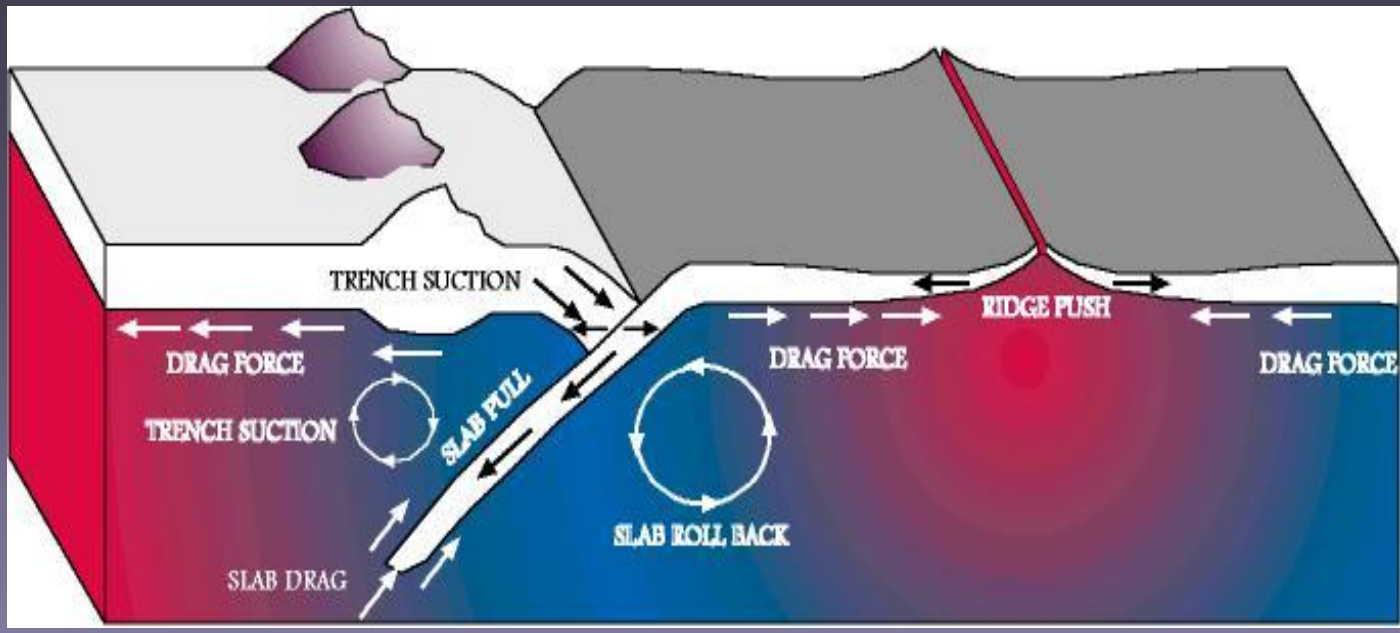
- Plates at our planet's surface move because of the intense heat in the Earth's core that causes molten rock in the mantle layer to move.

- It moves in a pattern called a convection cell that forms when warm material rises, cools, and eventually sink down.
- As the cooled material sinks down, it is warmed and rises again (Like a lava lamp).



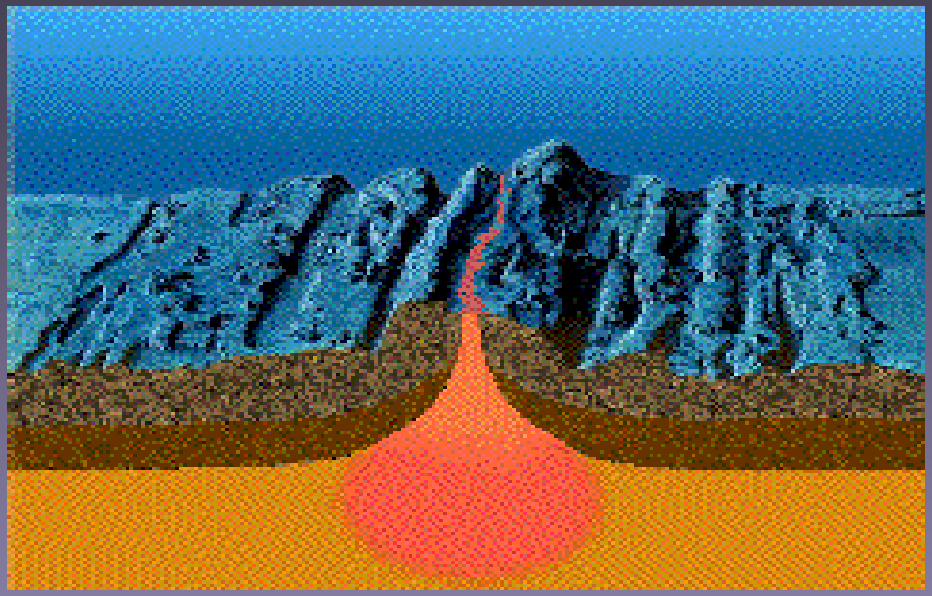
Causes of Plate Motion

Earth's Convecting System



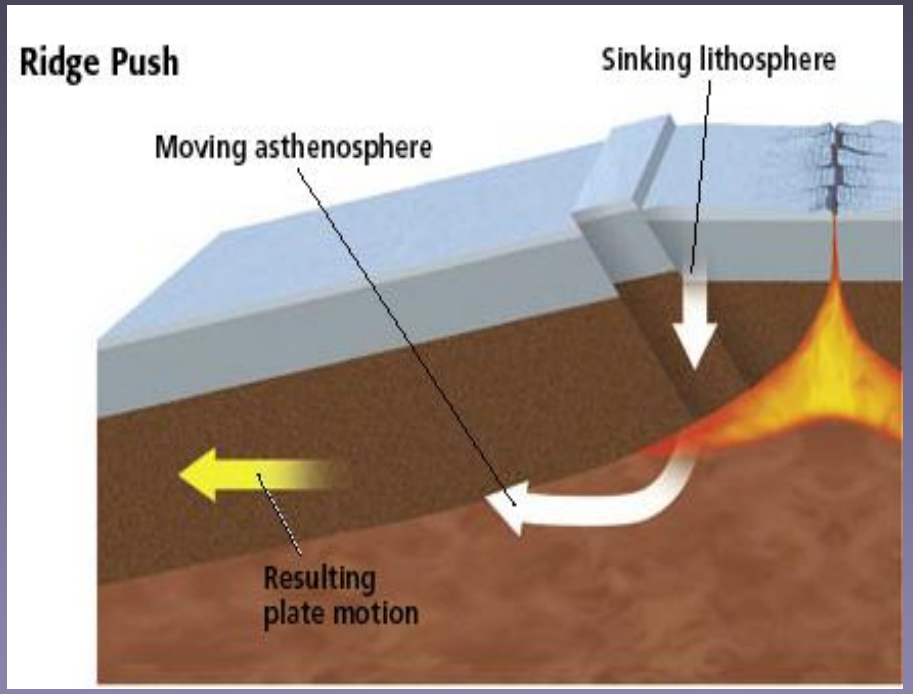
- There are also three mechanisms to Earth's convecting system.
- (1) Drag on tectonic plates
- (2) Ridge Push
- (3) Slab Pull

- The drag of tectonic plates refers to the resistance or dragging force associated the upper mantle and the lithosphere.
- Convection causes *mantle drag*



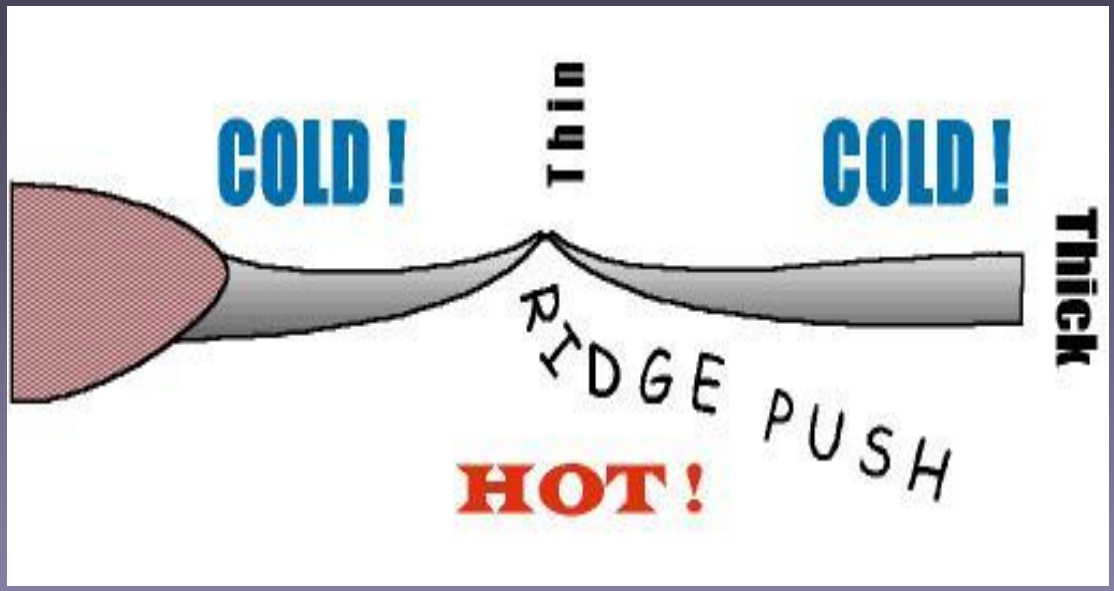
(1) Drag of Tectonic Plates

- New parts of a plate rise because they are warm and the plate is thin.
- As hot magma rises to the surface at spreading ridges and forms new crust, the new crust pushes the rest of a plate out of its way and this is called ridge push.

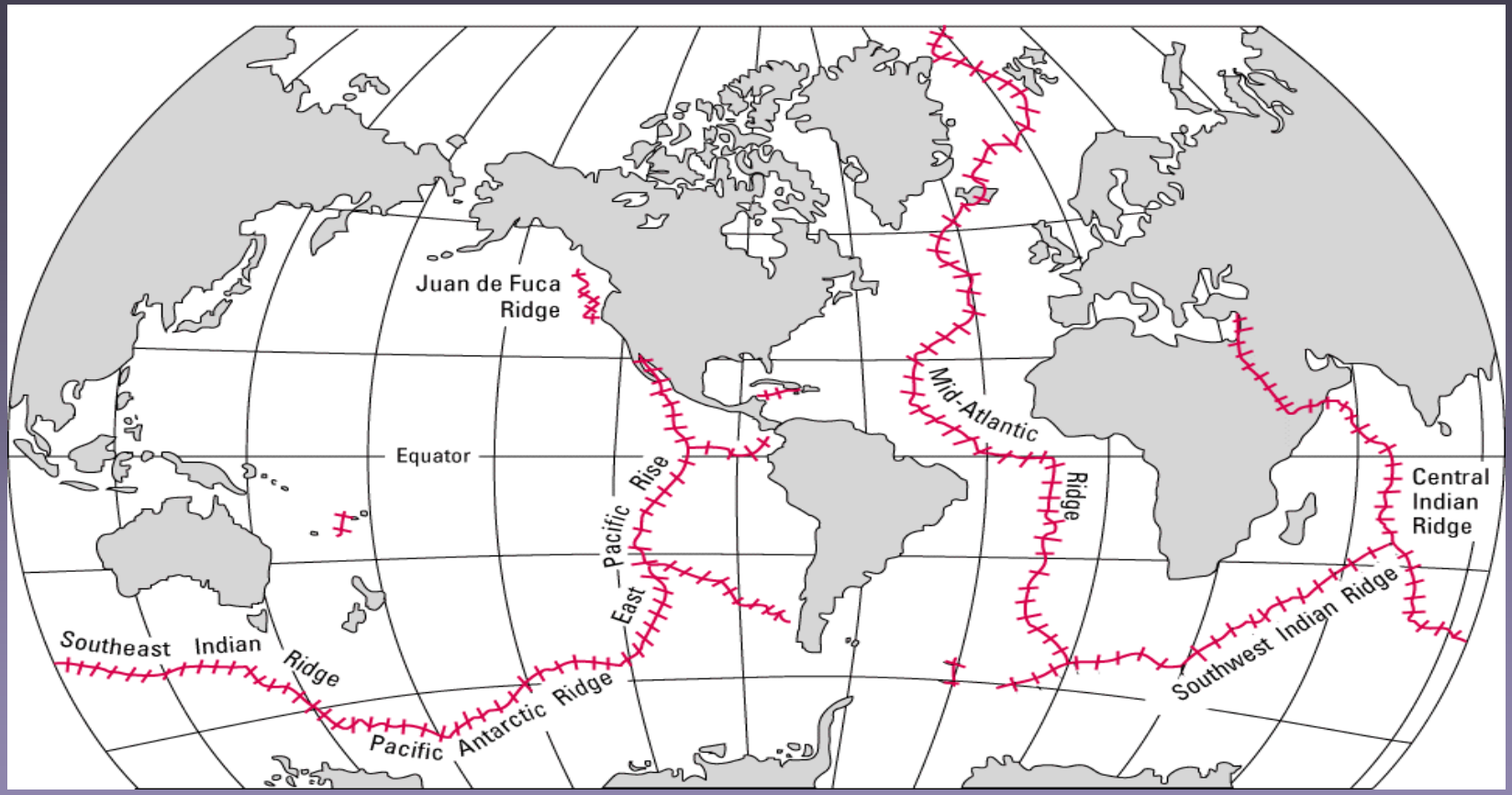


(2) Ridge Push

- This occurs because newer warm rock cools and becomes denser allowing it to sink into the asthenosphere and push away from the ridge.



(2) Ridge Push

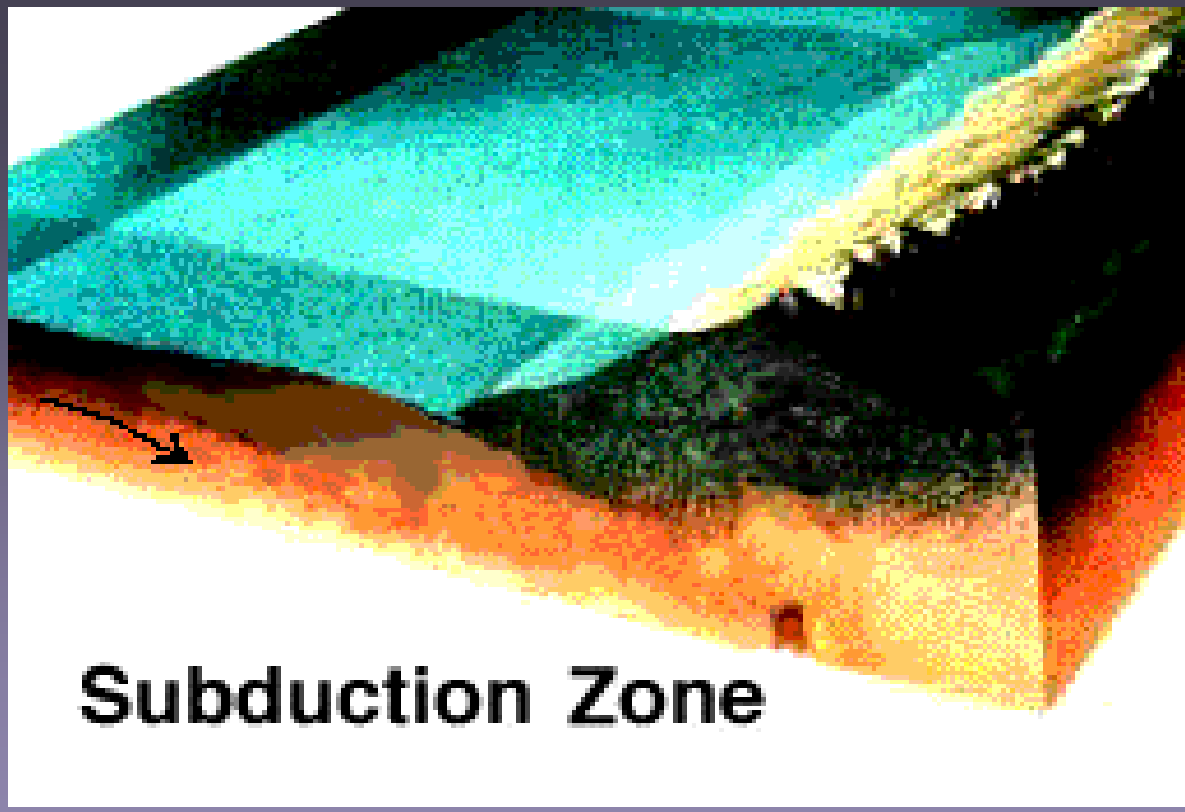


- The largest ridge on our planet is located in the Atlantic Ocean and is known as the Mid-Atlantic Ridge.

(2) Ridge Push

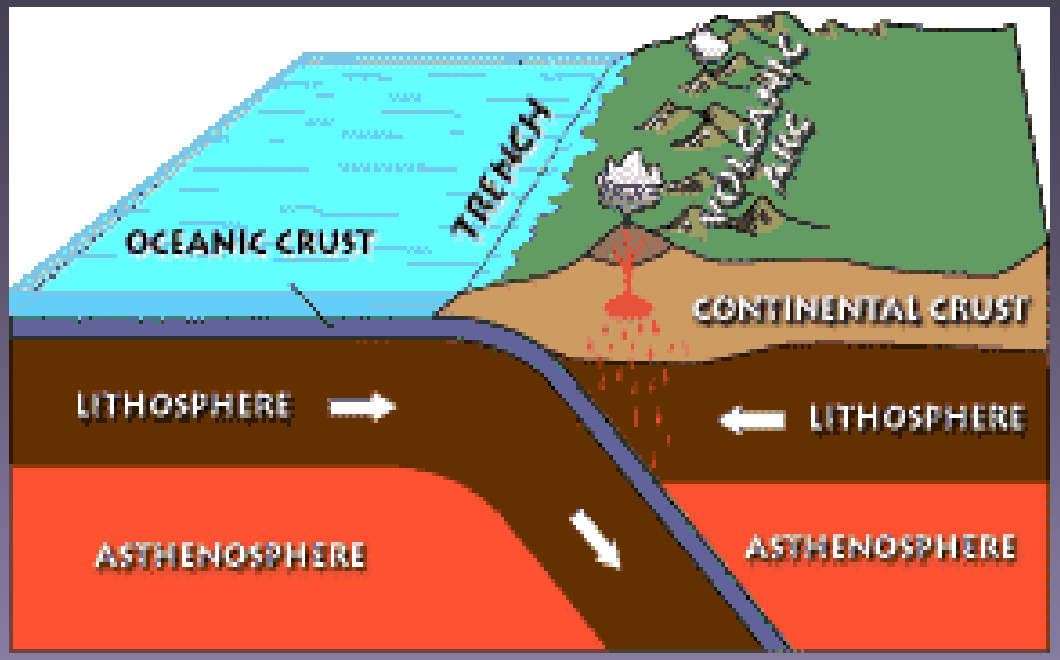
Chapter menu
Resources

- Old parts of a plate will sink down into the mantle at subduction zones because they are colder, denser and thicker than the warm mantle material underneath them.
- This force is called slab pull.

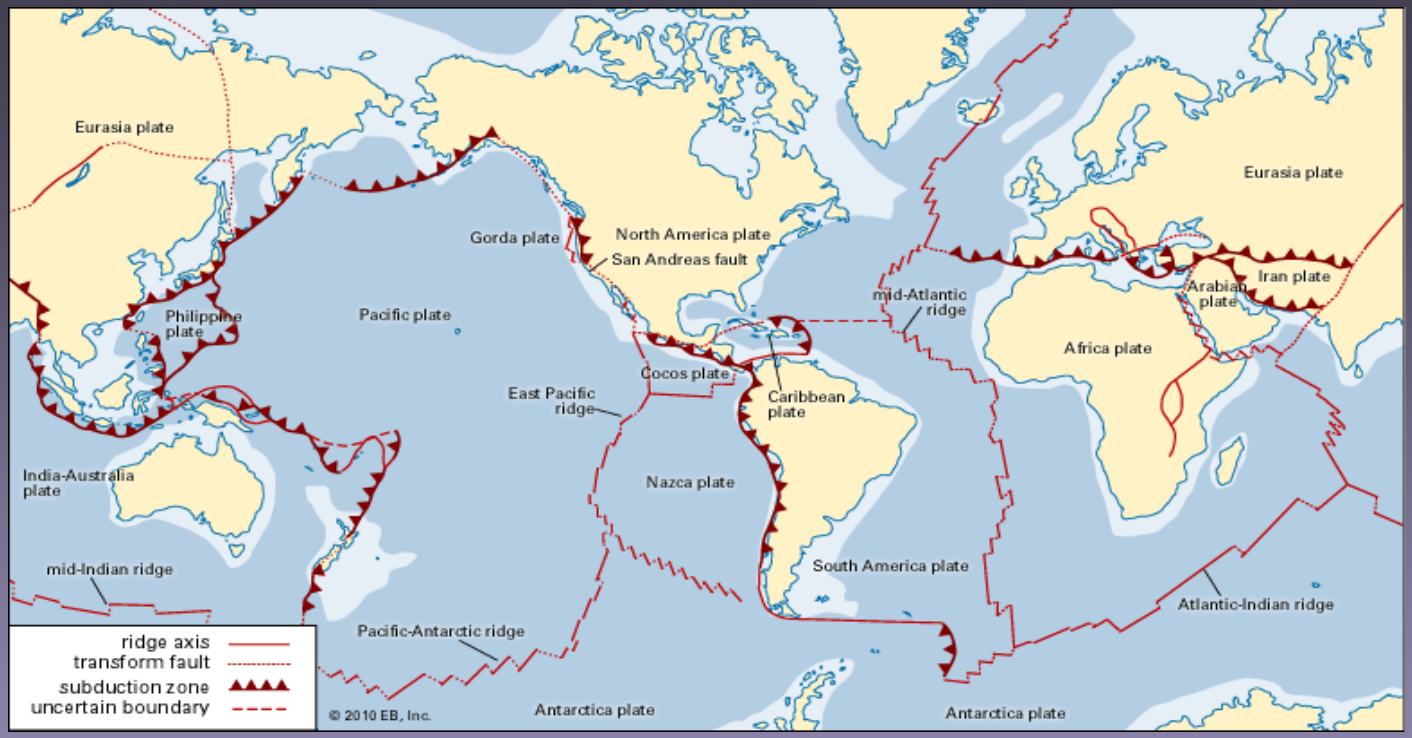


(3) Slab Pull

- Ultimately it is the plate densities that determines which of the two lithospheric plates will ride over the other.
- The plates density along with the Slab Pull helps move the plate along.



(3) Slab Pull



- The largest subduction zone in the world runs along the entire Pacific Ocean and is known as the ‘Ring of Fire’.

(3) Slab Pull

- The Ring of Fire has 452 volcanoes and is home to over 75% of the world's active and dormant volcanoes.
- About 90% of the world's earthquakes occur along the Ring of Fire.

Ring of Fire

Check for Understanding

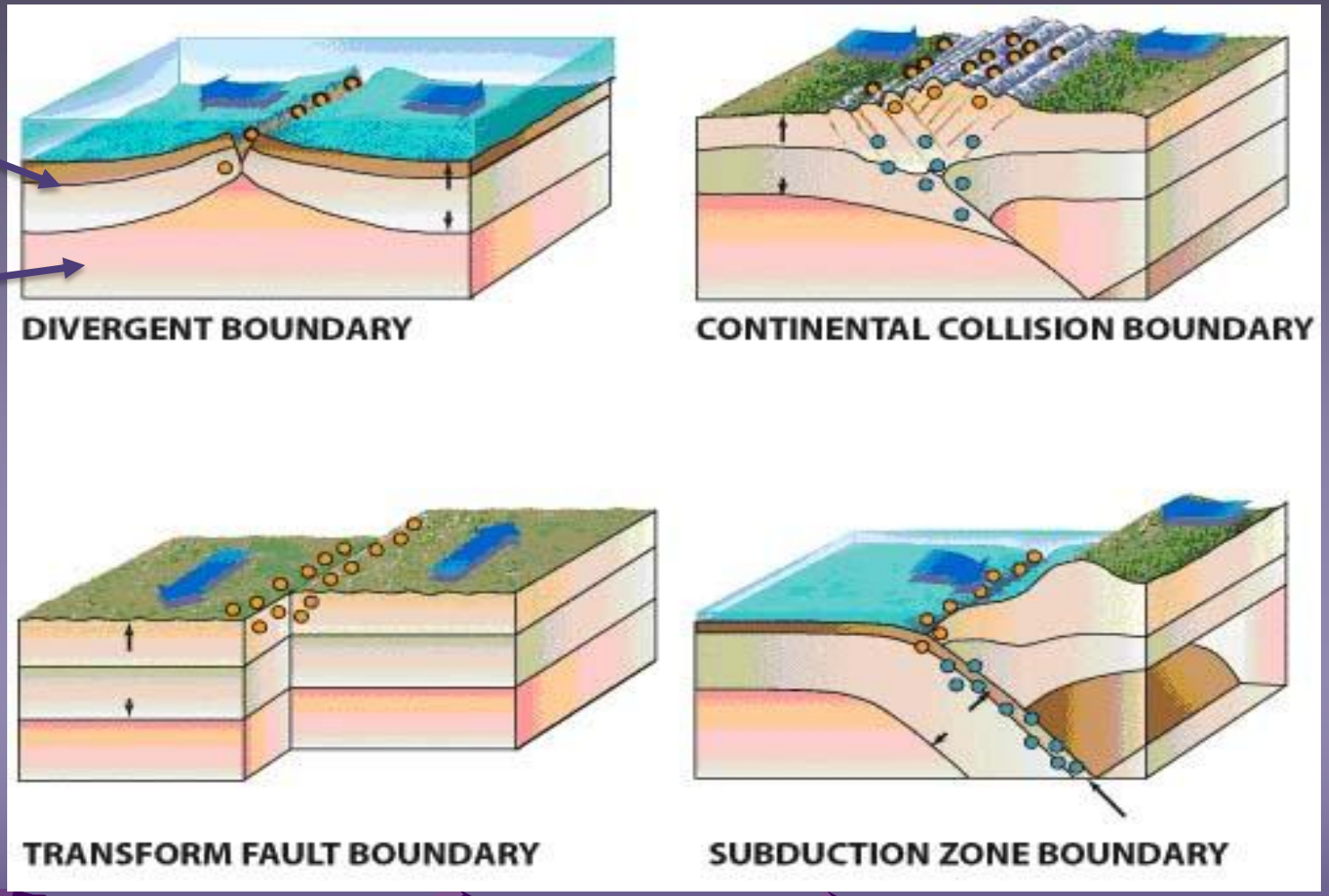
- Draw two of following plate boundaries.
  1. Convergent Plate Boundary where a mountain is formed
  2. Convergent plate boundary where a sub-duction zone is formed.
  3. Divergent plate boundary
  4. Transform plate boundary

  Identify lithosphere and asthenosphere

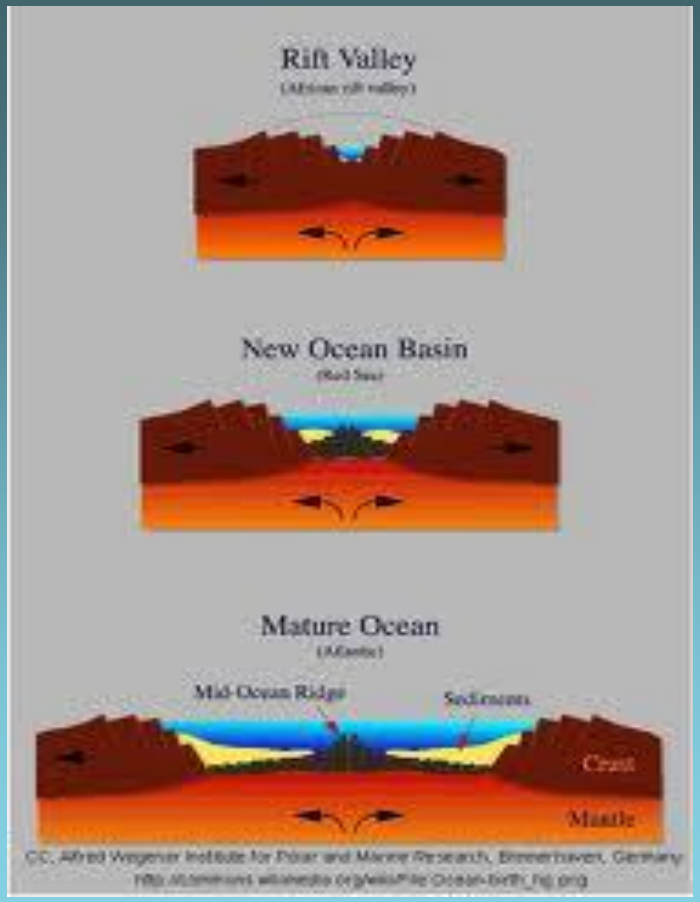
Check for Understanding Answers

Lithosphere

Asthenosphere



- **Rifting can occur within continental crust or oceanic crust and is the process by which Earth's crust breaks apart.**
- **It is the slow movements of tectonic plates that has changed the size and shape of the continents over millions of years.**



Reshaping Earth's Crust – Rifting

Ethiopia Rift

- In 2005, a gigantic, 35-mile-long rift broke open the desert ground in Ethiopia.

- Geologists believe the rift is the beginning of a new ocean as two parts of the African continent pull apart.

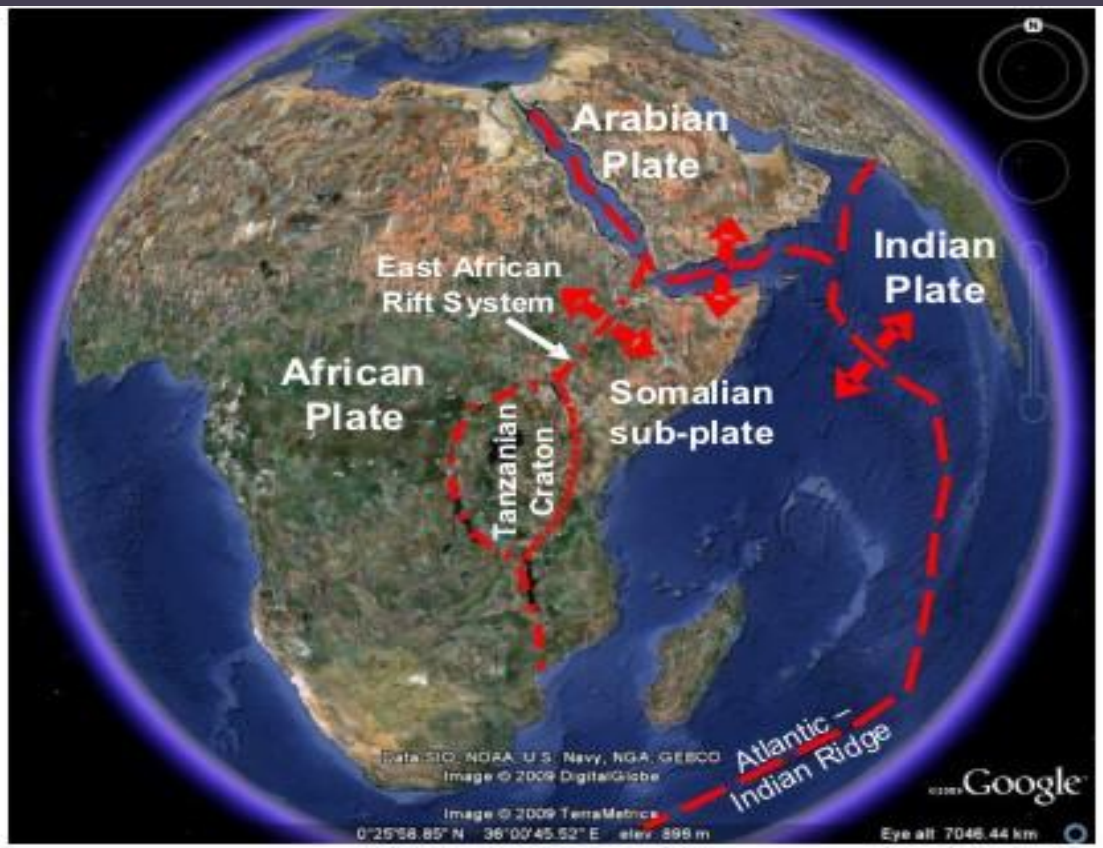


Figure 7: Regional plate tectonic setting. Red arrows show approximate direction of opening of the rift systems

Ethiopia Rift

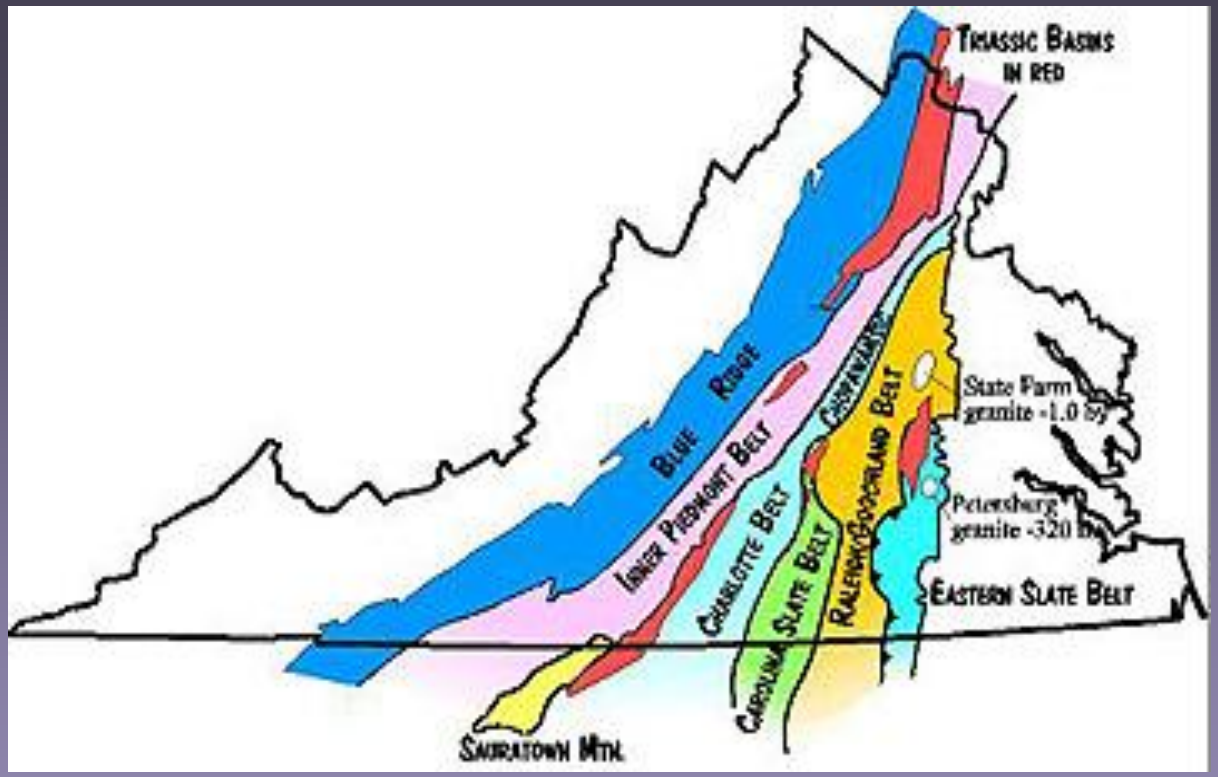
- All of the continents that exist today contain large areas of stable rock, called *craton's*, that are older than 540 million years (Think of it as original rock).

Cratons

- One way that continents change shape is by breaking apart or rifting.

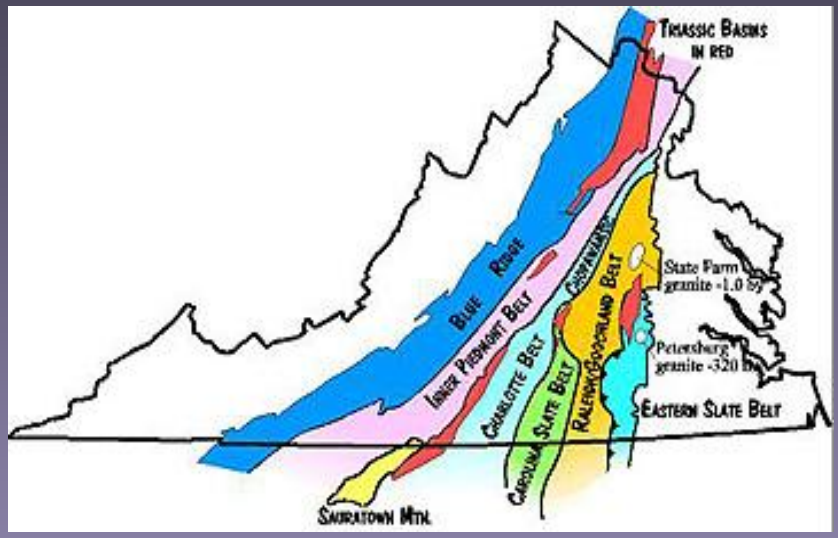
Cratons

- Continents change not only by breaking apart but also by gaining material.
- Most continents consist of cratons surrounded by a patchwork of terranes.



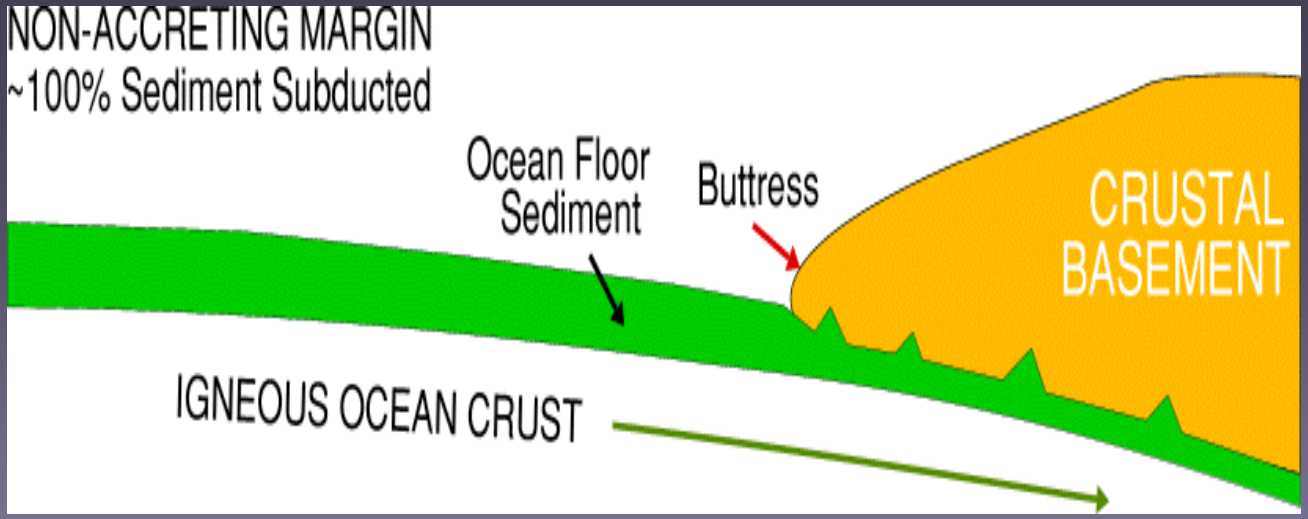
Terrane

- Terrane is a fragment of crustal material formed on, or broken off from, one tectonic plate and added to crust lying on another plate.
- The zone between a terrane and the crust it attaches it self to is usually identifiable as a fault.



Terrane

How Terranes Become part of Continent

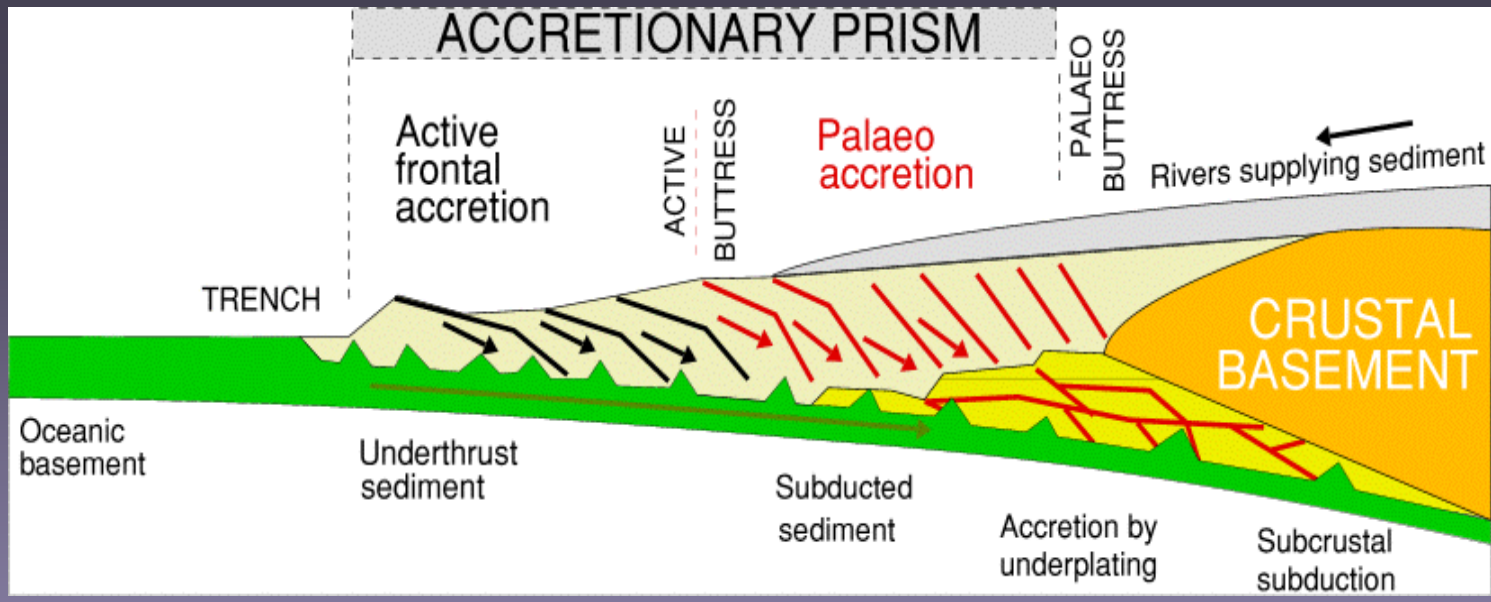


- When a tectonic plate carrying a terrane subducts under a plate made of continental crust, the terrane is scraped off of the subducting plate and becomes part of the continent.

Check for Understanding

1. Describe the following
    1. What is a rift?
    2. Where can a rift be found?
    3. What is a terrane?
    4. What is a craton?

Accretion



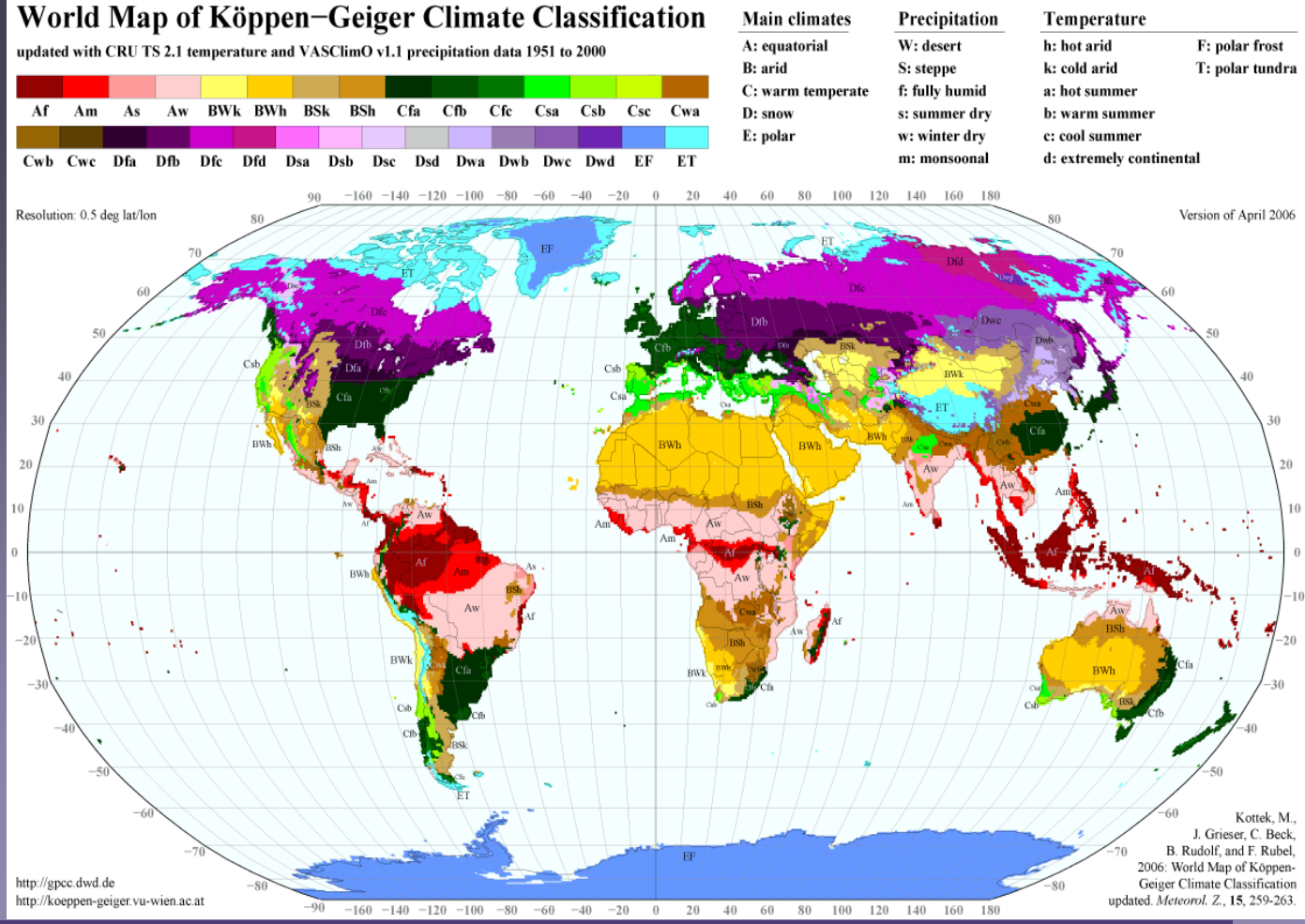
- The process in which a terrane becomes part of a continent is known as accretion and typically forms major mountain ranges like our own San Gabriel Mountains. (Transverse Mountain Range)

- About 5-7 million years ago, part of that block began rising as a mountain range along the Sierra Madre and Cucamonga fault zones, creating the San Gabriel's and forming an unusual bend in the otherwise orderly line of coastal mountain ranges.

Our San Gabriel Mountains

Chapter menu
Resources

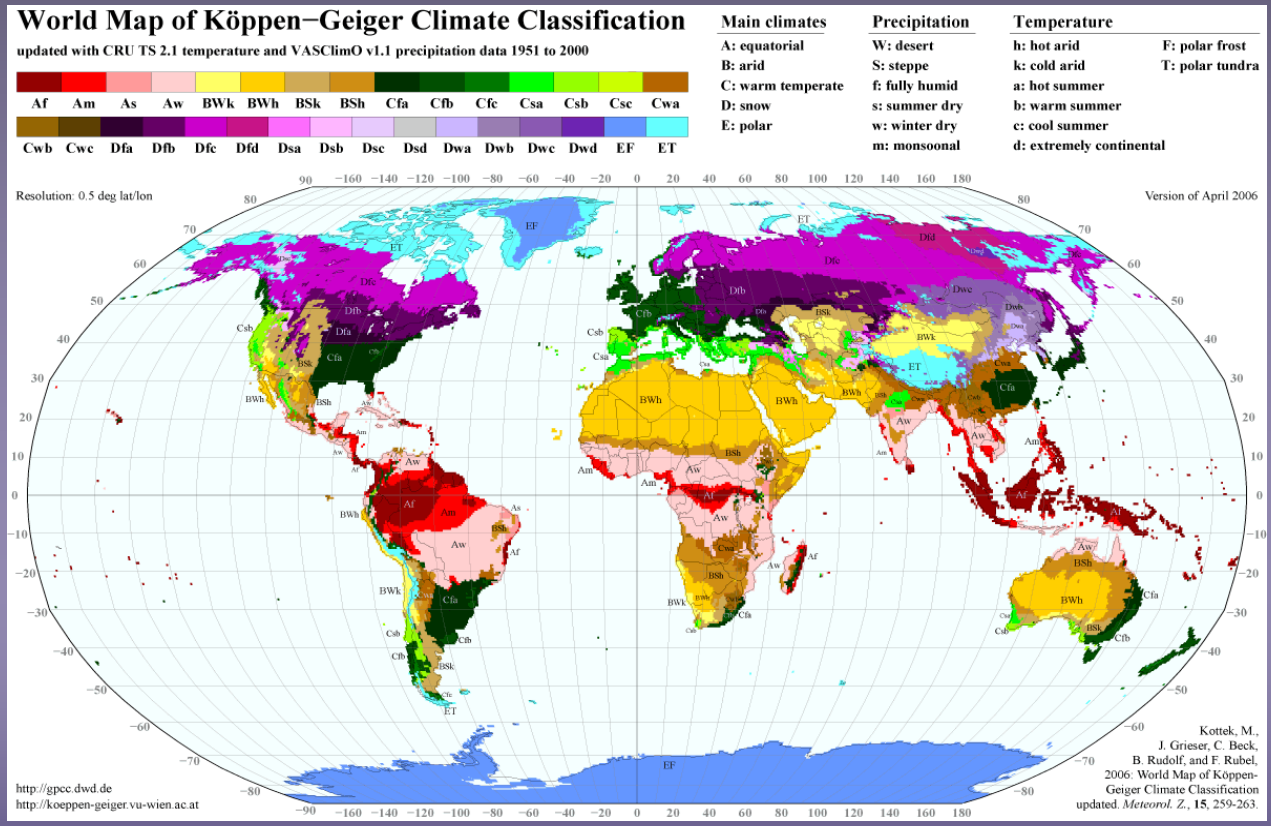
Plate Tectonics Effect on Climate



- Modern climates are a result of past movements of tectonic plates.

- The three factors that effect the continents climate are
- (1) location in relation to the equator and poles
- (2) location in relation to ocean and other continents
- (3) the continents mountain ranges

Plate Tectonics Effect on Climate



Chapter menu
Resources

- During the past billion years, the Earth's climate has fluctuated between warm periods – and cold periods (ice age).

Plate Tectonics Effect on Climate

- Cold periods included large glaciers that covered the continents.

Plate Tectonics Effect on Climate

- The major dynamic being the position and height of the continents along with solar output, ocean circulation, and the composition of the atmosphere.

Plate Tectonics Effect on Climate

- As continents rift or as mountains form, populations of organisms are separated.
- When populations are separated, new species may evolve from existing species.

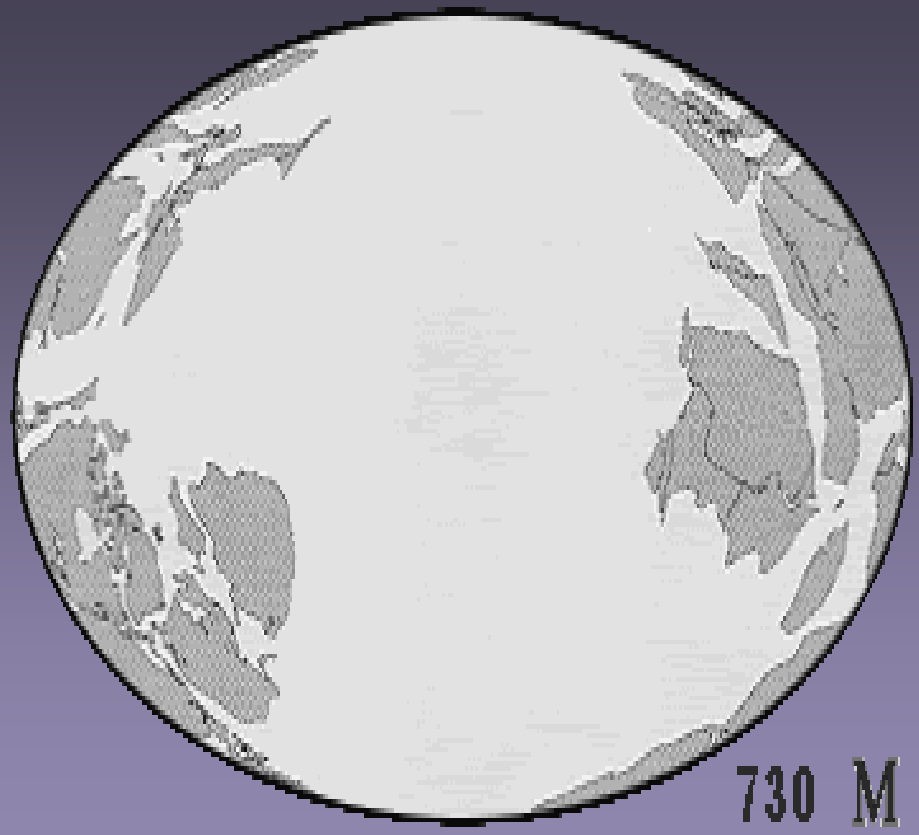
Plate Tectonics
Effect on Organisms

Exit Ticket- Answer the Following

- What is a accretion?
- How were the San Gabriel mountains formed?
- What three factors affect the global climate?
- Describe what would happen to the global climate if the Earth moved towards a super continent once again.

Answer using complete sentences

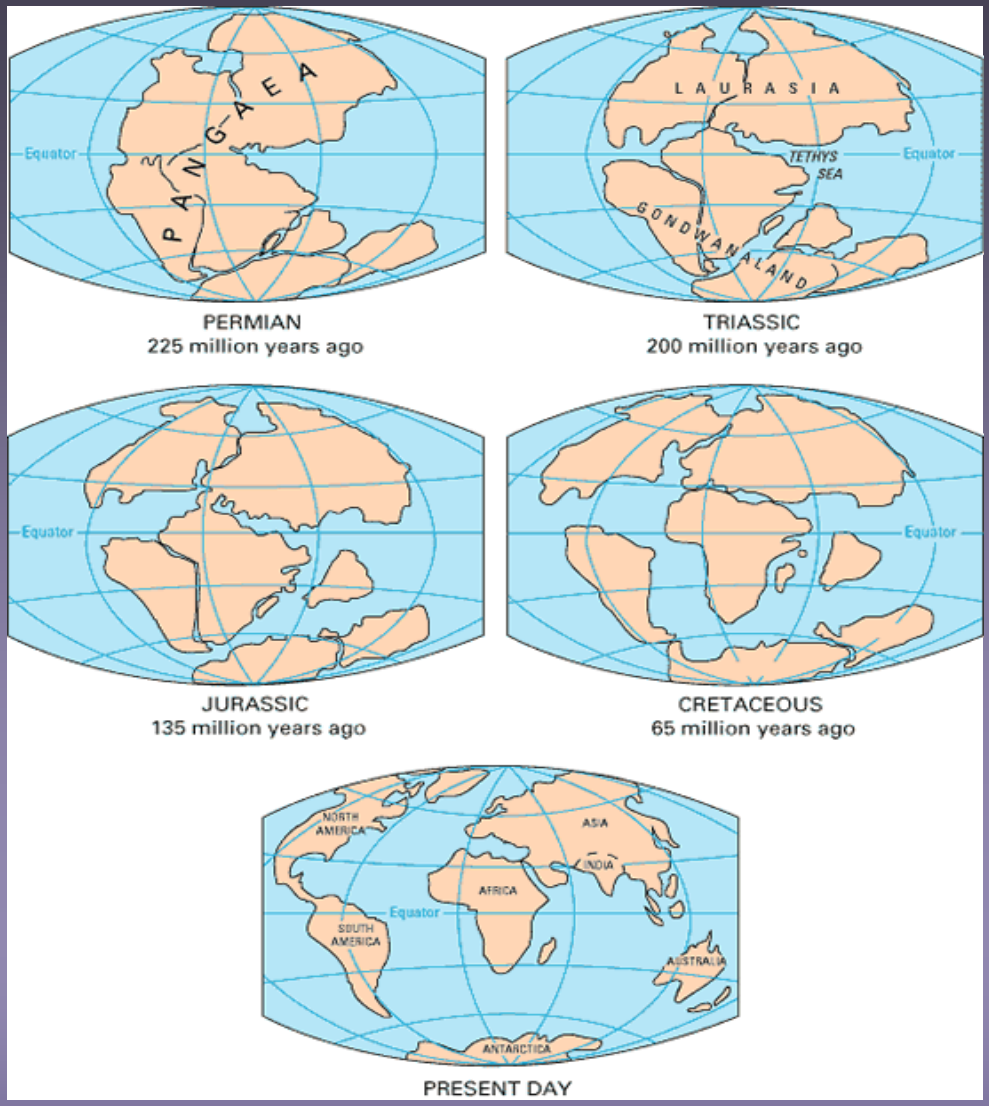
- On a larger scale – the theory in which supercontinents like Pangaea form and break apart over millions of years is called the supercontinent cycle.



Supercontinent Cycle

- Pangaea, the last known supercontinent formed around 300 million years ago (mya).

Former Supercontinent - Pangaea



- Several mountain ranges, such as the Appalachian Mountains and the Ural Mountains provide proof of the Pangaea period.

Pangaea Proof

End Of Slide

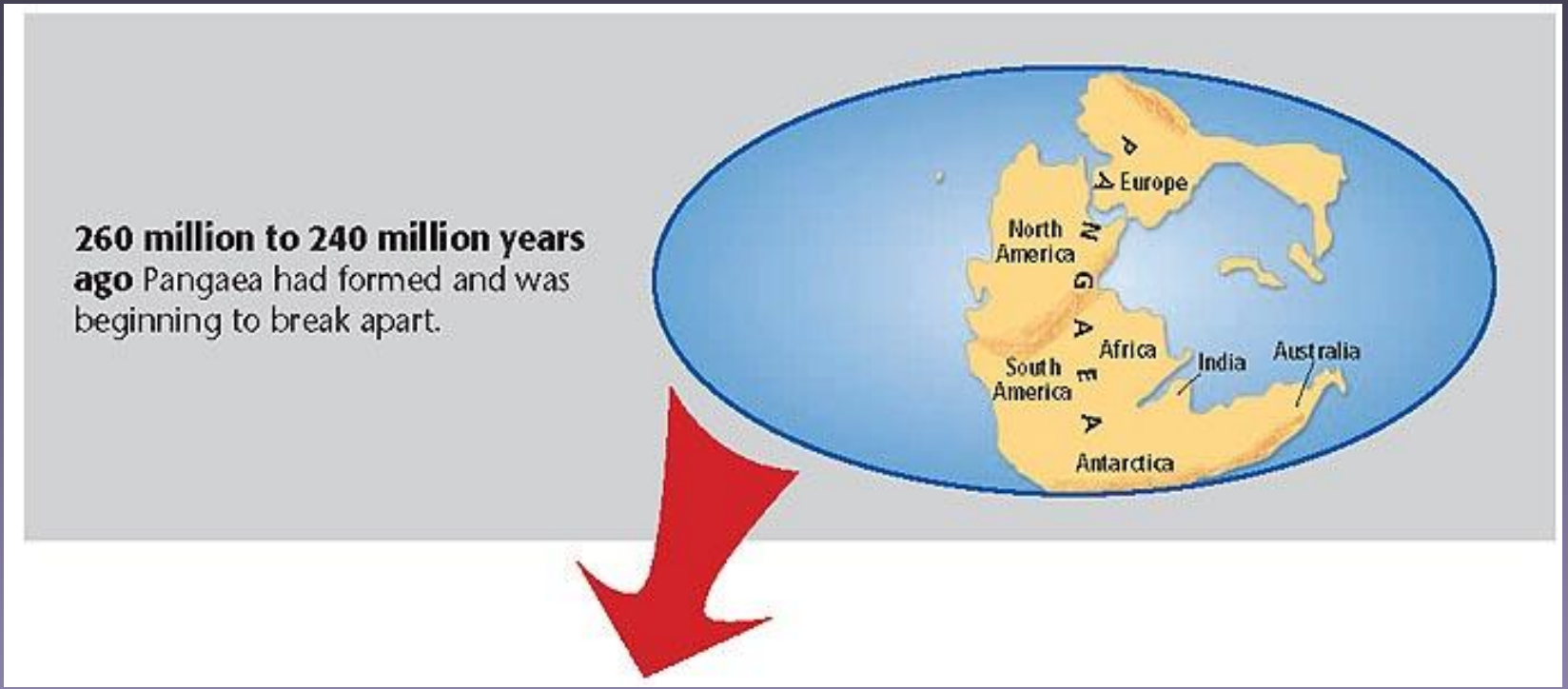
Chapter menu

Resources

- Ural Mountains formed when the continent of Siberia collided into the northern part of Euramerica, also completing Pangaea.

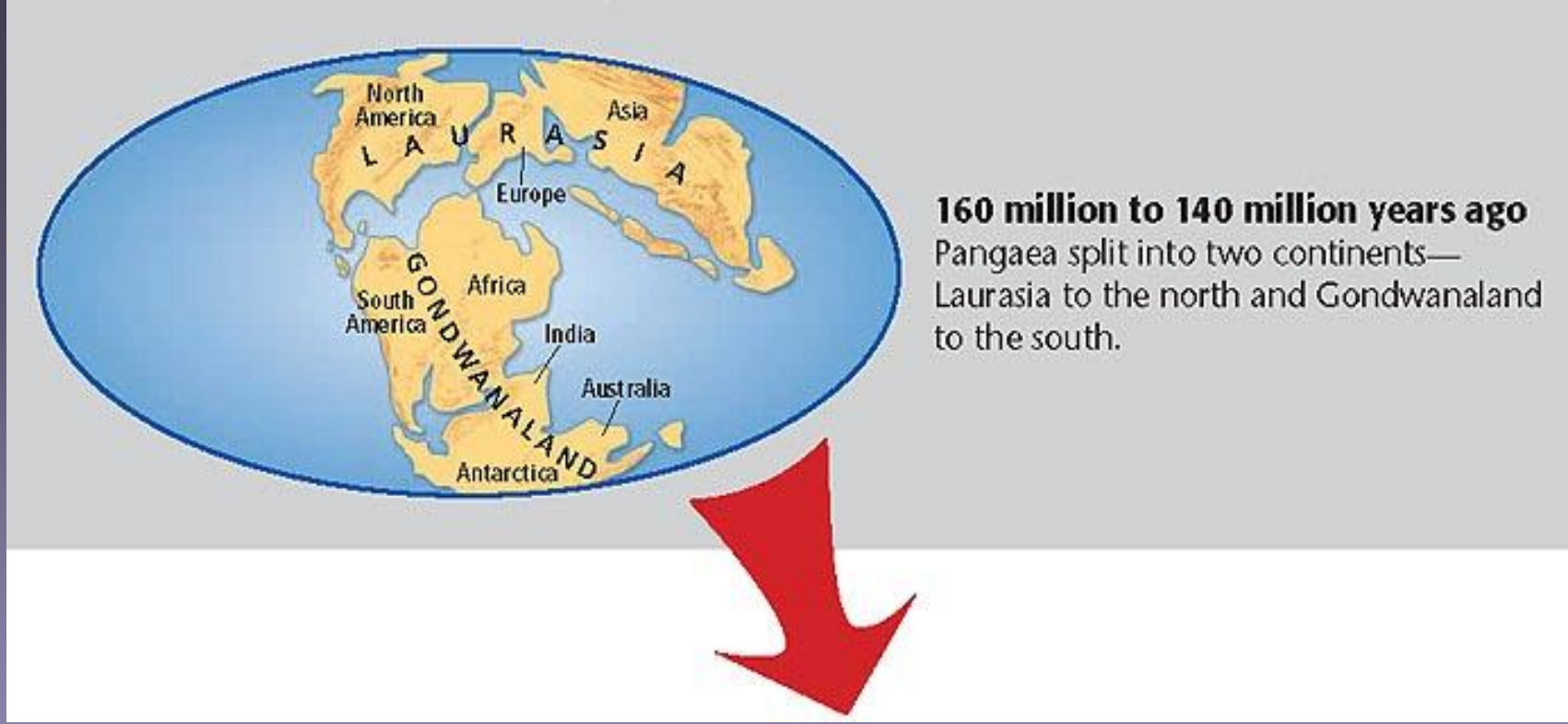
Pangaea Proof

Pangaea



- About ~250 million years ago Pangaea began to break up into two continents.

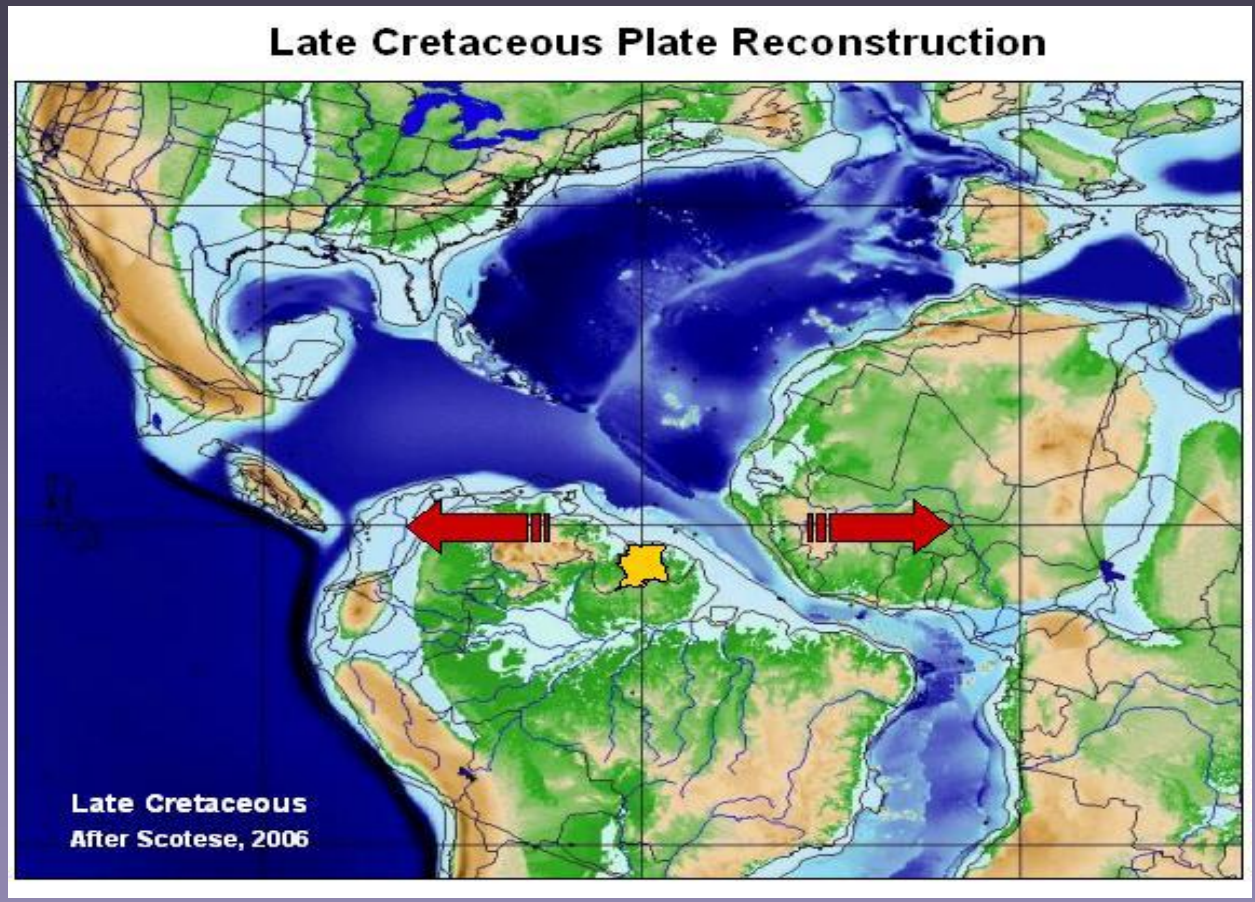
The Break up of Pangaea



- (1) Laurasia – which becomes North America and Europe and Asia.
- (2) Gondwana – which becomes Africa, India, Australia, Antarctica and South America.

The Break Up of Pangaea

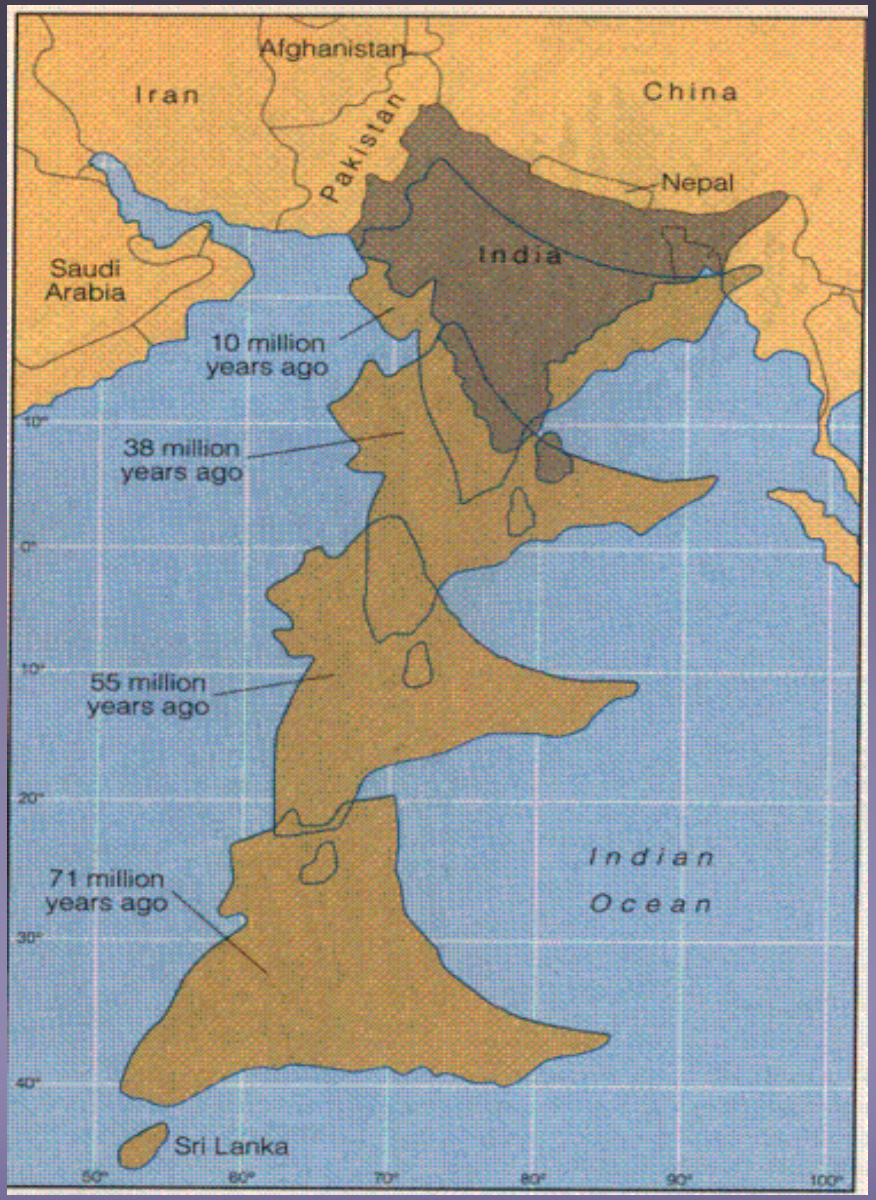
- About ~100 million years ago a rift opened to form the South Atlantic Ocean.



Africa and South America Form

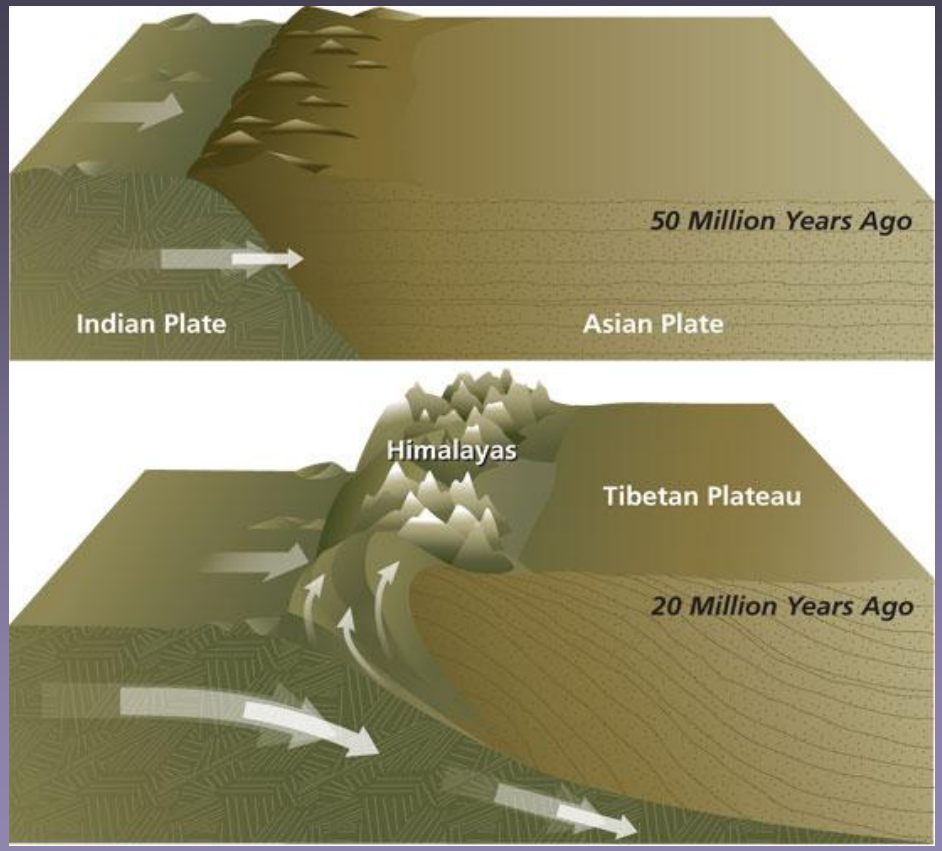
The Creation of the Himalayas

- One of plate tectonics awesome feats is the building of the Himalaya mountains. The highest point is Mt. Everest at 29,035 ft.
- The mountains were created about 10 million years ago when India collided with Asia after splitting with Gondwana.



Chapter menu
Resources

- Because continental rock has the same density these two continents have not created a subduction zone.

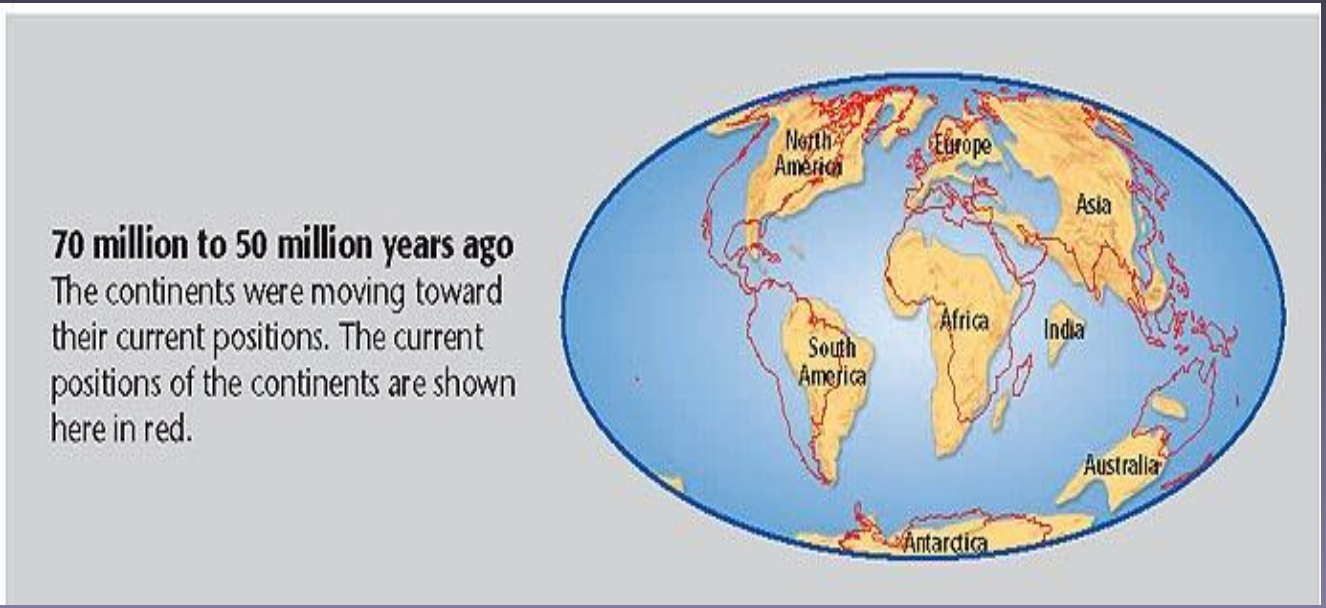


The Creation of the Himalayas

Mt. Baldy Comparison

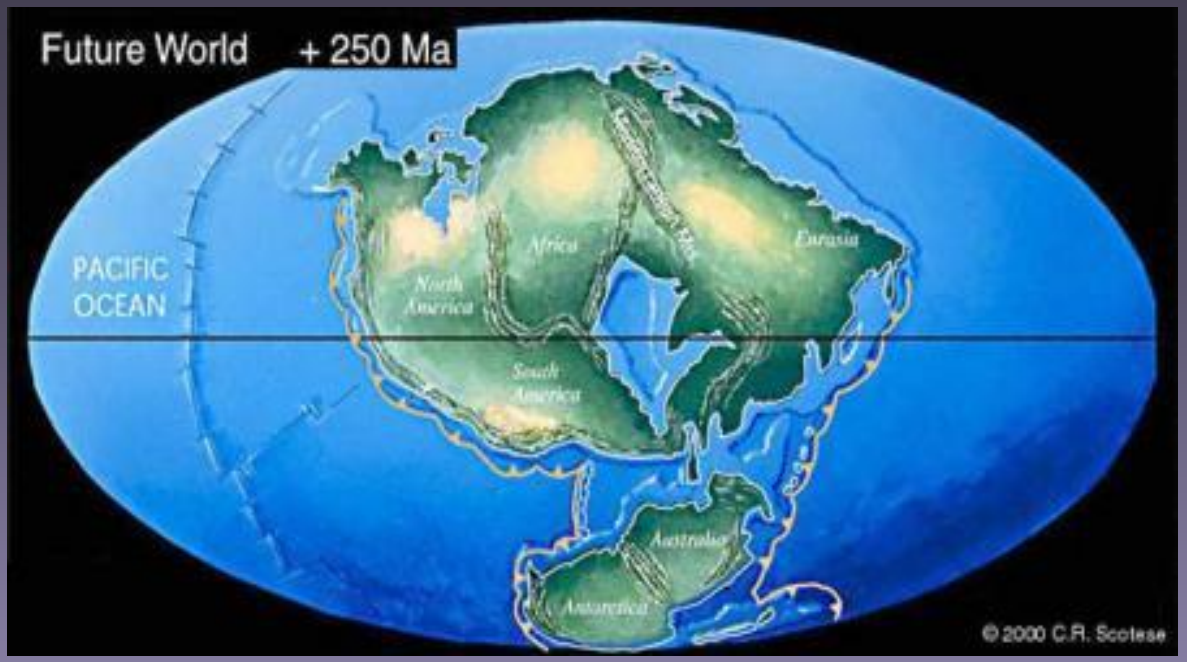
- Mount San Antonio, commonly known as Mt Baldy, at 10,068 ft, is the highest point in Los Angeles and would have to double it height to began to understand the height of the Himalayas.

The Modern Continents



- Slowly, the continents moved into their present positions and will continue to move due to plate tectonics.
- They have collided and formed present day mountain ranges, like as the Rocky Mountains, the Andes, Himalayas and the Alps, which all still are growing today.

Geography of the Future



- As tectonic plates continue to move, Earth's geography will change dramatically.
- Scientists predict that in 250 million years, the continents will come together again to form a new supercontinent (Pangaea Ultima).

Check for Understanding Questions

- In the video answer the following questions.
  - What types of plate are involved with the formation of the Himalayas?
  - Describe the process in which the Himalayan mountains formed.

    Through the process of plate tectonics the Himalayas formed by…