ELEMENTARY IDEA ABOUT PLATE TECTONICS AND ORIGIN OF MOUNTAINS

B.SC. SEM-1

GE-1

DEPT. OF GEOLOGY

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An Idea Before its Time

- In 1915, an eccentric German geologist, Alfred Wegener, proposed the hypothesis of *continental drift*
- **Continental Drift** – hypothesis that proposed that the continents had all been joined together to form one "supercontinent", the supercontinent broke into pieces and drifted apart forming the modern continents
- **Pangaea** – the supercontinent from continental drift, means "all land"

Breakup of Pangaea

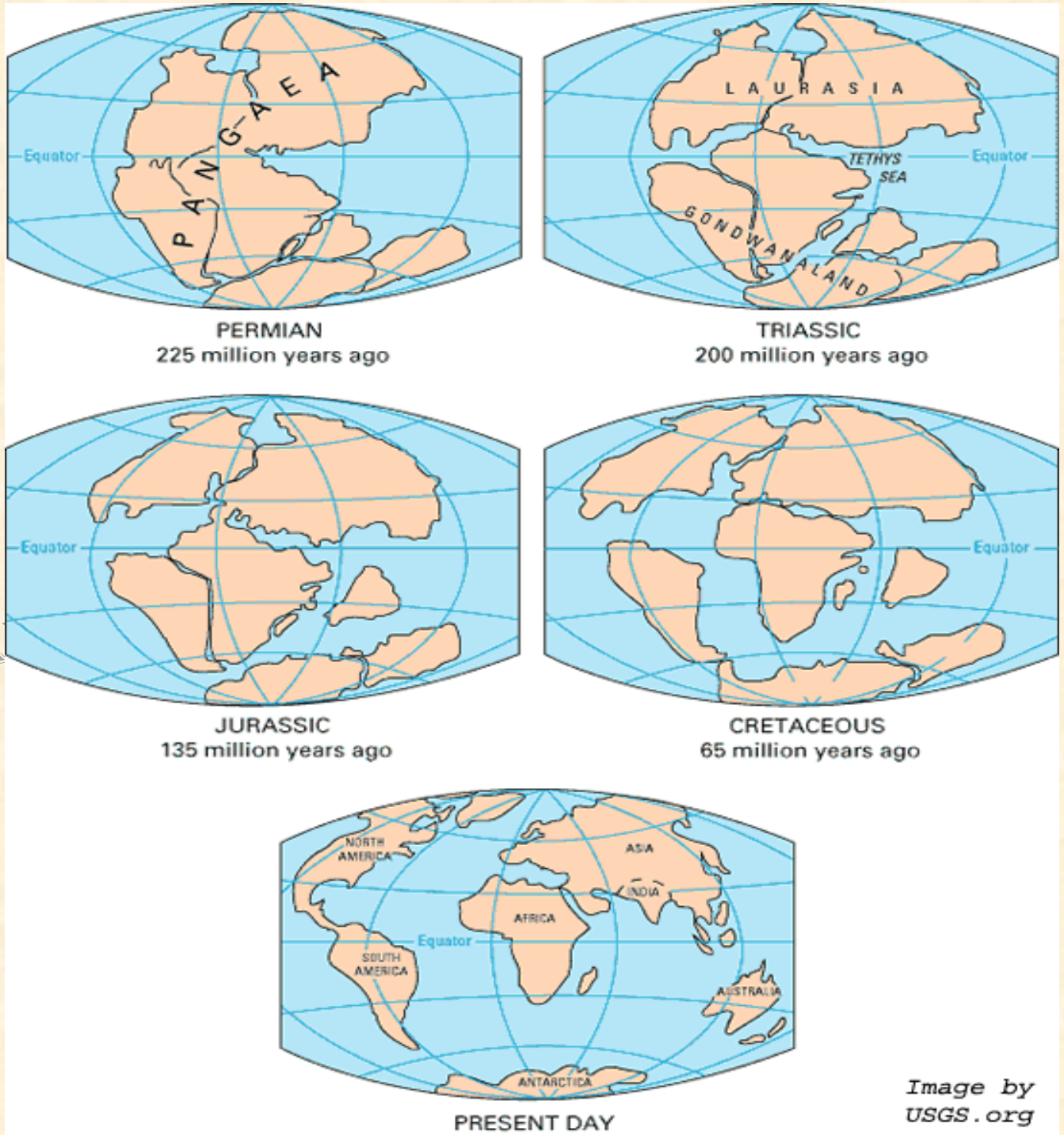


Image by USGS.org

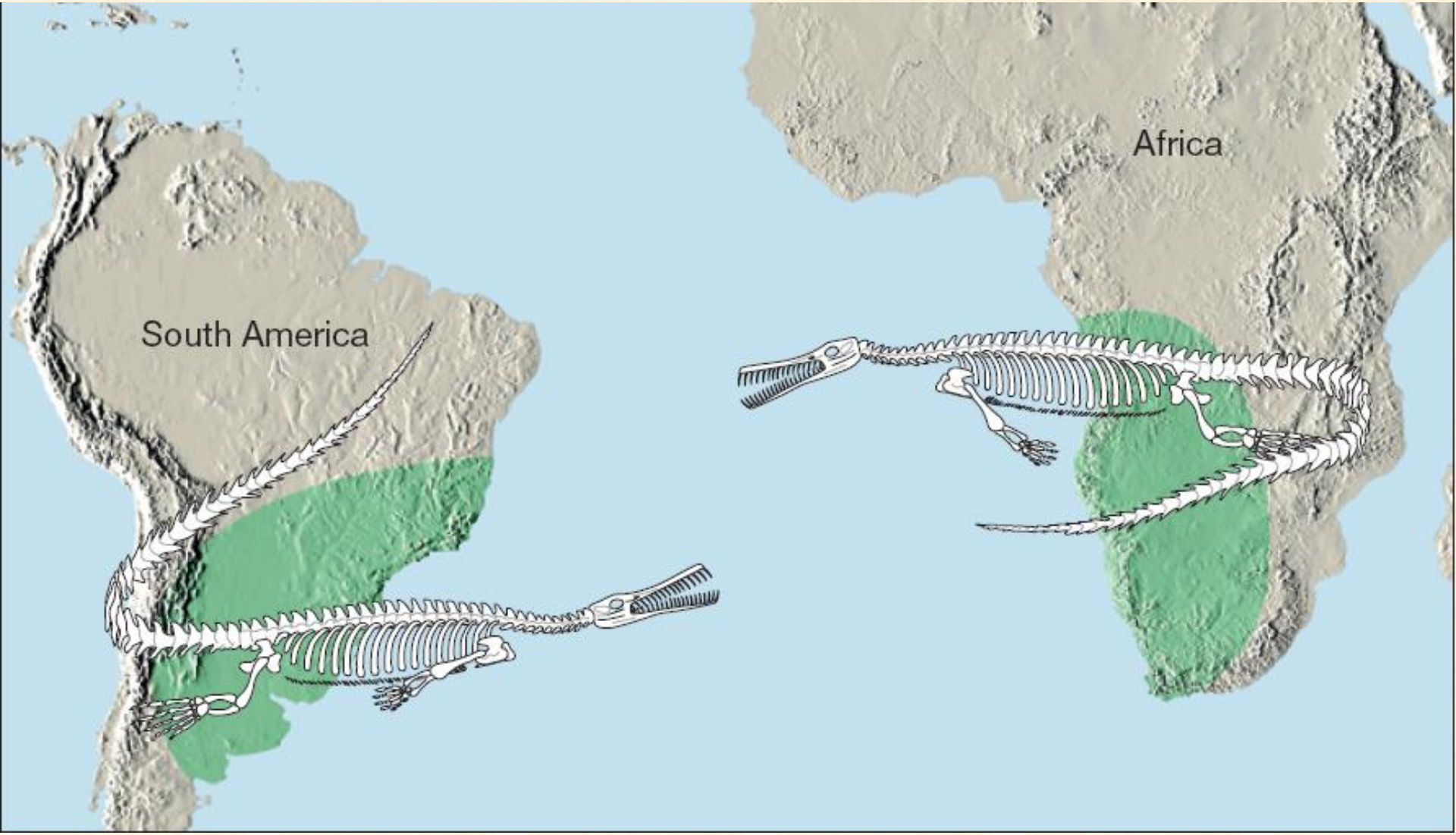
Evidence: The Continental Puzzle

- Wegener first thought the continents had been joined from the almost perfect fit of the shorelines of Africa and South America

Evidence: Matching Fossils

- Fossil evidence for continental drift includes several fossil organisms found on different landmasses.
- The Mesosaurus, an aquatic reptile, has fossils that are limited to eastern South America and southern Africa, if it were able to swim well enough to make it across the Atlantic Ocean, the fossils would be more widespread
- The idea that there were widespread land bridges was the most widely accepted theory to there being similar fossils in distant places

Matching Fossils



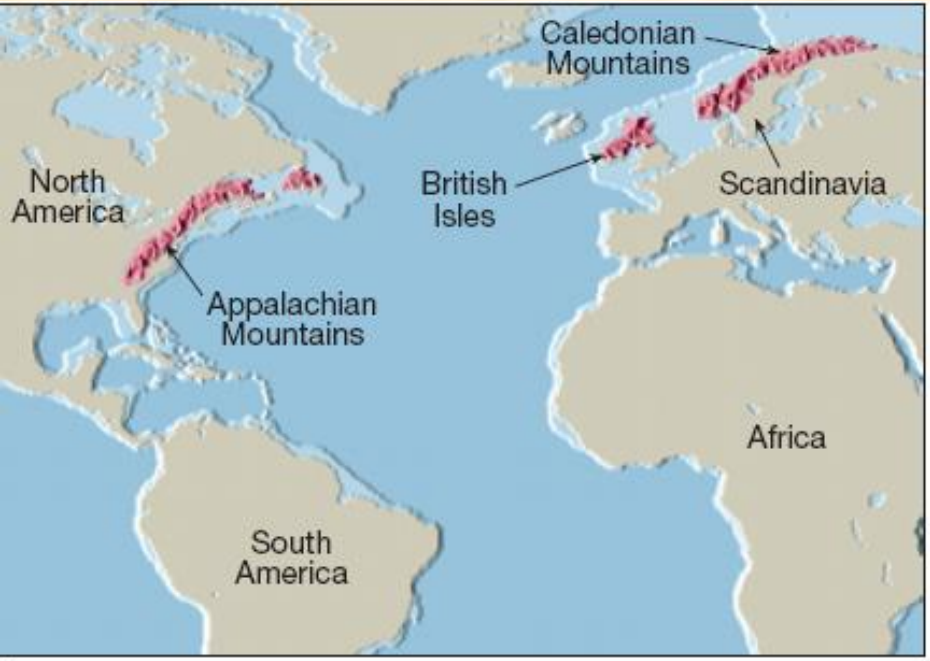
Concept Check

- How does the distribution of Mesosaurus fossils provide evidence for continental drift?
- Mesosaurus occurs only in eastern South America and southern Africa

Evidence: Rock Types and Structures

- If the continents existed together in Pangaea, they should have matching rock types and features should match closely in age and type
- Rock evidence for continental drift exists in the form of several mountain belts that end at one coastline, only to reappear on a landmass across the ocean
- The Appalachian Mountains on the Eastern side of North America have similar ages to mountains in the British Isles and Scandinavia

Matching Mountain Ranges



A.

B.

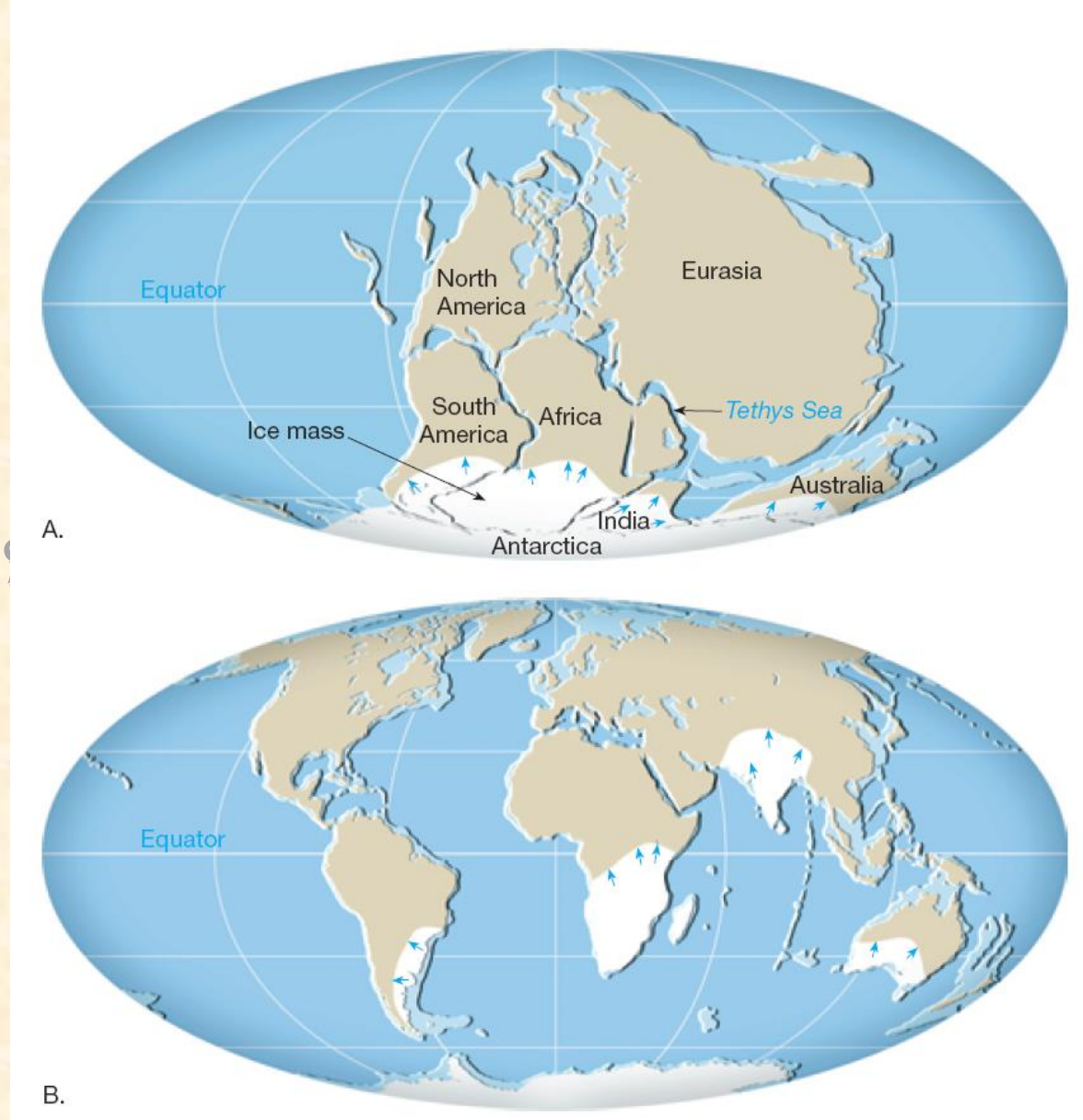
Concept Check

- How does the location of mountain chains provide evidence of continental drift?
- If mountain chains can be continued across present-day oceans, they provide evidence that the areas were once connected

Evidence: Ancient Climates

- Wegener was a meteorologist by profession and so looked closely at the ancient climates of the different continents
- He found evidence for massive glaciers all over Africa and South America that matched each other in age and position
- The problem was figuring out how ancient glaciers were on these now tropical regions, unless the continents moved to their current positions

Glacier Evidence



Rejecting the Hypothesis

- The main objection to continental drift was that it lacked a mechanism
- Wegener proposed that the continents "plowed" their ways through the ocean, however no evidence on the ocean floor was ever found to support this
- In the years that followed Wegener's hypothesis, we gained greater knowledge of earthquakes

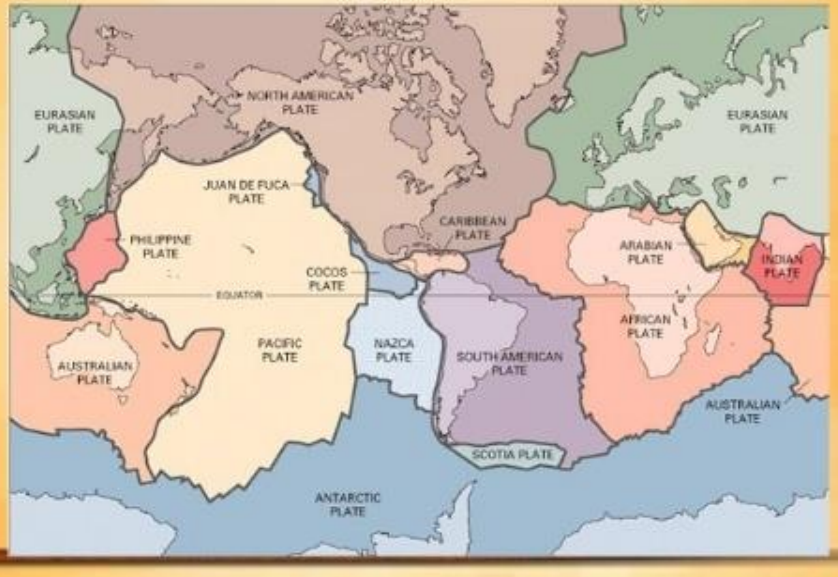
Concept Check

- Why was Wegener's hypothesis rejected?
- He could not provide a mechanism for the movement of the continents

What is Plate Tectonics?

Plate Tectonics

- Theory of Plate Tectonics - The theory of plate tectonics, the crust is broken up into sections/pieces that move on top of the liquid mantle (asthenosphere).
- Tectonic Plates – these sections/pieces of crust are called plates



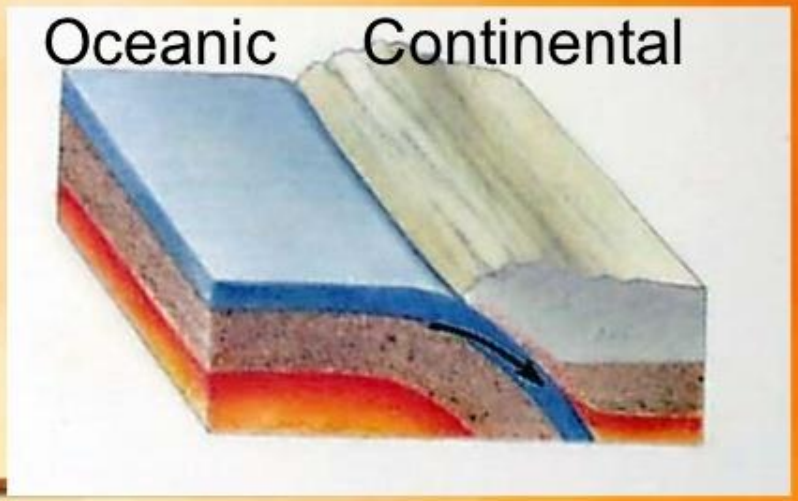
Plates

- There are 7 major plates on the earth that are moving extremely slowly but continuously.

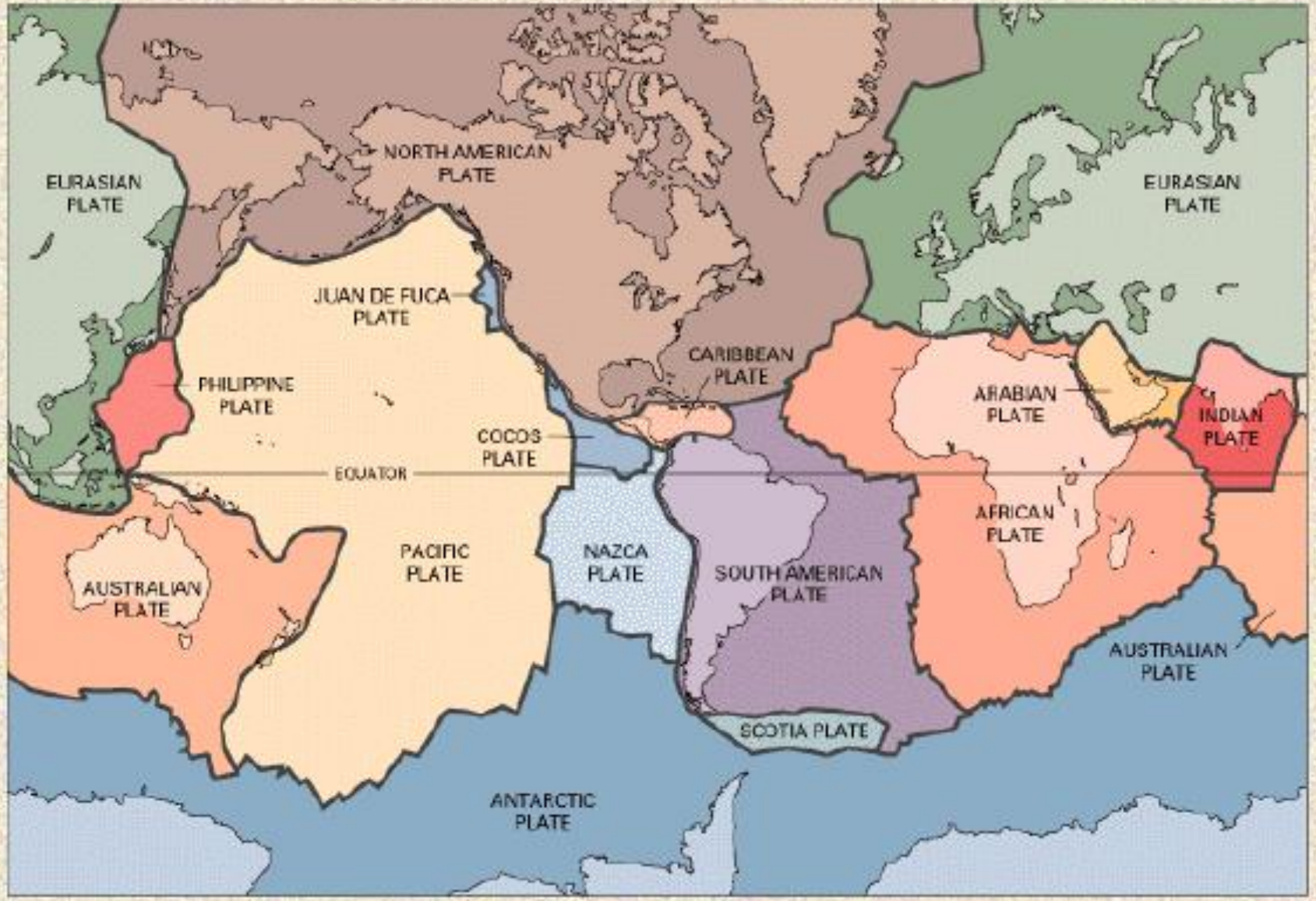
Major Plates: Eurasian, African, Australian-Indian, North American, Pacific, Antarctic and South American.

Intermediate Plates: Caribbean, Cocos, Nazca, Arabian, Phillippine, Juan de Fuca and Scotia

- 2 main types of plates:
  - Oceanic - ocean
  - Continental - land

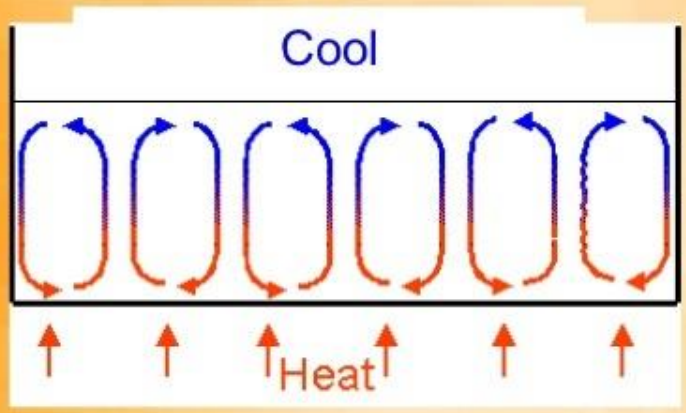


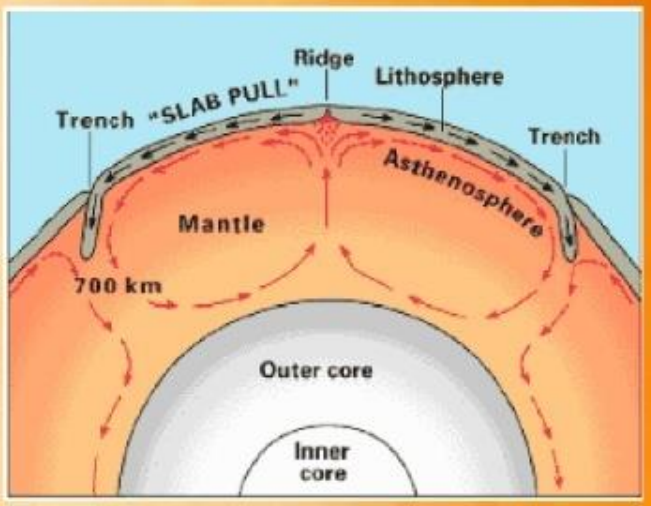
World Plates



Convection Currents

- Convection cells in the mantle **move the plates**.
  - *Hot in the center, less dense magma rises up due to heat.*
  - *When the magma reaches the surface, it cools and sinks back down creating a circular pattern of movement.*
- This process happens continually.





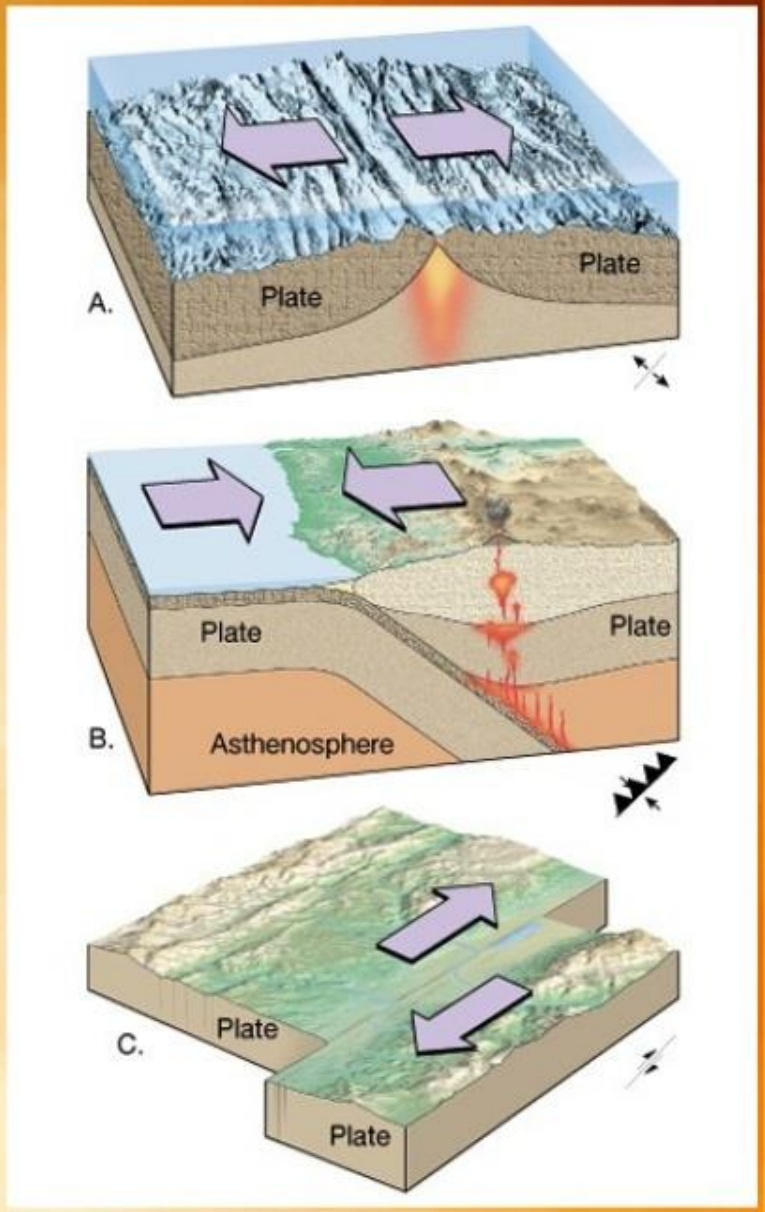
- Hot – goes UP
- Cool – goes DOWN

Crust Density

- Oceanic Plates (dense) – heavy
  - Sink (subduct) underneath continental crust
- Continental Plates (less dense) – lighter

Plate Boundaries

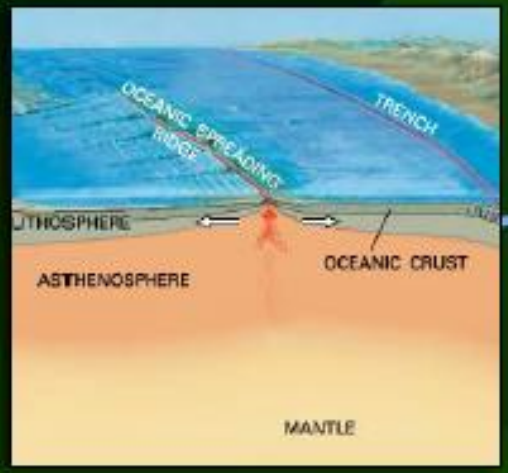
- Border between 2 plates
- *3 Boundary Types*
  - *Divergent*
  - *Convergent*
  - *Transform*



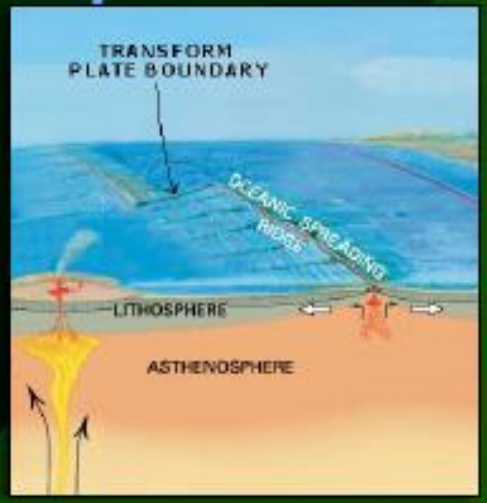
Three Basic Types of Plate Boundaries

Using hands to show relative motion

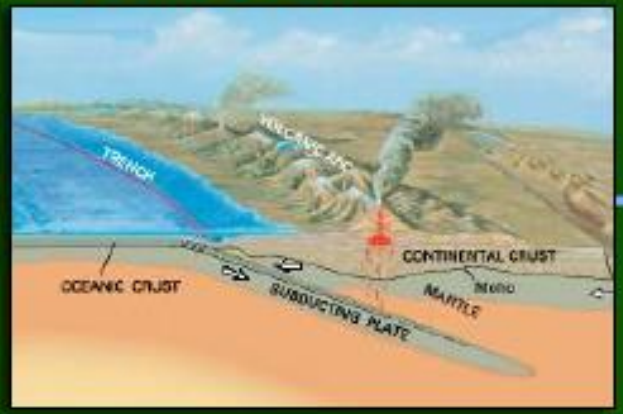
Divergent



Transform

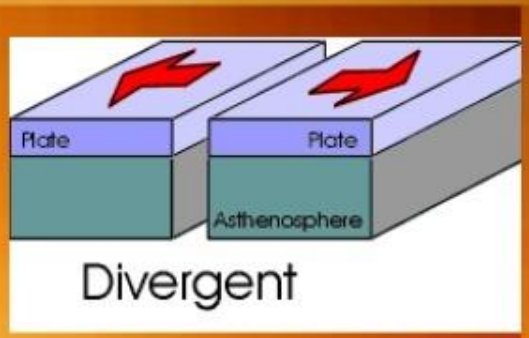


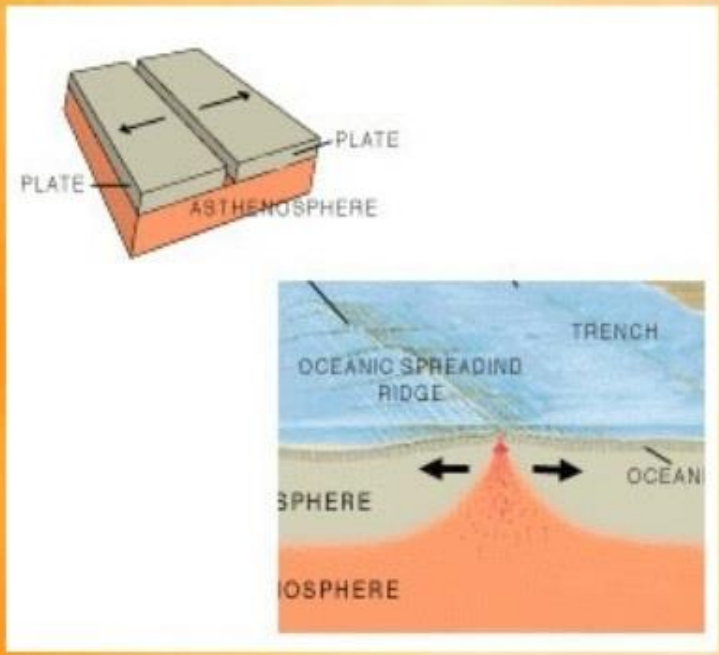
Convergent

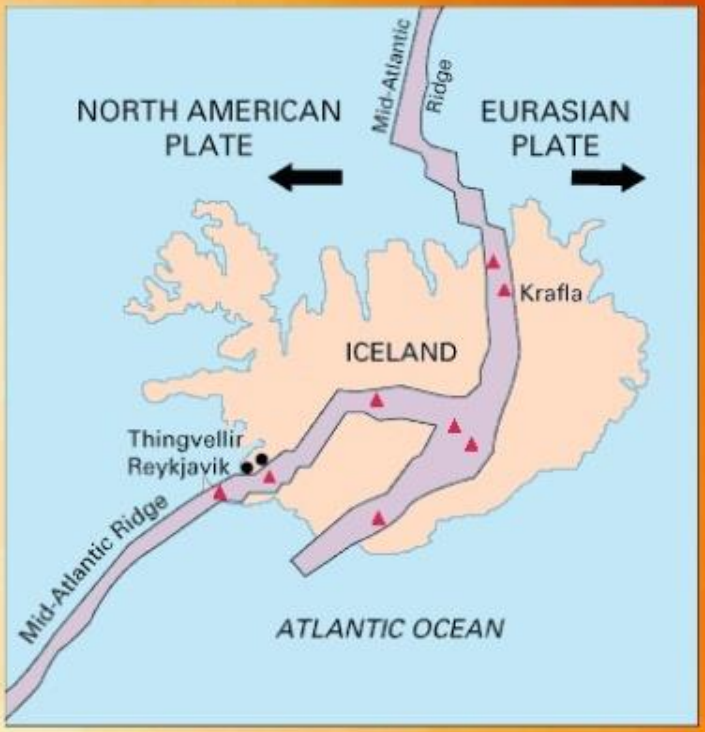


Divergent Boundaries

- Plates moving apart.

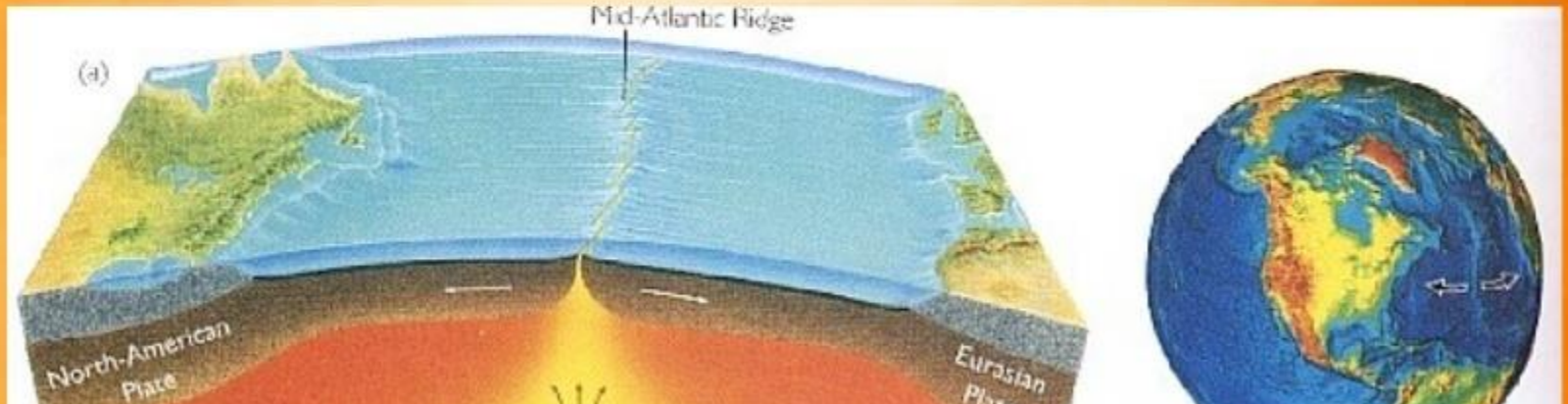






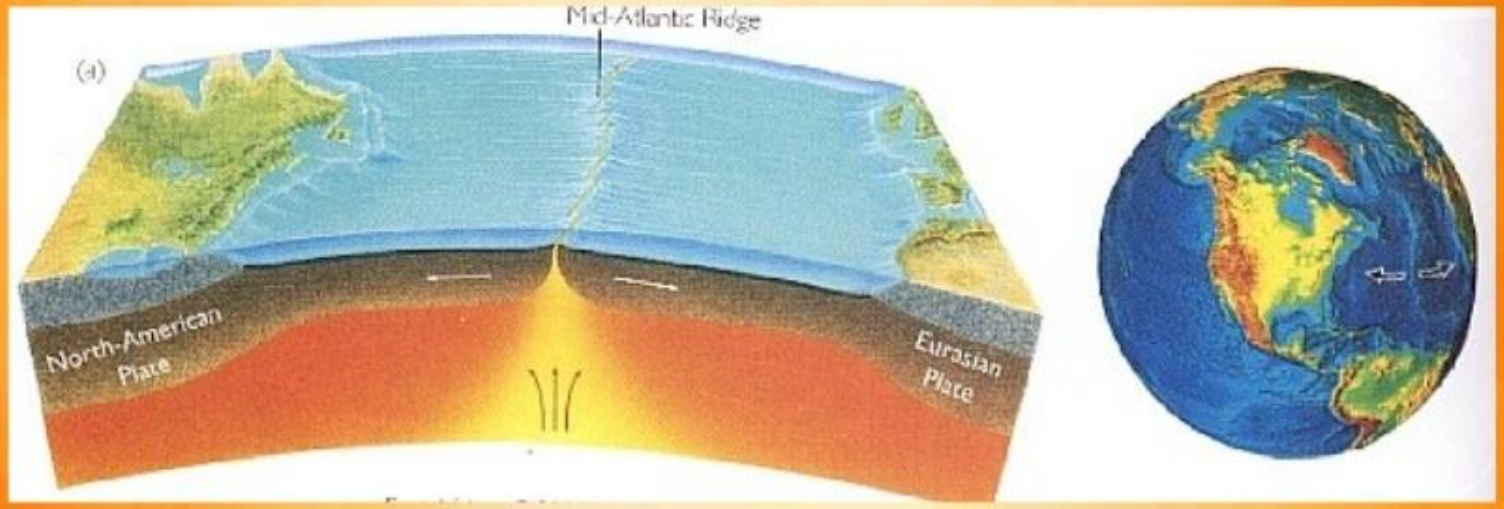
Seafloor Spreading
(oceanic-oceanic)

- The process by which new oceanic crust is created.
- Two oceanic plates move apart and magma comes up
- As rising magma cools, it forms new oceanic crust. (Example: Mid-Atlantic Ridge)



Mid-Ocean Ridges
(oceanic-oceanic)

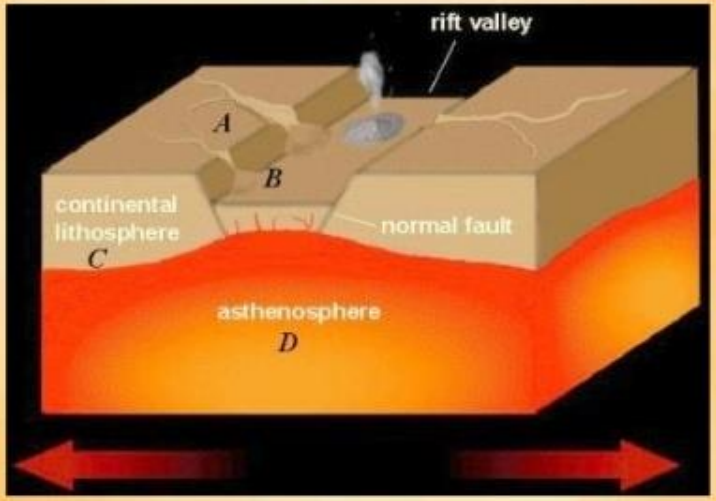
- A mountain under the ocean
- A mid-ocean ridge forms where oceanic plates continue to separate.



A Rift Valley
(continental-continental)

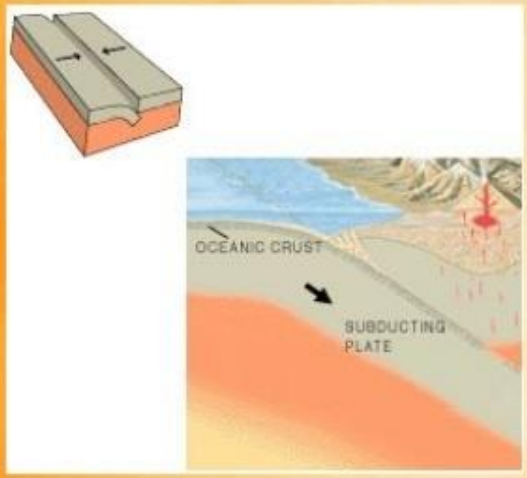
- When continental plates pull apart, they form rift valleys.
- Makes volcanoes and new land

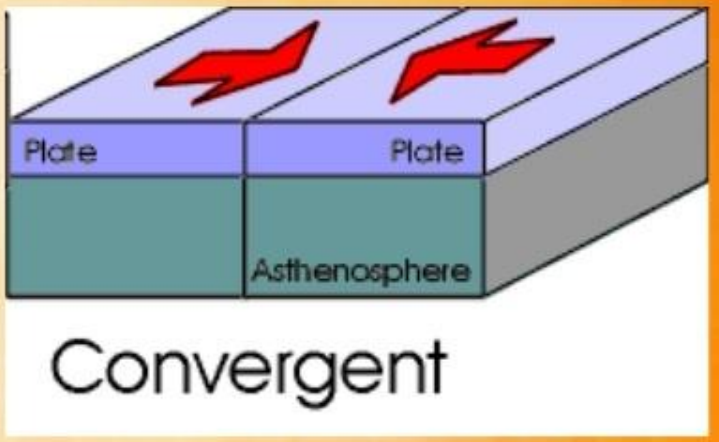
(Example: East African Rift Valley)



Convergent Boundaries

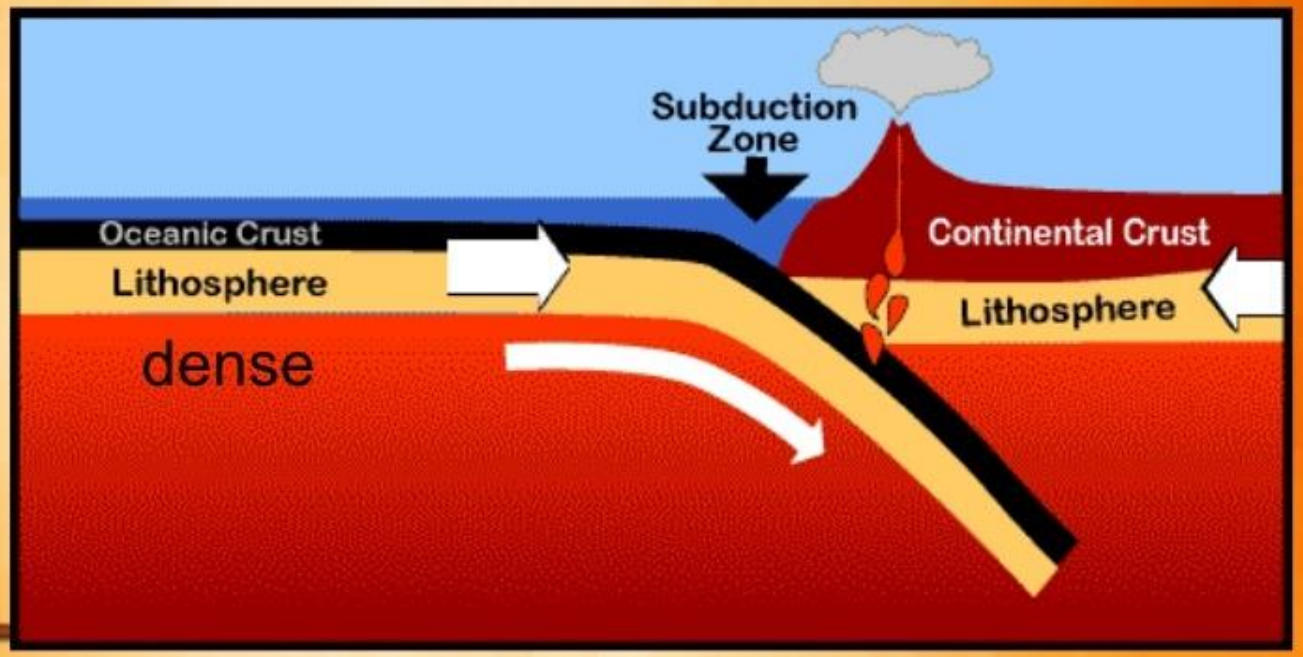
- Plates come together





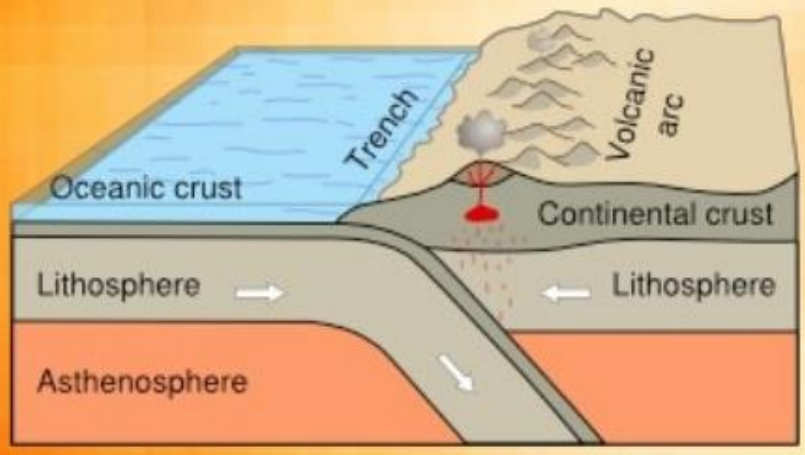
Subduction Zones

- When one plate goes under another plate.
- The more dense (heavier) plate goes under.



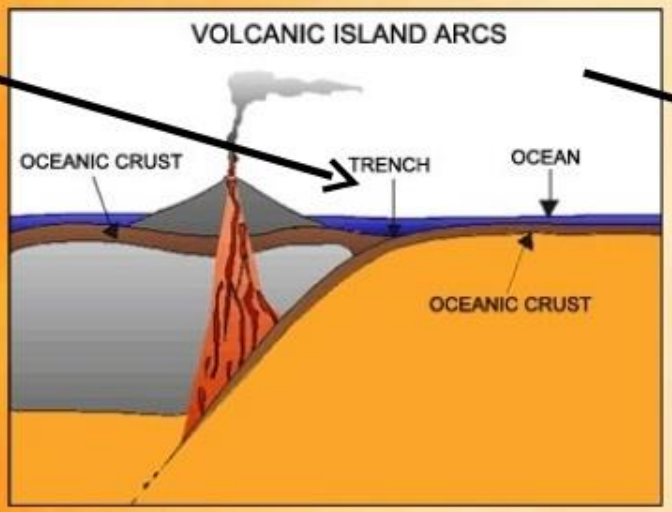
Volcanic Arc
(Subduction: Oceanic-Continental)

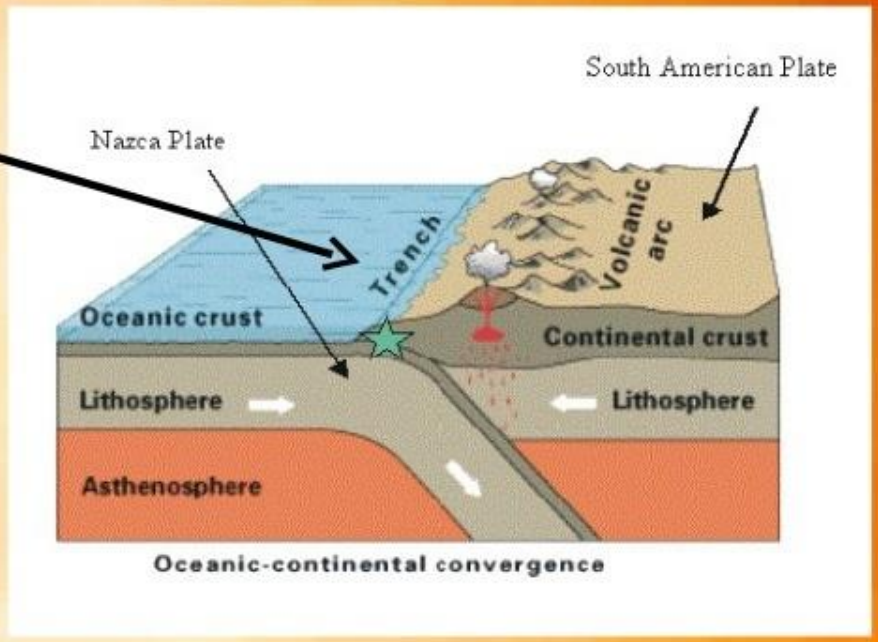
- More dense (heavier) oceanic crust goes under the less dense continental crust.
- As the plate moves under the continental plate, the rock melts and rises, creating volcanoes.
- Trenches are also created.



Deep-Sea Trench
(oceanic-continental)

- A depression (hole) in the ocean floor at a subduction zone, it has sand in it.



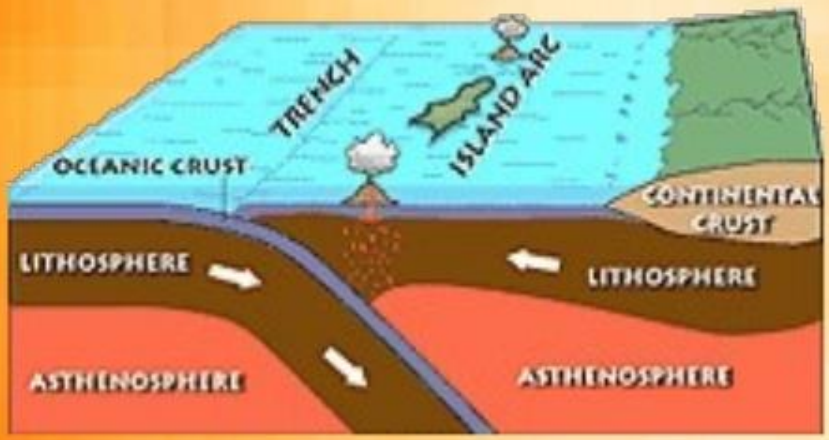


Volcanic Island Chains

(Subduction: Oceanic-Oceanic)

- When 2 oceanic plates meet and one goes under the other.
- Forms Volcanic Islands.

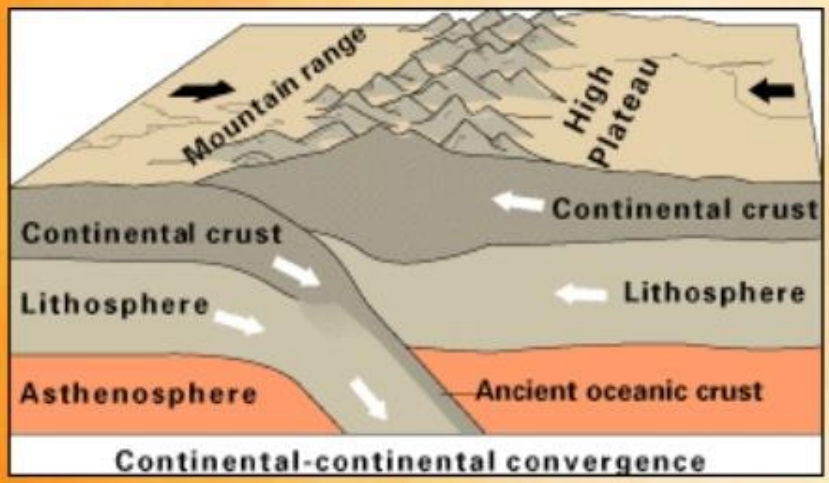
(Example: Aleutian Islands)



Mountains

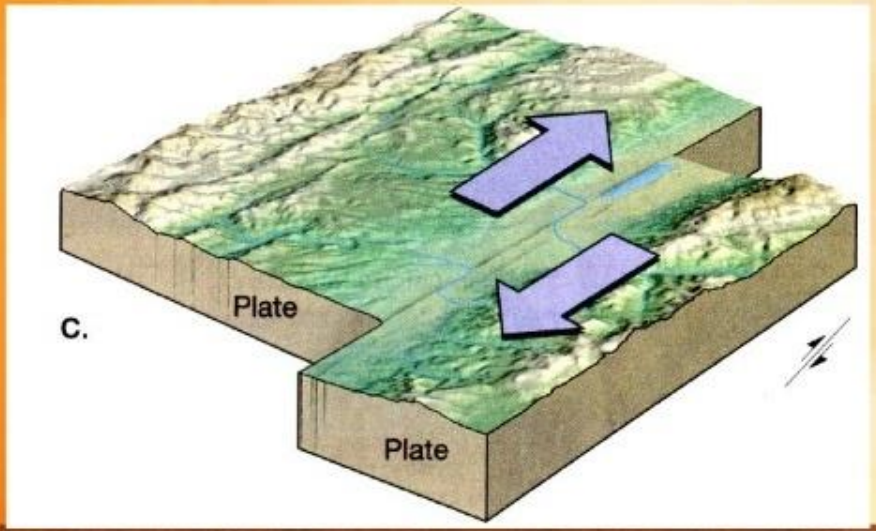
(Subduction: Continental-Continental)

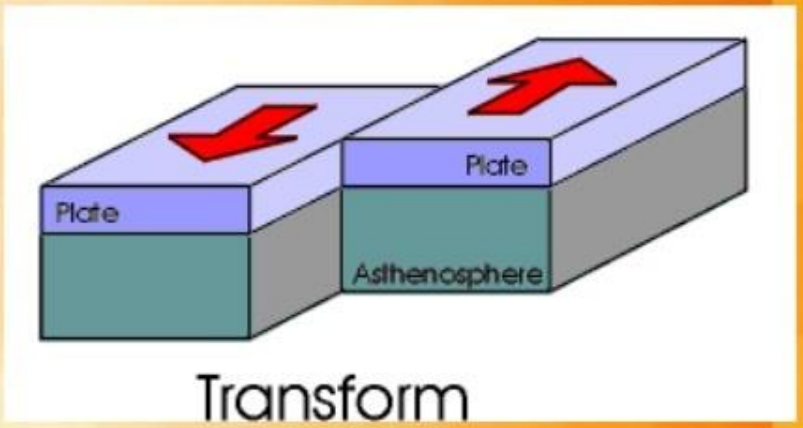
- When 2 continental plates come together.
- The plates push up and form mountains. (Example: Himalayas)



Transform Fault Boundaries

- Plates slide past one another moving in opposite directions.
- Also called FAULTS
- Causes earthquakes/tsunamis to occur.

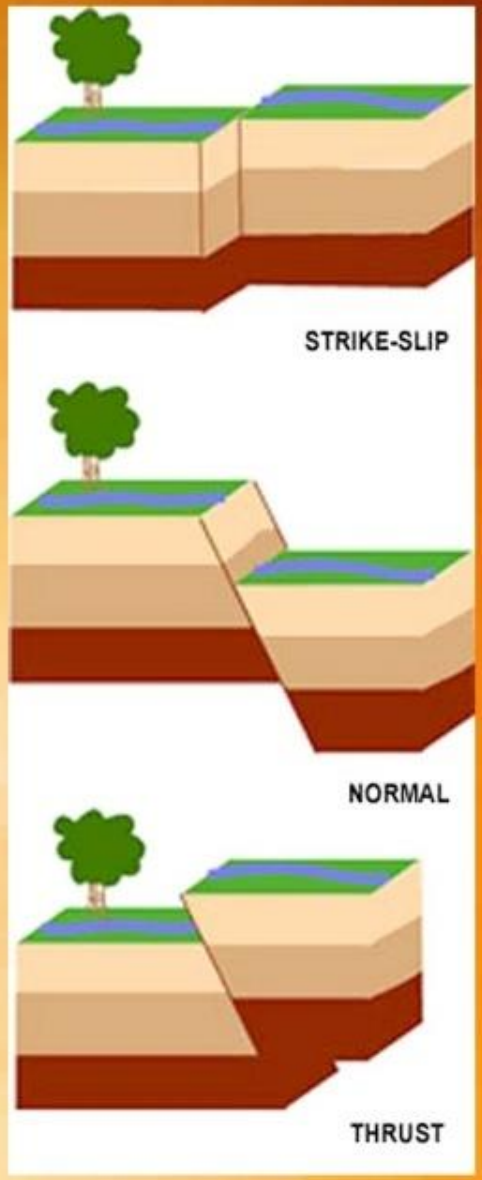




Faults

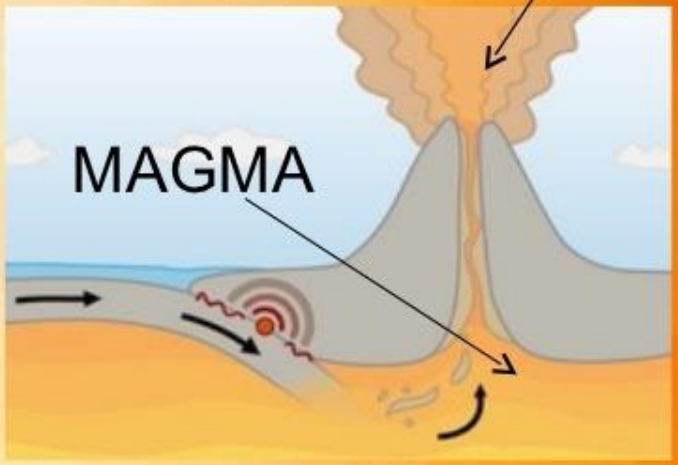
- Large fractures (a break) in the earth's crust.

- Types of Faults
  - Normal
  - Reverse (Thrust)
  - Strike-Slip



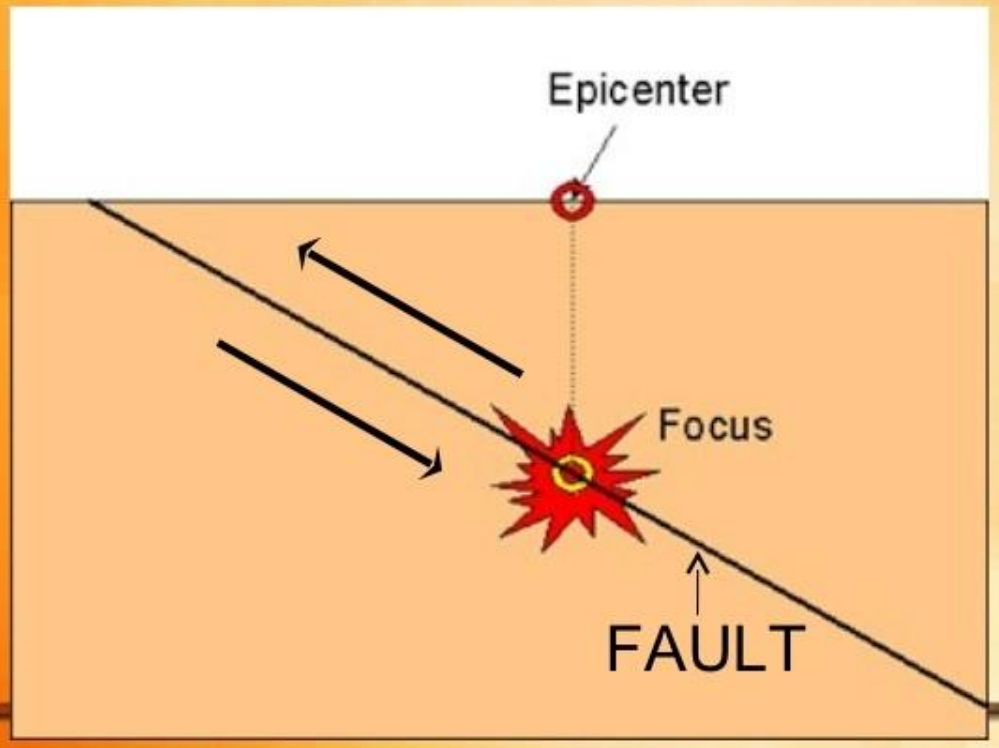
Volcanoes

- An opening in the earth that erupts gases, ash and lava.
- Caused by plate movement along boundaries.
- Occur at both divergent and convergent plate boundaries.
  - **Magma** - melted rock under the surface (INSIDE)
  - **Lava** – Melted rock above the surface (OUTSIDE)



Earthquakes

- Caused by movement along a fault.
- Occurs mainly at plate boundaries.
- **Focus** – point under the earth's surface where an earthquake starts
- **Epicenter** – place on earth's surface directly above the focus



Tsunamis

- Also called tidal waves
- Large ocean waves caused by an earthquake under the ocean.
- Ocean floor moves along a fault creating a wave.
- Can also be caused by a landslide under or above the water.

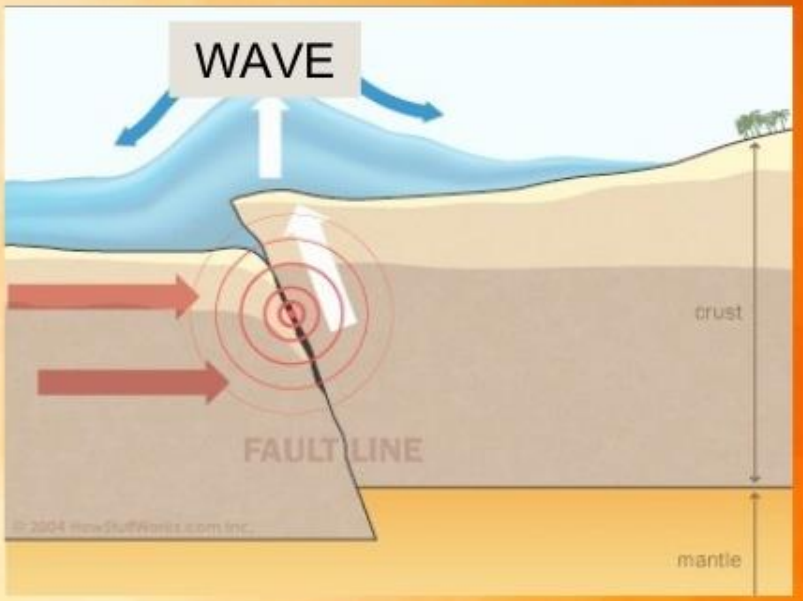


Plate Boundaries

DIVERGENT BOUNDARY – move apart		
Sea-Floor Spreading	oceanic-oceanic (o-o)	New Ocean Crust
Mid-Ocean Ridge	oceanic-oceanic (o-o)	Underwater Mountain
Rift Valley	continental-continental (c-c)	Volcanoes/New Land
CONVERGENT BOUNDARY- come together		
Mountains	continental-continental	Mountains created
SUBDUCTION ZONES		
Deep-Sea Trench	oceanic-continental	Depression (hole in ground)
Volcanic Arc	oceanic-continental	A line of volcanoes on land
Island Arc	oceanic-oceanic	A line of islands in the ocean
TRANSFORM BOUNDARY – slide past each other		
Faults	All types	Earthquakes/Tsunamis

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Mountain Formation

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MOUNTAINS

- Are land form have height of 900 Km or more from sea level.
- The name for the processes that collectively produce a mountain belt is orogenesis

Mountain Building at Convergent Boundaries

- With the original development of the theory of plate tectonics, an accepted model for orogenesis emerged
- Most mountain building occurs at convergent plate boundaries
- Colliding plates provide the compressional forces that fold, fault, and metamorphose the thick layers of sediments deposited at the edges of landmasses

TYPES OF MOUNTSINS

- Based on its origin there are

1) Fold mountains
2) Block mountains
3) Volcanic mountains
4) Residual mountains

Fold Mountains

- Fold mountains are the most common type of mountain. The world's largest mountain ranges are fold mountains. These ranges were formed over millions of years.
- Fold mountains are formed when two plates collide head on, and their edges crumbled, much the same way as a piece of paper folds when pushed together.
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- The upward folds are known as anticlines, and the downward folds are synclines.

Fold mountains

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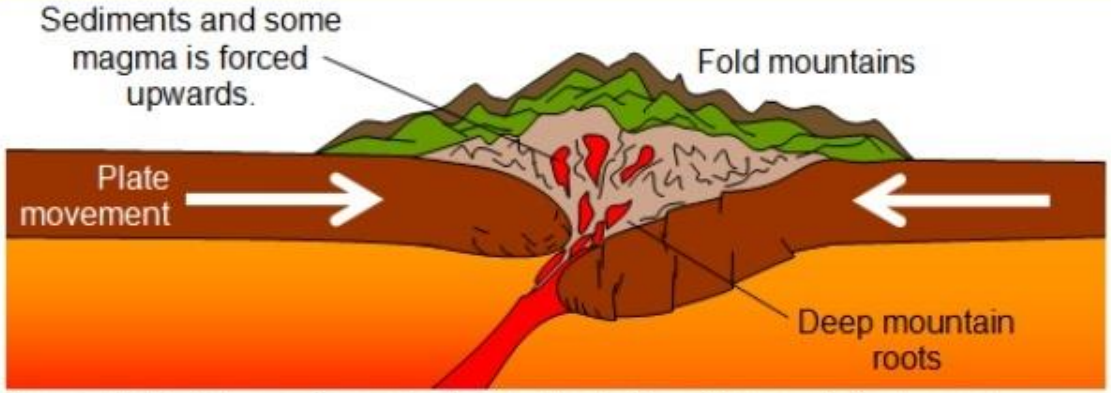

Two contintal plates moving against each other to form fold mountains. Image by ParkfieldPrimary.

Fold mountain rock formation

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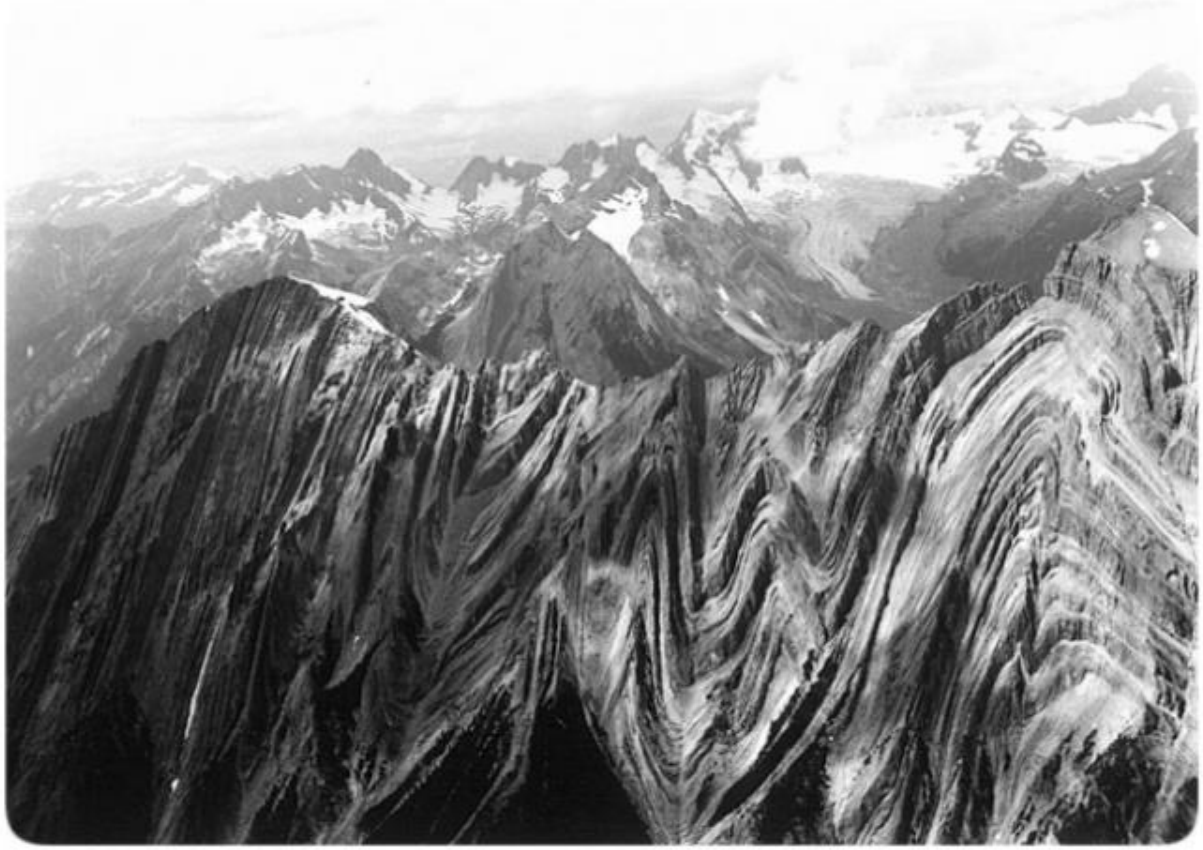
Zagros Mountains © Stefan Jürgenson , Flickr

Fold Mountain



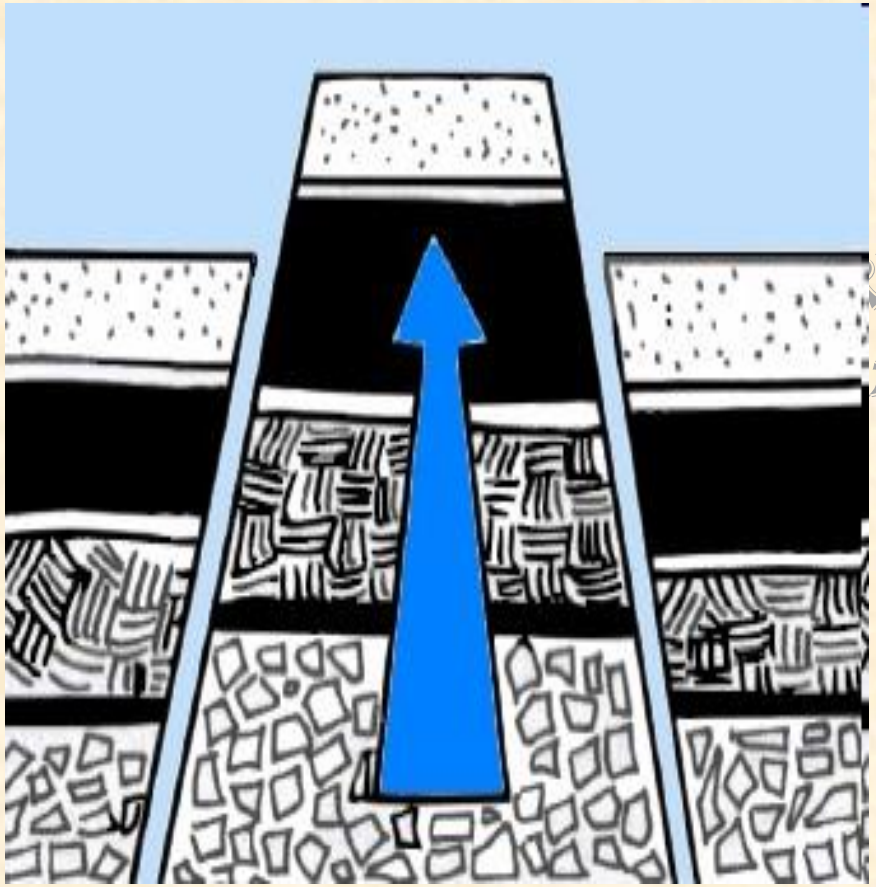
Examples of fold mountains include:

- **Himalayan Mountains in Asia**
- **the Alps in Europe**
- **the Andes in South America**
- **the Rockies in North America**
- **the Urals in Russia**
- **The Himalayan Mountains were formed when India crashed into Asia and pushed up the tallest mountain range on the continents.**
- **In South America, the Andes Mountains were formed by the collision of the South American continental plate and the oceanic Pacific plate.**

Fault-Block

- These mountains form when faults or cracks in the earth's crust force some materials or blocks of rock up and others down.
- Instead of the earth folding over, the earth's crust fractures (pulls apart). It breaks up into blocks or chunks. Sometimes these blocks of rock move up and down, as they move apart and blocks of rock end up being stacked on one another.
- Often fault-block mountains have a steep front side and a sloping back side.

Fault-Block



Fault block mountains

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Sierra Nevada from the east © Mary, Flickr

Fault Block Mountains

Sierra Nevada

Examples of fault-block mountains include:

- **The Sierra Nevada mountains in North America**
- **The Harz Mountains in Germany**

Volcanic Mountains

- Volcanic Mountains are formed when molten rock (magma) deep within the earth, erupts, and piles upon the surface.
  - Magma is called lava when it breaks through the earth's crust.
  - When the ash and lava cools, it builds a cone of rock.
  - Rock and lava pile up, layer on top of layer.

Volcanic mountains

Examples of volcanic mountains include:

- **Mount St. Helens in North America**
- **Mount Pinatubo in the Philippines**
- **Mount Kea and Mount Loa in Hawaii**

RESIDUAL MOUNTAINS

- Formed due to difference in weathering process.
- The upper layer of the rock is removed.
- Hard rock remained as residual mountains.
- E.g. Aravalli range, Nilgiri range

RESIDUAL MOUNTAINS

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