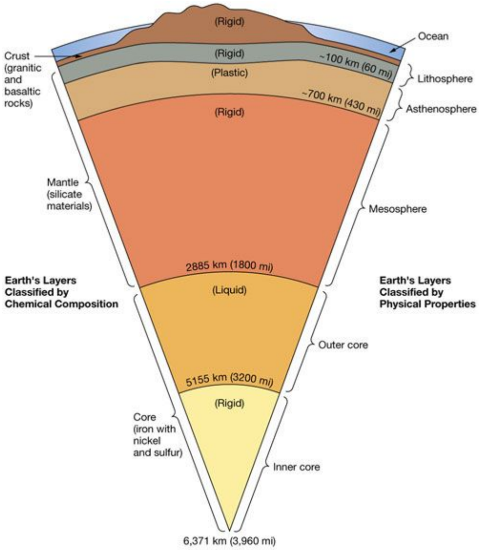
UNIT 1

THE INTERNAL STRUCTURE OF THE EARTH



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1.1.Earth's interior layers

The interior of the Earth can be divided into layers according to:

-**Composition layers** (organized in order of increasing density).

- -*Crust*: made up of less dense rocks
- -*Mantle*: rich in silicon and aluminium
- -*Core*:principally made up of iron

-**Physical layers**

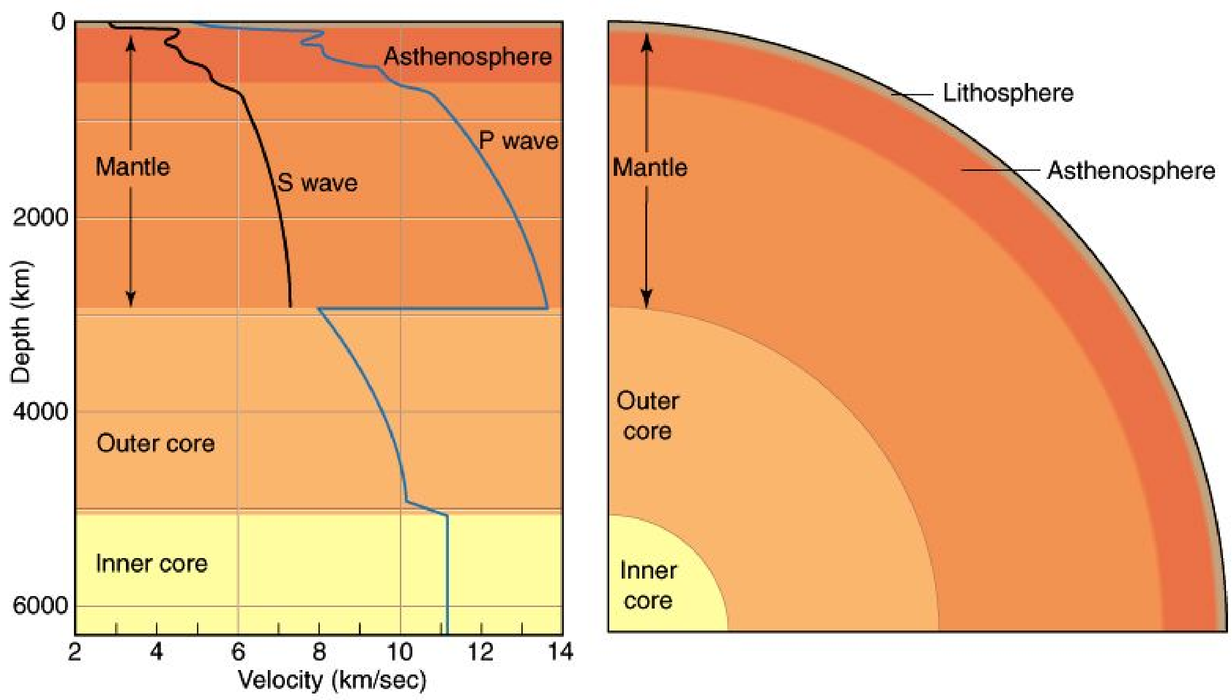
- **-Litosphere:** rigid surface layer.
- **-Asthenosphere:** is under the lithosphere where the mantle is ductile
- **-Lower mantle:** solid but flexible and ductile.
- **- Core:** molten outer layer with a solid inner part.

1.2. Seismic discontinuities

The interior of the Earth is studied using different methods like drilling and mines, and above all studied seismic waves produced in earthquakes.

There are 2 types of internal seismic waves:

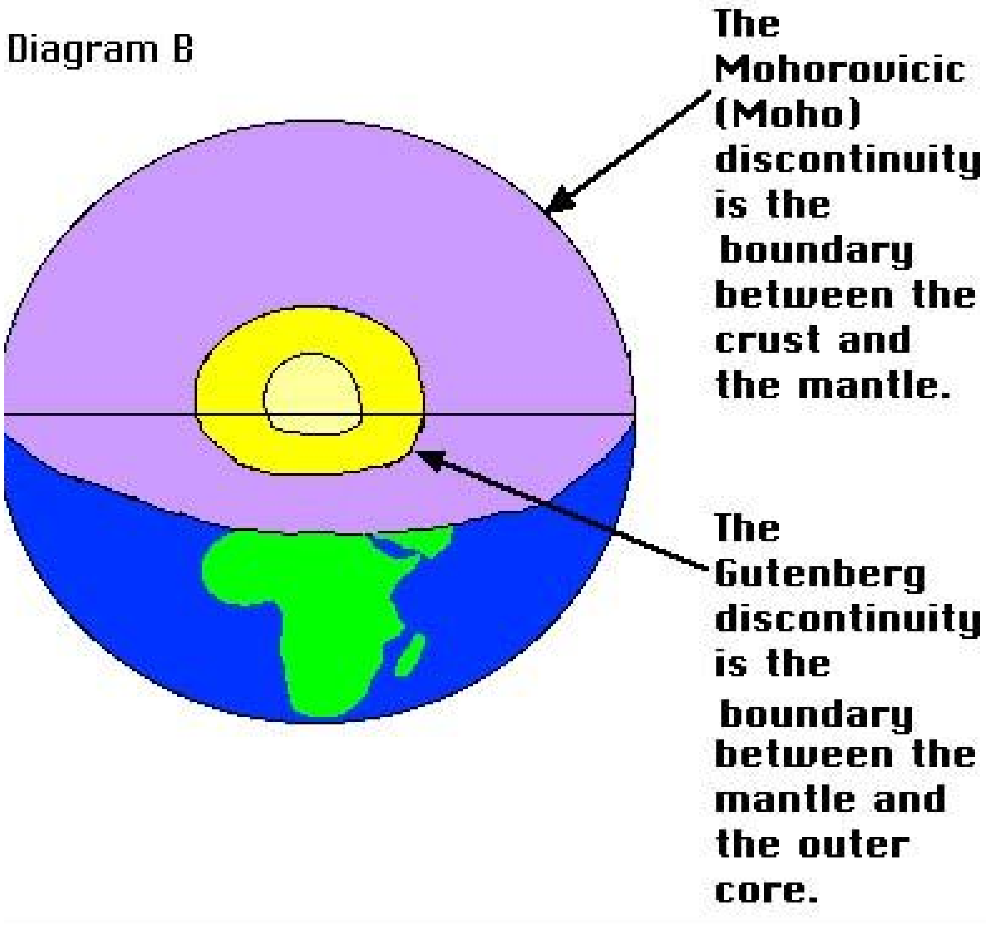
- Primary waves (P): they are the fastest and first to reach the surface.
- Secondary waves(S): they are slower and registred after P.
- P move solids and liquids.
- S only move solids.



The vibration caused by seismic waves travels through the interior of the Earth. They are recorded using sismometers.

But, there are changes in the speed caused by the change of composition of the material they're travelled:

- The Mohorovicic discontinuity: or Moho, marks the boundary between the crust and the mantle. This boundary is 30-40km
- The Gutenberg discontinuity: is found at a depth of around 2900Km. It marks the limit between the mantle and the molten layer of the Earth's outer core.

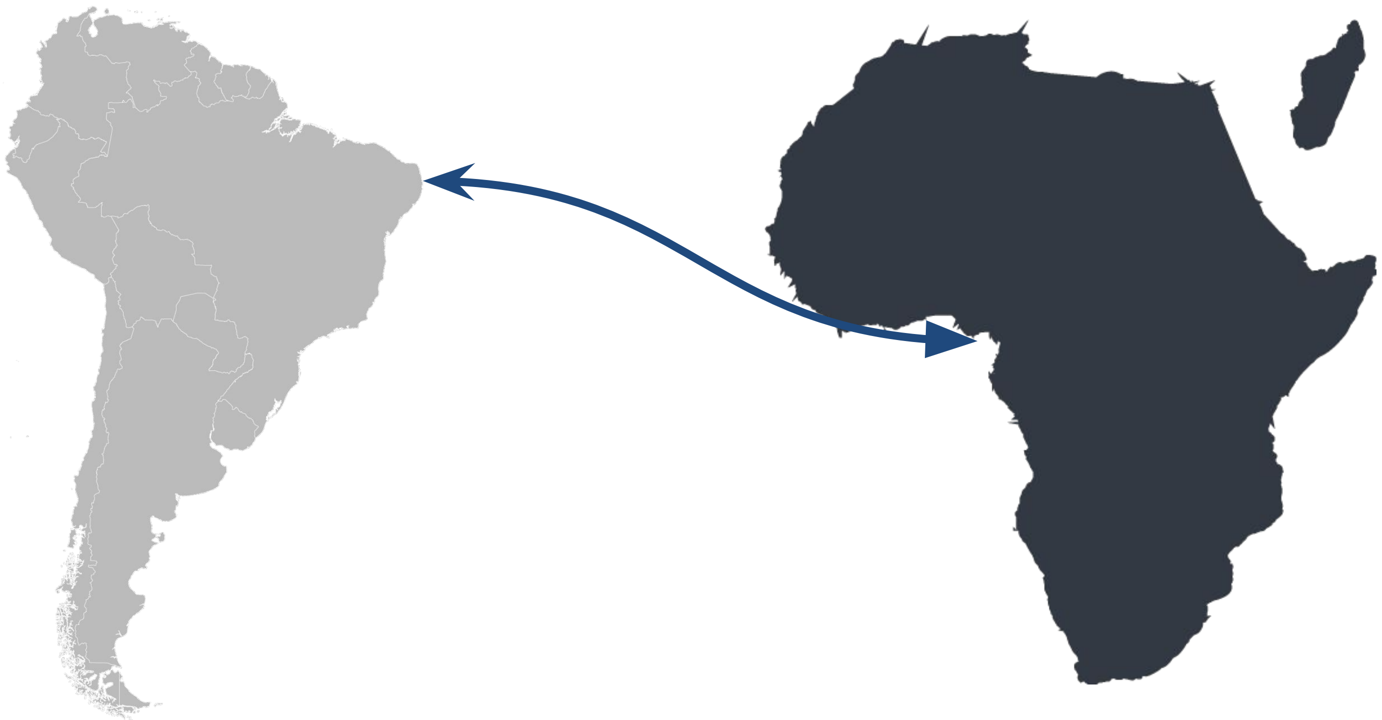


THE MOVEMENT OF CONTINENTS

During 19th and 20th centuries, there was CONTROVERSY => about geological history of continents

- the position of the Earth was fixed **VS** they had move great distances over periods of time.

Alfred Wegener, a German meteorologist, was the first to collect evidence to explain the similarities in the shape of the African and South American coastlines. he tried to demonstrate that the two continents had previously been joined.



2.1. Continental drift theory

In 1912, Wegener put forward his hypothesis about the movement of the continents in his theory of continental drift.

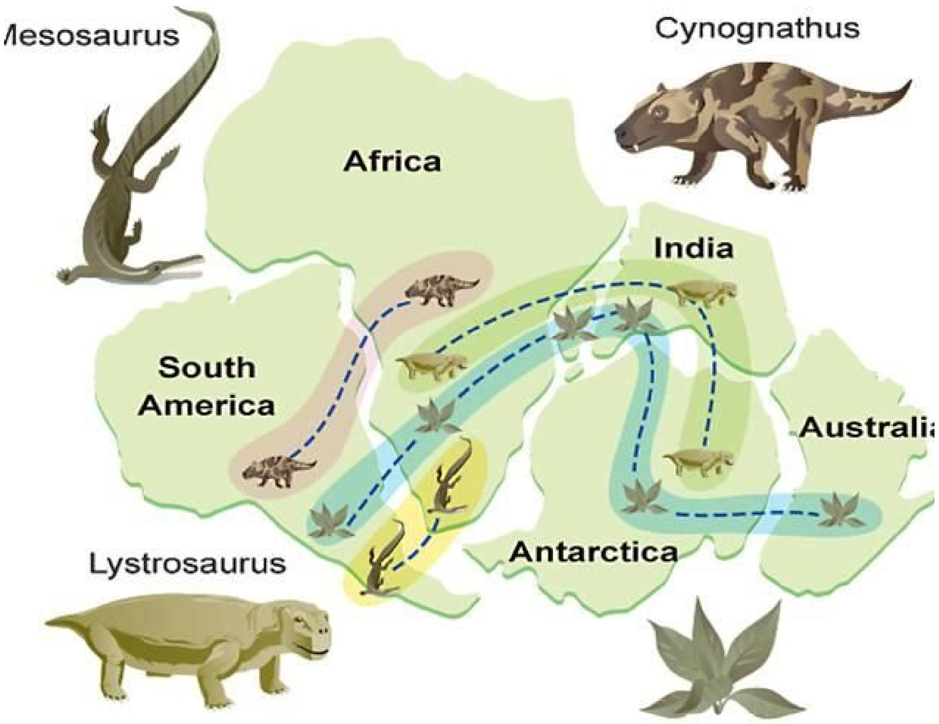
According to his theory, the continents, made of a lighter crust, slide over a continuous thicker layer (made up of ocean floor).

He proposed that around 200 million years ago, all the continents were joined as one, called Pangea, a word that means “the whole Earth”

Pangea–250 million years ago

Wegener collected a large amount of evidence to prove the existence of this supercontinent.

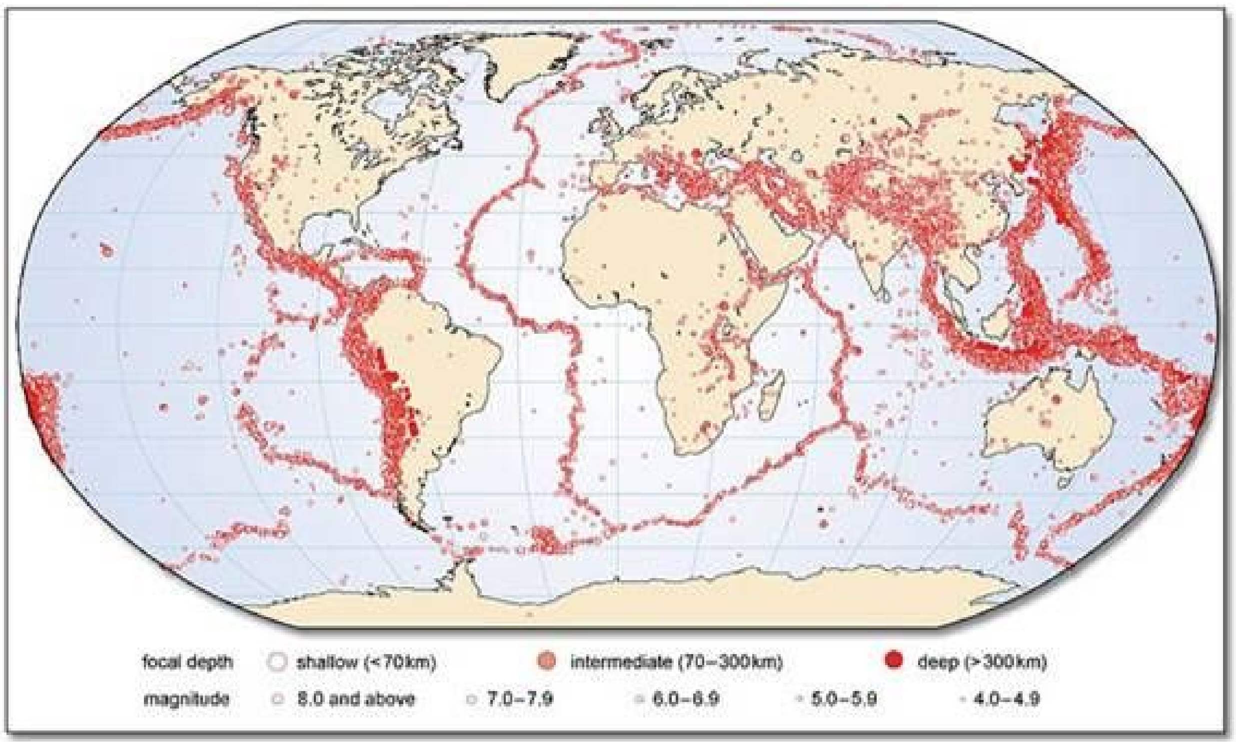
- **Palaeolithic evidence**: Identical fossil of land-based organisms such as reptiles and plants were found in continents situaded far apart.
- **Geological evidence**: The continents fit together along their coastlines and continental shelves
- **Palaeoclimatic evidence**: The continents which were situated in the South Pole of Pangea have glacial morraines from the same age.



THE THEORY OF PLATE TECTONICS

3.1. Seismic and volcanic belts

Seismometers (put into operation in 20th century), showed us that earthquakes were located in seismic belts, (narrow bands), which also contain volcanic areas.
Seismic belt areas have the same type of landforms.



3.2. Lithospheric plates

Or tectonic plates, are fragments of **lithosphere**, each separated by a **seismic belt.**

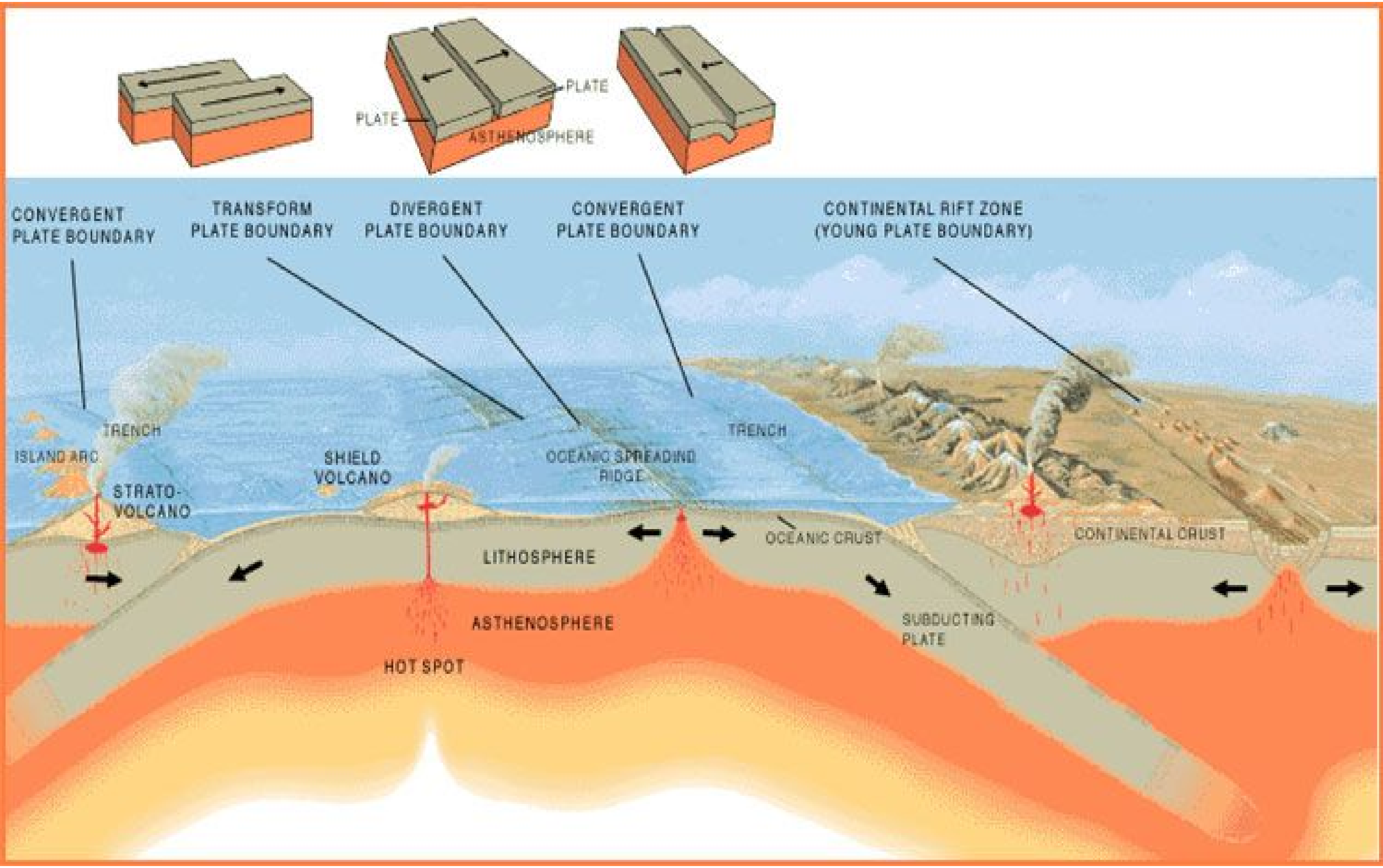
CLASIFICATION:

- SIZE: -large plates
  -microplates
- TYPE OF LITHOSPHERE: -oceanic plates: which are composed of oceanic lithosphere.
  -continental plates: are composed of continental lithosphere.
  -mixed plates: composed of both of them.

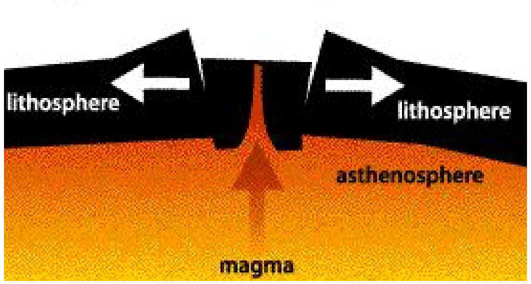
Depending on the type of boundary between plates, there are varying levels of risk of earthquakes and volcanic eruptions.

North American Plate
Eurasian Plate
Caribbean Plate
Philippine Plate
Pacific Plate
Cocos Plate
African Plate
South American Plate
Pacific Plate
Nazca Plate
Indian-Australian Plate
Scotia Plat
Antactic Plate

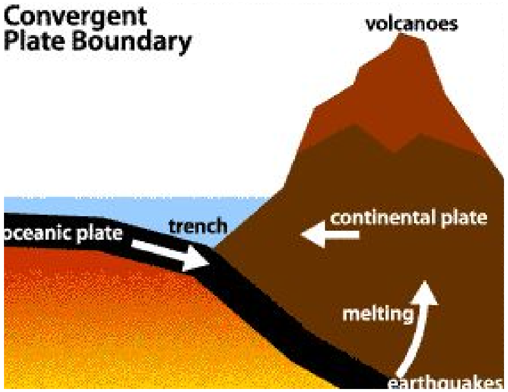
3.3. Types of plate boundaries



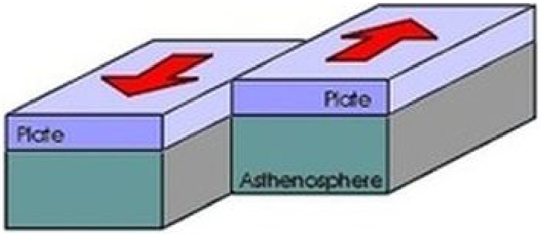
- **DIVERGENT BOUNDARIES** (constructive): zones where two plates move apart to create a new ocean lithosphere -separation-.



- **CONVERGENT BOUNDARIES** (destructive): zones where two continents collide or subduction zones where the ocean floor goes into the mantle. Ocean floor melts and forms magma.

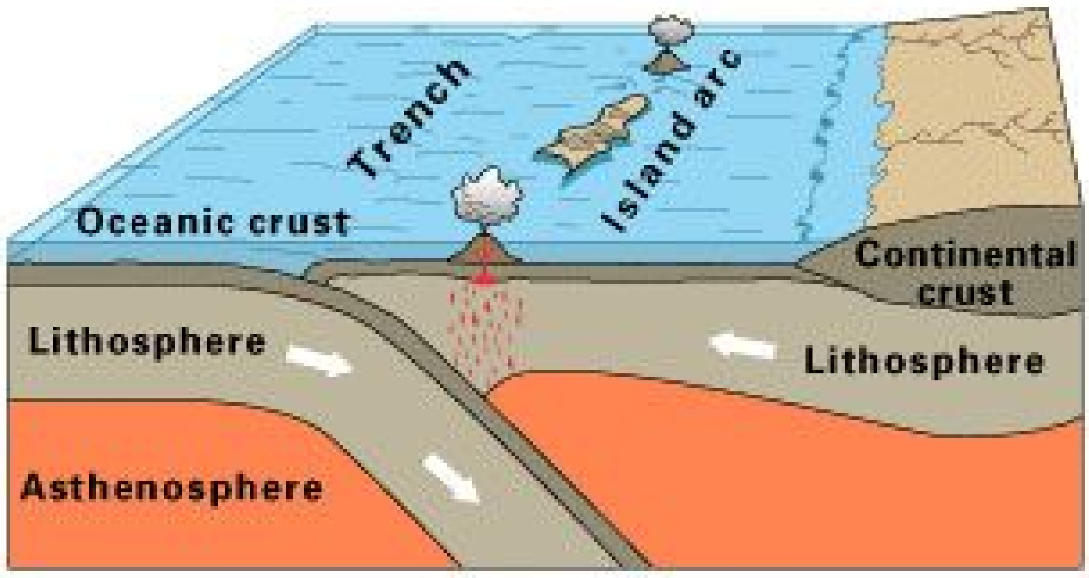


- **TRANSFORM BOUNDARIES** (passive): these are fractures, transform faults, where two plates slide horizontally against each other. These causes seismic and volcanic activity.



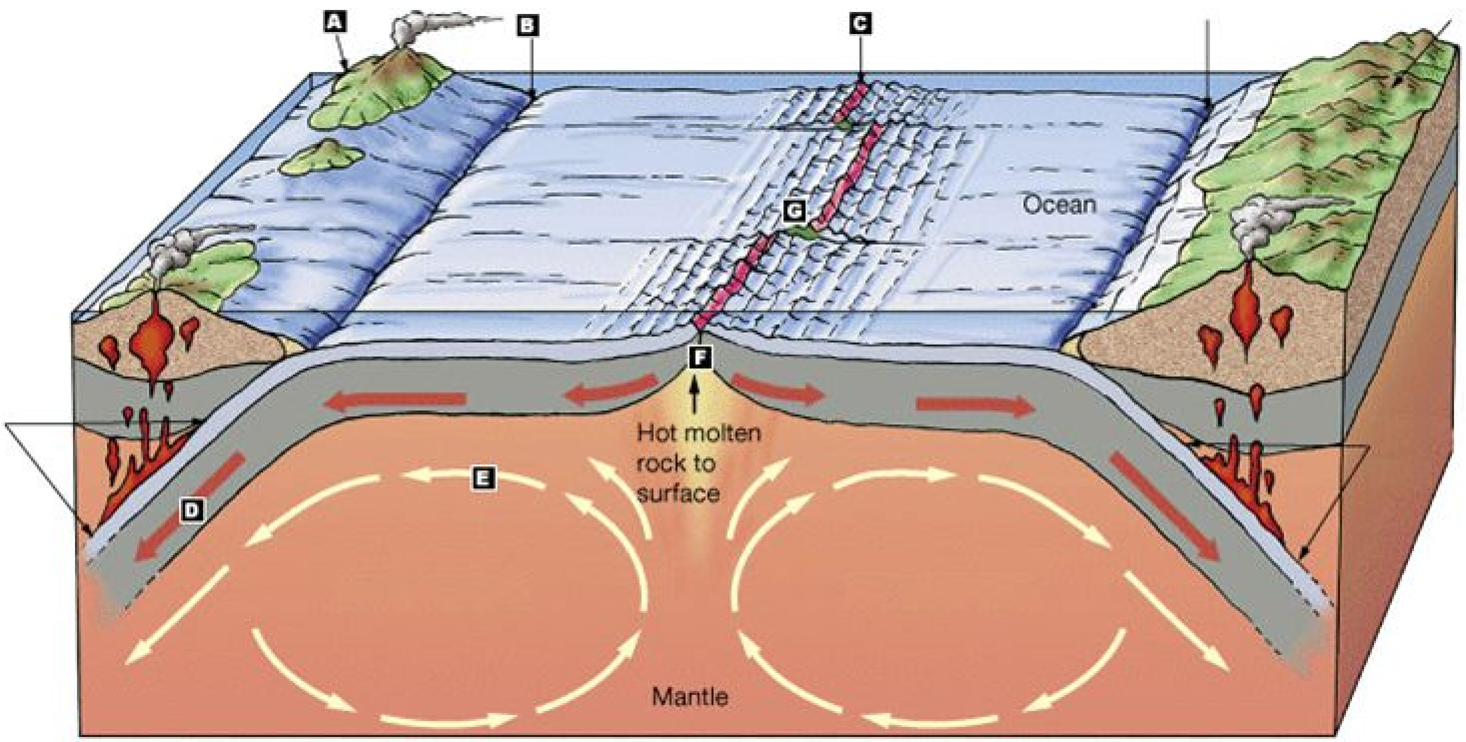
3.4 Subduction zones

- **Subduction under the continental lithosphere**:This occurs when the trench is next to the boundary of a continent. As a result of compression and volcanic activity , an Andean mountain range is formed.
- **Subduction under the oceanic lithosphere:** This creates an arc of volcanic islands on the upper plate.



3.5.Main concepts of plate tectonics

- The lithosphere is divided into great blocks, called plates, which cover the surface of the Earth and fit together like a jigsaw.
- Most of the Earth's internal geological activity happens at the boundary of the plates.
- The ocean floor is continually generated along the ridges and is destroyed by subduction in the trenches.
- Where the plate separate, the new oceans are creates. Where they collide, mountain ranges are lifted up.



THE OCEAN

4.1.The ocean floor

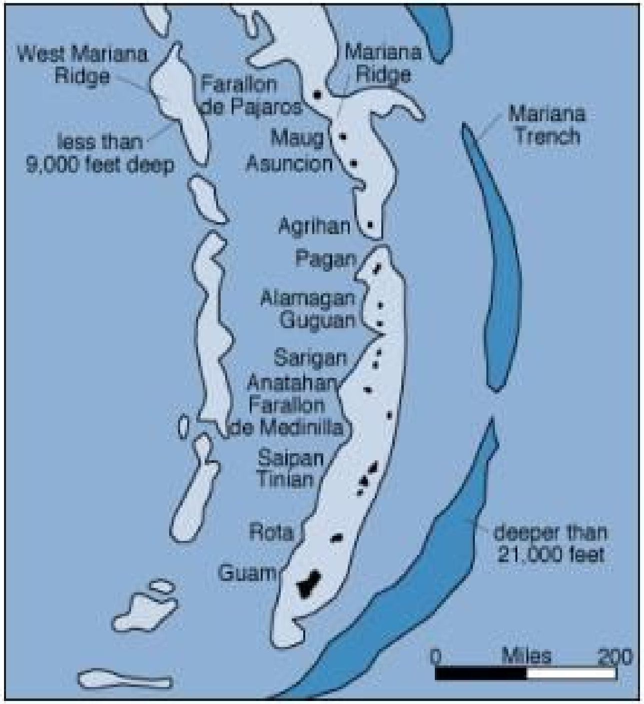
In the 60´s, scientists started to study the ocean floor. They discovered that at oceanic floor, there was seismic activity. It supports the theory of plate tectonics.

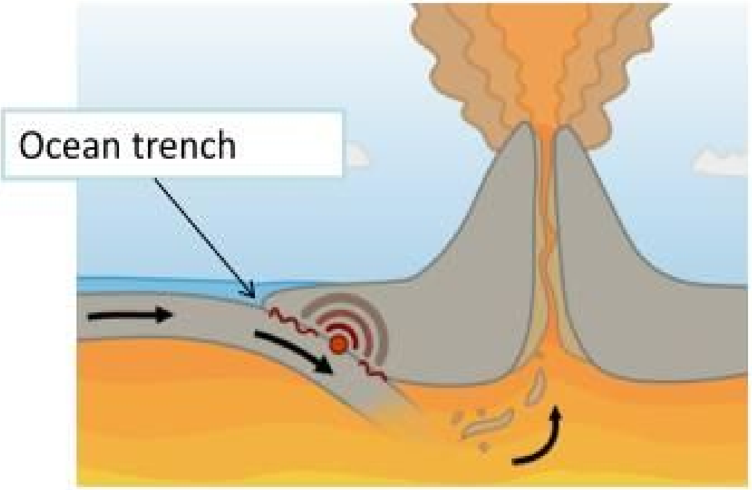
- **Landforms**
  - Mid-ocean ridge: This is an enormous mountain range more than 60000 Km long and up to 2000 Km wide which runs the lenght of the central zone of the oceans. For most of its length, it has a central channel known as a rift, crossed by perpendicular fractures, the transform faults.
  - Trenches: deep channels usually found next to continental boundaries or next to volcanic island arcs.
- **Composition**

  Made up of volcanic rocks covered in marine sediment => rocks very young.

Ocean trenches in more depth

- Form the deepest parts of the Earth
- Occur at **destructive (subduction) margins**
- As **oceanic plate** is subducted beneath the **continental plate** creates deep ocean trenches. The deepest ocean trenches are created by **oceanic-oceanic subduction**.





- **Mariana trench** is deepest part of the world's ocean.
- Created by the subduction of the **Pacific plate** beneath the **Mariana plate (oceanic-oceanic)**

4.2.Sea-floor spreading

Seafloor spreading happens at the bottom of an ocean as tectonic plates move apart (divergent boundaries). The seafloor moves and carries continents with it. At ridges in the middle of oceans, new oceanic crust is created.

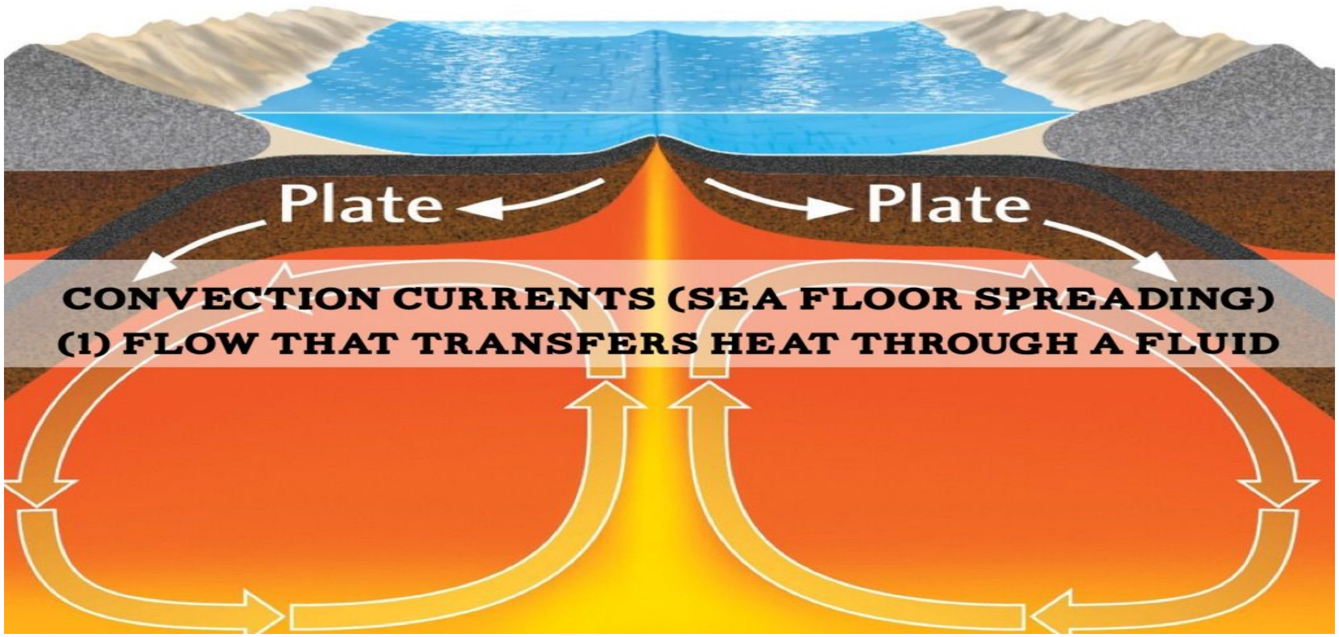
Lava covers the sediments on the limit of plates. Sediments are found next to the continents.

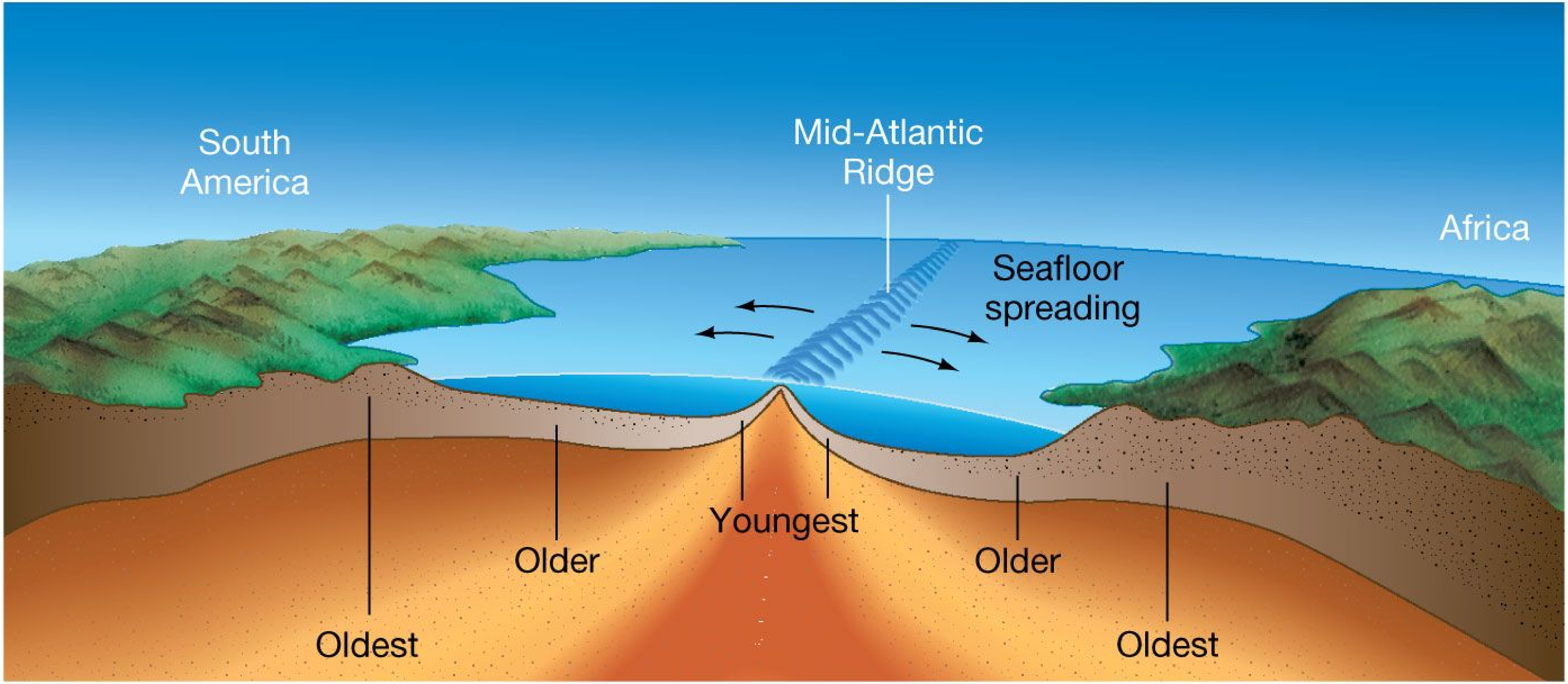
- Explains that moving away from either side of the ridge, the age of rocks increases (proof of this theory).

This creates new sea floor.

The nowadays accepted theory includes convection currents for explain this.

- ascendent currents: divergent forces.





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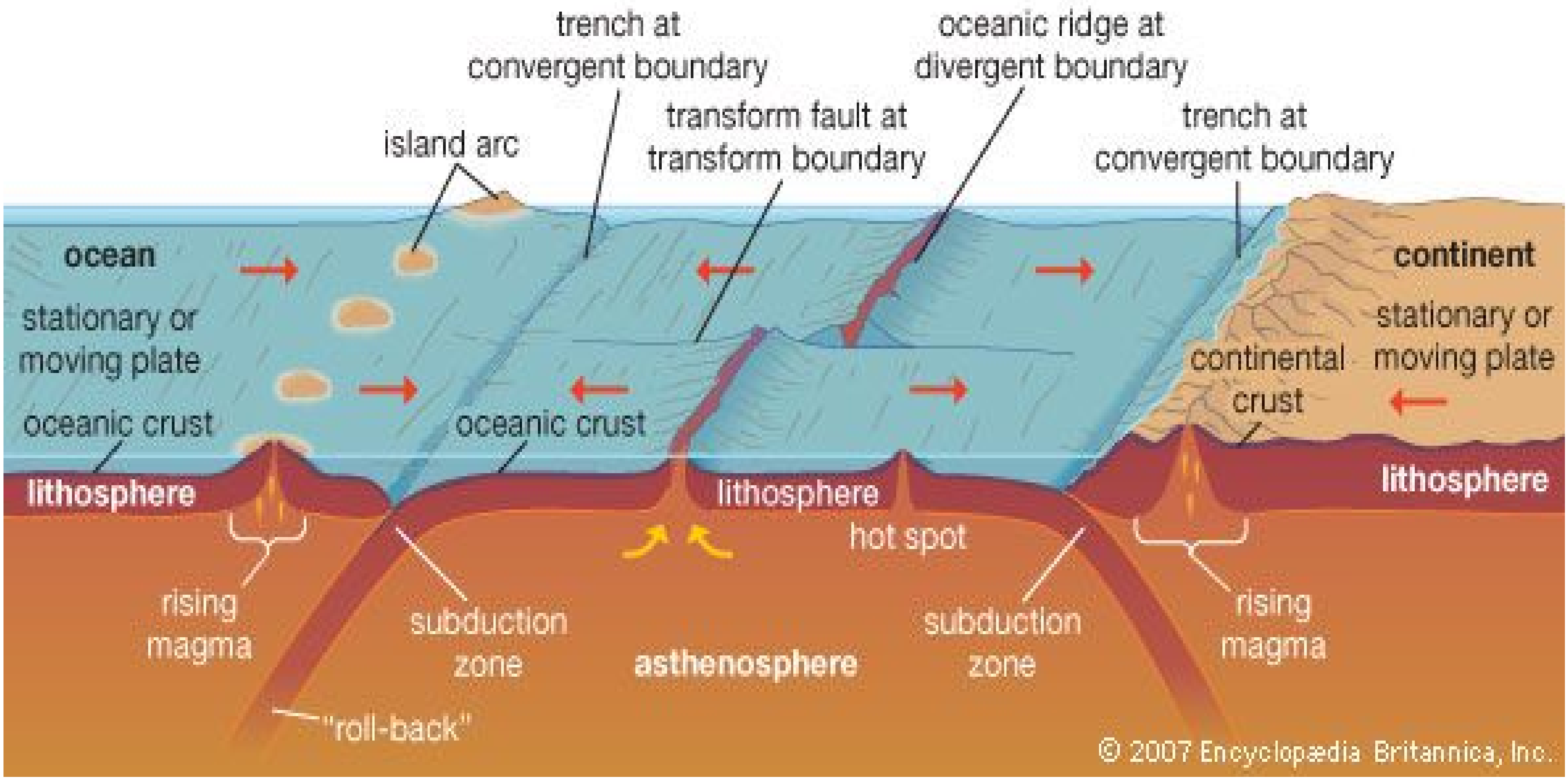

trench at
convergent boundary
oceanic ridge at
divergent boundary
island arc
transform fault at
transform boundary
trench at
convergent boundary
ocean
continent
stationary or
moving plate
stationary or
moving plate
continental
crust
oceanic crust
oceanic crust
lithosphere
lithosphere
lithosphere
hot spot
rising
magma
subduction
zone
asthenosphere
subduction
zone
rising
magma
"roll-back"
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THE MECHANISM BEHIND PLATE TECTONICS

5.1.Wilson cycle

Wilson, a Canadian geologist, said that there have been two cyclical processes of rifting and reuniting of supercontinents during Earth's history:

1) The heat under the continent causes the crust to expand and lift up. In the continental rift stage large fractures appear which make the lithosphere thinner and lead to the formation of a continental rift (for example the Rift Valley in Africa).

2) The narrow sea stage: the continent has completely split and separated. New oceanic lithosphere and a small ridge begin to form between the two sides.

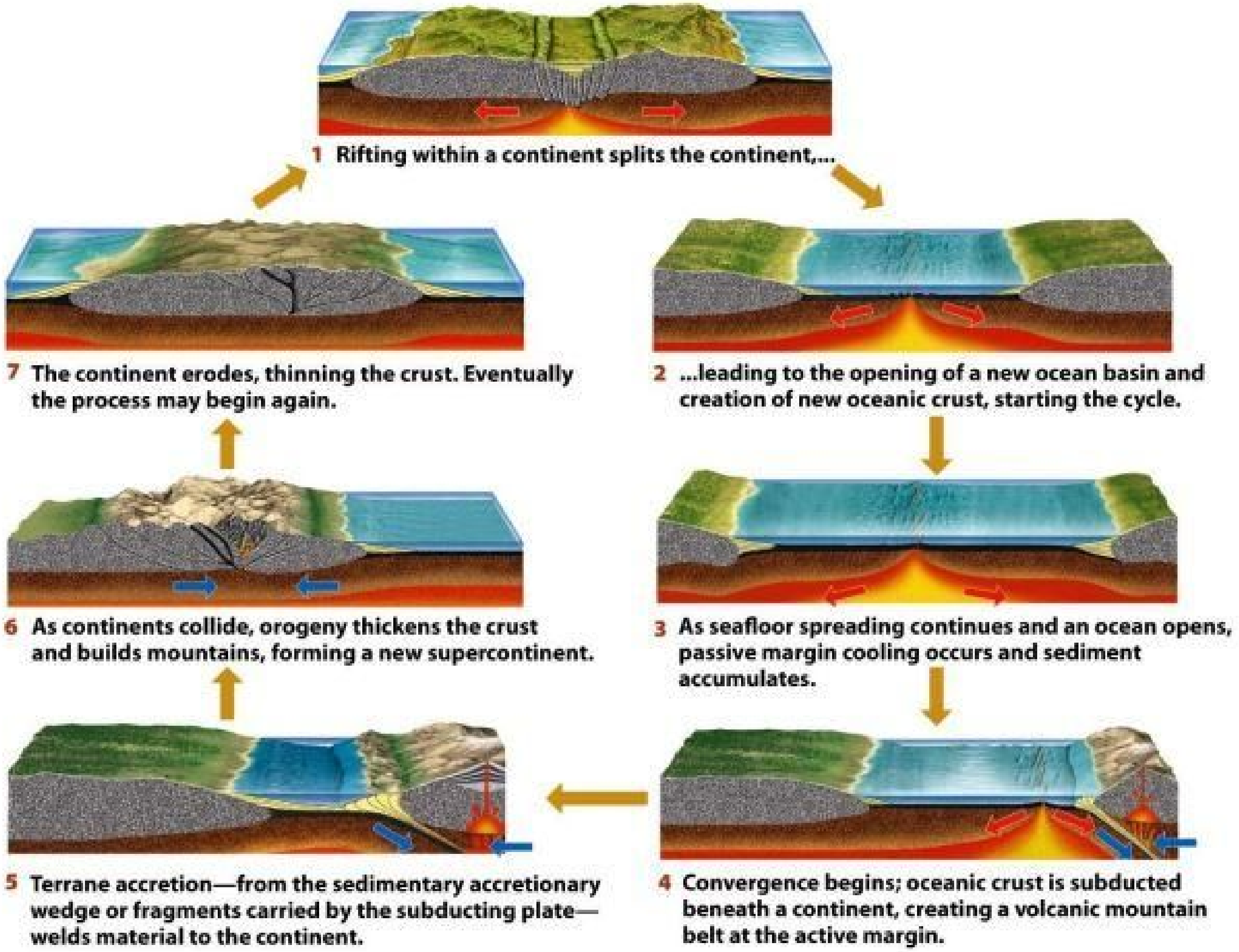
3) Maturing ocean stage: the divergence continues and the formation of oceanic lithosphere due to sea-floor spreading increases. The Atlantic Ocean is an example of this stage.

4) Shrinking ocean stage: the ocean begins to close because of subduction on its boundaries. The Pacific Ocean is currently at this stage in the cycle.

5) Convergence stage: the ocean has almost closed. The continents converge with marine sediment on their edges.

6) Continental collision stage: the boundaries of both continents and the sediment trapped between them are deformed.

7) Final stage: the continent masses are joined together and a mountain range is formed from the collision of the continents. Eventually the plate boundary will become inactive.



5.2. The evolution of plate tectonics

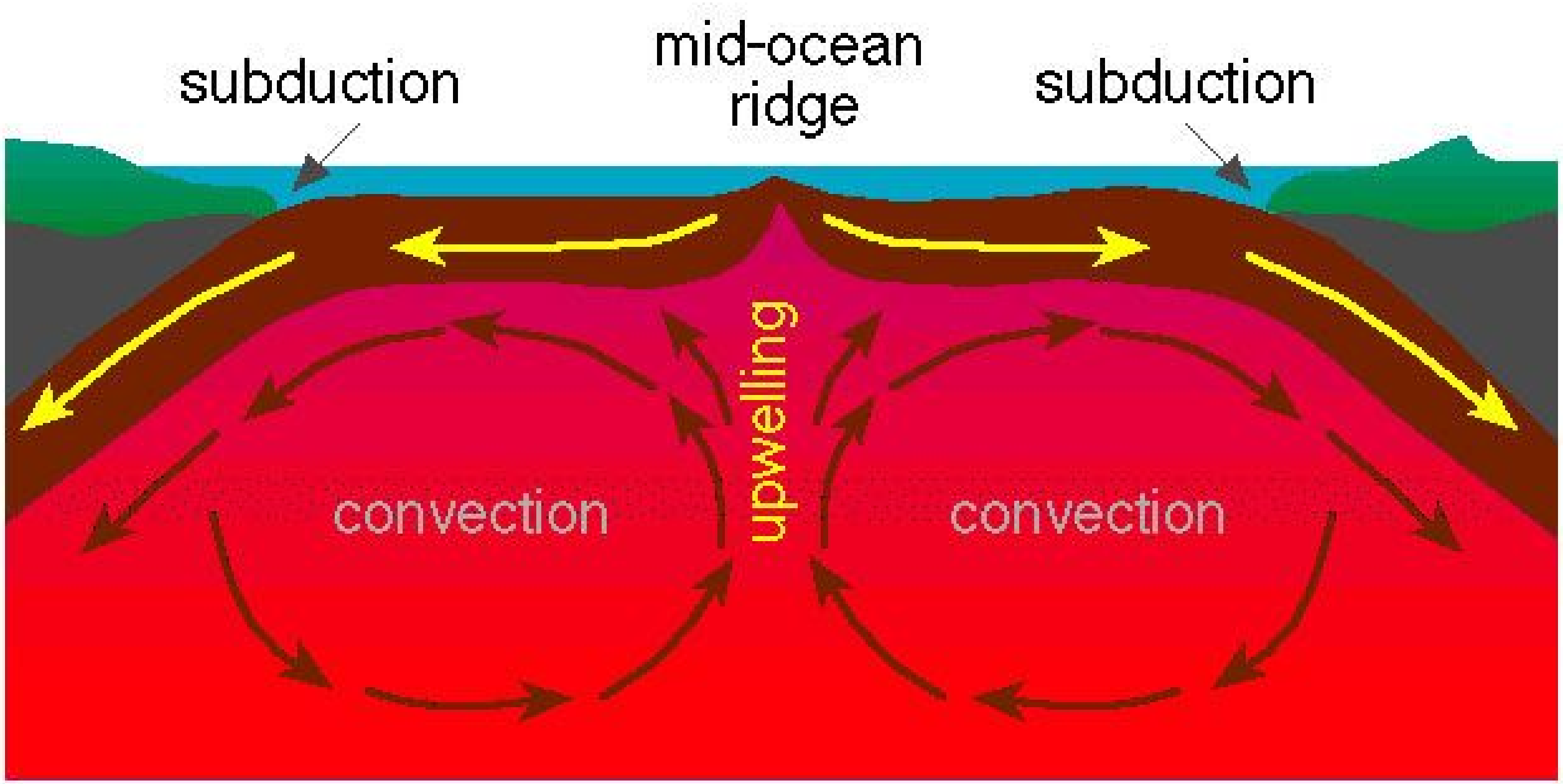
Original or classic explanation

-Convection currents in the asthenosphere cause tectonic plate movement.

-The lithosphere floats on the asthenosphere.

-In the areas where hot currents ascend and separate, ridges are formed.

-In the areas where currents cool and descend, trenches are formed.

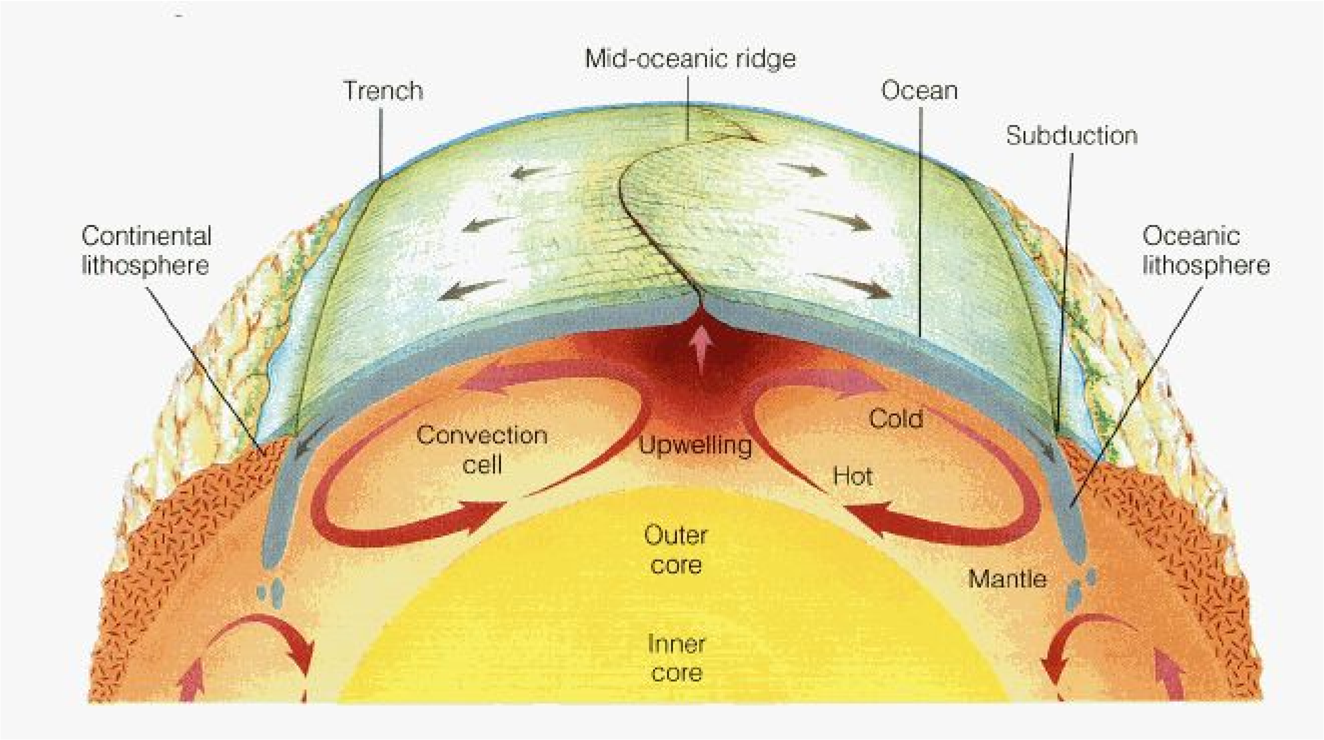


Current explanation

- The asthenosphere is not the only place where convection happens; currents have been detected throughout the whole mantle:

 -Below subduction zones, where cold currents transport plate fragment down towards the lower mantle.

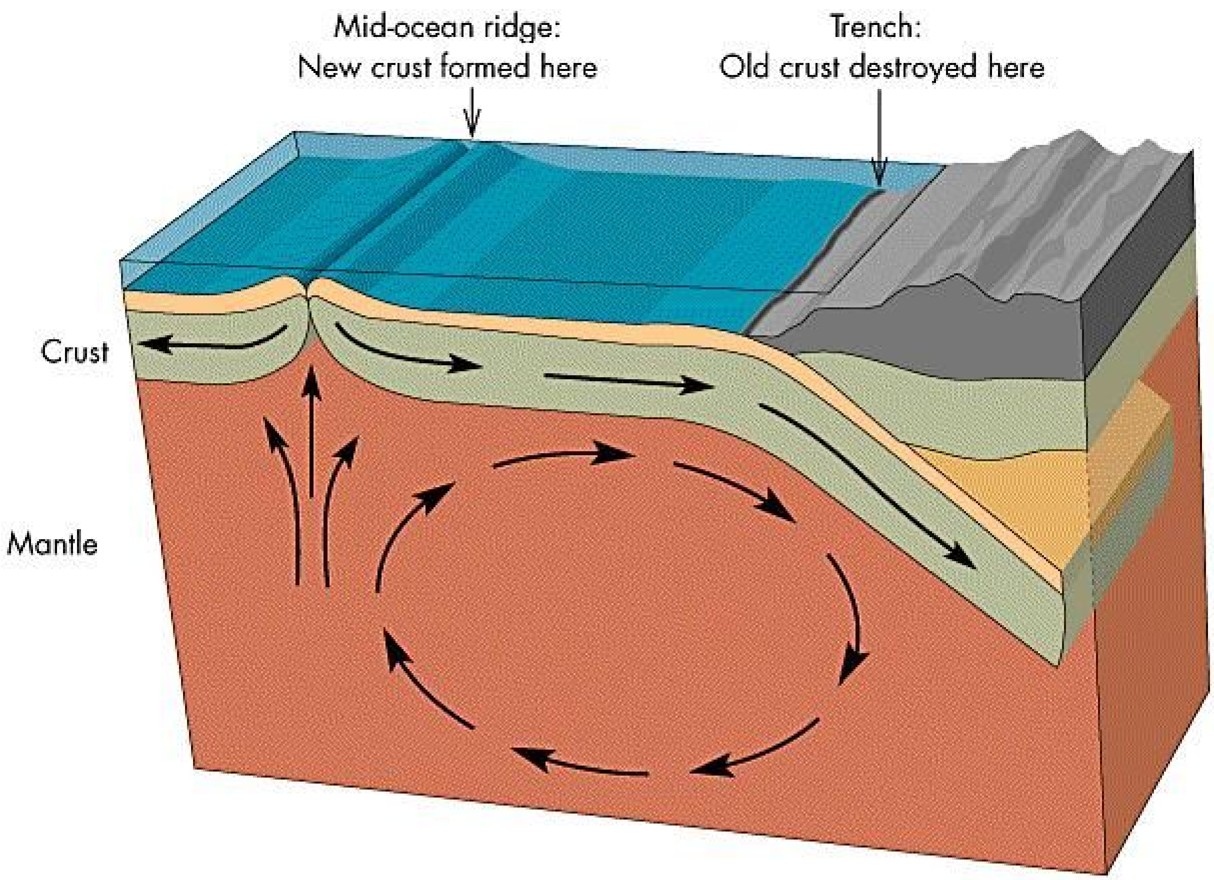
 -Hot currents from the mantle occasionally rise up through hot spot rather than through ridges.



- In addition to convection currents, there are two forces which cause movement in the lithosphere:

-On elevated ridges, the force of gravity pulls down on both sides of the lithosphere.

-Once a plate is being subducted, the weight of the sinking plate pulls it down lower.



5.3.Global tectonics

The development of the theory of plate tectonics caused a real scientific revolution, which resulted in a fast and radical change to the previous theories about the position of continents.

Plate tectonics is also known as global tectonics because it explains the relationship between many geological phenomena, which previously didn't seen to have a commom origin:

-volcanic activity

-earthquakes

-distribution of continents and oceans in space and time

-the formation of mountain ranges

-the formation and destruction of the ocean floor

-the location of mineral desposits and fossil fuels.