UPSC PATHSHALA

PHYSICAL GEOGRAPHY

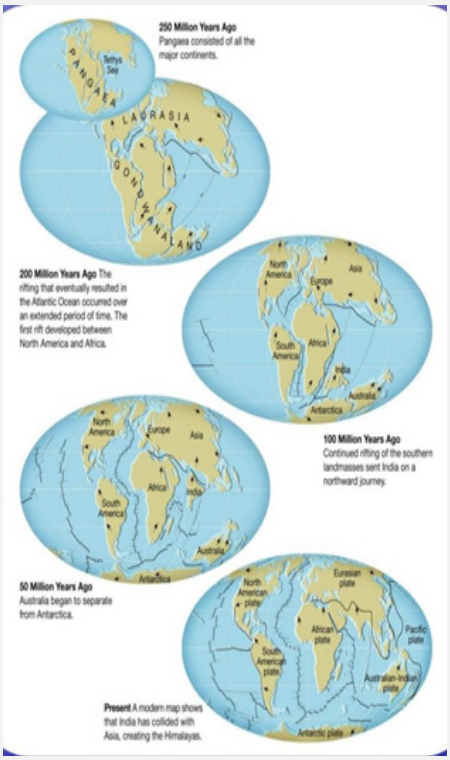
CHAPTER

3

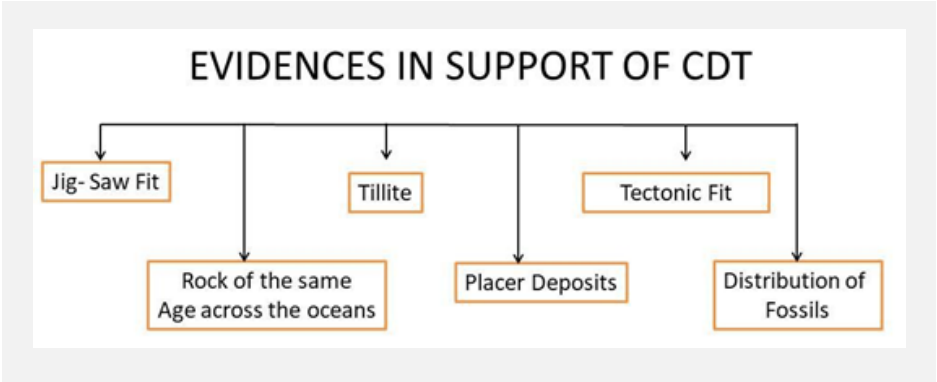
Plate Tectonics

CONTINENTAL DRIFT THEORY

- ***It was put forward by Alfred Wegener in 1912.***
- According to Continental Drift Theory, all the continents formed a single continental mass named **Pangaea** and a mega-ocean called **Panthalassa**.
- Around 200 million years ago, the supercontinent Pangaea began to split into two large continental masses.
- The space created between the two continents got filled by the water by a sea named **Tethys**.
- The continent to the north of Tethys was called **Laurasia** while the one in the south was called **Gondwanaland**.
- Subsequently even these continents started breaking down to smaller continents to form that exist today.

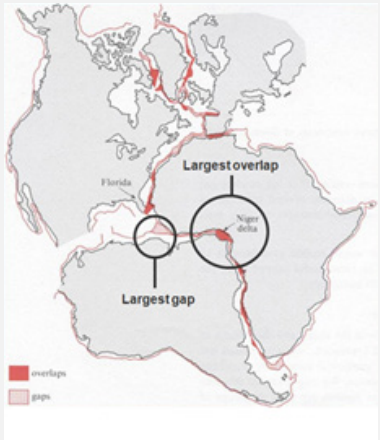


EVIDENCE IN SUPPORT OF THE CONTINENTAL THEORY



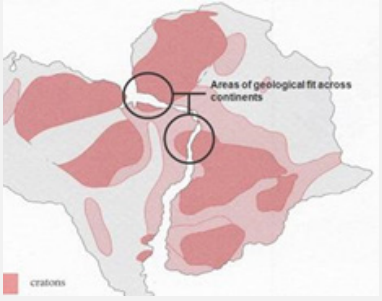
1. The matching of the continents (Jig- Saw Fit)

- This is one of the strongest evidences of Continental Drift Theory (CDT).
- The similarity in the outline of the coastlines of eastern South America and West Africa had been noted for some time. The best fits are obtained if the coastlines are matched at a depth of 1000m below current sea level.
- The gaps or overlaps found in any region can be explained by
  1. Coastal erosion since the continental separation
  2. Coastal deposition since the continental separation

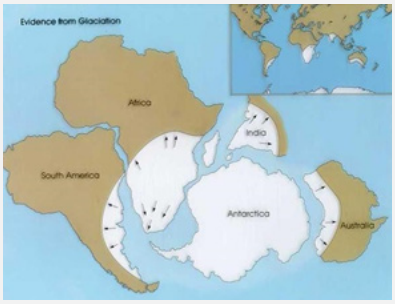


2. Rocks of same age across the ocean

- When the geology of the eastern South America and West Africa was mapped it revealed that ancient rock outcrops (cratons) over 200 million year old were continuous from one continent to the other.



3. Tillite



- Tillite is the sedimentary rock formed out of deposits of glaciers.
- Today these tillites which were formed around 300 million year ago are found in Antarctica, Africa, South America, India and Australia (southern Hemisphere).
- This suggests that an ice sheet extended from the South Pole to the equator.

4. Placer Deposit

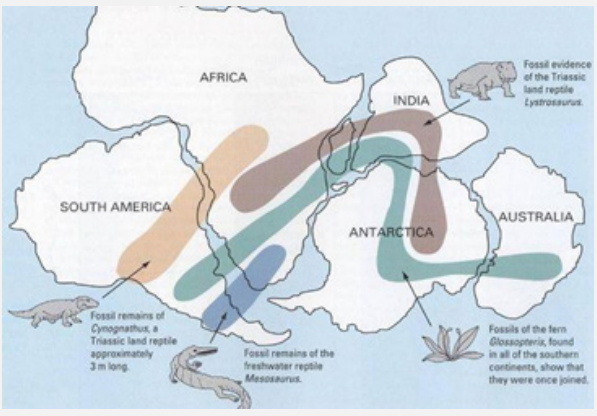
- The occurrence of rich placer deposits of gold are found in Ghana (Africa) but its source (gold bearing Veins are not found in Africa but in South America.
- This suggests the gold deposits are derived from South America when the continents lay side by side.

5. Tectonic Fit

- Fragments of an old fold mountain belt between 450 and 400 million year ago are found on widely separated continents today.
- Pieces of the Caledonian fold mountain are found in Greenland, Canada, Ireland, Scotland and Scandinavia.
- When these land masses are re-assembled the mountain belt forms a continuous linear feature.

6. Distribution of Fossils

- When identical species of plants and animals adapted to living on land or in fresh water are found on either side of the marine barriers, suggesting the continents were once joined.
- Lemurs are found in India, Madagascar and Africa leading to the conclusion that a continuous landmass 'Lemuria' linking all the three land masses must be present at one point in time.
- Remains of Mesosaurus, a freshwater



crocodile-like reptile, are found in South America and Brazil. It would have been physiologically impossible for Mesosaurus to swim in marine water present between the continents suggesting both places were joined together.

FORCES RESPONSIBLE FOR DRIFTING

- ***Wegener proposed two forces that drive the continental theory:***

1. **Pole fleeing force**-As earth is rotating, it creates a force similar to centrifugal force. It is this force that is causing continents to move from the poles towards the equator.

2. **Tidal force**- the force generated due to the attraction of moon and sun is responsible for slowly moving the continents.

- However, later these two forces were found to be insufficient reasons for drifting of the continents and hence Wegener's theory was criticized.

SEA FLOOR SPREADING

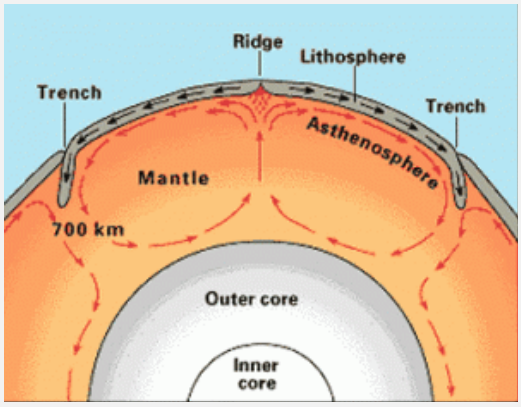
- ***This theory was proposed by Henry Hess in 1961. It is importance because:***
- It proves continental drift theory to be true.
- It explains the present distribution of ocean and continents.
- It also helps to understand the distribution of earthquakes, volcanoes, folds and faults.

The information which helped formulize sea-floor spreading are

1. Convectional current theory
2. Paleomagnetic studies

CONVECTIONAL CURRENT THEORY

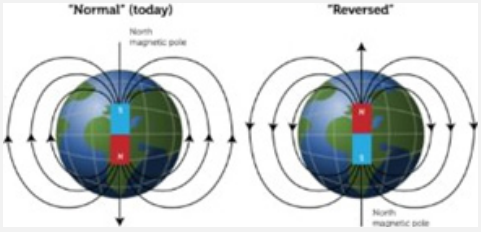
- ***This theory was proposed by Arthur Holmes in the 1930s.***
- He proposed that the continents are carried by the flow of the mantle on which they sit and that the mantle is convecting.
- He suggested that rocks in the interior of the Earth would buoyantly rise towards the surface from deep within the Earth when heated by radioactivity and then sink back down as they cooled and became denser.
- Wherever rising limbs of these currents

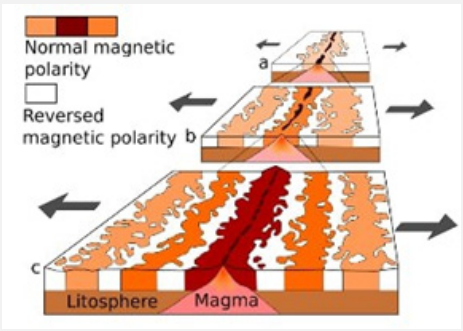


meet, oceanic ridges are formed on the seafloor and wherever the falling limbs meet, trenches are formed.

PALEOMAGNETISM

- Paleomagnetism is the study of Earth's magnetic fields with the help of magnetic fields recorded in the rocks.
- The rising magma assumes the polarity of the Earth's geomagnetic field at the time before it solidifies on the oceanic crust.
- Rocks closer to the mid-oceanic ridges have a normal polarity and are the youngest. As the convection currents pull the oceanic plates apart, the solidified band of the rocks moves away from the ridge and a new band of rocks takes its place a few million years later when the magnetic polarity of the Earth is reversed.
- The process repeats itself and we get alternating patterns of magnetic striping on the sea-floor.





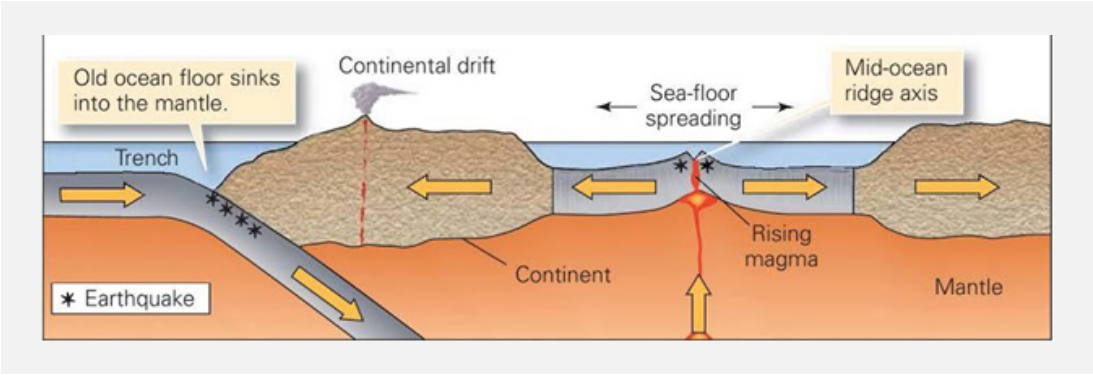
Based on the above two theories, Hess postulated the Sea-floor spreading theory.

- He argued that constant eruptions at the crest of oceanic ridges cause the rupture of the oceanic crust and the new lava wedges into it, pushing the oceanic crust on either side.
- The ocean floor thus spreads and also drifts apart the continents. For Example, the Mid –Atlantic Ridge is believed to be moving at the rate of 1-2 cm per year, thus increasing the breadth of the ocean basin twice that amount.
- Wherever continents are bordered by trenches, the ocean floor is plunged downwards and ultimately dissolving in earth's mantle from which it had originated.

PLATE TECTONIC THEORY

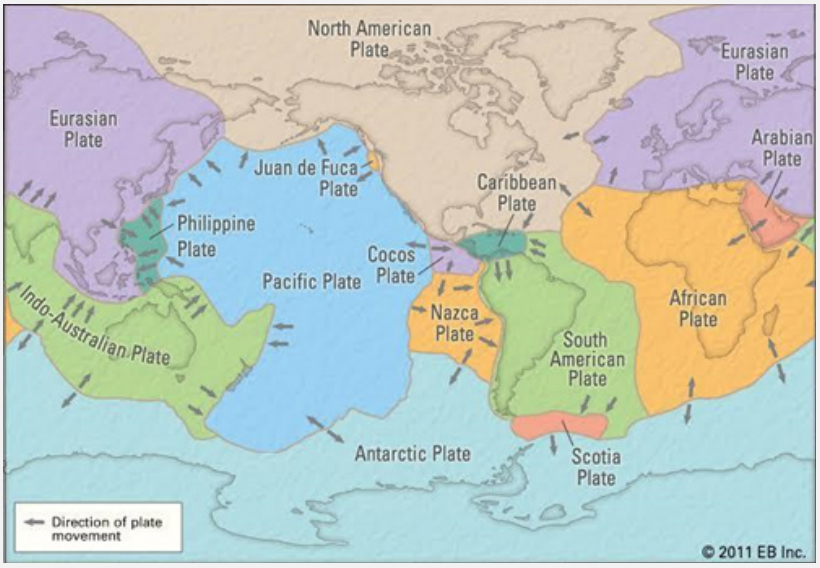
- By combining the sea-floor spreading theory with the continental drift and the information on global seismicity, the new theory of Plate tectonic was put forward to explain the crustal movements.
- It was independently proposed by McKenzie and Parker and Morgan.
- According to the theory, the lithosphere (includes crust and top mantle) is about 100km thick and it lies and floats above a plastic layer (moldable, partial molten) called an asthenosphere.
- The lithosphere plate or the tectonic plate consists of both the continent and oceanic lithosphere.
- A plate is a continental plate if its larger portion is above the ocean. Its thickness can be 200 km.

- A plate is an oceanic plate if its larger portion is under water. Its thickness
- varies from 5-100 km.



MAJOR AND MINOR TECTONIC PLATES

The tectonic theory proposes that the earth's lithosphere is divided into seven major plates and several minor plates.



Major plate

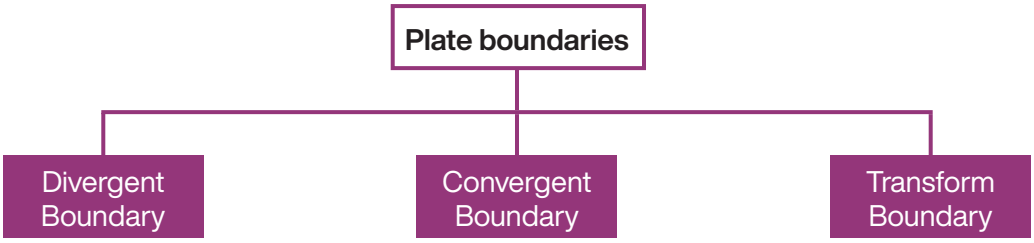
1. Antarctica and surrounding area
2. North American plate
3. South American plate
4. Pacific plate
5. India-Australia- New Zealand Plate
6. African plate
7. Eurasian plate

Minor plate

1. Cocos Plate
2. Nazca Plate
3. Arabian Plate
4. Philippines Plate
5. Caroline Plate
6. Fuji Plate
7. Juan De Fuca Plate
8. Caribbean Plate

TYPES OF PLATE BOUNDARY

Plate boundaries can be categorized in three fundamental types-



Plates separate and move in opposite directions ie. away from each other are called divergent boundaries.

- They allow new lithosphere to form from the upwelling magma.
- This either occurs at mid-ocean ridges (sea-floor spreading) or at rifted continental margins.
- During continental rifting, the continental crust is stretched and thinned. This extension produces shallow focus earthquakes and rift valleys.

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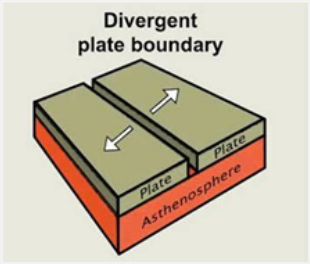
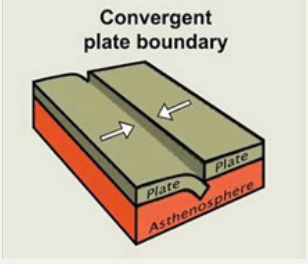
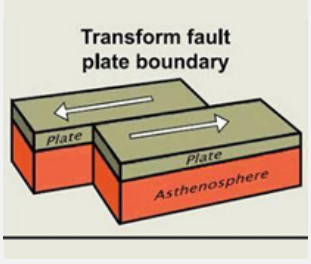
When the plates move horizontally past each other then it is a transform boundary. Here neither the crust is created nor destroyed.

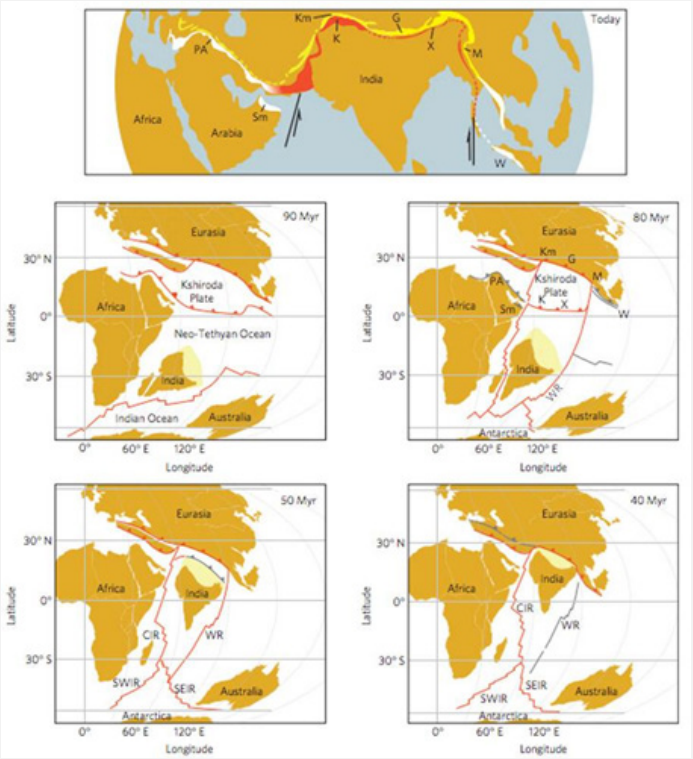






MOVEMENT OF INDIAN PLATE

Presently the Indian tectonic plate is located in the north east hemisphere. It is bounded by 4 major tectonic plates. Eurasian plate in the north, Australian plate in the south east, African plate to the south-west and Arabian plate to the west.



- More than 140 million year ago, India was a part of an immense supercontinent called Gondwana, which covered much of the southern hemisphere.
- Around 120 million years ago, there was a break in Gondwana and Indian plate started moving northwards. Initially the speed was slow but around 80 million years ago it moved at a high velocity of 15-20 cm per year.
- Around 60 million years ago, during the north movement of Indian plate, a major event that occurred was the outpouring of lava and formation of Deccan Traps. It continued for a long period of time by now it has crossed the equator and entered the northern hemisphere.
- About 50 million years ago, Indian plate collided into the Eurasian Plate and resulted in the formation of Himalayan mountain chain. Himalayas are called young mountains because they are rising even to this date.
- A present topographical map of the subcontinent will reveal that the merging mountain ranges run across parts of Pakistan, China, India, Nepal, Bhutan before ebbing away into the sea once again near the Myanmar-Thailand border area- all along the boundary of Indian plate.
- As Indian plate is still active today and drifts, earthquakes occur in the northern part of the plate.