Distribution of Oceans and Continents [UPSC Geography Notes]

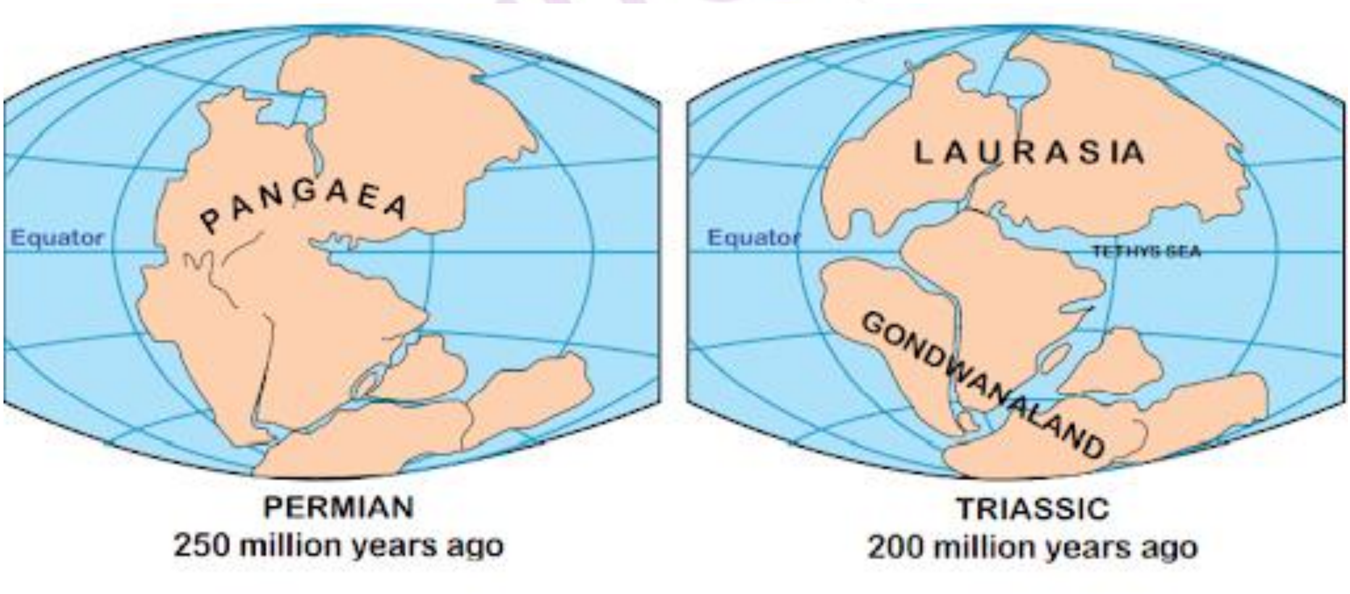
Geography is an important part of the UPSC syllabus. In this article, you can read all about the distribution of oceans and continents on planet earth, continental drift theory, and other theories. This is an important topic for the UPSC exam.

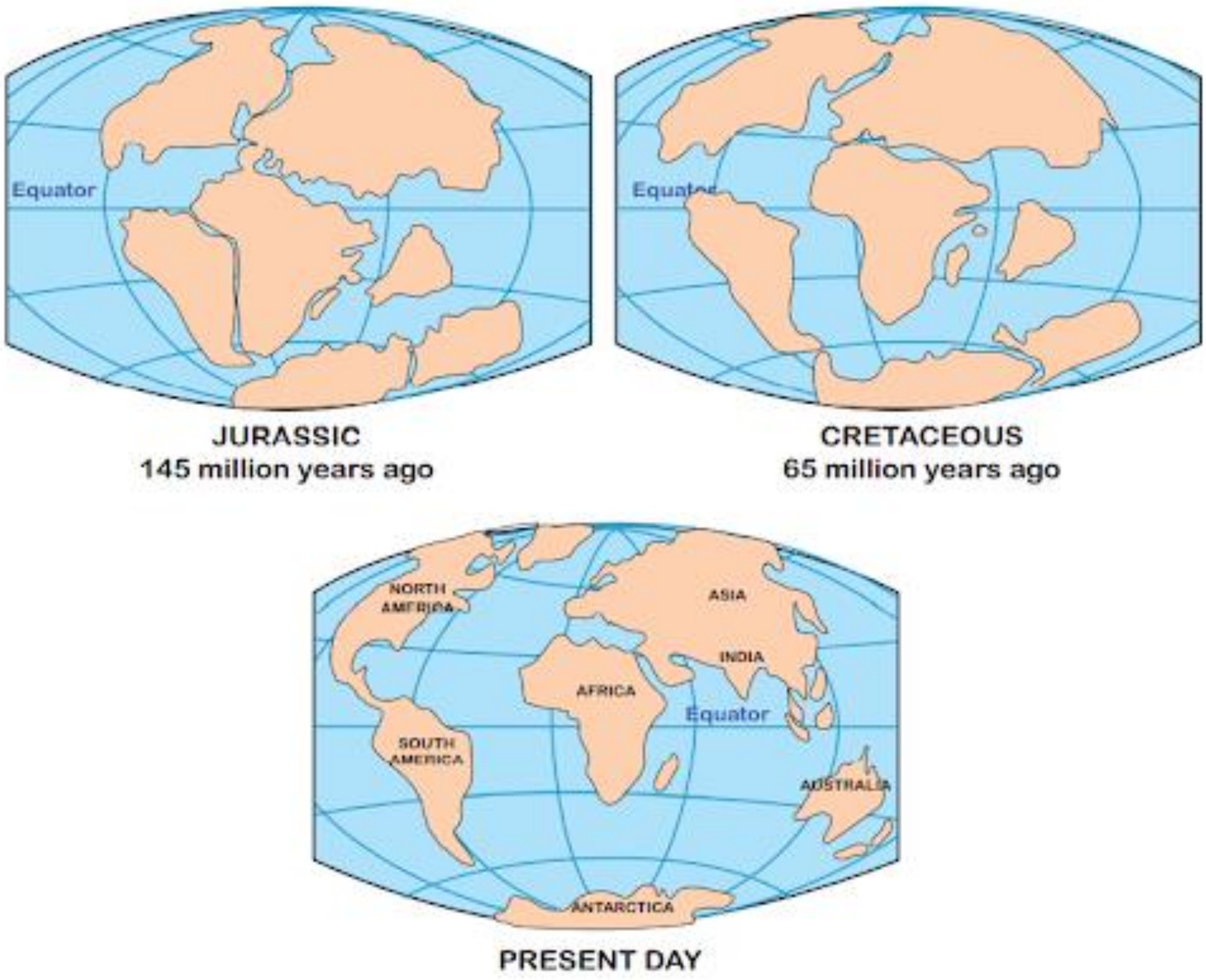
Continental Drift Theory

The continents cover about 29% of the total surface area of the earth and the rest, 79%, is covered by oceans. It is a well-accepted fact that the positions of the continents and the oceans have not been the same in the past and they will not continue to have their present positions in times to come.

In 1912, Alfred Wegener, a German meteorologist put forth a comprehensive argument in the form of "The Continental Drift Theory" regarding the distribution of the oceans and the continents.

- According to him, all the continents once were together forming a single continent. About 250 million years ago, the earth was made up of a single landmass (supercontinent) called Pangaea (meaning "all lands") and a single ocean surrounding it called Panthalassa (all water). He argued that around 200 million years ago, the supercontinent Pangaea began to split. Pangaea first broke into two large continental masses namely Laurasia in the north and Gondwanaland in the south. Laurasia further broke into Eurasia and North America. Gondwanaland split into Africa, South America, Antarctica, Australia and India.





Evidence to support Continental Drift Theory

The continental drift theory is supported by the following evidence -

1. The corresponding edges of the continents fit together. For example, the western side of Africa and the eastern side of South America fit together.
2. The belt of ancient rocks from Brazil's coast matches with those from western Africa. The earliest marine deposits along the coastline of South America and Africa are of the Jurassic age which clearly suggests that the ocean did not exist prior to that time.
3. Tillite is the sedimentary rock formed out of deposits of glaciers. The Gondwana system of sediments from India is known to have its counterparts in different landmasses of the Southern Hemisphere - Africa, Falkland Island, Antarctica, Madagascar and Australia. The resemblance of Gondwana type sediments clearly indicates that these landmasses had remarkably similar histories. These glacial tillites provide evidence of palaeoclimates and also of drifting of continents.
4. Certain identical rare fossils have been found on different continents. For example, the fossils of Mesosaurus (a small Permian reptile) have been found only in Africa and Antarctica. The fossils of a fern tree have been found only in India and Antarctica.

5. The rich placer deposits of gold occur on the Ghana coast, however, there is no source rock in the region. The gold-bearing veins are in Brazil and it suggests that the gold deposits of Ghana are derived from the Brazil plateau when the two continents lay side by side.

Force for Drifting of Continents

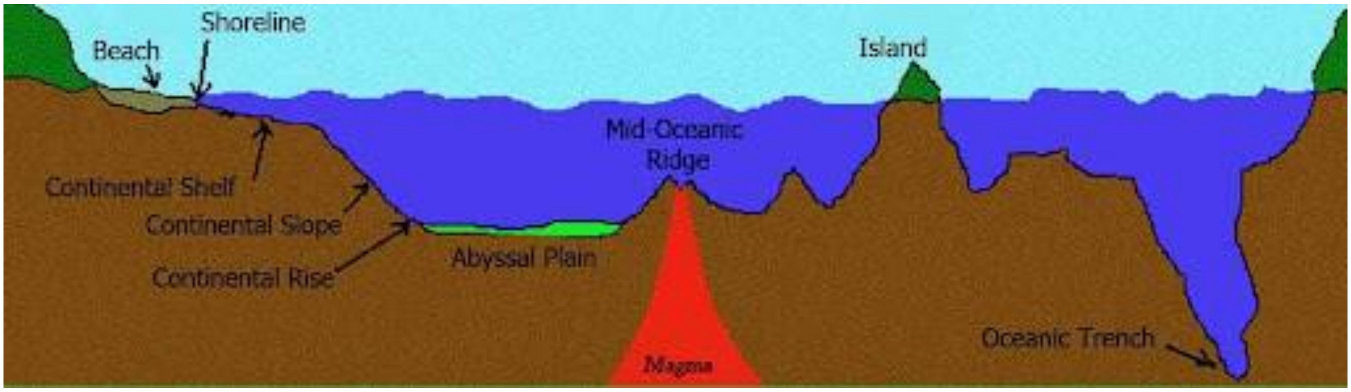
According to Wegener, two forces are responsible for the drifting of the continents -

1. The polar-fleeing force which is due to the rotation of the earth and,
2. The tidal force which is due to the attraction of the moon and the sun that generates tides in oceanic waters.

However, many scholars considered the above forces to be inadequate.

Post-Continental Drift Studies

- **Convectional Current theory -** According to Arthur Holmes (1930s) convectional currents operate in the mantle portion. These currents develop due to radioactive elements which cause thermal differences in the mantle portion. This was an attempt to provide an explanation to the issue of force, on the basis of which contemporary scientists discarded the continental drift theory.
- **Mapping of the Ocean Floor -** Expeditions to map the oceanic floor (post World War II) gave a detailed view of the ocean relief and revealed the existence of submerged mountain ranges as well as deep trenches, mainly located close to the continental margins. The mid-oceanic ridges were found to be most active in terms of volcanic eruptions. The dating revealed that the rocks present in the oceanic crust are much younger than the continental regions. Rocks on either side of oceanic ridges and having equidistant positions from the crest were found to have remarkable similarities in terms of the period of formation, chemical composition and magnetic properties. Rocks closer to the mid-oceanic ridges have normal polarity and are the youngest. The age increases as we move away from the crest.
- **Ocean Floor Configuration -** On the basis of depth and relief, the ocean floor is divided into three main parts. These are:
    1. Continental Margins - These include continental shelf, continental slope, continental rise and deep oceanic trenches. These form the transition between continental shores and deep sea basins.
    2. Abyssal Plains - These are regions where the continental sediments that move beyond the margins get deposited. These are extensive plains between continental margins and mid-oceanic ridges.
    3. Mid-Oceanic Ridges - This is an interconnected chain of mountain systems within the ocean. It consists of a central rift system at the crest, a fractionated plateau and flank zone all along its length. The rift system at the crest is the zone of high volcanic activity.



Sea Floor Spreading

Post drift studies and a detailed analysis of magnetic properties of the rocks on either side of the mid-oceanic ridge led Hess (1961) to propose his hypothesis, known as the "sea floor spreading". According to him, the frequent eruptions at the crust of the oceanic ridges cause rupture of the oceanic crust and the new lava merges with it, pushing the oceanic crust on either side. This way, the oceanic floor spreads. The fact that the oceanic crust is younger and also the spreading of one ocean does not lead to the shrinking of the other made Hess consider the consumption of the oceanic crust. He argued that the ocean floor gets pushed due to volcanic eruptions at the crust, sinks down at the oceanic trenches and thereby, gets consumed.

Plate Tectonics

In 1967, McKenzie and Parker, and Morgan independently formulated a theory called "plate tectonics". The earth's surface is composed of rigid lithospheric slabs (both continental and oceanic) technically called "plates". These lithospheric plates are also called crustal plates or tectonic plates. The word "tectonic" is derived from the Greek word 'tekton' meaning builders. These plates move horizontally over the asthenosphere as rigid units. A plate may be called the continental plate or oceanic plate depending on which of the two occupy a larger portion of the plate. For example, the Eurasian plate is called a continental plate and the Pacific plate is largely an oceanic plate.

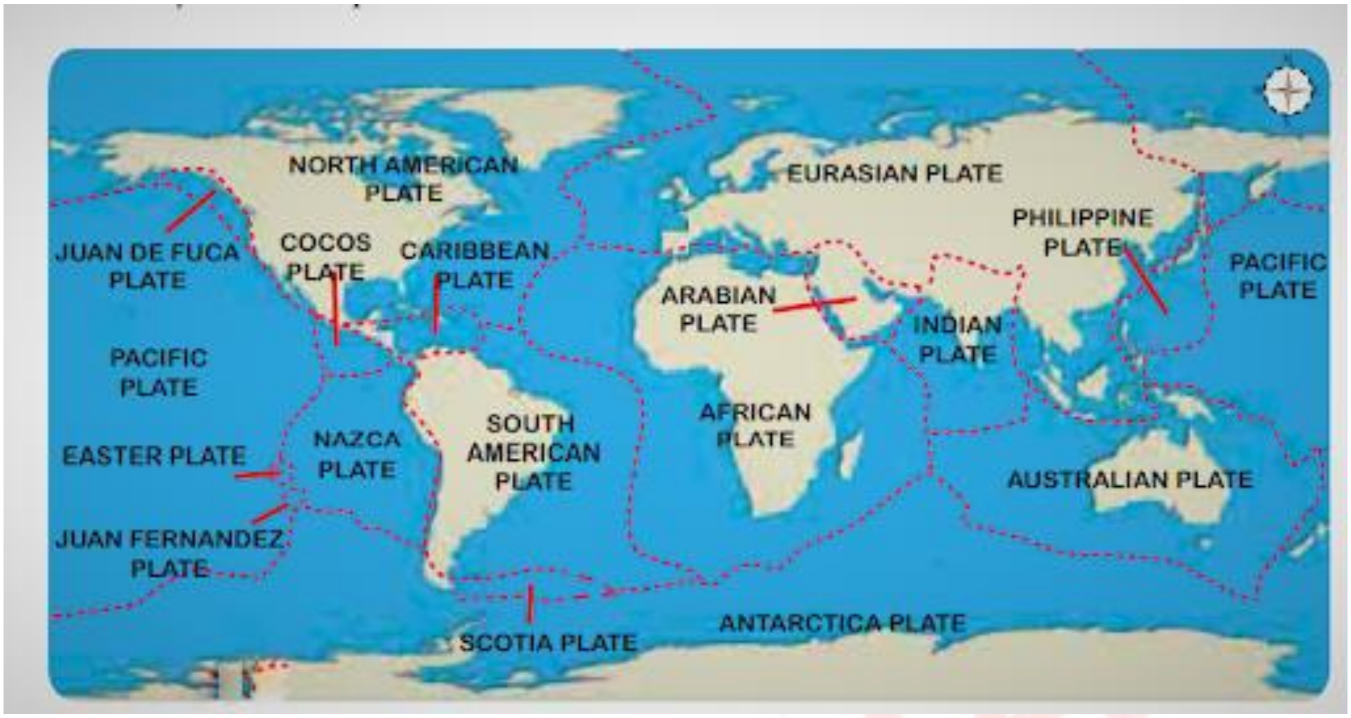
- According to the theory of plate tectonics, the earth's lithosphere is divided into seven major and several minor plates. The major plates are surrounded by folded mountains, ridges, trenches and faults. The movement of the plates builds stress which leads to folding, faulting and volcanic activities.

The seven major plates are -

- Antarctica and the surrounding oceanic plate.
- Pacific plate.
- India- Australia- New Zealand plate.
- Africa with the eastern Atlantic floor plate.
- Eurasia and the adjacent oceanic plate.
- North American plate and
- South American plate.

Some important minor plates are -

1. Nazca plate - between South America and Pacific plate.
2. Arabian plate - mostly the Saudi Arabian landmass.
3. Cocos plate - between Central America and Pacific plate.
4. Philippine plate - between the Asiatic and Pacific plate.
5. Fuji plate - North-east of Australia.
6. Caroline plate - between the Philippine and Indian plate (North of New Guinea).



Major and Minor Plates

- All the plates have moved in the geological past and shall continue to do so in the future as well. Pangaea was a result of the converging of different continental masses that were parts of one or the other plates. Using the paleomagnetic data scientists have been able to determine the positions of different continental landmasses in different geological periods.
- GNSS (Global Navigation Satellite System) measures the speed of the plate movements. The rate of plate movements varies considerably. For example, the arctic ridge has the slowest rate, less than 2.5 cm/ yr and the East Pacific rises in the South Pacific moves at a faster rate of more than 15 cm/yr.
- Convection cell/Convective flow - The plate movements are caused by the convection cells. Convection cell is the circulation of molten materials caused by the heat derived from the core. Heat within the earth comes mainly from two sources - radioactive decay and residual heat. The slow movement of the hot, softened mantle that lies below the rigid plates is the driving force behind the plate movement. The plate movements cause the formation of folds, faults, earthquakes and volcanoes to occur.

There are three main types of plate boundaries - Divergent boundaries, Convergent boundaries and Transform boundaries.

- **Divergent Boundary -**
  - Divergent plate boundary is the margin where the two plates move apart from each other. The sites where the plates move away from each other are called spreading sites. A fissure is created when the oceanic lithosphere separates along the oceanic plate boundary. The gap is filled by magma that rises from the asthenosphere.
  - The magma cools and solidifies to create a new oceanic crust. Hence, the divergent plate boundary is also termed as “constructive plate boundary”. It is also called an accreting plate margin.
  - Divergent boundaries within continents initially form rifts which eventually become rift valleys e.g., the African Rift Valley in east Africa. Most of the active divergent plate boundaries occur

between the oceanic plates and exist as mid-ocean ridges. The Mid-Atlantic Ridge is an ideal example of a mountain ridge in the Atlantic Ocean. It is the longest mountain ridge in the world.

- **Convergent Boundary -**
    - Convergent plate boundary is the margin where two plates collide with each other. The location where the sinking of a plate occurs is called a subduction zone. There are three ways in which subduction can occur. These are between an oceanic and continental plate, between two oceanic plates and between two continental plates.
    - A trench is formed when the oceanic plate slides down underneath the continental plate as the oceanic plate is denser than the continental plate. For example, the Mariana Trench in the Pacific Ocean (deepest trench in the world) is formed when the Pacific plate sinks down the Eurasian plate. It is about 10.99 km deep.
    - The convergent boundaries can also give rise to fold mountains. For example, the Himalayas were formed due to the collision of the Indian Plate with the Eurasian Plate. The zone marking the boundary of the two colliding plates is known as the suture line.
- **Transform Boundary -**
    - Transform plate boundary is the margin where two plates move side by side. The lithosphere is neither created nor destroyed by the transform plate boundary. Hence, it is called the conservative or passive plate boundary.
    - The San Andreas Fault, California is a transform boundary that separates the North American plate and Pacific plates.

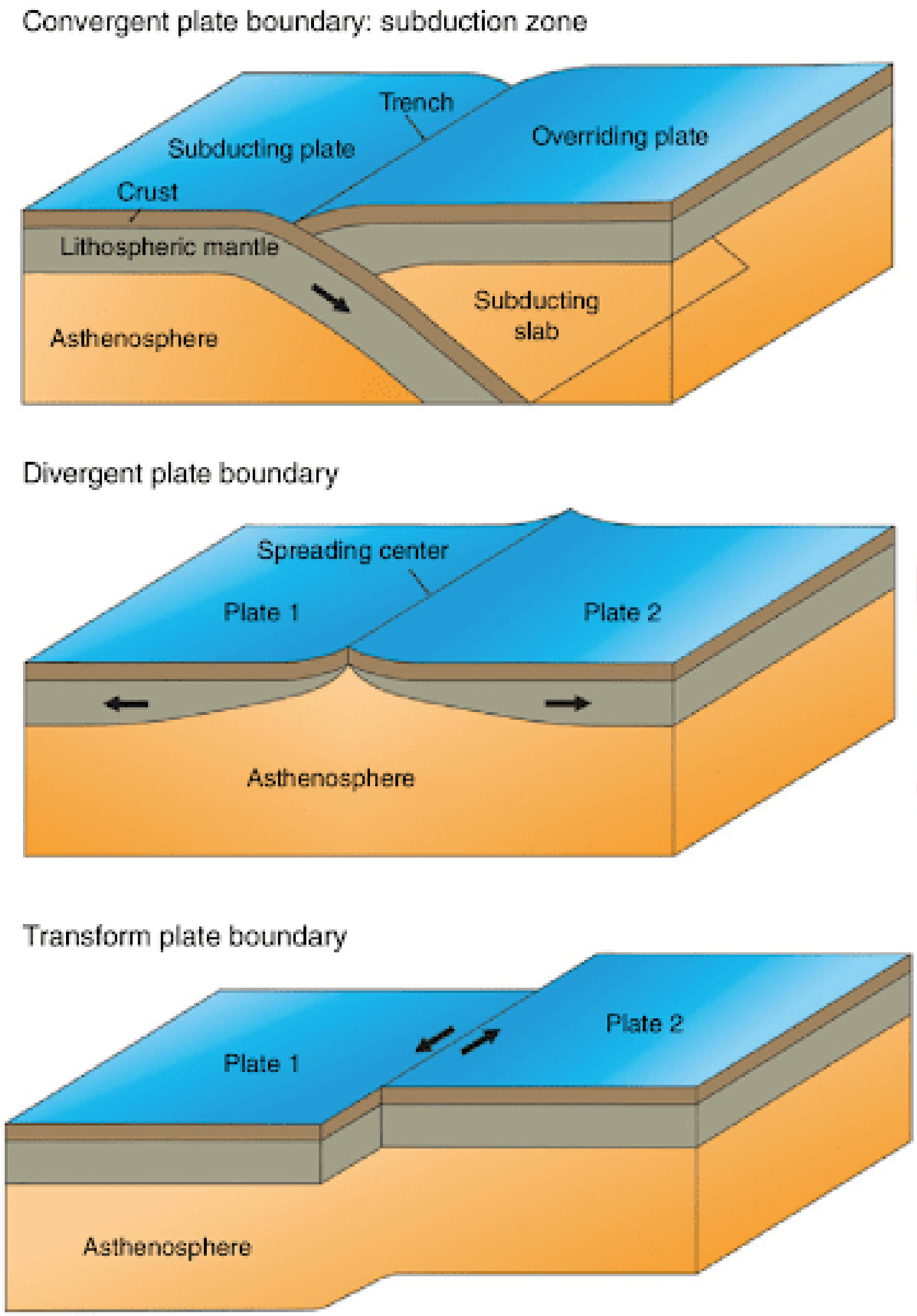


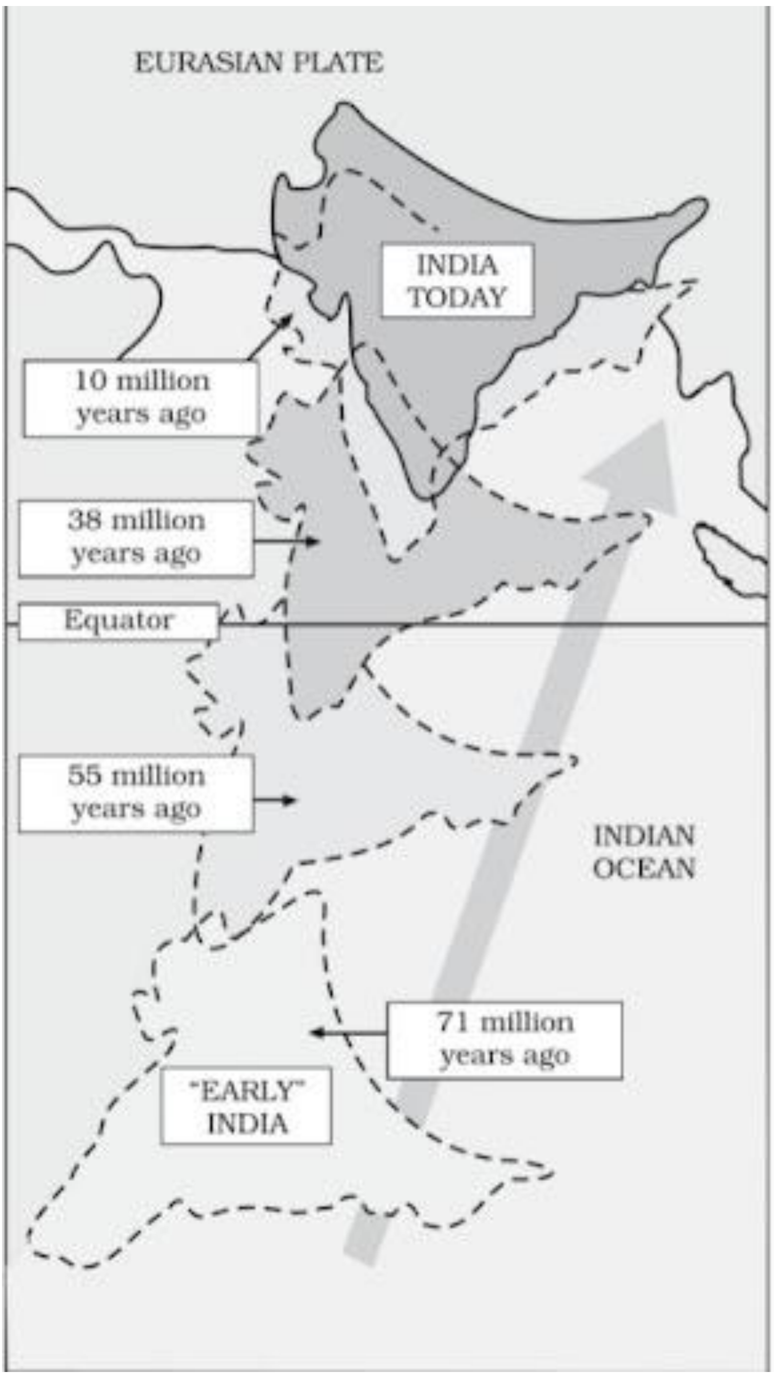
Plate Boundaries

Indian Tectonic Plate

The Indian tectonic plate includes Peninsular India and the Australian continental portions.

- The subduction zone along the Himalayas forms the northern plate boundary in the form of continent-continent convergence.

- It extends through the Rakinyoma mountains of Myanmar towards the island arc along the Java Trench in the east. The eastern margin is a spreading site lying to the east of Australia in the form of an oceanic ridge in the SW Pacific.
- The western margin follows the Kirthar mountain of Pakistan. It further extends along the Makrana coast and joins the spreading site from the Red Sea rift southeastward along the Chagos Archipelago. The boundary between India and the Antarctic plate is also marked by an oceanic ridge (divergent boundary) running in a roughly W-E direction and merging into the spreading site, a little south of New Zealand.



- The Indian plate formed part of the supercontinent Gondwana together with modern Africa, Australia, Antarctica and South America. Gondwana broke off and these continents drifted apart at different velocities, a process that led to the opening of the Indian Ocean.
- The Indian plate started moving to the north and collided with Asia about 40 - 50 million years ago resulting in the rapid uplift of the Himalayas. The height of the Himalayas is still rising even to this date.
- During the northward journey of the Indian plate towards the Eurasian plate, a major event that occurred was the outpouring of lava and the formation of the Deccan Trap. This process started around 60 million years ago and went on for a long period of time.
- About 140 million years ago, the Indian subcontinent was located as south as 50°S latitude. The two plates, the Indian plate and the Asiatic plate were separated by the Tethys Sea.