Lesson - 5

Origin of Continents and Oceans

Continents and oceans are landforms of first order. Different theories are propounded regarding their origin by many scholars. Out of which two theories have been widely accepted - 'Continental Drift' and 'Theory of Plate Tectonics'.

Continental Drift Theory :

Although hypothesis regarding the drifting of the continents was presented by Francis Bacon in 1620, Snyder in 1885, F.G. Taylor in 1910, but the theory was postulated in 1912 by a german, Alfred Wegner, a German scientist Wegner was a climatologist who was interested in solving the probelm of the changes in climates.

The two evidences in form of availability of coal in Antarctica and glaciation in the deserts provided Wegner with two assumptions :

1. Climate zones were shifted and land area remained stable.

2. Climatic zones remained stable and land area shifted.

Wegner based his hypothesis on the second assumption and specified that during the Carboniferous period, all the continents were in form of one landmass which was called angea by him. It was surrounded by water on all its side, which was named by Wegner as 'Panthalasa'.

According to Wegner, this 'Pangea' was formed of sial and was floating freely on oceanic floor named 'Sima' by him. The division of Pangea took place in Carboniferous Period. (Fig. No. 5.1)

During the first division, Tethys geosyncline was formed. The northern part of which was called

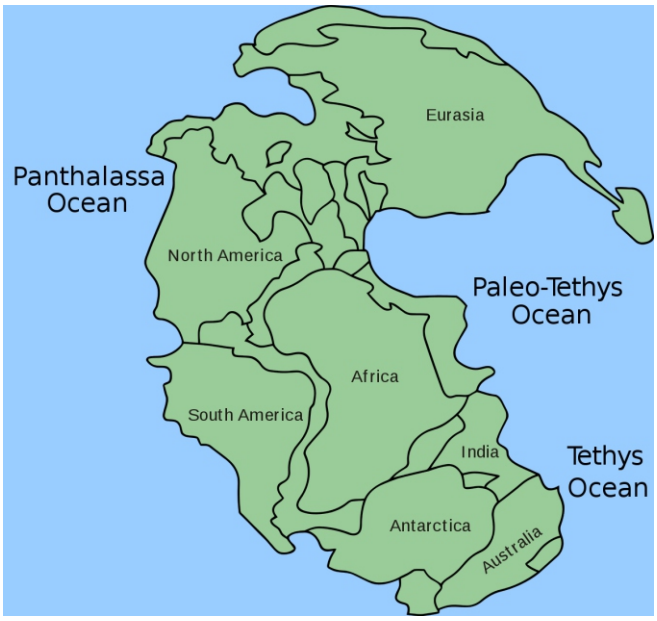

Fig. No. 5.1 : Pangea and Panthalasa

Angaraland (Lauracia) and southern part was called Gondwanaland. In due course of time, the westward and the equatorward drift of this division and its broken crustal parts led to the present position of the continents Wegner proposed two forces responsible for this drift.

1. Gravitational force and Force of buoyancy : Due to these forces the drift of continents was towards equator which resulted in the formation of India, Australia and Madagascar.

2. Tidal Force : This force caused the Westward drift of the continents which caused the formation of North and South America.

According to Wegner the space created due

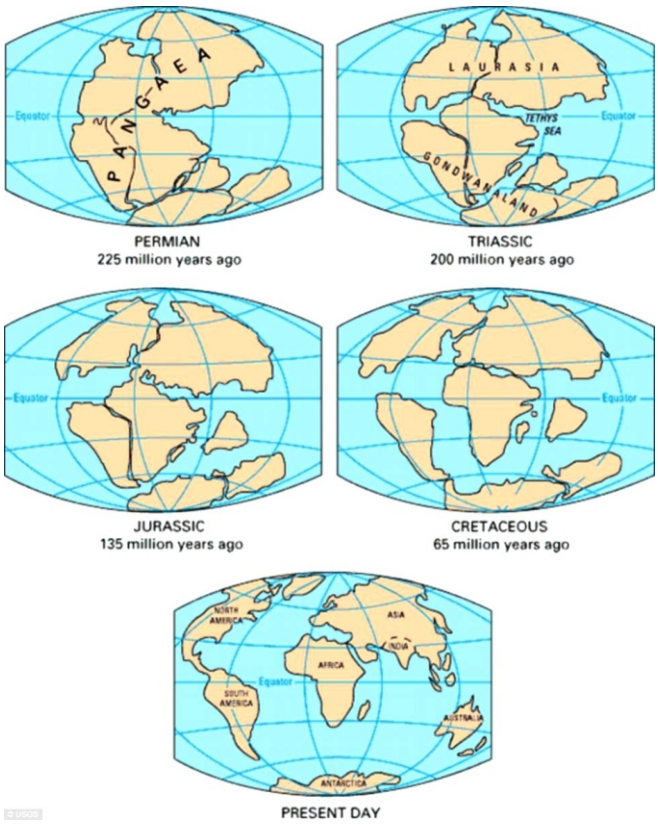

Fig. 5.2 : Continental drift of Pangea

separation North and South America, resulted into the formation of Atlantic Ocean and division of Australia and Antarctica led to the formation of Indian Ocean and rest of the water body 'Panthalasa' was named as 'Pacific Ocean'.

Evidences in the support of the theory :

1. Geographical Evidences :

(a) JIG-SAW FIT in Atlantic coast.

The coastal margins of Africa and South America which face each other have unique similarity. Both the coastal margins of Atlantic Ocean can be easily re-fitted together. This was named as JIG SAW FIT by Wegner. According to him, the Western African Bulge in Caribean Sea and North Eastern region of South America could be joined with gulf of Guinea Coast. (Fig. 5.3)

(b) Alignment of Mountains :

If the coastal margins of the drifted continents are joined then there is similarity in the alignment of all eras of mountains. This alignment is clearly visible in Caledonian, Hersian & Alpine mountain ranges.

(c) Origin of Young Fold Mountains :

Wegner proposed that the Rockies, Andes, Alps and Himalayan mountains were earlier the sites of geosynclines. The sediments of these geosynclines were folded up, due to excess of pressure.

2. Geological Evidences :

(a) Structural Similarities :

The structure of rocks of both the coasts of Atlantic Ocean bear a lot of similarities which prove that these coasts were once joined together.

(b) Stratigraphical Similarities :

The sequential similarities in the types of rocks of both the coasts of Atlantic Ocean prove that the coasts were joined earlier.

Fig. 5.3 : Coastal Similarity

3. Evidences of Geodesy :

The evidences of Geodesy prove that Greenland is drifting towards Canada which proves the drifting of continents.

Biological Evidences

(a) Paleontological Similarities :

Another evidence which proves that the Atlantic coasts were once joined, was the similarity in the fossils of the plant and animal species. (Fig. 5.5)

(b) Biological Habits : According to biologists,

Fig. 5.4 : Alignment of Mountains

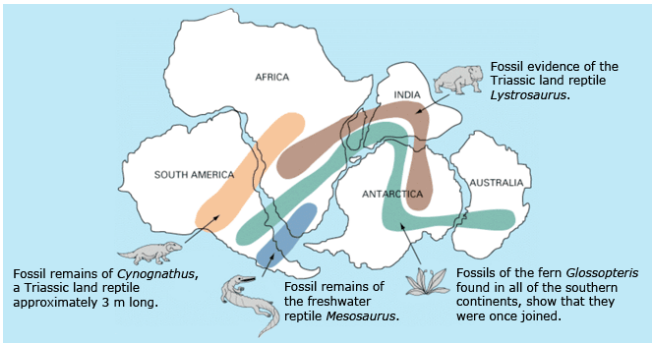

Fig. 5.5 : Palaeoclinatological Similarity

researchers have proved that creature named 'Liming' keep moving towards western direction and ultimately drown themselves in the Atlantic Ocean, its believed that these creatures must be following their habit of moving towards the west when North America was joined to Europe.

5. Palaeoclimatological Evidences :

The effect of glaciation during carboniferous period in India, South America, Africa and Australia, proves that this could only be possible if these countries would have been joined together as a one landmass.

Criticism of Continental Drift Theory :

1. Geographical Criticism :

(a) The concept of JIG-SAW Fit is erroneous, because of joining the Brazilian coast with Guinea Coast, will leave a gap of 15º.

(b) Mid-Atlantic ridge is a hurdle in joining two coasts. This was not explained by Wegner.

(c) The two processes i.e. drifting and folding as explained in this hypothesis are contrary. On one hand Wegner proposed that sial is floating on sima, on the other hand it has proposed that due to pressure exerted on the deposited sediments, folds were created.

2. Geographical Criticism :

According to Geologists there are negligible structural and stratigraphical similarities regarding the composition of rocks on both the coastal margins of Atlantic Ocean. Hence these evidences can not be regarded a sufficient evidence to prove that the coasts were joined.

3. Geodesical Criticism :

According to Wegner, the westward drift of the continents is due to gravitational force exerted by Sun and Moon. Whereas the mathematicians have proved that the force which is required for the westward drift of the America will be ten billion times more to what it is at the present day. Mathematician critics believed that it is impossible for this force to exist and if this would be possible then this force would cause disturbance in the rotation of the earth.

4. Biological Criticism :

The critics consider the biological evidences negligible.

5. Paleoclimatological Criticism :

Steers pointed out that in north western Africa, Boston in USA (which was at the equator at that time) and Alaska of deposits like 'Tillite' have been found, which belong to Ice Age. The Analogue of Continental Reconstruction of Wegner do not provide sufficient explanation for discrepancy indicated by Steers.

Despite of many short comings, the importance of this principle is due to the fact that it provided a basis for universally accepted scientific theory of plate tectonics, which reinforces the theory of continental displacement.

Plate Tectonics

Plate tectonics theory has been rendered in relation to the origin of continents and oceans on the basis of many researches related to Sea floor spreading, Magnetism and Seismic surveys during 1960's. Harry Hess (1960) has been considered as the father of 'Sea floor spreading theory'.

Plate :

The word 'Plate' was first of all used by Tuzo Willson to describe the outer layer of the earth. This is a combined unit of crust and Upper Mantle, which is also known as 'Lithosphere'. Its thickness is 100 km and is extended over both continents and oceans. This outer plate is similar to rigid, thin, and brittle reversed soup plate.

According to the principle, the entire lithosphere is divided into 6 major and 20 minor plates, which are moving converging, diverging and colliding in respect to each other, this causes tectonic movements like earthquakes, volcanic eruption, and formation of trenches. This entire sequence of movement of plates is called plate tectonics.

Major Plates :

There are many discrepancies regarding the total number of Tectonic Plates, but Morgan has divided the entire Lithosphere into 6 major and 20 minor plates. The 6 major plates are as follows : (Fig. 5.6)

1. Indo-Australian Plate: This plate includes Indian sub-continent and land crust of Australian, the souther-western oceanic crust of Indian and Pacific Ocean.

2. Eurasian Plate : This is the only plate which is entirely made up of continental crust. This plate is extended in Mid Atlantic Ridge, Alps-Himalayan series of mountain range and island arcs in east.

3. African Plate : Its a combined continental and oceanic plate. It is extended to India in east, Antarctica in south, Mid Atlantic Ridge in west and till Eurasian plate in north.

4. American Plate : This includes the continental crust of North and South America, oceanic plate of Mid Atlantic Ridge in the east. It is

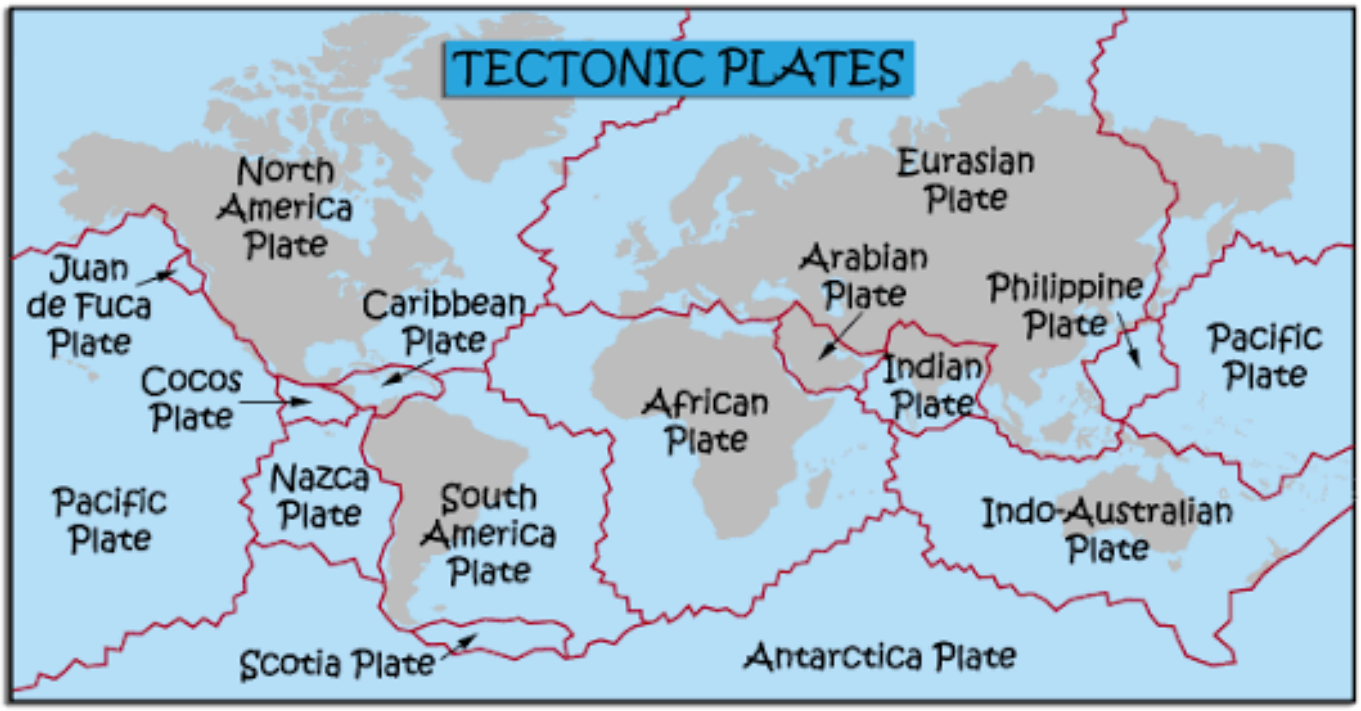

Fig. 5.6 : Tectonics Plates of the World

extended upto the western margins of the America and meets with Pacific Plate. It is in the westward drift as a whole unit and due to this there is no tectonic movements on the eastern margins of America.

5. Pacific Plate : It is extended from East Pacific Rise to entire Pacific Ocean, it is the only plate which is entirely made of oceanic crust.

6. Antarctica Plate : The major part of Antarctica Plate is snow covered. This plate extends all around Antarctica and to all mid oceanic ridges.

Types of Plates : On the basis of structure the plates are of three types :

1. Continental Plates : The plate which consists of entire or most of land is called Continental Plate.

2. Oceanic Plate : The plate which covers entire or most of the oceanic bottom is called Oceanic Plate.

3. Continental - Oceanic Plate : The plate on which the extension of both land and oceanic botoom is found is called continental- Oceanic Plate.

Plate Margins :

All the tectonic activities, of the interior of the earth are concluded on these plate margins. These plate margins are of three types. (Fig. 5.7)

1. Constructive Plate Margins : Along these plate margins two plates diverge, which creats empty place. Through which the magma erupts out and solidification of lava results into regional expansion. Due to this reason it is called constructive Plate Margins. Such plate margins are formed near Mid Atlantic ridge.

2. Destructive Plate Margin :

In the plate margins, due to convergence of two plates, one plate overides over the other plate and other plate undergoes subsidence. The front part of the incised plate melts as it enters the Mantle. Therefore it is called destructive Plate margin. This melted substance erupts out from the weaker margins of crust and forms island arcs. The series of volcanic eruptions and island arcs are extended on the margins of Pacific Oceanic Plate.

3. Conservative Plate Margins : In these plate margins the two plates pass along the sides of each other. Here, there is no erosion of any plate, neither any new material is created, only transform faults are formed. Hence it is called conservative margin. In the western region of North America, there are two transform boundaries near Andrias fault.

Causes of the movement of Plates : The radioactive substances generates geothermal energy, which rises in the form of convection currents in the interior of the earth and causes movement of the plates. The conventional currents just beneath the plates causes horizontal movements of the plates. Eruption of magma in the region of mid continental ridges and reaching of plates by subsidence in mantle along convergence margins are the main works of convectional current.

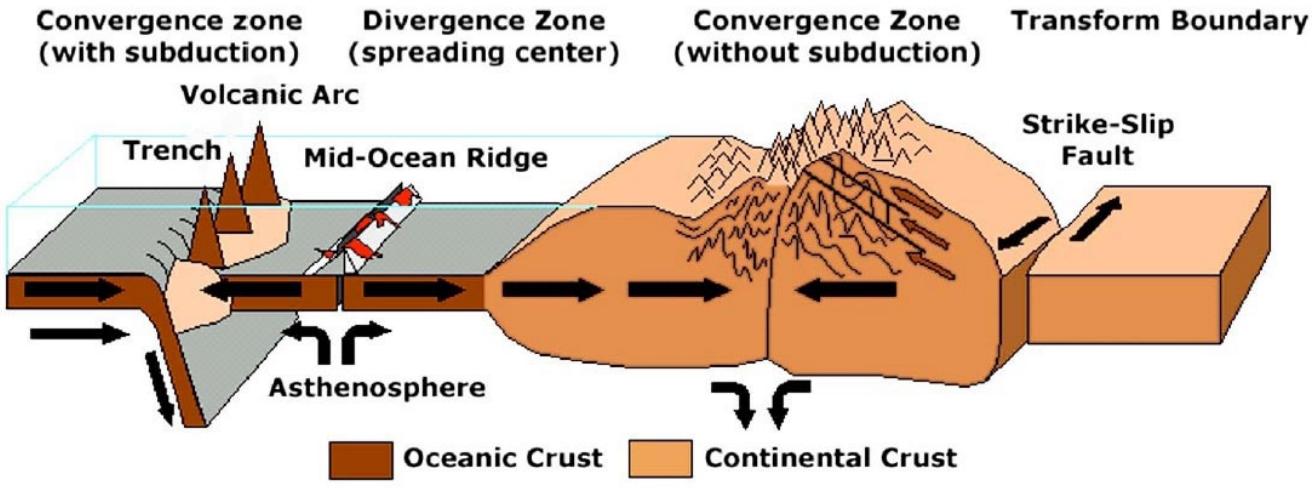

Fig. 5.7 : Types of margins of plates and their activities

Evidences of Plate Tectonics :

1. Sea Floor Spreading : Gaps are created due divergence of two plates moving in opposite directions. In these gaps, the magma emerges out due to convective currents and thus deposits in the form of lava which forms new layers of rocks. Due to continuity of this process new crustal layers keep on forming. This results in spreading of Sea floor. Like the lava comes out from both the sides of Mid Oceanic Ridge and forms new crusts. With the concept of Sea Floor Spreading, the hypothesis about unstability of the continents and oceans is also proved.

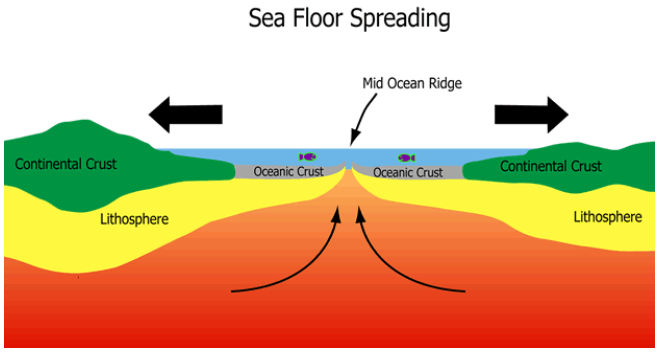

Fig. 5.8 : Sea Floor Spreading

2. Continental Drift : The new discoveries of Paleomagnetism and Sea floor Spreading, have strengthened the fact that the continents and oceans basins were never fix and stable.

On the basis of these discoveries, the information about Continental drift, prior to the last 20 million years, is available.

3. Broadening of Rift-Valleys : Those plate boundaries which have rift valleys, are getting broader. Red Sea and the Gulf of Eden is expanding at the rate of 1 cm per year. The Gulf of California is also expanding.

4. Other Effects : There are other effects of Plate tectonics which have been explained in the description of points earlier in this chapter. These effects include incidents of earthquakes, volcanic eruptions, mountain building, formation of island festoons etc.

Therefore it can be concluded that most of the geographers, geologists and geo-scientists are accepting the theory of continental drift. Presently, propelling force, as the only force for the drift is still controversial.

Recent research studies have revitalized the concept of convection current theory in the context of plate tectonics.

Thus the plate tectonic theory has not only strengthened the continental drift theory on the basis of scientific evidence but also it can explain many processes like earthquakes, volcanic eruptions and formation of island arcs.

Important Points

1. Continents and Oceans are called the first order landforms.
2. The basis of Wegners Theory of continental drift, is that climatic zones remained fix and landmass drifted.
3. Wegner described continental margins as Sial to be floating on Sima.
4. According to Wegner all the continents were in a form of one landmass called 'Pangea' and, it was surrounded on all sides by Panthalasa 'a vast ocean.
5. Gravitational force of moon caused the westward drift of the continents and force of buoyancy caused drift towards the equator.
6. Jig-saw-fit of Atlantic Coast, alignment of mountains, structural similarities, Geodesy evidences, biological evidences, Paleontological and Paleoclimatologieal evidences proves the Continental Drift Theory.
7. The word 'Plate' is used for outer layer of lithosphere. The entire sequence of movement of plate is called 'Plate tectonics'.
8. Continental and Oceanic Plates - Indo-Australian, Eurasian, African, American and Pacific Antarctica Plate.
9. Effects/Evidences of Plate tectonics - Sea floor spreading. Continental Drift, broodening of rift valleys .

Exercise
Multiple Choice Questions

1. The vast ocean surrounding Pangea was :
   (A) Atlantic (B) Panthalasa
   (C) Tethys (D) Arctic

2. According to Wegner, the direction to which the continents were drifted was :
   (A) South and North
   (B) East and Equator
   (C) North and west
   (D) West and Equator

3. The fact only related to Plate Tectonic is :
   (A) JIG-SAW FIT (B) Pangea
   (C) Tethys (D) Arctic

4. 'Pangea' was composed of :
   (A) SIAL (B) SIMA
   (C) Nife (D) Sial and Sima

5. The word 'Plate' was first used by :
   (A) Finch (B) Tuzo Wilson
   (C) Wegner (D) Griffith Taylor

Very Short Type Questions :

6. What is 'Pangea'?
7. Describe the types of plate margins?
8. Which ridge is an hurdle in Jig-Saw-Fit of Atlantic coasts?
9. What do you mean by 'Panthalasa'?
10. What is the average thickness of the Plate?

Short Type Questions :

11. Write the geological evidences of Continental Drift Theory.
12. What is meant by 'JIG-SAW-FIT'?
13. At which plate margins the process of formation of Island Arcs occurs Island Arcs?
14. Name the major plates of the earth.
15. Which forces are responsible for the drift of the continents according to wegner?

Essay Type Questions :

16. Critically describe the Continental Drift Theory of Wegner.
17. Describe the global Plates and give evidence about Plate tectonics.
18. Write an essay on Plate Tectonics.

Answer Key

1. B 2. D 3. C 4. A 5. B