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1. Learning outcomes

After studying this module, you shall be able to:

- Know about the importance of Plate Tectonics, Basin Evolution by plate tectonics, the history of Pangaea and its break up.
- Know about the three different types of plate boundaries like Divergent, Convergent and Transform.
- Know about the global distribution of hydrocarbon reserves.

2. Introduction

2.1 Importance of Plate Tectonics:

The plate tectonics principle helped explorers to understand and evaluate the hydrocarbon plays. Along the coasts of South America and Western Africa, these ideas have been successfully applied to presalt basins and turbidite fans, since the start of 21st century.

The previous successes often emerges new discoveries. The oil companies are able to apply characteristics from there play to a regional and global framework in search of other accumulations, once the play concept have been proved commercially viable. Geoscientist are finding analog plays across the ocean basins, through the integration of exploration integration, drilling data and geologic models from a successful plays and through the application of plate tectonics model.

Explorationists have discovered major oil and gas fields in *continental margin systems*, from the *North Sea to the Gulf of Mexico and from offshore South America to offshore Africa*. The *coast basins of Brazil, the Santos, Campos and Espirito Santo* contain prolific oil discoveries and the application of plate tectonics concepts has enabled explorers to extend that play across the Atlantic to offshore western Africa. From West Africa across equatorial Atlantic to French Guiana and Brazil, the exploration companies have applied the principles of plate tectonics to extend and relate upper cretaceous turbidite fan plays westwards, within the last few years.

2.2 Basin Evolution by Plate Tectonics:

The vital concepts of petroleum exploration are basins, petroleum system and hydrocarbon plays. The building blocks for petroleum system are the sediments which are got collected in the basins. A petroleum system must consist of mature source rock, a porous and permeable reservoir rocks in which the oil gets accumulated after migration and a seal or a cap rock, which blocks the further migration of the oil.

Basins may be deformed by tectonic motion, extension, compression, strike slip motion or any combinations are the derivatives of tectonic motion (As shown in the Fig.1). Extension may cause normal faulting and may be accompanied by stretching, thinning and sagging of the crust. Compression results in thrust faulting, folding, shortening and thickening strike slip motion give rise to translation and lateral faulting. A combination of these phenomena produces pull apart basin, push up blocks and transtenssion or transpression oblique shape. Thus, local or large-scale movements provide the imprints for creation of stratigraphic traps.

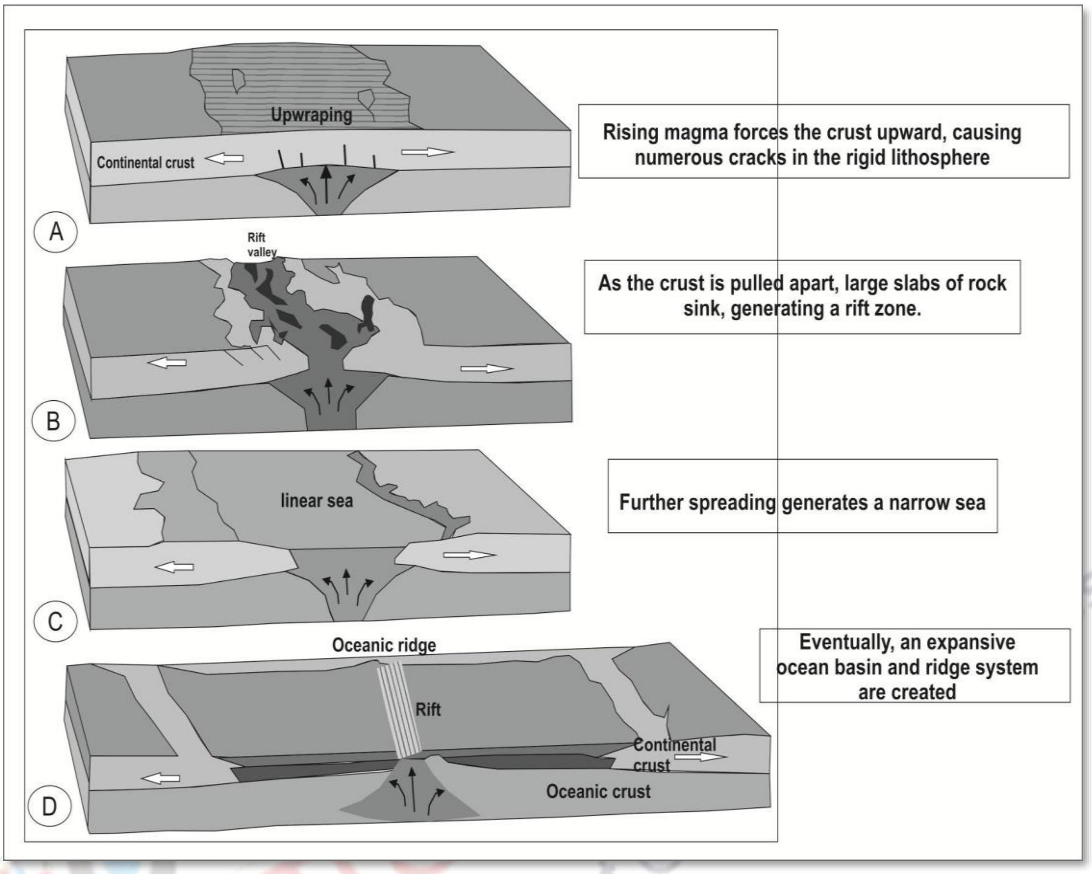


Fig. 1 Complete Basin Evolution Process.

2.3 Single Supercontinent- Pangaea:

Alfred Wegner in 1910 proposed the theory of continental drift. He suggested that at the beginning of the Mesozoic era (about 200 million years ago) all the continents of the earth were united together to form a single supercontinent which he called "Pangaea" and the huge ocean, which has surrounded it, is called "Panthlassa". Wegner proposed that this vast continent begin to breakup into smaller continents at the beginning of the Mesozoic era, which then drifted to their present positions just like pieces of wood floating on water. This motion is driven by the convection and flow of hot ductile material in the mantle underlying the lithosphere. Over geologic time, tectonic plate motions have amalgamated small continents to form supercontinents and separated them again into a collection of smaller continent distributed across the planet.

Some Geological evidences given by Wegner are as follows

Similarities in Shape of Coastlines

The Atlantic coasts of South America and Africa have a roughly similar shape (shown in Fig. 2). They would fit in nicely if they are brought in contact with each other. However, the coastlines are not reliable geological features because there shape changes with rise and fall of sea level relative to the land. The real edge of the continent occurs at the continental slope where sea bottom flows rapidly down to deep ocean floor. The mapping of the continental slopes of eastern south America and west Africa has indicated that there contours match excellently. This strongly suggests that these two continents were once joined together.

Fig. 2 Best Fit of South America and Africa along Continental Slope.

i. Similar Orogenic Belt: If the eastern coast of South America and the western coast of Africa are fitted together, the orogenic belts of the two continents, which have the same range ages and similar structural trend, are found to align themselves across the join.

ii. Permo-Carboniferous glaciations: In the Parana basin and eastern Brazil (South Africa) glacial deposits of Permo-Carboniferous age are widespread. Their average thickness is about 600 meters. The direction of ice movement suggests that the source area of these glacial deposits lies in south east of the present Brazilian coast. In southwest Africa, though the glacial deposits are meagre, there is abundant evidence for ice erosion. The direction of ice flow recorded is from east to west. This suggests that southwest Africa was covered by an actively eroding ice sheet which dumped its load further west in Brazil.

iii. Paleomagnetic evidence: Igneous rocks record the earth's magnetic field present at the time of their formation. A study of fossil magnetism in a region where several volcanic eruption had occurred on a widely separated occasions, has led to an interesting discovery. The orientation of the earth's magnetic field in each of the separate lava flows is found to be different. This suggests that between volcanic eruptions, the magnetic poles have moved to a new location. Thus, palaeomagnetic techniques, which locate the magnetic pole of any stage in the past, give consistent results on each continent only when they are placed in the proposed framework of the Gondwanaland.

iv. Animal And Plant Fossils: On the both sides of the south Atlantic, the fossil remains of Mesosaurus have been found. Nowhere else in the world, remains of Mesosaurus or other organisms were found on the continents of Africa and South America appears to link these landmasses during the Late Paleozoic and early Mesozoic eras (represented in Fig. 3).

The remains of the "glossopteris flora" occur in the rock beds of the Gondwana series in South America, South Africa, India, Australia and Antarctica. These floras reached their maximum development in the Permo- Carboniferous period. The nature of their species distribution can only be explained if all the southern continents were joined together.

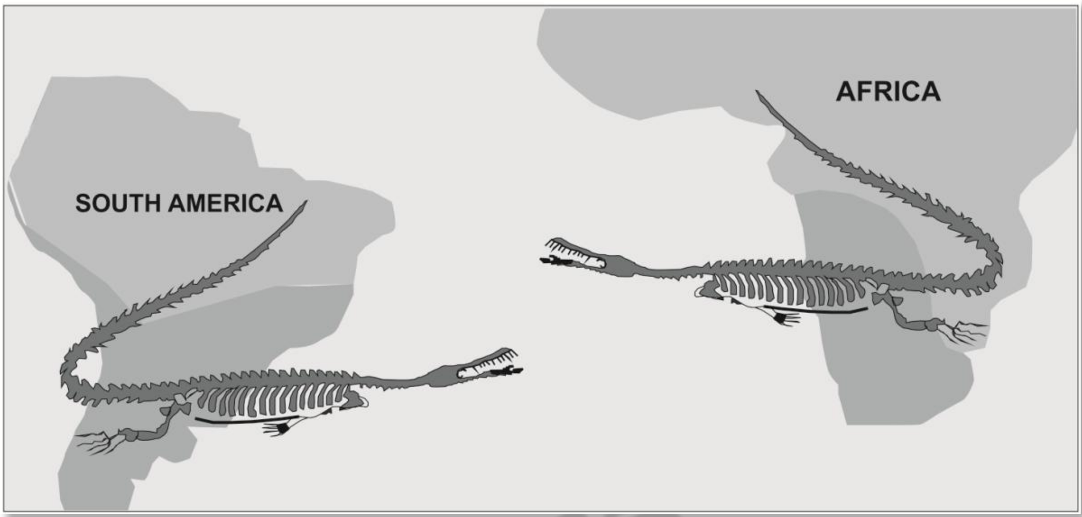


Fig. 3 The fossils of Mesosaurus found in South America and Africa.

2.4 Breakup of Pangaea

The chief events of the breakup of the supercontinent Pangaea are as follows-The breakup of Pangaea began in the Triassic Period (about 200 million years ago) with the formation of rifts. At the end of Triassic period (about 180 million years ago), the significant features of the geography of the world were as follows.

- The "North- Atlantic Ocean" was formed as North America was separated from Africa. Due to the Tethys Sea contracted.
- The Laurasia was separated from Gondwanaland.
- A Y-shaped rift was formed in the southern Pangaea, which separated Antarctica- Australia from Africa- South America and sent India on its northward journey.

2.5 Plate Boundaries

Depending on the relative motions of adjacent plates, the plate boundaries are classified into following three groups (COX, 1986):-

i. Divergent boundaries: Divergent boundaries are also called the "constructive zones" because in these zones the new crust is continuously created. Divergent boundaries occur at oceanic ridges. The divergent boundaries are boundaries along which plates move away from each other.

ii. Convergent boundaries: The “convergent boundaries” are boundaries along which two plates approach each other and the leading edge of one slips down under other at an angle of about 450. These boundaries are also called “destructive boundaries” or “subduction zones” (as shown in Fig. 4). They occur at the deep trenches. As a result of convergence three type of collision takes place –

- *Ocean to Continent collision*- when an Oceanic and a continental plate collide, eventually the oceanic plate is subducted under the continental plate due to the high density of the oceanic plate.
- *Ocean-to-Ocean collision*-When a convergent boundary occurs between two oceanic plates one of those plates will subduct beneath the other.
- *Continent-to-Continent collision*-when two continental plates collide neither plate can be subducted due to their high buoyancy.

iii. Transform Fault Boundaries: Transform fault boundaries are boundaries along which plate slides past one another and there is no production or destruction of lithosphere. The transform fault runs in the direction of plate movement and offset oceanic ridges. The margin at which the plates neither gain nor loose surface area is called “Conservative boundaries”.

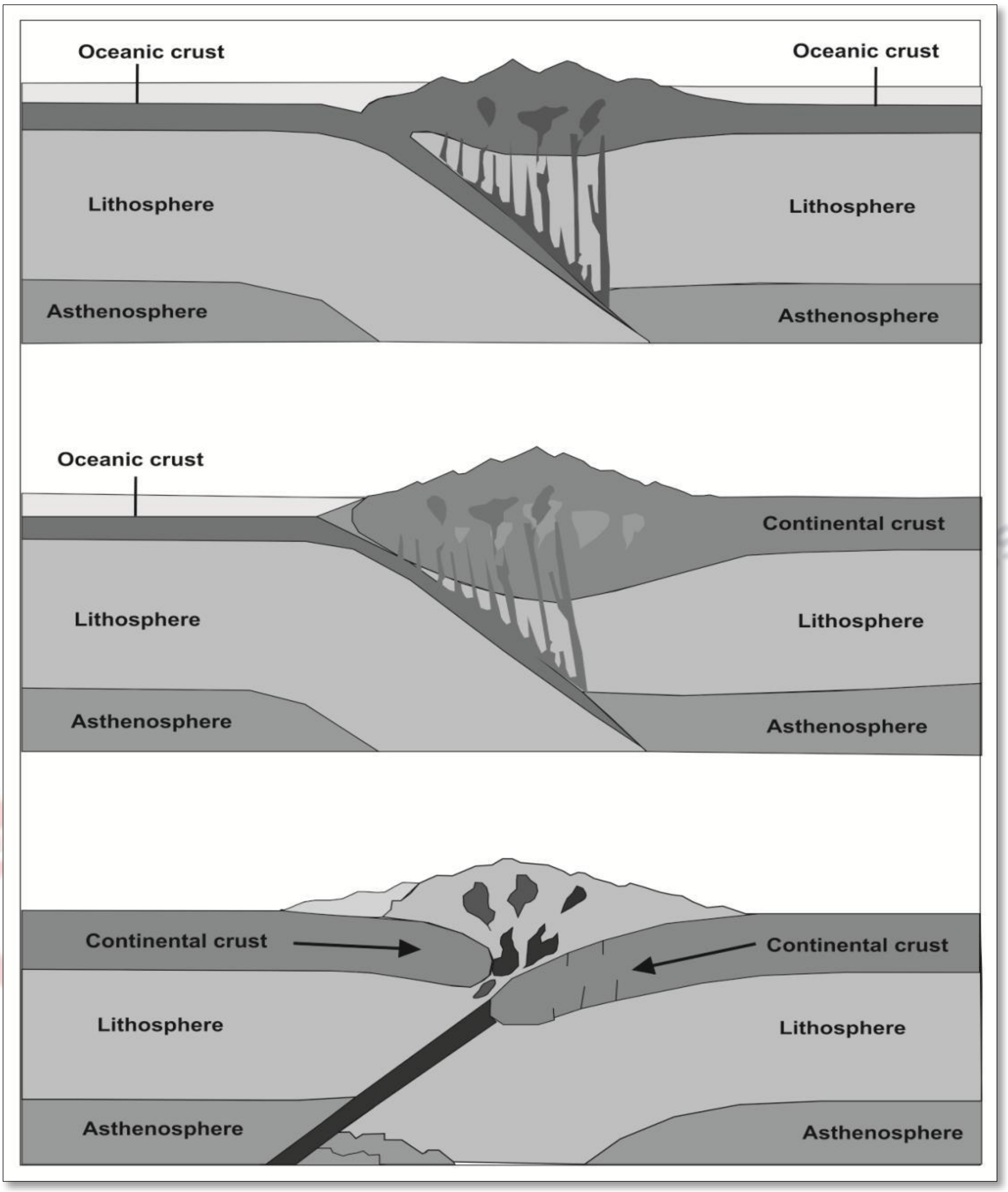
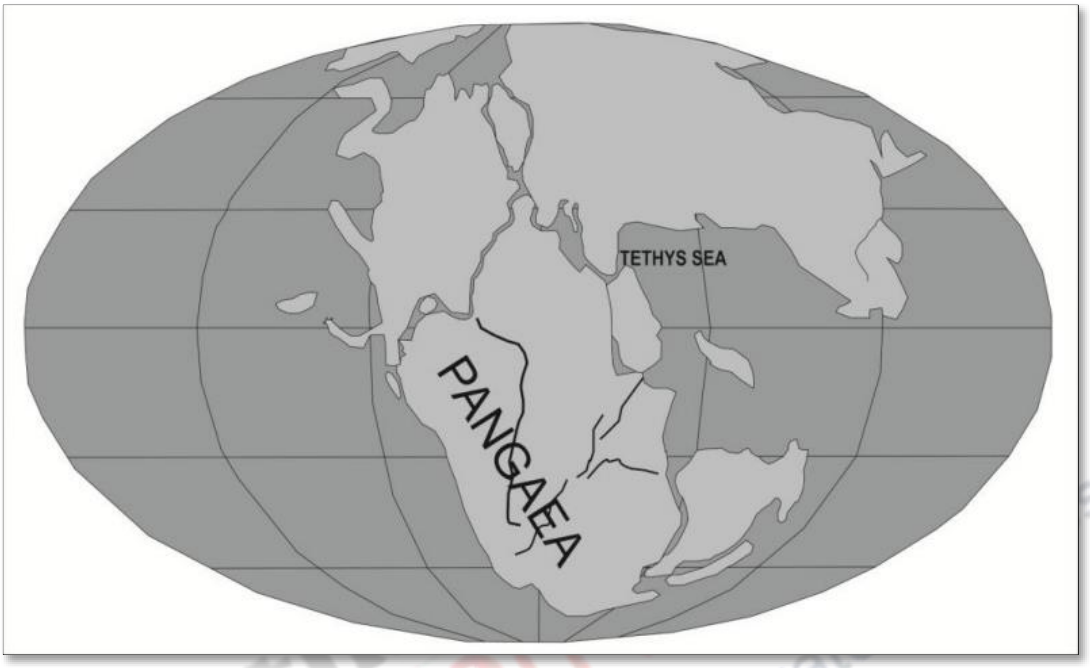
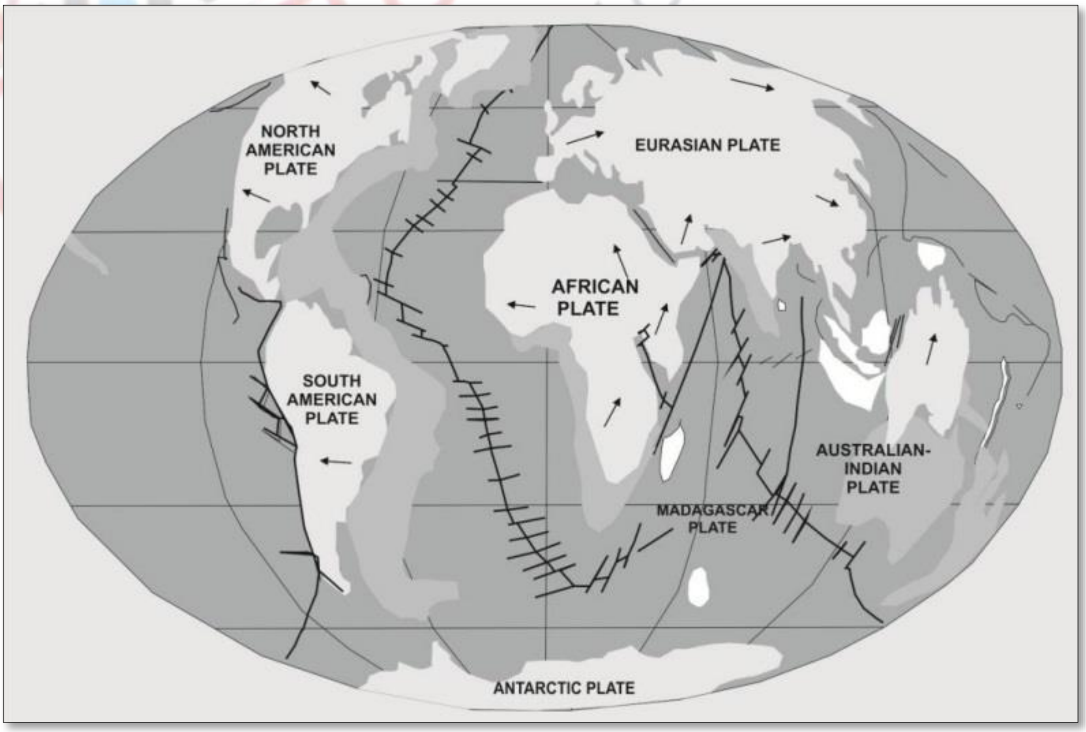


Fig. 4 Different convergent Boundaries (A) Oceanic- Continental, (B) Oceanic-Oceanic& (C) Continental- Continental.

A. RECONSTRUCTION OF PANGAEA AS IT IS THOUGHT TO HAVE APPEARED 200 MILLION YEARS AGO



B. THE WORLD AS IT MAY LOOK 50 MY FROM NOW



3. Sedimentary Basins and Hydrocarbon Occurrences

3.1 Basins Classification

The classification of the sedimentary basin differs preliminary in respect to one another on the factors such as geodynamic regimes basin structural profiles, positions of the basins on continents and tectonic stages in basin development (as shown in Fig. 6).

This classification of sedimentary basin is mainly based on –

- The position of basin within the tectonic area (cratons, accreted zones and convergent and divergent margins),
- The sequence of structural forms that reflects the basin's tectonic evolution.

The plate tectonic setting largely determines a basin's geologic history and results in· a specific basin structural profile. Structural expressions of basins in different stages of their development strongly affected the deposition of source rocks within the basin. The subsequent tectonic history of a basin (overlying structural forms) controlled maturation of the source rocks, formation of hydrocarbon pools, and their preservation or destruction.

The accumulation of oil and gas within the thick prisms of sediment are deposited along many rifted continental margins. The plates apparently rest upon a mobile layer called the asthenosphere, within which the geothermal gradient across the plates is controlled mainly by the conductivity between the basal temperature (that of the asthenosphere) and the surficial temperature (that of the troposphere [atmosphere and hydrosphere]).

The rigid blocks of plates are spherical caps, or arcuate slabs, of the earth's lithosphere that extend down to the so-called low velocity zone of the upper mantle. The shape and size of the basin, the nature of the stratigraphic fill and the types of structures & the thermal history of the basin are some factors which govern the amount, nature and location of fluid hydrocarbons within the basin (as shown in Fig. 7).

The factors important for analysis of the plate tectonics of sedimentary basin for hydrocarbon accumulation are given below –

i. Organic-rich source beds within the sedimentary sequence are generally fine-grained sediments deposited in black-bottom areas where oxidation by aerobic decay during early digenesis is limited, and rapid burial enhances the likelihood of preservation. Basins in which sedimentary fill includes the favorable sites that harbor the largest sources of potential hydrocarbons exist in oxygen-minimum zones on open slopes and in low-oxygen zones within saline non-marine or marginal marine environments.

ii. Fluid hydrocarbons are normally generated by appropriated heat for thermal maturation of liquid hydrocarbons or thermal gas.

iii. Permeable migration paths for the concentration of fluid hydrocarbons should have access to gather any hydrocarbons produced. The tilted conduit beds of well- sorted sandy strata beneath the impermeable sealing beds of shales or eruptive rocks are the most effective carriers of hydrocarbons.

iv. Petroleum hydrocarbons can be contained in porous reservoir beds (whether clastic or carbonate), and are confined by impermeable cap rocks or traps that may be formed either by stratigraphic enclosures or by structural features of tectonic or sedimentary origin. Plate tectonics may lead to a comprehensive theory of hydrocarbon genesis.

The interaction plates fully explain the causes of subsidence, the sequencing of depositional events, the development of structural features, and the timing of thermal flux- all of which in turn can explain conditions in the geologic record of sedimentary basins.

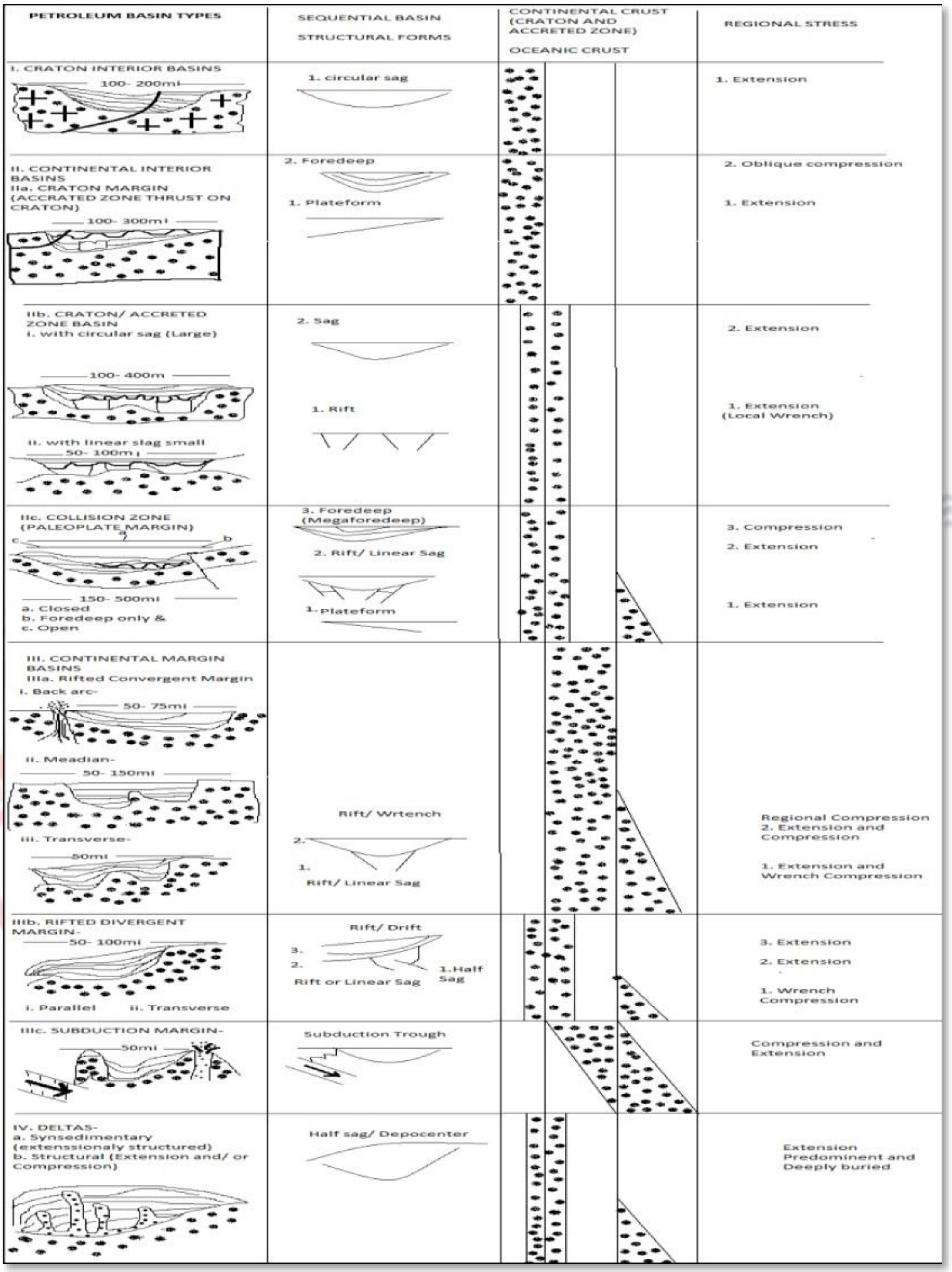


Fig. 6 The classification is based on the position of a basin within major geotectonic areas (shown by shading in column 3) and the sequence of structural forms that reflects the basin's tectonic evolution (shown in column 2).

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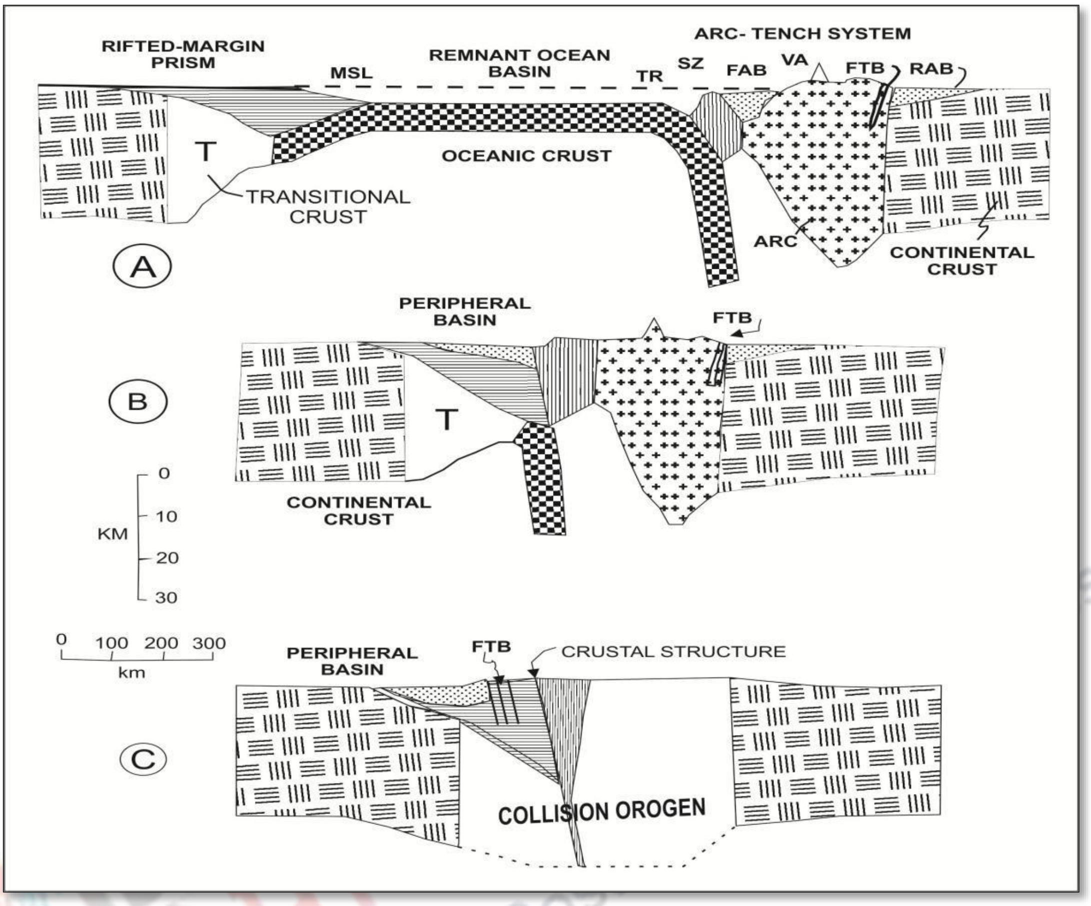

Fig. 7 Schematic diagrams (vertical exaggeration 10X) to illustrate sedimentary basins associated with crustal collision to form intercontinental suture belt with collision orogen. Symbols: TR, trench; SZ, subduction zone; FAB, forearc basin; RAB, retroarc basin; FTB, foreland fold-thrust belt. Diagrams A-B-C represent a sequence of events in time at one place along a collision orogen marked by diachronous closure; hence, erosion in one segment (C) of the orogen where the sutured intercontinental join is complete could disperse sediment longitudinally past a migrating tectonic transition point (B) to feed subsea turbidite fans of flysch in a remnant ocean basin (A) along tectonic strike.

3.2 Rifted-Margin Sediment Prisms

According to plate tectonics theory, the basins are initiated by the separation of continents that begin with the intercontinental rifting. The raw edges of continental blocks along rifted continental margins are in preferred positions to receive thick prisms of sediments, composed both of debris washed off the adjacent continental blocks and biogenic calcareous materials that were deposited in shoal areas at the flanks of the adjacent oceans, when complete separation of continental fragments is achieved. To induce down bowing of the lithosphere by flexure the growing rifted margin prism sediment have sufficient load on the lithosphere between the interfaces of old continental and new oceanic crust. The continental surface is tilted towards seaward to allow landward parts of the rifted- margin sediment prism to encroach as much as 100-25 km beyond the initial continental edge, which is depressed as much as 2.5-5 km. Continued growth of the rifted-margin sediment prism may in time allow its ocean ward edge to advance well into the adjacent oceanic basin until the continental shelf, and perhaps even part of an accretionary coastal plain, come to stand fully above the oceanic basement. The wholesale sedimentary progradation of the continental edge which has developed the types of rifted- margin sediment prism has been termed a continental embankment (Dietz 1963). The accumulation of hydrocarbons in rifted- margin sediment are well known. The various kinds of natural association of offshore source rocks and near shore reservoir rocks is inherent (represented in Fig. 8).

The following two factors combine to exert a pumping action that drives fluid hydrocarbons up dip from offshore source rock into favorable reservoir rocks.

i. Progressive loading of offshore source beds because of depositional growth of the rifted-margin prism.
ii. Progressive seaward tilting of the continental edge and the successive layers of the rifted-margin prism because of flexural bending of the lithosphere under the growing sedimentary load offshore.

These factors are probably most influential within fully developed continental embankments, where potential conduit beds, intercalated with sealing beds, connect offshore source beds with inshore facies suitable as reservoir beds without interruption by thin slope facies.

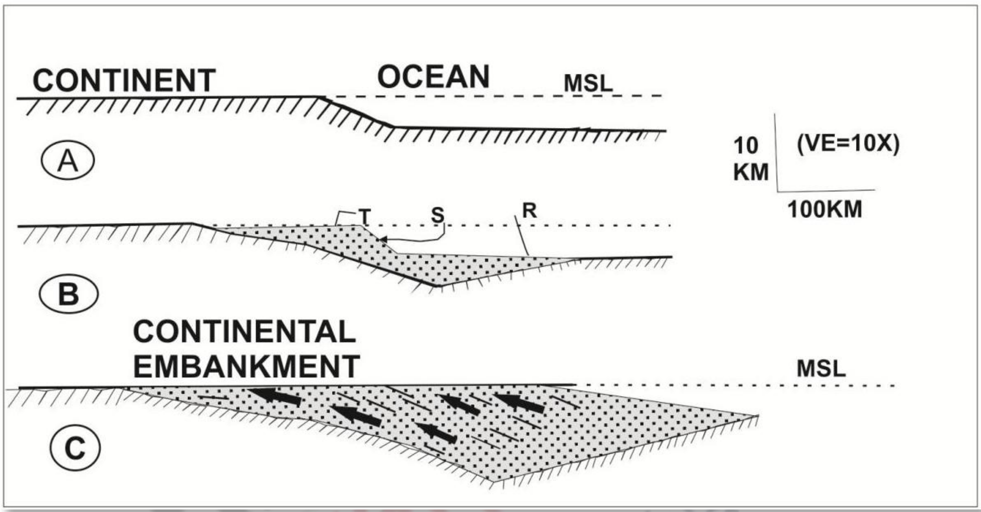

Fig. 8 Growth (schematic) of rifted-margin sediment prism (stippled), A, rifted continental margin without sedimentation; B, continental terrace (T)-slope (S)-rise (R configuration; C, progradational continental embankment; small arrows show rotational tilt of basement along continental margin downward toward ocean basin; heavy arrows show up dip migration of hydrocarbons parallel to bedding (dashes).

4. Global Hydrocarbon Reserve Distribution

Explorationists understand a basin and the sequences of tectonic events and various cycles of sedimentation. They unravel the source rock potential and identify reservoirs, traps prospects are identified, and 3D models are prepared using E&P software. In this module, few examples will be taken to illustrate the relation between plate tectonics and distribution of hydrocarbon reserves.

4.1 Petroleum system

According to explorationists, a petroleum system is a geologic element and processes that are necessary for the hydrocarbon accumulation. The cross-section below describes the petroleum system along a south Atlantic continental margin. The geologic elements should be present in the order as follows-

- The source rock must contain the organic matter in sufficient amount.
- There must be a porous and permeable reservoir rock for the accumulation of petroleum.
- There must be an impervious sealing cap rock to block the further migration of oil.
- Overburden rocks must buries the source rock to depths where there is optimal temperature and pressure to cock the organic matter for the hydrocarbon generation.

With the extension and faulting of continental crust the rifting of the South Atlantic Ocean has started due to this, the continental crust thinned and eventually split apart. Due to the separation of two parts of the continental crust (only the right side is shown here), the oceanic crust is formed at a mid-oceanic ridge during seafloor spreading. The continental margin is located where the thinned continental crust meets the oceanic crust. The source and reservoir rocks that were eventually trapped and sealed underneath salt preserve the synrift lacustrine basins (shown in Fig. 9). The hydrocarbons that are buried and trapped beneath postsalt marls are migrated from synrift source rocks to limestone reservoirs. The source rocks are also provided by marls. Clayey- sandy sediment buried the margin, source rock, reservoir rock, cap rock and overburden during the Tertiary period.

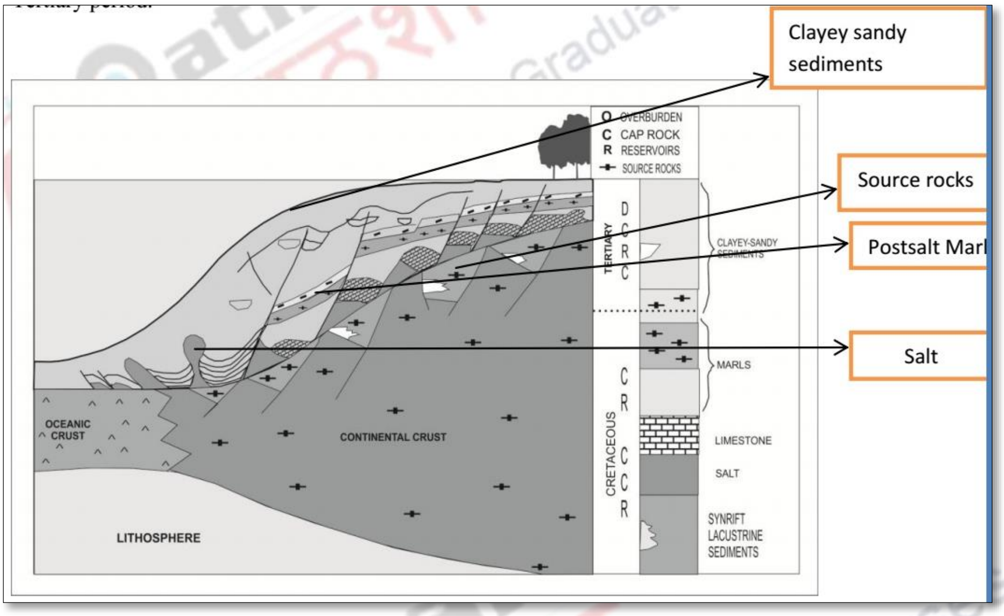

Fig. 9 Seismo geologic section along a South Atlantic continental margin rifting of the South Atlantic.

4.2 Evaporates in Santos Basin

Between the Rio Grande Rise and the Gulf of Guinea, the salt basins that face one another are among the largest found along Phanerozoic passive ocean margins. The formation of salt basins takes place during the opening stages of the central South Atlantic i.e., during Aptian (125 to 110 Ma). This lower Cretaceous salt deposition appears strikingly similar to the Mid- Late Miocene Red sea (15- 5 Ma) in terms of geometric, kinematic and temporal environment. The plates started to separate from one another slowly after the Tristan da Cunha hot spot has started to induce giant volcanic eruptions that covered huge areas of the African- South American lithosphere with thick flood basalts about 143 Ma. Along the newborn plate boundary the narrow rifts, 50 to 80 km (31 to 50m), which has overlapped were found. Basaltic volcanism and anoxic deep-water lakes- some deeper than 1,000m (3,300 ft.), similar to lake Tanganyika today- punctuated the geology of such rifts in the Late Hauterivian to Early Barramian (133 to 128 Ma).

There are mainly three conditions necessary for the formation of thick, layered salt deposits are: a basin deep about 1,500 m (4, 900 ft.), a continuous supply of mineral- laden seawater and a warm and arid climate. The basin water level drops quickly and stabilizes to a critical level when the evaporation takes place. The water intake rate is equaled by the evaporation rate. Until the saturation, concentration is reached for the least soluble salt mineral contained in the water the water salinity increases gradually. The halite (rock salt) is followed by layers of calcite, dolomite and gypsum precipitate respectively. The Aptain, about 120 Ma, salt basin was 1,700 km (1,060 mi) long and restricted from open ocean conditions by the Tristan da Cunha hot spot to its south and the embryonic equatorial Atlantic transform margin to its north. The black arrow indicates the direction of the plate movement (Map Courtesy of CR Scotese).

4.3 Late Cretaceous Turbidite

The Jubilee oil field offshore Ghana consists of turbiditic reservoir rocks. The Mahogany-I a high-quality pay in an upper Cretaceous turbidite, reservoir confined by the combination of structural-stratigraphic trap is a discovery well encountered at the depth of 90 m (300 ft.). Hyedua-1 well, located 5.3 km southwest of the Mahogany-I discovery, encountered 41 m (130 ft.) in equivalent turbidite sandstone of high- quality reservoir. The water play targeting reservoirs in Late Cretaceous turbidites along the equatorial African transform margin, which stretches from northern Sierra Leone east to southern Gabon in the equatorial segment of the South Atlantic Ocean.

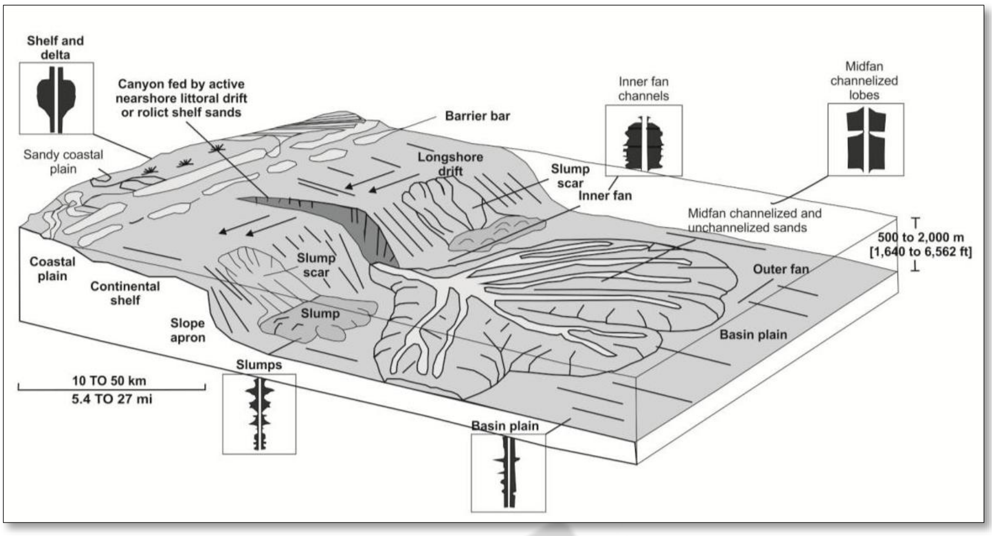

Fig. 10 Reservoirs in Late Cretaceous turbidites.

The offshore Ghana fields discovered by deep-water turbidite fields are charged with the hydrocarbons sourced with the rapidly filled organic rich sediments that are active pull- apart basins during the Early Cretaceous epoch. These basins are formed between transform faults formed on rifted continental crust. The beginning of sea floor spreading and the splitting of continents took place during the Albian age. Oblique motion between the two margins is recorded by transform faults and fracture zones, and subsidence and sediment deposition occurred during rifting and subsequent sag of the margins (represented in Fig. 10).

In the basin floor that originated from the Guyan continental shelf and slope, explorationists looked for canyons feeding reservoir rocks in channel- levee and turbidite fan deposits. Early Cretaceous organic rich sourced shales charged the reservoir rocks that were deposited during continental rifting. These reservoir rocks were sealed and buried by the marine shales. Expected well log responses are plotted for the five types of deposits; the left curve is spontaneous potential or gamma ray, and the right curve is resistivity.

5. Summary

i. The plate tectonics principle helped explorers to understand and evaluate the hydrocarbon plays.

ii. The Wegner's theory states that at the beginning of the Mesozoic era all the continents of the earth were united together to form single supercontinent called "Pangea" surrounded by huge ocean called "Panthalasa."

- Geological evidences that supports Wegner's theory –
- Similarities in shape of coastlines
- Similar orogenic belt
- Permo- Carboniferous glaciation
- Paleomagnetic evidence
- Animal and plant fossils

iii. There are mainly three types of plate boundaries- (a) Divergent Boundaries, (b) Convergent Boundaries, (c) Transform Boundaries.

iv. According to explorationists, the petroleum system is a geologic element, which includes source rocks, reservoir rocks and seals & traps.

v. Between the Rio Grande Rise and the Gulf of Guinea, the salt basins that face one another are among the largest found along Phanerozoic passive ocean margins. The formation of salt basins takes place during the opening stages of the central South Atlantic i.e., during Aptian (125 to 110 Ma).

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vii. In the basin floor that originated from the Guyan continental shelf and slope, explorationists looked for canyons feeding reservoir rocks in channel- levee and turbidite fan deposits.

Frequently Asked Questions-

Q1. Discuss the geological evidences in support of Wegner theory?

Ans: There are mainly five geological evidences, which support the Wegner theory, which are as follows:

i. Similarities in Shape of Coastlines: The Atlantic coasts of South America and Africa have a roughly similar shape. They would fit in nicely if they are brought in contact with each other. However, the coastlines are not reliable geological features because there shape changes with rise and fall of sea level relative to the land. The real edge of the continent occurs at the continental slope where sea bottom flows rapidly down to deep ocean floor. The mapping of the continental slopes of eastern south America and west Africa has indicated that there contours match excellently. This strongly suggests that these two continents were once joined together.

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v. Animal And Plant Fossils: On the both sides of the south Atlantic, the fossil remains of Mesosaurus have been found. Nowhere else in the world, remains of Mesosaurus or other organisms were found on the continents of Africa and South America appears to link these landmasses during the Late Paleozoic and early Mesozoic eras. The remains of the "glossopteris flora" occur in the rock beds of the Gondwana series in South America, South Africa, India, Australia and Antarctica. These floras reached their maximum development in the Permo- Carboniferous period. The nature of their species distribution can only be explained if all the southern continents were joined together.

Q2. Classify tectonic plate boundaries based on plate movement?

Ans: Depending on the relative motion of adjacent plates, the plate boundaries are classified into three groups as follow:

i. Divergent boundaries: Divergent boundaries are also called the "constructive zones" because in these zones the new crust is continuously created. Divergent boundaries occur at oceanic ridges. The divergent boundaries are boundaries along which plates move away from each other.

ii. Convergent boundaries: The "convergent boundaries" are boundaries along which two plates approach each other and the leading edge of one slips down under other at an angle of about 450. These boundaries are also called "destructive boundaries" or "subduction zones". They occur at the deep trenches. As a result of convergence three type of collision takes place –

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- *Ocean-to-Ocean collision*- when a convergent boundary occurs between two oceanic plates one of those plates will subduct beneath the other.
- *Continent-to-Continent collision*- when two continental plates collide neither plate can be subducted due to their high buoyancy.

iii. Transform Fault Boundaries: Transform fault boundaries are boundaries along which plate slides past one another and there is no production or destruction of lithosphere. The transform fault runs in the direction of plate movement and offset oceanic ridges. The margin at which the plates neither gain nor loose surface area is called "Conservative boundaries".

Q3. Discuss the role of plate tectonics in development of Turbidite reservoirs?

Ans: The plate tectonic theory plays a vital role in the development of turbidite reservoirs. These basins are formed between transform faults formed on rifted continental crust. The beginning of sea floor spreading and the splitting of continents took place during the Albian age. Oblique motion between the two margins is recorded by transform faults and fracture zones, and subsidence and sediment deposition occurred during rifting and subsequent sag of the margins.

Q4. Detail out the conditions that create evaporates?

Ans: There are mainly three conditions necessary for the formation of thick

- layered salt deposits are: a basin deep about 1,500m (4,900ft)
- A continuous supply of mineral- laden sea water and
- A warm and arid climate

The basin water level drops quickly and stabilizes to a critical level when the evaporation takes place. The water intake rate is equaled by the evaporation rate.

Q5. Correlate tectonic motions in creating of structural and stratigraphic traps?

Ans: With the extension and faulting of continental crust, the rifting of the South Atlantic Ocean has started due to this the continental crust thinned and eventually split apart. Due to the separation of two parts of the continental crust (only the right side is shown here), the oceanic crust is formed at a midoceanic ridge during seafloor spreading. The continental margin is located where the thinned continental crust meets the oceanic crust. The source and reservoir rocks that were eventually trapped and sealed underneath salt preserve the synrift lacustrine basins. The hydrocarbons that are buried and trapped beneath postsalt marls are migrated from synrift source rocks to limestone reservoirs. The source rocks are also provided by marls. Clayey- sandy sediment buried the margin, source rock, reservoir rock, cap rock and overburden during the Tertiary period.

Multiple Choice Questions-

1. Rock that records the earth's magnetic field present at the time of their formation

(a) Igneous rock
(b) Metamorphic rock
(c) Sedimentary rock
(d) All of the above

Ans: a

2. The remains of the "glossopteris flora" occur in the rock beds of Gondwana series in

(a) South America
(b) Australia
(c) India
(d) All of the above

Ans: d

3. There is no destruction of lithosphere in

(a) Divergent plate boundaries
(b) Convergent plate boundaries
(c) Transform fault boundaries
(d) All of the above

Ans: c

4. Tick the correct option

(a) Play- lead- prospect- drillable prospect
(b) Lead- play- prospect- drillable prospect
(c) Drillable prospect- prospect- lead- play
(d) Prospect- drillable prospect- play- lead

Ans: a

5. Conditions required to create Halite are

(a) Layered salt deposit
(b) 1.5km sediment thickness
(c) Mineral laden seawater
(d) All of the above

Ans: d

6. Jubilee oil field reservoir is

(a) Cut and fill reservoir
(b) Turbiditic reservoir
(c) Stratigraphic pinch out
(d) Stratigraphic wedge out

Ans: b

7. Compression results

(a) Faulting
(b) Folding
(c) Shortening
(d) All of the above

Ans: b

8. Seal to a reservoir is

(a) Sandstone
(b) Siltstone
(c) Shale
(d) All of the above

Ans: d

9. Which are the types of convergent plate boundaries

(a) oceanic- continental
(b) oceanic- oceanic
(c) continental- continental
(d) All of the above

Ans: d

10. The event of breaking of Pangaea took place in the era

(a) Triassic
(b) Jurassic
(c) Mesozoic
(d) Cretaceous

Ans: a

Suggested Readings:

1. Anderson, Don L. (2007). New theory of the Earth, 2nd Edn. Cambridge University Press. ISBN: 0521849594, 978-0521849593.
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5. Kearey, P., Klepeis, Keith A., & Vine, Frederick J. (2009). Global tectonics, 3rd Edn. Wiley-Blackwell Publishing. ISBN: 978-1-4443-0322-3.