# * OCEANOGRAPHY :

Neetu Singh IAS

(1) Physical properties of Ocean water :
   - Salinity
   - Temperature (Heat budget).

(2) Ocean water movements :
   - Sea waves
   - oceanic currents < Gyre circn, Thermohaline Circ'n.
   - Tides < Mechanism, Generated movements.

(3) Submarine Topography :
   Atlantic ocean, pacific ocean, Indian ocean.

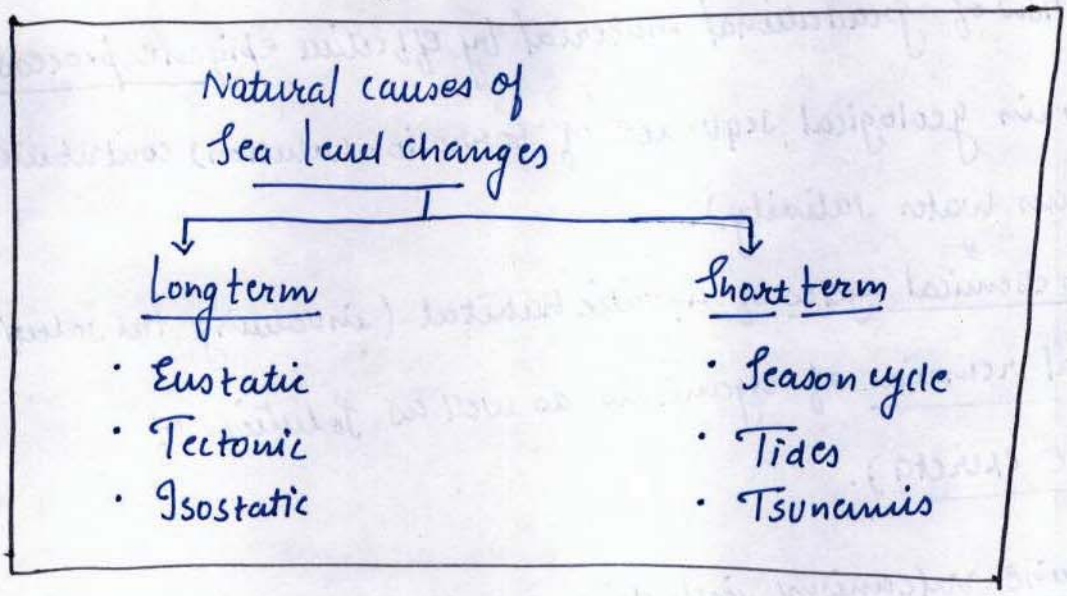
(4) Coral Reef : (coral Bleaching)

(5) Marine deposits :

(6) Marine resources : (fishing)
   (UNCLOS)

(7) Sea level changes :

## * Sea level changes:




## * Physical Properties of Ocean water:

1] The blue planet earth involves more than 70% of the area as water surfaces. of which oceans & marginal water bodies accounts for maximum share.

2] The ocean water is specified with two defined types of physical properties Salinity & temperature that are strongly correlated to each other.

3] The ocean water Salinity is defined to be amount of dissolved Sea salts in ocean water.

4) It is presence of salinity that essentially distinguishes ocean water from the fresh water sources.
However to begin with ocean water was also fresh water as it was formed due : accumulation of precipitation water in prolonged geological perspective.

The genesis of salinity in ocean water thus is related to:

a) Deposition of gradational material by effective epigene processes (which in geological sequence of corrosion (solution) contributed to ocean water salinity).

b) The bio chemical cycles of aquatic habitat (involving the solution of skeletal remains of organisms as well as solution of organic excreta).

c) Submarine volcanism including mantle plume (which facilitated genesis of igneous rocks with subsequent corrosion adding to the salinity).

5) Oceans being considered to be universal solvent involves 47 different types of sea salts. Out of which Sodium chloride (NaCl) accounts for more than 75% of share.

6) The avg. ocean water salinity is 34-35 parts per thousand (‰) i.e. 34-35 grams of dissolved sea salts per thousand grams of sample sea water.

7) The level of salinity however significantly varies in the regulating influence of:

(a) Prevailing temperature.
(b) Precipitation pattern.
(c) boundary currents.
(d) Influx of fresh water. * Ablation.
(e) Continentality.

(a) Prevailing temp.-

→ Forms the prime regulator.
→ As is determiner of rate of evaporational loss.
→ Involves positive relation with salinity.

(b) Precp'n Pattern:

→ 2nd prominent determiner in influencing planetary pattern of salinity.
→ It relates to diluting the ocean water.
→ Higher amount of precp'n thus develops lower salinity.

(c) Boundary currents:

→ Applicable to all open oceans with latitudinal basins (5 ⇄ N/S Atlantic, N/S Pacific, S Indian
→ The west boundary current being warm develops atmospheric instability thus decreases salinity.
→ East boundary current in comparison being cold develops stable atmospheric conditions thus increasing salinity.

(d) Influx of fresh water:

→ It relates to diluting the ocean water thus decreasing salinity.
→ River mouth largely denoted with perennial influx projects stronger role.
→ Ablated water with more seasonal dimension proves to be comparitively secondary agent of diluting.

(e) Continentality:

→ It is applied to the marginal water bodies.
→ This factor thus is applicable to the latitudes b/w 10°-60° N/S.
→ It thus is subdivided as tropical marginal water & temperate marginal water.
→ continentality as regulator of salinity essentially reflects prevailing temperature anomaly thus tropical marginal water having higher salinity than open counterpart & temperate marginal water having low salinity than the open counterpart.

## ✦ Pattern of ocean water salinity:

1] Analysis of pattern of ocean water salinity involves:

i) Latitudnal pattern
ii) Regional pattern
iii) Vertical pattern

(i) Latitudinally ocean water salinity depicts that, barring the exception of equatorial water ocean water salinity decreases with increase in sign of latitude.

→ Tropical water tends to depict highest levels of salinity (36-37 ‰) due to high prevailing temperature throughout the year & seasonal precipitation.

→ The temperate water projects avg. level of salinity (34-35 ‰) due to prevailing moderate temp. & precp'n conditions.

→ The sub polar water depicts lowest salinity (31-32 ‰) due to negligible evaporational loss & influx of ablated water during summers.

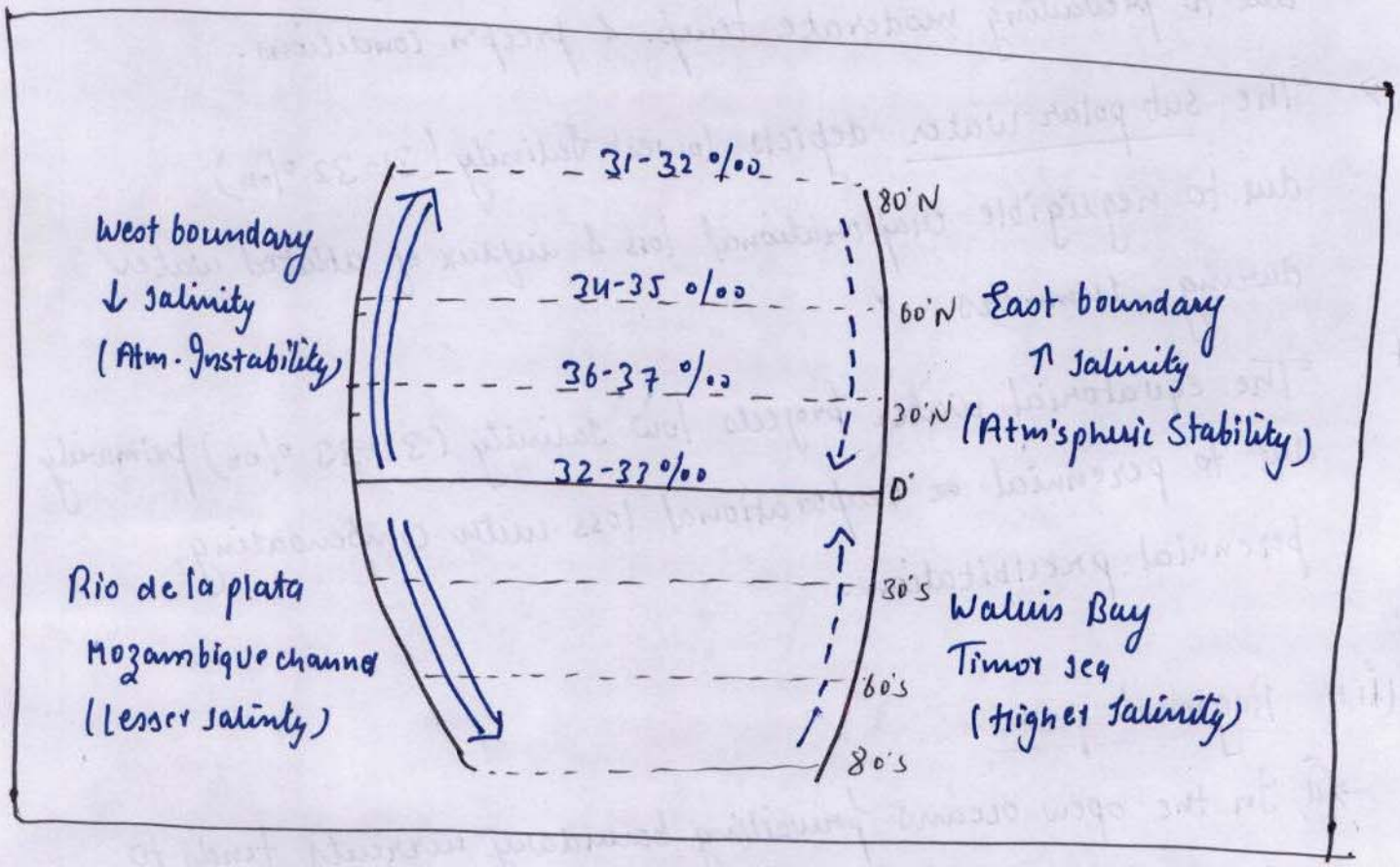
** The equatorial water projects low salinity (32-33 ‰) primarily due to perennial ~~e~~ evaporational loss with compensating perennial precipitation.

(ii) Regional pattern:

→ (a) In the open oceans prevailing boundary currents tends to influence nature of ocean water salinity i.e. + west boundary with warm oceanic current that induces atmospheric instability generates lower salinity levels than the east boundary.

→ (b) Influence of boundary current in determining salinity is well depicted in Southern Atlantic & Southern Indian ocean marginal water.

Being less demarcated by land Rio de la plata & mozambique channel in the influence of west boundary current projects lesser salinity than their eastern counterparts that are Walvis Bay & Timor Sea respectively.




(c) The closed current system called gyre circulation in North Atlantic combined with anticyclonic conditions of azores relates to the development of high salinity water of Sargasso Sea i.e. dark green sea in the mid latitudinal open atlantic ocean.

Hawaiian high of pacific ocean centred b/w pacific gyre circulation though also develops higher salinity zone it is not recognisable with the simple empirical observation

* Salinity in marginal water bodies:

→ In the influence of continentality marginal water projects different salinity levels than the open counterparts.

→ This variable salinity is demarcated as:

Tropical marginal water salinity & temperate marginal water salinity.

(a) Tropical marginal water bodies Salinity levels remains higher than the open oceanic counterpart.

→ Level of salinity however is regulated by 3 determining factors:

- Magnitude of continentality.
- Prevailing climatic conditions.
- Presence / Absence of river mouth.

→ In the combination of these 3 factors mediterranean sea, Arabian sea & Gulf of California proves to be more saline than Gulf of mexico, Bay of bengal & south china sea respectively.

→ In the specifications Gulf of Aqabah (Indian ocean) & Gulf of Sidra (NE Atlantic ocean) proves to be most saline water bodies.

* Dead sea extension of Gulf of Aqabah along Rift valley.

* Dogger bank - major fishing grnd.

(b) Temperate marginal water bodies:

→ Marginal water bodies in temperate zone projects salinity level to be less than their open counterpart.

→ It is therefore the sea of Okhotsk, Bering sea of pacific ocean and Baltic sea, Gulf of Bothnia of Atlantic ocean have salinity levels lesser than their respective open counterparts.

→ The lesser levels of salinity can be further depicted with prevailing magnitude of continentality and influx of fresh water (seasonal or perennial).

In the temperate water bodies North sea of Atlantic ocean and Norwegian sea of Arctic ocean however have higher salinity than their open counterparts as they are in the influence of warm oceanic currents called North Atlantic Drift & Norwegian current respectively (which tends to increase temperature & thus evaporational loss leading to increase in salinity levels).

(iii) Vertical pattern of Salinity:

→ Depicted as 'S' Diagram vertical pattern of ocean water salinity ideally involves 3 vertical stratas:

Pelagic Zone, Halocline Zone, Benthic Zone.

a) Pelagic Zone - forms surface mixing zone with all the variations in the salinity pattern. It ideally extends upto the depth of 500m.

(b) Benthic Zone - Is the deeper uniform zone demarcated below the depth of 1500m. It is characterized with near absolute uniform salinity

(c) Halocline level - forms intermediate compensating level where salinity can decrease or increase with increasing depth depending on surface salinity.

Ideally the Halocline level extends b/w 500-1500m of Depth.

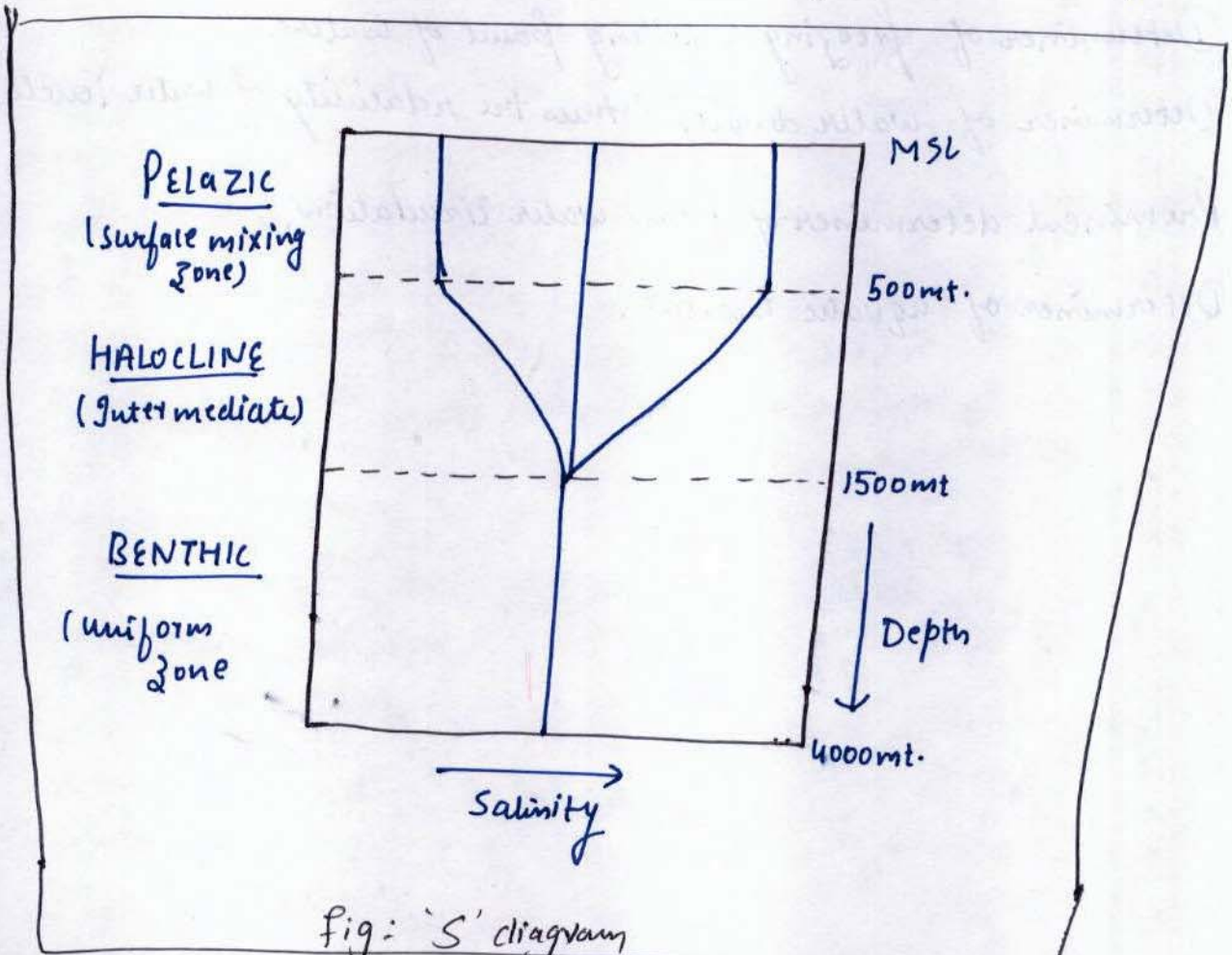



fig: 'S' diagram

MJO

- Intra Seasonal - (30-60 days / 90 days)
- Eastward propogation
- Tropical warm water pool < Indian ocean Region
  W. C. Pacific
- Dipolar < Enhanced convection
  Supression convection

## ✱ Significance of Salinity:

This physical property of ocean water is identified of its significance in multi dimensional inter related impacts.

These includes:

(a) Determiner of freezing & boiling point of water.
(b) Determiner of water density & thus the relativity of water levels.
(c) Prominent determiner of ocean water circulation.
(d) Determiner of aquatic habitat.

# Ocean water temperature :

1] The physical property of ocean water. The ocean water temperature is defined to be amount of heat present in ocean water.

2] The primary source of ocean water temp. forms incoming solar radiations. The secondary sources (with more regional effectivity) includes submarine vulcanism & hydrothermal vents.

3] Generally the annual range of ocean water temp. remains higher in smaller water bodies.
latitudnally the general pattern of surface water temperature involves :

- → Approx. 22°C at tropical latitudes.
- → 14°-15°C in mid latitude.
- → Near freezing point of water at polar latitude.

4] The pattern of ocean water temperature involves the influence of : i) Sign of latitude
ii) Amount of precipitation
iii) Oceanic currents
iv) Influx of cold water
v) Continentality

5) latidunally barring the exception of equatorial water ocean water temp. decreases with increase in sign of latitude.

6] In a given latitude among given oceanic latitudinal basins at the western margin, temp. remains higher compared to eastern margin.

7] In Southern Atlantic & Southern Indian ocean less demarcated marginal water involving influence of boundary current develops temp. difference i.e. Rio de la plata & mozambique channel are known for higher temperature than their respective eastern counterparts walvis bay & timor sea.

8] The tropical continental or marginal waterbodies commonly relates to higher temperature than the open counterpart ( with the variable influences in terms of season cycle as well)

9] The temperate marginal water in comparison projects lesser temp. than open counterpart.

** North sea of atlantic ocn & Norwegian sea of arctic ocean forms exceptional examples which in the influence of North altantic drift & norwegian current respectively projects higher temperature.

10) The vertical pattern of ocean water temp. involves 3 defined Stratas : (a) Surface mixing Zone - that have all temp. variations.

(b) Thermoclinal Zone i.e. Intermediate compensating Zone.

(c) Benthic - the uniform Zone.

In the presence of secondary source of ocean water temperature benthic thermocline marks its presence. with increase of temperature with increasing depth.

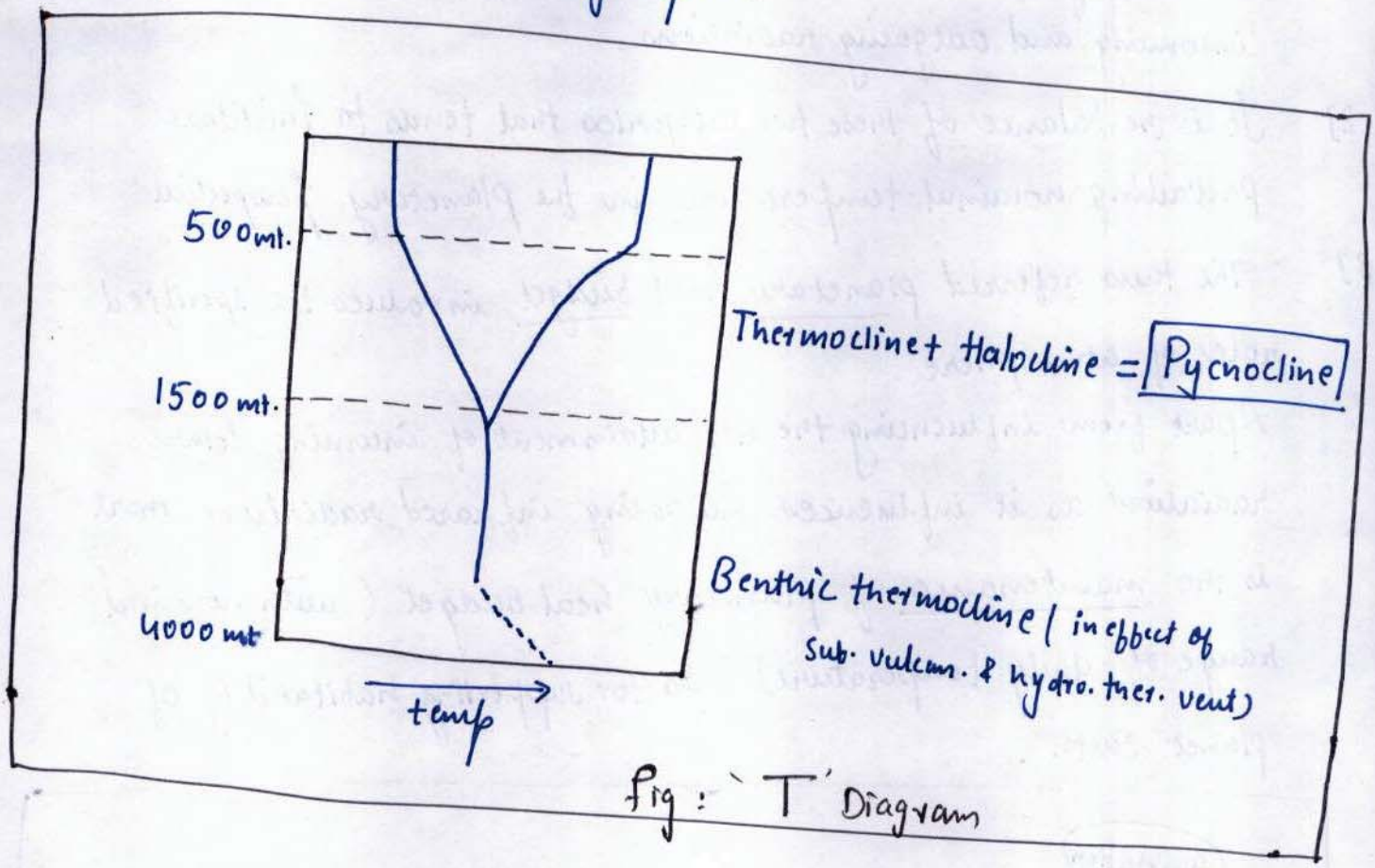



Fig: 'T' Diagram

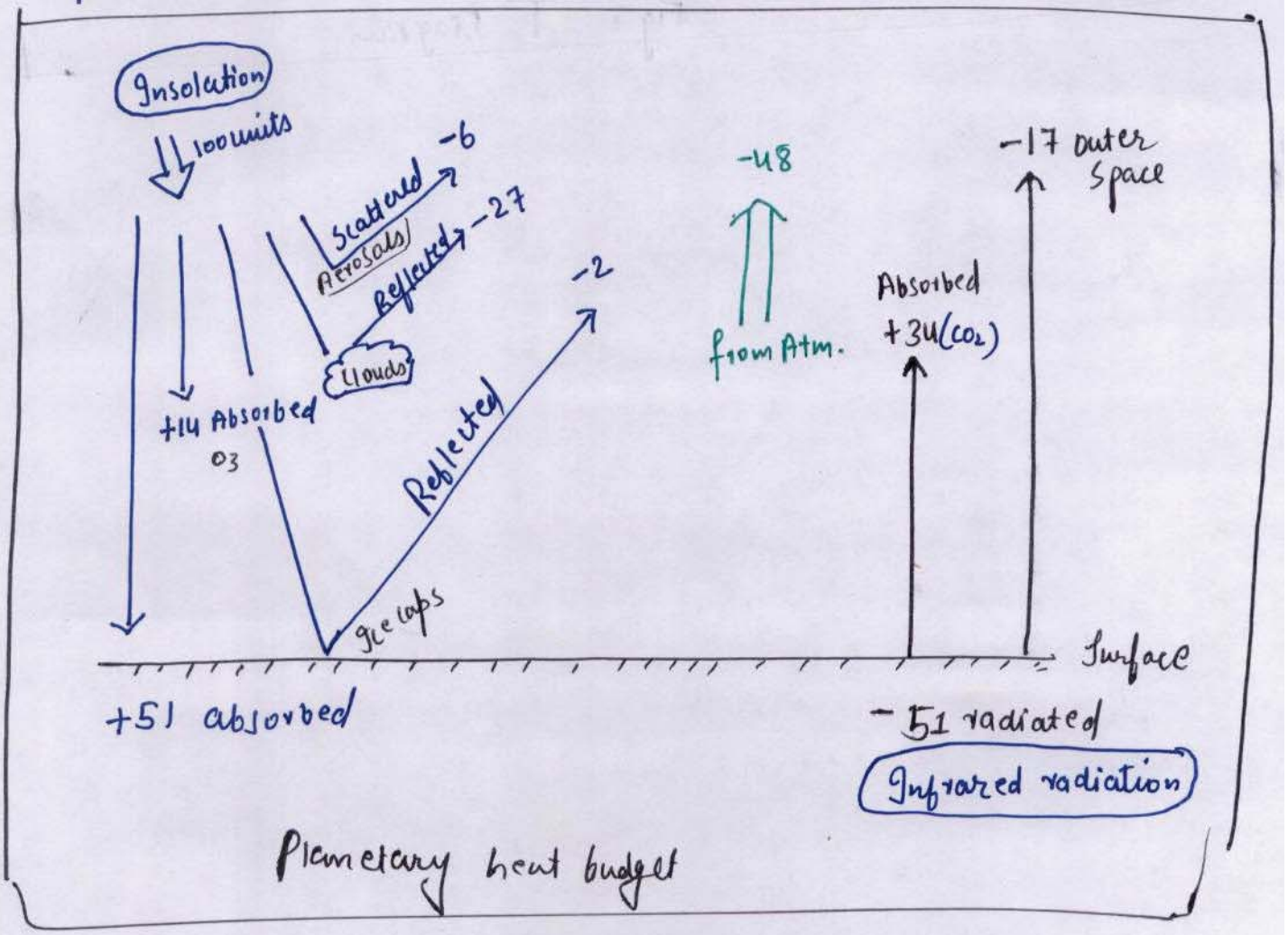
# ✱ Heat Budget :

1) Heat budget or heat balance is identified to be the balance between incoming and outgoing radiations.

2] It is the balance of these two categories that tends to facilitate prevailing nominal temperature in the planetary perspective

3] The thus referred planetary heat budget involves the specified role of atmosphere.

Apart from influencing the net attainment of incoming solar radiation as it influences outgoing infrared radiation there is the maintenance of planetary heat budget ( with nominal range of daily temperature) factor supporting habitability of planet earth.




Planetary heat budget

4] The planetary heat budget both at latitudinal & regional levels relates to the development of **Heat fluxes**.

The term is applied to denote inequality b/w incoming & outgoing radiations.

In order to maintain heat budget there is thus the requirement of terminating (minimizing) heat flux.

It is therefore that 3 additional factors justifies their role in the heat budget:

(a) Advection.
(b) Sensible heat.
(c) Latent heat.

(a) Advection:

→ Applied to latitudinal heat budget.

→ largely compensating heat flux b/w Insolation thus heat surplus low latitude & insolation thus heat deficit (higher latitude).

→ It involves Global circulation i.e. comprised of atmospheric circulation & Oceanic circulation.

→ At regional to local levels balance of heat flux is facilitated by:

(b) Sensible heat - i.e. defined to be heat loss from the surface due to the process of conduction & also ~~latent heat~~ th

c) latent heat - heat loss from the surface due to evaporation

The planetary heat budget (ocean water heat budget) thus is the interplay of 5 different factors

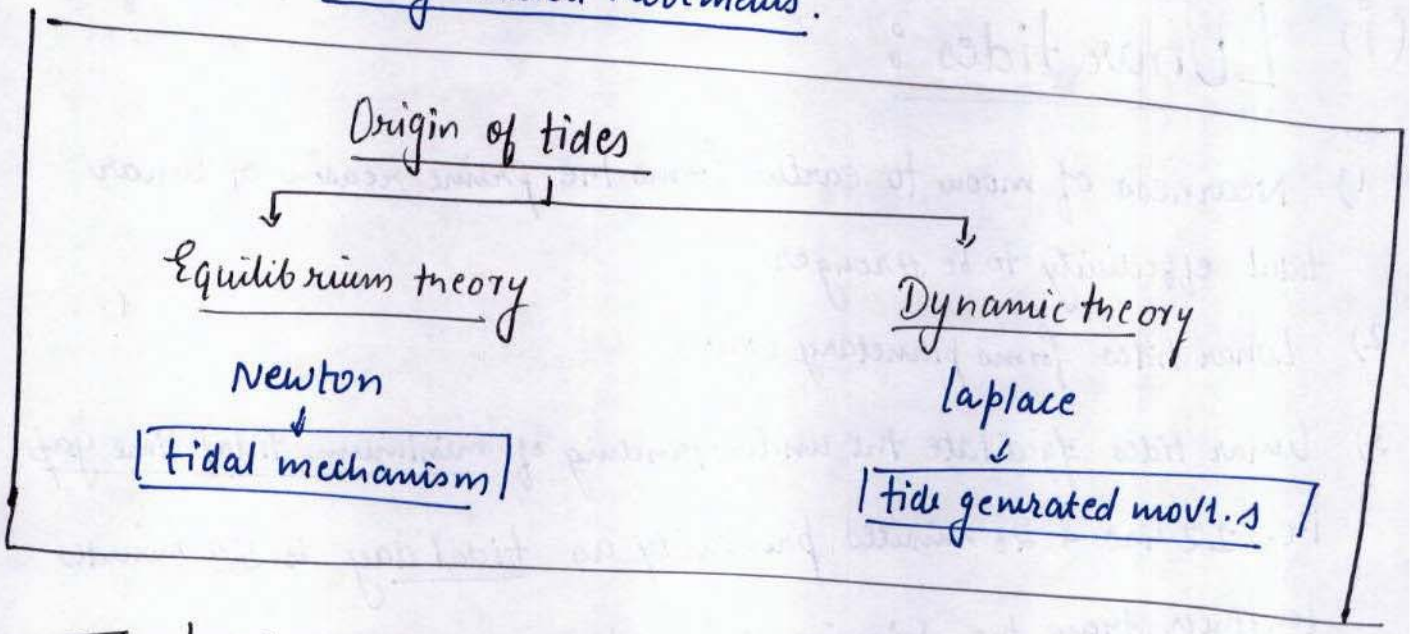
| Planetary | Latitudinal | Regional |
|---|---|---|
| (1) Insolation | (3) Atmospheric cir'n<br>- Atmospheric<br>- Oceanic | (4) Sensible heat |
| (2) Infrared radiation | | (5) Latent heat |

# * Ocean Water Movements :

1] The mobility of ocean water combining involved causative factors and geographical scale includes: Seas waves, tide generated movement & oceanic current system.

## * Tides :

1) Tides are defined to be the pulse or the bulge experienced on the water surface due to lunar & solar attraction.
2) Geographic study of tides incorporate analysis of tidal mechanism as well as tide generated movements.




## + The tidal Mechanism :

1) Is comprehended in the reference of equilibrium theory originally propounded by newton.
2) This theory identifies intervelation but with difference b/w the tide i.e. bulged water & ebb i.e. simultaneously developed depressed water surface.

3] Tides on the spinning earth as tends to develop attractive bulge with simaltaneous equal & opposite centrifugal bulge.

Tides are defined to be the planetary waves that've wavelength of half of the circumference of the earth & wave height of not more than 2 meters.

4] There are 3 different types of tides distinguished:

i) Lunar tides.

ii) Solar tides.

(iii) Mixed tides.

[ Kandla - child of partition, bcoz of loss of Karachi ]

## (i) Lunar tides :

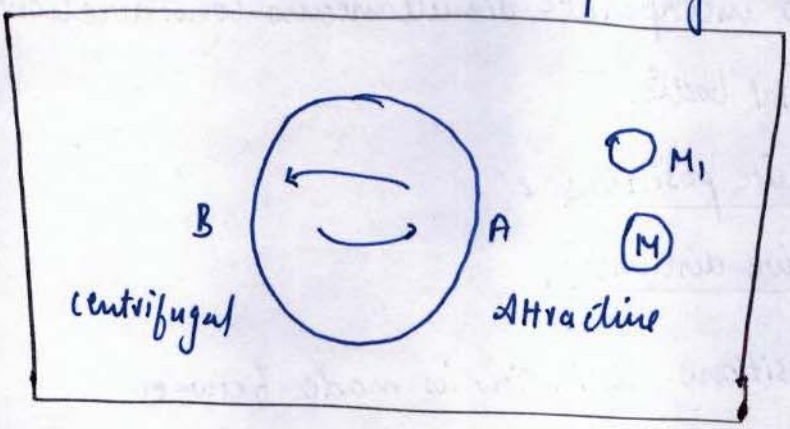
1) Nearness of moon to earth forms the prime reason of lunar tidal effectivity to be stronger.

2) Lunar tides forms planetary waves.

3) Lunar tides facilitate the understanding of minimum tidal time gap i.e. 12 hrs & 26 minutes primarily as tidal day is 52 minutes lengthier than the spinning time of the earth ( bcoz of lunar movement).

4) with lunar revolution path along earth's equatorial orbits involving declination b/w 28 1/2° N and 28° 1/2 S ( tropical & equatorial tides are generated).

with tropical tides projecting successive sequence of high & low water whereas equatorial tide depicting near maintained water level




## (ii) Solar tides :

1] Gravitational attraction of Sun also creates planetary waves of tides however due to the involved distance the comparative tide generated effectivity is less than half of that of lunar tidal effectivity

2] with axial inclination of planet earth & its revolution round Sun apparent change in the position of Sun in 365 days of cycle tends to generate tropical & equatorial tides.

It is however due to involved time that Solar tidal effectivity proves to be weaker than lunar tidal effectivity

## (iii) Mixed Tides :

1) This category of tides incorporate simultaneous consideration of three concerned celestial bodies.

2) It thus involves | relative positions &
relative distances.

3) In terms of relative positions distinction is made between syzgy tides & Quadrature tides.

4) The Syzgy tides :

→ This category of tides corrospands to alingned position of the three celestial bodies.

→ It thus corrosponds to both new moon & full moon positions.

→ The new moon position called Syzgy conjunction clearly involves both sun & moon on a given side of earth.

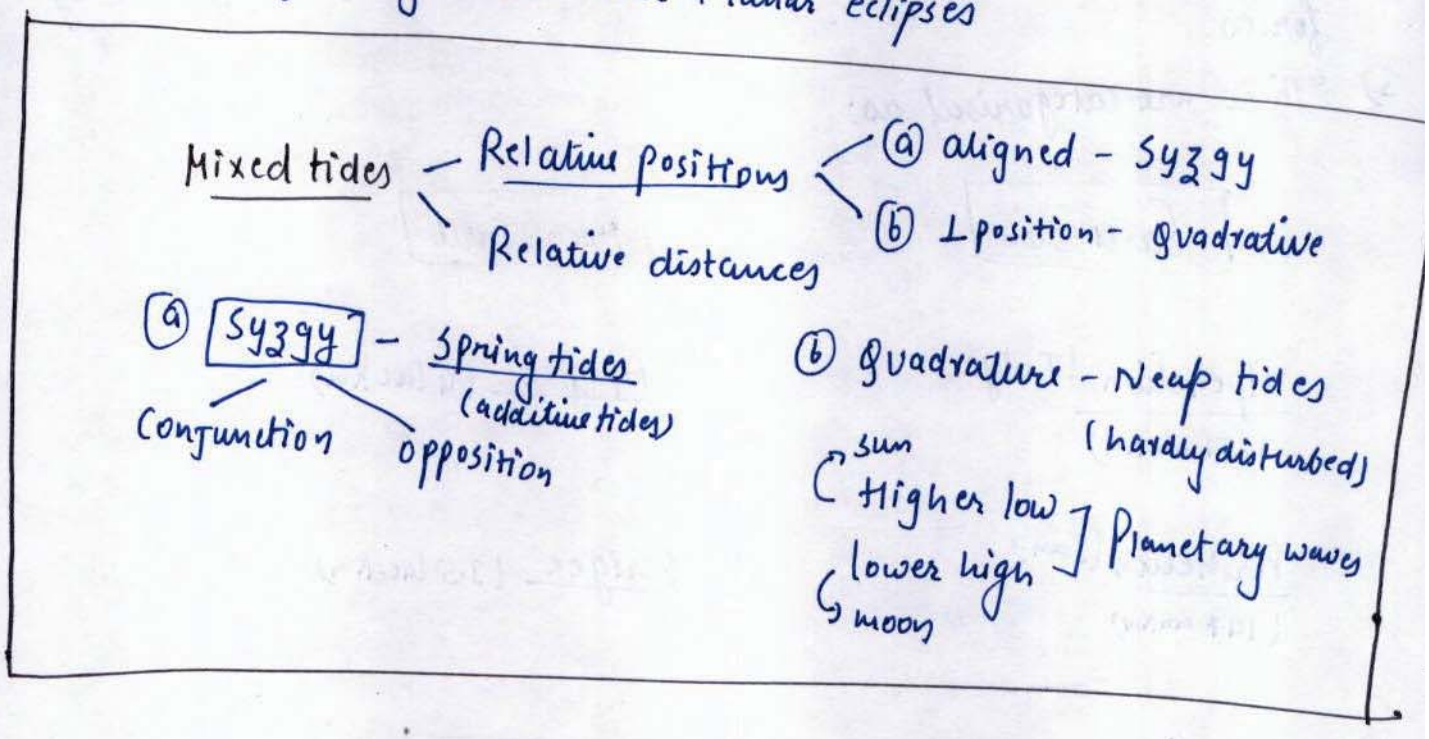
→ In comparison the full moon syzgy called Syzgy opposition relates to position of the sun & the moon on the opposite sides of earth.

→ In both the syzgy positions spring tides are experienced that are additive tides thus high tides.

** These develop when lunar & solar tide generating effectivity adds to each other. which however differs for syzgy conjunction (when attractive force work on the same side) & syzgy opposition (when attractive force combines with centrifugal force of other).

→ The Syzgy Spring tides are additionally recognized with:

- Reoccurence in periodicity of approx. 2 weeks.
- Development of planetary waves with higher high water and lower low water.
- corrosponding to both solar & lunar eclipses




5) Quadrature tides -

→ Corrosponds to 1st & last quarter of moon which involves perpendicular alignment of lunar & solar effectivity on the earth's surface.

→ As the both tide generating forces fails to add to each other Neap tides that are low tides experienced.

* Neap tides corrosponds to hardly disturbed water or diminishing tides.

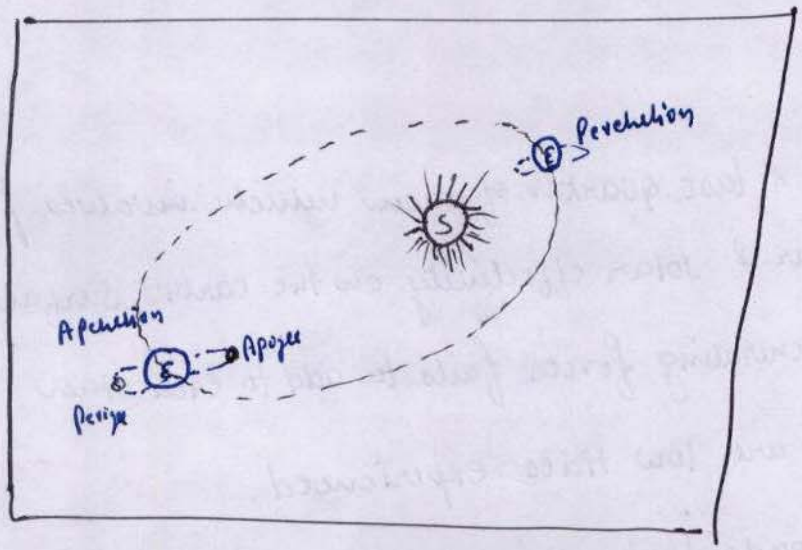
→ The Quadrature Neap tides are additionally characterized with

- Periodicity of development in approx. 2 weeks.
- Development of planetary waves with higher low water (sun) & lower high water (lunar effectivity).

## Relative distances:

1) The orbital path of earth around Sun and moon around earth as is elliptical both these celestial bodies tends to modify relative distances in reference to each other.
2) It is these relative distances that tends to modify tide generating forces.
3) These are categorised as:

| Earth-Sun | Moon-Earth |
|---|---|
| Aphelion (July) (151 mn Km) | Apogee (4 lac Km) |
| Perihelion (Jan.) (147 mn Km) | Perigee (3.5 lac. Km) |




- The equilibrium concept excellently explains: mechanism of tide generation & types of developed tides.

This concept however is based on hypothetical assumption that surface of earth is in constant equilibrium to tide generating forces

i.e. the developed tidal bulge tends to keep pace with changing position of moon.

* practically however with frictional drag induced by ocean water the developed bulge fails to keep pace with change in the lunar position resulting in tide generated movements.

## * Dynamic Concept of Tides:

1) Originally credited to laplace this concept facilitates the understanding of tide generated movements.

2) It is based on the practical observation that tidal bulge failing to keep pace with changing position of moon gets influenced by
   - Spin of the earth,
   - Shoreline barrier.
   - Coriolis effect.

3) In the combination of all these determiners tide generated movements are categorised as:
   (a) Progressive waves.
   (b) Amphidromic system.

### (a) Progressive waves:

→ These are also considered to be tidal currents that have near repetative characteristics of propagation in all the open latitudinal Oceanic basins.

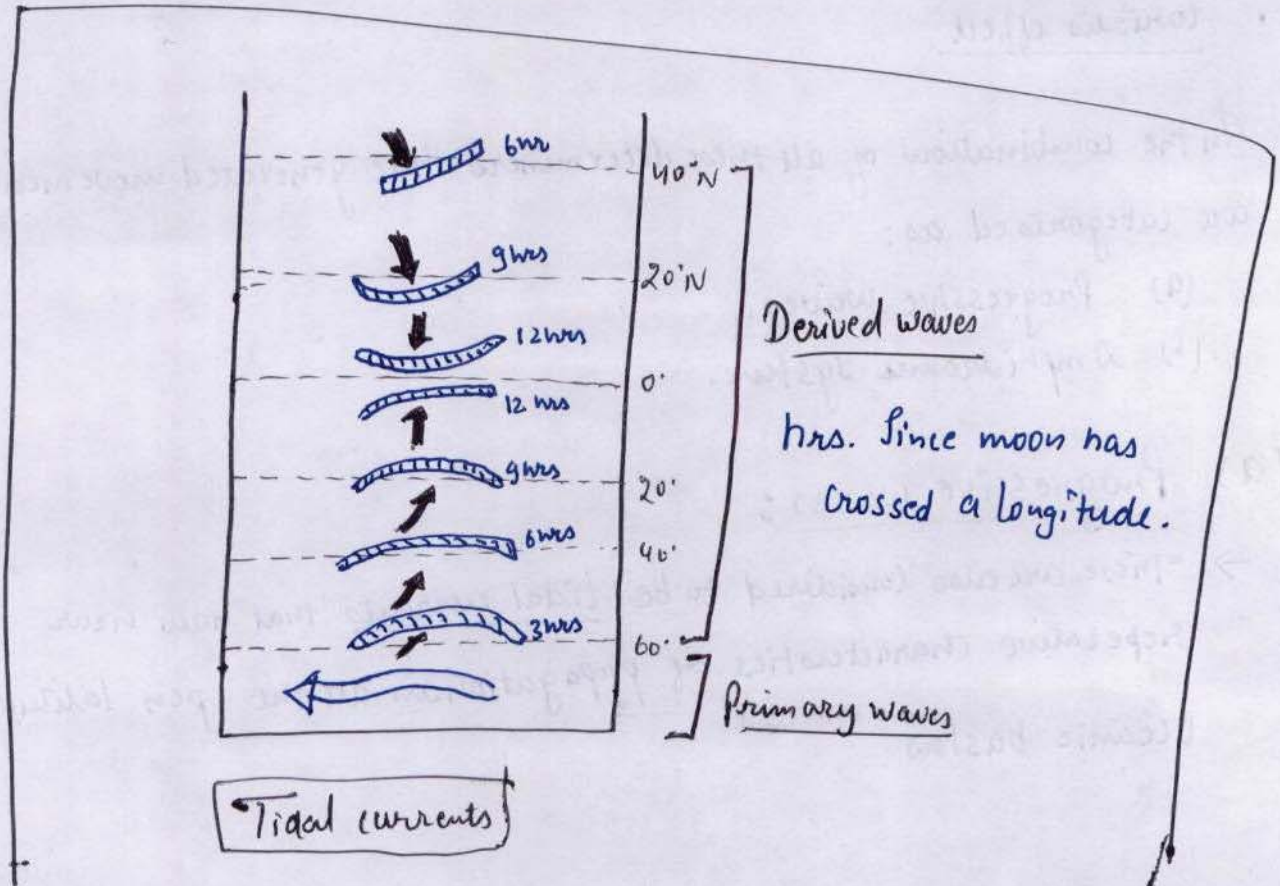
→ It incorporate distinction b/w primary waves & derived waves

* primary waves : Essentially forms slow westward moving tidal waves due to the spinning effect of earth. Its presence is most defined in Southern Ocean where there is complete absence of shoreline barrier.

* Derived waves : In comparison additionally involves Shoreline barrier piling up of water thus results in higher velocity retreat of derived waves.

It is in the influence of its higher velocity propagation that derived waves additionally experiences coriolis effect progressing towards equator.

** IMS The progressive waves or tidal currents tends to maintain mobility of water for upto 12 hrs since the moon has crossed the longitude sustaining the commerciality of tidal ports.



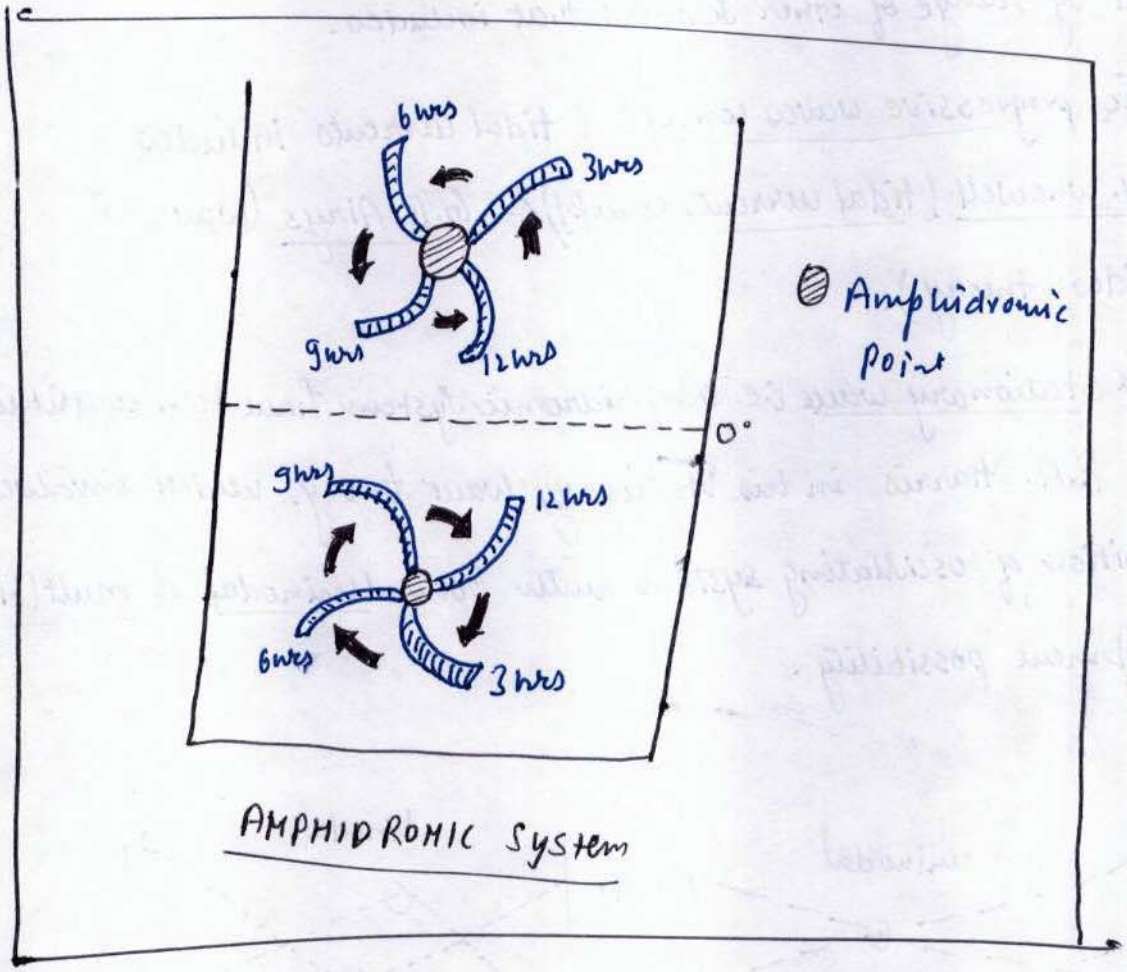
(b) Amphidromic System:

1) It forms the tide generated movement that is typical to marginal water bodies where the tidal bulge due to nearness of the shoreline projects higher effectivity.

2] These effective bulges in absolute difference to open oceanic counterparts do not develop primary waves.

3] The well defined development of derived waves thus tends to combine Spin of the earth and coriolis effect.

4] It is therefore that stationary* or Standing waves are generated with sequential rise of water around a depressed point called AMPHIDROMIC POINT.




AMPHIDROMIC System

5) The nature of circulation of amphidromic system thus is counterclockwise in northern hemi. & clockwise in southern hemisphere.

6) This tide generated movement also tend to maintain mobility of water to upto 12 hrs since the moon has thus sustaining commerciality of tidal ports.

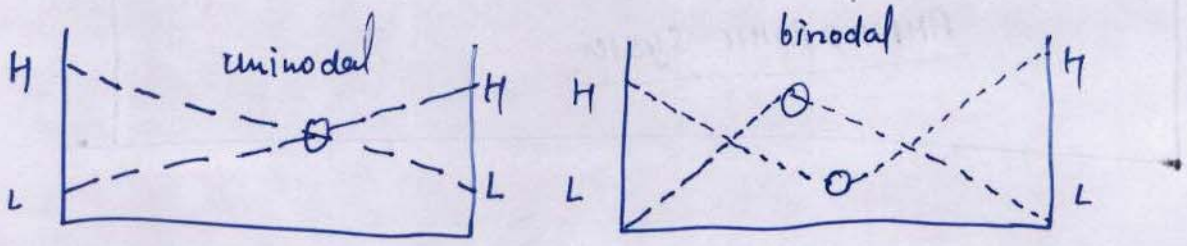
7] It additionally involves higher tidal range thus commercial harnessing of tidal energy.

e.g. Bay of fundy, canada (30 m tidal range)
Dover strait, France (15-17m)

** Tide generated movements also includes the theoritical analysis proposed by range of other scholars that includes:

(a) The progressive waves concept (tidal currents includes W. whewell [tidal currents concept] & G.B. Airys (waves & tides theory).

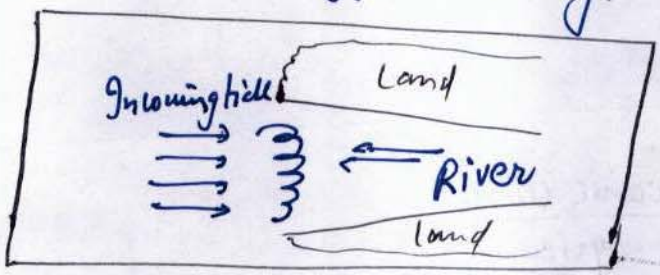
(b) The Stationary wave i.e. Amphidromic System have been contributed by R.A. Harris in his stationary wave theory. which involves recognition of oscillating system with both Uninodal & mult(bi)nodal development possibility.



## * Tidal Bore:

→ It is defined to be "Wall" of water that is created along river mouth with approaching high tidal wave.

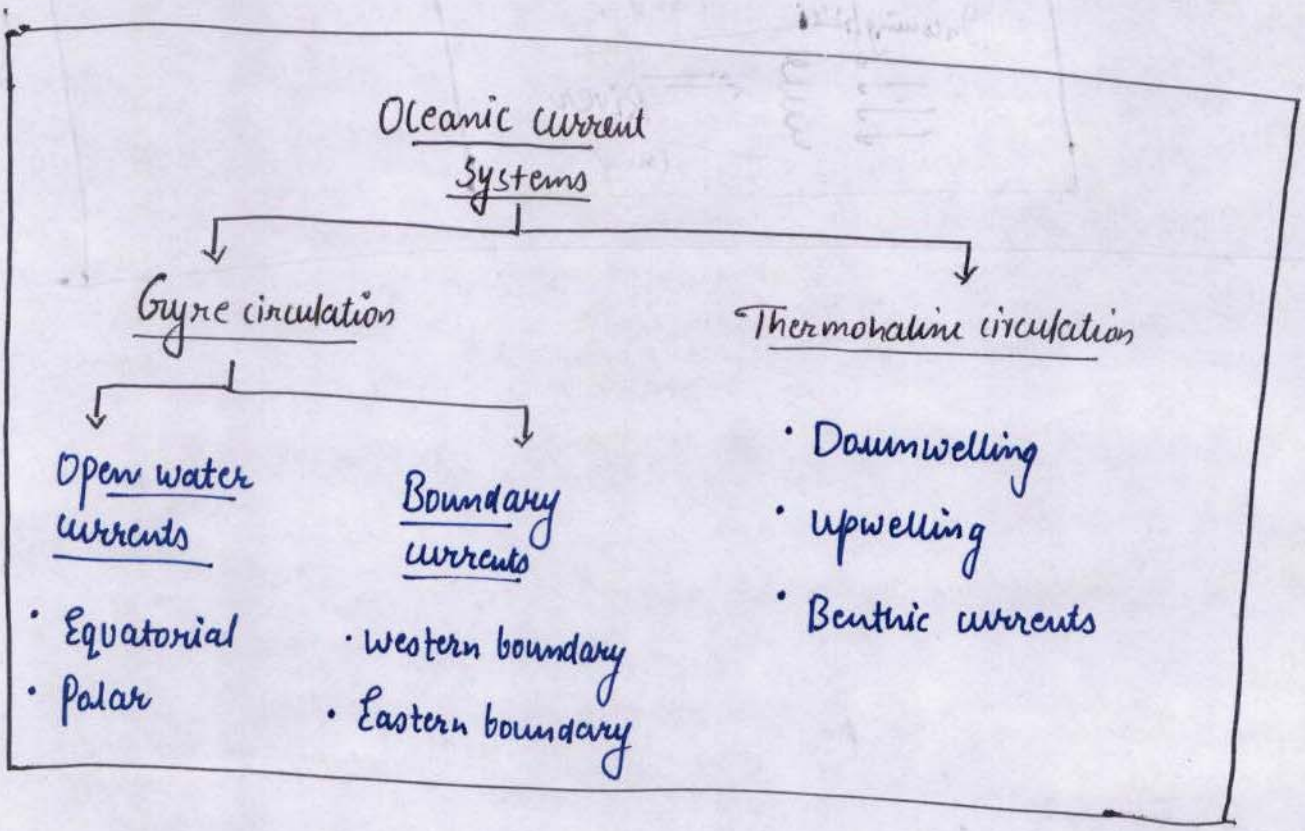
→ Tidal bores tends to develop both tidal ports & favourable tidal range for commercial energy harnessing.



# * Oceanic Currents System :

1) Movement of ocean water that is considered at planetary scale is collectively referred as Oceanic current system.

2] It is comprised of two distinctive systems with respective subdivides that includes :




## * Gyre circulation :

This category of oceanic current system is surface water oceanic currents that have consistent movement in a particular direction throughout the year under the influence of planetary winds.

This surface current system involves two defined constituents :

a) Open Oceanic currents

(b) Boundary currents.

(a) Open oceanic currents:

1] Represents the category of surface currents that have their advection throughout the ocean water from one shoreline to other.
It includes two distinctive currents that are principally categorised on the basis of their location.

(a) The equatorial current as open oceanic current tends to depict consistent westward movement due to:
- → Spinning effect of earth (major determiner).
- → Absence of coriolis force.
- → Equatorial easterlies.

2] These currents are distinguished as North equatorial current (NEC)- South equatorial current (SEC) in the respective basins.

** The equatorial water also involves Counter Equatorial current (CEC) (specifically in the doldrums) primarily due to piling up of water in the western shoreline.

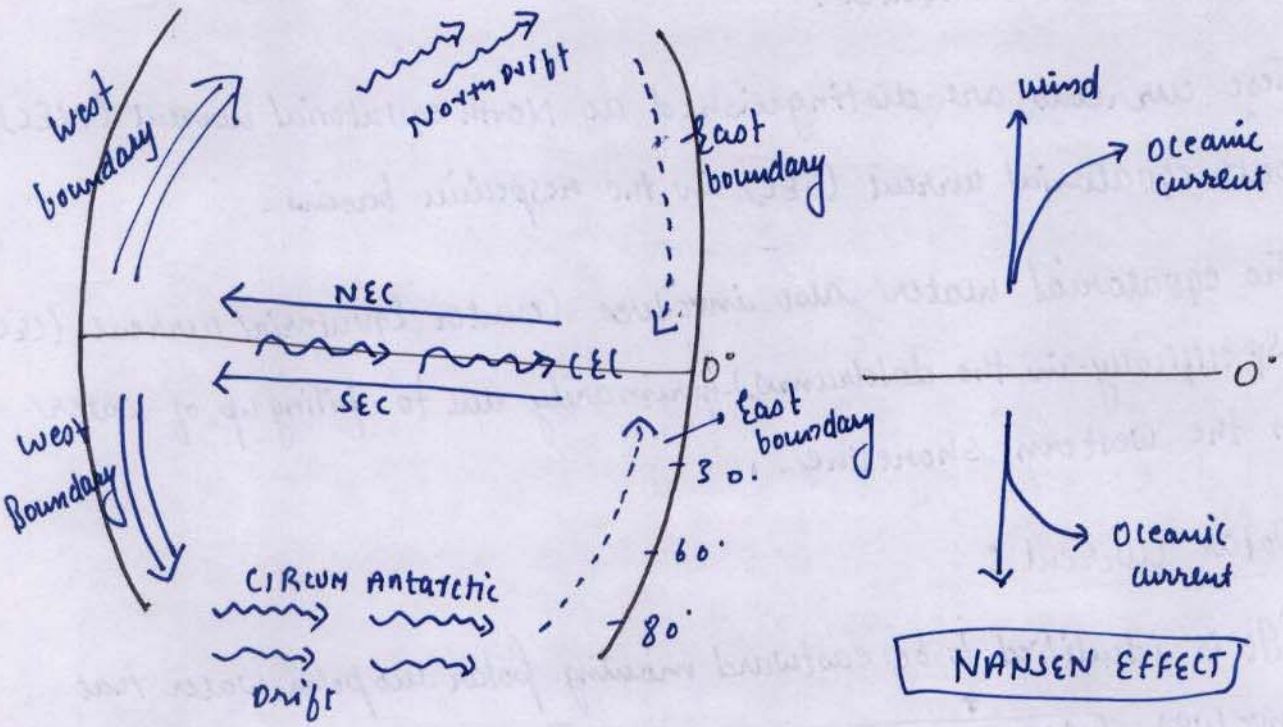
(b) Polar current:

→ It is identified to be eastward moving polar sub polar water that involves NANSEN EFFET (coriolis effect).

→ In Southern Ocean complete absence of shoreline barrier makes polar current advect absolutely eastward called CIRCUM ANTARCTIC DRIFT (CAO) or West Wind drift (WWD).

→ In northern basins however prevailing shoreline barrier makes polar water north east called northern drift.

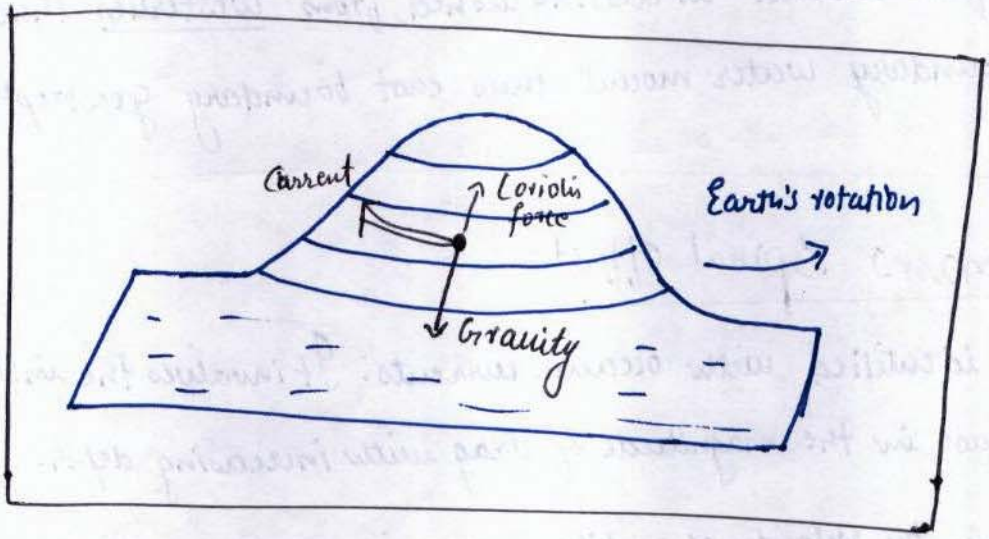
** The westward moving equatorial current combined with eastward moving polar faciliates the genesis of closed oceanic current system called Gyre circulation. The nature of this circulation is clockwise in northern hemisphere & counterclockwise in southern hemisphere.



[B] Boundary Currents:

1) These surface water currents marks their confinement in near absolute coastal water. They ideally makes examples of Geostrophic currents.

These are defined to be the oceanic currents that are generated when gravitational force influenced movement of water experiences "counter balancing" by coriolis effect resulting in movement of Ocean water. parallel to Contours of a water mount.




for the development of geostrophic current required water mount is developed due to Ekman's transport & Ekman's pumping effect.

The Ekman's transport effect is related to latitudinal Salinity differences thus the difference in the water levels.

The latitudinal advection called Ekman's transport thus develops

- Equatorial & Subpolar water as divergence zone.
- whereas tropical & temperate water Convergence zone.

The simultaneously experienced Ekman's pumping effect thus involves:

- Pumping down of water at divergence zone.
- Pumping up of water at convergence zone.

** In practicality pumping up of the water however takes place at the boundaries of oceanic basins creating water mounts thus Geostrophic currents.

Trade winds as develops Western boundary mount thus west boundary geostrophic current is distinguished from Westerlies that develops east boundary water mount thus east boundary geostrophic current.

## * Ekman's Spiral effect:

Is also identified with oceanic currents. It involves the influence of decrease in the magnitude of drag with increasing depth.

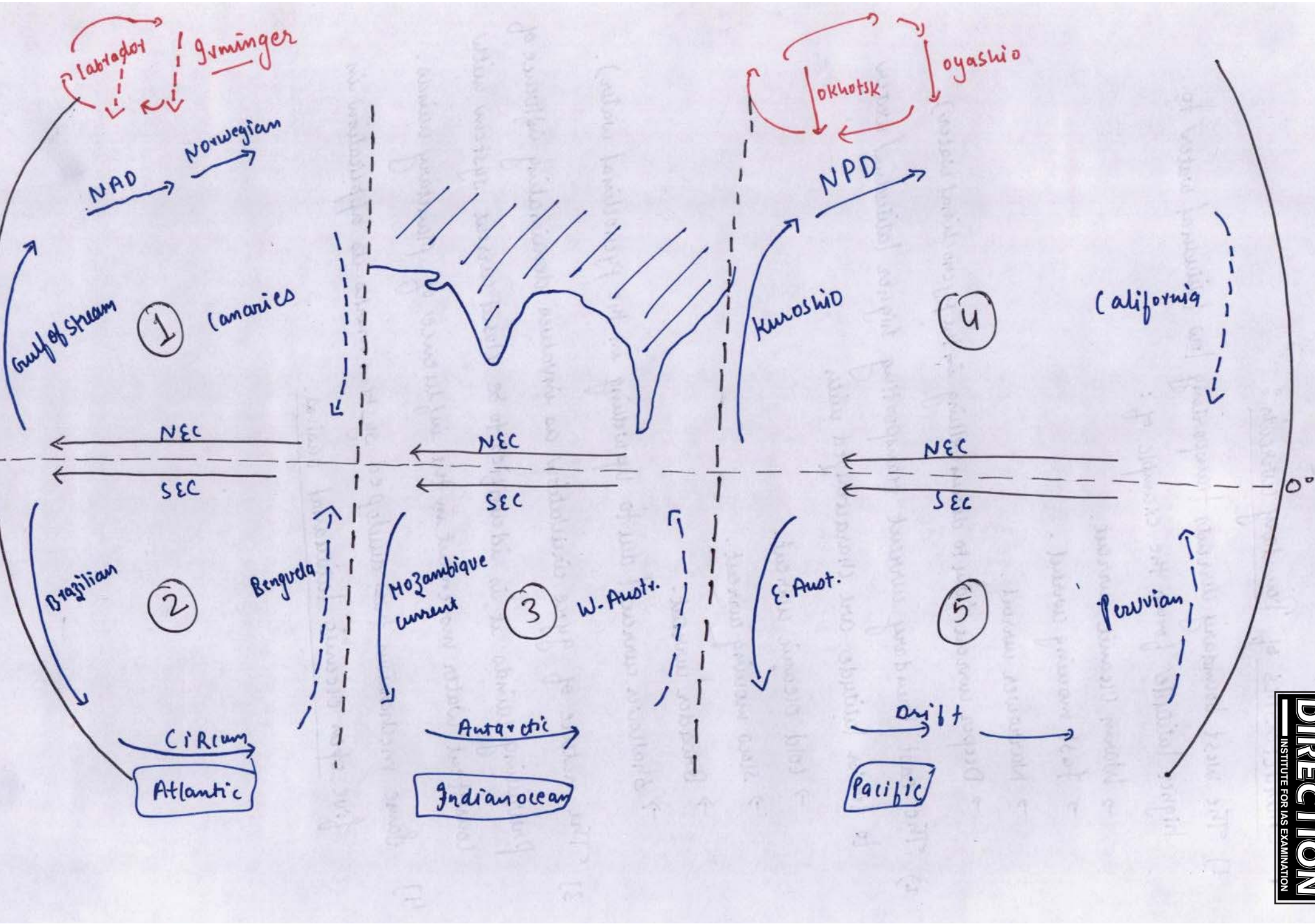
Decrease in the velocity of mobile water with increasing depth.

Thus decrease in the coriolis deflection with increasing depth generating Spiral effect.

The Ekman's spiral effect is identified upto 500mt. i.e. pelagic zone

## * Characterstics of Boundary currents :

1) The west boundary currents transporting low latitudnal water to higher latitude forms the example of :
   - → Warm Oceanic current.
   - → Fast moving current.
   - → Narrower current.
   - → Deeper current (due to downwelling in the pycnoclinal water).
2) The east boundary current transporting higher latitudnal water to lower latitude are characterized with
   - → Cold oceanic current.
   - → Slow moving current.
   - → Broader current.
   - → Shallower current (due to upwelling in the pycnoclinal water).
3) The nature of gyre circulation as involves dominating influence of prevailing winds it is identified to be closed current system with consistent water movement in the influence of planetary winds.
4) Same mechanism thus developed systems marks its application in five open oceanic latitudnal basins.



→ The repeated nature of Gyre circulation in the latitudnal open Oceanic basin involves three additional characteristics (constituents):

① In Northern Indian ocean basin inspite of prevalance of North equatorial current Gyre circulation is completely missing as this basin experiences Seasonal reversal of wind pattern.

② Subpolar gyres, these seasonal gyre circulations are experienced in Northern Atlantic & Northern Pacific involving the influence of ablated water cold oceanic currents called

~~Gyre~~ → Irminger & labrador currents of Atlantic ocean.

→ OKhostk & oyashio currents of pacific ocean.

** Though in Southern Atlantic ablated cold water current Fakland do exist it do not develop desired gradient for Seasonal gyre.

③ **ElNino & La Nina.**

→ The pattern of oceanic current system in all the five open Oceanic basin is considered to be consistent.

→ It is however that in Southern pacific gyre periodic interruptions in the gyre circulation is experienced.

This regular interruptions corelates to development of ElNino.

ElNino is defined to be warm water replacing cold peruvian current in the regular periodicity of 1½ - 2 years.

→ The mechanism of development of ElNino is absolutely related to:

(a) Distance b/w the shorelines in Southern tropical pacific.

(b) Maximum temperature contrast b/w cold peruvian current & warm East Australian current.

(c) Strong offshore winds from peruvian coast as the constituent of walker cell the ideal atmospheric circulation in this region.

(d) Genesis of maximum water gradient b/w peruvian shore (lower water levels) & Australian, Papua new Guinea shore (higher water level).

→ The normally developed water gradient tends to facilitate movement of warm water from the Australian shore to the peruvian shore.

→ Progress of warm water accross pacific tends to influence walker circulation at every level.

*** These levels are distinguished with increasing distance from Australian shoreline as ElNino1, ElNino2, ElNino3, called ElNino Modoki & ElNino4 i.e. warm water reached peruvian shore

→ The ElNino4 combined with strongest upwelling in the Pycnocline water of tropical peruvian current "terminates" existence of peruvian current (in tropical water) interrupting gyre circulation.

→ The developed ElNino conditions tends to completely reverse prevailing atmospheric circulation that is making Atacama desert experience unprecedented heavy precipitation with Onshore winds (of modified Walker cell).

→ In the consistency of this modified circulation "fresh water gradient (b/w Peruvian Shore & Australian Shore) marks the begenning of reverse movement of warm water (from the Peruvian Shore).

→ Effective retreat of surface water from the shoreline (of Peru) abruptly reestablishes cold peruvian current thus the gyre circulation the condition called La Nina.

SMS Apart from corrosponding to the reestablishment of "normal conditions" La Nina is uniquely known for its sudden or abrupt characteristics. [See Saw movement]

## * Thermohaline Circulation :

1) This planetary oceanic current system is considered to be Oceanic conveyor belt that tends to facilitate Vertical mixing of physical properties of ocean water alongwith influencing nature of aquatic habitat.

2] It is considered to be subsurface current system that largely involves sinking of cold dense water & upwelling of warm less dense water.

3] This circulation is comprised of three defined constituents :

(a) **Downwelling** -

→ The most recognised part of thermohaline circulation.

→ It involves vertical movement of water from pelagic via pycnocline to benthic or from pycnocline to benthic

→ This vertical movement tends to facilitate :

- Vertical mixing of salinity & temperature.
- Vertical transfer of dissolved oxygen & food resources from photic habitat to Aphotic habitat supporting the existence of life.

(b) **Upwelling** :

→ This is also vertical movement of ocean water from Benthic via pycnocline to pelagic or from pycnocline to pelagic.

→ In the reference to planetary conveyor belt it involves all the three stratas marking its confinement in the areas of

secondary source of ocean water temperature.

→ This vertical movement also facilitate mixing of salinity & temperature

© **Benthic current**

→ It is deep water current that exist below the depth of 1500 m.

→ Horizontal movement of benthic current is non-existing in perspective of human life.

→ In the benthic water common absence of salinity & temperature difference alongwith external factors like wind drag restricts advection.

→ The benthic current tends to propogate few degrees of latitude taking long span of time (ranging from 1000 thousand to millions of years).

→ When this benthic current reaches to the areas of secondary source of ocean water temperature it tends to upwell "reaching the surface water"

SMS On the water surface as the part of Gyre circulation it further marks latitudinal advection to experience downwelling in the cold dense locations.

# * MARINE SEDIMENTS / Oceanic deposits.

1) Submarine platforms lying below base level of erosion are characterized with variable amount of variable compositional and variable textured unconsolidated debris deposit collectively called marine sediments.

2] The deposited amount of these sediments forms the regulator of: (i) Ocean water salinity.
(ii) Diversity of available nutrient.
(iii) Modifier of habitat in terms of modifying the depth of platform.
(iv) Commercially significant as involves potentials to be marine resources.

3] These sediments are principally categorised on the basis of their source*. This classification was originally propounded by J. MURRAY & A.F. RENARD which includes:

(i) Terrogenous
ii) Biogenous
iii) hydrogenous
iv) Cosmogenous deposits

(i) Terrigenous deposits:

→ forms the major marine sediment approx. accounting for 40% of total area of submarine platforms.

→ These are sourced from the neighbouring continent & is identified to be dominant most deposit in terms of percent share of volume of marine sediments.

→ It principally includes gradational material involving argillaceous, arenaceous & Rudaceous textured deposits.

→ locationally it marks its dominating confinement in the continent margins (continental shelf & slope). But is also present in the deeper platforms.

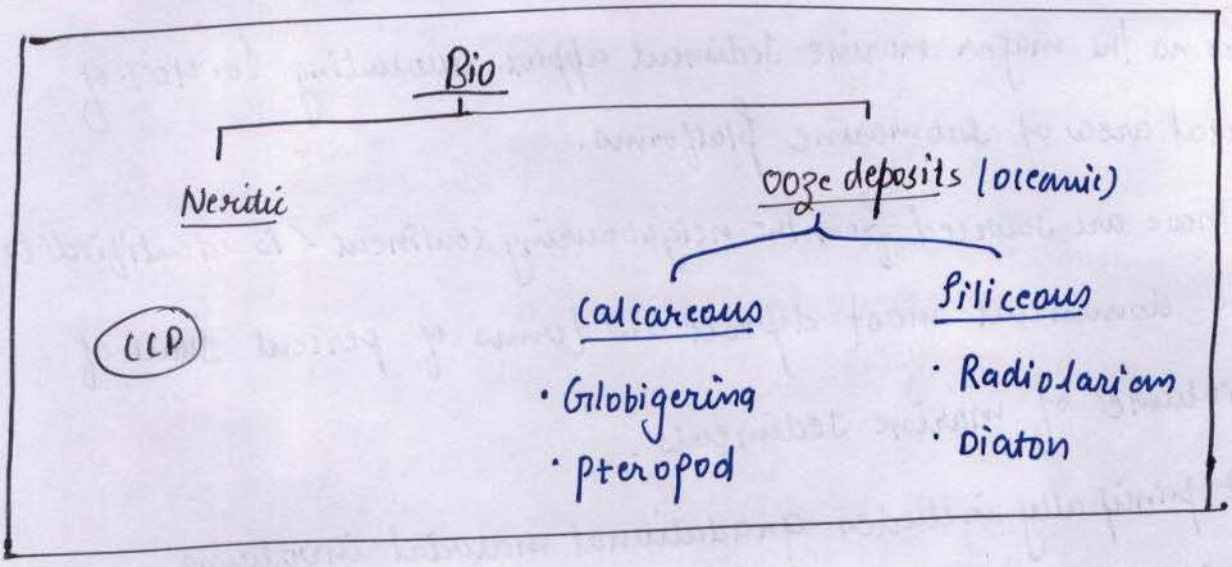
→ It is location of its presence that forms principal determiner of its amount and the texture.

- The margin deposits are larger in amount poorly sorted with dominance of Rudaceous textured material.
  The benthic platforms in comparison relates to lesser amount well sorted & argillaceous textured material.

→ The terrageneous marine sediments also includes:

- Continental pyroclast as well as
- Dead remains of terrestrial organisms (largely mixed with gradational deposits).

## (ii) Biogenous Sediments:




1] Sourced from the organic matter these sediments also represent major category of sediment.

2] It accounts for more than 50% of the floor area coverage however has lesser representation in the volume share of deposits.

3] Based on the source of organic matter it is sub categorised as:

(A) Neritic biogenous deposits:

→ It includes unclear mix of dead remains of neritic dwellers as well as the biotic remains of terrestrial organisms. The neritic deposits projects bigger diversity reflecting both productive neritic habitat & terragenous mix.

(b) Ooze deposits:

→ These are biotic deposits sourced by open oceanic organisms.

→ It incorporate restricted diversity in terms of its composition.

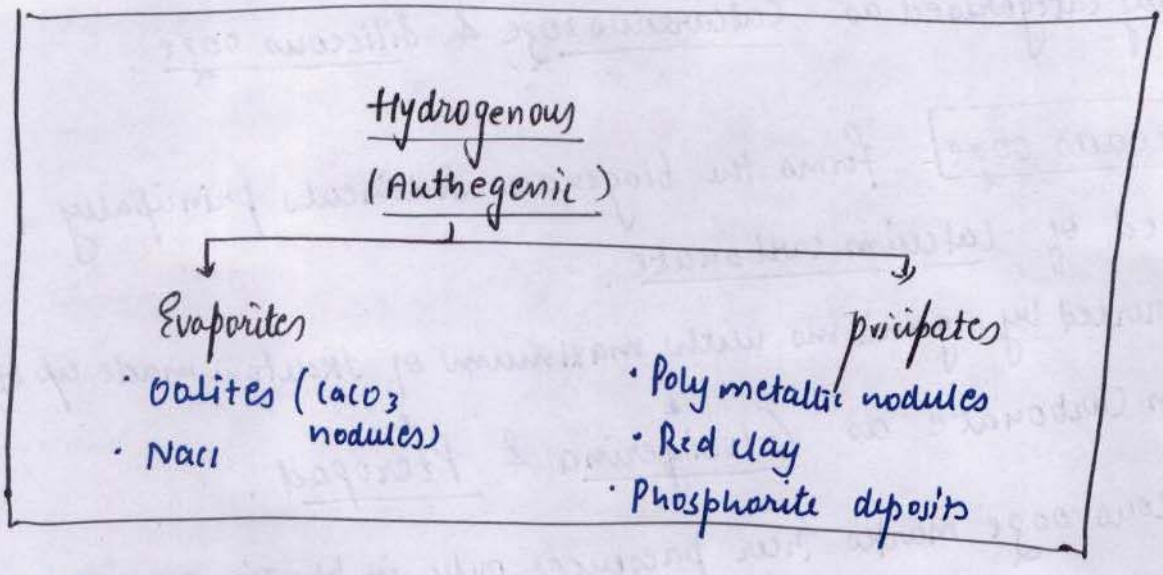
→ Principally categorised as Calcareous ooze & Siliceous ooze.

* **Calcareous ooze** forms the biogenous sediments principally comprised of Calcium carbonate.
It is sourced by organisms with maximum of skeleton made up of Calcium carbonate as Globigerina & Pteropod.
Calcareous ooze marks their presence only in photic zone as prevalance of photosynthesis restricts acidic nature of water thus carbonation.
It is in accordance that 2000 mt. of depth is considered to be **Calcium carbonate compensation Depth (CCD)**.

* Siliceous ooze - In comparison is silica prominent biogenous.
It is sourced by organism with maximum compositional share of skeleton being silica as Radiolarian & Diatom.
The siliceous ooze having restricted influence of ocean water solutional capacity have more omnipresence (including both photic & Aphotic zones).

Below the depth of 2000 mt. Siliceous ooze is only representative of ooze deposits.

## (iii) Hydrogenous deposits:




1] The hydrogenous marine sediments being sourced by water itself is considered to be authegenic deposits.

2] Both in terms of floor area coverage & percentage share of marine sediments it represents minor category.

3] These deposits are categorised as:

(a) Evaporites that are sediments concentrated due to ppt. evaporation of water.

→ It is thus confined to the shallower platforms in warm, dry climatic zones.

→ Nacl (sodium chloride) & Oolites ($CaCO_3$ nodules) makes example.

** Both being mobilised as marine resources as well.

(b) Precipitates:

It represent the Authegenic deposit that is precipitated (dropped by Ocean water). These mark their presence essentially in deeper platforms.

It includes:

- Polymetallic nodules (manganese nodules) that are being mobilised as commercial resource.

The other examples of precipitates includes:

- Red clay &
- Phosphorite deposits

(iv) Cosmogenous deposits:

1] The trace constituent of marine sediment. Is being sourced from extra terrestrial sources that includes:

Inter planetary dust or meteorite ash that marks their rare presence in earths environment.

Location based marine deposits classⁿ:

| Neritic (Shelf) | Pelagic (off the bottom) | Benthic (including Hadal) (on the bottom) |
|---|---|---|
| • Terragenous<br>• Biogenous<br>• Evaporites<br>• Cosmogenous | All deposits<br>Epipelagic<br>Mesopelgic<br>Bathypelagic<br>Abyssal pelagic | • Siliceous ooze<br>• Precipitates<br>• Terragenous<br>• Cosmogenous |

# ¥ SUBMARINE TOPOGRAPHY /

## Ocean bottom Relief / Hypsometric curve / Bathymetry :

Development

1] Genesis of Study of Submarine topography is traced back to prehistoric time with Posidonius the greek Scholar given the designation of being 1st oceanographer.

2] Elaborate empirical observations towards mapping of Submarine topography however is related to HMS Challenger expedition (1870) of late 19th century with successfully mapped mid Atlantic Ridge.

3] Continuation of modern approaches involves enrichment by Echo sound recording initiated by R. Fessenden in the begenning of 20th century. ↳ Acostic study (1914)
Utilising his developed technique of recording the Ping first holistic map of Submarine topography was developed in 1954.

4] In the contemporary terms:

(a) Multi Beam Sound recorders (involving upto 120 Beams in a Single attempt)

(b) Satellite ~~alt~~ Altimetry have further enriched Sophisticated and more dependable exploration & mapping of Submarine topography.

5] This Study of Submarine topography is collectively referred as BATHYMETRY i.e. largely dependend on Acostic Studies for empirical observations.

6] The term HYPSOMETRIC CURVE in comparison involves the graphical representation of on & off shore features in a Single frame facilitating analysis of height & depth range in a given region or for entire world.

SMS Practically the use of hypsometric curve is to project Submarine features that dominantly includes:

(a) Continental shelf.

(b) Continental Slope.

(c) Abyssal plain

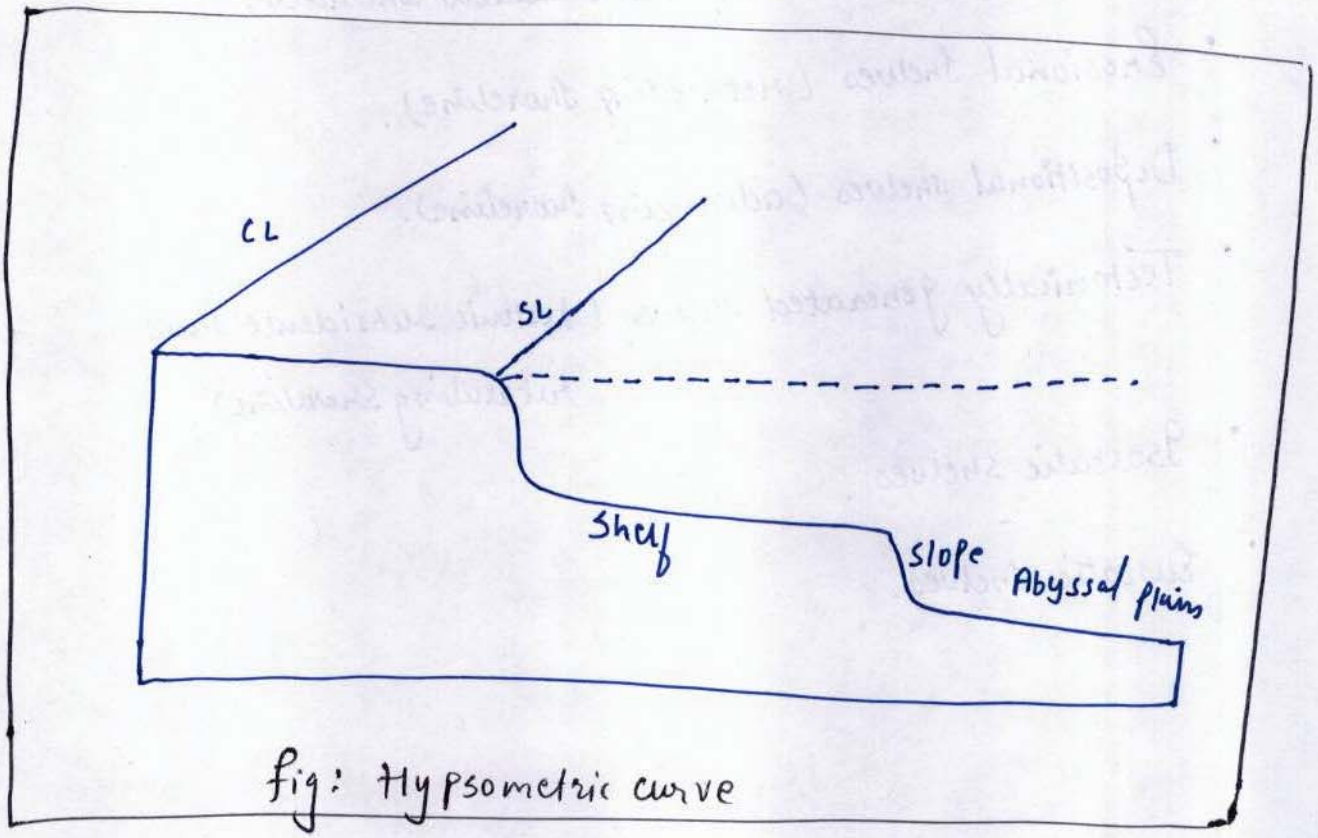



fig: Hypsometric curve

(a) Continental Shelf:

1] It is a true granitic crust (continental crust) that have submerged forming submarine features.

2] It has immediate offshore location with absolute gentle gradient characterstics in the range of 1°-3°
It is thus called platform or shelf.

3] Globally genesis of continental shelf is essentially related to Eustatic factors i.e. rise of the Mean Sea level after the termination of pleistocene ice age.
It is therefore that continental shelfs invalves 200mt. as its ideal depth.

↓↓ Practically continental shelfs are categorised on the basis of range of developmental mechanism which includes:

- Erosional shelves (retreating shoreline).
- Depositional shelves (advancing shoreline).
- Tectonically generated shelves (tectonic subsidence thus retreating shoreline).
- Isostatic shelves.
- Eustatic shelves.

4] The CONINTETAL SHELVES as continental margin features significantly varies in its horizontal extension.

** Globally it is related to the height of the shoreline.

5] Continetal shelfs also projects extreme shallow characterstics (60m of depth) in the areas where deposited sediments are not disturbed (passive tectonic boundary).

6] Continental shelfs can also be significantly deep (more than 700m of depth) if it incorporate **submarine canyons**.

(b) Continental slopes:

1] Extensive from shelf break to upto deep sea plain. Continental slopes is defined to be transitional feature between true granitic & true basaltic crust.

2] Ideally it is considered to be continent margin feature.

3] It is principally known for its gradient which can have range less than 10° to more than 60°.

4] This submarine feature is identified with:

(i) Continental Rise i.e. deposited material at pidemont location of continental slope which is typical to passive continental boundary.

It involves continent sourced material that is well sorted & finer texture which fails to to rest on gradient of continental slope.

It is the magnitude of development of continent rise that have its influence on aquatic habitat.

(ii) Submarine trenches.

→ This feature essentially develops due to subduction of basaltic crust. Is largely associated with transitional location of continental slope and abyssal plain.

→ Along the destructive plate boundary development of trenches by default restricts development of continent rise.

SMS It also justify presence of terragenous material in the deepest location of ocean floor.

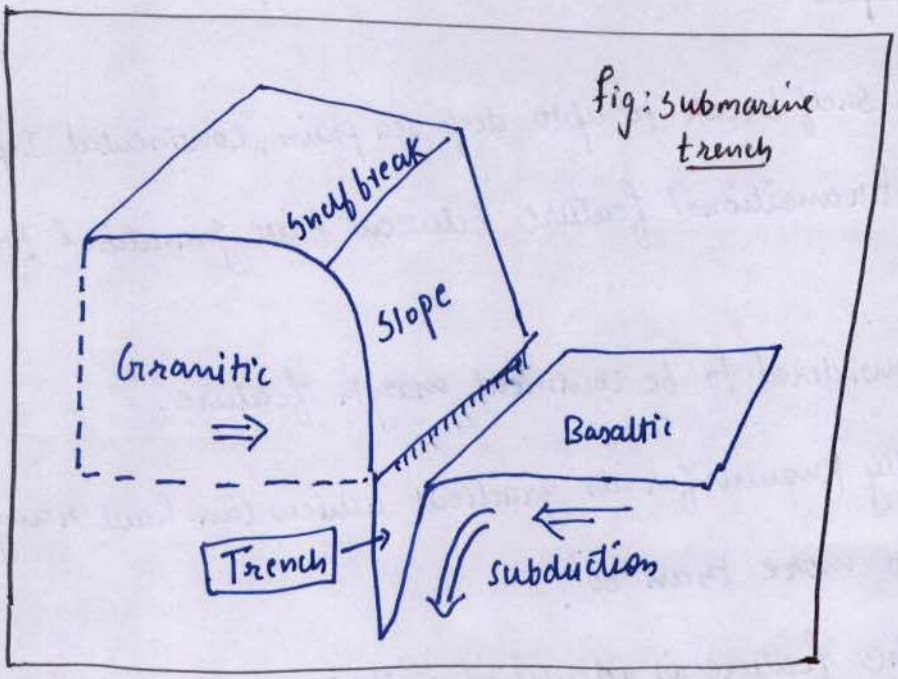
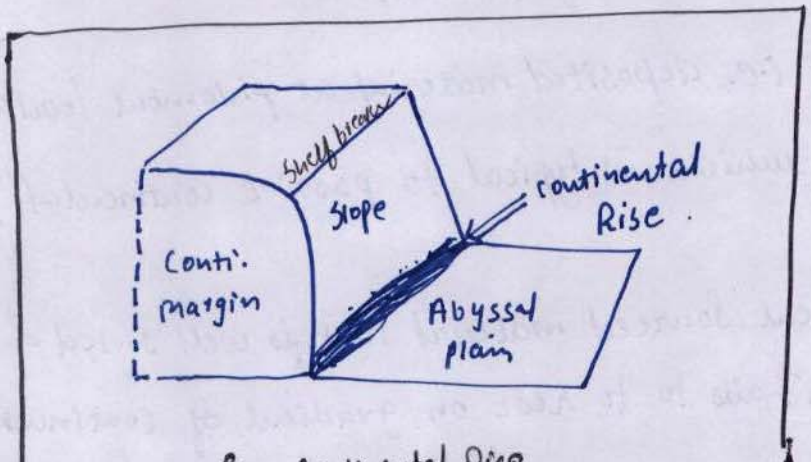



fig: submarine trench



(iii) Submarine canyons :

1] The submarine canyons represents long & deep valleys depicting process of vertical abrassion.

2] Originally considered to be 3rd order relief feature present in continent margin it is now recognised as submarine feature which can depict variable mechanisms of development.

These mechanism include : Eustatic
Diastrophic &
Turbidity current.

(a) Eustatic submarine canyons are also called MORPHOGENETIC SUBMARINE CANYONS that were prominently studied by scholars like Lawson & Gregory.

Such canyons relates to "developed first inundated later" as the approach of developmental mechanism.

Such types of canyons involves both inundated Glacial valleys (U shaped valley) that relates to Fiords shoreline.

It also involves inundated Non Glacial valleys (V-shaped valleys) associated with Ria shoreline.

## Shoreline of Submergence:

Developed due to termination of pleistocene ice age & resultant rise in MSL (thus retreat of shoreline) includes:

(i) Fiord Shoreline - This is shoreline of submergence involving submergence of glacial trough specifically of the mountains with perpendicular alignment with the present shoreline. Such shoreline is always related to threshold e.g. Norwegian shoreline

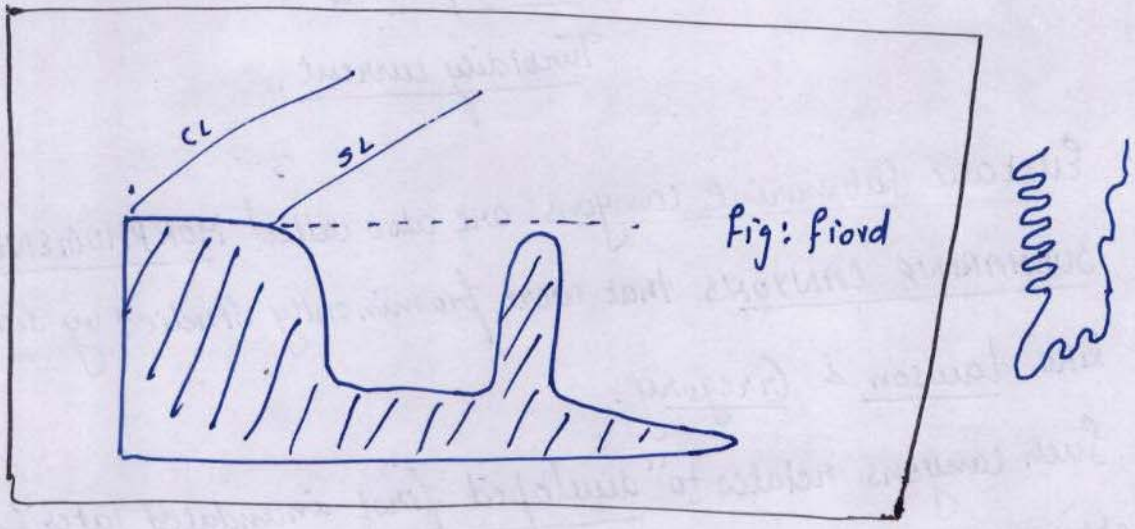
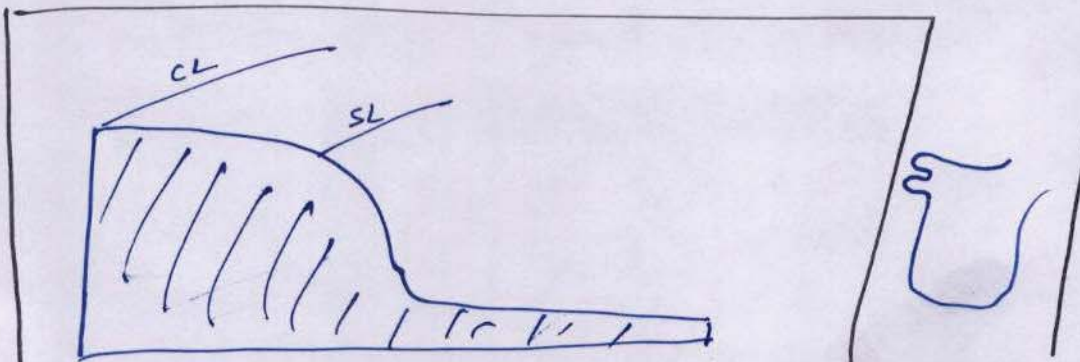


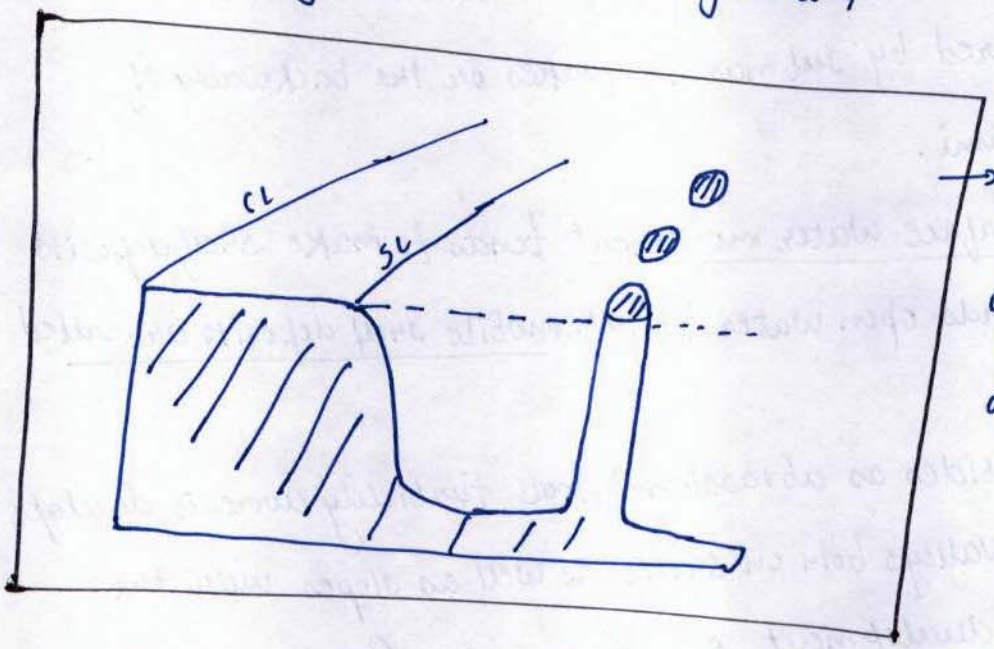

Fig: Fiord

(ii) Ria shoreline - This shoreline of submergence involves inundation of non glaciated valley. It marks its typical presence in mid & lower latitudes. Its development is also typical with the perpendicular alignment of relief to the present shoreline.
e.g. Iberian peninsula



(iii) Dalmation shoreline- It is also shoreline of submergence that can be applied to both glaciated & non-glaciated valleys.
It marks its development when inundated relief had parallel alignment to the shoreline.

e.g. Chilean shoreline - glaciated
Balkan (Agean shoreline) - non-glaciated




Unlike Ria & Dalmation → Not feasible for economic activities like ports/harbours due to obstructions.

(b) Diastrophic submarine canyons:

1] Integrated with tectonic forces. This approach of development of submarine canyon is also credited to scholars like Lawson.
This identifies deformational stress to be developing canyons which however has lesser universal implications as:

(i) faulting is normally parallel to shoreline whereas submarine ~~Can~~ submarine canyons are alway perpendicular to shoreline.

(ii) Submarine canyons marks their dominating presence even along passive tectonic boundary.

(iii) Turbidity current -

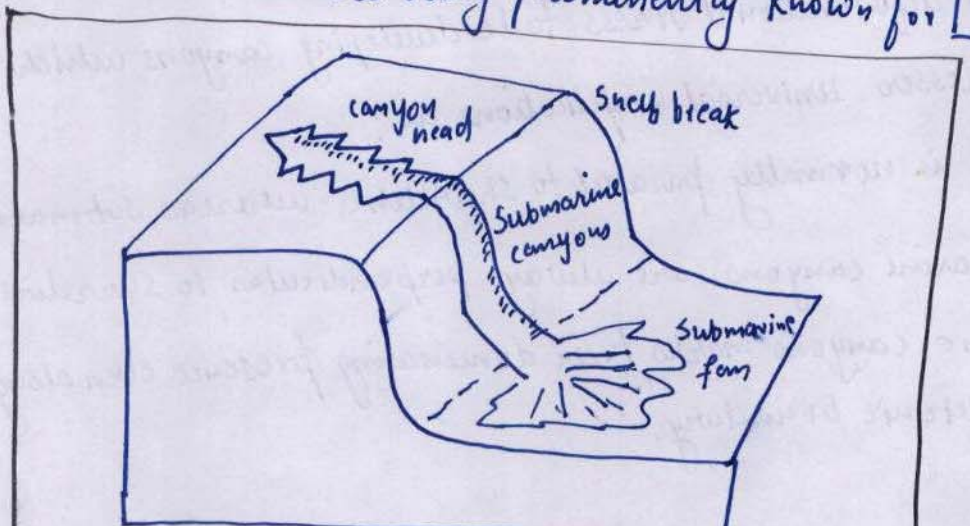
1] In the modification of subareal denudation (morphogenetic) approach of development of canyon W.H. Davis proposed the effectivity of turbidity currents in the development of submarine canyons.

2] The turbidity currents are subsurface water currents that are largely trigerred by submarine quakes or the backwash of strong tsunami.

3] These subsurface water movement tends to make shelf deposits drifted towards open water ( such mobile shelf deposits are called TURBIDES).

4] Utilising turbides as abrassional tools turbidity currents develops abrassional valleys both on shelfs as well as slopes with the subsequent development of submarine fan as deposits in Abyssal plain.

5] ### with favourable availability of gradient Vertical abrassion proves to be more effective on continental slope excellently explaining dominance of submarine canyons in continental slopes than the shelves ( shelves being prominently known for canyon head )



# Abyssal Plain



1] It is considered to be the typical most constituent of the ocean floor topography depicting oceanic crust (basaltic crust).

2] The submarine constituents ideally accounts for approx. 76% of the oceanic area.

3] It is characterized with range of tectonic features that includes:

(a) Constructive features:

→ corrospounds to submarine volcanism including main Ridge along active diverging boundary.

→ It also includes ancillary ridges along transform boundary with consistent volcanism.

→ The sea rises also corrosponding to transform boundary volcanism however involves isolated spots of volcanism.

This construction is distinguished on the basis of Shape as

**Sea mounts** (that are conical sea rises) &

**Guyouts** (that are flat topped sea rises)

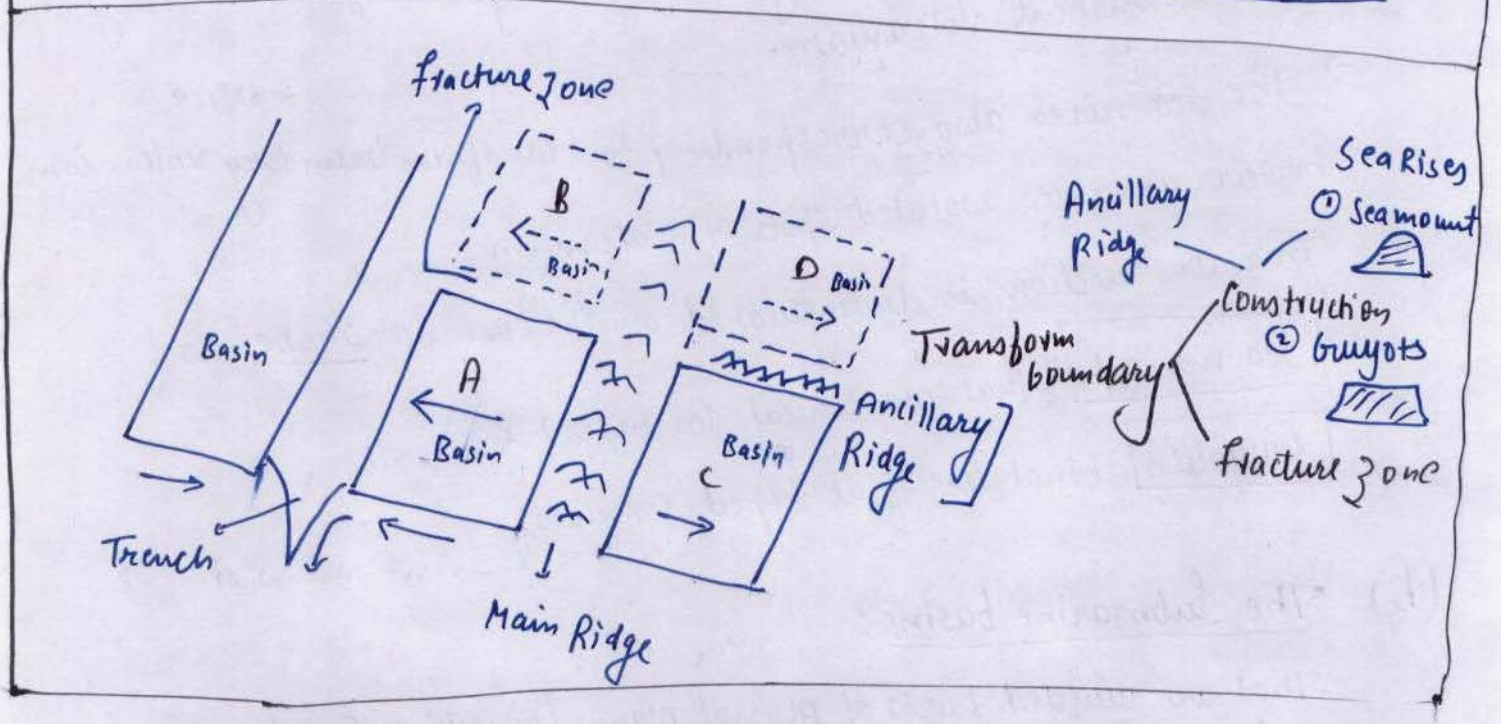
(b) The Submarine basins:

That are divided parts of Abyssal plain projecting simultaneous development with the genesis of constructive features.

(c) Destructive features:

Developed along subduction boundaries generates submarine trenches involving deeps that qualifies to be the deepest points of the earth's crust →

++ The deeper locations are also related to fracture zone that are transform faults without volcanism.




+ Atlantic = shelf water body (max. area under shelf).

# * Submarine features of Atlantic Ocean:

1] The 2nd largest ocean of the world Atlantic ocean extends from 50°N to 50°S latitudes (opening up as arctic ocean & Southern ocean respectively).

2] Longitudnally this ocean marks its extension b/w Shoreline of Americas on its west with Europe & Africa on its east.

3] This Ocean makes the example of younger crust that marked its genesis due to consistent Sea floor spreading (which got initiated in Paleozoic era).

4] Defined to be roughly 'S' in shape Atlantic ocean has narrowest extension at near equator.

5] Physiographically this 2nd largest ocean of the world is identified with
(i) Mid oceanic Ridge.
(ii) Continental shelves.

## (i) Mid Atlantic Ridge:

→ Is identified to be most developed MID OCEANIC RIDGE of the world that marks its extension in both northern & Southern basins of the ocean.

→ Based on their location they are subcategorised into:

- Dolphin Ridge &
- Challenger Ridge.

* Dolphin Ridge - Marks its confinement in Northern Atlantic basin that is extensive from Iceland (Mt. Hekla) to equator.

→ Significantly narrower ridge that runs parallel to mainland shoreline of North & south Americas, have average depth of 2000 mt.

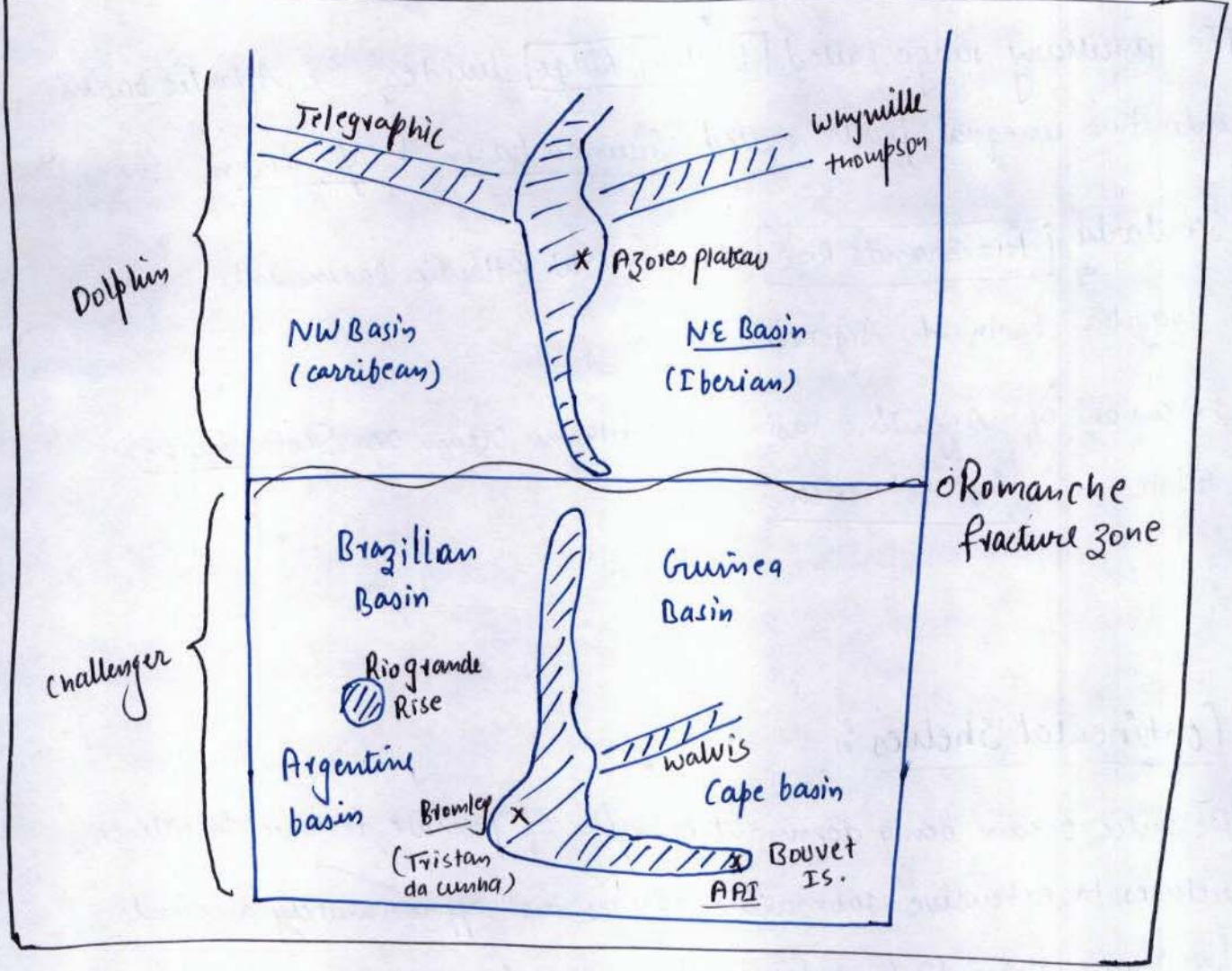
Dominating exceptions however relates to :

- Surface projection as active volcanoes of Iceland.
- Shallowest & broadest Submarine construct in the North central part called Azores plateau (corelates to sargasum)

→ Dolphin Ridge involves two defined Ancillary development called Whyville Thompson Ridge & Telegraphic plateau, both forming submarine boundary b/w Atlantic & Artic ocean.

Combining these Northern Atlantic is well divided into two different basins called North Eastern basin i.e. Iberian basin & Northwestern basin i.e. Carrebean basin.

- Tectonically active minor plate called Carrebean plate corrosponds to restricted number of submarine trenches including
  - Nares Trench
  - Cayman Trench
  - Puerto Rico Trench (Milwaukee deep)




## * Challenger Ridge:

→ It extends South of Romanche fracture zone that is world's most extensive transforms boundary with complete absence of volcanism.

→ The Ridge extends upto 50°s latitude running parallel to Shoreline of South America. It is in its Southern extension that challenger Ridge has Bromley plateau with volcanic island Tristan da cunha.

** South of Bromley plat. submarine ridge marks its continuation as Atlantic Antarctic Indian Ridge of Southern Ocean.

The challenger ridge along transform boundary relates to the development of ancillary ridge & sea rise.

→ The ancillary ridge called Walvis Ridge divides SE Atlantic basin into two unequal parts called Guinea basin & Cape basin.

→ Similarly Rio Grande Rise divides SW Atlantic basin into Brazilian basin & Argentine basin.

** Extension of Argentine basin in Southern Ocean as Scotia basin relates to Scotia trench.

## (ii) Continental Shelves:

1] Atlantic ocean being dominant example of passive tectonic shoreline relates to extensive submarine shelves that approximately accounts for more than 13% of the total area of the ocean making the Ocean designated as Shelf water body of the world.

2] Recognisable shelves though is present all along the shoreline, dominating example includes: NE Atlantic shelf, Patagonia shelf & NW Atlantic shelf.

### (i) NE Atlantic shelf:

→ Along the shoreline of Europe.
→ Is one of the broadest submarine shelves of the world.
→ Including: North sea, Baltic sea, Gulf of Bothnia, Gulf of Finland, Gulf of Riga, English channel, Irish sea

as absolute shelf water body.

.... → Principally known for fiord shoreline it relate to U shaped submarine canyons as OSLO canyon.

→ Dogger bank of North sea additionally represent major commercial fishing ground.

(ii) Patagonia shelf:

→ confined in South west Atlantic it forms one of the broadest submarine shelf in Southern basin.

→ It incorporate Rio de la plata

Grande Bay

as shelf water bodies.

(iii) → North west Atlantic shelf:

→ Confined along the shoreline of North America.

→ Is comparatively narrower shelf.

→ Involves physiographic prominence with Hudson canyon & Chesapeake canyon (USA).

→ Commercially both Grand bank of canada & George bank (longIs.) of USA (major fishing grounds) belongs to this shelf.

** The nature of shoreline of Atlantic ocean justifies dominating presence of marginal water in Northern basin.

Mediterranean Sea as deep marginal water & Gulf of Mexico as transitional depth marginal water forms significant example.

↓

Some part of water body is shelf & some is with depth.

** Atlantic ocean's physiography is essentially comprised of both continental & volcanic Islands.

→ The continental Islands are identified to be detached part of mainland due to Eustatic factors.

- British Isles
- Carribean Islands
- Mediterranean Sea Islands forms example.

→ Among Volcanic Islands that are surface projections of active submarine volcanism apart from including On Ridge* Islands (Azores Is. & Tristan da cunha Is.) also includes

Islands on sea rises · Canaries &
· Cape verde

(* Anticosti Island - detached part of Apallachian due to rise in MSL.)

# Submarine features of Indian Ocean:

1] 3rd largest ocean of world which is considered to be half ocean of world as is bounded by continent on 3 sides.

2] As continental ocean of the world it also projects warmest characterstics.

3] Its genesis represent to continent divergence applicable since paleozoic thus forming example of younger oceanic crust

4) latitudnally it marks its extension from South Asian landmass to upto 50's latitude opening as Southern ocean

5) longitudnally its western shoreline principally relates to African landmass however eastern shorline involves east Indies & Oceania shorcline.

6] Indian ocean is principally known for mid oceanic Ridge as its only dominating physiographic unit. This ridge denoting active oceanic divergence involves its extension both in Northern & Southern basin primarily distinguished as:

Chagos Ridge of Northern basin &
St. Paul Ridge of Southern basin

~~The cha~~

The Chagos Ridge marks its extension b/w lakshadweep Islands to Chagos archipalego (approx. located at 5°S latitude.

The main ridge in the southern basin involves St paul submarine plateau as well that is the broadest part of mid ridge which extends upto 50°S latitude.

** Extension of the submarine ridge beyond 50° South as Kerguelen ridge & Indian Antarctic Pacific Ridge in of Southern ocean.

The Mid Indian ocean Ridge divides the oceanic basin into 2 nearly equal parts : Western basin & Eastern basin

## (a) Western Indian Ocean basin:

→ Is characterized with Ancillary Ridges as well as Parallel ridge.

→ In the combination of these constructs well demarcated basins are outlined.

→ Among the ancillary ridges CARLSBERG RIDGE is extensive b/w chagos & Scotra Islands. It thus demarcates Souther boundary of Arabian basin.

→ The 2nd dominant ancillary ridge is Mascarene RIDGE that extends b/w Mauritius & seychelles. demarcating Southern boundary of Somali Basin.

** The mascarene ridge involves its extension north of madagascar islands as Seychelles comoros Ridge ....

..... that is considered to be Submarine connectivity b/w main ridge and the parallel ridge.

→ The parallel ridge in the western basin is MADAGASCAR RIDGE that involves Prince Edward and Prince Crozet islands.
It is madascar ridge that thus distinguishes MAURITIUS Basin and NATAL Basin.

** Natal basin marks its extension in Southern ocean as ~~Agrulhas basin~~ Agulhas basin.

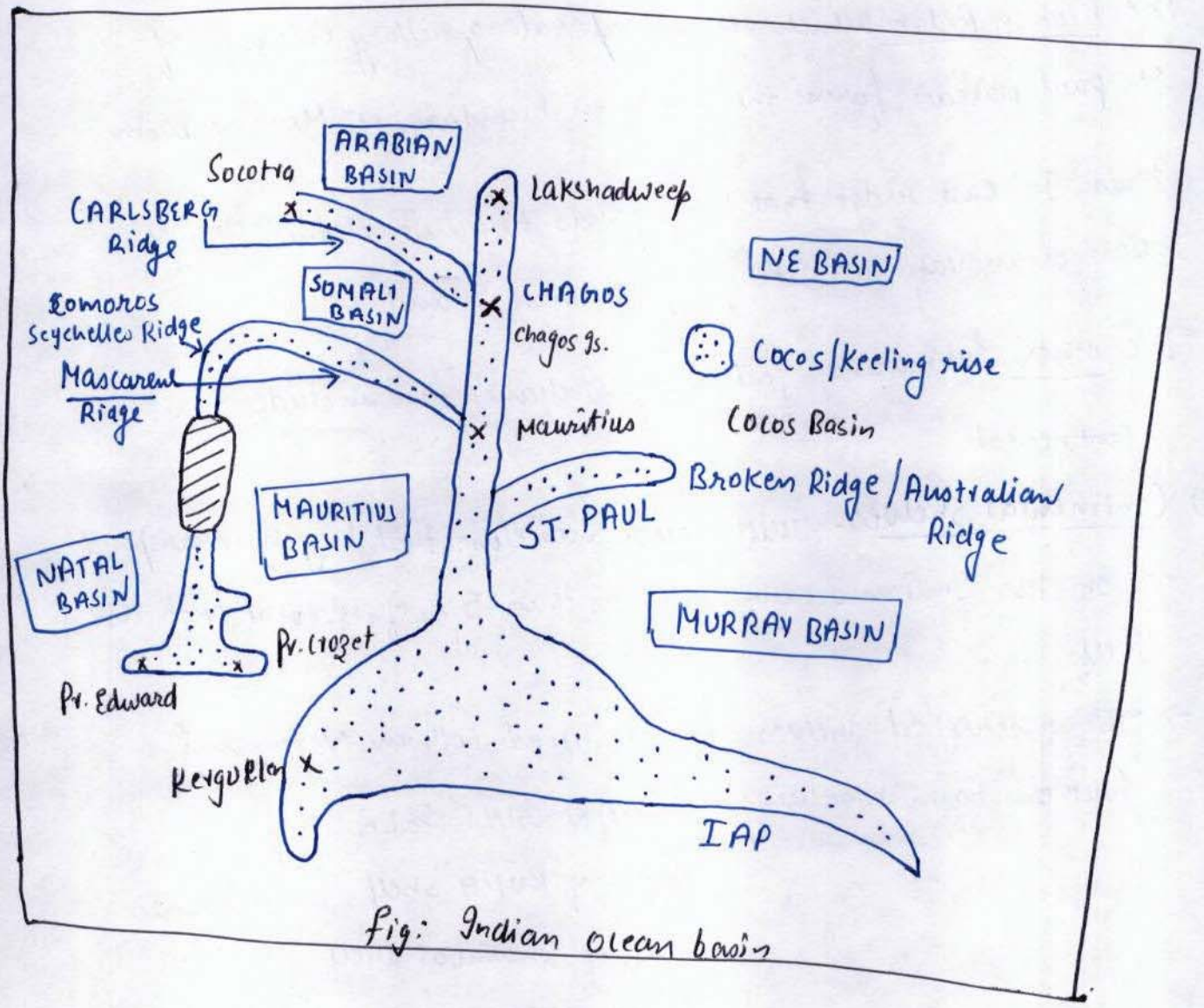



Fig: Indian ocean basin

* Eastern Basin:

1] It is characterized with fragmented chain of sea rises that are considered to be @ NINETY DEGREE East Ridge.

2] Recognisable constituent of this submarine construct includes:
Cocos or Keeling rise that forms demarcation boundary between NE Indian Ocean basin & Cocos basin.

→ It is in NE basin where a one of the worlds linear trenches called Java or Sunda trench is developed.

→ The Broken Ridge which also incorporate ancillary extension of St. paul plateau forms the northern boundary of Murray Basin.

** It is 90° east ridge that corrosponds to active volcanic sites of Indian ocean volcanic sites e.g. Barren Island.

3] The other submarine features of Indian ocean includes:
~~Continental~~

(i) Continental shelves - with taller shoreline that largely corrosponds to shields Indian ocean have less than 5% of its total area as shelf.

→ The restricted shelves are identified both in Northern & Southern basin involving PESIAN GULF SELF
GULF of KUTCH shelf
Gulf of Khambat shelf } Northern basin
Gulf of Martaban shelf

Joseph Bonaparde gulf shelf } Southern basin

→ Submarine canyons adds to the physiographic diversity of the continental shelf of this ocean. It prominently includes Indus canyon, Padma-Jamuna canyon (swatch of no ground), Pennerv canyon, Vizag canyon.

→ The nature of shoreline justifies larger number of water bodies in Northern basin where Red Sea & Arabian Sea makes significant example of deeper water. Though Bay of Bengal represents transitional depth water.
In Southern basin Timor Sea forms transitional depth water though mozambique channel forms comparitive deeper counterpart.
(due to vizag canyon Vishakapatnam is natural harbour).

*** SMS Physiographic features of Indian ocean also includes continental & Volcanic Islands. Prominent examples of
Continental Island : Madagascar
Sri lanka

Volcanic Islands essentially confined on ridges includes:
- Chagos
- Seychelles etc

* Java, sumatra or all East Indies are continetal Islands of Pacific ocean.

## ✱ Submarine features of Pacific Ocean:

1] The largest ocean of the world pacific ocean is also oldest oceanic crust (contracted Panthalasa).

2] Its submarine topography thus include the imprint of older tectonic activities as well.

3] Roughly triangular in shape pacific ocean is narrowest at Bering strait connecting it to Arctic ocean & is broadest at 50° south opening up as Southern ocean.

4] Its longitudnal boundary involves Americas to its east & Asia-oceania to its west.

5] Analysis of submarine topography of this ocean is based on regional divide as the ocean involves dominating most submarine feature that are: Submarine trenches.
Originally approached by oceanographer Johnson these regional divides includes: Southern Basin & Northern Basin.

## ✱ Southern Pacific Basin:

1] Accounts for largest part of ocean. It involves sequential series of submarine constructs & involving active tectonic cenozoic boundaries as well as Paleozoic constructs.
This basin includes ~~Albatross Ridge~~

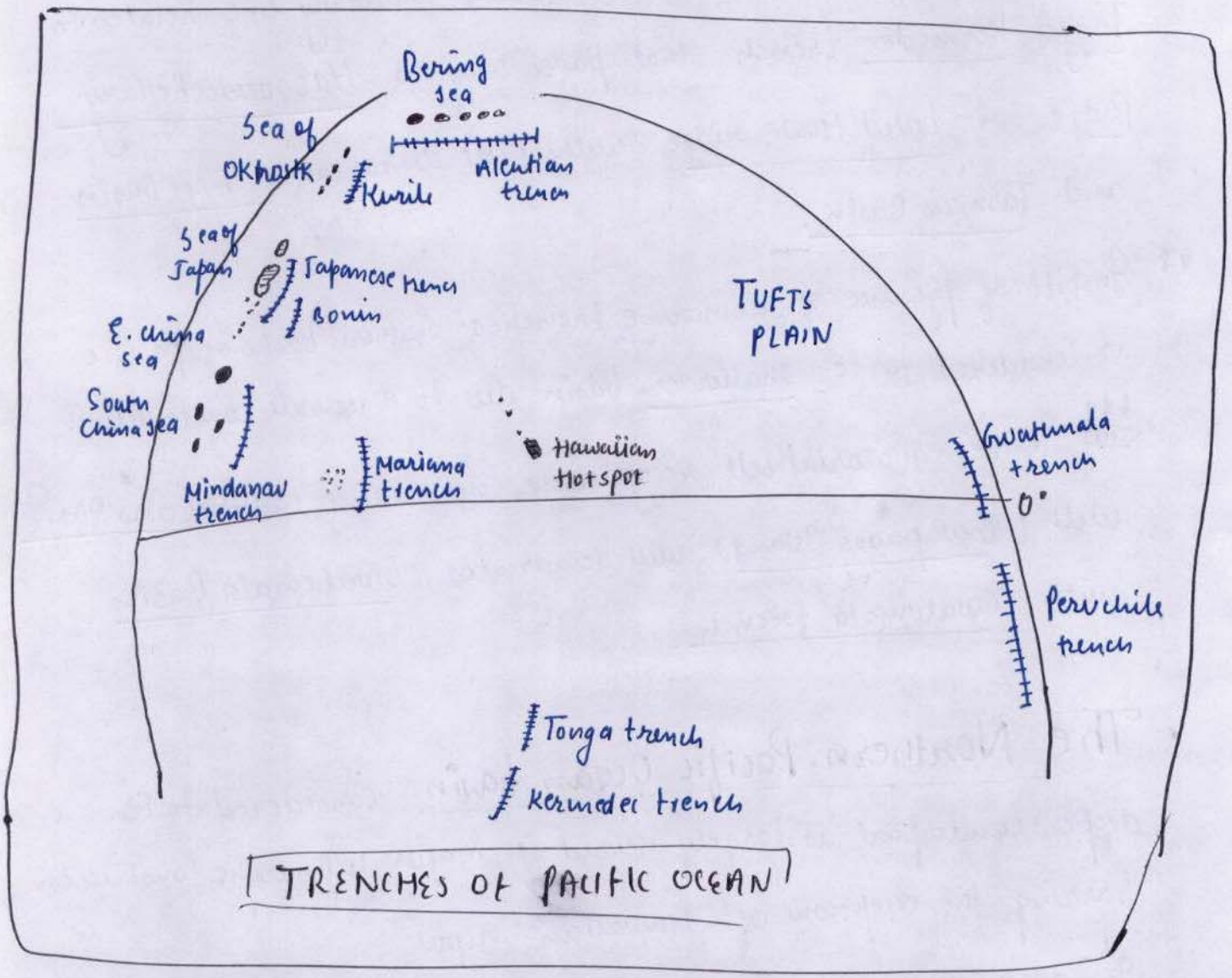
Albatross Ridge - The active & largest submarine construct.
It incorporate Tuamato Ridge as its central pacific extension.
With these soul constructs South East Pacific incorporate
Peru Basin with world's lengthiest linear trench called Peru chile trench
In the Southwest Pacific basin demarcated boundary line relates to
Tonga Kermedec trench that paves way to Macqueric Bellary
Ridge & Lord Howe ridge with well demarcated Fiji basin
and Tasman Basin.

** Inspite of presence of submarine trenches Southern basin of pacific is considered to be Shallower basin due to elaborate construction

SMS In the equatorial belt recognisable construction called Colas Ridge with ( Galapagos Island) well demarcates Guatemala Basin with Guatemala trench.

* The Northern Pacific Ocean basin considered to be deeper counterpart is largely devoid of major submarine constructs barring the exception of Hawaiian hotspot.
In North East this basin relates to uninterrupted Abyssal plain called TUFTS PLAIN whereas towards
North Western basin there is sequential submarine trenches.

- Aleutian trench in Aleutian basin
- Kuril trench in Kuril basin
- Japanese & Bonin trenches in Japanese basin
- Mindanao trench in phillipines basin
- Mariana trench the deepest submarine trench in Caroline basin




TRENCHES OF PACIFIC OCEAN

* Continental shelves accounts for less than 5% of total area of pacific largely because of its active tectonic boundary that is converging destructive in nature.

Sunda shelf forms one of the broadest submarine shelf of the world including Java sea, Gulf of thailand & Gulf of Tongking as shelf water bodies.

Australian shelf forms the other major submarine shelf including Arafura sea & Gulf of Carpentaria as shelf water bodies.

→ Nature of shoreline justifies pacific ocean having larger number of water bodies along its western shoreline with Bering sea, Sea of okhostk & South china sea forming examples of transitional depth water.

→ However, Tasman sea & Sea of Japan forms deeper water example.

→ Restricted number of marginal water in eastern pacific includes Gulf of california & Gulf of Alaska.

* Pacific ocean is also designated to be Island ocean of world that includes Continental Islands as Sunda Isla, Japanese Islands & philippine Islands. It also includes Volcanic Islands that is best represented by Hawaiian Islands.

# * Islands & its Types:

1] The Surface relief features incorporate Islands as Significant constituent.

2] These are defined to be landmasses that are Surrounded by water from all the Sides.

3] This physiographic unit incorporate range of practically utilised terminology, that includes:

(i) Islet - representing Single dominant island, variable in Size.

(ii) Islet / Keys / Cays - that denotes Small ____

(iii) Eyot / ait - that are Islands in the active channel or lake.

riverine - mayuli  lacustrine - Lizard Island, USA

(iv) Archipelago - Applied to denote closely Spaced group of Islands as a consistent chain as well as interrupted chain.

4) Geographically Islands are categorised into four prominent categories:

(i) Continental Islands.

(ii) Oceanic Islands.

(iii) Depositional Islands

(iv) Coral Islands

(i) Continental Islands:

→ Defined to be detached part of mainland largely involving Eustatic factors.

→ These Islands irrespective of their heights are considered to be low Islands.

→ continental Islands accounts for largest sized Island on map of world e.g. Greenland, Borneo, Baffin Island, New Guinea Is., Madagascar Is., Sumatra Is. & Honshu Island are among the biggest example.

** Zilandia makes the example of microcontinent which involves its smallest part newzealand as exposed over water surface forming continental Island. ( submerged ≃ 80%.)

(ii) Oceanic Island:

→ The oceanic Island incorporate tectonically generated Island thus having absolute association with tectonic plate boundaries.

→ Irrespective of their heights they are considered to be high Islands

→ These Islands are subcategorised as:

(a) Islands at diverging plate boundary - which incorporate projection of parts of ridges on the water surface.
e.g. Azores Is. of dolphin ridge.
Pitkaren & Easter Islands of Albatross Ride (Pacific)

(b) Islands of hotspot volcano - Mantle plume
It largely involves Island arcs as Hawaiian hotspot as well as small group of Islets or Cays as Reunion hotspot.

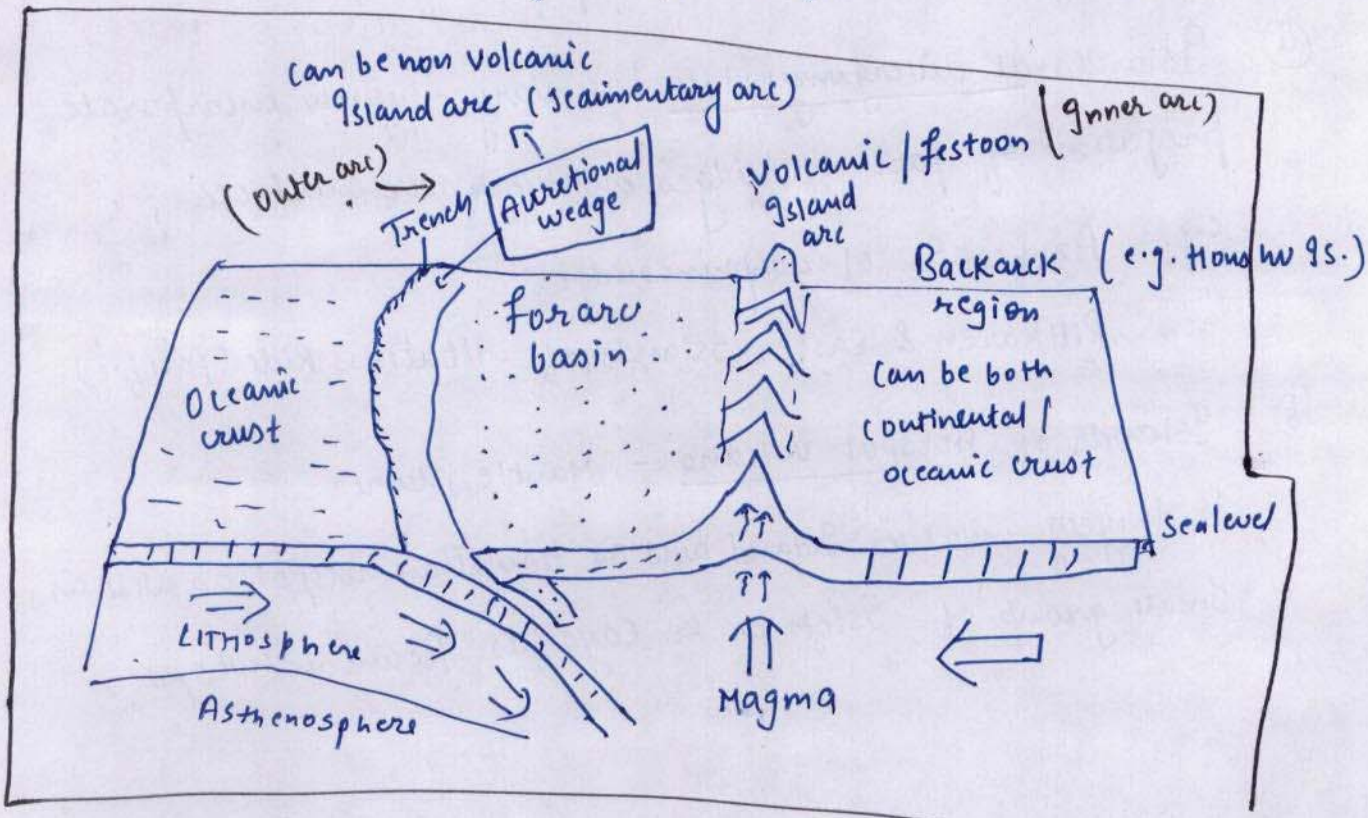
(c) Islands along transform boundary. It largely includes projection of sea rises over the water surface.

e.g. Cocos or Keeling Island (Indian ocean)
Canaries Is. (Atlantic).

(d) Islands at destructive plate boundary - Such Islands are commonly associated with the Island arcs that involves volcanic Island arc (Inner arc) called **festoons**.

→ With the possibility of outer arc of Islands that are non volcanic in nature.
The festoon Islands compositionally combines both basalt & andesite that is believed to be sourced from mantle and melting of descending slabs respectively.

→ Aleutian Islands, Kuril Is, Japanese Islands, Phillipine Islands involves dominating example of festoon Island arc.



(iii) Depositional Islands:

Corresponds to advancing depositional shorelines. Such Island involves both:

(a) Sea waves deposition ( long Is., Frisian Is.)

(b) Riverine deposition ( Gangasagar Is., Gandhar Is.)

(iv) Coral Islands:

## * CORAL REEFs:

1] In the tropical water Oceanic relief features includes coral reefs as a significant constituent.

2] These are organic constructs that represents non clastic Sedimentary rocks essentially made up of Calcium carbonate.

3] Developed due to cementation & compaction of Skeletal remains of marine colonial organisms called Coral Polyps.
It justifies its localised presence as Polyps makes example of Steno organisms which thrives only in the availability of combination of specific habitat that is:

- Warm
- Saline
- Transparent
- Shallow.

4] The available reef constructs are categorised into two major structural categories called Reef flat & Reef Crest.

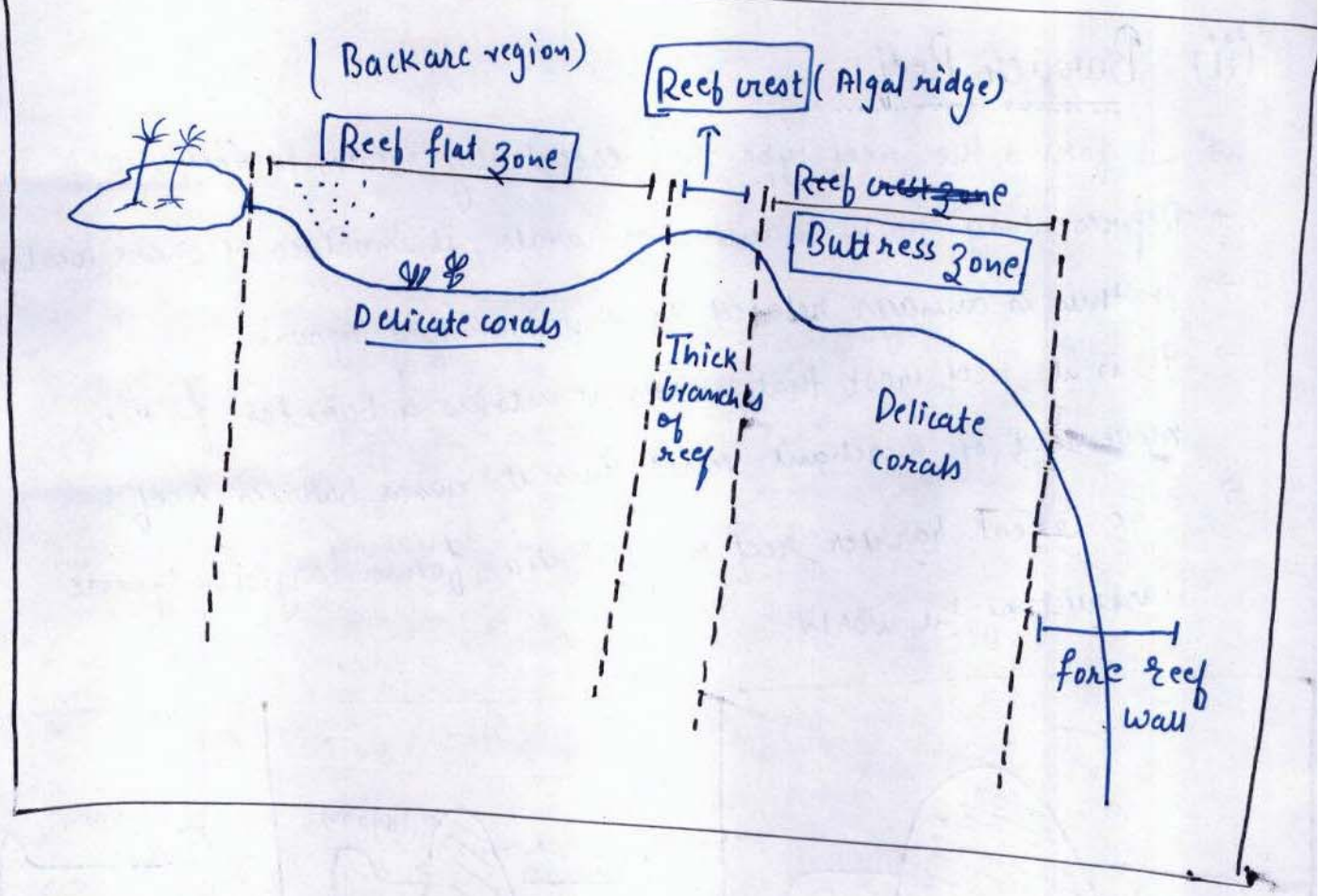
(a) Reef flat:

→ This structural category is applicable to backarc zone.
→ That is immediate offshore zone of an Island or mainland.
→ where inspite of available habitat restricted transparency of the water supports the growth of delicate branches of coral thus the reef structure called reef flat.

(b) Reef Crest.

→ In comparison is the structural category that involves thick branches of corals (reflecting most favourable habitat).
→ The reef crest typical with its offshore location forms the boundary b/w backarc & forearc zone.
→ It is reef crest that also denotes outer margin of development of coral reef & it is therefore that with increasing depth delicate branches of corals develops.

* Buttress zone i.e partially or weakly evolved reef construct (also called fore reef wall).




5] Based on the developed structure Coral reefs are categorised into three prominent types : i) fringing reef
ii) Barrier reef
iii) Atoll Islands

(P) Fringing Reef : Is defined to be the reef construct that absolutely fringes (attached) to the shoreline of mainland or an Island. It thus excellently represent reef structure called reef flat.

This reef construct thus is largely devoid of demarcated lagoon lake.

It however provides favourable offshore habitat.

Presence of fringing reef is related to all the areas involving coral polyps habitat.

## (ii) Barrier Reef:

→ It forms the reef type that essentially relates to reef crest.
→ Representing thick branches of corals, it involves offshore location.
→ It thus is always related to variable sized lagoon.
→ It is its reef crest that makes it acts as a barrier for the movement of merchant vessel thus its name barrier reef.
→ The Great barrier reef of Australia forms largest organic construct of the world.

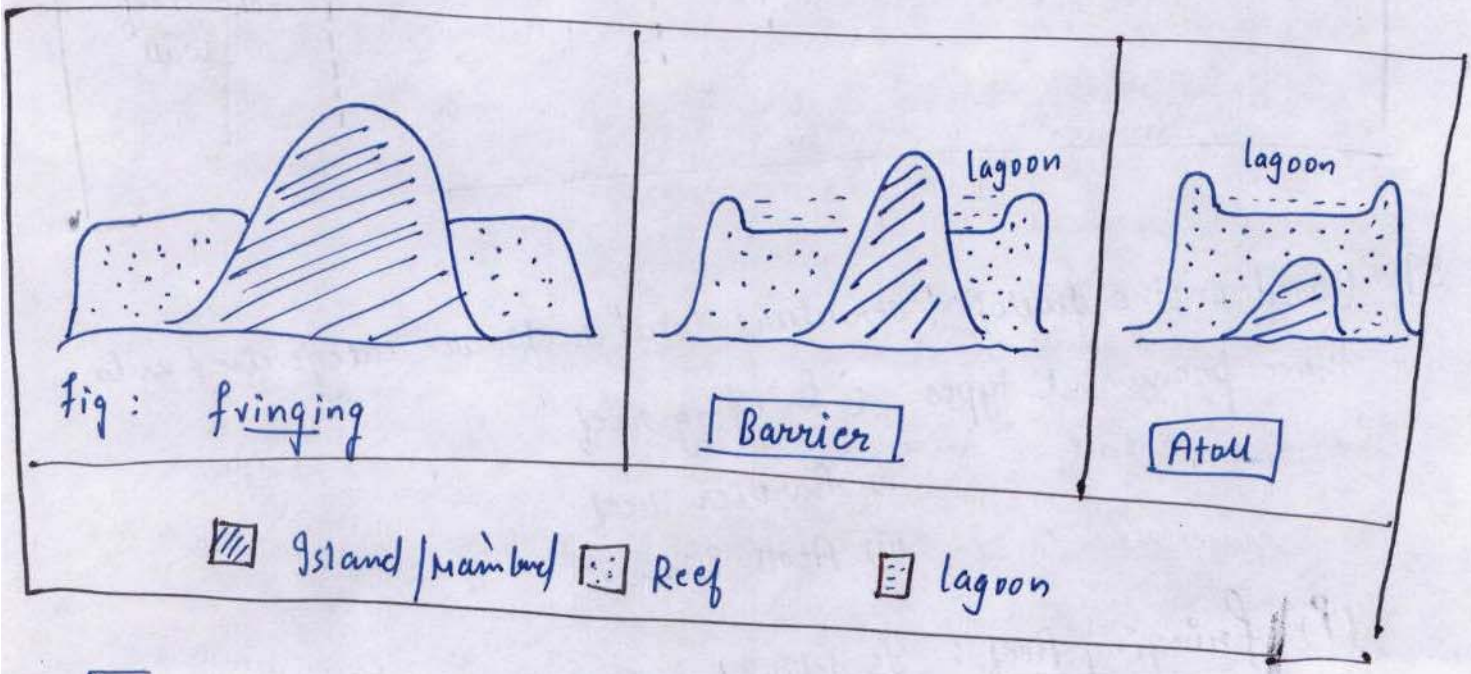



fig: fringing

[ Composite mills (sugar & textile mills) - Cairns, Townsville ] Australia.
Brisbane - commercial sea port
laged behind due to barriers ]

(iii) Atoll :

→ It forms coral Island that is commonly circular or oval in shape.
→ It incorporate reef crest as its structural characterstics.
→ Subjected to chemical weathering it largely involves fregmented arc of Islands with different sized & depth of lagoon.
→ Such dominantly cemented that it provides habitat for human settlements as well.
→ Eg :- Lakshadweep & Maldives (Indian Ocean)
- Suva (Fiji), Northern Mariana, Marshall Islands ] Pacific ocean
- Bermuda Island (Atlantic ocean).

## * Theories on Origin of Coral reefs :

1] Reef constructs in all its shape & size location & types are excellently deciphered.

2] However two defined practical challenges are associated with their presence beyond the possible habitats for coral polyps.
These includes both presence of reef at depth more than 200mt. and presence of coral Islands.
In order to provide explanation of the development of such reef constructs two set of theories are taken into consideration.

i) The Subsidence theory.
ii) Glacial control theory.

## (i) Subsidence theory:

1] It was originally propounded by darwin 1837 and was enriched by Dana (1842).

2] This concept involves tectonic force to depict the origin of coral reefs

3] It identifies that origin of reef involves three defined stages with each corrosponding to defined type of reef construct.

→ In the Preliminary stage smallest reef construct called fringing reef tends to develop.

→ with the begenning of tectonic subsidence of mainland or an Island rise in the water level combined with decrease in supplies of food resource tends to make coral polyps adjust growing upward & outward.

→ It is this growth that enlarges reef construct with well defined reef crest i.e. fringing reef paving way to barrier reef.

→ Continuation of subsidence tends to generate ultimate stage of reef development called Atoll (representing single Island along subsiding mainland as well as circular or oval Island arc along subsiding Island).

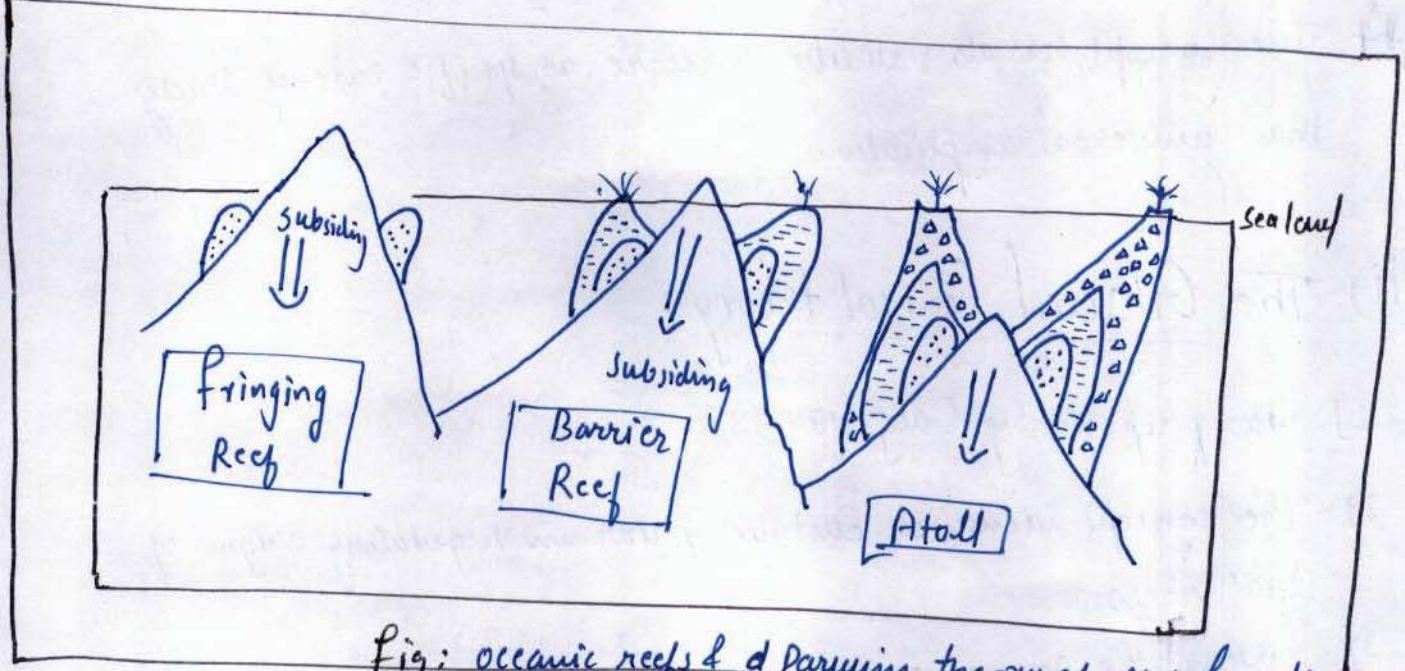



Fig: oceanic reefs & d Darwins theory of Atoll formation

* Appraisal:

4] The concept projects validity in explaining origin of coral reefs as:

→ Tectonic subsidence of land & Island involves global possibility.

→ It excellently explains presence of reef construct below the depth of 200m (at the time of development it being within the limit of polyps habitat).

5] The concept however has restrictions in its practical implication of development of coral reefs as:

→ There is no evidence of tectonic subsidence of all the tropical land & Island together.

→ Practically fringing barrier & Atoll reefs tends to coexist

→ The concept do not provide any defined explanation in the development of coral Islands.

The concept has its validity therefore as specific case of study than universal implication.

## (ii) The Glacial Control theory:

1] was proposed by Daly (1915).

2] The concept identifies Eustatic factor in regulating origin of coral reefs.

3] Marking the genesis of reef from pleistocene epoch this approach identifies development of reef constructs in tropical water below the levels of present continental shelfs (imprint of pleistocene ice age).

4] With termination of ice age by beginning of Holocene rise in the Mean Sea level interrupted existing habitat of coral polyps.

5] In absolute accordance to available possibility, adaptations by coral polyps generated fringing barrier or atoll constructs.

6] This concept projects its validity in the analysis of origin of coral reefs as:

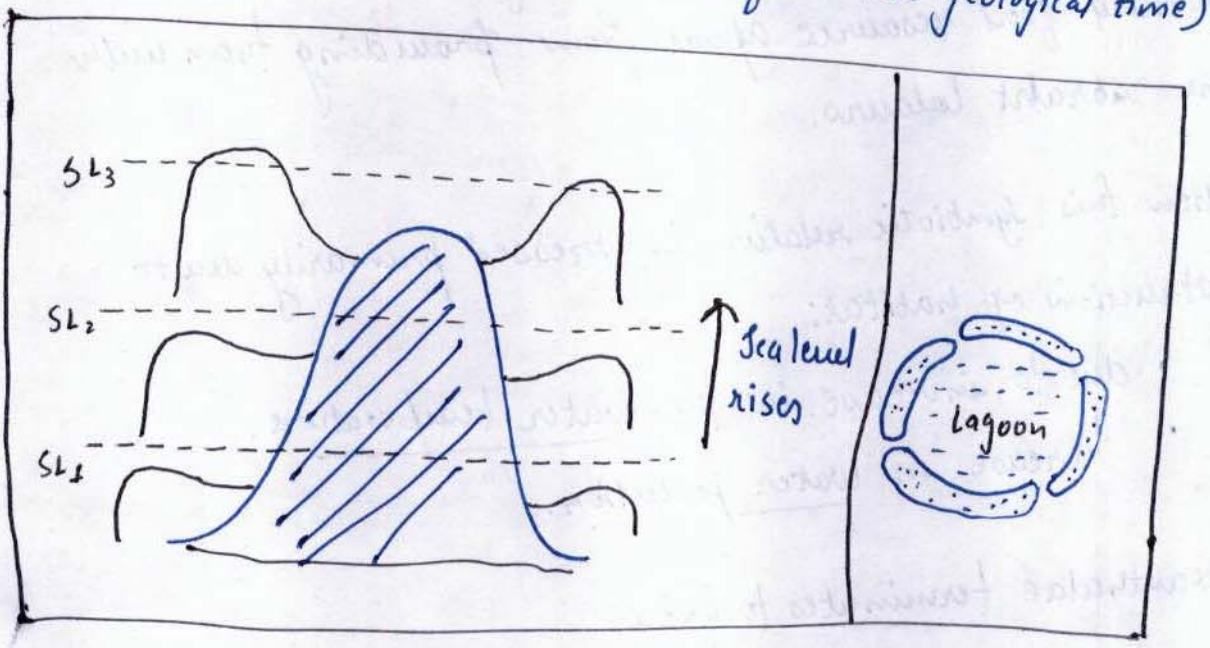
→ It is Eustatically correct approach.
→ It marks universal validity for all the tropical area.
→ It excellently explains coexistence of fringing barrier & Atoll reefs.
→ It explains the presence of reef construct below the depth of 200 m.
→

→ It explains the formation of coral Islands by involving defined role of Island building trees the littorals.

The reef constructs providing excellent shallow platform for the growth of offshore littorals.

It is the densest roots of these vegetation that not just facilitates further cementation & compaction of reef construct but also its possible projection at and over water surface forming coral Islands.

↓↓ The concept also recognises Isostatic rebouncing as the additional factor in the development of coral Islands (this possibility however implied to reef constructs of the older geological time).



# * Coral Bleaching:

1] Coral constructs in the tropical habitat are associated with one of the richest & diverse aquatic phototrophs that includes Periphytes, macrophytes, littorals & Planktons.
It is this combination that makes coral reefs designated as equatorial rainforest of the aquatic habitat.

2] The coral polyps are identified with Symbiatic (mutualistic) relation with microscopic algae called Zooxanthalae.
These thrive on coral reefs providing the corals with their primary food resource apart from providing them with the vibrant colours.

3] When this Symbiatic relation is stressed primarily due to destruction of habitat:

- due to increase in the water temperature.
- Increase in water pollution.

thus
4) Zooxanthalae terminates to grow.

4] The stressed corals thus represents decolourised characterstics both due to termination of existing Zooxanthalae as well as termination of possibilities of their revival.
The bleached corals in the absence of Symbiotic support faces scarcity of food supplies along with added challenges of ...

pollution & temperature increase induced carbonation

5] Combining these surpassed resilience of coral polyps generates mass destruction (bleaching of coral constructs).
Which corelate to Spiral of destruction that includes:

- Decrease of habitat for plants.
- Decreasing density of carbon sinks.
- Increasing acidic nature of water.
- Increasing carbonation of even healthy corals.

6] Coral reef protection therefore incorporate immediate (short term) solution to be artificial implantation of corals so as to protect phototroph habitat containing acidification of water & ensuring healthy survival of existing corals.

## * Indian Coral reef challenges:

1] Coral reef protection in the country forms the constituent of mangroves protection under MFF.

2] Ministry of EFCC in collaboration of NIO (National Institute of oceanography) & Space application centre of ISRO have outlined causes of coral stress & its resultant bleaching to be principally involving:

...

(a) Implications of climate change - that includes:

→ Increasing heat stress due to warming up of the ocean - It includes both (a) increase in the temperature of water (18°C for winters & 28°C for summers being the survival temperature for the corals) as well as (b) increase in days of heat stress (It is max. of 28 days of heat stress that corals can survive).

→ Changes in sea level due to thermal expansion.

→ Intensification & changes in the storm (cyclonic) pattern.

→ Changes in the pattern of precipitation modifying the runoff & resultant discharge.

→ Modified nature of oceanic current system.

→ Increased acidification of oceans.

(b) The other causes for coral stress includes:

→ Increasing water pollution. → oil & metal pollution

→ Unsustainable fishing methods (that specifically includes → use of dynamite under water destruction of coral by boat anchors).

→ Coral collection for variable types of ornament production ↓ use as souvenir

as secondary causes of coral destruction.

Based on this assesement Mass BLEACHING of coral reefs have been identified in entire Indian Ocean coral reef region including Andaman & Nicobar Islands, Lakshadweep, Gulf of Kutch, Gulf of Khambat.

* 2010 Assesement:

| | temp. | thermal stress duration |
|---|---|---|
| Gulf of Mannar - | ≃ 31°c | 48 days |
| Gulf of Kutch - | ≃ 31°c | 91 days |

* 2016 Assesement

| | temp | thermal stress days |
|---|---|---|
| Gulf of Mannar - | ≃ 31°c | 63 days |
| Gulf of Kutch - | ≃ 30°c | 7 days |

* 1970 - Indian Ocean declared Region of peace

# * Laws of Seas / Maritime Zones:

1] Demarcation of political Jurisdiction of the ~~week~~ maritime States under United Nations convention on laws of Seas (UNCLOS) is called maritime zone.

2] It incorporate defined objective of ensuring: peaceful coexistence of the neighbouring maritime states.

3] favourable commercial utilisation of marine resources.

4) Unabated continuation of scientific explorations & studies.

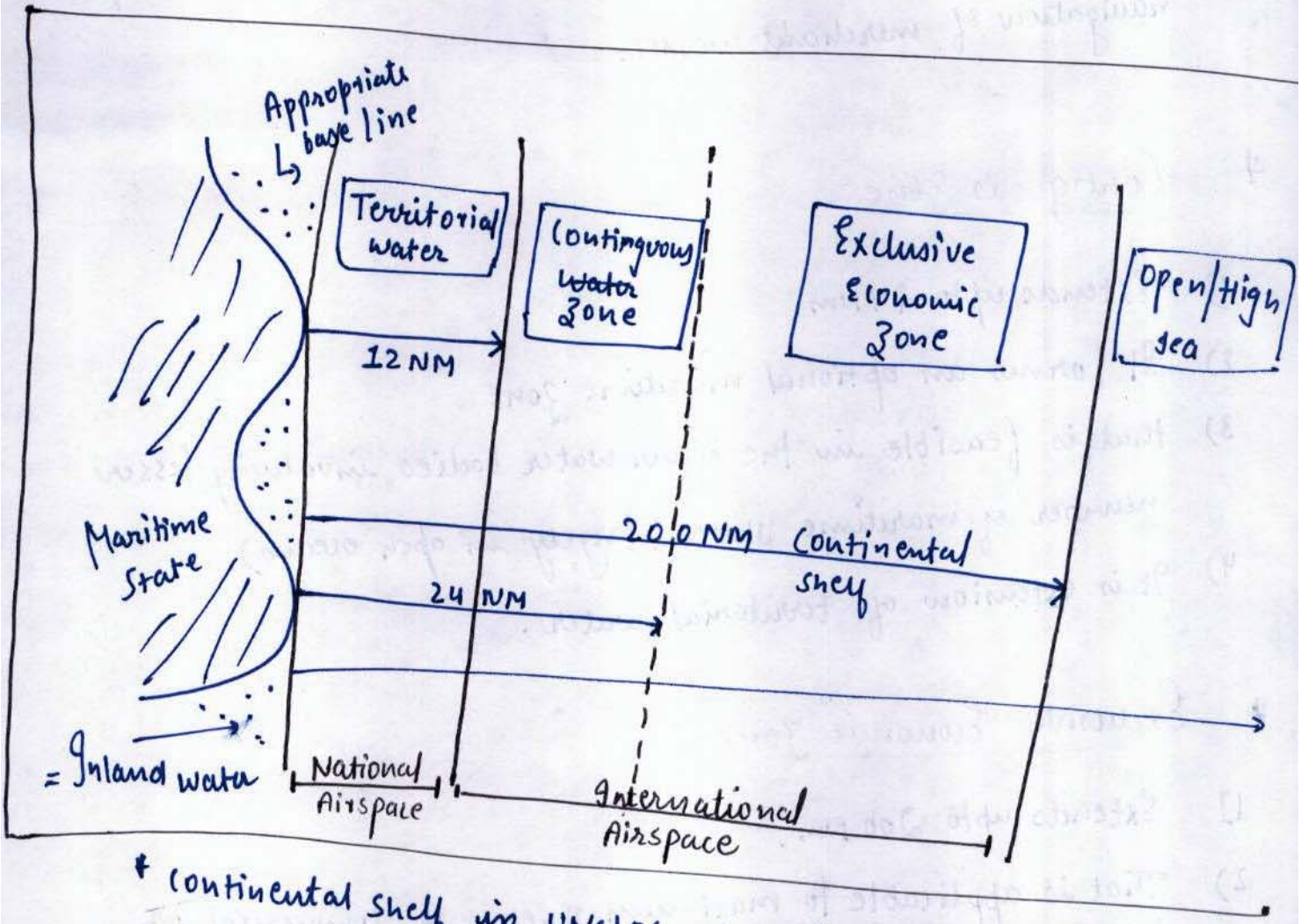
5) Uninterrupted transit of merchant vessels.

6) 1974-75 marked up the first demarcation of maritime zones in the consideration of "appropriate base line."

The appropriate base line forms the line joining all the major projecting peninsula of a maritime state by appropriating politico economic interest of all the neighbouring states.

It is with reference to appropriate base line that 'Inland water' or 'archipelago water' are being recognised as [onland features].

... All the maritime zones are measured of their extension from the appropriate shoreline.




* Continental shelf in UNCLOS means the area till Exclusive economic zone, whether geological shelf available or not.

* Territorial water :

1) Extends 12 Nm from appropriate base line.
2) It forms the political territory of the maritime states.
3) which implies absolute validity of laws of land.
4) It is this zone which thus relate to deployment of naval fleet and imposition of customs excise obligations.

5) Originally related to innocent passage, since 1982 it has been linked with "transit passage" so as to ensure uninterrupted navigation of merchant vessel.

* Contiguous Zone:

1) Extends upto 24 Nm.
2) It forms an optional maritime zone
3) that is feasible in the bigger water bodies involving lesser number of maritime states (largely in open oceans).
4) It is extension of territorial water.

* Exclusive Economic Zone:

1] Extends upto 200 Nm.
2) That is applicable to maximum stretch of commercial or economic continental shelf.
3] It involves overlaps of economic rights of neighbouring maritime states
4) It thus involves consistent bilateral or multilateral negotiations to counterbalance economic aspirations of stakeholders.
5) Exclusive economic rights of exploration, exploitation & conduction of scientific studies is shared among the maritime states.

6] In order to ensure this exclusive nature prior consent regime is implied in this zone for the third part.

* Open / high sea :

1) Beyond exclusive economic zone.
2) This maritime zone is open for global community.
3) It is largely utilised as maritime trade routes.

** These maritime zones provides blueprint for the required negotiations with our evolving politico economic aspirations so as to ensure fulfillment of desired objectives.

[* Debate of jurisdiction of caspian sea (lake) b/w the concerned countries].

* In case of lakes shared by multiple countries, the state with maximum shoreline ~~xxxxx~~ will have maximum jurisdiction.

# Fishing in World (Commercial):

1] Geographically commercial fishing grounds are completely absent in tropical water (when compared to the temperate counterpart) in the combination of:

(a) Impure shoals of fishes.
(b) High oil content in fishes.
(c) Varied & perennial agricultural potentials on land fulfilling the dietary requirements.
(d) hazard prone tropical waters. (cyclones etc.)
(e) thermal stresses & pollution of water.

2] Fishing techniques:

**Habitat** ⇒ **Dual**
- Anadromous (lives in saline water)
- Catadromous (lives in fresh water)

**Pelagic**
- Shallow

**Demersal**
- Deep

**Technique**
- Wall Net
- Drifters
- Trawlers

**Catch** (landing)
- Salmon
- eels

80% of landing:
- Mackerel
- Tuna
- Herring

→ Shell fishes
- Lobsters
- Crab

- Haddock
- Cod

## 3] Major fishing grounds of the world:

### ① NE Atlantic:

→ Dogger bank
→ Dual & pelagic habitat. (add techinques & harvest) → from table
→ Major fishing states: Norway, Netherland
UK, Germany
Denmark

### ② NW Atlantic:

→ Dual, pelagic & Demersal habitats (+)
→ Canada & USA as fishing nations.

### ③ NE pacific:

→ Dual, Demersal & restricted pelagic (absence of shelf)
→ Canada & USA.

### ④ NW pacific:

→ All the three habitat (+)
→ Japan, Russia, China & South Korea.

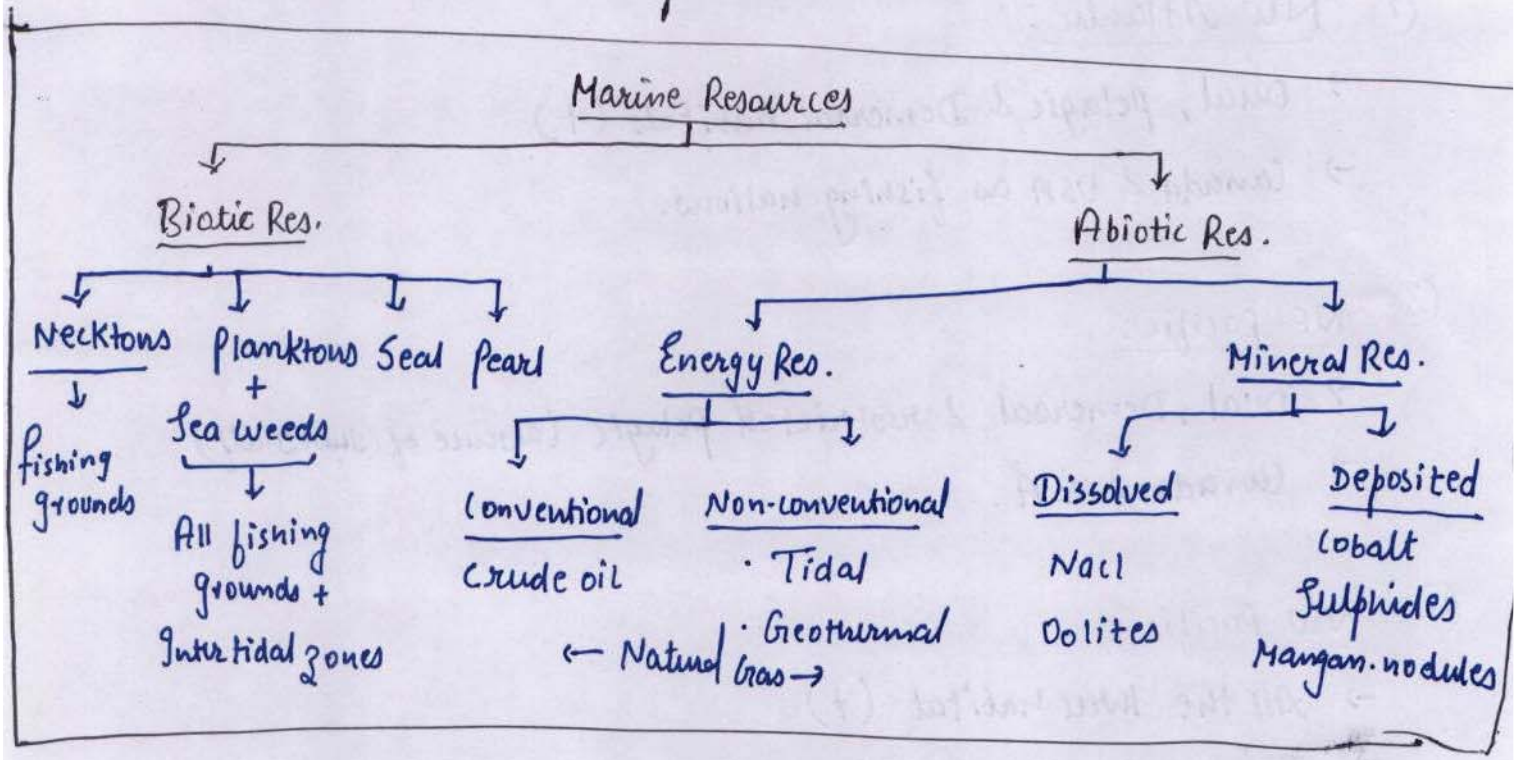
### ⑤ Southern ocean:

→ Involves Pelagic & Demersal habitats.
→ Commercial harvesting includes: Whale (storehouse of resource)
- Krill (swift regeneration capacity).
- White king fish (Gold fish - highest price in international market)

→ Major fishing Japan, Norway & Russia
→ Evolving players: Argentina & Australia

* Peru in tropical region under influence of peruvian current gives temperate like conditions thus major fishing ground with pure shoal of fishes.

## * Marine resources / Oceanic resources :




Planktons + sea weeds ] → direct consumption
→ used in FPI as emulsifying agent.

* Srilanka - pearl of world → shape
→ Gulf of Mannar (pearl fishing) → Gulf of Tongking
→ Gulf of Thailand

Seal → Gulf of Alaska, white sea

Pearl → Non food