Q1. *Define Physical Geography. Discuss various branches of Physical Geography.*

Answer: The word geography is derived from two Greek words (*Geo* referring to Earth and *Graphy* meaning description or writing) and literally means *'to write about the Earth'*. Geography is an all-encompassing science that seeks to bridge and understand, through an understanding of location and place, the world's physical and human features. Geography teaches us where things are and how they got there; it looks at the spatial connection between people, places and the Earth.

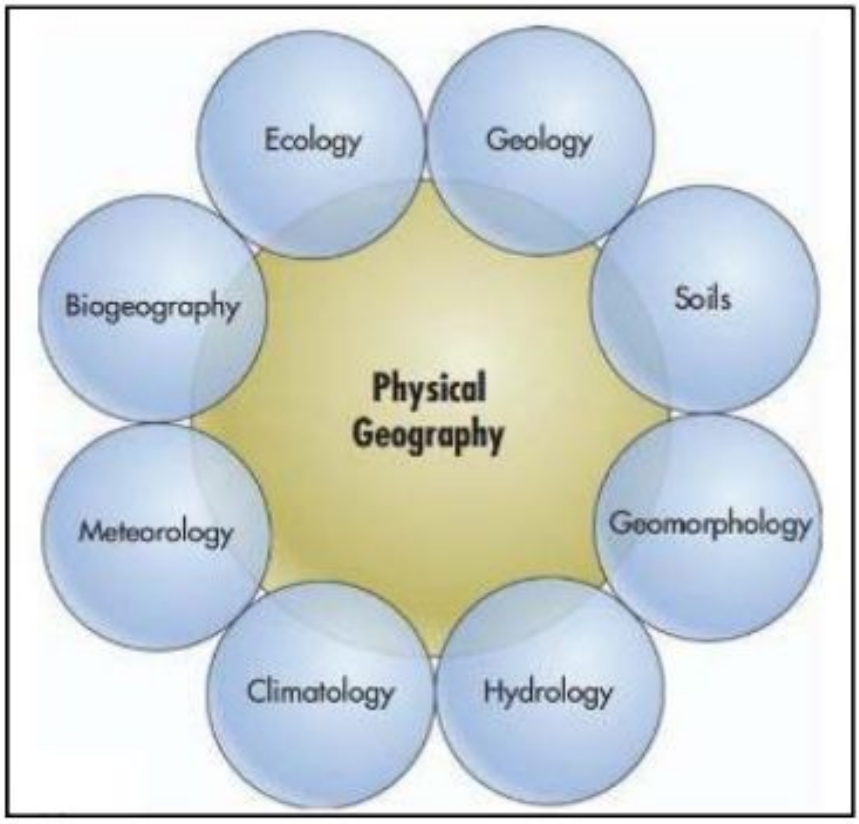


Fig. 1: Branches of Physical Geography

Physical geography may be defined as the integrated study of the natural environment on or close to the earth's surface. Physical geography involves the spatial analysis of the various physical components and natural processes of the Earth. It encompasses the processes and features that make up earth, including human activities where they interface with the environment. Some examples of earth's physical components are air, water, rocks, vegetation, and soil. It is a sub-discipline of geography that studies natural features and phenomena on the earth from a spatial perspective. The study of physical

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geography let us know about all the agents which play a key role in shaping and modifying the earth's surface features. It has a number of sub-branches **(Fig. 1)** which treat different kind of physical phenomena.

(i) **Geomorphology:** The science of study of landforms is known as *geomorphology*. It is concerned with the study of the nature, development and modification of landforms on the Earth's surface. It includes origin and development of landforms through erosional, transportational and depositional processes of water, wind and glaciers. Geomorphologists are interested in understanding and explaining variation in landforms, the processes that produce physical landscapes, and the nature and geometry of Earth's surface features.

(iii) **Climatology:** Climatology is the study of the atmospheric conditions and related climatic and weather phenomena. It includes the study of atmospheric composition, climatic regions, seasons, etc

(iv) **Oceanography:** It is concerned with the study of various oceans, their components and processes related to ocean floor depths, currents, corals reefs, and continental drift etc.

(v) **Soil Geography or Pedology:** It studies various soil forming processes, their physical, chemical and biological constituents, their colour and types, texture and distribution and carrying capacity etc.

(vi) **Bio-geography:** It is concerned with the biological phenomena in space, especially in terms of the distribution of various kinds of floral and faunal species. Biogeography may be subdivided into plant or floral geography, animal or faunal geography and human ecology. Biogeography examines natural and human-modified environments and the ecological processes that influence their characteristics and distributions over time. It also studies the ranges and patterns of vegetation and animal species, seeking to discover the environmental factors that limit or facilitate their distributions.

Q2. Explain the structure of earth's interior with the help of seismological evidence and describe in detail the zoning of earth.

Answer: The factual evidence concerning the interior of the earth is not readily available. Therefore, knowledge about the interior of the earth is based on indirect evidences as under:

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(i) *Seismic studies:* The study of seismic waves i.e the vibration, usually created by disturbances within the earth's outer crust reveals some useful information about the earth's internal structure.

(ii) *Density studies:* Using the spherical shape, the mean or average radius and mass of the earth, it is possible to determine the average density of the earth as 5.5 g/cm^3 (Core: 11.0g/cm^3; earth's surface: 2.6 to 3.3 g/cm^3)

Seismological evidence

There are three types of seismic waves:

- *Primary wave* or compressional waves, in which particles oscillate back and forth in the direction of propagation of wave.
- *Secondary waves* or transverse waves are transverse in nature similar to light waves, in which particles oscillate perpendicular to the direction of propagation.
- *L- Waves* or love waves or Rayleigh waves are confined to surface of earth.

The seismic waves are reflected when they strike the interface between two materials drawing different elastic properties and densities. The time required for the wave to arrive at any point on the surface of the earth depends on the path of the wave speed is known at any give depth, this can provide physical parameters such as density, rigidity, etc. for various layers within major unit of earth.

Thus, based on seismic investigations, the earth can be divided into three major zones with different chemical composition. These are:

(a) **Crust:** The innermost layer of earth is the crust of the earth. It is divided into continental crust and oceanic crust. The continental crust has a thickness of about 35 to 70 km and the oceanic crust has a thickness of 10 to 12 km. The dominant elements in crust are Silica and Aluminium (SIAL).

(b) **Mantle:** The next layer is mantle, which is 2900 km thick and is separated into the upper and lower mantle. The volume of the mantle is about 83% of the total volume of earth. The dominant elements found in mantle are Silicon and Magnesium (SIMA). Between 100 and 200 km depth of the upper mantle, the velocity of seismic waves is slowed down to 7.8km/sec, therefore, this zone is called *"zone of low velocity"*.

(c) **Core:** The inner most layer of the earth is called *'core'*. It is separated into the liquid outer core and the solid inner core. Earth's magnetic field is believes to be controlled by

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the liquid outer core. The outer core is 2300 km thick (fig.2) twice as thick as the inner core (inner core is almost 1200 km thick).

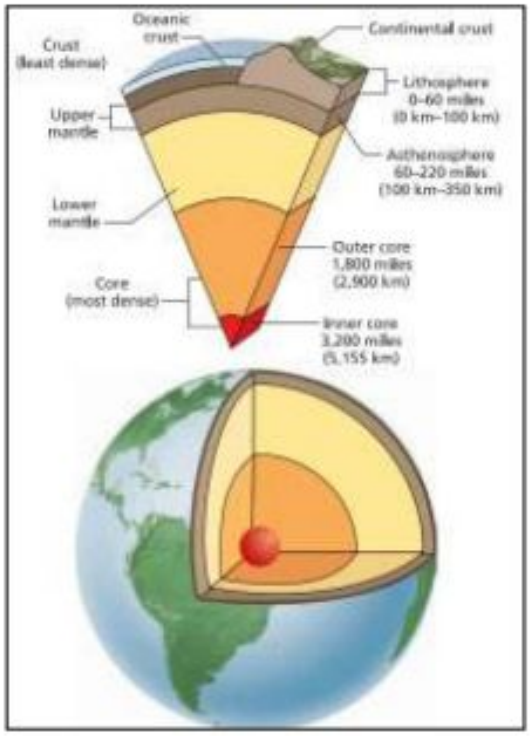


Fig. 2: Interior of earth

There are several discontinuities like *Conard discontinuity* (between upper crust and lower crust), *Moho discontinuity* (between upper mantle and lower crust), and *Weichart – Gutenberg* discontinuity (between lower mantle and outer core).

Q3. Explain in detail the Wegener's theory of continental drift.

Answer: As per the known records of the history of science, it was *'Abraham Ortelius'* a Dutch map maker, who first proposed the possibility of drifting of the continents as early as 1596 A.D. Then *'Antonio Pellegrini'* drew a map showing the three continents together. However, it was *'Alfred Wegener'* a German meteorologist who put forth a comprehensive argument in the form of *'The Continental drift Theory'* in 1912. This theory was regarding the distribution of oceans and continents.

Wegener postulated that throughout most of the geological time there was only one continent, a supercontinent, which he called *'Pangea'* surrounded by a massive ocean *'Panthalasa'*. At sometime during the Jurassic period (around 200 million years ago), Pangea began to split. Pangea first broke into *'Laurasia'* and *'Gondwanaland'* separated

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by the Tethys – a narrow shallow linear geosynclines (fig. 3). Subsequently, *Laurasia* and *Gondwanaland* continued to break into various smaller continents that exist today. As per Wegener, India and Africa moved northward under gravitational forces, while America moved westward under tidal forces. The northward movement and the subsequent collision with Laurasia produced the Himalayan mountain system by squeezing the sediments of Tethys Sea, while the westward movement led to the formation of the Rockies and Andes and the Island arcs of Caribbean.

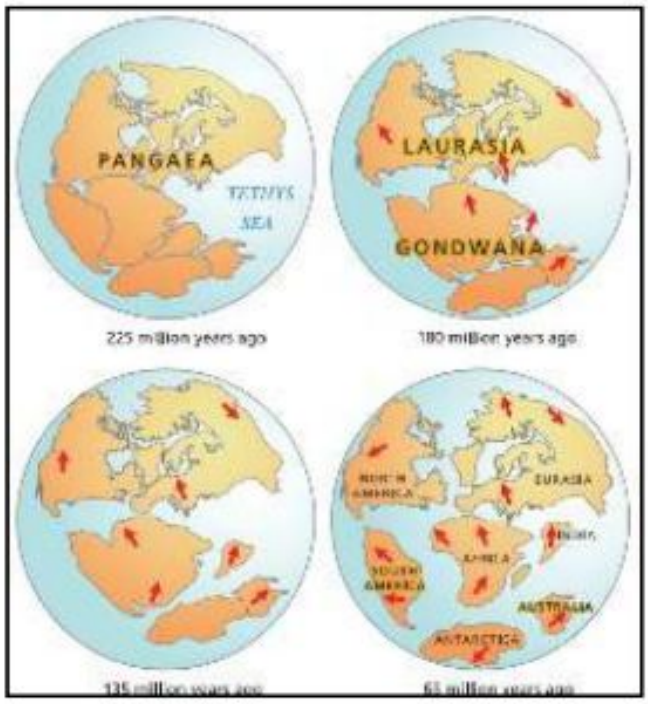


Fig 3: Breaking-up of Pangea and distribution of continents

Wegener cited evidences such as matching of boundaries of continents (Jig-saw fit); paleontological evidences (occurrence of mesosaurus – glossopteris fossil on various continents); structural evidences (stratigraphic similarities along eastern Brazil and northwest African coastlines) and Ice-flow directions (showing radiating pattern in all directions) in favours of his theory (figure 4).

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Fig.4: Geological and Paleontological evidences

The Wegener's hypothesis initially aroused much interest, debate and support but was strongly opposed later. The main flaws/ criticisms in this theory are:

1) It was weakened by its lack of suitable driving mechanism for continental movement, and hence by 1926 this theory was no longer a subject of serious investigation.
2) The second objection raised was that the Rockies and the Andes mountain system could not have been formed in the manner envisaged by Wegener, because if *'SAIL'* was floating over *'SIMA'*, the SIMA could have not offered such resistance to westward movement of continents to cause folds and build mountain system.
3) The oceanic crust is too rigid to allow sturdier (strong and solid build) continents to break through it, and lastly;
4) Distribution of fossils has been proved wrong, because the evolution of organisms at same time in different continents is possible.

Q4. Explain the concept of Sea Floor Spreading.

Answer: There are several mechanisms to explain *Sea Floor Spreading*. For example, Henry Hess postulated that the ocean ridges are situated over the rising limbs of convection currents in the earth's mantle. These convection currents led to rifts in the

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surface which providing path to the magna to come onto the surface in the form of volcanic activity. This magna then solidifies and forms new crust. The new crust pushes the old crust apart which is then consumed at trenches. The creation of new crust at constructive plate margins is termed as '*sea floor spreading*'.

The other view regarding sea floor spreading is that of *Vine* and *Mathews* who point out that it is because of the formation of magnetic strips of alternating positive and negative anomalies. Sea floor spreading can be detected through the presence of magnetic anomalies, age of ocean floor, heat flow and volcanic activity at mid oceanic ridges etc.

Q5. Explain the theory of Plate Tectonics.

Answer: The concept of plate tectonics has emerged from two earlier hypotheses of *continental drift* and *sea-floor spreading*. Plate tectonics is a theory of geology that has been developed to explain the observed evidence for large scale motions of the earth's lithosphere. The word *'Plate'* was first used by Canadian geophysicist *J.J. Wilson* in 1965.

The concept of Plate Tectonics was proposed simultaneously by *Mackenzie* and *Parker* in 1967 and *Morgan* in 1968. The concept was presented in a detailed from by *Le-Pichon* in 1973. The theory of plate tectonics explains the mechanism, evolution, nature and motion of plates. There are two parts in this concept - Geometric part and kinematic part.

Geometric part: This part believes that Lithosphere consists of mosaic of plates with different sizes which floats on Asthenosphere. There are six or seven major plates. These plates may be either completely continental like *Eurasian plate* or completely oceanic like *pacific plate* or may be combination of both like *African plate*.

Kinematic part: This part states that these plates are in motion with respect to ocean basins and with respect to each other. They can separate from one another or they slide simply over one another. These plates move on a mobile zone called *'Asthenosphere'*. Usually margins of plates come in contact and this is a weaker zone. When two plate margins meet, they form *Plate boundaries*. Plate boundaries are of three types;

(a) *Constructive plate boundaries:* Also called the '*divergent plate boundaries'*. When two plates move apart from each other, the magma rises from inside the earth which leads to the formation of mid-oceanic ridges. E.g; Mid Atlantic Ridge in Atlantic Ocean.

(b) *Destructive plate boundaries:* Also called the '*convergent plate boundaries'*.

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- ❖ Oceanic plate will be subducted in collision with continental plate, leading to the formation of subduction zones (ocean trenches).
- ❖ Collisions between two continental plates will lead to mountain building.

(c) *Conservative plate Margins:* These are also called as *Shear plate margins*. The plates slide past each other along *transform faults*. Plates neither gain nor lose material. e.g.; San Andreas Fault in California. These boundaries produce devastating earthquakes because great friction results as the moving plates grind past each other, e.g.; San Francisco and Los angles area experience great earthquakes because of San Andreas Fault. Different types of plate boundaries are shown in fig.5

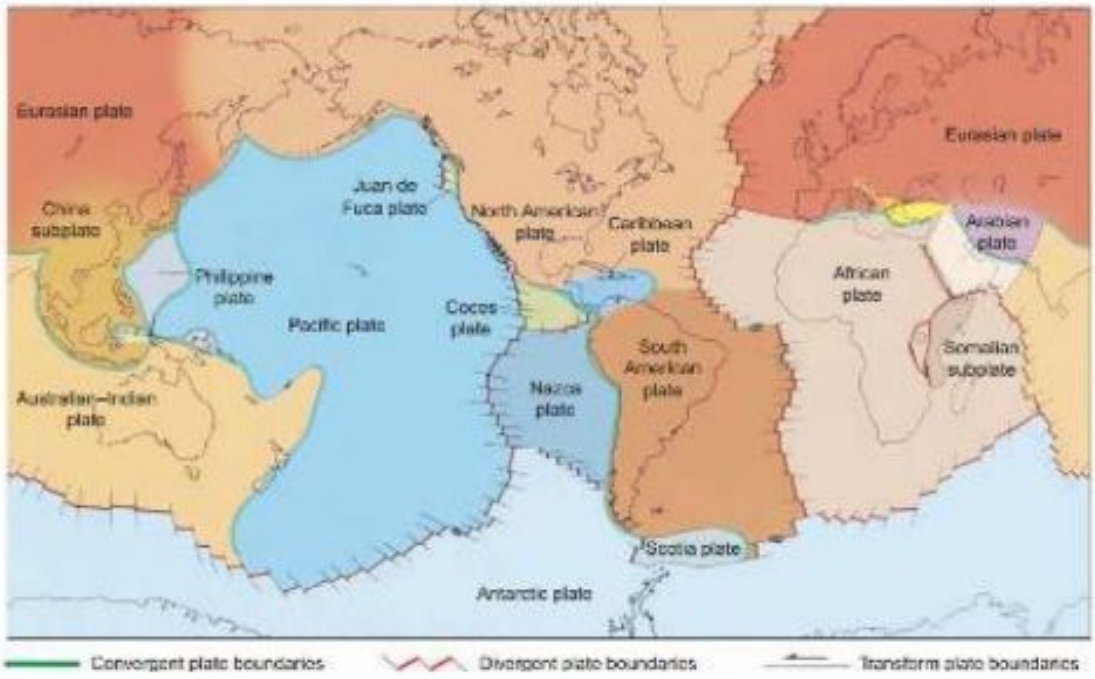


Fig.5: Plate boundaries

Q6. Explain the concept of Isostasy.

Answer: Isostasy refers to the condition of hydrostatic equilibrium between the sections of the lithosphere with respect to the underlying mantle. The concept was first used by Dutton in 1889. The theory of Isostasy presents a system for the distribution of material in the earth's surface which confirms and explains the observed gravity values. According to this theory, wherever equilibrium exists in the earth's surface, equal mass must underlie equal surface areas. The lithosphere is floating on the Asthenosphere with more massive portions reaching deeper to obtain needed buoyancy. It can be understood

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thus – a massive block of ice will extend deeper into the water than the small ice cube. A number of theories were put forward with respect to density distribution of rock material and associated phenomena's. Some important concepts or views are discussed below:

a) ***Airy's view:*** Sir George Airy postulated that there is a change in the density of rocks at depth in the earth's interior and that the upper lighter material floats on the more dense part, which behaves like a fluid. The depth of this change varies from place to place. Under mountains, the depth is greater than under oceans or plains. In other words, the mountains have roots of light weight materials which extend down into the lower, denser mantle rocks. The lower density (mass) of the rocks causes the observed gravity values measured in the mountain ranges to be lower than predicated theoretically (see figure) Therefore he proposed uniform density with varying depth.

b) ***Pratt's view:*** Pratt's theory differs from Airy's in that Pratt assumed that the boundary between the upper light material and the lower dense rocks is at a uniform depth of compensation. He further postulated that there are variations in the density of the lighter layer, which are related to the elevation to the surface. Lighter material lies under mountains and heavier material under oceans. The weight of columns of rock extending from the surface to the depth of compensation in different parts of the earth is thus the same.

c) ***Heiskanen's theory:*** Heiskanen's theory combines the assumptions of both Airy and Pratt and he postulates that density varies between columns and within columns That is, the higher densities are represented by the shorter columns and towards the bottom of each column. Therefore, rocks at sea level are denser on an average than those on higher elevations. Also, it accounts for the roots of mountains and for variation in density in different parts of the crust.

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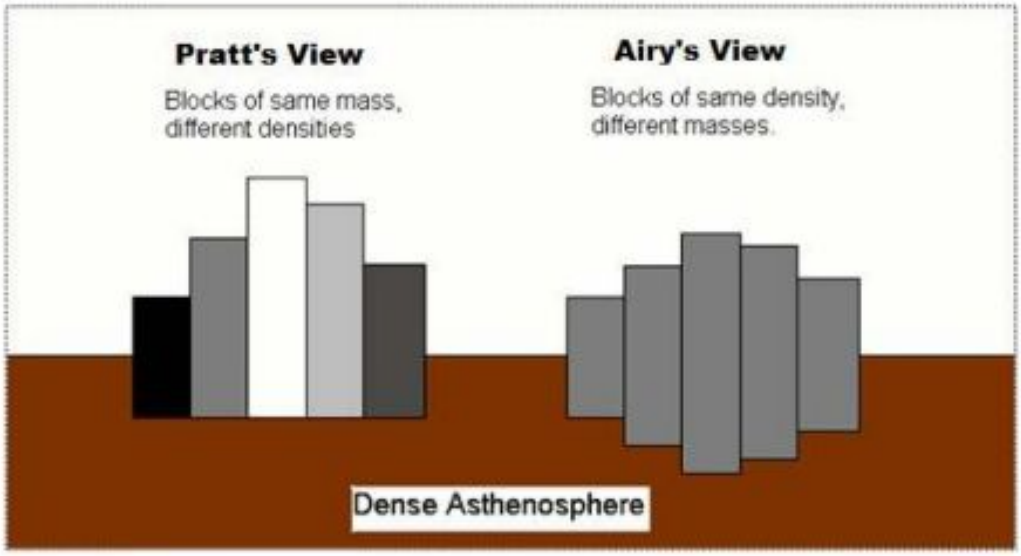


Figure 6: Airy and Pratt's View

Q7. Define an Earthquake and discuss its origin, types, measurements and distribution.

Answer: An earthquake also known as *'quake, tremor or temblor* is the shaking of surface of the earth **or** an earthquake may be defined as the sudden shaking of earth produced by the rapid release of energy that creates seismic waves. This energy radiates in all directions from the source of earthquake (*focus*). Earthquakes are among the most destructive of natural phenomena taking an average yearly total of 1400 lives, besides causing extensive damage to property. It is estimated that over 30,000 earthquakes strong to be felt occur worldwide annually. The earthquakes occur because of the rupture and sadden movement of rocks caused by more stress than the elastic limit of rocks. The other causes leading to earthquakes are tectonic movements, volcanism, construction of dams etc.

➢ **TYPES OF EATHQUAKES**

Earthquakes can be broadly classified into three groups on the basis of how deep beneath the earth they originate.

(i) Shallow or normal earthquakes: All those earthquakes which occur between the surface of earth to the depth of 44 miles are called *'shallow earthquakes'*. They occur frequently.

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(ii) Intermediate earthquakes: All those earthquakes which originate between 44 to 188 miles below the surface of earth are termed as *intermediate earthquakes.*

(iii) Deep earthquakes: The earthquakes which originate below the depth of 188 miles from the surface of earth are termed as *deep earthquakes*.

➢ **MEASUREMENT**

Earthquake measurement is basically done on two scales-one is *intensity scale* and the other is *magnitude scale*. Earthquake intensity represents the degree of shaking at a particle location on the earth surface. It indicates the local effect or damage of the earthquake. Therefore intensity of earthquake diminishes or decreases with increasing distance from the epicentre. Intensity is measured by *Modified Mercalli scale* whose values run from 1to 12.

Magnitude of an Earthquake is an expression of actual energy of the earthquake. It is measured on a standard scale called as *Richter scale* which runs from 0 to 8.9. Earthquakes of magnitude 1(one) is described as weakest earthquake and magnitude of 6.9 to 7.9 is termed as 'major earthquake'.

➢ **Distribution**

Most of the Earthquakes occur on the boundaries between lithospheric plates and arise directly from the motion between the plates. Three zones of seismic activity have been identified throughout the world, which are:

(i) ***Circum-pacific belt:*** The circum-pacific belt includes the ocean trenches and associated island arcs. This belt begins from the western side of the pacific; starting from Alaska, it runs towards south parallel to Japan and Philippine trenches. It also includes west coast of North America and Peru and Chile trenches. This belt is known for shallow, intermediate as well as deep earthquakes. Deep earthquakes are characteristic of this zone. About 68% of total earthquakes occur in this zone.

(ii) ***Mediterranean and trans-Asiatic belt:*** This belt extends along Alpine mountain system. This belt is characterized by large and shallow foci earthquakes. About 21% of the total earthquakes occur in this zone.

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(iii) ***Mid-oceanic ridges and African rift system belt:*** This zone lies mostly along the mid-oceanic ridges and transforms faults and contains shallow foci earthquakes. About 11% of the total earthquakes occur in this zone.

VERY SHORT ANSWER TYPE QUESTIONS

Q1. Define Lithosphere.

Answer: The outer, rigid shell of the earth is called lithosphere. It comprises of the crust and part of mantle.

Q2. What is hydrosphere?

Answer: The natural waters of the outer earth encompassing the oceans (98%), the rivers, waters vapour etc. is known as '*hydrosphere*'.

Q3. Define atmosphere.

Ans: The blanket of gases surrounding the earth is termed as '*atmosphere*'.

Q4. What do you mean by Biosphere?

Answer: Biosphere is that part of earth's surface and its immediate atmosphere that is inhabited by living organisms. It is that part of earth's surface where living forms survive.

Q5. What is cryosphere?

Answer: The portion of earth's hydrosphere where water is permanently frozen as snow, glacier or ground ice is called '*cryosphere*'. It is the ice at or below the earth's surface, including glaciers, ice-caps, ice sheers etc.

Q6. Define Earth's Crust.

Answer: The outer layer or shell of the earth including the continents and ocean floor is called '*crust*'. Its thickness varies from 10-35 km.

Q7. What is mantle?

Answer: That part of earth which lies in between crust and core is called *mantle*. The width of mantle is almost 2900 kilometres.

Q8. Define Core.

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Answer: The inner most part of the earth is called *Core*. Its thickness or width is almost 3500 kms. It is characterized by high pressure and high temperature.

Q9. Define a Plate.

Answer: A rigid segment of the earth's crust which can float on semi-molten rock below is known as "plate".

Q10. Define the term Isostasy.

Answer: The balance between the visible and invisible part of the continental crust of earth is termed as *'Isostasy'*. It refers to the condition of hydrostatic equilibrium between upper sections of the lithosphere with respect to the underlying mantle.

Q11. What is a Rock?

Answer: The aggregate of minerals is called a *rock*.

Q12. Define an Earthquake.

Answer: The sudden shaking of the earth occurring usually by release of stress along fault planes is termed as an *'earthquake'*.

Q13. Define a volcano.

Answer: It is an opening or vent or channel through which magna comes/erupts on to the earths' surface.

Q14.What are the various layers of earth's interior besides crust, mantle and core?

Answer: Earth's interior can be classified into Lithosphere, Mesosphere and Barysphere. *Lithosphere* is the upper most layer which comprises of the crust and solid portion of upper mantle. Solid lithosphere floats on a semi-liquid layer known as *Asthenosphere* (weak sphere) which enables lithosphere to move around. *Mesosphere* includes whole of mantle and lies below the Asthenosphere while *Barysphere* includes the whole of core.

Q15. How thick is the Earth's crust?

Answer: The thickness of the Earth's crust varies at different points around the planet. Under continents, the crust is approximately 15 miles (24 kilometres) thick, but under the oceans it is a mere five miles (8 kilometres) thick.

IMPORTANT POINTS TO REMEMBER

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- The concept of sea floor spreading was first given by Professor *Harry Hess* in the year 1960.
- Continental Drift theory is also known as *'Displacement Hypothesis'*.
- Surtsey island, south of Iceland has been formed by Volcanic activity in 1963.
- Transform fault is the type of plate boundary which is located where plates slide past one another without creation or destruction of the crust.
- Regions of local magmatic extrusions are popularly known as *'Hotspots'*.
- Seismology is the study of earthquakes.
- Seismographs are the seismic sensors, located throughout the world to record earthquake waves.
- Almost 30,000 earthquakes strong enough to be felt occur worldwide annually.
- Extrusive igneous rocks are also known as *volcanic rocks*.
- 87% of the minerals of earth's crust are silicates.
- Since sediments are usually deposited in distinct layers or strata, therefore these rocks are termed as *Stratified* rocks.
- Volcanic mountains are also called as *mountains of accumulation*.
- Common elements on earth's crust are silicon and oxygen, constituting 75% of it.
- A useful word to remember most abundant elements in the earth's crust is **MOSAIC**, i.e. Magnesium, Oxygen, Silicon, Aluminium, Iron and Calcium.
- L-waves or Rayleigh waves or surface waves cause maximum destruction among the seismic waves.
- Mount Stromboli is called *lighthouse of the Mediterranean*.
- The only active volcano is India is *Barren Island* in Andaman & Nicobar group of Islands.
- Epicentre is the point on earth's surface vertically above the seismic focus.

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Types and characteristics of rocks

Rocks are mineral aggregates with a combination of properties of all the mineral traces. Any unique combination of chemical composition, mineralogy, grain size, texture, or other distinguishing characteristics can describe rock types. Additionally, different classification systems exist for each major type of rock. There are different Types of Rocks existing in nature.



Rocks which are found in nature rarely show such simple characteristics and usually exhibit some variation in the set of properties as the measurement scale changes.

Types of Rocks – Rocks are broadly classified into three broad categories as the following.

- Igneous Rocks
- Sedimentary Rocks
- Metamorphic Rocks

Igneous Rock

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Igneous rock is one of the three main rock types. Igneous rock is formed through the cooling and solidification of magma or lava. Igneous rock may form with or without crystallization, either below the surface as intrusive (plutonic) rocks or on the surface as extrusive (volcanic) rocks.



This magma can be derived from partial melts of existing rocks in either a planet's mantle or crust. Typically, the melting is caused by one or more of three processes: an increase in temperature, a decrease in pressure, or a change in composition.

Sedimentary Rock

Sedimentary rocks are formed by the deposition and subsequent cementation of that material within bodies of water and at the surface of the earth. The process that causes various organic materials and minerals to settle in a place is termed as sedimentation.

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The particles that form a sedimentary rock by accumulating are called sediment. Before being deposited, the sediment was formed by weathering and erosion from the source area and then transported to the place of deposition by water, wind, ice, mass movement or glaciers, which are called agents of denudation. Sedimentation may also occur as minerals precipitate from water solution or shells of aquatic creatures settle out of suspension.

Metamorphic Rocks

Metamorphic rocks make up a large part of the Earth's crust and are classified by texture and by chemical and mineral assemblage. They may be formed simply by being deep beneath the Earth's surface, subjected to high temperatures and the great pressure of the rock layers above it.



Metamorphic rocks arise from the transformation of existing rock types, in a process called metamorphism, which means "change in form". The original rock is subjected to heat with temperatures greater than 150 to 200°C and pressure around 1500 bars, causing profound physical and/or chemical change.

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Weathering types and factors

Definition

It is a general term and applied to the combine action of all processes causing rocks disintegration physically and decomposition chemically.

Or

It is the process of weakening rock and producing a rock waste or soil cover. Weathering occurs when rocks and minerals comes in contact with the atmosphere, organic life and suicidal water. Essential feature of weathering is that it affects rocks in-situ (in place) and no transportation of material is involved.

Factors

a. A part of rainfall always snips into the soil on the covered rocks and looses the rock particle by dissolving it.
b. Frost action also takes place in the for-spaces of rocks and causes disintegration and splitting of rocks into fragments.
c. Chemical reactions are also taking place in rocks internally and causing rock-loosening.
d Slow geological process of construction and destruction is going on the surface of earth for millions of years because earth is old enough and has been completely leveled by weathering and erosion. Factors affecting rock weathering

Types of Weathering

There are two types of weathering:

1 Physical weathering
2 Chemical weathering

1. Physical weathering:

In the mechanical disintegration and breaking of the rocks to form particles of smaller size. In physical weathering, the composition of the weathered products remains unchanged. Following are the different agents of physical weathering:

a. Frost action
b Heating and cooling
c. Organisms

a. Frost action:

Freezing of water in the cracks of rocks tends to disintegrate them because volume of water increases 1-11 times of its actual volume. It exerts a great pressure on the wall having cracks. By this process, angular fragments of rocks are broken off from the main body of the rock, causing physical weathering.

b. Heating and cooling:

Heating and cooling of rock masses occur due to daily changes in temperature. Heating of rocks causes expansion and cooling cause contraction of rocks. This repeated heating and cooling helps to develop cracks in rocks and the rock will be disintegrated.

c. Organisms:

Plants and insects like earthworms, ants, termites and snakes play an important role in physical weathering because they convert rock into soil to get their food. Plants also grow in joints and cracks of the rocks and push them further apart. Similarly, man also breaks rocks by making roads, constructing dams and reservoirs by drawing tunnels and mines etc.

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2. Chemical Weathering:

It is the type of weathering in which the rock minerals are attacked by water, oxygen, or by alkaline or acid materials dissolved in the water. Chemical structure of the rock minerals is altered and Clay minerals are formed in this way.

3. Mechanical Weathering

It is the breakdown of the rock by physical or mechanical forces

Frost wedging and heaving

water enters cracks and expands on freezing, pressure splits rock. alternate freezing and thawing of water in fractures and cracks promotes the disintegration of rocks (water expands about 9% upon freezing)

Exfoliation

rock layers peel like layers of an onion Due to pressure release on igneous rocks (formed in Earth's crust)

Thermal expansion

repeated heating and cooling of rocks will induce stress and breakage - daily cycle of temperature change weakens rock

Organic activity

physical breakdown and/or transport of material by plants and animals, e.g. plant roots growing in cracks, burrowing animals

Minerals in the parent rock are unchanged

Result is a primary rock mineral, which is the constituent of most sands & gravels

Weathering of rock is a complex process and depends on many factors including:

- Climate – wind, rain, frost & temperature
- Topography (e.g. waterlogged valleys are subjected to deeper weathering than plateaus)
- Rock structure (e.g. presence of faults, joints etc dictate rock fracturing due to freeze-thaw cycles)
- Rock types (e.g. dominance of various minerals dictate resilience to weathering)

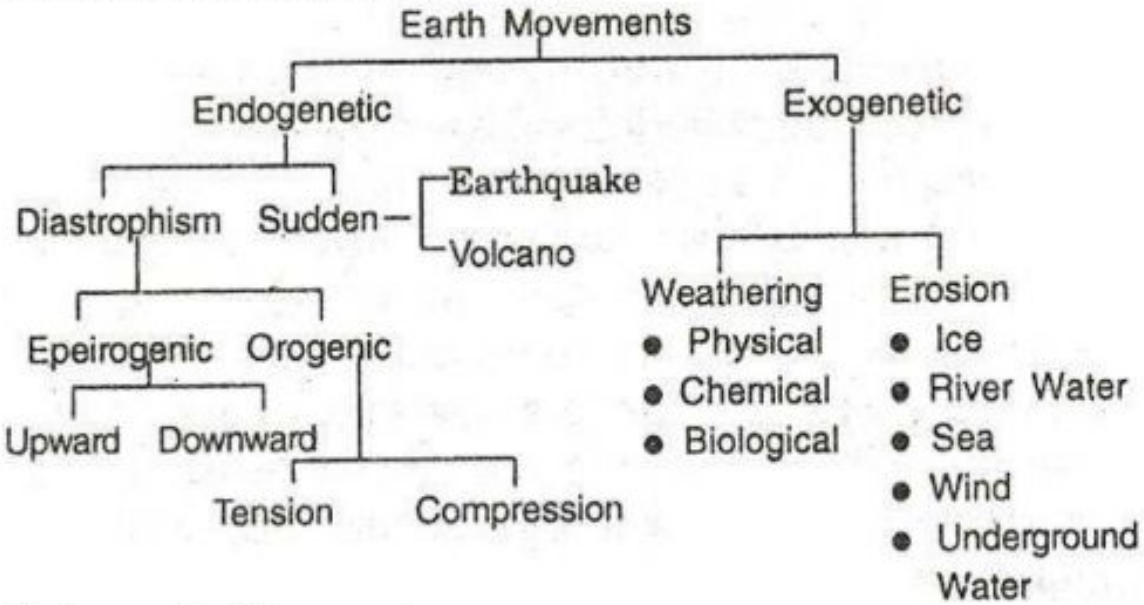
Looking at climate

- Mechanical weathering (due to freeze-thaw & heat-cool cycles) obviously depends on climate
- Chemical weathering is also strongly climate dependent as this form of weathering dominates in regions of relatively high humidity and rainfall

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Earth movements

- Our earth is undergoing deformations imperceptibly but inexorably.
- **These deformations are caused by the movements generated by various factors which are not completely understood and include the following:**
- 1. The heat generated by the radioactive elements in earth's interior.
- 2. Movement of the crustal plates due to tectogenesis.
- 3. Forces generated by rotation of the earth.
- 4. Climatic factors
- 5. Isostasy—according to this concepts, blocks of the earth's crust, because of variations in density would rise to different levels and appear on the surface as mountains, plateaux, plains or ocean basins (See box for details).
- **Classification of Earth Movements:**



- **Endogenetic Movements:**
- The interaction of matter and temperature generates these forces or movements inside the earth's crust. The earth movements are mainly of two types: diastrophism and the sudden movements.
- **1. Diastrophism:**
- It is the general term applied to slow bending, folding, warping and fracturing.

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- **Such forces may be further divided as follows:**
- (i) Epeirogenic or continent forming movements act along the radius of the earth; therefore, they are also called radial movements. Their direction may be towards (subsidence) or away (uplift) from the centre. The results of such movements may be clearly defined in the relief.
- Raised beaches, elevated wave-cut terraces, sea caves and fossiliferous beds above sea level are evidences of uplift. One of the reasons for believing that the Deccan was uplifted is that the nummuliticlimestones rest uncomfortably on the basaltic lavas near Surat well above sea level.
- Raised beaches, some of them elevated as much as 15 m to 30 m above the present sea level, occur at several places along the Kathiawar, Orissa, Nellore, Madras, Madurai and Thirunelveli coasts. Several places which were on the sea some centuries ago are now a few miles inland. For example, Coringa near the mouth of the Godavari, Kaveripattinam in the Kaveri delta and Korkai on the coast of Thirunelveli, were all flourishing sea ports about 1,000 to 2,000 years ago.
- Evidence of marine fossils above sea level in parts of Britain and Norway is another example of Epeirogenic uplift.
- Submerged forests and valleys as well as buildings are evidences of subsidence. In 1819, a part of the Rann of Kachchh was submerged as a result of an earthquake. Presence of peat and lignite beds below the sea level in Thirunelveli and the Sunderbans is an example of subsidence. The Andamans and Nicobars have been isolated from the Arakan coast by submergence of the intervening land. On the east side of Bombay Island, trees have been found embedded in mud about 4 m below low water mark.
- A similar submerged forest has also been noticed on the Thirunelveli coast in Tamil Nadu. A large part of the Gulf of Mannar and Palk Strait is very shallow and has been submerged in geologically recent times. A part of the former town of

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Mahabalipuram near Chennai (Madras) is submerged in the sea. (Fig. 1.11)

- **(ii) Orogenic:**
- Orogenic or the mountain-forming movements act tangentially to the earth surface, as in plate tectonics. Tensions produces fissures (since this type of force acts away from a point in two directions) and compression produces folds (because this type of force acts towards a point from two or more directions). In the landforms so produced, the structurally identifiable units are difficult to recognize.
- In general, diastrophic forces which have uplifted lands have predominated over forces which have lowered them.
- **2. Sudden Movements:**
- **These movements cause considerable deformation over a short spans of time, and may be of two types:**
- **(i) Earthquake:**
- It occurs when the surplus accumulated stress in rocks in the earth's interior is relieved through the weak zones over the earth's surface in form of kinetic energy of wave motion causing vibrations (at times devastating) on the earth's surface. Such movements may result in uplift in coastal areas.
- Another earthquake in Chile (1822) caused a one-metre uplift in coastal areas. Another earthquake in New Zealand (1885) caused an uplift of upto 3 metres in some areas while some areas in Japan (1891) subsided by 6 metres after an earthquake.
- Earthquakes may cause change in contours, change in river courses, 'tsunamis' (seismic waves created in sea by an earthquake, as they are called in Japan) which may cause shoreline changes, spectacular glacial surges (as in Alaska), landslides, soil creeps, mass wasting etc. (Fig. 1.17)
- (ii) Volcanoes a volcano is formed when the molten magma in the earth's interior escapes through the crust by vents and fissures in the crust, accompanied by steam, gases (hydrogen

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sulphide, sulphur dioxide, hydrogen chloride, carbon dioxide etc.) and pyroclastic material.)

- **Exogenetic Forces—Weathering and Erosion:**
- These forces act over the earth's surface and basically involve the process of 'gradation', which in turn is achieved by the simultaneous process of 'degradation' and 'aggradation'. The exogenetic forces involve two stages—firstly; the landforms (in form of rocks) weaken, break up, rot and disintegrate. This stage comes into play as soon as the newly created landform is exposed to the influence of weather. This stage is called Weathering.
- Then comes a stage of scraping, scratching and grinding on the surface rock. It includes removal or transportation of the weathered rock material from one place to another. This stage is called Erosion. The act of erosion is performed by a number of natural agents, such as running water, ground water, moving ice, wind, waves and currents of the sea. These agents use the eroded material as cutting tools to carve out and shape the landscape.
- Erosion is a mobile process while weathering is a static process because the disintegrated material and the products (or the result of weathering) do not involve any motion except the falling down of the material by the force of gravity.
- The reverse process of filling up of depressions on the earth's surface by the material deposited by the same agents of erosion is called aggradation or deposition. Weathering may be physical, chemical or biological depending on the nature of agents and the processes involved and the products created.
- **1. Physical Weathering:**
- The disintegration of rocks by mechanical forces is called physical or mechanical weathering. This type of mechanical force produces fine particles from massive rock by the exertion of stresses sufficient to fracture the rock, but does not change its chemical composition. Physical weathering may take place in many ways.
- **These are discussed below:**
- **(i) Granular Disintegration:**

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- Rocks composed of coarse mineral grains commonly fall apart grain by grain or undergo granular disintegration.
- **(ii) Exfoliation:**
- A rock mass disintegrates layer by layer leaving behind successively smaller spheroidal bodies and forming curved rock shells by disintegration. This type of rock break-up is also called spalling. These layers separate due to successive cooling and heating with changes in temperature.
- **(iii) Block Separation:**
- This type of disintegration takes place in rocks with numerous joints acquired by mountain-making pressures or by shrinkage due to cooling. This type of disintegration in rocks can be achieved by comparatively weaker forces.
- **(iv) Shattering:**
- A huge rock may undergo disintegration along weak zones to produce highly angular pieces with sharp corners and edges through the process of shattering. (Fig. 1.20)
- **(v) Frost Action:**
- This type of weathering is common in cold climates. During the warm season, the water penetrates the pore spaces or fractures in rocks. During the cold season, the water freezes into ice and its volume expands as a result. This exerts tremendous pressure on rock walls to tear apart even where the rocks are massive.
- **(vi) Mass Wasting:**
- Since gravity exerts its
- force on all matter, both bedrock and the products of weathering tend to slide, roll, flow or creep down all slopes in different types of earth and rock movements grouped under the term 'mass wasting".
- **This may take place in a variety of ways:**
- **(a) Talus Cones Rock:**
- Particles created by processes of mechanical weathering move down high mountain slopes and steep rock walls of gorges. These particles tend to get deposited in a distinctive landform, the talus cone. A talus slope or scree slope has a constant slope angle of 34° or 35°.

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- **(b) Earth flow:**
- In humid climate regions where there are steep slopes, the masses of soil saturated with water, overburden or weak bedrock may slide downslope during a period of a few hours in the form of earth flow.
- **(c) Landslide:**
- This is rapid sliding along hill slopes of rock mass. It may take place either by rockslide along a relatively flat inclined rock plane or by slump mechanism involving a rotating motion of the sliding rockmass on a slightly curved slope,
- **(d) Soil Creep:**
- This is extremely slow downslope movement of soil and overburden on almost all moderately steep, soil-covered slopes. Soil creep occurs as a result of some disturbance of the soil and mantle caused by heating and cooling of the soil, growth of frost needles (by frosting process), alternate drying and wetting of the soil, trampling and burrowing by animals and shaking by earthquakes. Because gravity exerts a downhill pull on every such rearrangement, the particles are urged progressively downslope. Rock fragments of larger size may accumulate at the mountain base to produce a boulder field.
- **(e) Mudflow:**
- In regions with sparse vegetation to check the flow of water, the sudden flow of water due to rain acquires a muddy character on its journey downslope. As it follows the stream course, it gets thicker and thicker until it becomes so overburdened as to come to a stop. It may carry huge boulders on its way. Such mudflows may cause massive loss of life and property.
- **(f) Solifluction:**
- This form of mass wasting is common in the Arctic regions. In late spring and early summer, the water penetrates and saturates the upper few feet of the soil, but is unable to go deeper because of frozen conditions below. The upper saturated soil mass starts flowing along slopes. This movement causes the formation of terraces and lobes due to punctuated deposition.
-

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- **2. Chemical Weathering:**
- This causes rocks to decay i.e. to decompose instead of disintegrating.
- The mineral contained in the structure of rocks undergo chemical changes when they get in contact with atmospheric water and air. These chemical changes cause rock particles to break up due to decomposition. Atmospheric water contains oxygen, carbon, sulphur, hydrogen etc. and the air also contains oxygen, nitrogen, carbon dioxide. High levels of temperature and water content enhance the pace of chemical reactions.
- **The chemical reactions may be classified as follows:**
- **(i) Carbonation:**
- It takes place in rocks containing calcium, sodium, magnesium, potassium etc. when they come in touch with rain water which contains dissolved carbon dioxide. This process is common in lower humid climates.
- **(ii) Chlorination:**
- It takes place when chloride salts are formed as a result of chemical reaction.
- **(iii) Oxidation:**
- This occurs in iron-based salts. The atmospheric oxygen present in rainwater unites with mineral grains in the rock, especially with iron compounds. This results in the decomposition of the rock and it starts crumbling. This process is called oxidation and is similar to the process of rusting.
- **(iv) Hydration:**
- The chemical action of water detaches the outer shell of aluminium-bearing rocks through the process of hydration.
- **(v) Desilication:**
- Removal of silica from rocks also leads to their weakening and eventual disintegration due to desilication.
- **(vi) Solution:**
- Some minerals, such as rock- salt and gypsum, are removed by the process of solution in water.
- The chemical reaction of rainwater brings about decomposition of minerals more rapidly than its mechanical action. The

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chemical weathering is capable of breaking up even a hard crystalline rock into minute particles.

Fluvial landforms

- The landforms created as a result of **degradational action (erosion)** or **aggradational work (deposition)** of running water are called fluvial landforms.
- The fluvial processes may be divided into three physical phases – erosion, transportation and deposition.

Fluvial Erosional Landforms

Various Aspects of Fluvial Erosive Action

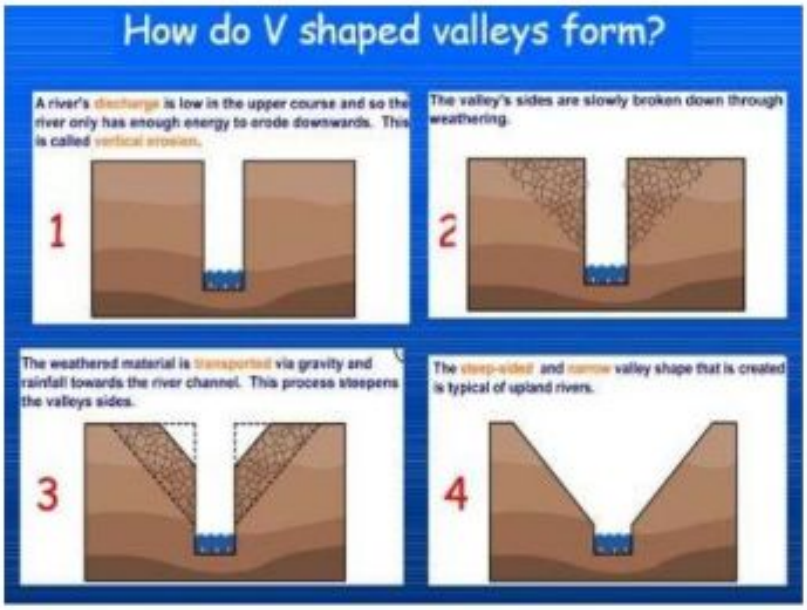
- Corrasion or abrasion == solid river load striking against rocks and wearing them down.
- Hydration == force of running water wearing down rocks.
- Attrition == river load particles striking, colliding against each other and breaking down in the process.
- Downcutting == Erosion in vertical direction (downcutting leads to valley deepening) or
- Lateral erosion == Erosion in horizontal direction, especially the walls of the stream.
- Corrosion == Chemical action that leads to weathering.

River Valley Formation

- The extended depression on ground through which a stream flows throughout its course is called a river valley.
- At different stages of the erosional cycle the valley acquires different profiles.
- At a young stage, the valley is deep, narrow with steep wall-like sides and a convex slope. The erosional action here is characterized by predominantly **vertical downcutting**The profile of valley here is typically 'V' shaped.
- A deep and narrow 'V' shaped valley is also referred to as **gorge** and may result due to downcutting erosion and because of recession of a waterfall. Most Himalayan rivers pass through deep gorges (at times more than 500 metres deep) before they descend to the plains.

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- An extended form of gorge is called a The Grand Canyon of the Colorado river in Arizona (USA) runs for 483 km and has a depth of 2.88 km.
- A tributary valley lies above the main valley and is separated from it by a steep slope down which the stream may flow as a waterfall or a series of rapids.
- As the cycle attains maturity, the **lateral erosion** becomes prominent and the valley floor flattens out. The valley profile now becomes typically 'U' shaped with a broad base and a concave slope.



River course



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Youth

- Young rivers (A) close to their source tend to be fast-flowing, high-energy environments with rapid headward erosion, despite the hardness of the rock over which they may flow.
- Steep-sided "V-shaped' valleys, waterfalls, and rapids are characteristic features.

Maturity

- Mature rivers (B) are lower-energy systems. Erosion takes place on the outside of bends, creating looping meanders in the soft alluvium of the river plain. Deposition occurs on the inside of bends and on the river bed.

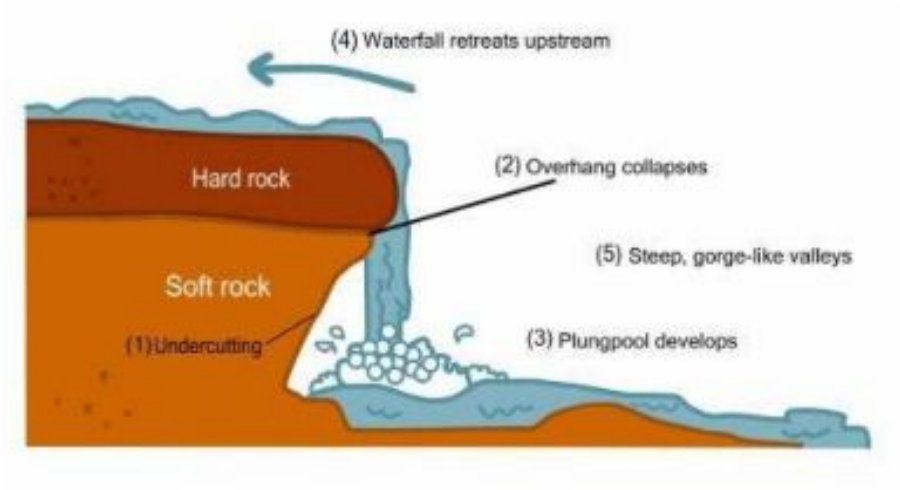
Old Age

- At a river's mouth (C), sediment is deposited as the velocity of the river slows. As the river becomes shallower more deposition occurs, forming islands and braiding the main channel into multiple, narrower channels.
- As the sediment is laid down, the actual mouth of the river moves away from the source into the sea or lake, forming a delta.
- **Head ward erosion** == Erosion at the origin of a stream channel, which causes the origin to move back away from the direction of the stream flow, and so causes the stream channel to lengthen.

Waterfalls

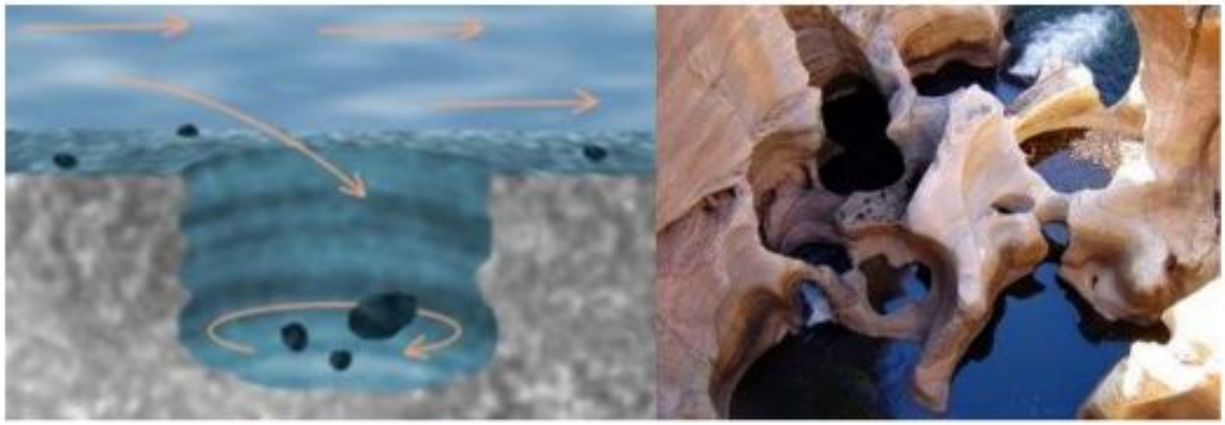
- A waterfall is simply the fall of an enormous volume of water from a great height.
- They are mostly seen in youth stage of river.
- Relative resistance of rocks, relative difference in topographic reliefs, fall in the sea level and related rejuvenation, earth movements etc. are responsible for the formation of waterfalls.
- For example, **Jog orGersoppa falls on Sharavati** (a tributary of Cauveri) has a fall of 260 metres.

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Pot Holes

- The kettle-like small depressions in the rocky beds of the river valleys are called pot holes which are usually cylindrical in shape.
- Potholing or pothole-drilling is the mechanism through which the grinding tools (fragments of rocks, e.g. boulders and angular rock fragments) when caught in the water eddies or swirling water start dancing in a circular manner and grind and drill the rock beds of the valleys like a drilling machine.
- They thus form small holes which are gradually enlarged by the repetition of the said mechanism. The potholes go on increasing in both diameter and depth.



Terraces

- Stepped benches along the river course in a flood plain are called terraces.
- Terraces represent the level of former valley floors and remnants of former (older) flood plains.

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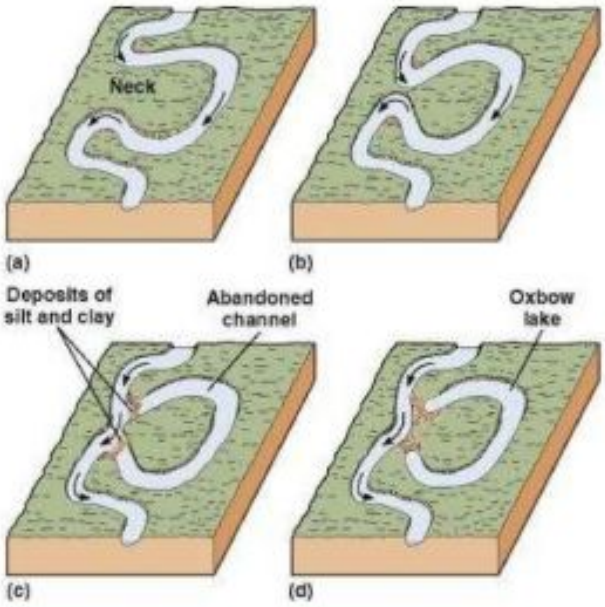
Gulleys/Rills

- Gulley is an incised water-worn channel, which is particularly common in semi-arid areas.
- It is formed when water from overland-flows down a slope, especially following heavy rainfall, is concentrated into rills, which merge and enlarge into a gulley.
- The **ravines of Chambal Valley** in Central India and the **Chos of Hoshiarpur** in Punjab are examples of gulleys.

Meanders

- A meander is defined as a pronounced curve or loop in the course of a river channel.
- The outer bend of the loop in a meander is characterized by intensive erosion and vertical cliffs and is called the **cliff-slope side**. This side has a concave slope.
- The inner side of the loop is characterized by deposition, a gentle convex slope, and is called the **slip-off side.**
- Morphologically, the meanders may be wavy, horse-shoe type or ox-bow/ bracelet type.

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Ox-Bow Lake

- Sometimes, because of intensive erosion action, the outer curve of a meander gets accentuated to such an extent that the inner ends of the loop come close enough to get disconnected from the main channel and exist as independent water bodies. These water bodies are converted into swamps in due course of time.
- In the Indo-Gangetic plains, southwards shifting of Ganga has left many ox-bow lakes to the north of the present course of the Ganga.

Peneplane (Or peneplain)

- This refers to an undulating featureless plain punctuated with low-lying residual hills of resistant rocks. It is considered to be an **end product of an erosional cycle**.
- Peneplain, gently **undulating (wave like)**, almost featureless plain that, in principle, would be produced by fluvial erosion that would, in the course of geologic time, reduce the land almost to baselevel (sea level), leaving so little gradient that essentially no more erosion could occur.

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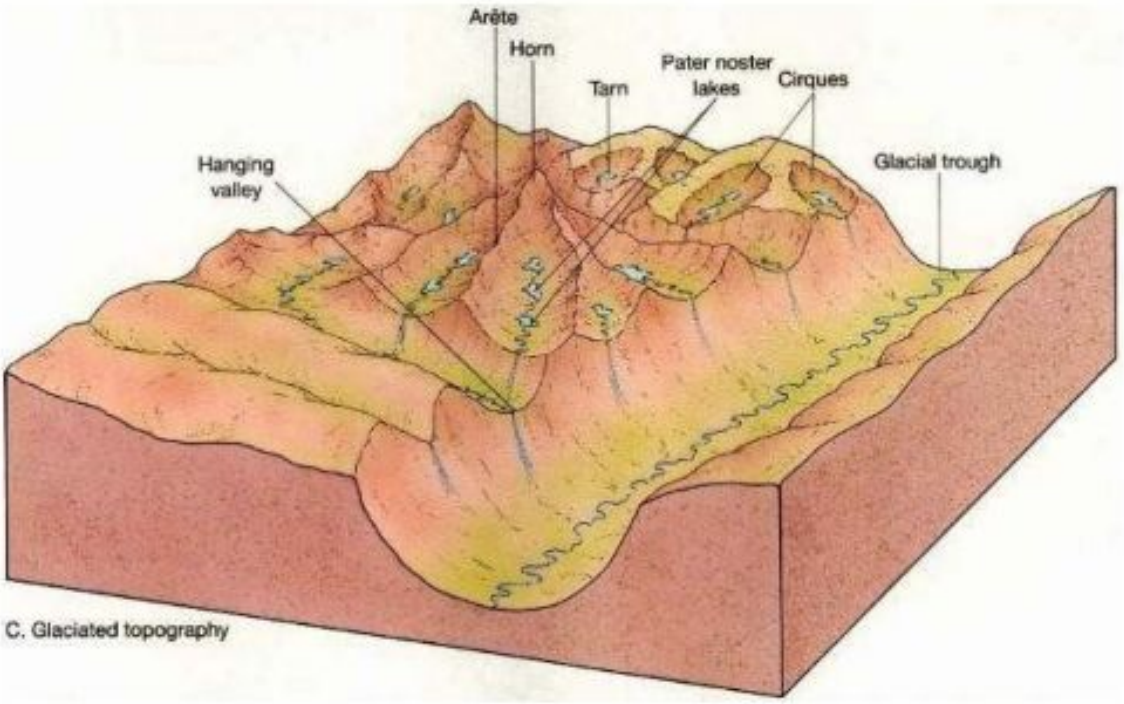


Glacial Landforms

- A glacier is a moving mass of ice at speeds averaging few meters a day.
- Types of Glaciers: **continental glaciers, ice caps, piedmont glaciers and valley glaciers**.
- The continental glaciers are found in the Antarctica and in Greenland. The biggest continental ice sheet in
- Ice caps are the covers of snow and ice on mountains from which the valley or mountain glaciers originate.
- The piedmont glaciers form a continuous ice sheet at the base of mountains as in southern Alaska.
- The valley glaciers, also known as Alpine glaciers, are found in higher regions of the Himalayas in our country and all such high mountain ranges of the world.
- The largest of Indian glaciers occur in the Karakoram range, viz. **Siachen (72 km),** while Gangotri in Uttar Pradesh (Himalayas) is 25.5 km long.
- A glacier is charged with **rock debris** which are used for erosional activity by moving ice.
- A glacier during its lifetime creates various landforms which may be classified into erosional and depositional landforms.

Glacial Erosional Landforms

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Cirque/Corrie

- Hollow basin cut into a mountain ridge.
- It has steep sided slope on three sides, an open end on one side and a flat bottom.
- When the ice melts, the cirque may develop into a **tarn lake.**

Glacial Trough

- Original stream-cut valley, further modified by glacial action.
- It is a 'U' Shaped Valley. It at mature stage of valley formation.
- Since glacial mass is heavy and slow moving, erosional activity is uniform – horizontally as well as vertically.
- A steep sided and flat bottomed valley results, which has a 'U' shaped profile.

Hanging Valley

- Formed when smaller tributaries are unable to cut as deeply as bigger ones and remain 'hanging' at higher levels than the main valley as **discordant tributaries**.
- A valley carved out by a small tributary glacier that joins with a valley carved out by a much larger glacier.

Arete

- Steep-sided, sharp-tipped summit with the glacial activity cutting into it from **two**

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Horn

- Ridge that acquires a 'horn' shape when the glacial activity cuts it from **more than two sides.**

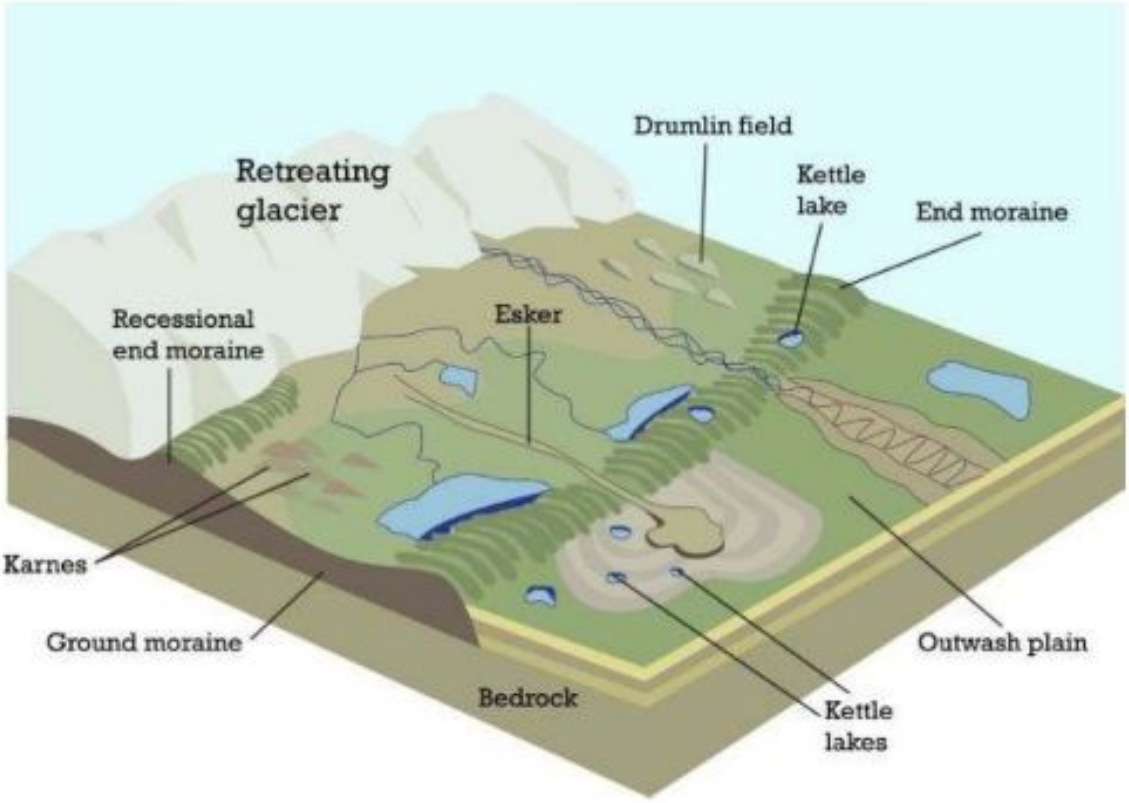
D-Fjord

- Steep-sided narrow entrance-like feature at the coast where the stream meets the coast.
- Fjords are common in **Norway, Greenland and New Zealand**.



Glacial Depositional Landforms

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Outwash Plain

- When the glacier reaches its lowest point and melts, it leaves behind a stratified deposition material, consisting of rock debris, clay, sand, gravel etc. This layered surface is called till plain or an outwash plain.

Esker

- Winding ridge of un-assorted depositions of rock, gravel, clay etc. running along a glacier in a till plain.
- The eskers resemble the features of an embankment and are often used for making roads.

Kame Terraces

- Broken ridges or un-assorted depositions looking like hump in a till plain.

Drumlin

- Inverted boat-shaped deposition in a till plain caused by deposition.

Kettle Holes

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- Formed when the deposited material in a till plain gets depressed locally and forms a basin.

Moraine

- General term applied to rock fragments, gravel, sand, etc. carried by a glacier.
- Depending on its position, the moraine can be ground moraine and end moraine.

Glacial Cycle of Erosion

Youth

- The stage is marked by the inward cutting activity of ice in a cirque.
- Aretes and horns are emerging. The hanging valleys are not prominent at this stage.

Maturity

- Hanging valleys start emerging. The opposite cirques come closer and the glacial trough acquires a stepped profile which is regular and graded.

Old Age

- Emergence of a 'U'-shaped valley marks the beginning of old age.
- An outwash plain with features such as eskers, kame terraces, drumlins, kettle holes etc. is a prominent development.

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Q1. Discuss in detail the relief and configuration of ocean floor?

Answer: The study of ocean floor is important for understanding the evolution of earth's crust. Earlier it was believed that ocean floor is a submerged part of continents and is uniform in relief. But developments in science and technology revealed that ocean basins are in many ways similar to the land surface having mountains, plateau, plains and canyons/trenches on its surface. The ocean floor can be divided into three major provisions:

1) Continental margins, which are shallow water areas close to the continents and includes continental shelf, continental slope and continental rise.
2) Deep-Ocean basins, which are deep water areas farther from land and includes abyssal plain, ocean deeps etc.
3) The mid oceanic ridge, which is composed of shallower areas near the middle of an ocean.

The main ocean floor features are:

a) *Continental shelf:* It is the seaward extension of the continent from the shore line to the continental edge. The continental shelves are rich source of fish and therefore world's major fishing grounds are located on it. E.g.; Grand banks of Newfoundland.
b) *Continental slope:* Continental slope refers to a relatively steeply sloping surface lying seaward of the continental shelf. The average slope gradient of continental slope in 4° 17'.
c) *Continental rise:* Continental rise or continental foot represents a gently inclined surface which acts as a link between continental slope and ocean bed, or deep-sea plain.
d) *Abyssal plain:* This is the undulating plain lying beyond the continental rise, covering almost 70% of the ocean-floor. It has submarine plateaus ridges, trenches etc. On its surface but are extensively flat as well (Slope less them 1: 1000).
e) *Ocean deeps:* These are the long, narrow trenches found on the surface of the ocean. The greatest known ocean deep is Challenger deep in Mariana trench near Gaum Island (More than 10,036m).

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f) *Mid-oceanic ridge:* It is the remarkable feature of ocean floor. The mid-oceanic ridges are formed at divergent plate boundaries and are present in every ocean. Mid-oceanic ridges have a depression known as rift-valley.

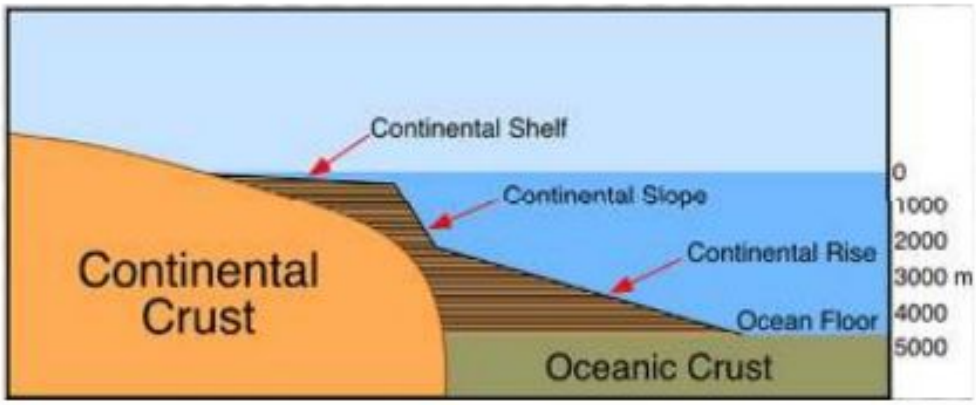


Fig. 4.1: Relief and Configuration of ocean floor

Q2. Describe briefly the bottom relief of Atlantic Ocean?

Answer: The bottom relief of Atlantic Ocean is described below in the following points:

- Extends over about 20.8% of total area of earth, and 24% of total areas of oceans.
- Most striking features of Atlantic ocean is the presence of *'Mid-Atlantic ridge'*. That divides this ocean into two halves.
- Atlantic Ocean is characterized by broad continental shelf
- Mid-Atlantic ridge has two parts, northern part is known as *'Dolphin Rise'* and the southern part is called *'Challenger Rise'*.
- In the north Atlantic, the mid-Atlantic ridge is relatively wider and forms broad *'Telegraph plateau'*.
- The other ridges of this ocean arte, Rio Granade Ridge, Wyville-Thompson Ridge, Walvis ridge, etc. as shown in figure.
- Continuity of mid-Atlantic ridge is broken by the *'Romanche deep'* (7373m).
- Beyond Cape of Good Hope, mid-Atlantic ridge is called the *'Atlantic-Antarctica ridge'*.

Basins

- Labrador basin, NE Atlantic basin, brazil basin, CAPE basin, NW Atlantic basin, Atlantic-Antarctic basin etc.

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- Puerto-Rico, deep is prominent among ocean deeps (Depth -8648m)

Islands

- British isles, New found land, Sandwich islands, Georgia islands, Falkland islands etc
- Oceanic islands, like *Azores* in north and *the ascension* and *Tristan de cunha* in south are higher path of mid Atlantic ridge.

Marginal Seas

- South Atlantic Ocean –absence of marginal seas.
- Northern side-Baltic sea, Mediterranean Sea, Carrabin Sea, Gulf of Mexico etc.
- Carrabin sea is separated from open Ocean by a number of islands like Cuba, Jamaica, etc which are called *'Great Antilles'*.
- *'Yucatan Strait'* connects Carrabin Sea with Gulf of Mexico.

Q3. Describe briefly the Bottom Relief of Pacific Ocean?

Answer: The bottom relief of Pacific Ocean is described below in the following points:

- Pacific Ocean covers 33% of total earth's surface and 46% of area of oceans.
- Pacific Ocean is of triangular shape with its apex in the '*Bering Strait*'.
- Continental shelf width is controlled by the shape and structure of its coastline.
- On the eastern side, due to the presence of Rockies and Andes, Continental shelf width is narrow (80 kms only).
- There are 9 trenches, 5 basins, 11 land features (mountains/ plateaus) in this ocean.
- Deepest oceanic trench is found in this ocean (Mariana trench – 10,900m).

Islands

Estimated number is 20,000. Islands are grouped and classified according to racial grouping, for example, Melanesia, Micronesia and Polynesia.

- Besides, there are Hawiian Islands, Clipperton, Jaun Fernandez etc.
- Volcanic cones of Mauna Kea and Mauna Loa belong to the Hawaiian group of Islands.

Marginal Seas

Gulf of California; East China Sea, Sea of Okhotsk, Banda Sea, Sula Sea etc

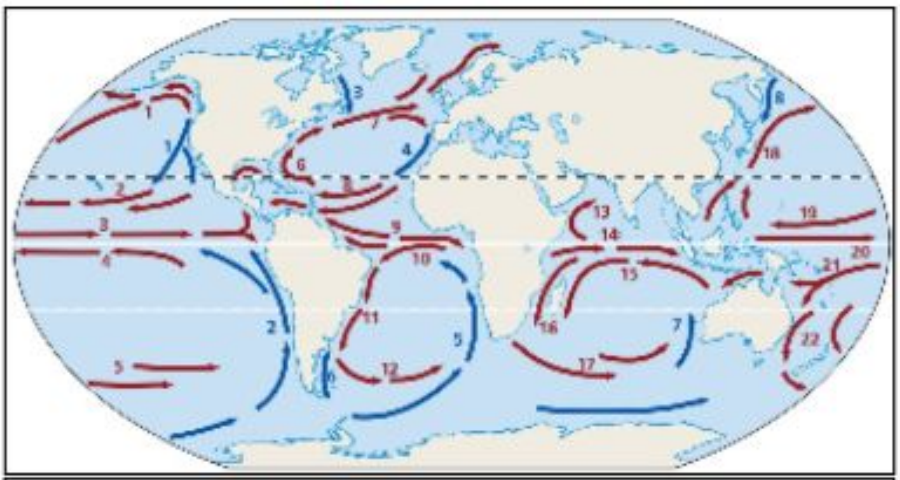
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Q4. Explain in detail the significance of ocean currents of Atlantic and Pacific Ocean?

Answer: Ocean currents are swift moving, large masses of surface water that move in a fairly defined direction over great distances. There are two types of ocean currents – warm currents and cold currents.

➢ ***Significance***

1) Ocean currents are important in the sense that they act as transporters of heat from equatorial to polar areas.
2) Ocean currents play a vital role in keeping heat balance of earth by constantly adjusting the earth's surface heat imbalances.
3) The warm Gulf Stream current brings warm air to the coasts of Britain and Europe thus modifying their climate.
4) The El-Nino (warm current) leads to upwelling of cold water along the peru coast which is an indication of heavy fish catching.
5) Cold currents like Labrador and Okhotsk currents bring planktons from the polar and sub-polar zones and thus increase the food supply for fishes.
6) The Benguela (cold) currents and Canaries (warm) currents modify the local climate in African continent.
7) Kuroshio (warm), California (cold) currents also modify local climate.



Cold currents

1. California Current
2. Humboldt Current
3. Labrador Current
4. Canaries Current
5. Benguela Current
6. Falkland Current
7. West Australian Current
8. Okhotsk Current

Warm currents

1. North Pacific Drift
2. North Equatorial Current
3. Equatorial Countercurrent
4. South Equatorial Current
5. West Wind Drift
6. Gulf Stream
7. North Atlantic Drift
8. North Equatorial Current
9. Equatorial Countercurrent
10. South Equatorial Current
12. West Wind Drift
13. Monsoon Current
14. Equatorial Countercurrent
15. South Equatorial Current
16. Mozambique Current
17. West Wind Drift
18. Japan Current
19. North Equatorial Current
20. Equatorial Countercurrent
21. South Equatorial Current

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Fig: Distribution of ocean currents

Q5. Describe in detail the sea waves and their types?

Answer: Waves are oscillatory movements in water, manifested by alternate rise and fall of sea surface. These moving curves on sea surface have two parts – the top part is called its *'Crest'* and the lower part is called *'trough'*. The waves are generated by wind striking the surface of water. The size and force of waves depends upon the velocity of wind, duration of wind, distance over which over wind can blow unhindered. The different parameters of sea waves are wave height, wavelength, wave velocity and energy etc. the different types of sea waves are:

(i) *Capillary waves:* The small rounded waves with wave lengths less than 1.74 cms are called 'capillary waves'.

(ii) *Gravity waves:* When more energy is transferred to the oceans, waves with wavelengths more than 1.74 cms generate which are called 'gravity waves'.

(iii) *Sea:* It is an irregular and chaotic wave caused by several waves of different wavelengths. The variety of wavelengths is caused by changing wind speed and direction.

(iv) *Swell:* The trains of waves which move on a uniform pattern of equivalent period and height are called 'swell'. The swells move with little loss of energy over large stretches of the ocean surface.

(v) *Surf:* the breaking waves at coastal region are known as 'surf'. They release their energy along the margins of the continents. Surfs are generated when one wave strikes shore and comes back with slow speed and other wave is moving towards shore tends to catch up with the wave, thus reducing the wavelength and increases the wave steepness(H/L).

(vi) *Tsunami:* It may be defined as 'seismic sea wave'. Tsunami is a long period gravity wave generated by a sub marine earthquake of volcanic event. They are often called as 'tidal waves'. The wavelengths of the tsunami may be as long as

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160kms and such waves travel at very high velocity sometimes reaching 650kms/hr.

Q6. Explain the tides, their origin, types and significance?

Answer: Tides may be defined as the periodic rise and fall in the oceans and seas due to the gravitational attraction of the sun and moon. Twice a day about 12 hours and 26 minutes, the sea level rises and twice a day it falls. The rise of sea level is called *'flood tide'* and fall is called the *'ebb tide'*.

According to the period of rise and fall, tides are divides into two diurnal, semidiurnal and mixed tides.

- **Diurnal tidal** pattern shows only one high tide and one low tide during a day.
- **Semidiurnal tides** mean tides occur twice a day (two high tides and two low tides).
- **Mixed tides** mean two unequal high tides and two unequal low tides in a day.

Origin of Ocean Tides

The origin of tides in the oceans is primarily concerned with the gravitational forces of the sun and the moon. It may be pointed out that the earth rotates from west to east and revolves around the sun following an elliptical orbit. Similarly, the moon rotates from west to east and revolves around the earth along an elliptical orbit so that the distance between the moon and the earth changes during different times in every month. The period of the farthest distance between the moon and the earth (407,000 km) is called *apogee* while the period of the nearest distance (356,000 km) is called *perigee* (See figure 4.1).

The surface of the earth with its diameter of 12,800 km (8,000 miles) is 6,400 km nearer to the moon than its centre. The gravitational force of the moon will be maximum at the earth's surface facing the moon (at T in fig. 4.1) while it will be minimum at the opposite side of the earth (at A in fig. 4.1). Consequently, the water of the earth's surface facing the moon is attracted and pulled and high tide occurs. High tide is also formed at the opposite side of the earth (A in fig. 4.1) simultaneously because of the reactionary force (centrifugal) of the gravitational (centripetal) force of the moon causing outward bulge of water.

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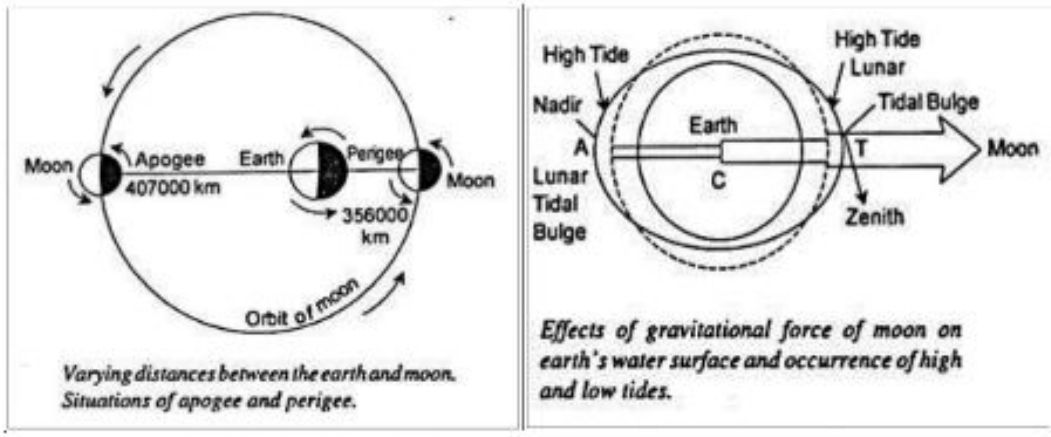


Fig.4.1: Varying distances of moon and occurrence of tides

On the basis of gravitational force, the position of sun, moon and earth, there are two types of tides as follows:

(i) **Spring tides:** when the earth, moon and sun are in a straight line either in conjunction or opposition (SYZYGY) that happens on new moon or full moon day , the tides attain maximum height and as known as *'spring tides'*.

(ii) **Neap tides:** When on the first and last quarter, the sun, moon and earth make an angel of 90^0, the force of the sun's gravitational pull lowers the gravitational pull of moon, results in the low tides called as *'Neap tides'*.

Significance of tides

The ocean tides can be used as a source of power. Tidal energy is considered a clean, renewable resource with vast potential. Though the initial cost of tidal power plant may be high, but operation costs are less because it does not need fossil fuels or radioactive substances to generate electricity. The tides are also important to many marine organisms. For example, grunion – small silvery fish time their spawning (laying eggs) cycle to match the pattern of tides.

Q7. Write a detailed note on the energy resources of oceans?

Answer: The oceans are a great source of energy in the following ways:

1. ***OTEC:*** Ocean thermal energy conversions idea was given by French Scientist Georges Claude long ago in 1950's, but it received much attention recently. It is a technique for extracting useful energy from the heat in the surface layers of ocean water which are warmed by the sun. OTEC systems are also called solar see power plants (SSPP). Such plants can generate electricity by exploiting the temperature

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difference between the warm surface water and colder water a few hundred feet below. OTEC system are closed systems and use propane as the working fluid, which is cold and boiled by sea water but is not mixed with it . the only drawback of OTEC system is that they are capital – intensive (need much money for establishment).

2. ***Tidal energy:*** The rise and fall of ocean tides represents a renewable energy source or system which could be used for generation of electricity. The exploitation of this source is restricted to a few sites only where there are large tidal ranges, such as Bay of Fundy (Canada); Cook Inlet (Alaska) seven estuary (UK) etc. the tipping of tidal energy requires large capital and has the disadvantage of long lead time before power is actually produced; therefore it is not a potential source of energy which could contribute to energy supply of countries.

Q8: Define a coral reef? Write down the favourable conditions for the growth of coral reefs? Discuss briefly the different types of corals and their significance?

Answer: Coral is a form of protoplasm that flourishes most in warm seas, where the average temperature exceeds 18°C throughout the year. Coral reef is formed of coral polyps, algae, mulluscus etc. The corals continuously extract calcium salt from sea water to build hard skeletons to protect their soft bodies.

When one generation of coral polyps dies, fresh structures are built upon the skeletons of old ones by the new generation. Thus, in due course of time, a great mass of coral reef is formed. The masses of hard cemented skeletons form calcareous rocks which have different colours and shapes. The coral reefs are mostly found only in shallow water surrounding the continents and islands of the ocean.

Conditions favourable for the growth of Corals

- Corals grow rapidly in tropical waters between 30°N and S latitudes.
- Corals need temperature between 20-25°C for best growth, so they avoid too cold and too hot waters of extreme regions of oceans.
- Coral polyps thrive best up to the depth of 60 meters because they need sunlight which is available up to this depth.
- The living corals also need sediment free water and as such they do not grow near river mouths.

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- High saline water is harmful for the growth of corals.

TYPES OF CORAL REEFS

Coral reefs are biological communities built o the floor of warm shallow waters. There are three main types of coral reefs.

(i) *Fringing Reef:* It is the belt of coral reef that grows attached to the coasts or around islands. It is a narrow belt and is remarkably flat. It varies in width and may be as much as 0.7 km wide. The surface of this reef is rough and at low water level, it appears above sea level.

(ii) *Barrier Reef:* This type of coral reef generally lies offshore, separated from land by a lagoon. This coral feature is the largest of all types of coral reefs. It may be several kilometers wide and several hundred kilometers long. It is formed of corals of various sizes. On its surface, debris, boulders etc are found. Example is Great Barrier Reef of Australia.

(iii) *Atoll:* Atoll is a ring like circular feature enclosing/encircling a lagoon. It is either having a plateau or an island beneath. Atolls are located at great distances from the deep sea platforms. Submerged island, volcanic cone are the favourable submarine features for its growth. Examples are Fiji atoll or Funafuti atoll.

SIGNIFICANCE

The coral reef formation is important as they protect the coastal areas from erosion. Moreover, the coral reefs act as barrier for the sea waves to inundate the coastal areas, thus save coastal areas from the ill effects of waves and tides. The coral polyps also help in maintaining the symbiotic relationship between the plant and animal life in the sea or water bodies.

Q9: Define Ocean Current. Write down its Origin, definition and types?

An *ocean current* is a continuous, directed movement of seawater generated by forces such as breaking waves, wind, the corolis effect, temperature and salinity differences etc. Depth contours, shoreline configurations and interactions with other currents influence a current's direction and strength. Therefore, ocean currents are primarily horizontal water movements. Ocean currents influence the temperature of the regions through which they travel. For example, the Gulf Stream current which makes northwest Europe much more temperate than any other region at the same latitude.

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Types and Function

Surface oceanic currents are sometimes wind driven and develop their typical clockwise spirals in the northern hemisphere and counter-clockwise rotation in the southern hemisphere due to imposed wind stresses. In these wind driven currents, the Ekman spiral effect results in the currents flowing at an angle to the driving winds

Surface currents make up only 8% of all water in the ocean, are generally restricted to the upper 400 m (1,300 ft) of ocean water, and are separated from lower regions by varying temperatures and salinity which affect the density of the water, which in turn, defines each oceanic region. Because the movement of deep water in ocean basins is caused by density driven forces and gravity, deep waters sink into deep ocean basins at high latitudes where the temperatures are cold enough to cause the density to increase. Surface currents are found on the surface of an ocean, and are driven by large scale wind currents. They are directly affected by the wind—the Corolis effect plays a role in their behaviors.

Deep ocean currents are driven by density and temperature gradients. Thermohaline circulation is also known as the *ocean's conveyor belt* (which refers to deep ocean density driven ocean basin currents). These currents called *submarine rivers*, flow under the surface of the ocean and are hidden from immediate detection. Where significant vertical movement of ocean currents is observed, this is known as *upwelling* and *down welling*. Deep Ocean currents are currently being researched using a fleet of underwater robots called *Argo*.

The Corolis effect is weak near the equator (and absent at the equator), water moving in the currents on either side of the equator is deflected slightly pole ward and replaced by deeper water. Thus, equatorial upwelling occurs in these westward flowing equatorial surface currents. Upwelling is an important process because this water from within and below the pycnocline is often rich in nutrients and greatly benefits the growth of marine organisms. By contrast, generally poor conditions for growth prevail in most of the open tropical ocean because strong layering isolates deep, nutrient rich water from the sunlit ocean surface. Ocean currents are measured in *sverdrup* (sv), where 1 sv is equivalent to a volume flow rate of 1,000,000 m^3 (35,000,000 cu ft) per second.

Importance

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Knowledge of surface ocean currents is essential in reducing costs of shipping, since traveling with them reduces fuel costs. In the wind powered sailing-ship era, knowledge of wind patterns and ocean currents is even more essential. A good example of this is the Agulhas Current, which long prevented Portuguese sailors from reaching India. Ocean currents are important in the study of marine debris, and vice versa. These currents also affect temperatures throughout the world. For example, the ocean current that brings warm water up the north Atlantic to northwest Europe also cumulatively and slowly blocks ice from forming along the seashores, which would also block ships from entering and exiting inland waterways and seaports. Hence, ocean currents play a decisive role in influencing the climates of regions through which they flow. Cold ocean water currents flowing from polar and sub-polar regions bring in a lot of plankton that are crucial to the continued survival of several key sea creature species in marine ecosystems. Since plankton is the food of fish, abundant fish populations often live where these currents prevail. Ocean currents can also be used for marine power generation, with areas off of Japan, Florida and Hawaii being considered for test projects. Currents are responsible for circulating water throughout the earth's oceans.

Q: Discuss in detail the Currents of the Atlantic Ocean.

Answer: The important currents of Atlantic Ocean are;

1. North Equatorial Current (warm)

North equatorial current is a significant Pacific and Atlantic Ocean current that flows east-to-west between about 10° north and 20° north. This current is generated because of upwelling of cold-water near the west coast of Africa. This warm current is also pushed westward by the cold Canary current. On an average, the north equatorial warm current flows from east to west but this saline current is deflected northward when it crosses the mid-Atlantic Ridge near 15°N latitude. It again turns southward after crossing over the ridge. This current, after being obstructed by the land barrier of the east coast of Brazil, is bifurcated into two branches viz. *Antilles current* and *Caribbean current*. The Antilles current is diverted northward and flows to the east of West Indies islands, and helps in the formation of Sargasso Sea eddy while the second branch known as the Caribbean current enters the Gulf of Mexico and becomes Gulf Stream.

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2. South Equatorial Current (warm)

The South Equatorial Current is a significant Pacific, Atlantic, and Indian Ocean current that flows east-to-west between the equator and about 20 degrees south. In the Pacific and Atlantic Oceans, it extends across the equator to about 5 degrees north. South equatorial current flows from the western coast of Africa to the eastern coast of South America between the equator and 20°S latitude. This current is more constant, stronger and of greater extent than the north equatorial current. In fact, this current is the continuation of the cold *Benguela current.* This warm current is bifurcated into two branches due to obstruction of land barrier in the form of the east coast of Brazil.

The northward branch after taking north-westerly course merges with the north equatorial current near Trinidad while the second branch turns southward and continues as Brazil warm current parallel to the east coast of South America. This current is basically originated under the stress of trade winds.

3. Equatorial Counter Current

Equatorial Counter Current is a significant ocean current in the Pacific and Indian oceans that flows west-to-east at approximately five degrees north. The Counter Currents result from balancing the westward flow of water in each ocean by the North and South Equatorial currents.

4. Gulf Stream

The Gulf Stream is a system of several currents moving in north-easterly direction. This current system originates in the Gulf of Mexico around 20°N latitude and moves in north easterly direction along the eastern coast of North America and reaches the western coasts of Europe near 70°N latitude. This system, named Gulf Stream because of its origin in the Mexican Gulf.

5. Canary Current (Cold)

The Canary current, a cold current, flows along the western coast of North Africa between Maderia and Cape Verde. In fact, this current is the continuation of North Atlantic Drift which turns southward near the Spanish coast and flows to the south along the coast of Canaries Island. The Canary cold current modifies the otherwise hot weather conditions of the western coasts of North Africa.

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6. Labrador Current (Cold)

The *Labrador Current*, an example of cold current, originates in the Baffin Bay and Davis Strait and after flowing through the coastal waters of Newfoundland and Grand Bank merges with the Gulf Stream around 50°W longitude. This current brings with it a large number of big icebergs as far south as Newfoundland and Grand Bank. These icebergs present effective hindrances in the oceanic navigation.

7. Brazil Current (Warm)

The *Brazil current* is characterized by high temperature and high salinity. This current is generated because of the bifurcation of the south equatorial current because of obstruction of the Brazilian coast near Sun Rock. The northern branch flows northward and merges with the north equatorial current while the southern branch known as the Brazil current flows southward along the east coast of South America up to 40°S latitude.

8. Falkland Current (Cold)

The cold waters of the Antarctic Sea flows in the form of *Falkland cold current* from south to north along the eastern coast of South America upto Argentina. This current becomes most extensive and developed near 30°S latitude. This current also brings numerous icebergs from the Antarctic area to the South American coast.

9. South Atlantic Drift (Cold)

The eastward continuation of the Brazil current is called *South Atlantic Drift*. This current is originated because of the deflection of the Brazil warm current eastward at 40°8 latitude due to the deflective force of the rotation of the earth. The South Atlantic Drift, thus, flows eastward under the influence of the westerlies. This current is also known as the *Westerlies Drift* or *the Antarctic Drift*.

10. Benguela Current (Cold)

The *Benguela current*, a cold current, flows from south to north along the western coast of South Africa. In fact, the South Atlantic Drift turns northward due to obstruction caused by the southern tip of Africa. Further northward, this current merges with the South Equatorial Current.

These currents and their path are shown in figure below.

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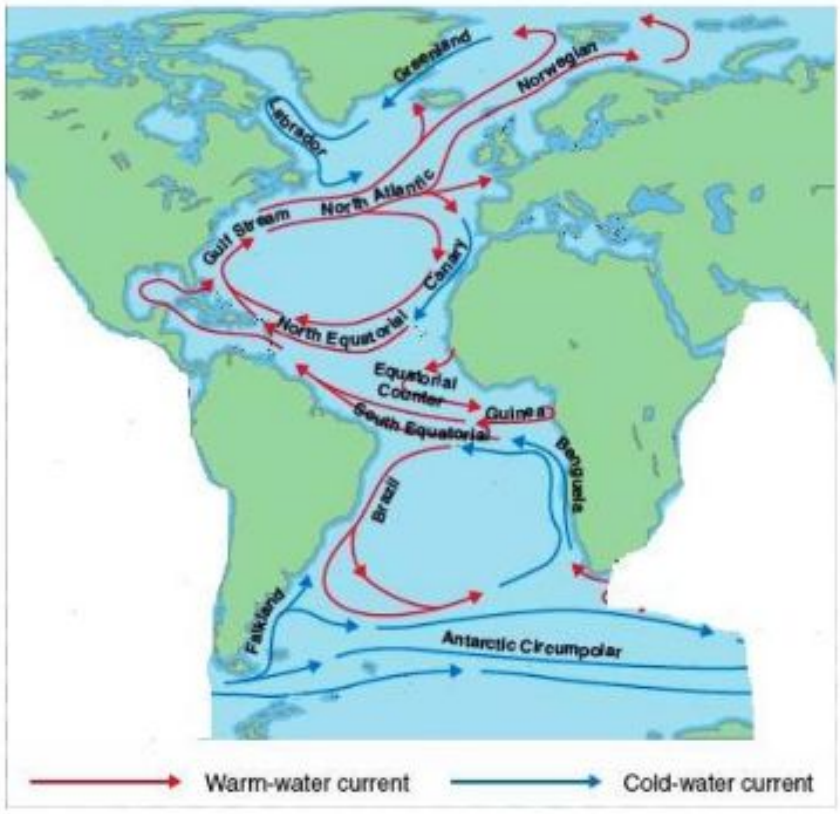


Fig. 4.2: Currents of the Atlantic Ocean

SHORT ANSWER TYPE QUESTIONS

Q1. Define Bathymetry?

Ans: The measurement of the ocean depths is called *'bathymetry'*.

Q2. What is Salinity?

Ans: The total amount of dissolved salts on grams per kilogram of water is termed as *'salinity'*. It is measured in parts per thousand.

Q3. What is an ocean current?

Ans: It may be defined as the persistent horizontal movement of ocean water in a fairly defined direction.

Q4. Give the definition of Tides?

Ans: It refers to the regular rise and fall of sea water due to the gravitational pull of sun and moon.

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Q5. Define waves?

Ans: It may be defined as the cyclic movement of particles. This cyclic movement occurs due to the energy transfer between particles in a medium.

Q6. What is a coral reef?

Ans: It is a rock like structure formed usually in warm sees by colonies of small animals called 'corals.

Q7. What do you mean by OTEC?

Ans: An acronym for ocean thermal energy conversions; refers to the process by which energy from ocean is transferred or utilized by different means.

Q8. What is tidal energy?

Ans: It refers to the kinetic energy derived from the rise and fall of sea water by means of technology.

Or

Rise and fall of the ocean tides represents a renewable energy source, which in principle could supply perhaps 1EJ of energy per year as electricity throughout the world.

Q9. Define a tidal range?

Ans: The difference between high and low tides is called *'tidal range'*.

Q10. Define a continental shelf?

Ans: The zone around the continents, extending from the low water line to the depths at which there is marked increase in slope is called *'Continental Shelf'*.

Or

Area of the ocean floor bordering the continental landmass at a depth of around 200m. Gradient of shelf is 0.1°.

Q11. Define continental slope?

Ans: It is the zone of marked slope (2°-6°) from the edge of the continental shelf to the deep sea plain.

Q12. What is a continental rise?

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Ans: It is the long and broad elevation of the deep sea floor which rises gently and smoothly.

Q13. What is an abyssal plain?

Ans: An abyssal plain is the deep sea-floor, formed of abyssal deposits. It is characterized by least gradient.

Q14. Define seamount?

Ans: It is defined as the isolated submarine peak with a steep slope in the ocean floor.

Q15. What is a Guyot?

Ans: A flat topped peak rising from sea floor is termed as *'Guyot'*.

Q16. Define submarine canyon?

Ans: A steep sided V-shaped trench usually found on the continental shelf and occasionally on continental slope is termed as *'submarine canyon'*.

Q17. Define thermocline?

Ans: It is defined as the region where temperature varies or changes rapidly with depth.

Q18. Define halocline?

Ans: It is defined as the zone in the water column where the vertical change of salinity is relatively sharp.

Q19. Define pycnocline?

Ans: It is defined as the zone of the ocean in which density increases rapidly depth.

Q20. What is an oceanic trench?

Ans: A long but narrow depression of the sea floor having steep sides is called an oceanic trench.

Q21. How many oceans are there?

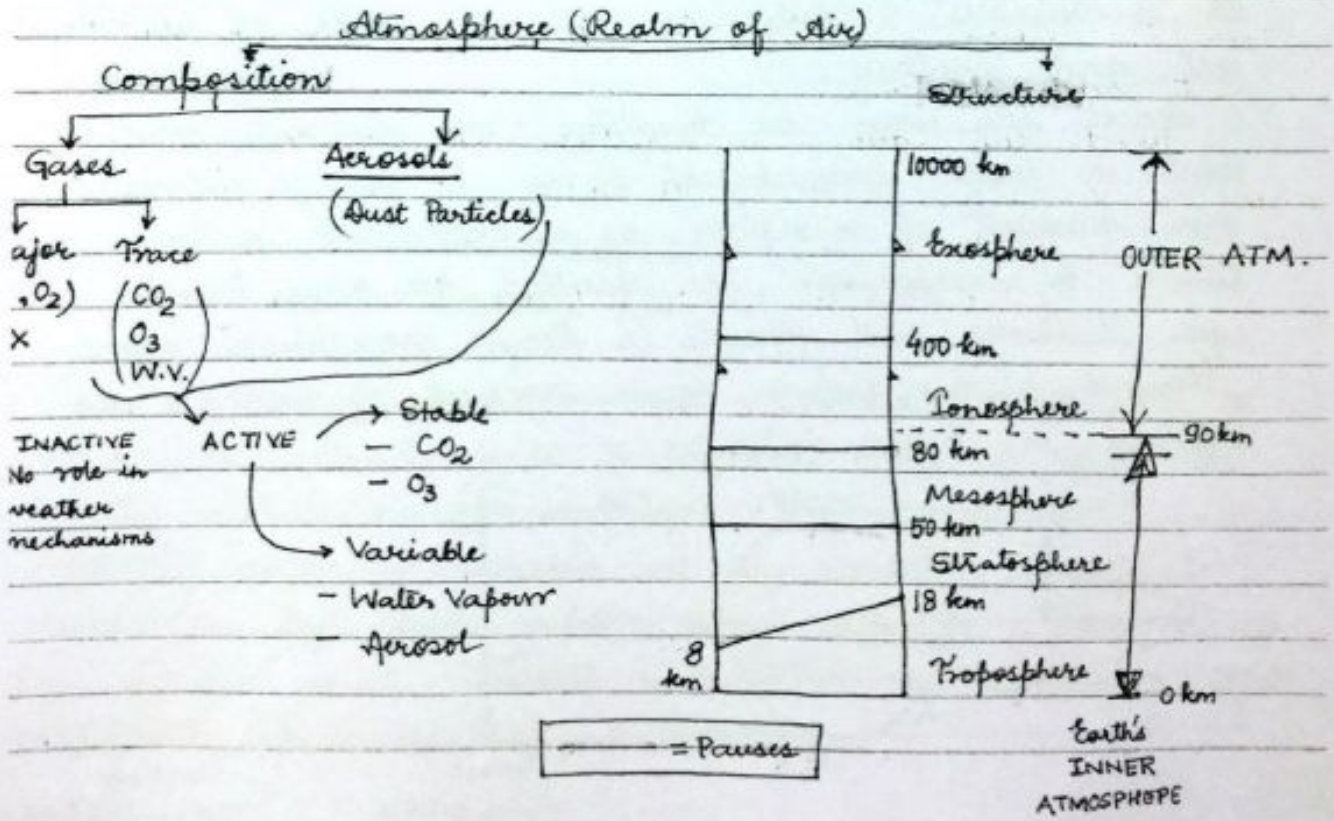
Ans: The seas and oceans of the world are actually one big "world ocean" because they are connected. Most of the time the world ocean is divided into four main parts: the Pacific, Indian, Atlantic, and Arctic. By far the largest is the Pacific Ocean, more than twice the size of the Atlantic. The Indian is third in size, followed by the Arctic Ocean.

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CLIMATOLOGY

1) Insolation
2) Temperature
3) Pressure & Global Circulation
   * Monsoonal mechanisms*
   * Jet Streams*
4) Atmospheric moisture
   * Hydrological Cycle
   * Precipitation : Types & Distribution
5) Cyclones*
   * Tropical & Temperate
6) Air masses*
7) Climatic classification
   * Koppen
   * Trewartha
   * Thornthwaite



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Earth's shape Orbit Eclipsed

[149.6 M km]

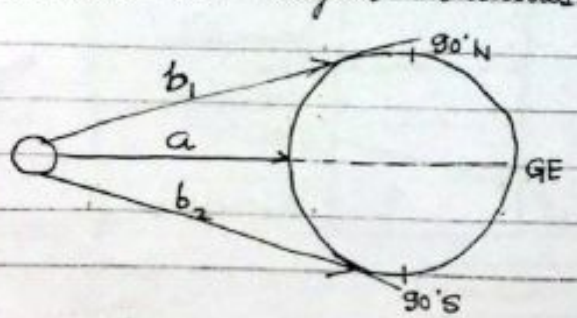
INSOLATION: INCOMING SOLAR RADIATION

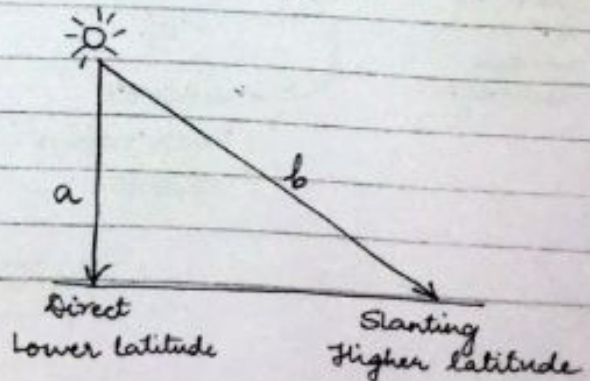
- Earth's System is completely dependent on the sun for requirement of heat and light. The total amount heat energy emitted from the surface of sun is lled solar radiation. Small amount of solar radiation it is received by the Earth's system because of the tance b/w the 2 celestial bodies is called insolation.
- amount of insolation received by Earth's system is gely constant (with minor exceptions generated during ihelion and Aphelion positions). However, the distribution insolation significantly varies. Among the factors that gulates the distribution of insolation:

Angle of sun rays
Season Cycles
Atmospheric influence, are included.

gle of sun's rays: In reference to the shape of planet th, it receives 2 distinctive types of angle of sun rays irect and slanting.

- direct sun rays, as travelled less distance and eads in lesser geographical space, it always induces gher amount of insolation as is experienced in lower titudes. In comparision, the slanting sun rays travels rger distances and spreads in larger geographical space, therefore, always induces lower amount of insolation as erienced in higher latitudes.



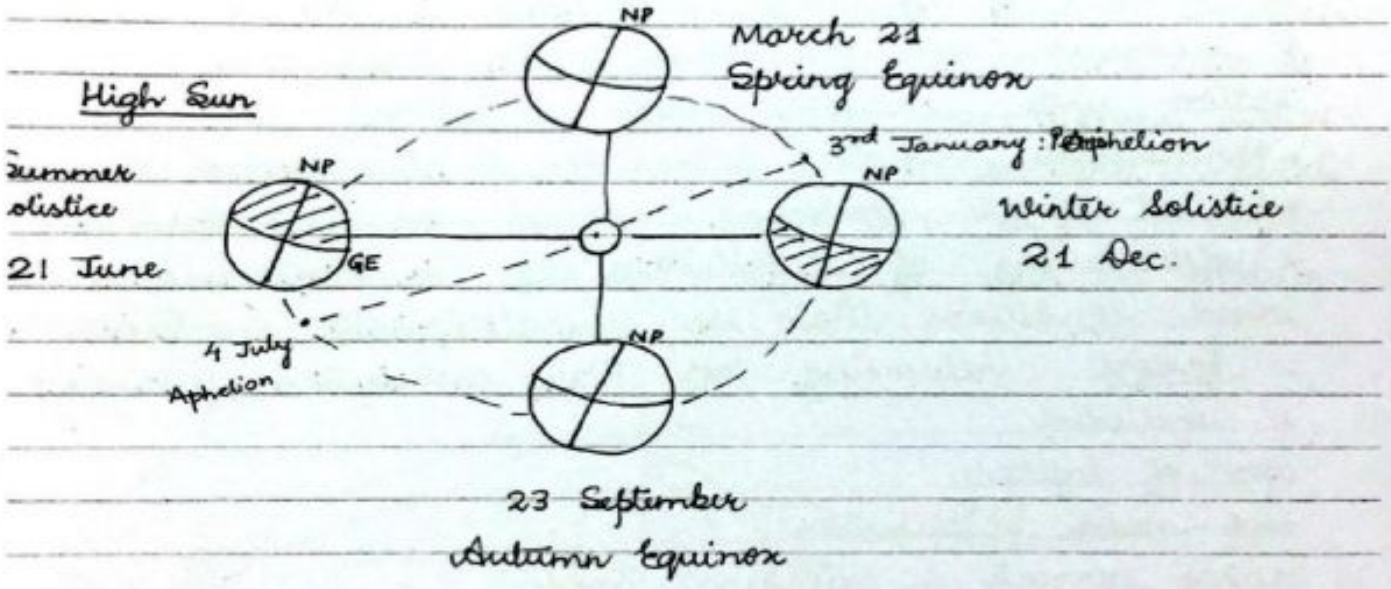


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Plane of the ecliptic

Season Cycle : Axial inclination of the earth and its revolution around the sun causes the shift of thermal equator or high sun. It is this shift that creates reversal of seasons between the hemisphere representing unequal distribution of insolation. In accordance to the season cycles, from Spring Equinox (21 March) to Autumn Equinox (23 Sep), Northern Hemisphere experiences high sun seasons with 21 June being Summer Solstice. In accordance southern hemisphere experiences high sun seasons from Autumn Equinox i.e. 23 Sep to Spring Equinox i.e. 21 March With 21st December being the winter solistice



) Role of atmosphere : The active variable constituents of atmosphere induces local to regional levels of effectivity in the distribution of insolation. The atmospheric influence includes: scattering carried on by aerosols, absorption carried on by water vapour and reflection carried on by clouds which results in wastage of incoming solar radiation influencing its distribution.

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March 2014

Lecture # 19

2. ATMOSPHERIC TEMPERATURE

Perehelion : Nearest (147 Mkm) ⇒ On or near January 3.
Apehelion : Farthest (152 Mkm) ⇒ On or near July 4.

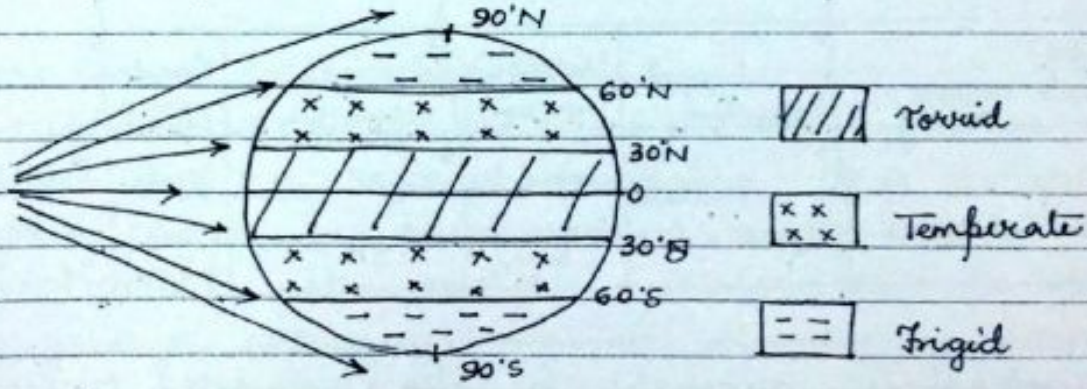
amount of heat present in the atmosphere is fined to be air temperature, atmospheric temp. or imply temp. It is an identified fundamental element of eather and climate which is regulated by incoming olar radiation and in turn regulates atmospheric ressure. The principle source of atmospheric temp. is utgoing long wave terrestrial radiation whereas coming short wave solar radiation forms the condary source. However, in the light of the fact that e source of terrestrial radiation is also the ~~solar~~ f incoming solar radiation, atm. temp has direct lation with incoming solar radiation.
e terrestrial radiation forms the prinple source of atm. np., it is the prevailing ground conditions that forms e determiners of distribution of air temp. Among the ound conditions, that are climatologically recognised as e factors influencing air temp. distribution, following e included :

ign of latitude
and-water distribution
ceanic currents & prevailing winds
oud cover, and
titude or height

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Sign of Latitude

With geographical equator dividing planet earth into two equal parts called northern & southern hemisphere with each one incorporating 90 degrees of latitude, Climatologically, lower latitude that is proximate to equator & higher latitude that is proximate to poles are distinguished. With ↑ in the sign of latitude, atmospheric temperature continuously decrease because of the decrease in the amount of received insolation. This rela b/w latitude & temperature was analysed by pre-historic contributors: Greek scholars. They recognised 5 thermal zones. The torrid zone, extensive b/w 30°N to 30°S, forms the lowest latitudinal thermal zones with highest temperature The frigid zones b/w 60° to 90°N & 60° to 90°S forms the highest latitudinal zones, thus have lowest atmospheric temperatures. In b/w these 2 extremes, are temperate zones, that is 30° to 60°N & 30° to 60°S with moderate temp. conditions thro' out the year with its middle latitudinal location



"5" Thermal Zones given by Greek Scholars

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Land-Water Distribution

he approach of thermal zones represents absolute validity describing latitudinal distribution of temperature. It is, owever, based on the perception that surface of the arth have homogenous relief. In practicality, maximum of Earth's surface involves unequal distribution of land nd water, with these reliefs revealing different temp conditions. In a given sign of latitude, water, primarily ue to its mobility and translucent characteristics, naintains the temperature whereas land always depicts xtreme. It is in the effect of this factor that horizontal istribution of temperature in regional perspective stand synonym to "temperature anamoly". It is defined to e deviations from normal projected temperature in any given sign of latitude. It involves positive nomaly that is more than normal and negative nomaly i.e. less than normal.

Temperature Anamoly				
+ve	+ve		−ve	
0–45° Lower Latitude	* Land (High Sun)	Water (Low Sun)	* Water (High Sun)	Land (Low Sun)
45–90° Higher Latitude	* Water (High Sun)	Land (Low Sun)	* Land (High Sun)	Water (Low Sun)

e temperature anamoly is also correlated to the revailing season cycles where during high sun easons land develops +ve temp. anamoly compared to e neighbouring water & therefore, during low sun season and develops −ve temp. anamoly compared to neighbouring water.

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NCERT — Isothermal Maps of World Physical

The characteristics of temperature anamoly is depicted on the map of world in the analysis of "isothermal patterns" Isotherms are imaginary lines drawn to join the places having the same temperature. These are drawn parallel to the latitude and are recognised with some of the typical characteristics of the patterns that depicts anamoly. With the change in the relief, that is, along the shoreline, isotherms always develops bends which by itself justifies that land and water in a given sign of latitude do not develop same temperature. The nature of bends varies in accordance to the prevailing seasons as well as the transition of the relief. As for example, summer isotherm traced from land to water will always show bend towards equator whereas winter isotherm traced from land to water will always bend towards poles.

Season
Relief transition } Nature of bends

5) Oceanic Currents & Prevailing Winds:

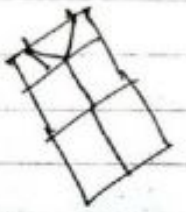
The oceanic currents & prevailing winds influences atmospheric temp. in regional perspective. It is in the effect of warm oceanic current called north Atlantic Drift (NAD) combined with onshore westerlies that European plains always experiences warmer climatic conditions than the similar latitudinal eastern counterpart Manchurian Plains. Beyond this perennial example, significant seasonal example correlates to BLIZZARDS, the cold polar winds accompanied with powdery snow which makes lower latitudinal USA experience polar climate during winters.

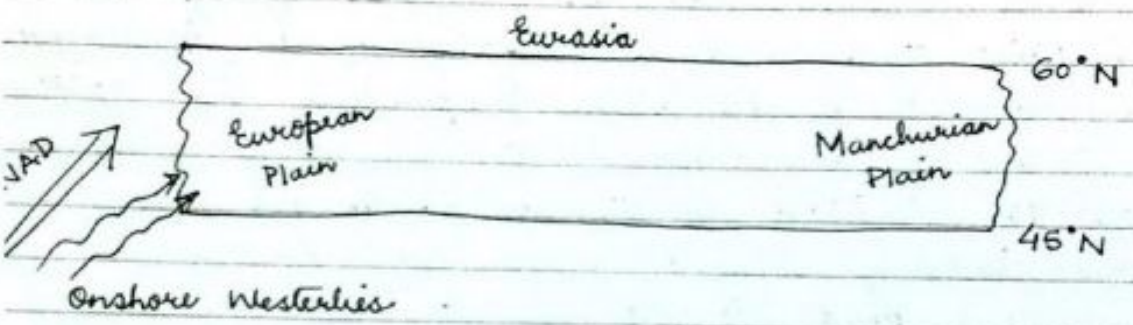
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Cloud Cover

t still more local levels, atmospheric temperature is lso influenced by cloud cover. It is in the effect of this factor that daytime temperature is decreased nd night temperatures increases.

eather & Climate → Only troposphere
tmospheric temp. → Troposphere + Stratosphere



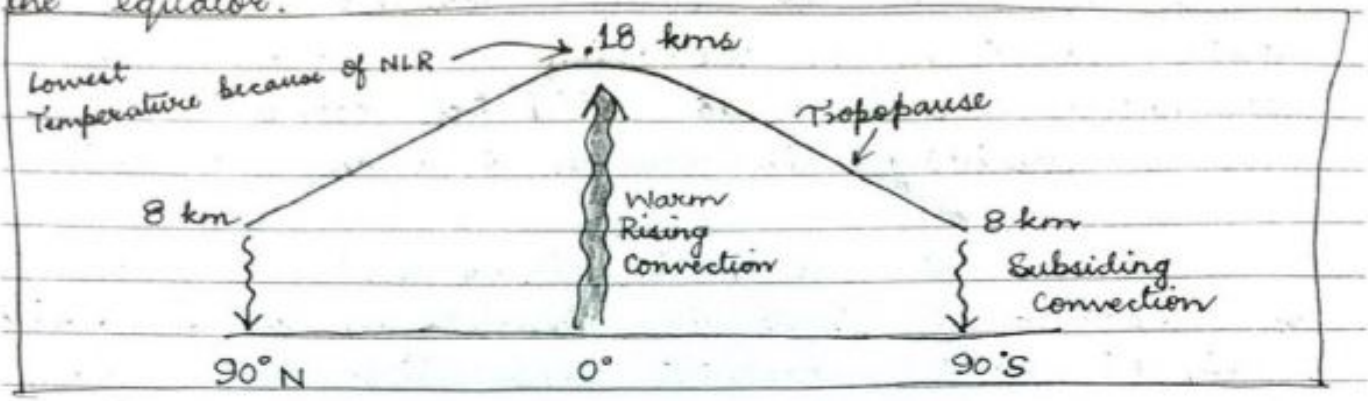


VERTICAL DISTRIBUTION OF TEMP. (HEIGHT/ALTITUDE)

ffect of height or altitude on atmospheric temp. s the fundamental element of weather and climate that it decreases with ↑ in height thro'out troposphere t the rate of 6.5 °C/km of rise called normal apse rate (NLR) or environmental lapse rate. This ↓ of mperature is simply attributed to increasing distance om the source of atmospheric temperature i.e. terrestrial adiation. The vertical distribution of temperature in ioposphere also provides the base to identify variable eight of tropopause at near equator and poles. t is warm rising convection that makes the height of ropopause higher at equator (18 kms) and it is ubsiding convection that makes the height of tropopause

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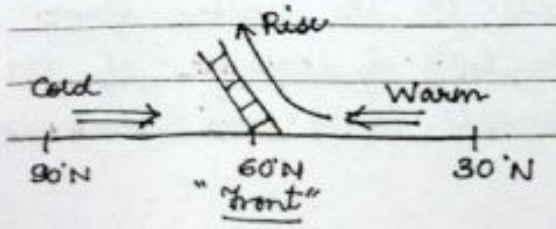
lower i.e. 8 kms over the poles. In the application of NLR, the lowest tropopause temperature is thus recorded over the equator.

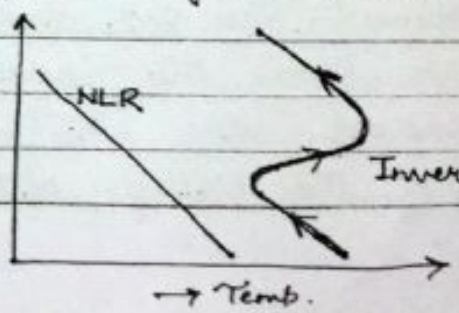


In troposphere under certain conditions, atmospheric temperature ↑ with ↑ height. Such condition are recognised to be temperature inversion. The specific & reoccuring conditions that generates temperature inversion includes :

i) Air convergence
ii) Adiabatic changes
iii) Air drainage

i) Air Convergence : The factor of air convergence is reoccuring in the mid-latitude at near 60th parallel where reoccuring convergence of cold and warm air columns generates most prominent climatological front. It is along this front, rise of warm air column generates temperature inversion, which forms the preliminary condition for temperate cyclonic circulation.





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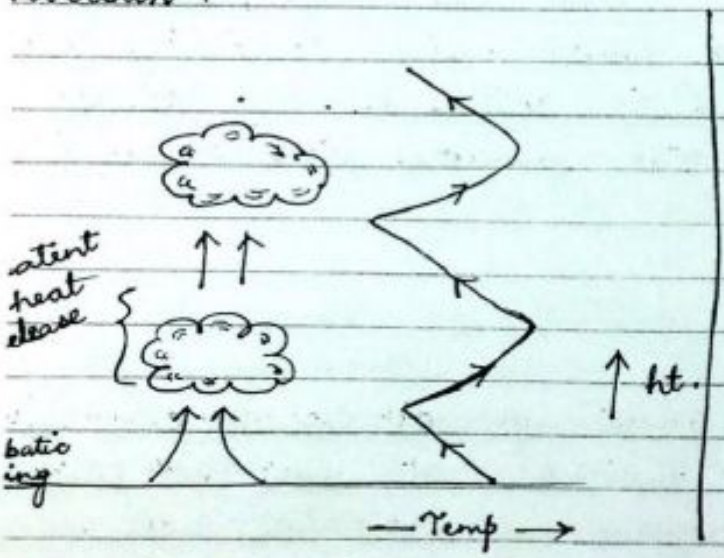
Air : Poor Conductor of heat

Fog : Near ground cloud

diabatic changes

he adiabatic change in air temperature is defined to the change due to vertical movements rather than ctual addition or subtraction of heat. Rising air olumns are subjected to adiabatic cooling effect hereas subsiding air column to adiabatic warming ffect.

It is with adiabatic cooling that reoccuring ulti-altitudinal temperature inversion is generated. as diabatic cooling facilitates condensation that marks e release of latent heat of condensation generating inversion.

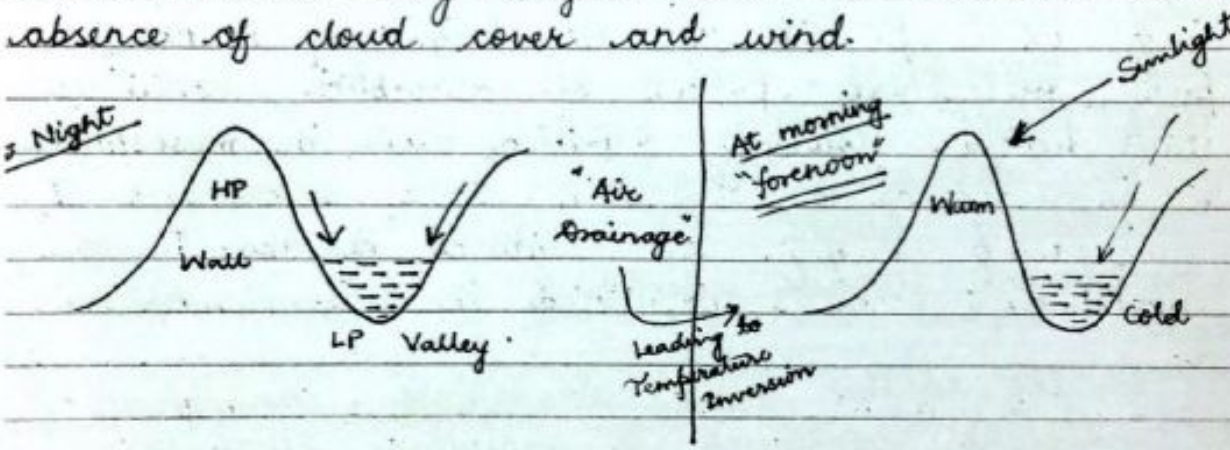


Air Drainage:

the mountainous regions with tall peaks & deep valleys, ir drainage related inversion is the common daily levelopment. The air drainage i.e. movement of air olumn from the mountain wall to the valley floor caused due to differential rate of cooling of the all & the valley after the sunset. It is air drainage

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that facilitates accumulation of air column in the valley floor to be eventually cooled down with the advancement of night. Such cold accumulated air column in the valley floor combined with heated mountain wall in the forenoon hours of subsequent day generates temp inversion. It is this reoccuring temparature inversion that facilitates mountain walls experiencing favourable penetration of sun rays. Thus, the commercial utilisation in terms of settlement or agricultural development, air drainage related inversion though is experienced throout the year, it evolves strong characteristics during winters with long nights wher is combined with absence of cloud cover and wind.



Vertical distribution of T : Write about T Inversion

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Lecture #20

e. : March 2014

Cloudy Day : T ↓
Cloudy Night : T ↑

HP ⟶ LP (wind)

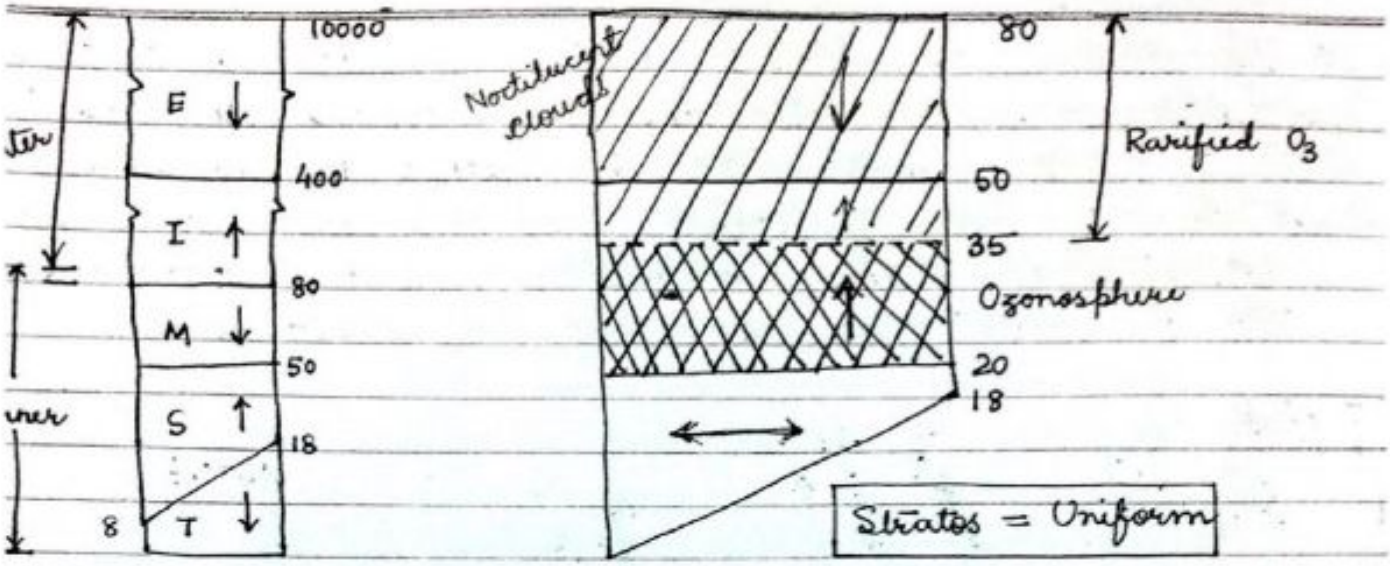
EMPERATURE REGD. IN OTHER ATM. LATERS :

eyond tropopause, atmospheric temperature depicts egular alternating sequence of temperature increase nd decrease due to different set of factors.

In stratosphere, temperature prominently ireases with increasing height due to the effective sorption carried on by ozone. It is within this layer at natural densest concentration of ozone called zonosphere is confined (20-35 kms). As the naturally curing ozone prevails till the height of 80 km i.e. omplete mesosphere process of absorbtion continues l that height. However, rarified ozone in mesosphere sults in decreasing absorbtion. Thus, decreasing T th increasing height. The evidence of low T are e noctilucent clouds identified in this atmospheric ayer.

In the earth's outer atmosphere, ionosphere nd exosphere continues to maintain alternating equence of temperature change where, in ionosphere lectrically charged particles called ions forms the ause of increasing T with increasing height. whereas eyond 400 kms i.e. in exosphere rarified air marks l in T effectivity with ↑ height.

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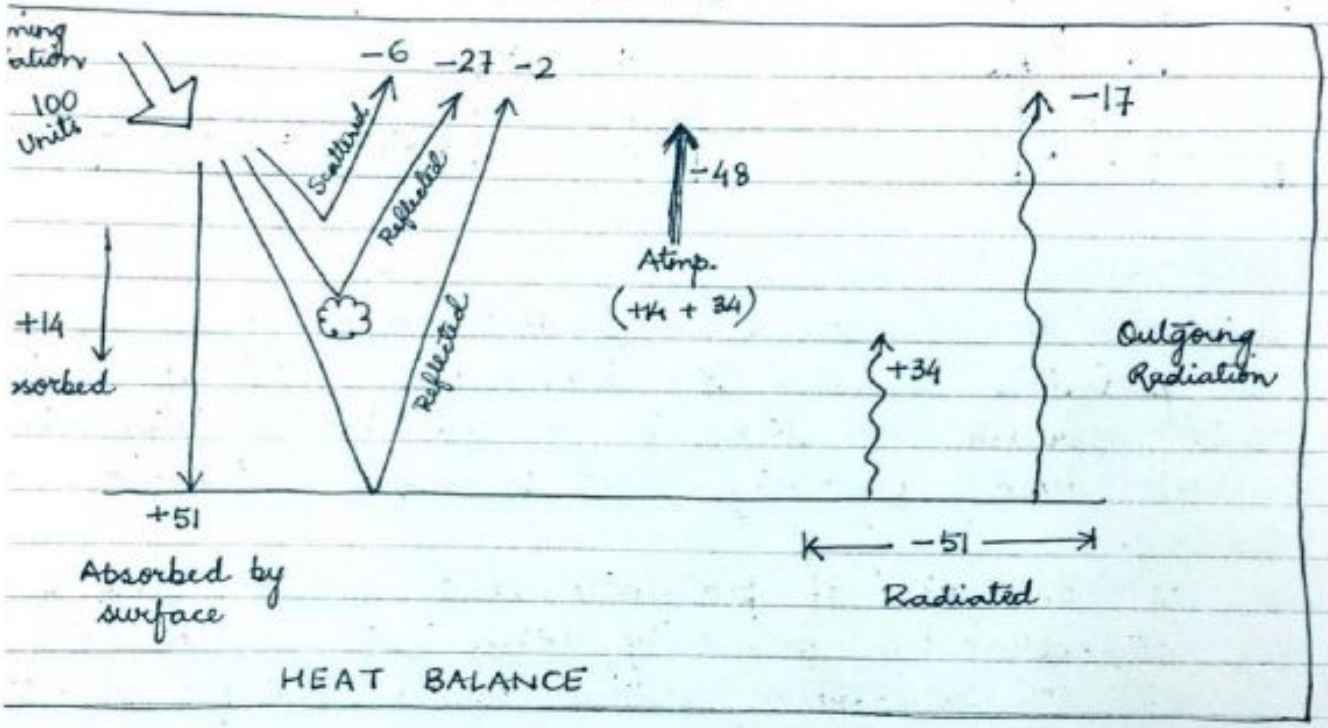
HEAT BUDGET / HEAT BALANCE

Analysis of atmospheric temperature also correlates to the persisting balance b/w incoming & outgoing radiation. This approach of study is divided into 2 interrelated levels called planetary heat budget & latitudinal heat budget.

In the analysis of planetary heat budget, role played by atmosphere is primarily taken into consideration wherein the atmosphere acting as blanket for planet earth restricts both incoming solar radiation as well as outgoing terrestrial radiation in maintaining the balance between insolation & terrestrial radiation. For the incoming solar radiation though atmosphere plays to a near transparent medium, significant amount is wasted as reflection by cloud cover & scattering by aerosols. Moreover, minor amount is absorbed as well by ozone leading to slightly more than half of incoming solar radiation reaching the earth's surface. It is this role played by atmosphere that restricts the

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of daytime T. During night, as surface of the Earth
adiates back all the absorbed incoming solar radiation
t is major part that is blocked by atmospheric
onstituents like CO_2 called greenhouse gases. It is this
ocking that makes atmosphere regulate decrease of
ight T sustaining habitability of planet earth.



e planetary heat budget significantly includes the effectivity
f global circulation which helps in maintaining latitudinal
eat budget. The lower latitudes receiving higher amount
insolation compared to higher latitudes are not
veloped as heat surplus zones because of the transfer
f heat & latitudinal mixing by Global Circulation.
There are 2 dimensions of global circulation:
/ Atmospheric circulation & (ii) Gyre Circulation
Oceanic Current Systems).

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ATMOSPHERIC PRESSURE & GLOBAL CIRCULATION :

The atmospheric pressure or air pressure forms the element of weather & climate that regulates and is regulated by global circulation. It is defined to be the weight exerted by air column on the earth surface. It is classified into 2 distinctive types of systems which are:

1) LP systems and
2) HP "

The low pressure system represents lesser weight exerted by air column on the earth's surface. It correlates to rising convection which includes both thermal direct and thermal indirect. In terms of geographical sizes, LP systems are classified as troughs and cyclones. The troughs represent bigger LP systems whereas cyclones represent smaller systems.

The HP systems represent higher weight exerted by air column on the earth's surface. It correlates to subsiding convection which includes thermal direct and thermal indirect types. In terms of geographical sizes, the HP systems are classified as wedges & Anticyclones wherein the wedges represent bigger sized HP systems and anticyclones smaller sized HP systems

The atmospheric pressure in the global perspective of climatological studies is analysed only in horizontal account. In the vertical perspective, each air column represents the distinction in the nature of changing pressure profile. At the mean sea level, the atmospheric

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essure is 1013.25 millibars. The horizontal profile f air pressure analysed latitudinally reveals the revalence of 7 pressure belts. Out of these, 3 essure belts are thermal direct and 4 are thermal direct. All these pressure belts represents dynamic titudinal locations due to apparent shift of sun. oreover, in the effect of unequal land-water distribution ey involve combination of belts as well as ctular profile.

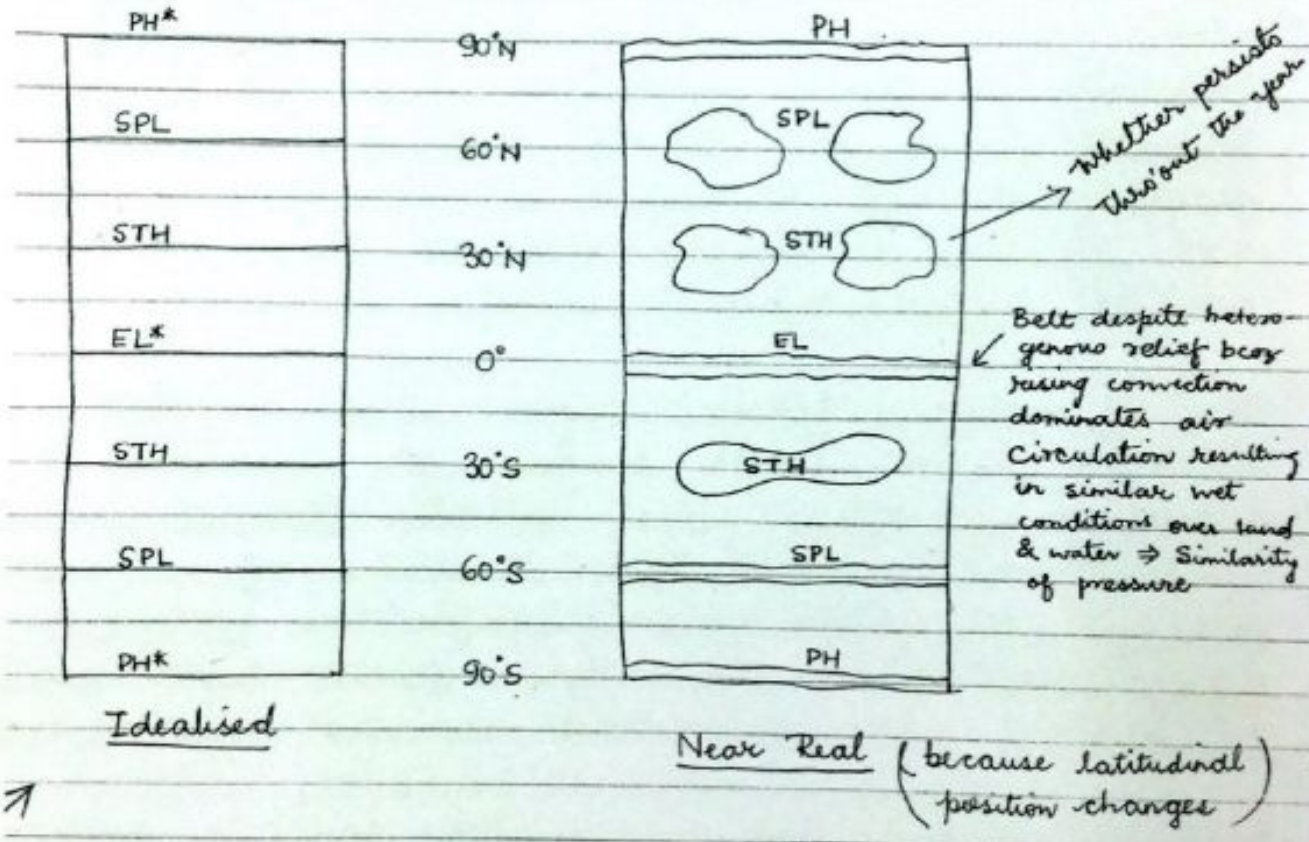


FIGURE : Horizontal Distribution of air pressure

gh Sur, STH	Low Sur, SPL	Distinct Cells in STH & SPL
Hawaiian High in Pacific	⇒ Aleutian Low in Pacific	
& Azores High in Atlantic	& Icelandic Low in Atlantic	
Bcoz Land +ve T-Anamoly	⇒ Bcoz land -ve T-Anamoly	

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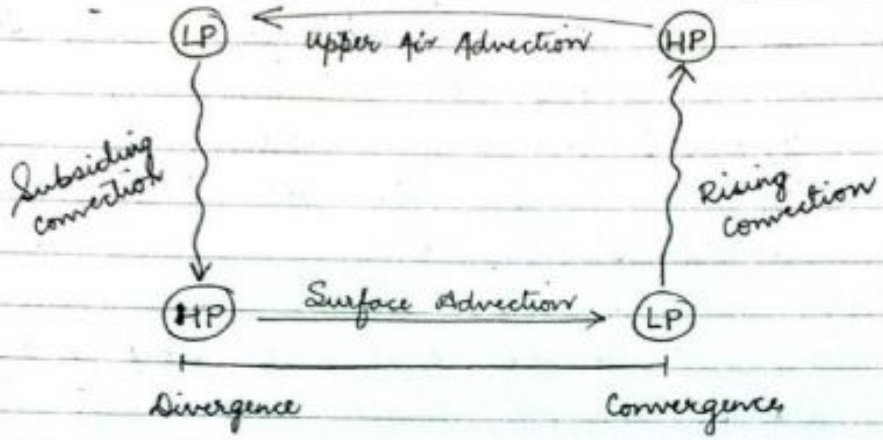
Polar high of both northern & southern hemisphere & sub-polar low of southern hemisphere forms continuous pressure belts because of homogeneity of relief. The equatorial low also forms the continuous pressure belt inspite of heterogeneity in relief because in this location rising convection dominates the air circulation resulting in similar wet conditions over land and water, thus, similarity of pressure. The subtropical high of southern hemisphere represents unique profile of being near cellular as unequal distribution of land and water is combined with dominance of water bodies. The true cellular characteristics, therefore, is identified with sub-tropical high and sub-polar low of northern hemisphere. The elementary cause of cellular characteristics for both these thermal indirect pressure is unequal land-water distribution.

The subtropical high generates absolute cellular characteristics during high sun seasons when the tropical landmasses generates positive temperature anamoly & thus, low pressure. The well defined cells developed in open oceans are called Hawaiian High in Pacific Ocean & Azores High in Atlantic Ocean. In comparision, the sub-polar low generates absolute cellular characteristics during low sun seasons when the temperate landmasses generates negative temperature anamoly. The well developed LP cells in the open water bodies includes Aleutian Low of Pacific Ocean & Icelandic Low of Atlantic Ocean.

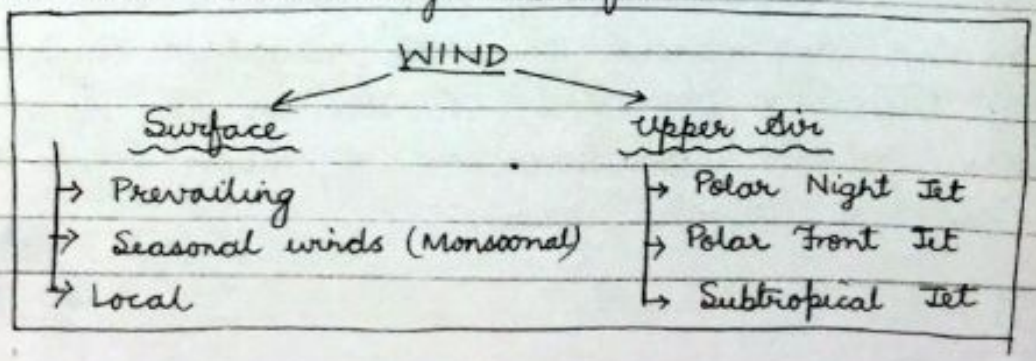
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'WIND'

ADVECTION :



e cause and effect interrelation between atmospheric ressure and global circulation relates to the fact that rtical movement of air, called convection, generates essure difference with every rising convection nerating LP on ground and HP vertically over and ery subsiding convection generating HP on ground and vertically over. This generated pressure difference rms the cause of advection. Advection is defined be horizontal movement of air, also called wind. the advective movement is compensatory movement the generated pressure difference, it always moves om HP to LP which makes every HP divergence zone nd every LP convergence zone. The advective novements are boldly classified :



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Date
9th March 2014

Lecture 21

Global circulation : Atmospheric & Gyre both

FACTORS AFFECTING WIND/ ADVECTION:

Horizontal movement of air, wind, is influenced by 3 distinctive forces called pressure gradient force, coriolis force & friction force. The pressure gradient force forms the genesis / source force of wind as it is the ΔP developed due to convective movement that facilitates the origin of advective movement with wind always moving from HP to LP, The pressure gradient force determines wind direction and it is in accordance to the direction from where the wind moves, the name of the wind is given. Additionally, pressure gradient force i.e. rate of change of pressure also forms the determiners of wind velocity. This rate of change is also called barometric slope or gradient with steeper slope facilitating higher wind velocity.

The coriolis force is the deflective force. For every moving entity on the surface of spinning Earth this force is applicable. The effect of deflective force is best interpreted as Ferrel's Law according to which moving wind gets deflected to its right in Northern hemisphere & left in southern hemisphere. In accordance this force influences only one property of wind i.e. wind direction. It however is influenced by sign of latitude & wind velocity. With ↑ in the sign of latitude coriolis deflection ↑.

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Sign of latitude
0° – 0%
30° – 50%
60° – 86.6%
90° – 100%

Similarly, with ↑ in the wind velocity coriolis deflection ↑.

The frictional force: It is the ag effect that the surface features induces on orizontal movement of air. This force influences nly the surface winds modifying both its direction nd velocity. The effect of frictional drag on advection as analysed by Ekman and the analysis, therefore, s prominently referred as Ekman's Spiral Effect, which ncludes Veering (clockwise) and Backing (Counter-clockwise) ffects. Importance of frictional force is in distinguishing urface gradient winds and upper air Geostrophic winds.

PREVAILING WINDS:

The planetary wind movement recognised with permanent haracteristics forms the most prominent surface wind ategory regulated by pressure gradient force, coriolis force and frictional drag. These winds always epresent to be the examples of gradient winds. Demarcated in latitudinal profile which is regulated y prevailing pressure belts, the prevailing winds are distinguished as:

(i) Trade Winds
(ii) Westerlies
(iii) Polar Winds

Surface Gradient Winds ⇒ PGF + FF + CF
Geostrophic Winds ⇒ PGF + CF

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) THE TRADE WINDS

These are the lowest latitudinal prevailing winds that moves from sub-tropical highs to equatorial low. It is NE trade in Northern hemisphere & SE Trade in southern hemisphere. They correlate to the development of inter tropical convergence zone (ITCZ) which regulates monsoonal mechanisms. At equatorial belt, these winds also correlate to the development of Doldrums i.e. quiet zone with complete absence of advective movement regulating equatorial climate.

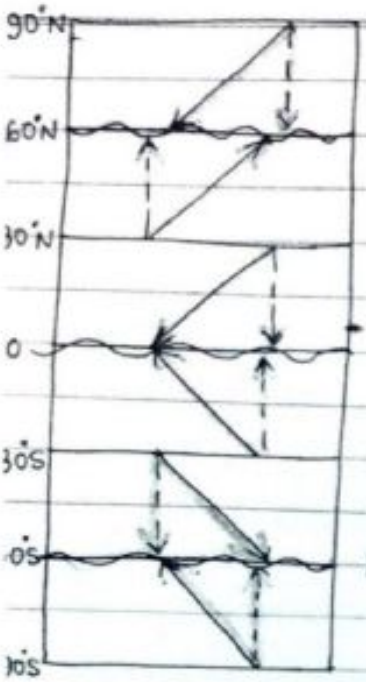
) WESTERLIES

These are the middle latitudinal planetary winds that are effective in between thermal indirect pressure belts. These are SW westerlies in northern hemisphere and NW westerlies in southern hemisphere. It is these winds that are known to be developing polar fronts which regulates the precipitation pattern of entire middle to high latitudes including temperate cyclonic circulations of northern hemisphere. It is NW westerlies that are also identified to be highest velocity prevailing winds. It is because of less frictional drag.

) POLAR WINDS

These are the highest latitudinal prevailing winds moving from polar highs to sub-polar low. These are NE polar winds in northern hemisphere and SE polar winds in southern hemisphere. Climatologically, these winds generates polar fronts in convergence with westerlies.

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NE Polar
Polar Front
SW Westerlies
NE
Trade ITCZ (Doldrum) } Trade
SE
NW Westerlies
Polar Front
SE Polar Polar

----→ Direction of pressure gradient
——→ Actual direction of winds (PGF + Coriolis effect)

ICELLULAR MERIDIONAL CIRCULATION:

e classical approach of atmospheric circulation tists have been oriented towards demarcating rface advection and upper air counterpart as radient winds. This orientation of study attempts f highlight development of 3 cells in the eridional dimensions in each hemisphere. In each f the cell, every surface wind is recognised with pposite flowing upper air counterpart called anti-winds. he demarcated cells includes:

Hco (i) Hadley Cell
(ii) Hohn Cell
(iii) Polar Cell

e Hadley Cell is the lowest latitudinal cell developed tween equatorial low and sub-tropical high. As it

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genesis is correlated to rising convection of warm air in the equatorial belt, it is called thermal direct cell. This cell is comprised of NE Trades, antitrade as advective movement with rising convection at equatorial belt and subsiding convection at STH as parts of circulation. Weather effectivity that is correlated to Hadley cell includes wetter weather conditions in equatorial regions and dry conditions in sub-tropics.

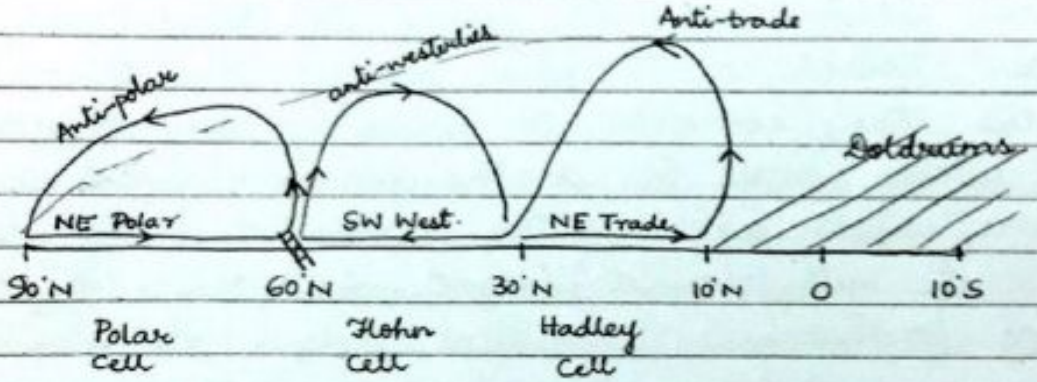
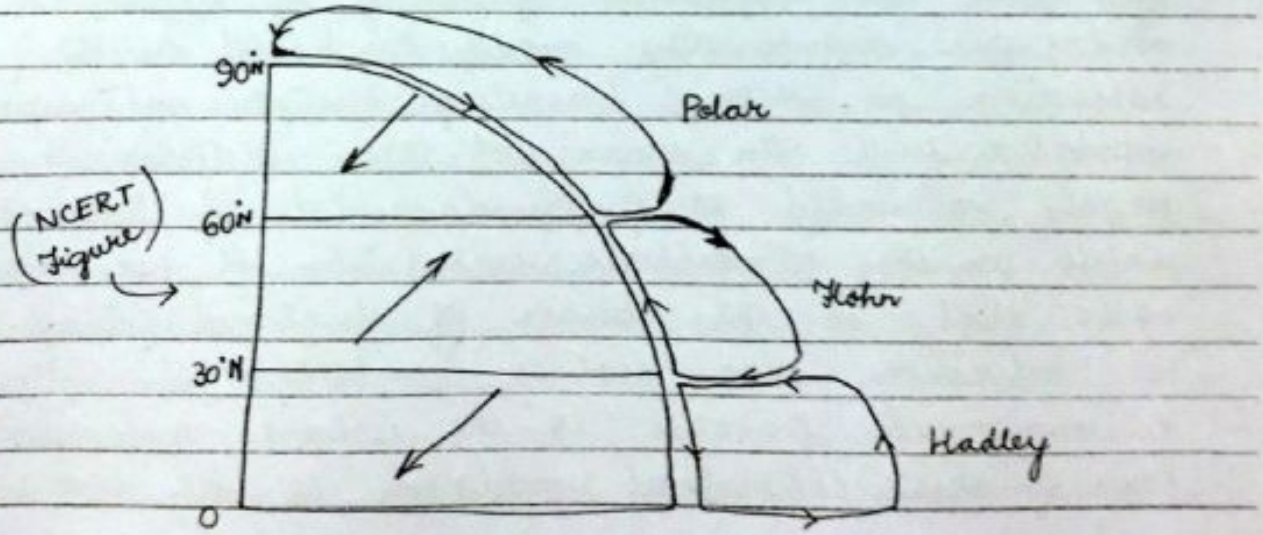


Figure: Tri-cellular Meridional Circulation



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e Ferrel cell is the mid-latitudinal thermal indirect ll which correlates to sub-tropical high & sub-polar w pressure belts. This cell is comprised of south estern (SW) westerlies and anti-westerlies as advective ovements and having subsiding convection at sub-tropical igh and rising convection at sub-polar low. It orrelates, therefore, to the prevailing wet conditions in e temperate latitude along with dry conditions in ub-tropics.

he polar cells : It is the highest latitudinal thermal irect cell which owes its genesis to the subsiding old air column in the polar region. This thermal irect cell, thus, correlates to prevailing dry conditions the polar areas. It involves NE polar winds and nti-polar winds as advective movements. It is also haracterised with lowest height due to its highest atitudinal location.

ET STREAMS (GEOSTROPHIC FLOW)

ast 1945, the approach of study of upper air ind was significantly modified based on the ealisation of strong prevailing westerlies at near ropopause level. The genesis of these westerlies is argely attributed to the fundamentals of pressure rofile in the atmospheric circulation. It, however, dds that in the absence of frictional drag upper ir advection also evolves geostrophic characteristics e. movements parallel to the isobars. These geostrophic low makes latitudinal garlands in both northern &

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southern hemisphere barring the exception of equatorial belt (no coriolis force). It is, therefore, that six different garland systems are identified in the global profile. The fast moving centres of these geostrophic flow are called jet-streams. Jet Streams are completely missing in southern hemisphere because of the dominance of water, making these fast moving tropopause winds confined in northern hemisphere. In accordance to their locations these are distinguished as:

(i) Polar Night Jet — Latitude, thermal direct, tropopause
(ii) Sub-tropical Jet — Highest isobaric level
(iii) Polar Front Jet — Smallest garland
* Complete absence of Rossby waves

) POLAR NIGHT JET

It is highest latitudinal thermal direct jet stream; which flows at lowest tropopause level (8 kms) and it is therefore that this jet stream moves at highest isobaric level. Applicable to highest latitudinal location, this jet stream forms smallest garland with complete absence of Rossby wave characteristics as there is complete absence of climatological difference b/w land and water beyond 60th parallel. This jet stream induces DRY weather conditions in the polar area. It is the perennial jet stream which is named as night jet as during six continuous months of north-polar nights, this jet stream attains maximum latitudinal expanse (60-90°) and attains highest velocity (more than 300 kmph).

) SUB-TROPICAL

It is the lowest latitudinal thermal direct jet stream

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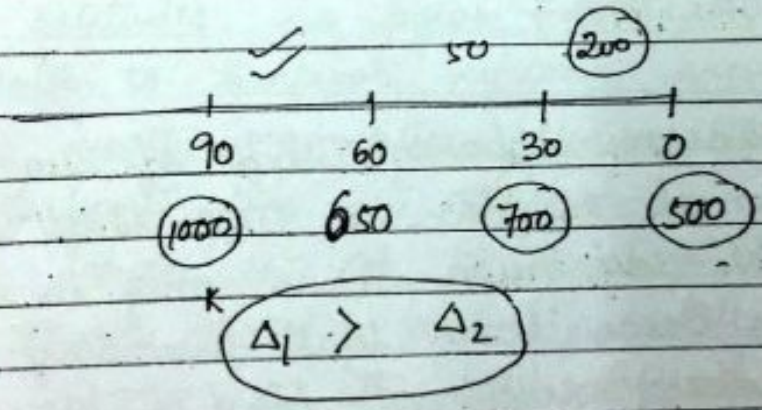
LP – Disturbances
HP – Stability

{Mid East : West Asia wrt. USA
Mid West : wrt. India
South West Asia : Global}

which flows at highest tropopause level - from among
te permanent jet streams (12-15 km) and it is therefore
tis jet stream moves at lowest isobaric level.
his jet stream forms largest garland system with
nost developed Rossby waves representing unequal
listribution of land and water. For the specific
altitude i.e 10 to 30-35° degrees this jet stream correlates
s its genesis to the thermal rise in equatorial belt.
's weather effectivity, however, is inducing dry
eather conditions in the global dimensions. [During
inters, in small part of SW Asia and South
'sia, this jet stream causes precipitation by blocking
nd transporting western disturbances which originates
n Mediterranean Sea.]

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1) Exceptional bend of ITCZ ⇒ Tropical Easterly Jet
2) Polar Front Jet
3) Modified Hadley Cell
4) Temperate Cyclonic Circulations.
5) Monsoonal Winds / Mechanisms
6) Hadley's Thermal Concept
7) Rossby Waves
8) ITCZ Bend Concept by Flohn
9) MONEX
10) Role played by Tibetan Plateau
11) Generation of N-S Alignment



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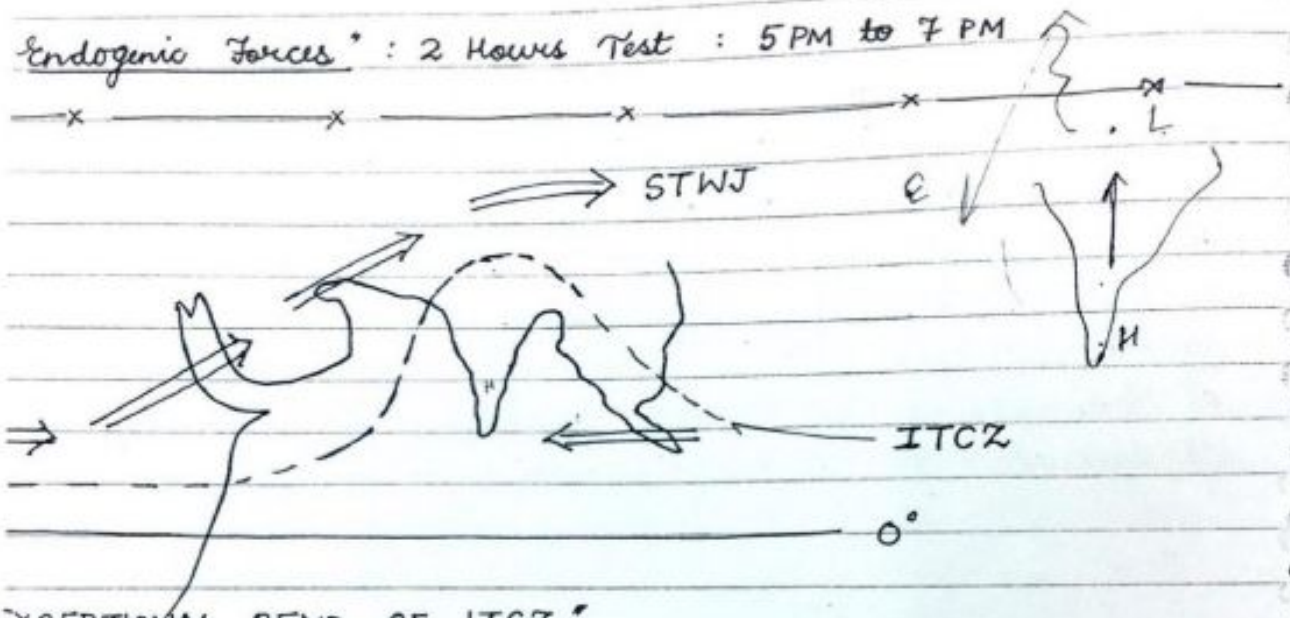
Facebook Group: Indian Administrative Service (Raz Kr)

March 2014

Lecture # 22

Thermal equator changes.
Geostrophic winds are absent in the Equatorial belt.

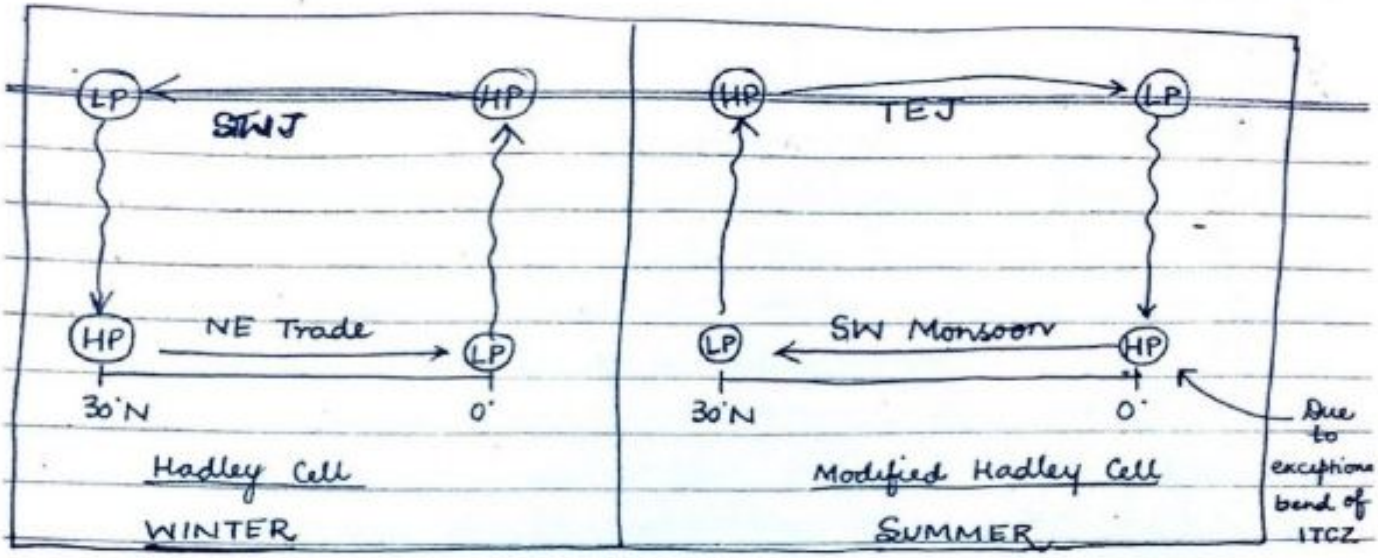
Endogenic Forces" : 2 Hours Test : 5 PM to 7 PM



EXCEPTIONAL BEND OF ITCZ"

wing high sun season apparent shift of sun towards orth makes 'thermal equator or ITCZ' shift upto °N in the global dimension. It is only in the case f northern Indian Ocean basin that prevailing ontinentality generates exceptional bend making ITCZ laced in northern plains of India. This exceptional bend ignificantly displaces sub-tropical jet in south and SE sian regions. Over these regions, during summers, here is the development of regional seasonal easterly pper air wind called tropical easterly jet. It is his jet stream that is the regulator of monsoonal echanism in the region.

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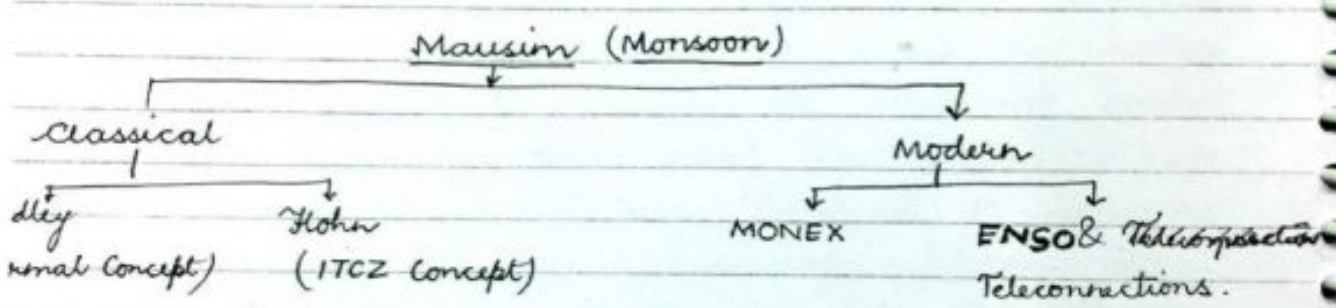
POLAR FRONT JET :

This mid-latitudinal jet stream forms the example of thermal indirect jet. Its development is correlated to genesis of front on ground. It is this polar front which facilitates the extension of polar jet to upto mid-latitudes as polar front jet. This jet stream, thus, correlates to temperate cyclonic circulations and thus, wetter weather conditions. Unlike the thermal direct counterparts, this jet stream is specified with life cycle which is of 15-20 days that involves genesis (no Rossby waves), maturity (well developed Rossby waves) and decay as the well-defined phases. It is recognised to be permanent jet as within a week's time, after the decay of the jet stream, there is the fresh development of polar front on ground. Climatologically, this thermal indirect jet stream regulates not just the precipitation pattern of the mid-latitude but also restricts polar deserts to absolute polar areas (±80-90 degrees).

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MONSOONAL WINDS / MECHANISMS

The regional seasonal surface winds are best represented as monsoons which regulates the climatic characteristics of tropical east margin locations. The beginning of study of monsoonal mechanisms is traced back to pre-historic times with Arab scholars analysing its mechanism as seasonal reversal of the wind pattern. They identified these winds as mausim. This significantly old approach of the weather mechanism involves big range of contribution via classical times to modern time period. Among the major contributors to the monsoonal mechanism, following are included:



MONSOONAL MECHANISM

Hadley's Thermal Concept based on the recognition of seasonal reversal of wind pattern by the Arab scholars identified the causes of the reversal. He recognised that differential heating and cooling of land & water causes such reversal in the surface wind pattern. During winters, prevailing STH over Indian landmass facilitates offshore NE Trade winds generating drier conditions. During summers, the development of low pressure over Indian landmass results in the movement of SW Monsoons as on-shore winds causing precipitation. In his thermal concept, Hadley compared offshore

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* What is the cause of deflection ??

NE Trades to land breeze & onshore SW Monsoons to sea breeze. However, with the capacity of SW monsoonal winds to induce precipitation in the remote continental interior, their comparision with sea breeze was incorrect expression. It was in the concept of ITCZ propounded by Flohn that the first time recognition of SE Trade being SW Monsoons is correlated. Flohn emphasized that prevailing continentality of Northern Indian Ocean basin causes exceptional bends of ITCZ making it placed in northern plains of India. It is in the effect of this bend that SE Trade encroaches in northern hemisphere causing precipitation in coastal Somalia & Yemen as SE Monsoons. And it is approx. b/w 40° to 60° East longitudes that it gets deflected* to become SW Monsoons encroaching India and Indo-China peninsula. Flohn's concept not just identified the genesis of SW Monsoons but also explained absence of west margin climate in Indo-China & Indian peninsula.

MODERN APRROACH

The classical approaches of the monsoonal mechanism excellently facilitated the understanding of surface wind pattern correlating to monsoons. These approaches, however, lacked in the analysis of unpredictabidis of monsoonal mechanism. Suffering from the consecutive agricultural drought in the late 1960s, India initiated fresh studies of monsoonal mechanism as monsoon expedition (MONEX). The conclusions drawn by MONEX was formally published by mid 70s which added 2 important aspects to the established monsoonal

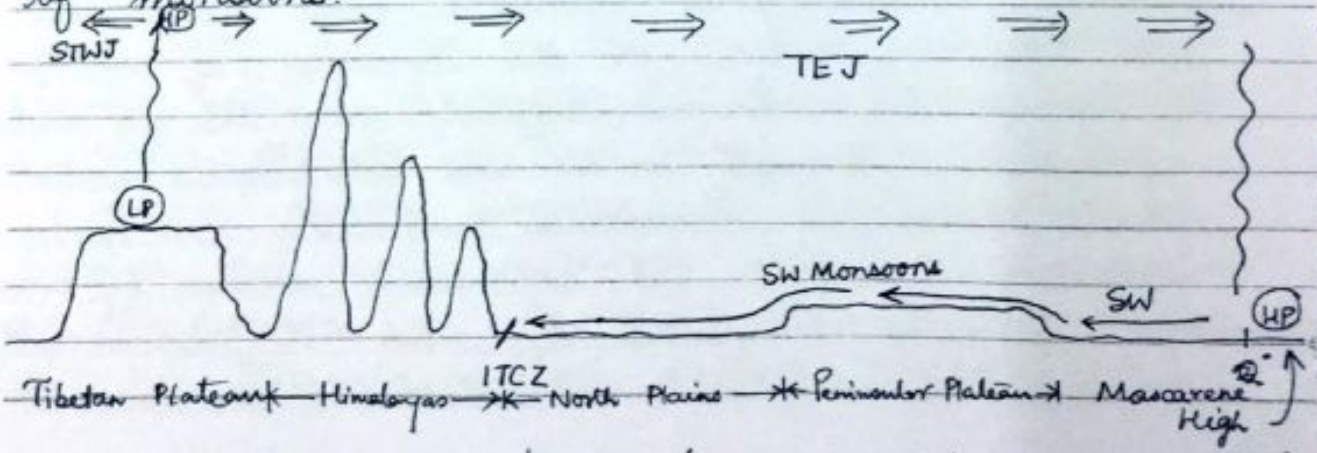
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studies :

Role played by Tibetan Plateau

Development of vortexes

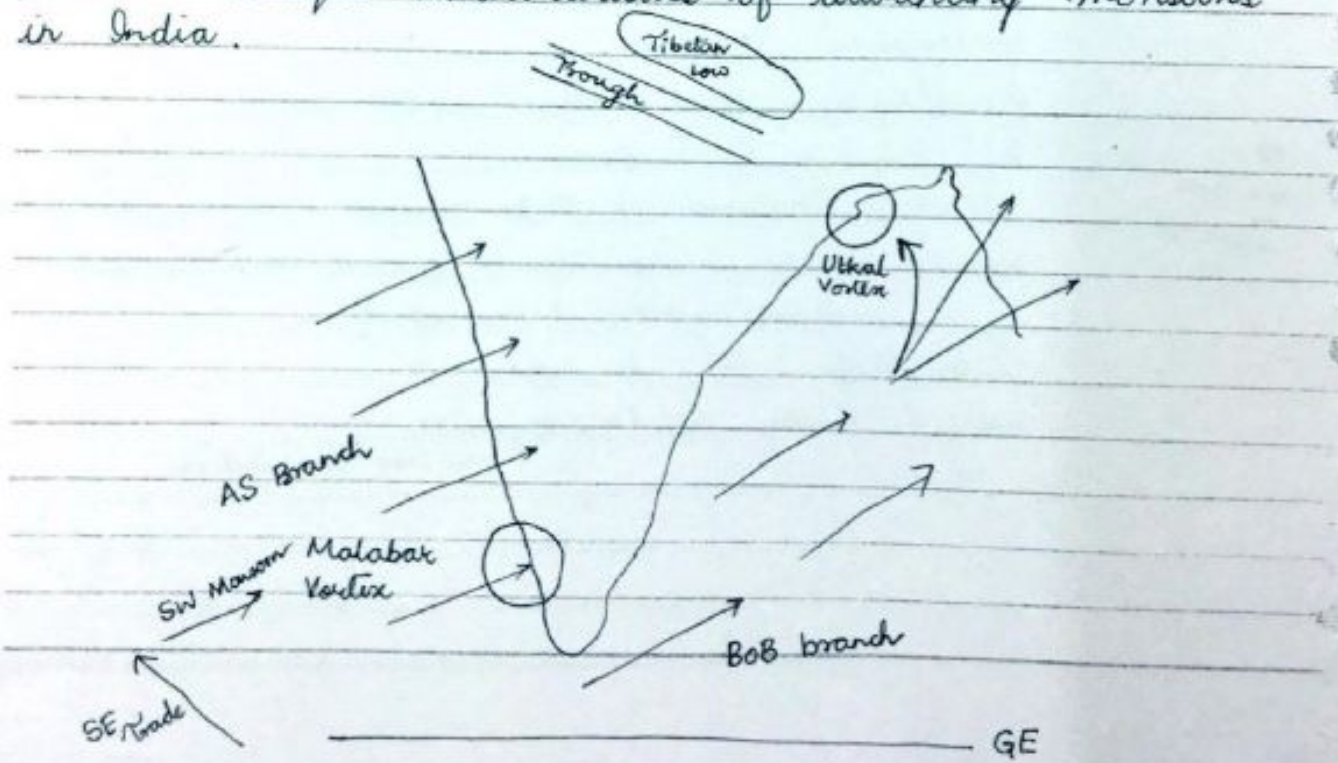
The role played by Tibetan Plateau practically represent upper air circulation in the monsoonal mechanism. In this analysis, it was concluded that exceptional bend of ITCZ resulting in to placing in northern plains of India makes the Tibetan Plateau generate low pressure marking the northern effective limit of low pressure on ground. In accordance, developed HP vertically over causes displacement of sub-tropical jet in Central Asia which makes the existing Hadley Cell getting modified with development of "Tropical Easterly Jet generating "N-S Alignment". It is this jet stream that not just mark the development of pressure gradient between Mascarene High and Tibetan Low but also maintains it for upto 4 months facilitating attraction of different branches of SE Trade as SW Monsoons. These different branches availed the expression for analysing periodicity of rain, unpredictability in amount of rain, variability in the onset or retreat of monsoons.



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VORTEX DEVELOPMENT :

Apparent shift of sun towards north readily generates -P over Indian landmass in terms of monsoonal trough as well as the Tibetan Low. Along with these developments, slow transition of the pressure profile in the water bodies is also experienced. In the effect of this transition, northern equatorial trough of Indian Ocean shifts towards north and continuously gets weakened. Encountering the Indian landmass, this LP trough also gets divided, which generates LP cells along the shoreline of India, recognised as Malabar Vortex and Utkal Vortex. The Malabar Vortex regulates the characteristics of advancing monsoons, that is first monsoonal showers experienced in Malabar coast and it is placing of Utkal Vortex that regulates encroachment of moisture-laden winds in Odisha Plains. Additionally, development of vortexes combined with monsoonal trough forms the cause of sudden beginning of monsoons, that is another unique characteristics of advancing monsoons in India.



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OCAL WINDS :

1) These are surface advection and thus represents gradient winds.
2) They are analysed in large scale perspective to interpret weather conditions of specific locations.
3) Commonly, local winds are categorised into 4 categories:
   (A) LAND & SEA BREEZES
   (B) KATABATIC & ANABATIC
   (C) DEPRESSION WINDS
   (D) DESCENDING WINDS

Land and Sea Breezes

These are typical to coastal areas with differential heating and cooling of land & water, with sea breeze effective during daytime & land breeze effective during night.

Katabatic and Anabatic Winds

The katabatic & anabatic winds are mountains & valley breezes respectively, representing differential heating & cooling of mountain wall & valley floors. The katabatic winds are typical to nights (air drainage) and anabatic winds are typical to daytime.

Depression Winds

These are categorised into temperature based categories which includes:

Depression
- (a) Cold & Dry with Polar Outbreaks
- (b) Warm with Dust Devils

(a) Cold Dry with polar outbreaks are typical to winter season, capable of extending cold polar conditions &

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significantly lower latitudes. These includes Blizzards, sourced from Canada, experienced in USA; as strongest example (no orographic barrier). Purgas, sourced from Siberia, experienced in China (with broken orographic barrier) with weaker polar outbreak and Pamperoes sourced from Antarctica experienced in Argentina; as weakest example (due to the intervening southern ocean).

(b) The warm winds with dust devils are typical to high sun seasons generated after dust devils. These are the strong winds generated due to sudden heating of sand which creates dusty environment with excessive supply of aerosols in the lower reaches of atmosphere. Dust devils, therefore, generates strong HP sourcing hot dry winds in the neighbouring areas. It is depending on the nature of prevailing conditions that induce weather effectivity are variable. Harmattan, the hot dry wind, experienced in Upper Guinea, decreases humidity levels converting oppressive weather favourable for human and livestock population. These are nick-named as doctor winds. Sirrocco are the hot dry winds that travelling via Mediterranean Sea attains significant amount of moisture causing precipitation in Southern European Islands and Peninsula; favourable winds as the region remains dry throughout summers. Khamsin experienced in coastal Libya and Egypt are hot dry winds that create health hazard, the heat stroke and thus, is the only unfavourable local wind correlating to dust devil (Indian 'Loo' belongs to some category).

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"Chinook" meaning "Snow Eater"

These are always subjected to adiabatic warming and thus are warm winds categorised into favourable and unfavourable categories. It includes Chinook (Canada), Foehn (Switzerland) sustaining commercial utilisation of cold frozen slopes of tall mountains; along with Shamoon (Iran), Santa Ana (California, USA) causing extreme dry and hot conditions which normally leads to forest fires, thus, unfavourable types.

"All katabatic winds are descending winds but not vice-versa".

Variable, active : Water Vapour ⇒ { Moisture → for troposphere; humidity → in specified air column

Evaporation → Condensation → Precipitation

ATMOSPHERIC MOISTURE

It is the fundamental element of weather and climate which is defined to be amount of water vapour present in troposphere. For the specific air column, it is humidity. that is the applied terminology to depote atmospheric moisture. This active variable constituent of atmosphere is sourced from the surface of the Earth by the process of evaporation. This process is defined by WMO as the process of converting water to gaseous state including the relative processes of transpiration and sublimation. Evaporation is a continuous process which varies in its rate. Determiners of rate of evaporation includes temperature of the air column and its humidity levels.

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Facebook Group: Indian Administrative Service (Raz Kr)

Climatologically, atmospheric humidity is correlated with two-out-of-three measures of humidity. These includes
(i) Absolute humidity (g/m^3)
(ii) Specific humidity (g/kg)
(iii) Relative humidity. (%)

The absolute humidity, not utilised for climatological purpose, is defined to be mass of water vapour per unit volume of air. This measure as correlates the humidity levels to highly dynamic air volume which changes with the minor change in the level of the air column do not support comparative global analysis.

The specific humidity in comparision is most applied method for the humidity levels of air masses. It is the measure of mass of water vapour per unit mass of air column. With ↑ in the sign of the latitude, ↓ temperature decreases moisture holding capacity, thus, specific humidity, with the warm wet equatorial air-mass depicting specific humidity of upto 8 g/kg whereas cold dry arctic air-mass has as low as 0.2 g/kg of specific humidity.

It is the most utilised method of humidity in climatological studies. It is the ratio of present amount of water vapour and carrying capacity of air at given temperature expressed in percentage. It is this measure that avails the distinction between unsaturated saturated and super-saturated air columns along with recognition of dew-point temperature.

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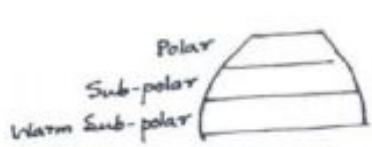
TEMPERATE CYCLONIC CIRCULATION

This low pressure system is also referred as extra-tropical cyclone or wave cyclone. It correlates to polar front of northern hemisphere that represents maximum contrast in converged air masses. In the effect of warm westerlies and cold polar winds, these cyclonic circulations regulates the precipitation mechanism of extensive latitudinal location i.e. from sub-tropics to sub-polar locations. This cyclonic circulation has 15 to 20 days of lifespan and is largely devoid of any type of turbulent weather mechanism. Analysis of temperate cyclonic circulations is attempted in context of polar front theory propounded by Jacob & Bjerkens. They outlined the life-cycle of temperate cyclonic circulation to be comprised of 6 stages :

(i) Stage of frontogenesis / Stable front
(ii) Division of stable front & beginning of cyclonic circulation
(iii) Quick shift of cold front
(iv) Closing down of warm sector
(v) Stage of occlusion
(vi) Stage of frontolysis / Front decay

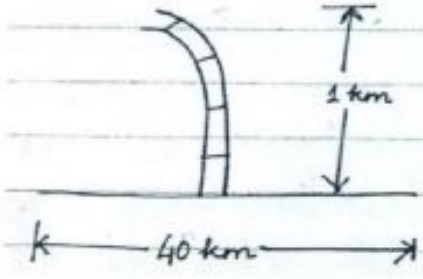
The stage of frontogenesis represents the convergence of contrasting air masses at near 60th parallel, In the influence of cold polar winds and warm westerlies, It is due to the contrast between the converged air masses that the front is maintained for a comparatively longer time which avails the possibility for the contrasting air masses to intrude in each other's domain. It is this intrusion process that leads to the division of stable front.

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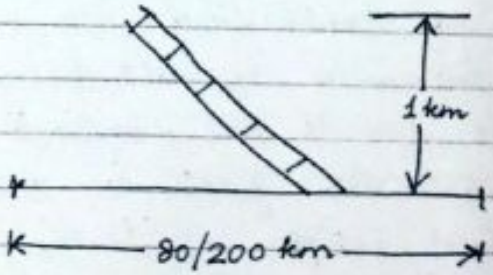
COLD FRONT

t is that part of stable
ront which is developed
ue to movement of cold
ir mass.
his front thus develops
the lower latitudes.
enser cold air mass as
lways maintains ground
ntact, it tends to push
eady unstable warmer
ir mass.
t is therefore that the cold
ont represents slight turbulent
eather conditions with abrupt
se.
: is also that the cold
ont thus have steeper profile
hich is normally 1:40 i.e.
km of vertical rise over
kms of horizontal expanse.



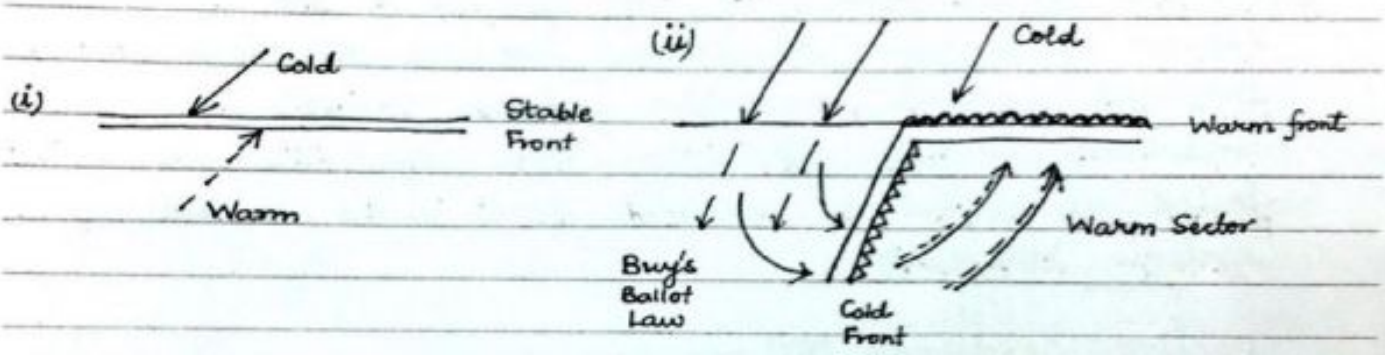
WARM FRONT

(1) It is that part of stable front which is developed due to movement of warm air mass.
(2) This front thus develop in the higher latitudes.
(3) Warm air mass registers gradual march over the ground lying cold air mass with complete absence of rush
(4) It is therefore that warm front weather represents absolute quiet precipitation mechanism
(5) It is also that the warm front thus have gentler profile which is in the normal range of 1:80 or 1:200

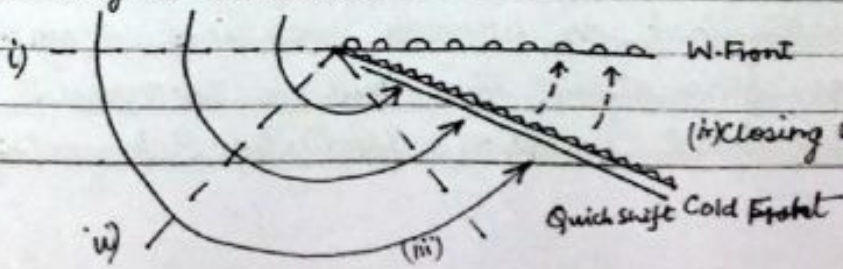


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The division of the fronts when is applied in specific reference to the warmer latitude, it represents increasing ground contact of the cold air mass resulting in simultaneous change in the pressure profile. Under the effect of polar winds, when cold air mass sufficiently intrudes in lower latitude, it encounters prevailing LP towards its left (Buy's Ballot Law), which results in the beginning of cyclonic circulation.



The beginning of cyclonic circulation paves way to transitional stages. As per the polar front theory, these includes quick shift of cold front and closing down of warm sector. Both these stages corresponds to each other as when the cold dense air swiftly continues to enlarge its ground occupancy, the warm air mass continuously loses out on the ground contact. These developments confined to the lower latitude is simultaneous to the continuous march of warm air mass over the cold in the higher latitude.



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The stage of occlusion represents cold air mass occupying complete geographical expanse of cyclonic circulation with warm air mass either pushed out or marched up. This stage, therefore, marks the beginning of frontal decay along with conclusion of wetter weather mechanism. This stage is followed on by the stage of frontolysis where the developed front gets terminated and cyclonic circulation come to an end. It is because similar characteristics air mass i.e. cold remains in contact with the ground in the entire expanse of cyclonic circulation. Evolving via these stages, temperate cyclonic circulation induces variable and important weather effectivities. These effectivities are interpreted in context of developed front in the sequence of cyclonic circulation:

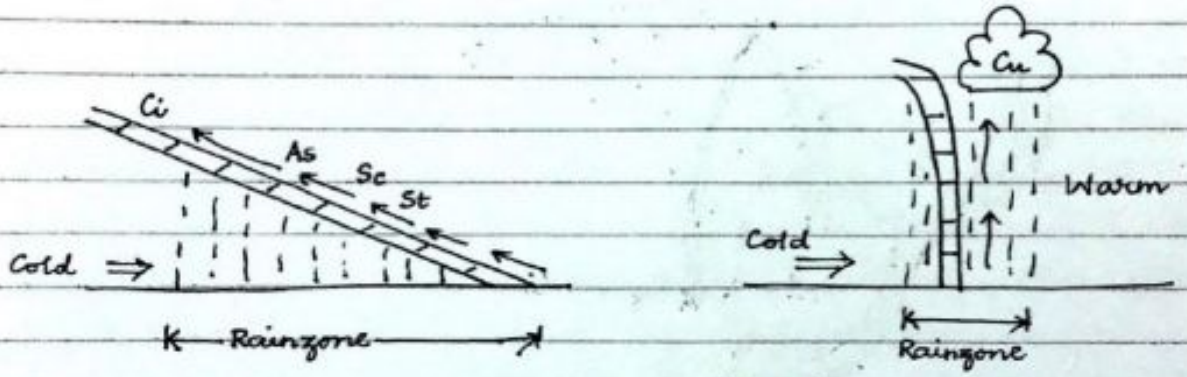
FRONTS DEVELOPED IN SEQUENCE

Stable front
Warm front
Cold front
Occluded front

The stable front weather is commonly recognised with quiet transitional weather conditions which depicts the beginning of the cyclonic circulation. The weather effectivities correlated to stable front includes short-lived temperature increase in the higher latitudinal margin with long-lived temperature decrease in the lower latitudinal or warmer margins. Moreover in lower latitudes, formation of dew is recognised to be most prominent weather effectivity representing stable front.

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The warm front weather experienced in higher latitude correlates to wetter weather conditions involving gradual march of warm air over cold air mass generating multi-altitudinal clouds, periodic precipitation relating to larger space and longer time. It is warm front weather that generates TAIGA (warm sub-polar) and TUNDRA (sub-polar) climatic regions restricting the polar deserts only in the frosted area. For taiga, ≤ 30 cms of annual precipitation, well distributed throughout the year and for tundra, 20 cms of annual precipitation confined only during summer relates to this front.



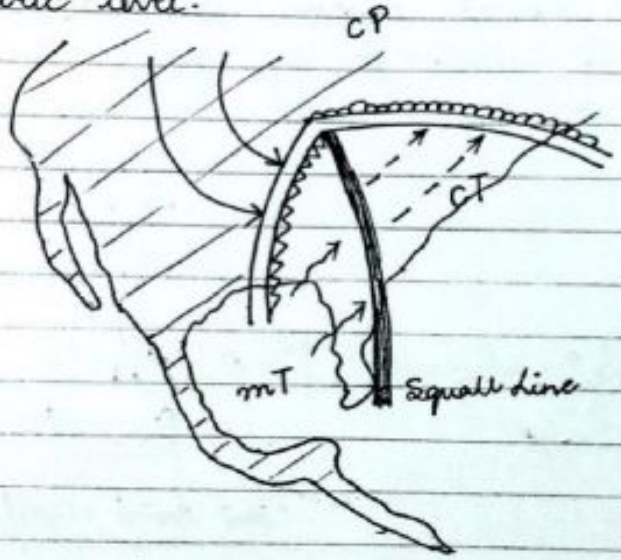
Warm Front Weather

Cold Front Weather

The cold front weather relating to lower latitudes also generates wetter weather conditions. However, unlike the warm front weather, it involves sudden rise one major episode of condensation with one major episode of precipitation resulting in formation of low altitudinal cloud, smaller rainzone and heavier precipitation for shorter duration. This weather effectivity adds to the many mechanism of precipitation in the lower latitude. Confined in the warm sector, specifically in USA, there is occasional development of

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additional front called SQUALL LINE, few kms ahead of cold front. This occasional development confined to the specific area represents turbulent-most mechanism of tornadoes depicting the immense thermal contrast developed between continental tropical air mass of USA and maritime tropical air mass of Gulf of Mexico due to polar outbreaks. Tornadoes represent combination of absolute and conditional instability, forming a LP funnel with its base on the ground and apex upto tropospheric level.



over latitude — ripe of warm air mass abrupt
light " — rise is gradual

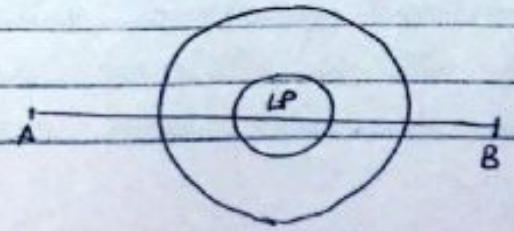
Occluded front weather: Develops similar wetter conditions in both the latitudinal location. This represents complete termination of ground contact of the warm air mass. Continuous moderate precipitation is recognised to be depicting the termination of the system with the effectivity remaining valid for 2 or 3 days.
Warm has lost ground contact.

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* TROPICAL CYCLONES

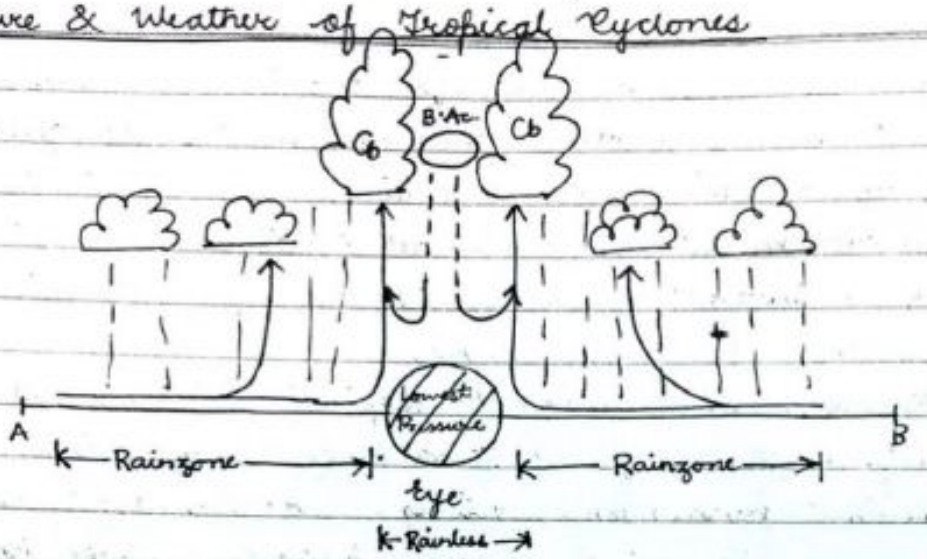
The thermal direct low pressure system of lower latitude that forms one of the determiners of precipitation pattern in the tropical east marginal climate is tropical cyclone. This LP system is also called tropical disturbances which involves intensity based categories called tropical storms, tropical cyclones and hurricanes.

Tropical storms are the weakest tropical disturbances with wind velocity in the range of 50-80 kmph representing weaker pressure gradient force. Comparatively stronger system is called tropical cyclone with wind velocity between 80-120 kmph. It is super-cyclones with wind velocity of more than 120 kmph to upto 200 kmph is called hurricanes. Locationally the requirement of tropical cyclones makes it restricted to limited geographical area. Requirement of temperature of 25-27°C, air pressure 920-940 milibars combined with moist air column makes this system confined to tropical marginal water bodies. In specific latitude, this represents 8° to 35° N and S. Absence of tropical cyclones in equatorial belt correlates to the absence of coriolis force along with absence of land-water difference. It is with coriolis effectively that this system registers counter-clockwise circulation in northern hemisphere and clockwise in southern hemisphere. Among the marginal water bodies where this system frequently evolves: Gulf of California and Gulf of Mexico (hurricanes); Bay of Bengal, Arabian Sea and Mozambique Channel (cyclones); South China Sea (Typhoon); Gulf of Carpentaria (Willy Willies) are included.



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Structure & Weather of Tropical Cyclones



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