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GEOGRAPHY

UNIT-I - GEOMORPHOLOGY

Origin of Universe:

The word Universe comes from the Old French word Univers, which comes from the Latin word universum. The Latin word was used by Cicero and later Latin authors in many of the same senses as the modern English word is used.

ORGIN OF EARTH

Two sets of theories about origin or earth: a. Catastrophic b. Evolutionary the catastrophic theories have hardly any evidence

- uniformitarianism supports evolutionary theories
- Nebular theory – Laplace
- Dust cloud Hypothesis – Weizsaker
- Nebular Hypothesis suggests that the matter which forms the Sun and the Planets originated as a disc shaped cloud of gas or nebula which eventually contracted into discrete bodies.

STRUCTURE OF THE EARTH

Earth has a layered structure

• Core

- **Mantle**
- **Crust**

The Nature of Seismic Waves

- The velocity of seismic waves depends on the density and elasticity of the intervening material. Seismic waves travel most rapidly in rigid materials.
- Within a given layer, the speed of seismic waves generally increases with depth because pressure increases and squeezes the rock into a more compact elastic material
- Compressional waves (P waves) travel through solids as well as liquids, because when compressed, these materials behave elastically. Shear waves (S waves) cannot travel through liquids because, unlike solids, liquids have no shear strength.
- In all materials P waves travel faster than S waves
- When seismic waves pass from one material to another, Based upon the seismological data, the earth has been divided into various layers.

CORE:

- 1/3rd of mass
- 1/6th of the earth's volume
- Pressure: millions of times that of atmospheric pressure at the surface.
- Temperature 4000oC - 5000oC
- Relative Density at the center 13.5 relative density.

INNER CORE

- Solid
- Predominantly Fe; also Nickel

OUTER CORE

It is in liquid form.

1. Addition of lighter elements, which when mixed with iron, lower its melting point.

2. In outer core, the pressure is comparatively lesser, to allow the hot iron to melt.

- There is a gradual flow of molten iron in the outer core and is very important for maintaining earth's magnetism.
- The core behaves like a self sustaining dynamo
- The driving forces- Earth's rotation and unequal distribution of heat in the earth's interiors

The existence of a liquid outer core when the inner core, which must be hotter, is solid. Most probably in its formative stage the entire core was liquid. Further, this liquid iron alloy was in a state of vigorous mixing . However, during the last 3.5 billion year's the material of the core has been slowly segregating.

As the core cooled, a portion of the iron components gradually migrated downward while some of the lighter components floated upward toward the outer edge of the core. The sinking iron rich components, depleted of the lighter elements which act to depress the melting point, began to solidity.

Interior of the Earth

EARTH'S INTERIOR

An understanding of the earth's interior is essential to follow the nature of changes going on over the earth's surface which are related to the deep laid internal forces operating from within the earth. This understating of the earth's interior is based mainly on indirect sources, because so far it has not been possible to have access to the inner levels of the earth's structure.

EVIDENCES ABOUT EARTH'S INTERIOR HIGH LEVELS OF TEMPERATURE AND PRESSURE DOWNWARDS

- The recurrent volcanic eruptions throwing out extremely hot, molten material from the earth's interior and the existence of hot springs, geysers etc. point to an interior which is very hot. Although the average rise in temperature from the surface downwards is 32oC per metre, this rise is not uniform throughout.
- In the upper 100 km the increase is estimate at 12oC per km, while it is 2oC per km in the next 300 km and 1oC per km after that.
- As per this calculation, the temperature is 2000oC at the earth's core.
- The high temperatures are attributed to the internal forces, automatic disintegration of the radioactive substances, chemical reaction and other sources.
- Although ideally the innermost part of the earth should be in a liquid or a gaseous state due to the high temperatures, yet, because the pressure also increases with depth, the core is a rigid mass.
- The layer enveloping the core is in a semi-solid ir plastic state.

2. BEHAVIOUR OF EARTHQUAKE WAVES

- The earthquake waves are measured with the help of a seismograph and are of three types-the ‘P’ waves or primary waves (longitudinal in nature), secondary waves or ‘S’ waves (transverse in nature) while the surface waves are long or ‘L’ waves.

- The velocity and direction of the earthquake waves undergo changes when the medium through which they are traveling changes.

- Thus, the velocity of P waves decreases towards the interior pointing to a less solid layer (a characteristic of longitudinal waves), but increase for a while when passing through the inner core only to a solid core surrounded by partially molten layer.

- Similarly, the S waves cannot pass through a liquid medium and are only transmitted through a rigid or solid medium. The S waves get defected while traveling inwards and come out at the earth’s surface. This again points to a molten, semi-solid layer below the crust and mantle. The L waves do not pass and do not go deeper inside the earth.

EVIDENCE FROM THE METEORITES :

The meteorites are solid bodies freely traveling in space which accidentally come under the sphere of influences of the earth’s gravity and as a result fall on earth (or collide with it). Their outer layer is burnt during their fall due to extreme friction and the inner core is exposed. The heavy material composition of their cores confirms the similar composition of eh inner core of the earth, as both evolved from the same star system in the remote past. From the above scientific evidence, a fairly convincing picture of the earth’s interior can be drawn.

A SECTIONAL PROFILE OF EARTH’S STRUCTURE

- The structure of the earth’s interior’s is layered, and broadly three layers can be identified – crust, mantle and the core. CRUST is the outer thin layer with a total thickness of around 100 km. it forms 0.5 per cent of the earth’s volume.
- The outer covering of the crust is of sedimentary material and below that be crystalline, igneous and metamorphic rocks which are acidic in nature.
- The lower layer of the crust consists CORE lies between 2900 km to 6400 km below the earth’s surface and accounts for 83 per cent of the earth’s volume.
- The central core has the heaviest mineral of highest density. It is composed of nickel and iron (ferrous)and is, therefore, called “nife”, while a zone of mixed heavy metals + silicates separated the core from outer layers.

Earth Movements

- Classification and Character of Forces and the Earth Movements Involved in Creation of Landforms 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:

- The heat generated by the radioactive elements in earth's interior Movements of the crustal plates due to tectogenesis. Forces generated by rotation of the earth.

Climate factors

Isostacy-according to this concept, 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)

ENDOGENETIC MOVEMETS

The interaction of matter and temperature generates these forces or movements inside the earth's. the earth movements are mainly of two types – diastrophism and the sudden movements.

1. DIASTROPHISM is the general term applied to slow bending, folding, warping and fracturing. 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 center. 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 nummulitic limestones 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 wer 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 Thiruvelveli, were all flourishing sea ports about 1,000 to 2,000 years ago.

- Evidence of marine fossils above sea level in parts of Britain in 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 Thirunveli and the Sunderbans is an example of subsidence.

- The Andamans and Nicobars have been isolate 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 Manner and Palk Strait is very shallow and has been submerged in geologically recent times. A part of the former town of Mahabalipuram near Chennai (Madras) is submerged in the sea

(ii) OROGENIC or the mountain-forming movement act tangentially to the earth surface, as in plate tectonics. Tension 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 recognise.

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 span of time, and may be of two types.

(i) EARTGQUAKE:

- 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 or subsidence. For instance, an earthquake in Chile (1822) caused aone-metre uplift in coastal areas.
- Another earthquake in New Zealand (1885) caused an uplift of upon 3 metre in some areas while some areas in Japan (1891) subsided by metres after an earthquake.
- Earthquake 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), landslines, soil creeps, mass wasting etc.

(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 sulphide, sulphur dioxide, hydrogen chloride, carbon dioxide etc.) and pyroclastic material.
- Depending on chemical composition and viscosity of the lava, a volcano may take various forms. Conical or Central When cooled lava particles from successive vulcanite eruptions form a cone around the vent, a conical mountain shape emerges.
- This is a central type of volcano. Example: Fujiyama (Japan) and Mount Vesuvius (Italy). The magma in such volcanoes is viscous, acidic and silicate.
- Shield Type The less viscous, less acidic and less silicate magma flows out slowly and quietly and gives rise to a wide based plateau-like formation with a gentle slope. Thus a "shield shaped" volcano with thin horizontal sheets emerges.
- **Example:** Mauna Loa (Hawaii) Fissure Type Sometimes, a very thin magma escape through cracks and fissures in the earth's surface and flows after intervals for a long time, spreading over a vast area, finally producing a layered, undulating, flat surface.
- **Example:** Deccan traps (peninsula India) Caldera Lake After the eruption of magma has ceased, the crater frequently turns into a lake at a later time. This lake is called a "caldera".
- **Example:** Lonar in Maharashtra and Krakatao in Indonesia. Volcanic Landforms These are large rock masses formed due to cooling down and solidification of hot magma inside the earth.
- Batholiths form the core of huge mountains and may be exposed on surface after erosion. Batholiths Laccoliths Dykes silla 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 crave out and shape the landscape. (The distinctive features created by some of these agents are discussed in detail under relevant topics, later in the chapter.)

- Erosion is a mobile 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.

- **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.

GRANULAR DISINTEGRATION

Rocks composed of coarse mineral grains commonly fall apart grain by grain or undergo granular disintegration.

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 temperatures.

BLOCK SEPATATION:

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.

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.

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 massive rocks.

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: 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 34o Earthflow 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 earthflow.
- 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.
- Soil Creep This is the 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 procees), 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 gragments of larger size may accumulate at the mountain base to produce a boulder field.
- Mudflow In regions with sparse vegetation to check the flow or 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.

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.

Prominent examples of products of physical weathering in India include granite blocks near Jabalpur in Madhya Pradesh, the granite domes of Mahabalipuram-especially Krishna's butter ball", dolerite blocks in Singhbhum district of Bihar and frosting action in the Himalayam rocks

2. CHEMICAL WEATHERING:

- This causes rocks to decay i.e. to decompose instead of disintegrating.
- The minerals 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, hudrogen, 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.

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.

CHLORANATION:

- It takes place when chloride salts are formed as a result of chemical reaction.

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

HYDRATION:

- The chemical of water detaches the outer shell of aluminium-bearing rocks through the process of hydration.

DESILICATION:

- Removal of silica from rocks also leads to their weakening and eventual disintegration due to desilication

SOLUTION:

Some minerals, such as rock-salt and gypsum are removed by the process of solution in water. This chemical reaction of rain water brings about decomposition of minerals more rapidly than its mechanical action. The chemical weathering is capable of breaking up even a hard crystalline rock into minute particles.

BIOLOGICAL WEATHERING:

- This refers to disintegration, break up and decomposition of rock masses by plants, animals and activities of man.
- Plant roots penetrate the cracks in rocks or at the rock base and dislodge large blocks from the cliffs. Roots may also cause break up of the rock.
- The burrowing by earthworms, ant, rats and the like make channel through the rock and contribute to their destruction.
- The excretion of many of these animals provide acids that bring about a gradual decay of the rock. Many activities of man, such as mining, quarrying, deforestation and unscientific agriculture practices (like shifting cultivation) etc. add to the weathering of rocks.
- Biological weathering may be physical or chemical in nature.

EFFETS OF WEATHERING:

- Weathering and erosion tend to level down the irregularities of landforms and create a peneplane. Weathering may cause visibly identifiable change in the general landscape.
- A general darkening of rocks, especially in dry climates due to chemical action, creates desert varnish and patination which basically involves changes in rockskin without change in the volume.
- The strong wind erosion leaves behind whale-back shaped rocks in arid landscape.
- These are called inselberg or ruware. Sometimes a solid layer of chemical residue covers a soft rock, through a process known as rind or case hardening.
- The hollowing action of weathering produces weathering pans or pits, which are also known as gnamma or taffoni. Sometimes, differential weathering of soft strate exposes the domelike hard rock masses, called tors.
- Tops are a common feature of South Indian landscape.

STRUCTURE OF THE EARTH

The earth's surface is being continuously reshaped by both the endogenic forces (internal) and exogenic forces (external). The changes brought about by these processes are known as 'geomorphic processes'.

- Diastrophism is the process by which the earth's surface is reshaped through rock movements and displacements. This includes both orogenic (mountain building) and epeirogenic processes (continental forming).

Earth's interior can be divided into the crust, upper mantle, lower mantle, outer core and inner core. The temperature increases as we move from the crust to the core, generally the temperature increases by 1℃ for every 32 m towards the interior of the earth.

CRUST

- It is the outermost solid part of the earth.
- The crust is further divided into upper crust (continental crust) composed of silica and aluminium (sial) and lower crust (oceanic crust) made up of silica and magnesium (sima). The boundary between the upper crust and the lower crust is called the "Conorod boundary".
- The thickness of the crust varies under the oceanic and continental areas. Continental crust is thicker as compared to the oceanic crust. The mean thickness of the continental crust is about 32 km whereas that of oceanic crust is 5 km. The continental crust is thicker in the areas of major mountain systems. It is about 70 km in the Himalayan region.
- The density of the crust is less than 2.7g/ cm^3.
- 80% of the earth's volume is contained within the mantle.
- Mantle is described as a solid rocky layer, and the most common rock is peridotite
- Peridotite – ultra basic rock, consisting largely of olivine, hence its predominantly dark green colour (olivine – silicate of magnesium mg2SiO4 to silicates of iron Fe2SiO4).
- The crust increases its temperature with depth, but this trend does not continue downward into the mantle. This means mantle has an effective method to transmit heat outward i.e., some form of convection.

- Material in this zone exhibit plastic behaviour, i.e., when the material encounters short lived stresses, such as seismic waves, the material behaves like an elastic solid. However, in response to long term stresses, this same rocky material will flow.
- So S waves can penetrate through mantle, yet, this layer is not able to store elastic energy like a brittle solid and is thus incapable of generating earthquakes.

MANTLE

- The portion of the earth beyond the crust is called the mantle. It is made up of magnesium, silica and iron. It extends to a depth of about 2900 km.
- The mantle is divided into upper mantle and lower mantle. The upper portion of the mantle is called the asthenosphere. The word "astheno" means weak. Asthenosphere extends up to 400 km and is the main source of magma which comes over to the surface during volcanic eruptions.
- The boundary which divides the lower crust and the upper mantle is called the "Mohorovicic".
- Its density is 3.9g/ cm^3.
- The crust and the uppermost part of the mantle is called lithosphere. Its thickness ranges from 10 – 200 km.

CORE

- The core is composed of heavy material mainly iron and nickel which is called NiFe (Barysphere).
- It forms the centre of the earth and its density is 13g/ cm^3.
- The outer core is in liquid state and the inner core is in solid state.
- The temperature of the core ranges between 5500℃ – 6000℃.
- Guttenberg margin is the boundary between the lower mantle and the outer core. The Lehmann boundary separates the outer core and the inner core.
- The core extends from 2900 km to 6378 km from the surface of the earth.

INTERNAL STRUCTURE OF THE EARTH:

CRUST:

- It is the outermost solid part of the earth, normally about 8-40 kms thick.

- It is brittle in nature.
- Nearly 1% of the earth's volume and 0.5% of earth's mass are made of the crust.
- The thickness of the crust under the oceanic and continental areas are different. Oceanic crust is thinner (about 5kms) as compared to the continental crust (about 30kms).
- Major constituent elements of crust are Silica (Si) and Aluminium (Al) and thus, it is often termed as SIAL(Sometimes SIAL is used to refer Lithosphere, which is the region comprising the crust and uppermost solid mantle, also).
- The mean density of the materials in the crust is 3g/cm3.
- The discontinuity between the hydrosphere and crust is termed as the Conrad Discontinuity.
- The discontinuity between the upper mantle and the lower mantle is known as Repetti Discontinuity.
- The portion of the mantle which is just below the lithosphere and asthenosphere, but above the core is called as Mesosphere.

MANTLE:

- The portion of the interior beyond the crust is called as **the mantle.**
- The discontinuity between the crust and mantle is called as the Mohorovich Discontinuity or Moho discontinuity.
- The mantle is about **2900kms in thickness.**
- Nearly 84% of the earth's volume and 67% of the earth's mass is occupied by the mantle.
- The major constituent elements of the mantle are Silicon and Magnesium and hence it is also termed as SIMA.
- The density of the layer is higher than the crust and varies from **3.3 – 5.4g/cm3.**
- The uppermost solid part of the mantle and the entire crust constitute theLithosphere.
- The asthenosphere **(in between 80-200km)** is a highly viscous, mechanically weak and ductile, deforming region of the upper mantle which lies just below the lithosphere.
- The asthenosphere is the main source of magma and it is the layer over which the lithospheric plates/ continental plates move **(plate tectonics).**
- The discontinuity between the upper core and the lower core is called as **Lehmann Discontinuity.**
- Barysphere is sometimes used to refer the core of the earth or sometimes the wholeinterior.

CORE

- It is the innermost layer surrounding the **earth's centre.**
- The core is separated from the mantle by **Guttenberg's Discontinuity.**
- It is composed mainly of iron (Fe) and nickel (Ni) and hence it is also called as **NIFE**.
- The core constitutes nearly 15% of earth's volume and **32.5% of earth's mass.**
- The core is the densest layer of the earth with its density ranges between **9.5- 14.5g/cm3.**
- The Core consists of two sub-layers: the inner core and the outer core.
- The inner core is in solid state and the outer core is in **the liquid state (or semiliquid).**

TEMPERATURE, PRESSURE AND DENSITY OF THE EARTH'S INTERIOR:

Temperature:

- A rise in temperature with increase in depth is observed in mines and deep wells.
- These evidence along with molten lava erupted from the earth's interior supports that the temperature increases towards the centre of the earth.
- The different observations show that the rate of increase of temperature is not uniform from the surface towards the earth's centre. It is faster at some places and slower at other places.
- In the beginning, this rate of increase of temperature is at an average rate of **1 0C for every 32m increase in depth.**
- While in the upper 100kms, the increase in temperature is at the rate of **120C per km and in the next 300kms, it is 200C per km.** But going further deep, this rate reduces to mere 100C per km.
- Thus, it is assumed that the rate of increase of temperature beneath the surface is decreasing towards the centre (do not confuse rate of increase of temperature with increase of temperature. Temperature is always increasing from the earth's surface towards the centre).
- The temperature at the centre is estimated to lie somewhere between **30000C** and **50000C**, may be that much higher due to the chemical reactions under high-pressure conditions.
- Even in such a high temperature also, the materials at the centre of the earth are in solid state because

of the heavy pressure of the overlying materials. Pressure

- Just like the temperature, the pressure is also increasing from the surface towards the centre of the earth.
- It is due to the huge weight of the overlying materials like rocks.
- It is estimated that in the deeper portions, the pressure is tremendously high which will be **nearly 3 to 4 million times** more than the pressure of the atmosphere at sea level.
- At high temperature, the materials beneath will melt towards the centre part of the earth but due to heavy pressure, these molten materials acquire the properties of a solid and are probably in a plastic state.

ASTHENOSPHERE

- Asthenosphere is located between **100 to 400 kms.**
- P and S waves show a marked decrease in velocity one. The most probable explanation for the observed slowing of seismic energy is that this zone contains a small percentage of melt.
- But Asthenosphere is not continuous and is absent below the older shield areas. The asthenospher is the layer of Earth that lies at a **depth 100 – 400 km** beneath **Earth's surface.**
- It was first named in **1914 by the British geologist J. Barrel,** who divided Earth's overall structure into three major sections: the lithosphere, or outer layer of rock like material; the asthenosphere; and the centrosphere, or central part of the planet.
- The asthenosphere gets its name from the Greek world for weak, asthenis, because of the relatively fragile nature of the materials of which it is made. It lies in the upper portion of Earth's structure traditionally known as the mantle. The material of which the asthenosphere is composed can be described as plastic-like, with much less rigidity than the lithosphere above it. This property is caused by the interaction of temperature and pressure on asthenospheric materials.
- Any rock will melt if its temperature is raised to a high enough temperature. However, the melting point of any rock is also a function of the pressure exerted on the rock. In general, as the pressure is increased on a material, its melting point increases.

- The temperature of the materials that makeup the asthenosphere tends to be just below their melting point. This gives them a plastic-like quality that can be **11 compared to glass**. As the temperature of the matericompared to glass.
- As the temperature of the material increases or as the pressure exerted on the material increases, the material tends to deform and flow. If the pressure on the material is sharply reduced, so will be its melting point, and the material may begin to melt quickly.
- The fragile melting point pressure balance in the asthenosphere is reflected in the estimate made by some geologists that up to 10% of the asthenospheric material may actually be molten.
- The rest is so close to being molten that relatively modest changes in pressure or temperature may cause further melting. In addition to loss of pressure on the asthenosphere, another factor that can bring about melting is an increase in temperature.
- The asthenosphere is heated by contact with hot materials that make up the rest of the mantle beneath it. In order for plate tectonic theory to seem sensible, some mechanism must be available for permitting the flow of plate.
- That mechanism is the semi-fluid character of the asthenosphere itself. Some observers have described the asthenosphere as the lubricating oil that permits the movement of plates in the lithosphere.

INNER OUTER MANTLE

- After about **400 kms,** the velocity of seismic waves increases as a result of phase change.
- A phase change occurs when the crystalline structure of a mineral changes in response to change in temperature and pressure.
- The mineral **olivine (Mg,Fe)SiO4** , which is one of the main constituents of the rock peridotite, will collapse to a more compact high pressure mineral – spinel.
- This structural change to a denser crystal form could explain the increased seismic velocities observed.

INNER MANTLE

- Another boundary at a depth of around 700 kms because, mineral Spinel, undergoes transformation to the mineral **Perovskite (Mg,Fe)SiO4 ,**

- Since Perovskite is the predominant mineral of lower mantle, it is the most abundant mineral in the earth.

LITHOSPHERE

- Situated above the asthenosphere is the cool brittle layer about 100km thick called the lithosphere
- Lithosphere included the entire crust as well as the uppermost mantle and is defined as the layer of the earth cool enough to behave like a brittle solid.
- But it is not a single layer. A density discontinuity is there in the lithosphere. It is broken/fractured along several lines. The different segments are known as plates.
- So plates are essentially lithospheric plates are capable of sliding or, moving over the plastic asthenosphere. Thus plates move from one point to another.

THE EARTH'S MAGNETIC FIELD:

- Anyone who has used a compass to find direction knows that the earth's magnetic field has a north pole and a south pole.
- In many respects our planet's magnetic field resembles that produced by a simple bar magnet. Invisible lines of force pass through the earth and out into space while extending from one pole to the other.
- A compass needle, itself a small magnet free to move about, becomes aligned with these lines of force and points toward the magnetic poles.
- It should be noted that the earth's magnetic poles do not coincide exactly with the geographic poles. The north magnetic pole is located in **northeastern Canada, near Hudson Bay**, while the south magnetic pole is located near Antarctica in the Indian Ocean south of Australia.

CONTINETAL DRIFT :

- Early in the **20th century Geologic** thought was dominated by a belief in the antiquity and Geographic permanence of oceans and continents, mountains were thought to result from Earth's cooling and contraction and were compared to the wrinkles on a dried out piece of fruit, changes in sea level and occurrence of fossils at depth were explained using the contraction model.

- ♣ Dramatic changes have taken place over the past few decades.
- ♣ Earth Scientists now realize the non-permanence of landmasses and ocean basins, creation and continued destruction of crust.
- ♣ This profound reversal of scientific opinion was termed as scientific revolution.
- ♣ An appreciable length of time elapsed between the inception of the idea and its general acceptance.
- ♣ After heated debates the idea of drifting continents was rejected, only to be resurrected during the 1960's.

DENSITY

- ❖ Due to increase in pressure and presence of heavier materials like Nickel and Iron towards the centre, the density of earth's layers also gets on increasing towards the centre.

- ❖ The average density of the layers gets on increasing from crust to core and it is nearly 14.5g/cm3 at the very centre.

Geomorphic Process - Concept

♣ The Geomorphic process is the result of factors such as endogenic and exogenic that generate physical stress and chemical reactions on the earth's substance, as well as changes in the configuration of the earth's surface.

♣ Diastrophism and volcanism are examples of endogenic processes, whereas weathering, mass wasting, erosion, and deposition are examples of exogenic processes.

♣ Exogenic materials in nature have the power to transfer earth material, that is why they are referred to as **Geomorphic agents**. When these elements are mobile due to gradients, they can remove materials, transport them over slopes, and deposit them at a lower level.

♣ These movements occur as a result of gradients, which always occur from higher to lower levels or from high to low-pressure zones.

♣ Some of the **geomorphic agents are** Groundwater; Glaciers; Winds; Waves; Currents and Running water.

♣ **Gravitational stress** is valued equally to other geomorphic processes. The force of gravity keeps us in contact with the surface, and it is also the force that causes all surface material on Earth to move.

TO BE CONTINUED…..