FUNDAMENTALS OF PHYSICAL GEOGRAPHY

UNIT-2 EARTH INTERIOR, ISOSTASY (Part-2)

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COURSE OUTLINE

2.6 EVIDENCES OF THE EARTH'S INTERIOR

- Sources through, which the knowledge about the mystery of the earth's interior of the earth may be classified into 3 group's i.e.

  1-Artificial Sources

  2- Evidences from the theories of the origin of the earth

  3- Natural Sources

Artificial Sources of the Earth's interior:

- Number of interferences can be drawn about the constitution of the interior of the earth on the basis of rocks density, pressure of super incumbent load and increase trend of temperature along earth's inside increasing depth.
- The studies by satellites have revealed that following results about the density of various parts of the earth.
- Sedimentary rock is a material of which the outer part of the earth is composed of as a belief and the thickness of which ranges between 0.8 km to 1.6 km.
- Just down this sedimentary layer of crystalline rocks, the range of density is between 3.0 km to 3.5 km at different places.
- The average density of whole of the earth is near about 5.5.
- Finally, 11.0 km is the density of the core of the earth is nearly.
- It is evident on the basis of information available from the findings of bore holes and deep mining that temperature increased from surface of the earth downward at the rate of 2◦ to 3◦C for 100 metres.

- Facts may be presented about the thermal condition of the interior of the earth are:

  (1) The asthenosphere is molten partially. The temperature is around 1100◦C at the depth of 100 km which is nearer to initial melting point.

  (2) The depths temperature of 400 km to 700 km has been estimated to be 1,500◦C and 1,900◦C respectively.

  (3) Temperature at the junction of mantle and outer molten core standing at the depth of 2,900 km is about 3700◦C.

  (4) Temperature at the junction of outer molten core and inner solid core standing at the depth of 5,100 km is 4,300◦C.

Evidences from the theories of the origin of the earth, of the Earth's interior:

- Different hypotheses and theories of the origin of the earth have assumed that the original form of the earth is to be solid or liquid or gaseous.
- Laplace's 'Nebular Hypothesis', 'Tidal Hypothesis' and 'Planetesimal Hypothesis' are some examples of these theories.
- We learned these theories in previous ppt.

Natural Sources of the Earth's interior:

- The natural evidences of the earth's interior are volcanic eruption, earth quake and seismology.
- Science which studies various aspects of seismic waves generated during the earthquakes occurrence is seismology.
- The different types of waves generated during the occurrence of an earthquake are called seismic waves. They are:
- 1-Primary waves
- 2-Secondary waves
- 3- Surface waves

- The primary waves are also popularly known as longitudinal or compression waves or simply ‘P’ waves are parallel to sound waves in which particles move both to and fro in the line of the propagation of the ray. Through solid materials it travels in fastest speed. As passing by liquid material speed get’s slow down.
- Transverse or distortional or simply S waves are secondary waves. Transverse waves cannot pass through liquid materials.
- Long Period waves or simply L wave’s are different names of surface waves. Of all seismic waves these waves cover longest distances. Though their speed is lower than P and S waves but these are most violent and destructive.

2.7 CHEMICAL COMPOSITION AND LAYERING SYSTEM OF THE EARTH

- E.Suess, has thrown light on the chemical composition of the earth's interior.
- 3 zones of different matter below the outer thin sedimentary cover have been identified by E.Suess.

1-SIAL: SIAL located just below the outer sedimentary cover. It is composed of granites. Silica and aluminium (SI+AL=SIAL) dominates this layer. 2.9 is average density of this layer whereas the range of thickness is between 50 km to 300 km. Acid materials and a silicate of potassium dominates this layer. Sodium and aluminium are found in excessive amount. Sialic layer formed Continents.

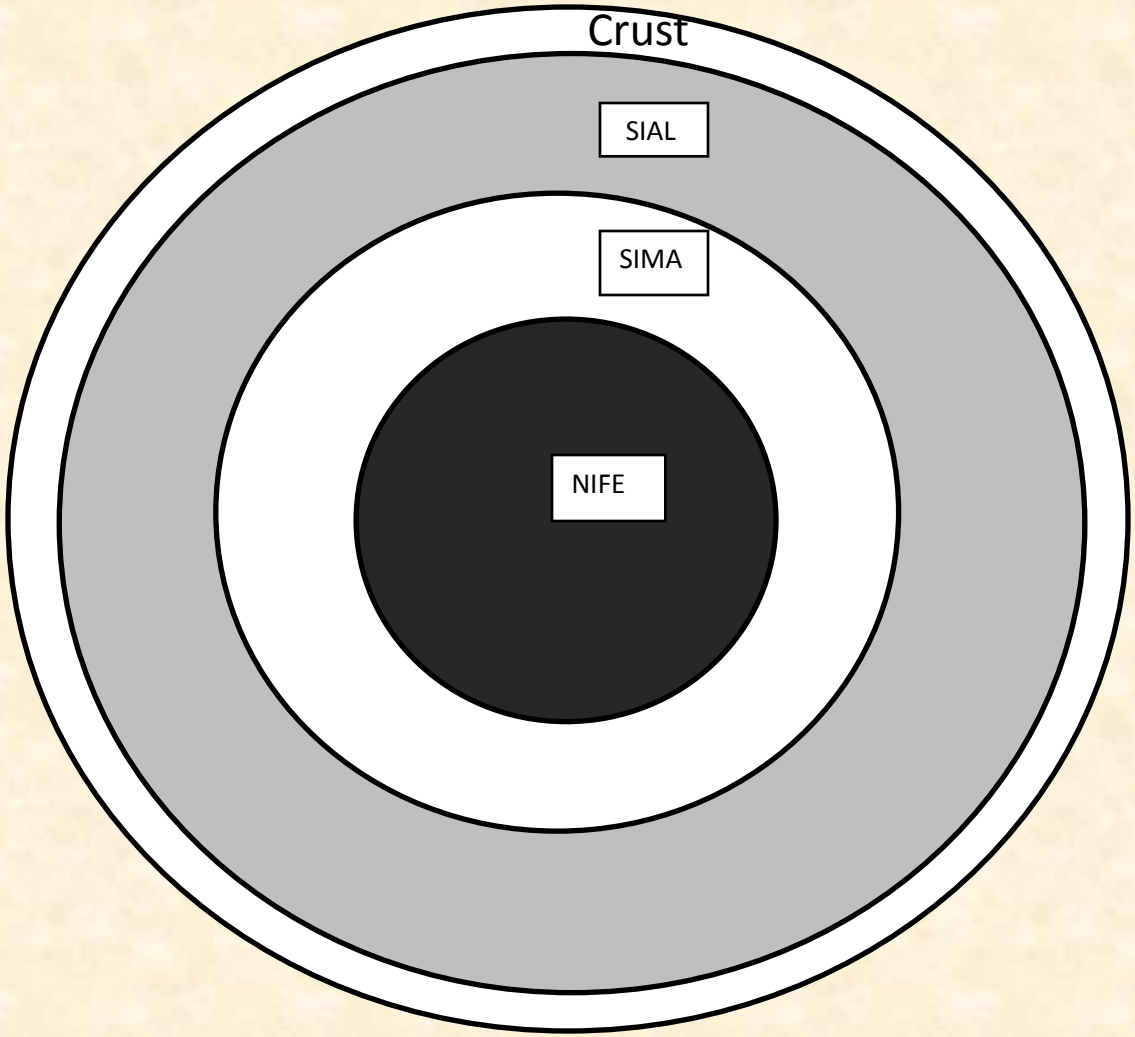
2-SIMA is just located below the sialic layer. SIMA is composed of basalt and is the source of magma and lava during volcanic eruptions. (SI+MA=SIMA) Silica and magnesium are the dominant constituents. Between 2.9 to 4.7 the average density ranges. Thickness varies from 1,000 km to 2,000 km. Basic matter is in plenty amount. Silicates of magnesium, iron and calcium are found richly.

3-NIFE is located below the 'sima' layer. (NI+FE = NIFE) is the composition of this layer.

Ni= nickel

Fe=ferrium

- This layer is formed from heavy metals. It is responsible for very high density (11) of this layer. 6880 km is the diameter of this zone. The presence of iron (ferrium) indicates the magnetic property of the earth's interior. Rigidity of the earth is also indicated by this property.



The layers of earth's interior

Source: Google

2.8 THICKNESS OF THE LAYERS

- There are 3 different layering system of the earth's interior and is commonly accepted by scientists in majority.
- Lithosphere is the first one with a thickness about 100 km is mostly composed of granites. Silica and aluminium are dominant constituents in this layer. 3.5 is the average density of this layer.
- Pyrosphere is the second one and stretches for a thickness of 2780mkm having 5.6 as an average density. Basalt is the dominant rock of this layer.
- Barysphere is the final layer and is composed of iron and nickel. Between 8 to 11the average density ranges and this layer gives from 2800 km to the nucleus of the core.

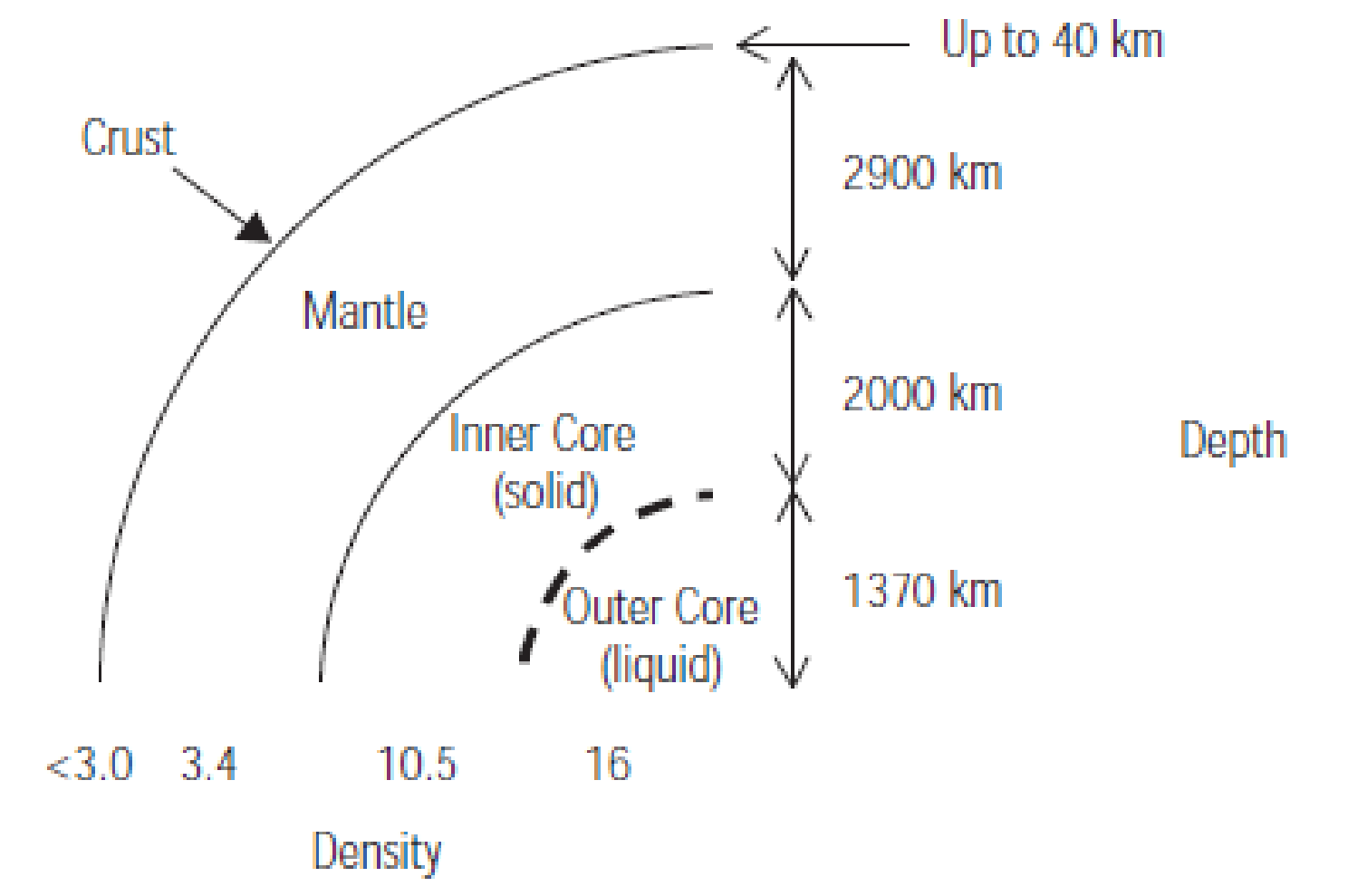
2.9 MODERN VIEW

Crust

- The solid outer layer of the Earth is called crust. In relative terms, crust is equivalent to the skin of an apple. Usually its depth is never more than 1 per cent of the Earth's radius, or an average 40–50 km, but around the globe this varies considerably.
- Two different types of crust:

  1-Continental

  2-Oceanic crust
- 'Moho' or Mohovoriãiç discontinuity is the boundary between the crust and the mantle. At this point, shockwaves initiate to travel faster, indicating a structure change.



The Structure of earth's interior

Source: Google

Mantle

- This zone ranges 25 to 70 km below the surface within the Earth's interior to a depth of 2,900 km.
- It is mainly composed of silicate rocks, rich in magnesium and iron.
- Mantle has two types; upper and lower mantle.
- In a semi-molten state the lower mantle remains, apart from the rigid top layer.
- At the mantles, temperatures may reach up to 5,000°C.
- High temperatures help to generate convection currents which drive plate tectonics.
- Weichert-Gutenberg discontinuity at the depth of 2900 km is the boundary between the mantle and core.

Core

- It is composed of iron and nickel and is the very centre of the Earth.
- It consists outer core and inner core.
- Temperature at the very centre of the Earth (6,300 km below surface) may reach 5,500°C.
- 10.5 are the density of the outer core and up to 16 is inner core.

2.10 CLASSIFICATION OF ROCKS

- Rocks are classified in to several types. Like mode of formation, physical and chemical properties, locations etc. Mainly rocks are divided into three broad categories on the basis of their mode of composition or formation. They are:
- Igneous rocks
- Sedimentary Rocks
- Metamorphic rocks

Igneous rocks

- Its forms due to cooling, crystallization and solidification of molten earth materials. It's known as magma and lava e.g. basalt, granites etc. The magma is in the below the earth's surface. And lava is on surface of the earth.
- Igneous rocks are knows as primary rocks. Because these were originated first of all the rocks during the formation of upper crust of the earth on cooling, solidification and crystallization of hot and liquid magmas, after the origin of the earth.
- All the subsequent rocks formed, whether directly or indirectly, from the igneous rocks in one way or the other. This is the reason igneous rocks have another name as parent rocks.

Characteristics of Igneous rocks:

- In all rocks, the igneous rocks are roughly hard rocks and with great difficulty along the joints they are water penetrates also.
- It is crystalline or granular rocks. There are size variations, form and texture of grains because these properties depend largely upon the rate and place of cooling and solidification of lavas and magmas.

Types of Igneous rocks:

- On the basis of the mode of occurrence the igneous rocks are classified into two major groups:
- Intrusive igneous rocks
- Extrusive igneous rocks

Sedimentary rocks

- Due to aggregation and compaction of sediments the sedimentary rocks are formed. They are also called as stratified or layered rocks. Sedimentary rocks have different layers or strata of different types of sediments.
- The sediments and debris derived through the decomposition and disintegration of the rocks by the agents of weathering and erosion are gradually deposited in water bodies.
- The sedimentation going on continuous increases the weight and pressure and thus different layers are consolidated & compacted to form of sedimentary rocks.
- Most of sedimentary rocks are deposited due to continuous deposition of sediments in water bodies. Just like ponds, lakes, seas, basins and land surface like loess, rocks of sand dunes, alluvial fans and cones.

Sedimentary rocks characteristics:

- Sediments derived from the older rocks, plant & animal remains forms sedimentary rocks. These rocks contain fossils of plants and animals.
- The rocks are found over the largest surface area of the globe.

  1-Sedimentary rocks may be well consolidated.

  2-Sedimentary rocks may be poorly consolidated and even.

  3-Sedimentary rocks may be unconsolidated.
- By different sizes of joints sedimentary rocks are characterised.
- Bedding plane is the connecting plane between two consecutive beds or layers of sedimentary rocks.
- Cracks generally of polygonal shapes developed as soft mud.
- Alluvia deposited by the rivers during flood period.

Sedimentary rocks classification:

- On the basis of the nature of sediments are classified into 3 parts:

  1-Mechanically formed that is Clay rock, Shale and Loess, Sandstones, Conglomerates.

  2-Sedimentary rocks that are chemically formed they are Gypsum and salt rock

  3-Organically formed sedimentary rocks are Lime stones, Dolomites, Coals and Peats.

- On the basis of transporting agents, it has been classified into three types:

  1-Argillaceous rocks that is Marine rocks, Lacustrine rocks and Riverine rocks

  2-Aeolian Sedimentary Rocks that is Loess

  3-Glacial Sedimentary Rocks that is Till and Moraines

Metamorphic rocks

- ‘Metamorphic rocks are rocks that have been changed either in form or composition without disintegration. Formed generally, due to changes in form of igneous and sedimentary rocks.
- During the process of metamorphism the change in the form of the rocks takes place in 2 ways:

  (1) Physical metamorphism: It is pertaining to changes textural composition of the rocks.

  (2) Chemical metamorphism: It is leading to changes in the chemical composition of the rocks.

Agents of Metamorphism:

- Three agents played a vital role in metamorphism.

  1-The most important factor for the development of metamorphic rocks from pre-existing parent rock is heat.

  2-Compression is resulting from convergent horizontal movement cause by endogenic forces causes rock beds folding.

  3-Solution is chemically active hot gases and water while passing through the rocks change their composition of chemical.

Classification of Metamorphism:

- Metamorphism processes may be classified on the basis of:

  1-Metamorphism agents nature i.e. Thermal, Dynamic, Hydro-metamorphic and Hydro-thermal metamorphism

  2-Place and area involved i.e. Contact and regional metamorphism

  3-Composite classification i.e. Contact and thermal metamorphism, Dynamic and regional metamorphism, Hydro-thermal metamorphism.
- Marbles, Schist, Slate, Gneiss and Quartzite are the examples of metamorphic rocks.

2.11 ISOSTASY: THE CONCEPTS

- The term “Isostasy” is derived from Isostasions, word of Greek language meaning the state of being in balance.
- Isostasy theory explains the tendency of the earth’s crust to attain equilibrium and the distribution of the material in the earth’s crust which conforms to the observed gravity values.
- A great continental mass must be formed of lighter material than that supposed to constitute the ocean – floor.
- You know that the mountain have many peaks and relatively great heights. Similarly plateaus and plain have flat surfaces and have moderate and lower height.
- Oceans and trenches have greater depths. There is a great difference in height among these features.
- Thus our earth is considered to be in isostatic equilibrium.

2.11.1 Model of Airy-HEISKANEN

- Airy assumed that, the inner parts of the mountains are not hollow; rather the excess weight is compensated by the lighter materials below.
- Airy told that the crust of relatively lighter material is floating in the substratum of dense material.
- Continents made of lighter sial are floating over the sub-stratum which is built of the denser sima.
- Thus, Himalaya is also floating in the denser glassy magma.
- Airy suggested that the lighter sial of the Himalaya is floating over the denser material of underneath lying sima.

2.11.2 Model of Pratt-Hayford

- According to the theory of Pratt, there is a difference in rock density in the crust and at the crustal blocks height are determined by their densities.
- As such blocks made up of lighter material and are at higher elevation than those consisting of denser material.
- Lighter material, has therefore, been assumed to lie under oceans and heavy materials under ocean and these also exists mountains and heavier material under ocean and there also exists a boundary, between upper blocks and the lower dense rocks, at a uniform depth known as the level of compensation.

2.11.3 Vening Meinesz or Flexura Isostasy Model

- This theory was suggested to explain how large topographic loads such as seamounts could be compensated by regional rather than local lithosphere displacement.
- This is more general solution of flexure lithosphere , as it approaches the locally compensated models above as the load becomes much larger than a flexural wavelength or the flexural rigidity of the lithosphere approaches 0.Where the lithosphere acts as an elastic plate and its inherent rigidity distributes local topographic loads over broad region by bending.

Global isostatic balance

- Isostatic balance may occur due to erosion and deposition of sediments.
- The earth's surface or higher part is subjected to rapid erosion and the eroded materials are deposited on the lower part of the earth surface.
- As a result the higher part weight gradually decreases and become lighter then the lower part and to rise gradually.
- In other side, the lower part sinks due to material deposition.
- These vertical movements occur when larger volumes of materials get eroded or deposited comports of the crust.
- Thus, in order to maintain isostatic balance between these two features there must be slow flowage of relatively heavier materials towards the lighter materials of the rising column of the mountain at or below the level of compensation.
- In process of redistribution of materials restores ultimately the disturbed isostatic condition to complete isostacic balance.

Thank You