CHAPTER 4

Earth's Structure

Syllabus

Earth's Structure: *Core, mantle, crust – meaning, extent and their composition.*

Our knowledge about the interior of the earth comes not from excavations and explorations of the interior parts of the earth but from the study of seismic waves, materials thrown up by volcanoes and the evidence from the theories of the origin of the earth. In respect of seismic or the earthquake waves, only primary waves (P-waves) reach the surface of the earth. The secondary waves (S-waves) do not pass through liquids. The scientific instruments which record these waves have enabled scientists to know about the density, pressure and temperature of the interior of the earth.

The molten material thrown up by volcanoes rises to the surface of the earth from the *magma chamber* deep inside the earth. From the study of this material, scientists have come to know about the materials that constitute the interior of the earth. Keeping in mind the theories of the origin of the earth, scientists study meteorites which fall on the surface of the earth. The earth is said to be constituted of the same materials as the meteorites. The heat given out by the earth comes from radioactive elements deep inside the earth. The study of this heat in interior areas helps us to estimate the temperature of the interior of the earth.

EARTH'S STRUCTURE

The earth is made up of several concentric layers. The outer layer is the earth's crust—the *lithosphere*. Parts of the earth's crust that are immersed under the oceans and seas form the *hydrosphere*. Extending upwards, the earth is enveloped by a blanket of gases which make up the *atmosphere* (Figure 4.1).

Chemical Composition

- The Lithosphere or the outer most crust of the earth is the thinnest layer.
- It is made up of rocks with large content of silicates, feldspar, mica etc.
- The Lithosphere can be divided into two broad divisions: the SIAL and SIMA.
- Sial appears to float above Sima because it has less density.
- The name Sial is taken from Silica (Si) and Aluminium (Al). Sima is named after Silica (Si) and Magnesium (Mg).

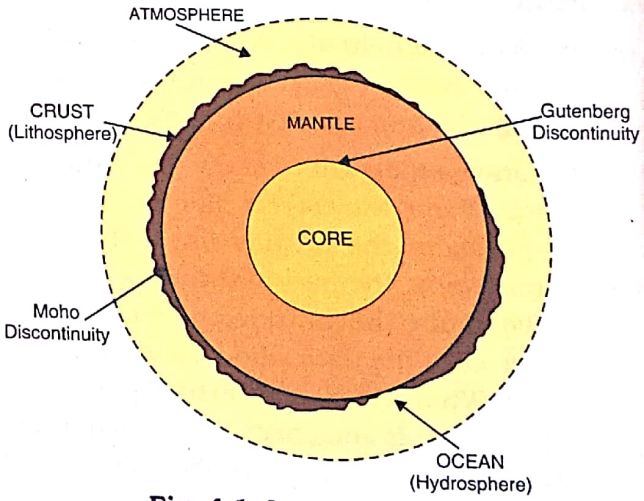

Fig. 4.1. Layers of the Earth

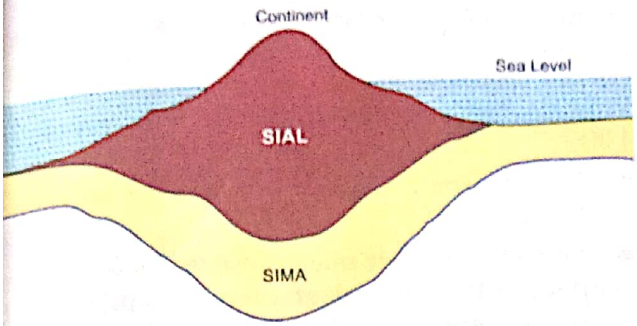

Fig. 4.2. Chemical composition of crust

- Sial layer forms the continents, while Sima makes up the Ocean floor.
- The core of the earth is called NIFE. It is made up of Nickle (Ni) and Iron (Fe). Since these are heavy metals, having high density, they are found deep inside the earth.

Internal Composition

Based on the above chemical composition, the earth's interior is divided into three layers—*Core, Mantle and Crust.*

Core

- It is the most inaccessible part lying at the centre of the earth.
- The core is the densest part of the earth.
- It is also divided into *outer* and *inner* core.
- The entire core is about 7000 km in diameter.
- The temperature ranges from about 4400°C to about 6000°C.
- It is generally believed, that the core is composed of iron and nickel which is responsible for earth's magnetism. The magnetic field is oriented towards North and South Poles.

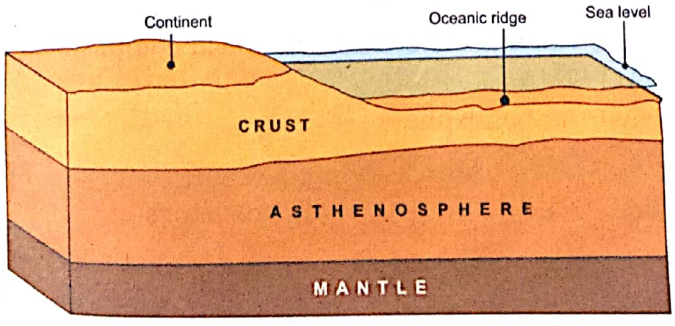

Fig. 4.3. Asthenosphere

- The solid state of the inner core is due to high density and pressure which have compressed the molten rock material. The S-waves disappear in the outer core which suggests it is in a molten state.

Mantle

- This layer lies below the crust.
- Its average thickness is 2900 km and makes up 84 per cent of the earth's total volume.
- The mantle is divided into two parts—*the upper mantle* and *the lower mantle.* The upper mantle extends from the Moho Discontinuity to a depth of 700 km. It is cooler and made of solid rocks. The lower mantle extends from 700 km to 2900 km.
- Lower mantle is hotter and denser than the upper mantle.
- At the depth of around 100–410 km, the mantle is partially molten and is known as *asthenosphere.* Lower mantle is solid due to high pressure.
- As the pressure increases towards the interior of the earth, the density also increases.
- The temperature varies between about 1000°C to around 3,700°C.

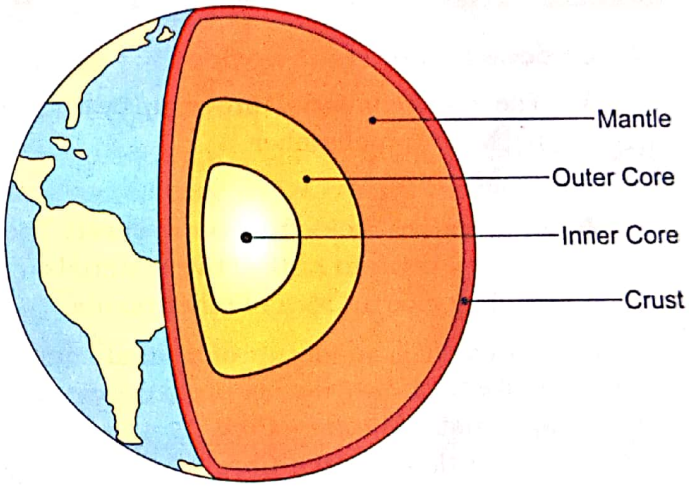

Fig. 4.4. Structure of the Earth

Gutenberg Discontinuity: *The boundary between the mantle and the core or the mantle-core interface is known as the* ***Gutenberg Discontinuity.***

- It begins at the depth of 2800 km.
- Here there is an abrupt change in the seismic waves (generated by earthquakes

or explosions) that travel through the earth. Primary seismic waves (P waves) decrease in velocity while secondary seismic waves (S waves) disappear completely.

- It is dense probably due to a greater percentage of iron.

Crust or Lithosphere

- The crust is called Lithosphere because it is a sphere of solid rocks (Lithos meaning stones or rocks). Crust is only 1% of earth's mass and contains all known life in the universe.
- The crust is a relatively thin layer of rocks with a thickness of 60 km below high mountains and just 5–10 km below the oceans.
- Considering the size of the earth, the crust is a relatively thin layer.
- The temperature of the upper part of the oceanic crust has been estimated at 0°C but it gradually starts rising towards the interior.
- The weight and pressure of rocks also starts increasing with depth.

Mohorovicic Discontinuity: *This discontinuity between the Crust and the Mantle is known as* ***'Moho Discontinuity'***. It was discovered by a Yugoslavian scientist Andreaja Mohorovicic in 1909.

- It forms the boundary between the crust and the mantle.
- Like the crust it does not exist at a uniform depth. It is found at about 8 km beneath the oceans and about 32 km beneath the continents.
- It has the characteristics of both the upper layer (the crust) and its bottom layer (the Mantle).

Because of the continuous changes in the earth's crust due to forces of nature, the thickness of the lithosphere is very fragile compared to the nature and composition of the earth. The Theory of Continental Drift put forward by Wegener in the early 20th century and the Theory of Plate Tectonics put forth in 1960s suggest that the earth's crust undergoes structural changes. Besides, the lateral movements give the earth a new shape though very slowly over millions of years.

EXERCISES

I. Choose the correct option:

1. The molten material thrown up by volcanoes rises to the surface of the earth from the _____.
   (a) Magnum chamber (b) Magma chamber
   (c) Magnum (d) Magma
2. Meteors are rocks from outer space. They hold special significance for scientists because
   (a) they contain radioactive materials. (b) the earth is made of same materials.
   (c) they give an idea of other plants. (d) they pass through the atmosphere of earth.
3. The earth is made up of several concentric layers. The correct order of the layers from the centre to the surface is
   (a) Crust – Mantle – Core (b) Core – Mantle – Crust
   (c) Mantle – Crust – Core (d) Mantle – Core – Crust.
4. Name the two broad divisions the earth crust is divided depending on chemical composition.
   (a) Lithosphere, hydrosphere (b) SIAL, SIMA
   (c) Core, Mantle (d) Crust, Asthenosphere
5. Continents : SIAL :: _____ SIMA
   (a) Mountains tops (b) Ocean floor (c) Plains (d) Volcanoes
6. This is the densest part of the earth believed to be composed of iron and nickel which is responsible for earth's magnetism. Identify it.
   (a) Mantle (b) Core (c) Crust (d) None of the above

7. Which of the following is the correct order as we move towards the interior of the earth.
   (a) SIAL - SIMA - NIFE (b) NIFE - SIMA - SIAL
   (c) NIFE - SIAL - SIMA (d) None of the above.

8. Which of the following is incorrect about the inner core?
   (a) It is in a molten state. (b) It is a region of high density.
   (c) It is a region of high pressure. (d) It is composed of iron and nickel.

9. At the depth of around 100-410 km, mantle is partially molten and is known as:
   (a) Asthenosphere (b) Mantlenosphere (c) Moltenosphere (d) None of the above

10. What is the temperature variation in the mantle in °C?
   (a) 1500 to 3700 (b) 1500 to 2500 (c) 1000 to 3700 (d) 1000 to 4000

11. Name the mantle-core interface where primary seismic waves slow down and secondary seismic waves disappear completely.
   (a) Gutenberg Discontinuity (b) Mantlic Discontinuity
   (c) Core Discontinuity (d) Mohorovicic Discontinuity

12. Name the boundary between the crust and the mantle which has characteristics of both layers.
   (a) Gutenberg Discontinuity (b) Crust Discontinuity
   (c) Mantlic Discontinuity (d) Mohorovicic Discontinuity

13. What life sustaining unit contains only one per cent of the earth's mass?
   (a) biosphere (b) lithosphere (c) crust (d) mantle

14. Mohorovicic discontinuity is found at about _____ beneath the oceans and _____ beneath the continents.
   (a) 8 km, 32 km (b) 8 km, 10 km (c) 10 km, 60 km (d) 10 km, 40 km

15. Extending upwards, the earth is enveloped by a blanket of gases. Name it.
   (a) Lithosphere (b) Hydrosphere (c) Atmosphere (d) Chamber

16. The entire core is about _____ km in diameter.
   (a) 5000 (b) 6000 (c) 7000 (d) 8000

17. Name the layer of the earth that is fragile as compared to the rest of the layers of the earth. Different theories suggest that this layer undergoes changes to give earth a new shape.
   (a) Mantle (b) Core (c) Crust (d) Asthenosphere

II. Short Answer Questions

1. In which part of the earth is NIFE found? What is it composed of?
2. What are the consequences of the pressure and temperature in the interior of the earth?
3. How do the meteorites help scientists to know about the interior of the earth?
4. What is the composition of the earth's crust?
5. What is the lithosphere?
6. Name the three layers of the earth's interior. Name their boundaries.
7. Describe the mantle. State its two chief characteristics.
8. Where is asthenosphere found? In which form does it exist?
9. What happens to the P and S waves at the Gutenberg Discontinuity.
10. Why is the earth's interior in most part found in a solid state despite great heat and pressure?

III. Distinguish between the following:

(i) Crust and Core. (ii) Sial and Sima.

(iii) Gutenberg Discontinuity and Mohorovicic Discontinuity.

IV. Structured Questions

1. (a) Describe the layers of the interior of the earth and their chemical composition.

   (b) There are two transitional zones between the two consecutive layers of the interior of the earth. Name them and state their chief characteristics.

   (c) Give a geographical reason for each of the following:

   (i) Temperature starts rising gradually towards the interior of the earth.

   (ii) The asthenosphere is in a semi-molten state.

   (iii) The inner core of the earth is in a solid state.

   (d) Look at the figure on the side and answer the questions:

   (i) Label the parts: (1), (2), (3), (4) and (5).

   (ii) Name the state (solid, liquid or gas) in which each part exists.

   (iii) Which part of the earth is suitable for human habitation? Why?

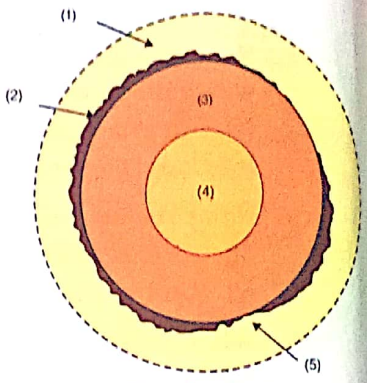

Fig. for Q. 1 (d)

2. (a) State two chief characteristics of the earth's crust.

   (b) Which layer is responsible for earth's magnetic field? Why?

   (c) Give a geographical reason for each of the following:

   (i) NIFE is so called.

   (ii) The core of the earth is the most inaccessible part of the earth.

   (iii) The earth's crust undergoes many changes.

   (d) Draw a well labelled diagram to show the interior of the earth.

V. Thinking Skills

1. The earth's crust is only one percent of earth's mass yet it is a large reservoir of resources for mankind. Justify this statement with examples.
2. What would happen if the earth's core no longer remain hot and the magma cools and hardens inside the earth? Give reasons to support your answer.

VI. Project/Practical Activity

Suppose you were given the responsibility to explore the interior of the earth. Draw a project report describing the steps you would take, your objectives and the estimation of the costs of the project, etc.

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