Interior of Earth

Structure and Composition of the Earth

The interior structure of the Earth is made up of three main shells: the very thin and brittle crust, the mantle, and the core. Furthermore, the mantle and core are each divided into two parts. The core and mantle are equal in thickness but, the core of the earth only occupies 15 percent of Earth’s volume whereas the mantel occupies 84 percent and the crust occupies remaining 1 percent.

Cross Section of the Earth

Sources of Information about Interior of the Earth

The earth’s radius is 6,370 km. It is rather difficult to make observations or collect samples of the material from inside of the earth due to its huge size and the
changing nature of its internal composition. Only a part of the information is obtained through direct observations and analysis of materials. Most of our understanding about the interior of the earth is based on estimates and inferences.

**Direct Sources of Information**

**Surface rock** – Surface rocks are the most readily available solid earth material to make direct observations. Laboratory experiments on surface rocks and minerals provide important information about the interior of the earth.

**Mining** – rocks that we get from mining areas are another source that gives us information about Earth’s interior. Through mining and drilling operations we have been able to observe the earth’s interior directly only up to a depth of few kilometres. World’s deepest mining is limited only to the depth of fewer than 5 kilometres. Going beyond this depth is not possible due to excessive heat at this depth.

**Deep Ocean Drilling Projects** – Scientists have undertaken some major projects to penetrate the surface of oceans to assess the conditions in crustal portions. The deepest drill at Kola, in the Arctic Ocean, has so far reached a depth of 12 km. This and many deep drilling projects have provided a large volume of information through the analysis of materials collected at different depths.

**Volcanic Eruptions** – Volcanic eruption forms an important source of obtaining direct information through laboratory analysis of the molten material (magma) that is thrown onto the surface of the earth, during a volcanic eruption. However, it is difficult to find out about the depth of the source of such magma.

**Indirect Sources of Information**

**Meteors** – Meteors are bits of interplanetary material falling through Earth’s atmosphere and heated to incandescence by friction. Meteors that at times reach the earth are an important source of information about the interior structure of the Earth. Although the material that becomes available for analysis from meteors do not from the part of the interior of the earth, they provide valuable information as the structure observed in meteors are similar to that of the earth.
Gravitation – The reading of the gravity at different places is influenced by many factors viz. distribution of mass, distance from the centre of the Earth. Such a difference is called gravity anomaly. Gravity anomaly gives us information about the distribution of mass of the material in the crust of the earth.

Magnetic Field – Magnetic surveys provide information about the distribution of magnetic materials in the crustal portion, and thus, provide information about the distribution of materials in this part.

Seismic Activity – Seismic activity is one of the most important sources of information about the interior of the earth. Body waves, generated by an earthquake, especially S-waves, which travel only through solid material, have helped in understanding the interior structure of the Earth.

The Layers of the Earth

Earth’s interior is divided into basically three layers – Crust, Mantle and Core, which we shall discuss in detail as below:-
The Crust

- Due to its accessibility, its geology has been widely studied
- So, we have good understanding of the structure and composition of the crust.
- The crust is the outermost layer of the earth.
- It is brittle in nature.
- The crust of the Earth has two distinct types: continental crust and oceanic crust.
- These two types have different chemical compositions and physical properties and were formed by different geological processes.
- The thickness and density of the crust vary under the oceanic and continental areas.
- Oceanic crust is thinner as compared to the continental crust.
- The mean thickness of oceanic crust is 5 km.
- The mean thickness of the continental crust is around 30 km. It is much thicker in the areas of major mountain ranges, extending up to 70 km in the Himalayan region.
- Oceanic crust is denser as compared to the continental crust.
- Continental crust has the mean density of 2.7 g/cm³. It is mainly composed of silicon and aluminium. Therefore, it is often termed as “sial.”
- The mean density of material in oceanic crust is 2.9 g/cm³. It is mainly composed of basaltic rocks.
- The crust makes up about 1% of Earth’s volume.

The Mantle

- Our knowledge of the upper mantle, including the tectonic plates, is derived from analyses of earthquake waves, heat flow, magnetic, gravity studies and laboratory experiments on rocks and minerals.
- The portion of the interior beyond the crust is called the mantle.
- The mantle extends from Moho’s discontinuity to a depth of 2,900 km.
- It has an average density higher than that of the crust (3.4 g/cm³).
- The mantle is divided into upper and lower mantle.
- **Asthenosphere** – The upper portion of the mantle is called asthenosphere, extending up to 400 km. The word “astheno” means weak. It is the main source of magma that finds its way to the surface during volcanic eruptions. It lies below the lithosphere.
• **Lithosphere** – The crust and the uppermost part of the mantle are called lithosphere. Its thickness ranges from 10-200 km. The lithosphere is subdivided into tectonic plates.
• The lower mantle extends beyond the asthenosphere. It is in the solid state.
• Major constituent elements of the mantle are magnesium and silicon. Hence, this layer is termed as “sima”.
• The mantle makes up about 84% of Earth’s volume

**The Core**

• The earthquake wave velocities have helped in understanding the existence of the core of the earth.
• The innermost layer surrounding the earth’s centre is called core, which is about 3500 km in radius.
• The core-mantle boundary is located at a depth of 2,900 km.
• The core consists of two sub-layers. The outer core is in the liquid state while the inner core is in the solid state.
• The core is the densest layer of the earth. The density of material at the mantle-core boundary is around 5 g/cm3, and at the centre of the earth at 6,300 km, the density value is around 13 g/cm3.
• The core is made up of very heavy material mostly constituted by nickel and iron.
• It is sometimes referred to as the “nife” layer.
• The core makes up about 15% of Earth’s volume.

**Seismic Discontinuities**

• Seismic discontinuities aid in distinguishing divisions of the Earth into the inner core, outer core, lower mantle, upper mantle, and the crust
• **Conorad discontinuity** – it refers to the zone between upper crust and lower crust.
• **Mohorivic discontinuity** – also called as moho discontinuity is the zone that separates the Earth’s crust from the upper mantle. It can be detected by a sharp increase downward in the speed of earthquake waves there.
• **Repiti discontinuity** – it refers to the zone between upper mantle and lower mantle.
• **Gutenberg discontinuity** – It refers to the zone separating the lower mantle from the core. It is located at a depth of about 2,900 km.
**Lehmann discontinuity** – it refers to the zone separating solid inner core from the liquid outer core.

**Mohorovicic discontinuity** – between lower crust & upper mantle

**Repliti discontinuity** – between upper & lower Mantle

**Guttenberg discontinuity** – between lower Mantle & outer Core

**Lehmann discontinuity** – between outer & inner core

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**Temperature, Pressure and Density of the Earth’s interior**

- The temperature increases towards the centre of the earth. However, the rate of increase of temperature is not uniform from the surface towards the earth’s centre. It is faster at some places than at others.
- The temperature at the centre is estimated to lie somewhere between 3000°C and 50000°C.
- Such a high temperature inside the earth may be due to chemical reactions under high-pressure conditions and disintegration of radioactive elements.
- The pressure also increases from the surface towards the centre of the earth due to huge weight of the overlying rocks.
Due to increase in pressure and presence of heavier materials towards the earth’s centres, the density of earth’s layers also goes on increasing. The materials of the innermost part of the earth are very dense.
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