



# Core-Mantle Connectivity

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## Why in News?

A study by **German researchers** reveals that **precious metals** like **gold, platinum, and ruthenium** are **leaking from the Earth's core to the surface** via **volcanic activity**, challenging the long-standing belief that the **core is geochemically isolated**.

## What are the Key Insights from Recent Studies on the Interaction Between Earth's Core and Mantle?

- **Core-Mantle Material Exchange:** Researchers studied **volcanic rocks** from **Hawaii**, created by **mantle plumes (hot rock columns)** rising from the **core-mantle boundary**.
  - They detected **high levels of ruthenium-100 ( $^{100}\text{Ru}$ )**, an isotope mainly found in the **Earth's core**, showing that **core materials travel upward through mantle plumes**.
    - This reveals **greater connectivity between the core and mantle** than earlier assumed.
- **Precious Metals Locked in Earth's Core:** The **Earth's core** contains over **99.999% of the planet's gold** along with other **siderophile (iron-loving) elements** like **platinum, iridium, and ruthenium**.
  - These metals were **traditionally thought to be inaccessible** due to a **thick rock barrier separating the core** from the mantle and crust.

# INTERIOR OF THE EARTH

## 1 THE CRUST

- Thin, outermost layer
- Oceanic crust – thinner
  - Mean thickness - 5 km
  - Made up of Silica and Magnesium (SiMa)
- Continental crust – thicker
  - Mean thickness - 30 km
  - Made up of Silica and Aluminum (SiAl)
  - Thicker in the areas of major mountain systems.
    - Around 70 km thick in the Himalayan region.
- Temperature increases with depth (rises by up to 30° C for every km)

### Lithosphere

- Rigid outer layer, thickness: 100 km
- Consists of the crust and the upper mantle
- Divided into tectonic plates responsible for large-scale changes in the earth's geological structure (folding, faulting)

## 3 THE CORE

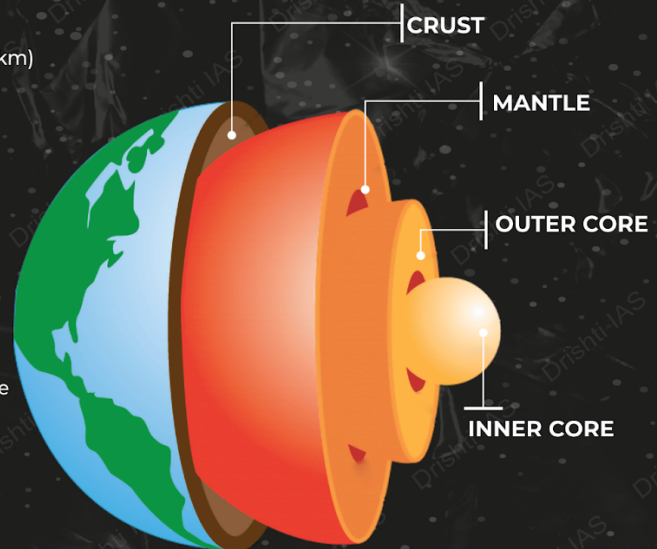
- Lies between 2900-6370 km below the earth's surface
- Made up of heavy materials, primarily nickel (Ni) and iron (Fe) - NiFe
- Outer core –
  - Between 2900-5100 kms
  - Liquid** because of not enough pressure to solidify
- Inner core –
  - Between 5100-6370 kms
  - Solid – it can transmit secondary waves** (earthquake) which outer core can't
- Denser than Mantle

### Boundaries/discontinuities between Earth's layers

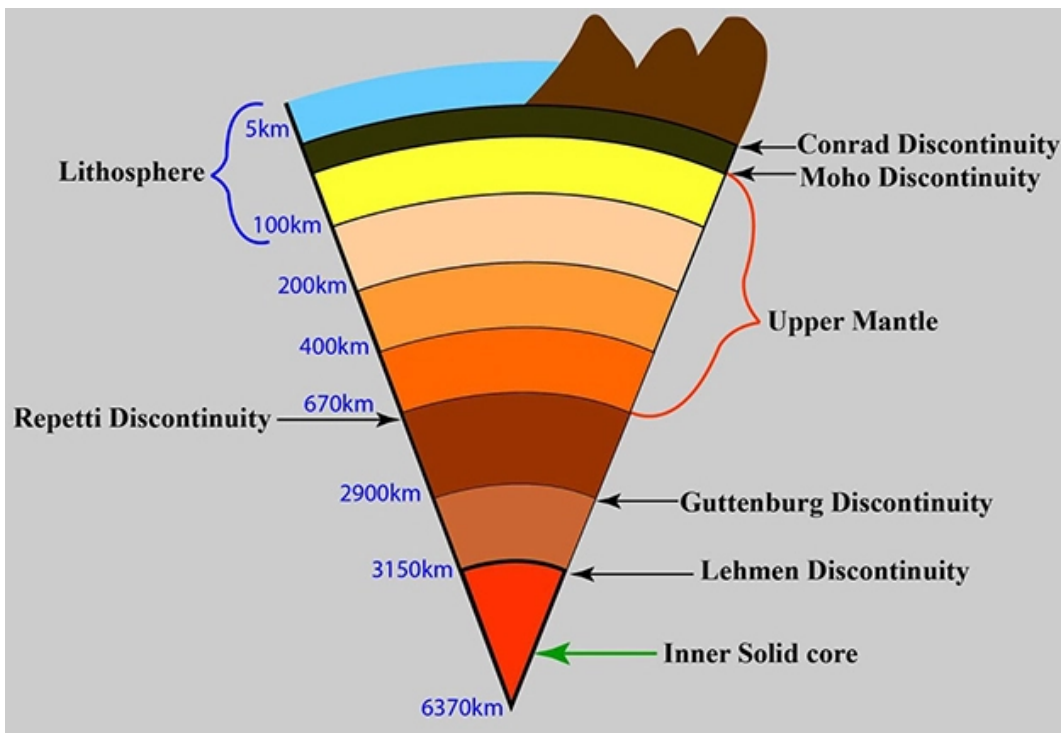
- Conorod Discontinuity- between upper and lower crust
- Mohorovicic Discontinuity (Moho) – separates the crust from the mantle, its average depth being about 35 km.
- Repiti Discontinuity – between the upper and lower mantle
- Gutenberg Discontinuity – lies between the mantle and the outer core.
- Lehman Discontinuity- between inner and outer core

## 2 THE MANTLE

- Extends from Moho's discontinuity to a depth of 2,900 km
- Upper portion is called **asthenosphere**
  - Zone of weak rocks; in semi molten or jelly like state
- Extends upto 400 kms
- Main source of magma** that comes out of volcanic eruptions



**What are the Key Facts About Earth's Mantle & Core?**



#### ■ Mantle:

- **Structure:** The mantle constitutes about **83% of Earth's volume** and **67% of its mass**, extending from the **Moho discontinuity (around 7-35 km depth)** down to the **core-mantle boundary at 2,900 km depth**.
  - It is primarily composed of **silicate rocks rich in iron and magnesium**, with elemental composition approximately **45% oxygen, 21% silicon, and 23% magnesium**.
    - Common silicates found in the mantle include **olivine, garnet, and pyroxene**.
- **Density and State:** The **upper mantle's density** ranges from **2.9 to 3.3 g/cm<sup>3</sup>**, while the **lower mantle's density** varies from **3.3 to 5.7 g/cm<sup>3</sup>**.
  - The **asthenosphere** is a layer of the **upper mantle**, while the **lower mantle extends deeper** into the Earth.
  - While the **asthenosphere is partially molten** and can flow, the immense pressure in the **lower mantle** keeps it in a solid state, despite the high temperatures.
- **Temperature Gradient and Convection:** Temperatures increase from around **200°C near the crust** to nearly **4,000°C at the core-mantle boundary**.
  - This temperature difference drives **mantle convection**, where solid silicate rock behaves plastically and circulates slowly.
  - This convection is fundamental to the **movement of tectonic plates** at the surface.
- **Seismicity:** Despite **high-pressure conditions** that normally inhibit **seismic activity**, earthquakes occur in **subduction zones** down to depths of **670 km**, within the mantle.

#### ■ Earth's Core:

- **Structure:** The Earth's core **lies beneath the mantle**, starting at about **2,900 km depth** and extending to the planet's center at approximately **6,371 km**.
  - It is primarily composed of **iron and nickel**, with some lighter elements.
- **Outer Core:** Extending from **2,900 km to about 5,150 km depth**, the outer core is a **molten, liquid layer** approximately **2,250 km thick**, with temperatures ranging between **4,000°C and 6,000°C**.
  - The **movement of its liquid iron generates Earth's magnetic field** through the **geodynamo process**. Its **density is lower than the inner core** due to its liquid state.

- **Inner Core:** Located from approximately **5,150 km depth to the Earth's center**, the inner core is a **solid sphere** with a **radius of about 1,220 km**.
  - Despite extremely high temperatures ranging from **5,000°C to 7,000°C**, it remains **solid** due to the **immense pressure** exerted by the overlying layers.
  - Composed primarily of an **iron-nickel alloy**, the inner core is **highly dense** and plays a critical role in **Earth's internal heat transfer**.
  - It also influences the planet's **magnetic field**, although the **geodynamo effect** (magnetic field generation) is primarily driven by the **swirling liquid iron** in the outer core.
  - The inner core exhibits **high thermal and electrical conductivity and rotates eastward slightly faster** than the Earth's surface, completing an extra rotation approximately every **1,000 years**.
  - It is **separated from the outer core** by a boundary known as the **Lehmann Discontinuity**.

## **Asthenosphere:**

- The asthenosphere is the **upper mantle layer from 80 to 200 km depth**, located **beneath the rigid lithosphere**.
- It is **ductile, mechanically weak, and highly viscous**, with **density greater than the crust**. These properties **facilitate tectonic plate movement and isostatic adjustments**.
  - It is also the **main source of magma** for volcanic eruptions.

## **UPSC Civil Services Examination, Previous Year Question (PYQ)**

### **Prelims**

**Q. In the structure of planet Earth, below the mantle, the core is mainly made up of which one of the following? (2009)**

- (a) Aluminium
- (b) Chromium
- (c) Iron
- (d) Silicon

**Ans: (c)**