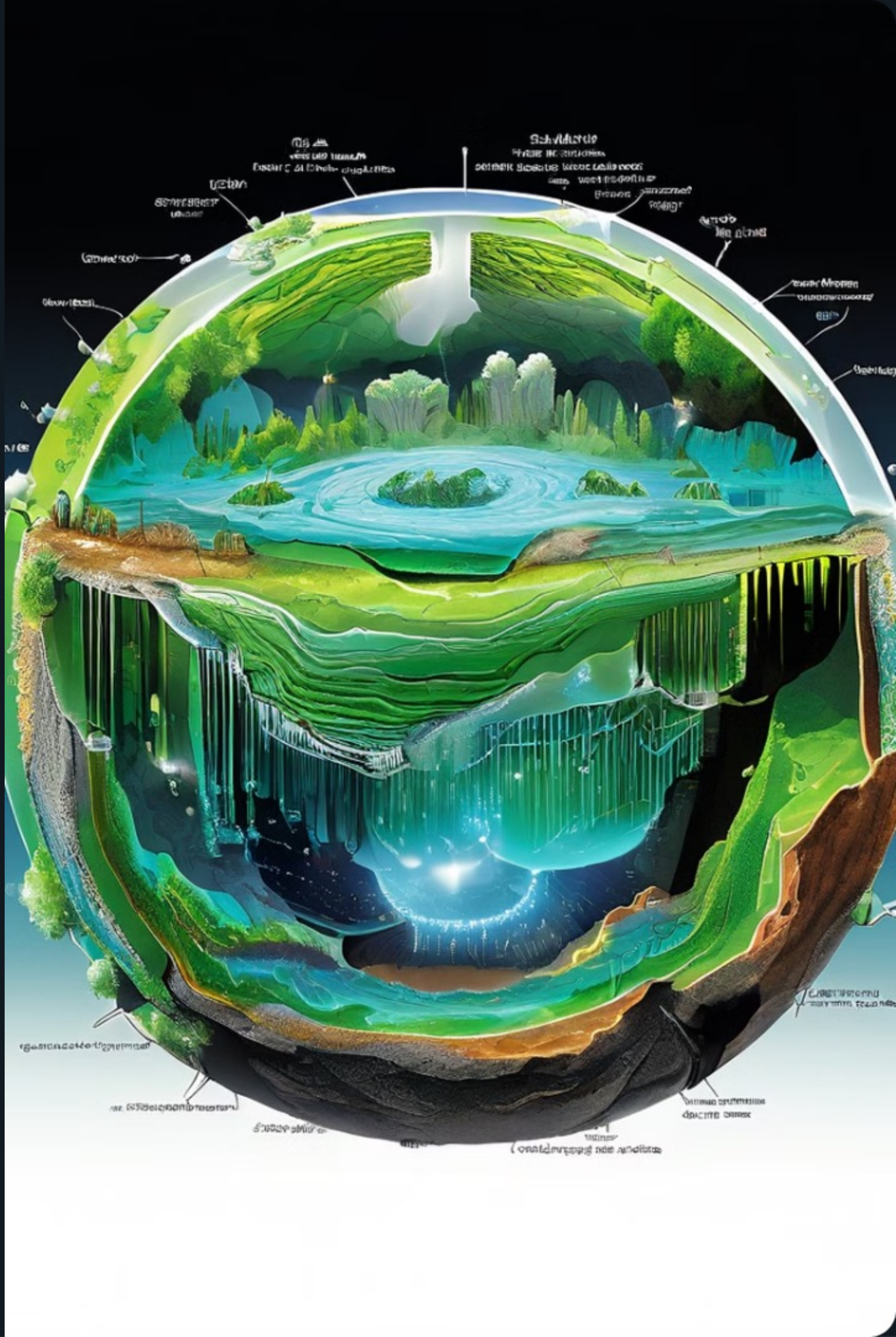
Introduction to the Internal Structure of Earth

Explore the fascinating layers that make up our planet, from the outer crust to the fiery core. Uncover the evidence that reveals the hidden depths of Earth's interior and the forces shaping its dynamic evolution.

Dr. Jagdish Chand
Asst. Prof, Geography
Govt. College Sangrah



The Crust

1

Definition

The Earth's crust is the outermost solid shell of the planet, ranging from 5-70 km in thickness. It is composed primarily of silicate rocks and minerals.

2

Composition

The crust is primarily made up of two types of rock: continental crust (granite) and oceanic crust (basalt). The continental crust is thicker and less dense than the oceanic crust.

3

Tectonic Plates

The crust is broken into large, moving pieces called tectonic plates. The movement of these plates drives geological processes like volcanoes, earthquakes, and mountain building.

The Mohorovičić Discontinuity

1

Definition

The Mohorovičić Discontinuity, or Moho, is the boundary between the Earth's crust and the underlying mantle.

2

Discovered in 1909

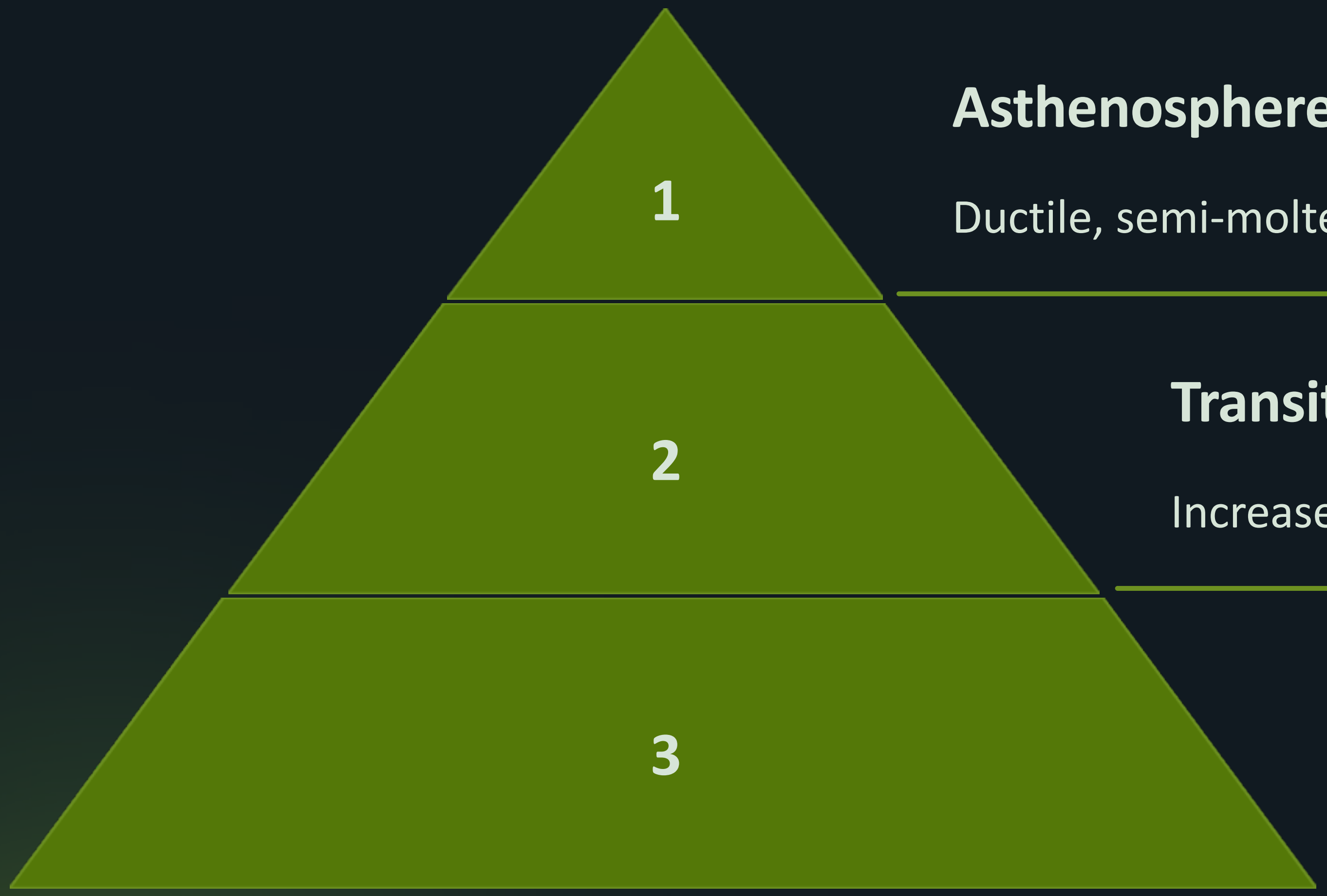
Croatian seismologist Andrija Mohorovičić discovered this distinct boundary by analyzing seismic waves.

3

Depth Variation

The Moho depth varies from around 5-10 km under the oceans to 30-50 km under the continents.

The Upper Mantle



Asthenosphere

Ductile, semi-molten rock layer

Transition Zone

Increase in density and seismic velocity

Upper Mantle

Rigid, solid rock layer

The upper mantle is the solid, rocky layer between the Earth's crust and the lower mantle. It is composed of dense, rigid rock that can flow slowly over long periods of time. The upper mantle contains the asthenosphere, a ductile layer where tectonic plates move, and the transition zone, where seismic properties change dramatically.

The Lower Mantle

1

Composition

Composed primarily of iron, magnesium, and silicate minerals.

2

Depth

Extends from about 660 km to 2,900 km below the Earth's surface.

3

Temperature

Extremely high, ranging from around 1,500°C to 2,500°C.

The lower mantle is the thickest and densest layer of the Earth's interior, comprising about 55% of the planet's total volume. It is characterized by its high temperature and pressure conditions, which allow for the presence of dense silicate minerals like bridgmanite and magnesiowüstite.

The Gutenberg Discontinuity

Boundary Between Mantle and Outer Core

The Gutenberg discontinuity marks the boundary between the Earth's lower mantle and the outer core. It is named after the German seismologist Beno Gutenberg.

Depth of Approximately 2,900 km

The Gutenberg discontinuity is located at a depth of approximately 2,900 km below the Earth's surface, marking the transition from the solid lower mantle to the liquid outer core.

1

2

3

Dramatic Change in Seismic Waves

At this boundary, there is a dramatic change in the

The Outer Core

1

Composition

Mainly molten iron and nickel

2

Density

Approximately 9.9 g/cm^3

3

Depth

2,900 km to 5,100 km below the surface

The outer core is the layer of the Earth just below the mantle. It is composed primarily of molten iron and nickel, giving it an extremely high density of around 9.9 g/cm^3. The outer core extends from a depth of 2,900 km to 5,100 km below the Earth's surface.

The Inner Core

1

Dense and Hot

The inner core is the innermost layer of the Earth, composed primarily of solid iron and nickel. It is extremely dense, reaching up to 13 g/cm3, and has a temperature of around 5,700°C.

2

High Pressure

Due to the immense gravitational forces acting on it, the inner core experiences astoundingly high pressures, reaching up to 3.6 million atmospheres at its center.

3

Constant Oscillations

The inner core is constantly oscillating and rotating, leading to changes in the Earth's magnetic field and the generation of seismic waves that can be detected around the globe.

Seismic Waves as Evidence

P-waves

Fastest seismic waves that travel through solids, liquids, and gases

S-waves

Slower transverse waves that can only travel through solids

Reflections

Changes in wave speed and direction reveal Earth's layered structure

Seismic waves generated by earthquakes provide crucial evidence for the internal structure of Earth. The behavior of different wave types, such as P-waves and S-waves, as they travel through the planet reveals the presence of distinct layers with varying densities and compositions. Analyzing the reflections and refractions of these waves helps scientists map the boundaries between the crust, mantle, and core.

Gravitational Anomalies as Evidence

1

Density Variations

Differences in the density of Earth's interior layers

2

Gravitational Pull

Variations in the strength of gravity across the planet

3

Geoid Measurements

Precise mapping of Earth's gravity field and shape

Gravitational anomalies, observed as variations in the strength and direction of Earth's gravitational pull, provide important evidence for the internal structure of the planet. Differences in the density of materials within the crust, mantle, and core result in localized changes in gravitational acceleration that can be measured using highly sensitive gravimeters. Detailed mapping of Earth's gravity field, known as the geoid, further reveals the lumpy, irregular shape of the planet's surface caused by its uneven internal composition.

Magnetic Field as Evidence

1

Earth's Magnetic Field

The Earth's magnetic field, generated by the spinning molten outer core, provides evidence for the layered internal structure.

2

Magnetic Anomalies

Variations in the magnetic field strength and direction across the Earth's surface reveal differences in the composition and density of the layers.

3

Magnetic Reversal

The periodic reversal of the Earth's magnetic poles, recorded in rocks, is linked to the complex dynamics of the outer and inner core.

Meteorite Impacts as Evidence

1

Crater Formation

Meteorite impacts leave distinctive craters on the Earth's surface, providing physical evidence of the planet's internal structure and composition.

2

Seismic Waves

The shockwaves generated by meteorite impacts travel through the Earth's interior, allowing scientists to study the propagation of seismic waves and infer the planet's layered structure.

3

Mineral Composition

Meteorites that reach the Earth's surface contain unique mineral compositions that match the materials found in the planet's core, mantle, and crust, validating the differentiation of these layers.

Volcanic Activity as Evidence

1

Magma Composition

Differences in magma composition and viscosity

2

Volcanic Gases

Release of gases like CO_2, SO_2, and H_2O

3

Volcanic Eruptions

Explosive eruptions and lava flows provide insights

Volcanic activity on the Earth's surface provides valuable clues about the planet's internal structure. Differences in the composition and viscosity of magma can indicate variations in temperature and pressure within the Earth's interior. The gases released during volcanic eruptions, such as carbon dioxide, sulfur dioxide, and water vapor, also offer insights into the chemical makeup of the deeper layers. Furthermore, the explosive nature of some volcanic eruptions and the flow of lava reveal the dynamic processes occurring within the Earth's mantle and crust.

Plate Tectonics as Evidence

Earthquake Patterns

The distribution of earthquakes around the world aligns with the boundaries of tectonic plates, providing evidence for their existence and movement.

Seafloor Spreading

The continuous formation of new oceanic crust at mid-ocean ridges, where plates are moving apart, is a key piece of evidence for plate tectonics.

1

2

3

Volcanic Activity

Volcanoes are concentrated along plate boundaries, where molten rock and magma can rise to the surface as the plates move and collide.

Conclusion and Summary

In conclusion, the internal structure of the Earth is a complex and fascinating subject, with numerous lines of evidence supporting our current understanding. From seismic waves to gravitational anomalies, the Earth's layers and boundaries have been meticulously mapped and studied, revealing the dynamic nature of our planet's interior.