SENIOR FIVE TERM 1

TOPIC 1/3: The Structure of the Earth

Competency: The learner demonstrates appreciation of the structure of the Earth and its influence on geomorphic processes and formation of some natural resources by examining the properties of each of its layers to better understand the geologic foundation of human development.

The External Structure of the Earth

The Earth's "external structure" can refer to two concepts: the planet's major interacting physical systems (spheres) or its rigid outer shell (the lithosphere).

Earth's External Spheres

The Earth system is typically divided into four major, interacting spheres that form its external environment:

Atmosphere

The layer of gases surrounding the planet, primarily composed of nitrogen (78%) and oxygen (21%). It protects the surface from solar radiation, absorbs and emits heat, and is where weather occurs. It is further divided into layers: the troposphere, stratosphere (which contains the ozone layer), mesosphere, and thermosphere.

Hydrosphere:

Encompasses all of the Earth's water in solid, liquid, and gaseous forms, including oceans, lakes, rivers, groundwater, and ice. The global ocean covers about 71% of the Earth's surface.

Lithosphere:

The solid, rocky outer part of the Earth, including the crust and the brittle upper portion of the mantle. It is broken into large segments called tectonic plates, which move slowly and whose interactions cause earthquakes, volcanoes, and mountain building.

Biosphere:

The sphere that contains all the planet's living things, from microorganisms to plants and animals, interacting within ecological communities called biomes.

Earth's internal structure

Earth's internal structure consists of three main chemical layers—the thin crust, the thick mantle, and the dense core, which is split into a liquid outer core and solid inner core—but also has mechanical layers like the rigid lithosphere (crust + upper mantle) and the flowing asthenosphere, with the liquid outer core's movement generating Earth's magnetic field.

(i) Crust

- The outermost solid layer where we live.
- Thickness: 5–70 km.
- Two types:
  - **Continental crust**: thicker, less dense, mainly granite.
  - **Oceanic crust**: thinner, denser, mainly basalt.
- Separated from the mantle by the **Mohorovičić discontinuity (Moho)**.

(ii) Mantle

- Extends from the Moho down to ~2,900 km.
- Composed mainly of silicate minerals rich in magnesium and iron.
- Divided into:
  - **Upper mantle**: includes the asthenosphere, partly molten and responsible for plate tectonics.
  - **Lower mantle**: more rigid due to higher pressure.
- Heat transfer occurs through **mantle convection**, driving earthquakes and volcanism.

(iii) Outer Core

- Depth: ~2,900–5,150 km.
- Composed of liquid iron and nickel.
- Movement of molten metal generates Earth's **magnetic field**.
- Responsible for geomagnetic phenomena like auroras.

4. Inner Core

- Depth: ~5,150–6,371 km.
- Solid sphere of iron and nickel due to immense pressure.
- Extremely hot (up to 5,700 °C), comparable to the Sun's surface.
- Plays a role in stabilizing Earth's magnetic field.

Comparison Table

Layer	Depth Range	State	Composition	Key Role
Crust	0–70 km	Solid	Granite, basalt	Land, ocean floor
Mantle	70–2,900 km	Solid (plastic in parts)	Silicate minerals	Plate tectonics, volcanism
Outer Core	2,900–5,150 km	Liquid	Iron, nickel	Generates magnetic field
Inner Core	5,150–6,371 km	Solid	Iron, nickel	Stabilizes magnetic field

Methods of Studying Earth's Interior

Direct Methods

- **Mining and drilling**: Humans have drilled up to ~12 km deep (Kola Superdeep Borehole), but this is tiny compared to Earth's 6,371 km radius.
- **Volcanic eruptions**: Magma and gases expelled from volcanoes provide samples of material from beneath the crust.
- **Exposed rocks**: Erosion and tectonic uplift reveal deeper rocks at the surface, giving clues about subsurface composition.

Indirect Methods

- **Seismology**: The most important technique. Seismic waves from earthquakes travel differently through solid and liquid layers, allowing scientists to map the crust, mantle, and core.
- **Gravity studies**: Variations in Earth's gravitational field reveal density differences inside the planet.
- **Magnetic field analysis**: Earth's magnetic field originates in the liquid outer core; studying its behavior helps understand core dynamics.
- **Laboratory experiments**: High-pressure and high-temperature simulations recreate conditions of Earth's interior to test how rocks behave.
- **Meteorite studies**: Since meteorites are remnants of early solar system material, they provide analogs for Earth's internal composition.

Comparison Table

Method	Type	What It Reveals	Limitation
Mining & drilling	Direct	Crust composition	Very shallow depth
Volcanic eruptions	Direct	Mantle material samples	Limited to volcanic zones
Exposed rocks	Direct	Crustal layering	Surface only
Seismology	Indirect	Layer boundaries, density, state	Requires earthquakes or explosions
Gravity studies	Indirect	Density variations	Less precise than seismology
Magnetic field analysis	Indirect	Core dynamics	Indirect inference
Lab experiments	Indirect	Rock behavior under pressure	Simulations, not actual samples
Meteorite studies	Indirect	Composition clues	Assumptions about similarity

The link between the properties of the internal layers of the Earth, geomorphic processes; and their impact on humans

Internal Layers and Their Properties

- **Crust**: Solid, brittle outer shell.
- **Mantle**: Semi-solid/plastic, convecting layer.
- **Outer Core**: Liquid iron and nickel, generates magnetic field.
- **Inner Core**: Solid iron-nickel sphere, stabilizes magnetic field.

Geomorphic Processes Driven by Internal Layers

- **Plate Tectonics (Crust + Upper Mantle)**: Movement of lithospheric plates causes earthquakes, mountain building, and volcanism.
- **Volcanism (Mantle)**: Rising magma creates volcanoes, islands, and new crust.
- **Earthquakes (Crust + Mantle)**: Sudden release of stress along faults shakes the surface.
- **Isostatic Adjustment (Crust + Mantle)**: Land rises or sinks due to loading/unloading (e.g., glaciers melting).
- **Magnetism (Outer Core)**: Earth's magnetic field shields life from harmful solar radiation

Impacts of Earth's internal layers and geomorphic processes on humans

Hazards

- Earthquakes destroy infrastructure and cause loss of life.
- Volcanic eruptions damage settlements but also enrich soils.
- Tsunamis (triggered by tectonics) devastate coastal communities.

Resources

- Minerals and fossil fuels originate in crustal and mantle processes.
- Geothermal energy harnesses mantle heat.
- Fertile volcanic soils support agriculture.

Protection

- Magnetic field (outer core) protects humans and technology from solar radiation.

Linking Table

Internal Layer	Property	Geomorphic Process	Human Impact
Crust	Solid, brittle	Plate tectonics, earthquakes	Hazards, mineral resources
Mantle	Semi-solid, convecting	Volcanism, mountain building	Fertile soils, geothermal energy
Outer Core	Liquid iron-nickel	Magnetic field generation	Radiation protection, navigation
Inner Core	Solid iron-nickel	Stabilizes field	Long-term planetary habitability

Thank you
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