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CUET · GEOGRAPHY · CLASS XI · CODE 313

Interior of the Earth

CUET unit: Interior of the Earth (Fundamentals of Physical Geography)

By **UniDrill** · NCERT-grounded study material

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📌 Snapshot

- Scientists gather information about the earth's interior through both **direct sources** (mining, volcanic eruptions, deep drilling — Kola at 12 km is the deepest) and **indirect sources** (seismic waves, gravity anomalies, meteors, magnetic surveys).
- **Earthquake waves** — P-waves, S-waves and surface waves — are the most important tools for understanding the layered interior; their behaviour reveals the existence and physical state of each internal layer.
- The earth has a **three-layer structure** (**crust, mantle, core**) with precise depth boundaries (**Moho's discontinuity, 2,900 km core boundary, 5,100 km outer-inner core boundary, 6,378 km radius**), which underpins all subsequent study of plate tectonics and volcanic activity.
- **Volcanoes and volcanic landforms** (shield, composite, caldera, flood basalt, mid-ocean ridge) along with **intrusive igneous forms** (batholith, laccolith, lapolith, phacolith, sill/sheet, dyke) are systematically covered, making this chapter highly testable for CUET.
- CUET tests this chapter through direct recall of layer depths/properties, wave behaviour, shadow zones, Richter vs Mercalli scales, and identification of volcanic/intrusive forms — all standard NTA question types.

📖 Detailed Notes

2.1 Core concepts

Sources of information about the interior

- The earth's radius is about **6,378 km**; no one can reach the centre to collect samples. Most knowledge about the interior is based on **estimates and inferences**; yet part is obtained through direct observations and analysis (NCERT §Sources of Information, p. 18).
- **Direct sources** include (NCERT §Direct Sources, p. 18):
- The most easily available solid earth material — **surface rocks and mining**. **Gold mines in South Africa are as deep as 3–4 km**; deeper than this is impossible because it gets very hot.

- Two major drilling projects — **"Deep Ocean Drilling Project"** and **"Integrated Ocean Drilling Project"**; the **deepest drill at Kola in the Arctic Ocean has reached 12 km**.
- **Volcanic eruptions** that bring magma to the surface for laboratory analysis; depth of source is hard to ascertain.
- **Indirect sources** include (NCERT §Indirect Sources, p. 19):
- **Temperature, pressure and density** changes with depth, inferred from mining.
- **Meteors** — solid bodies of materials similar to the earth.
- **Gravitation** — gravity force g is greater near the poles and less at the equator (Earth is not a perfect sphere; distance from centre at equator is greater). Gravity values also differ by mass distribution; readings deviating from expected values are called **gravity anomalies** and reveal distribution of mass in the crust.
- **Magnetic surveys** — show distribution of magnetic materials in the crustal portion.
- **Seismic activity** — one of the most important sources of information about the interior.

Earthquake

- An **earthquake** is the shaking of the earth caused by a **release of energy** that generates waves travelling in all directions (NCERT §Earthquake, p. 19).
- Energy release occurs along a **fault** — a sharp break in the crustal rocks. Rocks along a fault tend to move in opposite directions; overlying rock strata press the two blocks, locking them by friction. When tendency to move overcomes friction, the blocks slide past one another abruptly, releasing energy. The **focus (hypocentre)** is the point where energy is released; the **epicentre** is the point on the surface nearest to the focus, directly above it — first to experience the waves (NCERT p. 19).
- All natural earthquakes occur in the **lithosphere** — the portion up to **200 km depth** from the surface. An instrument called the **seismograph** records the waves reaching the surface (NCERT §Earthquake Waves, p. 19).

Earthquake waves

- Earthquake waves are basically of two types: **body waves** (generated at the focus, travelling through the body of the earth) and **surface waves** (generated when body waves interact with surface rocks; move along the surface; most destructive). The velocity of waves changes as they travel through materials with different densities — denser material → higher velocity; direction also changes through reflection or refraction (NCERT §Earthquake Waves, p. 20).
- Two types of body waves — **P-waves and S-waves** (NCERT §Propagation of Earthquake Waves, p. 20):
- **P-waves (Primary waves)** — move faster and arrive first; similar to sound waves; travel through **gaseous, liquid and solid materials**. They vibrate **parallel** to the direction of the wave, exerting pressure on material in the direction of propagation;

they create **density differences leading to stretching and squeezing** of the material.

- **S-waves (Secondary waves)** — arrive with some time lag. The critical fact is that they **travel only through solid materials**. They vibrate **perpendicular to the direction of propagation**, in the vertical plane, creating **troughs and crests** in the material through which they pass.
- **Surface waves** are the **last to report** on the seismograph; they are more **destructive** and cause displacement of rocks and collapse of structures.

Shadow zones

- Earthquake waves get recorded in seismographs located at far-off locations, but there exist specific areas where waves are not reported — the **shadow zone**. For each earthquake, the shadow zone is different (NCERT §Emergence of Shadow Zone, p. 20).
- Seismographs located at any distance **within 105° from the epicentre** record both P- and S-waves. Seismographs located **beyond 145°** from the epicentre record the arrival of **P-waves but not S-waves**. Thus the zone **between 105° and 145° from the epicentre is the shadow zone for both types of waves**.
- **The entire zone beyond 105° does not receive S-waves**. The S-wave shadow zone is much larger than that of P-waves — **a little over 40 per cent of the earth's surface**. The P-wave shadow zone appears as a **band around the earth between 105° and 145°** away from the epicentre.

Types of earthquakes (NCERT p. 20–21):

- (i) **Tectonic** — sliding of rocks along a fault plane (most common).
- (ii) **Volcanic** — special class of tectonic earthquake, confined to active volcanic areas.
- (iii) **Collapse** — caused by roofs of underground mines collapsing in intense mining areas; minor tremors.
- (iv) **Explosion** — caused by chemical or nuclear explosions.
- (v) **Reservoir-induced** — occur near large reservoirs.

Measuring earthquakes (NCERT §Measuring Earthquakes, p. 21)

- **Richter scale** — magnitude scale; relates to **energy released** during the quake; expressed in numbers from **0–10**.
- **Mercalli scale** — intensity scale named after Italian seismologist; takes into account **visible damage**; range **1–12**.

Effects of earthquake (NCERT §Effects of Earthquake, p. 21)

- Immediate hazardous effects: (i) Ground Shaking; (ii) Differential ground settlement; (iii) Land and mud slides; (iv) Soil liquefaction; (v) Ground lurching; (vi) Avalanches;

(vii) Ground displacement; (viii) Floods from dam and levee failures; (ix) Fires; (x) Structural collapse; (xi) Falling objects; (xii) Tsunami.

- The first six bear upon landforms; the rest threaten life and property. **Tsunamis** occur only when the epicentre of the tremor is **below oceanic waters** and the magnitude is sufficiently high. Tsunamis are generated by the **tremors and not by the earthquake itself**. Quakes of magnitude **more than 5 on the Richter scale** are devastating.

Frequency of earthquake occurrences — quakes of high magnitude (**8+**) are quite rare, occurring **once in 1–2 years**, whereas 'tiny' quakes occur almost every minute (NCERT p. 22).

Structure of the Earth

- **The Crust** — outermost solid part; brittle. Thickness varies under oceanic and continental areas — **mean oceanic crust is 5 km**; **mean continental crust is about 30 km**, thicker under major mountain systems and **as much as 70 km thick in the Himalayan region** (NCERT §The Crust, p. 22).
- **The Mantle** — extends from **Moho's discontinuity to a depth of 2,900 km**. The upper portion is called the **asthenosphere** ("astheno" means weak); it extends up to **400 km** and is the **main source of magma** that finds its way to the surface during volcanic eruptions; it has higher density than the crust. The **crust and the uppermost solid part of the mantle together form the lithosphere**, which is **10–200 km thick**. The lower mantle (below the asthenosphere) extends beyond the asthenosphere and is in **solid state** (NCERT §The Mantle, pp. 22–23).
- **The Core** — the **core–mantle boundary is at a depth of 2,900 km**. The **outer core is in liquid state** while the **inner core is in solid state** (boundary at about **5,100 km**). The core is made up of very heavy material — mostly **nickel (Ni) and iron (Fe)** — and is sometimes referred to as the **nife layer** (NCERT §The Core, p. 23).

Volcanoes and volcanic landforms

- A **volcano** is a place where gases, ashes and/or molten rock material (**lava**) escape to the ground. The layer below the solid crust is the **mantle**, which contains the **asthenosphere** — the weaker zone from which molten rock finds its way upwards. The molten rock in the upper mantle is called **magma**; once it starts moving toward the crust or reaches the surface, it is called **lava**. Material reaching the ground includes **lava flows, pyroclastic debris, volcanic bombs, ash and dust, and gases** such as nitrogen compounds, sulphur compounds, chlorine, hydrogen and argon (NCERT §Volcanoes and Volcanic Landforms, p. 23).
- **Types of volcanoes** (NCERT pp. 23–24):
- **Shield Volcanoes** — barring basalt flows, these are the **largest** volcanoes on the earth. Mostly made of **basalt — very fluid lava**; for this reason **not steep**. They become explosive only if water gets in; otherwise low-explosivity. **Hawaiian**

volcanoes are the most famous examples. The upcoming lava moves in a fountain and throws out a cone at the top of the vent that develops into a **cinder cone**.

- **Composite Volcanoes** — eruptions of **cooler and more viscous lavas than basalt**; often result in **explosive eruptions**. Along with lava, large quantities of **pyroclastic material and ashes** are released; these accumulate in the vicinity of the vent leading to formation of **layers** that make the mounts appear composite.
- **Caldera** — **the most explosive** of the earth's volcanoes; so explosive that on eruption they tend to **collapse on themselves** rather than build a tall structure. The collapsed depressions are called **calderas**. Their explosiveness indicates that the magma chamber is huge and in close vicinity.
- **Flood Basalt Provinces** — outpour highly fluid lava that flows for long distances. Some parts of the world are covered by **thousands of sq km** of thick basalt lava flows; flows may attain **thickness of more than 50 m** and extend hundreds of km. The **Deccan Traps** of India — presently covering most of the **Maharashtra plateau** — are a much larger flood basalt province; initially the trap formations covered an even larger area (NCERT p. 24).
- **Mid-Ocean Ridge Volcanoes** — occur in oceanic areas. There is a system of **mid-oceanic ridges more than 70,000 km long** stretching through all ocean basins; the central portion experiences **frequent eruptions** (NCERT p. 24).
- **Intrusive Forms** — lava released during volcanic eruptions, on cooling, develops into igneous rocks. Cooling at the surface produces **volcanic rocks**; cooling within the crust produces **plutonic rocks**. Intrusive forms (NCERT §Intrusive Forms, p. 25):
- **Batholiths** — large bodies of magmatic material cooling in the deeper crust as **large domes**; appear on the surface only after denudation; cover large areas; **granitic bodies** — the cooled portion of magma chambers.
- **Laccoliths** — large dome-shaped intrusive bodies with a **level base** connected by a **pipe-like conduit** from below. Resemble the surface volcanic domes of composite volcanoes but at deeper depths. The **Karnataka plateau** is spotted with **domal hills of granite** (now exfoliated) that are examples of laccoliths or batholiths.
- **Lapolith** — when lava moves upwards and a portion moves horizontally finding a weak plane, it may rest in different forms; when it develops a **saucer shape concave to the sky**, it is called a **lapolith**.
- **Phacolith** — a **wavy mass** of intrusive rocks found at the **base of synclines or at the top of anticlines** in folded igneous country; has a definite conduit to source magma chambers (subsequently developed as batholiths).
- **Sill / Sheet** — **near-horizontal bodies** of intrusive igneous rock; the **thinner** ones are **sheets** and the **thicker** ones are **sills**.
- **Dykes** — when lava makes its way through cracks and fissures in the land, it solidifies almost **perpendicular to the ground**, cooling in place to develop a **wall-like structure**. Dykes are the **most commonly found intrusive forms in the**

western Maharashtra area and are considered the **feeders for the eruptions that led to the development of the Deccan Traps**.

2.2 Definitions to memorise

Term	Definition	Page
Focus / Hypocentre	Point within the earth where earthquake energy is released	19
Epicentre	Point on the earth's surface nearest the focus; first to experience waves	19
Fault	A sharp break in the crustal rocks along which rocks move in opposite directions	19
Seismograph	Instrument that records earthquake waves reaching the surface	19
Body waves	Waves generated at the focus that travel through the body of the earth	19
Surface waves	Waves generated when body waves interact with surface rocks; most destructive	20
P-waves (Primary)	Fastest body waves; travel through solid, liquid and gas; vibrate parallel to direction of propagation	20
S-waves (Secondary)	Body waves that travel only through solid materials; vibrate perpendicular to direction of propagation	20
Shadow zone	Area where direct earthquake waves are not received; 105°–145° for both; entire zone beyond 105° for S-waves	20
Tectonic earthquake	Generated by sliding of rocks along a fault plane; most common type	20
Volcanic earthquake	Special class of tectonic earthquake confined to active volcanic areas	20
Collapse earthquake	Caused by collapse of underground mine roofs in intense mining areas	21
Explosion earthquake	Caused by chemical or nuclear explosions	21
Reservoir-induced earthquake	Earthquake occurring near large reservoirs	21
Richter scale	Magnitude scale (0–10) measuring energy released	21
Mercalli scale	Intensity scale (1–12) measuring visible damage; named after Italian seismologist	21
Tsunami	Wave generated by tremors (not by the quake itself) when epicentre is below oceanic waters	21
Moho's discontinuity	Boundary between the crust and the mantle	22
Asthenosphere		22

Term	Definition	Page
	Weak upper portion of the mantle (up to ~400 km); main source of magma	
Lithosphere	Crust + uppermost solid mantle; 10–200 km thick	23
Nife layer	Earth's core, composed mostly of nickel (Ni) and iron (Fe)	23
Magma	Molten rock material in the upper mantle	23
Lava	Magma that has moved towards or reached the surface	23
Pyroclastic debris	Fragmental volcanic material (ash, bombs, lapilli) thrown out during explosive eruptions	23
Shield volcano	Largest volcanoes (apart from flood basalts); fluid basaltic lava, not steep, low explosivity (Hawaii)	23
Composite volcano	Cooler, more viscous lava; explosive; layered with pyroclastic material	24
Caldera	Most explosive volcanoes that collapse to form depressions	24
Flood basalt province	Highly fluid lava flows extending over thousands of sq km; Deccan Traps are the Indian example	24
Batholith	Large dome of granitic magma cooled at great depth; cooled magma chamber	25
Laccolith	Dome-shaped intrusive with a level base and pipe-like conduit	25
Lapolith	Saucer-shaped intrusive concave upward	25
Phacolith	Wavy intrusive mass at base of synclines or top of anticlines	25
Sill / Sheet	Near-horizontal intrusive igneous body — thick (sill) or thin (sheet)	25
Dyke	Vertical wall-like intrusive formed in cracks/fissures; feeders of the Deccan Traps in western Maharashtra	25

2.3 Diagrams / processes to remember

- **Figure 3.1 (p. 20) — Earthquake Waves** — a seismograph record showing three distinct sections in order: **P-waves (first), S-waves (with time lag), Surface waves (last, greatest amplitude)**. The sequence P → S → Surface is a standard CUET point.
- **Figure 3.2(a) and (b) (p. 21) — Earthquake Shadow Zones** — top diagram shows the **P-wave shadow zone as a band between 105° and 145°** from the epicentre, with P-waves received beyond 145°. Bottom diagram shows the **S-wave shadow zone as the entire zone beyond 105°** (over 40% of earth's surface) — revealing the **liquid outer core**.
- **Figure 3.3 (p. 23) — Interior of the Earth** — cross-section showing **Crust (0–100 km), Asthenosphere (part of upper Mantle), Mantle extending to 2,900 km,**

Liquid outer Core to ~5,100 km, Solid inner Core to 6,378 km. The Lithosphere is highlighted as crust + uppermost solid mantle.

- **Figure 3.4 (p. 24) — Volcanic Landforms** — single block diagram showing **Batholith (base), Laccolith, Lapolith, Phacolith, Sill, Dyke, Composite Volcano, Cinder Cone, Lava Plateau, Volcanic neck with radiating dykes, Caldera with cinder cone on floor, Ash cone with volcanic dome, Lava Mesa, eroded laccolith**. Students should be able to identify each form.
- **Process — Why we know there's a liquid outer core**: S-waves cannot travel through liquids → S-waves don't appear beyond 105° → entire zone beyond 105° is S-wave shadow → outer core must be liquid → P-waves still reach beyond 145° (so they pass through some kind of medium) → 105°–145° is the combined P+S shadow.
- **Process — Earthquake genesis**: fault locked by friction → tectonic stress builds → friction overcome → abrupt slip → energy released at focus → body waves radiate (P then S) → on hitting surface, generate surface waves → seismograph records P, then S, then surface waves.
- **Process — From magma to intrusive landforms**: magma rises from asthenosphere → cooling near surface = volcanic rocks; cooling within crust = plutonic (intrusive) rocks → forms depend on cooling location (batholith deep dome, laccolith with level base, lapolith saucer, phacolith wavy, sill/sheet horizontal, dyke vertical).

2.5 Key data table (NCERT figures from this chapter)

#	Item	NCERT figure	Page
1	Earth's radius	About 6,378 km	18
2	Gold mines (South Africa) depth	3–4 km	18
3	Kola deepest drill (Arctic Ocean)	12 km	18
4	Lithosphere depth (where quakes occur)	Up to 200 km	19
5	P-wave shadow zone	105°–145° band	20
6	S-wave shadow zone	Entire zone beyond 105° (>40% of earth's surface)	20
7	Richter scale	0–10 (magnitude — energy)	21
8	Mercalli scale	1–12 (intensity — visible damage)	21
9	Devastating quake threshold	> 5 on Richter	21
10	8+ quakes frequency	Once in 1–2 years	22
11	Mean oceanic crust thickness	5 km	22
12	Mean continental crust thickness	About 30 km	22
13	Crust thickness under Himalayas	As much as 70 km	22

#	Item	NCERT figure	Page
14	Mantle to depth of	2,900 km (Moho to core boundary)	22
15	Asthenosphere extends up to	400 km	22
16	Lithosphere thickness	10–200 km	23
17	Core–mantle boundary	2,900 km	23
18	Outer core / Inner core boundary	About 5,100 km	23
19	Mid-oceanic ridge system	> 70,000 km long	24
20	Flood basalt single flow thickness	More than 50 m	24
21	Deccan Traps location	Most of Maharashtra plateau	24
22	Most common intrusive form in W. Maharashtra	Dykes (feeders of Deccan Traps)	25

2.4 Common confusions / NTA trap points

- **P-waves vs S-waves medium of travel**: S-waves travel **only through solid materials**, not liquid; P-waves travel through **solid, liquid and gas**. The diagnostic that S-waves cannot pass the liquid outer core is the key to the large S-wave shadow zone.
- **P-wave shadow zone (105° –145° band) vs S-wave shadow zone (entire zone beyond 105°)** — NTA frequently inverts these.
- **Lithosphere vs Asthenosphere** — Lithosphere = **crust + uppermost solid mantle (10–200 km)**; Asthenosphere = **upper portion of mantle up to ~400 km (weak, source of magma)**. Lithosphere is NOT just the crust. NCERT Exercise 1(iv) tests this directly.
- **Richter vs Mercalli** — Richter measures **energy released (magnitude, 0–10)**; Mercalli measures **visible damage (intensity, 1–12)**. Easily swapped.
- **Magma vs Lava** — magma is molten rock in the upper mantle/crust; once it moves toward or reaches the surface it is **lava**. Same material, two names depending on location.
- **Deccan Traps are from FLOOD BASALT eruptions**, not shield or composite or caldera — a classic NTA trap (NCERT Exercise 1(iii)).
- **Direct vs indirect sources** — volcanoes are a **direct** source; earthquake waves, gravitation and magnetism are **indirect** sources (NCERT Exercise 1(ii) tests this).
- **Surface waves are most destructive**, not P or S — surface waves cause displacement of rocks and collapse of structures (NCERT Exercise 1(i)).
- **Tsunamis are generated by tremors**, not by the earthquake itself, and only when the epicentre is below oceanic waters with high magnitude.
- **Most common intrusive form in western Maharashtra = dykes**, NOT sills or batholiths.

- **Shadow zone area share** — over **40%** for S-waves, not 4% or 14%.
- The **nife layer** is the **core**, not the mantle — composed mostly of **nickel and iron**.
- **Outer core liquid, inner core solid** — students sometimes invert.

🎯 Practice MCQs

📊 PYQ Alignment

This chapter is a consistent source of CUET Geography questions, with 4–6 MCQs appearing annually from the broad "Interior of the Earth" unit. Questions typically focus on **wave properties and shadow zones**, **layer characteristics** (depths, states of matter), **Richter vs Mercalli scales**, **direct vs indirect sources**, **Deccan Traps as flood basalts**, and identification of **volcanic/intrusive landforms** — all aligned with the CUET 2023–25 pattern of direct recall and statement-based questions. For drill sets and previous-year analyses see /pyq/geography.