GN02 — Physical Geography: Geomorphology

📖 GN02 · NDA General Ability Test — Geography

★ Highest-Yield Physical Chapter — 3–4 Questions

If Chapter GN01 told you *where* Earth is, this chapter tells you *what* Earth is made of and why its surface looks the way it does. Geomorphology — the study of landforms and the processes that create them — is the single most tested physical geography topic in NDA. Questions range from identifying rock types, to understanding plate tectonics, to knowing the difference between a focus and an epicentre. Master this chapter and you secure 3–4 marks guaranteed.

🌎 **NDA Focus:** Richter scale = magnitude (size); Mercalli scale = intensity (damage); P-waves pass through solids AND liquids; S-waves through solids ONLY (used to discover liquid outer core); Convergent plates → Himalayas; Marble from Limestone; Diamond from Carbon (not graphite — graphite IS diamond under pressure); deepest trench = Mariana (Pacific Ocean).

PART 1 — EARTH'S INTERIOR

1. Structure of the Earth

We cannot directly observe Earth's interior below a few kilometres — the deepest borehole ever drilled (Kola Superdeep, Russia) reached only 12 km, barely scratching the surface. Instead, scientists study seismic waves (earthquake waves) that travel through the Earth, changing speed and direction at different layers. This is how we know the composition of Earth's interior.

Layer	Depth	Composition	Key Facts

Crust (Sial + Sima)	0–35 km (continental), 0–10 km (oceanic)	Continental: granite-like (Si + Al = Sial); Oceanic: basaltic (Si + Mg = Sima)	Thinnest layer; site of all human activity; Moho discontinuity separates crust from mantle
Mantle	35–2,900 km	Solid rock (peridotite); partially molten asthenosphere (100–200 km depth)	Asthenosphere is where tectonic plates 'float'; source of magma for volcanoes; Gutenberg discontinuity separates mantle from outer core
Outer Core	2,900–5,100 km	Liquid iron and nickel (Fe-Ni)	Only liquid layer; movement of liquid iron generates Earth's magnetic field
Inner Core	5,100–6,371 km (centre)	Solid iron and nickel (Fe-Ni)	Hottest part (~5,000°C); immense pressure keeps it solid despite the temperature; Lehmann discontinuity separates outer and inner core

Key Discontinuities (Boundary layers) — NDA tests these names directly:

- **Conrad Discontinuity:** Within the crust; separates upper (Sial) from lower (Sima) crust
- **Mohorovičić (Moho) Discontinuity:** Between crust and mantle — density increases sharply
- **Gutenberg Discontinuity:** Between mantle and outer core — S-waves stop here (liquid outer core)
- **Lehmann Discontinuity:** Between outer core and inner core

PART 2 — ROCKS & ROCK CYCLE

2. Types of Rocks

All rocks on Earth belong to one of three families based on how they formed. Understanding these families is essential — NDA regularly asks about rock examples, their properties, and the processes linking them.

Rock Type	Formation	Examples	Key NDA Facts
Igneous (Primary rocks)	Crystallisation of molten magma/lava; no fossils	Granite (intrusive, slow cooling, coarse); Basalt (extrusive, fast cooling, fine); Pumice, Obsidian	Parent rocks — all other rocks derived from these. Intrusive: inside Earth; Extrusive: on surface (volcanic)

Sedimentary (Stratified)	Compaction and cementation of deposited sediments over time	Sandstone, Limestone, Shale, Coal, Conglomerate	Contain fossils (most important for palaeontology); formed in layers (strata); most widespread surface rocks; ~75% of Earth's surface
Metamorphic (Changed)	Transformation of igneous/sedimentary rocks under heat and pressure	Marble (from Limestone); Slate (from Shale); Quartzite (from Sandstone); Diamond (from graphite under extreme pressure)	No fossils (destroyed by heat/pressure); hardest rocks; Marble used in buildings (Taj Mahal)

The Rock Cycle: *No rock type is permanent. Igneous rocks get weathered into sediments → compacted into sedimentary rocks → heated/pressurised into metamorphic rocks → melted into magma → cooled back into igneous rocks. This continuous cycle is called the Rock Cycle. NDA may ask which rock is formed from which — always trace the transformation chain.*

PART 3 — PLATE TECTONICS

3. Plate Tectonics

The crust of the Earth is not one solid piece — it is broken into about **15 major tectonic plates** that float on the semi-molten asthenosphere (upper mantle). These plates move very slowly (2–10 cm per year) driven by convection currents in the mantle. The theory of plate tectonics, built on Alfred Wegener's earlier **Continental Drift Theory (1912)**, explains most major geological phenomena — mountain building, ocean trenches, earthquakes, and volcanoes.

📌 **Wegener's Evidence for Continental Drift:**

- **Jigsaw fit:** South America's east coast and Africa's west coast fit together like puzzle pieces
- **Fossil evidence:** Same fossils (Glossopteris plant; Mesosaurus reptile) found on continents now separated by oceans
- **Rock similarity:** Same rock formations found on opposite sides of the Atlantic
- **Coal in Antarctica:** Indicates Antarctica was once near the equator (tropical climate)

Plate Boundary Type	Movement	Feature Formed	Example
Divergent (Constructive)	Plates move APART	Mid-Oceanic Ridges; Rift Valleys; new ocean floor created	Mid-Atlantic Ridge; East African Rift Valley; Iceland (sits on Mid-Atlantic Ridge)

Convergent (Destructive)	Plates move TOWARD each other	Ocean trench (oceanic-oceanic or oceanic-continental); Fold Mountains (continental-continental)	Mariana Trench (Pacific plate dives under Philippine plate); Himalayas (India + Eurasia plates colliding)
Transform (Conservative)	Plates slide PAST each other horizontally	Fault lines; Earthquakes (no mountains or trenches formed)	San Andreas Fault (California); North Anatolian Fault (Turkey)

💡 **Himalayas — NDA's Favourite Plate Tectonic Question:**
The Himalayas formed when the **Indian Plate** (moving northward) collided with the **Eurasian Plate**. This is a continent-continent convergent boundary. Both plates are equally dense so neither subducts — instead, the crust crumples upward forming fold mountains. The Himalayas are still rising (about 5 mm per year) because the collision continues today.

PART 4 — EARTHQUAKES

4. Earthquakes

Earthquakes occur when stress built up along fault lines is suddenly released, sending seismic waves in all directions. Understanding the types of seismic waves is critical for NDA — they were used to discover Earth's internal structure.

Seismic Waves

📈 Body Waves (travel through Earth)

- **P-waves (Primary / Compressional):** Fastest; travel through solids, liquids AND gases; first to arrive at seismograph; compress and expand rock
- **S-waves (Secondary / Shear):** Slower than P-waves; travel through solids ONLY; cannot pass through liquid outer core — this absence in a

📌 Surface Waves (travel along surface)

- **L-waves (Love waves):** Move side to side; most destructive to buildings
- **Rayleigh waves:** Move in an elliptical rolling motion (like ocean waves)
- Surface waves travel slowest but cause **maximum damage**
- Felt on the surface; buildings

"shadow zone" proved the outer core is liquid

experience whip-like motion

Focus vs Epicentre (NDA tested directly):

- **Focus (Hypocentre):** The actual point inside the Earth where the earthquake originates. Can be shallow (0–70 km), intermediate (70–300 km), or deep (300–700 km).
- **Epicentre:** The point on Earth's surface directly above the focus. Maximum damage is felt here.

Measuring Earthquakes:

- **Richter Scale:** Measures *magnitude* (total energy released); logarithmic (magnitude 7 = 10× more powerful than magnitude 6); no upper limit; measured by seismograph
- **Mercalli Scale:** Measures *intensity* (how much damage/shaking is felt); subjective; ranges from I (not felt) to XII (total destruction)

PART 5 — VOLCANOES & LANDFORMS

5. Volcanoes

A volcano is an opening in the Earth's crust through which molten rock (magma), gases, and ash escape to the surface. Once magma reaches the surface, it is called **lava**. The "Ring of Fire" around the Pacific Ocean has about 75% of the world's volcanoes because many tectonic plate boundaries meet there.

Volcano Type	Characteristics	Shape	Examples
Shield Volcano	Gently sloping; low viscosity lava (basaltic); frequent non-explosive eruptions; lava flows far	Broad, dome-shaped (like an upturned shield)	Mauna Loa, Kilauea (Hawaii)
Composite/ Stratovolcano	Steep slopes; alternating lava and ash layers; high viscosity; explosive eruptions	Tall, conical	Fuji (Japan), Vesuvius (Italy), Krakatau (Indonesia), Mt. St. Helens (USA)
Cinder Cone	Smallest type; steep slopes; made of ejected cinders; brief, explosive eruptions	Steep, small, conical crater	Parícutin (Mexico)

Cald era	Formed when magma chamber collapses after eruption; can be filled with water	Large crater / lake	Crater Lake (Oregon, USA); Toba (Indonesia)

6. Landforms — Erosional and Depositional

🌊 River (Fluvial) Landforms

- **V-shaped valley:** Upper course; fast flow, vertical erosion
- **Waterfall:** Hard rock over soft rock; Niagara, Victoria, Jog Falls
- **Meander:** Middle/lower course; lateral erosion; S-bends in plains
- **Oxbow lake:** Cut-off meander; Horseshoe-shaped lake
- **Delta:** At river mouth; sediment deposition; Ganga-Brahmaputra delta (world's largest)

🏂 Glacier (Glacial) Landforms

- **U-shaped valley:** Glacial erosion; wide, flat bottom; unlike V-shaped river valley
- **Cirque:** Armchair-shaped hollow on mountain where glacier forms
- **Arête:** Sharp, knife-like ridge between two cirques
- **Horn / Pyramidal peak:** Peak formed by three or more cirques; Matterhorn (Alps)
- **Moraine:** Sediment deposited by glacier; terminal moraine = end deposit

🌎 Wind (Aeolian) Landforms

- **Barchan:** Crescent-shaped sand dune; concave side facing wind direction
- **Mushroom rock / Pedestal rock:** Formed by wind erosion; narrow base, broad top
- **Loess:** Fine wind-deposited sediment; forms fertile plains

🍁 Karst (Limestone) Landforms

- **Caves / Caverns:** Dissolved by slightly acidic groundwater (carbonic acid)
- **Stalactites:** Grow DOWN from cave ceiling (remember: c = ceiling)
- **Stalagmites:** Grow UP from cave floor (remember: g = ground)

(China's Loess Plateau)

- Found in deserts (Sahara, Thar, Gobi)

- **Sinkholes / Dolines:** Collapsed limestone surface; can swallow buildings

📝 NDA PYQs — Geomorphology

Q1. Which seismic waves can travel through both solid and liquid material?

NDA PYQ

(a) S-waves only (b) P-waves only (c) Both P and S waves (d) L-waves only

✓ Answer: (b) P-waves only

P-waves (Primary/Compressional waves) travel through solids, liquids, and gases — they are the only seismic waves that pass through all states of matter. S-waves travel through solids only — they cannot pass through the liquid outer core, creating a "shadow zone" on the opposite side of the Earth. This inability of S-waves to pass through liquid is the primary evidence that Earth's outer core is liquid. This distinction is directly tested in NDA.

Q2. The Richter scale measures: NDA PYQ

(a) Intensity (damage) of earthquakes

(b) Magnitude (energy released) of earthquakes (c) Depth of earthquake focus

(d) Speed of seismic waves

✓ Answer: (b) Magnitude — energy released

The **Richter Scale** measures the magnitude — the total energy released by an earthquake — using a seismograph. It is a logarithmic scale (each whole number = 10× more energy). The **Mercalli Scale** measures intensity — the degree of shaking and damage felt at a specific location, which varies with distance from the epicentre. Mercalli is subjective (observed effects); Richter is objective (instrument measured).

Q3. The Himalayas were formed due to which type of plate boundary?

NDA PYQ

(a) Divergent boundary (b) Transform boundary

(c) Convergent boundary (continent-continent)

(d) Convergent boundary (oceanic-continental)

✓ Answer: (c) Convergent boundary — continent-continent collision

The Himalayas formed when the **Indian Plate** (which was part of the ancient Gondwana supercontinent) moved northward and collided with the **Eurasian Plate**. Since both plates carry continental crust of similar density, neither subducts — the crust buckles and crumples upward into fold mountains. The Himalayas are still rising because the collision continues. This is one of NDA's most frequently repeated geography questions.

Q4. Marble is formed from which parent rock? NDA PYQ

(a) Granite (b) Sandstone (c) Limestone (d) Shale

✓ Answer: (c) Limestone

Marble is a metamorphic rock formed when limestone is subjected to heat and pressure. The calcite in limestone recrystallises into larger grains — creating the characteristic crystalline appearance of marble. Marble was used to build the Taj Mahal. Other important metamorphic rock pairs: Shale → Slate → Phyllite → Schist → Gneiss; Sandstone → Quartzite; Coal → Graphite → Diamond.

Q5. Which is the deepest ocean trench in the world? Tricky

(a) Puerto Rico Trench (Atlantic) (b) Java Trench (Indian Ocean)

(c) Mariana Trench (Pacific) (d) Tonga Trench (Pacific)

✓ Answer: (c) Mariana Trench, Pacific Ocean

The **Mariana Trench** in the Pacific Ocean is the deepest point on Earth (~11,034 m at Challenger Deep). It was formed where the Pacific Plate subducts under the Mariana Plate (oceanic-oceanic convergent boundary). The Pacific Ocean has most of the world's deep trenches. NDA sometimes asks about the deepest in each ocean: Pacific = Mariana; Atlantic = Puerto Rico; Indian = Java (Sunda) Trench.

🧠 Quick Memory Chart — GN02

🌍 Earth's Interior

- Crust (Sial + Sima) → Mantle → Outer Core

🪨 Rocks & Plates

- Igneous → primary; no fossils

🌊 Earthquake & Volcanoes

(liquid) → Inner Core (solid)

- Moho: crust-mantle boundary
- Gutenberg: mantle-outer core boundary
- Earth's magnetic field: liquid outer core
- Deepest borehole: Kola, Russia (12 km)

- Sedimentary → fossils; most widespread
- Metamorphic → heat+pressure; Marble←Limestone
- Divergent → Mid-ocean ridges; Rift valleys
- Convergent → trenches; fold mountains

- P-waves: solid + liquid; S-waves: solid only
- Richter = magnitude; Mercalli = intensity
- Focus = origin; Epicentre = surface above
- Deepest trench: Mariana (Pacific, ~11 km)
- Ring of Fire: 75% of world's volcanoes

📝 Practice Exercise

E1. Which type of volcano has gently sloping sides and non-explosive eruptions?

(a) Composite volcano (b) Cinder cone (c) Shield volcano (d) Caldera

E2. Stalactites grow from the:

(a) Cave floor upward (b) Cave ceiling downward (c) Cave walls inward (d) Cave entrance

E3. The San Andreas Fault in California is an example of which plate boundary?

(a) Divergent (b) Convergent (c) Transform (d) Subduction

Answers:

E1 → (c) Shield volcano [broad, dome-shaped; low viscosity basaltic lava flows far; Mauna Loa, Hawaii] | E2 → (b) Cave ceiling downward [mnemonic: stalacTITES hold TIGHT to ceiling; stalagMITES MIGHT reach ceiling someday] | E3 → (c) Transform boundary [plates

slide past each other horizontally; no new crust created or destroyed; frequent earthquakes]

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