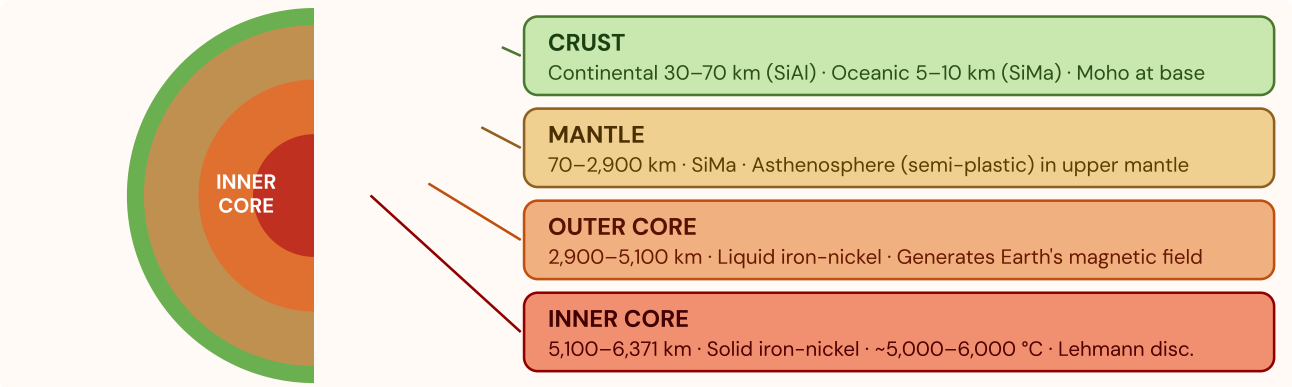
GC02 — Geomorphology

🌍 Physical Geography – GC02 CDS Level ★ High Priority

📌 **CDS Focus:** High-weightage topic. Questions focus on **Earth's internal structure** (layers, depths), **plate tectonics** (types of plate boundaries and resulting landforms), **rock types** (igneous, sedimentary, metamorphic with examples), **volcanoes and earthquakes** (types, seismic waves, scales), and **landform identification** (fold mountains, block mountains, plains, karst). Endogenic vs exogenic processes distinction is directly tested.

1. Earth's Interior

FIG. 1.1 — EARTH'S INTERNAL STRUCTURE: LAYERS, COMPOSITION & DEPTH



Topic A **Earth's Layers** Depths & Composition

Crust **Outermost solid layer.** Continental crust (SiAl — Silicon + Aluminium): 30–70 km thick. Oceanic crust (SiMa — Silicon + Magnesium): 5–10 km thick, denser. Separated from mantle by the **Mohorovičić discontinuity (Moho).**

Mantle **Largest layer (~84% of Earth's volume).** Depth: 70–2,900 km. Composed of SiMa (silicates of magnesium). Upper mantle includes the **asthenosphere** (semi-

plastic, on which tectonic plates "float"). Lower mantle is more rigid. Separated from outer core by the **Gutenberg discontinuity**.

Outer Core — **Liquid iron-nickel.** Depth: 2,900–5,100 km. Convection currents here generate Earth's **magnetic field** (magnetosphere). Generates Earth's protective shield against solar wind.

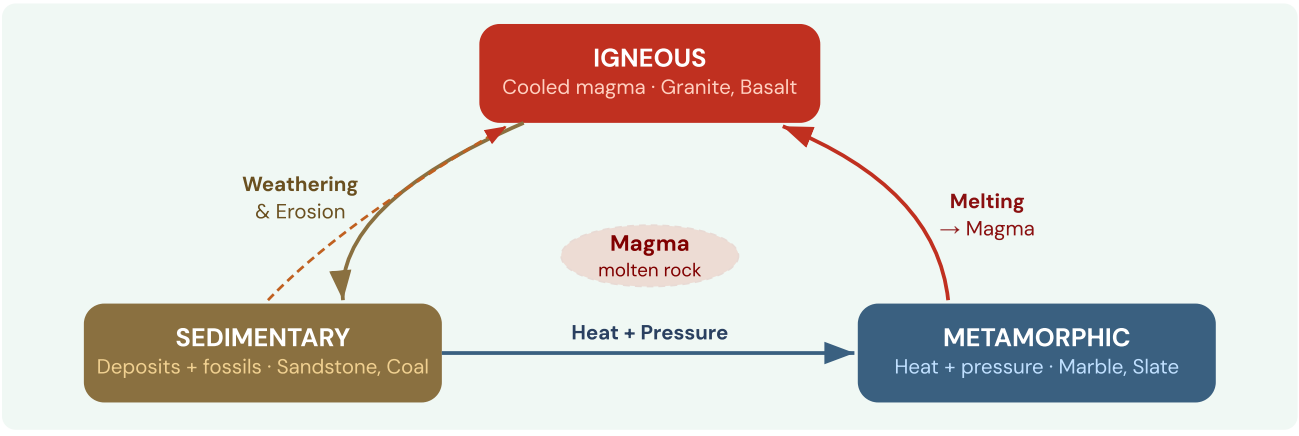
Inner Core — **Solid iron-nickel despite very high temperatures (~5,000–6,000°C)** because of immense pressure. Radius ~1,250 km. Separated from outer core by the **Lehmann discontinuity**.

⚠️ **Discontinuities — CDS Direct Questions:** Moho = crust-mantle boundary · Gutenberg = mantle-outer core boundary · Lehmann = outer-inner core boundary. Inner core is **solid** despite high temp (due to pressure). Outer core is **liquid** — generates Earth's magnetic field.

ROCKS & THE ROCK CYCLE

2. Rocks & Minerals

FIG. 2.1 — THE ROCK CYCLE: HOW THE THREE ROCK TYPES TRANSFORM INTO EACH OTHER



Rock Type	Formation	Examples	CDS Fact
Igneous	Cooling of magma/lava (intrusive = slow/coarse; extrusive = fast/fine)	Granite (intrusive), Basalt (extrusive), Obsidian, Pumice	Basalt forms Deccan Traps; Granite → forms peninsular India's base
Sedimentary	Deposition, compaction & cementation of eroded material; contain fossils	Sandstone, Limestone, Shale, Conglomerate, Coal	Fossil fuels found in sedimentary rocks; cover ~75% of Earth's surface
Metamorphic	Pre-existing rocks transformed by heat & pressure; no fossils	Marble (from limestone), Quartzite (from sandstone), Slate (from shale), Diamond (from carbon)	Diamond is metamorphic; Marble used in Taj Mahal

GEOMORPHIC PROCESSES

3. Endogenic & Exogenic Processes

FIG. 3.1 — ENDOGENIC VS EXOGENIC PROCESSES: ORIGIN & KEY EXAMPLES

ENDOGENIC (Internal Forces)

Source: Earth's interior heat & pressure

- Diastrophism — folding & faulting of crust
- Volcanism — lava flows, calderas
- Earthquakes — at plate boundaries
- Plate tectonics — convergent, divergent, transform

Result: BUILD UP landforms

EXOGENIC (External Forces)

Source: Solar energy (water, wind, ice)

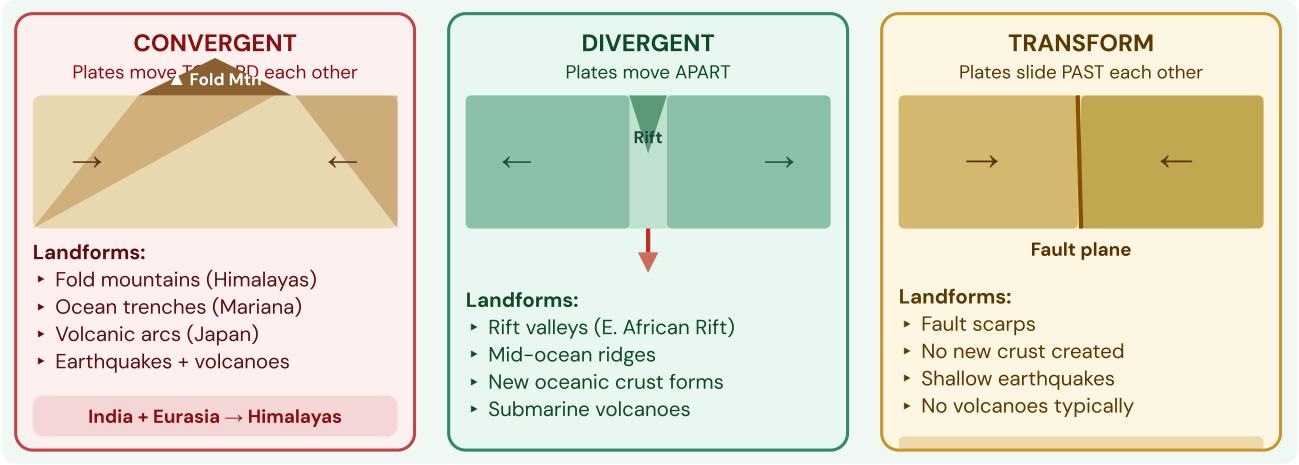
- Weathering — physical, chemical, biological
- Mass wasting — landslides, soil creep
- Erosion — river, wind, glacier, wave
- Deposition — deltas, fans, sand dunes

Result: WEAR DOWN & reshape landforms

PLATE TECTONICS

4. Plate Tectonics

FIG. 4.1 — THREE TYPES OF PLATE BOUNDARIES & RESULTING LANDFORMS



Topic D

Continental Drift & Plate Tectonics

Wegener

Alfred Wegener (1912) — Continental Drift Theory. All continents were once joined as a supercontinent called **Pangaea** (~200–300 million years ago), surrounded by a universal ocean called **Panthalassa**. Pangaea split into Laurasia (north) and Gondwanaland (south) first, then further fragmented. Evidence: matching coastlines, fossil correlation, coal in Antarctica, Glossopteris flora.

Seafloor

Seafloor Spreading (Hess, 1960s) — new oceanic crust forms at mid-ocean ridges as plates diverge; older crust is subducted at trenches. This explained the mechanism of continental drift that Wegener could not provide.

EARTHQUAKES & VOLCANOES

5. Earthquakes

🌊 Seismic Waves

- **P-waves** (Primary/longitudinal) — fastest; travel through solids AND liquids; first to arrive
- **S-waves** (Secondary/transverse) — slower; travel only through solids; do NOT pass through liquid outer core

📏 Scales & Terms

- **Focus / Hypocentre** — origin point inside Earth
- **Epicentre** — point on surface directly above focus
- **Richter Scale** — measures magnitude (logarithmic); each unit = 10× more amplitude

- **L-waves** (Surface/Love waves) — slowest; most destructive; travel on surface only
- **Shadow zone** — area between 103°–143° from epicentre where no waves are received (S-waves absent beyond 103°)

- **Mercalli Scale** — measures intensity (observed damage)
- **Isoseismal lines** — connect points of equal intensity
- **Tsunami** — seismic sea wave; caused by undersea earthquakes

⚠️ **Seismic Wave Traps:** (1) S-waves cannot pass through liquids — this is how we know the outer core is liquid. (2) P-waves travel through everything — solids AND liquids. (3) L-waves are the most destructive (surface waves). (4) Richter scale is **logarithmic** — a magnitude 7 is 10× more than magnitude 6 in amplitude, but ~32× more in energy.

6. Volcanoes

Topic F

Types of Volcanoes

CDS Direct

Shield **Broad, gently sloping volcano.** Low-viscosity lava flows freely. Non-explosive eruptions. Example: **Mauna Loa, Hawaii** (largest volcano by volume on Earth).

Composite **Stratovolcano — steep, conical shape.** Alternating layers of lava and ash. Highly explosive. Examples: **Mt. Fuji (Japan), Mt. Vesuvius (Italy), Mt. St. Helens (USA).** Most dangerous type.

Cinder Cone Smallest and simplest. Built from ejected lava fragments (cinders). Steep sides. Single vent. Example: Paricutín, Mexico.

Caldera **Collapsed volcano crater** after a massive explosion empties the magma chamber. Can fill with water to form crater lakes. Example: Crater Lake, Oregon; Lonar Lake, Maharashtra.

Ring of Fire **Circum-Pacific Belt** — zone around the Pacific Ocean with ~90% of world's earthquakes and ~75% of active volcanoes. Includes Japan, Philippines, Indonesia, west coast of Americas. Associated with subduction zones.

MAJOR LANDFORMS

7. Mountains, Plateaus, Plains & Special Landforms

Landform	Formation	Type	Example
Fold Mountains	Convergent plate collision; rocks fold upward	Young (steep) / Old (rounded)	Himalayas, Andes, Alps, Rockies (young); Aravallis, Appalachians (old)
Block Mountains	Faulting — central block (horst) rises; flanks (graben) drop	Horst = uplifted block; Graben = down-dropped	Black Forest, Vosges (Europe); Vindhya range
Volcanic Mountains	Accumulation of lava/ash	Shield / Composite / Cinder cone	Mt. Kilimanjaro, Mt. Fuji, Hawaiian islands
Plateaus	Uplifted, flat-topped elevated areas	Dissected / Lava / Intermontane	Deccan Plateau (lava); Tibetan Plateau (highest, ~4,500m); Chota Nagpur
Plains	Deposition by rivers / glaciers	Alluvial / Glacial / Coastal	Indo-Gangetic Plain (alluvial); North European Plain

Karst Topography

Formed in areas of soluble rocks (limestone) by **chemical weathering** (carbonation). Underground water dissolves limestone creating characteristic features. Directly tested in CDS.

Underground Karst Features

- **Caves** — underground hollow spaces
- **Stalactites** — hang from ceiling (calcium carbonate)
- **Stalagmites** — rise from floor
- **Speleothems** — general term for cave deposits

Surface Karst Features

- **Sinkholes (Dolines)** — circular depressions
- **Uvala** — coalesced sinkholes
- **Poljes** — large flat-floored depression
- **Disappearing streams** — rivers sink underground

💡 **Stalactite vs Stalagmite:** Stalactite has a **C** → hangs from **C**eiling. Stalagmite has a **G** → grows from **G**round. When they meet, they form a column/pillar.

Glacial Landforms

⛰️ Erosional (Carved by ice)

- **Cirque** — bowl-shaped depression at glacier head
- **Arête** — sharp ridge between two cirques
- **Horn** — pyramidal peak (3+ cirques meeting) — e.g., Matterhorn
- **U-shaped valley** — carved by glacier (vs V-shape by river)
- **Fjord** — U-valley flooded by sea

🪨 Depositional (Left by ice)

- **Moraine** — ridges of deposited debris (lateral, medial, terminal)
- **Drumlin** — oval hill of glacial till; elongated in direction of ice movement
- **Esker** — sinuous ridge deposited by subglacial streams
- **Outwash plain** — sediment deposited beyond terminal moraine

📐 Formula Sheet & Key Facts — GCo2

Earth's Layers (Depth)

Crust: **0–70 km** (continental)
Mantle: **70–2,900 km**
Outer Core: **2,900–5,100 km (liquid)**
Inner Core: **5,100–6,371 km (solid)**

Discontinuities

Crust–Mantle: **Mohorovičić (Moho)**
Mantle–Outer Core: **Gutenberg**
Outer–Inner Core: **Lehmann**

Seismic Waves Speed

Fastest: **P-waves** (through all media)
Medium: **S-waves** (solids only)
Slowest + most destructive: **L-waves** (surface)

Rock Examples

Igneous: **Granite, Basalt, Obsidian**
Sedimentary: **Sandstone, Limestone, Coal**
Metamorphic: **Marble, Quartzite, Slate**

Plate Boundaries

Convergent: **fold mts + trenches**
Divergent: **rift valleys + mid-ocean ridges**
Transform: **fault scarps + shallow quakes**

Pangaea & Continents

Supercontinent: **Pangaea**
Universal ocean: **Panthalassa**
Proposed by: **Wegener (1912)**
Split into: **Laurasia + Gondwanaland**

📝 Topic-Wise PYQs & Tricky Questions — GC02

Q1. The liquid outer core of the Earth is primarily composed of: CDS PYQ

(a) Silicon and Aluminium (b) Iron and Nickel (c) Silicon and Magnesium

(d) Carbon and Sulphur

✓ Answer: (b) Iron and Nickel

Both the outer core (liquid) and inner core (solid) are composed primarily of iron and nickel. The outer core's liquid iron-nickel generates Earth's magnetic field through convection. The crust is composed of SiAl (continental) or SiMa (oceanic). The mantle is SiMa (silicates of magnesium).

Q2. Which type of seismic waves cannot pass through liquid? CDS PYQ

(a) P-waves (b) S-waves (c) L-waves (d) All of the above

✓ Answer: (b) S-waves

S-waves (Secondary/transverse waves) can only travel through solids. They cannot pass through the liquid outer core — this is the key evidence that helped scientists determine the outer core is liquid. P-waves (Primary) travel through solids AND liquids. L-waves travel only on the surface. This is a frequently tested direct question.

Q3. The Himalayas are an example of which type of mountain? CDS PYQ

(a) Block mountains (b) Volcanic mountains (c) Fold mountains

(d) Residual mountains

✓ Answer: (c) Fold mountains

The Himalayas formed ~50 million years ago when the Indian Plate collided with the Eurasian Plate (convergent boundary), folding the sedimentary rocks upward. They are

young fold mountains and are still rising. Block mountains (e.g., Black Forest, Vindhyas) are formed by faulting. The Aravallis are old fold mountains.

Q4. Which of the following rocks is correctly matched with its type? Tricky

(a) Marble — Igneous (b) Limestone — Metamorphic (c) Granite — Igneous

(d) Coal — Metamorphic

✓ Answer: (c) Granite — Igneous

Granite is intrusive igneous rock (cooled slowly underground → coarse-grained). Marble is metamorphic (formed from limestone under heat/pressure). Limestone is sedimentary (from marine organism shells). Coal is sedimentary (compressed plant material). Diamond is metamorphic carbon — a common CDS trap.

Q5. The term "horst" in geology refers to: Tricky

(a) A fold mountain (b) An uplifted block between two faults

(c) A down-dropped block (d) A volcanic caldera

✓ Answer: (b) An uplifted block between two faults

In block mountain formation, tensional forces along faults cause the central block to be uplifted — called a **horst**. The down-dropped blocks on either side are called **graben**. Graben form rift valleys (e.g., East African Rift Valley, Rhine Valley). Black Forest and Vosges Mountains in Europe are examples of horsts flanking the Rhine Graben.

Q6. Lonar Lake in Maharashtra was formed by: Tricky

(a) Tectonic activity (b) Meteorite impact (c) Volcanic caldera (d) Glacial erosion

✓ Answer: (b) Meteorite impact

Lonar Lake (Maharashtra) was formed by a meteorite impact ~52,000 years ago — it is a **saline impact crater lake**, not a volcanic caldera. It is situated in the Deccan Trap basalt. This is a frequently asked CDS trap. Crater Lake, Oregon (USA) is a volcanic caldera example. Lonar is one of only four known hyper-velocity impact craters in basaltic rock worldwide.

Q7. Stalactites in a cave are formed by: CDS PYQ

(a) Glacial deposition (b) Wind erosion

(c) Chemical deposition of calcium carbonate from dripping water (d) Volcanic activity

✓ Answer: (c) Chemical deposition of calcium carbonate

Stalactites hang from cave ceilings; stalagmites grow from the cave floor. Both are speleothems formed by the deposition of calcium carbonate ($CaCO_3$) from dripping groundwater. This occurs in limestone (karst) regions where water dissolves and re-

deposits the calcium carbonate. Memory aid: stalac**T**ite → **T**op; stalag**M**ite → **M**ound on floor.

🧠 Quick Memory Chart — GCo2

🌍 Earth's Layers

- Crust–Mantle: **Moho**
- Mantle–Outer Core: **Gutenberg**
- Outer–Inner Core: **Lehmann**
- Outer core: **liquid Fe-Ni** → magnetic field
- Inner core: **solid** (high pressure)
- Largest layer: **Mantle**

🪨 Rocks Quick Match

- Granite → **Igneous (intrusive)**
- Basalt → **Igneous (extrusive)**
- Limestone → **Sedimentary**
- Coal → **Sedimentary**
- Marble → **Metamorphic** (←limestone)
- Diamond → **Metamorphic** (←carbon)

⛰️ Mountain Types

- Himalayas → **Fold mountains**
- Black Forest → **Block mountain**
- Aravallis → **Old fold mountains**
- Vindhyas → **Block mountains**
- Mt. Fuji → **Composite volcano**
- Mauna Loa → **Shield volcano**

⚡ Seismic Waves

- P-waves: **fastest; all media**
- S-waves: **solids only**
- L-waves: **surface; most destructive**
- S-wave absence → outer core = liquid
- Richter: **logarithmic** magnitude
- Mercalli: **intensity (damage)**

🌋 Plate Tectonics

- Convergent → **Fold mts + Trenches**
- Divergent → **Rift valleys + Ridges**
- Transform → **Faults + Quakes**
- Pangaea (Wegener, 1912)
- Ring of Fire → 90% quakes
- India-Eurasia → Himalayas

🕳️ Karst & Glacial

- Stalactite → from **ceiling**
- Stalagmite → from **ground**
- Sinkhole = doline (karst)
- Horst = uplifted block
- Graben = down-dropped block
- U-valley = glacial; V-valley = river