Sleepy Classes
Awakening Toppers

LAST MINUTE REVISION NOTES

Geography

- ROCKS, ROCK CYCLE AND VOLCANISM

Sleepy Classes IAS

Rocks, Rock Cycle and Volcanism

LMR - Last Minute Revision Sheet

GS-I: Physical Geography | Geography Lecture 4 | UPSC 2027 Mentorship Program

#	Section	#	Section
1	Rocks - Basics and Three Families	7	Types of Volcanoes
2	Igneous Rocks	8	Intrusive Volcanic Landforms
3	Sedimentary Rocks	9	Hotspots and Mantle Plumes
4	Metamorphic Rocks	10	Effects of Volcanoes
5	The Rock Cycle	11	Ring of Fire and Plate Boundaries
6	Volcanism - Causes and Materials	12	Global Distribution + Prelims Traps

1. Rocks - Basics And Three Families

- **Rock** = any natural mass of mineral matter making up the earth's crust; an aggregate of one or more minerals with **no definite structure** of mineral constituents.
- Rocks vary in hardness and colour: **granite hard, soapstone soft; gabbro black, quartzite milky white**.
- **Feldspar and quartz** = most common minerals found in rocks.
- Three families grouped on the basis of **mode of formation**: igneous, sedimentary, metamorphic.

Feature	Igneous	Sedimentary	Metamorphic
Formation	Solidification of magma / lava	Deposition and lithification of fragments (exogenous)	Recrystallisation of existing rocks under PVT
Other name	Primary rocks	Secondary / stratified rocks	Changed-form rocks
Fossils	Absent (unfossiliferous)	Present - plants and animals	Generally destroyed
Structure	Crystalline, no layers	Layers (strata), porous	Foliation, lineation, banding
Examples	Granite, gabbro, basalt, pegmatite, tuff, volcanic breccia	Sandstone, shale, limestone, coal, loess	Gneiss, slate, schist, marble, quartzite

2. Igneous Rocks

- **Ignis (Latin) = fire**; formed when magma / lava cools and solidifies; cooling may occur within the crust or on the surface.
- Grain size depends on **rate of cooling**: slow cooling = large crystals; rapid cooling = fine grains.
- **Deccan Traps** in the peninsular region are of **basaltic** (extrusive) origin.
- Granite is used for **grinding stones** (spices, grains) - an intrusive rock exposed only after uplift and denudation.

Classification of Igneous Rocks

A. By place of cooling (grain size)

Intrusive (Plutonic)	Intermediate	Extrusive (Volcanic)
- Cools slowly at great depth - Large crystals, coarse grains - Seen only after uplift and denudation - Eg Granite, Gabbro	- Cools at moderate depth - Medium-sized grains - Intermediate rate of cooling	- Lava cools rapidly at surface - Fine grains, little crystallisation - Eg Basalt - Deccan Traps are basaltic

B. By silica content (acid forming radical)

Acid Rocks	Basic Rocks
- Silica up to 80 percent - Form the SIAL portion of the crust - Viscous magma cools fast, flows little - Gives rise to high mountains - Eg Granite	- Silica about 40 percent, magnesia up to 40 - Magma cools slowly, spreads far - Gives rise to plateaus - Not very hard, weathers easily - Eg Basalt, Gabbro, Dolerite

Ignis (Latin) = fire. Igneous rocks are primary rocks and unfossiliferous (formed at high temperature).

Acid vs Basic Igneous Rocks

Parameter	Acid Rocks	Basic Rocks
Silica content	**High - up to 80 percent**	**Low - about 40 percent**; magnesia up to 40 percent
Crust portion	Constitute the **SIAL**	Denser, ferromagnesian composition
Magma behaviour	Cools fast; does not flow far	Cools slowly; flows and spreads far
Landform	**High mountains**	**Plateaus**
Weathering	Resistant	Weathered relatively easily
Examples	Granite	Basalt, gabbro, dolerite

3. Sedimentary Rocks

- From Latin **sedimentum = settling**. Rocks of all three types are broken up by **denudational agents**; fragments are transported and deposited by exogenous agencies.
- Deposits turn into rocks through compaction - process called **lithification**.
- Layers retain their characteristics after lithification - hence **strata of varying thickness** (sandstone, shale).
- Contain **fossils**; generally **porous**, allowing water to percolate. Eg alluvial deposits of the **Indo-Gangetic plain**.

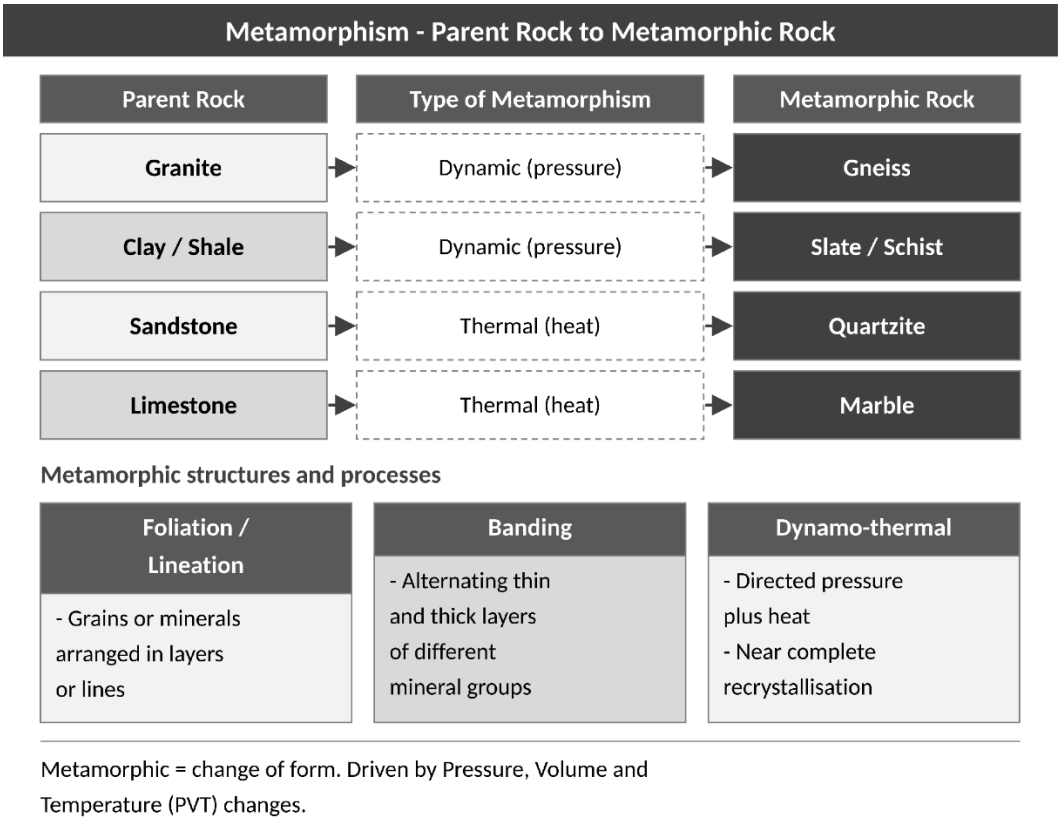
Classification by Mode of Formation

Type	Process	Examples
Mechanically formed	Mechanical agents - running water, wind, ocean currents, ice	Sandstone, conglomerate, limestone, shale, loess
Chemically formed	Mineral-rich water evaporates at mouths of springs or salt lakes	Stalactites, stalagmites, chert, limestone, halite, potash
Organically formed	Plant / animal remains buried under sediments; altered by heat and pressure of overlying layers	Geyserite, chalk, limestone, coal

- **Trap:** Limestone appears in all three sub-types - it can be mechanically, chemically or organically formed.

4. Metamorphic Rocks

- Metamorphic = change of form; formed under Pressure, Volume and Temperature (PVT) changes.
- Already consolidated rocks undergo recrystallisation and reorganisation of materials within the original rock.
- Occurs when rocks are forced to lower levels by tectonic processes, or when rising magma contacts crustal rocks.

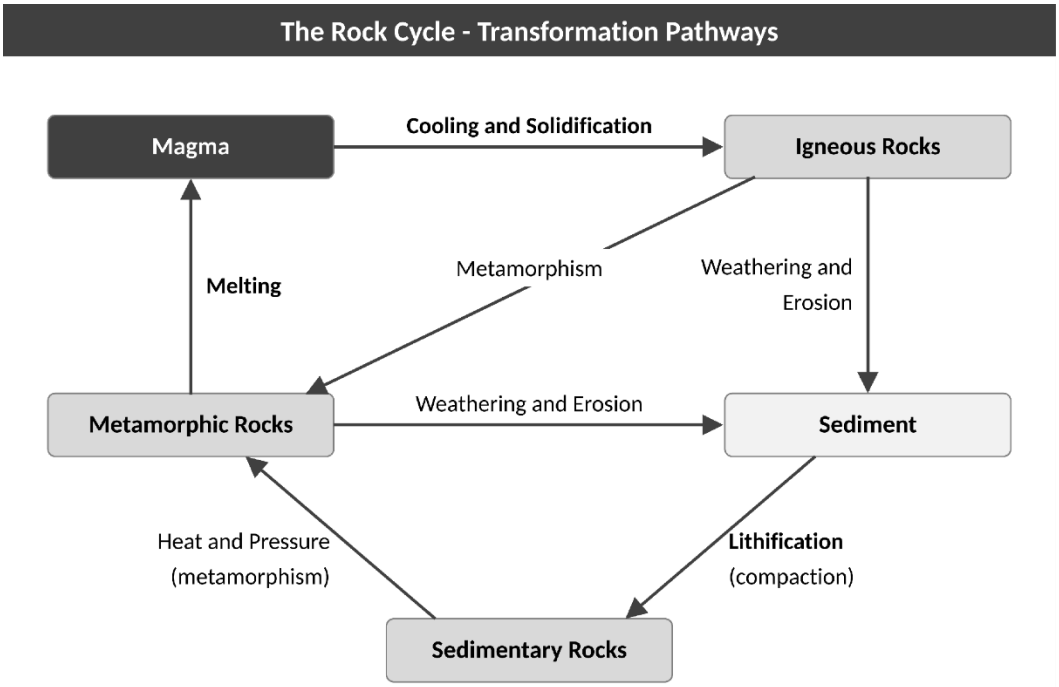


Dynamic Metamorphism	Thermal Metamorphism
Driven by **high pressure** (often with heat and chemically charged water)	Driven by **high temperature**
Directed pressure plus heat = **dynamo-thermal** metamorphism; near complete recrystallisation	Change of form / recrystallisation of sedimentary and igneous rocks
Granite to gneiss; clay and shale to schist	**Sandstone to quartzite; limestone to marble**

5. The Rock Cycle

- **Rock cycle** = continuous process through which old rocks are transformed into new ones.
- Igneous rocks are **primary**; sedimentary and metamorphic rocks form from them.

- Igneous can become metamorphic; fragments of igneous and metamorphic rocks form sedimentary rocks; sedimentary rocks can themselves be fragmented to form new sedimentary rocks.



Igneous = primary rocks. Sedimentary rocks can also be re-eroded into fresh sediment. Rock cycle = old rocks continuously become new ones.

6. Volcanism - Causes and Materials

- **Volcanism** = movement of molten rock onto or toward the surface, plus formation of intrusive and extrusive forms.
- **Volcano** = a place where gases, ashes and / or molten rock (lava) escape to the ground.

Causes of Volcanism

Step	Mechanism
1	Differential **radioactivity** creates a huge temperature difference between inner and outer layers
2	Temperature difference generates **convection currents** in the mantle
3	Convection creates **convergent and divergent boundaries** (weak zones)
4	**Divergent:** molten / semi-molten material surfaces at first opportunity; earthquakes expose fault zones - **fissure-type** eruptions
5	**Convergent:** subduction of the denser plate creates high-pressure magma - **violent eruptions**

Magma vs Lava and Ejected Material

- Molten material originates in the **asthenosphere** (weaker zone of the mantle).
- **Magma** = material in the upper mantle; called **lava** once it moves toward the crust or reaches the surface.
- Ejecta: lava flows, **pyroclastic debris, volcanic bombs**, ash, dust and gases - **nitrogen and sulphur compounds**, minor chlorine, hydrogen, argon.

7. Types of Volcanoes

- Classified on the basis of **nature of eruption and form developed at the surface**: Shield, Composite, Caldera, Flood Basalt Provinces, Mid-Ocean Ridge.

Types of Volcanoes - Nature of Eruption and Form

Shield	Composite	Caldera
- Basalt lava, very fluid - Gentle slopes, not steep - Low explosivity unless water enters vent - Largest after flood basalts - Eg Hawaiian volcanoes	- Cooler, more viscous lava than basalt - Explosive eruptions - Lava plus pyroclastics and ash in layers - Builds layered cones	- Most explosive volcanoes - Collapse on themselves - Collapsed depression = caldera - Huge magma chamber close below

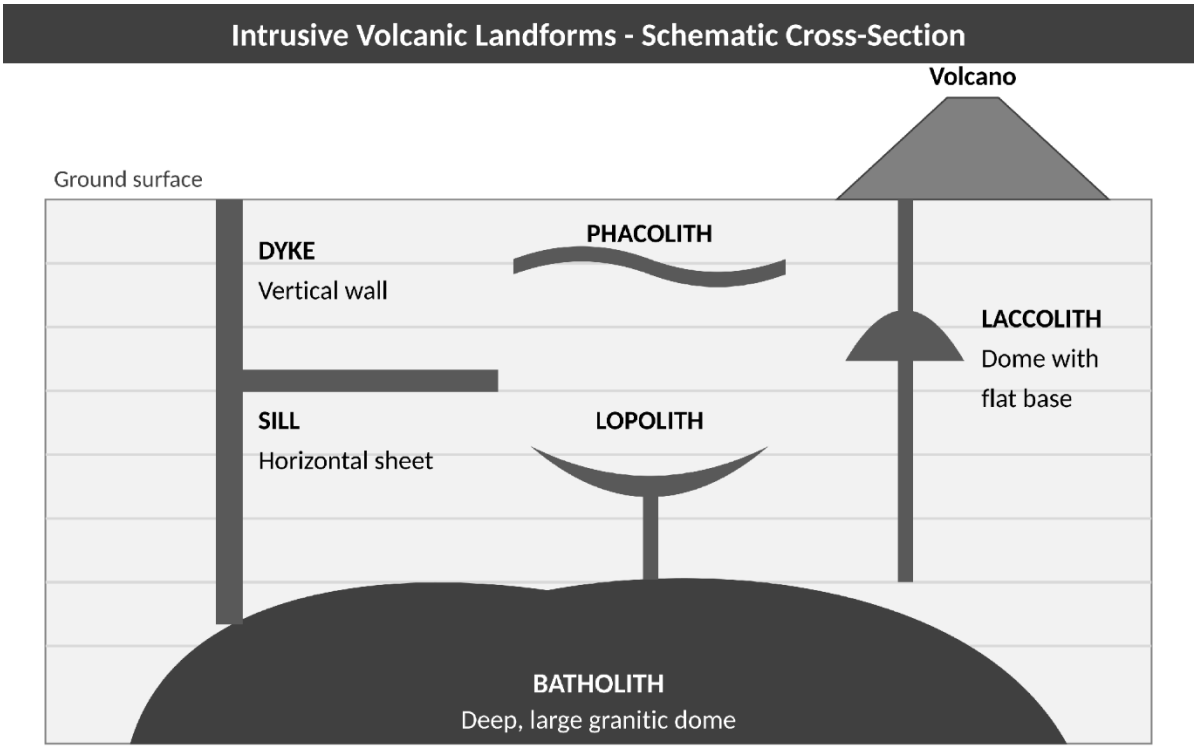
Flood Basalt Provinces	Mid-Ocean Ridge Volcanoes
- Highly fluid lava flows for long distances - Some flows thicker than 50 m - Individual flows extend hundreds of km - Eg Deccan Traps (Maharashtra plateau)	- In oceanic areas - Ridge system over 70,000 km long - Central portion: frequent eruptions - Linked to seafloor spreading

Explosivity rises with viscosity and silica: Shield (least) - Composite - Caldera (most).

Type	Lava / Explosivity	Key Example
Shield	Fluid basalt; low (explosive if water enters vent)	Hawaii (Mauna Loa, Kilauea)
Composite	Viscous, cooler; explosive with pyroclastics	Layered cones near vents
Caldera	**Most explosive**; collapses into depression	Toba (Sumatra), Yellowstone
Flood Basalt	Highly fluid; flows over 50 m thick	**Deccan Traps** - much of Maharashtra plateau
Mid-Ocean Ridge	Frequent central eruptions	Ridge system over 70,000 km

8. Intrusive Volcanic Landforms

- Igneous rocks: **volcanic** (cooling at surface) vs **plutonic** (cooling in the crust). Lava cooling within the crust forms **intrusive forms**.



Phacolith = wavy mass at base of synclines or top of anticlines.
Lopolith = saucer shape, concave to sky. Sheet = thin sill.
Dykes feed the Deccan Traps (common in western Maharashtra).
Karnataka plateau domal granite hills = laccoliths or batholiths.

Landform	Shape / Orientation	Key Points
Batholith	Large dome at great depth	Granitic; cooled portion of **magma chambers**; exposed after denudation; may be several km deep
Laccolith	Dome, **level base**, pipe-like conduit below	Localised source of lava; Karnataka plateau domal granite hills
Lopolith	**Saucer**, concave to sky	Lava moving horizontally along a weak plane
Phacolith	**Wavy** mass	At base of synclines / top of anticlines; conduit to magma chambers
Sill / Sheet	**Near horizontal**	Thick = sill; thin = sheet
Dyke	**Near vertical** wall	Most common intrusive form in **western Maharashtra**; feeders of **Deccan Traps**

- **Spelling note:** Lecture uses 'lacolith / lapolith'; standard terms are **laccolith / lopolith**.

9. Hotspots and Mantle Plumes

- **Hotspot volcanism** occurs in the **interior of lithospheric plates**, not at plate margins; explains 'anomalous volcanism' (Hawaii, Yellowstone).
- **Exceptions** on divergent boundaries: **Iceland and Afar** hotspots. Other hotspots: Hawaiian, Yellowstone, **Reunion**.
- **Mantle plume** = convection of abnormally hot rock; theorised to form at the **core-mantle boundary**; position **relatively fixed**.
- Shape: **mushroom** - bulbous head plus long tail; becomes a **diapir** in the upper mantle; diameter a few hundred km.

- **Hotspot chain:** plate moves over fixed plume; volcano cut off, becomes extinct, cools and sinks; a new volcano forms - chain parallels plate motion.

Hawaiian Chain - Age Progression (Prelims favourite)

Island	Kauai	Oahu	Molokai	Maui	Hawaii
Age (Ma)	5.6 - 4.9	3.4	1.8	1.3	0.7 - 0

- Oldest seamounts lie towards the **Aleutian Trench (NW)**; youngest at present-day Hawaii (SE). Active hotspot volcanoes: Mauna Loa, Kilauea, Loihi (submarine).

Applications of Mantle Plumes

Application	Mechanism	Example
Flood basalts / LIPs	Plume head flattens at lithosphere base; decompression melting; basalt erupts through fissures	Deccan Traps, Siberian Traps, Ontong Java Plateau, Iceland
Rifting / divergence	Plume diverges below plate; tensile stress stretches and ruptures plate	Afar - East African Rift
Continental thinning	Plume thins overlying continental crust	Yellowstone hotspot
Supervolcanoes	Magma over **1,000 cubic km** trapped below plate; erupts after pressure build-up	Yellowstone Caldera (hotspot); Toba (subduction)

10. Effects of Volcanoes

Positive Effects	Destructive Effects
New landforms - islands, plateaus, volcanic mountains	Showers of cinders and bombs damage life
Volcanic ash and dust - **highly fertile** soils	**Tsunamis** from violent eruptions in water bodies
Bring **metallic ores** to surface; copper fills gas-bubble cavities	Ash lowers regional / **global temperatures** - famines
Heated groundwater - **hot springs and geysers**	**Lahars** (violent mudflows) bury cities in minutes
Geothermal electricity	Gas plume disrupts **air travel**
National parks centred on volcanoes	Super-eruptions - small-scale **extinction events**

11. Ring of Fire and Plate Boundaries

- **Ring of Fire** = string of volcanoes and seismic sites around the Pacific; result of **plate tectonics**. Lecture figures: about **90 percent of earthquakes** and **75 percent of active volcanoes**.

Boundary	Process	Ring of Fire Example
Convergent	Heavier plate subducts, forms deep trench; mantle material becomes buoyant magma; **volcanic arc**	Andes parallel to **Peru-Chile Trench** (Nazca under South American Plate); **Ojos del Salado** - highest active volcano
Divergent	Plates pull apart; magma wells up; seawater cools it - **seafloor spreading**; ocean ridges	**East Pacific Rise** - Pacific, Cocos and Nazca plates
Transform	Plates slide horizontally; stuck parts build stress; slip causes earthquakes; **faults**	**San Andreas Fault** - Pacific Plate (moving north) vs North American Plate

Island Arcs - Ocean-Ocean Convergence

Archipelago	Subducting Plate	Overriding Plate
Philippine island arc	Philippine Sea Plate	Sunda Plate
Indonesian archipelago	Indo-Australian Plate	Sunda Plate

12. Global Distribution and Prelims Traps

Belt	Share of Earthquakes	Coverage
Circum-Pacific	About 81 percent of major quakes (also cited 70 percent)	Largest belt: New Zealand, Japan, Aleutians, Alaska, west coast of the Americas
Mid-Continental (Alpine-Himalayan)	About 17 percent (also cited 20 percent)	Europe to Sumatra: Mediterranean, Asia Minor, Himalayas, NW China
Mid-oceanic ridges / rifts	Remaining	Arctic, Atlantic, western Indian Ocean ridges; East African Rift

Volcanic Regions Beyond the Pacific

- **Atlantic:** few active volcanoes; many dormant / extinct - St Helena, Cape Verde, Canary Islands. **Iceland and Azores are active**.
- **Great Rift (Africa):** Mt Kilimanjaro, Mt Kenya along East African Rift Valley.
- **Earthquake depth (NCERT):** mid-oceanic ridges = **shallow foci**; Alpine-Himalayan belt and Pacific rim = **deep-seated**.

Common Prelims Traps

Statement Type	Correct Position
Igneous rocks contain fossils	**False** - unfossiliferous
Acid lava builds plateaus	**False** - basic lava builds plateaus; acid builds high mountains
Hotspots occur only at plate margins	**False** - mainly plate interiors; Iceland / Afar are exceptions
Caldera = tall volcanic cone	**False** - collapsed depression of the most explosive volcanoes
Sandstone becomes marble	**False** - sandstone to quartzite; limestone to marble
Dykes are horizontal	**False** - dykes vertical; sills horizontal
Mantle plume position shifts with convection cells	**False** - plume position relatively fixed

- End of LMR Sheet -