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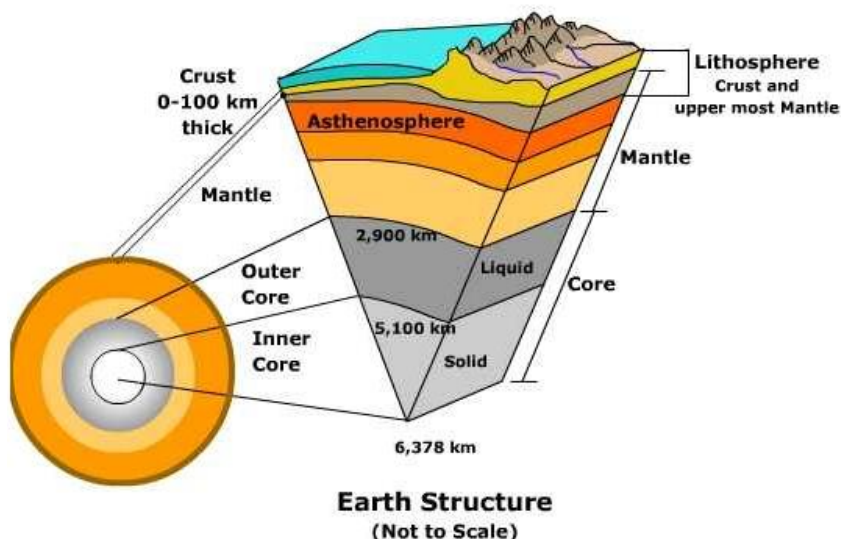
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GEOGRAPHY-3

TOPICS: Geomorphology - Internal structure, Earth Movements, Theory of Plate Tectonics, Convergence & divergence, Mountains, Tertiary landforms, Volcanism, Rock types, Plateaus

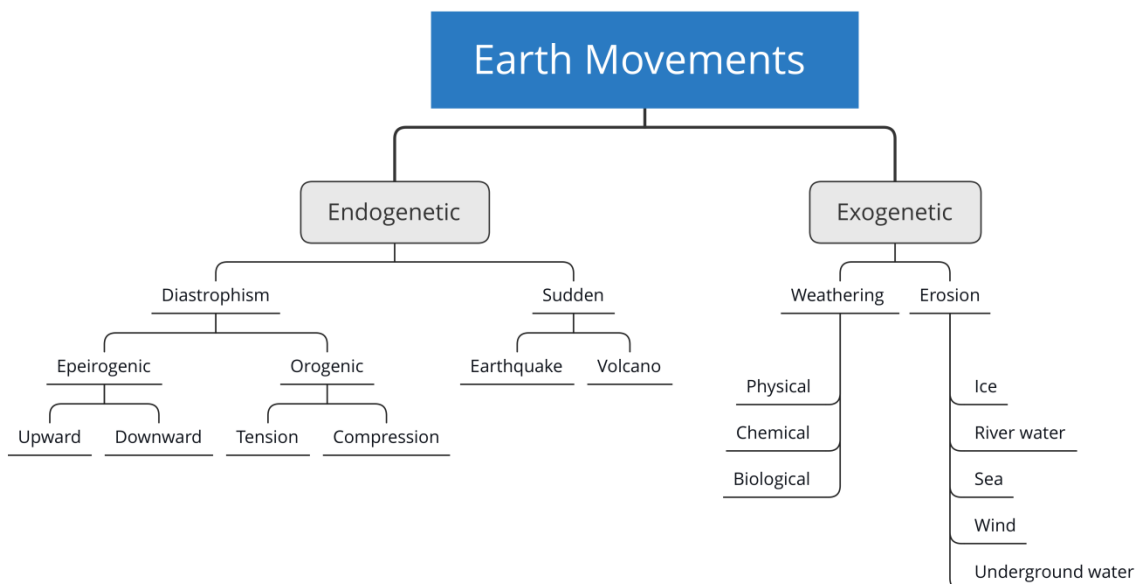
1. INTERNAL STRUCTURE



<u>LAYER</u>	<u>FEATURES</u>
Crust	<ul style="list-style-type: none"> • It is the outermost layer over the earth's surface. • It is the thinnest of all the layers. • About 35 km on the continental masses and only 5 km on the ocean floors. • The main minerals constituting the continental mass (SIAL) are: Silica & Alumina • The main mineral constituents of the oceanic crust (SIMA) are: Silicon & Magnesium • Continental crust has a density of 2.7 g/cm³ and Oceanic crust with 3 g/cm³.
Mantle	<ul style="list-style-type: none"> • The portion of the interior beyond the crust is called as the mantle. • The discontinuity between the crust and mantle is called as the Mohorovich Discontinuity or Moho discontinuity. • The mantle is about 2900kms in thickness. • Nearly 84% of the earth's volume and 67% of the earth's mass is occupied by the mantle. • The major constituent elements of the mantle are Silicon and Magnesium and hence it is also termed as SIMA. • The density of the layer is higher than the crust and varies from 3.3 – 5.4g/cm³. • The uppermost solid part of the mantle and the entire crust constitute the Lithosphere. • The asthenosphere (in between 80-200km) is a highly viscous,

	<p>mechanically weak and ductile, deforming region of the upper mantle which lies just below the lithosphere.</p> <ul style="list-style-type: none"> • The asthenosphere is the main source of magma and it is the layer over which the lithospheric plates/ continental plates move (plate tectonics). • The discontinuity between the upper mantle and the lower mantle is known as Repetti Discontinuity. • The portion of the mantle which is just below the lithosphere and asthenosphere, but above the core is called as Mesosphere.
Core	<ul style="list-style-type: none"> • It is the innermost layer surrounding the earth's centre. • The core is separated from the mantle by Guttenberg's Discontinuity. • It is composed mainly of iron (Fe) and nickel (Ni) and hence it is also called as NIFE. • The core constitutes nearly 15% of earth's volume and 32.5% of earth's mass. • The core is the densest layer of the earth with its density ranges between 9.5-14.5g/cm³. • The Core consists of two sub-layers: the inner core and the outer core. • The inner core is in solid state and the outer core is in the liquid state (or semi-liquid). • The discontinuity between the upper core and the lower core is called as Lehmann Discontinuity. • Barysphere is sometimes used to refer the core of the earth or sometimes the whole interior.

2. EARTH MOVEMENTS



Endogenetic Movements - The interaction of matter and temperature generates these forces or movements inside the earth's crust. The earth movements are mainly of two types: diastrophism and the sudden movements.

Diastrophism - It is the general term applied to slow bending, folding, warping and fracturing.

- Epeirogenic or continent forming movements act along the radius of the earth; therefore, they are also called radial movements. Their direction may be towards (subsidence) or away (uplift) from the centre. The results of such movements may be clearly defined in the relief. Raised beaches, elevated wave-cut terraces, sea caves and fossiliferous beds above sea level are evidences of uplift.
- Orogenic or the mountain-forming movements act tangentially to the earth surface, as in plate tectonics. Tensions produce fissures (since this type of force acts away from a point in two directions) and compression produces folds (because this type of force acts towards a point from two or more directions). In the landforms so produced, the structurally identifiable units are difficult to recognise.

Sudden Movements - These movements cause considerable deformation over a short span of time, and may be of two types.

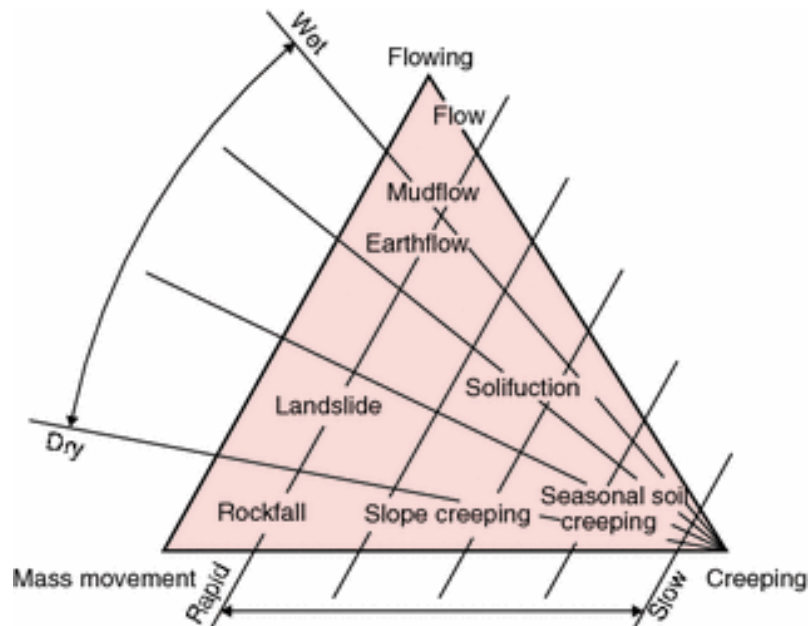
- Earthquake - It occurs when the surplus accumulated stress in rocks in the earth's interior is relieved through the weak zones over the earth's surface in form of kinetic energy of wave motion causing vibrations (at times devastating) on the earth's surface. Such movements may result in uplift in coastal areas.
- Volcanoes - a volcano is formed when the molten magma in the earth's interior escapes through the crust by vents and fissures in the crust, accompanied by steam, gases (hydrogen sulphide, sulphur dioxide, hydrogen chloride, carbon dioxide etc.) and pyroclastic material.

Exogenetic Forces - are those forces which derive their strength from the earth's exterior or are originated within the earth's atmosphere. Examples of forces – the wind, waves, water etc.

Weathering - is the action of elements of weather and climate over earth materials. Weathering is defined as mechanical disintegration and chemical decomposition of rocks through the actions of various elements of weather and climate. Its processes are responsible for breaking down the rocks into smaller fragments.

- **Chemical weathering** causes rocks to decompose or dissolve and reduce them to a fine clastic state through chemical reactions by oxygen, water or acids.
 - Solution - when something is dissolved in water or acids, the water or acid with dissolved contents is called solution.
 - Carbonation - is the reaction of carbonate and bicarbonate with minerals
 - Hydration - is the chemical addition of water.

- Oxidation - means a combination of a mineral with oxygen to form oxides or hydroxides.
- Reduction - when oxidised minerals are placed in an environment where oxygen is absent, reduction takes place.
- **Physical weathering** - the disintegration of rocks by some applied forces is called physical or mechanical weathering. These applied forces could be due to the action of gravity, heat and water.
 - Unloading - involves removal of overlying rock load because of continued erosion. It causes a release of vertical pressure on the rock resulting in expansion of upper layers which further results in disintegration of rock masses.
 - Temperature changes - with the rise in temperature, every mineral expands, and as the temperature falls, a corresponding contraction takes place.
 - Frost weathering - occurs due to the growth of ice within pores and cracks of rocks during repeated cycles of freezing and melting.
 - Salt weathering - many salts in rocks like calcium, sodium, magnesium, potassium expands due to thermal action, hydration and crystallisation.
- **Biological weathering** - this refers to disintegration and decomposition of rock masses due to growth or movement of organisms. Burrowing and wedging by organisms like earthworms, termites, rodents etc., help in exposing the new surfaces to moisture and chemical attack causing their decomposition. Human activities like ploughing and cultivating cause mixing of air, water in the minerals, thereby aiding in weathering process.
- **Mass movements** - these movements transfer the mass of rock debris down the slopes under the direct influence of gravity. The debris may carry with its air, water or ice. The process of weathering aids in mass movements. Mass movements are very active over weathered slopes rather than over unweathered materials. No geomorphic agent like running water, glaciers, wind, waves and currents participate in the process of mass movements. Mass movements are aided by gravity



- **Erosion** - involves acquisition and transportation of rock debris. Erosion results in degradation of the surface relief i.e. wearing down of the landscape. When massive rocks break into smaller fragments through weathering and any other process, erosional geomorphic agents like running water, groundwater, glaciers, wind and waves remove and transport it to other places
- **Deposition** - is a consequence of erosion. Gradually, the erosional agents lose their velocity and hence, the materials carried by them start to settle themselves. The coarser materials get deposited first and finer ones later. The same erosional agents, viz. running water, glaciers, wind, waves and groundwater act as aggradational or depositional agents also.

CONTINENTAL DRIFT THEORY

- This theory was suggested by Alfred Wegener in 1920's.
- According to Wegener's Continental Drift Theory, there existed one big landmass which he called Pangaea which was covered by one big ocean called Panthalassa.
- A sea called Tethys divided the Pangaea into two huge landmasses: Laurasia (Laurasia) to the north and Gondwanaland to the south of Tethys.
- Drift started around 200 million years ago (Mesozoic Era), and the continents began to break up and drift away from one another.

Forces for Continental Drift - The drift was in two directions,

- Equator wards due to the interaction of forces of gravity, pole-fleeing force and buoyancy
- Westwards due to tidal currents because of the earth's motion. Tidal force is due to the attraction of the moon and the sun that develops tides in oceanic waters.

Evidence in support of Continental Drift

- The Matching of Continents (Jig-Saw-Fit) - The coastlines of South America and Africa fronting each other have a remarkable and unique match.
- Rocks of the Same Age across the Oceans - The radiometric dating methods have helped in correlating the formation of rocks present in different continents across the ocean.
- Tillite - It is the sedimentary rock made from glacier deposits.
- Placer Deposits - The presence of abundant placer deposits of gold along the Ghana coast and the complete lack of its source rocks in the area is a phenomenal fact.
- Distribution of Fossils - The interpretations that Lemurs occur in India, Africa and Madagascar led to the theory of a landmass named "Lemuria" connecting these 3 landmasses.

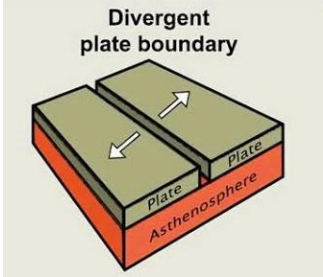
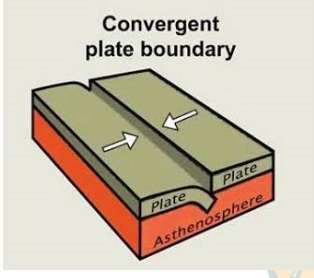
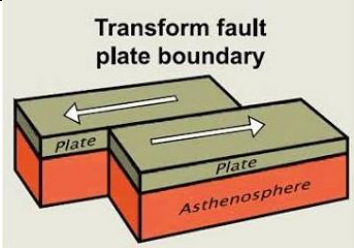
SEA FLOOR SPREADING

- The idea that the seafloor itself moves as it expands from a central axis was proposed by Harry Hess.
- Continued with convectional theory ie., intense heat tries to escape leads to convectional current meeting of rising limbs causes ridges and falling limbs trenches.
- Seafloor spreading is a process that occurs at midocean ridges, where new oceanic crust is formed through volcanic activity and then gradually moves away from the ridge.
- Seafloor spreading helps explain continental drift in the theory of plate tectonics.
- When oceanic plates diverge, tensional stress causes fractures to occur in the lithosphere, basaltic magma rises up the fractures and cools on the ocean floor to form new sea floor.
- Older rocks will be found farther away from the spreading zone while younger rocks will be found nearer to the spreading zone.

PLATE TECTONICS THEORY

- In 1967, McKenzie and Parker suggested the theory of plate tectonics.
- According to the theory of plate tectonics, the earth's lithosphere is broken into distinct plates which are floating on asthenosphere (upper mantle). Plates move horizontally over the asthenosphere as rigid units.
- The lithosphere includes the crust and top mantle with its thickness range varying between 5-100 km in oceanic parts and about 200 km in the continental areas.
- Lithospheric plates (crustal plates, tectonic plates) vary from minor plates to major plates, continental plates (Arabian plate) to oceanic plates (Pacific plate), sometime a combination of both continental and oceanic plates (Indo-Australian plate).

Types of Plate boundaries –

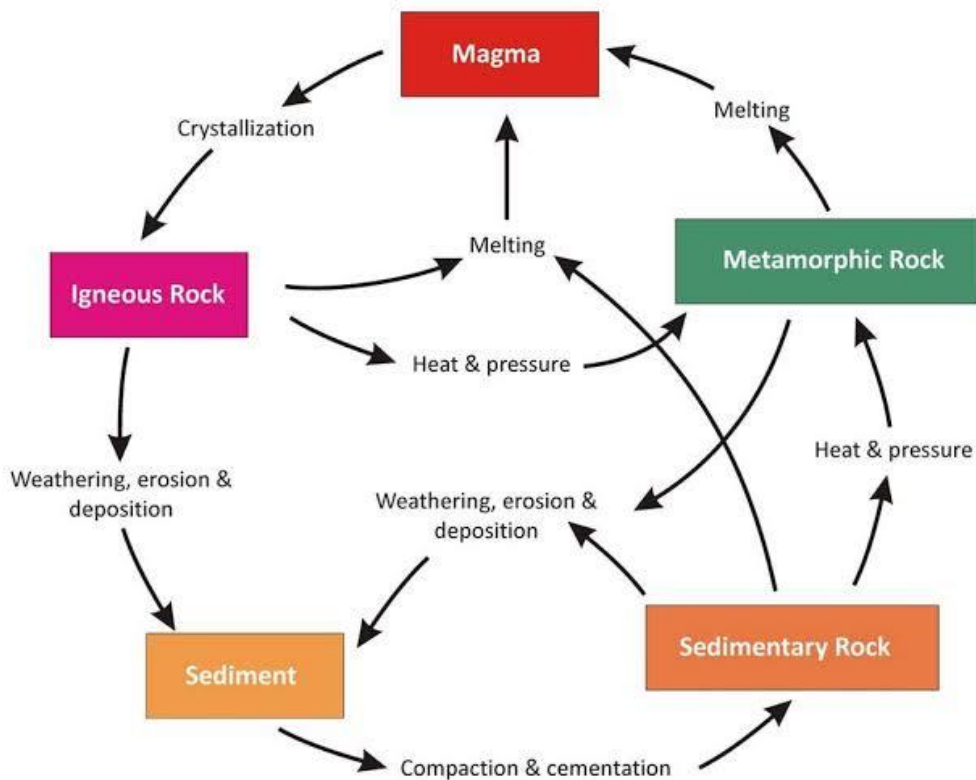
<u>BOUNDARY</u>	<u>FEATURES</u>
<p style="text-align: center;">Divergent plate boundary</p> 	<ul style="list-style-type: none"> • Diverging currents produce tension at the contact-zone of crust leading to fracture. • Magmatic material penetrates into the fractures and gets solidified. • This continuous process pushes the blocks in opposite direction and creates a new zone, known as “zone of construction”. • Found mostly at mid-oceanic ridges. Eg – Mid Atlantic ridge
<p style="text-align: center;">Convergent plate boundary</p> 	<ul style="list-style-type: none"> • At convergent boundary, two adjacent plates come further and further closer to each other and collide. • When both sides are of continental nature, a mountain formation is evident. • When one of the two is continental and the other maritime again mountain comes into being along the boundary. • In this case, continental plate overrides the maritime. • When both plates are of maritime, both of them break, subduct and penetrate below and, hence, trenches are formed. • Along this boundary earthquakes and volcanic activities are prominent. • In all these three situations, surface area is reduced, therefore, this is also known as “zone of destruction”.
<p style="text-align: center;">Transform fault plate boundary</p> 	<ul style="list-style-type: none"> • Transform fault is the one when two adjacent plates slide past each other. • Direction of movement may be along or against but they move parallel to each other. • Therefore, neither there is any construction of fresh area nor it has any destruction. Hence, it is known as “zone of preservation”. • Plates are not permanent features but they vary in size and shape. Plates can split or get welded with adjoining plate. • Almost all tectonic activities occur along the plate boundaries.

MOUNTAINS

<u>TYPE</u>	<u>FEATURES</u>
Fold Mountains	<ul style="list-style-type: none"> • Mountain ranges mainly consisting of uplifted folded sedimentary rocks are called Fold Mountains. • They are formed due to the force of compression arising from the endogenic or internal forces. • Synclines (trough) and anticlines (crest) are part of Fold Mountains. • The Himalayas in Asia, the Alps in Europe, the Rockies in North America, and the Andes in South America are the most prominent fold mountains of the world. • Since these mountain ranges were formed during the most recent mountain building period, they are also known as Young Fold Mountains.
Block Mountains	<ul style="list-style-type: none"> • Block Mountains are also formed by the internal or endogenic earth movements which cause the force of tension and faulting. • The down-lifting or uplifting of land in between two parallel faults results in the formation of Block Mountains. • A block mountain is also called as Horst and the rift valley formed as a result of faulting is called Graben. • Examples: The Sierra Nevada in North America, Black Forest Mountains in Germany etc are typical examples of Block Mountains.
Volcanic Mountains	<ul style="list-style-type: none"> • The mountains formed by the accumulation of volcanic materials are called as Volcanic Mountains or Mountains of accumulation. • Examples: Mount Mauna Loa in Hawaii Island, Mount Popa in Myanmar, Fuji Yama in Japan etc are some examples.
Residual or Relict Mountains	<ul style="list-style-type: none"> • The process of wearing down depends on the shape and structure of the rocks upon which it acts. • Some portions of an elevated area escape from the process of weathering due to the hardness of the materials it is made of. • These portions remain unweathered while its surrounding area gets eroded constantly. This results in the formation of Residual or Relict Mountains. • Examples: Hills like Nilgiri, Palkonda, Parasnath and Rajmahal and Mountains like the Aravalli, the Vindhya, and the Satpura are some of the examples of Relict Mountains in India.

ROCKS

- The Rock Cycle



<u>ROCK</u>	<u>FEATURES</u>
Igneous	<ul style="list-style-type: none"> • These are primarily formed out of magma and lava and are known as primary rocks. • Granite, gabbro, pegmatite, basalt, etc., are some of the examples of igneous rocks. Igneous rocks are crystalline in structure. • Extrusive rocks: These are formed by rapid cooling of the lava thrown out during volcanic eruptions. Ex: Basalt - The Deccan traps. • Intrusive rocks: Sometimes, the molten matter is not able to reach the surface and instead cools down very slowly at great depths. Slow cooling allows big sized crystals (large grains) to be formed. Granite is a typical example.
Sediment	<ul style="list-style-type: none"> • Formed as a result of denudation (weathering and erosion). • These deposits through compaction turn into rocks. This process is called lithification. • Cover 75 per cent of the earth's crust but volumetrically occupy only 5 percent. • These rocks consist of layers in which fossils of plants and animals are present. • Different varieties of sandstone are spread over Madhya Pradesh, eastern Rajasthan, parts of Himalayas, Andhra Pradesh,

	<p>Bihar and Orissa.</p> <p>Depending upon the mode of formation, they are classified into</p> <ul style="list-style-type: none"> • Mechanically formed — sandstone, conglomerate, limestone, shale, loess etc. • Organically formed — coal, some dolomites, and some limestones, form from the accumulation of plant or animal debris. • Chemically formed — such as rock salt, iron ore, chert, flint, some dolomites, and some limestones.
Metamorphic	<ul style="list-style-type: none"> • Form under the action of pressure, volume and temperature (PVT) changes. • Metamorphism occurs when rocks are forced down to lower levels by tectonic or recrystallisation and reorganization of materials. • In the process of metamorphism in some rocks grains or minerals get arranged in layers or lines called as foliation or lineation. <p>Some Examples of Metamorphism:</p> <ul style="list-style-type: none"> • Quartzite is a coarse-grained metamorphic rock derived from sandstone. • Marble is a metamorphic rock that comes from metamorphosed limestone or dolomite. • Slate is a fined grained metamorphic rock.

EARTHQUAKE

An earthquake is a violent and vigorous shaking of the earth's surface.

The subsurface area along a fault plane, where the seismic waves are initiated, is the focus, or hypocenter, of an earthquake.

The area at the surface directly above the focus is the epicentre.

Richter scale - The magnitude relates to the energy released during the quake. The magnitude is expressed in absolute numbers, 0-10.

Mercalli scale - The intensity scale takes into account the visible damage caused by the event. The range of intensity scale is from 1-12.

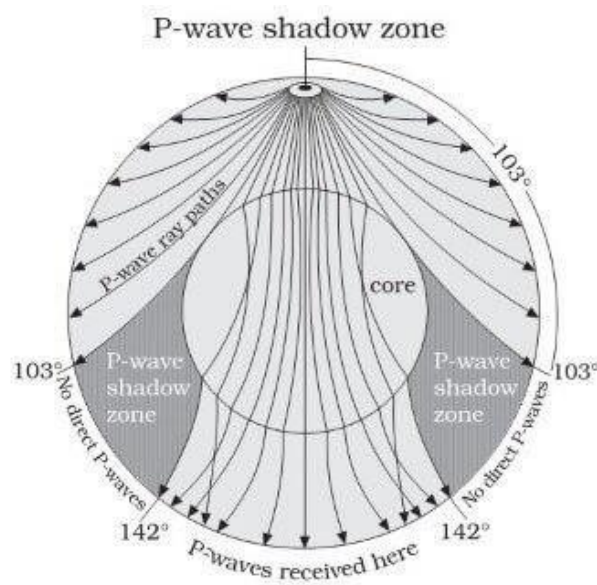
Causes of earthquakes

- Plate Movements - Folding, faulting and displacement of rock strata, upwarping and downwarping of crust are some of the main causes of earthquakes.
- Volcanic eruptions
- Endogenic forces - Gaseous expansion and contraction within the earth can cause stress in strata which build up over time and is released suddenly in the form of earthquakes.

- Exogenic forces - An earthquake may also be caused due to landslide and collapse of cave or mines etc. which can cause a sudden release in energy.
- Anthropogenic causes - These may range from dam building, mining, dredging, road building, drilling etc.
- Seismic waves – they are basically of two types – body waves and surface waves.

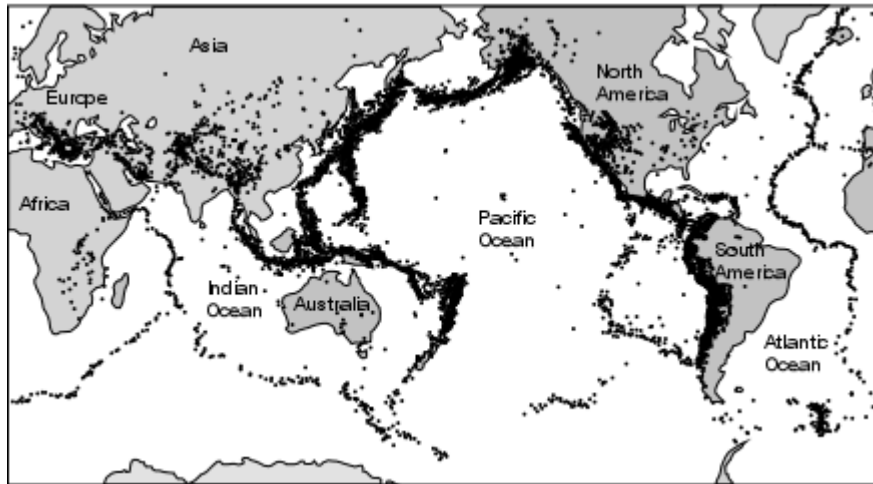
<u>WAVE</u>	<u>TYPES</u>
<p style="text-align: center;">Body Waves</p> <ul style="list-style-type: none"> • They are generated due to the release of energy at the focus and moves in all directions traveling through the body of the earth. Hence, the name – body waves. • They travel only through the interior of the earth. • Body waves are faster than surface waves and hence they are the first to be detected on a seismograph. • There are two types of body waves as primary waves and secondary waves. 	<p style="text-align: center;">Primary waves (p-waves)</p> <ul style="list-style-type: none"> • Primary waves are the fastest body waves (twice the speed of s-waves) and are the first to reach during an earthquake. • They are similar to sound waves, i.e, they are longitudinal waves, in which particle movement is in the same direction of wave propagation. • They travel through solid, liquid and gaseous materials. • They create density differences in the earth material leading to stretching and squeezing. <hr/> <p style="text-align: center;">Secondary waves (s-waves)</p> <ul style="list-style-type: none"> • They arrive at the surface with some time-lag after primary waves. • They are slower than primary waves and can pass only through solid materials. • This property of s-waves led seismologists to conclude that the earth’s outer core is in a liquid state. • They are transverse waves in which directions of particle movement and wave propagation are perpendicular to each other.
<p style="text-align: center;">Surface Waves</p> <ul style="list-style-type: none"> • When the body waves interact with surface rocks, a new set of waves is generated called as surface waves. • These waves move along the earth surface. • Surface waves are also transverse waves in which particle movement is perpendicular to the 	<p style="text-align: center;">Love waves</p> <ul style="list-style-type: none"> • This kind of surface waves causes horizontal shifting of the earth during an earthquake. • They have much slower than body waves but are faster than Rayleigh. • They exist only in the presence of semi-infinite medium overlain by an upper finite thickness. • Confined to the surface of the crust, Love waves produce entirely horizontal motion. <hr/> <p style="text-align: center;">Rayleigh waves</p> <ul style="list-style-type: none"> • These waves follow an elliptical motion. • A Rayleigh wave rolls along the ground just

<p>wave propagation.</p> <ul style="list-style-type: none"> Hence, they create crests and troughs in the material through which they pass. Surface waves are considered to be the most damaging waves. Two common surface waves are Love waves and Rayleigh waves. 	<p>like a wave rolls across a lake or an ocean.</p> <ul style="list-style-type: none"> Because it rolls, it moves the ground up and down and side-to-side in the same direction that the wave is moving. Most of the shaking felt from an earthquake is due to the Rayleigh wave, which can be much larger than the other waves.
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Distribution of earthquakes in the world

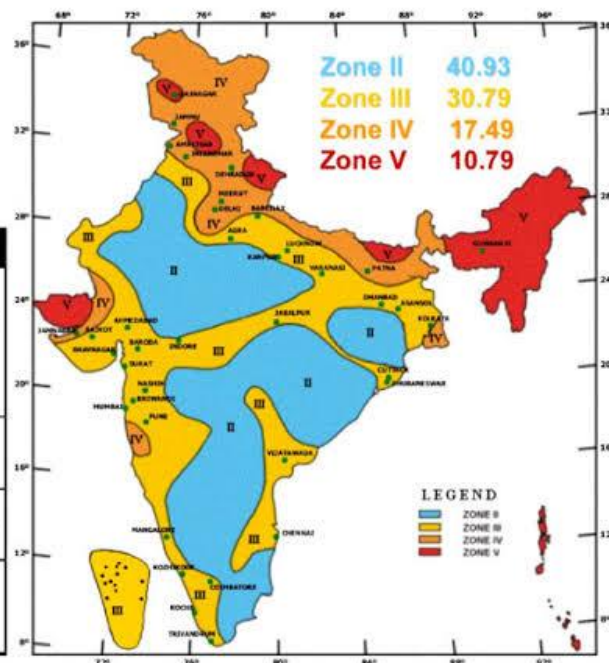
- The Circum Pacific Belt - It encircles the Pacific Ocean from end to end. The earthquakes in this belt are associated with the ring of mountains and volcanoes. It is estimated that about 68 % of earthquakes of the world occur in this belt alone.
- The Mid-world Mountain Belt extends from the Alps with their extension into the Mediterranean the Caucasus and the Himalayan region and continues into Indonesia. About 21 % of total earthquakes of the world originate in this belt. Remaining 11 % occur in the other parts of the world.



Seismic Zone Map of India: -2002

About **59 percent** of the land area of India is liable to seismic hazard damage

Zone	Intensity
Zone V	Very High Risk Zone Area liable to shaking Intensity IX (and above)
Zone IV	High Risk Zone Intensity VIII
Zone III	Moderate Risk Zone Intensity VII
Zone II	Low Risk Zone VI (and lower)



VOLCANO

A Volcano is a fissure or vent, communicating with the interior, from which flow of lava, explosive burst of ashes are erupted at the surface.

Types of Lava:

- Acidic – light coloured, highly viscous, flow slowly, steep-sided, lead to explosion throwing out pyroclasts or bombs, forming spine or plug at craters.
- Basic– hottest, highly fluid, rich in iron and magnesium, lack silica, dark colour, highly fluid, flow quietly, forms thin sheets and spread over large area forming shield or dome.

Types of Volcanoes on the basis of nature of eruption and the form developed at the surface.

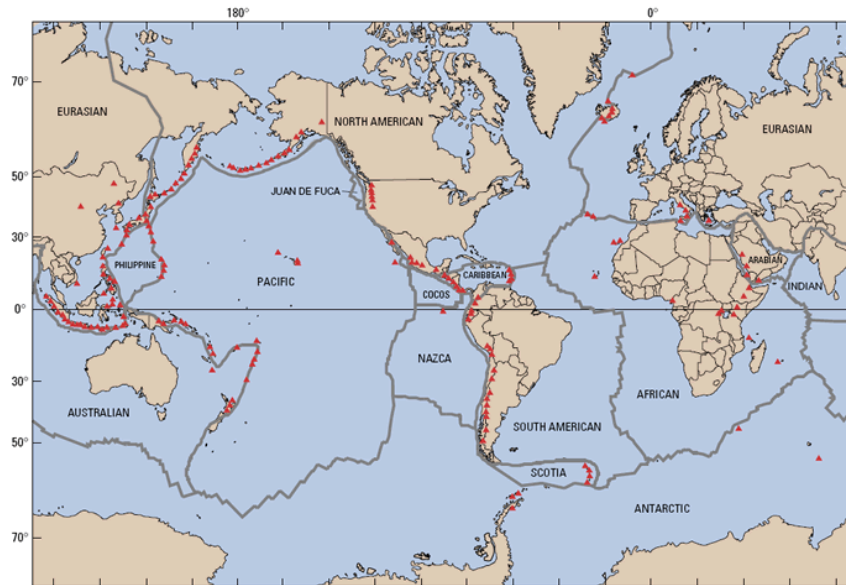
	Volcano Type	Characteristics	Examples	Simplified Diagram
	Flood or Plateau Basalt	Very liquid lava; flows very widespread; emitted from fractures	Columbia River Plateau	
	Shield Volcano	Liquid lava emitted from a central vent; large; sometimes has a collapse caldera	Larch Mountain, Mount Sylvania, Highland Butte, Hawaiian volcanoes	
	Cinder Cone	Explosive liquid lava; small; emitted from a central vent; if continued long enough, may build up a shield volcano	Mount Tabor, Mount Zion, Chamberlain Hill, Pilot Butte, Lava Butte, Craters of the Moon	
	Composite or Stratovolcano	More viscous lavas, much explosive (pyroclastic) debris; large, emitted from a central vent	Mount Baker, Mount Rainier, Mount St. Helens, Mount Hood, Mount Shasta	
	Volcanic Dome	Very viscous lava; relatively small; can be explosive; commonly occurs adjacent to craters of composite volcanoes	Novarupta, Mount St. Helens Lava Dome, Mount Lassen, Shastina, Mono Craters	
	Caldera	Very large composite volcano collapsed after an explosive period; frequently associated with plug domes	Crater Lake, Newberry, Kilauea, Long Valley, Medicine Lake, Yellowstone	

Volcanoes in India

- The Barren Island of Andaman and Nicobar Islands which is in the northeast of Port Blair is a volcanic island. The Barren Island volcano was the last active recently in 2017 and in 1991 and 1995.
- Narcondam which is in the north-east of Barren Island is another volcanic Island in India. Narcondam volcano has not been active in the recent past. Other parts of India do not have an active volcano.

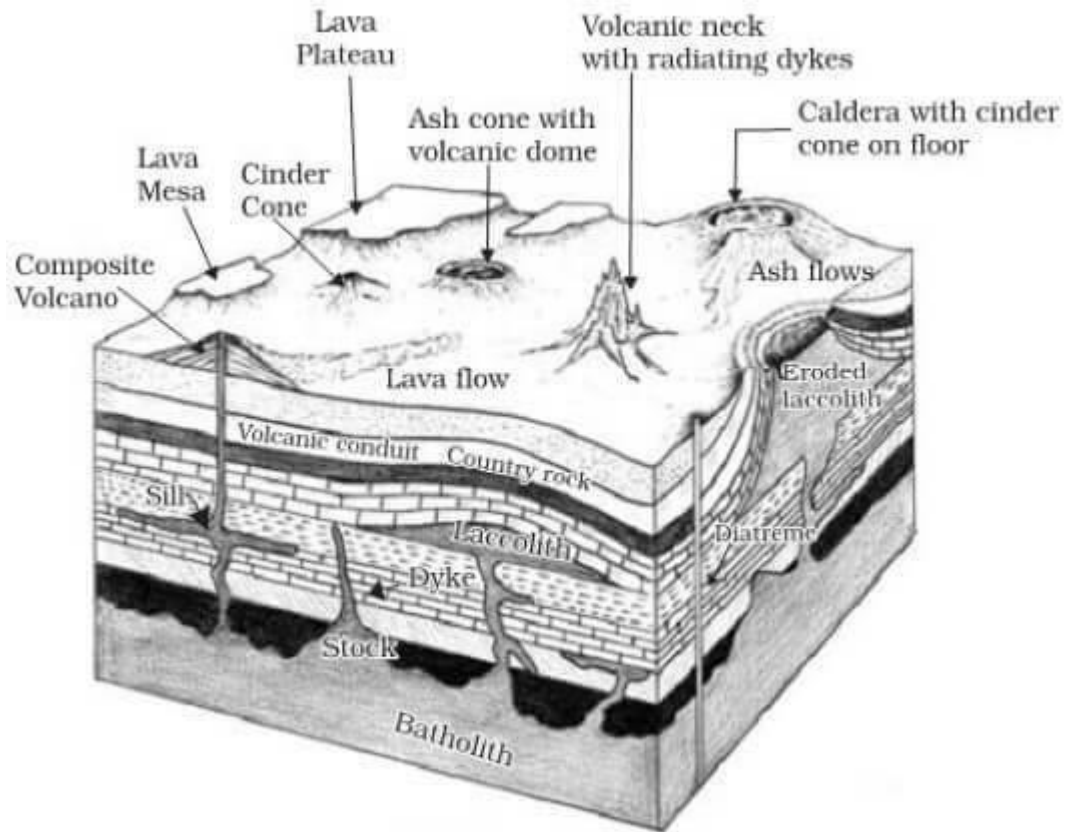
Distribution of Volcanoes in the world

- The Circum-Pacific Belt (The Pacific Ring of Fire).
- The Mid-World Mountain Belt.
- The African Rift Valley Belt.



Volcanic landforms or Intrusive igneous rocks are classed into the following types according to their forms.

- Batholiths: A large body of magmatic material that cools in the deeper depth in the form of a large dome. These are granitic bodies. They sometimes appear on the earth surface when the denudation processes remove the overlying materials.
- Laccoliths: Large dome shaped intrusive bodies with a level base and pipe-like conduit from below. Resembles a composite volcano structure, but beneath the earth. (Eg: Karnataka Plateau)
- Lapoliths: They are saucer shaped, concave to the sky.
- Phacoliths: Wavy materials which have a definite conduit to source beneath.
- Sheets/ sills: They are the near horizontal bodies of intrusive igneous rocks. Thinner ones are called as sheets and while thick horizontal deposits are called sills.
- Dykes: When the lava comes out through cracks and fissures, they solidify almost perpendicular to the ground to form wall like structures called dykes. (Eg: Deccan traps in Maharastra region).



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