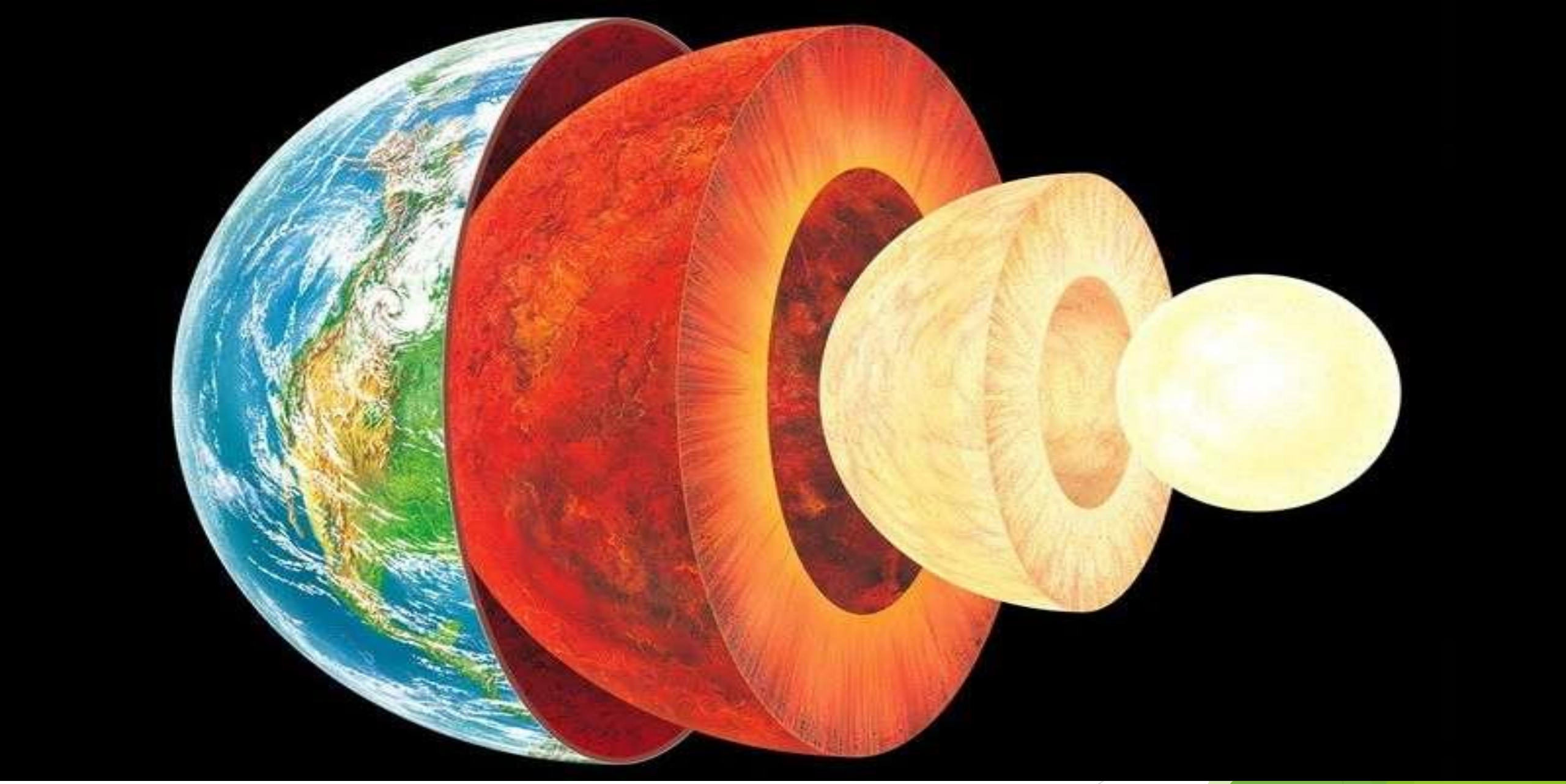


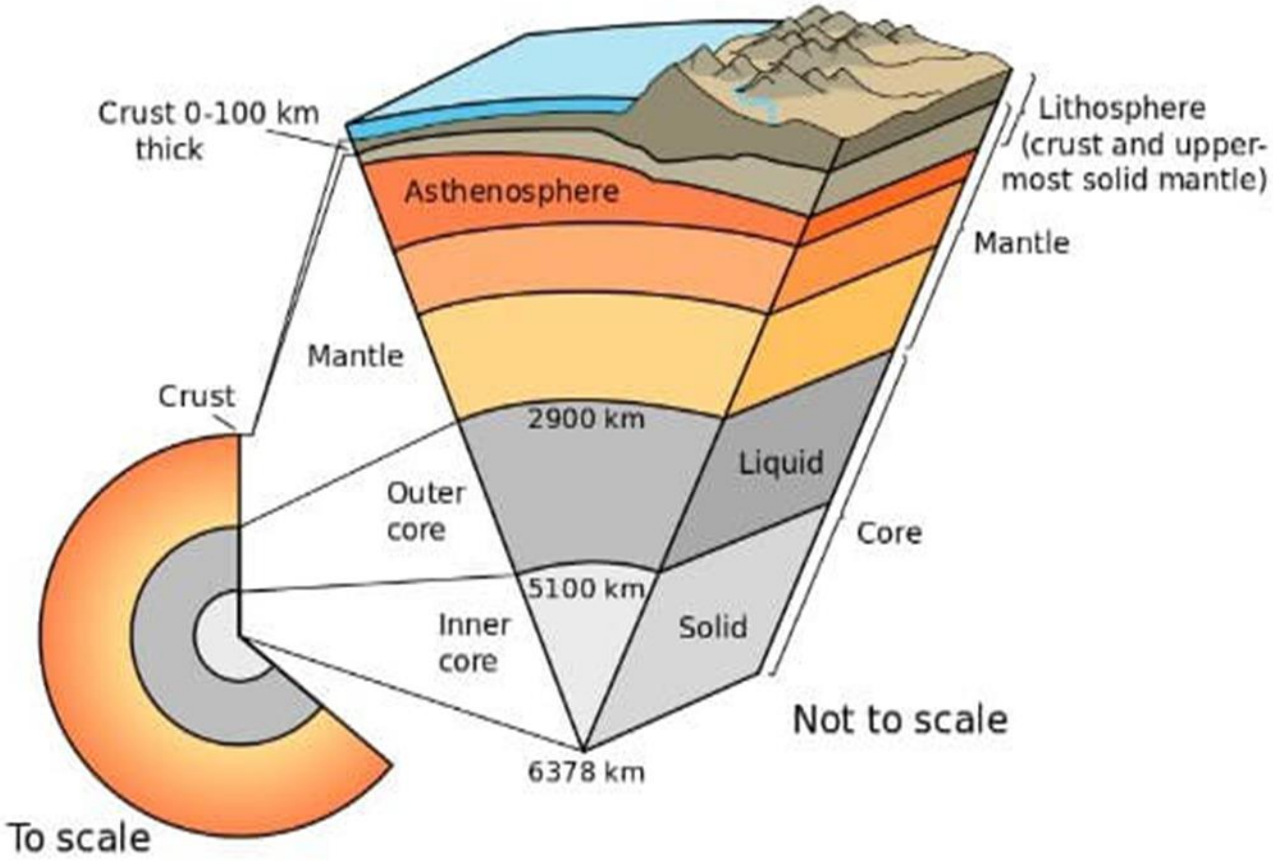
Interior of the Earth

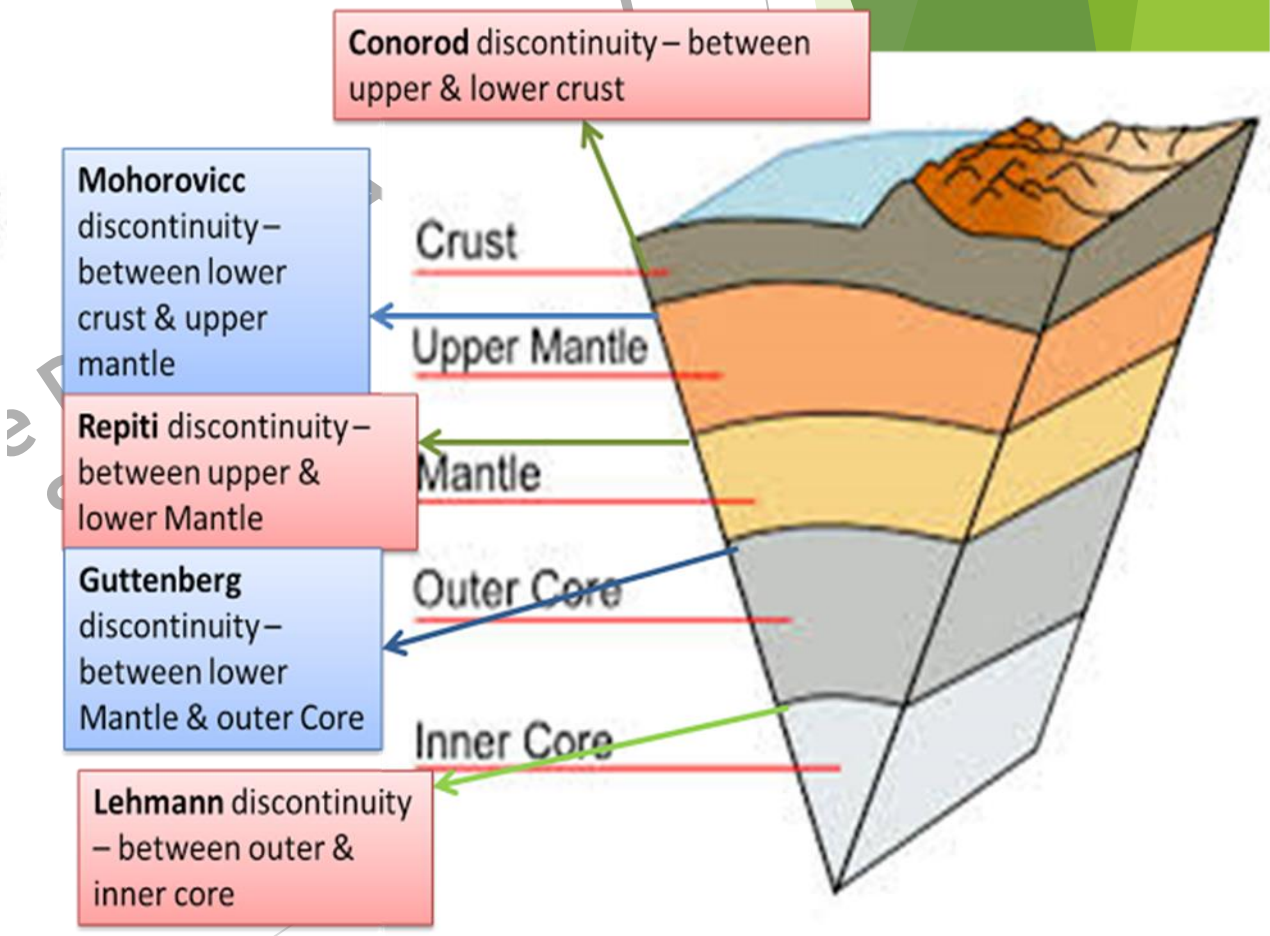
Interior of the Earth

- Understanding the Structure of the Earth's interior (Crust, Mantle, Core) and various forces (Heat, Seismic waves) emanating from it is essential to understand the evolution of the earth's surface, its current shape and its future.
- **Why is it essential to Study Earths Interior:**
  - To Understand the Earth's Surface.
  - To Understand the geophysical phenomenon like Volcanism, Earthquakes etc.
  - To understand the Earths Magnetic Field.
- **Sources of Information about Earths Interior:**
  1) Direct Sources
  2) Indirect Sources
  - **Direct Sources:**
  - Deep earth mining and drilling reveal the nature of rocks deep down the Surface of Earth.
  - But the mining and drilling are not practically possible beyond a certain depth, they don't reveal much information about the Earths Interior.
  - Mopneng Gold mine is the deepest mining of 3.9 Km and Kola Peninsula is the deepest Drilling of 12.3 Km.

- **Indirect Sources:**
- The **Gravitation** of the earth help in estimating the material deep inside Earth.
- **Meteorites** and Earth are born from the Same nebular Cloud. Thus, they are likely to have a similar internal Structure.
- The Reflection and Refraction of **Seismic Waves** is used for research into the Structure of Earths Interior (we can study this Earthquakes Topic).

Layers of Earth:





- **Crust:**
  - It is Brittle in Nature.
  - It is divided into Oceanic Crust(0-10 Km) and the Continental Crust (10 – 100 KM)
  - Nearly 1% of Earths Volume and 0.5 % of Earths Mass are made of the Crust.
  - Major Constituent elements of the crust are Silica(Si) and Aluminium(Al) in the Continental Crust and Silica(Si) and Magnesium(Ma) in the Oceanic Crust.
  - The Continental Crust density is 2.7 g/cm^3 and the Continental Crust is 3 g/cm^3.
- **Mantle:**
  - Nearly 84% Earths Volume and 67% Earths mass is occupied by the Mantle.
  - The Major Constituent elements of the Mantle are Silicon(Si) & Magnesium(Ma).
  - The density of the layer is higher than the Crust i.e 3.3 – 5.4 g/cm^3.
  - The Solid Portion of the Upper Mantle is Lithosphere, and the weak portion of Semi liquid layer below lithosphere is called Asthenosphere.
  - The Asthenosphere which is present in the Upper Mantle is main Source of Magma and it is the layer over which lithospheric Plates/Continental Plates moves.
- **Core:**
  - It Constitutes nearly 15% of the Earths Volume and 32.5 % Earths Mass.
  - It is Composed mainly of Iron(Fe) and Nickel(Ni) and hence it is called as NIFE.
  - The Core is the densest Layer of the earth with its density ranges between 9.5 – 14.5 g/cm^3.
  - The Inner Core is Solid State and the Outer Core is Liquid State.

Temperature & Pressure:

- The Rate of Increase of Temperature is Not uniform from the surface towards the Earths Centre, It is Faster at Some places and Slower at Some Places.
- Beginning it is 1°C for every 32 metre increase in Depth, while after 100 Km it is 12°C/km and above 300 Km it is 20°C/Km and further it reduces to 10°C/Km.
- The rate of increase of Temperature reduces towards the Centre.
- The Temperature at the Centre is around 3000°C to 5000°C but the core is Solid State because of High pressure of Overlying Materials.
- Just like Temperature the pressure also increases from the Surface towards the Centre of the Earth.

LAYER	MASS PERCENT	VOLUME PERCENT
CRUST	<1%	<1%
MANTLE	66%	83%
CORE	33%	16%

Earth's Crust	Entire Earth
Oxygen-47%	Iron-35%
Silicon-28%	Oxygen-30%
Aluminium-8%	Silicon-15%
Iron-5%	Magnesium-13%
Magnesium-4%	Nickel-2%
Calcium-2%	Sulphur-2%
Pottassium-2%	Calcium-1%
Sodium-2%	Aluminium-1%
Others-2%	Others-1%

The Mantle makes up 66% of the Earth's mass and 83% of the Earth's volume

Earthquakes

Earthquakes

- An Earthquake can be defined as a sudden Violent Shaking of the Ground as a result of Movements in the earths Crust or Volcanic Actions.
- Just like Volcanoes the Earthquakes is also an Endogenic Process.
- The Network of Seismographic (Seismograph is the instrument used to measure earthquake) stations all over the world to record earthquake.
- The Point Within the earth where an earthquake originates is Called **Focus** (or) **Hypocenter** (or) **Seismic focus.**
- The Point Vertically above the focus on the earths Surface is called as **"Epicenter".**
- The Intensity of the Earth quake is heavy at epicentre and decreases as one moves away.
- All the natural Earthquakes take place in lithosphere.

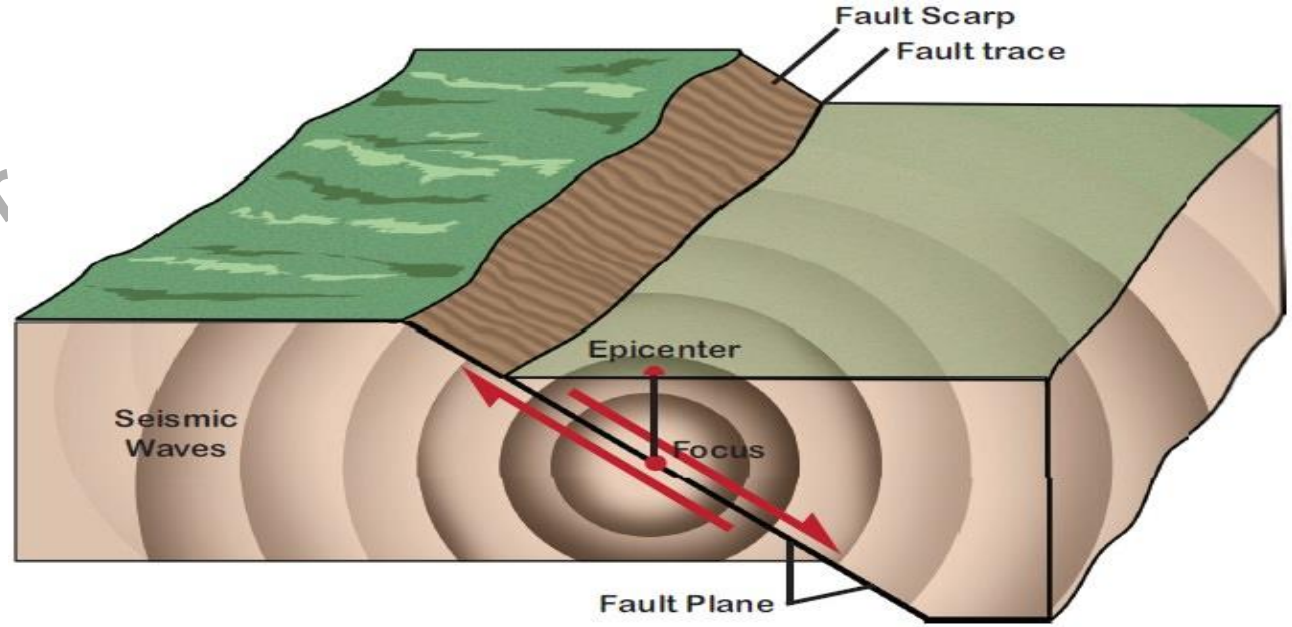
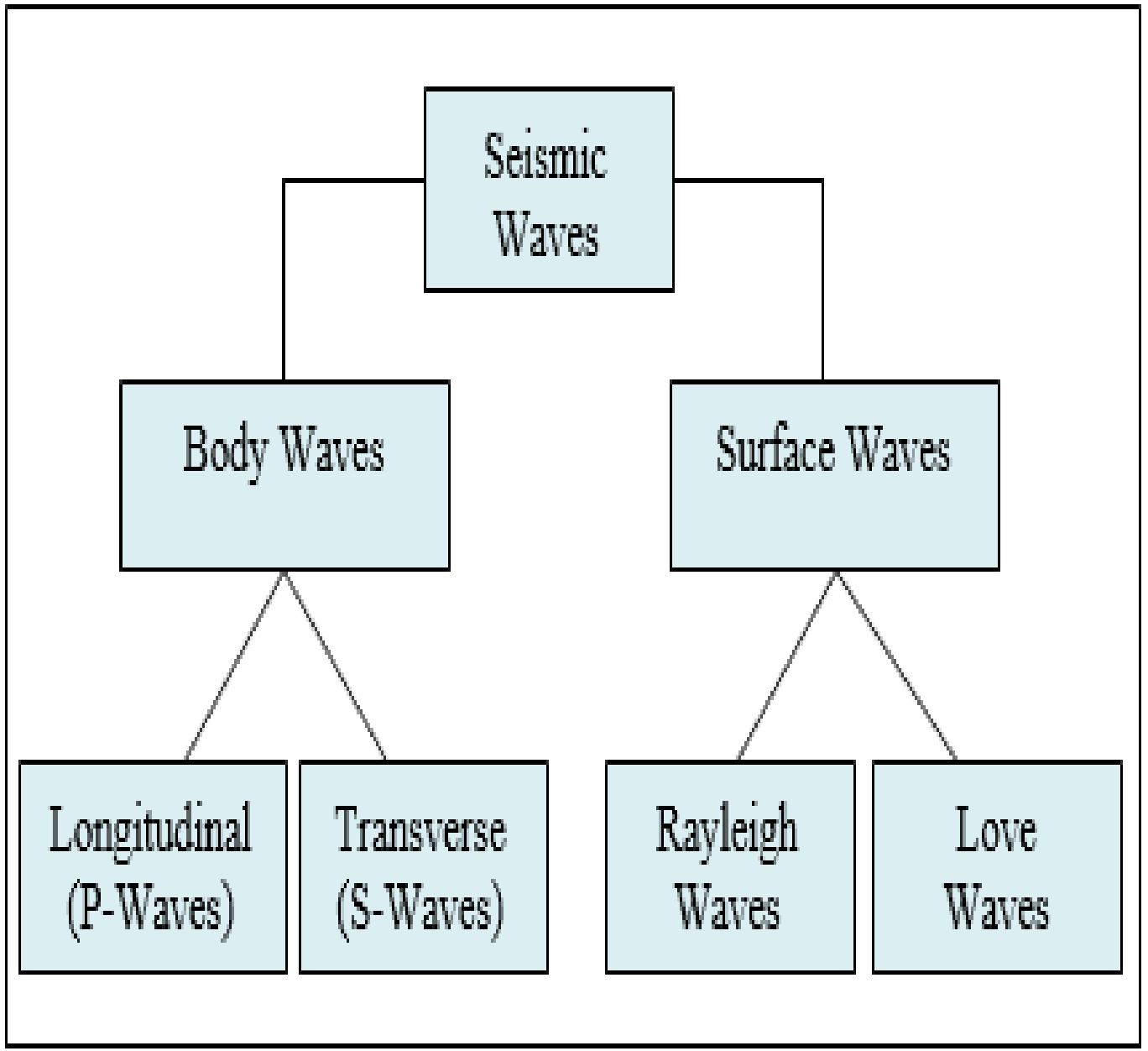
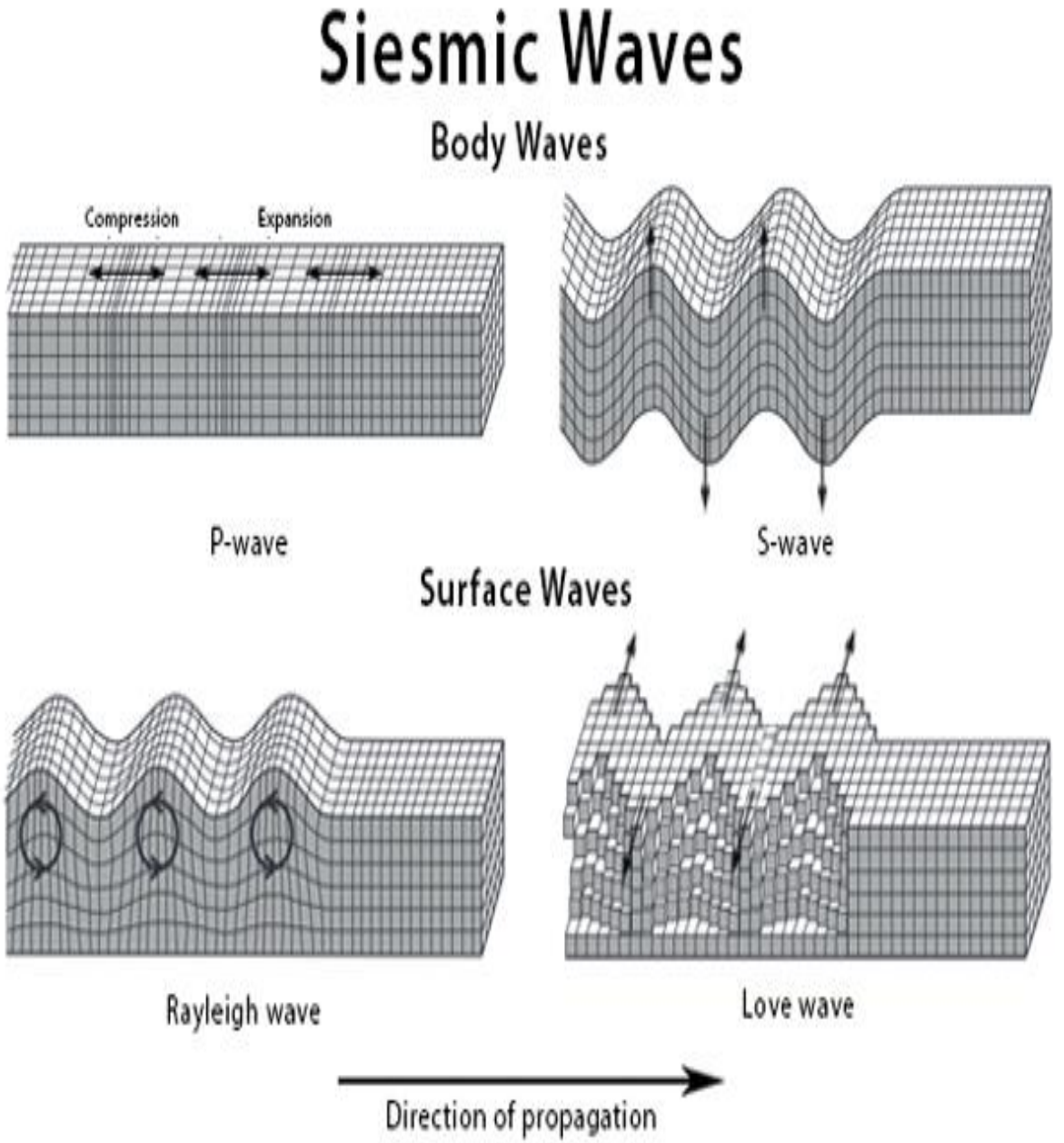


Figure 3.22 Parts of an Earthquake

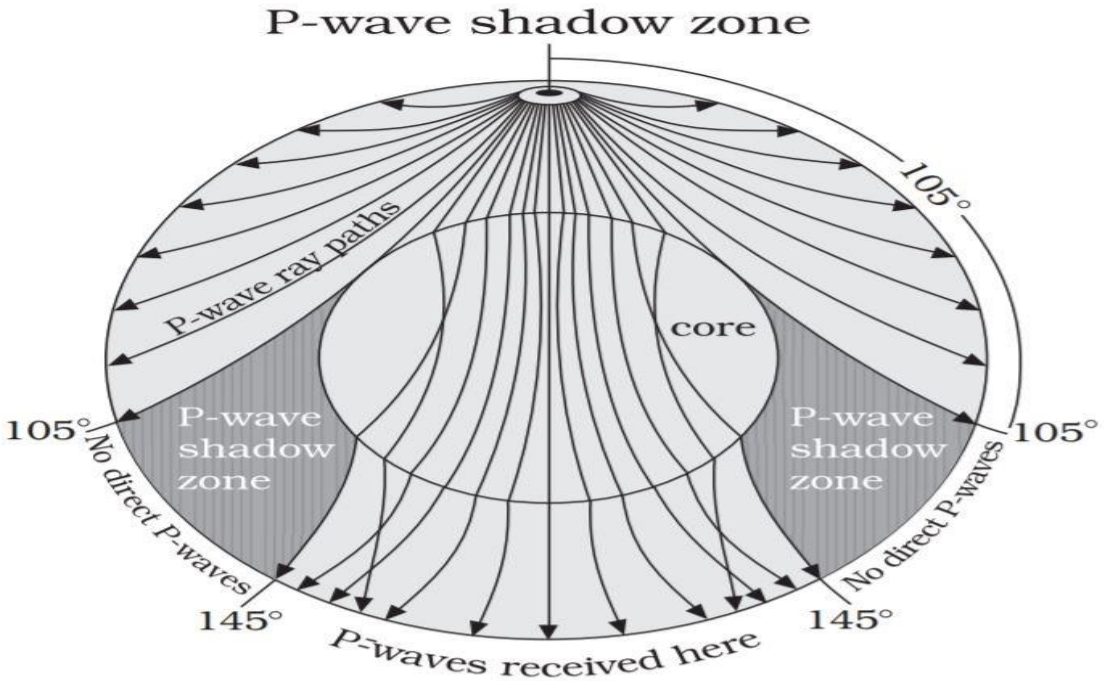
Earthquake Waves (or) Seismic Waves

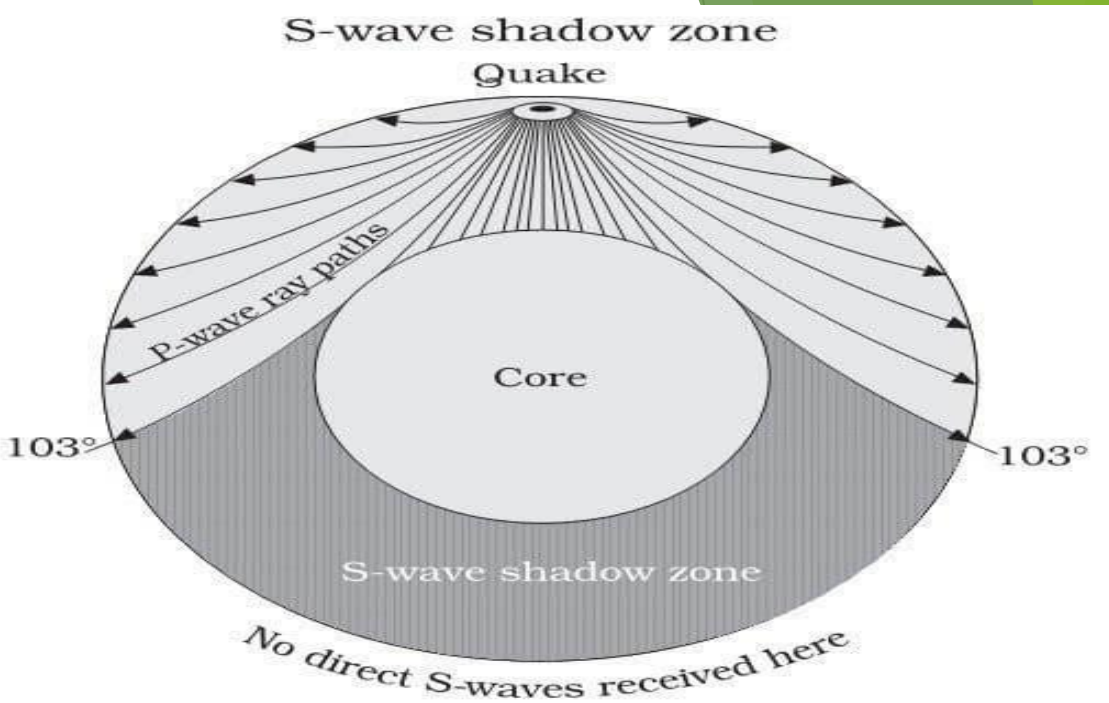




- **Body Waves:**
- **Primary Waves:**
  - Travel through the Body of the earth (body waves), They are the First to arrive at the Surface of the earth.
  - They push and pull what they travel through.
  - They can travel through Solid, Liquid and Gases.
  - These are the Longitudinal in nature just like Sound Waves.
  - P-waves are called Earthquake warning Waves.
- **Secondary Waves:**
  - Travel through the Body of the earth (body waves), they are second to reach the Surface of the earth.
  - They move the Materials up and down so it damages the buildings from the Base.
  - They can pass only through Solids.
  - The movement is Transverse in Nature, the wave direction and particle direction is Perpendicular.

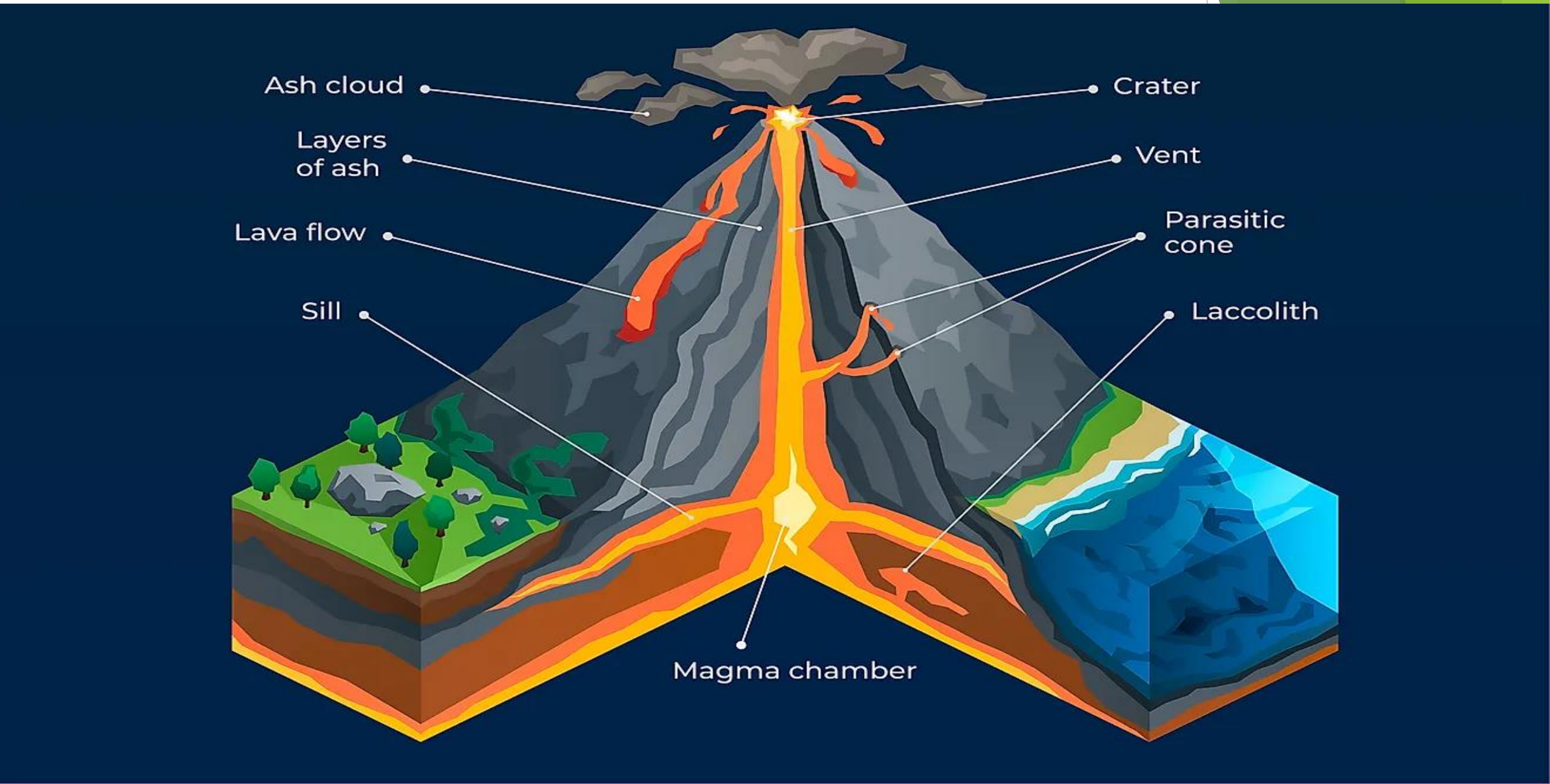
- **Surface Waves:**
  - The Surface Waves are called long waves because of their long wavelength.
  - They develop in the immediate neighbourhood of the epicentre and effect only the surface of the earth and die out at smaller depths.
  - There are two sets of Surface Waves Love Waves(L Waves) & Rayleigh Waves(R Waves).
- **Love Waves:**
  - It is the Fastest Surface wave and moves on the ground from Side-to-Side.
- **Rayleigh Waves:**
  - A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean.
  - 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 and the damage from the earthquake is due to the Rayleigh waves.
- The entire zone beyond 103° does not receive S-waves and hence this zone is identified as the shadow zone of s-waves. This observation led to the discovery of the liquid outer core.
- The Shadow zone of P-waves appears as a band around the earth between 105° and 145° on the both sides away from the epicentre.
- This is because P-waves are refracted when they pass through the transition between the semisolid mantle and the liquid outer core.





- **Measuring Earthquakes:**
  - **Seismometers** are the instruments which are used to measure the motion of the ground, which including those of seismic waves generated by earthquakes.
  - A **Seismometer** is also another term used to mean seismometer.
  - The recorded graphical output from seismometer/seismograph is called as **seismogram**(seismograph is instrument while seismogram is the recorded output).
  - **Mercalli Scale** – Represents the after intensity range from 1-12.
  - **Richter Scale** – Represents Magnitude of Earthquake range from 1-10.

Volcanoes


Ash cloud
Crater
Layers of ash
Vent
Lava flow
Parasitic cone
Sill
Laccolith
Magma chamber

Volcanoes

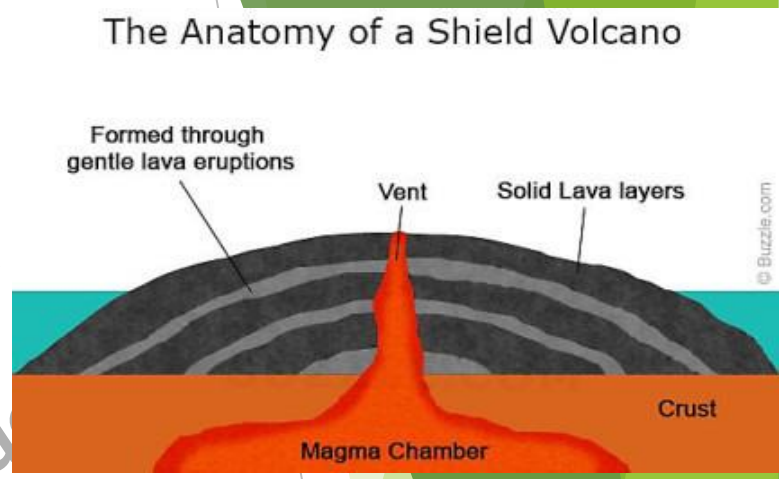
- A volcano is an opening in the earths crust through which gases , molten rock materials(lava), ash, steam etc are emitted outward in the course of an eruption.
- Volcanic activity is an example of endogenic process and different land forms can be formed depending upon the eruption type of Volcanoes.
- If Volcanoes is not much explosive then Plateaus and if Volcanoes are explosive then mountains are formed.
- **Magma Vs Lava:**
  - Magma is the molten rock and related materials seen inside earth.
  - Once the magma come out to the earth surface through the vent of a volcano, it is called as the Lava, therefore Lava is nothing but the magma on earth surface.
- On the basis of nature of eruption and the form developed at the surface the volcanoes are classified into:

1) Shield Volcanoes
2) Composite Volcanoes
3) Caldera Volcanoes
4) Flat Basalt Province Volcanoes
5) Mid-Ocean Ridge Volcanoes

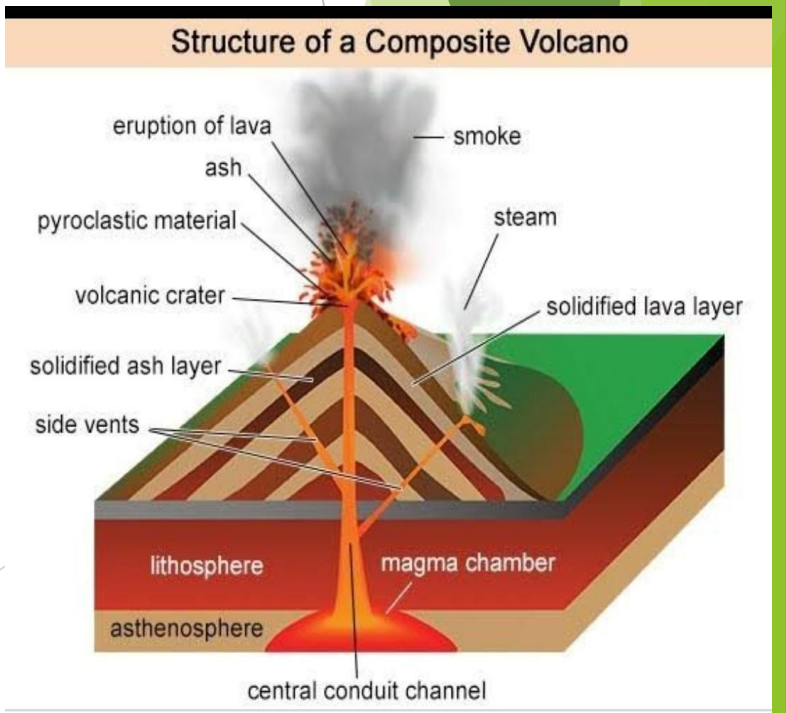
- On the basis of frequency of eruption:
- 1) Active Volcanoes 2) Dormant Volcanoes 3) Extinct Volcanoes.

Types of Volcanoes based on Nature of Eruption

- **Shield Volcanoes:**
  - They are not very steep but are far and wider and covers longer distances.
  - They are the largest of all volcanoes in the world as lava flows for longer distances.
  - The lava which comes out of it is of low viscosity, so it spreads more.
  - It resembles like a warrior shield from the Top, so they are called Shield Volcanoes.
  - Examples are Hawaiian Volcanoes (Mauna Loa is largest).



- **Composite Volcanoes:**
  - It is called Composite because it is made up of Several materials.
  - Cone shaped with moderately steep sides.
  - These are made up of Multiple Eruptions.
  - Lava which flows out will turn into thin crust, as viscosity of lava is thick.
  - Along with lava, large quantities of pyroclastic materials and ashes come out.
  - Examples are **Mount Fuji in Japan, Mount Cotopaxi in Ecuador.**

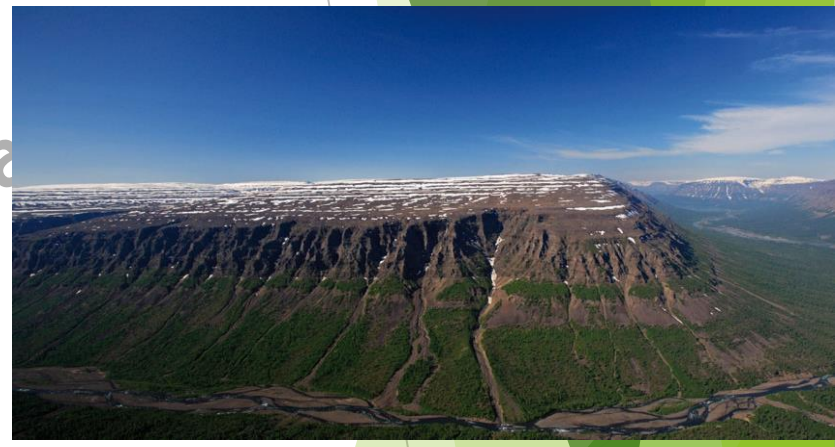


Caldera type Volcanoes:

- These are most explosive of earths Volcanoes.
- They are usually so explosive that when they erupt they tend to collapse on themselves rather than building any tall structure.
- The Collapsed depressions are called **“Calderas”.**
- Their explosiveness indicates that their magma chamber is larger and in close vicinity.

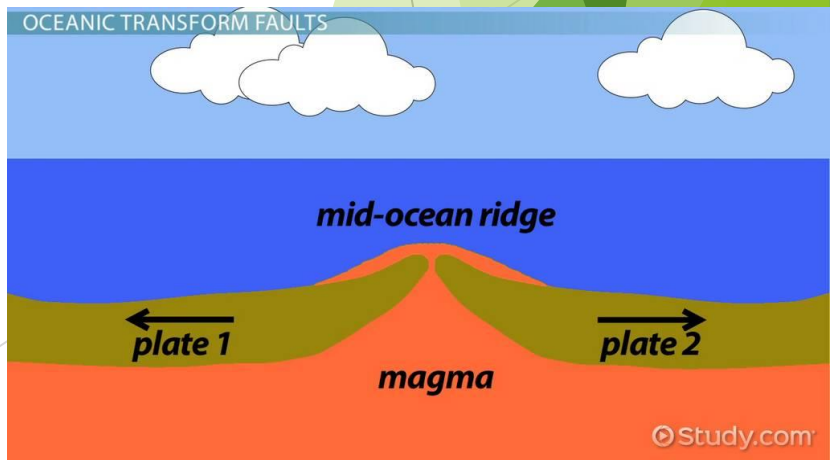
Flood Basalt Provinces:

- These Volcanoes outpour highly fluid lava that flow over long distance(flat) may be 1000’s of Km forming landscapes.
- The Deccan traps from India, presently covering most of the Maharashtra plateau is flood basalt province.



Mid Oceanic Ridge Volcanoes:

- Under water mountain range formed by plate tectonics.
- Occurs due to divergent of Plate Boundaries.
- Crust and Upper mantle up to lithosphere are the plates which float and move.
- In Oceans mainly Divergent mechanism takes place.



Volcanoes on the frequency of Eruption

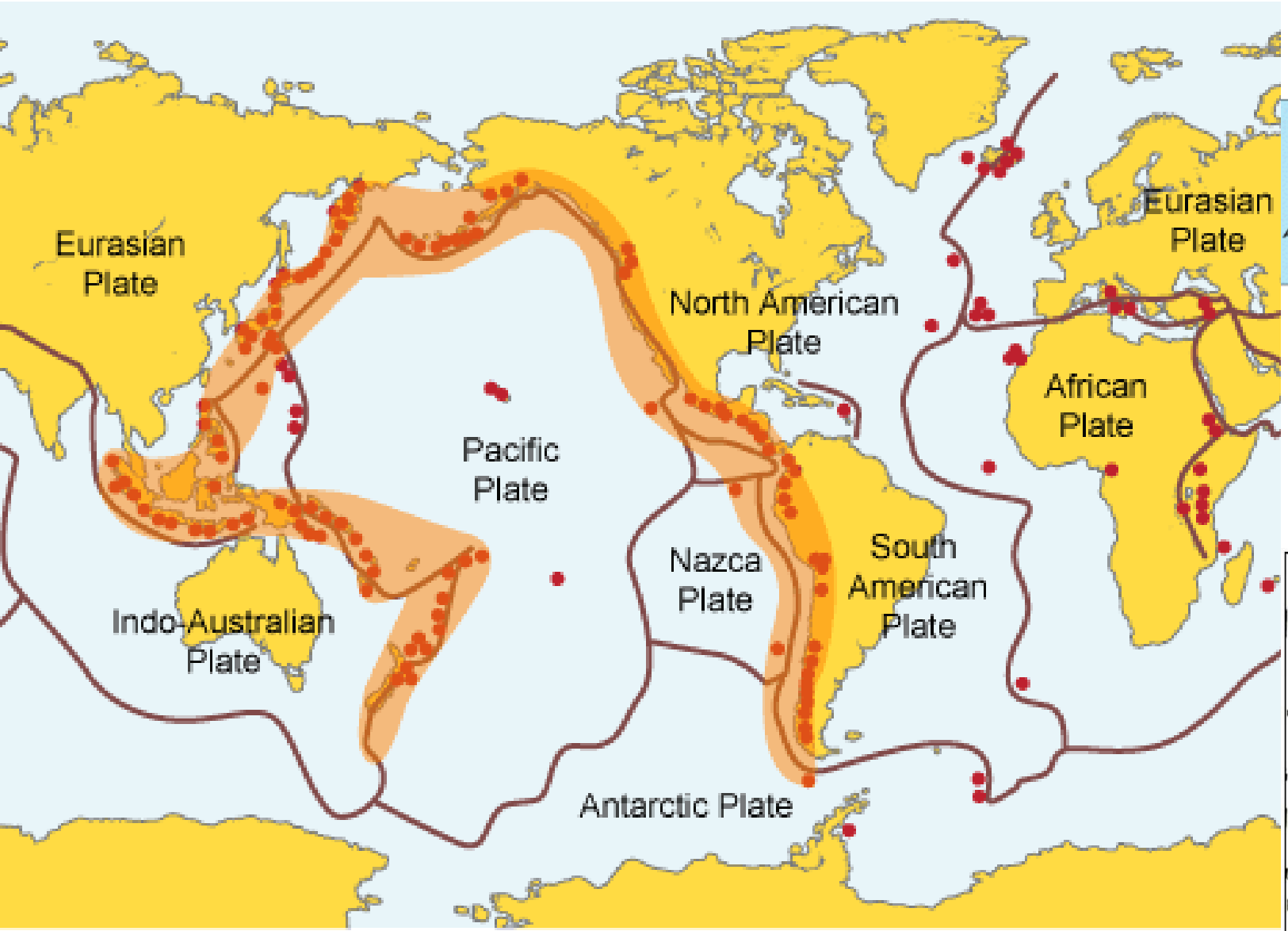
- **Active Volcanoes:**
  - Erupt Frequently or have erupted recently or are in action currently.
  - Examples are **Barren Islands (India), Stromboli (Italy), Mount Etna (Italy), Mauna Loa(Hawaiian).**

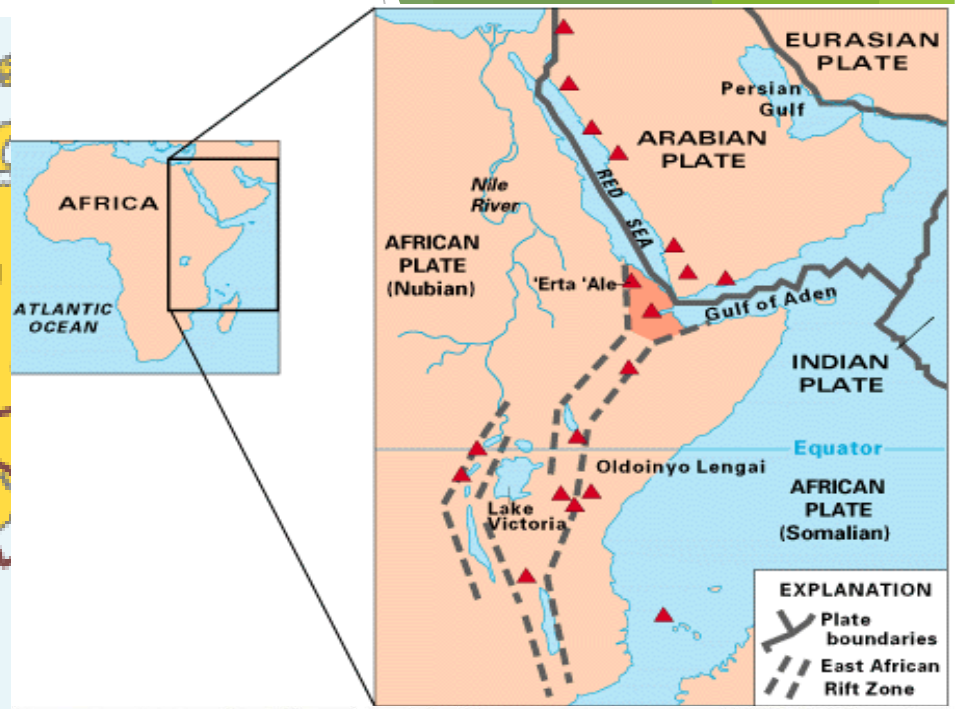
- **Dormant Volcanoes:**
  - Not erupted in the recent times, but at least erupted once in human history.
  - Examples are **Mount Kilimanjaro(Tanzania, Africa), Mount Fuji (Japan), Mauna Kea (Hawaii).**

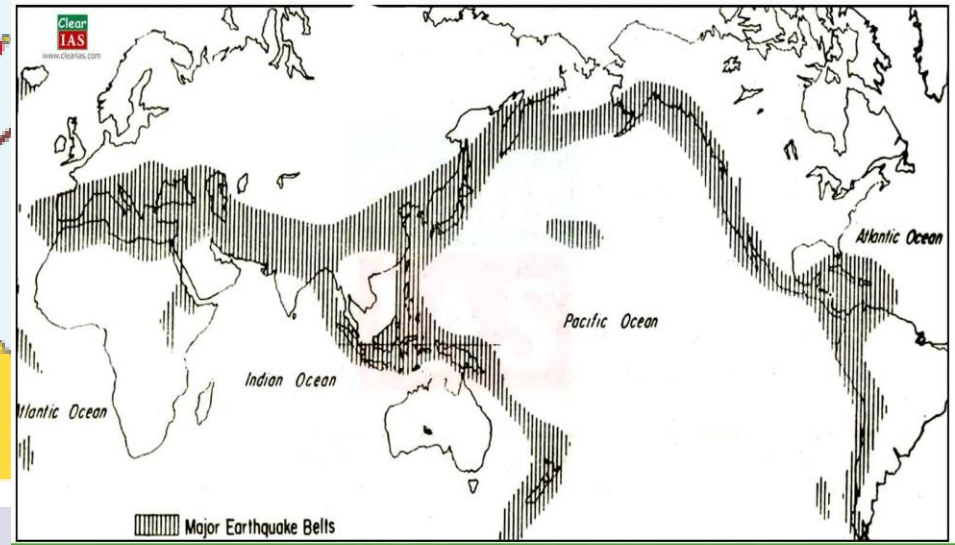
- **Extinct Volcanoes:**
  - Not erupted in human history.
  - Examples Ben Nevis(UK), Kyushu-Palau Ridge in the Philippine Sea.

- **Distribution of Volcanoes:**
  - The Circum - Pacific Belt (The pacific ring of fire).
  - The mid – world Mountain Belt.
  - The African Rift valley Belt.

Distribution of Volcanoes



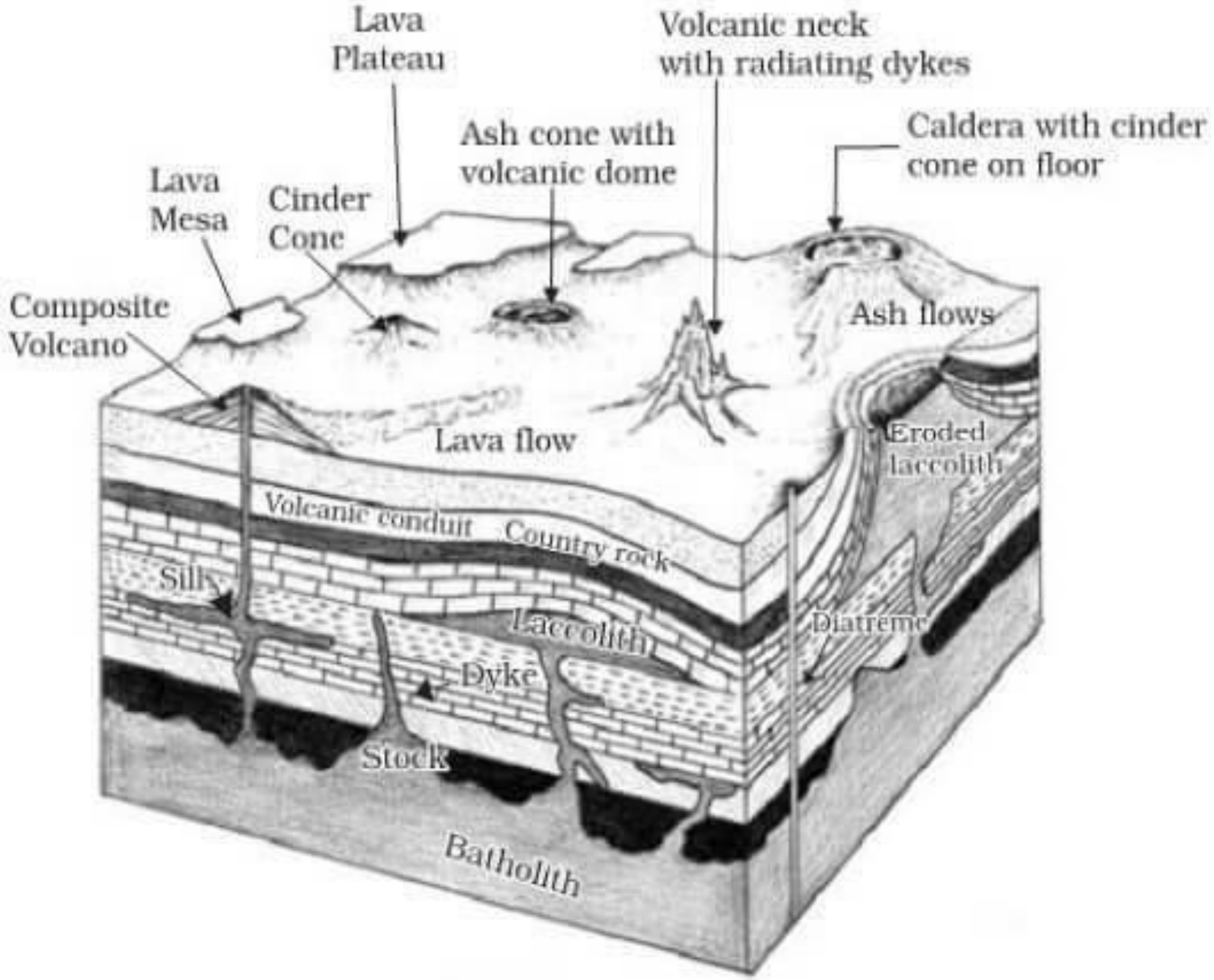




Volcano | Plate boundaries | Pacific Ring of Fire

Major Earthquake Belts

Volcanic Landforms



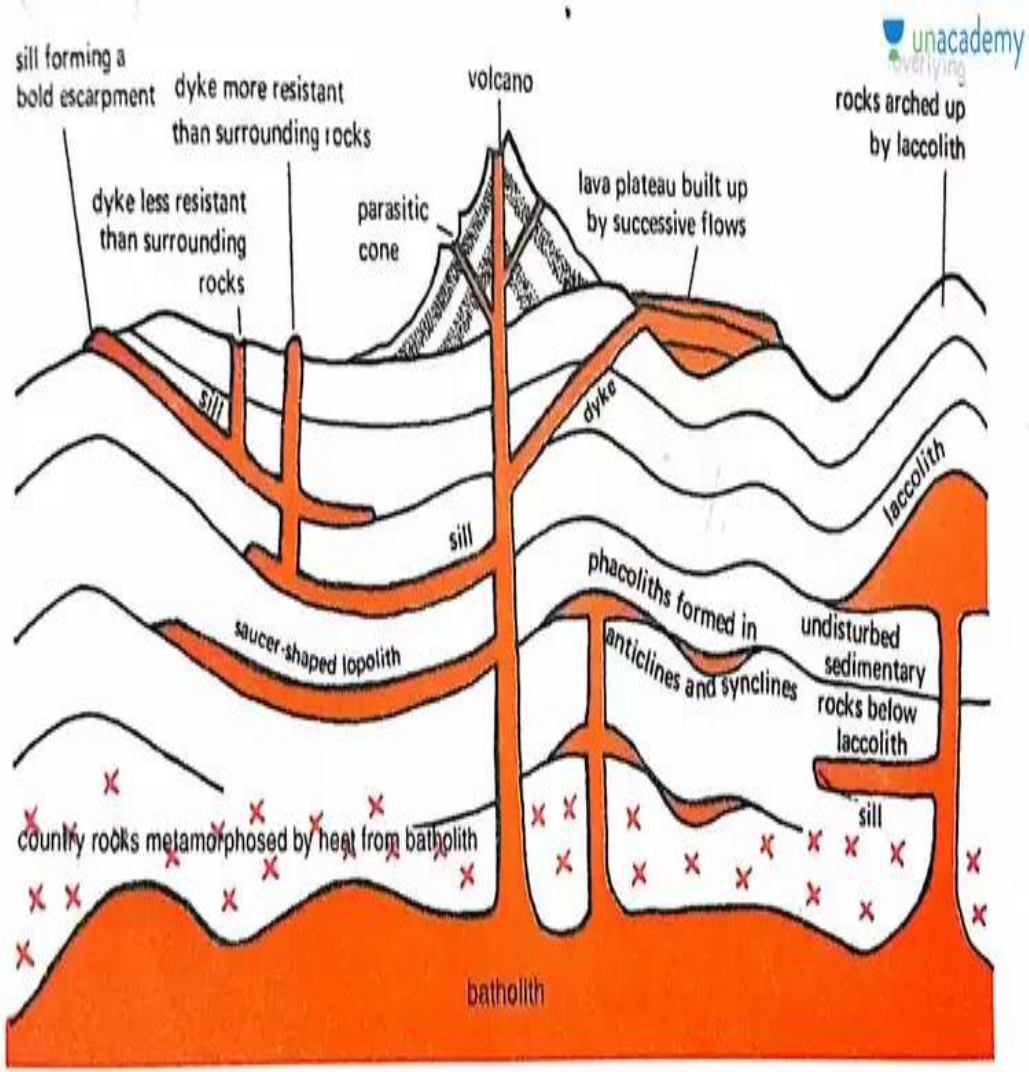


Fig. 26 Intrusive landforms of igneous intrusions in volcanic regions (showing sill, dyke, laccolith, lopolith phacolith and batholith)

- Volcanic landforms are divided into **extrusive and intrusive landforms** based on whether magma cools within the crust or above the crust.
- Rocks formed by the cooling of magma within the crust are called **Plutonic rocks.**
- Rocks formed by the cooling of lava above the surface are called **Igneous rocks**.
- In general, the term 'Igneous rocks' is used to refer to all rocks of volcanic origin.
- **Extrusive Volcanic Landforms:**
  - Extrusive landforms are formed from material thrown out to the surface during volcanic activity.
  - The materials thrown out include lava flows, pyroclastic debris, volcanic bombs, ash, dust and gases such as **nitrogen compounds, sulphur compounds** and minor amounts of **chlorine, hydrogen** and **argon**.
  - Examples are Composite Volcano, Lava Mesa, Lava Plateau , Volcanic neck with riding Dykes, Caldera Volcanic Landform.
- **Intrusive Volcanic Landforms:**
- **Batholiths:**
  - These are large **granitic** rock bodies formed due to solidification of hot magma **inside the earth**.
  - They appear on the surface only after the denudation processes remove the overlying materials.
  - Batholiths **form the core of huge mountains** and may be exposed on the surface after erosion.
- **Laccoliths:**
  - These are large dome-shaped intrusive bodies connected by a pipe-like conduit from below.
  - The **Karnataka plateau** is spotted with dome hills of granite rocks. Most of these, now exfoliated, are examples of laccoliths or batholiths.

- **Phacolith:**
  - A wavy mass of intrusive rocks, at times, is found at the base of synclines or the top of the anticline in folded igneous strata.
  - Such wavy materials have a definite conduit to source beneath in the form of magma chambers (subsequently developed as batholiths). These are called the Phacoliths.
- **Sills:**
  - The near horizontal bodies of the intrusive igneous rocks are called sill. The thinner ones are called sheets.
- **Dykes:**
  - When the lava makes its way through cracks and the fissures developed in the land, it solidifies almost **perpendicular** to the ground.
  - It gets cooled in the same position to develop a **wall-like structure**. Such structures are called dykes.
  - These are the most commonly found intrusive forms in the western Maharashtra area.
  - These are considered the **feeders for the eruptions** that led to the development of the **Deccan traps**.