



## Earthquake

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- An earthquake in simple words is the shaking of the earth. It is a natural event. It is caused due to release of energy, which generates waves that travel in all directions.
- The vibrations called seismic waves are generated from earthquakes that travel through the Earth and are recorded on instruments called seismographs.
- The location below the earth's surface where the earthquake starts is called the **hypocenter**, and the location directly above it on the surface of the earth is called the **epicenter**.

### Types of Earthquake and Causes

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#### Fault Zones:

- The release of energy occurs along a fault. A fault is a sharp break in the crustal rocks.
- Rocks along a fault tend to move in opposite directions. As the overlying rock strata press them, the friction locks them together.
- However, their tendency to move apart at some point of time overcomes the friction. As a result, the blocks get deformed and eventually, they slide past one another abruptly.
- This causes earthquake in the form of release of energy, and the energy waves travel in all directions.

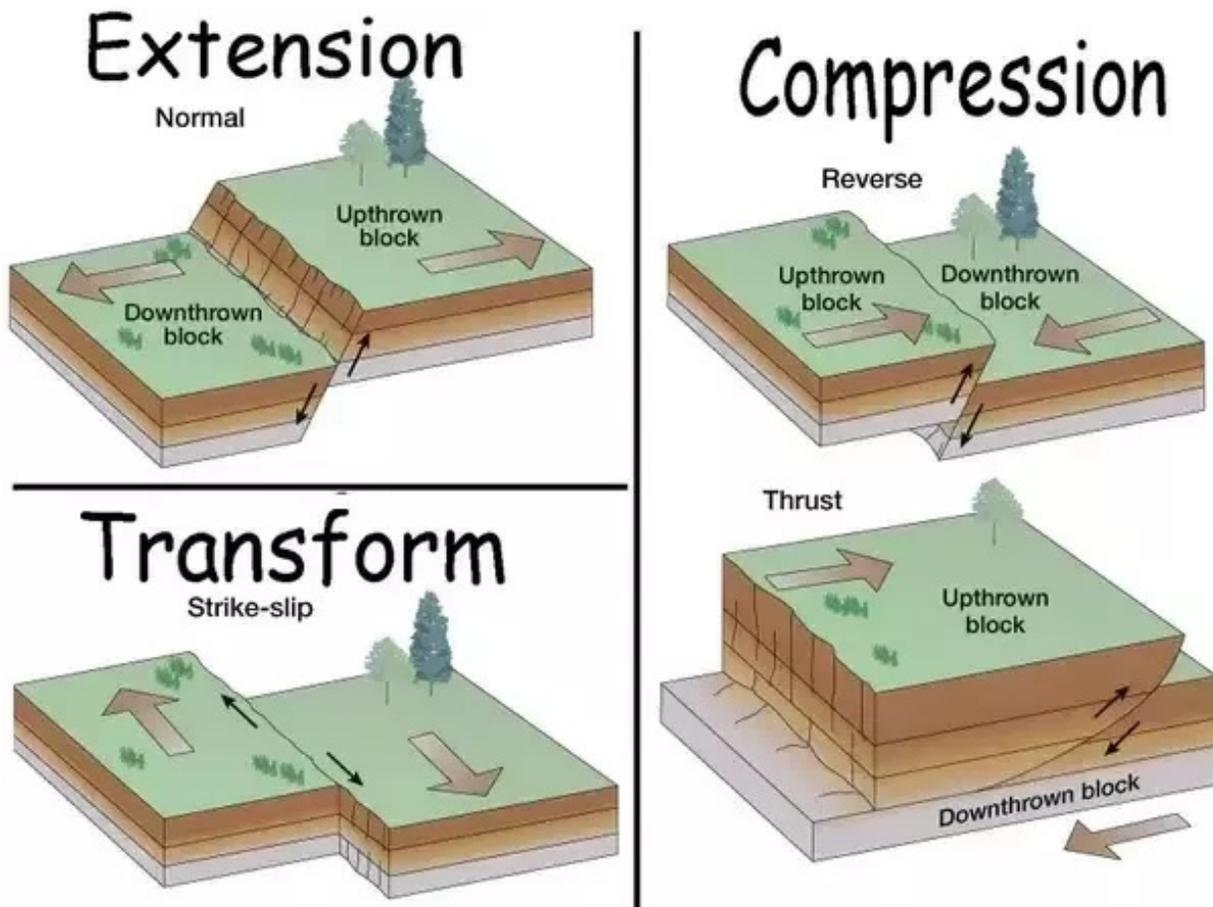
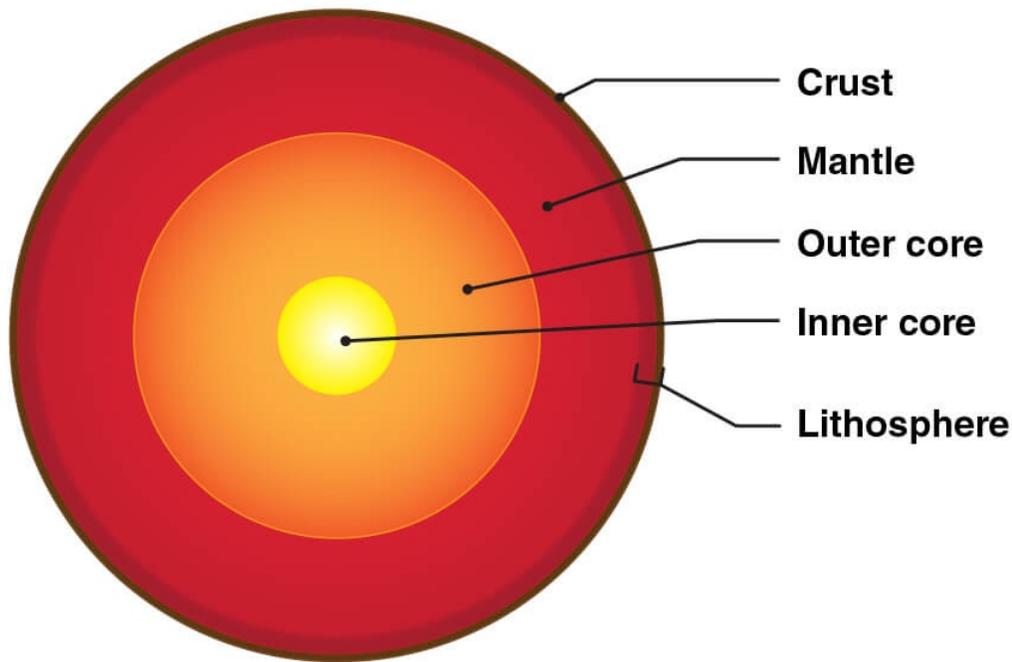


Fig: Earthquakes in the faults

### Tectonic Earthquakes:

- The most common ones are the **tectonic earthquakes**.
- Although the Earth looks like a pretty solid place from the surface, it's actually extremely active just below the surface.
- The Earth is made of four basic layers (generally three): a **solid crust**, a **hot, nearly solid mantle**, a **liquid outer core** and a **solid inner core**.

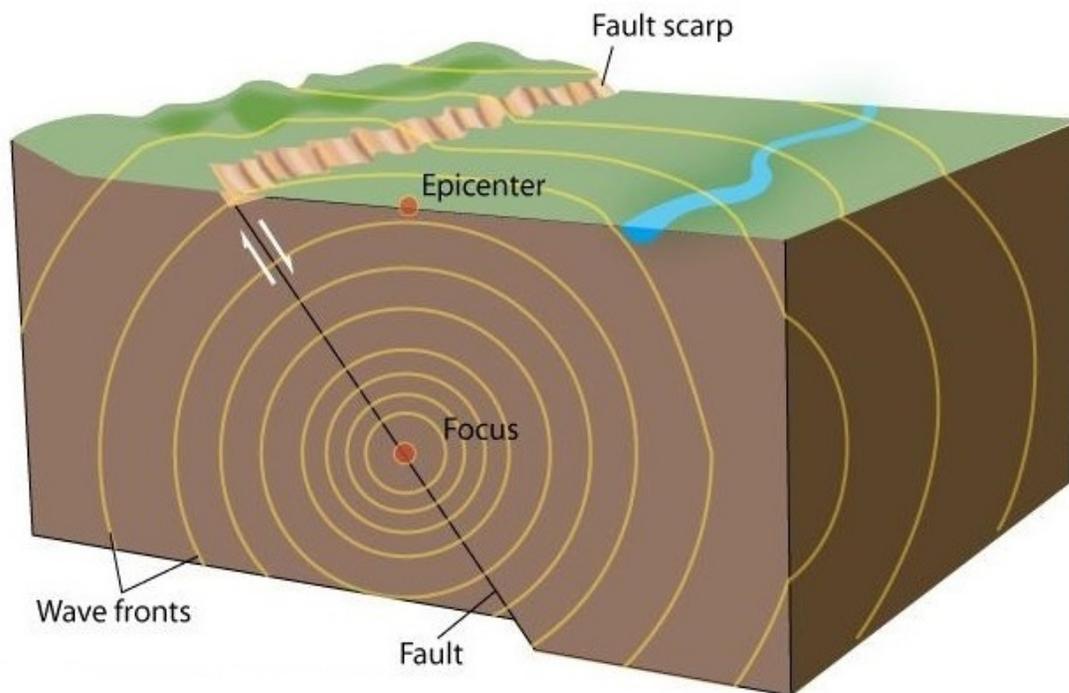


Tectonic plates (Lithospheric plates) are constantly shifting as they drift around on the viscous, or slowly flowing, mantle layer below.



- This non-stop movement causes stress on Earth's crust. When the stresses get too large, it leads to cracks called faults.
- When tectonic plates move, it also causes movements at the faults. Thus, the slipping of land along the faultline along convergent, divergent and transform boundaries cause earthquakes.

- The point where the energy is released is called the **focus of an earthquake**, alternatively, it is called the **hypocentre**. The energy waves travelling in different directions reach the surface.
- The point on the surface, nearest to the focus, is called **epicentre**. It is the first one to experience the waves. It is a point directly above the focus.



### Volcanic Earthquake

- A special class of tectonic earthquake is sometimes recognised as volcanic earthquake. However, these are confined to areas of active volcanoes.
- Earthquakes produced by stress changes in solid rock due to the injection or withdrawal of magma (molten rock) are called volcano earthquakes.
- These earthquakes can cause land to subside and can produce large ground cracks. These earthquakes can occur as rock is moving to fill in spaces where magma is no longer present.
- Volcano-tectonic earthquakes don't indicate that the volcano will be erupting but can occur at any time.

### Human Induced Earthquakes

- In the areas of **intense mining activity**, sometimes the roofs of underground mines collapse causing minor tremors. These are called **collapse earthquakes**.
- Ground shaking may also occur due to the explosion of chemical or nuclear devices. Such tremors are called **explosion earthquakes**.

- The earthquakes that occur in the areas of large reservoirs are referred to as **reservoir induced earthquakes**.

### Earthquakes based on the depth of focus

The earthquakes are divided into three zones: shallow, intermediate, and deep based on their depth which range between 0 – 700 km.

- **Shallow earthquakes** have a focus 0 – 70 km deep.
- **Intermediate earthquakes** have a focus 70 – 300 km deep.
- **Deep earthquakes** have a focus 300 – 700 km deep.

### Wadati–Benioff zone

- Deep earthquakes (300-700 km) are produced in this zone.
- It is a zone of subduction, along which earthquakes are common, which are produced by the interaction of a downgoing oceanic crustal plate against a continental plate.
- Some of the most powerful earthquakes occur along this zone.
- These earthquakes can be produced by slip along the subduction thrust fault or by slip on faults within the downgoing plate as the plate is pulled into the mantle.

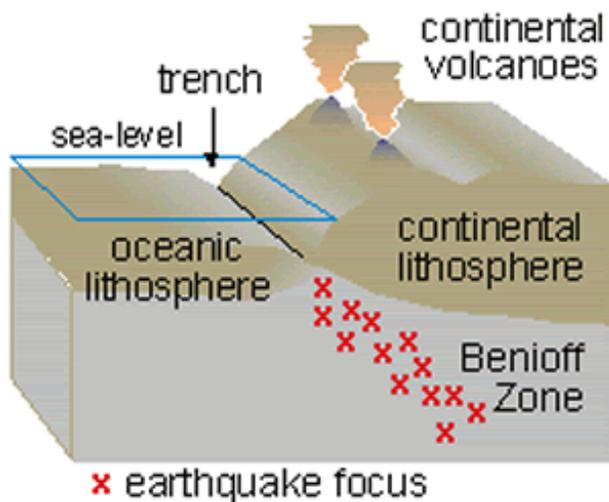


Fig: Cross-section of the Benioff zone.

### Distribution of Earthquakes

Earthquakes can strike any location at any time, but history shows they occur in the same general patterns year after year, principally in three large zones of the earth:

- The world's greatest earthquake belt, the **circum-Pacific seismic belt**, is found along the rim of the Pacific Ocean, where about 81 percent of our planet's largest earthquakes occur.
  - It has earned the nickname "**Ring of Fire**".
  - The belt exists along boundaries of tectonic plates, where plates of mostly oceanic crust are sinking (or subducting) beneath another plate. Earthquakes in these subduction zones are caused by slip between plates and rupture within plates.
- The **Alpine earthquake belt (mid Continental belt)** extends from Java to Sumatra through the Himalayas, the Mediterranean, and out into the Atlantic. This belt accounts for about 17 percent of the world's largest earthquakes, including some of the most destructive.
- The third prominent belt follows the submerged **mid-Atlantic Ridge**. The ridge marks where two tectonic plates are spreading apart (a divergent plate boundary). Most of the mid-Atlantic Ridge is deep underwater and far from human development.

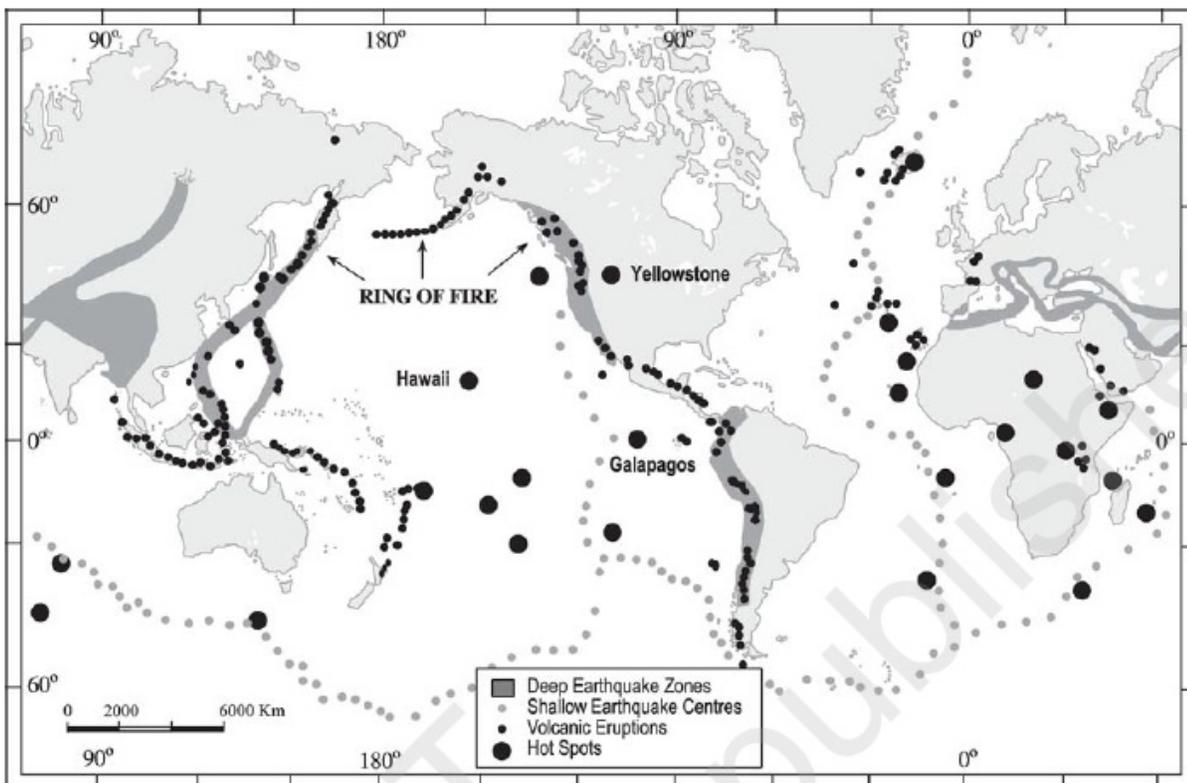


Fig: Distribution of Earthquake

### Measurement of Earthquakes

- The energy from an earthquake travels through Earth in vibrations called **seismic waves**.

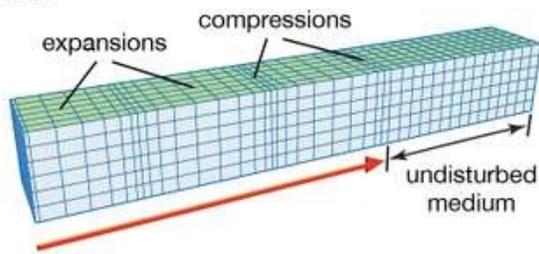
- Scientists can measure these seismic waves on instruments called **seismometers**.
- A seismometer detects seismic waves below the instrument and records them as a series of zig-zags.
- Scientists can determine the time, location and intensity of an earthquake from the information recorded by a seismometer. This record also provides information about the rocks the seismic waves traveled through.
- The earthquake events are scaled either according to the magnitude or intensity of the shock. The magnitude scale is known as the **Richter scale**. The magnitude relates to the energy released during the quake. The magnitude is expressed in absolute numbers, 0-10.
- The intensity scale is named after **Mercalli**, an Italian seismologist. The intensity scale takes into account the visible damage caused by the event. The range of intensity scale is from 1-12.

### **Seismic Waves (Earthquake Waves)**

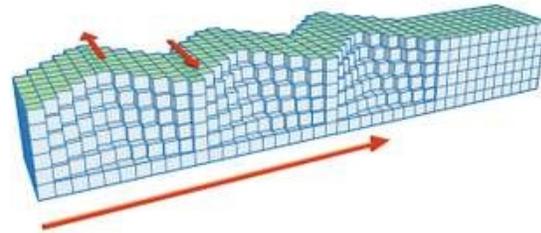
- Seismic waves are the waves of energy caused by earthquakes or an explosion. They are the energy that travels through the earth and is recorded on seismographs.
- Earthquake waves are basically of two types — **body waves and surface waves**.
- **Body waves** are generated due to the release of energy at the focus and move in all directions travelling through the body of the earth. Hence, the name body waves.
  - There are **two types of body waves**. They are called **P and S-waves**.
  - **P-waves** move faster and are the first to arrive at the surface. These are also called ‘primary waves’. The P-waves are similar to sound waves. They travel through gaseous, liquid and solid materials.
  - **S-waves** arrive at the surface with some time lag. These are called secondary waves. An important fact about S-waves is that they can travel only through solid materials.
- The body waves interact with the surface rocks and generate a new set of waves called **surface waves**. These waves move along the surface.
- The surface waves are the last to report on seismographs. These waves are more destructive. They cause displacement of rocks, and hence, the collapse.
- Thus, the characteristics of the seismic waves are quite important. It has helped scientists to **understand the structure of the interior of the earth**.

## Main types of seismic waves

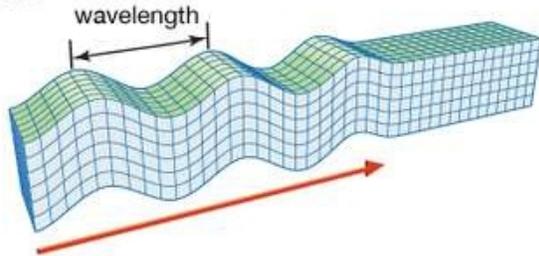
P wave



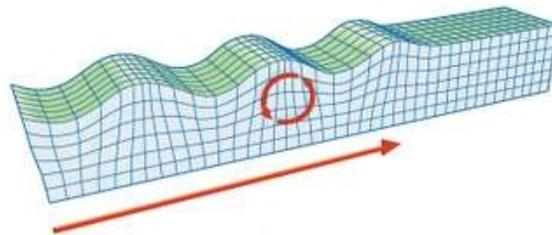
Love wave



S wave



Rayleigh wave



## Effects of Earthquake

Earthquakes are a natural hazard. If a tremor of high magnitude takes place, it can cause heavy damage to the life and property of people. The following are the immediate hazardous effects of earthquake:

- Ground Shaking
- Differential ground settlement
- Land and mudslides
- Fires
- Ground lurching
- Avalanches
- Ground displacement
- Floods from dam and levee failures
- Structural collapse
- Tsunami

## Earthquake in India

- India is one of the highly earthquake affected countries because of the presence of technically active young fold mountains - Himalaya.
- India has been divided into **four seismic zones (II, III, IV, and V)** based on scientific inputs relating to seismicity, earthquakes occurred in the past and tectonic setup of the region.

## 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	<b>Very High Risk Zone</b> Area liable to shaking Intensity IX (and above)
Zone IV	<b>High Risk Zone</b> Intensity VIII
Zone III	<b>Moderate Risk Zone</b> Intensity VII
Zone II	<b>Low Risk Zone</b> VI (and lower)

