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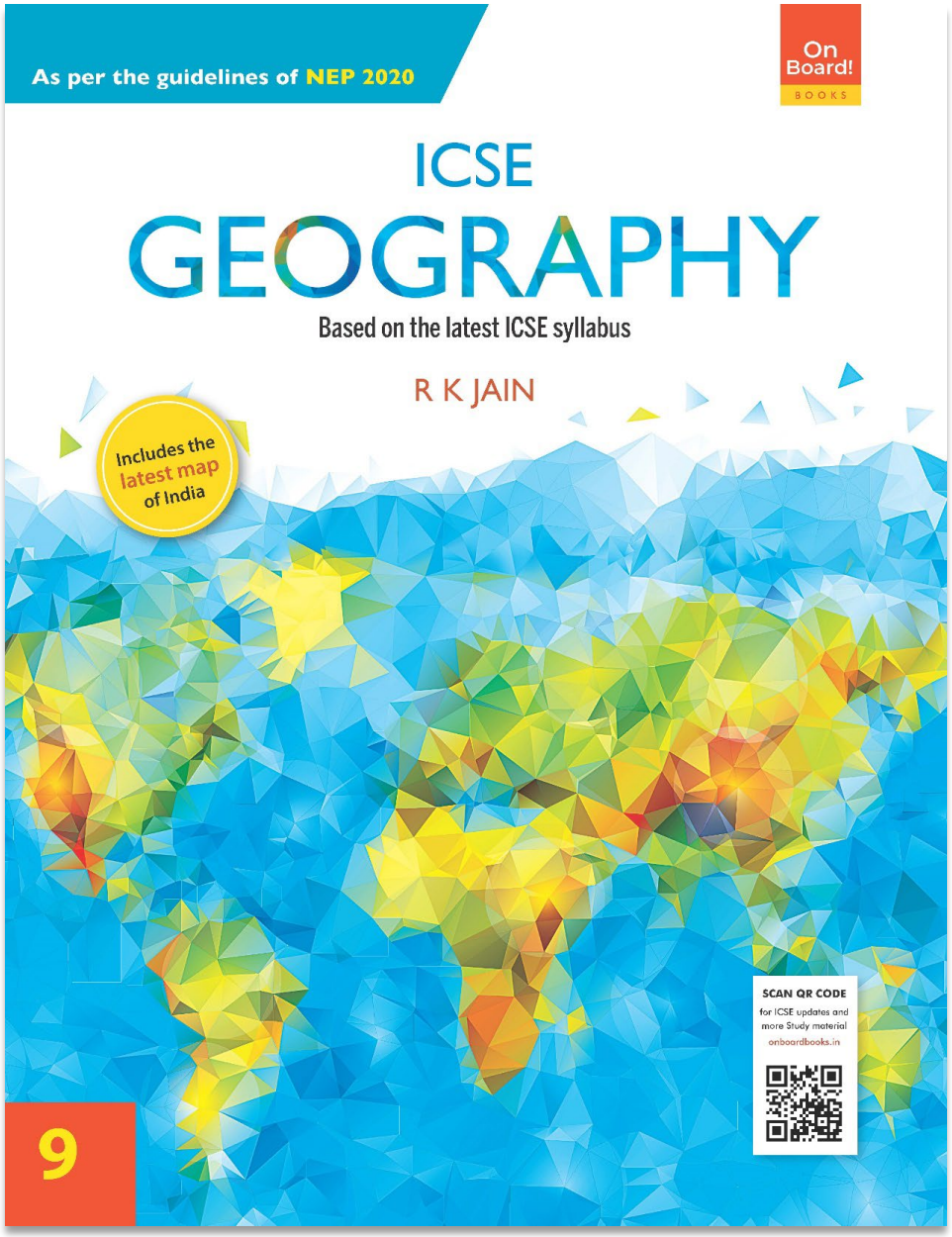
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9

CONTENTS

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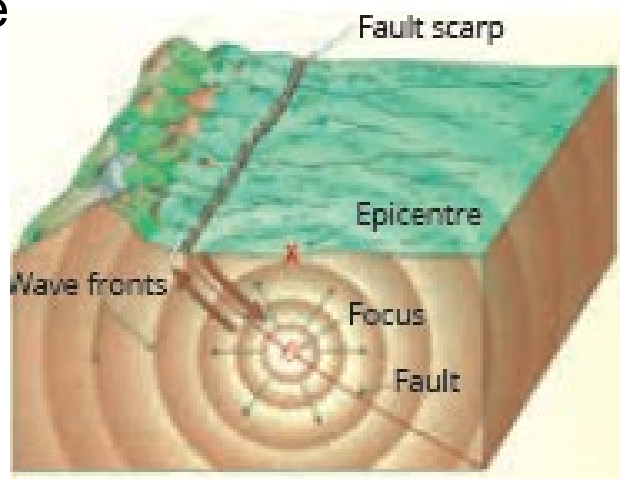
Class 9

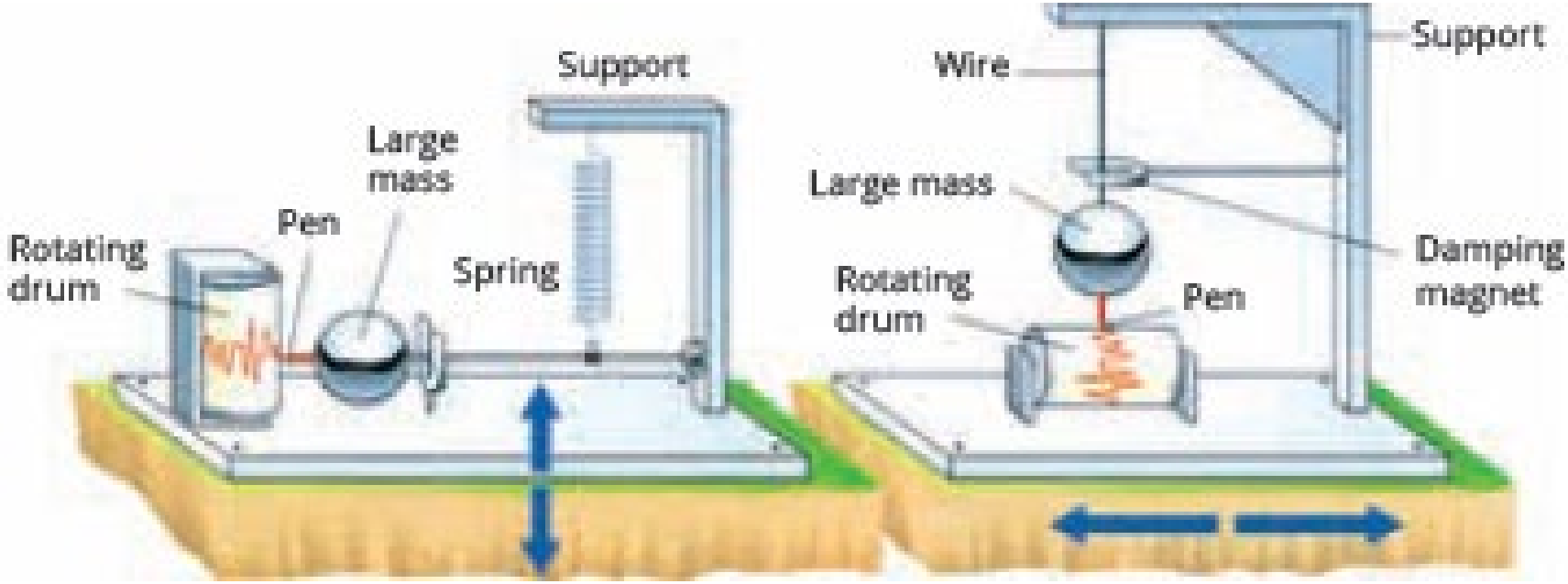
Chapter 8: Earthquakes

Any sudden disturbance below the Earth's surface, due to tectonic forces, may produce vibrations or tremors in the Earth's crust. These vibrations or tremors can cause an **earthquake**. In other words, the shaking of the ground caused by the sudden movements in the Earth's crust is called an earthquake

The place of origin of an earthquake is called the **focus**. The point on the Earth's surface, vertically above the focus is called the **epicentre**. The waves generated by an earthquake are called the **seismic waves**. These are recorded by an instrument called the **seismograph**. The science that deals with the seismic waves is called **seismology** and the earthquake scientists are called **seismologists**. **The magnitude of earthquake is maximum near the epicentre.**



Location of focus and epicentre



The seismograph

The **magnitude** or intensity of an earthquake is measured in relation to its effects on human life. Magnitude is the amount of energy released. The intensity of an earthquake at a specific location depends on the following factors.

- The total amount of energy released
- The distance from the epicentre
- The type of rocks

TYPES OF SEISMIC WAVES

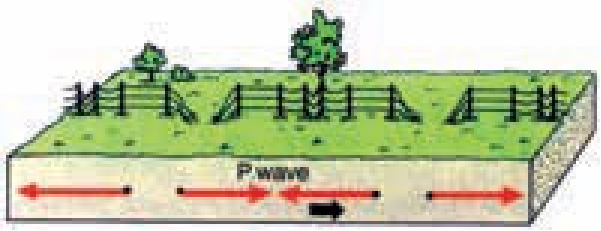
- The enormous energy released by an earthquake travels through the ground in the form of **waves**.
- The earthquake waves originate from the focus and radiate in all directions in concentric circles.
- The characteristics of the earthquake waves are recorded on the screen of a seismograph, and is called a **seismogram**.

According to their mode of travel and the rate of movement, the seismic waves are classified into the following three types:

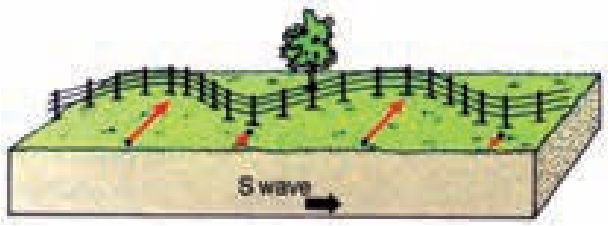
1. **Primary Waves (P) or Push Waves** are the fastest and travel at a speed of about 6 km per second. These waves are the first to arrive.

2. **Secondary Waves (S) or Shake Waves** are the next to arrive. Their rate of movement is less than that of the primary waves. The vibrations caused by these waves are at right angles to the direction of their movement. These waves move at right angles to the primary waves. The secondary waves cannot pass through liquids.

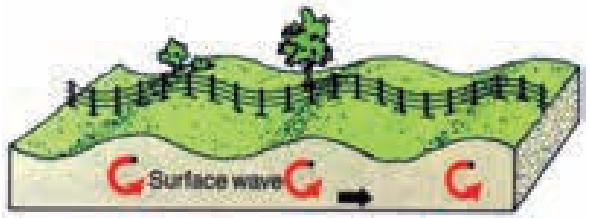
3. **Surface waves** are last to arrive. These waves travel over the surface of the Earth and cause maximum destruction. The surface waves can travel much longer distance than the primary and secondary waves. Their effect is not seen at great depths.



Motion produced by a P wave: Particles are compressed and then are expanded in the line of wave progression. P waves can travel through any Earth material



Motion produced by a S wave: Particles move back and forth at right angles to the line of wave progression. S waves travel only through solids.



Motion produced by a surface wave: Particles move in a circular path at the surface. The motion diminishes with depth, like that produced by surface waves in the ocean

CAUSES OF EARTHQUAKES

The earthquakes are caused by the tectonic forces, which can cause imbalance in the crust of the Earth. The imbalance can be due to (a) volcanic eruptions, (b) folding and faulting, (c) upwarping and down warping, (d) gaseous expansion and contraction inside the Earth, (e) hydrostatic pressure of man-made water bodies such as reservoirs, and (f) plate movements.

Volcanic Activity

- The volcanic activity is considered to be one of the main causes of earthquakes. In fact, volcanicity and seismic events are cause and effect for each other. In other words, each volcanic eruption is followed by an earthquake and many of the severe earthquakes can cause volcanic eruptions.
- The materials during the process of volcanic eruption try to escape upward and hence they push the crustal surface from below with great force. This leads to severe tremors of high magnitude, which depend upon the intensity of volcanic eruptions.

❖ The violent eruption of Krakatoa volcano, between Java and Sumatra islands, caused such a severe earthquake, that its impact was felt as far away as Cape Horn (some 12,000 km away).

TECTONIC PLATES

All tectonic activities, such as seismic events, vulcanicity, mountain building, faulting, etc. occur along the tectonic plate margins. The Earth's crust has 6 major plates and 20 minor plates, which are floating independently on asthenosphere. The movement of the tectonic plates is of three types. These are as under:

a. Diverging or Constructive Plates

These plates move away from each other and create wide rift on the surface of the Earth. This leads to the widening of oceans.

b. Converging or Destructive Plates

These plates move close to each other and may collide along a line. If two continental plates converge, folding takes place. The Himalayan mountain ranges were formed due to the convergence of the Indian plate with the Asian plate.

c. Conservative Plates or Transform Plates

These plates pass or slide past one another along the transform faults. The movement of these plates neither creates nor destroys anything, but causes earthquakes.

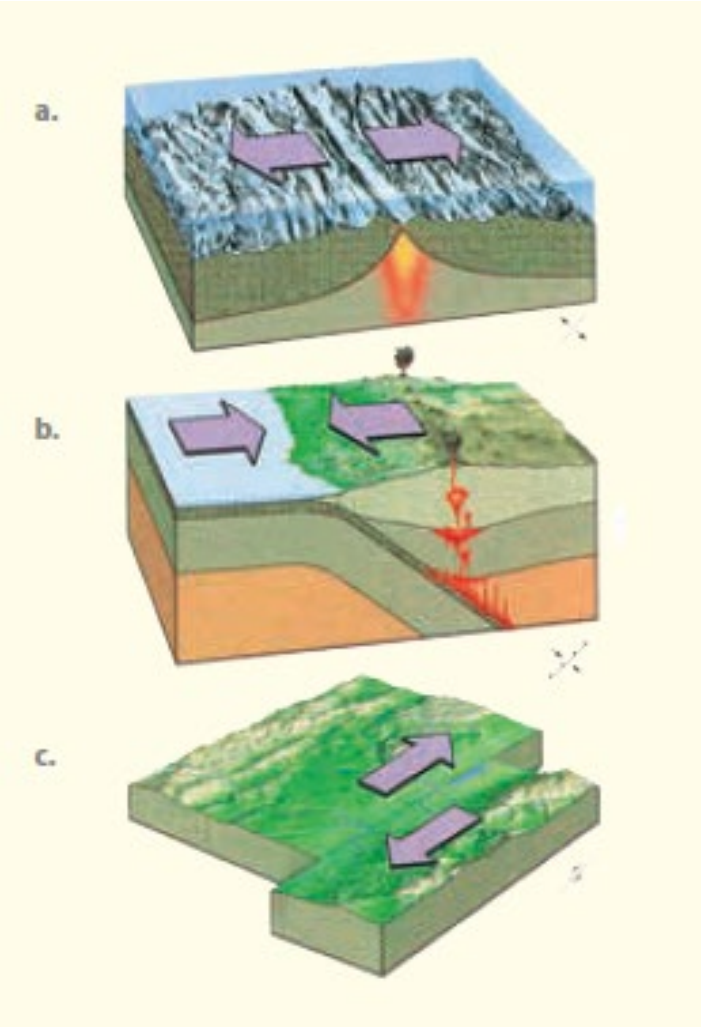


Plate boundaries – **a.** Divergent boundary, **b.** Convergent boundary, **c.** Transform fault boundary

Folding and Faulting

- Folding and faulting take place due to the horizontal and vertical movements in the Earth's crust. These movements cause imbalance in the crustal rocks which results in earthquakes of varying magnitude.
- The sudden dislocation of rock blocks, due to the forces of tension and compression, cause tremors.
- The Koyna (India) earthquake in 1967 was due to an underground active fault zone. The devastating earthquake of San Francisco (USA) in 1906 was also due to the active work of faulting (San Andreas Fault).

Hydrostatic Pressure

- Certain human activities such as pumping of ground water and oil, deep underground mining, blasting of rocks by dynamites (for the construction of dams, reservoirs, roads), nuclear explosion, water storage in big reservoirs, etc. can cause tremors of serious consequences.

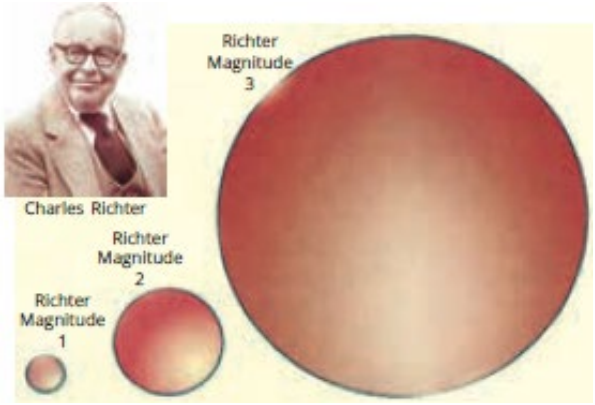
Plate Tectonic Theory

- This theory has been accepted as the most suitable explanation for the cause of an earthquake. The crust of the Earth is composed of moving plates. The tectonic events are taking place along the boundaries of these moving plates.
- Normally, moderate earthquakes are caused along the divergent plate boundaries, because the rate of movement of plates away from the mid-oceanic ridges is rather slow.

- Earthquakes of a higher magnitude and a deeper focus (up to 700 km deep) are caused along the convergent plate boundaries. This is due to the collision and subduction of heavy oceanic plate beneath the lighter continental plate in the asthenosphere.
- The devastating earthquake of Bhuj (Gujarat) on 26 January 2001 was caused due to the subduction of the Indian plate below the Asiatic plate.

RICHTER SCALE

- The magnitude or intensity of an earthquake is measured on the **Richter Scale**, developed by Charles F Richter, a US seismologist, in 1935.
- The number indicating the magnitude or intensity on a Richter Scale ranges between 0 and 9.
- In fact, the scale is an open ended **logarithmic scale** and thus has no upper limit or number.



Magnitude of earthquake on a Richter Scale (The volume of the spheres are roughly proportional to the amount of energy released by earthquakes of the magnitude indicated.)

An ancient Chinese seismograph (The movement of an earthquake shakes a ball out of a dragon's mouth into a toad's mouth below.)

Other scales are also used for measuring the magnitude of earthquakes. The intensity scale commonly used in the United States (Mercalli Scale) is the one named after an Italian volcanologist **Giuseppe Mercalli**. The values on this scale are given from I to XII in Roman numerals.

DISTRIBUTION OF EARTHQUAKE BELTS

The minor and less destructive earthquakes occur more frequently than the major ones. In fact, earthquakes of one kind or the other are being recorded almost continuously by seismographs in different parts of the world. The earthquakes in the world are associated with

a. the zones of young fold mountains,
b. the zones of faulting and fracturing,
c. the zones representing the junctions of continental and oceanic margins,
d. the zones of active volcanoes, and
e. along the different plate boundaries.

Aftermath of an earthquake .

MAIN SEISMIC BELTS

1. **Circum-Pacific Belt** includes the coastal margins of North America, South America and East Asia. These areas represent the eastern and western margins of the Pacific Ocean respectively, and account for about 65 per cent of the total earthquakes of the world. The **western marginal zones** are represented by the Rockies and the Andes mountain chains. The **eastern marginal zones** are represented by the island arcs of Kamchatka, Sakhalin, Japan and Philippines.

MAIN VOLCANIC BELTS

Circum-Pacific Belt

- The Circum-Pacific Belt includes the volcanoes of the eastern and western coastal areas of the Pacific Ocean. This belt is also known as the **Ring of Fire** of the Pacific Ocean.
- Cotopaxi in Andes (5896 m) is the highest volcanic mountain in the world. The other famous volcanoes are **Mt Fujiyama** (Japan), **Mt Shasta**, **Mt Rainier** and **Mt St Helena** (USA).

Mid-Continental Belt

- The Mid-Continental Belt includes the volcanoes of the Alpine mountains and the Mediterranean Sea.
- Some of the famous volcanoes of the Mediterranean Sea such as the **Stromboli**, **Vesuvius**, **Etna**, etc. are in this belt.

Mid-Atlantic Belt

- The Mid-Atlantic Belt includes the volcanoes along the Atlantic ridge which is the divergent plate zone.
- They are mainly of the fissure eruption type.
- **Iceland**, which is a part of the Mid-Atlantic ridge, is the most active volcanic area.
- The fractures in the crust are created by the divergent plates.

EFFECTS OF VOLCANIC ERUPTIONS

Volcanic eruptions can cause constructive as well as destructive effects. Some of them are as under:

World – Distribution of major earthquake belts

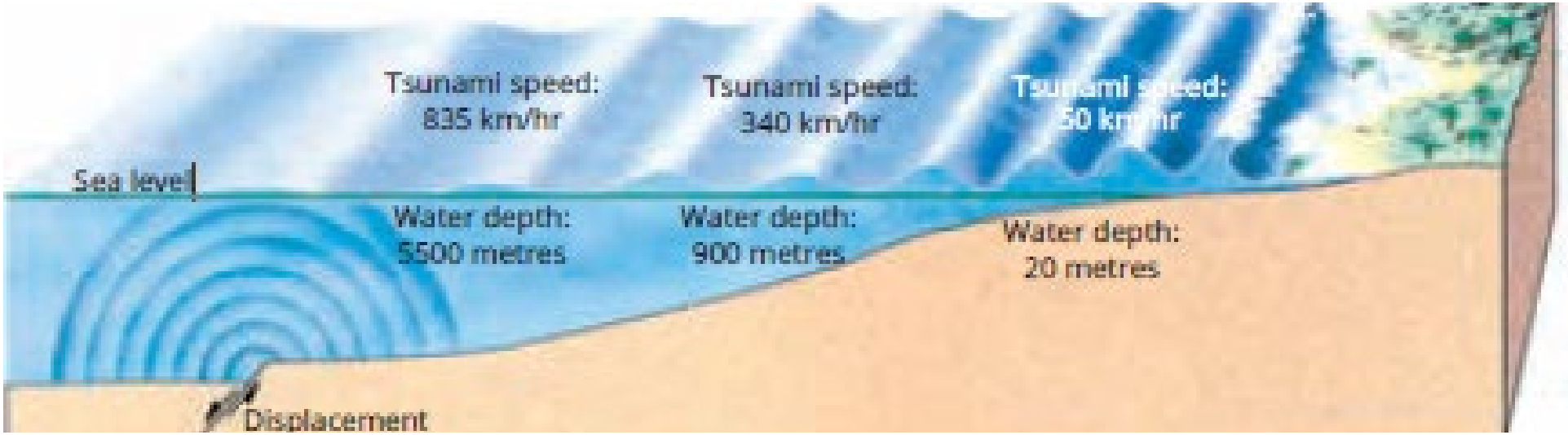
2. Mid-Continental Belt includes the Alpine mountains and their offshoots in Europe, Mediterranean Sea, northern Africa, eastern Africa and the Himalayas.
The Himalayan region is a zone of maximum intensity and it is gradually rising at the rate of 5 cm per year. This causes earthquakes in India, Tibet and Nepal.

3. Mid-Atlantic Ridge Belt includes the Mid-Atlantic ridge and several islands near the ridge. It records moderate earthquakes which are caused due to the moving of plates in the opposite directions. Thus, the sea floor spreading and the fissure type of volcanic eruptions cause earthquakes of moderate intensity in this region.

EFFECTS OF EARTHQUAKES

The intensity of an earthquake and its hazardous impact are determined not on the basis of the magnitude on the Richter Scale, but on the basis of the extent of the damages done by a specific earthquake to life and property.

The direct and indirect effects of an earthquake include deformation of ground surface, damages and destruction of man-made structures, loss of life, violent fire, landslides, flash floods, etc. The seismic waves, apart from having devastating effects, also provide an effective probe of Earth's interior.



Schematic drawing of tsunami

DESTRUCTIVE EFFECTS

- **Deformed ground surface:** The earthquake tremors result in the deformation of the ground surface, due to the rise and subsidence of the ground surface and faulting activity.
- **Damage to man-made structures:** Man-made structures such as buildings, roads, rails, factories, dams, bridges, etc. get severely damaged.

- **Damage to towns and cities:** The towns and cities are the worst affected due to high density of buildings and population. Under the impact of tremors, large buildings collapse and men and women get buried under the debris. Groundwater pipes are damaged and thus water supply is totally disrupted.
- **Loss of human and animal life:** The destructive power of an earthquake depends upon the loss it can cause in terms of loss of life and property.
- **Devastating fires:** Earthquake can cause fire in houses, mines and factories due to the bursting of gas cylinders, contact with live electric wires, churning of blast furnaces, displacement of other electric and fire related appliances.
- **Landslides:** The tremors in hilly and mountainous areas can cause instability of unconsolidated rock materials. This ultimately leads to landslides, which damage settlements and transport systems.
- **Flash floods:** Very strong seismic events can result in the collapse of dams and cause severe flash floods. Floods are also caused when the debris produced by tremors blocks the flow of water in the rivers. Sometimes the main course of the river is changed due to the blockage.
- **Tsunamis:** When the seismic waves travel through sea water, high sea waves are generated, which can cause great loss to life and property, especially in the coastal areas. Since the Circum-Pacific Belt is associated with volcanoes and earthquakes, tsunamis are common in the Pacific ocean.

CONSTRUCTIVE EFFECTS

- The earthquakes, apart from having destructive effects, are also considered as constructive movements by the Earth scientists.
- Over a period of time, a large amount of energy is stored up in the Earth. This stored up energy is released along the plate boundaries by the earthquake. This activity helps the Earth in keeping itself in proper shape.
- The landslides caused by an earthquake can form depressions, which are formed as lakes. There are many such lakes in the Himalaya mountains.
- The coastal areas can possibly be uplifted or subsided by an earthquake. This may lead to the formation of new landforms.
- The earthquake waves are the main source of collecting data about the structure and interior of the Earth.

THANK YOU