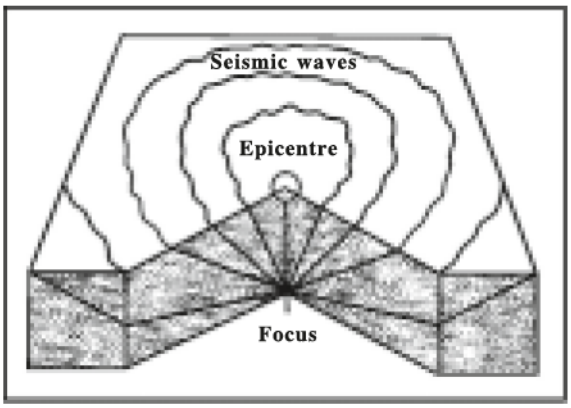
4 Earthquake and Volcanoes

The Earths crust appears to have solidified from the outside. But still there is a great amount of heat in its interior. In the interior there is a great amount of pressure of the overlying rock layers. Because of this heat in the interior and changes in pressure, there is expansion or contraction in the form of the rock matter. So movements are experienced in the crust. This process is known as **'Earth movements'**. Earth movements may be slow or sudden.



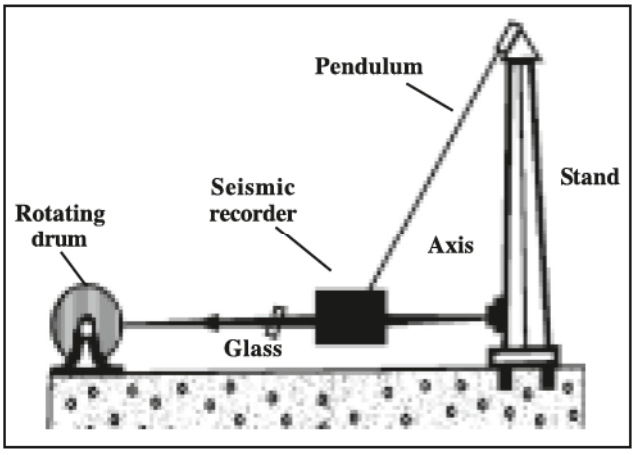
4.1 Focus and Epicentre

The earth movements experienced due to sudden changes in heat and pressure in the interior are known as sudden earth movements. Processes of volcanism and earthquake are sudden earth movements.

It brings many changes in regions of weak geological structure. When due to earth movement some weak portion of the earths surface gets suddenly vibrated, then such vibrations are known as **earthquake**. Earthquakes occur all of a sudden, accidently and rapidly. The Bhuj earthquake of 26 January, 2001 caused great devastation within few minutes. Earthquake is a natural phenomenon. Wave like vibrations that arise from disturbance in rocks within the interior of earth are called earthquake. **(Arthur Holmes)**. Just as circular ripples are produced when a stone is dropped in a pool of calm water that propagate outside from centre, in the same way, seismic waves also spread in all directions from the point of disturbance. The place from where seismic waves originate is called the **Focus**. The place on the earths surface exactly above the focus where seismic waves reach first is called the **Epicentre**. The most disastrous effect of earthquake is experienced around this centre.

The focus of the earthquake is located between a depth of 60 km to 700 km. The earthquake (seismic) waves originate at this depth and reach the surface within few seconds. It is called a **Shallow Earthquake**, if the focus lies upto a depth of 60 km from the surface, an **Interim Earthquake** if the focus lies between 60 km to 250 km, and a **Deep Earthquake** if the focus lies between 250 km to 700 kilometres.

Seismograph and Seismic Waves

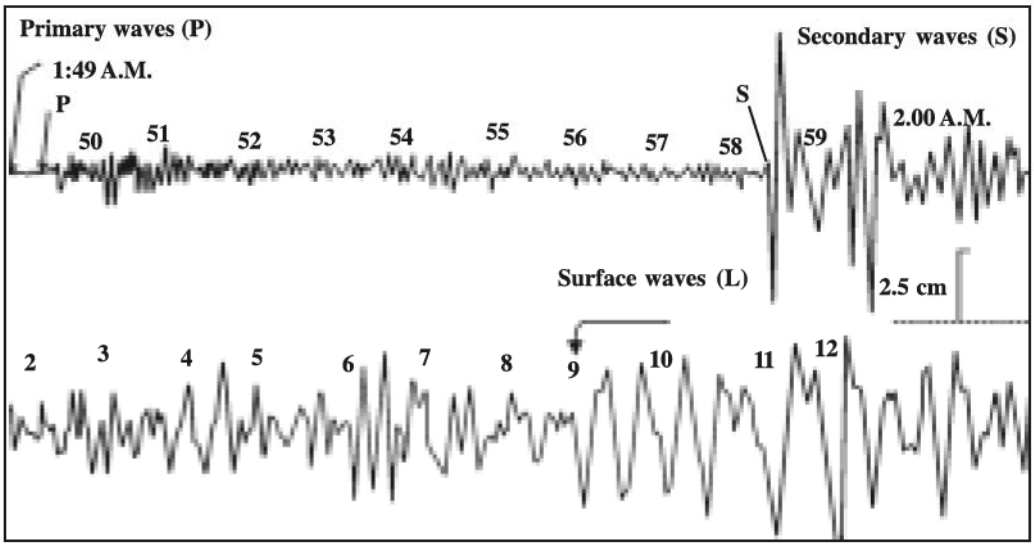


4.2 Seismograph

The science that studies earthquake is called Seismology. The word Seismology is derived from the Greek word Seismos, which means earthquake. Information about earthquake intensity and the point of origin can be obtained from the Seismograph. The main part of this instrument is a hanging pendulum. Its upper end is attached to a pillar. The other end is kept free for movement. A pen is attached to it. The pen rests on a cylinder, around which a paper or a graph is wound. It is linked to a clock as well. During earthquake, lines continue to be drawn on the paper depending on the magnitude of vibration. Being linked with the clock time is also recorded.

By comparing the graphs recorded on **Seismographs** kept at different places, it is possible to obtain information about the focus and epicenter of the earthquake. In India centres that record earthquake are located at Mumbai, Kolkata, Delhi, Dehradun, Hyderabad and in Gujarat at Rajkot, Vadodara, Gandhinagar, etc.

Three types of seismic waves are recorded on a seismograph.



4.3 Seismic waves

(1) Primary Waves (Longitudinal waves or P-Waves) : These waves have the highest speed. Hence they are the first to be recorded on an earthquake station. These waves can pass through both liquid and solid mediums. Their speed decreases as they enter liquid medium. In central part they travel at the speed of 8 to 14 km per second. The waves are refracted as the density of matter changes.

(2) Secondary Waves (S-Waves) : The speed of these waves is less compared to the primary waves. They can pass through only solid medium. In these waves, particles move up and down at right angles to the wave direction. These are similar to light waves. They end up in sea or liquid medium. They also penetrate to greater depths from earths surface.

(3) Surface Waves (L-Waves) : These waves spread over the earths surface in a direction perpendicular to its circumference. These waves are similar to waves produced when a stone is dropped in a calm water body. Their speed is 3 km per second. These waves are the most destructive. Destruction caused by earthquakes is due to these waves. When these waves enter the sea, very high and destructive waves are generated in sea water, known as tsunami. Since these waves cannot pass through the core they are not useful in understanding the earths interior. Characteristics of speed and direction of P and S Waves give information about the interior parts of the Earth.

Causes of Earthquakes

Earthquakes are caused because of some disturbance in the Earths state of equilibrium. Also, earthquakes occur because of some responses to invisible phenomena that occur below the Earths crust. Major causes of earthquakes are : (1) Faulting (2) Volcanic eruption (3) Isostasy (4) Water vapour (5) Man.

(1) Because of tectomic movements in the interior, **tension** and **compression** are created on the rock strata. Under these forces, geo-materials in the interior experience compression and expansion. Earthquakes are caused because of faulting. Faulting is responsible for earthquakes experienced in African Rift Valley and Narmada Valley and in the young fold mountains like the Himalayas, Alps.

(2) Most of the earthquakes that occur on the earths surface are because of volcanic eruptions. During explosion, hot magma tries to make its way out. A strong earthquake is experienced in an area of about 150 to 200 km around the volcano.

(3) When isostatic imbalance occurs, a transfer of magma occurs in the interior at some depth for reestablishment of isostasy, producing vibrations in rock layers. Earthquakes occur because of this in the Hindukush range near the Pamir Plateau. Its effect is seen over long distances. The effect of Nepal earthquake of April, 2015 was experienced upto Bihar in India.

(4) When some surface water enters below the Earth's surface, it gets converted to water vapour because of heat there. Vapour occupies 1300 times more space than water. Because of this pressure of vapour, earthquake occurs in the weak relief zones of the Earth.

(5) Man constructs tunnels, dams and mines on the Earth's surface. He brings out oil from below the surface. He also constructs dams, skyscrapers, railway tracks, roads and levels the land. Experiments of atomic explosions result in artificial earthquake in nearby areas.

(6) Landslide, snowfall, fall of rock boulders and a meteor hit from outer space may also cause earthquake in mountainous regions.

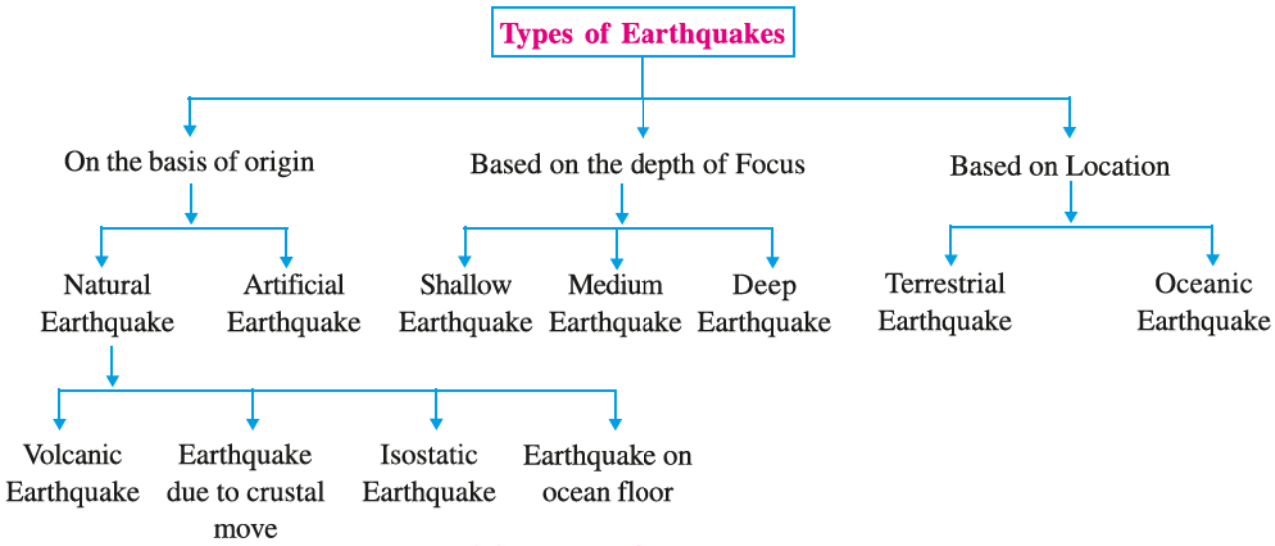
Effects of Earthquakes

Effects of earthquakes are destructive and constructive. Because of earthquakes thousands of human deaths occur. Also several buildings collapse in the earthquake affected area. The Bhuj, Kutch disastrous earthquake of 26 January, 2001 in India had an intensity of 7.9 on Richter scale. Thousands died in the incidence. Parts of Turkeys Tangiers city, Japans Tokyo city, Macedonias Skopje city have been devastated due to earthquakes. Many buildings collapsed into the ground. Roads were broken. Systems of water and electricity were disrupted. Sometimes rivers change their courses due to earthquake. When an earthquake occurred in Assam in 1950, Dihang and Brahmaputra rivers changed their courses. The dam on Subansiri river in Assam was also destroyed. In the past Indus river flowed into the Gulf of Kachchh but now it flows through Pakistan. Thus because of earthquakes, roads are destroyed, railway tracks bent, bridges and dams on rivers collapse and rivers change their courses. When earthquakes occur on sea or ocean bed, a high and huge wave called **Tsunami** develops. In December 2004, tsunami waves developed near Sumatra island of Indonesia and reached the Andaman and Nicobar islands and the Coromandel coast of Tamil Nadu, causing great loss of life and property. A major part of Indias southern most point, the Indira Point has become submerged in water. Such type of waves cause great damage to coastal cities and ports.

Constructive effects of earthquakes

- Because of earthquake we can know about the interior structure of the Earth.
- Because of earthquake tensional and compressional forces act on rock layers, resulting in faulting and folding. As a result landforms such as rift valley, mountains, plains, plateaus, continental shelf, etc are formed. New sources of water become available.
- Earthquakes cause drastic changes in rocks and this makes many minerals available. It helps to locate oil and gas reserves and related research works.
- New islands or archipelago are formed in mid sea water. **New Moor island** to the south of Kolkata in the Bay of Bengal is an example.

Types of Earthquakes



4.4 Types of Earthquakes

There are two scales to measure earthquake : (1) Richter Scale that measures earthquake intensity and (2) Mercalli scale that shows extensiveness of earthquake.

Probable Seismic Zones : Most of the identified seismic zones lie in the oceanic and continoutal margins with a weak geological structure. They are mainly distributed in two belts.

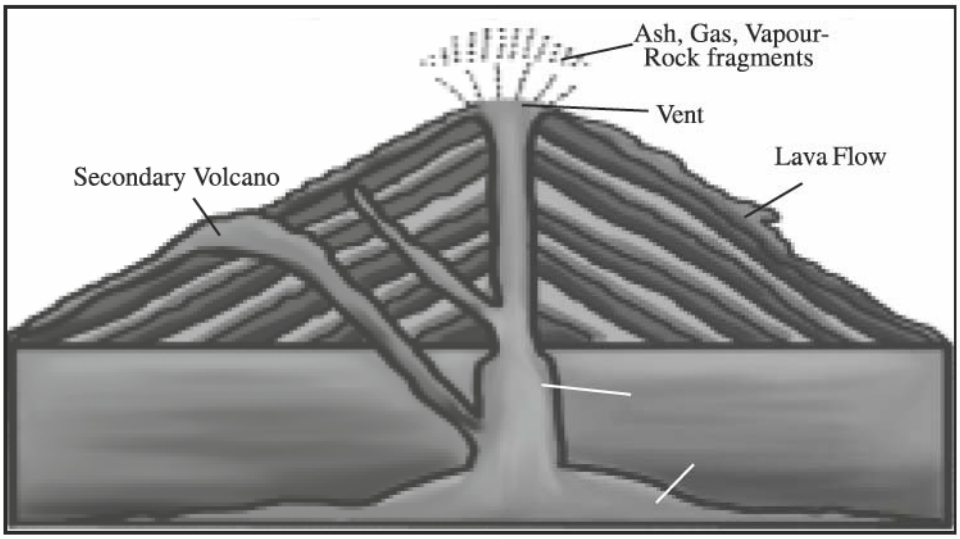
(1) Circum-Pacific Belt : About 68 % of the worlds earthquakes occur in this belt. Rockies and Andes mountain ranges located along the Pacific coast of North America and South America, mountain coastal ranges of China, Japan, Philippines and Indonesia in Asia and also of New Zealand are included in it.

(2) Mid-Continental Belt : About 21 % of the worlds earthquakes occur in this belt. The young fold mountain ranges that extend from Atlantic coast in the west to the Pacific coast in the east are possible earthquake zones. In this belt, earthquakes mainly occur in the Alps and the Atlas mountain ranges located to the north and south of the Mediterranean Sea respectively and in the Himalayas in Asia. Other than these, scattered islands in the Indian and Atlantic Oceans are also possible earthquake zones. (See Figure 4.6)

Volcanoes

Volcanoes are a sudden and surprising phenomena that occur on the Earth's surface. It is a natural phenomena that brings about a change in a limited region of the Earth. Its effects are big and long lasting. When balance of surface relief is disturbed, hot magma, ash, water vapour and other gaseous material rush to the surface with great velocity and making their way through a fissure or vent in the weak rock layers and are thrown out on the surface. This process is known as **Volcanicity**.

The path through which volcanic material magma, gases, ash, water vapour, etc are ejected from the Earths interior on to the surface is known as **'Volcanic Pipe'**. A funnel shaped hole that develops on the land surface above the volcanic pipe through which materials from the interior are ejected on to the surface is known as volcanic mouth or **vent**. Because of repeated volcanic eruptions when the volcanic mouth becomes quite big it is known as **'Caldera'**. When lava, rock material, ash etc get deposited around the vent, a cone shaped mountain is formed, known as **'Volcanic Mountain'**. A saucer shaped landform that develops above the volcanic pipe is known as a **'Crater'**.



4.5 Volcano

The reasons for volcanic eruption are as follows :

(1) The Earth's hot interior and its form : When the Earth originated it was in the form of a hot gaseous ball. The crust cooled and solidified. Still there is great heat in the interior. Due to radioactive decomposition of elements such as uranium, radium, thorium present in the Earths interior, heat is generated. This also keeps the interior hot.

(2) Origin of Magma : When because of some reason, in areas of weak strata, the pressure of overlying rock layers is reduced, the rock materials turn into magma due to heat in the interior. The magma thus formed in the Earths interior is responsible for **volcanic eruption**.

(3) Origin of gases and water vapour : As the magma expands, its heat gives rise to various gases. The surface water percolating through cracks in rock layers on coming in contact with magma, turns into water vapour. Also waters of seas and oceans on entering the interior, get converted into vapour, which rushes to the surface at the time of eruption.

(4) Upwelling of magma to the Surface : Water vapour occupies 1300 times more space than water. When water vapour in the interior doesnt get enough space, it tries to force its way out. It also drags liquid magma to the surface with itself. It rushes out rupturing the rock layers, either as explosion or slowly. This process is known as **volcanic eruption**.

Types of Volcanoes

According to the form or time duration between two eruptions, types of volcanoes are as follows :

(1) Active Volcano : A volcano from which lava, water vapour, gases and other materials continue to be ejected almost continuously is called active volcano. Mt. Etna volcano of Italy is an example. It is active since last 2500 years. In the Stromboli volcano of Sicilys Lipari islands, explosions occur after almost every 15 minutes. Mt. Cotopaxi in South America is the worlds highest (6500m) active volcano. Stromboli is well known as the Lighthouse of the Mediterranean because the light from burning gases coming out of it is seen quite far. Barren Island in Indias Andamans becomes active after regular intervals. Hence it is an active volcano.

(2) Dormant Volcano : When a volcano erupts after remaining quiet for many years, it is called a dormant volcano. Vesuvius of Italy is its best example. After remaining dormant for many years, it erupted in the year 1931. Since then it is dormant. Indonesias Krakatoa, Chiles Aconcagua and Japans Fujiyama are dormant volcanoes.

(3) Extinct Volcano : If the vent of a volcano is filled with water to form a lake and there are no signs that it will erupt in any future, such volcano is called an **'extinct volcano'**. Mt.Kilimanjaro in Africa, Mt. Popa of Myanmar, Irans Koh-e-sultan and Narcondam in Andaman in the Bay of Bengal are extinct volcanoes.

Destructive effects of Volcano

- When volcanic eruptions occur on ocean floor exceptional sea waves tsunami are formed. They cause great destruction near coastal areas. When Krakatoa volcano erupted in 1883 tsunamis caused great destruction in the coastal areas of Java and Sumatra and some regions also got submerged in water.
- Hot gases, ash and hot lava coming out of the volcano cause destruction in the region around volcano. Many people are believed to have been died up till now when Italys Vesuvius volcano erupted spewing hot ash and suffocating gases.
- Gases such as hydrogen, carbon dioxide and sulphur dioxide coming out from a volcano heavily pollute the atmosphere.
- When a volcano erupts on a sea floor, sea creatures of that area are destroyed. This causes marine ecological imbalance.
- Violent eruptions of volcano cause earthquakes. When Mt. St. Helens volcano erupted in 1980 in America, about 40 earthquakes were recorded per hour on that day.
- The natural hazard of volcanic eruption damages human and vegetation life.
- The ash that is added to the atmosphere due to volcano acts as a barrier to air traffic.

Constructive effects of Volcano :

- Volcanoes act as a natural safety valve. Magma and gases under heavy pressure beneath the surface get released through this medium.
- Volcanism helps us in understanding the Earths historical evolution and its structure.
- Many minerals are obtained from the lava that solidifies after a volcanic eruption.
- Igneous rocks like basalt and granite formed from lava are used in building purposes.
- Lava rocks when eroded produce fertile soils. Such soils are very useful for crops like cotton, sugarcane, tobacco, wheat, etc.
- The ash coming out of a volcanic eruption gets deposited in nearby areas. As a result, lands of farms and gardens become fertile. In Italy, after eruption of Vesuvius, the soils that have become fertile with ash deposited on its slope, give maximum yield of grapes.
- In Japan, Hawaii islands and Iceland, volcanoes are useful in getting geo-thermal energy.
- In some areas near dormant volcanoes, natural scenery develops. Hence, tourist places develop here. In Japan, Mt. Aso located at a distance of 50 km from the volcanic mountain Unzen is considered one of the best tourist places. Beautiful white fumeroles coming out of it attract tourists.
- Lakes formed in crater and caldera sometimes form headwaters of rivers. Africas Lake Victoria is its example. The river Nile originating from it is the lifeline of Egypt.
- When rain water collects in a crater, a beautiful crater lake is formed. Lake Lonar in Maharashtra and Dudhia pond over Pavagadh in Gujarat are its examples.
- Volcanic eruptions give rise to hot water springs, hot water ponds and geysers. Taking a bath in such hot water containing sulphur cures skin diseases. In Gujarat, Tulsishyam is well known for its hot water springs. Many patients of skin disease come here.

Distribution of Volcanic Regions

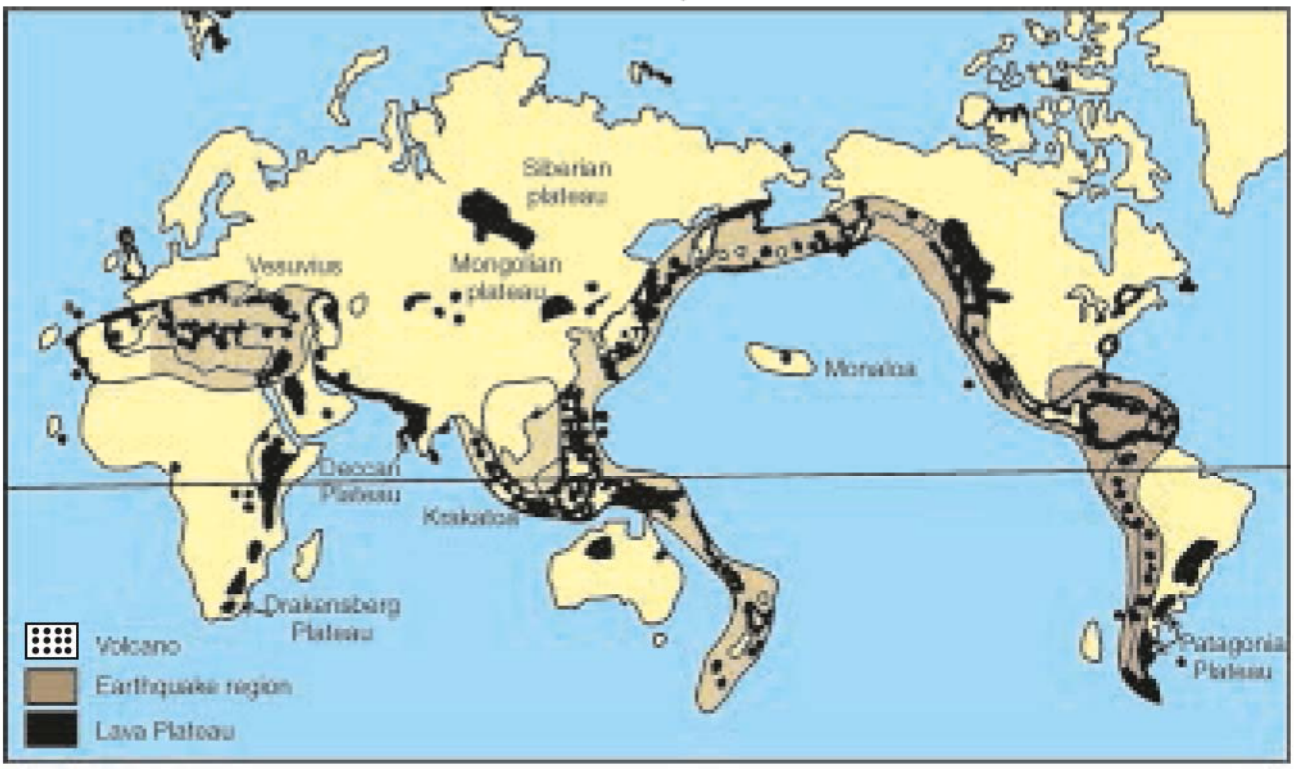
Volcanic regions are located in areas of weak structure of the Earths surface. Volcanoes are also located in areas of young fold mountains. Vodcanoes of the world are mainly located in three areas :

(1)Circum Pacific Belt (2) Mid-Continental Belt (3) Belt of the Atlantic Ocean.

(1) Circum Pacific Belt : Maximum volcanoes are found here. Hence some scholars term it as the Pacific Ring of Fire. On the eastern coast of the Pacific Ocean, the Rockies and the Andes mountain ranges and on the opposite side, New Guinea, Solomon, New Zealand, Indonesia, Phillipines, Japan and Alieutian Islands are included in this zone. In south pole region, Foss Island is a volcanic region. The highest volcanic mountain of the world, Mt. Cotopaxi of Equador in South America (altitude more than 6500 m) is situated in this belt. Besides, Mt. Mayon (Phillipines), Fujiyama (Japan), Popocatipetal (Mexico) are other well known volcanoes of this belt.

(2) Mid-Continental Belt : In this belt, the Alps in southern Europe and the Himalayas mountain range extending east-west in central Asia are volcanic areas. The belt starts from Iceland, passes through Scotland and extends upto Cameroon of Africa. A branch of this belt extends upto West Indies and another branch passes through Spain, Italy, Mediterranean Sea, Caucasus, Iran, Afghanistan and after passing to the north of the Himalayas, turns towards Myanmar. Surprisingly, there is not a single active volcano in the Himalayas. Barren Island and Narcondam Island in the Bay of Bengal are volcanic islands. Also, Koh-e-sultan (Iran), Ararat (Turkey), Kilimanjaro (Africa) and Mt Popa (Myanmar) etc. are well known volcanoes of this belt.

(3) Belt of the Atlantic Ocean : This belt starts from Iceland in the north Atlantic and passing through Azores reaches Tristan-d-Cunha island in the south Atlantic. Azores and St. Helena are major volcanoes of this belt. South Antilles islands is a major volcanic area.



4.6 Distribution of Volcanoes, Earthquakes and Lava Plateaus

EXERCISE

1. Answer the following questions in detail :

(1) Write in detail about the seismic waves.

(2) Describe the destructive effects of earthquakes.

(3) Write about the types of volcanoes.

2. Write to-the-point answer of the following questions :

(1) What are the causes of earthquakes ?

(2) Prepare a short note on seismograph

(3) What are the reasons for volcanic eruptions ?

(4) Describe the constructive effects of a volcano.

3. Answer the following questions in brief :

(1) Underground explosions are harmful. Explain.

(2) What are the types of volcanoes ?

(3) Write names of important volcanoes of the world.

(4) Volcanic eruption is a natural hazard How ?

4. Answer the following questions in one-two sentences :

(1) Which landforms are formed because of earthquake ?

(2) Which is an active volcano ?

(3) Which are the scales for measuring earthquake ?

(4) Which is the worlds highest active volcano ?

(5) Which pond of Pavagadh is formed by filling of water in volcano ?

5. Select the correct option from the options given and write the answer :

(1) Which volcanic mountain of Japan is considered dormant ?

(a) Mount Popa (b) Vesuvius (c) Fujiyama (d) Stromboli

(2) Which country uses volcano to generate geo-thermal energy ?

(a) Sri Lanka (b) Japan (c) India (d) Iran

(3) The earthquake intensity can be measured by which instrument ?

(a) Seismograph (b) Barograph (c) Anemometer (d) Barometer