CHAPTER

3 OUR CHANGING EARTH

GEOGRAPHY

Fact File

The temperature inside the Earth increases with depth. The average rate of increase is 1°C for every 32 metres of depth. The temperatures at various depths were measured in the mines and bore wells.

The upper mantle (100 km thick) together with the crust forms the **lithosphere**. But usually the crust is taken as the lithosphere. The lithosphere is broken into a number of plates known as the **lithospheric plates**. The Earth's crust consists of several large and small, rigid, irregularly shaped rock **plates (slabs)** which carry continents and the ocean floors. This theory, called as **the theory of 'Plate Tectonics'** was put forth in 1968. Under the oceans, the **plates** are about 5 km thick and under the continents about 35 km thick.

The temperature increases with depth from the surface of the crust. So, the rocks of the mantle are in molten form called magma. The magma contains dissolved hot gases at high pressure. There is more pressure due to overlying rocks. Thus, a balance is maintained between the opposite forces of heat and pressure. That is why the crust of the Earth does not explode.

The magma within the lower mantle is not stationary, but rises up and down due to the convection currents. It may gush out through volcanoes or other openings in the crust (crevices or cracks in the rocks). The plates holding the ocean floor and the continents and the upper mantle float on the lower molten part of the mantle (2,800 km thick). **The dynamic processes which determine the movement of the crust plates are powered by the mantle**. The upper mantle is in the form of viscous magma and the plates float over this viscous magma. That is why their movement is *very slow*. These plates have been in constant motion and, thus, have formed continents and ocean basins. The shape of the continents is believed to have evolved and changed over millions of years due to crustal movements.

In 1915, Alfred Wegener, a German meteorologist put forward the **theory of 'Continental Drift'** based on the jigsaw fit of different continents. According to this theory, millions of years ago, the continental plates were all joined together to form a single land mass, now called *pangaea* (a Greek word meaning 'all land'). The total land covered about one quarter of the Earth's surface (three quarters water). This large land mass split into northern mass Laurasia and a southern

one called Gondwana. From these two land masses the continents gradually drifted to where they are now located between the oceans and the process is still continuing. The continents are still drifting, i.e., the plates are moving around very slowly–just a few millimetres each year.

Activity : To show that the molten magma inside the Earth moves in a circular motion. Take a beaker half filled with water. Put a small coloured paper pellet in it. Place the beaker on a tripod stand and heat it. As the water warms up, we observe that the paper pellet is moving upward along with the warm layers of water and then sinks back along with the cooler layers of water. The molten magma inside the Earth moves in a similar manner.

The movements in the interior of the Earth and on the surface of the Earth are caused by the movements of the plates. Slow movements are not perceptible but the sudden movements are felt very much as they cause mass destruction.

Most of the Earth's volcanic activity, earthquakes and mountain-building activity take place along the plate boundaries.

Slow Tectonic Movements

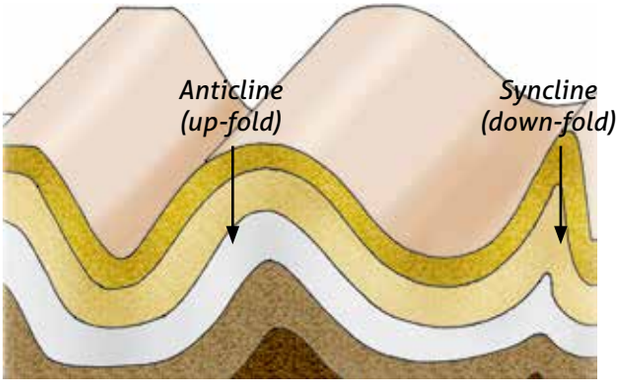
Gradual and slow tectonic movements are hardly noticed by us. They may take hundreds or thousands or more years to become perceptible. For example, the Himalayas are constantly rising, but we cannot notice the change. Movements are of two kinds—*vertical movements and horizontal movements.*

The **vertical movements** are also called continent-building movements. They cause an uplift (rising) or subsidence (sinking) of a part of the Earth's crust. The place where an uplift takes place, a plateau is formed and the place where sinking occurs, valleys are formed. The vertical movements do not disturb the rocks which are mostly horizontal.

The **horizontal movements** bring about folding or bending of layers of horizontal rocks. The compressional movements cause folding and tensional movements cause *faulting*. When two plates collide, they are compressed. A **fold** is a bend in a rock caused by compression. Folds occur in elastic rocks which bend than break. The *up-folds* form mountains and *down-folds* form valleys.

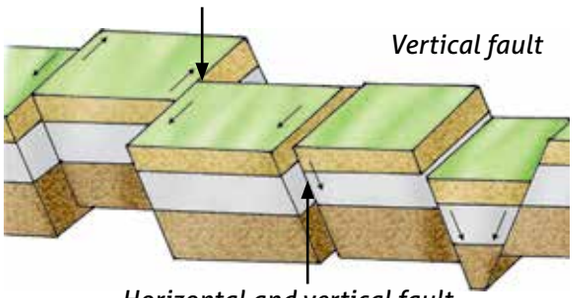
In tensional movements, the horizontal forces act in opposite direction moving from a specific point. They cause cracks or fissures in the Earth's surface.

The faulting can be horizontal or vertical or both.



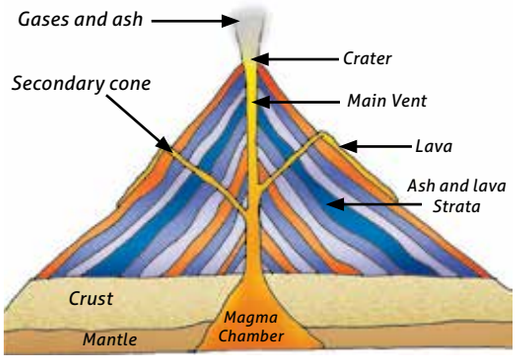
Volcanoes

Volcanoes are vents (openings) or fissures in the Earth's crust through which magma (molten rock) erupts suddenly. When the magma reaches the Earth's surface, it is called lava. The lava cools down



to form solid rock. Alongwith lava, cinder (hot particles of rocks), ash, stream and gas also come out. Tremors generally occur and it may lead to earthquakes also. The funnel-shaped basin around the vent is called a crater. Repeated volcanic eruptions result in the formation of a volcanic hill or mountain.

The eruption through a crack or fissure can build a vast lava plateau or plain. For example, North-West part of Deccan plateau in India, Kimberlay in the West Australtlian Plateau. Violent eruptions of Lava occur where plates collide.



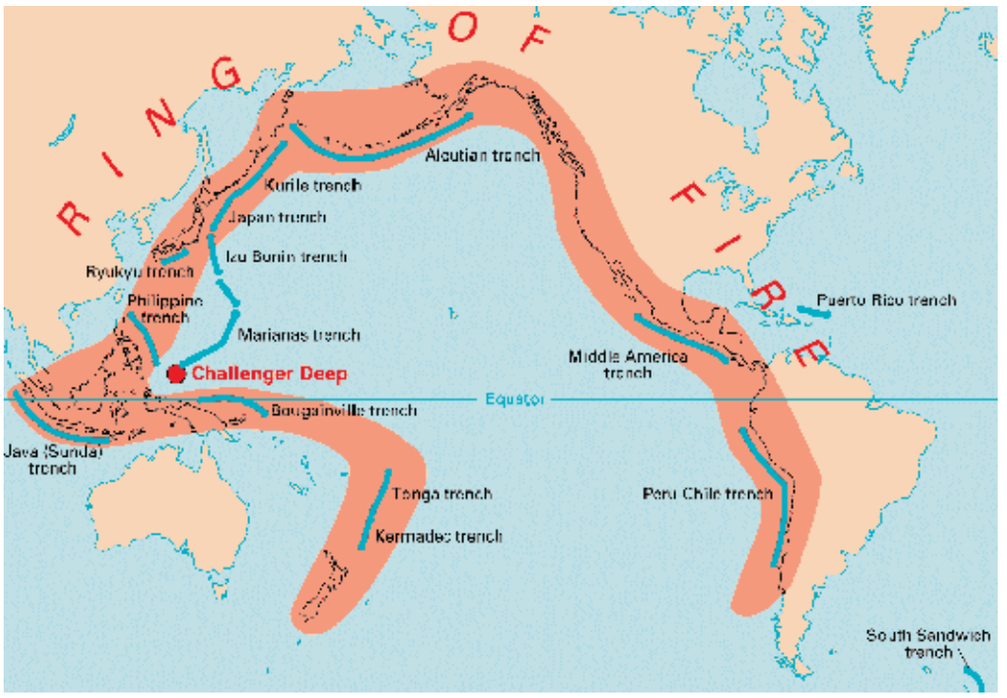
A Volcano

Eruption of a volcano can cause destruction. But the volcanic areas are sources of rich minerals and the volcanic soil is very fertile.

Most of the volcanoes are situated around the Pacific rim (also called the Ring of Fire). This 22,500 km long ring runs along the edge of the Pacific Ocean, i.e., Western and Eastern Coasts of the Pacific Ocean. This has two-third of all the volcanoes of the world. The other belt is the Mid-world Belt along the Mediterranean Sea.

The plate boundaries are the primary location of volcanic activity throughout the world where the magma always tries to outflow at various points. **The pacific rim is the boundary of a whole tectonic plate**.

Types of Volcanoes



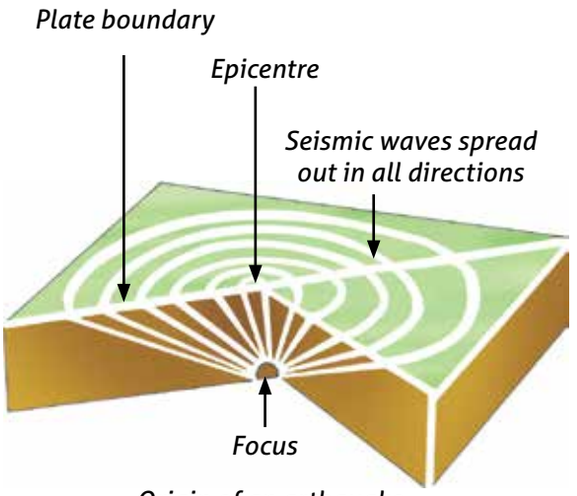
Ring of Fire

Depending on the frequency of their eruptions, volcanoes are classified as active, dormant and extinct. The **active** volcanoes are those which frequently erupt. For example, Stromboli and Mt. Etna in Italy, Europe. **Dormant** or sleeping volcanoes rarely erupt. For example, Mt Vesuvius in Italy. **Extinct** volcanoes are those which have not erupted for a very long time and it is thought that they have stopped erupting altogether. For

example, Mt. Kilimanjaro in Tanzania, Africa. Mount Krakotoa, thought as an extinct volcano, erupted most violently in AD 883. It exploded, sank and disappeared in a trench formed by the eruption. One cannot predict when the vents or fissure of a volcano may get connected to the magma chamber.

Earthquake

The crust of the Earth is not one single whole. It is composed of several big and small portions called plates. These plates always move on the semi-molten and molten material below. In several situations these plates collide or go past each other or diverge from each other. In each case, massive waves or vibrations are generated at a certain point. These vibrations are called **earthquakes**. The point of origin of an earthquake inside the Earth is called Seismic focus or hypocentre. This is where the earthquake occurs. From this point shock waves spread out in all directions. The waves can be longitudinal or transverse.



Origin of an arthquake

The spot on the Earth's surface above the focus of an earthquake is called an **epicentre**. The impact of the earthquake is usually the strongest near this spot. During the Gujarat Earthquake of 26 January 2001, Bhuj was the epicentre. Greatest damage is usually closest to the epicentre and the strength of the earthquake decreases away from the centre.

A weak point in the Earth's crust where the rock layers have rupture and slipped is called **fault**. It is caused by earthquakes and they are likely to reoccur in this part. After the first big quake, smaller quakes or **tremors** may happen. These are called **after shocks**. These occur when rocks that have been moved out of their place start falling back into place. In the Kashmir Earthquake of 8 October 2005, aftershocks were felt for many days.

Earthquakes generally occur at the plate margins, but interplate earthquakes also occur along faults and other zones of weakness within the plates. Underground nuclear explosions, deep underground mining or blasting of rocks by dynamite, also leads to the occurrence of earthquake. Thus, main causes of earthquakes are the following :

1. Plate Tectonics 2. Volcanic Eruptions 3. Folds and Faults 4. Explosions by Humans

Seismic Zone : A region in which earthquakes are known to occur is called seismic zone. About 70% of the earthquakes in the world happen around the Pacific rim (also called the Ring of Fire), a zone of volcanoes and seismic activity, 32,500 km long, that encircles the Pacific Ocean, i.e., Western and Eastern coasts of the Pacific Ocean.

Fact File

Great earthquakes (intensity 8.0 or higher) occur once a year, major earthquakes (intensity 7.0–7.9) occur about 18 times a year, strong earthquakes (intensity 6.0–6.9) 10 times a month and moderate earthquakes (intensity 5.0–5.9) more than twice a day over the globe. Earthquakes of intensity lesser than 5 are not generally felt by us.

Intensity of an Earthquake

The intensity, strength or magnitude of an earthquake is the same thing. The system used to measure the strength of an earthquake is called the *Richter Scale*. It is a collection of mathematical formulas and not a physical device. An instrument that records the intensity of an earthquake is called *seismograph/seismometer*. Earthquakes of intensity lesser than 5 are not generally felt by us. An earthquake of intensity 4 overturns unstable objects, may break some dishes. An earthquake of intensity 5 is felt by everyone. It moves some heavy furniture. Plaster of the walls may fall and a few cracks may appear in the walls due to earthquake of intensity 6.

Considerable damage is noted in ordinary building by an earthquake of intensity 7. It overturns heavy furnitures. Specially designed structures and buildings collapse partly by an earthquake of intensity 8. Earthquakes of intensity 9 destroys most of the masonary structures and cracks appear in the ground. Earthquake of intensity 10 destroys nearly all masonary structures and broad fissures appear in the ground.

Effects of Earthquakes

Specially designed structures even can be severely damaged when the ground gives way beneath them. The oscillations of the seismic wave can shake the building to shatter if it is not specially designed structure of Reinforced cement concrete. A mass of rocks or mud can slide down a hill due to the subsidence of ground beneath it. A landslide into a lake or reservoir can cause flooding down stream or change the course of a river. Under the impact of severe earthquakes, dams and embankments develop fissures which become the cause of flash floods. Broken gas pipes can catch fire or the flammable materials can be thrown into a cooking or heating fire. The severe fire cannot be put off because of the blocked ways or broken water pipes stopping the flow of water further. All these effects multiply by the damage of human property and loss of human and cattle lives. Many loose their lives by getting trapped under heavy slabs that have fallen. Damage and destruction of roads, bridges and railway lines block the way of the rescue teams. Undersea earthquakes produce tidal waves or tsunamis. Huge walls of water dash against a coast in a tidal wave causing great damage and loss of life.

Areas affected by earthquake 2001 in Gujarat

The tremors of January 26, 2001 earthquakes in Bhuj area of Gujarat were felt in an area of 4 million square kilometre. Its tremors were felt throughout India and adjoining countries. It measured 8 on the Richter Scale. The damage occured in one lakh sq km of area. The buildings

around the epicentre were totally flattened. About 1 lakh people died and 2 lakh were injured.

On 8 October, 2005, a powerful earthquake, measured 7.6 on the Richter scale killed 87,350 people in Pakistan and POK and 1360 in India. Its epicentre was located 19 km north-east of Muzzafrabad town and the focus at a depth of 26 km below Earth's surface. The earthquake was centred in north Pakistan.

Earthquake-proof Buildings

The following precautions should be observed to construct an earthquake proof structure :

1. Not many windows, doors and almirahs be made in the walls. The walls should be more solid than hollow. For special needs, reinforced cement concrete should be used.
2. Distance of a window and door from the other should be at least one metre.
3. The infrastructure and foundation should be made of the reinforced cement concrete. Special attention should be given at the cross joints of two walls.
4. The framework of the building should be bolted securely to the foundation to keep it in place.
5. A qualified and registered architect must be consulted.

Prediction of Earthquakes

Earthquakes create small tremors well before their big waves reach a place. These tremors can act as an advanced warning to move people and valuables to safer places. Changes also occur in the electric and magnetic properties of rocks and often a gas called radon is released. Radon dissolves in water, so if the radon content of lake or well water increases, an earthquake may well be on its way. But these all are not sufficient to predict clearly and well is advance.

It has been seen that dogs howl, animals run from buildings and fish thrash about in water before an earthquake. Seismologists are also researching on the behaviour of some insects too before earthquake.

Reinforced Cement Concrete : A framework of iron/steel bars is used as a support inside the wet concrete (1 part cement + 3 parts sand and gravels + water to form a slurry). As the concrete sets to very hard mass, it sticks to the framework and binds the bricks and stones firmly. Iron/steel bars reinforce the concrete, that is why, it is called reinforced cement concrete.

Safety Tips During Earthquakes

National Disaster Management Authority, Government of India issues the following notice to all public from time to time in newspapers :

When an earthquake happens

(i) If you are inside a weak structure

- Leave the building through the safest and fastest way out, with hands on your head (to save it).
- Do not use elevators (lift). Use the staircase.
- Stay away from glass objects and fire places.
- Do not panic. Stay calm.

(ii) If you are in a structurally safe building

- Stand next to the corners of the rooms.
- Drop to floor, take cover under a sturdy table and hold onto it.
- Stay away from fire places and glass objects.
- Do not panic. Stay calm.

(iii) If you are outside

- Move away from power lines, lamp posts, walls, trees and other objects that may collapse and fall.
- If you are driving, pull over to an open area. Do not block the road. In a hilly terrain, keep away from slopes.
- Do not attempt to cross bridges and flyovers.

Be prepared for aftershocks. Keep the emergency kit, torch, water and dry food ready in a bag next to you. Wear shoes to avoid cuts from broken glass.

Do not run outside blindly, you may get killed by falling bricks and debris just outside the buildings. Do not rush to the roof of the house. Never enter a cracked or partially damaged house. The slightest movement may lead to its collapse.

Weathering And Erosion

Exposure of the rocks to different weathers– heating by the sun in the day and cooling at night, very much heat in summer and very much cold in winter, rainfall, snowfall, winds, cause the rocks to breakup sometimes rapidly sometimes slowly. This is called **rate of weathering**. When the breaking up takes place without change in composition and state, it is called **physical or mechanical weathering.** When there is change in the composition of the rock, i.e., decomposition of minerals in the rocks and consequently a change in state, it is called **chemical weathering**. For example, salts may dissolve in water, iron may rust or there may be water absorbing minerals in rocks, which may cause chemical weathering of rocks. Cold and arid areas generally help physical weathering while warm and wet places generally help chemical weathering.

Rate of weathering depends upon the range of temperature, rainfall, type of rocks, slope of rocks and type of vegetation on them. The rocks break very fast in hot deserts because the range of temperature is

high there. Some minerals of rocks dissolve in water and thus help in their breaking up. The rocks of steep slopes break at a faster rate than gentle slopes.

Wearing away of the rocks by different agents like water, wind and ice is called **erosion**. **Weathering** includes only break up of rocks and not their removal. When the rock pieces after break up are removed/ carried from one place to another by wind, water, ice it is termed as **erosion**. Temperature, trees help only in weathering but running water, wind, moving ice help weathering as well as erosion.

The eroded material is carried away or transported by water, wind etc. and eventually deposited. This process of erosion and deposition create different landforms on the surface of the Earth. The weathered rock material carried by a river or wind becomes itself a tool of erosion. In fact, weathering and erosion together sculpt the landforms or shape the Earth's crust. They do not raise the mountains but shape and sculpt them or change them into hills, plateaus and plains.

Fact File

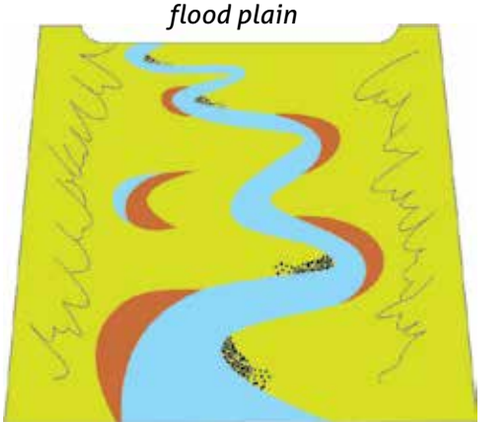
The highest waterfall in the world is 'Angel Falls' of Venezuela in South America. Other famous waterfalls are 'Niagra falls' located on the border between Canada and USA in North America and 'Victoria Falls' on the borders of Zambia and Zimbabwe in Africa.

Agents of Denudation/Creation of Landforms

The processes of weathering and erosion together are known as **denudation**. It is the work of agents like rivers, sea waves, ice and wind. The high and low parts that stand out on the surface of the Earth are termed as **relief** or **landforms**.

Work of a River : Water flows from certain height down stream by the force of gravity. The running water in the river erodes the landscape. When the river tumbles at steep angle over very hard rocks or down a steep valley side, it forms a **waterfall**. In the process the softer rock is undercut by the power of running (falling) water.

flood plain



Features made by a river in a flood plain.

In the mountainous or hilly area the river flows swiftly through steep sided valley. The pieces of rocks it carries, rush down with the water. They grind each other, the banks of the river as well as its bed. Thus maximum erosional work takes place. As a result many landforms are created. Further many streams join the main river to increase the volume of water and load (pieces of rocks) carried by the river. When the river leaves the mountains area and enters the plains, the velocity of water slows down due to gentle slope and great volume of water and load. Here many tributaries (streams and small rivers) join the main river. Due to increased volume of water and load, the river begins to widen its valley and deposit some of its load on the banks. At times the river overflows its banks. This leads to the flooding of the neighbouring areas. At it floods, it deposits its load (layers of fine soil and other material called sediments). The area of low lying ground where the river begins to deposit its load as a result of flooding is known as **flood plain**. The raised banks are called **levees**.

In the plain the river twists and turns forming large bends known as **meanders**. Due to continuous erosion and deposition along the sides of the meander, the ends of the meander loop come closer and closer. In due course of time the meander loop cuts off from the river and forms a cut-off lake, also called an **ox-bow lake**.

Delta

As the river approaches the sea, its slope becomes very gentle. The speed of the flowing water decreases. There is little erosion work. Now the main work of the river is deposition. The place where the river joins the sea is known as its **mouth**. Due to deposition, the sediments on the river bed rise high at several places and divide the main course of the river into several streams called **distributaries**. Each distributary forms its own mouth. The collection of sediments from all the mouths forms a **delta**. It is these distributaries that spread out and give the delta a triangular shape. However the rivers flowing through rift-valleys (with very steep sides) flow swiftly near their mouth too and do not form any deltas.

Work of Sea Waves : The erosion and deposition by the sea waves give rise to coastal land forms. Strong winds raise a ridge of water which dashes against the sea shore with great force. These are called sea waves which strike on rocks continuously. The force of the wind and the rock pieces they carry become their tools of erosion. The steep rocky coast rising almost vertically above sea water is called **sea cliff**. The rocks are broken into small blocks over time and then pebbles and sand. The sea waves deposit sediments along the shores forming **beaches**. The pounding of sea waves on rocks continuously alsoproduce cracks. The salts contained in sea water also weakens the rocks. The cracks develop and become larger and wider over time. Thus, hollows like caves are formed on the rocks. They are known as **sea caves**. As these cavities become bigger and bigger, only the roof of the caves remains. They are called **sea arches**. Further erosion breaks the roof and only walls are left called stacks.

Sea beach

Sea Cave

Sea Arch

Sea Stack

Glacier

Work of Ice : Glaciers are huge masses of slowly moving ice formed by snowfall on high mountains. Thus glaciers are 'rivers' of moving ice which act as a bulldozer to move the big and small rocks, stones and soil. Thus they erode the landscape and carve out hollows which become deep over time. When the ice melts, the deep hollows are filled up with clear water and become beautiful lakes in the mountains. The material carried by the glacier such as rocks, big and small, sand and

silt gets deposited in a line below it. Such deposit is called a **glacial moraine**.

Work of Wind : The sand particles moving with the wind striking the rocks perform the actions of plucking and grinding. Winds erode the lower section of the rocks in a desert more than the upper part. Therefore, such rocks have narrower base and wider top. Such rocks look like the shape of a mushroom and are commonly called **mushroom rocks**. Winds carry coarser or heavy particles to short distances and finer particles to long distances. When they stop blowing, the sand falls and gets deposited in low hill-like structures called **sand dunes**. The deposits of very fine and light sand over very long distances in large areas is called **loess**.

Sea dunes

Human beings also create various types of landforms by their activities of deforestation, building

roads, houses, dams, canals, mining, water extraction from the earth, etc.

Key Words

- Tectonic Activity : large scale processes involving movement of plates of the lithosphere.
- Volcano : vents (openings) or fissures in the Earth's crust through which molten rock erupts suddenly.
- Vent/Fissure : an opening that allows gas or liquid to pass through.
- Earthquake : vibrations produced by colliding/diverging plates of the lithosphere.
- Focus : the point in Earth's interior at which an earthquake starts to occur.
- Epicentre : the point on the Earth's surface exactly above the focus of an earthquake.
- Tremors : smaller earthquakes.
- Aftershocks : smaller earthquakes happening after the first big earthquake.
- Relief or Land form : high and low parts that stand out on the surface of the Earth.
- Weathering : breaking of rocks at their original place.
- Erosion : process of wearing, down of a landform through removal of weathered materials.

SUMMARY

- The upper mantle together with the crust forms the lithosphere.
- The plates holding the ocean floor and the continents and the upper mantle float on the lower molten part of the mantle.
- The movement of the plates may be vertical or horizontal.
- Most of the volcanoes are situated around the Pacific rim also known as the Ring of Fire.
- After the first big quake, smaller quakes may happen which are called aftershocks.
- About 70% of the earthquakes in the world happen around the Pacific rim.
- An earthquake of more intensity produces more damage.
- Earthquakes cannot be predicted clearly and well in advance.
- The infrastructure of an earthquake proof building should be made of reinforced cement concrete.
- Weathering and erosion create a variety of landforms on the surface of the Earth.

Exercise Time

A. Tick (✓) the only correct choice amongst the following :

1. Which is caused by the sudden movements of the Earth ?
   a. Folding b. Fault c. Flood plain d. Moraine
2. Ox bow lakes are found in
   a. Glaciers b. River valleys c. Deserts d. Mountains
3. Which is not an erosional feature of sea waves ?
   a. Cliff b. Beach c. Sea Cave d. Sea Cave
4. The depositional feature of a glacier is
   a. Beach b. Moraine c. Flood plain d. Loess
5. Mushroom rocks are found in
   a. Plateaus b. Deserts c. Glaciers d. River valleys

B. Fill in the blanks :

1. The eruption of a volcano is the throwing out of _____ from Earth's interior.
2. The plates and the upper mantle _____ on the lower molten part of the mantle.
3. The combined process of weathering and erosion is called _____.
4. The continents are still drifting just _____ millimetres each year.
5. The up-folds form mountains and down-folds form _____.

C. Match the Following :

1. Earthquake	a. Deserts
2. Beach	b. Vibrations of Earth's surface
3. Meanders	c. River of ice
4. Sand dunes	d. Seashore
5. Glacier	e. Rivers

D. Write true (T) or False (F) against the following statements in given brackets :

1. Erosion without weathering cannot take places. ( )
2. In hot and dry regions rocks break quickly. ( )
3. Dormant volcanoes erupt frequently. ( )
4. Specially designed structures and buildings collapse partly by an earthquake of intensity 8. ( )
5. In the mountainous area the river does little erosion work. ( )

E. Define the following terms :

1. Meander 2. Glacier 3. Levees 4. Flood Plain 5. Stack
6. Cliff 7. Loess 8. Delta 9. Moraine 10. Epicentre

F. Answer in one word or one pharse :

1. What is a tectonic activity ?
2. Name the three chief agents of denudation.
3. What is the point of origin of the earthquake in the interior of the Earth called ?

4. The Ring of Fire runs along the edge of which ocean ?
5. Through which is magma forced out of Earth's interior ?

G. Answer these questions briefly :

1. Why do the crust plates move ?
2. Why do buildings collapse due to earthquakes ?
3. Why are flood plains very fertile ?
4. What is erosion ?
5. How are flood plains formed ?

H. Differentiate between :

1. Volcano and Earthquake
2. Weathering and Erosion
3. Sea caves and Sea arches
4. Tributary and Distributary

I. Answer these questions in detail :

1. Discuss the chief causes of earthquake waves.
2. Describe weathering and erosion.
3. How do sea waves affect the landforms on the surface of the Earth ?
4. Describe the action of the wind in changing landforms on the surface of the Earth.
5. Describe the Erosional and Depositional work of the river from its source to its mouth.

PROJECT WORK

1. Observe your surroundings and draw the pictures of landforms affected by weathering and erosion.
2. Draw a diagram to show the work of a river from its source to its mouth.
3. Draw the ring of fire on a world map with bold marker pen.