Notes

2

ENDOGENIC FORCES

You have already studied about the development of geography, its themes as well as different branches. This lesson belongs to the branch – Geomorphology. Your book laying on the table will remain there until you or someone else remove or shift it by applying some force. Only then the book's position will change. Its position may also change when the table itself is moved by any force. Movement of tables is caused due to internal mechanisms. Your hand is an external force which removes the book. Therefore, there are two types of forces – Internal and External. All the features observed on earth's surface are the results of the balance between these two types of forces. These forces are dependent upon numerous factors. Hence, it is necessary to understand the interior of the earth and internal forces in operation. Due to internal forces, the surface with sizable thickness is always on move. In this context, we will study the continental drift and its improvised version of plate tectonics. Its results like folds, faults and earthquakes are also there to study in this lesson.

OUTCOMES

After studying this lesson, learner:

- explains changing temperature, rocks density, and state of matter in the interior;
- identifies endogenic forces shaping the earth;
- explains continental drift and mechanism of plate movement;
- describes fold, fault, their types their formation, and
- explains the causes, occurrences and spatial distribution of volcanoes and earthquakes.

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2.1 EARTH'S INTERNAL FORCES

The features seen on earth's surface are the result of two types of forces – Endogenic (internal) and Exogenic (external). The forces which are generated from below the earth's surface are termed as endogenic forces. Forces which are operational on or above the earth's surface are known as exogenic forces. In this lesson, we are going to discuss Endogenic forces, while the exogenic forces will be covered in the next lesson.

You might be knowing that the temperature in the interior goes on increasing if we go from the earth's surface. Increase in temperature leads to expansion among rock molecules. Heat is transferred from the higher temperature to lower temperature areas. Since the temperature towards surface is lower in comparison to the internal parts, the dissipation of heat is possible only towards surface. In the process of heat transport, conventional current is produced. Once convection currents are created, it causes numerous changes.

2.2 EARTH'S INTERIOR

You might have watched volcanic eruptions on television or in movies. Huge amounts of molten material, dust particles, smoke and flame come out from the mouth called crater. In that way, we receive some internal materials on the earth surface. Beyond the depth of volcanic origin, there is no availability of materials on the earth surface for direct observation and analysis. The average radius of the earth is about 6371 km. Our reach in the interior is confined to the depth of mining and drilling. The material from that depth is available to us for study. Therefore, to know the interior, we have to take the help of different sources.

A. Sources to Study Earth's Interior

Primarily, there are two types of sources by which we try to know the interior. They are Direct sources and Indirect sources.

a. Direct Sources: It is that source in which we get the materials from the interior into our hands. The material from the interior is available through mining, drilling or volcanic eruption.

i Mining : For a very long time, mining has been done at several places all over the globe. In mining, we dig the earth surface and extract ores or needed matter. Hence, we get the matter from below the surface into our hands. But the mining is confined to a little skin depth of earth's interior. Gaut gold mine of South Africa is the deepest. Its depth is around 3.8 km from the surface. With respect to the earth's radius, it is negligible.

ii. Drilling : Further deep materials are also brought to the surface by drilling. The deepest drilling has been recorded at north-eastern part of the Scandina-

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vian landmass on Kola Peninsula in Russian territory. Its depth is more than 12.2 km from the surface. It is also very small in depth and not able to tell about the deep internal parts.

iii. **Volcanic Eruption :** Volcanic erupted materials are ejected from a much deeper part of the earth's interior. The exact deepest origin of the volcano is not known but it is also not very significantly deep in comparison to the earth's radius. Hence, it is also not of great importance to know the deep interior.

b. **Indirect Sources** The meaning of the term 'indirect' is quite obvious. It includes those sources which are studied based on certain scientific principles and investigations. The study of rock density, pressure and temperature at different depths are included. Let us study these sources.

i. **Density :** A rock is composed of a mineral or many minerals. The characteristics of minerals determine the nature of rock. The density of the rock is the property of rock's compactness. Density is defined as the relationship between the mass of the rock and how much volume it occupies. Thus, a rock with greater mass and lesser volume will become denser, whereas less mass with greater volume will lead to lesser density.

ii. **Pressure :** The rock of the interior is more compressed due to overlying rocks. Initially, it was believed that rocks of the interior are denser due to compression. But it is also scientifically proved that the density of the rock cannot be increased simply by compression or pressure beyond a certain limit.

iii. **Temperature :** It is observed that the temperature is increasing in the interior. The increase is about 3^{o} Celsius per 100 meter (or about 30 degree Celsius per km) of depth in the top layer only. This rising trend of temperature is not maintained for much deeper. On the basis of recent experiments, geoscientists have calculated the temperature of the core to be around 5000^{o} Celsius with a variation of around 500^{o} Celsius.

Relationships of Density, Pressure and Temperature with Depth

From the discussions made above, it is quite clear that all the three components are increasing with increasing depth. Their increase is not uniform continuously but with changing rates. Their relationships can be seen in given Figure.

Relationships of Density, Pressure and Temperature with Depths in the Earth's Interior

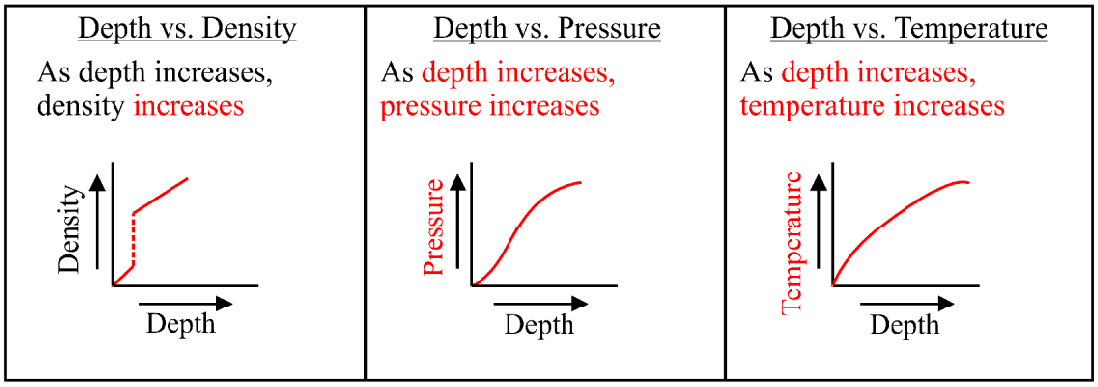

Fig. 2.1: Density, Pressure and Temperature with Depths

INTEXT QUESTIONS 2.1

1. The sources to know about the earth's interior are: (a)..... (b) .....

2. The temperature increase in the upper crust is ..... C. Per Km.

B. Seismology and Earth's Interior

Seismology is a branch of scientific knowledge to study the earthquake and its waves propagated through different parts and depths of the earth. An earthquake is a sudden vibration or shake of the ground of an area due to abrupt movement of landmass. This leads to earthquake waves. They are recorded by an instrument commonly known as seismograph.

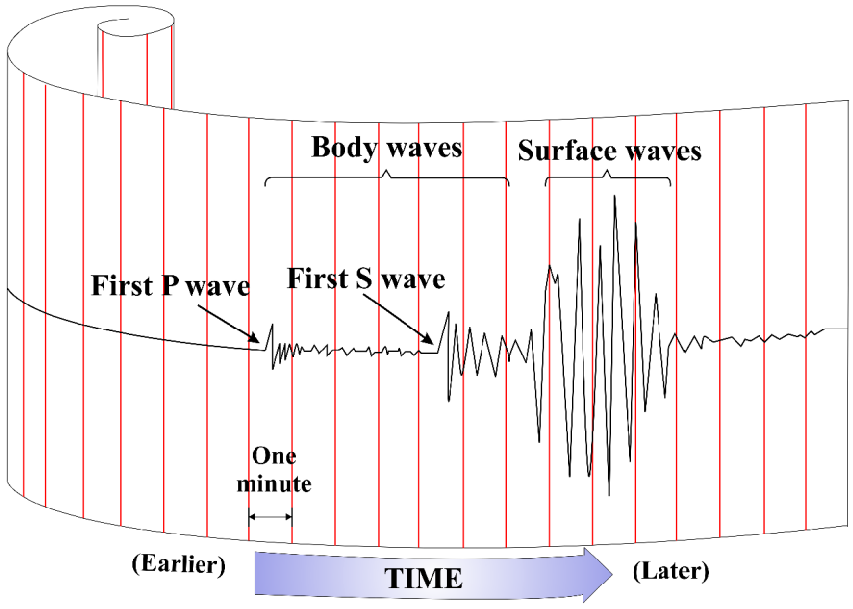

Fig. 2.2: An Ideal Seismograph

It is important to mention here that seismology is the only source by which the entire earth could be scanned. The scanning provides authentic and complete information about all parts and depths of the earth. Earthquakes originate from a depth below the earth surface. This depth could be anything from a few meters to hundreds of km.

The point from where the earthquake originates is known as focus (Figure 2.3). The shortest distance from focus to earth's surface (perpendicular distance exactly above from focus), is referred to as epicenter. Epicenter, being the closest place on the earth's surface, experiences the earthquake first. It is recorded later to places away from the epicenter. Principally, there are three types of seismic waves – Primary (P), Secondary (S) and Surface (L) waves which are recorded one after the other by the instrument.

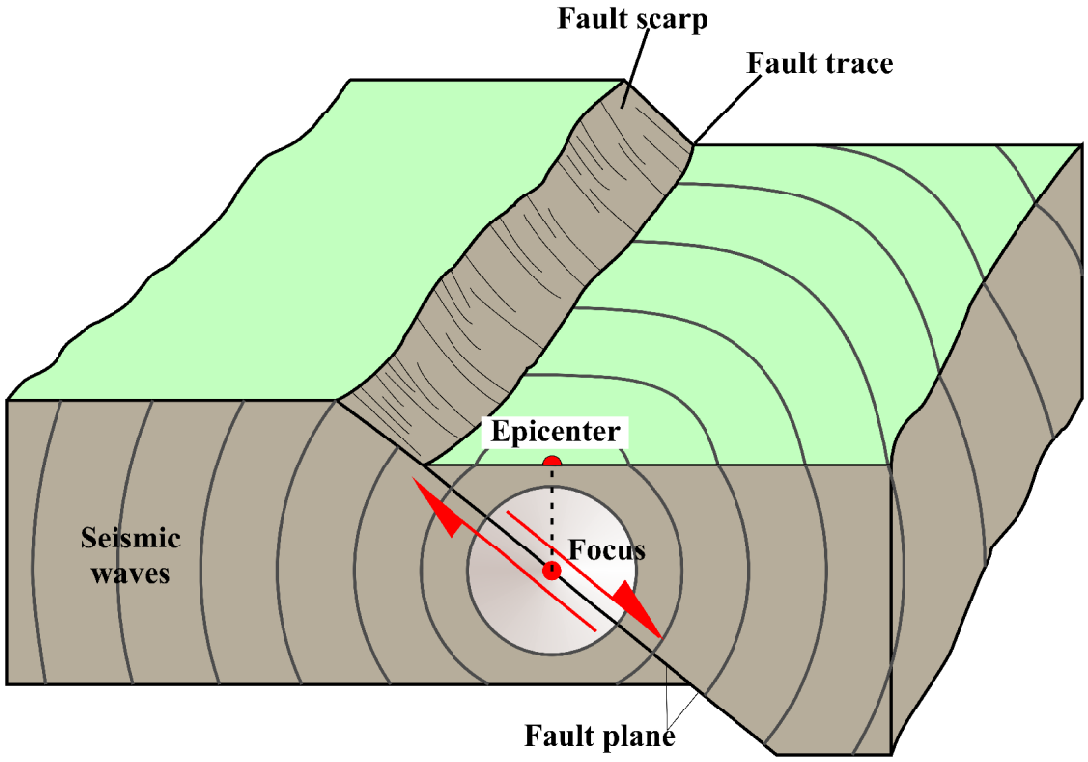

Fig. 2.3: Diagrammatic Presentation of Seismic Wave Propagation

Primary (P), Secondary (S) and Surface/Long (L) Waves

Primary (P) waves are known as compressional waves. They are also termed as push and pull waves. It is like sound waves that we hear. Secondary (S) waves are known as transverse waves. These waves travel at right angles to the direction the wave propagation. These waves seem to be like the light waves. Surface waves travel through the earth's surface with a large distance. Hence, they are also known as long (L) waves. In fact, surface waves are a combined display of the P and S waves. The characteristics of these waves are given in Table 2.1.

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Table 2.1: Characteristics of Seismic Waves

Primary (P) Waves	Secondary (S) Waves	Surface/ Long (L) waves
Fastest wave and reaches first at the surface. Travels in solid, liquid and gas medium of matters. High velocity is in solid, becomes less in liquid and very slow in gas state of matter. Increase in density of rocks, velocity increases and vice versa. Change in the state of matter from solid to viscous or liquid, its velocity decreases even if the density is more. Velocity of P waves varies from 5.5 km per second at or near the surface to 13.0 km per second in the deep interior.	Its velocity is lesser than Primary (P) waves. So it is recorded after P waves on the seismograph. Travels only through the solid state of matter. Increase in density of rocks, velocity increases and vice versa. Once the state of matter changes from solid to viscous, its velocity is reduced. But when the rocks are melted, it disappears completely. Velocity of S waves varies from 3.25 km per second at or near the surface to 7.0 km per second in the interior.	Its velocity is lesser than P and S waves. So, it is recorded after P and S waves on the seismograph. Travels only through the solid state of matter. Velocity varies from 2.0 to 4.4 km per second.

a. Seismology and Constitution of the Earth's Interior

The waves generated at the time of the earthquake radiate in all directions. They are along curved paths. Curvature of the paths is due to changing density from the earth's surface to the core. Due to refraction of the waves, S waves are not found beyond an angular distance of 105^0 from the epicenter of the earthquake. In the same way, P waves are not traceable from 105^0 to 140^0 from the epicenter of the earthquake. These are known as shadow zones.

The interior of the earth is revealed by the nature of the propagation of P and S waves. Approximately at an average depth of 40 km, there is sudden increase in the velocity of both waves which suggests sudden increase in density of rocks.

At a depth of around 100 to 250 km, the velocity of both waves starts declining and after around 700 km velocity again becomes higher. Decreasing velocity between these depths indicate that the matter of rocks is semi-solid. Because of this the velocity of both waves declines. This low velocity zone is known as the nosphere. It is also named as the transition zone.

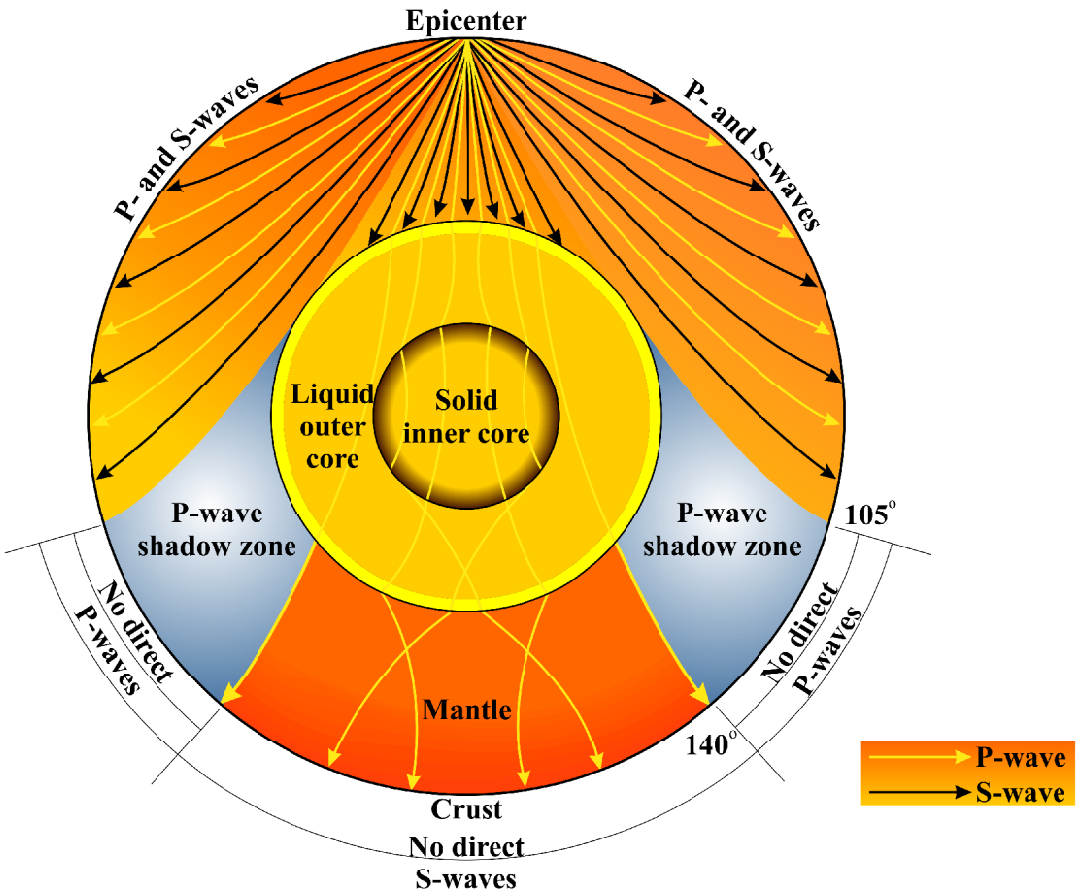

Fig. 2.4: Propagation of P and S Waves in the Interior

Further the velocity of both waves increases continuously until a depth of 2900 km. Increasing velocity shows that the density is higher and the state of the rocks is solid. From 2890 km to 2900 km, the rocks are again almost in a plastic state, i.e., neither solid nor liquid. It is termed as Gutenberg discontinuity.

Beyond the depth of 2900 km, there is no trace of S waves and the velocity of P waves declines very drastically. The rock at this depth is melted and the S wave does not travel in liquid. Reduction in the velocity of P waves is also due to the changing state of the matter or rocks. At around 5150 km depth, the velocity of the P waves increases. This is proof that the rocks become solid again.

Notes

INTEXT QUESTIONS 2.2

1. Name the earthquake measuring instrument.

2. 'P' waves travel in ..... layer/layers and 'S' waves travel in ..... layer/ layers.

b. Chemical Composition of the Earth

There are three major and almost concentric layers in the earth. These are explained by Swiss and they are SIAL, SIMA and NIFE.

SIAL: It is the topmost layer of the earth found just below the sedimentary thin cover of the crust. Silicon (Si) and Aluminum (Al) are the two very important elements found in abundance in this layer and so they are named as SIAL. The average density of this layer is 2.75 to 2.90 g/cm^3 and its average depth is 40 km. It is very thin below the oceanic bed (5 to 10 km) but below the mountains, it is very thick (up to 70 km). The main rock occupying here is of granite types.

SIMA: It is the second layer after SIAL from the surface. It is named after Silicon (SI) and Magnesium (MA) as both of these elements are very much abundant in this layer. It is a very thick layer which goes almost up to 2900 km depth. Below the continents, it starts from an average depth of 40 km while below the oceans, it is found at about 0 to 5 km depth. Its average density varies from 2.90 g/cm^3 to 4.75 g/cm^3. The main rocks in this layer are silicates of magnesium and iron. This layer is largely composed of basalt.

NIFE: It is the innermost layer of the earth. This layer is made up of Nickel (NI) and Ferrous (FE) and so it is named as NIFE. It is just below the SIMA from a depth of 2900 km to the earth's centre. Nickel and Ferrous are very heavy and dense elements and therefore this layer has higher density. Its density is about 11 to 12 g/cm^3.

c. Earth's Internal Structure

The study of the propagation of seismic waves in the interior enabled the scientists to theorize about its structure. Based on the abrupt changes in the paths of seismic waves, the structure of the earth has clearly been demarcated into three zones. They are Crust, outer and a very thin layer including our earth surface; Mantle, an intermediary layer thick with large volume of rocks below the crust; Core, the innermost layer which is spread all-around the center of the earth.

i. **The Earth's Crust:** The earth's crust is the outermost and the thinnest layer with an average depth of 5 km below oceans and 40 km below the continents. Its depth reaches about 70 km below the mountains. Apart from a very thin sedimentary layer on the continental crust and adjoining ocean floors, it is primarily composed of igneous and metamorphic rocks. The density of the crust at the surface is 2.7 g/cm^3 and at the bottom limit, it is 2.9 g/cm^3. The demarcating limit is known as Mohorovicic (Moho) discontinuity from where mantle starts.

ii. **The Mantle :** Just after the upper layer, i.e., crust, the density of the mantle at the boundary increases to 3.0 g/cm^3. It extends from the base of the crust to about 2900 km below the surface and occupies over 80% of the earth's volume and 65% of the total mass. Mantle is composed of ultramafic rocks which are igneous in nature and very rich in minerals constituting magnesium and iron with very low silica content. Roughly up to a depth of 100 to 250 km from the surface of the earth, the rocks are firm, solid and rigid. It is termed as lithosphere. Below this depth, the state of the matter is partially molten and plastic in behaviour. This plastic and semi-solid belt extends about a depth of 700 km. It is known as the asthenosphere from this depth to about 2900 km. the state of rock is rigid and solid. It is termed as mesosphere.

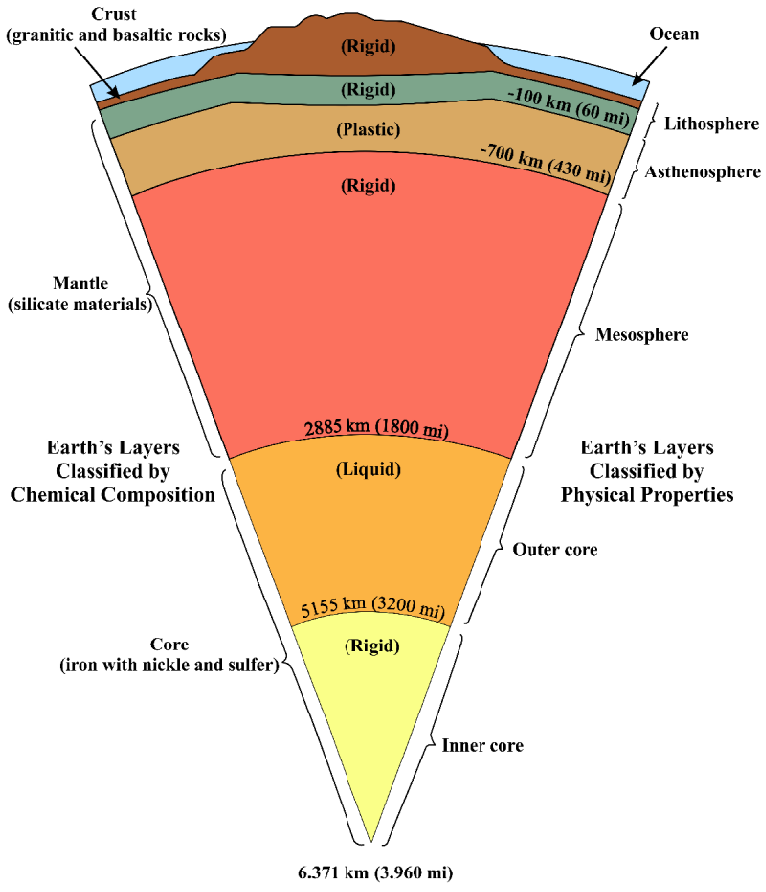

Figure 2.5: Earth's Internal Structure

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iii. **The Core** : It is the innermost layer of the earth starting from 2900 km to the centre (6371 km). It has a volume of only 17% of the earth but it contains 34% of the mass. It is because of the very high dense materials lying over there. The density of the core at the outer boundary is about 10 g/cm^3 and in the innermost part it is 13g/cm^3. The core is made up of iron and nickel. It is divided into layers upper and lower.

INTEXT QUESTIONS 2.3

1. Name different layers of earth explained by Swiss.

2. Earths core starts from ..... km.

2.3 CONTINENTAL DRIFT

As the term itself is self-explanatory – "continental drift". It means continents are drifting or shifting their positions with passage of time.

Alfred Wegner was first to introduce the concept of Continental Drift in a detailed and comprehensive manner in 1912. He was a German meteorologist and geophysicist and was studying the distribution of plants over the globe. During his study, he was trying to study the plant's fossils underlying in the sedimentary rocks of the east and west coasts of the Atlantic Ocean. He came across the similarity between the two coasts in terms of plant fossils and geology. On the basis of this study, he proposed the concept of continental drift.

According to Alfred Wegener, the entire landmass of the globe was together about 200 million years ago. He termed it Pangea, a super continent of the beginning. The huge water body surrounding the Pangea was known as Panthalasa. About 135 million years ago, Pangea was broken latitudinally into northern and southern parts known as Laurasia (Angaraland) and Gondwanaland, respectively. Both of them drifted away and in between a shallow sea emerged by filling up the water from Panthalasa. It was known as Tethys Sea. Later on Laurasia and Gondwanaland were rifted and finally drifted to form the present day distribution of land and water on the earth.

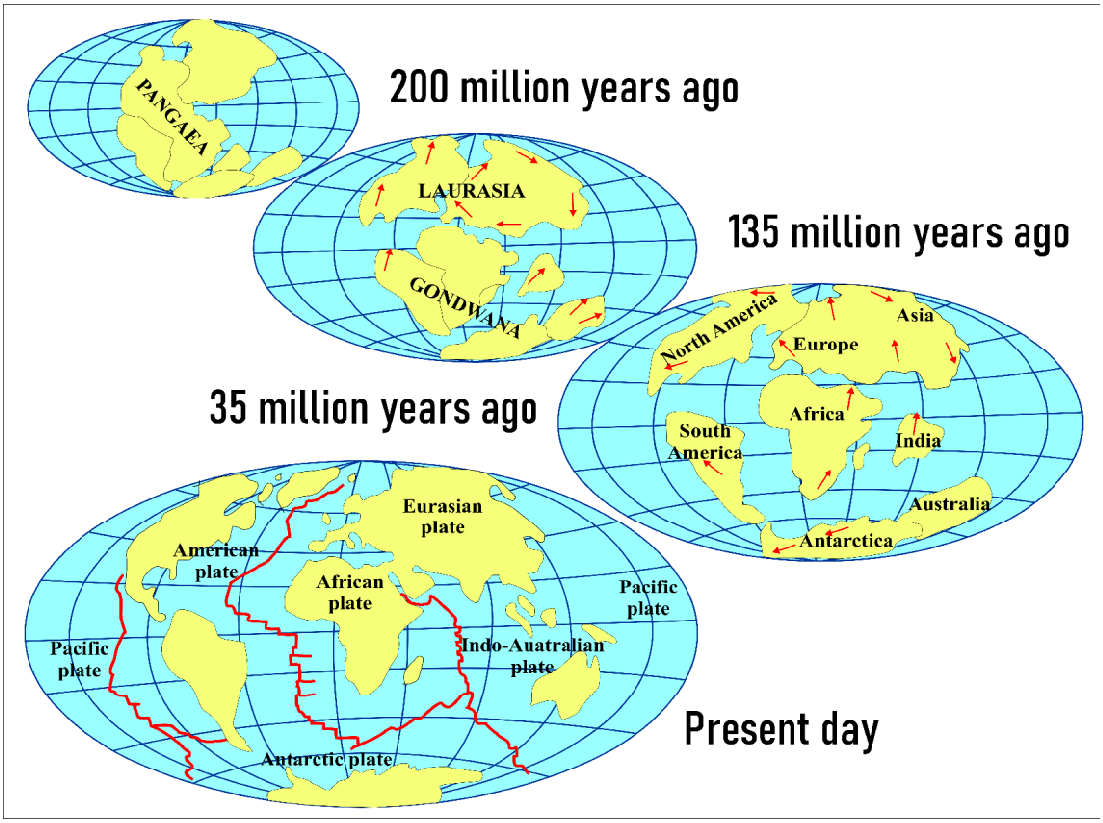

Fig. 2.6: Continental Drift through Time

Evidences of Continental Drift

While proposing his hypothesis, Wegener presented several pieces of evidence of continental unification a long time back which later on drifted away. The evidence was quite convincing and it was widely accepted. They are:

Jig-saw-fit: Both coasts of the Atlantic with South America and Africa are identical and fit very well. This fitting is said to be a jig-saw-fit. It means, as a piece of wood cut in a zigzag way can be jumbled together and that fits as well to form one unit. In the same way, continents broken by endogenic forces are dragged in different directions and could easily be matched.

Geological Matching: There is a very high degree of similarity in terms of the mountain systems of South America and Africa. The mountain system of South Africa is continuing in Argentina of South America. The geological characteristics found in the Appalachian region of North America are found continuing in the British Isles and Scandinavia of Europe.

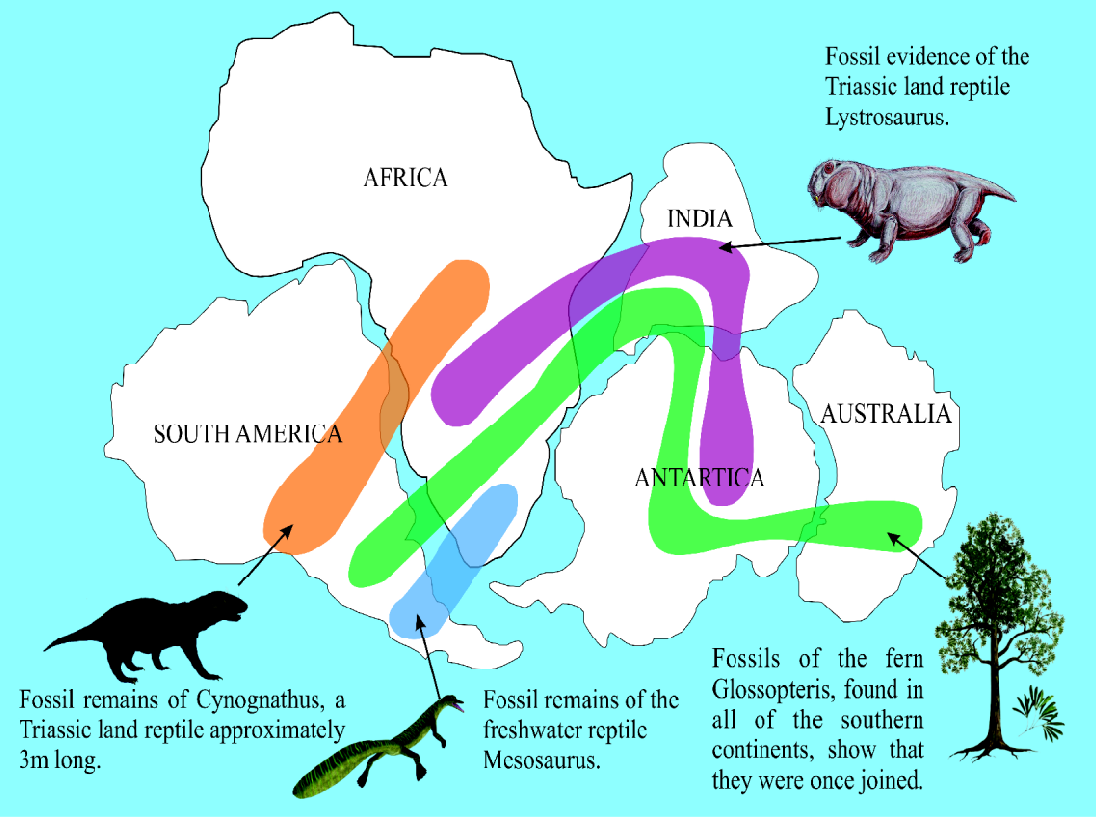

Fig. 2.7: Jig-Saw-Fitting of the Continents

Coal and Vegetation evidence: The distribution of coal and vegetation over South America, Africa, India and Australia proves that they were together in the geological past. The classical glacial deposits during the carboniferous period over these landmasses resemble each other which tell the story of togetherness. Today they lie in different climatic zones.

2.4 PLATE TECTONICS

Continental drift was well accepted for about 50 years from Wegner's proposal in 1912. During this period, numerous scientific studies were conducted like convectional current theory, sea-floor spreading and paleomagnetism. These studies help the scientists to propose the theory of plate tectonics.

According to plate tectonic theory, the earth surface is composed of several plates. Plates are the solid and rigid upper part above the asthenosphere segmented into several blocks. Those blocks are known as lithospheric plates.

A. Major and Minor Plates

There are seven major plates. They are: Eurasian, African, Indo-Australian, Pacific, North American, South American and Antarctic Plates. Apart from above seven major plates, there are about 20 minor plates. A few important among them are: Arabian, Caribbean, Scotia, Nazca, Cocos, Juan De Fuca, Philippine, Caroline, Bismarca, Fiji etc.

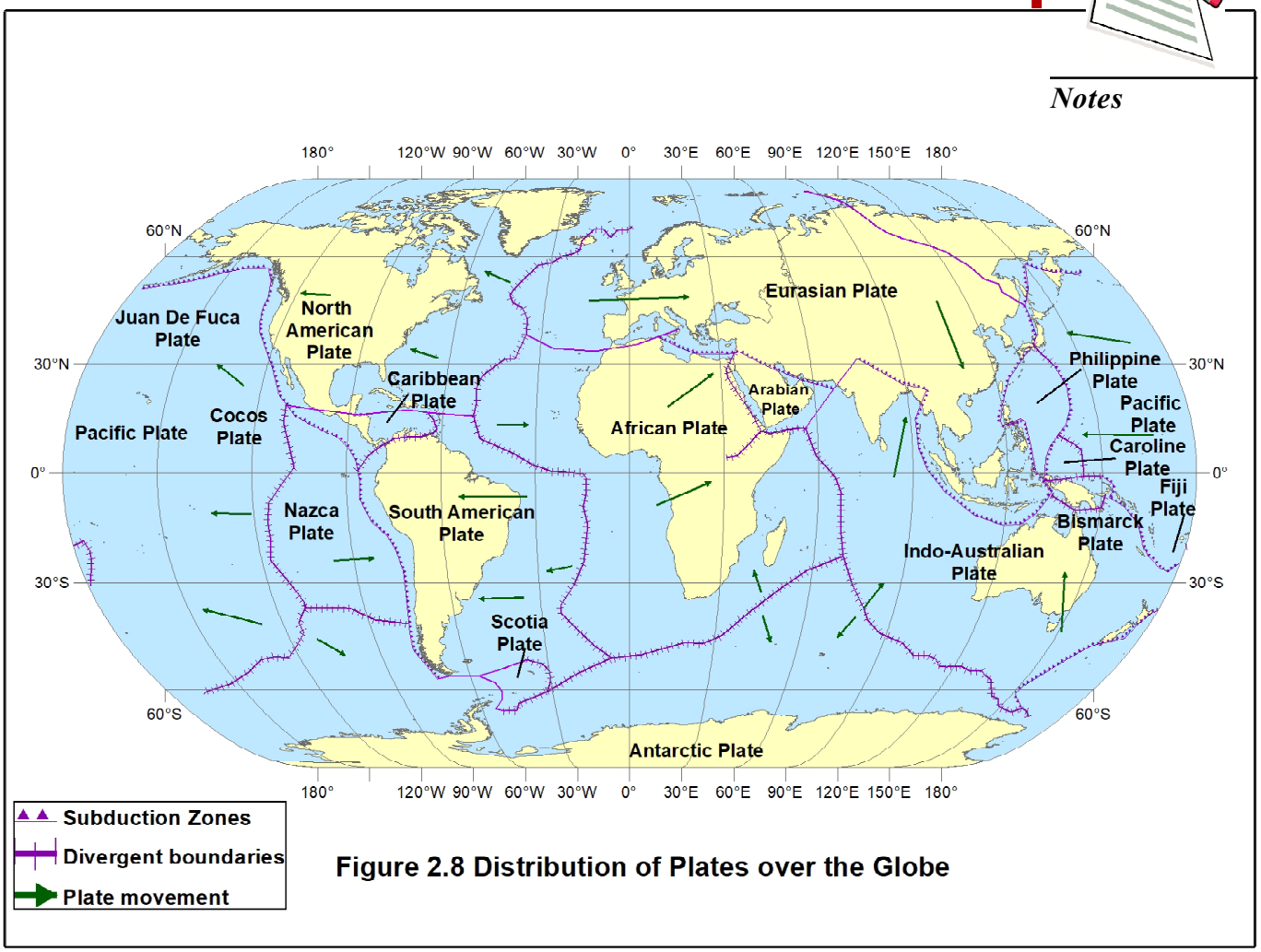

Figure 2.8 Distribution of Plates over the Globe

Fig. 2.8: Distribution of Plates over the Globe

Plates constitute the entire surface of the earth. Plate's thickness is about 100 to 250 km deep from the surface. Below it, the state of the matter is viscous/semi-solid over which plates are moving.

B. Mechanism of Plate Movement and Associated Features

British geologist Arthur Holmes proposed the existence of convection currents underneath the lithosphere. It is getting generated from the asthenosphere by the excessive

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heat available there. The excessive heat is dissipated towards the surface.The convection currents are classified into two rising and falling with divergence and convergence actions respectively.

Divergent Plate Boundary: With rising convection currents, transport of hot and viscous rock material is brought to the surface by splitting it. The molten material penetrates into the split. Hence, a new surface is created and the mammoth sized plate is pushed apart. It happens below the mid-oceanic ridge. It is called a divergent plate boundary. It is also termed as a constructive boundary.

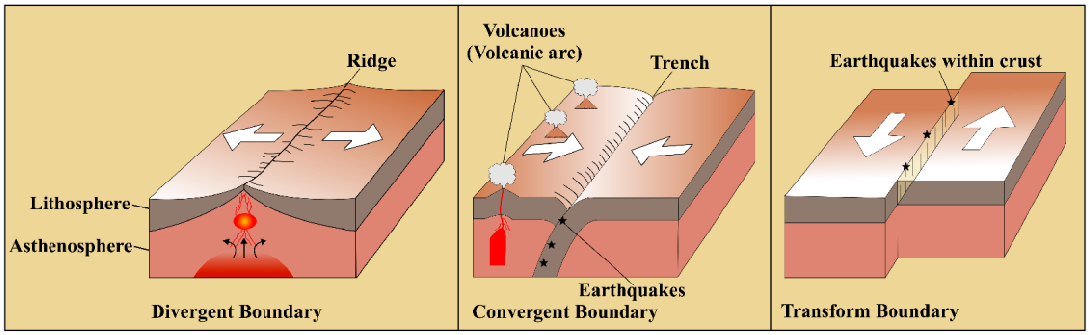

Fig. 2.9: Types of Plate Boundaries

Convergent Plate Boundary: When two sets of convection currents bring two plates together, it is called convergent plate boundary. At this boundary, subduction of plate or formation of mountain is seen. Because of this process, the surface area is reduced or destroyed. Hence, it is termed as a destructive plate boundary.

Transform Plate Boundary: Sometimes plate boundary and plate margin are used as synonymous. But for practical purposes, boundary is a thin line separating the plates whereas margin is an area or zone along the plate boundary. The earth's surface is of two types – land and water. In the same way, the boundary of the plate is also of two types – oceanic and continental.

Due to differential magma ejection along the divergent plate boundary, the differential departure of the plate segment is also observed. This boundary is known as the transform boundary. Along this boundary, neither surface is created or destroyed. Therefore, it is also termed as conservative boundary.

C. Plate Boundaries and Associated Features

Plate boundaries and activities along them are explained above. Due to different actions, different types of features are formed. They are given in Table 2.2:

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Table 2.2: Characteristics of Plate Boundary and Feature Resulted

Activities		**Types of Boundaries**	
	Divergent	**Convergent**	**Transform**
Movement	Plates going apart	Plates coming closer	Lateral sliding
Zone known as Effects	Constructive New surface creation	Destructive Surface loss, lowering of plate into the interior, mountain formation	Conservative Side by side sliding of plates
Features formed	Fault, mid ocean ridge	Trench formation, volcanic islands	No major feature
Volcanism	Yes	Yes	No
Earthquake	Yes	Yes	Yes, but minor

INTEXT QUESTIONS 2.4

1. Who introduce the concept of continental drift.

2. Name any two pieces of continental drift.

   (a)..... (b) .....

3. Plate boundaries are:

   (a) ..... (b) ..... and (c) .....

2.5 FOLDS AND FAULTS

Folds are formed when flexible rocks are subjected to compression due to endogenic forces. faults are caused when tough or rigid rocks are broken due to endogenic forces.

A. Folds

Fold is that surface of the earth which is wavy and undulating. Wavy or undulating structure is formed because of compression. Generally, the folding occurs in sedimentary rocks. In folds, there are several layers from surface to inner side. Surface layers are newest in terms of formation while the inners are older by age.

Notes

Folds are upward and downward in appearance. Upward formation is known as anticline while the downward shape is termed as syncline; both the limbs are called hinge zones. When an imaginary line is drawn to separate the fold into two parts, it is called the axial plane. This description is very well understood from Figure.

Types of Folds: Depending on the appearance of the fold and its angle, folds are put into following types:

a. **Symmetrical Fold**: Both sides are similar in terms of length and angle of inclination.

b. **Asymmetrical Fold**: Both sides are dissimilar in terms of length and angle of inclination. One limb is smaller than the other. Smaller side is steeply sloped while the longer side is gently sloped.

c. **Overfold**: When the greater force of compression is operational from one side the fold keeps on turning to the other side and thus inclination is observed. In this fold the turning of the side is more than 90 degrees, and the overturned fold becomes visible.

d. **Recumbent Fold**: When overfold is further intensified, the greater - turned side overlies the other side. In this way, the layer becomes almost horizontal.

e. **Overthrust Fold**: Further intensification of force causes to overthrusting of the overlaying limb. In this case, due to more and more compression, the layer is so stretched that it is about to break but not broken. But when it is broken, it no longer remains a fold, but becomes faulty. It is called nappe which is dealt under fault.

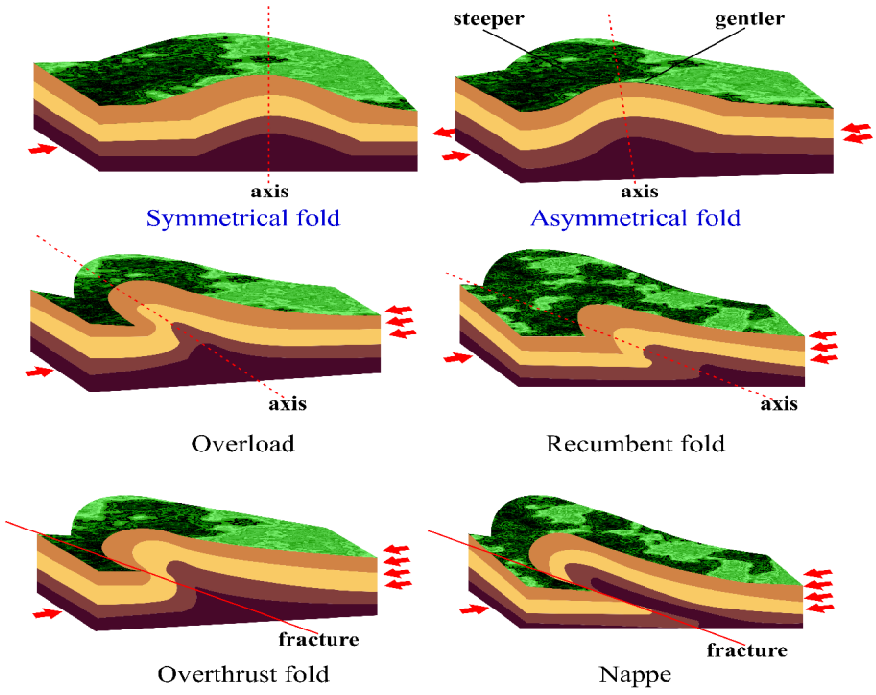


Fig. 2.10: Types of Folds

Features formed by Folds: Fold Mountains are formed by the process of folding. Most of the mountains found on the globe belong to this category. The surface area is reduced when folds occur because of the inclination of the crust. In terms of plate tectonics, it is called the zone of convergence or the zone of reduction of the horizontal distance of the crust.

B. Faults

Due to internal forces, when the earth's crust bends, a fold is formed, but when it cracks or gets separated, it is called a fault. In this process, minor to significant displacement of crust is resulted. Faults occur due to tension as well as compression both.

Types of Faults

According to the way of formation of the faults, they are grouped under the following types:

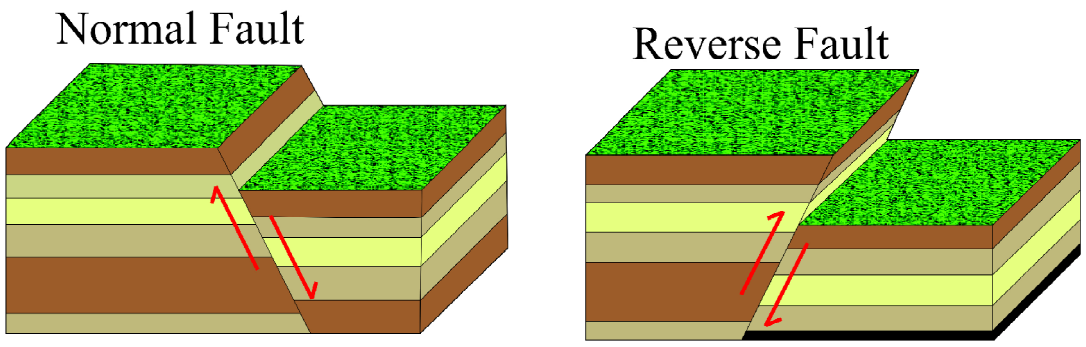
a. **Normal Fault**: Normal fault is formed due to tensional force caused from the interior. In this fault, there is an increase in the surface area.

b. **Reverse Fault**: Reverse fault is formed due to compressional force caused from the interior. In this fault, there is shortening in the surface area.

c. **Strike-slip Fault**: In strike-slip fault, the crustal block/mass slips past one another. It is also called a lateral fault.

d. **Oblique Fault**: In oblique fault, the crustal mass is shifted not only away like the normal fault but also gets rotated by sideways movement. For this, just compare the movement in normal fault and oblique fault shown in Figure.

e. **Nappe**: Refer to Figure 2.14. Because of excessive force, when the limb of the fold is broken, it gets detached and thrown away from its original position. This breaking no longer remains a fold but it turns into a fault known as nappe.



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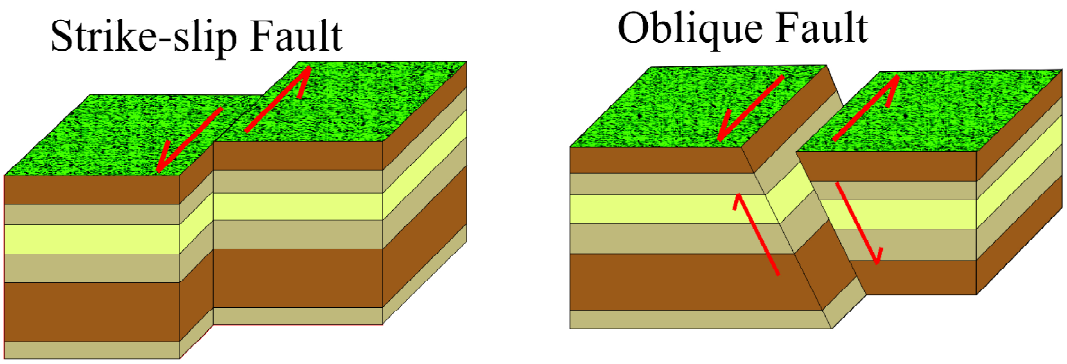

Fig. 2.11: Types of Faults

Features formed by Faults

Two types of features are formed due to faulting. One is depressed called graben or rift valley and the other is elevated called horst. When there is normal faulting, the downthrown side with respect to other forms the graben through which rivers generally occupy. When the widening of the depressed/ downthrown side gets widened, it becomes a rift valley. When there is an upthrown-side with respect to other forms, horst. Horst is also sometimes known as Block Mountain if the height is more.

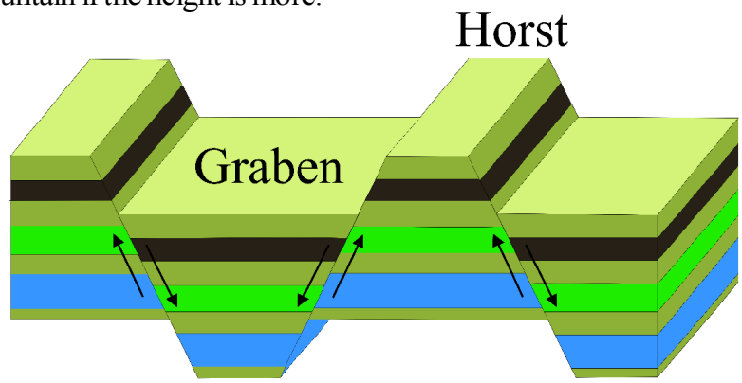

Fig. 2.12: Graben and Horst

INTEXT QUESTIONS 2.5

1. Upward formation of fold is ..... and downward is.....

2. Name any three types of fold.

   (a) ..... (b) ..... and (c) .....

3. Name any three types of fault.

   (a) ..... (b) ..... and (c) .....

2.6 VOLCANOES

A volcano is a vent or an opening in the earth's crust through which molten rock material, rock fragments, ash, steam and other hot gases are emitted slowly or forcefully. These materials are thrown out from the hot interior of the earth to its surface. Such vents or openings occur in those parts of the earth's crust where rock strata are relatively weak.

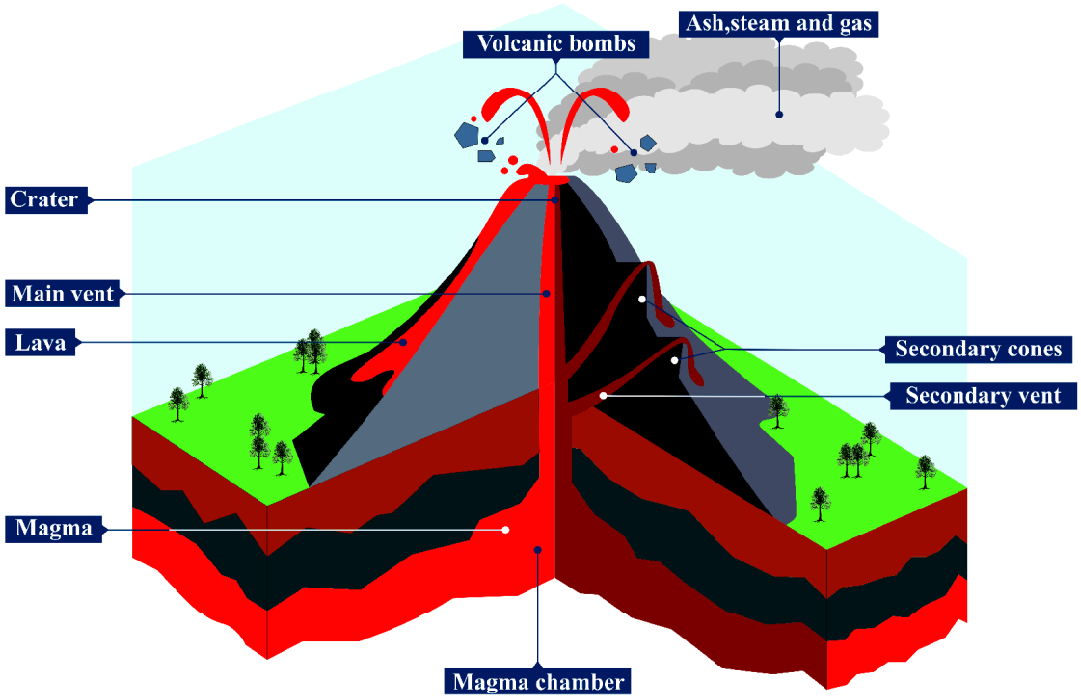

Fig. 2.13: Volcanoes

You may be wondering why such eruptions take place. Hot and molten rock material beneath the solid outer crust is known as magma. When this magma is thrown out to earth's surface, it is known as lava. The tremendous force created by magma and gases break the crust. Magma appearing on the surface is termed as lava. The process by which solid liquid and gaseous materials escape from the earth's interior to the surface of the earth is called volcanism. The volcanic materials gets accumulated around the opening or hole and form a cone. The top of the cone has a funnel shaped depression. It is called its crater.

Types of Volcanoes: Volcanoes are classified on the basis of the nature of volcanism . It includes frequency of eruption, mode of eruption or fluidity and the manner in which volcanic material escapes to the surface of the earth.

A. On the basis of the frequency of eruption, volcanoes are of three types

a. Active: This category of volcanoes erupts frequently or has erupted recently.

Important among these include Stromboli in Mediterranean, Krakatoa in Indonesia, Mayon in Philippines, Mauna loa in Hawaii Islands and Barren Island in India.

b. **Dormant**: The volcanoes which have not erupted in recent times are known as dormant volcanoes . They are termed as such the 'sleeping volcanoes'. Important among these are Vesuvius of Italy, Cotopaxi in South America.

c. **Extinct**: Contrary to these two, there are volcanoes which have not erupted in historical times. They are called extinct volcanoes. Mount Popa of Myanmar and Kilimanjaro of Tanzania are important extinct volcanoes.

B. On the basis of mode of eruption

a. **Central Eruption**: When the eruption in a volcano takes place from a vent or a hole, it is called a central type of volcano. Different types of domes or conical hills are formed by this type of eruption depending on the nature of erupted materials. The other characteristics of this mode of eruption are marked by violent explosions due to sudden escape of gases and molten rocks. Visuvious and Fuji-yama belong to this group of volcanoes.

b. **Fissure Eruption**: Sometimes, deep elongated cracks develop due to endogenic forces discussed above in plate tectonics. In this process, magma is expelled through long fissures. Therefore, it is termed as fissure eruption. When lava is spread over a large area, it is called lava plateaus. Deccan Traps of India is one example of fissure type of eruption.

C. On the basis of the fluidity of lava

a. **Volcanoes of acid lava**: Acid lava is rich in silica and has a relatively high melting point. Therefore, it is highly viscous and solidifies quickly. Hence, the acid lava volcanoes cause the formation of usually higher domes with steeper slopes.

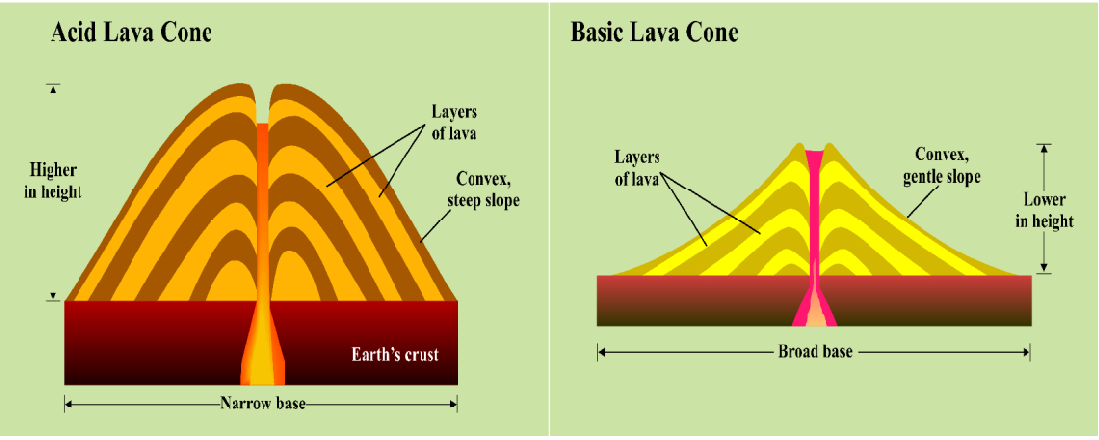

Fig. 2.14: Acidic and Basic Lava Cone

Notes

b. **Volcanoes of basic lava**: Since the basic lava is rich in metallic minerals and has a low melting point, it has greater fluidity. In this type of eruption, lava flows far and wide quietly with greater speed and spreads out in thin sheets over a large area. Thus, it leads to the formation of shields and lava domes. The shield volcano of Hawaii Island in the Pacific Ocean is one of these volcanoes.

Distribution of Volcanoes: Most of these volcanoes are found in three well defined belts. First, the Circum-Pacific region has the greatest concentration of volcanoes.That is why; it is called the- 'Pacific Ring of Fire'. This ring extends along the Andes Mountains of South America to Alaska and from the Aleutian Islands to Japan, Philippines, and Indonesia to New Zealand. The Mid-world mountain belt occupies the second position with regard to the numbers of volcanoes. It runs from the Alps in Europe to the western parts of South west Asia. The African rift valley region ranks third.

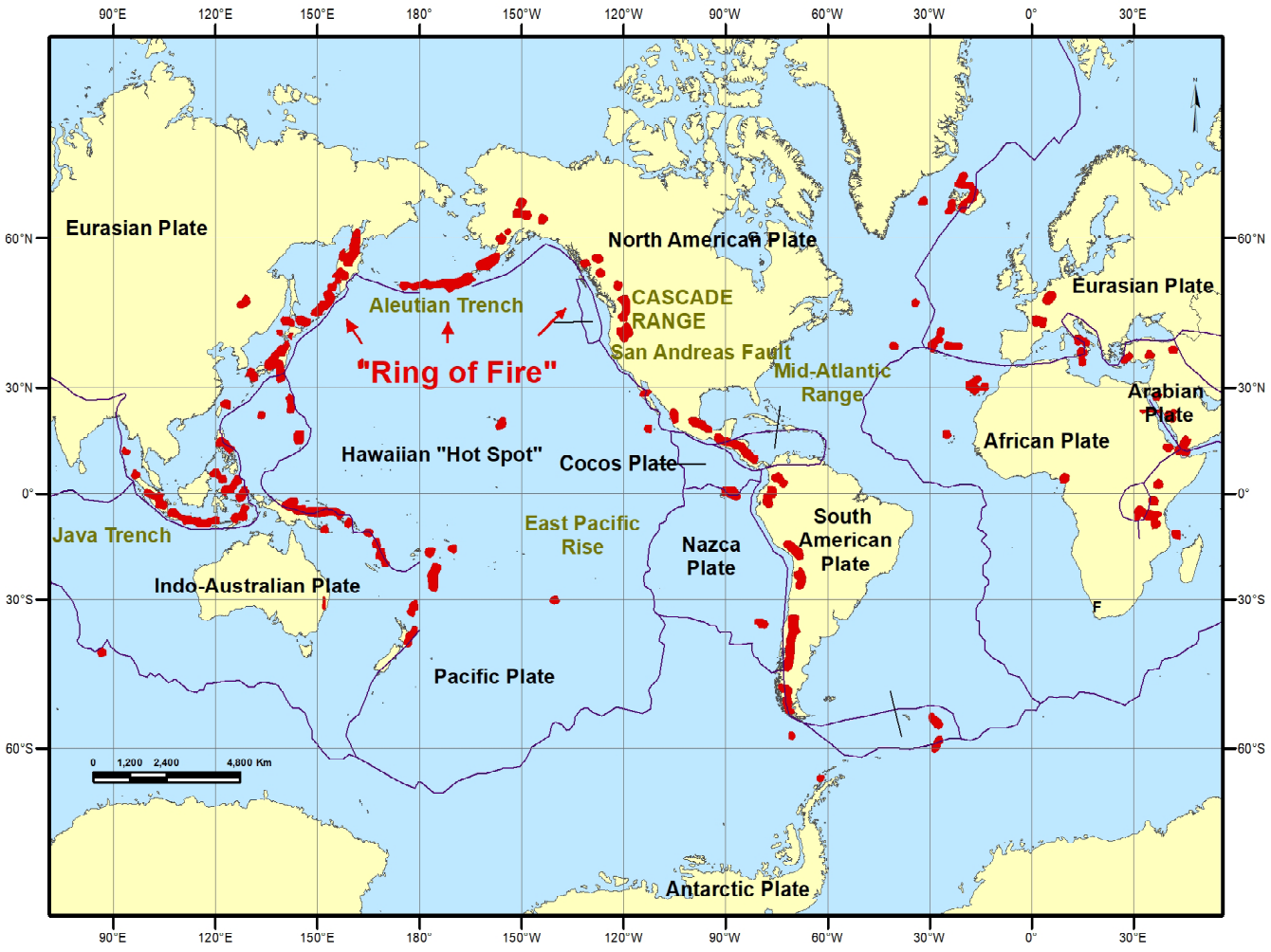

Fig. 2.15: Distribution of Volcanoes and Earthquakes

Notes

2.7 EARTHQUAKES

An earthquake is a sudden shaking of the ground surface, ranging from a faint tremor to a wild motion. The frequency of earthquakes varies largely from place to place. The network of seismographic stations all over the world records hundreds of earthquakes every day. But, occurrences of severe earthquakes are limited. The intensity is the highest at or near the epicentre. That is why the maximum destruction occurs at and around the epicentre.

Causes and Effects of Earthquakes : Endogenic forces are the main cause of earthquakes. It results in folding and faulting. Sudden shift or movement in the crust causes the surface to shake. The second important cause is volcanic eruption. The violent volcanic eruption causes vibrations in the earth's crust. The earthquakes are limited to the areas of volcanic activity.

Violent earthquakes are very disastrous. They may themselves cause land-slides, damming of river courses and occurrence of floods. It changes the drainage system of an area as was witnessed in Assam after its 1951 earthquake. The sea waves caused by earthquakes prove most catastrophic in coastal regions. Such tidal waves are called Tsunamis. These waves may wash away coastal cities. Buildings and bridges collapse causing the death of thousands of people. Lines of transport, communication and of electric transmission get disrupted.

Distribution of Earthquakes :The occurrence of earthquakes is a phenomenon in almost every part of the world. But, there are two well-defined belts where they occur more frequently. These belts are the Circum-Pacific belt and the Mid-world mountain belt.The Circum Pacific belt comprises the western coast of North and South America; Aleutian Islands and island groups along the eastern coasts of Asia such as Japan and Philippines. As it encircles the Pacific Ocean, it is named so. The earthquakes in this belt are associated with the convergence boundary of the plates. It is estimated that about 68 percent of earthquakes of the world are occurring in this belt alone.

The second belt extends from the Alps with their extension into the Mediterranean the Caucasus and the Himalayan region and continues to Indonesia. About 21 percent of total earthquakes of the world originate in this belt. Remaining 11 percent occurs in the other parts of the world.

INTEXT QUESTIONS 2.6

1. Krakatoa is a/an .....volcano and Kilimanjaro ss a/an ..... volcano.
2. Acidic lava forms ..... cone while basic lava
3. Name any two effects of earthquake.

WHAT YOU HAVE LEARNT

- The interior of the earth is studied based on two types of sources – direct and indirect.
- Study through mining, drilling and volcanic eruptions comes under direct sources while knowing interior by the study of density, pressure and temperature is grouped under indirect sources.
- Seismology is another indirect source which scans the entire earth and tells about it completely.
- Seismic waves are recorded by seismograph in detail and studies by seismologist.
- There are three types of seismic waves - 'P', 'S' and 'L' waves.
- 'P' and 'S' waves are known as body waves as they travel in the interior while 'L' wave are termed as surface waves as they travels in the top layer of the earth surface.
- Based on the chemical characteristics of the rocks found at different depths, earth is divided into three layers SIAL (silicon and aluminium), SIMA (silicon and magnesium) and NIFE (nickel and ferrous).
- Based on the change in the seismic waves velocity in the interior, earth is divided into three layers.
- They are crust – top thin solid later, mantle – top solid, intermediary viscous and again solid denser rocks and core- highly sense rocks with outer liquid and inner solid and abundance of nickel and ferrous.
- The top layer of around 100 to 250 km depth, continents are mobile and it has been proposed by Alfred Wegner with sound evidence.
- Later on it was modified into plate tectonics based on newer researche conducted after the continental drift proposition.
- There are seven major plates such as - Eurasian, African, Indo-Australian, Pacific, North American, South American and Antarctic Plates.
- Apart from them, about 20 minor plates are there with which the surface of the earth is composed of.
- Due to magma coming out along the mid-oceanic ridges, divergence and convergence of plates are eminent.

Notes

Notes

- At both the boundaries – convergence and divergence, different types of features are formed. Due to divergence and convergence of plates folds and faults are resulted and different types and faults are seen.

TERMINAL QUESTIONS

1. Describe the interior of the earth on the basis of seismic evidence.
2. Explain seismic wave propagation with changing density and state of rocks in interior.
3. Illustrate the characteristics of seismic waves.
4. Examine the chemical composition of the earth's interior.
5. Evaluate the concept of continental drift by giving approprate evidences.
6. What is a plate? Explain its mechanism, and features formed at plate margins.
7. What is fold and how are they formed? Describe the types of fold.
8. What is the fault and how are they formed? Describe the types of fault.
9. Explain the distribution of earthquakes with respect to plate tectonics.

ANSWERS TO INTEXT QUESTIONS

2.1

1. a. Direct
   b. Indirect
2. 10 degree

2.2

1. Seismograph
2. All (crust, Mantle and core), top two (crust and mantle)

2.3

1. a. SIAL b. SIMA and c. NIFE
2. 2900 km

Notes

2.4

1. Alfred Wegner
2. Any two
   a. Jig-saw
   b. Geological Matching
   c. Coal and vegetation endemics
3. a. Divergent
   b. Convergent
   c. Transform

2.5

1. Anticline and syncline
2. Any three
   a. Symmetrical
   b. Asymmetrical
   c. Overfold
   d Recumbent
   e. Overthrust.
3. Any three
   a. Normal
   b. Revere
   c. Strike slip
   d. Oblique
   e. Nappe

2.6

1. Active and Extinct
2. Sleep and Flat

Notes

3. Any two

   a. Landslide

   b. Jamming of river course

   c. Occurrence of floods

   d. Damage to life and property

   e. Any relevant effects.