

Chapter- 15

Structure of the Earth

The distance of the earth from the sun is about 15 crore kilometers. This distance is also called as the astronomical unit. The earth is constantly in motion. It rotates on its axis in a day, forming day and night. On the part where sunlight falls, there is day and in the part there is night. Earth revolves around the sun in one year. Earth does not stand straight on its axis but it is 23.5 degree inclined. That is why the sun is in the state of uttarayan (Summer solstice) and dakshinayan (Winter solstice) and seasons are formed on earth. These qualities make the earth special from the point of view of life.

15.1 Origin and evolution of earth

Nothing can be said about how exactly the earth has originated. The earth is a member of the solar system, hence it is assumed that it would have originated with the solar system. Tidal hypothesis is currently considered the most reliable. According to it a huge star came near the sun, due to its attraction a lot of matter bulged out of the sun. This bulge was thin at the tips and thick in the middle. Later the star went on its way and the part came out of the sun and broke up to form the planets. If the planets are arranged according in a sequence, cigar like structure is formed having thin heads and middle part thick.

Evidence gathered from various branches of science reveals that the earth was formed about 4.5 billion years ago. Earth's age is about one third of the age of the universe. Initially the earth was very hot. Its rotation speed was also very fast. The outer part of the earth cooled down due to rotation, but it would have been separated by splitting. It took millions of years to cool down. While cooling, the heavy elements went into the depth and the surface was formed by lighter elements. Atmosphere was formed by remaining gases. After the origin of life there have been many changes on Earth. It is also called as the world. Some uncommon names of the

earth are land and terra. The earth is the largest solid planet in the solar system in terms of diameter, mass and density.



Fig. 15.1 Earth's picture taken from space

15.2 Structure of earth

Since very ancient times man has been keen to know about the structure of the earth. When there were no resources for digging too deep into the earth, man became aware that the texture inside the earth was not exactly the same everywhere after seeing the lava coming out of the volcano. By indirect methods such as study of seismic waves etc. information about more depth is collected.

Immediately after separating from the sun, the earth must have been like a boiling liquid. Even after the formation of the earth for a very long time a major part of the earth was liquid. One of the reasons for this is that the objects of space used to collide with it. 4.40 million years ago moon was formed by the collusion of an object of the size of Mars with earth. Moon is earth's only natural satellite. By its attraction power it produces marine tides, helps the earth bend properly on its axis, slows down the rotation of the earth.

Some rocks formed on earth after cooling were light and some were heavier. Heavy rocks sank deeper

and the rocks made up of lighter elements remained above. The earth's surface was formed by these lighter rocks.

Today we know that the earth's structure is in the form of layers like onions peels. The distance from the surface to the center of the earth is estimated to be around 3900 km. So far it is has not been possible to make a hole deeper than 15 km. into the earth.

It is roughly believed that the earth is made up of three types of layers. The thickness of these layers is demarcated on the basis of either the chemical composition of rocks or the mechanical characteristics.

The upper layer of the earth is a solid layer called crust. It can also be considered as the skin of the earth. Its thickness is not uniform at all the places. Due to this difference at some place the mountains and at some places seas are formed. Earth surface is divided into two parts the hydrosphere and the lithosphere. Most of the part of the lithosphere is formed of soil. The part of the hydrosphere, the lithosphere and the atmosphere where life exists is called as the biosphere. The biosphere has not yet been formed on any planet other than earth. The structure of the earth crust has not been the same from the beginning as it is today. At present 70 percent of the earth surface is covered with water. This normally remains flat. The remaining 30 percent part is land, which has plains, mountains, desert sand valleys at different places.



Pic. 15.2 Internal structure of the earth

For a few million years after the earth's creation the earth's crust was thin and in the form of a unit. With the cooling of the earth, the crust turned into huge rocks. These huge rock segments are called the

tectonic plates. The continents are located on these tectonic plates. These tectonic plates are slowly moving away. The speed of movement of these plates is compared with the speed of the growth of our nails. Initially when the tectonic plates were light their speed was fast, now it is slow. 29 tectonic plates have been found on the surface of the earth.

The second layer of the earth is called as mantle. This is the thickest layer. It is normally made up of hot molten rocks. The amount of iron and magnesium in these silicate rocks is more as compared to the earth crust. Bubbles keep rising as in a boiling liquid. In the middle part of the earth the mantle keeps moving up and down. The Earth's central part is called the core. Being the deepest part, it is the hottest part of the earth. The temperature of the core is estimated to be 7000 degree celsius. The reason for the high temperature of the core is, the heat which was left inside during the formation of earth. There are also evidences of the gradual cooling of the core. The core of the earth is divided into two parts. The internal core is believed to be solid and is purely formed of iron. Some scientists have expressed the possibility of having gold and platinum in this part. Outer core has molten, iron and nickel prominently present in it. Scientists believe that the core is not stable but keeps on revolving faster than earth. Core is the most dense part of the earth. Its density is much higher than that of the crust. The cause of the magnetism of the earth is the core. Earth's chemical structure is similar to that of the meteorites. So the earth can also be called a large meteorite.

Table 15.1 Main elements and their quantities found in the earth

S.No.	Name of element	Percentage
1	Iron	34.6
2	Oxygen	29.5
3	Silicon	15.2
4	Magnesium	12.7
5	Nickel	2.4
6	Sulphur	1.9
7	Titanium	0.05
8	Others	3.65

15.3 Energy system of the earth

We live on the surface of the earth. About 70 percent of the surface of the earth is covered with water. Plains, mountains, valleys, deserts are seen on the remaining 30 percent part which is land. There are many evidences which can prove that the surface of the earth was not always the same like the one we are familiar with. Where there is a huge mountain like the Himalayas there was once a sea named Tethys. Several types of forces work continuously to change the surface of the earth. These powers are called the tectonic powers. Tectonic powers are of two types:-

1. Internal tectonic powers
2. External tectonic powers

15.3.1 Internal tectonic forces

These forces work by staying inside the earth and can not be seen from outside. Their origin is due to the spreading of the rocks by molten, below the surface of the earth and also due to the shifting of the magma. When the internal tectonic forces work vertically to the earth's centre, some part of the surface of earth rises and some others are submerged, thus the continents, islands, plateaus, plains, oceans etc are formed. Sedimentary rocks which are formed inside the seas rise and move towards continents.

Waves are produced when the internal tectonic forces work horizontally. Due to these waves there is a huge upheaval of the rocks found on the earth surface. Folds and cracks are formed on the surface, valleys and mountains are also formed.

15.3.1.1 Volcano

Volcano is the strangest event of the internal tectonic forces. The earth shakes due to the activity happening inside the earth and by breaking the crust the smoke, ash, vapours and gases begin to flow out. Many times the extremely heated rocks melt and flow out in the form of lava. This causes horrific destruction. There is heavy loss of life and property. Due to the flames coming out of the mouth formed on the surface of the earth, they are named Jwalamukhi in hindi. Volcano name in english is named after Volcanic islands. The old volcano present on this island was

considered to be the way to the hell by the Romans.

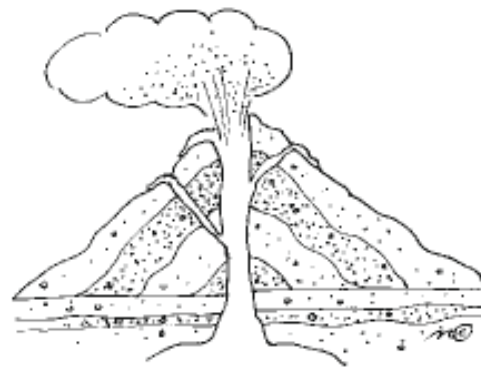


Fig. 15.3 Structure of a Volcano

Volcano is related to earth's womb. Due to the pressure, lava rises in the form of a tube and erupts and spreads all over. Some volcanoes are continuously active while some become active after a gap. Many a time active volcano becomes inactive. Volcanoes are found in every part of the world, but generally they are found along a chain of mountains. eg. They are found on the islands on the coastal regions of the Pacific ocean. There are many advantages and disadvantages of volcanoes. Many useful chemical substances like sulphur, boric acid etc, and precious metals come out with the lava. Hot water springs are also formed due to volcanoes.

15.3.1.2 Earthquake

Earthquake is one of the effects of internal tectonic forces. Earthquake means the shaking of earth surface. Any activity inside the earth causes shaking. The point from where the vibrations initiate is called the epicenter. Waves spread in all directions from the centre. The waves moving from the depth when they reach the surface of the earth make the surface to move to and from and sometimes up and down. The effect of earthquake depends on its intensity. The intensity of the earthquake is sometimes so less, that the earthquake is not even felt. The intensity of earthquake at any place depends on the intensity of the shaking of the earth's womb and its distance from the epicenter. The earthquake under the water of the sea is called

seaquake or under water earthquake. Earthquake is measured by seismographs. The intensity of an earthquake is expressed on the Richter scale. Earthquakes with a magnitude of 4 are weak, upto 5.5 are strong. Earthquakes above the 6 are considered as destructive and above this are are disastrous.

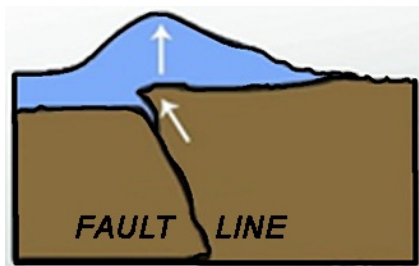


Fig. 15.4 Diagram of earthquakes on the basis of the internal structure of the Earth

The cause for the origin of the earthquakes is the disturbance in the equilibrium in the internal structure of the earth. An imbalance can also occur naturally or due to the pressure of man made water reservoirs or explosions. At present earthquake is interpreted on the basis of plate tectonic theory. We have previously learnt that the surface of the earth is distributed in 29 plates. Among these 6 are main. We also know that these plates move slowly. All tectonic events occur on the edges of these plates. The edges of the plates are of three types creative, destructive and conservative. The destructive earthquakes of greater magnitude come only on the destructive edges. Platonic collisions are believed to be the reasons for the occurrence of earthquakes in Northern India, Tibet and Nepal. Earthquakes also occur in parts where the edges of the plates are not destructive and their occurrence is difficult to explain. India is divided into 5 parts according to Earthquake risk. Some parts of Jammu Kashmir, Himachal, Uttarakhand are considered to be the most risky, some parts of Punjab, Haryana and Uttar Pradesh are considered as least risky. It is seen that this division is generally disregarded. Even though Kolkata was the area of minimum risk, there was a terrible earthquake in 1737 in which about 3 lakh people were killed.

15.3.1.3 Tsunami

Tsunami is also one of the destructive events caused by internal tectonic forces. Due to the Tsunami, waves of high energy rise in the sea. These waves cause heavy damage in the coastal areas. Tsunami is a Japanese word which means "seismic sea wave". Earthquakes of more than 7 units at the bottom of the sea, are the main reasons for the occurrence of tsunami. The tsunami moves from the originating center in two directions one towards the deep sea and the other towards the shore. The tsunami which runs towards the shore causes destruction. Debris etc which flows with the tsunami hits very deep inside coastal regions. The buildings, human and animals suffer heavy losses. Earlier there were no good means of giving warning of the tsunami. Now due to the use of various apparatuses its occurrence can be known much earlier. The hazardous areas are now cleared and people can move to safer places, but the immovable property is damaged. India's National Institute of Oceanography has discovered the submerged harbour in the Dholavira region of Gujarat. Studies say, 1500 years ago the biggest harbour of Harappan civilization was buried in due to some sea storm like Tsunami. 14 to 18 meter wide wall found here is believed to be a textimon, in that period also Indians knew how to deal with the destructive storms like tsunami.

15.3.1.4 Constructive and destructive natural forces

Two types of forces work on the surface of the earth all the time. A group of forces help in creating new land forms like planes, mountains etc. on the ground, but the second group starts destroying the newly formed mountains etc. The forces inside the surface of the earth create new land forms on the surface but the external forces destroy the new forms. As soon as any land part emerges out of water the external eroded forces start acting on it. Their endeavour is to reduced or erode the the rising structure.

15.3.2 External tectonic forces

Based on the method of work, the external

tectonic forces can be divided into two parts. In the first group there are forces that work only by staying at its place. They have no speed but by initial preparation they help the second group of tectonic powers. First group of external tectonic powers are called weathering forces. Second type of forces which move from its place are called erosional forces.

15.3.2.1 Weathering forces

The weathering forces try to break the rocks and change them into soil. Sun heat, rain, frost and physically breaks the rocks. During the day time the rock expands by the heat of the sun and during night it contracts by cool it down. By repeated expansion and contraction, the rocks become weak and breaks down. Rain hitting hot rocks also accelerate their this disintegrating speed. Rain water also cuts the rocks. At the time of frost water collected in the cracks of the rocks freezes to form ice and expands. Force generated cracks the rocks. When the dust particles flying with the air collide with the rocks, they wear out the rocks like emery paper. Due to this continuous flow for thousands of years, comprehensive effect of these forces can be seen. The reason for not finding a mountain in the desert is the weathering force of air. The weathering forces reduced the desert mountains and converted them into deserts.

Chemical reactions in nature like oxidation, carbonating, joining of water molecules, mercurialization etc weaken the rocks and helps in their weathering. Biological forces like plants, animals and other organisms also play a major role in weathering. The root of the trees enters the rocks, later grows and breaks the rock. Animals helps in breaking rocks by making burrow in it. Man has proved to be the biggest enemy of the rocks. The force of weathering by human is currently the highest with the help of machines and gun powder. Organism produce out different chemical substances in nature, they are also helping in weathering process.

The forces of weathering has proved to be very useful from the point of agriculture. Soil is very

important for agriculture and it is formed by the forces of weathering. Their role in the construction of plains for agriculture is important. Many types of chemicals come out of the rocks due to weathering.

15.3.2.2 Erosion forces

Air, water and snow are three such substances found on the earth which flow from one place to another in large quantities. There is force in their drift. The large structures which come in their way breaks and flow away. Air, water and ice also do erosional work. Their work does not end there but they transports these substances collected from the place of erosion to far distances. Where these substances get deposited and the shape of that surface changes.

15.3.2.3 Power of wind

A cover of different gases is found around the surface of the earth which we call atmosphere. We are alive by with the gases of the atmosphere. Plants also need the gases of the atmosphere for photosynthesis, by which animals get their food.



Fig. 15.5 Effect of flowing air

Besides these important work, erosion is also an important work of the air. The air remains in motion and is not static. The speed of the air provides it, the power of erosion. With an increases in the velocity of the air, its erosion power also increases and destroys large tracts of land.

To understand the erosional force of air, we have to understand what runs the air? When we turn on the fan due to the rotation on of the fan the air gets pushed and starts rotating. We know that energy is required to perform any work. Fan gets its energy from electricity to rotate. The arrangement of the air flowing in nature is somewhat complicated in comparison to the air flowing in a room.

The only source that gives, the energy needed to do any work in nature is the sun. You know that the sun is a star, due to the nuclear reaction in it, enormous amount of energy dissipates in all directions. A small part of this energy also reaches the earth. This small part of solar energy is enough to carry out all the activities on the earth. The energy of sun does not reach in the same amount to every part of the earth and in all the months of the year. Due to this imbalance of the energy the air is less warm at some places and more warm at other places. Air expands after getting heated and rises up due to being lighter. Air pressure at that place becomes low. In this case the air starts flowing from area of high pressure to the area of low pressure. Flowing air is called wind. The speed of the wind depends on the difference between the air pressures at both places. The greater the difference, the higher is the velocity of the wind. On many places on earth the difference in air pressure remains uniform throughout the year, for this reason the wind blows in the same direction with same speed throughout the year. In ancient times, wind was used to sail ships in the direction of the wind.

The direction of some winds on land is not always the same. Their direction changes according to the season, because of this they are called as Monsoon. For 6 months in summer the wind blows from the ocean to the land and becomes the cause of summer monsoon. In winter for 2 months the wind moves from the land to the oceans and becomes the cause of winter monsoon. In India the south-west monsoon brings on rain everywhere. Water is available for the full year due to the monsoon rain. Monsoon rains are affected by many elements. For this reason the rainfall is scarce at some places and abundant at other places. Floods occur when there is more rain at one place in comparison to the availability of storage or drainage. The flowing water destroys everything coming in its way. There is a lot of economic loss due to floods.

Irregular winds

Many a time winds with irregular speed arise.

The cyclone is a prime example of the variable winds. In the cyclone the winds do not move straight it moves towards the central point in a circular path. Cyclonic winds arise due to the low air pressure at the center. The area of a cyclone ranges from 400 km to 3000 km. The extension of cyclones and the speed of air is more in the temperate zone as compared to the tropical zone.

Due to cyclone the weather of that area changes completely. In the month of May the Monsoons arrive. With strong winds there is heavy rainfall. The heavy thunder of clouds and lightening generates a feeling of fear. Trees are uprooted and roofs of houses fly away. Normal life is interrupted due to power failure. After a few days the situation becomes quite normal. Powerful storms also arise due to the formation of pressure difference at local level. These storms cause great destruction in that particular area.

15.3.2.4 Hydropower

You must have seen the power of running water in the form of a river. River originates from mountains and ends up in a lake or in sea, it constructs many land forms like valley or delta. The importance of the river depends on the water flowing in it. Some rivers flow only during rain and some keep flowing for twelve months. River holds an important place in the development of human civilization. Vedic civilization developed on the banks of such a river called the Saraswati. Later on after the change in the route of Saraswati rivers flow, the people had to settle in other places. Efforts are on to find the Saraswati river again. Everyone knows about the importance of the ever flowing rivers like Ganga, Yamuna and Chambal. Water and fertile soil obtained from these help millions of people to live. To emphasize the importance of river, it is called mother. When the rivers get more water we have to face its destructive power.

Glaciers

There is no rain in cold areas. Water freezes and rains in the form of snowflakes. This event is called as snowfall. Conditions of snowfall on high mountains like Himalayas or polar regions continue. Thus a thick

layers of snow or ice accumulates in these areas. Later due to the gravitation force the entire layer of the ice starts moving downwards. The moving layers of ice is called a glacier or a snow river. Due to the slow speed of the snow river its impact cannot be seen immediately as seen in the case of a river. But the long term effects are seen very much. Due to the huge size of the glacier, their power too is very high. They grinds the rock that obstruct their path like flour. Ganga and Yamuna are the rivers which originate from the glaciers. Now a days the average temperature of the world is increasing. It is called global warming. Due to global warming less snow is forming and more snow is melting. Because of this the glaciers started shrinking in size. The sea level is rising due to the glacier have water flowing into it. Many cities situated at the sea shores are gradually submerging into the water. The Dwarka city of India has submerged in water several times in ancient times and every time a new dwarka has been created. Old drawkas have been discovered inside the water.

Oceanic Currents

Most of the water is contained in the oceans. Because of its huge size the sea always looks the same. Floods or drought like situations rivers are not seen in sea. Thats why the sea is called calm. By looking deep the power of sea can be seen. Due to the influence of the air you must have seen sea water rising up and down in the form of waves. Sea waves becomes fatal when earthquakes or a volcano burst or a storm occurs.

The second form of the power in sea water is seen in the ocean currents. Oceanic currents can also be called a river flowing in the sea. In this, the water flows continuously in a certain direction. In some oceanic currents warm water flows while in some the cold water. The reason for the flow of the oceanic current is not due to the slope but because of the difference in the inter temperature density. These currents have a great effect on human life. The hot streams makes the area hot and the cold streams makes the area cold. Winds that pass through the hot streams takes away lot of moisture with it, which is

the reason for rainfall in high altitudes. In the places where the hot and the cold streams meet, temperature variation is created, which gives birth to storms like hurricane and typhoon. These currents affects the operation of the ships and the life of sea organisms.

In the form of tides too much power is propagated by the sea water. Tide is formed when the sun and the moon are in straight line. If this happens the gravitational force on the sea water increases. Due to its stretch tides are generated.

We have seen that various powers keep this trend alive while working continuously. Today humans have learned a lot about the causes for these forces being generated. By continuously keeping an eye on these, he started predicting the storms, rains etc. When humans started an attempt to understand the nature, he must have become impressed on seeing the effects of the natural powers. Human did not have the knowledge of the reason behind the natural powers.

You know that science is all about finding solutions and answers of the questions. Initially humans did not have the means to do research and to find solutions to the questions. Thus the imagination powers were used to find solution to the questions. Just like a child when he asks his father who runs the air, the father would have given the name of wind God (Varun) to calm the child's curiosity. Similarly in other parts of the world, other Gods and demons were created. After the birth of a character many of his stories were also formed. Even today these stories are enjoyed around the world. There are some scientific information in these stories too. In the story of the child Dhruva, there is a scientific fact that the pole star remains stable at its place. Even today we have not understood how without any means, in that period, people came to know that the pole star remains still.

Important Points

1. Evidences gathered by many branches of science shows that the earth was born about 4.5 billion years ago by solar nebula.
2. Immediately after separation from the sun the

earth would have been like a sphere made up of boiling fluid. After the creation of earth, for a long period most of its part was liquid.

3. The structure of the earth is in the form of layers like that of onion peels. The distance from the surface to the center of the earth is estimated to be around 3900 kilometers.
4. The upper layer of the earth or earth's crust is a solid layer it can also be considered as the skin of the earth. The thickness of earth crust is not same at all places. After the cooling down of the earth the earth crust turned into huge rock clusters. The huge rock clusters are called the tectonic plates.
5. The second layer of earth is called the mantle. It is the thickest layer. It is formed of hot molten rocks.
6. The central part of the earth, the core is the hottest part. Its temperature is estimated to be 7000 degree centigrade. The earth's core is divided into two parts. ? The internal core is solid and is made up of pure iron.
7. Around 70 percent part of the earth surface is covered with water. On there 30 percent land area, mountains, plains, plateau, valleys, deserts etc are seen. There are many evidences by which can say that the way we are familiar with the surface of the earth it was not always the same.
8. Several types of forces work continuously to change the surface of the earth, these forces are called as tectonic forces. Tectonic forces are of two types, internal tectonic forces and external tectonic forces.
9. The internal tectonic forces originate due to the heat present in the depth below the surface of the earth, spreading of rocks and due to the transfer of the hot fluid, the magma.
10. The earth shakes due to the bustle inside it and by cracking the crust the smoke, ash, vapors and gases begin to flow out. Many a times the extremely heated rocks melts and flows out in

the form of lava. This is called a volcano.

11. Meaning of the word earthquake is the shaking of the earth surface. The cause of the vibration is any bustling inside the earth. At present, earthquake is described on the basis of plate tectonic theory.
12. Due to tsunami waves with high energy rises in the sea. These waves cause heavy damage in coastal areas. Tsunami is a Japanese word which means seismic sea wave.
13. Two types of powers work on the surface of the earth all the time. A group of power helps in creating new forms like mountains etc on the ground, but the second group starts destroying the new formed mountain etc.
14. First group of external tectonic powers is called as weathering forces. The second type of powers that is the powers which work with speed are called erosion forces.
15. Sun's heat, rain, frost, and air physically breaks the rocks. Chemical reaction in nature like oxidation, carbonating, joining of water molecules, mercurialization etc weakens the rocks and helps in their weathering.
16. Air, water and ice are three such substances found on earth, which flows from one place to another in huge quantity. There is excessive power in their drift. The large structures which comes in their way breaks and flows away.
17. Air flows from the region of high pressure to the region of low pressure. Blowing air is called as wind. The direction of wind on land is not always the same. Their direction changes according to the season. At the time of cyclone the winds do not go straight but moves towards the central point in a circular path. This happens due to the reduced air pressure at the centre.
18. The importance of river depends on the water flowing in it. Rivers hold an important place in the development of human civilization. Due to the gravitational forces the entire layer of ice starts

moving downwards, this is called glacier.

19. Oceanic currents can also be called as a river flowing in the sea. In this water flows continuously in a certain direction. In some oceanic currents warm water flows and in some cold water.
20. In the form of tides too much power is generated in the sea water. Tide is formed when the sun and the moon are in a straight line. Due to the increase in the gravitation force on the sea water, the tides form.

Practice questions

Objective type questions

1. Which one is not the name of the earth-
(a) Bhoomi (b) Gaiy
(c) Bhanu (d) Tera
2. At present how much part of the earth surface is covered with water-
(a) 70 percent (b) 30 percent
(c) 50 percent (d) Uncertain
3. The most abundant element found in Earth-
(a) Silicon (b) Gold
(c) Oxygen (d) Iron
4. Where was the largest harbor of Harappan civilization was found-
(a) Dwarka (b) Dhoulavera
(c) Surat (d) Karnawati
5. What is reason for the occurrence of tides-
(a) Sun (b) Moon
(c) both
(d) Sun and moon being in a straight line

Very short type questions

6. What is the reason for sun being in the state of Uttarayan- dakshinayan?
7. What is the unit of measuring an Earthquake?
8. Where are tectonic plates found?
9. What is the reason for tsunami?
10. Which types of winds arise due to the decreasing air pressure in the centre?

Short type questions

11. What will be the condition of a place after an earthquake of the magnitude of 7 on richer scale had hit?
12. What are oceanic currents?
13. What are the advantages of weathering forces in agriculture?
14. Write down four causes which helps in weathering?
15. How the moon was born?

Essay type questions

16. Explain the internal structure of the earth. Also draw a well labelled diagram?
17. What do you mean by the earths internal tectonic powers? Describe any two?
18. What erosion? Explain the importance of the two types of erosion powers on human life?

Answer key

1. (c) 2. (a) 3. (d)
4. (b) 5. (d)