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Indian & World Geography Chapter 8

Short Answers

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This Chapter Contains

- Origin of Solar System and Sun
- Stars, Sun & Planet
- Latitudes and Longitudes
- Motions of the Earth: Rotation and Revolution
- Geomorphic Processes: Endogenic Forces and Evolution of Landforms
- Origin of the Earth
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1. Origin of Solar System and Sun

1.1 Solar System

The Solar System is the gravitationally bound system of the Sun and the objects that orbit it, either directly or indirectly. It consists of the sun (the star) at the centre with eight planets (i.e. Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune), satellites, asteroids, meteors and comets that move around the Sun.

The solar system, according to scientists, was formed when a cloud of gas and dust in space was disturbed, possibly by the explosion of a nearby star known as **SUPERNOVA.** This explosion sent shockwaves into space, compressing the gas and dust cloud. Gravity drew the gas and dust together, forming a solar nebula, as the cloud began to collapse.At the dense center of this nebula, the sun's nuclear flames erupted. In the churning currents of the vast cloud, the planets were created.Mercury, Venus, Earth, and Mars all began as rock globes orbiting the Sun. It was impossible to capture them since they were too small and had weak gravitational fields.The enormous planets Jupiter and Saturn, which are far from the sun and have powerful gravitational fields, did, nevertheless, draw and hold thick gaseous atmospheres of Hydrogen and Helium.

Another group of Scientists believe that the Sun has been formed from a moving cloud of gases, which is called Nebula. The Sun and the planets were born out of this cloud. The force of gravity has created them. For over millions of years, these balls of dust and gas are moving around the Sun. The Sun by virtue of its mass and weight, controls the movement of the planets. This force is called the force of gravity.

Till 2006, there were nine planets in the solar system. Pluto was the farthest planet from the Sun. In 2006, the International Astronomical Union (IAU) adopted a new definition of a planet. Pluto and other celestial bodies like Ceres, 2003 UB313 does not fit this definition. It is no longer considered as a planet of the solar system. The solar system is enormous, with a diameter of at least 100 Astronomical Units (15 trillion km). Our Solar System is thought to be over 4.6 billion years old, according to several experts.

Out of the eight planets, mercury, venus, earth and mars are called as the inner planets as they lie between the sun and the belt of asteroids the other four planets are called the outer planets.

Alternatively, the first four are called Terrestrial, meaning earth-like as they are made up of rock and metals, and have relatively high densities. The rest four are called Jovian or Gas Giant planets. Jovian means jupiter-like. Most of them are much larger than the terrestrial planets and have thick atmosphere, mostly of helium and hydrogen.The difference between terrestrial and jovian planets can be attributed to the following conditions:

- The terrestrial planets were formed in the close vicinity of the parent star where it was too warm for gases to condense to solid particles. Jovian planets were formed at quite a distant location.
- The solar wind was most intense nearer the sun; so, it blew off lots of gas and dust from the terrestrial planets. The solar winds were not all that intense to cause similar removal of gases from the Jovian planets.
- The terrestrial planets are smaller and their lower gravity could not hold the escaping gases.
- All the planets were formed in the same period sometime about 4.6 billion years ago.

2. Stars, Sun & Planets

2.1 Sun

The Sun is at the centre of our solar system and also the largest objects of our solar system. However, it is an average star. It is roughly 109 times the size of Earth. The Sun has a diameter of 1,392,000 kilometres. It comprises 99.8% of the mass of the solar system. It isn't the hottest, it isn't the coolest, and it isn't the oldest. Nor is it brightest, biggest, etc. The surface temperature of sun is 60000 degrees Celsius. It is largely made up of hydrogen gas, with a minor quantity of helium thrown in for good measure. The Sun accounts for 99.85% of all the matter of the solar system.

The Sun is the solar system's closest star. It belongs to the Milky Way galaxy. It's thought to be more than 4 billion years old. The Sun is a yellow dwarf, a medium-sized star. As it rotates around the galaxy, the Sun spins gently on its axis. It is composed mainly of hydrogen and helium. Nuclear fusion in the core of the Sun is source of all its energy. The glowing surface of the Sun is called Photosphere. About it is red coloured Chromosphere and beyond it is Corona (visible during eclipses). The surface of the Sun changes continuously. Bright regions are called Plages and dark spots are called Sun spots which frequently form and disappear.

The Earth would be a dead sphere of rock and ice if it were not for the Sun. The Sun warms our globe, influences our weather, and provides energy to plants, which provides food and energy for life on Earth. The Sun's energy reaches the Earth and other planets in all directions. The planet absorbs less energy as it gets further away from the Sun.

2.2 Sun Statistics

- Distance from the Earth - 150 mn km
- Diameter-1391980 km
- Core temperature - 15000000°C
- Rotation time - 25 days
- Age - 5 billion years
- Composition – H_2 - 71%, He - 26.5% and other 2.5%
- Mass-1.99 x $l0^{33}$kg

2.3 Solar Eclipse

- Solar eclipse is caused when the Moon revolving around the Earth comes in between the Earth and the Sun, thus making a part or whole of the Sun invisible from a particular patrol the Earth.

2.4 Lunar Eclipse

- During the revolution of Earth, when comes between moon and the Sun the shadow of the Earth hides moon either fully or partially. This is called lunar edips.

2.4 The Planets

Planets are actually spinning around the Sun. They have their own elliptical path of movement known as the orbits. Movement around its own axis is called rotation and around the Sun is revolution. Planets, unlike stars, have no light or heat of their own. The word ‘planet’ comes from the Greek word “Planetai” which means ‘wanderers’. Planets keep changing their positions with respect to the stars.

Mercury: It is nearest to the Sun. It is the smallest planet of the solar system, nearly of the same size and mass as the moon. It takes 88 days for one orbit around the Sun and 59 days for one spin on its axis. It has no satellite. There is no atmosphere on mercury. The surface of mercury is rocky and mountainous. One side of the surface facing the Sun receives maximum heat and light. The surface of this planet does not receive Sunlight or heat on its other side. One part of mercury, therefore, is very hot while the other part is very cold.

Venus: It has no moon or satellite of its own. It rotates on its axis is somewhat unusual i.e. from east to west. The mass of Venus is nearly 4/5 times that of the earth. It takes 255 days for one orbit around the Sun and 243 days for one spin on its axis. Therefore it is often called a morning or an evening star. It has an atmosphere that consists of mainly carbon dioxide. It is the hottest planet in our solar system.

The Earth: Our earth rotates from west to east. Our earth is more or less like a sphere, which is slightly flattened in the north and south. Slightly flattened or tapered at the poles, the earth is best to be described as geoids which mean earth like shape. It is the third nearest planet to the Sun. It is called blue planet due to presence of water and landmasses the earth appears blue-green in colour from the space. The earth is the only planet where some special environment conditions are responsible for the existence and continuation of life because it has the right temperature range, the presence of water, soil, minerals, suitable atmosphere and a blanket of ozone.

Mars: It is almost half the size of the earth. It takes 687 days for one orbit around the Sun and 1 day for one spin on its axis. It appears slightly reddish and, therefore, it is also called the red planet. Mars has two small natural satellites named Phobos and Deimos.

Jupiter: It is the largest planet of the solar system. It takes 11 years and 11 months for one orbit around the Sun and 9 hours, 56 minutes for one spin on its axis. It has 16 satellites. It also has faint rings around it. Its most distinguishing feature is the great red spot. Because of its large mass, it exerts a strong gravitational pull on other objects which pass by it. It is consists of hydrogen and helium in gaseous form. Its cloud like outer regions consists of methane in gaseous form while ammonia is present in crystalline form.

Saturn: Beyond Jupiter is Saturn which appears yellowish in colour. What make it unique in the solar system are its three beautiful rings. It takes 29 years, 5 months for one orbit around the Sun and 10 hours, 40 minutes for one spin on its axis. It has 18 satellites. Saturn is the least dense among all the planets. Its density is less than that of water. It is similar in size, mass and composition to Jupiter. It is however cooler than the Jupiter.

Uranus: It was the first planet to be discovered with the help of a telescope by William Herschel in 1781. Hydrogen and methane have been detected in the atmosphere of Uranus. It rotates from east to west. The most remarkable feature of Uranus is that it has highly tilted rotational axis. As a result, in its orbital motion it appears to roll on its side. It takes 84 years for one orbit around the Sun and 17 hours, 14 minutes for one spin on its axis. It has 17 satellites.

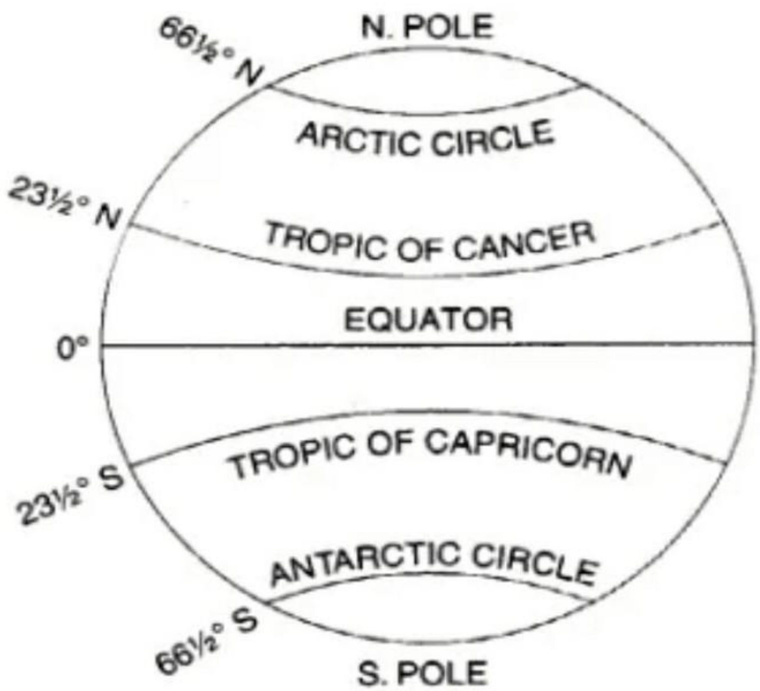
Neptune: It takes 164 years for one orbit around the Sun and 16 hours 7 minutes for one spin on its axis. It has 8 satellites.

3. Latitudes and Longitudes

The Earth is an Oblate Spheroid. Therefore it is difficult to locate places on it unless a mathematical system is used. There are two reference points on the Earth- the North Pole and South Pole. With the help of these two points it has been possible to draw the Equator, as it lies exactly midway between the poles. In order to locate places accurately, a network of lines are drawn o the globe. The horizontal lines are the lines of latitudes and the vertical ones are the lines of longitudes. These lines intersect each other at right angles and create a network called a grid or graticule. The graticule helps us to locate places on the surface of the Earth accurately.

3.1 Latitudes

The latitude is the angle formed by a line going from the center of the earth to the equator at the point on the equator that is closed to the point of interest and another line that goes from the center of the earth to the parallel that goes through the point of interest. In other terms it is a measurement on a globe or map of location north or south of the Equator. Lines joining places with the same latitudes are called parallels ie the lines running East to West are called “Parallels” or “lines of latitude”



Technically, there are different kinds of latitude—geocentric, astronomical, and geographic (or geodetic)—but there are only minor differences between them. In most common references, geocentric latitude is implied. Given in degrees, minutes, and seconds, geocentric latitude is the arc subtended by an angle at Earth’s centre and measured in a north-south plane poleward from the Equator. Therefore, the greatest possible latitudes are 90° N and 90° S. The value of equator is 0° and the latitude of the poles are 90°N and 90°S.

If parallels of latitude are drawn at an interval of one degree, there will be 89 parallels in the northern and the southern hemispheres each. The total number of parallels thus drawn, including the equator, will be 179. Depending upon the location of a feature or a place north or south of the equator, the letter N or S is written along with the value of the latitude.

If the earth were a perfect sphere, the length of 10 of latitude (a one degree arc of a meridian) would be a constant value, i.e. 111 km everywhere on the earth. This length is almost the same as that of a degree of longitude at the equator. But to be precise, a degree of latitude changes slightly in length from the equator to the poles. While at the equator, it is 110.6 km at the poles, it is 111.7 km. Latitude of a place may be determined with the help of the altitude of the sun or the Pole Star.

Distances between them are measured in 'degrees of longitude'; each degree is further divided into minutes, and minutes into seconds.

- A Circle = 360 Degrees
- 1 Degree = 60 Minutes
- 1 Minute = 60 Seconds

They are *semi-circles and the distance between them decreases steadily polewards until it becomes zero at the poles,* where all the meridians meet.

3.2 Heat Zones

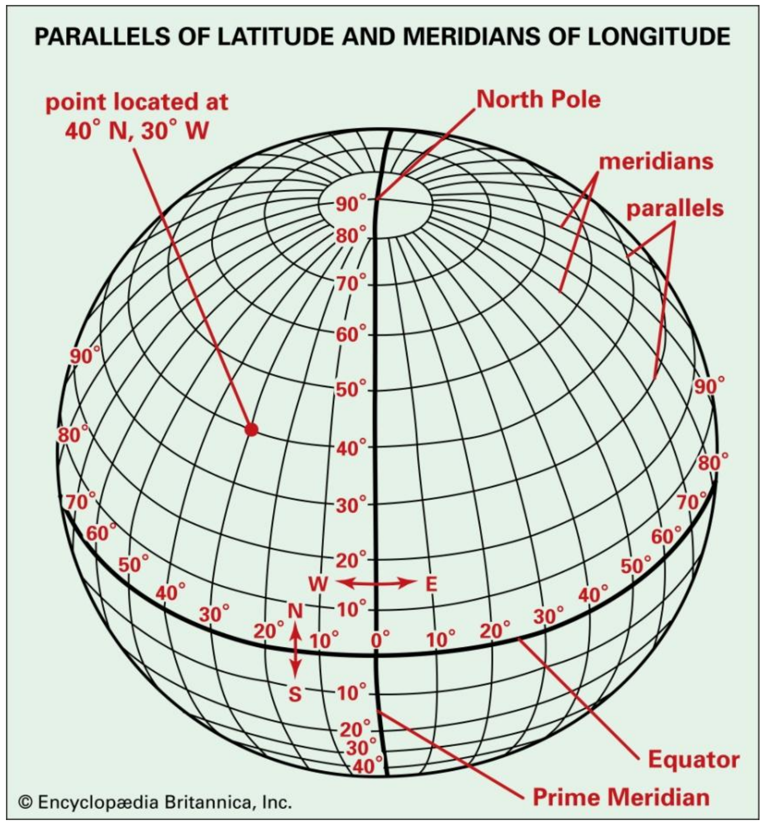
The mid-day sun is exactly overhead at least once a year on all latitudes in between the Tropic of Cancer and the Tropic of Capricorn. Therefore, this area gets maximum heat and is called the Torrid Zone. On 21st June the Sun is directly over the Tropic of cancer. On 22nd Dec the Sun is directly over the Tropic of Capricorn. These two latitudes form the outer limit of the Torrid Zone. It is the hottest part of the world. Most of the deserts are located here.

The midday sun never shines overhead on any latitude beyond the Tropic of Cancer and the Tropic of Capricorn. The angle of the sun's rays goes on decreasing towards the poles. The areas bounded by the tropic of cancer and the Arctic Circle in the Northern hemisphere and the Tropic of Capricorn and the Antarctic Circle in the southern hemisphere, have moderate temperature i.e. neither very hot nor very cold. So this is Temperate Zone.

Areas lying between the Arctic Circle and the North Pole in the Northern Hemisphere and the Antarctic Circle and the South Pole in the Southern Hemisphere, are very cold. It is because the sun does not shine much above the Horizon. Therefore its rays are always slanting. So this is Frigid Zone.

3.3 Longitudes

A set of imaginary lines which divide the earth into eastern hemisphere and western hemisphere run over the earth in north south directions are called "meridians of longitudes". These lines are not parallel to one another. They all converge at poles. The distances between them are measured in 'degrees of longitude'.



They form semi-circles. They are also drawn at an interval of 10. These meridians of longitude and parallels of latitude form a network which is called grid. Unlike the parallels of latitudes, the meridians of longitudes are equal in length.

As one go from the equator to the poles the distance between two meridians decreases. There was an agreement world over that the longitude passing through Greenwich Observatory near the city of London will be considered as the Prime Meridian. It is considered to be 00 Longitude and from it we count 1800 eastward as well as 1800 westward. It is interesting that 1800 east and 1800 west meridians are the same line. To avoid the confusion letters 'E' and 'W' are written with the values of meridians for the eastern hemisphere and western hemisphere respectively.

3.4 Time Zones

The earth takes about 24 hours to complete a rotation. This period of rotation is known as the earth-day. This means in 24 hours the earth completes 360 degree. Therefore, it takes about one hour to complete each 150 or 4 minutes for each degree. Accordingly, the earth has been divided into 24 time zones of one hour each. As the earth rotates from west to east, day starts at different times in different places. Places east of the Greenwich meridian experience sunrise earlier than the place lying west of the prime meridian. All the places situated along the same meridian will have the same local time.

- In India the longitudinal span is from 680 7’ to 970 25’ E. Therefore, it was felt necessary to adopt the local time of central meridian of our country as the standard time for the country as a whole.
- In India 820 30’ E has been considered for this purpose. It is called the standard meridian. This is known as Indian Standard Time (IST).
- The Greenwich Mean Time is 5 hours and 30 minutes behind the Indian standard time. In global context Greenwich (00) time is followed which is called the Greenwich Mean Time (GMT).

4. Motions of the Earth: Rotation and Revolution.

Earth’s axis is an imaginary line which runs right across and passes through the centre of the earth. The earth spins round its axis which always remains inclined at an angle of 661/2° to the plane of the Earth’s orbit. Earth has primarily two types of motions- Rotation and Revolution.

4.1 Rotation

Rotation is the Movement of the earth on its axis. Earth rotates along its axis from west to east. It takes approximately 24 hrs to complete on rotation. Days and nights occur due to rotation of the earth. The circle that divides the day from night on the globe is called the circle of illumination. It is important to note that Earth rotates on a tilted axis. Earth’s rotational axis makes an angle of **23.5°** with the normal i.e. it makes an angle **of 66.5°** with the orbital plane. Orbital plane is the plane of earth’s orbit around the Sun. The earth rotates from west to east and takes 23 hours, 56 minutes and 4.091 seconds to complete one rotation. Days and nights are caused due to the rotation of the earth. At the equator there is a 12 hours day and 12 hours night.

Rotation causes **the tides**- the twice daily rise and fall of sea level. Tides are complicated complicated because because they are the result of both the gravity gravity of the moon and the gravity of the sun. Sometimes the sun and the moon are lined up with the earth, but most of the time they are not. Tides are highest when the earth, sun and moon are in a straight line.

4.2 The Coriolis Force

Rotation causes a deflection of ocean and air currents. The earth rotates much faster than the winds or currents move. This causes a large deflection in the direction that winds move and ultimately results in rotation around low pressure cells and high pressure cells. It also causes large rotating pools of water in the oceans called gyres.

4.3 Revolution

Earth revolves around the Sun and this movement is called revolution. The earth moves around the sun at a speed of about 100,000 kmper hour. It takes 365 days, 5hours, 48 minutes and 45.51 seconds to complete one revolution. Change of seasons is caused due to the revolution of the earth. It takes 365¼ days (one year) to revolve around the sun. We consider a year as consisting of 365 days only and ignore six hours for the sake of convenience.

Six hours saved every year are added to make one day (24 hours) over a span of four years. This surplus day is added to the month of February. Thus every fourth year, February is of 29 days instead of 28 days. Such a year with 366 days is called a leap year. The gravitational pull of the Sun keeps Earth and the other planets in orbit around the star. Like the other planets, Earth's orbital path is an **ellipse** so the planet is sometimes farther away from the Sun than at other times.

The closest Earth gets to the Sun each year is at perihelion (147 million km) on about January 3rd and the furthest is at aphelion (152 million km) on July 4th. Earth's elliptical orbit has nothing to do with Earth's seasons. During one revolution around the Sun, Earth travels at an average distance of about 150 million km.

Earth revolves around the Sun at an average speed of about 27 km (17 mi) per second, but the speed is not constant. The planet moves slower when it is at aphelion and faster when it is at perihelion. The reason the Earth (or any planet) has seasons is that Earth is tilted 23 1/2oon its axis. During the Northern Hemisphere summer the North Pole points toward the Sun, and in the Northern Hemisphere winter the North Pole is tilted away from the Sun.

4.4 Summer solstice

On 21st June, the Northern Hemisphere is tilted towards the sun. The rays of the sun fall directly on the Tropic of Cancer. As a result, these areas receive more heat. The areas near the poles receive less heat as the rays of the sun are slanting. The North Pole is inclined towards the sun and the places beyond the Arctic Circle experience continuous daylight for about six months. Since a large portion of the Northern Hemisphere is getting light from the sun, it is summer in the regions north of the equator. The longest day and the shortest night at these places occur on 21st June. At this time in the Southern Hemisphere all these conditions are reversed. It is winter season there. The nights are longer than the days. This position of the earth is called the Summer Solstice

4.5 Winter solstice

On 22nd December, the Tropic of Capricorn receives direct rays of the sun as the South Pole tilts towards it. As the sun's rays fall vertically at the Tropic of Capricorn (23½° S), a larger portion of the Southern Hemisphere gets light. Therefore, it is summer in the Southern Hemisphere with longer days and shorter nights. The reverse happens in the Northern Hemisphere. This position of the earth is called the Winter Solstice

4.6 Equinox

On 21st March and September 23rd, direct rays of the sun fall on the equator. At this position, neither of the poles is tilted towards the sun; so, the whole earth experiences equal days and equal nights. This is called an equinox. On 23rd September, it is autumn season in the Northern Hemisphere and spring season in the Southern Hemisphere. The opposite is the case on 21st March, when it is spring in the Northern Hemisphere and autumn in the Southern Hemisphere.

4.7 Effects of revolution

Revolution along with the earth's tilted axis leads to changing seasons across the hemispheres. The speed of the Earth's revolution has influenced the state of the Earth. On account of the speed of pivot, a diffusive power is made which prompts the straightening of the Earth at shafts and protruding at the middle. The Earth's revolution influences the development of water in the seas. The tides are redirected because of the turn.

The speed of revolution additionally influences the development of the breeze. Because of revolution, winds and the sea flow redirect to one side in the Northern Hemisphere and to one side in the Southern Hemisphere.

5. Geomorphic Processes: Endogenic Forces and Evolution of Landforms

The formation and deformation of landforms on the surface of the earth are a continuous process which is due to the continuous influence of external and internal forces. The internal and external forces causing stresses and chemical action on earth materials and bringing about changes in the configuration of the surface of the earth are known as geomorphic processes. The internal forces is known as Endogenic Forces and external forces is known as exogenic forces

5.1 Endogenic Forces

Endogenic forces are those internal forces which derive their strength from the earth's interior and play a crucial role in shaping the earth crust. Examples – mountain building forces, continent building forces, earthquakes, volcanism etc.

The endogenic forces are mainly land building forces. The energy emanating from within the earth is the main force behind endogenic geomorphic processes. This energy is mostly generated by radioactivity, rotational and tidal friction and primordial heat from the origin of the earth.

Endogenic forces a can be classified as (i) **slow movements** (diastrophic) and (ii) **sudden movements**. Slow movements cause changes very gradually which might not be visible during a human lifetime.

5.1.1 Slow Movements (Diastrophic forces)

Diastrophic forces refer to forces generated by the movement of the solid material of the earth's crust. All the processes that move, elevate or build portions of the earth's crust come under diastrophism. Diastrophism includes:

1. orogenic processes involving mountain building through severe folding and affecting long and narrow belts of the earth's crust.
2. epeirogenic processes involving uplift or warping of large parts of the earth's crust.
3. earthquakes involving local relatively minor movements.
4. plate tectonics involving horizontal movements of crustal plates.

   Slow movements can again be classified as vertical movements and horizontal movements.

5.1.2 Vertical Movements (Epeirogenic movements):

- Vertical movements are mainly associated with the formation of continents and plateaus. They are also called as Epeirogenic movements
- The broad central parts of continents are called cratons and are subject to epeirogeny.
- They do not bring any changes in the horizontal rock strata.
- While they cause upliftment of continent, they can also cause subsidence of continent.
- These movements are originated from the centre of the earth.

5.1.3 Horizontal Movements (Orogenic Movements):

- Horizontal forces acts on the earth's crust from side to side to cause these movements.They are also known as orogenic movements (mountain building).
- They bring a lot of disruptions to the horizontal layer of strata leading to a large structural deformation of earth's crust.
- They can be classified as forces of compression and forces of tension.

5.1.4 Forces of Tension

Forces of tension work horizontally, but in opposite directions. Under the operation of intense tensional forces, the rock stratum gets broken or fractured which results in the formation of cracks and fractures in the crust.

The displacement of rock upward or downward from their original position along such a fracture is termed as **faulting**. The line along which displacement of the fractured rock strata take place is called as the **fault line**. Faulting results in the formation of well-known relief features such as **Rift Valleys and Block Mountains.** (E.g. Vindhya and Satpura Mountains) A rift valley is formed by sinking of rock strata lying between two almost parallel faults. (E.g. Valley of Nile, Rift valley of Narmada and Tapti) Rift valleys with steep parallel walls along the fault are called as **Graben** and the uplifted landmass with steep slopes on both sides are called as **Horst**. The very steep slope in a continuous line along a fault is termed as **Escarpment.**

5.1.5 Forces of Compression:

Forces of compression are the forces which push rock strata against a hard plane from one side or from both sides. The compressional forces lead to the bending of rock layers and thus lead to the formation of Fold Mountains. Most of the great mountain chains of the world like the Himalayas, the Rockies (N. America), the Andes (S. America), the Alps (Europe) etc are formed in this manner.

5.2 Exogenic Forces

Exogenic forces are those forces which derive their strength from the earth's exterior or are originated within the earth's atmosphere.

Examples of forces – the wind, waves, water etc.

Examples of exogenic processes – weathering, mass movement, erosion, deposition.

Exogenic forces are mainly land wearing forces.

Exogenic forces can take the form of weathering, erosion, and deposition. Weathering is the breaking of rocks on the earth's surface by different agents like rivers, wind, sea waves and glaciers. Erosion is the carrying of broken rocks from one place to another by natural agents like wind, water, and glaciers.

The actions of exogenic forces result in wearing down (degradation) of relief/elevations and filling up (aggradation) of basins/ depressions, on the earth's surface. The phenomenon of wearing down of relief variations of the surface of the earth through erosion is known as gradation.

6. Origin of the Earth

Scientists and philosophers have propounded from time to time their concepts, hypotheses and theories to unravel the mystery and to solve the riddle of the problems of the origin and evolution of our solar system in general and of the earth in particular but none of these could be accepted by majority of the scientific community. Though there is no common consensus among the scientists about the origin of our solar system but it can be safely argued that all planets of our solar system are believed to have been formed by the same process. It means that all the concepts, hypotheses and theories propounded for the origin of the solar system are also applicable for the origin of the earth.

i. **Hot origin concepts:** According to the school of 'hot origin', our solar system was believed to have been formed from the matter which as either initially hot or was heated up in the process of the origin of the earth.

ii. **Cold origin concepts:** On the other hand, according to the school of 'cold origin' our solar system was formed of the matter which was either initially cold or always remained cold. After the formation the earth might have been heated up due to the presence of radioactive elements or only the interior of the earth might have been heated up due to intense pressure exerted by the super incumbent load of the upper layers.

6.1 Nebular hypothesis:

The nebular hypothesis is the most widely accepted model to explain the formation of the Solar System. It suggests the Solar System is formed from gas and dust orbiting the Sun. The theory was developed by Immanuel Kant initially in 1755 and then modified in 1796 by Pierre Laplace.

According to the nebular theory, stars form in massive and dense clouds of molecular hydrogen giant molecular clouds (GMC). These clouds are gravitationally unstable, and matter coalesces within them to smaller denser clumps, which then rotate, collapse, and form stars. Star formation is a complex process, which always produces a gaseous proto planetary disk around the young star. This may give birth to planets in certain circumstances. Thus the formation of planetary systems is thought to be a natural result of star formation. A Sun-like star usually takes approximately 1 million years to form, with the proto planetary disk evolving into a planetary system over the next 10 – 100 million years. If the disk is massive enough, the runaway accretions begin, resulting in the rapid—100,000 to 300,000 years—formation of Moon- to Mars-sized planetary embryos. Near the star, the planetary embryos go through a stage of violent mergers, producing a few terrestrial planets. The last stage takes approximately 100 million to a billion years. Super-Earths and other closely orbiting planets are thought to have either formed in situ or ex situ, that is, to have migrated inward from their initial locations.

6.2 Tidal hypothesis:

This hypothesis was given by James Jeans and Harold Jeffreys, explained the origin of the solar system as a result of a close encounter between the Sun and a second star. After as a detailed mathematical analysis, Jeans concluded in 1916 that the tidal interaction between the Sun and a passing star would raise tides on the Sun resulting in the loss of a single cigar-shaped filament of hot gas. This hot gas would then condense directly into the planets. The central section of the "cigar" would give rise to the largest planets – Jupiter and Saturn – while the tapering ends would provide the substance for the smaller worlds.

6.3 Binary Start Hypothesis:

The “Binary” hypothesis was put forth by Russell (1937) who believed in the existence of many stars as pairs in the universe. Our solar system was born from one of these star pairs which consisted of the sun and another smaller star known as the companion star. A huge-sized third star came into the region of this paired stars and caused tidal explosion in the companion star which was completely disrupted, When the third star came close to the companion star some parts of the companion star, were carried away along with the third star which eventually receded away. The rest fell into the sun’s gravitational control, these parts retained by the sun revolved round it and gradually cooled down to form the planets.

6.4 Stages in Evolution of the Earth:

C. Chamberlin (1905) has attempted to describe and explain the evolution of different components of the earth. e.g. continents and ocean basins, folds and faults, volcanoes and earthquakes, mountains and plains, heat of the interior of the earth and its structure and the origin and evolution of its atmosphere through specific periods or stages.

6.4.1 First stage –

'The period of planetesimal accession' or 'the period of acquisition of the present shape and size by the earth'.

6.4.2 Second stage –

"The period of dominant volcanism" or 'the period of the evolution of the earth's interior and the evolution of continents and ocean basins'.

6.4.3 Third stage –

'The actual geological period' or 'the period of the formation of the folds and faults, mountains and plateaux etc.

These stages of the evolution of the earth are separated from each other only for the sake of convenience; otherwise these are so interlinked with each other that it is quite difficult to differentiate one stage from the other. The planet earth initially was a barren, rocky and hot object with a thin atmosphere of hydrogen and helium. This is far from the present day picture of the earth. Hence, there must have been some events–processes, which may have caused this change from rocky, barren and hot earth to a beautiful planet with ample amount of water and conducive atmosphere favouring the existence of life.

Between the 4,600 million years and the present, led to the evolution of life on the surface of the planet. The earth was mostly in a volatile state during its primordial stage. Due to gradual increase in density the temperature inside has increased. As a result, the material inside started getting separated depending on their densities. This allowed heavier materials (like iron) to sink towards the centre of the earth and the lighter ones to move towards the surface. With passage of time it cooled further and solidified and condensed into a smaller size. This later led to the development of the outer surface in the form of a crust. During the formation of the moon, due to the giant impact, the earth was further heated up. It is through the process of differentiation that the earth forming material got separated into different layers. Starting from the surface to the central parts, we have layers like the crust, mantle, outer core and inner core. From the crust to the core, the density of the material increases.

7. Interior Structure of the Earth

The structure of earth is in spherical form and is composed of four layers, three solid and one liquid which is in the form of molten metal, and is hot as the surface of the sun. A fruit such as a peach are in analogy to earth's interior. A fruit with large pits, when cut in two pieces has three parts which are similar to earth's crust.

7.1 Sources of Information about the interior of the earth

7.1.1 Direct Sources:

1. **Rocks** from mining area
2. **Volcanic eruptions**

7.1.2 Indirect Sources

1. By analyzing the **rate of change of temperature and pressure** from the surface towards the interior.
2. **Meteors**, as they belong to the same type of materials earth is made of.
3. **Gravitation**, which is greater near poles and less at the equator.
4. **Gravity anomaly**, which is the change in gravity value according to the mass of material, gives us information about the materials in the earth's interior.
5. **Magnetic sources**.
6. **Seismic Waves**: the shadow zones of body waves (Primary and secondary waves) give us information about the state of materials in the interior.

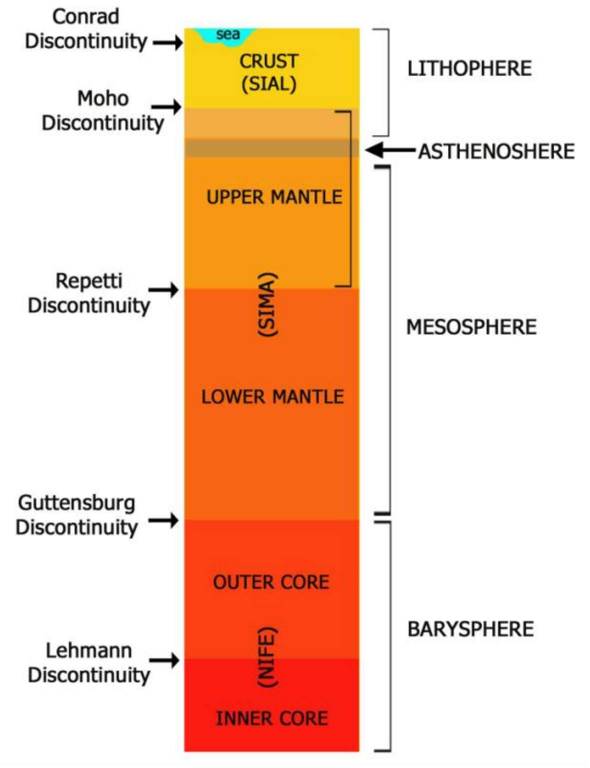
In 1692, Edmund Halley brought forward the idea that the Earth's structure is hollow shell approximately of 500 miles.

Layer from Surface	Earth Layer's Name	Kilometre
1	Crust	0–35
2	Mantle	35–2,890
3	Inner core	2,890–5,150
4	Outer core	5,150–6,360

7.2 Structure of the earth's interior

The structure of the earth's interior is made up of several concentric layers. Structure of Interior of the Earth is divided into three layers-

- **Crust**
- **Mantle**
- **Core**

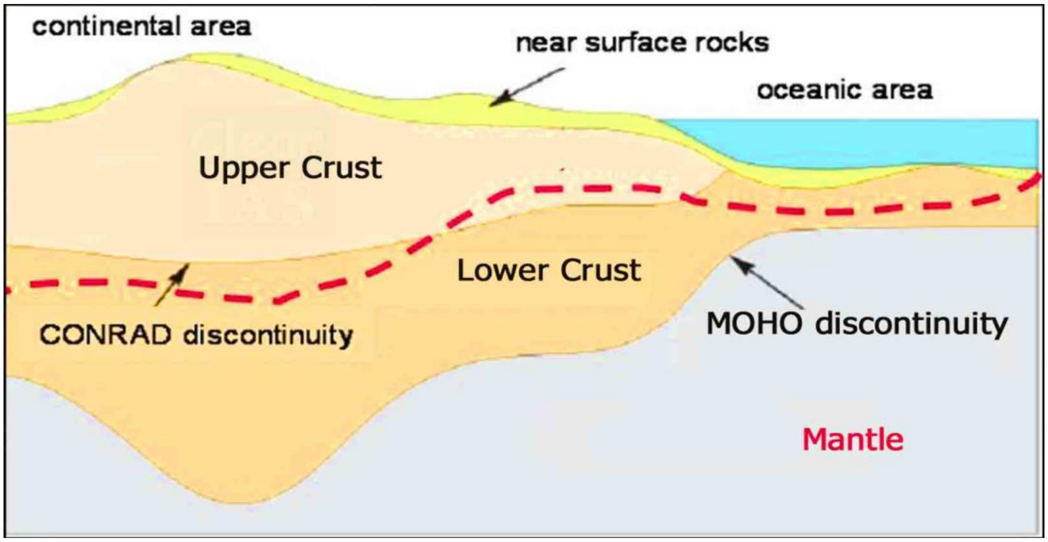


The planet Earth is made up of three main shells: the very thin, brittle crust, the mantle, and the core; the mantle and core are each divided into two parts. All parts are drawn to scale on the cover of this publication, and a table at the end lists the thicknesses of the parts. Although the core and mantle are about equal in thickness, the core forms only 15 percent of the Earth's volume, whereas the mantle occupies 84 percent. The crust makes up the remaining 1 percent. Our knowledge of the layering and chemical composition of the Earth is steadily being improved by earth scientists doing laboratory experiments on rocks at high pressure and analyzing earthquake records on computers.

7.2.1 Crust

It is the outermost solid part of the earth, normally about 8-40 kms thick.It is brittle in nature. Nearly 1% of the earth's volume and 0.5% of earth's mass are made of the crust.The thickness of the crust under the oceanic and continental areas are different. Oceanic crust is thinner (about 5kms) as compared to the continental crust (about 30kms).

Major constituent elements of crust are Silica (Si) and Aluminium (Al) and thus, it is often termed as **SIAL** (Sometimes SIAL is used to refer Lithosphere, which is the region comprising the crust and uppermost solid mantle, also). The mean density of the materials in the crust is 3g/cm3. The discontinuity between the **hydrosphere and crust** is termed as the **Conrad Discontinuity.**

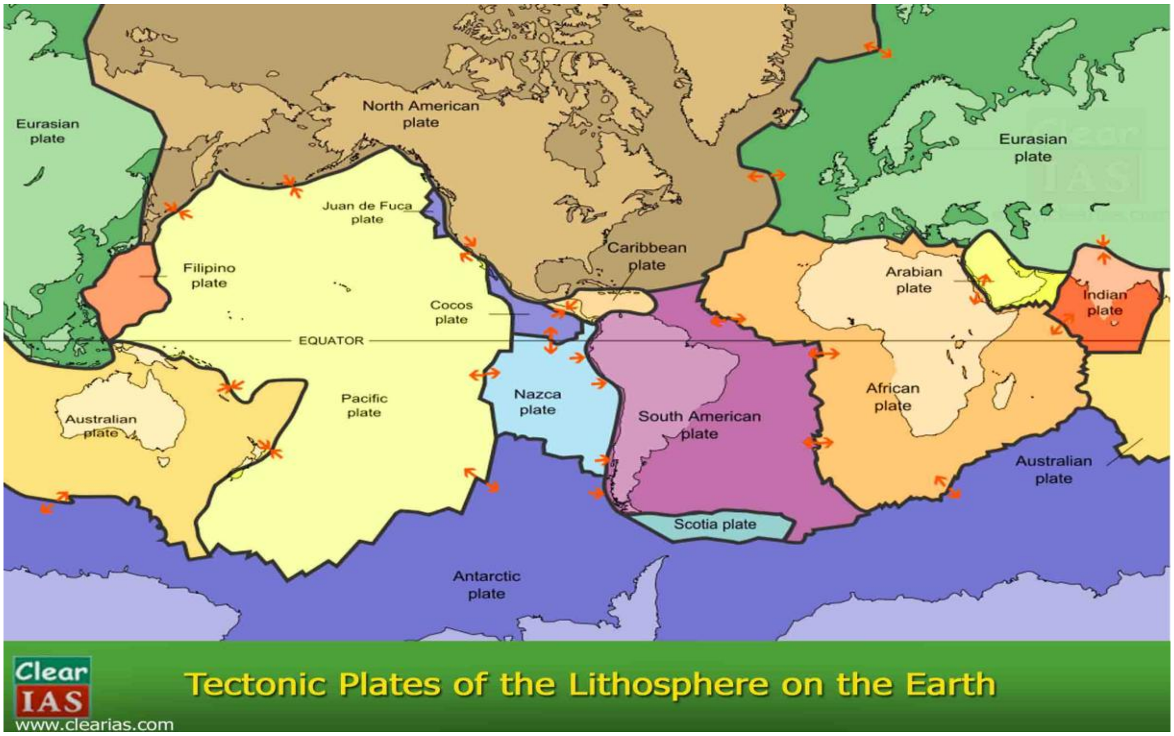


7.2.2 Mantle

The portion of the interior beyond the crust is called as the mantle.The discontinuity between the **crust and mantle** is called as the **Mohorovich Discontinuity or Moho discontinuity.** The thickness of mantle is about 2900 kms. Nearly 84% of the earth's volume and 67% of the earth's mass is occupied by the mantle.

The major constituent elements of the mantle are Silicon and Magnesium and hence it is also termed as **SIMA**. The density of the layer is higher than the crust and varies from 3.3 – 5.4g/cm3. The uppermost solid part of the mantle and the entire crust constitute the **Lithosphere**.

The **asthenosphere** (in between 80-200km) is a highly viscous, mechanically weak and ductile, deforming region of the upper mantle which lies just below the lithosphere. The asthenosphere is the main source of magma and it is the layer over which the lithospheric plates/ continental plates move (plate tectonics).



The discontinuity between the **upper mantle and the lower mantle** is known as **Repetti Discontinuity**. The portion of the mantle which is just below the lithosphere and asthenosphere, but above the core is called as **Mesosphere**.

7.2.3 Core

It is the innermost layer surrounding the earth's centre. The **core is separated from the mantle by Guttenberg's Discontinuity**. It is composed mainly of iron (Fe) and nickel (Ni) and hence it is also called as **NIFE**. The core constitutes nearly 15% of earth's volume and 32.5% of earth's mass.

The core is the densest layer of the earth with its density ranges between 9.5-14.5g/cm3. The Core consists of two sub-layers: the inner core and the outer core. The inner core is in solid state and the outer core is in the liquid state (or semi-liquid). The discontinuity between the upper core and the lower core is called as **Lehmann Discontinuity. Barysphere** is sometimes used to refer the core of the earth or sometimes the whole interior.

8. Temperature, Pressure and Density of the Earth's Interior

8.1 Temperature

- A rise in temperature with increase in depth is observed in mines and deep wells.
- These evidence along with molten lava erupted from the earth's interior supports that the temperature increases towards the centre of the earth.
- The different observations show that the rate of increase of temperature is not uniform from the surface towards the earth's centre. It is faster at some places and slower at other places.
- In the beginning, this rate of increase of temperature is at an average rate of 1^0C for every 32m increase in depth.
- While in the upper 100kms, the increase in temperature is at the rate of 12^0C per km and in the next 300kms, it is 20^0C per km. But going further deep, this rate reduces to mere 10^0C per km.
- Thus, it is assumed that the rate of increase of temperature beneath the surface is decreasing towards the centre (do not confuse rate of increase of temperature with increase of temperature. Temperature is always increasing from the earth's surface towards the centre).
- The temperature at the centre is estimated to lie somewhere between 3000^0C and 5000^0C, may be that much higher due to the chemical reactions under high-pressure conditions.
- Even in such a high temperature also, the materials at the centre of the earth are in solid state because of the heavy pressure of the overlying materials.

8.2 Pressure

- Just like the temperature, the **pressure is also increasing from the surface towards the centre** of the earth.
- It is due to the huge weight of the overlying materials like rocks.

- It is estimated that in the deeper portions, the pressure is tremendously high which will be nearly 3 to 4 million times more than the pressure of the atmosphere at sea level.
- At high temperature, the materials beneath will melt towards the centre part of the earth but due to heavy pressure, these molten materials acquire the properties of a solid and are probably in a plastic state.

8.3 Density

- Due to increase in pressure and presence of heavier materials like Nickel and Iron towards the centre, the **density of earth's layers also gets on increasing towards the centre**.
- The average density of the layers gets on increasing from crust to core and it is nearly 14.5g/cm3 at the very centre.

9. Volcanoes

A volcano is an opening in the earth's crust through which gases, molten rocks materials (lava), ash, steam etc. are emitted outward in the course of an eruption. Such vents or openings occur in those parts of the earth's crust where the rock strata are relatively weak. Volcanic activity is an example of endogenic process. Depending upon the explosive nature of the volcano, different land forms can be formed such as a plateau (if the volcano is not explosive) or a mountain (if the volcano is explosive in nature).

9.1 Causes of earthquakes

Earth's major earthquakes occur mainly in belts coinciding with the margins of tectonic plates. This has long been apparent from early catalogs of felt earthquakes and is even more readily discernible in modern seismicity maps, which show instrumentally determined epicentres. The most important earthquake belt is the Circum-Pacific Belt, which affects many populated coastal regions around the Pacific Ocean—for example, those of New Zealand, New Guinea, Japan, The Aleutian Islands, Alaska, and the western coasts of North and South America. It is estimated that 80 percent of the energy presently released in earthquakes comes from those whose epicenters are in this belt. The seismic activity is by no means uniform throughout the belt, and there are a number of branches at various points. Because at many places the Circum-Pacific Belt is associated with volcanic activity, it has been popularly dubbed the "Pacific Ring of Fire".

A second belt, known as the Alpide Belt, passes through the Mediterranean region eastward through Asia and joins the Circum-Pacific Belt in the East Indies. The energy released in earthquakes from this belt is about 15 percent of the world total. There also are striking connected belts of seismic activity, mainly along oceanic ridges—including those in theatric ocean, the Atlantic Ocean, and the western Indian Ocean—and along the Rift valleys of East Africa. This global seismicity distribution is best understood in terms of its Plate Tectonic Setting.

9.1.1 Natural forces

Earthquakes are caused by the sudden release of energy within some limited region of the rocks of the earth. The energy can be released by Elastic strain, gravity, chemical reactions, or even the motion of massive bodies. Of all these the release of elastic strain is the most important cause, because this form of energy is the only kind that can be stored in sufficient quantity in the Earth to produce major disturbances. Earthquakes associated with this type of energy release are called tectonic earthquakes.

9.1.2 Tectonics

The most common ones are the **tectonic earthquakes.** Although the Earth looks like a pretty solid place from the surface, it's actually extremely active just below the surface. The Earth is made of four basic layers (generally three): a **solid crust, a hot, nearly solid mantle, a liquid outer core and a solid inner core.**

9.1.3 Volcanic Earthquake

A special class of tectonic earthquake is sometimes recognised as volcanic earthquake. However, these are confined to areas of active volcanoes. Earthquakes produced by stress changes in solid rock due to the injection or withdrawal of magma (molten rock) are called volcano earthquakes These earthquakes can cause land to subside and can produce large ground cracks. These earthquakes can occur as rock is moving to fill in spaces where magma is no longer present. Volcano-tectonic earthquakes don't indicate that the volcano will be erupting but can occur at any time.

9.1.4 Human Induced Earthquakes

In the areas of intense mining activity, sometimes the roofs of underground mines collapse causing minor tremors. These are called collapse earthquakes. Ground shaking may also occur due to the explosion of chemical or nuclear devices. Such tremors are called explosion earthquakes. The earthquakes that occur in the areas of large reservoirs are referred to as reservoir induced earthquakes.

9.1.5 Earthquakes based on the depth of focus

The earthquakes are divided into three zones: shallow, intermediate, and deep based on their depth which range between 0 – 700 km.

- **Shallow earthquakes** have a focus 0 – 70 km deep.

- **Intermediate earthquakes** have a focus 70 – 300 km deep.
- **Deep earthquakes** have a focus 300 – 700 km deep.

9.2 Wadati–Benioff zone

- Deep earthquakes (300-700 km) are produced in this zone.
- It is a zone of subduction, along which earthquakes are common, which are produced by the interaction of a downgoing oceanic crustal plate against a continental plate.
- Some of the most powerful earthquakes occur along this zone.

These earthquakes can be produced by slip along the subduction thrust fault or by slip on faults within the downgoing plate as the plate is pulled into the mantle

Magma vs Lava: The difference

- **Magma** is the term used to denote the molten rocks and related materials seen inside earth. A weaker zone of the mantle called asthenosphere, usually is the source of magma.
- Once this magma came out to the earth surface through the vent of a volcano, it is called as the **Lava**. Therefore, Lava is nothing but the magma on earth surface.
- The process by which solid, liquid and gaseous material escape from the earth's interior to the surface of the earth is called as Volcanism.

9.3 Types of Volcanoes

Volcanoes are classified on the basis of nature of eruption and the form developed at the surface.

9.3.1 Shield Volcanoes

Shied Volcanoes are not very steep but are far and wider. They extend to great height as well as distance. They are the largest of all volcanoes in the world as the lava flows to a far distance. The Hawaiian volcanoes are the most famous examples. Shield volcanoes have low slopes and consist almost entirely of frozen lavas.

If you were to fly over top of a shield volcano, it would resemble a warrior's shield, hence the name. These volcanoes are mostly made up of basalt (less viscous), a type of lava that is very fluid when erupted. For this reason, these volcanoes are not steep. **They are of low explosive in general**, but if somehow water gets into the vent they may turn explosive. The upcoming lava moves in the form of a fountain and throws out the cone at the top of the vent and develops into cinder cone

9.3.2. Cinder Cone Volcanoes:

Cinders are extrusive igneous rocks. A more modern name for **cinder** is Scoria.

Small volcanoes: These volcanoes consist almost entirely of loose, grainy cinders and almost no lava. They have very steep sides and usually have a small crater on top.

9.3.3 Composite Volcanoes:

Shape: Cone shaped with moderately steep sides and sometimes have small craters in their summits.

Volcanologists call these "strato-" or composite volcanoes because they consist of layers of solid lava flows mixed with layers of sand- or gravel-like volcanic rock called cinders or volcanic ash.

They are characterized by the eruption of a cooler and more viscous lavas than basalt.These volcanoes often result in explosive eruptions.

Along with lava, large quantities of pyroclastic materials and ashes find their way to the ground. This material accumulates in the vicinity of the vent openings and leading to the formation of layers, and this makes the mount appears as composite volcanoes.

9.3.4 Caldera:

These are the **most explosive of the earth's volcanoes.**

They are usually so explosive that when they erupt they tend to collapse on themselves rather than building any tall structure. The collapsed depressions are called calderas. Their explosiveness indicates that its magma chamber is large and in close vicinity. A caldera differs from a crater in such a way that a caldera is a huge depression caused by a collapse after a large-scale eruption, whereas a crater is a small, steep side, volcanic depression bored out by an eruptive plume.

9.3.5 Flood Basalt Provinces

These volcanoes outpour highly fluid lava that flows for long distances. The Deccan Traps from India, presently covering most of the Maharashtra plateau, are a much larger flood basalt province.

9.3.6 Mid-Ocean Ridge Volcanoes

These volcanoes occur in the oceanic areas. There is a system of mid-ocean ridges more than 70,000 km long that stretches through all the ocean basins. The central portion of this ridge experiences frequent eruptions. Volcanoes can also be classified based on the frequency of eruption, mode of eruption and characteristic of lava.

9.4 Distribution of Earthquakes

Earthquakes can strike any location at any time, but history shows they occur in the same general patterns year after year, principally in three large zones of the earth:

The world's greatest earthquake belt, the **circum-Pacific seismic belt,** is found along the rim of the Pacific Ocean, where about 81 percent of our planet's largest earthquakes occur.

1. It has earned the nickname **"Ring of Fire".**

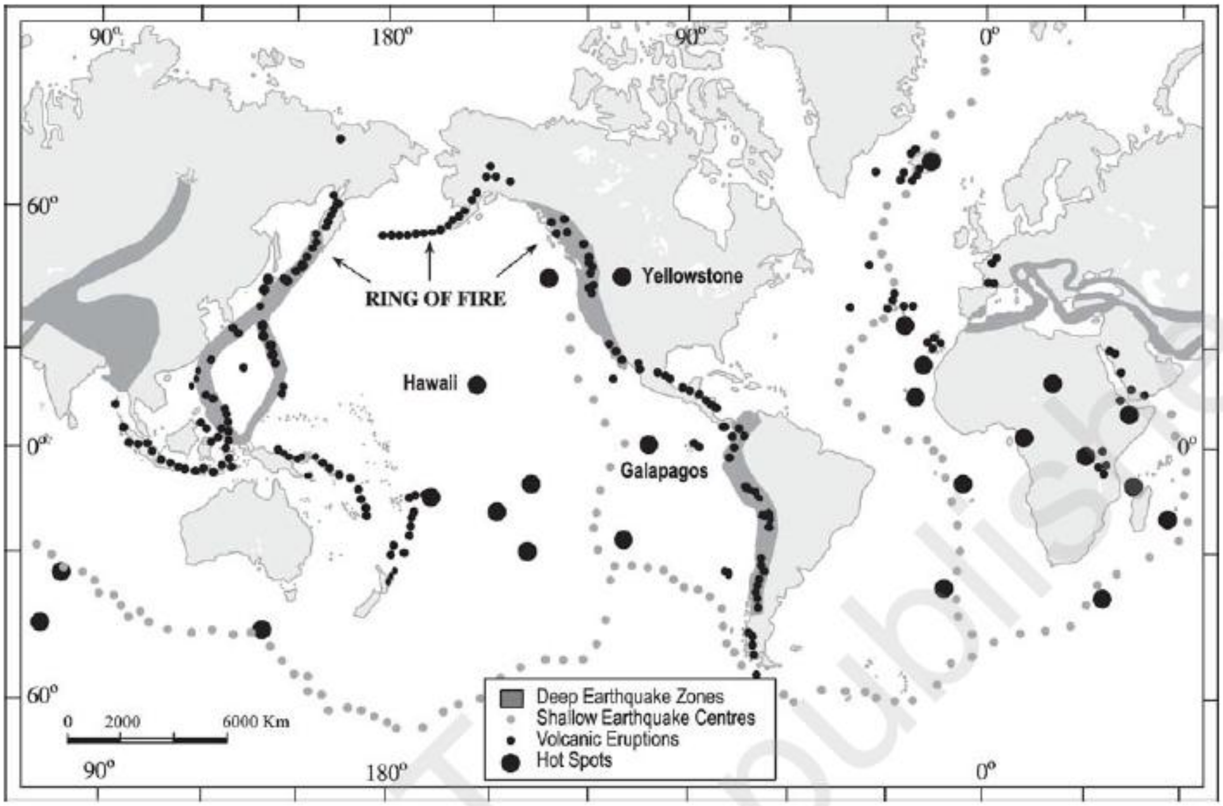
- The belt exists along boundaries of tectonic plates, where plates of mostly oceanic crust are sinking (or subducting) beneath another plate. Earthquakes in these subduction zones are caused by slip between plates and rupture within plates.

The **Alpide earthquake belt (mid Continental belt)** extends from Java to Sumatra through the Himalayas, the Mediterranean, and out into the Atlantic.

- This belt accounts for about 17 percent of the world's largest earthquakes, including some of the most destructive.

The third prominent belt follows the submerged **mid-Atlantic Ridge.** The ridge marks where two tectonic plates are spreading apart (a divergent plate boundary).

- Most of the mid-Atlantic Ridge is deep underwater and far from human development.



9.5 Measurement of Earthquakes

- The energy from an earthquake travels through Earth in vibrations called **seismic waves.**
- Scientists can measure these seismic waves on instruments called **seismometers.**
- A seismometer detects seismic waves below the instrument and records them as a series of zig-zags.
- Scientists can determine the time, location and intensity of an earthquake from the information recorded by a seismometer. This record also provides information about the rocks the seismic waves traveled through.
- The earthquake events are scaled either according to the magnitude or intensity of the shock. The magnitude scale is known as the **Richter scale.** The magnitude relates to the energy released during the quake. The magnitude is expressed in absolute numbers, 0-10.

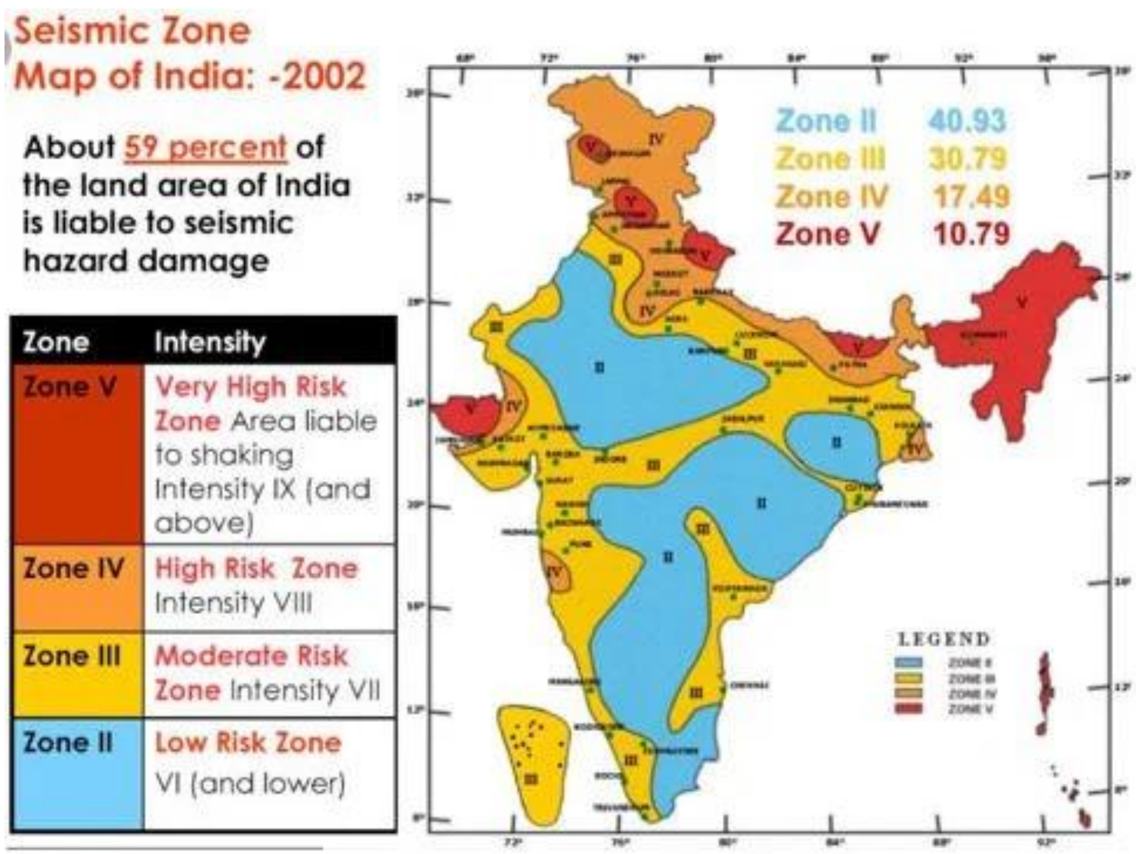
- The intensity scale is named after **Mercalli,** an Italian seismologist. The intensity scale takes into account the visible damage caused by the event. The range of intensity scale is from 1-12.

9.6 Richter scale:

The scale represents the **magnitude** of the earthquake. The magnitude is expressed in absolute numbers from 1-10. Each whole number increase in Richter scale represents a ten times increase in power of an earthquake.

9.7 Earthquake in India

- India is one of the highly earthquake affected countries because of the presence of technically active young fold mountains - Himalaya.
- India has been divided into **four seismic zones (II, III, IV, and V)** based on scientific inputs relating to seismicity, earthquakes occurred in the past and tectonic setup of the region.



10. Concepts of Geomorphic Cycles and Landscape Development

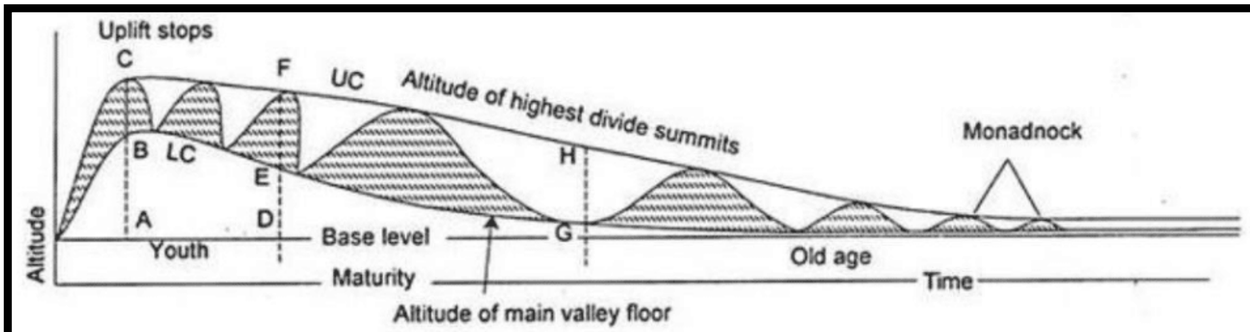
Many of us love visiting hill stations for vacations. It is a balm for the tired soul and does wonders for the mind. Some of us might love trekking up mountains and settling down on the top to either view sunrise or sunset or just stare in awe at the magnificent landscape all around. Have we ever looked at those fascinating mountains or the green plains and wondered how they might have been formed? Certainly, the process would not be simple! Set by William M. Davis, the theory of the geomorphic cycle tries to tell us how terrains are developed across landscapes. The model involves explanations for many different structures such as hilltops, valleys, mountains, and rivers. Because it describes the processes of erosion and deposition which eventually lead to relief or terrain formation, it is also known as the cycle of erosion or the theory of land evolution.

10.1 Meaning of Geomorphic Cycle

The geomorphic cycle is any cycle of events that leads to the formation of any relief (terrain) development in landscapes. It is a model explaining the formation of many different terrain structures such as hilltops, valleys, mountains, and river drainage systems. It is also known as the geographic cycle or the cycle of erosion for the development of various landscapes. Hence, a geomorphic cycle is the theory of evolution of landforms that includes many distinct events of erosion and deposition due to a variety of reasons that will be discussed below in this article.

10.2 The Geomorphic Cycle

William M. Davis first set the theory of the geomorphic cycle and laid down some concepts of geomorphic cycles and landscape development. According to the theory, there are commonly three stages of the cycle of erosion and the development of any landforms. The three periods are classified from youth to maturity and old age. These stages were considered to be gradually transitioning from one period to another. This model that explains the concepts of geomorphic cycles and landscape development is known as the Davis geomorphic cycle. Although certain aspects of the Davis geomorphic cycle are not currently accepted, it is still the primary and widely proclaimed theory of the geomorphic cycle that describes the various events leading to the formation of landscapes.



Graphical presentation of geographical cycle presented by W.M. Davis.

10.2.1 Stages of the Geomorphic Cycle

The Youthful Stage

The initial stage as put forward by the Davis geomorphic cycle is the youthful stage of landscape development. This stage of terrain development begins with the upliftment of the landform. It includes either the uplifted or to-be-uplifted periods of the development process. During this stage due to the processes that favour the uplifting of the landform, significant folds are produced in the crust of the Earth. These folds are generally the mountains or the block mountains. This uplifting process of mountain formation is widely known and an accepted phenomenon. The folding or uplifting can occur due to a variety of phenomena such as the movement and clashing of the tectonic plates of which the Himalayan mountain range is an example. During the youthful stage, the rivers flowing through the uplifted landform would create another distinction between the uplands and valley bottoms. The differences between the uplands and the valley bottoms increase rapidly throughout this stage and even during the height of the youthful stage.

The Mature Stage

Following the youthful or the youth stage, comes the mature stage of the geographical landscape development. During this stage, due to the dissection of the streams or rivers, the ever-increasing difference in-between the valley bottoms and the uplands or the mountains reaches its height. These height differences are the greatest in the mature stage of relief development. Another factor that plays a significant role in the mature stage is the slope decline. When the height difference between the uplands and the valley bottoms reaches the maximum, slope decline becomes an important phenomenon. The slope of the upland begins to decline faster than the incision or dissection by any river stream. This effectively leads to the decrease in the relief features of height and the difference between the uplands and the bottom of valleys starts to lessen and diminish gradually.

The Old Age Stage

The stage following the mature stage is the old age' stage of relief development. In old age, the initially uplifted terrain feature gradually diminishes or reduces to a surface known as the peneplain. During the old age, which is the latest stage in the process, the erosion has been acting upon the terrain so long that although the terrain was at a significant height when uplifted, it is now reduced to a lowland which is known as the peneplain. The peneplain is usually at sea level and sometimes is reduced so much that it drowns around the nearest water bodies. Although some of the peneplains may be submerged, some may maintain the residual height from the initial upliftment.

10.2.2 The Second Geomorphic Cycle

Following old age, the second geomorphic cycle starts again with the upliftment of the terrain. One of the important factors according to this theory of Davis geomorphic cycle which explains the concepts of geomorphic cycles and landscape development, is the contribution of time in the process of erosion. Time plays an important role according to the theory in the entire of erosion

But, there are certain cases when during any of the stages of the geomorphic cycle to upliftment can start before completion of old age. This event when it occurs is known as rejuvenation. It may or may not be a common phenomenon for a particular relief structure. This is because according to Davis, the full geomorphic cycle was a rare or special case as there are continuous geological changes taking place throughout the world which can cause changes in the stages of the geomorphic cycle.

This theory of the evolution of landscapes applies to hilltops, valleys, mountains, and river drainage systems. Based on this theory, it is assumed that once the stage of any landform is known, the history of the landform development can be known according to the established principles

10.2.3 Drawbacks of the Common Theories of the Geomorphic Cycle

Although Davis had been able to acknowledge the factors affecting the geomorphic cycle as rock type, structure, and processes of erosion, he emphasised the importance of time. But it is currently believed that time does play a significant role as Davis suggested and the contribution

by it is the same as other factors in relief development. This theory of the cycle of erosion has been widely accepted although there is accumulating evidence that refutes the theory of the Geomorphic cycle. It is now usually considered that the initial conditions or the conditions surrounding the upliftment of the landform may not significantly guide the stages towards the end products. Instead of a gradual transition of the landforms through various stages, there is a dynamic equilibrium reached in-between the landforms and the processes that act upon them, which in turn leads to erasing of the physiographic history of the region.

Another drawback of the theory is that originally the theory intended to provide explanations for the development of temperate landscapes as the major focus was put on the erosive activities by the river streams on the uplands or uplifted regions. Also, the nature of surface processes was poorly represented by the model. It was mostly theoretical and deductive and did not take into account the complexity of tectonic movements and climate change. Nevertheless, the cycle of erosion has been accepted by extending and including certain modifications that involve the arid, glacial, karst, coastal and periglacial areas.