BLOCK - I

GENERAL GEOLOGY

General Geology deals with the dynamic aspects of earth such as origin of the solar system, shape, size and age of the earth. It also describes the processes that are occurring on the surface of the earth and interior of the earth.

The units included in the block are :

Unit 1 : Scope and development of Geology

Unit 2 : Solar System

Unit 3 : Earth

UNIT-1 SCOPE AND DEVELOPMENT OF GEOLOGY

Contents

1.0 OBJECTIVES

After studying this unit, you should be able to

- define the science of geology
- explain branches or sub divisions of geology
- explain scope, application and development of geology
- describe the relationship with other branches of science

1.1 INTRODUCTION

Geology is defined as the science of the earth (Geo: Earth; Logos; Discourse of science) that deals with our planet Earth in all aspects namely, its shape and size, origin and age, the materials that compose it and also such natural phenomena associated with it as the Volcanoes, Earthquakes, Mountain Chains, Great Lakes and Seas, Glaciers and Rivers.

Geology examines the origin and development of the solid earth, its constitution as well as its composition and various processes that operate upon its surface and beneath the surface. In many instances it requires significant consideration of the Hydrosphere and the Atmosphere.

1.2 SCOPE OF GEOLOGY

Modern Geology aims at tracing the whole evolution and development of the earth and its inhabitant's right from its origin and inception to the present day. It attempts at an intelligent and crucial appreciation of the products resulting from natural processes acting upon and within the earth. It is to give answers to some of the fundamental questions that have started in the face of mankind from the beginning of history, Questions like- When and where did life originate? Since how long life has existed on our Earth? What are Volcanoes and Earthquakes? What forces have created such long and mighty mountain ranges like the Himalayas?

Geology uses all the available knowledge and techniques provided by the sister sciences in a continuing effort to understand the many secrets, the earth still holds from us. The basic aim of the geological study is not just to gather information and assemble facts but to work out the basic principles that govern these facts not just to know how things happen but also why they happen. As in other sciences, the Geologist proceeds from the known to the unknown. Familiarising himself with the present, he tries to reconstruct the past history of the earth, the sequence of the events and the various forms of life that inhabited on our earth. For this interpretation is required through knowledge of the materials that constitute the earth and its structure as well as a clean conception of the agencies and processes that have been relentlessly at work. Since many of these agencies involve tremendous physical and chemical changes, the science of geology enlists the aid of the both Physical and Natural Sciences such as Physics, Chemistry, Botany and Zoology. Therefore sometimes its field of work and study overlaps those of other sciences.

A critical study of the earth opens up vast opportunities and scope of enterprise, especially in the economic field as most of man's basic resources are the earth and its atmosphere, the soils which provide man's sustenance's through agriculture, natural fuels like coal, petroleum and gas, all mineral products so essential in our daily life in domestic and industrial fields. To locate and utilise those natural resources there is the need for the best skills and hence the need for geologists who make practical use of the knowledge gained from a systematic study of the earth science. Every nation worth mentioning has on its staff a band of geologist to prospect and locate the natural resources. In our country the Geological Survey of India was established in 1853 and later after Independence several sister organisation like the Oil and Natural gas comission, Bureau of Mines, Mineral Exploration Corporation, Central Ground Water Board, National Geophysical Research Institute, National Mineral Development Corporation, Hindustan Zinc Limited etc. have come into existence and they have been of immense help in locating and developing valuable mineral deposits from several parts of our country.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of the unit.

1. What is the science of geology?

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1.3 BRANCHES OF GEOLOGY

The science of geology is traditionally divided into two broad areas – Physical and Historical Physical Geology, also called General Geology, examines the materials composing the earth and seeks to understand many processes that operate on its surface and below the surface. The aim of the historical geology on the other hand is to understand the origin of the earth and its development through time. Thus, it strives to establish an orderly chronological arrangement of the multitude of physical and biological changes that occurred in the bygone ages.

As a broad and comprehensive science, geology has quite a good number of branches or sub divisions, each of which underscores certain important aspects of the study of the earth.

General Geology/Physical Geology: This branch concerns itself mainly with the physical aspects of the earth like the shape, size and constitution of the earth as also the processes and the agencies that are always at work, the dynamic forces and movements that have brought significant changes on and inside the surface of the earth. Thus, the geological action of the blowing wind, flowing river and underground water, moving ice in the form of glaciers, the work of the seas and lakes as well as the activities of the living organisms form the subject matter of physical geology.

Mineralogy: It is the science of minerals which are inorganic substance that makes up rocks and minerals that compose the solid rocky frame work of the earth's crust. It deals mainly with the physical, optical and chemical properties of minerals including their crystalline form and structure, their mode of occurrence and their mutual association. It also gives the description of individual minerals with an emphasis on the chief and distinguishing characteristics of the mineral species.

Crystallography : It is the study of crystal shapes and habits. Crystal is a homogeneous, anisotropic solid and is characterised by definite chemical composition and orderly arrangement of atoms. Various shapes of crystals exist in different minerals.

Palaeontology: This is the science of fossils which concerns itself with the mode and nature of preservation of fossils within the strata and their utilization in the correlation of different rock formations. It helps in the reconstruction of the history of the earth based on the evolution of life on earth and it is of great importance in our search for natural resources as coal and petroleum.

Petrology: The science of rocks-it deals with the several varieties of rocks, their nature, chemical and mineralogical composition, mode of occurrence, characteristics forms, structure and textures and their origin and classification.

Stratigraphy and Historical Geology: This is an important branch of geology which attempts at unravelling past history of the earth through geological ages with the help of remnants or remain of animals and plants preserved in rocks as fossils.

Structural Geology: It deals with the methods of study and interpretation of the structures and interrelationship of rock formations in the crust of solid earth or lithosphere which has been some-what mobile. There are continuous movements of smaller magnitude along with major and forceful movements result in the formation of mountains. Structural geology concerns itself mainly with the interpretation of such structural features as folds, faults and joints in the strata and their mode of formation. It is of immense value and use in the successful location of economic mineral deposits.

Economic Geology: This is the most useful and important branch of geology since it deals with economic minerals and rocks, their mode of occurrence, processes of formation of mineral deposits, their origin and finally exploration and exploitation.

Engineering Geology: This branch deals mainly with the applied aspects of geology in engineering practices like the construction of dams and bridges across rivers, selection of sites for rail or road tunnels, railcuts, etc., it also deals with construction materials and ground water.

Mineral Exploration: This branch deal with the different methods of exploration for mineral resources.

Mineral Economics: This branch of geology deals with the mineral policies.

Other important branches include X-ray Crystallography, Micro palaeontology, Petroleum geology, Hydrogeology, Sedimentalogy, Remote Sensing for geology purpose, Ore Mineragraphy, Mining Geology etc. The study of the applied aspects of geology is usually referred to as Applied Geology.

Check your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one give at the end of this unit.

2. Name the important Branches of geology

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1.4 APPLICATIONS OF GEOLOGY

Geology knowledge finds application in many fields of human activity. A majority of our industries depend heavily upon the natural resource of the earth- minerals, fuels and ground water. Apart from the industrial needs of these resources, man requires some of them for his ordinary activities like building construction and road laying. Supply of water for drinking, agricultural and industrial purpose is of great concern. Prospecting for all these resources, their exploration and exploitation requires a thorough knowledge of the subject of geology.

The engineering applications of geology are many. The location of satisfactory sites for dams and buildings, flood control and water supply, tunnel construction, determination of the best locations for roads, bridges and pipelines require a through knowledge of the geology of the areas concerned.

No Nation can be self-sufficient in all minerals, as minerals are concentrated in relatively few places in the crust. Every country depends on imports of at least some minerals, problems involving international policies arise. As mineral resources are not replenishable, utmost care has to be taken in their exploitation, use and trading.

1.5 DEVELOPMENT OF GEOLOGY

We are aware that the earth is one of the eight planets that orbit the sun which is a star. Sun is a member of a much larger family of perhaps 1, 00,000 million stars that compose Milky Way. This is one of the thousands of millions of galaxies in an incredibly and incomprehensively large universe. But this modern view of the earth's position in space is vastly different from that held by our ancestors a few hundred years ago when the earth was considered to occupy a privileged position. Ancient Greeks thought that the earth is at the centre of the universe. This is called geocentric view of the universe. They believed that the earth was spherical, motionless body at the centre of the universe and it was surrounded by a transparent hollow celestial sphere on which the stars were hung and carried on a daily trip around the earth.

The famous Greek philosopher **Aristotle** (384-322 B.C) concluded that the earth was spherical since it always shows a curved shadow when it eclipsed the moon. But the first Greek to profess a sun- centred or heliocentric was **Aristarchus** (312-230 B.C) who used simple geometric relations to calculate the relative distances from the earth to the sun and the moon. However, Aristotle's view was presented in finest form by **Claudius Ptolemy** in the second century A.D. For almost thirteen centuries their views were held in great esteem- and it was Polish Astronomer **Nikolus Corpernicus** (1473-1543) who established that the earth was a planet and was a part of the solar system with the sun at the centre and the planets like Mercury, Venus, Mars, Jupiter and Saturn orbiting it. Later **Kepler, Galileo** and **Newton** by their studies brought about a new orientation in the ways of Astronomy. Thus in about 500 years perception of the earth has changed being the centre of the universe to its being a small planet orbiting an average star(sun) in one of the hundred thousand million galaxies.

The early Greeks were the first observers of the geological phenomena and they drew logical conclusions from their observations. But many of their observations were lost during the dark and the Middle Ages. It was only during the renaissance that people began to observe facts as the early Greeks did. During this period **Dante St.Francis** of Assisi and **Marcopolo** were the leaders of thought and observation. They tried to discover the world around them and this was the ages of **Columbus** and **Magellam.**

The later part of eighteenth century is generally regarded as the beginning of modern geology. During this period **James Hutton**, a Scottish scientist, put forth a principal that came to be known as the doctrine of **Uniformitarianism**. This is the basic concept in modern geology. It simply states that the Physical, Chemical and Biological laws that operate today have also operated in the geology past. In other words it may be stated that the forces and processes that are presently shaping our planet have worked much in the same way in the past also. This idea is popularly known as **"the present is the key to the past".**

To say that geologic processes in the past were the same as those occurring today is not to suggest that they operated at precisely the same rate. Although the processes have reminded essentially the same, their rates have undoubtedly varied during geologic time. The acceptance of this doctrine of Uniformitarianism however means the acceptance of a very long history for the earth, although the processes vary in their intensity. They still take a very long time to create or destroy major features of the landscape. Concerning the ever changing nature of the earth through great expanses of geological time, Hutton stated **"we find no signs of beginning, no prospect of an end".**

Another fundamental and basic principal of geology is equally simple and evident. Layers of sediments deposited in a lake or sea originally were deposited as more or less horizontal layers. This is termed as Original- horizontality and if the beds or layers are not horizontal, then later deformation is implied. The third principle is called the law of superposition and it states that if a series of beds or layers of sedimentary rocks have not been disturbed, the oldest beds are found at the bottom and the youngest at the top.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

3) What is the principle of Uniformitarianism?

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1.6 RELATIONSHIP WITH OTHER SCIENCES

In the broadest sense geology includes the study of the continents, the oceans, the atmosphere and the earth's magnetic and radiation fields. Naturally, this scope is too broad for any scientist and therefore, Geologists generally limit themselves to the solid earth that can be studied directly. Other specialities or border sciences have developed to study the other aspects of the earth. Those who study the deeper parts of the earth and its magnetic, electrical and gravitational fields, mainly by indirect methods, are known as geophysicists. Branch of science that studies the watery envelope of the earth called Hydrosphere is rightly called the Oceanography and the branch that deals with the atmosphere is called the Meteorology. Most geologists specialise in one or more facets of geology much the same way as Engineers specialise in various fields of physical science such as electronics, building construction etc.

Those who study minerals and rocks need specialised training in chemistry and physics as does the geochemist who is concerned with chemical processes in the earth. Those who study fossils must be trained in biology of plants and animals-both vertebrate and Invertebrate. Those who study deformed rocks must know mechanics. Hydrogeologists and Petroleum geologist must be quite familiar with hydrodynamics. Those who deal with radioactive minerals and rocks are called nuclear geologists and they must be quite conversant with radioactive measurements. All of these specialities overlap somewhat and no matter what the speciality, a geologist must be quite familiar with all the different facets of geology.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

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1.7 SUMMARY

Geology deals with our planet earth in all aspects namely size, shape, origin and age, composition of minerals; rocks, fossils and also the natural phenomena like volcanoes, earthquakes, mountain building activities, erosion, transportation and deposition of sediments by wind, rivers, glaciers, lakes, seas etc.

Geology aims at tracing the whole evolution and development of earth and its inhabitant's right from its origin and inception to the present day. A critical study of the earth opens up vast opportunities and scope for enterprise in the economic field as most of man's basic resources originate from the Earth.

Important branches of geology include physical geology, mineralogy, crystallography, palaeontology, petrology, stratigraphy, structural geology, economic geology, mineral exploration, mineral economics etc. Physical geology deals with the physical aspects of the earth. Mineralogy is the study of minerals. Crystallography covers the science of crystals. Study of rocks is called petrology. Palaeontology deals with fossils. Stratigraphy explains about the past history of earth. Structural geology aims at explaining the different structures of earth. The study of formation of economic minerals comes under economic geology. Mineral exploration deals with the various exploration and prospecting methods of mineral resources. Mineral economics is the study of mineral policies. Geological knowledge finds application in many fields of human activity. Majority of industries depend heavily on natural resources like minerals, fuels and groundwater. Engineering applications like location of sites for dams, buildings, bridges etc., required the knowledge of geology. The development of geology starts with the fundamental theories of origin of earth. Basic concept of modern geology starts with the James Hutton's theory of Uniformitarianism. It simply states that the physical, chemical and biological processes which operate today have also operated in the geologic past.

The other basic Sciences like Physics, Chemistry, and Biology are directly or indirectly related to the Science of geology.

1.8 CHECK YOUR PROGRESS- MODEL ANSWERS

1. Geology is one of the branches of science which deals with different aspects of Earth like size, shape, age, origin, internal composition and natural processes within and outside the earth.
2. Important branches of geology include physical geology, mineralogy, crystallography, palaeontology, petrology, structural geology, stratigraphy, economic geology, mineral exploration, mineral economics etc.
3. Present is the key to the past is the principle of uniformitarianism.
4. The branch that combines the knowledge of geology and physics is called geophysics.

1.9 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Give a brief account of the various branches of geology.
2. Explain the scope and development of Geology.

II. Answer the following questions in about 10 lines each.

1. Mention briefly about the application of geology.
2. What is the relation of geology with other basic sciences?

1.10 GLOSSARY

Fossil : Remnants or remains of animals and plants preserved in rocks.

Geocentric : The theory by which the earth is believed to be at the centre of the Universe.

Geochemistry : The study of the composition of the earth and the chemical processes.

Heliocentric : The theory in which the sun is believed to be the centre of the universe.

Hydrosphere : Watery envelope of the earth.

Lithosphere : Rock formations in the outer cover or crust of the earth.

Oceanography : Physical Science of the oceans.

UNIT-2 SOLAR SYSTEM

Contents

2.0 OBJECTIVES

After studying this unit, you should be able to

- describe the solar system
- define sun
- explain the planets

2.1 INTRODUCTION

The **Solar System** is the gravitationally bound system comprising the Sun and the objects that orbit it, either directly or indirectly. Of those objects that orbit the Sun directly, the largest eight are the planets, with the remainder being significantly smaller objects, such as dwarf planets and small Solar System bodies. Of the objects that orbit the Sun indirectly, the **moons**, two are larger than the smallest planet, Mercury.

The Solar System formed 4.6 billion years ago from the gravitational collapse of a giant interstellar molecular cloud. The vast majority of the system's mass is in the Sun, with most of the remaining mass contained in Jupiter. The four smaller inner planets, Mercury, Venus, Earth and Mars, are terrestrial planets, being primarily composed of rock and metal. The four outer planets are giant planets, being substantially more massive than the terrestrials. The two largest, Jupiter and Saturn, are gas giants, being composed mainly of hydrogen and helium, the two outermost planets, Uranus and Neptune, are ice giants, being composed mostly of substances with relatively high melting points compared with hydrogen and helium, called volatiles, such as water, ammonia and methane. All planets have almost circular orbits that lie within a nearly flat disc called the ecliptic.

The solar wind, a stream of charged particles flowing outwards from the Sun, creates a bubble-like region in the interstellar medium known as the *heliosphere*. The heliopause is the point at which pressure from the solar wind is equal to the opposing pressure of the interstellar medium, it extends out to the edge of the scattered disc. The Oort cloud, which is thought to be the source for long-period comets, may also exist at a distance roughly a thousand times farther than the heliosphere. The Solar System is located in the Orion Arm, 26,000 light-years from the centre of the Milky Way.

2.2 STRUCTURE AND COMPOSITION

The principal component of the Solar System is the Sun that contains 99.86% of the system's known mass and dominates it gravitationally. The Sun's four largest orbiting bodies, the giant planets, account for 99% of the remaining mass, with Jupiter and Saturn together comprising more than 90%. The remaining objects of the Solar System (including the four terrestrial planets, the dwarf planets, moons, asteroids, and comets) together comprise less than 0.002% of the Solar System's total mass.

Most large objects in orbit around the Sun lie near the plane of Earth's orbit, known as the ecliptic. The planets are very close to the ecliptic, whereas comets and Kuiper belt objects are frequently at significantly greater angles to it. All the planets, and most other objects, orbit the Sun in the same direction that the Sun is rotating (counter-clockwise, as viewed from above Earth's North Pole). There are exceptions, such as Halley's Comet.

The overall structure of the charted regions of the Solar System consists of the Sun, four relatively small inner planets surrounded by a belt of mostly rocky asteroids, and four giant planets surrounded by the Kuiper belt of mostly icy objects. Astronomers sometimes informally divide this structure into separate regions. The inner Solar System includes the four terrestrial planets and the asteroid belt. The outer Solar System is beyond the asteroids, including the four giant planets. Since the discovery of the Kuiper belt, the outermost parts of the Solar System are considered a distinct region consisting of the objects beyond Neptune.

In compliance with Kepler's law, the nearest planet to the sun, Mercury has the fastest orbital motion of 48 Km/sec and the shortest period of revolution of 88 days. And the farthest planet Pluto has an orbital velocity of 5 Km/sec and requires 248 years to complete one revolution (See Table 2.1).

Planet	Number of satellites or Moons	Mean distance from sun Millions of Miles)	Period of revolution (in days)	Period rotation (in days)	Diameter (in miles)	Density (gm/cm)
Mercury	-	36	88	59	3,105	51
Venus	-	67	225	243	7,526	5.3
Earth	1	93	365.25	23 Hr.56m.0.4s	7,920	5.52
Mars	2	142	687	24 Hr. 37 m 23s	4,216	3.94
Jupiter	15	483	12 years	9Hr.50m	88,700	1.34
Satrun	15	886	29.5 years	10hr.25m	75,000	0.70
Uranus	5	1,780	84 years	10Hr.25m	29,000	1.55
Neptune	2	2,790	165 years	18 Hr.	28,000	2.27
Pluto	1	3,670	248 years	6.4 days	1,500	1.52

Table 2.1 Description of Solar System

Most of the planets in the Solar System have secondary systems of their own, being orbited by planetary objects called natural satellites, or moons (two of which, Titan and Ganymede, are larger than the planet Mercury), and, in the case of the four giant planets, by planetary rings, thin bands of tiny particles that orbit them in unison. Most of the largest natural satellites are in synchronous rotation, with one face permanently turned towards their parent. All planets of the Solar System lie very close to the ecliptic. The closer they are to the Sun, the faster they travel *(inner planets on the left, all planets except Neptune on the right)*.

Kepler's laws of planetary motion describe the orbits of objects around the Sun. Following Kepler's laws, each object travels along an ellipse with the Sun at one focus. Objects closer to the Sun (with smaller semi-major axes) travel more quickly because they are more affected by the Sun's gravity. On an elliptical orbit, a body's distance from the Sun varies over the course of its year. A body's closest approach to the Sun is called its ***perihelion***, whereas it's most distant point from the Sun is called its ***aphelion***. The orbits of the planets are nearly circular, but many comets, asteroids, and Kuiper belt objects follow highly elliptical orbits. The positions of the bodies in the Solar System can be predicted using numerical models.

Although the Sun dominates the system by mass, it accounts for only about 2% of the angular momentum. The planets, dominated by Jupiter, account for most of the rest of the angular momentum due to the combination of their mass, orbit, and distance from the Sun, with a possibly significant contribution from comets.

The Sun, which comprises nearly all the matter in the Solar System, is composed of roughly 98% hydrogen and helium. Jupiter and Saturn, which comprise nearly all the remaining matter, are also primarily composed of hydrogen and helium. A composition gradient exists in the Solar System, created by heat and light pressure from the Sun, those objects closer to the Sun, which is more affected by heat and light pressure, are composed of elements with high melting points. Objects farther from the Sun are composed largely of materials with lower melting points. The boundary in the Solar System beyond which those volatile substances could condense is known as the frost line, and it lies at roughly 5 AU from the Sun.

The objects of the inner Solar System are composed mostly of rock, the collective name for compounds with high melting points, such as silicates, iron or nickel, that remained solid under almost all conditions in the protoplanetary nebula. Jupiter and Saturn are composed mainly of gases, the astronomical term for materials with extremely low melting points and high vapour pressure, such as hydrogen, helium, and neon, which were always in the gaseous phase in the nebula. Ices, like water, methane, ammonia, hydrogen sulphide and carbon dioxide, have melting points up to a few hundred **Kelvin's**. They can be found as ices, liquids, or gases in various places in the Solar System, whereas in the nebula they were either in the solid or gaseous phase. Icy substances comprise the majority of the satellites of the giant planets, as well as most of Uranus and Neptune (the so-called "ice giants") and the numerous small objects that lie beyond Neptune's orbit. Together, gases and ices are referred to as ***volatiles***.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of the unit.

1. When solar system is evolved?

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2.3 DISTANCES AND SCALES

The distance from Earth to the Sun is 1 Astronomical Unit (150,000,000 km), or AU. For comparison, the radius of the Sun is 0.0047 AU (700,000 km). Thus, the Sun occupies 0.00001% (10^{-5} %) of the volume of a sphere with a radius the size of Earth's orbit, whereas Earth's volume is roughly one millionth (10^{-6}) that of the Sun. Jupiter, the largest planet, is 5.2 Astronomical Units (780,000,000 km) from the Sun and has a radius of 71,000 km (0.00047 AU), whereas the most distant planet, Neptune, is 30 AU (4.5×10^{9} km) from the Sun.

With a few exceptions, the farther a planet or belt is from the Sun, the larger the distance between its orbit and the orbit of the next nearer object to the Sun. For example, Venus is approximately 0.33 AU farther out from the Sun than Mercury, whereas Saturn is 4.3 AU out from Jupiter, and Neptune lies 10.5 AU out from Uranus.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of the unit.

2. What is the distance between sun and Earth?

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2.4 SUN

The Sun is the Solar System's star and by far its most massive component. Its large mass (332,900 Earth masses) produces temperatures and densities in its core high enough to sustain nuclear fusion of hydrogen into helium, making it a main-sequence star. This releases an enormous amount of energy, mostly radiated into space as electromagnetic radiation.

The Sun is a G2-type main-sequence star. Hotter main-sequence stars are more luminous. The Sun's temperature is intermediate between that of the hottest stars and that of the coolest stars. Stars brighter and hotter than the Sun are rare, whereas substantially dimmer and cooler stars, known as red dwarfs, make up 85% of the stars in the Milky Way.

The Sun is a population star it has a higher abundance of elements heavier than hydrogen and helium ("metals" in astronomical parlance) than the older population II stars. Elements heavier than hydrogen and helium were formed in the cores of ancient and exploding stars, so the first generation of stars had to die before the Universe could be enriched with these atoms. The oldest stars contain few metals, whereas stars born later have more. This high metallicity is thought to have been crucial to the Sun's development of a planetary system because the planets form from the accretion of "metals".

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of the unit.

3. Define electromagnetic radiation.

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2.5 PLANETS

The four terrestrial or **inner planets** have dense, rocky compositions, few or no moons, and no ring systems. They are composed largely of refractory minerals, such as the silicates, which form their crusts and mantles, and metals, such as iron and nickel, which form their cores. Three of the four inner planets (Venus, Earth and Mars) have atmospheres substantial enough to generate weather; all have impact craters and tectonic surface features, such as rift valleys and volcanoes. The term *inner planet* should not be confused with *inferior planet*, which designates those planets that are closer to the Sun than Earth is (i.e. Mercury and Venus).

Mercury : Mercury (0.4 AU from the Sun) is the closest planet to the Sun and the smallest planet in the Solar System (0.055 Earth masses). Mercury has no natural satellites, besides impact craters, it's only known geological features are lobed ridges or rupes that were probably produced by a period of contraction early in its history. Mercury's very tenuous atmosphere consists of atoms blasted off its surface by the solar wind. Its relatively large iron core and thin mantle have not yet been adequately explained. Hypotheses include that its outer layers were stripped off by a giant impact or, that it was prevented from fully accreting by the young Sun's energy.

Venus : Venus (0.7 AU from the Sun) is close in size to Earth (0.815 Earth masses) and, like Earth, has a thick silicate mantle around an iron core, a substantial atmosphere, and evidence of internal geological activity. It is much drier than Earth, and its atmosphere is ninety times as dense. Venus has no natural satellites. It is the hottest planet, with surface temperatures over 400 °C (752°F), most likely due to the amount of greenhouse gases in the atmosphere. No definitive evidence of current geological activity has been detected on Venus, but it has no magnetic field that would prevent depletion of its substantial atmosphere, which suggests that its atmosphere is being replenished by volcanic eruptions.

Earth : Earth (1 AU from the Sun) is the largest and densest of the inner planets, the only one known to have current geological activity, and the only place where life is known to exist. Its liquid hydrosphere is unique among the terrestrial planets, and it is the only planet where plate tectonics has been observed. Earth's atmosphere is radically different from those of the other planets, having been altered by the presence of life to contain 21% free oxygen. It has one natural satellite, the Moon, the only large satellite of a terrestrial planet in the Solar System.

Mars : Mars (1.5 AU from the Sun) is smaller than Earth and Venus (0.107 Earth masses). It has an atmosphere of mostly carbon dioxide with a surface pressure of 6.1 millibars (roughly 0.6% of that of Earth). Its surface, peppered with vast volcanoes, such as Olympus

Mons, and rift valleys, such as Valles Marineris, shows geological activity that may have persisted until as recently as 2 million years ago. Its red colour comes from iron oxide (rust) in its soil. Mars has two tiny natural satellites (Deimos and Phobos) thought to be captured asteroids.

The outer region of the Solar System is home to the giant planets and their large moons. The **centaurs** and many short-period comets also orbit in this region. Due to their greater distance from the Sun, the solid objects in the outer Solar System contain a higher proportion of volatiles, such as water, ammonia, and methane than those of the inner Solar System because the lower temperatures allow these compounds to remain solid.

The four outer planets, or giant planets (sometimes called Jovian planets), collectively make up 99% of the mass known to orbit the Sun. Jupiter and Saturn are together over 400 times the mass of Earth and consist overwhelmingly of hydrogen and helium, Uranus and Neptune are far less massive and are composed primarily of ices. For these reasons, some astronomers suggest they belong in their own category, "ice giants". All four giant planets have rings, although only Saturn's ring system which is easily observed from Earth. The term *superior planet* designates planets outside Earth's orbit and thus includes both the outer planets and Mars.

Jupiter : Jupiter (5.2 AU), at 318 Earth masses, is 2.5 times the mass of all the other planets put together. It is composed largely of hydrogen and helium. Jupiter's strong internal heat creates semi-permanent features in its atmosphere, such as cloud bands and the Great Red Spot. Jupiter has 67 known satellites. The four largest, Ganymede, Callisto, Io, and Europa, show similarities to the terrestrial planets, such as volcanism and internal heating. Ganymede, the largest satellite in the Solar System, is larger than Mercury.

Saturn : Saturn (9.5 AU), distinguished by its extensive ring system, has several similarities to Jupiter, such as its atmospheric composition and magnetosphere. Although Saturn has 60% of Jupiter's volume, it is less than a third as massive, at 95 Earth masses. Saturn is the only planet of the Solar System that is less dense than water. The rings of Saturn are made up of small ice and rock particles. Saturn has 62 confirmed satellites composed largely of ice. Two of these, Titan and Enceladus, show signs of geological activity. Titan, the second-largest moon in the Solar System, is larger than Mercury and the only satellite in the Solar System with a substantial atmosphere.

Uranus : Uranus (19.2 AU), at 14 Earth masses, is the lightest of the outer planets. Uniquely among the planets, it orbits the Sun on its side, its axial tilt is over ninety degrees to the ecliptic. It has a much colder core than the other giant planets and radiates very little heat into space. Uranus has 27 known satellites, the largest ones being Titania, Oberon, Umbriel, Ariel, and Miranda.

Neptune : Neptune (30.1 AU), though slightly smaller than Uranus, is more massive (equivalent to 17 Earths) and hence more dense. It radiates more internal heat, but not as much as Jupiter or Saturn. Neptune has 14 known satellites. The largest, Triton, is geologically active, with geysers of liquid nitrogen. Triton is the only large satellite with a retrograde orbit. Neptune is accompanied in its orbit by several minor planets, termed Neptune Trojans, that are in 1:1 resonance with it.

Pluto and Charon : The dwarf planet Pluto (39 AU average) is the largest known object in the Kuiper belt. When discovered in 1930, it was considered to be the ninth planet; this changed in 2006 with the adoption of a formal definition of planet. Pluto has a relatively eccentric orbit inclined 17 degrees to the ecliptic plane and ranging from 29.7 AU from the Sun at perihelion (within the orbit of Neptune) to 49.5 AU at aphelion. Pluto has a 3:2 resonance with Neptune, meaning that Pluto orbits twice round the Sun for every three Neptunian orbits. Kuiper belt objects whose orbits share this resonance are called plutinos.

Charon, the largest of Pluto's moons, is sometimes described as part of a binary system with Pluto, as the two bodies orbit a barycentre of gravity above their surfaces.

The Solar System also contains smaller objects. The asteroid belt, which lies between the orbits of Mars and Jupiter, mostly contains objects composed, like the terrestrial planets, of rock and metal. Beyond Neptune's orbit lie the Kuiper belt and scattered disc, which are populations of trans-Neptunian objects composed mostly of ices, and beyond them a newly discovered population of sednoids. Within these populations are several dozen to possibly tens of thousands of objects large enough that they have been rounded by their own gravity. Such objects are categorized as dwarf planets. Identified dwarf planets include the asteroid Ceres and the trans-Neptunian objects Pluto and Eris. In addition to these two regions, various other small-body populations, including comets, centaurs and interplanetary dust clouds, freely travel between regions. Six of the planets, at least four of the dwarf planets, and many of the smaller bodies are orbited by natural satellites, usually termed "moons" after the Moon. Each of the outer planets is encircled by planetary rings of dust and other small objects.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of the unit.

4. What is the difference between inner and outer planets?

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2.6 SUMMARY

Solar system consists of Sun at the centre and 8 planets revolving around the Sun. This system was evolved about 4.6 billion years ago with a big explosion. The planets move around the sun in circular orbits that lie within a nearly flat disc called the ecliptic. Sun possesses about 99.865 of the total mass of the solar system. The distance from earth to sun is 1 Astronomical Unit. The large mass of sun produces the temperature and densities with the fusion of Hydrogen into Helium. Thus it releases enormous amount of energy, mostly radiated into the space as electromagnetic radiation. The four inner planets are Mercury, Venus, Earth and Mars. Mercury is the closest planet and Earth is the largest planet. Life exists on only earth. Mars is the smaller planet than Earth and Venus. The four outer planets are Jupiter, Saturn, Uranus and Neptune. Earlier Pluto was considered as ninth Planet; however the recent studies considered it as a binary system.

2.7 CHECK YOUR PROGRESS-MODEL ANSWERS

1. It is about 4.6 billion years
2. The distance from Earth to the Sun is 1 astronomical unit (150,000,000 km), or AU.
3. The large mass of sun produces the temperature and densities with the fusion of Hydrogen into Helium. Thus it releases enormous amount of energy, mostly radiated into the space as electromagnetic radiation
4. The inner planets are closure to Sun and the outer planets are farther to Sun.

2.8 MODEL EXAMINATION QUESTIONS

I Answer the following questions in 30 lines each.

1. Describe the Solar System
2. Describe the Structure and composition of solar system.
3. Explain Inner planets.

II Answer the following questions in 10 lines each.

1. Explain about Pluto.
2. What are Dwarf Planets?

2.9 GLOSSARY

Solar System	:	Sun and Eight planets
Perihelion	:	Closest distance from the sun.
Aphelion	:	Most distant point from the sun.
AU	:	Astronomical unit.
Inner Planets	:	Mercury, Venus, Earth and Mars.
Outer Planets	:	Jupiter, Saturn, Uranus and Neptune.

UNIT-3 EARTH

Contents

3.0 OBJECTIVES

After studying this unit, you should be able to

- explain the origin and age of Earth
- describe shape and size of the Earth
- explain constitution of earth
- define geological processes.

3.1 INTRODUCTION

You are already aware that our Earth is member of the solar system. **Earth,** is the third planet from the Sun and the only object in the Universe known to have life. It is the densest planet in the Solar System and the largest of the four terrestrial planets. Earth's gravity interacts with other objects in space, especially the Sun and the Moon, Earth's only natural satellite. During one orbit around the Sun, Earth rotates about its axis over 365 times thus, an Earth year is about 365.26 days long. Earth's axis of rotation is tilted, producing seasonal variations on the planet's surface. The gravitational interaction between the Earth and Moon causes ocean tides, stabilizes the Earth's orientation on its axis, and gradually slows its rotation.

Earth's lithosphere is divided into several rigid tectonic plates that migrate across the surface over periods of many millions of years. About 71% of Earth's surface is covered with water, mostly by its oceans. The remaining 29% is land consisting of continents and islands that together have many lakes, rivers and other sources of water that contribute to the hydrosphere. The majority of Earth's Polar Regions are covered in ice, including the Antarctic ice sheet and the sea ice of the Arctic ice pack.

Moon: Planet Earth has only one satellite the Moon, which accompanies it on its annual flight around the sun. The planet satellite system is unique in the solar system because Moon is at about 348,000 kilometres or 2, 40,000 miles. The diameter of the Moon is about 2,160 miles or 3,475 Kms and its density is computed to be 3.3 times that of water. This is comparable to that of the crustal rocks of the Earth, the gravitational attraction of the Moon is about 1/6 of that experienced on the Earth's surface.

Like the Earth, the moon rotates on its axis but does so at a much slower rate than the Earth. It also revolves around the Earth with a period of about a month. The latter motion causes the relative position of the Sun, Earth and Moon to Change producing the phases of the Moon and the Eclipses of the Sun and the Moon. Since the period of rotation, we observe always the same side of face of the periodic rise and fall of the ocean level and these tides have a profound influence on the geological action of the rivers and seas.

3.2 ORIGIN OF EARTH

Earlier theories about the origin of Earth

1. **Nebular Hypothesis:** Proposed by **Kant** and **Laplace,** it proposes a 'hot' origin for the earth formed from a single gaseous incandescent nebula, it explained the single direction of rotation of sun and the planets and the near circular shape of the planetary orbits etc. It could not explain the retrograde movements of certain planets and their satellites nor could it explain the observed differences in the densities, size and mass of planets.

2. **Biparental Hypothesis :** Dynamic encounter theory of **Buffen**, the Planetesimal hypothesis of **Moulton** and **Chamberlin**; and the Tidal hypothesis of **Jeans** and **Jeffreys** are included here.

   (a) **Plantesimal Hypothesis**- Proposed by Moulton (1901) and Chamberlim (1905). Planets formed from the little fragments given off from the solar surface when a large star approached a wandering sun. It explained the rigidity of the mass of the earth and the phenomenon of meteorites.

   (b) **Tidal Hypothesis-** 'Hit and Run' or the 'Catastrophic' theory- Jeans (1919) and Jeffreys (1929)- Planets formed from the filament thrown out of the sun when a huge star passed closed to it. It explained the coplanar placement of planets, but could not explain the distribution of the angular momentum.

3. **The Meteorite Hypothesis** of **O.J Schmidt** (1944) **C.F. Weizacker** (1944) and **G.P Kuiper's** hypothesis belong to the category of the 'cold' origin of earth.

Recent Theory:

The earth and the rest of the solar system were formed from an enormous cloud of fragments of both icy and rocky material which was produced from the explosions (**super nova**) of one or more large stars. Although most of the cloud was made of hydrogen and helium, the material that accumulated to form the earth also included a significant amount of the heavier elements, especially elements like carbon, oxygen, iron, aluminium, magnesium and silicon. As the cloud started to contract, most of the mass accumulated towards the centre to become the sun. Once a critical mass had been reached the sun started to heat up through nuclear fusion of hydrogen into helium. In the region relatively close to the sun - within the orbit of what is now Mars - the heat was sufficient for most of the lighter elements to evaporate, and these were driven outward by the solar wind to the area of the orbits of Jupiter and the other gaseous planets.

As a result, the four inner planets - Mercury, Venus, Earth and Mars are "rocky" in their composition, while the four major outer planets, Jupiter, Saturn, Neptune and Uranus are "gaseous". As the ball of fragments and dust that was to eventually become the earth grew, it began to heat up - firstly from the heat of colliding particles - but more importantly from the heat generated by radioactive decay (fission) of uranium, thorium, and potassium. Within a few hundred million years the temperature probably rose to several thousand degrees, hot enough to melt most things. This allowed the materials to be sorted out so that the heavier substances sank towards the centre, and the lighter substances floated towards the surface.

To begin with, much of the iron and magnesium would have combined with silicon and oxygen to form heavy silicate minerals such as **olivine** $(Mg, Fe)_2SiO_4$ and **pyroxene** $(Mg, Fe)SiO_3$. Most of the remaining iron (along with some nickel and sulphur) would have migrated towards the centre - forming a very heavy metallic **core**. Meanwhile, much of the aluminium, sodium and potassium would have combined with oxygen and silicon to form minerals such as **quartz** (SiO_2) and **feldspar** ($NaAlSi_3O_8$) that would have floated towards the surface to form the **crust.** The original material that formed the earth included some hydrogen, oxygen, carbon and nitrogen, and these would have been brought to the surface during volcanic eruptions as molecules such as water, carbon dioxide, and methane and nitrogen gas. By around 4 billion years ago it is likely that the earth had an atmosphere rich in carbon dioxide and nitrogen along with lots of water vapour. Initially the earth's surface and atmosphere were probably too hot for the water to come down as rain, but as the crust cooled and hardened it kept most of the earth's internal heat inside, and eventually the atmosphere cooled enough for rain to fall and create bodies of water on the surface.

The early atmosphere was largely composed of carbon dioxide, nitrogen, hydrogen-sulphide, and probably some ammonia and methane. The elements in these substances, particularly the carbon, hydrogen, oxygen and nitrogen (**CHON**) are fundamental to the formation of the molecules that were the precursors of life and those found in all living organisms. There are numerous ways in which these **amino acids** and other similar molecules could have been formed. For example, in 1953 it was shown by **Stanley Millar** that amino acids could have formed as a result of the interaction between an electrical current - such as lightning - and ammonia and water - as long as there was no oxygen. The early atmosphere had no free oxygen. We know that because the minerals in very old rocks show no signs of being oxidized (i.e., formed in the presence of oxygen, which commonly results in a reddish colouration due to the oxidation of iron).

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

1. List out the eight planets in order of the distance from the sun.

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3.3 AGE OF THE EARTH

So far scientists have not found a way to determine the exact age of the Earth directly from Earth rocks because Earth's oldest rocks have been recycled and destroyed by the process of plate tectonics. If there are any of Earth's primordial rocks left in their original state, they have not yet been found. Nevertheless, scientists have been able to determine the probable age of the Solar System and to calculate an age for the Earth by assuming that the Earth and the rest of the solid bodies in the Solar System formed at the same time and are, therefore, of the same age.

The ages of Earth and Moon rocks and of meteorites are measured by the decay of long-lived radioactive isotopes of elements that occur naturally in rocks and minerals and that decay with half lives of 700 million to more than 100 billion years to stable isotopes of other elements. These dating techniques, which are firmly grounded in physics and are known collectively as radiometric dating, are used to measure the last time that the rock being dated was either melted or disturbed sufficiently to rehomogenize its radioactive elements.

Ancient rocks exceeding 3.5 billion years in age are found on all of Earth's continents. The oldest rocks on Earth found so far are the Acasta Gneisses in north-western Canada near Great Slave Lake (4.03 Ga) and the Isua Supracrustal rocks in West Greenland (3.7 to 3.8 Ga), but well-studied rocks nearly as old are also found in the Minnesota River Valley and Northern Michigan (3.5-3.7 billion years), in Swaziland (3.4-3.5 billion years), and in Western Australia (3.4-3.6 billion years). These ancient rocks have been dated by a number of radiometric dating methods and the consistency of the results give scientists confidence that the ages are correct to within a few percent. An interesting feature of these ancient rocks is that they are not from any sort of "primordial crust" but are lava flows and sediments deposited in shallow water, an indication that Earth history began well before these rocks were deposited. In Western Australia, single zircon crystals found in younger sedimentary rocks have radiometric ages of as much as 4.3 billion years, making these tiny crystals the oldest materials to be found on Earth so far. The source rocks for these zircon crystals have not yet been found. The ages measured for Earth's oldest rocks and oldest crystals show that the Earth is at least 4.3 billion years in age but do not reveal the exact age of Earth's formation. The best age for the Earth (4.54 Ga) is based on old, presumed single-stage leads coupled with the Pb ratios in troilite from iron meteorites, specifically the Canyon Diablo meteorite.

The Moon is a more primitive planet than Earth because it has not been disturbed by plate tectonics; thus, some of its more ancient rocks are more plentiful. Only a small number of rocks were returned to Earth. These rocks vary greatly in age, a reflection of their different ages of formation and their subsequent histories. The oldest dated moon rocks, however, have ages between 4.4 and 4.5 billion years. These primitive objects provide the best ages for the time of formation of the Solar System. There are more than 70 meteorites, of different types, whose ages have been measured using radiometric dating techniques. The results show that the meteorites, and therefore the Solar System, formed between 4.53 and 4.58 billion years ago. The best age for the Earth comes not from dating individual rocks but by considering the Earth and meteorites as part of the same evolving system. Scientists have used this approach to determine the time required for the isotopes in the Earth's oldest lead ores, of which there are only a few, to evolve from its primordial composition, as measured in uranium-free phases of iron meteorites, to its compositions at the time these lead ores separated from their mantle reservoirs. These calculations result in an age for the Earth and meteorites, and hence the Solar System, of **4.54 billion** years with an uncertainty of less than 1 percent. To be precise, this age represents the last time that lead isotopes were homogeneous throughout the inner Solar System and the time that lead and uranium was incorporated into the solid bodies of the Solar System. The age of 4.54 billion years found for the Solar System and Earth is consistent with current calculations of 11 to 13 billion years for the age of the Milky Way Galaxy (based on the stage of evolution of globular cluster stars) and the age of 10 to 15 billion years for the age of the Universe (based on the recession of distant galaxies).

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

2. What is the approximate age of Earth?

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3.4 SHAPE AND SIZE OF THE EARTH

That the shape of the Earth is spherical needs no special emphasis since the age old explanations are part of general knowledge like the gradual disappearance of a receding ship from the beach. Shape is the shape of the shadow of the Earth as seen against the face of the Moon during a full lunar eclipse is also spherical. It can be demonstrated geometrically that a sphere is the only body that will always cast a circular shadow upon another sphere.

But careful observation by several eminent geographers have led to the conclusion that the shape of the earth is not a perfect sphere but an oblate spheroid, that is, it is flattened at the poles . A cross section of the Earth through the poles gives an ellipse while the equator remains a circle. The Earths oblateness is attributed to the centrifugal force of the Earth's rotation which deforms the somewhat plastic Earth into a form in equilibrium with respective forces of gravity and rotation.

But with recent advances in geodesy it is now established that the earth's figure is not been even a spheroid but a Gold. Its surface is the sea-level surface of the oceans extended in an imaginary way under the continents to form a continuous figure.

The Earth's equatorial is 12,756 Kms where as the length of the polar diameter is 12,714 Kms. Relatives to the size of the Earth this difference is small and in significant. None of the other departures from this sphericity like ocean depths and mountain peaks is as great as the polar attiring since the highest mountain is only about 5.5 miles above sea level and the greatest depth of the oceans is less than 7 miles. The mass of the Earth is computed to be in the order of 7×10^{21} tons, and the average specific gravity of the Earth is about 5.5.

Check your progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

3. The average specific gravity of the Earth is

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3.5 CONSTITUTION OF THE EARTH

There are three major layers in the earth namely crust, mantle and core.

(a) The Crust

It is the uppermost solid shell of the earth which has varying thickness in different areas as follows:

(a) Under the oceans : 5-6 km

(b) Under the continents : 30-35km

(c) Under the mountains : 60-70km

It is obvious that when compared with the radius of the Earth (6730km, on the average), the crust makes just an insignificant part in the structure of the earth. It is at best analogous to the skin of a big sized apple. As regards the chemical composition of the crust, analyses made by Clake, Washington, Goldscmith and Plodervaat on rock samples from different geographic zones have all shown that:

(i) **Silica** ($Si\ O_2$) is the most dominant component, its value lies above 50% by volume in the oceanic crust and above 62% in the continental crust.

(ii) **Alumina** ($Al_2\ O_3$) is the next dominant component; its value varying between 13-16 percent;

(iii) **Iron Oxide** ($Fe_2\ O_3$) - 8% **Lime** (CaO)-6% **Sodium Oxide**-4%, **Magnesium Oxide**-4% **Potassium Oxide**-2.5 % and **Titanium Oxide**-2% are the other components making the crust of the Earth.

The solid aggregate that makes the crust of the earth is named as a rock. This is undoubtedly the most common term used in geological literature, and is broadly synonymous with the word stone. The entire Crust is made up of different types of rocks.

(b) The Mantle

Materials making the earth become quite different in properties at the base of the crust. Professor **S. Mohoravicic**, a seismologist of Yugoslavia, first discovered this fact in 1904. This depth below the surface of the Earth at which a striking change in the properties of the material is observed has been named as **Mohorovicic discontinuity**. In geological literature, it is often referred as M-discontinuity or simply as Moho. The material below Moho forms a nearly homogeneous zone till a depth of 2,900km is reached. At that depth, another striking change is observed in the quality of the material on the basis of the seismic waves reaching there. Hence, mantle is that zone within the Earth that starts from M-discontinuity and continues up to a depth of 2,900km. Mantle is made up of extremely basic material called aptly ultra basic that is very rich in iron and magnesium but quite poor in silica. This zone is characterized with a high density that increases with depth. The material of the mantle is believed to be variably viscous in nature so much so that the overlying crustal blocks can virtually float over it, of course at a very slow rate and in a broader sense of the term.

Many of the most important geological processes such as volcanism, seismic activity and formation of mountains-orogeny are believed to originate in the mantle. In fact, very little is known as yet about the mantle because we have not yet been able to pierce the earth up to actual depth of this zone. All observation s about this zone are of indirect nature, mostly based on the behavior of seismic waves (shock waves released during an earthquake) from their passages within the earth. These studies show that the mantle also has a complex layered structure like the crust. It is also sometimes distinguished into upper mantle, middle mantle and lower mantle.

(c) The Core

It is the third and the innermost structural shell of the earth as conclusively proved by the seismic evidence. It starts at a depth of 2,900km below the surface and extends right up to the center of the earth, at a depth of 6,370km.

The core remains a mystery in many ways. Within the core, the physical nature and composition of the material is not uniform throughout its depth. Further, it has a very high density at mantle-core boundary, above 10g/cc. But despite such a high density, the outer core behaves like a liquid towards the seismic waves. The liquid like core extending from a depth of 2,900km to about 4,800km is often termed as outer core.

The inner core- starting from 4,800km and extending up to 6,370km is of unknown nature but definitely of solid character and with properties resembling to a metallic body. According to a widely favored view, the core may be made up of iron and nickel. Alloyed in some yet unknown manner, this view gets some support from the composition of meteorites that are often recovered from different regions of the globe. The meteorites, as already mentioned, are wandering fragments from the interiors of some other destroyed planets that enter out atmosphere as meteors from time to time.

Check your progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

4. The earth's principal layers are

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3.6 CONTINENTAL MASSES AND OCEAN BASINS

Of the nearly 197 million square miles that make up the surface of the earth, nearly 70% is covered by the interconnecting bodies of sea water, the pacific ocean alone covering fully one third of the globe with an average depth of 14,000ft. The continents of Europe, Asia, Africa, North America, South America, Australia and Antarctica are the parts of the continental masses that rise above sea-level. The high stand of the continents above the sea floors is accidental. They are mainly made up of the sialic matter which is generally less dense than the simatic ocean floors and the continents stand higher, like the ice-bergs in sea water, than the denser material beneath and around them. The surface of the crust reaches different levels in different places. The area of land and sea floor between successive levels has been estimated and quite interesting results are obtained. Accordingly it is known that there are two dominant levels 1) the continental platform and 2) the deep-sea platform with a gentle slope called the continental slope connecting both of them. The continental platform includes the submerged outer border known as continental shelf which extends beyond the shore zone to an average depth of about 100 fathoms (or 200 meters). The real ocean basins must be regarded as commencing at the edge of the continental shelf. The basins are more than full and the overflow sea water intrudes about 11 million square kms of the continental platform. The North Sea, Baltic Sea etc.., are example of the shallow seas (shelf seas) which lie on the continental self.

The continents themselves have a varied relief of plains, plateaus and mountain ranges, the last reaching its high pinnacle in **Mount Everest** in the mighty **Himalayas** (29,140ft). The ocean floors are less vigorously diversified than the continents, but island areas and submarine ridges rise from their normally monotonous surface, and basin and trenches sink to more than average depths. The deepest sounding of the oceans so far made is 34,340ft. (**Swire deep off the Philippines**).

3.7 GEOLOGICAL PROCESSES

Throughout the life time of the earth changes of all kinds have been going on in the earth's crust and on its surface, in its materials, their structures, distribution of land and sea, Mountains and plains and even climate and weather. The processes responsible for these changes are called **geological processes**. They can be divided broadly as follows.

1. **External processes** or processes of external origin, which include weathering, erosion and deposition.
2. **Internal processes** or processes of internal origin, which include diastrophism and igneous activity.

The external processes operate on the surface of the surface of the Earth tending to reduce its many irregularities to a common level and hence are referred to as the processes of gradation or denudation. Weathering refers to the natural processes of disintegration and decomposition of rocks. Erosion is the natural processes of disintegration and decomposition of rocks. Erosion is the natural removal and transportation of rock material. As there are processes of destruction which tend to wear down the higher parts of the Earth's surface, they are regarded as processes of degradation. The processes of deposition on the other hand operate to fill and raise the lower portion of the Earth's surface and hence are referred to as processes of **aggradations.**

These processes of gradation are in constant operation and produce changes in our land space. The principal agents of gradation also called geological agents, are (a) running water, (b) ground water, (c) moving ice(glaciers), (d) oceans, (e) lakes, (f) wind, (g) gravity and to a small extent organisms also participate in these processes.

The internal processes, though of internal origin, show their effects on the surface as well. Diastrophism includes all movements of the Earth's solid crust – slow movements which cause elevation or subsidence of large or small portions of the Earth's crust without compression of rocks (epirogenic movements) or those which cause compression and crumpling of rocks and their upraising into mountain ranges (orogenic movements) and sudden movements such as Earth quakes.

Igneous activity includes phenomena associated with the movements of hot molten rock material (magma or lava) within and upon the Earth's crust. These phenomena could be intrusive (confined to the interior of the Earth) or Extrusive (operating upon the Earth's surface- volcanic eruptions).

Within the last few decades, a great deal of new information has been gathered about the nature of our dynamic planet. The recent theory of Plate tectonics has given the geologists a comprehensive model with which to view the Earth's Internal processes. According to this theory, the Earth's outer rigid lithosphere is broken into several individual pieces called the plates. The very slow movements within the asthenosphere below are believed to cause the plates to move in relation to one other.

These movements are considered to be responsible for igneous activity, Earth movements, sea-floor spreading etc.

Check Your Progress

Note: a) Space is given below for writing your answer

b) Compare your answer with the one given at the end of this unit.

5. Name the two major processes which are responsible for the changes on the land.

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3.8 SUMMARY

Earth is one of the eight planets of the solar system. The eight planets are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. Each of these eight planets moves in an elliptical path around the sun. On the whole, the solar system consists of eight planets, their moons or satellites and numerous small bodies like asteroids, comets and meteoroids.

The planet earth has only one natural satellite called the moon. Like the earth, the moon rotates on its axis but at much slower rate than the earth.

By careful observations, eminent geographers concluded that the shape of the Earth is not a perfect sphere but an oblate spheroid and is flattened at the poles. Now days the scientists are calling the shape of earth as geoid. The Earth's equatorial diameter is 12,756 km whereas the polar diameter is 12,714 km. The mass of the earth is in the order of 7×10^{21} tons and the average specific gravity is about 5.5. The internal structure consists of three main layers called crust, mantle and core. The crust is again divided into upper layer Sial and lower layer Sima. Very important layer in the mantle is the asthenosphere.

Out of the total surface area of the earth 70% is covered with water bodies. The continents of Europe, Africa, Asia, North America, South America, Australia and Antarctica are the parts of continental masses. The continents themselves have varied of plains, plateaus and mountain ranges. The changes in the Earth's structure, materials, and climate are due to geological processes. The external processes are of external origin, which includes weathering, erosion and deposition and internal processes include diastrophism and igneous activity.

3.9 CHECK YOUR PROGRESS- MODEL ANSWERS

1. The eight planets in distance from the Sun are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.

2. The approximate age of Earth is 4.54 billion years

2. The average specific gravity of Earth is 5.5

3. The Earth principal layers are crust, mantle and core.

4. External processes (Weathering, Erosion and Deposition) Internal processes (Diastrophism & Igneous activity)

3.10 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1) Explain the origin of the earth.

2) Describe the major features of the surface of the earth.

3) Describe the various geological processes.

II Answer the following questions in about 10 lines each.

1) Give brief accounts of the shape and size of the Earth.

2) Write briefly about the internal structure of the Earth.