GEOLOGY

I - PUC TEXT BOOK

DEPARTMENT OF PRE-UNIVERSITY EDUCATION
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Director's Message

Dear Students,

We at the Department of Pre-university Education, Karnataka strive to empower each student to dream big and equip them with the tools that enable them to reach new heights and successfully deal with the challenges of life. As Swami Vivekananda said, "**Real education is that which enables one to stand on one's own legs**".

The course contents in this book are designed with the objective of equipping you well for the next level of study.

We wish you well on your journey and look forward to you becoming a responsible citizen of the nation and give back to the betterment of the society.

With best wishes,

Sd/-
C. Shikha, IAS
Director
Department of Pre University Education
Bengaluru

PREFACE

This textbook is on par with NCF-CBSE guidelines and is prepared to suit the Pre-University I year students of Geology. The content of this text incorporates some major branches of Geology and is built to make the students understand the basic principles and fundamental concepts of the subject. The content is designed with brief but precise text, numerous diagrams highlighting important aspects, summary and model questions keeping in mind not only to fulfill the requirements of Pre-University I year students but also the general readers and those preparing for competitive examinations. The text book comprises VII units focussing on endogenous & exogenous processes. It is hoped that this text material fills the long-felt vacuum due to non-availability of a text book for the PU I year students of Geology.

Geology is the most natural, imaginative, fascinating and an innovative subject. It is often utilizes principles of other branches of science. Study of Geology insights into the history of earth, paleo-climate and evolution of life on one hand and exploration for minerals and metals, including fossil fuels (Petroleum, Oil & Natural Gas) and groundwater on other hand. It also has applications in understanding and predicting natural hazards, identification and remediation of environmental problems, major civil engineering projects etc.

Study of Geology and its demand is growing due to the ever-increasing requirements for mineral resources, groundwater and other natural resources; and also in the area of environment and disaster managements.

The text book committee members are greatly thankful to the review committee members for their kind co-operation and critical reviews in preparing this text book.

Authors express their gratitude to authorities of Pre-University Education Board, Bengaluru, Karnatak Science College, Dharwad, Nalanda Pre-University College, Jagalur and Govindram Sekseria Science College, Belagavi for their constant help and co-operation to bring out this text book.

The author's are also thankful to Miss. Manisha Dhuri (Lecturer) and Mr. Suraj Mense (Research Asst.) G.S. Sc. College, Belgaum; and Sureshaiah H.M. Darukaradhya Multipoints, Jagalur for compilation and editing work.

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Note for the student:-

The exercises given to have the awareness about the formation of rocks, rock types, structures, fossils, stratigraphic sequence, geological timescale etc. Their importance or uses in various fields and to encourage the students.

Note for the teachers : -

The exercises given here are for general information and not for the examination.

1. The teacher has to give the reliable information about the rocks, geological structures, fossils and their significance in various fields. The teacher may also bring out the application in fields like civil engineering projects and their commercial importance.

2. The teacher has to take the students to the place of geological importance under educational tours, this will help the students to improve the practical knowledge about geology.

3. The teacher may give the relevant information about the present syllabus and its context.

I YEAR PUC SYLLABUS (CBSE) 2014-15
N.C.F
Sub Geology 37

Total = 120 Hours

Unit	Chapter	Title	Hours
I	1.0	**General Geology** 1.1 Definition 1.2 Introduction to Geology 1.3 Branches of Geology and Relation with other sciences 1.4 Scope and Significance	5 Hours
	2.0	**Universe and Solar system** 2.1 Universe, Galaxy & Milky way, Stars & Planets 2.2 Solar system- Inner group of planets, Outer group of planets, Sun, Earth, Meteors & Comets. 2.3 Origin of Earth- Big Bang Theory 2.4 Earth Sphere - Geosphere, Atmosphere, Hydrosphere & Biosphere.	6 Hours
	3.0	**Parameters of Earth** 3.1 Shape of Earth: Flat, Oblate, Spheroid, Elliptical & Geoidal 3.2 Circumference, Diameter (polar & equatorial) and Density of the earth.	5 Hours
	4.0	**Earth Motion** 4.1 Rotation – Day and Night 4.2 Revolution - Seasons	5 Hours
II	5.0	**Zones of the Earth** 5.1 Atmosphere – Composition, Structures & Layers 5.2 Hydrosphere – Water Cycle. 5.3 Geosphere – Crust, Mantle, Core & discontinuities; Composition, temperature, density 5.4 Biosphere	6 Hours

Unit	Chapter	Title	Hours
III	6.0	**Geological Processes** 6.1 Endogenous & Exogenous **Exogenous Process** 6.2 Agents, weathering, types (mechanical / physical, chemical & biological) and products of weathering 6.3 Wind- Geological action Erosion (deflation, abrasion & attrition) and erosional features (pedestal rocks & ventifacts)Transportation (suspension & saltation), Deposition (dunes)	02 Hours 30 Hours
		6.4 River Geological action: Erosion (Hydraulic action, corrasion , corrosion & solution) and erosional features (pot holes) Transportation, Deposition	
		6.5 Glacier Introduction, Types of glaciers – Valley, piedmont, continental/sheet glaciers, Movement of glaciers,Erosion (abrasion, frost wedging, plucking & quarrying); and erosional features (Hanging valley, U-shape valley, Cirque, Horn & Arete) Transportation Deposition (moraines – lateral, medial, ground & terminal; drumlins and eskers)	
		6.6 Underground water Hydrolgical properties – porosity & permeability Zones – aeration & saturation; water table; aquifers, wells & springs, Karst topography- Stalactite & Stalagmite	06 Hours
IV	7.0	**Endogenous Process** 7.1 Earthquake - Focus or hypocenter, Epicenter, classification based on depth of focus. Seismic waves - Body & surface waves. Amplitude & intensity (Richter Scale), Seismogram & Seisopraph, origin of earthquakes (tectonic & non tectonic)	17 Hours

Unit	Chapter	Title	Hours
.		7.2 Volcano – Typical volcano, Products of volcano - Solid, liquid & gaseous material Types (Active, Dormant & Extinct) Excercises	
V	8.0	**Mineralogy** 8.1 Introduction , Definition of mineral. 8.2 Physical properties – Color, streak, luster, diaphaneity, form, cleavage, fracture, hardness, tenacity, specific gravity, chemical composition. 8.3 Study of mineral groups describing physical properties, chemical composition, crystal system, occurrence & uses of –Quartz , Feldspar, Mica. Ores – Metallic & non metallic 8.4 Specific gravity by Walker's Steel Yard balance. Summary	15 Hours
	9.0	**Crystallography** 9.1 Definition of crystal 9.2 Morphology of crystal- face, edge, solid angle & Euler's law 9.3 Interfacial angle and its measurement using contact goniometer 9.4 Symmetry characters- plane of symmetry, axes of symmetry & centre of symmetry 9.5 General characters of normal class systems- Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic & Triclinic Excercises.	15 Hours
VI	10.0	**Environmental Geology** 10.1 Hazards (Natural & anthropogenic) 10.2 Pollution (Air, Water & Soil)	05 Hours

Unit	Chapter	Title	Hours
VII	11.0	**Role of Indian Organsiation/ Institutes in Geology** DMG - Department of Mines & Geology MML – Mysore Minerals Limited GSI – Geological Survey of India ONGC- Oil and Natural Gas Commission NMDC-National Mineral Development Corporation NGRI- National Geophysical Research Institute NRSC-National Remote Sensing Centre NIO-National Institute of Oceanography NIH -National Institute of Hydrology ISRO - Indian Space Research Organisation MMTC- Minerals & Metals Trading Corporation CGWB-Central Ground Water Board HGML - Hutti Gold Mines Limited SOI - Survey of India CAI- Coal Authority of India CESS - Centre for Earth Science Studies **PRACTICALS** 1.0 Crystallography 2.0 Mineralogy	03 Hours 40 Hrs 16 Hrs 24 Hrs

I PUC GEOLOGY PRACTICALS

Each practical of 2 hours duration (Total 40 Hours)

Total number of experiments 20 Total 30 Marks

Unit	Practical	Title	Hours
1.0		**Crystallography**	**16 Hours**
	01	Morphology of crystal	01 Hour
	02	Study of mathematical relationship of a	
		crystal (Euler's Law)	01 Hour
	03	Measurement of Interfacial angle of a	02 Hours
		crystal using Contact Goniometer	
	04	Classification of crystal based on axial	02 Hours
		characters	
	05	Planes of symmetry	01 Hours
	06	Axes of symmetry	02 Hour
	07	Centre of symmetry	01 Hour
		Study of Six normal class crystal systems	
	08	Isometric	01 Hour
	09	Tetragonal	01 Hour
	10	Hexagonal	01 Hour
	11	Orthorhombic	01 Hour
	12	Monoclinic	01 Hour
	13	Triclinic	01 Hour
2.0		**Mineralogy**	**24 Hours**
	14	Physical properties of minerals	06 Hours
	15	Quartz group- Rock Crystal, Rosy & Milky.	04 Hours
	16	Quartz group- Jasper, Amethyst, Agate	
	17	Feldspar Group- Orthoclase, Plagioclase	04 Hours
		& Microcline	
	18	Mica Group- Biotite & Muscovite	04 Hours
	19	Moho's hardness Scale	2 Hours
	20	Measurement of Specific Gravity by	4 Hours
		Walker's Steel Yard Balance	

Note: Students have to carry out a minimum of 16 practical's

CONTENTS

UNIT 1

1.0 GENERAL GEOLOGY

1.1 Definition of Geology:

The sciences that deal with one or more aspects of the earth are grouped into earth sciences. The term Geology is a Greek word meaning earth science (Geo = earth and logos = science). It is the science that deals with the study of the earth as a whole.
This includes the study of the earth's origin, structure, history, evolution and its inhabitants as preserved in rocks.

1.2 Introduction:

The earth is a dynamic component of the Solar system having its unique features and processes. It is the only planet providing shelter for life. The earth is encompassed with air, water, solar/cosmic radiation; and has the many natural resources, such as metals and non metals, coal, oil and gas deposited within the rock formations. These natural resources are useful resources to man. The rocks and minerals are integral parts of earth's crust. The economic growth of any country is dependent upon the availability of such natural resources.
The planet earth has undergone evolution and modifications through variety of natural processes occurring inside the earth (endogenic) and outside the earth (exogenic), which are called the geological processes. The features what we see on the surface of earth viz., mountains, valleys, gorges, lakes, rivers, seas, oceans, glaciers, waterfalls, springs, beaches, deserts, islands and many more are the result of the geological processes. These geological processes are still at work.

1.3 BRANCHES OF GEOLOGY AND THE RELATIONSHIP OF GEOLOGY WITH THE OTHER SCIENCES

a) PLANETARY GEOLOGY: This is branch of geology which deals with the study of cosmic bodies such as planets, comets, meteorites, stars, etc.

b) PHYSICAL GEOLOGY: It deals with the origin, development and ultimate products of various surface features of the earth on one hand and the structure of the earth as a whole on the other hand. The role played by internal (Volcanism & earthquakes) and external (wind, water & ice action) agents on the physical features of the earth makes an important part of the branch. This branch is also clubbed with-

   i) DYNAMIC GEOLOGY: It deals with the agencies both inside and outside, which tend to bring about changes upon the earth's surface.
   ii) GEOMORPHOLOGY: These deals with the surface features of the earth, mainly the land surface, which involves their development, structure, modification etc., Thus evolution of slopes, depressions, plains, valleys and plateaus by various aerial and subaerial agencies are of importance.

c) MINERALOGY, CRYSTALLOGRAPHY AND PETROLOGY: These deals with minerals and rocks. Mineralogy is the study of minerals, which includes the study of mineral formation, mineral chemistry, mineral association, mineral analysis and their distribution. Crystallography is the study of crystals, their formation, their inner structure and forms. Petrology is the study of rocks involving their formation (origin), association and mode of occurrence etc.

d) GEMOLOGY: It deals with the naturally occurring and artificially prepared minerals, their uses in ornamental and decorative purposes.

e) GEOCHEMISTRY: It deals with distribution and abundance of different elements and their components in the earth.

f) GEOPHYSICS: In this branch, important principles and processes of physics are applied to study and solve the geological problems such as seismic, magnetic and electrical resistivity methods to study the underground structure of a region or delineating under-ground water, gas and petroleum etc.

g) STRUCTURAL OR TECTONIC GEOLOGY: It deals with the different kinds of structures produced in the earth's crust (faults, folds, joints, basins etc.), as a result of the tectonic movements of the earth's crust.

h) ECONOMIC GEOLOGY: It deals with the study of useful minerals and ore minerals (metallic and non metallic), rocks as building materials,

construction sand and other such materials, their exploitation for the economic growth of the country and for the benefit of the mankind.

i) PALEONTOLOGY: It deals with fossil remains of plants and animals once lived in the past geological ages. This study helps to understand the evolution of animals and plants and to construct the geological time scale.

j) HISTORICAL GEOLOGY: It is also known as stratigraphy and deals with the past history of earth from the study of its rocks-stratified and unstratified. Rocks are treated as pages of earth's history, each having some information about the time during which it was formed. Hence the basic principle here is "the present is the key to the past".

k) MINING GEOLOGY: It is geology as applied to mining practice. i.e., exploitation of economic mineral deposits, including mode of formation of economic minerals, their distribution, exploitation; and the geological characters of these minerals. This branch mainly deals with the study of mining and quarrying practices for the exploration and exploitation of economic mineral deposits. The location and development of mines are derived primarily on the basis of mode of formation, mode of occurrence and structural disposition of economic minerals and ore deposits like iron, copper, gold, diamond including coal and petroleum.

l) ENGINEERING GEOLOGY: This field deals with the geotechnical study of the construction sites and construction materials viz., selection of dam & bridge sites, and other engineering projects such as assignments of railway lines, tunneling, underground water prospecting, mining and prospecting of minerals etc.

m) HYDROGEOLOGY: It is the interaction of geology and hydrology. It mainly deals with the aspect of ground water and surface water bodies with regards to their occurrence and movements through different types of rocks. This branch also deals specifically with the occurrence and geological setting of groundwater and it's prospecting.

In addition to these there are few newly developed branches of science that have geology as a very important component. These are-

n) OCEANOGRAPHY AND MARINE GEOLOGY: It includes the study of oceans, its climate, under ocean features and coastal features such as

beaches, estuaries, islands, bays coastal dynamics, coastal geomorphology etc. It provides also the economic importance of oil and natural gas deposits, oozes, coral reefs, , phosphate and manganese nodules, which are the future sources of natural resources for the benefit of mankind.

o) ENVIRONMENTAL GEOLOGY: It deals with environmental awareness, geological hazards, better management of the natural resources and waste disposal etc. Environmental science is the study of the interactions of organisms and their surroundings. The subject includes natural resources, pollution, alternative energy sources, and the impact of humans on the atmosphere. Environmental geologists study the positive and negative effects of organisms.

p) SEISMOLOGY: It deals with the study of seismic waves that leads to earthquakes, the effects and nature of disaster.

q) METEOROLOGY: It mainly deals with the study of atmosphere, concerned with weather and atmosphere. This branch has been playing a significant role, using satellite data, modeling etc., for forecasting of weather and climate.

r) SOIL SCIENCE (PEDOLOGY): It deals with the study of soil types, soil pattern, formation of soil, composition and processes.

s) ENGINEERING GEOLOGY: It is an applied science that has developed due to interaction between the geological science and civil work practices. This branch deals with the Geotechnical studies involving selection of sites or location for major construction works viz., projects like - thermal/nuclear/hydal Power Stations, bridges, tunnels, dams, multistoried buildings, urban planning, flyovers, reservoirs etc. This branch also deals with Rock Mechanics, which deals exclusively with study of behavior of rocks under various types of loads imposed on them.

t) GEOSTATISTICS: This branch deals with application of statistics to the geologic data for the use of better understanding of the processes and modeling.

u) GEOINFORMATICS (PHOTOGEOLOGY, REMOTE SENSING AND GIS): This branch deals with the interpretation of geological features such

as landforms, structural features, land use patterns etc., with the help of the Aerial Photographs and satellite imageries through software for better and fast management of geological resources.

v) MEDICAL GEOLOGY: It is the upcoming branch, which deals with the use of minerals and ores for the medicinal, cosmetic purposes especially in Ayurveda.

As more asteroids were discovered, they were given numbers along with names. In 1923, the one thousandth asteroid to be named was called 1000 Piazzia in honor of Scientist Piazzi. Because of his accomplishments in astronomy, a large crater on Ceres—revealed by the Hubble Space Telescope—was named Piazzi.

1.4 SCOPE AND SIGNIFICANCE OF GEOLOGY

Geology is considered as one of the fundamental subject of basic sciences. The geologist plays an important role in the successful development of mining industry and in turn economy of the country. As a prospector and as an advisor, his advice is essential for the better use of an ore body and other natural resources. He is useful not only in the field of mining and metallurgical industry, but also in the field of engineering, scientific development etc., where in, the geologist help in construction of dams, suggesting dam sites, bridge sites, railway line alignments, tunnels, construction of buildings in earthquake prone areas, choice of rocks as building material, oil and natural gas and water prospecting etc.

A geologist provides information for the mining company regarding the availability of ores, grade of the ore, percentage of the ore and tonnage etc. Geologists are useful in the other fields such as, land evaluation, oceanography, marine archeology, archeology, environmental evaluation, nuclear study etc.

GEOLOGY

*Illuminates the **Past***

*Sustains the **Present***

*Promotes the **Future***

2. UNIVERSE AND SOLAR SYSTEM

2.1 Universe, Galaxy, Milky Way & stars
2.2 Solar system- Sun, Planets, satellites, asteroids, comets and meteors
2.3 Origin of Earth- Big Bang Theory
2.4 Earth's Spheres

2.1 Universe, Galaxy, Milky Way, Stars & Planets

a) Universe: Universe is infinite in time and space which includes the planets, stars, asteroids, comets, constellations, galaxies and all the matter and energy.

b) Galaxies: Galaxies are association of billions of stars (star clusters) or groups of stars which are bound gravitationally, and interstellar matter. There are millions of galaxies; each galaxy is composed of millions of stars. A single galaxy with its constituents of stars makes a stellar system.

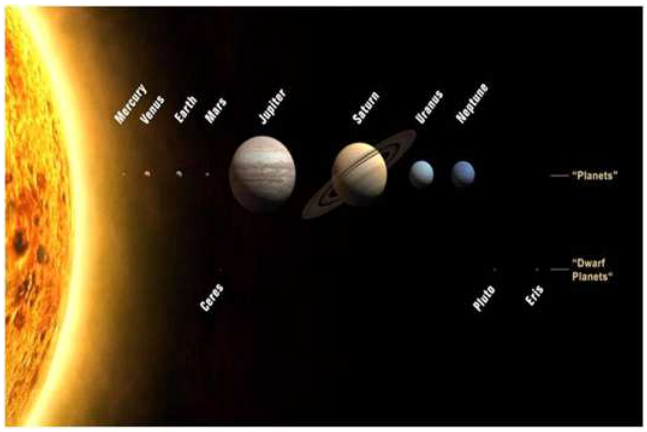
c) Milky Way: The name of our Galaxy. Also the name given to the band of diffuse light seen in the night sky that originates in the disk of our Galaxy.

d) Stars – These are massive, luminous bodies of plasma. The illumination is being the effect of nuclear fusion reactions of Hydrogen.

e) Planets – These are non luminous or non-radiating bodies, and are formed by the consolidation of gaseous nebula enriched with various elements.

Meteorite:
The earth receives at least 10,000 tones of meteoric and cosmic materials every year.

2.2 SOLAR SYSTEM



It is the arrangement of all the 8 planets in a systematic order by Sun's gravitational force.

The solar system is divided into two groups:
1] Terrestrial group of planets or inner group of planets.
2] Giant planets or outer group of planets.
Both these groups are separated by a zone of asteroids.

2.2.1 Inner group of planets: The planets Mercury, Venus, Earth and Mars form the inner group of planets. Their locations depend on the basis of their relative density. They are characterized with-

i) Relatively smaller masses with higher density
ii) Relatively slow speed of rotation
iii) Less number of natural satellites (moon)

2.2.2 Outer group of planets or Giant planets: This group of planets includes Jupiter, Saturn, Uranus, and Neptune. Pluto is now not regarded as the planet of our solar system. It is regarded as dwarf planet. The outer planets are characterized by-

1. Larger masses with low densities.
2. Relatively high speed of rotation.
3. Higher no of natural satellites.

There are over 1700 identified planets outside our solar system, identified in 2014

a. The Sun : Sun is a typical star, where all the planets are revolving around by its gravitational force. The sun and these planets make the solar system.

b. The Earth : Earth is the third planet from the Sun. It is the densest and fifth-largest of the eight planets in the Solar System. It is also the largest of the Solar System's four terrestrial planets. It is sometimes referred to as the Blue Planet. Earth formed approximately 4.54 billion years ago, and life appeared on its surface within its first billion years. Earth's biosphere then significantly altered the atmospheric and other basic physical conditions, which enabled the proliferation of organisms as well as the formation of the ozone layer, which together with Earth's magnetic field blocked harmful solar radiation. Earth has one natural satellite (moon).

c. Meteors : These are also cosmic bodies which lose their orbital path and thrown off in the space. Some of them fall on the earth. During their path the cosmic body burns they are called metorites.

d. Comets : These are the bodies of solar system; they are most remote from the Sun. These are countless in number. Their orbit is eccentric and consist head & tail. They reappear periodically.

2.3 ORIGIN OF EARTH - BIG BANG THEORY

The recent Big Bang theory tells us how the Universe began and is evolving. In essence, it is a theory that was created to explain two facts that we know about the Universe - it is gradually expanding and cooling.

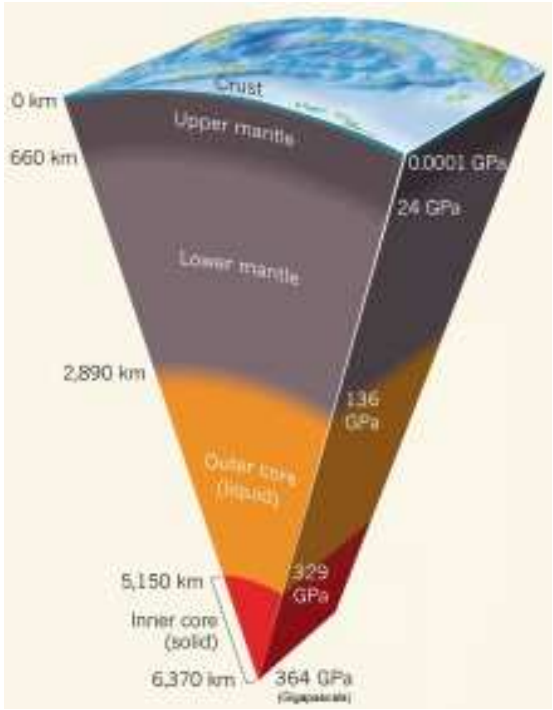
In the 1920s, Edwin Hubble found that galaxies far from our own Milky Way are moving away from us. In fact, the further away galaxies are, the faster they are receding. So he concluded that the whole Universe must have been expanding. Working backwards this means that at one stage the Universe must have come from a single point. The Big Bang describes how the universe grew to form all the stars and planets we see around us now. During the Big Bang space was first created and then stretched.

The easiest way to understand this tricky concept is to think of the Universe as a fruitcake in an oven. Imagine you are a bit of fruit inside the cake. As it bakes, the cake rises and all the other bits of fruit around you move further and further away. No matter whereabouts in the cake you are, everything around you is moving away at the same rate. But unlike the fruitcake, there is no centre to the Universe.

2.4 EARTH SPHERES

The Earth has four main spheres - the geosphere, atmosphere, hydrosphere, and biosphere. Each system is unique, and each interacts with the others.

2.4.1 Geosphere, is the area from the surface of Earth down to its center, it is divided into three main parts: the crust, mantle, and core. The rigid outer shell of Earth is called the crust. There are two kinds of crust—continental crust and oceanic crust. Just below the crust is Earth's mantle. The mantle differs from the crust both in composition and behavior. The mantle ranges in temperature from 100°C to 4000°C — much warmer than the temperatures found in Earth's crust. The mantle contains semi fluid hot molten rock material called **magma**. Below the mantle is Earth's core. The core is further divided into outer core and inner core. The outer core is fluid in nature comprising Iron and Nickel; the inner most layer is called inner core, which is a solid Iron ball.

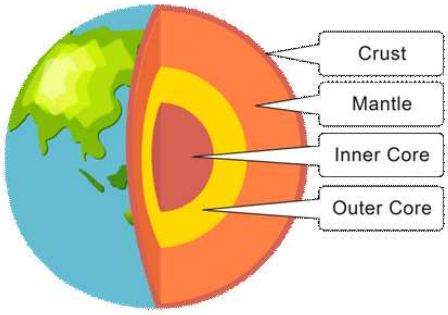


Lithosphere is a part of geosphere and comprises crust and upper mantle**.** The lithosphere or the crustal layer includes three kinds of rocks:

i) Igneous rocks or Primary rocks.

ii) Sedimentary rocks or Secondary rocks

iii) Metamorphic rocks or Tertiary rocks.

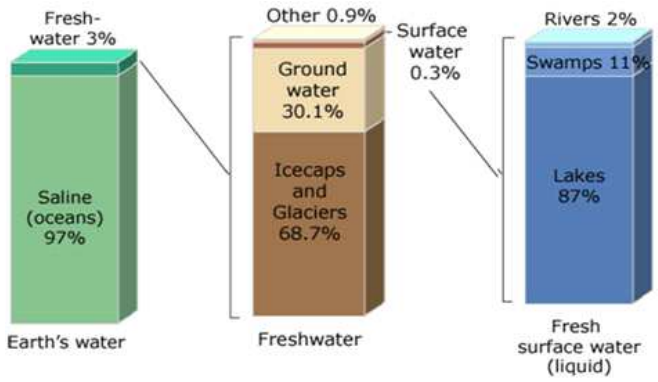


2.4.2 Atmosphere, the blanket of gases that surrounds our planet is called the atmosphere. Earth's atmosphere contains about 78 % nitrogen and 21 % oxygen. The remaining 1 percent of gases in the atmosphere includes water vapor, argon, carbon dioxide, and other trace gases. Earth's atmosphere provides oxygen for living things, protects Earth's inhabitants from harmful radiation from the Sun, and helps to keep the planet at a temperature suitable for life. Ozone layer acts as a protection layer for reflected cosmic rays towards the sun.

2.4.3 Hydrosphere, all the water on Earth, including the water in the atmosphere, makes up the hydrosphere. About 97 % of Earth's water exists as salt water, while the remaining 3 % is freshwater contained in glaciers, lakes and rivers, and beneath Earth's surface as groundwater. Only a fraction of Earth's total amount of freshwater is in lakes and rivers.

2.4.4 Biosphere, the biosphere includes all organisms on Earth as well as the environments in which they live. Most organisms live within a few meters of Earth's surface, but some exist deep beneath the ocean's surface, and others live high atop Earth's mountains. All of Earth's life forms require interaction with at least one or the other systems for their survival.

Global Distribution of Water

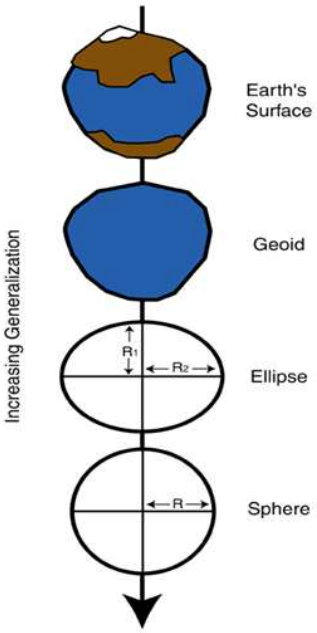


3.0 PARAMETERS OF EARTH :

3.1 Shape of Earth
3.2 Circumference, Diameter (polar & equatorial) and Density of earth

3.1 SHAPE OF EARTH

There are different views/opinions about the shape of earth, such as – Flat, Spheroidal, Oblate, Elliptical, and Geoidal shape.



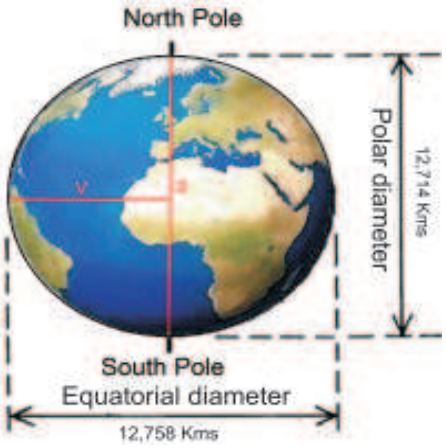
Apart from the earth position in its orbit relative to the Sun, its spherical shape also plays a considerable role in the distribution of climatic zones. Its spheroidal shape was discovered by Greek philosopher Pythagoras (574-479 B.C.). Our planet is in fact very close in shape to a sphere. The difference in the length of Polar Regions and equatorial radius (21.5 kms).
Earth is having shape of it's own (Geoidal) i.e. neither sphere nor a spherical oblate (flattened at poles & bulged at equator).

3.2 Circumference, Diameter (polar and Equatorial) and Density of the Earth

3.2.1 Circumference : 510 million Km³ in length

a. The mean density of the earth is 5.517 gm/cm3
b. Volume – 1.083 x 10^{27} cm^3 = 1100 million cubic meters
c. Mass - 5.975 x 10^{27} g

3.2.2 Diameter of the Earth :



a slight flatterning by 2mm
Circumference 510 million cubic meters in length

V = Radius
D = Diameter

1] Equatorial diameter = 12,757.776 Kms
2] Polar diameter = 12,713.824 kms

The difference = 43.952 Kms

3.2.3 Density of the Earth : The mass and density of the earth are found by the principle laws of physics. Thus the force of gravity at its surface is calculated by Newton's Second law. The mass is found to be 5.98 x 10^{21} tones.

4.0 EARTH'S MOTION

4.1 Rotation – Day and Night
4.2 Revolution – Seasons

The planet earth has two motions – (1) Rotation 2) Revolution.

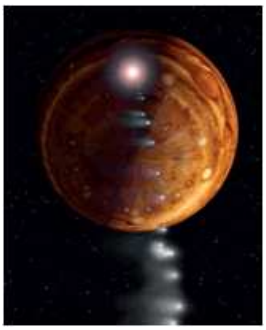
4.1. Rotation: The planet earth takes 24.0 (23 hrs.56 min) hours for one complete rotation about its own axis**.** The earth rotate from west to east.

4.1.1 Day and Night: Rotation of planet earth around its own axis in 24 hours, causes day and night.

4.2. Revolution: The earth takes 365 days for one complete revolution around the Sun in clockwise direction**.** The revolution takes place along a slightly elongated, close to circular with a radius of 1,49,500,00 Kms. The periodic change in the flattening of the orbit is a cause of fluctuations in mean annual temperature and consequently in the character of geological processes on earth. The effect of revolution are seasons with different intensities of light.

At the North Pole, the sun actually rises above the horizon on March 20 and has six months until it sets on September 22. Therefore this region is called the "Land of the Midnight Sun".

Asteroids are rocky mini-planets, which are sometimes called minor planets or planetoids. Many of them revolve around the Sun in a large orbit between Mars and Jupiter. The **gravity** of the Sun and nearby objects, such as planets, is what keeps the asteroids moving in an orbit.

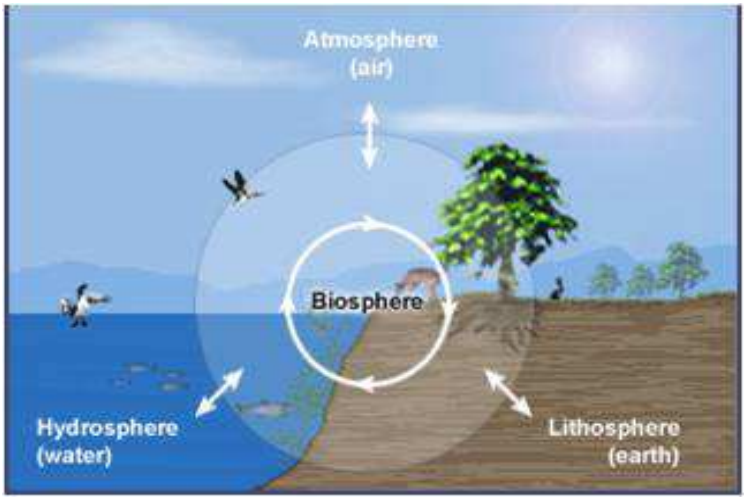


The comet called Shoemaker Levy 9, after Carolyn and Eugene Shoemaker and David Levy, the astronomers who discovered it, which crashed into Jupiter in July 1994.

UNIT – II

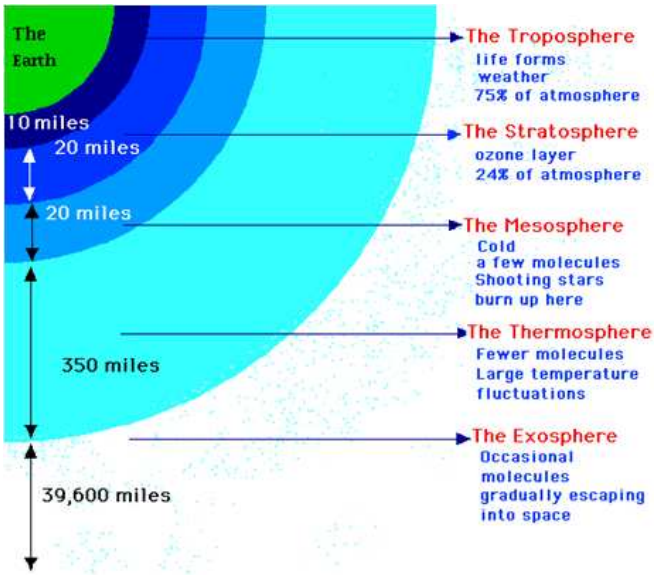
5.0 ZONES OF THE EARTH

5.1 Atmosphere – Composition, Structures & Layers
5.2 Hydrosphere – Water Cycle.
5.3 Geosphere – Crust, Mantle, Core & discontinuities; Composition, temperature, density
5.4 Biosphere



5.1 Atmosphere: Composition, Structure and Layers.

Atmosphere: It is the earth's air envelope, it is a mixture of various gases, whose total mass is estimated at 5.13x 10^{110} tones, and constitutes around 0.000001% of the earth's mass.



5.1.1 Composition: Air is the mixture of gases. The main components are N_2-78.8%, O_2-20.105%, Ar-0.03%, H_2-0.00005%, CO_2-0.03%, He-0.0005%, Ne-00.0018% and other gases of negligible amount. This also includes the water vapor -0.05 to 4.0%, other products of volcanic gas, dust and mineral salts.

5.1.2 Troposphere:

The lower part of the atmosphere is the Troposphere. The thickness is about 8-10 Kms, at the poles, and 16-18 Kms at the equator. In this layer the temperature and pressure continuously changes from morning to till evening.

A considerable part of the CO_2 is concentrated in the troposphere. The inclination of the earth's axis of rotation and the change in the distance from the Sun causes unevenness in the illumination of light from various parts of the earth's surface. The polar regions receives more heat (> 1000 cal/cm^2 a day) than the tropics.

The Sun's thermal radiation absorbed by the earth (45%) is radiated. This radiation is completely absorbed and accumulates which is called the **"Hot House Effect".** Long exposure to this effect leads to a rising of the earth's surface temperature to 288 K (+15^{0}C) and the effective temperature to 253 K (-20^{0}C).

There is an Ozonosphere, which absorbs the Ultra Violet Rays (UVR). This Ozone layer will act as screening layer which protects the living organisms on earth.

5.1.3 Properties of Atmosphere:

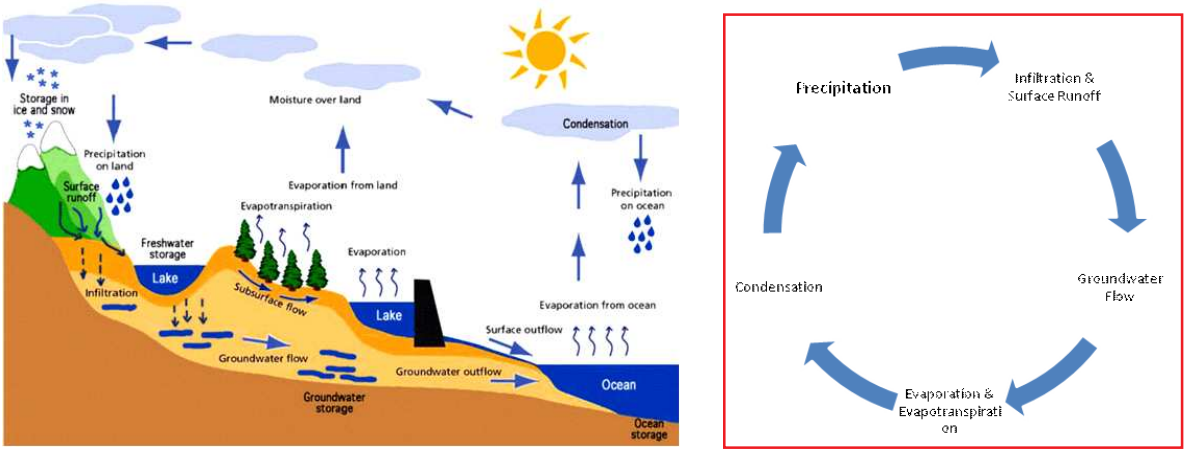
1. Humidity
2. Relative humidity
3. Clouds
4. Precipitation
5. Trade winds
6. Monsoons
7. Climatic factors

5.2 HYDROSPHERE

The water layer on earth surface is called hydrosphere including subsurface or underground water. It includes Lakes, Ponds, Water Pools, Tanks, Rivers, Oceans, Seas, precipitation and Rain runoff.

5.2.1 Water Cycle :

The water cycle is all about storing water and moving water on, in, and above the Earth.



Hydrologic Cycle

The water cycle has no starting point. But, we'll begin in the oceans, since that is where most of Earth's water exists. The sun, which drives the water cycle, heats water in the oceans. Some of it evaporates as vapor into the air. Ice and snow can sublimate directly into water vapor.

Rising air currents take the vapor up into the atmosphere, along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil. The vapor rises into the air where cooler temperatures cause it to condense into clouds. Air currents move clouds around the globe, cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Snow packs in warmer climates often thaw and melt when spring arrives, and the melted water flows overland as snowmelt. Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with stream flow moving water towards the oceans.

Runoff, and ground-water seepage, accumulate and are stored as freshwater in lakes. Not all runoff flows into rivers, though. Much of it soaks into the

ground as infiltration. Some water infiltrates deep into the ground and replenishes aquifers (saturated subsurface rock), which store huge amounts of freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as ground-water discharge, and some ground water finds openings in the land surface and emerges as freshwater springs. Over time, though, all of this water keeps moving, some to reenter the ocean, where the water cycle "ends" or where it "begins."

Evaporation, is the process by which water changes from a liquid to a gas or vapor. Evaporation is the primary pathway that water moves from the liquid state back into the water cycle as atmospheric water vapor. Studies have shown that the oceans, seas, lakes, and rivers provide nearly 90 percent of the moisture in our atmosphere via evaporation, with the remaining 10 percent being contributed by plant transpiration.

Condensation, the opposite of evaporation, occurs when saturated air is cooled below the dew point (the temperature to which air must be cooled at a constant pressure for it to become fully saturated with water), such as on the outside of a glass of ice water. In fact, the process of evaporation removes heat from the environment. Evaporation from the oceans is the primary mechanism supporting the surface-to-atmosphere portion of the water cycle. The large surface area of the oceans (over 70 percent of the Earth's surface is covered by the oceans) provides the opportunity for such large-scale evaporation to occur. Evaporation is more prevalent over the oceans than precipitation. Most of the water that evaporates from the oceans falls back into the oceans as precipitation. Only about 10 percent of the water evaporated from the oceans is transported over land and falls as precipitation.

Sublimation is most often used to describe the process of snow and ice changing into water vapor without first melting into water. Sublimation occurs more readily when certain weather conditions are present, such as low relative humidity and dry winds. It also occurs more at higher altitudes, where the air pressure is less than at lower altitudes.

Evapotranspiration, is defined as the water lost to the atmosphere from the ground surface and the transpiration of groundwater by plants through their leaves.

Transpiration, is the release of water from plant leaves. Transpiration is the process by which moisture is carried through plants from roots to small pores on the underside of leaves, where it changes to vapor and is released to the atmosphere. It is estimated that about 10 percent of the moisture found in the atmosphere is released by plants through transpiration.

Precipitation, is water released from clouds in the form of rain, freezing rain, sleet, snow, or hail. It is the primary connection in the water cycle that provides for the delivery of atmospheric water to the Earth. Most precipitation falls as rain.

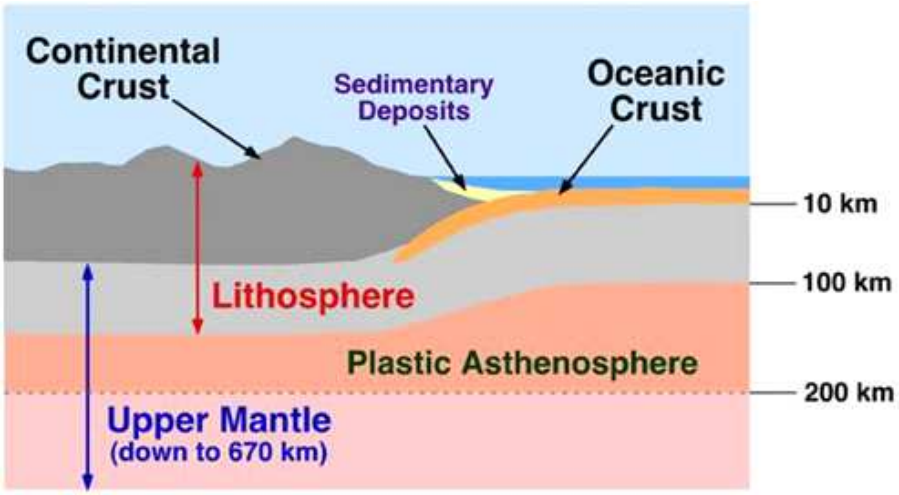
When rain hits saturated or impervious ground it begins to flow overland downhill which is defined as surface runoff. Some water that infiltrates will remain in the shallow soil layer, where it will gradually move vertically and horizontally through the soil and subsurface material. Eventually it might enter a stream by seepage into the stream bank. Some of the water may infiltrate deeper, recharging ground-water aquifers. If the aquifers are shallow or porous water moves freely through it.

A **spring** is a water resource formed when the side of a hill, a valley bottom or other excavation intersects a flowing body of ground water at or below the local water table, below which the subsurface material is saturated with water. A spring is the result of an aquifer being filled to the point that the water overflows onto the land surface. They range in size from intermittent seeps, which flow only after much rain, to huge pools with a flow of hundreds of millions of liters per day.

Springs may be formed in any sort of rock, but are more prevalent in limestone and dolomite, which fracture easily and can be dissolved by rainfall that becomes weakly acidic. As the rock dissolves and fractures, spaces can form that allow water to flow. If the flow is horizontal, it can reach the land surface, resulting in a spring.

The groundwater, the runoff, the spring water either directly or through rivers join ultimately the ocean to complete the water cycle.

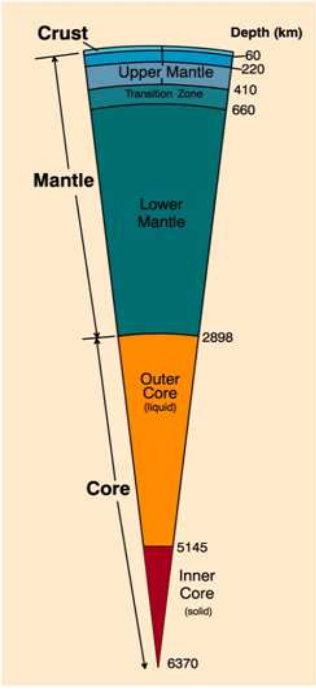
5.3 GEOSPHERE



5.3.1 Lithosphere

The lithosphere is divided as-
1] Continental Crust, 2] Oceanic Crust and 3] Transitional Crust.

In other words entire crustal layer is treated as lithosphere. It is the lower portion of the crust and rests above the asthenosphere of the mantle. The crust is made of igneous, sedimentary and metamorphic rocks.



Continental Crust: This layer represents continental regime. The thickness is 60 to 70 Kms lying below the continent. It is hard and solid formed by cooling and consolidation of magma by eruptive forces. Depending upon the cooling conditions of magma three types of rocks are differentiated. a) Volcanic rocks, which are formed due to rapid cooling, b) Hypabyssal rocks, which are formed at the intermediate or shallow depth; and c) plutonic rocks, formed due to slow cooling at deeper levels from the surface.

Transitional crust: Is the peripheral, marginal and transitional region occupies the place between continental and oceanic crust.

Oceanic Crust: It is representing a thickness about 11 km. It consists of two layers – The upper sedimentary layer representing deep water sediments, while the lower consisting of basaltic layer, which include oceanic floor, Mid Ocean Ridges, and deep trenches.

5.3.2 Mantle:

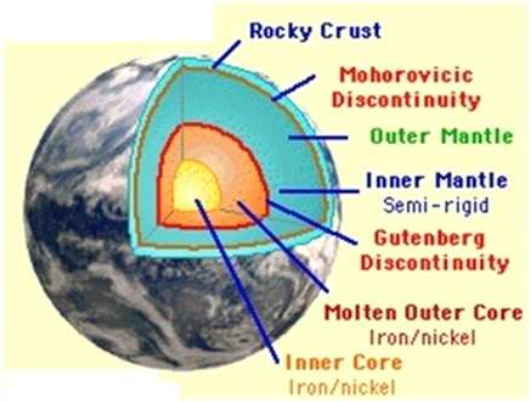
It is the biggest component of the earth. This zone continues up to a depth of 2100 km and it is separated into upper and lower mantle. The uppermost part of the upper mantle is part of the lithosphere, and is solid and rigid. The lower part of the upper mantle is partially molten, and hence can flow. The lower mantle is solid, but behaves in a plastic fashion. This is where most of the internal heat of the Earth is located. Large convective current cells in the mantle circulate heat and are the main cause for plate tectonic processes viz., earth quakes, volcanoes etc. The rocks of mantle are denser as compared to that of the crust (Density increases from 3.3 at the top of the mantle to 5.7 at its base). These evidences suggest that rocks of the mantle are mainly composed of ferro-magnesian silicates (Fe,Mg,Al,Si,O).

5.3.3 Core :

It is the third major and inner shell of the earth, which begins at 2100 km below the surface and extends up to the centre 6370km. The core at its outer part is fluid like. Core is further sub-divided into an outer and an inner core. The inner core is believed to start at 5121 km and extend up to the centre. The high density of the earth (5.5) as a whole and the composition of the meteorites indicate that the outer core is made up of nickel-iron alloys (Fe, S), while the inner core is almost entirely composed of solid Iron. The Earth's magnetic field is believed to be controlled by the liquid outer core because the solid core inside rotates (opposite direction to earth's rotation E-W), which provides magnetism and electricity to the earth.

5.3.4 Discontinuities of Earth

If the seismic waves show abrupt change in the velocity at some depth, it can mean that there is a change in the nature of medium at that particular depth. Similarly if the waves are continuous, the nature of the medium is homogenous. The change in the seismic velocity of seismic waves is called as seismic discontinuity.



With the study of the discontinuities within the earth, two major discontinuities were observed; 1) the crust-mantle discontinuity at about 30-35km below the continents and 5-6 km below the oceans, known as Mohorovicic Discontinuity. The mantle-core discontinuity occurring around 28108km, known as Gutenberg Discontinuity.

POINTS TO REMEMBER

1.0

1. Planets are the non luminous bodies.
2. Stars are self luminous bodies, illuminating their own light.
3. A galaxy is a massive, gravitationally bound system consisting of stars, stellar remnants, an interstellar medium of gas and dust and dark matter.
4. The sun is a star, and it is pivot of all the planets in the solar system.
5. The sun and eight planets make our solar system. The solar system includes 4 inner planets (high density but smaller sizes) and 4 outer planets (low density and larger in size).
   There are two kinds of geological process –Exogenous and Endogenous.
6. The processes which are carried out by the geological agents upon the earth surface are called exogenous process.
7. The processes which undergo inside the earth are called endogenous process.
8. The process which is carried out by the activity of magma within the crustal layer that brings changes in rocks.
9. The earth made up of three layers. Such as
   a. Crust: Crust is the outer most layer of earth. Further divided as basaltic and granitic crust.
   b. Mantle: Mantle is the middle layer of earth. Further divided as lower and upper mantle.
   c. Core: Core is the inner most layer of earth. Further divided as inner (Solid Iron ball) and outer (liquid) core.
10. Magma - is the hot mobile molten rock material available inside the earth.
11. Mineral is an inorganic substance that possesses a definite chemical composition, atomic structure and crystal system.

2.0

1. Universe is the infinite matter in space and time. It includes Stars, Planets, Asteroids, Galaxies, Meteorites and Comets.

2. Arrangements of 8 planets each rotating in a plane under the Gravitational Force of Sun is called Solar System.
3. Mercury is the nearest planet to the Sun.
4. Jupiter is the largest planet in solar system.
5. Saturn and Uranus are having gaseous rings.
6. Moon is the natural satellite of the earth.
7. Asteroids are minor planets, especially those of the inner Solar System. The larger ones have also been called planetoids.
8. The asteroid belt is the region of the Solar System located roughly between the orbits of the planets Mars and Jupiter.

3.0

1. The earth's diameter - Equatorial – 12.757 Kms and Polar – 12.713 Kms.
2. The circumference of earth is 510mln km^3 in length.
3. The mean density of earth is 5.517 gm/cm^3

4.0

1. The earth revolving in its own orbit by taking 23 hours, 56 minutes is called rotation.
2. The earth takes 365 days for one complete round around sun is called revolution. One revolution is called One year.

5.0

1. The earth has 4 zones- Atmosphere, Hydrosphere, Geosphere and Biosphere.
2. Atmosphere is the gaseous air layer, which envelopes the earth.
3. Air is in motion is called wind.
4. Hydrological cycle describes the continuous movement of water on, above and below the surface of the Earth.
5. Water media on earth surface is called Hydrosphere.

EXERCISES.
UNIT – I & II
GENERAL GEOLOGY

One Mark Questions:

1. What are Planets?
2. Define Crust?
3. What is Mantle?
4. Name the three layers of Earth
5. Define Core.
6. What is Magma?
7. What are Asteroids?
8. Define a Star
9. Name the nearest planet to the Sun
10. Name the biggest planet in solar system.
11. What is lithosphere?
12. Name the inner group of planets.
13. Name the outer group of planets.
14. What is Mohorovicic discontinuity?
15. Mention the approximate continental thickness of crust.
16. What is the thickness of Mantle?

Two / Three Marks Questions :

1. What is Physical Geology?
2. What is Hydrology?
3. Name the Geological agents?
4. What is Lithosphere?
5. What is Hydrosphere?
6. What is Atmosphere ?
7. Name the sub layers of Core ?
8. What is Asthenosphere?
9. What is crust?
10. Define Universe.
11. What is Galaxy?

12. What are Meteorites?
13. What are Comets?
14. Define Revolution and Rotation.

Five Marks Questions:

1. What is Solar system?
2. Explain the Inner group of Planets.
3. Explain the Outer group of Planets.
4. Explain the Internal structure of earth with neat sketch.
5. Explain the parameters of Earth.
6. Discuss the different shapes of earth.
7. What is Geosphere?
8. Explain the properties of Atmosphere.
9. Explain the Mantle.
10. Explain the Core.
11. Explain the Hydrological Cycle with neat diagram
12. Describe the lithosphere with neat diagram.

UNIT – III

6.0 GEOLOGICAL PROCESSES

6.1 Endogenous & Exogenous Process
6.2 Weathering, Agents of weathering, types (mechanical, chemical & biological) and products of weathering.
6.3 Wind- Geological action, Erosion (deflation, abrasion & attrition) and erosional features (pedestal rocks & ventifacts), Transportation (suspension & saltation), Deposition (types of dunes)
6.4 River -
6.4.1 Head & mouth.
6.4.2 Geological action: Erosion (Hydraulic action, corrasion , Corrosion & solution) and erosional features (v-shape valley, gorges, canyon, water fall, pot holes, meander & oxbow lake)
6.4.3 Transportation.
6.4.4 Deposition.
6.5.1 Snow, snowfield, snowline,
6.5.2 Types of glaciers – Valley, piedmont, continental/sheet glaciers, Movement of glaciers,
6.5.3 Erosion (abrasion, frost wedging, plucking & quarrying); and erosional features (Hanging valley, U-shape valley, Cirque, Horn & Arete)
6.5.4 Transportation
6.5.5 Deposition (glacial drift, moraines – lateral, medial, ground & terminal; depositional features- Drumlins, Esker)

6.1 Endogenous & Exogenous Processes: These are the processes carried out inside & outside (surface) the earth by the influence of natural geological agents (temperature, water, wind and air) bringing a desirable change upon the earth.

Exogenous Process: The processes carried out on the earth's surface by the geological agents like sun's temperature (heat), atmospheric gases, wind, water, ice etc.

Endogenous Process: The processes carried out inside the earth by tectonic forces, like plate movements, intrusion of magma, volcanic activity, earthquakes etc.

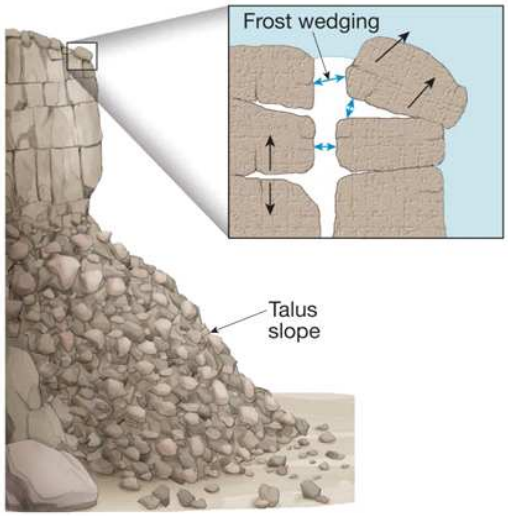
6.2 Agents of weathering, types (mechanical or physical, chemical & biological) and products of weathering

Natural agencies such as atmospheric gases, heat, moisture, surface and subsurface water, wind, sea water and ice originate upon the earth's surface and are defined as exogenic agents.
The tectonic activity which causes earth's movement and the volcanic eruption have their origin beneath the surface of the earth, hence they are classified as endogenic processes. The agents involved in such processes are called endogenic agents.

Weathering: It is natural process of disintegration and decomposition of the rocks. The weathering processes are - (1) Physical /Mechanical Weathering, (2) Chemical Weathering, and (3) Biological Weathering

6.2.1 Physical / Mechanical weathering:

Physical weathering is also called as mechanical weathering. It involves application of mechanical forces. The rocks breaks up or crumble with little or no change in the chemical composition of the material. It increases the amount of surface area for chemical attack. The chief processes are- Frost action (wedging and heaving), Action of gravity, Temperature change and Biological factors



Frost action : When water circulates into cracks and fissures of the rocks during day time and at night with fall in temperature water freezes, and due to this the rocks expands nearly $1/10^{th}$ of its Volume and it will exert pressure upon walls of the rock. It widens the opening and rock will be broken into pieces. This sort of disintegration action is called frost action.

Action of Gravity : In steep mountainous regions loosened weathered material will fall down by the action of gravity and accumulate at the base of the mountain. The fragments are called slide rocks. The heap like material formed by them is called Scree or Talus.

Temperature change (Exfoliation): The effect of daily variation in temperature causes the rock to disintegrate. During day time the rock surface is heated up while in night time it cools down. Such variations in temperature are repeated day after day for many years which affect the rocks. The binding is weekened and minerals separate giving rise to disintegration. This effect provides the peeling up off upper surface of rocks, giving rise to Exfoliation, similar to onion peeling.

6.2.2 Chemical Weathering: Water is the main agent in the process of chemical weathering. It brings about change in the composition of the rock material by decomposition. The chemical processes which are in the rock decomposition are: Hydration, Carbonation & Oxidation

Oxidation: It the interaction between oxygen molecules and all the different substances they may contact. eg., rust. Oxidation occurs on a variety of iron minerals present in the rocks. The most commonly observed is the oxidation of Fe^{2+} (iron) and combination with oxygen and water to form Fe^{3+} hydroxides and oxides such as goethite, limonite, and hematite. This gives the affected rocks a reddish-brown coloration on the surface which crumbles easily and weakens the rock.

Hydration : is the process by which certain minerals absorbs water or react with it to produce new minerals. e.g.

1. Hematite $\xrightarrow{reaction\ with\ water}$ limonite

   $Fe_2O_3+3H_2O \rightarrow Fe_2O_3.3H_2O$

2. Feldspar are decomposed by water resulting to clay

   $KAlSi_3O_8 + H_2O \rightarrow KOH + AlSiO_4 + 2SiO_2$

   Soluble Salts — Cla — Quartz

Carbonation : The rain water combines with CO_2 to form acids (H_2O_3). This acid reacts with various elements such as calcium, magnesium, and iron in the minerals and transforms them into carbonates and bicarbonates.

e.g. $CaCO_3+H_2O+CO_2 \rightarrow Ca(HCO_3)_2$

Ca -Bicarbonate

6.2.3 Biological Weathering :

The process of weathering is mainly related to the activities of various organisms, plants, animals, and Bacteria which take part in the transformation of rock at the surface of the earth.

6.2.4 Products of weathering

The products of weathering are commonly classified into- **Elluvium and Delluvium**

Elluvium : Is the end product of weathering that happens to live over and above the parent rock in the form of fragments.

Delluvium : It is also end products of weathering the fragments are bigger than the size of **Elluvium.**

6.3 WIND

Air in motion is called wind, which is one of the highly active natural weathering agent and responsible for a variety of geological changes on the earth's surface. In general, winds are produced mainly due to non-uniform heating and cooling of the surface of the earth at different places causing differences in atmospheric pressures.

6.3.1 Geological action :

Wind acts as an erosional agent, and carries particles of sand and other particles from one place to other and deposits this material.

A. **Erosion:** It is the removal of already weathered, disintegrated and decomposed material by wind. The wind erosion is caused mainly by -

a) **Deflation**: Winds when moving with greater velocity over, dry and loose sands or bare ground, it can remove huge quantity of the particles from the surface. This phenomena of removal of loose particles by wind is called as deflation.

b) **Attrition:** It is the regular impacts between the grains themselves and between the grains and the bed causing them to be broken up into smaller and smaller fragments. This process also makes them rounder and smoother.

c) **Abrasion or Corrosion**: The wind in its movement, when loaded with minute grains of sand and silt becomes a powerful scouring or abrading agent. The grains act as tools of abrasion or polishing against such rock surfaces over which the wind blows. This type of erosion by a natural agent aided by its load is called abrasion.

Erosional Features :

i) Pedestal or mushroom rock, these are flat-topped rock bodies that have very thin supporting lower region. The excessive thinning in the lower regions is mainly due to the fact that, the bulk of the sand is carried by wind is only one to two meters above the ground. This naturally results in greater erosion in the lower portion of the rock. The rock is effected on the upper parts also but not to the same extent. This differential erosion causes flat overhang at the rock top and from distance it looks like mushroom.

ii) Ventifacts: These are the pebbles of rocks or minerals, which have developed smooth plane surface due to **"Wind Abrasion"**

B. Transportation

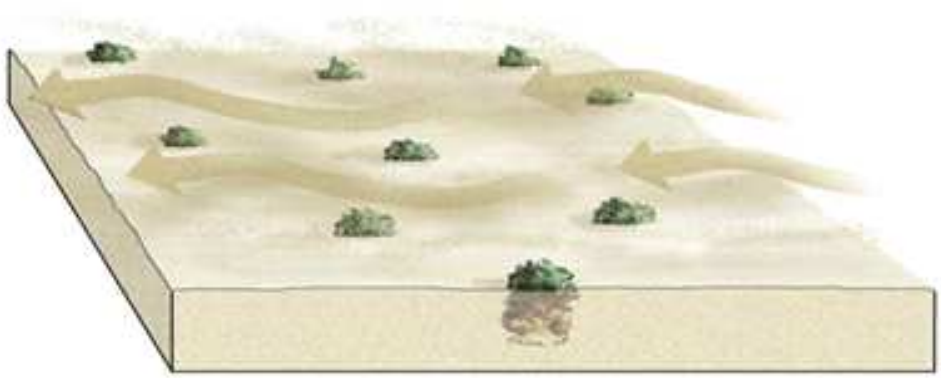

Sand movement by wind

Wind is an active agent of transport of fine materials, especially sand and dust, and moves thousands of tons of these materials from one place to other. The material under transport by wind is called as load.

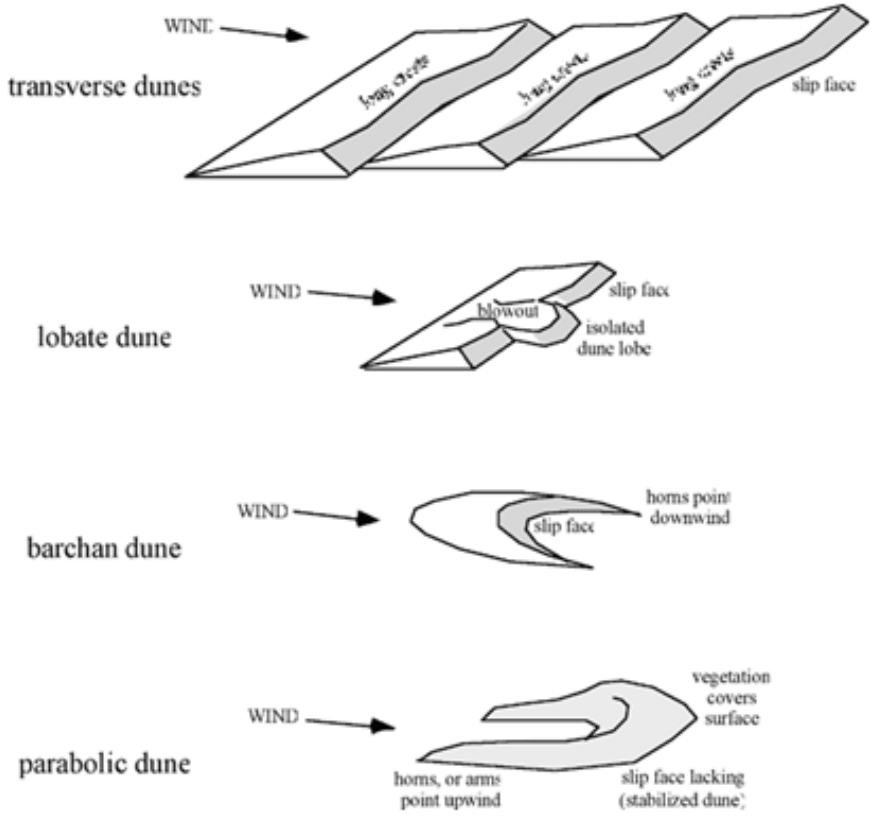
The wind carries its load either in suspension or by saltation. When the finer particles are lifted and carried at higher levels of the wind it is called suspended load. On the other hand, the coarser and heavier particles are lifted temporarily during high velocity and are mostly rolled on the ground by leaps and jumps. This is called as saltation.

The transporting power of wind mainly depends upon the wind energy or velocity and the material available.

C. Deposition : Depending upon the carrying capacity of the wind, the material is deposited. Whenever, the velocity of wind is checked because of one or the other reason, a part or whole of the load is dropped or deposited at the place of obstruction. Sediment deposited by wind in a particular region varies- it may be small or of considerable volume. Such wind deposits or accumulations deposited by wind are termed as 'aeolian deposits'. These are of two types – dunes and loess (the finest particle of dust).



Dunes : These are wind deposits made up of sand grade particles. A dune is defined as a ridge or mound of sand with a crest. The dune is developed normally when the wind deposits its load due to some obstructions during its transport. When this process continues for some time, the accumulated sand takes some typical shapes of a heap known as dune. Depending upon the wind velocity and direction there are variety of dunes viz., Barchans, Fore dunes, Transverse dunes, Longitudinal dunes and transverse dunes.



6.4 RIVER

6.4.1 Geological action: Erosion (Hydraulic action, corrasion , Corrosion & solution) and erosional features (pot holes)
6.4.2 Transportation
6.4.3 Deposition

A River is a water body that flows in its own channel. The high land or mountainous region from where the river actually originates is called the head region. The surface runoff flows down the slopes and collects in depressions. As these depressions get filled, they overflow to next depression. In this way an imperfect drainage system is established to form streams. Once a concentrated flow of the runoff is established a valley or gully develops and such streams join the major channel to form a river.
The place where a river enters a sea is called river mouth. At this place the saline and fresh water mixes and this region is called an estuary. The sediment carried by the river and deposited at the river mouth is called Delta.

6.4.1 Geological action of River:

The main function of rivers is to drain water from the land to sea. While carrying out this function, rivers erode valleys, pickup the weathered material and transport the rock debris, take some material into solution and deposit the rest. Hence, three factors are at work here i.e., erosion, transportation and deposition.

a) **Erosion:** It involves mechanical or chemical activity. Rivers erode, i.e., remove material from their beds and banks in different ways. It involves removal of the material in four principle ways-

i) **Hydraulic action:** The forces inherent in the flow of running water lead to mechanical erosion.

ii) **Corrasion or abrasion:** It is the process of mechanical abrasion of rocks of the riverbed and the sides. Fragments of the rocks are always striking against the bed and the sides of the river valley. As a result rocks get eroded and the products of abrasion are carried by the river current. The rock waste serves as the tools of destruction for the river current. One important feature formed due to this is **pot hole**.

Pot hole : These are more or less rounded or ellipsoidal hollows in the form of vertical shafts. These are produced on the riverbeds by the rock chips, pebbles cobbles etc. revolved by the action of swirling currents of rivers. These are produced mainly due to the working of hard chips or pebbles on soft bedrock.

Attrition : It is the mechanical wear and tear done on the transported rock fragments themselves. During abrasion and transit these fragments often collide among themselves, the bedrock and the sides. The angular fragments become rounded and the coarser grains become finer.

Corrosion and solution : This involves chemical action by river water. As the water is a good solvent the dissolving power of river water increases by the presence of alkali matter and some gases like hydrogen, carbon dioxide etc. with the aid of these dissolved substances it dissolves the substances coming under its course and carries it as solution.

b) Transportation : Rivers give rise to net shift of land material to the sea. The sources of river load, however, are more important than bed and bank erosion by the river itself. Even the rain, washes material from slopes into the river. Slope wash constitutes the largest fraction of load of most rivers.

c) Deposition or accretion : The river carries much of its load in suspension and solution. Whenever there is a velocity check or whenever the load exceeds the carrying capacity of the river the deposition of the sediment takes place. Obstruction to the velocity is offered by the irregularities in the river course, especially at river bends.

6.5 GLACIER

6.5.1	Introduction- Snow, snowfield, snowline,
6.5.2	Types of glaciers – Valley, piedmont, continental/sheet glaciers, Movement of glaciers,
6.5.3	Erosion (abrasion, frost wedging, plucking & quarrying); and erosional features (Hanging valley, U-shape valley, Cirque, Horn & Arete)
6.5.4	Transportation
6.5.5	Deposition (glacial drift, moraines – lateral, medial, ground & terminal; drumlins)

6.5.1 Introduction

Glaciers are streams of ice, which flow on the hill slope and valleys under the action of gravity. It is a permanent body of ice, consisting largely of recrystallized snow that shows evidence of down slope or outward movement due to the pull of gravity. The distribution of snow is controlled by latitude and altitude.

Snow is abundant at high altitude and high latitude. A snowfield is a region of permanent snow cover or the accumulation area of a glacier; and a snowline is the lowest line of permanent snow (perpetual) or the lower boundary of the snow cover.

6.5.2 Types of Glaciers: Three types of glaciers are distinguished:

a) **Valley / Mountain Glaciers/ Alpine type**

As the name suggests, these occupy mountain valleys. They are characterised by a clear drainage area called the glacier reservoir. Mountain glaciers are classified as simple and complex. Simple glaciers are separated from one another. Complex glaciers consist of a number of glacial streams coming out of various source regions and merging together. They resemble a river with its tributaries.

b) **Continental / Inland glaciers/Ice sheets** :
These are very large and can cover whole continents and islands. As a rule their surface has a plain-convex shape resembling a shield. They are distributed in the Polar Regions. Ex. Ice sheets of Greenland and Antarctica.

c) **Piedmont or Scandinavian or Intermediate Glaciers** :
These include elements of sheet and valley glaciers. These form at the foothills of the mountains. When two or more valley glaciers come out and fall on the plain, they unite to form bigger ice mass, which is called as piedmont glacier.

6.5.3 Movement of Glaciers:

On mountain slopes masses of ice and snow begin to flow down slope under the action of gravity. The movement of ice starts when the weight of the ice becomes more or adds up. The movement of a glacier follows the valley trends in which it flows. Glacier ice consists of two parts- one, viscous moving below due to pressure and other upper part which is solidified and is carried by the underlying flow mass. Hence, cracks or crevasses (cracks) are found on the upper part of the glaciers.

6.5.4 Geological action of Glacier

a) Erosion: The erosive action of glacier is effected by abrasion and is aided by frost action. There are several processes-

i) Abrasion: The frontal portion (head) of the glacier functions like a bulldozer pushing and scraping the ground in front of the ice. This effect in removing soil and the semi consolidated sediments. It is called as “abrasion”. Scraping occur when the rocks or boulders are frozen at the bottom of the flowing ice sheet. This is particularly affective on the valley floor and the sides. As a result the floor is scoured leaving long grooves, striations and polished surfaces.

ii) Mass washing: It is an important act of glacial erosion. Along the margins of valley glaciers the valley sides are scraped and blocks are broken which are frozen in the ice and are carried away.

iii) Frost Wedging or Plucking or Quarrying: During daytime or in summer days with the rise of temperature, some snow will melt and the melt water percolates through the joints of the rocks. During night this water freezes leading to the increase in volume due to which the rocks experience shattering. As a result the rocks are quarried and the debris are plucked and carried forward by glaciers.

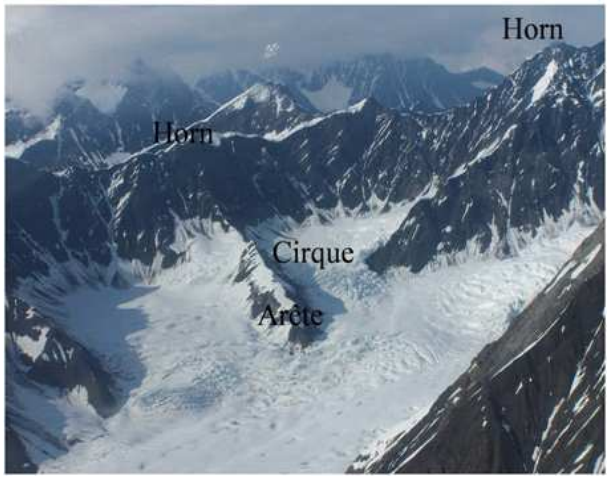
b) Erosional features :

i) U-Shaped Valley: The valley occupied by glaciers is usually U-shaped. Most valley glaciers originate and disappear in pre-existing valleys carved out by streams. The glacier has a huge mass of ice which erodes the valley and sides producing the U-shape.

ii) Hanging Valley :

A valley glacier may have one or more small tributary glaciers meeting it from sides. The rate of glacial erosion being more in the main valley glacier, a time comes when the side glaciers are no longer in direct contact; their small valleys are gradually left higher at junctions with the main valley. Such tributary valleys are called hanging valleys.

iii) Cirque: A cirque is defined as a semi-circular or half-bowl shaped depression with a uniform valley slope. Such depression is bounded on sides by steep walls. Cirques are found occurring commonly at the heads of glacier valleys.



iv) Arêtes: If two adjacent valleys are filled with glacial ice, the ridges between the valleys can be carved into a sharp knife-edge ridge, called an arête.

v) Horns: Where three or more cirques are carved out of a mountain, they can produce a sharp peak called a horn.

c) Transportation & deposition :

A large part of the load of the valley glaciers is carried on its surface. Much of this load is carried frozen within the ice. The larger blocks or boulders slowly sink towards the bottom leading to accumulation / deposition of heavy load at or near the bottom and the remaining part of the load is pushed along in front of the ice. All this loose fragmental material of rocks, both the transported and that deposited by the glaciers is called moraine. Moraines are of four types. In the mountain valley glaciers among the transported or moving moraines several varieties according to their position with respect to the body of glacier can be distinguished.

i) Ground Moraines :

The ground moraines are deposited upon the ground/valley floor on which the glacier is moving.

ii) **Lateral Moraines** :

These are the materials deposited along the margins of the glaciated valleys and they look like ridges of rock debris often they persist even after the disappearance of glacier.

iii) **Medial Moraines** :

These are moraines generally observed at the centre of the glacier parallel to the valley. These are formed when the tributary glaciers join the larger glacier. The lateral moraines of each glacier unite to give rise to medial moraines.

iv) End Moraines or **Terminal Moraines** :

These are the deposits or accumulations of rock debris (moving moraines) at the terminus of the glacier. These are exposed when the portion of the edge of the glacier remains stationary for a considerable time. These are also called as marginal moraines.

d) Depositional features :

i) Drumlins : In glaciated region the ground moraines consists of low mounds of clay, which sometimes contain cores of bedrock. These small hillocks are similar to inverted teaspoons.

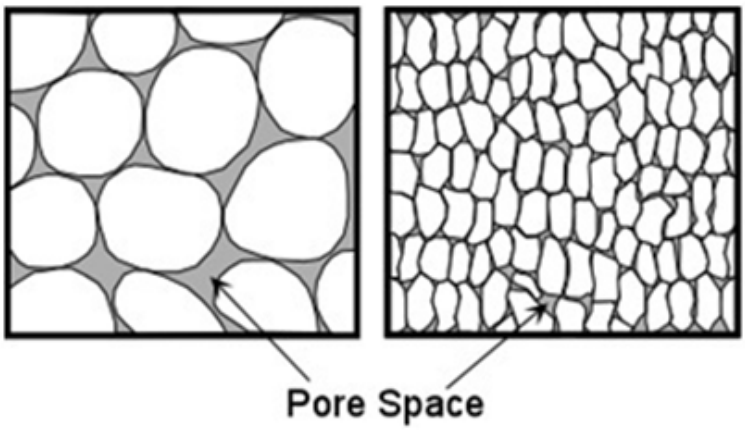
ii) Eskers: These are the narrow ridges extended in the direction of the movement of the glacier, and are composed of washed layered deposits of sand, gravel and pebbles. Their forms resemble railroad embankments, with height varying from 10-30 m spreading hundreds of meters to several kilometers.

6.6 UNDERGROUND WATER

6.6.1 Hydrological properties – porosity & permeability
6.6.2 Zones – aeration & saturation; water table; aquifers,
6.6.3 Well
6.6.4 Springs
6.6.5 Karst topography- Stalactite & Stalagmite

6.6.1 Hydrological properties

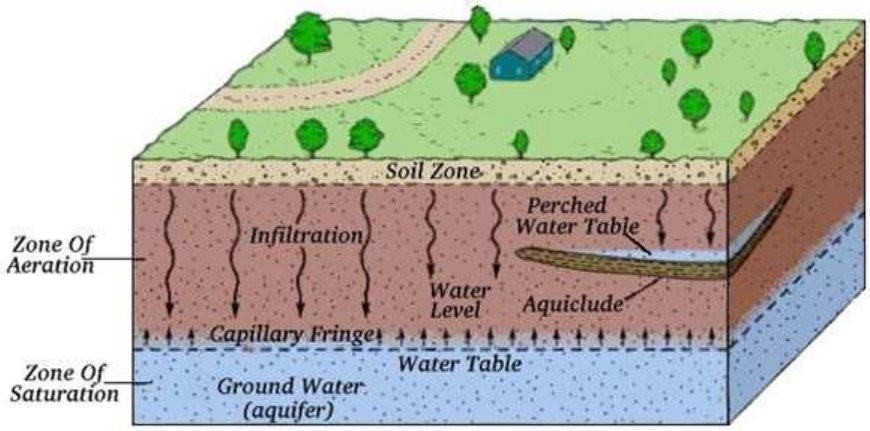
Porosity is the percentage and volume of the rock that is open space or pore space. This determines the amount of water that a rock can contain. Porosity of a rock and soil, depends on grain size, the shapes of the grains and the cementing material.



Permeability is a measure of the degree to which the pore spaces are interconnected, and the size of the interconnections. Low porosity usually results in low permeability, but high porosity does not necessarily imply high permeability.

6.6.2 Zones

a) Zone of aeration : The zone of aeration consists of interstices occupied partially by water and partially by air. This zone is divided into three sub zones:



i) **Soil water zone :** The belt of soil water which constitutes the upper portion of the zone of aeration is limited to the surface layer penetrated by roots. The water here occurs in thin films of moisture known as **hygroscopic water** which is remained adsorbed on the fine grained soil particles.

ii) **Intermediate Vadose Zone :** This zone extends from the lower edge of the soil-water zone to the upper limit of the capillary zone.

iii) **Capillary zone:** The capillary zone extends from the water table up to the limit of capillary rise of water. The capillary fringe lies above the water table and is in contact with it. The water of the fringe is held above the water table by capillarity.

b) Zone of saturation :

In the zone of saturation all the interstices/openings are filled with water under hydrostatic pressure. Hence, the porosity provides direct measure of the water contained per unit volume.

Water Table : It is the line between zone of aeration and zone of saturation or it is the upper surface of zone of saturation.

Aquifer : Aquifer is a large body of permeable material where groundwater is present in the saturated zone. It is a geologic formation that is water bearing or saturated with water and is capable of yielding sufficient quantity of water for exploitation.

6.6.3 WELLS :

A well is any opening into the ground used to obtain water, where the depth of the opening is greater than the largest surface dimension. Well depths can range from a few feet to thousands of feet deep.

TYPES OF WELLS

Dug wells : are typically constructed in areas with very high groundwater levels and utilize a constructed box or circular structure, which allows water to seep into the well. As these wells often pose a safety hazard and are more prone to contamination, they are generally discouraged for use.

Drilled/Bore Wells : Almost all modern wells constructed for public use are drilled wells. They can be drilled using different methods. In Wisconsin, the two most common methods are- i) **Rotary drilling**, which utilizes a spinning drill bit. Water or air is pumped down either outside or inside of the drill bit to cool the bit and carry the drilled material to the surface; ii) **Cable-tool**, method uses an impact bit that crushes the soil material and rock it encounters. Periodically, the bit and the crushed material are brought to the surface.

6.6.4 Springs : Water infiltrates into the ground to become groundwater. It eventually drains out lower in the landscape under the influence of gravity. Such discharges are known as springs.

Springs generally can be divided into five groups - fracture springs, bedding springs, alluvial fan springs, water table springs, and artesian springs.

Fracture springs : Rainfall and snowmelt in the mountains seeps into cracks and fractures in the bedrock and travels underground through these openings until it reaches a low area such as a canyon. At this point, the water seeps out of the fractures and onto the surface.

Bedding springs : These are also noticeable in the mountain and canyon areas. When one type of rock is setting on top of a different type of rock, we call this bedding, where one can see many different layers of rocks stacked on top of each other. Some rocks can transmit water easier than others. When a rock type that transmits water easily sits above a rock type that is mostly impermeable, the water in the upper rocks tends to move laterally instead of downward. Quite often, bedding springs are the locations of vegetation such as trees and bushes that occur on the walls of canyons.

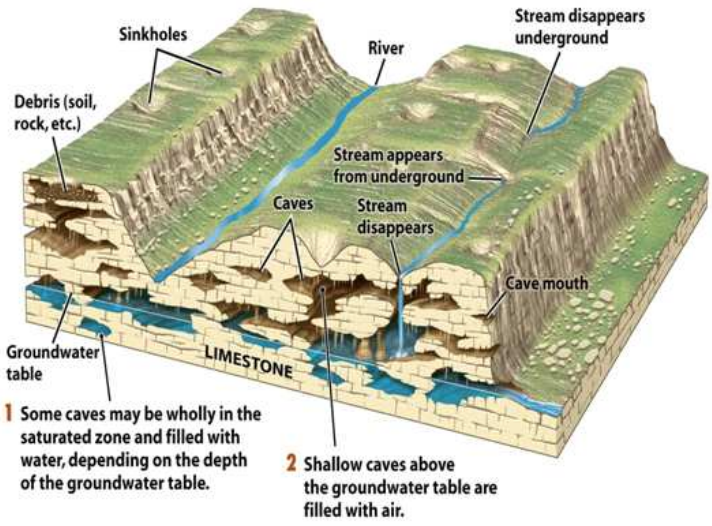
Alluvial fan springs: It occurs in the area of rocks and sand at the mouth of a canyon coming off of the mountains. As water moves down a canyon, it carries sediment with it. The sediment can get deposited out onto the valley floor as the stream leaves the canyon. Over many years, the sediments build up and form a fan-shaped feature near the mouth of a canyon (similar in principle to a river delta) which is called an alluvial fan. The infiltered water will seep back out near the base of the fans. These are alluvial fan springs.

Water table springs (Contact spring) : These occur near the middle of valleys. This is where the ground water is high enough to intersect land surface and the water exits the ground. Typically these areas are locations of wetlands or lakes.

Artesian springs : These result from release of water under pressure from confined aquifers either at an outcrop of the aquifer or through an opening in the confined bed.

Springs are very useful to hydrologists for looking at changes in natural conditions. Changes in evapotranspiration due to changes in the type and amount of vegetation cover can alter ground-water levels and affect spring discharge. And human impacts from pumping certainly can have an affect on the ground-water levels and availability of water to feed the springs.

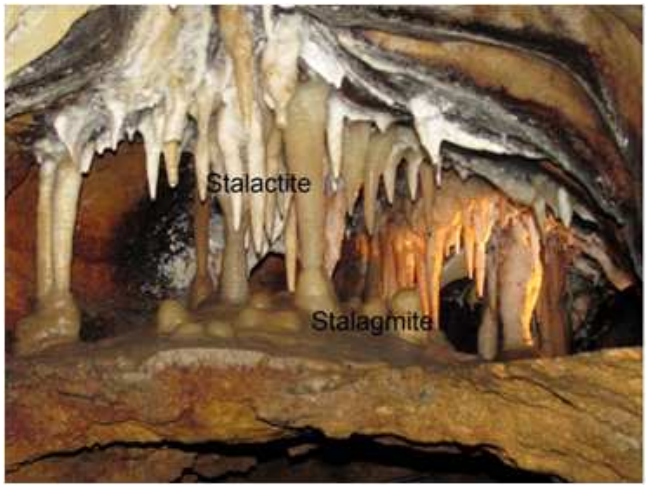
6.6.5 Karst Topography



Karst landforms are a feature created on the Earth's surface in area of limestone and dolomite rocks the solution action of underground water gives rise to highly distinctive landforms both on and below the surface which are collectively known as Karst landform. Underground stream and cavern are distinctive features of limestone region. The cavern or cave is a subterranean hollow, formed essentially by the solutional and corrasional activity of underground water

Stalactite and Stalagmite :

When the underground water drips from the cavern ceiling, it contains carbonate of lime. When the droplets of water are hanging by the ceiling, some water is evaporated and portion of the carbonate of lime is deposited on the ceiling giving rise to distinct and attractive structural features of rock. These rock features hang from cave roof insitu (at the same place). These features are formed by the trickling of concentrated solution of calcium carbonate solution, which keep on growing towards floor which are called as stalactites. Stalagmites are opposite to stalactites, where in the trickled solution falling on the ground grows towards roof.



SIGNIFICANCE OF EXOGENOUS PROCESS

Exogenous process plays a vital role in restructuring and moulding of the earth's surface. This process is also destructive providing the effect of environmental, ecological imbalances of the atmosphere, hydrosphere and biosphere

Stalagmite and Stalactite structures observed at Ulavi Caves.

UNIT – III
Geological Processes

One Mark Questions :

1. Name two important Geological Processes.
2. What is weathering?
3. Define Exfoliation.
4. Define Hydration.
5. What is Oxidation?
6. What is Wind?
7. Define Deflation?
8. What are Ventifacts?
9. What is Saltation?
10. What are Barchans?
11. What is Snow field?
12. What is Snow line?
13. Define Neeve
14. What is Crevasse?
15. What are oxbow lakes?
16. What are Drumlins?
17. Define Crater.
18. Define Moraines.
19. Define pyroclasts.
20. What is Karst topography?
21. Define Horns.
22. Define snowline.
23. What is hanging valley.
24. Define River.
25. What is meandering.

Two Marks Questions:

1. What is Frost Action?
2. What is Exfoliation?
3. What is Spheroidal Weathering?
4. What is Biological Weathering?
5. What is abrasion?
6. What are Pedestal rocks?
7. What are dunes?

8. What is v-shape valley?
9. What is Loess?
10. What are geological agents?
11. What are Moraines?
12. What is cirque?
13. What is crevasses?
14. Define Meanders?
15. Define Pot Holes?
16. Define Delta?
17. What are Ox bow lakes?
18. What is snowfield?
19. Define magma
20. Define lava

Five marks questions:

1. What is weathering? Explain the types of weathering.
2. Explain the geological action of wind.
3. Explain the erosional features of wind
4. Explain the depositional features of wind.
5. Describe the geological action of glaciers
6. Explain the different types of glaciers.
7. Explain the erosional features of glaciers.
8. Explain the Karst topography.
9. Explain the erosional features of Rivers.
10. Explain the depositional features of river.

UNIT- IV

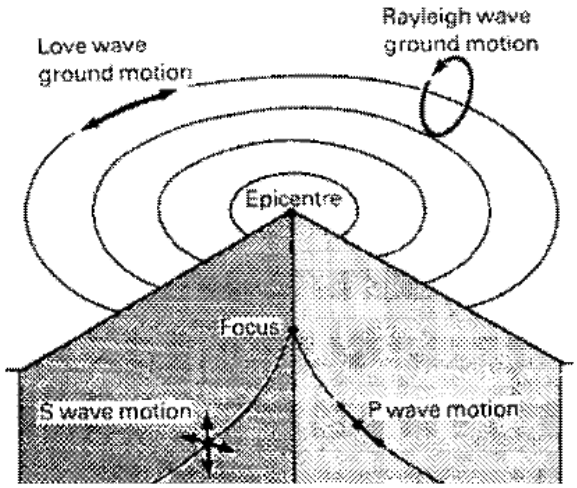
7.0 ENDOGENEOUS GEOLOGICAL PROCESSES

7.1	Earthquake - Causes (tectonic & non tectonic) & effects. Seismic waves- Body & surface. Seismograph, Seismogram, magnitude (Richter scale), Intensity
7.2	Volcano – Typical volcano & Structure, Types (Active, Dormant & Extinct) Products – Gaseous, Liquid & Solid.

Endogenous processes: The processes carried out inside the earth by tectonic forces are responsible for the crustal deformation and movements. These forces are generated mainly due to convection currents (converging, diverging) generated by magmatic fluids within the zone of mantle.

7.1 EARTHQUAKES

Earthqakes are vibrations induced in the earth's crust that virtually shake up or gives a jerking blow/movements of a part of the crust. These are extremely short-term movements rarely exceeding few minutes and highly variable in their intensity and distribution.



7.1.1 Focus or Hypocentre: The place from which an earthquake triggers is known as focus or hypocentre. It is the point below the earth's surface where the disturbance is commonly in the form of displacement or faulting of rocks.

7.1.2 Epicentre: The point or place on the surface vertically above the focus of an earthquake is termed as epicentre of that particular earthquake. It is a place on the earth where the earthquake disturbances reach first and do the maximum damage.

7.1.3 Classification based on depth of focus :

a. Shallow earthquake :
The depth of focus lies any where up to 60 km below the surface.

b. **Intermediate earthquake** :
These originate between 60-300 km below the surface.

c. Deep seated earthquake :
These are due to disturbances far below the surfaces generally below 300 km but not beyond 700 km depth from the surface.
However, great majority of the earthquake had been of shallow type.

7.1.4 Seismic waves :

These are elastic waves characterised by velocity, frequency and amplitude. Seismic waves in the earth's crust exceed up to 7km/sec. However, the velocity depends upon the type of wave and the nature of the medium in which it travels. Seismic waves are classed as body and surface waves. Body waves are P (Primary) and S (Secondary) waves which travel through earth's interior; and surface waves are L (Love) and R (Rayleigh) waves, which travel through the surface), and radiate in all directions.

7.1.5 Amplitude :

It expresses the rating of an earthquake on the basis of amplitude of seismic waves recorded as seismograms. Such a rating is obtained by comparing the actual seismograms of an earthquake with the standard records.

7.1.6 Intensity :

It also expresses the rating of an earthquake but it is on the basis of its effects on the material things of the earth, the effects being observed without help of any instruments. The effects are directly related to the degree of shaking of the earth crust during an earthquake.

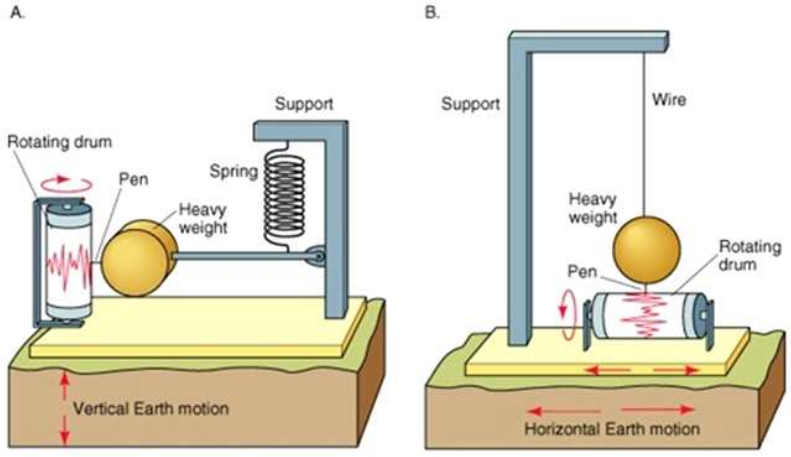
A logarithmic scale is generally worldwide used to compare the magnitude of earthquake. This scale was devised by **C.F. Richter** (1935) for comparing the magnitude of earthquake

Richter Scale or Magnetic No.	Amount of TNT explosive in terms of equivalent energy.
0	600 gm
1	20 kg
2	600 kg
3	20 mega gram
4	600 mega gram (= $1H_2$ Bomb)
5	20 giga gram
6	600 giga gram
7	20 tera gram
8	600 tera gram

1 Mega gram = 1000 kg; 1 giga gram = 1000 met.ton
1 Tera gram = 1 mega ton

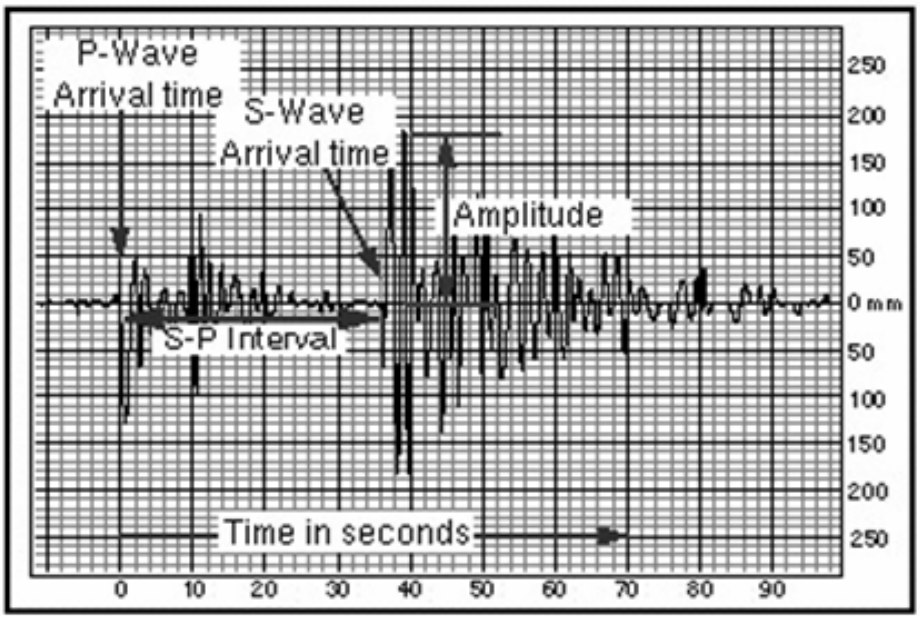
7.1.7 Seismograph:

It is the instrument designed to record earth motion set up by seismic waves. A seismograph may be designed to record vertical, horizontal or both components of ground vibration. The essential part of such a seismograph is a pendulum which swings either vertically (up & down Figure A) or horizontally (to & fro Figure B) during an earthquake. In normal condition it remains at rest. During an earthquake its oscillations recorded differently depending upon the design. The seismograph consists of a pendulum attached to a delicate beam suspended with a vertical axis through a wire. In front of the pendulum a drum is placed which is capable of rotating at a fixed speed. A paper is wrapped over the drum. The pendulum is provided with a recording device (a printer or pencil). The drum is also provided with a clock and time marking device.



7.1.8 Seismogram :

The record left on the paper through seismograph is known as the seismogram.



7.1.9 Origin of Earthquakes: Earthquakes are caused due to two processes - Non tectonic & tectonic.

a) **Non-tectonic** :

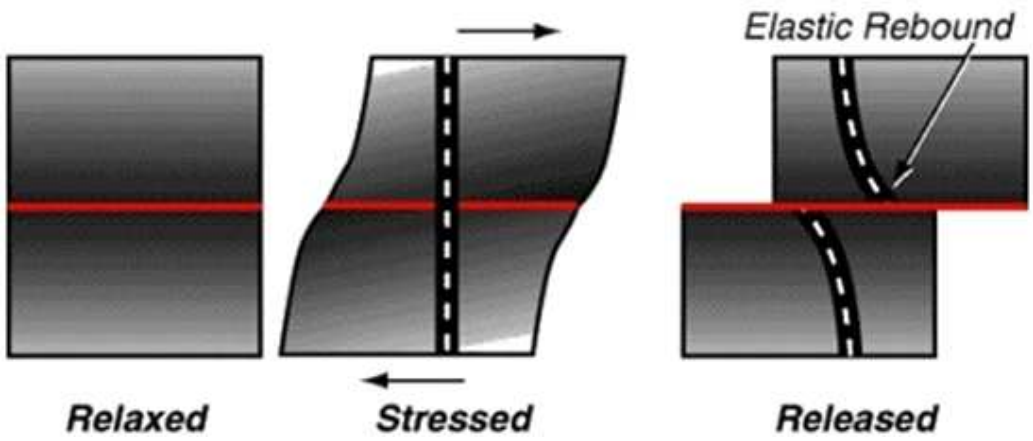
These are caused either by volcanic eruption or by collapse of ground. Generally both of these types are felt locally. The volcanic earthquake is caused due to jerks or vibrations induced in the ground due to volcanic eruption of lava/magma and due to sudden blow/ explosion of gases & lava.

The collapse earthquake is of very local nature and is rare. These are caused due to subsidence or collapse of small parts of ground. Similarly huge landslides or rock bursts give rise to earth quakes.

b) **Tectonic :**

These are the most common and most destructive events. It is broadly agreed that these are caused by displacement of blocks of rocks of the earth crust.

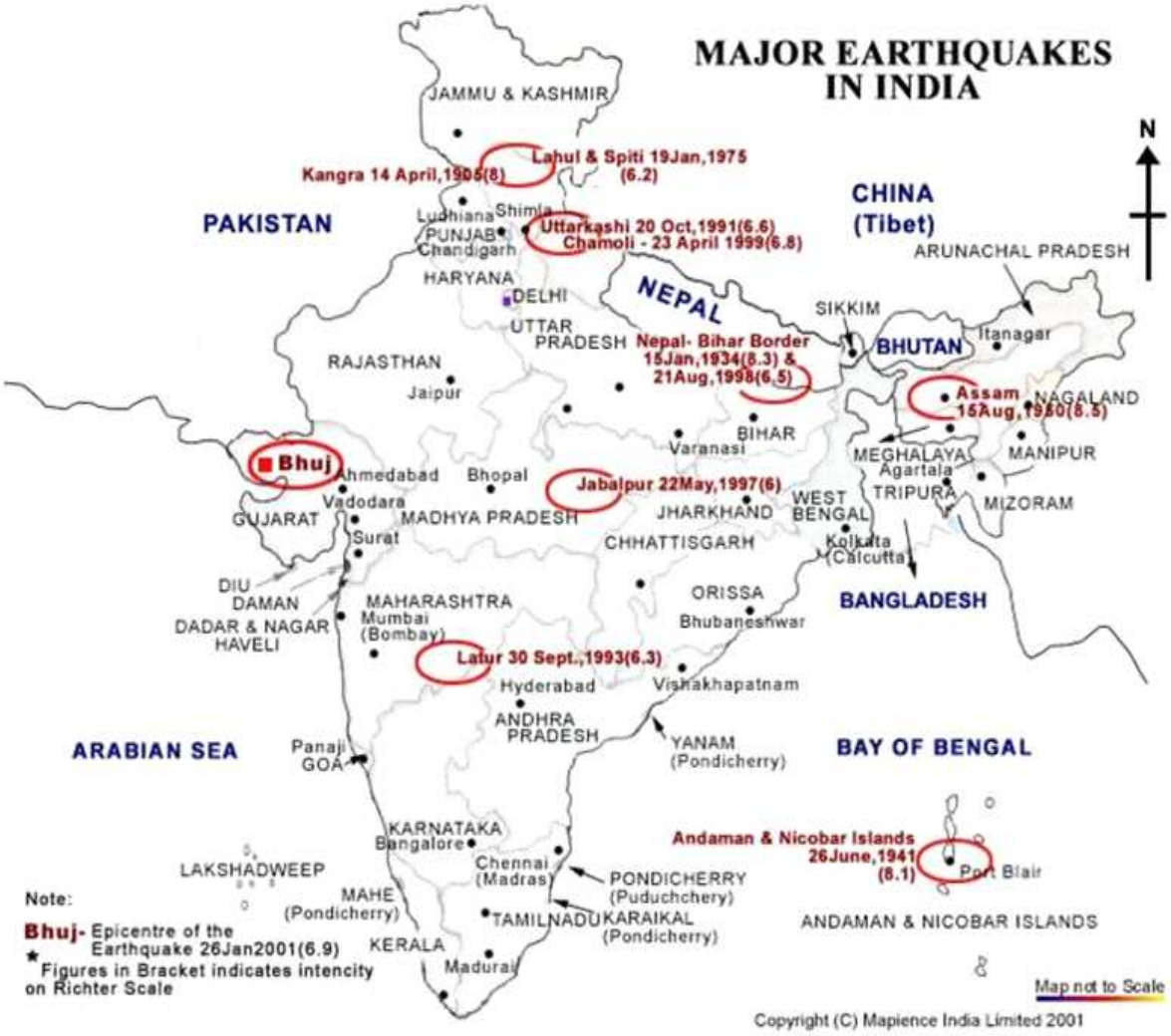
The **elastic rebound theory** of H.F.Reid is presently the most popular theory in explaining the mechanism of tectonic earthquakes.



According to this theory any block of the earth that is under the influence of unequal forces would withstand these forces in the initial stages by undergoing elastic deformation. The forces get stored in the rock as elastic strain till a limit is reached when the elasticity of the rock block exceeds by the forces. A fracture is caused at that stage in the block and under the influence of these forces the blocks so created by fracturing move apart each other releasing the stored pressure. This is called faulting. The movement at which rupture takes place and faulting starts the earthquake is caused.

List of recent Earthquakes occurred in India with > 5 magnitude on Richter scale

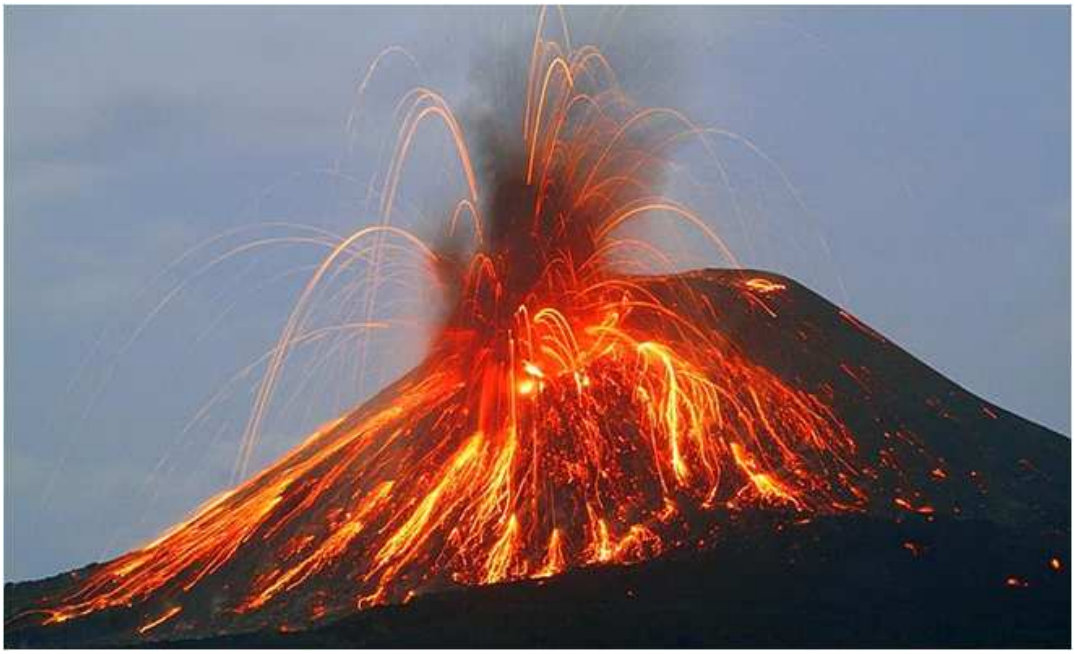
Dates	Time	Location	Latitude	Longitude	Deaths	Magnitude
October 3, 2013	11.30 IST	Gangtok, Sikkim	26.1 °N	88.7 °E	0	5.2
May 1, 2013	12.27 IST	Jammu & Kashmir	33.1 °N	75.8 °E	2	5.8
April 16, 2013	14.04 IST	Dibrugarh, Assam	28.87 °N	105.12 °E	0	4.6
March 5 2012	13:010:00 IST	New Delhi	28.8 °N	76.7 °E	5	5.2
Sept. 18, 2011	18:23 IST	Gangtok, Sikkim	27.72 N	88.07E		5.7
Sept. 18, 2011	18:10 IST	Gangtok Sikkim	27.723 °N	88.064 °E	118	6.10
August 10, 20010	01:21 IST	Andaman Island	14.1 °N	102.8 °E	26	7.7
April 6, 2006	23:210 IST	Gujarat	23.3 °N	70.4 °E	None	5.5
Oct. 8, 2005	08:50 IST	Kashmir	34.4103 °N	73.6210 °E	130,000	7.6
December 26, 2004	010:28 IST	Off west coast northern	3.30 °N	105.87 °E	283,106	10.3
		Sumatra India Sri Lanka				
		Maldives				
January 26, 2001	08:50 IST	Gujarat	23.6 °N	610.8 °E	20,000	7.6/7.7
March 210, 1101010	00:35 IST	Chamoli Dist Uttarakhand	30.408 °N	710.416 °E	103 Approx	6.8
Sept. 30, 110103	010:20 IST	Latur - Maharashtra	18.08 °N	76.52 °E	10,748	6.2
October 20, 110101	02:53 IST	Uttarkashi, Uttarakhand	30.73 °N	78.45 °E	>2,000	7.0



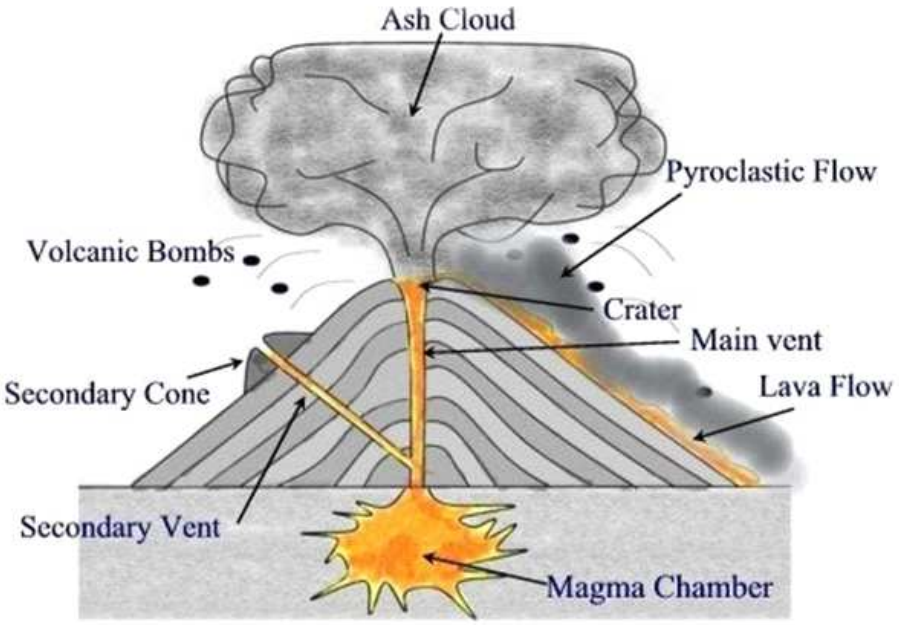
7.2 VOLCANO

A volcano is most commonly a conical hill or mountain built around a vent that connects with reservoirs of molten rock below the surface of the Earth. The term volcano also refers to the opening or vent through which the molten rock and associated gases are expelled. A volcano is essentially a fissure or vent, communicating with the interior, from which flows of lava, explosive bursts of gases and volcanic ashes are erupted at the surface. The fragmental materials produced during volcanic eruptions are known as pyroclasts.

However, if the magma solidifies within the earth at a depth it is called as intrusive magmatism. The magma when it emerges out of earth's crust it is called as lava and the process is called volcanic eruption.



Very recent (5 Feb 2014) volcanic eruption 'Anak Krakatoa stratovolcano', located between the islands of Sumatra and Java.



Typical Volcano

7.2.1 Typical Volcano :

A typical volcano (figure) is a conical shaped hill and has a vertical pipe, that communicates between surface of the earth and the interior mass of magma or lava.

It is the passage for lava, hot gasses and fragments of rocks when the volcano erupts. The mouth of the volcano is called as crater. It is funnel shaped. When the crater is wide it is called caldera, and it is formed due to violent explosion. Resulting in the blowing up of the summit of the volcanic cone or due to subsidence or collapse. The mountain shape of a volcano is due to the accumulation of lava and other material that come out of it. Lava on its way up through the fissures sometimes cut across the country rocks as **dykes** instead of taking the usual central path. These are also called discordant intrusions. If the eruptions is through a number of weak zones or linear fissures distributed around the volcanic region and having no cones or craters like central eruptions, it is called **fissure eruption**.

7.2.2 Products of Volcanoes:

The material which are thrown out or erupted by a volcano consist generally of all the three phases of the matter i.e., solid, liquid and gases.

a) **Solid materials** (Pyroclasts): These are solid materials thrown out by the pressure of the rising lava generally of country rocks. Pyroclasts consists of fragments of different sizes. The biggest fragments formed as **Volcanic blocks** (>32mm) accumulates near the crater. Whereas those with a size between walnut and pea known as **cinders** or **lapilli**'s are thrown further away. The finest particles are called as volcanic dust, is blown away still greater distances, which after consolidation forms volcanic tuff. Solidified or semi solidified clots of lava, which are also thrown along with the other materials, are called as **volcanic bombs**.

b) **Liquid materials** (Lava): The bulk of the material erupted from volcanoes in the form of an excessively hot and mobile liquid is called as lava. This lava is charged with gasses, which escapes when it erupts on the earth surface and produce cavities in the rock formed after cooling and consolidation.

c) **Gases** : Gases are generally the first to reach the surface and acquire great heights over a volcano. The most dominant gas is steam; carbon dioxide, sulphur dioxide and carbon monoxide; nitrogen and hydrogen are other chief gases. Gasses play very important role in the volcanic eruptions in that they impart to the magma sufficient mobility and also supply pressure necessary for the ascent in the volcanic column. These gases add up to atmospheric warming.

Volcanic explosion of gases
(Mount-redoubt, Alaska, April 21 1990)

7.2.3 Types of Volcano:

Depending upon the time interval between two volcanic eruptions the volcanoes are called as-

a) **Active Volcano**: is one, from which a volcanic eruption can be erupted at any time. The eruption may take place after a few years or tens of years.

b) **Dormant Volcano**: is one, which erupts with a period of rest that could be a few years, or several years.

c) **Extinct Volcano**: is one, where the activity of the volcano seems to have ceased altogether.

A great majority of volcanoes of the world appear to be concentrated along two main belts. The Circum Pacific Belt and Alpine - Himalayan Belt. The first belt is well defined and covers many parts of America, Japan, East Indies, and New Zealand etc., these belts are not continuous.

Deccan Volcanic Lava Flows of Mahabaleshwar, Maharashtra

Very recently a volcanic eruption has created a new island in the sea south of Tokyo, Japan.

Pompeii, Italy was the largest of several towns buried by the raging eruption of Mt. Vesuvius that began at about noon on August 24 of 79 AD.

SIGNIFICANCE OF ENDOOGENOUS PROCESS

Endogenous processes are highly destructive. The volcanoes are destructive as well as constructive (they create and destroy the land). Volcanoes build mountains (orogeny). These processes are destructive giving rise to hazards and impact on earth's environment. Earthqakes can occur both in the continent and oceanic crust. When it occurs in oceanic crust, it triggers Tsunami, which is highly disasterous.

UNIT – IV.

ENDOGENOUS GEOLOGICAL PROCESS

One mark questions:

1. Name the three kinds of seismic waves.
2. Define focus.
3. What is epicenter?
4. What is Hypocenter?
5. What is Seismograph?
6. What is Seismogram?
7. What is Vent?
8. What is Crater?
9. Name the three kinds of Volcanoes.
10. What is Active Volcano.
11. What is Dormant Volcano.
12. What is Extinct Volcano.
13. What are pyroclasts

Two Marks Questions:

1. Mention the causes for earth quakes.
2. Mention the causes for Volcanoes
3. What are P & S waves?

Five Marks questions:

1. What are earthquakes? Explain origin & causes of earthquakes.
2. Explain the effects of earthquakes.
3. Explain the causes of earthquakes.
4. Explain seismograph and seismogram.
5. Explain the types of volcanoes.
6. Write a note on major volcanic eruption (Deccan volcanism) in India.
7. Write a note on distribution of earthquakes.
8. Explain the Richter Intensity scale of earthquakes.
9. Explain the classification of earthquakes.
10. Write a note on distribution of volcanoes.

UNIT V

8.0 MINERALOGY

8.1 Introduction, Definition of mineral.
8.2 Physical properties – Color, streak, luster, diaphaneity, form, cleavage, fracture, hardness, tenacity, specific gravity, chemical composition, crystal system & uses
8.3 Study of mineral groups describing physical properties, chemical composition, crystal system, occurrence & uses of – Quartz , Feldspar, Mica, Ores – Metallic & non metallic
8.4 Specific gravity by Walker's Steel Yard balance.

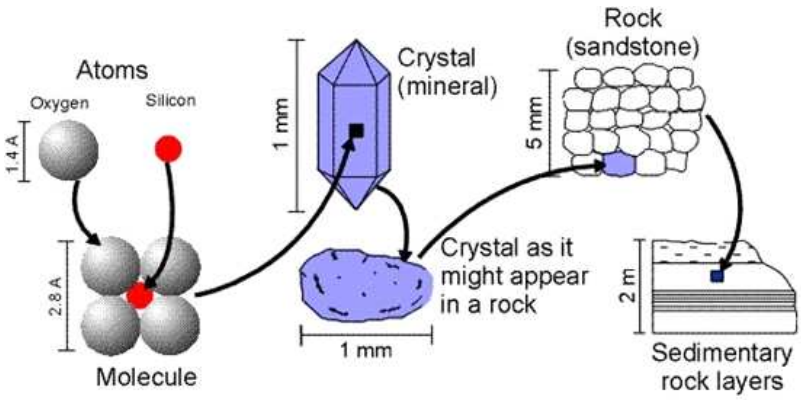
Mineralogy is the branch of Geology, dealing with the study of the chemistry, atomic structure, physical properties, and genesis of the mineral. Minerals are the smallest geological units forming the crust.

Minerals are further characterized by their more of less fixed chemical composition and more often found to occur in nature, these minerals exhibiting geometric forms (crystal) characteristic of internal atomic structure.

8.1 Definition of Mineral : Minerals are naturally occurring inorganic substances having definite chemical composition and atomic structure. For ex., quartz, feldspar, pyroxene, mica etc.

Minerals can be made of: elements – for ex., a native mineral is made up of only one element (Carbon, Gold); and compounds – contain atoms in a fixed ratio, most minerals are compounds. For ex., SiO_2 , $CaCO_3$.

Common mineral forming elements		
Element	**Symbol**	**% of continental crust mass**
Oxygen	O	46.6
Silicon	Si	27.7
Aluminum	Al	8.1
Iron	Fe	5.0
Calcium	Ca	3.6
Sodium	Na	2.8
Potassium	K	2.6
Magnesium	Mg	2.1



The major mineral categories based on chemical composition are – native elements, sulphides, oxides, halides, sulphates, carbonates, phosphates and silicates.

The minerals are classified into

(1) Rock forming minerals - Quartz, Feldspar, Mica, Olivine etc.
(2) Economic minerals or ore minerals – these are minerals from which metals or other elements can be profitably recovered. Hematite, Pyrolusite, Chalcopyrite, etc.

During formation of a rock, the minerals can be -

(a) Primary minerals – Quartz, Felspars, Amphibole, Pyroxene etc., which are formed during the formation of the rock.
(b) Secondary minerals – usually Zeolites, Calcite, Quartz etc., which are formed after the formation of the rock.

While grouping the rocks, the minerals available are grouped as-

a) Essential minerals- are minerals, the presence of which is useful to designate a particular mineral. Olivine (for Dunite), Orthoclase feldspar (Syenite) etc.
b) Accessory minerals – are minerals that are common but usually are found only in small amounts. Magnetite, Mica, Zircon etc.

From the earliest prehistoric times to our technological age we have found beauty, power and mystery within stones. Just as herbs possess energies, the minerals and metals also do possess the energy.

Many of the goods and products we use every day are made from minerals, such as: Machinery, Cars, stereos, televisions, DVD players, Computers, refrigerators, toasters, ovens, can openers, pots and pans, vacuums, doorknobs, iron & steel furniture, light fixtures, lamps

8.2 Physical Properties of Minerals :-

The studies of minerals involve understanding their crystalline form, internal atomic structure, physical, chemical, optical properties and their mode of occurrence.

a) Colour: Colour of the mineral depends upon nature of light absorbed by the mineral and reflection. It is the striking feature and first thing to notice. Minerals show great variety of Colours. Same mineral can occur in different colors too. For ex., Quartz – Milky, Rosy, Violet, Colorless etc. Metallic minerals show greater consistency in Colour.

b) Streak : It is the colour of the powder of the mineral. It differs from the main color of the mineral, For ex. Sulphur is yellow, but its streak is colorless; Magnetite is black, but its streak is reddish; Similarly, orpiment's colour and streak both are yellow.

c) Diaphaneity: It is an ability of a mineral to transmit light. There are three type's viz.,
a) Transparent, b) Translucent; and c) Opaque.

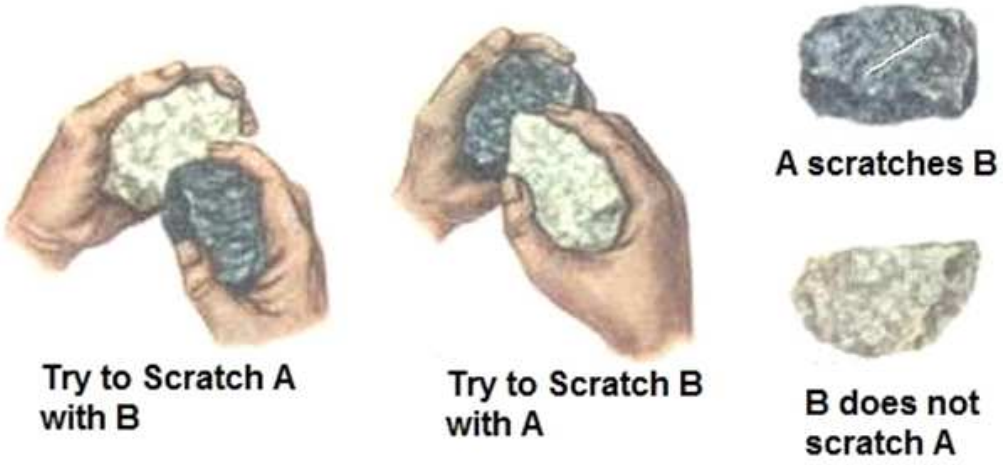
d) Luster :- It is the quality and intensity of the light reflected from a mineral's surface. There are two types of luster – Metallic and Non-metallic.

a) Metallic: it is the luster shown by the metals - eg., Galena
b) Non-metallic: This shows variety of lusters-

i) Adamantine- mineral shows brilliant glossy luster eg., Diamond,
ii) Vitreous- like broken glass eg. Quartz.
iii) Pearly – like pearl eg. Talc, Calcite.
iv) Silky- like fibre or threads eg. Asbestos.
v) Greasy or waxy- like oil or grease eg., Chalcedony, Serpentine
vi) Resinous- like resin or gum eg., Opal.

e) Hardness : It is the resistance offered by the mineral to scratching or abrasion. To study this, Friedrich Moh has devised a scale using a set of 10 minerals arranged order of ascending hardness, well known as "Moh's Scale of Hardness". It is a relative scale. The softest mineral Talc is assigned **1;** and hardest is the Diamond **(10)**. Hardness of any mineral will lie between 1 and 10. Minerals with higher numbers will scratch minerals below them on the scale**.**

Method of testing hardness



f) Cleavage : Tendency of a mineral to split along the definite planes. The plane along separation takes place is called cleavage plane. There are two types of cleavages

a) perfect cleavage (distinct eg., Calcite); ii) imperfect cleavage (indistinct eg., Beryl)

g) Fracture : Broken surface of the mineral is called fracture. The mineral breaks other than that of the cleavage plane. There are mainly four types of fractures -

i) Even fracture- The surface of the fracture is flat eg., calcite

ii) Uneven fracture- The fractured surface is irregular eg., feldspar.

iii) Conchoidal fracture- The fractured surface shows curved, concave and convex surface eg., quartz.

iv) Hackly fracture- Highly irregular fracture eg., native copper.

h) Form or habit: It is the form or occurrence of mineral in natural state. There are mainly two types- viz.,

i) crystalline/ crystallized, and

ii) amorphous. Generally they are described as -

a Crystalline – consisting of well developed faces eg., Rock crystal

b Fibrous – consisting of fine threads/fibers eg., asbestos.

b Foliated/Flaky- consisting of thin sheets of flakes or scales eg., mica

c Tabular/Platy- mineral is in the form of flattened plates eg., plagioclase.

d Massive – mineral occurs as thick mass eg., orthoclase.

e Bladed – mineral has sharp edges, shaped like knife/blade eg., kyanite.

f Botryoidal – resembling bunch of grapes eg., manganese & iron.

i) Specific Gravity: The specific gravity of a mineral is defined as the ratio of its weight to the weight of an equal volume of water. It is measured by Walker's Steel Yard balance.

j) Chemical composition: This property is useful in mineral identification. It is the combination of two or more elements. That combination state of the mineral is called chemical composition. Ex: Quartz - SiO_2; Galena – PbS; Calcite - $CaCO_3$.

k) Tenacity: The resistance of mineral offers to crushing, tearing and breaking. Important types of tenacity are;

i) Sectile - mineral can be cut into slices eg., talc.

ii) Malleable – mineral can be flattened under hammer eg., copper

iii) Flexible – mineral can be bent eg., chlorite.

iv) Elastic- mineral can be bent and regains its original shape eg., mica

v) Brittle - mineral crumbles to grains eg., feldspar

8.3 STUDY OF MINERAL GROUPS.

A. Quartz (Silica) Group :-

- It is common rock forming mineral.
- Quartz occurs in three different forms,crystalline, cryptocrystalline and amorphous. Chemical composition of the quartz is SiO2.
- Crystallizes in hexagonal system

Physical properties :

- Colour of the quartz varies from colourless to different colours and hardness is 7. Cleavages are absent streak is colourless, luster is vitreous, uneven to Conchoidal fracture, specific gravity is 2.65, Diaphaneity is transparent to translucent.

- **Occurrence** : It occurs in igneous, sedimentary and metamorphic rocks.
- **Uses :** Quartz is used in glass industries (opticals, lenses, mirrors etc.), ceramicindustries, abrasive, ornamental and semi-precious stones.
- The varieties of quartz are Rose quartz, Rock Crystal, Milky Quartz, Amethyst, Opal, Agate, Jasper, Flint, Chert and chalcedony.

B. Feldspar Group :

- It is most common rock forming mineral,
- Composed of aluminosilicate of potassium, sodium, calcium and barium.
- It crystallizes in monoclinic and triclinic system.

Physical properties:

- Feldspar shows white, grey and pinkish or flesh red colours, streak is colourless, Diaphaneity translucent, Luster is vitreous, cleavages are perfect, fractures are uneven, hardness is 6, tenacity is brittle, specific gravity is 2.65, massive to tabular in form.
- **Occurrence:**It occurs in igneous, sedimentary and metamorphic rocks.
- **Uses:**The uses of feldspars are in ceramic, pottery , glazing enamel, fertilizers and also in medicine.
- Verities of feldspars are Orthoclase, Microcline and plagioclase.

c) Mica Group :

- Minerals of this group are silicates of potassium, aluminum, magnesium, sodium, iron and lithium with hydroxyl (OH) and fluorine.
- It crystallizes in monoclinic system,.

Physical properties:

- Colour varies from colourless to black, streak is colourless Diaphaneity is transparent, pearly luster, perfect cleavages (basal), fracture are uneven, tenacity is flexible and elastic, hardness is 2.0 to 2.5. Specific gravity is 2.7. Form is foliated,.
- **Occurrence:**Mica occurs in igneous, sedimentary and metamorphic rocks.
- **Uses:**Micas are used in electrical industries as insulators and in making lubricant.
- Verities of mica are Biotite and Muscovite.

Ore minerals: It is an aggregation of one or more metals and non-metals from which metal is extracted. They are classified into;

i) Metallic ore minerals- Hematite (Fe ore), galena (Pb ore).
ii) Non-metallic minerals- Magnesite (Mg ore), Bauxite (Al ore)

Some important properties of metals and non metals	
Metals	Non metals
Less abundant in nature	More abundant in nature
Share similar properties	Have different properties
Mostly solids at room temperature	Mostly gases at room temperature
Oxides are basic	Oxides are acidic
Hard, shiny, and malleable	Weak, dull, and brittle
High densities	Low densities
High boiling and melting points	Low boiling and melting points
Good conductors of heat and electricity	Poor conductors of heat and electricity

8.4 Specific gravity by Walker's Steel Yard balance

This balance consists of graduated horizontal beam supported from near one end over knife edge of a vertical support on the shorter side there is an adjustable weight to bring the beam in horizontal position. The end of the longer side can move freely within the slot of another vertical support with a mark to indicate the horizontal position of the beam. The vertical support is fixed on a wooden base.

8.4.1 Determination of Specific Gravity :

The mineral sample whose specific gravity is to be determined is tied with a tread and hung from near the middle point of the beam. The tread is moved on the beam till the beam remains horizontal with adjusting the counter balance take the reading that is weight of the mineral in air (w1). Then the mineral is immersed in water again the thread is moved on the beam till it remains horizontal take the second reading that weight of the mineral in water (w2). The reading w1 and w2 are inversely proportional to the weight of the specific gravity. The specific gravity of the mineral is calculated as given below.

Specific Gravity = Weight of mineral in air

Loss of weight of mineral in water

The specific gravity = $\frac{1/w1}{w1-1/w2} = \frac{w2}{w2-w1}$

Where, weight of the mineral weighed in air = w1 grams.

Weight of the mineral is weighed in water = w2 grams.

Therefore, actual weight of the mineral = w1/w2 – w1 grams.

The subtracted weight is the specific gravity of the mineral.

Mineral resources are index of prosperity -Koutilya

Nearly 4,000 types of minerals are known to exist in the Earth's crust, only a small number—between 50 and 100—are important because they are common or valuable.

Summary :
Minerals are the substance that make up rocks. A mineral is a naturally occurring inorganic solid with a definite chemical composition and crystalline structure. Each mineral consists of chemical elements bonded together in definite proportions, and the chemical composition is used to give a chemical formula. Every mineral is distinguished from others by its chemical composition and crystal structure. Most common minerals are easily recognized and identified visually based on set of observations. Identification is aided by observing a few physical properties, including crystal habit, cleavage, fracture, hardness, specific gravity, color, streak, and luster. Although about 3500 minerals are known in the Earth's crust, only the nine rock-forming mineral groups are abundant in most rocks. They are feldspar, quartz, pyroxene, amphibole, mica, the clay minerals, olivine, calcite, and dolomite.

The silicates are the most abundant minerals because silicon and oxygen are the two most abundant elements in the Earth's crust. Accessory minerals are commonly found, but in small amounts. Ore minerals, industrial minerals, and gems are important for economic reasons. Many minerals show compositional variation because of ionic substitution. In general, one element can substitute for another if the two are similar in charge and size.

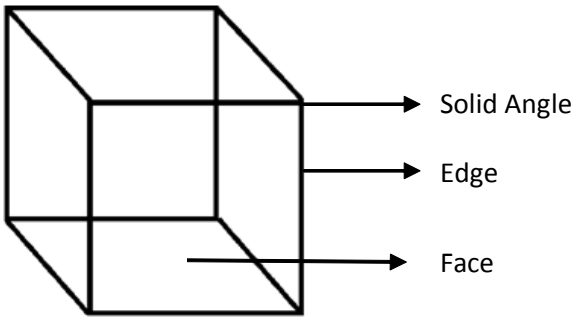
9.0 CRYSTALLOGRAPHY :

The study of all aspects of a crystal is known as crystallography.

9.1 Definition of Crystal :

Crystal is a solid polyhedral body bounded by faces, edges & solid angles. Defined precisely, crystals are three dimensional solids 'bounded by smooth, more or less plane surfaces arranged in regular pattern and are formed by internal atomic forces at the time of consolidation and crystallization of magma under favorable conditions'.

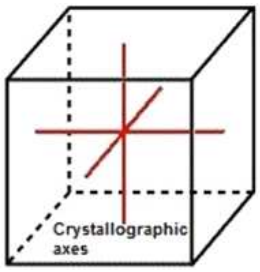
9.2 Morphology of a crystal.



1. **Face:** Flat and smooth surface of the crystal.
2. **Edge:** Intersection of any two adjacent faces.
3. **Solid Angle:** Intersection of three or more edges gives rise to solid angle.
4. **Form :** The combination of like faces is called a form. It is an internal atomic arrangement of a mineral. Crystal bounded by all like faces exhibit "simple form" (cube), when two or more different faces bounded by a crystal is said to be "combination form"(prism).

All minerals are not crystals but all crystals are minerals.

Crystallographic axes :

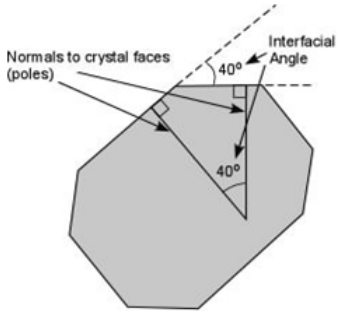


While defining a crystal and the position of its faces it is necessary to consider the imaginary axes of reference converging at the center of a crystal. The location of such axes of reference are taken by considering the three axes of a plane of solid geometry and are known as crystallographic axes.

Euler's Law:- States that "sum of the total number of faces and solid angles is always equal to the sum of the number of edges and the constant.
Euler's formula is F + S = E + 2

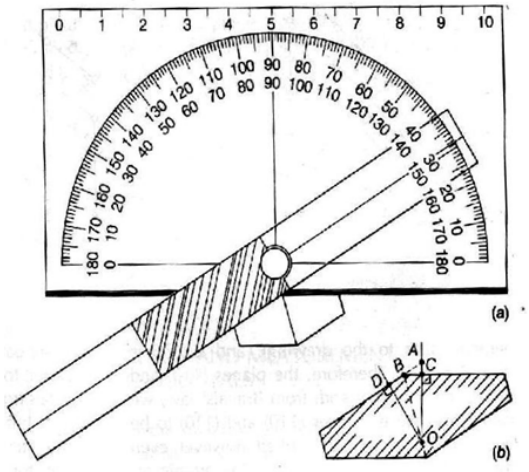
Where, F = Number of Faces.
S = Number of Solid angles,
E = Number of Edges.
2 is the Numerical Constant.

9.3 Interfacial angle :



The angle subtended between any two faces of a crystal is termed as **"Interfacial angle",** and this is measured using Contact Goniometer.

9.3.1 Contact Goniometer :-



Contact Goniometer is a simple device used to measure interfacial angles of the crystals. This instrument is designed by a protractor fixed upon the circumference of a semicircle which is graduated from 0^{o} to 180°. It has an arm equal to the diameter of the semicircle and is fixed at its mid point with the help of a pivot and can be rotated freely at that point.

Determination of Interfacial angle :

To measure the Interfacial angle between any two adjacent faces of a crystal the base of the semicircular graduated disc is made to lie in contact with two adjacent faces which need to be measured. The reading on the graduated semicircular disc gives the internal angle between the two faces of a crystal. Subtract the measured angle in 180^0 to get the Interfacial Angle. To confirm the obtained value the value observed below the reading can be checked which is same as that of calculated value.

9.4 SYMMETRY CHARACTERS :

Symmetry of the Crystal :-

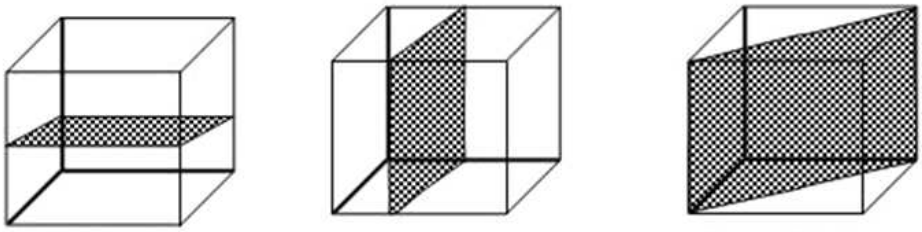
Regularity of a position of like faces, edges etc., constitutes the symmetry of a crystal. It is dependent on the type of lattice space and unit cell involved in its construction.

The degree of symmetry varies in different minerals and it is defined with reference to the following three criteria

i. **Plane of Symmetry**

ii. **Axes of symmetry**

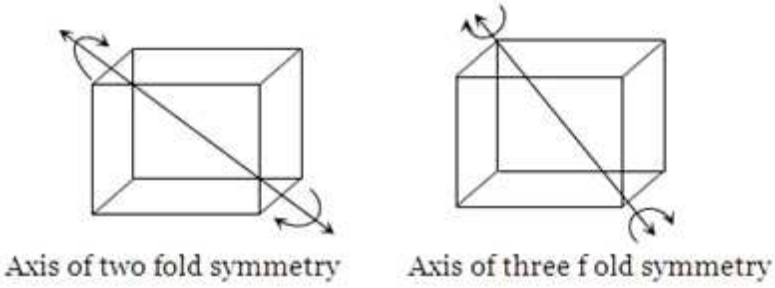
iii. **Centre of symmetry**



i. Plane of Symmetry: A plane of symmetry divides a crystal into similar and similarly placed halves. Such a plane divides a crystal so that one is the mirror image of the other, eg., a cube has 9 planes which divides it into two halves so that one half is the reflection of the other.

ii. Axes of Symmetry:

Crystal on rotation a particular face comes to occupy the same position in space more than once in a complete rotation. The axis about which the rotation has taken place is called an axis of symmetry.

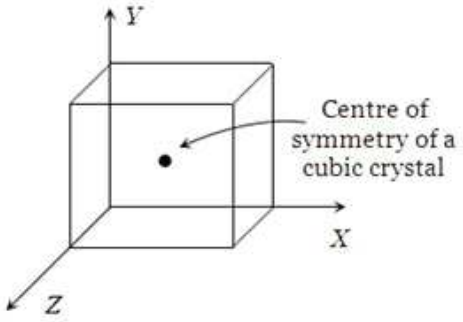


Depending upon the degree of symmetry a crystal may come to occupy the same position 2,3,4 or 6 times in a complete rotation. The terms applied to these different classes of axis are as follows

2 time 2 fold- diad (diagonal axis)
3 times 3 fold – triad (trigonal axis)
4 times 4 fold – tetrad (tetragonal axis)
6 times 6 fold - Hexad (Hexagonal axis)

iii Center of Symmetry:

A crystal has center of symmetry when like faces, edges etc., are arranged in pairs in correspedning position on opposite sides of a central point.



9.5 General characters of normal class crystal systems

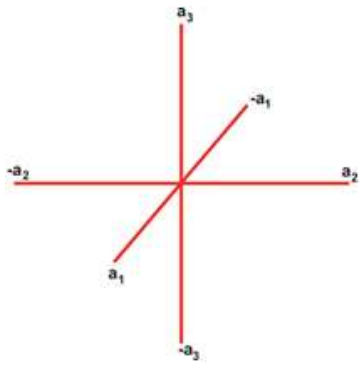
The class with highest degree of symmetry is called **Normal class**

The crystal can be classified on the basis of nature of the crystallographic axes and the degree of symmetry. Accordingly all the crystal forms which can be referred to the same set of crystallographic axes constitute a crystal system. Depending upon the crystallographic axes the crystals are classified into six different system -

1. Isometric or cubic system.
2. Tetragonal system.
3. Hexagonal system.
4. Orthorhombic system.
5. Monoclinic system
6. Triclinic system.

9.5.1 Isometric or Cubic system :-

Definition : The crystal belonging to Isometric or cubic system, is referred to three equal and interchangeable mutually perpendicular**.**



Crystallographic axes, there are three axes which are designated as a_1, a_2, a_3, of which the a_1 axis runs from front to back, a_2 axis side to side, and a_3 top to bottom. The front, left and top ends are positive; whereas the back, right and bottom ends are negative.

- **Axial relation:** All the three axes are equal and interchangeable.
- **Type mineral:** Galena (PbS).

- **Symmetry Characters :**

  i. Planes of symmetry - 9 planes (3 principle and 6 diagonal)

  ii. axes of symmetry- 13 (3^{IV} , 4^{III} , 6^{II})

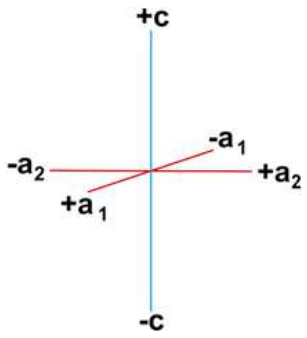
  iii. Centre of symmetry- Present.

- **Forms:** Some common forms of crystals crystallizing in Isometric system are cube octahedron, dodecahedron, hexoctahedron etc.

Hardest and most fascinating mineral **diamond** belongs to Isometric system

9.5.2 Tetragonal system :

Definition : All the crystal forms which can be referred to- two equal horizontal axes and a longer/shorter vertical axis, all are mutually perpendicular.



♦ **Crystallographic axes:** The two horizontal axes are of equal lengths and the longer/shorter vertical axis. There are three axes designated as a_1 - running from front to back, a_2- running from side to side, and C axis running from top to bottom. The front, left and top ends are positive; whereas the back, right and bottom ends are negative.

♦ **Axial relation:** Three mutually perpendicular axes of which two horizontal axes are equal and one vertical axis either shorter or longer.

♦ **Type mineral: Zircon ($ZrSiO_4$),**

Symmetry Characters:

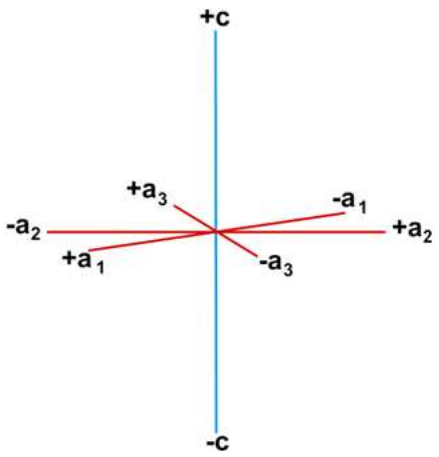
♦ **Planes of symmetry :**

i) 5 planes (3 principle and 2 diagonal)
ii) Axes of symmetry- 5 (4^{II} 1^{IV})
iii) Centre of symmetry- Present.

♦ **Forms: C**ommon forms of crystals crystallizing in Tetragonal system- pinacoid, prism and pyramid etc.

9.5.3 Hexagonal system:

Definition : Crystal belonging to hexagonal system has four crystallographic axes of which three are horizontal and equal while the fourth one vertical axis is either longer or shorter.



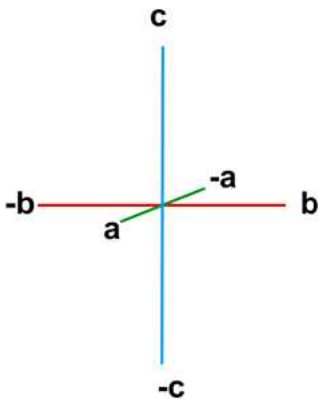
♦ **Crystallographic axes:** There are three equal horizontal axes making equal angles with each other, these are designated as a_1, a_2 , a_3 axes and C the vertical axis. Note the positions of the positive ends of the horizontal axes and that positive and negative ends of these axes alternate. The vertical C axis has top end positive and bottom end negative.

- **Axial relation :** Four axes of which three are horizontal and equal, the fourth one is verticle which is either shorter or longer.
- **Type mineral:** Beryl ($Be_3Al_2Si_6O_8$)
- **Symmetry Characters :**
  i) Planes of symmetry : 7 planes (4 principle 3 diagonal)
  ii) Axes of symmetry - 7 (6^{II} 1^{VI})
  iii) Centre of symmetry- Present.
- **Forms :** Common forms of crystals crystallizing in Hexagonal system- pinacoid, hexagonal prism and hexagonal pyramid etc.

Hexagonal bond is strongest bond in the nature.
It is the only system having four crystallographic axes.

9.5.4 Orthorhombic System :

Definition: All the crystal forms can be referred to three unequal, mutually perpendicular crystallographic axes.



- **Crystallographic axes:** All the three axes are of different lengths- a-axis, running front to back, b-axis, running left to right, and c-axis running from top to bottom. The front, left and top ends are positive; whereas the back, right and bottom ends are negative. Among the two horizontal axes a-axis is shorter which is also called as **brachy axis;** b axis is longer and is **macro axis**.

- **Axial relation:** Three mutually perpendicular crystallographic axes are unequal.

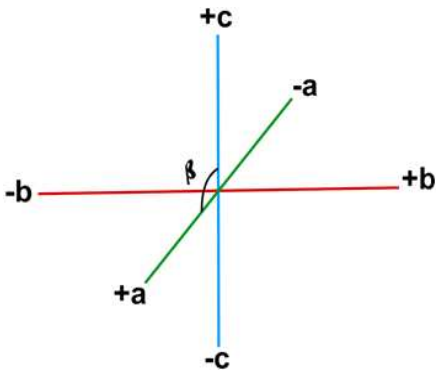
- **Type mineral:** Barytes ($BaSO_4$)
- **Symmetry characters:**
  i) planes of symmetry: 3 (all axial planes)
  ii) axes of symmetry : 3^{II}
  iii) Centre of symmetry: present

- **Forms**: Common forms are pinacoid (basal, brachy and macro) , dome (brachy, macro) and pyramid.

9.5.5 Monoclinic system :

Definition: All crystals that can be referred to three unequal axes, two of which are at right angles and third makes an angle not a right angle with the plane containing other two axes (inclined axis).

- **Crystallographic axes:** All the three axes are of different lengths denoted as- a axis **(clino)** running from front to back, b- axis (**Ortho**) running from left to right being perpendicular to the vertical axis; c-axis running from top to bottom. The front, left and top ends are positive; whereas the back, right and bottom ends are negative.



- **Type mineral:** Gypsum ($CaCO_4.2H_2O$)

- **Axial relation:**Three unequal axes of which 'b' and 'c' axes are mutually perpendicular where as a-axis is inclined.

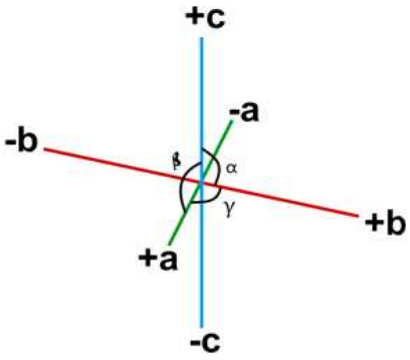
- **Symmetry characters:**
  - **i) Planes of symmetry-** 1(Axial plane)
  - **ii) axes of symmetry-** 1^{II}
  - **iii) Centre of symmetry-** present.

- **Forms :** Pinacoid (Basal clino and ortho), prisms (Clino and Ortho) dome (clino and ortho) and pyramid.

9.5.6 Triclinic system:

Definition : This system includes all those crystal forms which can be referred to three axes of unequal lengths and all are inclined.

Crystallographic axes: three unequal axes in inclined positions, these are designated as a-axis (brachy) running from front to back, b-axis (macro) running from left to right, and c-axis running from top to bottom. The front, left and top ends are positive; whereas the back, right and bottom ends are negative. The angle between axes b+ and c+ is **α** , between a+ and c+ is **β** , and between a+ and b+ is **γ.**



Triclinic system have three inclined axes a axis is known as Branchy axis, b axis is known as Macro axis the angles of intersection designated as α, β & γ ,

- **Axial relation:** Three unequal inclined crystallographic axes.

  Planes of Symmetry - Nil

  Axes of Symmetry - Nil

  Centre of Symmetry - Present

- **Type mineral:** Kyanite $Al_2(SiO_3)_2$
- **Forms:** pinacoid (basal, brachy and macro), prism, dome(brachy and macro) and pyramid

The Symmetry Elements of Different Crystal Systems Exhibited by their Normal Classes as Shown in the Table

Crystal System	No.of Plane of symmetry	No.of Axis of symmetry				Center of Symmetry present or absent
		Diagonal	Triangle	Tetrad	Hexagonal	
Isometric	9	6	4	3	-	Present
Tetragonal	5	4	-	1	-	Present
Hexagonal	7	6	-	-	1	Present
	4	3	1	-	-	Present
Orthorhombic	3	3	-	-	-	Present
Monocline	1	1	-	-	-	Present
Triclinic	-	-	-	-	-	Present

UNIT – V.
MINERALOGY AND CRYSTALLOGRAPHY

One Mark Question:

1. Define mineralogy.
2. Define a mineral.
3. Define a crystal.
4. Name the parts of a crystal.
5. Define a face of a crystal.
6. Define an edge of a crystal.
7. What is solid angle?
8. What is contact Goniometer?
9. Define fracture of a mineral.
10. Define cleavage of a mineral.
11. What is hardness of mineral?
12. What is streak of a mineral?
13. What is Luster?
14. What is prism of a crystal?
15. What are pinacoidal faces?
16. Define a dome of a crystal.
17. Define pyramidal face.
18. What is specific gravity?

Two / Three marks questions:

1. What are Crystallographic axes?
2. Give the scientific classification of Minerals
3. Define Interfacial angle
4. Define Specific Gravity.
5. Euler's law
6. Diaphaneity
7. Moho's Scale of hardness.
8. Types of lustre

Five marks questions:

1. Explain the measurements of interfacial angle of a Crystal.
2. What is contact Goniometer, explain with neat diagram.
3. Explain the physical properties of Minerals.
4. Explain the symmetry characters.
5. What is symmetry? Explain the types of symmetry.
6. Explain the axial characters of (each for 5 marks)
   Isometric system, Tetragonal system, orthorhombic system, Hexagonal system, Monoclinic & Triclinic system.
7. Explain quartz group of minerals.
8. Explain feldspar group of minerals.
9. Explain mica group of minerals.

UNIT VI

10.0 ENVIORNMENTAL GEOLOGY

10.1 Hazards (Natural and Anthropogenic)
10.2 Pollution (Air, water and soil)

Environment refers to the total set of circumstances which surround an organism or a group of organisms.

Environmental Geology is the application of geologic principles and knowledge to problems created by anthropogenic (human) interference and exploitation of the physical environment.

Ecology is the science of the living environment dealing with the relationship between organisms and their habitats, their functional processes on land and in water.

10.1 Hazards

Natural events (volcano, earthquake, landslide, floods, draught, fire etc.) occurring suddenly and swiftly, threatening life and property or causing harm to the people and their property are called hazards. Hazards also result from

human interference with the physical environment. Whether naturally occurring or man induced, geological phenomena are hazardous to life.
Earthquakes are perhaps the most disastrous of all the natural phenomena, occurring frequently destroying large parts of the earth in geodynamically active zones. Volcanic activity is a violent and hot manifestation of natural forces destructing the areas of volcanic belts, and polluting the atmosphere on a large scale. There are about 516 active volcanoes in the world that erupts regularly.
Floods are a recurrent phenomenon in the flood plains of rivers, which destruct the agricultural areas where the population is densest.
The coastal areas are frequently affected severely by the cyclones, hurricanes, tsunamis etc., causing destruction to the land and people living on the coast.
Natural landslides mostly occur during high rainfall and are restricted mainly to the highlands/hilly regions.

Forest fires also destruct the flora and fauna, apart from the pollution of atmosphere. Most hazards are aggravated by human interference with the environment for ex, when the forests are cut down, the soil exposes to direct rainfall, giving rise to colluvial creep and land sliding. A related effect is soil erosion, removing fertile top soil which is needed for agriculture; and also giving rise increased dust because the wind break effect of trees is lost. Likewise construction of dams aggravate- firstly, coastal erosion, because they hold back sediments which earlier reached the coast and redistributed along the coast. Waves free of sediments tend to cut the coast; secondly, the reduced water flow causes salt water intrusion and pollution of coastal wells, and finally floods also occur when the water accumulates in large quantity in the catchment area.

10.2 Pollution

It is contamination of a matter (Air, Water and Soil etc.,) which exceeds the permissible limit.

10.2.1 Air, Water and Soil pollution

Air is a mixture of gases and is precious to life. It is elastic and invisible. It contains mainly oxygen, hydrogen and nitrogen. Without oxygen, aerobic life is not possible. If there is any pollution or degradation in the air, it will lead to many serious health hazards. Air pollution is defined as the presence of one or more pollutants or contaminants in the air, which are injurious to the living kinds. Rapid industrialization, urbanisation and other developmental activities of mankind disturb the balance of the natural atmosphere. The pollutants occurring in the atmospheric air are gaseous pollutants and particulate pollutants.

As the population has grown alarmingly, the magnitude of pollution and contamination have also increased. As a consequence, the environment has been diversely affected leading to hazards to health and the landscape in one or the other way. In small quantities (mg/l = milligrams per litre) common gases such as coarbon dioxide, nitrogen and nutrients such as phosphates and nitrates are useful materials. But, when their proportion rises beyond certain limits, the ecosystems get imbalanced, and thus inhospitable. Heavy metals like lead, zinc, mercury, cadmium etc., measurable in parts per million (ppm) or billion (ppb) are harmful. Different living beings have different levels of sensitivity or tolerance to the presence of these materials in the ecosystems. Therefore addition of these hazardous metals or gases more than the tolerance levels is known as pollution or contamination.

Many a times, the water flows in mineral/ore body zones, which are sometimes toxic when the level of contamination in water is high, such as lead and zinc, uranium, zircon, sulphur, apatite, arsenic, magnesium etc. In some areas, the ground water contamination is due to a high content (>1.5 ppm) of fluorine.

Approximately 2000 tremors strike the earth surface each day. About 15-20 earthquakes each year produce widespread damage and destruction worldwide. The loss from the various geological hazards each year on an average is 2,50,000 deaths mostly in the developing countries.

SIGNIFICANCE OF ENVIRONMENT

Environment is a most important component of earth and living kinds. The environment is having a wide spectrum on living kind of the earth and global warming.

UNIT – VI

1. What is environment?
2. What is pollution?
3. Name the types of pollution?
4. What is air pollution?
5. What is water pollution?
6. What is soil pollution?

UNIT VII

11.0 Role of Geological Organsation/ Institutes of India

1. Geological Survey of India (GSI), established in 1851, is a government organization in India which is an office attached to the Ministry of Mines of Union Government of India for conducting geological surveys and studies. It is one of the oldest of such organizations in the world and the second oldest survey in the country located in Kolkata. GSI is the prime provider of basic earth science information to the government, industry and the general public, as well as responsive participant in international geoscientific fora. The vibrant steel, coal, metals, cement and power industries.

2. The **Department of Mines and Geology (DMG)** is more than 110 years old located at Bangalore. The erstwhile Mysore Geological Department was established in the year 1894 with the objective of Geological and structural mapping of the then Mysore State. The pioneering efforts of the Geologists like R.Bruce Foote, H.K.Slater, W.F.Smeeth, P.Sampath Iyengar and others has resulted in the preparation of the Geological map of old Mysore State. Geological investigations lead to the discovery of different mineral deposits in the State. This has helped in establishing many mineral based industries in the State.

3. Oil and Natural Gas Corporation Limited (**ONGC**) is an Indian multinational oil and gas company headquartered in Dehradun, India. It is a Public Sector Undertaking (PSU) of the Government of India, under the administrative control of the Ministry of Petroleum and Natural Gas(MoP&NG). It is India's largest oil and gas exploration and production company. It produces around 69% of India's crude oil (equivalent to around 30% of the country's total demand) and around 62% of its natural gas. ONGC was founded on 14 August 1956 by Government of India, which currently holds a 69.23% equity stake. It is involved in exploring for and exploiting hydrocarbons in 26 sedimentary basins of India, and owns and operates over 11,000 kilometers of pipelines in the country.

4. The **Atomic Energy Commission** (AEC) was set up in August 1948 to look after atomic energy activities in the country. The functions of the Atomic Energy Commission are: (i) to organize research in atomic scientists in the country; (ii) to train, atomic scientists in the country; (iii) to promote nuclear research in commission's own laboratories as well as in India; (iv) to undertake prospecting of atomic minerals in India and to extract such minerals for use on industrial scale.

It has five research centre viz.

- Bhabha Atomic Research Centre (BARC), Mumbai
- Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam (Tamil Nadu)
- Centre for Advanced Technology (CAT), Indore
- Variable Energy Cyclotron Centre (VECC), Kolkata
- Atomic Minerals Directorate for Exploration and Research (AMD), Hyderabad.

5. National Institute of Oceanography (NIO) is one of 37 constituent laboratories of the CSIR - Council of Scientific and Industrial Research, an autonomous research organization in India. The institute has its headquarters in the coastal state of Goa, and regional centres in Kochi, Mumbai and Vizag. The Institute was established on 1 January 1966. At the end of over 40 years it has grown today into a large oceanographic laboratory of international repute mainly focusing on the understanding of special oceanographic features of the Northern Indian Ocean.

6. Indian Space Research Organization (ISRO) is amongst the largest government space agencies in the world. Its primary objective is to advance space technology and use its applications for national benefit. Established in 1969, ISRO superseded the erstwhile Indian National Committee for Space Research (INCOSPAR). Headquartered in Bangalore, ISRO is under the administrative control of the Department of Space, Government of India. Since its establishment, ISRO has achieved numerous milestones. It built India's first satellite, Aryabhata, which was launched by the Soviet Union in 1975.

7. National Mineral Development Corporation (NMDC) is a state-controlled mineral producer of the Government of India. It is fully owned by the Government of India and is under administrative control of the Ministry of Steel.

It is involved in the exploration of iron ore, copper, rockphosphate, limestone, dolomite, gypsum, bentonite, magnesite, diamond, tin,t ungsten, graphite etc.

It is India's largest iron ore producer and exporter producing about 30 million tons of iron ore from 3 fully mechanized mines in Chhattisgarh and Karnataka. It also operates the only mechanized diamond mine in the country at Panna in Madhya Pradesh.

8. National Remote Sensing Agency (NRSA) in Hyderabad is a Department of Space sponsored organization devoted to the acquisition, processing, and dissemination of remote sensing data. Data is acquired primarily via India's own IRS 1-A and 1B, as well as satellites belonging to other countries, such as USA's Landsat. Whereas the reception and processing facilities are available at NRSA, the development of the sensors and the payloads are developed at ISRO's Satellite Application Center (SAC).

9. National Geophysical Research Institute (**NGRI**) is a geoscientific research organization established in 1961 under the Council of Scientific and Industrial Research (CSIR), India's largest Research and Development organization located at Hyderabad. It is supported by more than 200 scientists and other technical staff whose research activities are published in several journals of national and international interest.

Research areas covered by this institute include hydrocarbon and coal exploration, mineral exploration, deep seismic sounding studies, exploration and management of groundwater resources, earthquake hazard assessment, structure of earth's interior and its evolution (theoretical studies), and geophysical instrument development.

10. Coal India Limited (**CIL**) is an Indian state-controlled coal mining company headquartered in Kolkata, West Bengal, India. It is the largest coal producer company in the world and contributes around 81% of the coal production in India. It produced 452 million tonnes of coal during FY 2012–13 and earned a revenue of INR 882.81 billion from sale of coal in the same financial year. Union Government of India owns 61% of the shares in CIL and controls the operations of CIL through Ministry of Coal. In April 2011, CIL was conferred the Maharatna status by the Union Government of India.

11. Centre for Earth Science Studies (CESS): It is located in Trivandrum, Kerala and was established in 1978. The primary objective is to promote modern scientific and technological research and focus on developmental programmes relevant to the country in general and Kerala State in particular. CESS undertakes studies in tune with these objectives in the fields of geosciences, environmental sciences, marine sciences and atmospheric sciences. CESS had, over the years, endeavored to contribute substantially to natural hazard assessment and mitigation, in understanding atmospheric parameters, coastal processes, natural resource management and probing the dynamic processes of earth.

POINTS TO REMEMBER

UNIT – II.

WEATHERING

1. Alteration of rocks by physical and chemical phenomenon is called weathering.
2. Three kinds of weathering
   a. Physical
   b. Chemical
   c. Biological
   d. The earth's geosphere – lithosphere (crust and asthenosphere), mantle and core
   e. Crust includes – continental crust and Oceanic Crust.

UNIT – III

GEOLOGICAL AGENTS.

1. Wind: Air is in motion is called wind.
2. Removal of finer sand particles by strong winds is called deflation.
3. The collision between the wind borne particles and exposed rock body is called abrasion.
4. Ventifacts are the pebbles of rocks, which develope smooth plane surface due to wind abrasion.
5. Pedestal rocks are Erosional features of wind:
6. Sand dunes are depositional features of winds – Barchans, Loess.

RIVERS :

1. Head region: where the river originates. This is especially the hilly or mountainous region, where rain water or ice melt accumulates and flows down slope.
2. Mouth region: the place where a river meets the sea.
3. Geological work rivers includes – Erosion, Transportation and Deposition
4. Depositional features of rivers- Alluvial fan, Natural leaves, Flood plains and Deltas.
5. Pot Holes: these are cylindrical bowl like depression ranging from few inches to few feet depressions are pot holes. Are formed on the valley floor comparatively softer rocks struck on to swirling these depressions area called pot holes.

6. Meandering: a stream flow when reaches the plain land (mature stage), it attains a curved or zig – zag path having a loop shaped form mainly due to the lateral cutting of the river channel.
7. Oxbow lake: By the normal course of the meander growth, the neck of a meander loop may become progressively narrowed and finally cut through. In the early stages of the cutoff, a part of the water continues to travel around the bend through the old channel, another part travels across the neck through the new channel. The part of the water that enters the old meander loop has its velocity checked because of the lower gradient and may deposit sediment at the end of the meander, damming it off. The resulting feature is called 'oxbow' or 'horse-shoe' lake.
8. Delta: These are deposits built at the junctions where river meets a lake or ocean. Deltas are generally flat topped and characteristically have pronounced frontal slopes and lobate outlines.

GLACIERS : These are the rivers of ice moving along the valleys of mountains due to gravity.

1. Glacier is a river of ice flowing in its own channel under gravity.
2. Snow line is the lowest line of permanent snow (perpetual) or the lower boundary of the snow cover
3. A snowfield is a region of permanent snow cover or the accumulation area of a glacier.
4. A Crater is a mouth of a volcano.
5. Moraines are erosional products i.e, sediments deposited by glaciers.
6. Crevasses are the cracks or fractures on the surface of a glacier.
7. There are three types of glaciers-
    a. Valley/Mountain / Alpine/Himalayan
    b. Sheet/Island type
    c. Piedmont or intermediate type
8. Geological action of Glacier: the process of glacial erosion, transportation and deposition.
9. Drumlin- This is a type of glacier deposit, in the shape of inverted spoon. The core of the drumlin is a rock on which clay materials are deposited.
10. Moraines : these are the glacial products Or rocks debris deposited in the by glaciers. Moraines are of following types.

a. Lateral moraines
b. Medial moraines
c. Ground moraines.
d. End or Terminal Moraines

11. Horns : Horns are peaks with sharp ridges formed at the junction of more than two cirques.
12 Aretes: These are sharp ridges between two cirques.

UNIT – IV

ENDOGENOUS GEOLOGICAL PROCESS

1. A Volcano is essentially a fissure or vent eruption, communicating with the earth's interior, from which flows of lava, explosive bursts of gases and volcanic ashes are erupted at the surface.
2. Pyroclasts are the fragmental materials produced during volcanic eruptions.
3. These are three kinds of volcanoes- Active volcanoes, Dormant volcanoes and Extinct volcanoes.
4. A typical volcano exhibits- Crater, Vent, conical hill with pyroclastic material.
5. Vent is the main track or pipe, from where the lava comes out.
6. Volcanic products are of three types – gaseous, liquid (lava) and solid (cinder Lapilli and other solid volcanic material).
7. Majority of the volcanoes are concentrated at the fringes of continents oceanic islands, particularly in pacific and Atlantic Ocean.

EARTHQUAKES :

8. Earthquakes are vibrations induced in the earth's crust that virtually shake up or gives a jerking blow/movements of a part of the crust.
9. Earthquakes are caused due to non tectonic (earthquakes, volcano, land slides etc); and tectonic (elastic rebound theory).
10. Tectonic cause (elastic rebound theory): Any block of the earth that is under the influence of unequal forces would withstand these forces in the initial stages by undergoing elastic deformation. The forces get stored in the rock as elastic strain till a limit is reached when the elasticity of the rock block exceeds by the forces. A fracture

is caused at that stage in the block and under the influence of these forces the blocks so created by fracturing move apart each other, which is called faulting. The movement at which rupture takes place & faulting starts the earthquake is caused.

11. Focus or Hypocentre: The place from which an earthquake starts is known as focus or hypocentre. It is the point below the earth's surface where the disturbance is commonly in the form of displacement or faulting of rocks.
12. Epicentre: The point or place on the surface vertically above the focus of an earthquake is termed as epicentre of that particular earthquake. It is a place on the earth where the earthquake disturbances reach first and do the maximum damage.
13. Classification based on depth of focus: Three classes of earthquake are recognized- Shallow earthquake (depth < 60 km); Intermediate (depth between 60-300 km); and Deep seated earthquake (> 300 km)
14. There are two kinds of seismic waves: Body waves - Primary waves (P) & Secondary (S); and surface waves - Love & Raleigh waves.
15. Seismograph is an instrument, which is used to measure the intensity of earthquakes.
16. Seismogram is the output given by the seismograph.

UNIT – V

1. Minerals are inorganic substances which have a definite chemical composition, atomic structure and crystal system.
2. Crystals are solid bodies bounded by faces, edges, solid angles.
3. Physical properties of minerals are -
    a. Colour,
    b. Streak,
    c. Diaphaneity
    d. Lustrue,
    e. Fracture
    f. Cleavage
    g. Hardness
    h. Chemical composition
    i. Sp. Gravity.

4. Parts of a Crystal are -
    a. **Face** is a plane surface of the crystal.
    b. **Edge is -** Any two faces when meet a common plane of a crystal is called edge.
    c. **Solid angle :** If three or more faces are meeting at a common point is called solid angle
5. Euler's formula : face (F) +A = E+2
6. States of matter : i. Amorphous (powder form) & Crystalline
7. Contact goniometer is a device which is used to measure the interfacial angles of crystals.
8. Symmetry: a systematic, regular arrangement of faces, edges, solid angles etc.
9. There are three types of symmetry : Plane of symmetry, Axis of symmetry and Centre of symmetry.
10. Six crystal systems :
    i. Isometric system – type mineral garnet
    ii. Tetragonal system – type mineral zircon
    iii. Hexagonal system – type mineral quartz
    iv. Orthorhombic – type mineral Barite
    v. Monoclinic - type mineral Gypsum
    vi. Triclinic – type mineral Auxinite.

UNIT – VI

1. Environment- refers to the total set of circumstances which surround an organism or a group of organisms.
2. Environmental geology is the application of geologic principles and knowledge to problems created by man's interference and exploitation of the physical environment.
3. Ecology is the science of the living environment dealing with the relationship between organisms and their habitats, their functional processes on land and in water.
4. Earthquakes cause far greater hazards than any other natural phenomena.
5. Volcano, Earthquake, landslides, avalanche, forest fire (natural), cyclones, hurricane, tsunami etc are natural hazards.
6. Landslides along road, tunnels, bridges; forest fire, electric short circuit fires etc are manmade hazards.

7. Natural events occurring suddenly and swiftly, threatening life and property or causing harm to the people and their property are called hazards. Hazards also result from mans interference with the physical environment.
8. Water and soil pollution sources are many. Among them the principal ones are-
    a) Discharge of domestic and municipal sewage.
    b) Effluents from industries.
    c) Use of agricultural chemicals such as fertilizers, pesticides and insecticides.
    d) Accidental and or delieberate release of oil/chemicals in the ocean/river water.

CHAPTER WISE ACTIVITIES

General Geology

(Choose the Right answer)

1. Arrangement of planets around the sun in a plane is called _____
   a. Galaxy b. Meteorites c. Solar system d. Asteroids

2. Non luminous bodies are called _____
   a. Stars, b. Planets, c. Asteroids, d. Sun.

3. Asteroids are located between _____ planets.
   a. Mercury and Venus b. Venus and Earth,
   c. Mars and Earth d. Mars and Jupiter.

4. Two planets are having gaseous rings. _____
   a. The earth and Mercury, b. Jupiter and Mars
   c. Neptune and Uranus d. Saturn and Uranus.

5. The inner groups of planets are characterized by _____
   a. Relatively smaller sizes with high density
   b. Relatively slow speed of rotation
   c. By increasing of sizes.
   d. By less no. of natural satellites.
   e. By none of the all these.

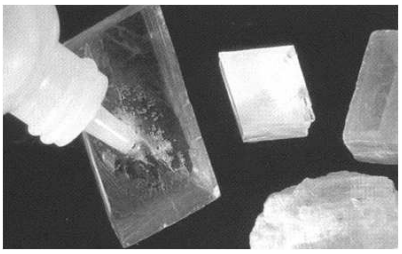
(Tick True OR False of the given statement)

6. Moon is a natural satellite (True OR False)
7. Mercury is nearest to the sun (True OR False)
8. Oxbow lakes are formed in a glacier valley (True OR False)
9. Pedestal rocks are found in the desert areas (True OR False)
10. Crater is a mouth of a volcano (True OR False)

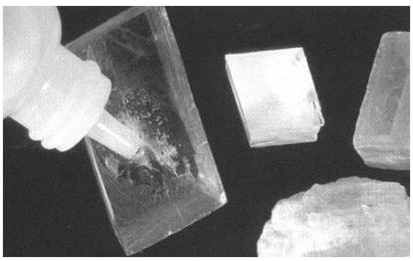
Exercise to Students. :

1. List out important aspects about terrestrial planets.
2. Make a chart about revolution and rotation of all the planets with their satellites.
3. Prepare a model of river stages by making use of raw materials under the guidance of your teacher.
4. Prepare a working volcano model by making use of raw materials under the guidance of your teacher.

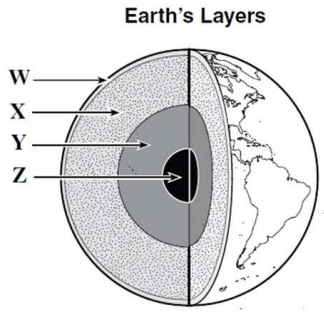
PICTURE BASED ACTIVITIES



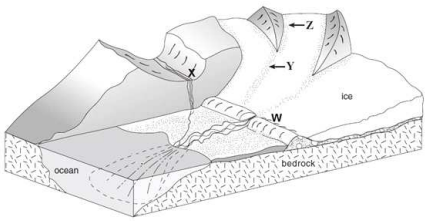
1. The mineral in the photo gives effervescence with acid and also can be scratched with nail, which mineral this is_____
   a) Quartz b) Feldspar c) Calcite d) Gypsum



2. The mineral in the photo gives effervescence with acid and also can be scratched with nail, what is the hardness of the mineral _____
   a) Quartz b) Feldspar c) Calcite d) Gypsum

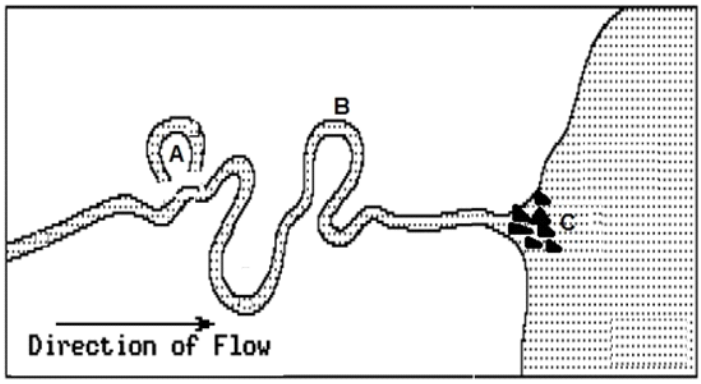


3. Name the layers of earth:
   w = X = Y = Z =



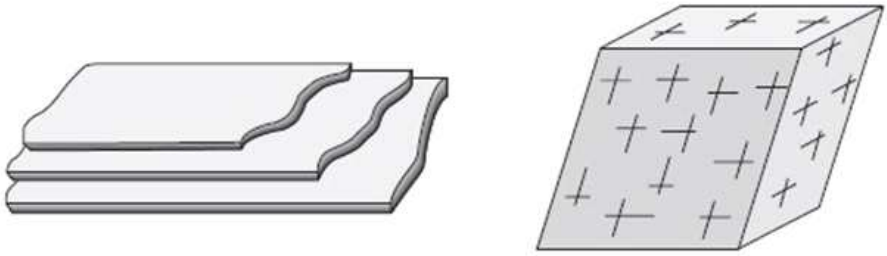
4. Label the given sketch of a glacier:
   W = X= Y= Z=

5. Name the feature in the given photograph.
a) Asteroid b) planet c) meteorite d) Comet



6. Label the given sketch of a glacier:
A = B= C=

7. Name the feature and the geological agent that produced the feature in the given photograph.
a) U-Valley & Glacier b) V-Valley & River
c) Crater & Volcano d) Dune & Wind



8. Name the two minerals in the given pictures based on their structure.
   a) Mica & Garnet b) Mica & Quartz
   c) Mica & Calcite d) Mica & Plagioclase

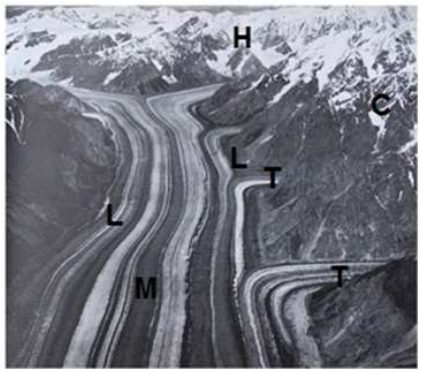
9. What property of mineral is being tested in the above picture?
   a) Streak b) Fracture c) Habit d) Hardness

10. What structure is exhibited in the above picture?
    a) Spheroidal weathering b) Rounded Fracture
    c) Rounded weathering d) core rock

11. What type of weathering is exhibited in the above picture?
    a) Spheroidal weathering b) Biological weathering
    c) Bedded weathering d) None

12. What type of structure is exhibited in the above picture?
    a) Pedestal rock b) Onion weathering
    c) Bedded weathering d) Tree weathering

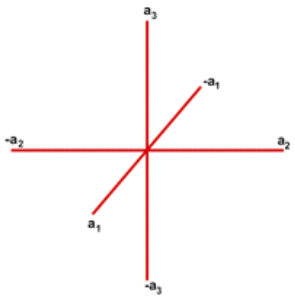
13. What type of structure is exhibited in the above picture?
    a) Pedestal rock b) Rock hole c) Pot hole d) Vesicular



14. Identify the geological process in the above picture? And label the important features in it.

H = L = M =

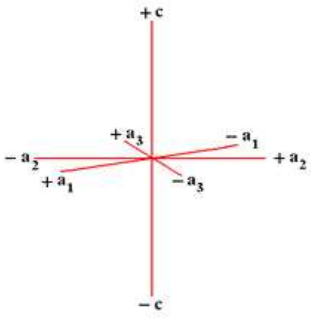
T = C =



15. Identify the crystal system using the axes shown in the picture?

a) Isometric b) Tetragonal

c) Hexagonal d) Orthorhombic



16. Identify the crystal system using the axes shown in the picture?

a) Isometric b) Tetragonal

c) Hexagonal d) Orthorhombic

Answers

1) c) Calcite

2) 3

3) Crust, Mantle, Core

4) X = U Shaped Valley, Y = Glacier

5) c) meteorite

6) A = Oxbow Lake B = Meander C= Delta

7) a) U-Valley & Glacier

8) c) Mica & Calcite

9) d) Hardness

10) a) Spheroidal weathering

11) b) Biological weathering

12) a) Pedestal rock

13) c) Pot hole

14) Valley Glacier. H = Horn, L = Lateral moraine, M = Median moraine, T = Tributary Glacier & C = Cirque.

15) a) Isometric

16) c) Hexagonal

BIBILOGRAPHY

For additional reading on the topics covered in this textbook, students may refer the following text books. However this prescribed text book is genuine, condensed with more information for the academic interest of the students.

Geology Made Simple	William H. Matthews
Mineralogy	F. H. Hatch
Principles of Physical Geology	A. Holmes
Geomorphology	V.K. Sharma
Aspects of tectonics	K.S. Valdiya
Environmental Geology	K.S. Valdiya
General Geology	Radhakrishanan. V
A text book of Geology	Mahapatra, G.B
Text book of Geology	P.K.Mukherjee
Text book of Geology	A.K.Datta
Engineering Geology	Parbin Singh
Rutley's Elements of Mineralogy	H.H. Read
Dana's Text book of Mineralogy	W.E. Ford
Mineralogy	Berry & Mason
Mineralogy for students	M.I. Batty
Field Geology	Lahee
Engineering Geology	F.C.Bell
A Text Book of Hydrology	P. Jaya Rami Reddy

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