

Definition and Division of Geography

The word of Geography is derived from two Greek words 'geo' mean earth 'graphein' means description. As a discipline Geography is focus on description of the earth surface as a world of man. Eratosthenes was the first Greek scholar who coined the term of Geography as "The study of Earth as a home of man". The roots of modern Geography are traced back to the thought of ancient Greek Roman, Indian and Arab scholars. In the beginning a person knowing the name of the countries, continents, river length height of mountain etc. was know as a Geographer and study of these things was called as geography. But with passage of time by including more and more aspect for scientific investigation under the subject matter of Geography, it goes on increasing day by day and all the information with earth were included under it. The foundation of modern scientific geography has been laid down by he ancient Greek scholars. Both literary and mathematical tradition can be traced in the works of Greek philosophers.

They produce topographical description of places in the known worlds, discussing both natural conditions and the culture both natural conditions and the culture of the inhabitants. They also developed the knowledge of astronomy. The town of Millets on the eastern side of Aegean sea emerged as the centre of geographic philosophy. Thales was the first among Greek scholars to be concerned about measnurement and location of things on the face of the Earth during the 7th and 6th centuries B.C

After the Greeks, the Roman, the Arab and the Indian Geographer contribute more in development of knowledge of Geography. Before the rise of Hellenic culture, geography was regarded as the knowledge of topographical features, mountains, rivers and places of one's own country and its boundaries. Later on maritime trade and commercial relations provides a store of geographical information. Thus Geography is the study of the

features of the earth's surface including their spatial distribution and interrelationship and interaction of man with them.

Different Scholar has define the Geography as :

Carl Ritter : Says that Geography is concerned with the objects on the earth's surface around man.

Hettner Considered Geography as a chronological Science in term of spatial difference and their relationship.

American College Dictionary : Geography is the study of the areal differentiation of the Earth's surface as shown in he character, arrangement and interrelationship of various elements on the earth's surface, such as climate, relief and population etc.

Marth : Considered Geography as the study which describes that how the things are distributed over space.

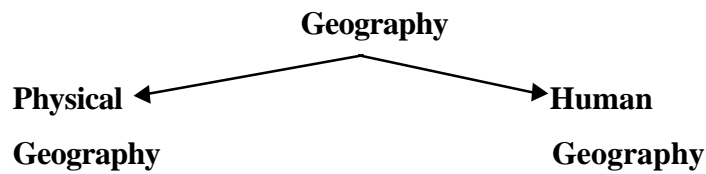
Hartshone : Geography is the Science that interprets the realities of areal differentiation of the world as they are found not only in terms of the difference in certain things from place to place but also in term of total combination of the phenomenon in each different from those at other place.

Spykman : Geography is the strategy of men, space and resources. He considers the locational factor having prime importance in the study of Geography.

Hagget : Says, Geography is uniquely relevant to the current, concern both with environment and ecology and with regional contrast and imbalance in welfare.

Now in the present day Geography is concerned with providing accurate, orderly, and rational description and interpretations of the variable character of the earth surface. On the work of **Yeates**, "geography can be regarded as a science concerned with the rational development, and testing of theories that explain and predict the spatial distribution and location of various characteristic on the surface of the earth."

Division of Geography :



Physical Geography : Physical Geography may be defined as the integrated study of the natural environment on or close to the earth's surface, Environment in its broadest sense includes all energy and matter capable of influencing man from the astronomic to sub atomic level. But practically the scope of Physical Geography is extended to the visible natural environments. Physical Geography has been described as an integration or over view of earth and life sciences which give insight into the nature of man's environment.

In short, we can say that Physical Geography is the study of the features of the earth which form the environment of the man and their development through time.

Physical Geography is systematic in nature. It is the study of physical and natural features of the earth, like mountains, rivers landforms, vegetation, soil, earth movements and climae, etc.

Physical Geography is further divided into following branches :

1. **Geomorphology :** It is the description and interpretation of the landforms. It is the study of the physical features on the surface of the earth as envisaged in the light of endogenic and exogenic forces.
2. **Climatology :** It is the study of climae. It includes the study of climatic phenomena and their influence on natural environment. It is the scientific study of the climate of a particular region or area. It also explains the nature of climate as it differs from place to place. It is dependent upon metrology for statistic regarding temperature, pressure and precipitation.
3. **Oceanography :** It is the scientific study of all aspects of the ocean including the nature of the water (salinity chemical composition), temperature, movemnet (tides, currents and waves), depth and biology (fauna and flora).

4. **Soil Geography** : It deals with various types of soil, their formation and distribution. It also helps in studying the land use of an area.

Human Geography

According to the father of Human Geography Vidal De la Blache', Human Geography is a recent sprout from venerable Trunk of Geographical Sciences. The relationship of man and nature is the subject matter of Human Geography and it offers a new conception of the interrelationship between the earth and man.

In the words of Miss Sample, "Human Geography is the study of changing relationship between the unresting man and unstable earth. Human Geography deals with conditions on the earth, The distribution of people on the earth's surface and finally relationship of man to the environment."

In general, Human Geography has two fold importance :

1. Scientific for the development of geography and
2. Practical for the planning of national economy in particular the full use of natural advantages, the response to the adjustment of nature which depends on the technical skill and degree of civilization of human group living in the region.

Its scientific importance derives from the basic facts :

That Human Geography brings all the important relationships between man and his activities.

That Human Geography similar to other Geographical Sciences has to begin with study to some concrete material phenomenon.

Human Geography may also be divided into a number of sub fields :

1. **Economic Geography** : It deals with the economic activities, natural resources, industries agriculture, etc. It studies the distribution and utilization resources of the earth. It also studies the products in the form production, consumption and

exchange.

The subject has a vast scope and is further subdivided into different fields, such as:

- (i) Agricultural Geography
 - (ii) Industrial Geography
 - (iii) Geography of Transport
 - (iv) Commercial Geography
2. **Political Geography** : It studies the political phenomenon including state and frontiers, their variations, interrelationship and their form and impact on the earth's surface it focuses attention on both internal and external relationships of the state.
 3. **Social Geography** : This is concerned with study of the spatial arrangement of social phenomena in relation to the total environment. It studies social aspects, like ; caste, religion or stratification of society. It studies the racial groups blacks and whites in relation to their social implications. It also includes the study of tribes, customs traditions, etc.
 4. **Historical Geography** : It is the branch of geography which is concerned with the past. As History has Geography on its back Similarly Geography too has History of its own development. The two main aspects of this are the reconstruction of past environment and the study of sequence of changes that take place with the passage of time at a place.
 5. **Population Geography** : It describes and explains the number of people living in an area. It explains different characteristics of human population, such as; sex ratio, age, sex composition literacy, man power, density and distribution of population, fertility mortality and migration etc.
 6. **Settlement Geography** : It deals with the nature of human shelter, its origin, various forms, development of early settlement, geographical location and relationship of settlement with natural environment.

7. **Biogeography** : The term includes the study of plants and animals, We study the habitat of various species of plants and animals and their relationship to man and Geographical environment.
8. **Urban Geography** : It is a systematic study of urban settlement. It includes the functions, morphology, concepts and planning of urban units.
9. **Cultural Geography** : It deals with the cultural aspects of different human groups. It includes shelter, food, clothing, skills, tools, languages and religions etc.

BOOKS RECOMMENDED :-

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“Geomorphology and other Disciplines”

The processes of the atmosphere acting on the earth's surface over both the short term and the long term provide the essential catalysts that mediate the geomorphic system. On occasions geomorphology can replay the compliment by preserving on transit morphology and surficial deposits, the records of past climatological events, (Baker and Kachel 1982) with the essential energetics supplied by the atmosphere, it is obvious that a detailed knowledge of how these inputs vary in space and time is a paramount importance to geomorphology.

The process of weathering at the land air interface give rise to a regolith from which the soil develops. The soil cover is, and has been, of the utmost importance to man as an agriculturalist over the last several thousand years. The soil, present or absent, is a fundamental control on how the morphology of landscape develops because the soil reveals on intimate and delicate balance between the forces leading it to accumulate and those of wash and wind that are tending to remove it.

A similarly intimate relation exists between geomorphology and vegetation, with soil and climate as important mediating agents. It is difficult to imagine Europe or North America as they looked a few millenia, or a few centuries ago and to realise the full extent of the forested cover that extended over both continents untill forest gave way to tundra or to grassland. Nevertheless, the landforms we see have developed largely beneath a 'natural' vegetation. That we no longer see, except perhaps in nature reserves. One great change in the character of landform evolution occurred when turf- forming grasses became a dominant vegetation in mid to high latitudes during the Tertiary. The resulting change in the nature of overland flow, which is severely inhibited by turf, probably converted many ecological deserts with sheetflow on extensive pediments into more undulating country with many small streams.

In our present day landscapes we find equally dramatic environment

metamorphisms, on the one hand in the deforestation associated with diffusing agricultural systems (Darby 1955) and on the other hand in the creation of that curious hictrological desert known to man as the city. Both have serious effects on flestial processes which are not difficult to document and both serve the illustrate that the control on landscape processes exerted by vegetation cannot be under rated.

Very large scale gemorphalogy shares some common problems with geophysics. When sediment is eroded from a landscape over pullods of millions of years, many thousands of cubic miles of sediment are removed from an area and transported horizontally to another area. The resulting changes of load on the earth's crust give rise to isostatic change in level of the surface, measured loads, such as substantial lakes, volcanic cones, deltas or ice caps also give rise to deformations of the earth's curst. The important of these effects to changes in the land level, measured with respect to a constant sea level, was not properly appreciated by geologists untill the begining of this century. The elucidation of the details of the regional deformations caused by, for example, the pleistocene ice caps in North America and Scandinavia has depended substantially on the methods of regional geomorphalogy. (de Geer 1892, Antevs 1922, Daly 1934, Andrews 1970). Geomorphological data helps shape geophysical theory and in return geophysical models can provide insights into isostatic changes are usually due to harizontal shifts of sediment, erosional loading and unloading, although it may be modulated by short term effects due to pleistocene ice.

At the global scale, the almost universal recognition since the late 1960's that plate tectonics provides a global theory of geology means that, over time scales of the order of millions to hundreds of millions of years at continental to sub continental spatial scales, geomorphalogy is having to take account of continental refting, mountain building and sea-floor subduction within the scope of its own theories. The first geomorphological attempt to work at the global scale was L.C king's 'Morphology of the Earth' (1962, 1967). Charley (1963) provides, for the period before the adoption of plate tectonics, a fascinating review of the influence of changing geological notions of diastrophism on geomorphological thought since 1900.

Finally, hydrology and hudraulics are subjects with connections to geomorphology - especially that part of it dealing with the role of flowing water. Practical experience with these subjects goes back beyond Roman times since irrigation for agriculture, and the

supply of water to cities, both require the construction of artificial water ways. The impact of these practical skills on geology and geomorphology was slight until well into this century. Although potentially it might have been much larger than it was. But the time fluvial erosion of valleys was generally accepted, after about 1982, interest in geomorphology concerned landform evolution at the regional scale and over millions of years.

After world war - II , a serious interest in the geomorphology of flooding in the united states led to a reutilization of the discipline by the infusion of ideas from civil engineering, Currently much work is being done at the interfaces of geomorphology, hydrology and hydraulic engineering and although the main emphasis in recent decades has been upon processes at short time scales of the order of one to one hundred years, longer time scales are coming into focus once more the experience of consciousness is so rooted in the temporal domain that the loss of memory is counted one of man's tragic afflictions. The loss of memory removes the basis of action and it must be a curious person indeed who sees no virtue before. There is a natural curiosity to search out the roots of modern thought, what ever the discipline, and it often comes as a shock to discover just how perceptive our predecessors were. Yet curiosity itself is only a partial justification. For more important is the perspective gained on the environment in which ideas grow or wither, are rejected or discussed. At any point in history it is important to try to establish the intellectual and technological constraints on contemporary thought and from such a consideration we should constraints currently binding our subject in particular, isostatic compensation due to erosional unloading and sedimentary deposition and the effects of ice loading and unloading during the Quaternary were almost neglected. Similarly the world wide change in sea level due to glaciation, first pointed out and calculated by McClaren in 1892, were mostly neglected until Daly (1910) laid the basis for understanding both isostatic and eustatic changes of level.

It is probably significant that it was in North America, where the scale is so grand and where subaerial processes are so active, that the first linkings of a comprehensive system of landscape evolution developed through the field work of Powell, Dutton, McGee and Gilbert and the masterly, if synthetic writings of Davis (1899). Yet after almost a century of discussion on the Davisian model and its many derivatives, the debate about how landscapes evolve in time, or even if they do evolve in time, is settled not settled. It is significant that Higgins (1975), in a review of this problem, called for a future geomorphic

theory that is comprehensive and diverse, flexible and explanatory : in short, it must be able to accomodate under one head alternate modes of landform development.

Studying the history of the discipline will not in itself solve the problem or provide the theory but it may indicate in general terms the sources we need to draw upon and the scope of the scientific philosophy we have to encompass. It will also demonstrate the pitfalls that will likely be encountered in trying to propagate the new theory, and it will teach us that the essential stimuli may be voices in the wilderness, rather than prophets in our midst.

Evolution of Solar System

Solar system is a home given to the heavenly bodies which move around in the universe with sun as a centre. It basically consists of nine planets namely Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. Along with these nine planets it also has other planet like objects known as asteroids, some chunks of iron and stone also move around with the planets called Meteors. In addition to all these our solar system consists of drifting particles and electrically charged gas called Interplanetary dust and plasma respectively. Interplanetary dust consists of Microscopic solid particles the planets of solar system are as under :-

1. Planets

Heavenly bodies which are revolving around in the space considering sun as their centre are known as 'Planets' these are further classified into the groups :

- a) Inner or Inferior planets
- b) Outer or superior planets

a) **Inner planets** : The first four planets of our solar system namely mercury, Venus, earth and Mars are known as inner planets. The earth is the largest among them and densest of all. All these inner planets are collectively known as Terrestrial planets Mercury and Venus are collectively known as inferior planets because they are closer to sun than to earth on the other hand the planets outside the earth's orbit are known as "Superior planet."

b) **Outer Planets** : The other four planets except pluto known as outer planets.

There are namely. Jupiter, Saturn, Uranus and Neptune these are composed by Helium, hydrogen, ammonia and Methane these are also called as “Jovian Planets”.

Barnard’s Star :

Barnard’s star is one of the first star to have a planetary system of its own. It is abt 6 million light years away from the earth. In 1947 it was claimed by two canadian astronomus that this star have five planets which orbit around it. These planets have masses ranging from 0.7 to 1.6 time the mass of Jupiter. It is feeble dway only 1/6th the mass of the sun and it shiner faintly on its planes. This is also known as a “flying star” because it flies in the sky in arc of 10 seconds per year.

THE SUN

The sun is one of the more than 100 billion stars in the gaint spiral galaxy called the “Milky way” It is the centre of the solar system. It is the centre of the solar system. It has a mass of almost 740 times as that of all the planets takes together this huge Mass creates a gravetional force which keeps other objects moving around on a fixed path and in an orderly manner. It is the ultimate source of energy to each and every person and particle on this earth.

STRUCTURE

Sun’s outer surface which is visible to haped eyes is known as “Photosphere” Above photosphere there is another layer which is reddish in colour, known as chromosphere. It is formed due to emission of hydrogen from sun. Beyond chromosphere lies the magnificent ‘Corona which is visible only during eclipses. as a remarkable pearl like silver glow around the sun. The inner part of corona is the brightest one. Rounded off to the most precised fig. sun has a temperature of about 6000⁰c.

Sun Sports

As it appears, our sun is not without spots, there are dark patches noticed on the surface of the sun. They appear dark in colour because they are cooler than the outer surface of the sun which has a temperature of about 6000⁰C. The largest spot ever measured covered 18130 million square kms or approximately 0.7% sun’s visible surface. The life

span of these spots also vary. They may last a few hours to a few weeks. The number of sunspots and the area they occupy change periodically with a period of eleven years. Sunspots show strong magnetic fields. During the maximum sunspot period, the sun shows marked activity in shorter wave lengths like X-rays and UV rays etc.

Polar Aurorae

These are observed in ring zones with a radius of 23° and the centre near the magnetic poles of the earth. There are two types of aurorae namely the aurora borealis or northern lights and the aurora australis or southern lights. These lights are very often multicoloured and provide one of the finest spectacles in nature. They occur in the arctic and antarctic regions. Northern lights could be seen as far as "New Orleans" in America and southern lights as far as North Australia. The aurorae are chiefly caused by sunspots, which are magnetic storms on the surface of the sun.

The Inner Planets

1. **Mercury** : It is the closest planet to the sun. It has a diameter of 4849.6 kms and is at an average distance of 57.6 million kms from the sun. It revolves around the sun in an elliptical orbit at a speed of 176000 kms per hour. The days are very hot and nights are frigid.

2. **Venus** : It is the second planet to the earth. It is also the brightest planet in our solar system. It has a diameter of 12032 kms. It doesn't have any moon or any natural satellite. It is at a distance of 107.52 million kms from the sun. It orbits around the sun in 225 days. It has a diameter and mass equivalent to that of earth. It has a temperature recorded as high as 500° . It rotates around the sun in a direction opposite to that of the other planets.

3. **Mars** : It is the third planet of our solar system. It has a diameter of about 6755.2 kms, and is at an average distance of 225.6 million kms from the sun. It is a planet covered with soils having a pinkish appearance and large boulders. A thorough study of the planet by space scientists has revealed that it was more active in the past years, due to dormant volcanoes and deep chasms where once water used to flow.

It is 1.5 times as far from the sun as the earth and receives half as much heat from the sun in 687. "days of earth of 668 Mars days.

4. Jupiter : Jupiter is the most giant among all the planets of the solar system it's mass is 71% of the total mass of the other planets. It has a diameter of 141968 kms, and is at a distance of 772.8 million kms from the sun. It is 300 times more massive than the earth and has a total of 16 moons. It takes 11.9 years to orbit around sun 40% of its mass is composed of light gases like hydrogen and Helium and temperature at its centre is about 1,00,000°C and on the outer surface it is as cold as - 140°C. It has a rotation period of about 9 hrs 50 min and radiates 2.5 more heat than it receives from sun.

5. Saturn : It is the second largest planet of solar system after Jupiter. It has a diameter of 119298 kms and is at a distance of about 1417.6 million kms. from the sun. It has a specific gravity of less than 1.0 which means it could even float in an ocean if larger than Saturn. It has about 20 moons of its own. The two most interesting among these are "Phoebe" & "Titan". The spiral golden rings of the planet are made of thousands of rippling, spiralling bands about 100 feet in thickness. These rings disappear in every 15 years.

6. Uranus : It is the seventh planet of our solar system. It has a diameter of about 52096 kms and is at an average distance of 2852.8 million kms from the sun. It takes about 84 years to orbit the sun. It is a watery planet and lies only on one side of it faces sun while orbiting it, It is because its axis is inclined at an angle of 98° to its orbital plane. It rotates about 10 hours and 50 minutes over its own axis.

7. Neptune : It is the eighth planet of our solar system. It possesses a diameter of 49,000 kms It is at an average distance of 4497 million kms from the sun. It takes 165 years to orbit the sun. Its atmosphere appears to be blue in colour without any air and is too cold to bear. It's a dark and desolate planet. It rotates around sun in 16 years. Its temperature is as low as 180°C. It contains certain poisonous gases like methane, ammonia etc.

8. Pluto : It is the ninth and the farthest planet in the solar system. It has just one moon and is at an average distance of 5865.6 million kms. from the sun. It takes 248 years. It is 40 times as far from sun as that the earth. It has a rotation period of 6 days, 9 hours and 17 minutes. Its moon is known as "Charon" which has a size nearly half of that of the planet due to this it often appears as a bi-planet. It has a layer of frozen nitrogen over it. Nitrogen makes 78 percent of its air.

9. Meteors : Meteoroids commonly known as “Shooting Stars” are meteoroids that pass through the atmosphere and become hot enough to emit light. As they pass through the air by the process of compression, free air cannot pass or move faster than the speed of sound where as meteors move at a speed of 30 to 60 times the speed of sound. This causes compression of the surrounding air which gets heated. Most of this heat is absorbed by the passing meteoroids which shine as a meteor of “Shooting star”.

10. Meteorites : Everyday million of meteoroids pass into our atmosphere but not more than one or two a day survive the compression and strike the earth as “Meteorites” the rest are burnt up in the air or reduced to meteoric dust. The largest ever known meteorite is imbedded in ground near Grootfontein in S.W. Africa. It is estimated to weigh 70 tons. The second largest weighing some 34 tons was recovered from Greenland. The earth must have been struck by bigger meteorites, this is evidenced by large meteoric craters that crust today. The largest of such craters known as ‘Lac-Couture, Quebec’ which is more than 15 kms across. It lies submerged in a lake.

11. The comets : The word ‘comet’ has been derived from the Greek word. “Aster kometer” meaning “Long haired star”. The long hair is the tail which looks like hair blowing in the wind. The head or the ‘Coma’ is the star.

According to most of the astronomers comets are primordial remnants from the formation of the solar system. They always remain in the cold outer fringe of the solar system away from the outer fringe of the solar system away from the outermost planet. In this dark and cold domain where there is almost no sun, millions of cometary nuclei are congregated. Here the comets are non luminous and have no tails and move slowly in enormous orbits around the far distant sun. But due to gravitational changes some of these move into the solar system eventually to become the brilliant long tailed comets that are visible for our earth.

12. Structure : A comet consists mainly of three parts namely a nucleus, a head and a tail. The nucleus is a tiny object, only a few kilometers in dimension, made up of ices of various compounds like ammonia, water, dust and large particles. It reflects sunlight and appears as a bright spot in the centre of the head.

The head is comparatively big extending up to a Million kilometers. It is made up

of gas and microscopic dust particles. The front part of the head has a shape of "Paraboloid".

The tail which is the distinguishing feature of a comet, is much larger than the head, extending to a length of 20 to 50 million kilometers. The tail develops and changes differently in different comets. The comet does not possess its tail or head when it is far away from the sun. The head appears when it comes near Jupiter and the tail appears after it crosses the orbit of Mars.

13. The Asteroids : These are the swarms of tiny planets, revolving round the sun, mostly between the orbits of Mars and Jupiter. This region is called the "Asteroidal Belt" and extends from 2.2 to 3.6 A.U. Their total number is estimated to be between 40,000 and 50,000.

In 1801, an Italian, Giuseppe Piazzi, discovered a star-like body named Ceres. It proved to be the first and largest of the asteroids, Ceres, an airless and lifeless ball 955 kms in diameter, is large enough to be called a planet. These are basically irregular chunks. Around one and half kilometers or so in diameter. The first ten asteroids discovered in the first half of the 19th century are also the biggest.

ORIGIN OF EARTH

The earth is an important planet of the solar system. It is the planet which has life and atmosphere only. It is also called as watery planet. It is one of the inner or terrestrial planets with a diameter of 12740 km and lies at an average distance of 149 million km from the sun. The age of the earth is believed to be 4.7 billion years. The origin of the earth is a matter of great speculation and discussion. Man has propounded many theories of the origin of the earth. Historical and political circumstances, religious sentiments and the progress of scientific thoughts have forced man to make change in his theories. In the search of truth the views of many philosophers were proved wrong and new theories came into existence. In fact no theory is wholly wrong or right. Every theory tries to explain facts to the greatest extent and connects them with the prevailing concept of things. Exact process of her origin has not been known till now. As a member of solar system the process of its origin can be understood in the genesis of solar system. Different scientists have put forward various theories to explain the origin of earth. Some of the important are as under.

Nabular hypothesis : On the basis of earlier work of *Kant* the French scientist *Laplace* (1794) propounded Nabular hypothesis to explain the origin of the earth. His hypothesis evoked great interest among the thinkers and scientists of 19th century. The important features of this theory are given below :

- * There was a hot gaseous mass rotating in the space called “nebula”.
- * Due to cooling effect by radiation and temperature the nebula contracted and shrunk gradually. Due to decreasing volume by contraction and shrink. The rotation of nebula increased. The mass of nebula began to shift towards equator.
- * Due to increase in rotation the centrifugal forces also increase. The matter of nebula was attracted towards the centre of nebula on account of the force of gravitation. Thus the 2 forces (centrifugal and gravitational) oppose to each

other. When the centrifugal force become equal to gravitational force the excess matter around the equator separate from the equator in the form of ring and became weightless. With time as nabulla cooled further. Its rotation increased which increased its centrifugal force. When the centrifugal force exceeded the gravational force the ring moved away from the nabulla and broke into many smaller rings. These rings on cooling took the form of planets and sub-planets.

- * The central part of the nebulla which remained behind became the sun.

Criticism : The nabular hypothesis was widely accepted during the past century owing to the confirmation of different characterstics of present solar system with the Idea develop by Laplace : The merits and demerits of his hypothesis are as follows :

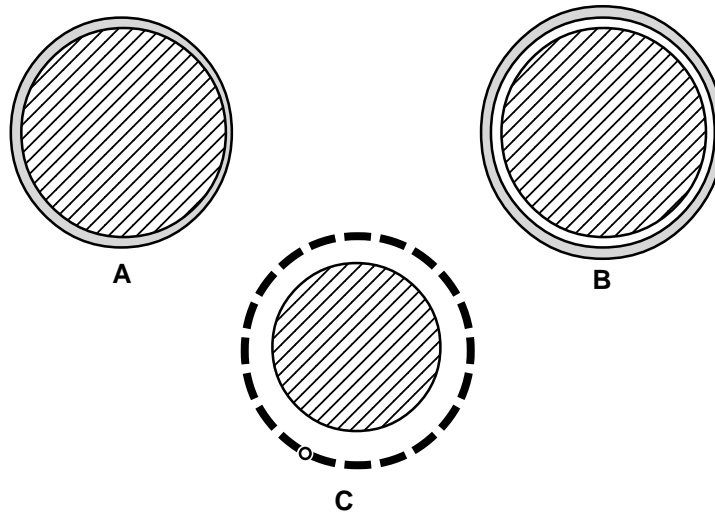
MERITS :

- * ***Rotation and revolutjion of the planets explained*** : It explains the rotation and revolution of planets and sub-planets because it assumes a hot and rotating nabulla.
- * ***From ring to planet*** : The rings seperating from the rotating nubulla must also be rotating and could take the form of a planet.
- * ***Same plane*** : Laplace explains that the planes form from the same ring revolves around the sun in same direction, in same plane an innearly circular orbits.
- * ***Hot interior*** : The inner molten and upper solid part of the earth is confirmed by this theory. This explains that planets were formed from cooling of hot gaseous rings separated from nabulla. Thus the upper part become solid and inner remained liquid.
- * ***Same elements in composition*** : The fact that all the planets are composed by same elements supports laplace's hypothesis because all the planets have been formed from the same ring.

- * **DEMERITS** : Laplace's hypothesis suffers from a number of shortcomings which are as under :
- * **Rings into solid planets not explained** : Laplace did not explain how the parts of the ring took the form of solid masses. In fact, the ring should disappear by disintegration into tiny particles.
- * **Opposite revolution not explained** : Some of the subplanets of Uranus and Saturn revolve in direction opposite to those of other planets. This fact can't be explained on the basis of this theory.
- * **Why only one ring** : According to Laplace only one ring separated out but the process of separation of the ring should have continued uninterrupted. However the ring should have continued uninterrupted. However Roche's modification eliminates this drawback.
- * **Why not binary stars** : According to Laplace, the nebula should have been converted into binary stars. In this system both the stars revolve round each other. The structure of the present solar system does not favour this hypothesis.
- * **Why does the sun rotate slowly** : According to this hypothesis the rotation of the sun should be much faster than that of the planets. The sun should also rotate about its axis in the same way as the planets do but its speed of rotation is very low as compared to the rotation of planets.
- * **Why no bulge** : If the sun is remaining part of the original nebula, there should be a bulge visible in the middle part of the sun signifying another ring in the offing there is no such bulge in the sun.
- * **Why only nine planets** : It is also clear that why the ring broke into only 9 planets. It can be proved mathematically that the ring will disintegrate into numerous small meteors. The formation of such giant planets as Jupiter and Saturn can in no way be explained on this hypothesis.
- * **Molton's Objection** : According to Molton the ring should disintegrate into small planets of unequal size.

- * **Cooling period too short** : The sun is about 4 billion year old. If it is believed that nabulla in the beginning spread over the whole space of the solar system it cannot be contracted into the present volume of the in such a small period of time.

Fig. A — C Nabular Hypothesis of Laplace



- * Nabular Hypothesis A - Nabula (Shaded) Bulging at the equatorial zone (Bulged portion dotted)
- * B - Bulged portion separated out in the form of a ring.
- * C - Ring coalsced to form a globe or planet which rotate around nabula in its orbit (dotted line)

PLANETESIMAL HYPOTHESIS :

Two Amercian scientists *Chamberlin* and *Moultion* (1904) propounded a new theory called as planetesimal hypothesis. In this hypothesis they attempt to overcome the objections raised against nabular hypothesis. The process of formation of solarsystem was explained in he following manner :-

- * According to them there was a cold proto-sun and an intruding star of considerable size moving in the space.

- * The intruding moving star approached the proto-sun and a tidal bulge was caused on the surface of sun due to gravitational force of the star.
- * The ejected mass of the sun was scattered in the form of solid particles around the sun. These particles are called planetesimats.
- * These solid particles coalesced and bigger pieces and ultimately took the form of planes.
- * A lot of heat was generated in this process and the temperature of the planets rase high.
- * The rise of temperature was contributed by four processes.
 - Due to collision of particles.
 - By the synthesis of nuclie of the particles.
 - Due to the high pressure experienced by the nuclie on account of the inccess of mass.
 - The formation of bigger maecules by collison of smaller molecules under tremendous pressure.
- * In the begning there was no atmosphere on the earth when the earth get bigger by coaleseing with smaler particles its gravitational pull attracted the gas molecules which previously moved about freely. Later on the atmospher was strengthened by the gases which came out from valeanic eruptions. The atmospher gradually grew denser.
- * Due to high pressure the melted material of the earth came out and spread over the earth surface while the inner part grew heavy and hot.
- * The increasing content of water vapours started to condense due to cooling of the atmospher and consequently rainfall occured for a long time and oceans were formed on the earth.

MERITS :

- * **Hot beginning :** The hypothesis rejected the concept of earth being cold in the beginning and thus free from much criticism.
- * **Origen of Oxygen :** It has now been proved that Oxygen is a part of the gases emitted by volcanoes. In this way the presence of oxygen in the atmosphere is explained properly.
- * **Formation according to its structure :** The process of formation of earth confirms to its structure.
- * **Formation of volcanoes :** The volcanoes were formed by the molten pocket which were forced up by high pressure.
- * **Formation of planets :** The planets were formed by small separated matter of the mother star (sun). The fact that the total mass of the planets is about 1/700 of the solar system is readily explained by this hypothesis.
- * **Demerits :** *Jeffreys* thinks that the formation of big planets by a process of coalescence of small particles does not appear credible and is based upon insufficient facts.
- * **Collision does not promote growth :** The particles after collision should become gas and not grow in size which appear improbable.
- * **Pressure Insufficient for mountain formation :** This hypothesis has hinted at insufficient pressure for the formation of mountains. The pressure explained in this hypothesis is insufficient for this process.
- * **Atmosphere formation not clear :** The principle explaining the formation of the atmosphere is defective. In the beginning when the planetesimals were small their gravitational pull was insufficient to prevent them setting free. The atmosphere which was absorbed with the planetesimals could not come out because it was buried thousands of kilometers under the surface of planet. It means the atmosphere can only be produced from planetesimals which are like present meteors. The then

planetesimals should not have been without atmosphere as the present meteors are. This is a defect which could not be explained by the hypothesis.

- * **Shape of the orbit :** Due to collision of planetesimals the orbit of the planets should not be near circular as it is at present.
- * **Problem of momentum :** The low angular momentum of the planets are not explained by the hypothesis.

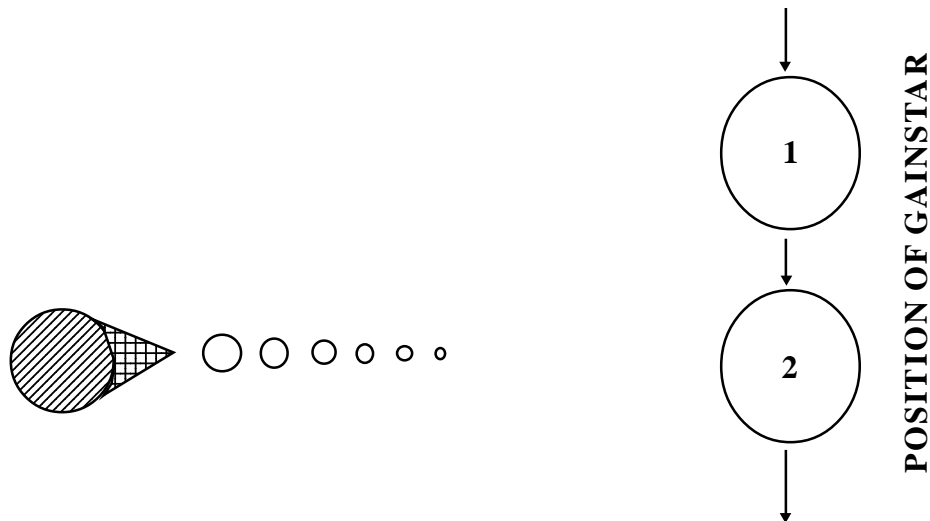


Fig. Planetesimal Hypothesis of Chamberlin and Moulton.

Big Bang Theory

The superdense or “Big Bang” Theory advanced by Ryle propounds that the universe was created by a vast explosion of superdense matter; this produced the galaxies or stars which are scattered throughout space and which are flying apart from each other at the astonishing speed of 164 million m/s (370 million m.p.h).

Edwin Hubble observed that galaxies in the universe are moving away from each other. This observation indicated that the universe is expanding.

He explained that all the galaxies of the universe shrank to a single point called Primeval Atom. The Primeval atom expanded 15 billion years (15×10^9 years) ago and

caused a big bang. At the time of explosion matter and energy rushed a part and the universe expanded. The whole space was filled with the matter of the primeval (original) atom. At the end of few seconds the universe became cool enough and the protons and neutrons begin to form simple nuclei. First of all a nucleus of heavy hydrogen (made of one proton and two neutrons) were also formed. The temperature was still high and atoms could be formed. The matter in the universe continued to expand. As a result of this, it became cooler and less dense.

Now, the electrons began to join with nuclei to form atoms and molecules of gases. These gases began to form clumps (groups) under the influence of gravitational pull. Almost 5 billion years after big bang the clumps (groups) of gases condensed and formed the galaxies and stars.

The galaxies move apart from each other due to outward force exerted at the time of big bang. So the universe is expanding day by day. But due to mutual attraction, the expansion of the universe is slowing down. It has been estimated that the expansion will stop in about 30 billion years.

When the universe stops expanding the receding galaxies would again come closer to each other due to gravitational pull. At this stage again the big bang is expected and the universe will again come into existence.

Belgian astronomer — Priest Abbe Georges Lemaitre explained the Big Bang Theory. He urged that billions of years ago, cosmic matter (universe) was in an extremely compressed state from which expansion started by primordial explosion. The explosion broke up the superdense ball and cast its fragments far out into space, where they are still travelling at thousands of miles per second. Due to these speeding fragments of matter our galaxies have been formed. But the formation of galaxies and stars has not halted the speed of expansion. And, as it happens in all explosions that farthest pieces are flying the fastest.

“Continental Drift” (Tetrahydal Hypothesis)

Introduction :

The face of the earth, that is, its visible surface has undergone radical changes in the past. Geologists explained these changes as the consequences of the cooling and contraction of the earth through thousands of years. The surface of the earth can be divided into two division - **Land** and **water**. About 70.8 percent of total surface area of the globe is represented by the ocean and remaining 29.2 percent is represented by continent. Different views, concepts hypothesis and theories regarding the origin of continent. he distributed different continents in both hemisphere is not uniform. *The following characterstice features of the distributional pattern of the continents may be highlighted.*

- * There is overwhelming dominance of land area in the northern hemisphere. More then 75% of total land area of the globe is situated to north of the equator and water bodies dominate in the southern hemisphere.
- * Continents are arranged in roughly triangular shape. Most of the continent have their base in the North while their apices are pointed towards south. If we take North and South Americas together, they represent equilateral triangals, the base of which would be along the *arctic sea* while the apex would be represented by cape horn. Similarly, the base of African triangle is toward North while its apex is the cape of Good Hope.
- * The north pole is surrounded by oceanic water while the south pole is surrounded by land area (of the Antarctic continent)

In fact all the previous hypotheses and theories dealing with origin of the continent have faded away after the postutation of *plaltectonic theory*.

“...Old view about the permanence of continent”

Old View : Ancient geographer did not believe in the permanence of continents and oceans. They thought that continents and oceans are a transitory phenomenon. The place occupied by continents can house oceans and vice-versa.

Nowadays such views don't hold much acceptance. There were a number of reasons for accepting the old views regarding the continent & ocean the reasons can be described briefly in the following way :-

- * Land areas have fossils of sea animals and vegetation.
- * According to old view, the sea was not very deep but their floors were covered with a layer of sediments.
- * There are large numbers of small islands in the oceans.
- * They thought that the continents have similarly risen over the sea level.

Modern views :

Nowadays the permanence of the continents and oceans is held correct for the following reasons :

- * The water bodies are not shallow. Most of the ocean floors lie between 3000 to 6000 metres. Moreover, the ocean floors are not covered by sediment received by land.
- * The red and fine soil found from the floors of deep oceans is nowhere found in the sedimentary rocks of the land. Had the continents arisen over the sea level, this red soil would have been found in the layers of the rocks.
- * The ocean floors are composed of heavy liquid *sima*. The land is composed of light rocks - *sial*. Both of them are floating in heavy liquid according to the principles of isostasy. The difference between them is so much that the ocean can neither rise in the form of continent nor the continents sink into the position of ocean.

- * Though the areas along the coasts have many time been submerged and many coastal areas have been uplifted, yet this change is local and therefore no evidence of this change on a large scale.

Hence the continent and oceans are considered to be permanent. As we have already discuss that there is one symmetry in the distribution of continents and oceans which provide us with some hints to their origin.

Keeping in view all these above discussed points regarding the earth, the following theories have been discussed to understand the origin of continent and ocean on the globe.

“Hypothesis Regarding the Origin of continents and ocean “

- *
 1. The hypothesis related to the contraction of the earth.
 2. The hypothesis related to the splitting of the earth.
 3. The hypothesis related to the drift of the continents.
 4. The hypothesis of continental subsidence.

This grouping help in discussing the problem in a proper perspective.

1. The hypothesis related to the contraction of the earth.

The earth was considered to be hot gaseous mass in the earlier stage. Cooling its upper layers contracted into solid from. The following hypothesis are based upon this principle.

- a) The tetrahedral concept of Lothian Green.
- b) The hypothesis of Lapworth and love.
- c) The hypothesis of Jefferys.

We have to discuss here only the tetrahedral concept of Lothian Green. And out of these hypothesis the Tetrahedral concept of Lothian Green had attracted the great attention of scientists.

- a) “The tetrahedral concept of Lothian Green”.

Introduction :

A few scientist have attempted to solve the problems of the origin of the continents and ocean basin on the basis of fundamental principles of geometry the *pentagonal dodecahedral hypothesis* (dodeca is a Greek word which means twelve) of *Elie de Neaumont* is considered to be the first attempt in this field but the tetrahedral hypothesis of *Lothian Green* is most significant of all the hypothesis based on geometrical principles.

In 1857, *Lowthain Green* presented his tetrahedral concept to explain the origin of continent and ocean with the help of a geometrical design of tetrahedron. His concept is based on the characteristics of a tetrahedron which is a solid body having four equal plane surface, each of which is an equilateral triangle or it is a shape. Which is formed by the combination of four triangles. *This hypothesis successfully explains the following characteristics of the continent and the ocean basins.*

- i) Dominance of Land area in the Northern hemisphere and water area in the southern hemisphere.
- ii) Triangular shape of continent and ocean.
- iii) Situation of continuous ring of land around north polar sea and location of South pole in land area (Antarctica) surrounded by water from all sides.
- iv) Antipodal arrangement of the continent and oceans.
- v) Largest extent of Pacific ocean covering one third area of the globe.
- vi) Location of chain of folded mountains around the Pacific ocean.

* *Lowthain Green* developed his theory on the basis of following two basic principles of geometry.

- 1) A sphere is that body which contains the largest volume with respect to its surface area and.
- 2) The tetrahedron is that body with which contains the least volume with respect to its surface area.

A tetrahedron is placed over a surface of water in such a way that it does not cover the sphere completely. In this case, its corners and edges will appear out of water and represent the continent. If its four faces will represent the oceans.

After making various experiences, he assumed that if the force from all directions are put on a spherical body, it would collapse and change into tetrahedral form. He came to a conclusion after crushing a wrought iron tube through the experiment. This experiment, he applied to the earth. He thought that various forces, used on the earth planet to contract it, would cause the collapse of spherical surface of the earth into tetrahedral form.

According to him when the earth was originated it was in the form of sphere. In the beginning the earth was very hot but it gradually began to cool down due to the loss of heat. First the outer part of the earth cooled down and thus a crust formed but the inner part of the earth continued to cool down. Consequently, the inner part of the earth was subjected to more contraction due to continued cooling and there was a marked reduction in the volume of the inner part of the earth. This resulted into a possible gap between the upper and inner part of the earth. Consequently, the upper part collapsed on the inner part and ultimately the earth began to assume the shape of tetrahedron.

* Following derivations have been made in the light of the theory regarding the earth surface.

All apices and coigns have represented the continents (land) and faces or planes to the ocean (water). The three important shields, Laurentian, Siberian and Baltic are represented by the north edge of tetrahedron while the Antarctic coincides with the apex in the South. The topmost face of it is assumed as *Arctic* whereas the other three faces are represented by *Pacific*, *Atlantic* and *Indian Ocean*.

Merits of Theory :

The tetrahedron theory of L. Green, now-a-days, is having very few supporters but it will not be irrelevant to consider its main implication as it serves to focus attention on some important points in the earth's surface structure. The following facts support the validity of the theory.

- i) The arrangement of lands on coigns and water on the face of tetrahedron is well corresponding into the antipodal arrangement of land and water on the earth surface. *America* lies opposite to *Indian Ocean*, *Asia* and *Australia* are on opposite of *Atlantica ocean*, and Europe and Africa are antipodal to Pacific ocean.
- ii) Extension and position of continents and ocean in tetrahedron are in triangular shape. Continents or shields of land mass taper southwards and the ocean toward north. Such features are very much coincident to the present geometrical shape of continents and ocean in the world ; and.
- iii) The dominance of land area in northern part of the tetrahedron clearly verifies the unequal hemispherical distribution of land and water on the earth surface.

'Demerits of Theory'

The tetrahedral theory is criticised on the basis of two following demerits :-

- i) The speed of rotation of earth is more than enough to counter balance the tendency of tetrahedral earth. Thus it is believed that the assumption of change of spherical globe into tetrahedral form is of little significance; and
- ii) It is also very difficult to believe that spherical earth with complex structure would have been constructed into tetrahedral form.

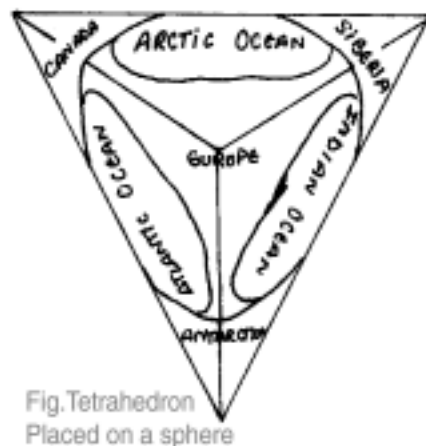
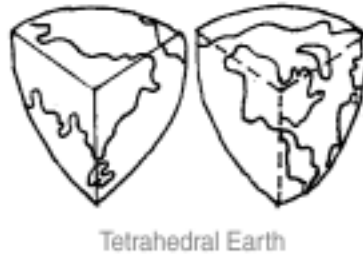


Fig. Tetrahedron
Placed on a sphere



Tetrahedral Earth

Fig. Tetrahedron placed on a sphere

Fig. Tetrahedral Earth

- iv) The tetrahedron does not represent the isostatic balance. Even if the earth's surface happens to take this form, the forces maintaining isostatic balance will destroy this shape.

*** Supporter of tetrahedral Shape :**

Gregory's Support :

The modern supporter of the tetrahedral shape of the earth's face is J.W. Gregory. He cited many evidence in support of this hypothesis in 1930. He represented fact on map and proved that the distribution of continent and ocean in the cambrian era was similar to what it is now but its position were different.

Paleographic supporter :

Paleographic supports these points, for example, *Bailey will is* proved that the continent of the combrion disappeared in the *silurian period*. *Frech* has prepared an outline map of that period and it is clear from it that the continents were dominant in the southern hemisphere. In other words the tetrahedran of that period was exactly opposite to that in the modern time. *Gondwan* land which was previously in the northern. hemisphere has been shown in the southern hemisphere in the upper paleozoic era. The existance of continent in the *Arctic ocean* and that of ocean in the Antarctica area has, also been

proved. All these fact support the tetrahedral hypothesis.

Conclusion :

Though the tetrahedral hypothesis through light on the problems of the continents and ocean basins and to major extent it successfully explain the characterstics features of the distributional pattern of the present day continents and ocean basins but because of certain basic defects and error the hypo thesis is not acceptable to all the modern scientific community.

Geological Time Scale

Radio metric dating has made possible the specific or absolute dating of rock, units which represent various events in the earth's distant past. The geological history of the earth or the 'geological clock' refers to the reconstruction of evolutionary sequence of the geological events involving the information of various zones (crust, mantle of core) of the earth, formation of evolution of geomaterials (rocks), formation of development of mountains of faults, evolution of different lives etc. The when geological history right from the origin of the earth to its present form has been divided into major or minor periods on the basis of forms of life (organic remains), characteristic rock types, places of rock formation, major electronic events etc.

The history of the earth has been divided into 2 Eras.

1. Cryptozoic Era.
2. Phanerozoic Era.

1. Cryptozoic Era : In this Era, the life was in hidden form. It has been divided into 1 Era of 2 periods.

- a) Pre-Cambrian Era
- b) Azoic period
- c) Proterozoic period

Pre Cambrian Era : It is the history of the period beginning from the birth of earth of ending 600 million year ago. When the earth could formed the hot of gas state into liquid, a thin solid crust must have formed over the surface of the liquid. The solid crust was the first rock.

Azoic Period : During this period, earth was formed, cooled of underwent many changes. The upper crust of the earth has cooled but there was volcanic activity in the interior part of the earth. This is in reality an Era of violent volcanism, large scale contraction of the earth of explosions. There was neither any sign of life nor the earth was suitable for sustaining life. Therefore rocks of this era exhibit no forms of organisms. Therefore, this era is called Azoic.

Proterozoic Period : This era is supposed to have started about 2,000 million years ago and was spread out for 1,500 million years. The fossil record is thin, because the earliest forms were soft bodies. Fossils of bacteria, blue green algae, fungi in mats of sponges, jelly fish, corals, round worms of brachiopods in animal groups have been found. This era is further divided into different epochs.

2. Pherozoic Eon : Life started its development in the pherozoic Eon. In this Eon, the conditions became suitable for sustaining life. It is divided into different periods of epochs.

The four periods are :

- 1) Palaeozoic Era
- 2) Mesozoic Era
- 3) Cainozoic Era
- 4) Neozoic Era

1. Palaeozoic Era : This era is the indication of ancient life. It is also called Primary Era, and persisted for about 370m yrs. It is composed of 6 important periods.

a) Cambrian : The name given to this period is after the name 'Cambria' - a Latin name of Wales. The duration of this period is of 70m yrs. This period saw the transgression of sea over the land surface of the rocks of this period are quiet extensive. They have light limestones at the bottom over which are laid the layers of sand stone, shale and at the top is a thin layer of limestone again. These layers hold the first evidence of life.

b) Ordovician Period : The name of this period is after 'Ordovices' - a tribe of Wales. Its duration is of 65m yrs. This period saw a large portion of land surface being

submerged under water. Several volcanic eruptions also took place in this period. The animal life evolved still further of the sea-grass was the main vegetation. Towards the end of this period a mountain building movement occurred, it brought out the mountain system in the state of Massachusetts (USA). Climate appeared warm with no climatic zone.

c) Silurian Period - Its name is after 'Silurs' tribe of Wales. Its duration is of 40 m yrs. This period is important for the birth of fish of large vegetation. The spineless animals reached a huge dimension of for the first time the animals which could breathe came into existence. Levels of seas tended to rise and fall. Plants adapted themselves on land for the first time but were leafless. Coral reef formation was maximum in this period. The red sandstone is a product of this period.

d) Devonian Period : The name is after 'Devon' in S-W- England. The period saw at its beginning the well known mountain building movement - the Caledonian movement. This resulted in the folding and faulting of the area from Scandinavia to Greenland. The second important activity of this period was another onslaught of sea on the land. The chief rock is the red sandstone of the chief creatures of this period were predominantly aquatic. Spiders, Willipeds of wingless insects also appeared on land.

e) Carboniferous or Coal Age Period : This is the period when the coal -beds of the earth came to be formed. Hence it is also known as the 'Coal Age'. This period also saw the beginning of such animal life that could live on both land of sea. The duration of this period was of 65 m yrs. Most of the Europe and large part of Russia was under water. Coal mainly found in N. Hemisphere Climate became dry in the interior land of coastal areas were warm of moist. Giant evergreen trees evolved in this period, also called 'Selvous'.

f) Permian Period : Its name is after the word 'Perm' a province in erstwhile USSR is of 55 m yrs. duration. It was the time when the Hercynian mountain - building movement occurred. This movement left its mark in central Europe, North America of several other areas. The animals which could live on both land of sea evolved. Towards the end of this period, the climate of the earth became dry and the temperature began to rise.

2. Mesozoic Era : This is also known as the age of reptiles and consists of three distinct periods as detailed below.

- a) **Triassic Period :** The name triassic is after the three fold division of deposits in Germany and its duration is of 32 m yrs. During this period, South of central Africa, South India, Madagascar of Australia were part of one compact landmass known as Gondwanaland. During this very period, the Gondwanaland which was near the South pole began to drift northwards of it began to be torn apart. Flying fish evolved of first habster (sea creature) appeared. Reptiles dominate on land. Dinosaurs are also there but it was 6" long. Flies of termites came into being.
- b) **Jurassic Period :** Its name is after 'Jura' mountain in Switzerland and is of 60 m yrs. This period saw the reptiles to reach their greatest proportions. They dominated the land, sea and perhaps the air also. But with increasing heat of dryness, They were gradually disappearing. The fossils of the first bird of the earth belongs to this period.
- c) **Cretaceous Period :** Its name is after latin word 'Creta' means chalk and is of 72 m yrs. The period is well known for its widespread deposits of chalk. In Europe of N. America, widespread layers of chalk were deposited. The other main rocks of this period are soft sandstone, clay of limestone. It was during this period that the deciduous trees appeared. Birds of early mammals also appeared in this period. Besides several mountain - building movement in Europe of N. America, this period was characterized with effusions of lava in South India.

3. **Cainozoic Era :**

This period is of 63 m yrs. duration of also called Tertiary Era. This period is sub-divided into 5 periods. These are Eocene (Eos means day break) Oligocene (Oligos means little), Miocene (meion means smaller), Pliocene (Placion means greater). Tertiary is the period when the old animals were replaced by mammals such as horses, cows, elephants, dogs, pigs, bears, monkeys etc. There was also considerable development of deciduous trees, flowering plants of grassland. It is also the period of mountain building earth movement. The Mesozoic geosyncline were folded and uplifted to form the intensive mountain ranges in the Tertiary. The Tethy's sea disappeared from Europe and Asia by the Pliocene. In India, the folding of uplift of the Himalayas in the eastern part of the Tethy's sea

began towards the end of the Eocene and reached its peak in the Mid-Miocene. In Peninsulas India, The Deccan trap (lava) was formed, which is nearly 5,000 ft. thick of covers even at present time, an area and about 2 lakh sq. miles. The Rockies of the Andes of North America and South America were also formed.

4. Neozoic Era : This is the most recent of the periods of geological history. At the beginning of this period, the temperature of the atmosphere became so low that the surface of the earth came under a vast ice-sheet. Scandinavia was the centre of moving glacial - like wise, great areas of Canada and N.USA were also under ice. Besides, there were small patches of ice-caps on the Himalayan of the Alps. Therefore, this era is known as 'Great Ice-Age'. The alluvial deposits of the world were laid in this very era. This very era saw the evolution of man of the growth of his intellect. Birds were also quite developing in the beginning of this era. This era is continuing even today.

Geological Time Table

From Youngest to Oldest

ERAS	Epochs	Periods	Duration	Starting Time before present (million years)
		2. Holocene		
NEOZOIC	Quaternary	1. Pleistocene	0.990	1.000
		4. Pliocene	10m yrs.	11.000
		3. Miocene	14 m yrs.	25.00
		2. Oligocene	15 m yrs.	40.00
ENOZOIC	Tertiary	1. Eocene	30 m yrs.	70.00
		3. Cretaceous	72m yrs.	135.00
		2. Jurassic	60m yrs.	180.00

MESOZOIC	Secondary	1. Triassic	32 m yrs.	225.000
		6. Permian	55m yrs.	270.000
		5. Carboniferms	65m yrs.	350.000
		4. Devonian	55m yrs.	400.00
		3. Siherian	40m yrs.	440.000
		2. Ordovician	65 m yrs.	500.00
		1. Cambrian	70m yrs.	600.00
PALAEOZOIC PRIMARY				
		Pre cambrian		700.00
Pre-Palaeozoic			or Algonican	
Azoic a Archaen		Archaean		800.00

“Plate Tectonic Theory”.

Introduction :

New concepts and theories based on evidence and interpretation of sea-floor spreading and palaeomagnetic field have been advanced after 1960 in the field of Geology, geophysics and geomorphology of this theory of plate tectonic is most significant. This concept divides earth surface into about 20 plates in which 7 plates are major and the rest are minor.

Meaning & Concept :

The word Tectonic is derived from Greek word ‘tekton’ means ‘builder’ applied to all internal forces which build up or form the features of the earth crust, including both Diastrophism and vulcanicity.

The rigid lithospheric slabs or rigid and solid crustal layers are technically called *Plates*. Tectonics simply means the study of rocks structure involved in earth movement. Plate tectonic deals with such sites as are in the form of plates.

The study of whole mechanism of evolution, nature and motions of plates, deformation within plates and interactions of plates margins with each other is collectively called as *Plate tectonics*. Plate tectonics tells us that it is not only the continents that are in motion, but the ocean as well. This is so because the top crust of the earth is not an unbroken shell of granite and basalt, but a mosaic of several rigid segments called plates. In other words, the whole process of plate motion and resultant deformation is referred to as plate tectonics. These plates include not only the earth’s solid upper crust, but also parts of the denser mantle below. They have an average thickness of hundred kilometres. They float on the plastic upper mantle of the earth called *Asthenosphere* and carry the continents and oceans on the backs like *mammoth rafts*.

History : It may be mentioned that the term 'Plate' was first used by Canadian geophysicists. J. Tuzo Wilson in 1965. *MacKenzie* and *Parkas* discussed in detail the mechanism of plate motion on the basis of Euler's geometrical theorem in 1967. *W. J. Morgan* and *Le Pichon* elaborated the various aspects of plate tectonics in 1968. It may thus be pointed out that the theory of plate tectonics is not related to any individual scientist rather a host of scientists of various scientific disciplines and research groups and expeditions have contributed in the development of this valuable concept of the second half of the 20th century.

Fig. Diagrammatic presentation of main aspects of plate tectonics. And also the type of plate boundaries.

Movements of Plates :

All the plates are in motion at different rates. Their rate of motion varies in ways in which plate motion takes place. First

- * Convergent in which the plates come together
- * The second is divergent where plates move apart
- * The third is parallel in which plates move in the same direction

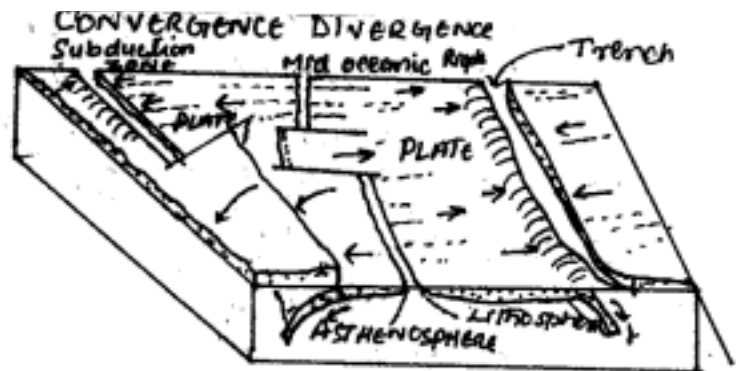


Plate margins or Boundaries & Earth movements :

It may be highlighted that tectonically plate boundaries or plate margins are most

significant because all the tectonic activities occur along plate margins e.g., seismic activities, volcanicity, mountain building and faulting etc.

There are three types of plate boundaries on the basis of direction of their movement with relation to each other. They are

- i) Convergent plate boundaries.
- ii) Divergent plate boundaries.
- iii) Transform plate boundaries.

Along these boundaries various kinds of tectonic features are formed. They are discussed in the following lines.

Convergent plate margin :

are also called as '*destructive plate margins*' or '*consuming plate margin*' because two plates move toward each other (face to face) or two plates converge along a line and collide where the leading edge of one plate (of relatively lighter material) overrides the other plate (of relatively denser material) and the overridden plate is subducted or thrust into the upper mantle and thus a part of the crust is lost in the mantle, this is why the *convergent plate margin* is called as *destructive plate margin* and also called as '*collision zone*' '*Subduction zone*' and *Benioff zone* (after the scientist Hugo Benioff).

The following important geological phenomena take place along the convergent boundary.

- i) Occurrence of volcanic activity in the oceanic area near the trench. For example, the Ring of Fire in the Pacific Ocean.
- ii) Formation of sea arches and islands. i.e., sea arches in the Pacific Ocean including Japan, Philippines etc.
- iii) Earthquake occurrence; and
- iv) Formation of fold mountains and trenches.

Divergent Plate Margin :

are also called as conservative plate margin and also shear plate margin and parallel/transform fault boundaries where two plates are moving a part in opposite direction from a common line. These are called conservative because crust is neither created.

Divergent Plate boundary :

also called as *constructive plate margin* or *accreting* plate boundaries. The plates divergent boundary is one in which plates are moving apart in opposite direction from a common line. Due to moving away of the plates, a rift is formed along this boundary or margin. The width of rift or fracture is widening as long as plates move. Through this passage of fracture, molten materials are upwelling and deposited both sides of the fracture. Such margin occurs usually in ocean and along the mid-oceanic ridges. Along the *mid-oceanic ridge* especially in *Atlantic ocean*, due to deposition of new ejected molten material, new oceanic floor is created. The creation of new ocean floor is described as ocean floor spreading. Hence the divergent margin is also called as construction margin as new crust is formed. The following events are associated along this margin.

- i) Formation of rift or fracture
- ii) Upwelling of molten materials from the mantle.
- iii) Formation of ocean floor spreading.
- iv) Occurrence of fissure type volcanic eruption.

Transform Margin or Conservative Margin :

All the plates from two sides (both converging and diverging plates) move parallel to each other and slide along common margin. Such margin is called as *Transform margin* because transform fault is formed. Plates in this process may join *ridge to ridge*, a *ridge to trench* or a *trench to trench*.

A ridge trench transform will always change length with time, A trench to trench transform may either lengthen, shrink or remain constant depending on which of plates, that form of subduction system, is the downgoing plate and the transform which join two

ridge owe's will change in length with time.

The following events taking place along the transform plate margin.

- i) Formation of Transform Faults.
- ii) Earthquakes.

The conservative plate margin include no volcanic activities, Seismic events, creation of ridges and valley, fracture zone etc.

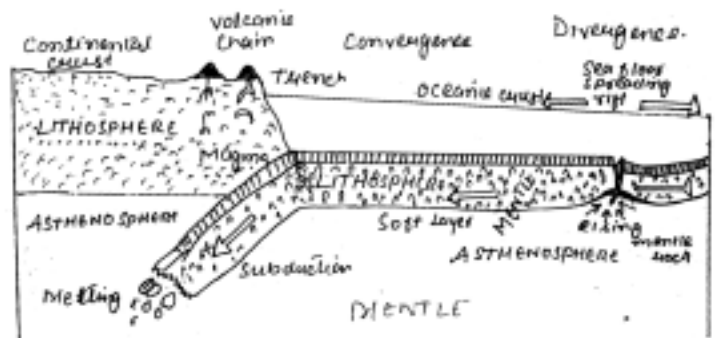
Fig. Diagrammatic presentation of different types of plate margins.

Division of crust into plates :

The earth crust can be divided into six major lithospheric plates and six minor plates.

Major Plates :

1. Indian Plate
2. Pacific Plate
3. American Plate
4. African Plate
5. Eurasian Plate
6. Antarctic Plate



Minor Plates

1. Arabian Plate

2. Phillippines Plate
3. Cocos Plate
4. Caribbean Plate
5. Nusch Plate or East Pacific Plate
6. Antarctica Plate

Table : Summary of plate tectonic Movement and Tectonic phenomenon on the earth's surface.

Boundries with reference to nature of plates

Margin	Ocean Ocean Plate	Ocean continental Plate	Continental Continental Plate
Convergent	1. Trench Formation 2. Island Formation 3. Earthquake	1. Subduction 2. Volcanic eruption 3. Formation of Trench. 4. Earth quakes 5. Young mountain	1. Formation of fold mountain 2. Earthquakes
Divergent	1. Fissure eruption 2. Ocean Floor spreading Ridge Formation 3. Earthquakes	----	1. Formation of Rift Valley 2. Inland Sea 3. Volanism 4. Earthquake
Conservative (Parallel)	1. Transform fault 2. Ridge and Valley fracture 3. Earthquakes	----	1. Transform 2. Earth quakes

INTERIOR OF THE EARTH

STRUCTURE

- 1.0 Objectives
- 1.1 Introduction
- 1.2 Views Evidences regarding Earth's Internal Structure.
- 1.3 Internal Structure of the Earth according to Vander Gracht.
- 1.4 Some other views of Earth's Internal Structure.

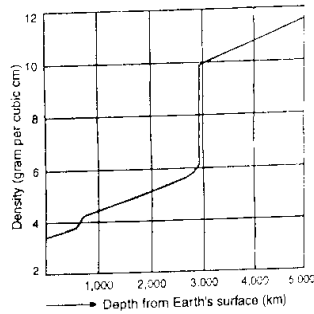
1.0 Objectives

- * To identify the aim and importance of studying the Earth's Internal structure.
- * To identify the various evidences regarding the nature of the Earth's interior.
- * To elaborate the viewpoints of various scientists regarding the earth's internal structure.
- * To be able to make a comparative study of the different theories.

1.1 Introduction:

It is essential to study the earth's interior and its structural composition because the forces originating and operating in the interior have an impact on the surface of the earth as well. From ancient times man's inquisitive mind has been filled with curiosity about

what lies below the surface. With time many views were put forwarded and subjected to criticism regarding earth's interior. Since thge interior at various times ejected all types of materials upon the surfgace - solid, liquid and gas, it was difficult to pinpoint the exact composition of the earth's interior. It was with regard to the scismological evidences that the nature of structural composition of the earth'sw interiof began to the brought to light.



1.2 VIEWS/EVIDENCES REGARDING EARTH'S INTERNAL STRUCTURE :

A collection of various scientific evidences are responsible for forming the modern views regarding earth's internal structure. The detailed study of earth's physical characteristics lead us to the true identification of its structure. However certain variations exist with regard to the interspretation of such physical characteristics.

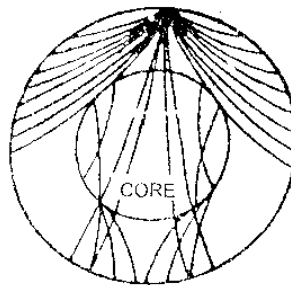


Fig. 1.2 The passage of Earthquake wave in the Earth's interior

(a) Density Related Evidences :

The upper rock layers have an estimated density of 2.7 while the total estimated

density of the Earth has been scientifically varied to be 5.5. However the lower rocks in the interior have an estimated density ranging between 11 and 12. The calculation of increasing density towards the interior has been made by Bullen. He even prepared a graph (fig 1.1) which clearly indicates increase in the density with increase in the depth.

(b) Temperature Related Evidence:

As with density, it appears that temperature too increases with depth. Infact it is documented that there is an increase in the temperature at the rate of 1°C with every 32 metres of depth. Other studies have indicatyed that the volcanic material ejected from the surface of the Earth comes from an approximate depth of 50km. The temperatuyre at that depth should therefore be about 1500°C which further proves that the interior of the Earth lies in a molten state.

(c) Seismological Evidences :-

The waves produced at the time of earthquakes are known as seismic waves (fig1.2) and these are of three different types.

- (i) P-waves which are also called longitudinal waves and traves at a speed ranging between 5 to 12 km per second.
- (ii) S-waves which are also called transverse waves and travel at a speed ranging between 3 to 7 km/sec.
- (iii) L-Waves which are also known as surface waves and travel at a speed considerably lower than even the S-waves.

During their movement the P and S waves encounter certain interruptions which tend to split them into many parts. As a result certain different types of waves have also been detected. Such obstacles in the path of the waves are different layers having different densities which gives strength to the argument that the Earth is composed of different layers or shells.

Based upon the presentation of these evidences, Jeffray provided a three pronged classification of the Earth's interior. According to him the interior of the earth was divided into three layers - (i) Lithosphere (ii) Pyrosphere (iii) Barysphere.

Later based upon their composition German scientist Vander Gracht renamed these layers.

1.3 Internal Structure of the Earth according to Vander Gracht

Vanbder Gracht modified the earlier work of such scientists as Jeffrey, Leinck and Gutenberg to present his own view of the internal structure of the Earth (fig 1.3). According to him there are three distinct or major layers into which the earth is divided

Layer	Relativedensity	Thickness
1. Sial Layer	2.75-2.90	Upto 60 km
2. Sima Layer	3.10-4.75	1400 km
3. Mixed Silicates	4.75-5.0	1700 km
4. Metallic Nucleus	11.0	3400 km

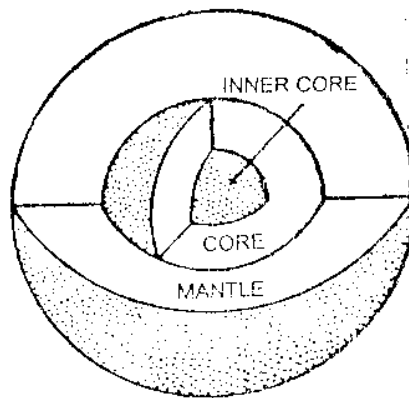


Fig. 1.3

Mantle core and inner core of the Earth

Detailed Composition :

Name of Layer	Relative Density	Depth (In km)	Composing Elements
External Sial Layer	2.75-2.90	(i) 60 km below continents (ii) 29 km below Atlantic Ocean	Mostly Silicon and aluminium with traces of oxygen, potassium Magnesium etc.
Internal Sial Layer	3.1-4.75	60-1200	Mostly silicon and Magnesium with traces of aluminium, Potassium, Sodium etc.
Mixed Silicate Layer	4.75-5.0	1200-2900	Oxygen, Silicon mixture of iron and nickel
Nucleus	7.8-11.0	2900-6371	Nickel and Iron

1.4 Some other views of Earth's Internal Structure :-

(1) According to Suess emphasised the chemical composition of the Earth's interior. The Earth's crust according to him is covered by a thin layer of sedimentary rocks of low density. The identified three distinct zones of different matter just below the outer sedimentary cover (fig 1.4).

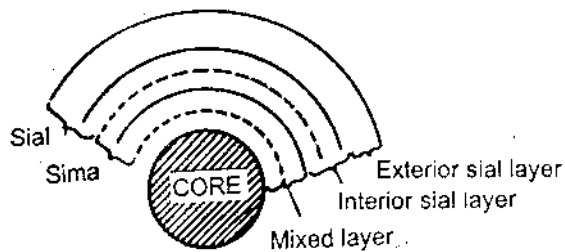


Fig. 1.4 The various layers of the Earth

- (a) Sial Layer - The outer layer dominated by silicon and aluminium, hence $SL+AL = SIAL$.
- (b) Sima Layer - The basaltic layer located below the sial and dominated by silicon and magnesium, hence $SI+MA = SIMA$.
- (c) Nife Layer - Layer of heavy metal located below Sima and dominated by iron (fe) and nickel (ni), hence - NIFE.

(2) According to Daly :-

Daly has recognized three layers of differing density and thickness as -

- (a) Outer Zone- This layer is composed of silicates, has an average density of 3.0 with a thickness of approximately 1600 km.
- (b) Intermediate Zone- This layer is composed of a mixture of iron and silicates, has an average density ranging between 4.5 and 9.0 with a thickness of 1.280 km.
- (c) Central Zone - This layer is composed of iron and is in a solid state. The average density is 11.6 and its diameter is about 7,000 km.

(3) According to Harold Jeffreys :-

On the basis of the study of seismic waves, Jeffrey has identified four layers.

- (a) Outer layer of sedimentary rocks
- (b) Second layer of granites
- (c) Third layer of thachylyte or diorite
- (d) Fourth layer of olivine, peridotite and eclogite.

(4) Recent views :-

Three zones of varying properties have been identified in the earth on the basis of changes in the velocity and passage of seismic waves. (fig 1.5 Each zone has varying properties of density, depth and thickness.

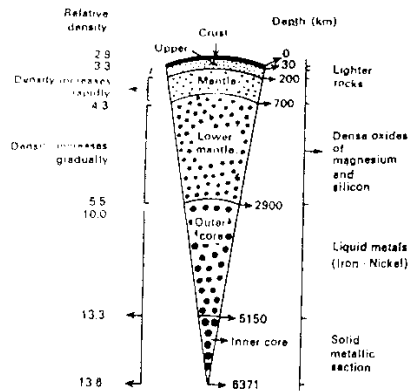


Fig. 1.5 Section through Earth,
(Relation between Density, Section and Depth)

(a) **Crust** - It is further divided into two layers

- Upper crust
- Lower crust.

The average density of upper and lower crust is 2.8 and 3.0 respectively. The thickness of the crust ranges between 50 - 100 kms.

(b) **Mantle** - It is also divided into two sub layers.

- Upper mantle (Density 3.0-4.5)
- Lower mantle (Density 4.5 - 5.5)

The mantle extends upto a depth of 2900 kms. It also contains 83 percent of the total volume and 68 percent of the total mass of the earth.

(c) **Core** - It is divided into two sub layers.

- Outer core (density 10.0 - 12.3)
- Inner core (density 12.3 - 13.6)

The core extends upto a depth of 6371 kms. It's density is more than twice the density of the mantle but only 16 percent of its volume.

“ROCKS - THEIR ORIGIN & FORMATION”**STRUCTURE:**

- 1.0 Objectives
- 1.1 The Earth's Crust
- 1.2 Rocks - Their Origin
- 1.3 Classification of Rocks
- 1.4 Igneous Rocks
- 1.5 Classification of Igneous Rocks
- 1.6 Sedimentary Rocks
- 1.7 Classification of Sedimentary Rocks
- 1.8 Metamorphic Rocks
- 1.9 Metamorphic Transition

1.1 The Earth's Crust :-

The Earth has a solid crust which has a thickness of about 64 kms. Both the lithosphere and the hydrosphere are included in the crust with a respective of approximately 1:2.4. A major part of the study of the Earth's crust includes an analysis of its composition. As many as 98 different elements in varying composition have been found to be present in

the crust. However the distribution of these elements is highly uneven. There are eight major elements which account for more than 98% of the composition. The rest 90 elements account for approximately 1.5% of the earth's crust. Even out of these 90 only fifteen elements e.g. titanium, hydrogen, phosphorous, manganese etc. account for 1.25% of the crust while the rest 75 elements are called trace elements account for only about 0.25% of the crust.

1.2 Rocks - Their origin :-

The elements forming the Earth's crust generally combine with each other to form a specific compound which has definite chemical composition and physical properties. Such compounds are called minerals. Although most minerals are composed of multiple elements, these are certain prominent minerals which are composed of a singular element eg. gold. In these turn, then minerals combine with each to form a new compound which is an immediate part of the Earth's crust. Such mineral formed compounds are known as rocks.

Definition of Rock:

* An aggregate of minerals is referred to as a rock.

* The substance formed of one or more minerals and is a part of the Earth's crust is called rock.

Contrary to common belief rocks are not always hard but can also be soft eg. graphite. They also vary in size from large size eg. basalt to fine grained eg. sand. As with the predominance of few elements in the composition of the crust rocks too are mostly composed of six major minerals. These minerals are feldspar, quartz, pyroxenes amphiboles, mica and olivine.

1.3 Classification of Rocks:-

The Most universally accepted classification of rocks is the one which is based on the mode of formation. Although the rocks are composed of minerals, their mode of formation determines the following characteristics of rocks-

- (a) Level of mineral composition
- (b) Chemical composition
- (c) Physical attributes and properties
- (d) Rock structure and form.

On the basis of the mode of formation rocks are divided into three major types-

- (1) Igneous Rocks
- (2) Sedimentary Rocks
- (3) Metamorphic Rocks

Each type of rock has definite physical and chemical properties as well as chemical composition.

1.4 Igneous Rocks :-

In the initial stages of its formation the Earth was composed of molten matter which gradually started to cool down and due to the action of water, wind and glaciers began to take on a compact and consolidated form. This solidification of the molten material led to the formation of the igneous rocks. In other words, whenever magma reaches the surface of the Earth it starts to cool down and solidified magma is called igneous rock.

Characteristics of Igneous Rock :-

- 1) Layers of solidified and compact magma represent igneous rocks.
- 2) Most igneous rocks are non-porous in nature ie. water cannot percolate through them.
- 3) Igneous rocks are generally resistant to erosion
- 4) Igneous rocks are both crystalline and non-crystalline in nature. When the magma cools down at a fast rate the igneous rocks formed are non-crystalline in nature and vice-versa.

- 5) Silica content ranges between 40-80 percent
- 6) Due to their solidity and compactness, igneous rocks do not form fossils.

1.5 Classification of Igneous Rocks :-

Igneous rocks can be classified on many bases but generally three types of classifications are recognized.

- (a) On the basis of mineral composition:

On the basis of their mineral composition igneous rocks are divided into two sub-types-

- (i) **Acid Igneous Rocks :-** Such igneous rocks have an excess of silicon oxide which imparts acidic nature to the rocks. Other elements present are magnesium, sodium, potassium etc. The common example is granite. Acidic igneous rocks are poorly eroded.
- (ii) **Basic Igneous Rocks :-** The silicon content in these type of rocks is less than 40%. In addition it also possesses 40% magnesium and about 20% of the rest is composed of iron, aluminium, potassium etc. Common examples are basalt, gabbro and dolerite.

(b) On the basis of place of formation :

Although igneous rocks are formed due to the cooling down of the magma, the process of cooling takes place both above and below the surface of the Earth. On this basis two sub-types of igneous rocks are identified

- (i) **Extrusive Igneous Rocks :-** When the molten material cools above the surface, the type of rocks formed are called extensive or extrusive igneous rocks. eg. Basalt and Gabbro.
- (ii) **Intrusive Igneous Rocks :-** When the magma lacks intensity and pressure it cannot reach the surface. As a result it starts to cool down below the Earth's surface at various depths. According to their situation below the

surface three types of intrusive igneous rocks are identified-

* **Minor Igneous Rocks**

* **Intermediate Igneous Rocks**

* Major Igneous Rocks.

(c) On the basis of form and shape :

The molten magma begins its cooling process in various crevices, depressions or cavities. Consequently its shape resembles the shape of the cavity where it solidified. Therefore, on this basis five sub-types of igneous rocks are identified all with unique and distinctive form, shape and size.

- (i) **Laccoliths :-** Magma with a comparatively higher concentration of silica gets solidified at normal temperature. However, accumulation of hot magma below the hardened rock layer exerts pressure on it and the layer rises in the form of a dome. Such dome like formations are called laccoliths (fig 2.1)

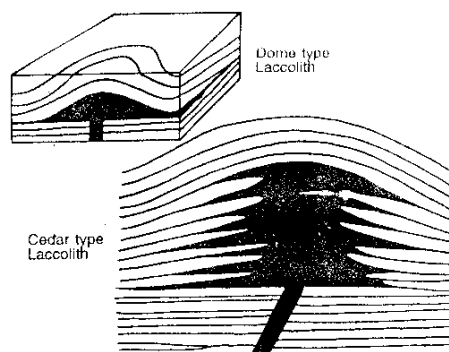


Fig. 2.1 Dome Type and Cedar type Laccolith.

- (ii) **Batholiths :-** Sometimes the magma on acquiring a large space spreads over the entire area and begins to cool. Its extent is extremely large and on some occasions exhibits cylindrical formations with it. These are known as batholiths (fig 2.2) and a common example can be observed in the British Columbia state where a batholith formation stretching for 2,400 km in length and 160 km in width can be found.

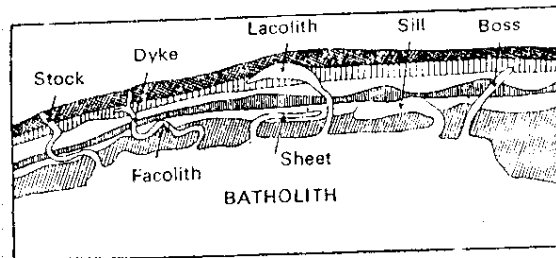


Fig 2.2 Various forms of igneous intrusive rocks.

- (iii) **Lopoliths :-** When batholiths are deposited in concave form, they are known as lopoliths. It is a common feature of South African topography.
- (iv) **Phacoliths :-** When magma is deposited in a wave like form it is known as Phacolith eg. Saddle Reef in Australia.
- (v) **Dykes :-** After the process of cooling, the magma appears to make an angle of almost 90° with its surrounding layers. This formation is known as a dyke eg. Colorado and Columbia in U.S.A.

1.6 Sedimentary Rocks:-

Although a vast majority of crustal rocks are igneous, sedimentary rocks account for more than 80 percent of surface rocks. Such rocks are formed due to the weathering and erosion of existing rocks and their layers by layer deposition. Sedimentary rocks are created in four step formation after the weathering of rocks takes place.

- (i) **Transportation:-** Agents like water and wind are responsible for transporting and modifying weathered loose materials.
- (ii) **Deposition:-** As the intensity and carrying capacity of the transporting agent is reduced it deposits the material at various locations eg. bed of water bodies, along their banks or on the surface. The deposition takes place layer by layer and the process is called stratification.
- (iii) **Cementation:-** Water containing loose rock materials: enters into cracks and opening of rock layers. It joins the layers with each other and the process is called cementation.

- (iv) **Consolidation:-** As the number of layers go on increasing, the Upperf layers start to exert pressure on the lower layers. Due to this pressure the layers become compact and the space between them gets reduced. This process is called consolidation.

Characteristics of Sedimentary Rocks :-

- (1) Sedimentary rocks clearly show distinct layers.
- (2) Since different size particles compose these rock, they are of a porous nature.
- (3) Layered deposition over an extended period of time means such rocks also show fossils of plants and animals which also helps in datring them.
- (4) Sedimentary rocks are generally susceptible to eriosion.
- (5) Coastal rocks show imprint of sea waves which are known as ripple marks.

1.7 Classification of Sedimentary Rocks:-

Sedimentary rocks may be classified on the following bases.

- (a) On the basis of structure:-

This classification of sedimentary rocks is made on the basis of the contributing particles in their formation which determines their structure.

- (i) **Calcerous Rocks :-** When the deposited particles are predominantly of lime content, such type of rocks are formed. Limestone and dolomite are common examples.
- (ii) **Carboneceous Rocks:-** Sediments amounting in coal content from trees are responsible for formation of such rocks which have high carbon content.
- (iii) **Sandstone Rocks:-** Sedimentary rocks formed predominantly from sand are called sandstone rocks and have reddish colours.
- (iv) **Conglomerate Rocks:-** These type of sedimentary rocks are formed when

particles ranging from small grains to large rocks are most easily eroded if cementing process fails to take place.

(b) On the basis of place of formation:-

Various types of agents are responsible for the formation of sedimentary rocks. These rocks therefore can also be classified on the basis of the agent that is responsible for its formation.

- (i) **Aqueous Rocks:-** These rocks are formed when water is the principal agent in their formation.
- (ii) **Lacustrine Rocks:-** These sedimentary rocks which are formed due to particle accumulation on lake beds.
- (iii) **Riverine Rocks:-** When river enters a plain area, its particle carrying capacity is reduced. It therefore deposits its load on its bed or along its banks. Alluvium is a common example of sedimentary formation along rivers.
- (iv) **Aeolian Rocks:-** These rocks are formed in dry areas where the main agent of formation is wind.
- (v) **Glacial Rocks:-** When glacier acts as an agent of erosion it deposits material along its floor or along the banks of the water body such rocks called Glacial rocks are common in areas of higher latitudes.

1.8 Metamorphic Rocks:-

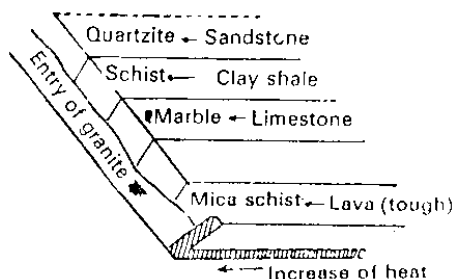
The rocks which are formed from both igneous and sedimentary rocks but having properties different from both the types are called metamorphic rocks. In fact, metamorphic rocks are said to form under two conditions-

- (i) When either igneous or sedimentary rocks undergo conditions of extreme heat and pressure.
- (ii) When there is a change in the structure of igneous or sedimentary rocks

due to mechanical or chemical changes.

Causes of Metamorphism :-

- (i) On certain occasions mountain building or orogenic forces exert so much pressure on the rocks that they became warped and compressed. This changes their form, shape and structure.
- (ii) Conditions of high temperature and pressure are triggered by lava which occupies empty spaces in between rocks. (fig 2.3)



- (iii) Underground water dissolves existing rocks and transports them to another place where they are reformed with different physical and chemical properties.
- (iv) Existing rocks undergo conditions of extreme pressure due to the work of geodynamic forces.

Types of Metamorphism :-

Two types of metamorphism are observed-

(i) On the basis of Agency : On this basis metamorphism of rocks may take place by either thermal or dynamic agencies.

(a) Thermal Metamorphism: Heat is a common cause of metamorphism and is generated through following agencies:-

- * Hot Magma
- * Hot gases, vapours or liquids.

* Mutual Friction; and

* Geothermal Heat.

(b) **Dynamic Metamorphism:-** Pressure is also a common cause of metamorphism and is generated by the operation of geodynamic force.

(ii) On the basis of Zones of Influence:

On this basis the metamorphism is also of two types-

(a) **Contact Metamorphism:-** When the empty spaces between rocks are filled by magma, conditions of high temperature and pressure are exerted on the rocks in immediate vicinity or contact zone.

(b) **Regional Metamorphism:-** The pressure exerted on the rocks developed in geosynclines are responsible for this type of metamorphism. This metamorphism is commonly observed in major mountain ranges like Himalayas.

1.9 Metamorphic Transition:-

As is understood that metamorphic rocks are formed from igneous and sedimentary rocks, it is relevant to give examples of igneous or sedimentary rocks and their metamorphosed form

TYPE OF ROCK	METAMORPHIC ROCK FORMED AFTER METAMORPHISM
<p>(1) Igneous Rock</p> <p>(i) Mica Rocks</p> <p>(ii) Granite</p> <p>(2) Sedimentary Rocks</p> <p>(i) Sandstone</p> <p>(ii) Limestone</p> <p>(iii) Clay</p> <p>(iv) Peat</p>	<p>Schist</p> <p>Gneiss</p> <p>Quartzite</p> <p>Marble</p> <p>Shale, Slate, Phyllite, Schist.</p> <p>Lignite, Bituminous, Anthracite.</p>

“WEATHERING & ITS TYPES”**Structure**

- 1.0 Objectives
- 1.1 Weathering
- 1.2 Types of Weathering
- 1.3 Physical/Mechanical Weathering
- 1.4 Chemical Weathering

1.0 Objectives :-

- * To understand the concept and definition of weathering and differentiate it from erosion.
- * To give brief outline of the types of weathering
- * To describe the process of physical weathering and its types
- * To explain the concept of chemical weathering and its different types.

1.1 Weathering :-

Due to constant actions of such agents as temperature, air, water etc, rocks start to break down into smaller particles. The breakdown occurs as a result of disintegration through physical action and decomposition through chemical action. The broken down

and loose rock material is deposited over the bedrock and is called regolith. Weathering also takes place when layer by layer of rocks are periodically peeled off. This particular process is termed as Exfoliation. Although both weathering and erosion are responsible for breaking down rocks into smaller particles. Weathering process takes place at the point of origin without any movement of the particles as associated with erosion. Therefore, weathering always precedes erosion.

Definition:- The definition which truly identifies the true meaning of the term weathering is as follows.

“Weathering is the mechanical fracturing and chemical decomposition of rocks ‘in situ’ by natural agents at the surface of the earth”.

In the above definition the latin term ‘in situ’ refers to the breakdown of the rocks at their original site or situation. The broken down smaller particles then can be carried away easily by an agent of erosion.

1.2 Types of Weathering :-

Since weathering is defined as both the ‘mechanical’ as well as ‘chemical’ breakdown of rocks, therefore it is of two distinct types

- (a) Physical or Mechanical Weathering
- (b) Chemical weathering

The climate and topography of a place determines the type of weathering a rock undergoes. Hot and humid climates with abundance of rainfall promote chemical type of weathering while arid and semi-arid type of regions generally promotes physical type of weathering. However both these processes are not exclusive of each other. The breakdown of a rock is well and truly brought about by both physical and chemical types of weathering acting alternately or simultaneously on a rock.

1.3 Physical or Mechanical Weathering :-

The main factors which are responsible for physical weathering are as follows.

(a) Temperature:- Temperature as an active agent of weathering is most evident in those areas where daily range of temperature is very high. During day time when the temperature is high the rocks tend to expand. However as the temperature drops especially during night time the rocks start to contract. Over a long period of time continuous expansion and contraction leads to a pressure exertion on the rocks. This pressure starts to affect the outer surface of the rocks and the process of exfoliation sets in. Apart from exfoliation temperature change also leads to cracks and fissures developing in the rock surface which ultimately leads to breakdown.

(b) Pressure and Release:- Many types of rocks especially metamorphic rocks are created under conditions of extreme pressure. This pressure provides stability to the rock and it retains its form. However weathering in the upper layers lead to release of this pressure on the lower layers. The lower rock layer this exposed are prone to weathering. Release of pressure also leads to cracks appearing on the rock surface.

(c) Freeze and Thaw :- Those rocks which already possess cracks and fissures are most likely to be affected by freeze and thaw action. In areas of cold climate water gets logged into rock openings. During night time when there is sudden drop in mercury that water freezes into ice. Consequently there is an increase in the volume which exerts pressure on the rock. This leads to the widening of the cracks and ultimately to splitting up to of the rock. (fig 3.1)

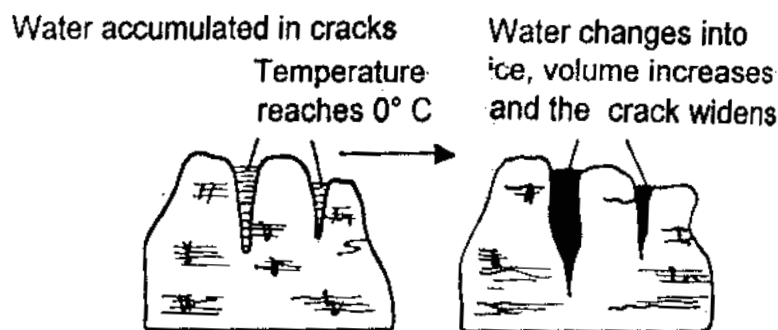


Fig. 3.1 The Widening of fissures due to ice formation.

(d) Gravity :- Large jointed rocks especially those found on slopes are most affected by gravity. Rocks roll down slope and get crushed in the process.

(e) Biological/Organic Action :- Plants and animals also contribute towards the

process of physical weathering. The roots and branches of plants and trees have a tendency to enter cracks in the rock. As these roots start to extend and strengthen they exert a great deal of pressure on the rocks until they finally break into smaller parts. Animals especially grazing animals and insects like worms are responsible for weathering of rocks.

1.4 Chemical Weathering :-

Oxygen and carbon dioxide of the atmosphere become very active in the presence of water and water vapour and bring about chemical changes in the rock composition. Therefore, chemical weathering is much more evident in areas having hot and humid type of climate. Chemical weathering of rocks takes place through the following Process :-

(a) Oxidation :- Atmospheric oxygen reacts with the mineral compounds of rocks in the presence of water oxidation is most evident among rocks rich in iron content as the action of water changes ferrous state of iron to ferric. In other words, water starts to rust the iron of the rocks. Pyrites are also affected by water and this produces sulphuric acid which proceeds to dissolve the pyrites and remove them from the rocks.

(b) Corbonation :- Humid areas commonly experience the process of corbonation during excessive rainfall. Calcium carbonate content of the rocks readily reacts with the rain water which possesses carbonic acid. Calcium carbonate and magnesium carbonate in presence of the carbonic acid are converted into bicarbonates of calcium and magnesium. Rocks rich in lime content also readily lose their lime content in presence of rain water.

(c) Hydration :- In this type of chemical weathering water is absorbed and incorporated into the mineral content of the rocks. This leads to swelling up of the rocks and then the breakdown of rocks especially coarse grained rocks, eg. hydration leads to the formation of gypsum from calcium sulphate.

(d) Hydrolysis :- This process leads to the formation of a new mineral in the presence of water. The granite rock commonly undergoes hydrolysis. The feldspar content of granite rock gets converted into kaolin.

(e) Desilication :- Running water separates silica content of rocks. Continuous desilication leads to disintegration of the rock.

**EROSION WORK OF RUNNING WATER
“EROSION & FLUVIAL TOPOGRAPHY”**

Structure:

- 1.0 Objectives
- 1.1 Erosion, Transportation and Deposition
- 1.2 Agents of Erosion
- 1.3 Process of Erosion
- 1.4 Fluvial of Erosion
- 1.5 Fluvial Erosional Landforms.

1.0 Objectives :-

- * To understand the concept of erosion
- * To identify the agents of erosion.
- * To outline the stepwise process of erosion.
- * To highlight the concept and process of fluvial erosion (erosion by running water).
- * To briefly present the major types of landforms which result as a consequence of erosion by running water i.e. fluvial erosional landforms.

1.1 Erosion, Transportation and deposition :-

Rocks are the dominant feature of the earth's surface and are constantly affected by climatic phenomena and other agents which work to modify the character of earth's surface. Weathering breaks down the rocks into smaller particles 'in situ'. However the broken down rock pieces may then be transported forward to a different location due to the action of aforementioned agents. Therefore, whenever there is movement or displacement of material from its original position, the process is known as erosion. Erosion usually accompanies or follows weathering and is defined as that process by which weathered materials are transported and deposited in different locations by the action of various agents which may collectively be referred to as the agents of erosion.

1.2 Agents of Erosion :-

Due to the action of weathering the earth's surface is covered by a layer of loose rock material called Regolith. This regolith which is an unconsolidated rock mixture undergoes the process of erosion through the action of various agents of erosion.

(i) Running water : Water is an important erosional agent particularly when it is in motion. Running water therefore can be considered as a very important agent of erosion as well as transportation. River water has great capacity for erosion and also possesses a vast carrying capacity for load which includes sediments, rock mixture, sand etc. A river can carry out all three activities of erosion, transportation and deposition. Through its action running water can create both erosional as well as depositional landforms. Such type of landforms are known as fluvial landforms.

(ii) Moving Ice :- The intensity of moving ice i.e glaciers as an agent of erosion is comparatively less than that of running water. Glaciers have the capability to erode large blocks of lands or even part of a mountain side. Since they are in motion they also carry out the activity of transportation. However when the speed of glaciers is reduced, it deposits the transported materials along the banks of the water body over which it is travelling or even on the body of the glaciers. As with rivers, the glaciers also form erosional as well as depositional landforms.

(iii) Wind :- Winds as erosional agents are mostly active in arid type of climate. Wind by itself does not carry out erosion but the material that it carries with it erodes mountain sides, rocks and even large boulders. Arid type of landforms which are both erosional as well as depositional in nature are created by the action of wind.

1.3 Process of Erosion :-

The process of erosion can be divided into the following steps :-

(i) Picking and Plucking :- An erosional agent with sufficient intensity can pluck or break off a piece of a rock and carry it forward. Picking generally involves the collection of regolith that lies over the bedrock.

(ii) Transportation :- After picking up the weathered particles the erosional agent proceeds to transport it from its place of weathering to another location. The process of erosion continues through transportation as well because erosional agents tend to rub, scrape, scratch, abrade and disintegrate the rock pieces further while in motion. Although landforms are not actually created during transportation but the shape, nature and size of depositional features is dependent upon the activity of transportation.

(iii) Mutual Friction :- Erosion is caused not only by wind, water and ice but weathered pieces of rocks also become agents of erosion. These rock pieces collide with each other and modify their shape, size and texture. Angular edges of rocks due to constant contact with other rock pieces, become rounded and smooth. The rock pieces being transported also affect the river banks, bed and floor of the river by creating depression like features.

(iv) Deposition :- The process of erosion ends with deposition. Transportation and mutual friction can continue only till the agent has the capability to carry the material forward. At the point where carrying capacity diminishes, the load is deposited. The larger pieces are deposited earlier than the smaller pieces. This further leads to the formation of depositional landform features.

1.4 Fluvial Erosion :-

Running water is an extremely active agent of erosion and is capable of creating a great variety of landform features. The landforms created during the different stages of a river are collectively called fluvial landforms. A river carries out the process of erosion in three different ways :-

(i) Hydraulic Action:- Due to its velocity the river water lifts rocks and debris and pushes them forward. Size of the eroded material depends upon the flow intensity of the water.

(ii) Abrasion Action :- The impact of the running water loosens pieces of rocks and as they are pushed forward they start to strike and rub against each other. As a result they get broken down further. This process is called abrasion or corrasion.

(iii) Solution Action :- Some types of rocks contain certain soluble elements. As they come into contact with the water the soluble components dissolve in the water and rocks lose their original shape, form and structure.

1.5 Fluvial Erosional Landforms :

As a consequence of fluvial erosion many unique type of erosional landforms are created. The important ones are :-

(i) River Valleys :- Valleys are the most common type of landform feature created by fluvial action. Valleys are formed during different stages of the river course. In the youthful stage V-shaped valleys having very steep sides are formed. During the mature stage the valley are slowly broadened with flat floor and uniform gentle sides. In the old stage the valleys are further modified into broad and shallow valleys with concave sides. River valleys are of two main types-

(a) Gorge : These are the narrow and deep valleys formed during the youthful stage of the river. They are a common feature in the Himalayan rivers. (fig 4.1)

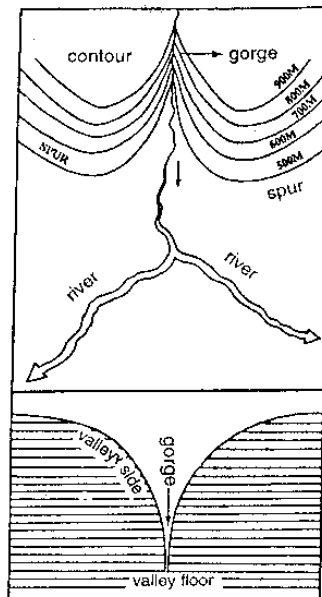


Fig. 4.1

Contour plan of gorge and spurs and cross section of a gorge.

(b) Canyon : These are generally referred to as extended form of a gorge. The Grand Canyon on Colorado River, USA is an example. It extends to about 500 kms and has a depth of about 2000 mtrs.

Valleys can also be classified on the basis of their origin :-

- a) **Consequent Valleys :-** Valleys formed as a result of land upliftment.
- b) **Subsequent Valleys :-** Valleys formed due to erosional action of streams flowing over layers of weak rocks.
- c) **Obsequent Valleys :-** Valleys in which the flow of water is opposite direction to that in a consequent valley.
- d) **Insequent Valleys :-** Valleys formed by the accumulation of water in some depression.
- e) **Inconsequent Valleys :-** The slope of the land controls the stream. The

valleys formed where the river is not able to make complete adaptation with the land are called inconsequent valleys.

f) **Resequent Valleys :-** When the stream erode the upper layers of the rocks and flow on the exposed underlying layers, resequent valleys are formed.

(ii) **Waterfalls :-** Generally waterfalls are caused in those areas where a layer of hard resistant rocks is followed by an extended layer of soft rocks. The soft rock layer is eroded causing the stream to abruptly fall. Waterfalls can be formed either when rock beds are in a vertical position or in a horizontal position. The Angel Falls in Venezuela are considered the highest waterfall in the world with a height of 979 mts. Niagra falls in Canada have the greatest volume of water. (fig 4.2)

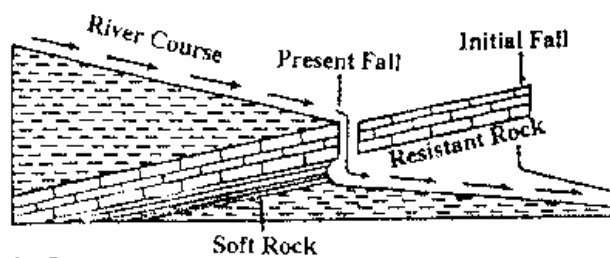


Fig. 4.2 Origin of waterfalls when the rocks dip upstream.

(iii) **Rapids :-** Rapids are a series of turbulent flows formed in those areas where hard and soft rocks are present. The river where rapids are formed is extremely shallow.

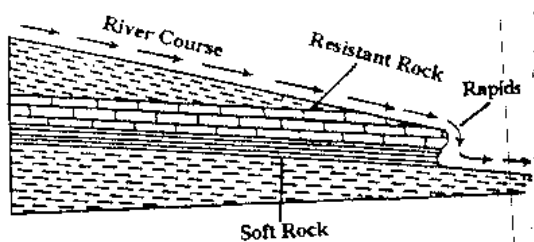


Fig. 4.3

Formation of rapids when the rock beds dip downstream.

(iv) **River Meanders :-** S-shaped formations in the river course are called meanders. They are formed when the river starts to erode its banks. The place where the banks are eroded, the river appears to have a curved appearance. Meanders are semi-circular in shape with alternating concave and convex sides. They can be further divided on the basis of the type of erosion.

- (a) **Normal Meanders :** Those meanders which are formed as a result of lateral erosion. (Fig. 4.3)

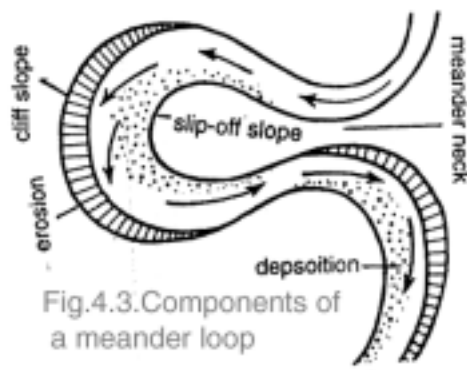


Fig. 4.3 Components of a meander loop

- b) **Incised Meanders :** Those meanders which are formed as a result of vertical erosion.

(v) **Oxbow Lakes :-** When extensive erosion takes place the meanders become more curved and two curves extend towards each other. One end of a meander gets connected to the end of a succeeding meanders. Later the stream abandons its meandering cause and the abandoned end begins to fill with rock debris. Therefore a detached body of water having a crescent shape is created alongside the river. This known as an Oxbow lake. (fig 4.4)

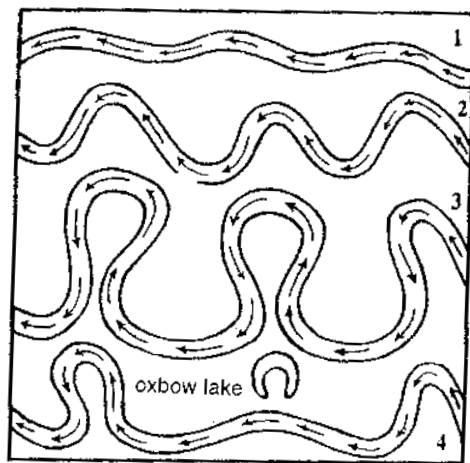


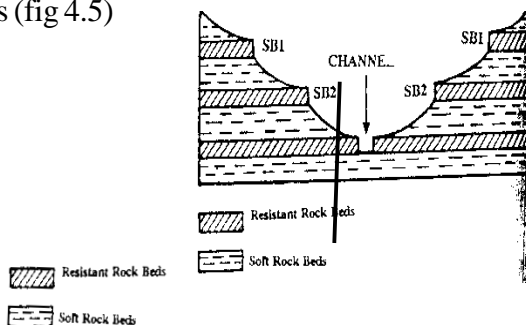
Fig. 4.4

Stages of the formation and development of meanders.

1-2. wavy meander, 3. horse shoe mender and 4. ox-bow or brace type of meander

(vi) Structural Benches :-

Such type of erosional landforms are formed as a result of differential erosion. It derives its name due to its step-like formation along both banks of the river. The hard rock layers remain resistant and project out while the soft rock are eroded and curve inwards. Therefore structural benches appear as that steps of hard rocks alternating with a concave layer of soft rocks (fig 4.5)



S B Structural Benches

Fig. 4.5 Structural Benches : SB = Structure Benches.

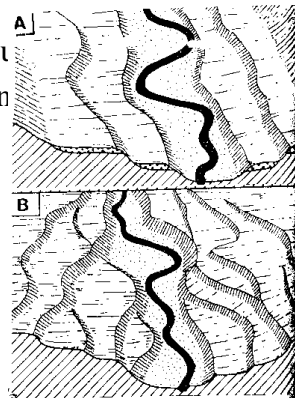
(vii) Pot Holes:- These are ‘tea pot’ shaped erosional features. They are cylindrical

depressions formed in the river beds as a result of the erosion soft and sandy type of rocks. The diameter of pot holes is directly proportional to their age as erosion continues to widen and deepen them. They are a common feature at the base of waterfalls.

(viii) River Terraces:- As their name indicates, river terraces are step-like structures formed on either side of valley floor. The number of terraces formed along a river valley can vary with valley depth. Their structure, form and location can differ on the basis of their mode of formation and the type and intensity of erosion. They are of two main types - (fig 4.6)

(a) Paired Terraces :- Here the valley floor is characterised by corresponding pairs of terraces on either slope of the river valley.

(b) Unpaired Terraces :- Such are characterized by isolated terrace formation on an adjacent terrace.



EROSIONAL WORK OF WIND**Structure-**

- 1.0 Objectives
- 1.1 Wind
- 1.2 Wind Erosion
- 1.3 Wind Erosional Landforms

1.0 Objective :

- * To identify the work of winds.
- * To understand the process of wind erosion
- * To give an account of wind created topography on the basis of erosion

WIND :-

Air in motion is defined as wind. It is also an important agent of erosion. Winds agents erosion are particularly active in dry or a desert areas. This is because there is no dense vegetation and trees to hamper its movement. It is estimated that the speed of wind should at least be 5 metres per second so that it is able to lift small particles. Light and fine particles especially sand and lifted with ease by the wind and consequently are also carried to great distances. In order to lift heavier particles like rocks and stones the velocity of wind needs to be much higher. The activity of wind can best be observed in the 'Dust Bowl' area of USA. Such a large amount of dust is blown here by the wind that visibility

becomes impossible. Therefore it can be concluded that the winds possess great capability of lifting sand and dust particles and cause a great deal of erosion especially in arid areas.

1.2 WIND EROSION -

In dry areas especially the wind acts as a very active agent of erosion. It causes erosion in three different ways :-

(i) Deflation:- Loose particles lying over the rock layers are blown away by the winds. This is called deflation action. Deflation becomes more prominent and uninterrupted when there is little or no vegetal cover to hamper the flow of the wind.

(ii) Abrasion:- The different types of particles lifted up by the wind themselves becomes agents of erosion by rubbing, scraping and striking against rocks and eroding them. This action is called abrasion. It is comparable to the work of a sand paper rubbing against a surface.

(iii) Attrition:- While in the air the particles strike against each other as well and further modify their shape.

1.3 WIND EROSIONAL LANDFORMS OR ARID TOPOGRAPHY

Some of the important types of landforms created by wind erosion are as :-

(i) Deflation Basin :- Deflation action of winds lifts up particles from a particular areas and carries them forward. As such depressions are formed in those areas which loose the particles. These depressions are called deflation basins. Their diameter usually ranges between 1-2 kms and depth between 2-3 mts.

(ii) Deflation Armour :- Lighten particles are lifted and carried away easily by the wind while the heavier particles like stones and rocks are left behind. With the passage of time the number of heavier particles goes on increasing. There comes a time when they form a wall like structure. This is known as a deflation armour and is a common sight alongside a deflation basin or sometimes even inside one (fig 5.1)

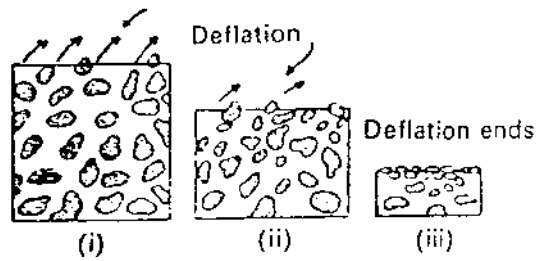


Fig.5.1 Deflation activity and the development of deflation armour

(iii) Blow Outs :- Sand dunes are the most common feature of desert topography. Deflation action of wind is particularly active on sand dunes. However wherever a small piece of vegetation like cactus is located on the dune it blocks the wind's action to lift the sand particles. Therefore winds lift the sands from exposed areas while other areas (where vegetation exists) remain undisturbed. Small depressions are caused in those areas where the sand is eroded and they are known as blow outs.

(iv) Inselbergs:- Inselbergs is a word of German origin and literally means an 'island mountain'. The Inselbergs are identified as a mountain top rising suddenly from the plains and plateaus. Their height ranges between a few metres to several hundred metres and are predominantly composed of gneiss. Due to wind erosion continuing to take place the sides of an inselberg become very steep. (fig 5.2)

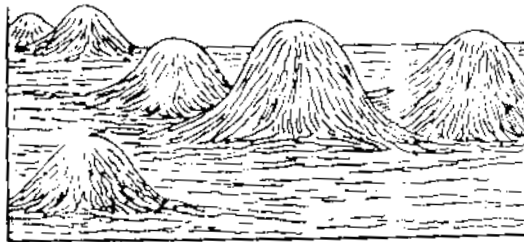


Fig. 5.2 Inselbergs (bornhardts)

(v) Zeugen :- Differential wind erosion takes place in those areas where layers of hard and soft rocks are found alternately. The lower portion of soft rocks are eroded while the hard rocks remain resistant. These hard rocks appear as table like formation on the lower layers. These are known as Zeugens and if their basis are eroded, the Zeugens fall down and disintegrate. (fig 5.3)

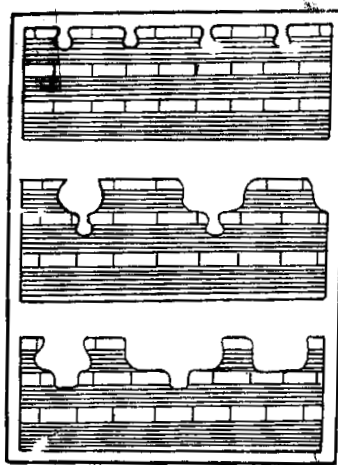


Fig.5.3. Stages of the formation of Zeguens

(vi) **Yardangs** :- Wind erosion in areas of hard and soft rocks gives rise to the formation of a strange type of landform. The rocks which remain unaffected by erosion appear as rib like structures with steep slopes. These are known as Yardangs. They are usually formed in series and can be as high as 7-10 metres. (fig 5.4)



Fig.5.4 Yardangs

(vii) **Mushroom Rocks** :- Due to action of wind the lighter particles blow above the ground while the heavier particles roll down. If the lower portions possess soft rocks on sands they get eroded and the lower and becomes very narrow. The upper area appears to be a dome like structure supported on a narrow base. This unique feature is called a mushroom rock. (fig 5.5)

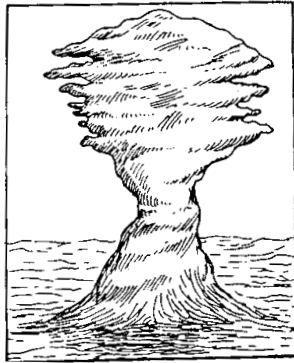


Fig.5.5. Example of mushroom rock or gara

(viii) Hammada: The exposed lower layers of rocks after extensive wind srosion are called hammadas. They have a level surface and then height differs from area to area.

(ix) Wadi :- Occasional showers in arid areas make valleys which are as much as 40 metres deep and about a 100 metres broad. Such valleys are called Wadis and are a common feature of the Sahara desert.

(x) Demoiselle :- The upper parts of rocks are constantly subjected to abrasion action. However the lower parts remain unaffected. The wind also affects one end of the rock layers giving it an irregular appearance. Such pillar like structures with one end eroded and the other seemingly smooth are called demoiselles. (fig 5.6)

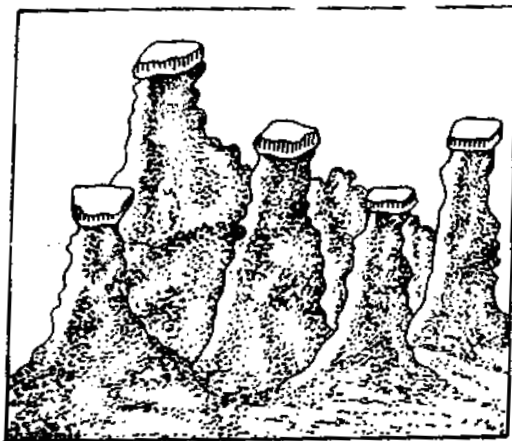


Fig 5.6 Demoiselles

EROSIONAL WORK OF ICE***Structure***

- 1.0 Objectives
- 1.1 Glaciers
- 1.2 Glacial Erosion
- 1.3 Glacial Erosional Landforms

1.0 Objectives

- * To define glaciers and their movement.
- * To outline the erosional activities of glaciers.
- * To provide an account of the various glacial erosional landform features.

1.1 Glaciers :-

By common definition glaciers are described as moving rivers of ice. However a glacier does not consist of ice alone as it has several peculiarities in its structure. The upper surface of a glacier is comparatively very hard and brittle. When a glacier descends down a slope its surface suffers many cracks which are known as crevasses. Crevasses can be as deep as 50-60 mts. Although the movement of a glacier is slow it still acts as an effective agent of erosion. The movement of a glacier can be classified under two categories-

- (i) **Gravity Flow :-** Earth's gravitational pull forces the ice particles to flow from higher to lower levels.
- (ii) **Extrusion Flow :-** Gravitational force is neutralized in areas with level or gentle slope. As ice continues to accumulate the extract pressure on the terminal layers and this pushes the glacier forward.

1.2 Glacial Erosion :-

Glacier performs the activity of erosion by the following ways:

(i) **Abrasion :-** Rocks, stones and pebbles are present at the base of the glacier. As the glacier moves it rubs against these rock pieces and then ends are rounded off. The rock pieces are also modified by mutually striking against each other.

(ii) **Plucking :-** The glacier by its sheer volume has the capability to pick large rocks and move them forward. In this process rocks are broken down into smaller pieces. A glacier can also affect a mountain side or a large boulder in a similar way.

(iii) **Frost Wedging :-** Water generally enters into the cracks of rocks. Due to proximity of a glacier this water freezes and exerts pressure on the sides of the rock ultimately splitting it. This process also takes place on the glaciers when water enters the crevasses.

1.3 GLACIAL EROSIONAL LANDFORMS-

Some of the important landforms produced by glacial action are:

- (i) **Cirque :-** It is an extended form of a crevasse which is formed on the slope of the glacier. Areas having cirques are sometimes referred to as areas of 'armchair topography' because a cirque resembles an armchair. Its slope is steep, sometimes almost vertical while the base is gentle and level. It is called by different names in different regions like 'Corrie' in Scotland and 'Cwom' in Wales. (fig 6.1)

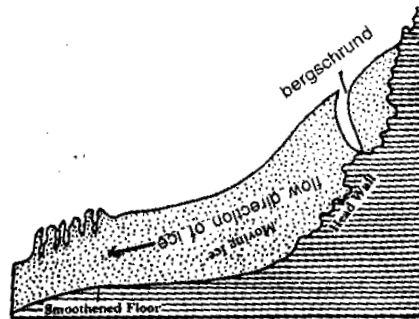


Fig.6.1 Cirque and ... ts

- (ii) **Arete :-** When two cirques are formed on the same slope, they tend to cut towards each other due to continuous erosion. There comes a time when the two cirques meet each other and as a result the mountain peak is destroyed. The peak appears irregular with sharp edges. This kind of structure is known as arete.
- (iii) **Horn :-** When three cirque are created on the same slope a triangular or pyramid shaped structure is formed on the summit. The peak resembles a pyramid with a narrow base. This kind of peak is called horn. Due to continued erosion the horn falls off and an arete is created (fig 6.2)

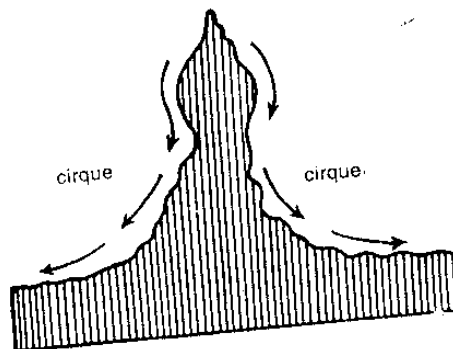


Fig.6.2 An exam

- (iv) **Hanging Valley :-** Most glaciers are accentuated with the aid of tributary glaciers. The valleys of tributary glaciers are at a higher level than those of the main glacier. The ice of the tributary glacier descends to the main glacier

and its valley appears to be hanging over the main glacier. This is known as a hanging valley and it is responsible for many waterfalls or ice falls. (fig 6.3)

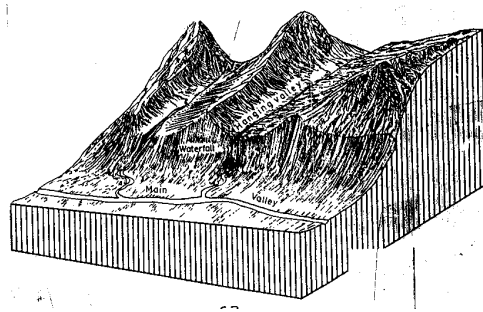


Fig.6.3 Hanging valley

(v) **Fjords :-** Fjords are a common feature in the northern arctic regions. They are actually U-shaped valley which are formed due to glacial erosion. The characteristic feature of a fiord is that its base is usually submerged inside the water.

(vi) **Roche Moutonnes :-** Hard and resistant rock layers act as obstacles in the path of travelling glaciers. Glaciers simply move over the rock layers and descend over the other side. The slope over which the glacier ascends is smothered out while the part where it descends is broken down and irregular. Such rock mounds which have a smooth and gentle slope on one end and an irregular slope on

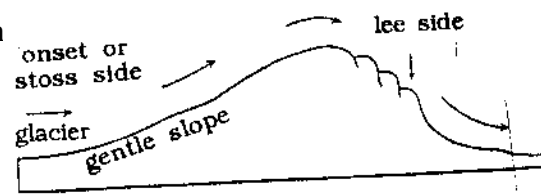


Fig.6.4 Roches moutonnes

(vii) **Crag and Tail :-** Areas of soft rocks are quickly eroded by glaciers. The glacier continues to move forward. The material on the descending side is protected by ice. It appears as if the layer of the rocks over which the

glacier has moved has a long tail attached to it. This kind of feature is called crag and tail. (fig 6.5)

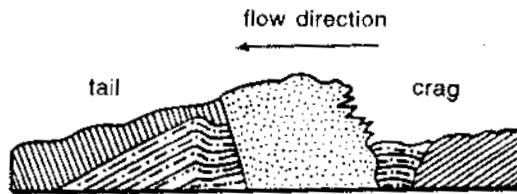
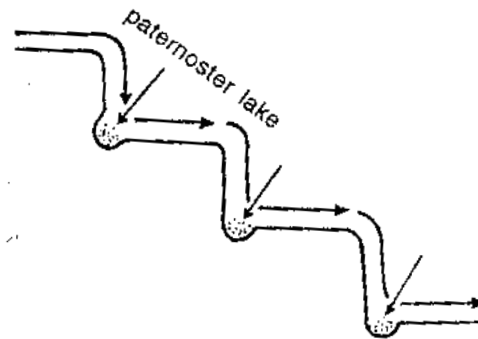


Fig.6.5 Crag and tail

- (viii) **Pass :-** When the cirques from opposite sides of a hill develop and meet each other the mountain top or peak is lowered. This creates a pathway for commutation. This pathway is called a 'Pass' or 'Col'. These are a common feature of the Alps mountain region.
- (ix) **Paternoster Lakes :-** Layers or steps of the glacier form lakes of varying sizes on the glacial body. This topography appears as a stepwise formation of small lakes. These are known as paternoster lakes. (fig 6.6)



**“Erosional Work of Underground
Water and Sea Waves”**

STRUCTURE

- 1.0 Objectives
- 1.1 Underground Water
- 1.2 Work of Underground water
- 1.3 Erosional Work of underground water
- 1.4 Erosional Landforms by underground water
- 1.5 Sea Waves
- 1.6 Sea Wave Erosion
- 1.7 Sea Wave Erosional Landform

1.0 Objectives

- * To understand what underground water is and what its sources are.
- * To understand the various activities of underground water.
- * To know about the erosional process of underground water.
- * To briefly outline the various erosional landforms created by underground water erosion.

- * To understand sea waves and their causes.
- * To highlight the erosional activities of sea waves.
- * To briefly enlist the erosional landforms which are formed by sea wave erosion.

1.1 Underground Water:-

The water found below the surface of the earth is collectively called Underground Water. It is generally found in the cracks and openings of the underlying rocks or in the fissures below the surface. The underground water accumulates as a result of various sources.

- (i) **Rain Water :-** The rain water is perhaps the most abundant source of underground water. It is also referred to as meteoric water. There are certain elemental similarities between rain water and underground water which proves it to be the main source.
- (ii) **Connate Water :-** The water which is a part of the sediments being carried by a river is later released as underground water. It is known as connate water.
- (iii) **Magmatic Water :-** Vapours and steam accompany the magma. These are later condensed into water and is regarded as a source of underground water.

1.2 Work of Underground Water

The flow of underground water is several times slower than the flow of river water. Its flow depends upon two factors.

- (i) Porosity of rocks.
- (ii) Permeability of rocks.

The flow is in fact directly proportional to the two factors. The more the porosity

and permeability the more is the flow and vice versa. Since the flow of the water is very meagre the erosional work accomplished by this agent is very less. Infact underground water is more likely to modify topography by the process of solution. Solution process refers to the dissolving of various types of rocks over a long period of time. The underground water slowly dissolves the underground rocks at a differential rate. Limestone rocks have a weak structure and are more readily dissolved than other types of rocks. Underground water has a majority of rain water which acquires carbonic acid on its way to the earth's surface Rain water having a higher concentration of carbonic acid dissolves rocks more readily. The water also dissolves many minerals of the rocks and produces many chemical salts like chlorides, sulphates and bicarbonates of calcium, magnesium, sodium, potassium etc.

1.3 Erosional Work of Underground Water

The erosional work of underground water is carried out by following methods:-

- (i) **Chemical Action :-** Slow moving underground water dissolves mineral compounds in the presence of carbonic acid laden rain water.
- (ii) **Solution Action :-** Many chlorides, nitrates, oxides etc. are also dissolved by the underground water.
- (iii) **Hydraulic Action :-** Rocks also break down due to the constant pressure of the water.
- (iv) **Abrasion Action :-** Very little effect of abrasion is felt on the rocks because the flow is negligible.
- (v) **Attrition Action :-** Smaller particles of rocks strike against each other and modify their shape.

1.4 Erosional Landforms-

- i) **Irregular or Uneven surface :-** Layers of limestone rocks are permeable and water enters very deep. The limestone content is dissolved by solution. The upper layers due to loss of support collapse and lead to the

formation of an uneven or irregular surface.

- (ii) **Lapies :-** Constant solution action leads to the formation of parallel grooves with smooth walls. These are known as lapies and have walls which are 5-7 metres high with sharp surface. (fig 7.1)

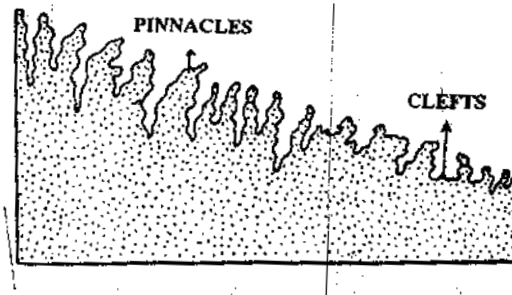


Fig.7.1. Lapies

- (iii) **Caverns :-** Due to solution of limestone content large hollowed out features are formed. Their shape is very much like the caves found on the earth's surface. They are either small or quite large extending to a length of about 1500-2000 metres and height to nearly 100 metres.
- (iv) **Natural Bridge :-** When a cavern collapses a part of it remains intact and gives the appearance of a bridge. It is known as a natural bridge. (fig 7.2)

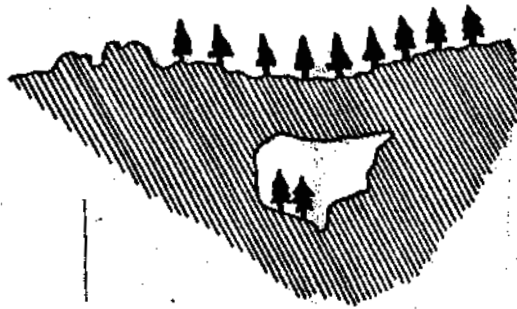


Fig.7.2. Natural Bridge.

- (v) **Sink Holes :-** They are cylindrical or funnel shaped holes which are a common feature of limestone areas. Their walls are nearly vertical and

their diameter may vary from a few metres to thousands of metres. (fig 7.3)

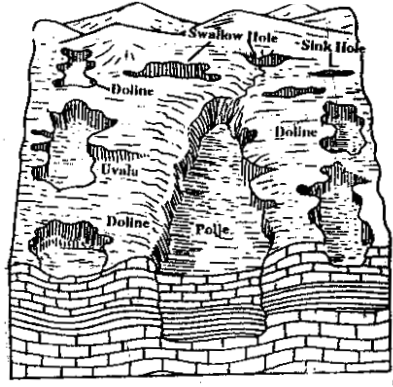


Fig.7.3. Sink holes, swallow holes, dolines, uvalas and poljes

- (vi) **Karst Window :-** Sometimes the sink holes collapse and form a broad and open area called a Karst Window.
- (vii) **Uvala :-** Sink holes formed close to each other extend towards each other and form bigger holes known as Uvalas. (as shown in fig 7.3)

1.5 Sea Waves

The main characteristic of sea water is that it is rarely placid like oceans. There continues to be some type of movements in the form of waves. The waves can be as light as a small ripple or as magnanimous as a tsunami. There are many causes of sea waves or even movements or turbulence of sea water. Some of the important causes are :-

- (i) **Winds :-** Winds of varying intensity are the most common cause of sea water movement.
- (ii) **Storms :-** Sea storms of great force and intensity are generally responsible for raising the level of sea water particularly near the coast. This may lead to the encroachment of the water on the coast.
- (iii) **Evaporation :-** Continuous evaporation leads to reduction in the volume of sea water and increase in its density and salinity. This is a further cause of movement.

- (iv) **Rivers :-** Many rivers dump their low density fresh water over the sea water. This water floats over the saline water of the sea and leads changes in the content of the sea water.
- (v) **Earthquakes :-** Earthquakes particularly those localized near the coast lead to disturbances in the sea water in the vicinity of the shore. This further leads to the devastating occurrence of tsunamis or tidal waves which may extend several kilometres inland and cause immense loss of life and property.

1.6 Sea Waves Erosion-

The waves of varying intensity strike against the coast and cause erosion. Generally this erosion is accomplished by following processes:-

- (i) **Hydraulic Pressure :-** The pressure that sea waves exert on the coast can be as much as 4-5 tonnes per square metre. It may even increase during storms. Coastal rocks are greatly affected by such monumental pressure.
- (ii) **Corrasion :-** The sea waves carry rocks and stones from one place and transport them elsewhere. At times such rocks are thrown against the coast with a lot of force causing erosion.

1.7 Sea Wave Erosional Landforms-

The process of sea wave erosion results in the formation of many types of landforms.

- (i) **Cliff :-** When the waves particularly those carrying debris strike against the coast they erode its lower part while the upper part remains undisturbed. This leads to the lower part assuming a concave shape. Excessive erosion can sometimes destroy the overhanging part of the cliff so that it falls off. The almost vertical or concave rise of land with broad or overhanging top is called a cliff or sea cliff. (fig.7.4)

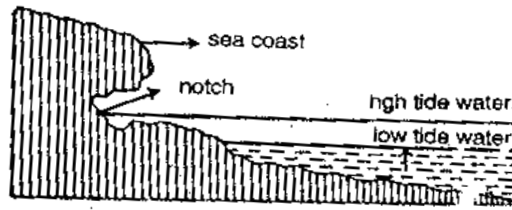


Fig 7.4 An example of sea cliff

- (ii) **Wave Cut Platform :-** As the cliff backs off or its top is destroyed the sea waves continue to modify the coast. This sometimes results in the formation of a flat platform like structure. This is known as a wave-cut platform (fig 7.5)

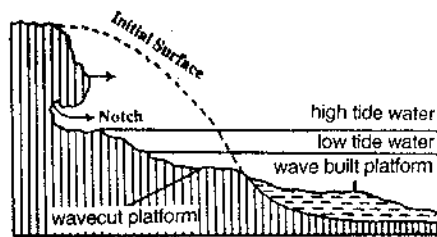


Fig.7.5. Wave cut and wave-built platforms.

- (iii) **Sea Caves :-** Continued erosion cuts through and hollows out a part of the coast in the shape of a tunnel. These formations are called sea caves and are a common feature along the world's sea coasts (fig 7.6)

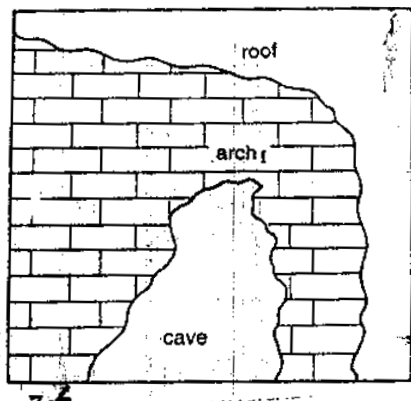


Fig.7.6. An example of sea arch.

- (iv) **Marine Arches :-** If a portion of the coast extends into the sea, erosion leads to the formation of sea caves on both its ends. When the two sea caves meet each other on extended opening or doorway is formed. This is known as a marine arch which is topped by a natural bridge. (fig 7.7)

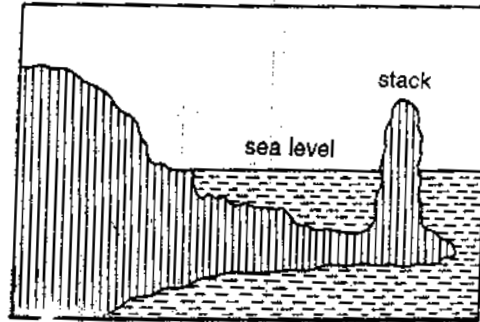


Fig.7.7. Formation of stack

- (v) **Stacks :-** When erosion leads to the collapse of marine arches, its remains stands as vertical columns. Such pillar like structure of rocks and debris are called stacks.
- (vi) **Blow Hole :-** A blow hole is small depression on opening formed at the roof of a sea cave.
- (vii) **Coves :-** The coasts consists of both hard and soft rocks. The soft rocks are soon eroded while hard rocks remain resistant. Narrow gulfs are formed between layers of hard rocks and are called coves or inlets. (fig 7.8)

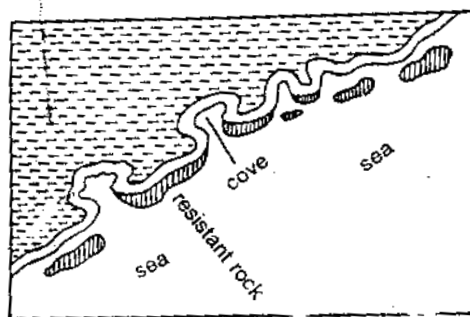


Fig.7.8. Formation of coves and island

(viii) **Hanging Valley :-** If the rate of retreat of cliffs is faster than the rate of erosion of the rivers flowing down the coast, the rivers appear to be hanging over the sea and the valleys they form are called hanging valleys.

EARTH MOVEMENTS AND EARTHQUAKES

Structure

- 1.0 Objectives
- 1.1 Earth Movements
- 1.2 Endogenetic Forces
- 1.3 Diastrophic Forces
- 1.4 Sudden Forces
- 1.5 Exogenetic Forces
- 1.6 Earthquakes.

1.0 Objectives :-

- * To understand the concept of earth movements and their types.
- * To describe endogenetic forces.
- * To describe diastrophic forces and their various sub-types.
- * To briefly outline the concept of sudden forces and their types.
- * To outline the types of exogenetic forces.
- * To explain the concept of earthquakes and briefly discuss their causes,

intensity and effects.

1.1 Earth Movements :-

Earth movements refer to all those forces which operate from within and without the earth's crust and are responsible for constantly changing and modifying the earth's crust and all types of relief features that are located both on the earth's surface as well as its interior. Such movements or forces may be so gradual that they are barely noticeable and their effect may be felt over thousands of years. However there are also certain forces which make their impact felt within seconds. Earth movements therefore include a very wide variety of such movements or forces which are constantly shaping or reshaping the earth and its relief. Based upon their operation and origin earth movements are classified into two types of major forces as :

- (1) Endogenetic Forces
- (2) Exogenetic Forces (fig 8.1)

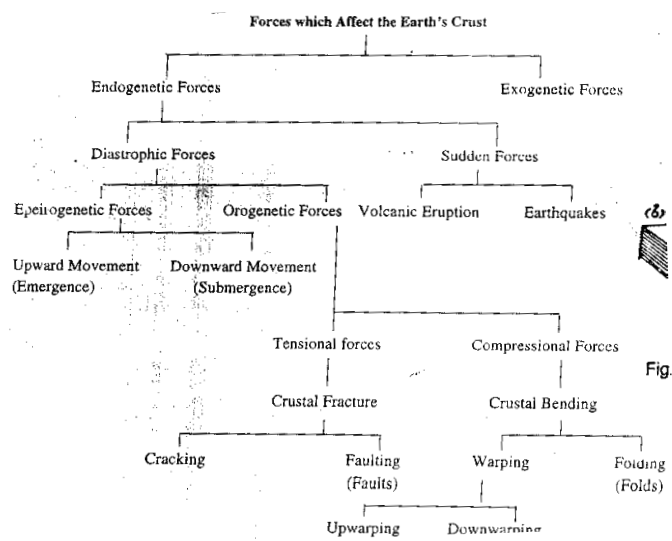


Fig 8.1 Schematic presentation of forces (endogenetic) affecting the earth's crust

1.2 Endogenetic Forces :-

These forces originate from the earth's interior and include a wide variety of other forces. Endogenetic forces generally cause both vertical as well horizontal movements in the earth. Irregularities of the earth's relief are also attributed to these forces. Such forces are usually differentiated on the basis of their intensity. They include both long period as well as short period changes the endogenetic forces are classified into two main categories based upon their intensity.

(1) Diastrophic Forces (2) Sudden Forces

1.3 Diastrophic Forces :-

These are also sometimes called the long period changes as they move very slowly and their effect is becomes visible after passage many thousand years. In opposition to the sudden forces which are usually the cause of destruction, the diastrophic forces are called forces of construction. They are responsible for providing character to the earth's relief by assisting in mountain building processes. Their impact is felt on all major relief features on the earth. The diastrophic forces are further divided into two types of forces.

(1) Epeirogenetic Forces :- These forces consist of upward and downward movement which leads to the upliftment and subsidence of continental land masses respectively. Upliftment can be of the whole continent or a part of it. Upliftment can also be in the form of emergence of coastal land. The downward movement or subsidence means the subsiding of land area or coastal area below sea level which is termed as submergence.

(2) Orogenetic Forces :- Such forces are a result of the horizontal movement of endogenetic movements. They are of further two types.

(i) Tensional forces :- When orogenetic forces work in opposite directions they are called divergent or tensional forces. Tensional forces are responsible for the following activities.

(a) Rupture (b) Cracking (c) Faulting (d) Fracture

Therefore such forces create openings and cracks in crustal parts of the earth.

(ii) Compressional forces :- When orogenic forces act in the same direction they are called convergent or compressional forces. They are responsible for the following activities :-

(a) Crystal Bending

(b) Crustal Warping - Both anticlines and Synclines.

(c) Folding - Both anticlines and Synclines.

1.4 Sudden Forces :-

These are short period changes that make their effect felt within a few minutes or even seconds. They are very sudden and are generally associated with destruction and as such are also called destructive forces. The two main events associated with sudden forces or movements are :-

(i) Volcanic Eruptions; and (ii) Earthquakes.

Both the above movements originate in the interior but their effect is felt on the surface as well.

1.5 Exogenetic Forces :-

The exogenetic forces originate and operate on the surface of the earth. They are sometimes also called denudational forces which through their effect break down and modify those relief features created by endogenetic forces particularly diastrophic forces. They include three main activities :

(i) Weathering-

(a) Physical b) Chemical c) Biological

(ii) Erosion (iii) Deposition.

The weathering and erosional activities are denudational in nature while the activity of deposition is a constructional process.

1.6 Earthquakes-

Earthquakes are a phenomena which is part of sudden Endogenetic forces. It is defined as -

“Earthquakes are tremors which are produced by the passage of vibratory waves through the rocks of the Earth”.

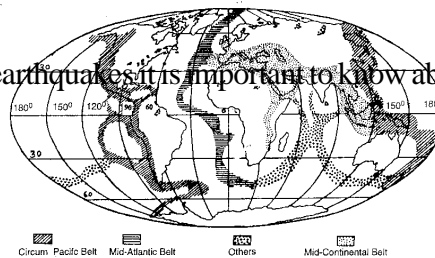
They are associated with death and destruction because they have a great capacity of changing the entire area where they strike (fig 8.2)

Fig 8.2 World distribution of earthquakes

In India Assam and Gujarat have been witness to the most devastating earthquakes ever witnessed in the country. Movement along the San Andreas fault is the cause of frequent earthquakes.

While studying the phenomenon of earthquakes it is important to know about the following things :-

- (1) Causes of Earthquakes
- (2) Intensity of Earthquakes
- (3) Consequences of Earthquakes.



(1) Causes of Earthquakes

- i) **Volcanic Activity :** It is commonly observed that volcanic eruptions are followed by earthquakes. The emission of lava takes place under tremen-

dous pressure. Once emitted, the pressure is released on the underlying layers which leads to disturbance in the earth's crust and ultimately earthquakes.

- ii) **Local Causes :** Volcanic activity is also considered a local cause of earthquakes. Other local causes include landslides, water vapour emission from rocks and collapse of karst topography.
- iii) **Faulting :** Perhaps the most important and common cause of earthquakes is faulting and movement along existing faults. San Andreas fault line is a prime example of earthquakes being caused due to movement along fault line. (Fig. 8.3)

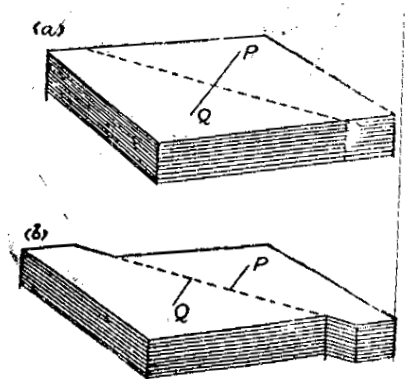


Fig 8.3 Movement of San Andreas drift.

(2) Intensity of Earthquakes:

The intensity of the earthquakes is defined as the impact which they have on life and property. Therefore a scale is devised on that basis which can measure the intensity of the earthquakes. Mercalli was the first to come with a qualitative scale which had 12 classes depending upon the destruction caused by the earthquake. However this scale has since been rejected as it does not offer a scientific viewpoint and the intensity can be known only after assessing the loss to life and property.

For some time the intensity of earthquakes have been measured by the Richter

scale named after the scientist Richeter who devised it. It measures the intensity with the help of a machine called seismograph which present out a graph of the ECG machine. Unlike Merrali has not restricted the upper limit but till date . Earthquake have not crossed the intensity of 9. The is oseimal line is the imaginary line which gains the plants of an area having equal earthquake intensity. The point of origin of an earthquake is called focus. The point on the earth's surface vertically above the focus is called epicentre. The earthquake and spreads is all directions. The extent to which the earthquake is felt depends upon its intensity.

(3) Consequence of Earthquakes:

Contrary to common belief earthquakes do not cause only destruction they have certain advantage as well the disadvantages and advantages of earthquakes may be given as

(i) Disadvantages

- (a) The earthquakes travel in waves around the epiecentre and creates cracks and fissures in the land surface.
- (b) Buildings, houses etc are destroyed.
- (c) The communication liens are completely broken down including roads and railways.
- (d) Floods result due to river water encroaching upon land
- (e) Electric fires break out.
- (f) Landslides occur and cover houses, agricultural fields
- (g) Water recedes from the ports but returns in the form tsunami waves

(ii) Advantages:

- (a) Water is flushed out of lakes and other small water bodies and the exposed area proves to be fertile agricultural land

- (b) Subsidence of sea floor gives rise to the formation of sea ports
- (c) High altitude areas are lowered and in the long run helps in communication, connectivity and transportation.
- (d) Mineral deposits are uncovered.
- (f) New streams, springs and waterfalls are created
- (g) New layers of soil are formed due to destruction of rock layers

VOLCANOES

Structure :

- 1.0 Objectives
- 1.1 Volcanoes
- 1.2 Structure of Volcano
- 1.3 Volcanic Materials
- 1.4 Classification based on activity
- 1.5 Causes of Vulcanism

1.0 Objectives :

- * To introduce the concept of volcanoes and quote their examples and effects.
- * To understand the basic structure of a volcano.
- * To classify the different types of materials which are present in the volcanic explosions.
- * To briefly outline their main types based on the frequency of activity.
- * To list out some important causes of volcanic explosions.

1.1 Volcanoes :-

Volcanoes and volcanic explosions are considered almost as deadly a phenomena as earthquakes. Mountains with active volcanoes eject molten material from an opening in their top. This molten material is called magma or lava and includes a mixture of chemicals, rocks and gases emitting from the mountain at an extremely high temperature. Volcanoes are a part of the sudden endogenitic forces which originate within the earth's interior. There are many active volcanoes in the world which explode with a varying frequency. Mount Etna, Vesuvius and Stromboli are three active volcanic peaks all situated in Italy. The word volcano is derived from the name of the Roman god Vulcan. The process which includes all the phenomena associated with the movement of molten material from the interior of the earth to its surface, is called Vulcanism.

1.2 Structure of a Volcano :-

A volcano is defined as a group of closely spaced vents through which molten material is ejected from deep within the earth's interior. The structure of a volcano reveals the following parts : (Fig 9.1)

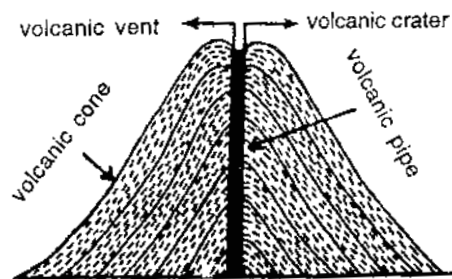


Fig.9.1 Different components of a volcano.

- i) **Vent :** It is an irregular shaped opening in the crustal rock layer of the earth through which hot molten material is ejected.
- ii) **Pipe :** The material from the vent travels through a cylindrical pipe like structure towards the top.
- iii) **Cone :** Continuous emission of magma leads to the formation of a series of cones over the vent. These cones increase the size of the volcanic peak.

- iv) **Crater** : The opening on mouth at the top of the volcanic peak from which magma is released on the earth's surface is called crater.

1.3. Volcanic Material :

Different types of materials come out of the volcano. A classification of that material is as follows :

- i) **Solid Materials** : Large and small rocks are part of the solid materials. The diameter of such particles ranges between 5-50 mm. Large pieces are called volcanic blocks while the tiny ones are ash particles.
- ii) **Liquid Materials** : The liquid material is collectively called magma. It is nothing but liquid rocks and chemicals at a very high temperature. Its major composing element is silica.
- iii) **Gaseous Materials** : Hot gaseous materials are an integral part of the volcanic materials. Steam and water vapour are in abundance. Carbon dioxide is also present as are sulphur, chlorine, fluorine and boron in gaseous form.

1.4 Classification Based on Activity : There are three known categories of volcanoes based on the frequency of their eruptions.

- i) **Active Volcanoes** : Those volcanoes which erupt with regularity are active. The frequency of their activity can range between a few minutes to a few years. Mount Stromboli in Sicily is called the lighthouse of the world because it explodes in varying degrees every 15 minutes on average.
- ii) **Dormant Volcanoes** : Those volcanoes which have stopped exploding for a great period of time are called sleeping or dormant volcanoes. However they can be expected to become active at any time in the future. Mount Vesuvius in Italy is an example of dormant volcanoes. It is difficult to predict with certainty the explosion of dormant volcanoes.
- iii) **Extinct Volcanoes** : Those volcanoes which were active a long time into

the past but are dead are called extinct volcanoes. There is very little change of such volcanic peaks exploding. However it is difficult to distinguish between dormant and extinct volcanoes.

1.5 Causes of Volcanoes :-

There are some important causes of volcanic explosions.

- i) **Water :** Water from the surface seeps underground through fissures. The lava present in the interior comes into contact with this water and the water dissolves in the Lava. Due to crystallisation of lava this water which is at an extremely high temperature and pressure is freed in the form of steam. This steam rises up and exerts pressure on the surface. If it has enough pressure it creates an opening and reaches the surface followed by magma.
- ii) **Folds :** The magma lies in layers and the pressure of layers keeps the magma in unmelted state. Due to orogenic action sedimentary rocks rise in folds and pressure on the lava is released. This causes it to melt and rise towards the surface. Due to release of immense pressure the lava explodes out of the volcano and onto the surface.
- iii) **Radio Activity :** Scientific studies have proved that magma contains certain radio active particles. There is a belief that the heat generated by these radio active elements melts and heats the magmatic materials and ultimately forces it out of the surface.

SOIL FORMATION, COMPOSITION, STRUCTURE AND TYPES

Soil is a natural resource of inestimable value to man, as all our food comes directly or indirectly from it. It represents the uppermost layer of the earth's crust provides organic as well as mineral matter for the growth of plants. The organic matter or humus is derived from the decomposition of plants and animals, whereas the inorganic or mineral matter results from the sub-aerial denudation of rocks.

The soil-formation process is, however, a very slow one and it may take for instance, one thousand years to form a layer of soil, 2.5 centimeters thick. This period of time varies from place to place, depending upon the nature of the parent rock, climate and vegetation.

The soil is not just a lifeless, residual layer, which has accumulated over a long period of time, and which merely holds a supply of things necessary for plant growth, but a dynamic layer in which many complex chemical, physical and biological activities are going on constantly. Far from being a static lifeless zone, it is a changing and developing body. Soils become adjusted to conditions of climate, landform, and vegetation and change internally which those controlling conditions change.

Soil Profile or**Various layers of the soil**

Soil is initially the product of weathering of rocks when it consists of the fresh weathered material lacking in organic matter. The soil profile consists of weathered material derived from the rocks.

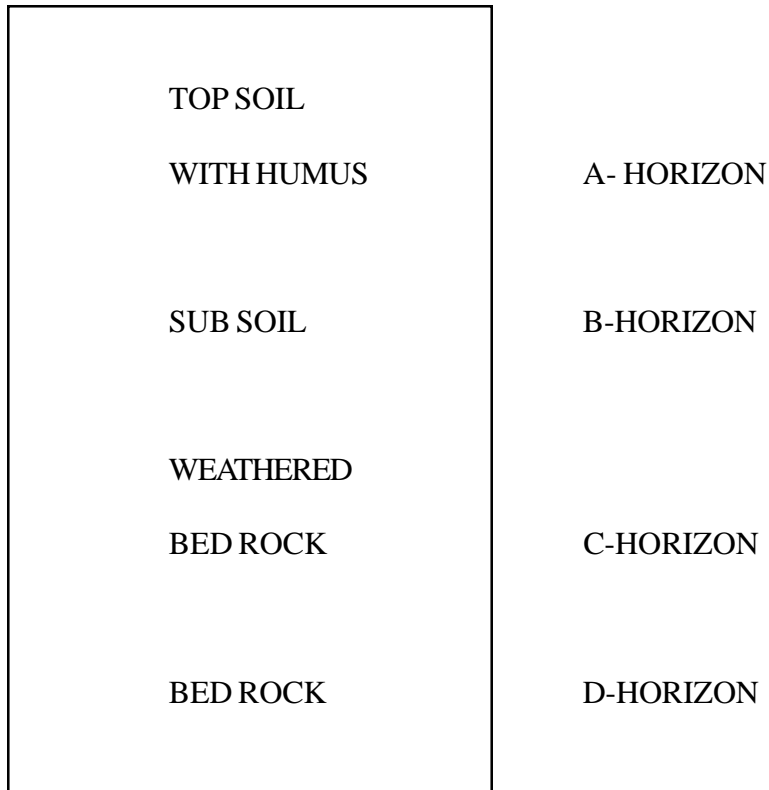


Fig. Soil Horizons

Three well marked layers of soil are found above the bed rocks. These horizontal layers are called soil horizons. The order of these layers over the bed rock is called soil profile. These three layers are as under :

- i) **A Horizon :** This is the upper most layer of the soil profile. It consists of organic matter having fine material rich in humns. Bacterias and earthworms live in the lower art of this horizon. This is also called the zone of alluvation because the mineral solution is carried downwards by leaching of soil.
- ii) **B Horizon :** This is called sub soil. It is zone of accumulation where the leached material from horizon A is retained. It is also known as the zone of alluvation. This layer is compact and contains sand, silt and clay.
- iii) **C Horizon :** This layer contains weathered rock material. C Horizon is often known as mantle. Below this underlies the bed rock known as D Horizon.

Formation of Soil :

The physical and chemical processes of weathering cooperate closely with biological processes to produce soil which is the surface layer of the mantle of rock-waste. Of all processes none are so important as those which help to produce soil, since all forms of plants and animals depend directly or indirectly on soil for their existence. Since these processes are influenced by climate. The resulting soils also vary with the climate. The nature of the soil depends particularly on the kind of bedrock from which the soil was formed.

Factors in Soil Formation :

There are five factors that influence the rate and kind of soil development :

1. Nature of the parent material
2. Topography
3. Climate
4. Biologic activity and
5. Time

All these factors interact to produce great variation in the rate of development as well as the kind of soil that is produced.

Parent Material :

The nature of parent material determines the kind of regolith produced. Rocks-granite, sandstone, and limestone, for example-consisting of different mineral components will produce radically different kinds of regolith. Granite is slow to weather, but the transition from granite to soil produces an increase in bulk of almost 88 percent simply by the take up of water, through a process called hydration, and the production of clays and silica. Some sandstone contains abundant, unaltered particles of the mineral called mica, which may weather by hydration and cause the rock to break down into its constituent grains.

THE CLIMATE EFFECT :

When soil is first formed, it is closely related to the rock from which it is derived. But other influences that form the character of the soil gradually become dominant. The single most important influence in soil formation is climate, and the most potent climatic element in the soil-forming process is precipitation. Climate influences soil formation through temperature, too. Weathering, erosion, and leaching -all important in the soil-genesis process are directly affected and influenced by the temperature and precipitation patterns in a region

The development of a soil profile is significantly affected through the leaching process, which is particularly sensitive to the precipitation pattern in a region. Soils with calcium arid conditions where precipitation is less than 24 inches (61 cm) a year because the moisture supply is not sufficient to maintain a continuous downward flow.

With approximately 5 inches (13 cm) or less of annual precipitation, soluble salts, including lime, accumulate on the surface. When annual precipitation is in the range of 12 inches (30 cm), lime is leached downward but it accumulates at a depth of 6 to 20 inches (15 to 50 cm).

Climate also influences soil formation indirectly through its action on vegetation. A Soil profile developed under a forest canopy has more well-developed horizons than a profile developed under grass. Prairie grasses - under which we find deep, dark, uniform surface soils -develop in sub- humid to semiarid climates. Semiarid climatic conditions supply only enough moisture to encourage sparse and short plains grasses that do not afford adequate protection against wind and water erosion. The soil that develops under a cover of plains grass tends to be shallow and does not have a well developed profile.

BIOLOGICACTIVITY :

Plant and animal activity and the decomposition of their organic residues and wastes have a direct impact on the development of a soil. Organic matter and its distribution, soil acidity, and the compactness of the soil are characteristics influenced by the life forms in the soil.

Some of the first plants to move in an grow on weathering rock are the lichens, which are made up of an alga (green plant) and a fungus (non green plant) growing in

symbiotic association. The fungus dissolves minerals out of the rock and passes them along with water to the green plant.

Microorganisms help soil development by bringing about the decay of the organic matter added to the soil by plants and animals. During the process of slowly decomposing organic matter, the microorganisms form weak acids that dissolve minerals faster than water. The work of the microorganisms leaves a decomposed residue, called humus, in the soil. The humus is a brown or black complex material that forms an important part of the organic portion of the soil.

Burrowing animals-moles, gophers, earth formation of soils. These burrowing animals have different life styles but perform essentially the same function: they mix, overturn, and aerate the soil. The earthworm, for example, feeds on decaying plant matter but in the process of its tends to mix the soils somewhat.

TOPOGRAPHY :

The contour of the surface, called topography, is also referred to as relief. Topography, or surface relief, influences soil formation primarily through the water and temperature conditions associated with it. On a slope that is quite steep, however, gravity makes a direct impact on soil formation because gravity constantly moves the regolith downhill and fresh bedrock is continuously exposed to weathering. The zone of weathered rock under such conditions is extremely shallow; it is difficult for soil to form on a steep slope with an actively moving regolith.

Soils that do develop on hillsides typically have thinner A- and B- horizons as well as less organic matter than their contiguous counterparts in flatter terrain. The development of the A-and B-horizons is conditioned by the amount of water that moves down through the profile.

TIME :

Soil, like other things in nature, passes through a cycle of development. The soil's cycle includes (1) the weathering of bedrock, and (2) the processes that lead to the development of an orderly soil horizon from the regolith. Climate, vegetation, the character

of the bedrock, and the topography play an important role in how fast a soil develops and evolves.

There are a number of conditions that can retard the development of a soil profile. Among the most prominent of these conditions are (1) low rainfall which slows the weathering process and places a limit on the amount of leaching that can occur; (2) low relative humidity that limits algal, fungal, and lichen growth; (3) poor aeration and slow water movement caused by a high percentage of clay in the profile; (4) very steep slopes (5) temperatures that are cold enough or slow chemical processes; (6) severe wind and water erosion that strips the soil and exposes new material and (7) resistant parent materials, such as granite.

SOIL STRUCTURE:

The way in which the soil separates - sand, silt, and clay –are grouped together into stable collections or aggregates is referred to as soil structure. Aggregates, which are secondary units or granules, consist of many soil particles bound together by substances that serve as cementing agents. Iron oxides, carbonates, clays, and silica are some of the materials that bind particles in soil into aggregates.

The natural aggregates that occur in soil are known as peds. Structural peds form in soil because of alternate swelling and shrinking. Wetting and freezing cause soils to swell; drying and thawing cause soils to shrink. The cracks that define and outline a ped develop along lines of weakness in response to the stresses produced by shrinking.

Based on the shape and arrangement of peds, four types of soil structure can be described : (1) platy structure, (2) prismatic and columnar structure, (3) angular blocky and sub angular blocky structure, and (4) granular and crumb structure.

PLATY STRUCTURE :

Peds, which consist of thin plates arranged in a horizontal position, exhibit a matted, flattened, or compressed appearance. Frost heaving, fluctuating water tables, compaction from above, and the loss of materials through translocation can cause a separation of soil into horizontal layers. This kind of structure can be readily observed where there is a thin layering of alluvium.

PRISMATIC AND COLUMNAR STRUCTURE:

When the swelling-shrinking cycle in the soil takes place primarily in a vertical direction, the peds produced have a long vertical axis. The columns of these peds are bounded by somewhat flattened sides. The horizontal dimensions of the peds are somewhat limited and considerably less than the vertical dimension. When the tops and bottoms of the columns are flattened, the peds are referred to as prismatic. If the tops of these peds are rounded, they are simply referred to as columnar peds.

BLOCKLIKE STRUCTURE :

The peds in this type of structure resemble imperfect cubes. They may have plane or curved surfaces. A block like ped with flattened faces and sharply angular vertices - sharply angular edges where the sides meet -is referred to as an angular blocky structure. If the ped has mixed, rounded and flattened faces with many rounded vertices, it is called a sub angular blocky structure.

SPHEROID STRUCTURE :

The peds in a spheroid structure are small, sand.-sized, imperfect spheres as shown in Figure 13.7. When the peds are relatively nonporous the structure is termed granular; porous peds of this structure are given the name crumb. The mineral particles in these spheroidal peds are cemented by organic substances. The rounded edges and small size of the peds results from mixing by rodents, earthworms, frost action, and cultivation.

Types of Soil :

Soils are classified *on* the basis of three systems. They are :

- i) Empirical based on certain physical properties.
- ii) Morphologic based on the nature of soils profiles.
- iii) Genetic based on the known formation and environmental factors involved.

The above-mentioned three systems have been compared for proper classification

of soils.

Broad classification of soils

I. Zonal 2. Intrazonal 3. Azonal.

The Podzols : The Podzols is the most widely distributed of the zonal soils of the humid climates. They occur in the sub-arctic climatic and northern arcs of humid continental areas. They develop under conditions of cold winter and adequate precipitation spread through out the year . Grey-Brown Podzolic soil occurs in humid climates. The profile of the soil is similar to that of the Podzolic soil, but leaching is less intense and the colour is brownish. Its physical and chemical properties are similar to that of Podzols but less pronounce in their expressions. Agriculture on it is highly productive. They are good for diversified crop farming and dairying. Eastern U .S.A, the North European plains and the North Chinese Plains are the typical areas of its occurrence.

Red Yellow Podzolic Soil occurs to the south of the gray brown Podzolic belt. There is general similarity in its properties with those of the Podzols. But the humus content is low and iron hydroxides give typical red and yellow colour. In warm humid tropical areas this soil contains large quantities of aluminum hydroxide. Pine vegetation is associated with this soil and southeastern U .S.A is the typical area of its occurrence.

Latosol or Lateritic soils are characteristics of humid tropics. Their characteristics include the complete chemical and mechanical decomposition of the parent rock, complete leaching of silica. Reddish brown colour given by the oxides of iron, aluminum and manganese and a complete lack of humus. The soil has few plant nutrients, hence it loses its fertility quickly, when brought under cultivation. The soil is associated with luxuriant rain forest of hard woods and lianas. In the top horizons there is an accumulation of iron and aluminum oxides, which is used in making bricks. The material is called laterites. On weathering laterites becomes extremely hard. Laterites gives bauxite, limonite and magnetite. India, Southeast Asia, the Amazon basin, the Congo basin is the typical areas of occurring.

The Tundra soil is wide spread and coexists with tundra climatic and vegetation type. Hence it is a zonal type but as it is poorly drained, it can be consider to be Intrazonal. Excessive humus is another characteristic. There is no distinctive profile but there are thin

layer of clay and humus. It is an acidic soil.

Arid Semi-arid sub humid zonal order soils include chernozem, chestnut, chestnut brown, gray desert and red desert varieties. They occur in areas in increasing order of temperature and aridity .

Chernozem is associated with a continental, warm, moist early summer, later summer and winter drought and dry snow free climate, and long grass steppe. In the profile horizon A is black, deep and mineral organic, horizon B has clay accumulations and C-horizon is calcareous. Horizon A is rich in humus while horizon B is in colloids and bases. The Chernozem is generally acidic. A typical area of its occurrence is Ukraine but it is also wide spread in central U.S.A, central Africa, South America and Australia. Chernozem is highly productive for small grain crop such as wheat, oats barley and rye.

Chestnut soils occur towards the arid side of chernozem belt in the semi-arid middle latitude steppe land of North America and Asia. Its profile is similar to that of the chernozem but it contains far less humus and has prismatic structure. There is a lot of alkaline matter. High agricultural yields are possible through the application of soil moisture conserving techniques.

Grey desert soil also termed as sierozem soil, occurs in vast east west belt between 30 and 50 degrees north latitudes in the northern hemisphere. It is coexistent with the spread of middle latitude desert climate. The principal characteristics of this soil are little humus, slightly differentiated horizons and the hard resistant deposit of calcium carbonate.

Desert soil has thus minimum humus. Red colour is imparted by small amount of iron compounds. A coarse texture, poorly developed horizons, fragments of parent rock, the deposits of like carbonates are characteristic properties. Desert soils are suitable for cultivation along the flood plains and on the terraces where the texture is fine.

Intrazonal Soils

Bog Soils : These soils developed in humid continental climate and are found both in hot and cold areas. The soil has no use for agriculture. Jute is the only crop that is grown.

Meadow Soil : These soils develop in those parts of middle latitudinal areas where there

is drainage of water from the marshy soils. Meadow soils have an upper thin layer of humus. This allows grass to grow. Fodder for the animal is the main crop.

Saline Soils : These soils are found in steppe and dry areas. The evaporation is greater than rainfall. This causes the deposits of saline over the upper layer. This is a reason why these soils are called saline and they are not fully developed.

Azonal Soils : These soils are found in those areas where due to insufficiency of time they could not develop into layers. These soils have no well-developed soil horizons. There may be a variety of reasons for non-development of soil horizon e.g.

- a) Lack of sufficient time
- b) Steppe slope terrain
- c) Renewal of soils every year because of deposition of new material as in case of flood plain.

These soils are :

- a) Lithosols
- b) Dry sandy soils
- c) Alluvial soils,

SOIL EROSION

Soil erosion is the removal or destruction of to layer of soil by natural forces such as water and wind more rapidly than the various soil forming processes can replace it or in other words soil erosion is the removal of top soil from one place to another with the help of natural agents like running water, wind etc. Soil erosion makes the land unsuitable for cultivation. Soil erosion is mainly due to men's ill-judged activities such as deforestation, over-grazing and faculty erodes soil it is called gully erosion. Large part of soil is blown away by strong winds in dry area. As a result of this, the top layer of soil is eroded. This is known as sheet erosion. The erodability is influenced by the inner properties of the soil, texture, structure, consistency, and cohesiveness. On a gently slope, adequately clothed by a vegetation cover, clay soil will resist erosion to a great extent. On such a soil, channel erosion will succeed but not sheet erosion. Here ploughings are done across the contour lines.

Factors Responsible for Soil Erosion

The various agents of Erosion, i.e. running water, winds and glaciers, etc. and now man with his technological tools are busy in destroying the soil. The process of soil erosion has done a great harm to the productivity of crops in India.

The following factors are mostly responsible for soil erosion.

1. Sand Storm: Before the onset of rainy season sand storms are common. These storms take away the particles of upper surface of the soil. The greater, the intensity of these way, the fertility of soil is reduced. The soils of Sr Punjab, Haryana, Rajasthan, U.P. and Bihar etc. are rendered unproductive every year.

2. Methods of Agricultural process: The older methods of Agriculture were wasteful and have destroyed the soil cover in many areas. The Jhooming as practiced in North Eastern states, the subsistence Agriculture, etc. have rendered large fertile land almost barren. The scientific methods can prevent the soil erosion to a great extent.

3. Deforestation : Man has been destroying forests without knowing the harm that is being done to preservation of soil. Due to eroding away of the upper zone of vegetation cover, the water starts flowing faster and destroys soil. It is estimated that harm is to the extent of 300 tonnes per hectare but it is quite less in the grass land area and forest area.

4. Grazing : Due to over grazing of animals the vegetation becomes too thin to protect the soil. While grazing the animals pull the roots of the plants out and there by soil becomes open to rapid erosion due to rain and wind. Now a day efforts are being made to protect the soil and control the grazing.

5. Steep Slopes : The steep slopes increase the spread of the flow of water and therefore increase the erosion of soil. Such slopes should be covered with vegetation so that the fast flow of water is obstructed.

6. Torrential rainfall : Heavy rainfall loosens the soil particles and scoops out the soil forming gullies and ravines. This gives rise to a dissected surface called bed land in Chambal valley of India.

7. Over cropping : Crop rotation maintains soil fertility. But over cropping and shifting cultivation renders soil infertile.

SOIL CONSERVATION:

Methods by which soil is prevented from being eroded constitute soil conservation. Soil conservation has an urgent significance throughout the world because of the slow rate of soil formation. In tropical and humid temperature areas for example, one centimeter deep soil is formed during about 200 and 150 years respectively. Soil erosion, on the other hand, can take place in a short time.

METHODS OF SOIL CONSERVATION :

All methods of soil conservation ultimately have to aim at reducing the amount and velocity of surface run-off and of the erodability of the soil. Following few methods are adopted for soil conservation:

1) **Vegetation Cover :** The cover of the vegetation not only reduces the surface run-off but also binds the soil particles through the roots and increases its strength. Thus, vegetation cover protects the soil from the attack of erosional processes. The planting of forests has been the most important of the soil conservation techniques. The planting of forests in areas from where the original vegetation has been removed by man is termed reforestation. The planting of forests in those areas which have never had any vegetation is termed afforestation. Both reforestation and afforestation are needed more specifically on slopes where trees retard the surface run-off and bind the soil.

2) **Erecting Dams :** Many rivers cause heavy erosion of soil in rainy season due to swift flow of the water current. This can be checked by erecting dams across the rivers.

3) **Preventing Overgrazing :** An indirect passive measure is to prevent the slopes from being grazed intensively by sheep and goat and other livestock. Overgrazing causes a packing of the soil and decreases of its water permeability .

4) **Changes in agricultural practices:** We can check soil erosion to a great extent by bringing about some basic changes in our agricultural practices. This includes crop rotation, crop combination, terraced cultivation etc. Contour ploughing is a very effective method of checking soil erosion on hill slopes. This is the practice of ploughing along the contours rather than ploughing up and down the slope. Viewed from above, the resulting furrows look like contour lines on maps. By this method, the surface run-off of the rain and irrigation water is checked and soil is prevented from being washed away.

LANDSLIDES AND AVALANCHES

Landslides and avalanches are usually secondary disasters, caused by such primary natural occurrences as heavy snowfalls, monsoon rains, volcanic eruptions, or earthquakes.

To occur at all, an avalanche needs an insecure base. Snow that has accumulated upon a mountain-side can be loosened by tremors, echoes, or uneven melting of the snow base. Secure landmasses can be turned to mud by weeks of unrelieved rain. The underpinnings of cities can be rattled loose by repeated natural or man-made Earth tremors or by the superheating of subterranean depths under the soil brought on by volcanic activity.

Whatever the cause, an avalanche is sudden, unanticipated, and violent. Mountains, lake, and seaside waterfronts and entire population areas can be abruptly uprooted. Helped by accumulated force, speed, and gravity itself, these avalanches generally grow in size and destructive power as they accumulate loose debris, rocks, soil, trees, water, and anything that happens to be unlucky enough to find itself in their paths.

The most spectacular and lethal avalanches occur in regions of heavy snow and ice. In these places, as much as 1 million cubic yards of snow have been known to give way and thunder down slope at a time -an amount that would fill the beds of 10,000 10-cubic-yard dump trucks, which in turn is equivalent to a line of vehicles that would reach for approximately 200 miles.

A valanches of snow can be triggered by the most delicate vibration, which is why some Alpine farmers muffle the bells on their livestock in winter. A falling stone, the movement of animals, thunder, the sonic boom of a jet, a man slicing across a slope on skis can become the genesis of an avalanche of snow and ice.

Haiti,

Grand Riviere Du Nord,

November 13-14, 1963

Mudslides brought about by long periods of tropical downpours killed 500 residents and tourists in Grand Riviere du Nord on November 13 and 14, 1963.

Iceland,

Sudavik,

January 13, 1995

Most of the village of Sudavik, Iceland, was either destroyed or dislodged by an early morning avalanche on January 13, 1995. Fourteen residents, most of them children, died in the incident.

India,

Bihar, West Bengal and Assam,

October 1-4, 1968

One thousand residents of Bihar, West Bengal and Assam were killed by a combination of landslides and floods and the oil pipeline linking Bihar and Assam was largely destroyed between October 1 and 4, 1968.

India

Darjeeling

September 7, 1980

Thirty thousand residents of the Darjeeling area of India were cut off from the outside world and 250 were killed when avalanches, caused by monsoon rains, descended from the Himalayas on September 7, 1980

India**Kashmir****January 18, 1995**

Over 200 died in the avalanche that buried hundreds of vehicles on the Srinagar-Jammu Highway in Kashmir on January 18, 1995. Over 5000 were rescued from their trapped buses or cars, or from the 1.7 mile-long Jawahar tunnel.

India**Uttar Pradesh****August 17, 1998**

Over 200 pilgrims, residents, and officials were killed when a square kilometer of land, loosened by monsoon rains, slid down a mountainside in the state of Uttar Pradesh, India, on August 17, 1998. The entire village of Malpa was swept into a gorge of the swollen Kali River.

Iran**Roudehen****January 13, 1998**

Thirty-two people were killed and over 80 injured by an immense avalanche that roared across the mountain row that links Iran's capital of Tehran with the Caspian Sea. The avalanche, which occurred near Roudehen, happened on the evening of January 13, 1998, while the road was crowded with traffic.

Italy**Belluno****October 9, 1963**

An earthquake caused a landslide, which in turn caused a flood in the Piave River

Valley of Italy on October 9, 1963. Over 4000 residents of the area drowned.

Japan

July 17, 1972

Torrential rains caused landslides that precipitated floods throughout Japan during the week of July 10, 1972. On Monday, the 17th, the destruction reached its climax, Three hundred seventy persons were killed; over \$472 million in property damage was caused by the combination of landslides and flooding.

Japan

Niigata

July 18-19, 1964

An earthquake combined with heavy rains caused landslides near Niigata, Japan, on July 18 and 19, 1964. One hundred eight died; 223 were injured; 44000 were rendered homeless.

Medico

Minatitlan

October 29, 1959

An earthquake, a tsunami, and a series of landslides combined to kill 5000 people in Mexico on October 29, 1959. The village of Minatitlan was obliterated, and 800 residents died in their beds.

Nepal

Katmandu

November 11-12,1995

Ninety-one people died in one of Nepal's worst avalanche disasters on November 11-12, 1995, on or near the slopes of Mount Everest. Eight helicopters managed to rescue

and evacuate 237 survivors.

Pakistan

Kel

March 15, 1996

Forty-four residents of the village of Kel, on the Kashmir-India border, were buried under an avalanche that despoiled the small military post on March 15, 1996.

Peru

Chungar ,

March 19, 1971

Chungar , a mining camp 10000 feet up in the Andes, was destroyed by an avalanche caused by an earthquake on March 19, 1971. Between 400 and 600 were killed 50 were injured.

Switzerland

Goldau Valley

September 2, 1806 †

An avalanche caused by the sudden erosion of the top of Rossberg Peak in the Swiss Alps on September 2, 1806, set forest fires and inundated four villages in the Goldan Valley. Eight hundred were killed.

Switzerland

St. Gervais

July 12, 1892

One hundred forty people were killed in the giant avalanche caused by the calving of the Tete Rousse glacier on Mont Blanc on July 12, 1892.

Switzerland

Vals

January 20, 1951

Two hundred forty people died, and over 45000 were trapped on January 20, 1951, when a series of avalanches, caused by a combination of hurricane force winds and wet snow overlaying powder snow, thundered through the Swiss, Austrian, and Italian Alps.

Tajikistan

Anzob Mountain Pass

October 23, 1997

Forty-six people were killed when a sudden avalanche buried 15 trucks and cars on the 11000-foot-high Anzob Mountain Pass in Central Tajikistan. Only four survivors were pulled from a 40-foot blanket of snow.

United States

California

January 18-26, 1969

Ninety-five persons died and over \$138 million in damage was caused in southern California by series of mudslides, brought about by nine days of torrential rain, and a subtropical storm, from January 18 to 26, 1969.

United States

Washington

Sellington

March 1, 1910

Snow loosened by rain broke loose from a mountain in the Cascade range of Washington on March 1, 1910, and buried the village of Wellington and a stranded train at its railroad station. Ninety-six died in one of the worst avalanches in U.S. history.

Wales

Aberfan

October 21, 1966

The collapse of a slag heap outside of Aberfan, Wales, on October 21, 1966, caused the worst landslide in Wales's history. One hundred forty-five persons - 116 of them children - were killed.

ENVIRONMENTAL HAZARDS AND MANAGEMENT

Natural hazards, is a term indicating action of abrupt modifying natural events, such as floods, droughts, earthquakes, landslides, and the like, while anthropogenic hazards are indicated by the term technological hazards or environmental risk (O’Riordan, 1986.)

A hazard by definition is an expected damage, injury, or death to people and property, subsequent to general distress, and economic loss. A natural hazard is considered a problem if occurring in built areas, while people are not aware of its characteristics in order to cope with it.

Natural hazards pose serious problems in the zone. Natural hazards problems exist over a wide range of scale and aspect. Each hazard is peculiar in its situation.

Till the early 1900 -, peruses of natural disasters were merely descriptive in nature. Scientific scrutiny of physical causes responsible for such disasters, were then established quite fairly. Yet, Their relation to society and anthropogenic perception were but little. Primarily, the main emphasis on any research relating to hazards was based on anthropogenic hazards (O’Riordan, 1981). A gradual realization was being made on the relevance of these findings with natural hazards. However, by 1950 -, the time of establishment of a Committee on Disaster Research by National Academy of Sciences U.S.A. (1953), and a decade later, the parallel research of social responses to natural and anthropogenic hazards, attributed an academic respectability to hazard research.

Environmental Hazards :

Man has always been subject to natural disasters over which he has little control. Most people would include volcanic eruptions, earthquakes, landslides, tornadoes,

hurricanes and cyclones, storm surges, floods, droughts, blizzards and forest fires in a list of environmental hazards. It is worth emphasizing that many of these only become hazards because man elects to use areas susceptible to these natural phenomena; this applies especially to earthquakes and floods. Clearly, what is far more difficult to assess is the seriousness of these hazards in any particular place, for much depends on people's perception of the hazard. For example, the possibility of cyclone damage has always existed around the Timor Sea.

Weather Hazards :

In dealing with weather hazards, meteorological information is usually employed to predict their occurrence rather than to prevent them. Good weather observation networks are obviously of great importance here. Long term meteorological records help us to identify the times and places of severe weather events, and to relate them to the occurrence of other climatic phenomena. For example, there seems to be a close relationship between hurricane and cyclone seasons and the position of the inter tropical convergence zone.

Flooding :

Flooding is one of the most ubiquitous of natural hazards to affect man, mainly because he chooses to live in so many flood-prone areas. The reasons for widespread flood-plain occupancy are many and varied: availability of flat land, access to water, lack of perception of the flood hazards, are but a few of these. In contrast to the response to hurricanes and cyclones, man is in a better position to prevent and control floods, since surface water is more amenable to interference than atmospheric processes.

Many aspects of physical geography dealt with in this book come into play when dealing with flooding as an applied problem, including climatic, geomorphological, hydrological and biotic factors. The close relationship within a drainage basin between systems operating on slopes and river response, provides an important theoretical base. In practice, there are two fundamental approaches to flood control. The first is to prevent the flood forming in the first place, or at least to diminish the amount of water reaching the rivers. This can be achieved by modifying the slopes in the upper catchment or by building small dams on fingertip tributaries. We noted in the previous chapter that some of man's activities on the land appear to have aggravated floods. Reversing these actions -for

example, by reafforesting slopes to increase the amount of interception and infiltration - can have a large effect on run-off. The other approach is to control the flood in the channel. Normal practice is to build large dams, usually as part of multi-purpose schemes, or to modify the channel and its banks. Engineering measures such as retaining walls and river diversions can be introduced where they are needed, close to centres of population or valuable land. These measures in themselves can of course have important consequences on river velocity and the patterns of erosion and deposition.

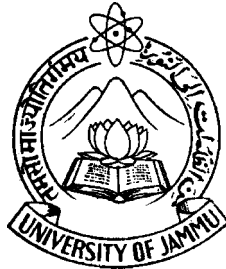
In the United States, considerable arguments have developed about the relative effectiveness of these two approaches, and this has become known as the 'upstream-downstream controversy'. Ideally, flood control and administration should be geared to total catchment areas, but frequently several States may be involved, each reluctant to pay for measures not within their administrative boundaries.

Environmental Management :

The term 'environmental management' is a very popular one today. It implies the sensible and sustained application of the principles of science and technology to the landscape, and so brings together a wide range of individuals, both environmental scientists and decision-makers. Geographers in theory ought to be in a good position to act in the role of both, or at least to take an overview. Here it is inappropriate to discuss the problems of decision-making. Instead, we can take a brief look at the contribution of the physical aspects of geography : this contribution can be very much wider than simply modifying environmental hazards. Physical geographers ought to be able to evaluate the nature of the interactions between the various systems in the natural environment and deal with individual problems in integrated management context. Drainage basin or watershed management is an example of this: it emphasizes that river catchments are a natural unit for the operation of many physical and biological systems, including human activity. Although drainage basins do not exert a restrictive influence on man, it can be argued that they form a much better framework for environment management than the administrative boundaries we are familiar with.

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