Catalog

UNIT – I

PHYSICAL GEOLOGY

SYLLABUS

Geology in civil engineering – branches of geology – structure of earth and its composition - weathering of rocks – scale of weathering – soils – landforms and processes associated with river, wind, sea and groundwater, relevance to civil engineering - Plate tectonics – Earth quakes – Seismic zones in India.

1.1 GENERAL GEOLOGY

Introduction:-

Geology(in Greek, Geo means Earth, Logos means Science)

- Geology is the branch of science deals with the study of Earth.
- It is also known as earth science.
- The study of earth as whole, the origin, structure, composition and the nature of the processes.

1.1.1 GEOLOGY IN CIVIL ENGINEERING

Engineering Geology

The principles and methods of geology is adopted for the purpose of civil engineering operations. Broadly speaking, engg geology has two divisions:

1. The study of raw materials
2. The study of the geological characteristics of the area where engineering operations are to be carried out such as Groundwater characteristics; the load bearing capacity of rocks; the stability of slopes; excavation; rock mechanics etc for civil engineer.

Scope of Geology

In Civil Engineering

- ✓ Geology provides necessary information about the construction materials at the site used in the construction of buildings, dams, tunnels, tanks, reservoirs, highways and bridges.
- ✓ Geological information is most important in planning stage, design phase and construction phase of an engineering project.
- ✓ Geology is useful to know the method of mining of rock and mineral deposits on earth's surface and subsurface.
- ✓ Geology is useful for supply, storage and filling up of reservoirs with water.

Importance of Geology in Civil Engineering

- Before constructing roads, bridges, tunnels, tanks, reservoirs and buildings, selection of site is important from the point of stability of foundation.
- Geology provides a systematic knowledge of construction materials and their properties.
- The *foundation problems* of dams, bridges and buildings are directly related with geology of the area where they are to be built.
- The *knowledge of ground water* is necessary in connection with excavation works, water supply, irrigation and many other purposes.
- The knowledge of *Erosion, Transportation and Deposition* (ETD) by surface water helps in soil conservation, river control.
- *Geological maps* and sections help considerably in *planning* many engineering projects.
- If the geological features like faults, joints, beds, folds are found, they have to be suitably treated. Hence, the *stability of the rock structures* is important.
- Pre-geological survey of the area concerned reduces the *cost* of planning work.
- Minerals, Rocks and soils constitute earth materials. They play a vital role in the site evaluation and operations in civil engineering practice.
- Whether it is tunnelling, hydro-electric projects, ground water development, foundation for structures, study of slope stability etc. A basic understanding of the earth materials is essential.

- Thus, study of minerals, rocks and soils forms the first step in civil engg point of view. Hence, a civil engineer should know the introduction of Geology and its branches and importance of a few branches such as Physical Geology, Petrology; Structural Geology and so on.

1.1.2 BRANCHES OF GEOLOGY

Geology comprises the following branches:

1. Crystallography
2. Mineralogy
3. Petrology
4. Geophysics
5. Geochemistry
6. Structural Geology
7. Stratigraphy
8. Physical Geology
9. Geomorphology
10. Paleontology
11. Hydrogeology
12. Engineering Geology
13. Photo Geology
14. Economic Geology
15. Mining Geology

- **Crystallography**: The study of the characters of crystals is known as crystallography. Crystals are bodies bounded by flat faces (surfaces), arranged on a definite plane due to internal arrangements of atoms.

- **Mineralogy:** The study of the characters of minerals (Eg: quartz, pyroxene, amphibole, mica, chlorite, garnet) is known as Mineralogy. A mineral is a naturally occurring homogeneous substance, inorganically formed with a definite chemical composition, with a certain physical properties and crystalline structures.

  Note: Coal, oil etc are considered as minerals though they arises by organic matter under exceptional conditions.

- **Petrology:** The study of rocks in all their aspects including their mineralogies, textures, structures (systematic description of rocks in hand specimen and thin sections); origin and their relationships to other rocks.

- **Geophysics**: The section of the earth which include the structure, physical conditions and evolutionary history of the earth as a whole.

- **Geochemistry**: The study of chemical composition of minerals and rocks of the earth.

- **Structural Geology** is the study of rock structures such as folds that have resulted from movements and deformation of the earth's crust.

- **Stratigraphy**: The study of the stratified rocks especially their sequence in time, the character of the rocks and correlation of beds at different localities.

- **Physical Geology**: It deals with the geological processes which bring about changes in the crust and upon the surface of the earth. It also deals with the surface features of the earth (land forms) or its topography

- **Geomorphology**: The description and interpretation of land forms.

- **Palaeontology** is the study of ancient life, determination of environment, evolution of organisms etc.

- **Hydrogeology** the study of the geological factors relating to earth's water.

- **Mining Geology** deals with the method of mining of rocks and mineral deposits on earth's surface and subsurface.

1.1.3 STRUCTURE OF EARTH AND ITS COMPOSITION

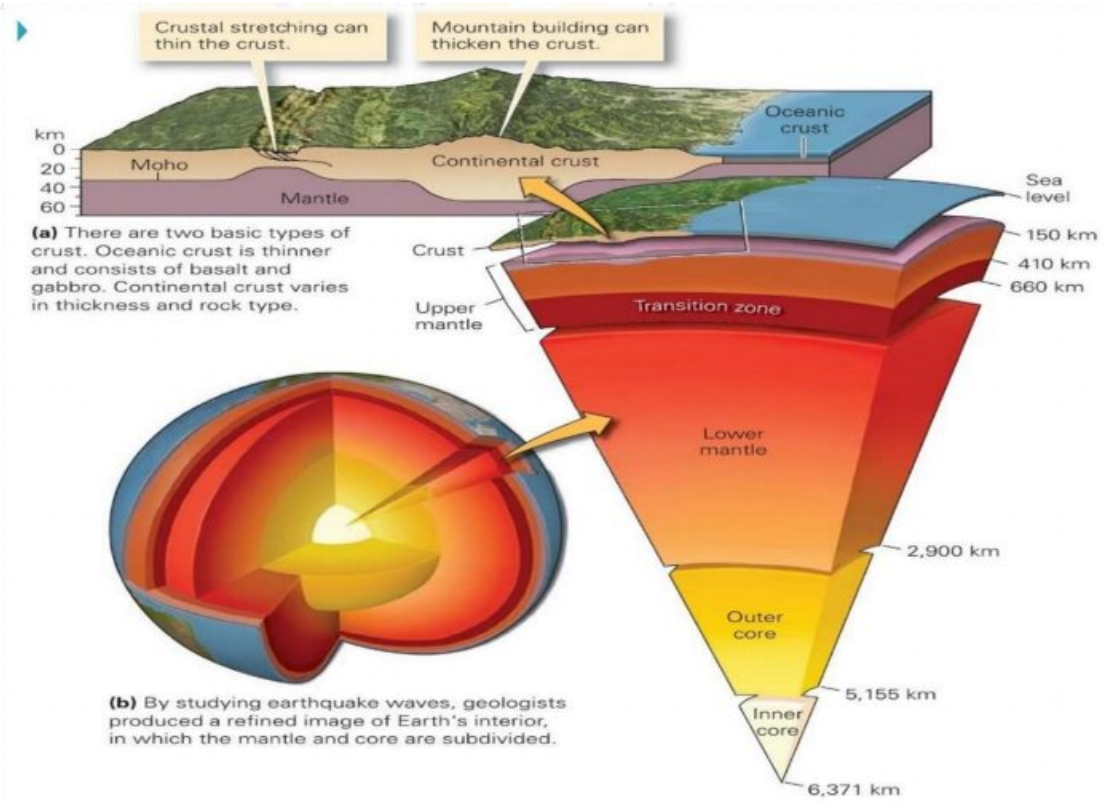
Introduction about Lithosphere:

- Litho is a Greek word, which means stone. Accordingly the lithosphere is the part of the Earth, which is solid crust.
- The thickness of lithosphere is approximately 50 km. The crust thickness is not the same at all places.
- It is thicker in the continent and thinner on the ocean floors. Lithosphere is a source of various minerals.
- It contains variety of landforms such as mountains, plateaus, valleys, plains.

Plates:

- The surface of the earth is the crust of the earth. It is made of interlocking pieces called Plates.
- The continents and oceans rest in these places and are separated by wide cracks. The plates move constantly.

STRUCTURE OF EARTH



Crust:

- Early in the 20th century the reality of earth crust was demonstrated by a scientist named Mohorovicic.
- He noted that in measurements of seismic wave arriving from an earthquake, those focus lay within 40km of the surface, seismographs within 800 km of the epicentre.
- Recorded two distinct sets of P and S-waves.
- He concluded that one part of waves must have travelled from the focus to the station by a direct path whereas the other pair of waves had arrived slightly later because they had been refracted.

There are two types of crust:

- Continental crust
- Oceanic crust.

Continental Crust:

- ✓ The continental crust consists of two layers separated by a well-defined discontinuityknown as Conard discontinuity.
- ✓ The layers have been defined on the basis of seismic wave velocities and densities.
- ✓ In the upper layers the velocity of seismic waves corresponds to the velocity found byexperimental to be characteristic of granite.
- ✓ Hence they are called as Granitic or silica layer.

Oceanic Crust:

- The earth's crust beneath the oceans consist of a low velocity layer of deep sea sediments about 300-400m thick in pacific and 600-700 m in the Atlantic.
- The Layer of intermediate velocity called basement about 0.8 km thick, composed of compacted and indurated sediments and lave flows.
- The third layer is called the oceanic layer about 4.1 to 5.8 km thick and certain composition. This three-layered oceanic crust is generally 5 to 8 km thick.

Mantle:

- Materials making the earth become quite different in properties at the base of the crust.
- This depth below the surface of the earth at which a striking change in the properties of the materials is observed has been named as Mohorovicic discontinuity.
- In geological literature itis often referred as M-discontinuity or simply as Moho.
- Hence mantle is that zone within theearth that starts from M-discontinuity and continues up to a depth of 2900km.Mantle is made up of extremely basic material called aptly ultra-basic that is very rich iniron and magnesium but quite poor in silica. The material of the mantle is believed to be variably viscous in nature.

Core:

- ❖ It is the third and the innermost structural shell of the earth as conclusively proved by the seismic evidence.
- ❖ It starts at a depth of 2900 km below the surface and extends right up to the centre of the earth, at a depth of 6371km.
- ❖ The core remains a mystery in many ways.
- ❖ Within the core the physical nature and composition of the material is not uniform throughout its depth.
- ❖ It has a very high density at mantle core boundary above 10g/cc.
- ❖ The outer core behaves like a liquid towards the seismic waves.
- ❖ The inner core starting from 4800km and extending up to 6371km is of unknown nature but definitely of solid character and with properties resembling top a metallic body.

1.2 WEATHERING OF ROCKS

- Weathering is defined as a process of decay, disintegration and decomposition of rocksunder the influence of certain physical and chemical agencies.
- Weathering, is a natural process of in-situ mechanical disintegration and/or chemical decomposition of the rocks of the crust of the Earth by certain physical and chemical agencies of the atmosphere.
- The most important aspect of this process is that the weathered product remains lying over and above or near to the parent rock unless it is removed from there by some other agency of the nature.

Disintegration:

It may be defined as the process of breaking up of rocks into small pieces by themechanical agencies of physical agents.

Decomposition:

It may be defined as the process of breaking up of mineral constituents to form newcomponents by the chemical actions of the physical agents.

Denudation:

It is a general term used when the surface of the earth is worn away by the chemical as well as mechanical actions of physical agents and the lower layers are exposed.

The process of weathering depends upon the following three factors:

- ✓ Nature of rocks
- ✓ Length of time
- ✓ Climate

Three types of weathering are commonly distinguished on the basis of type of agency involved in the process and nature of the end product. They are:

- ✓ Physical or mechanical weathering
- ✓ Chemical weathering
- ✓ Biological weathering

Physical weathering:

- ✓ It is the physical breakdown of rock masses under the attack of certain atmospheric agents.
- ✓ A single rock block is broken gradually into smaller irregular fragments and then intoparticles of still smaller dimensions.
- ✓ It is the most active in cold, dry and higher areas of the earthsurface temperature variations are responsible to a great extent of physical weathering.

Forms of Physical Weathering

1. **Abrasion:-**

Water carrying suspended rock fragments has a grinding action on surfaces.

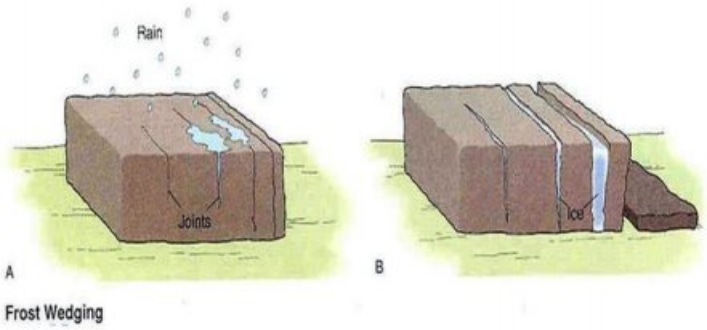
E.g.:- Grinding action of glaciers, gravels, pebbles and boulders with fast flowing streams.

2. **Wetting and Drying:-**

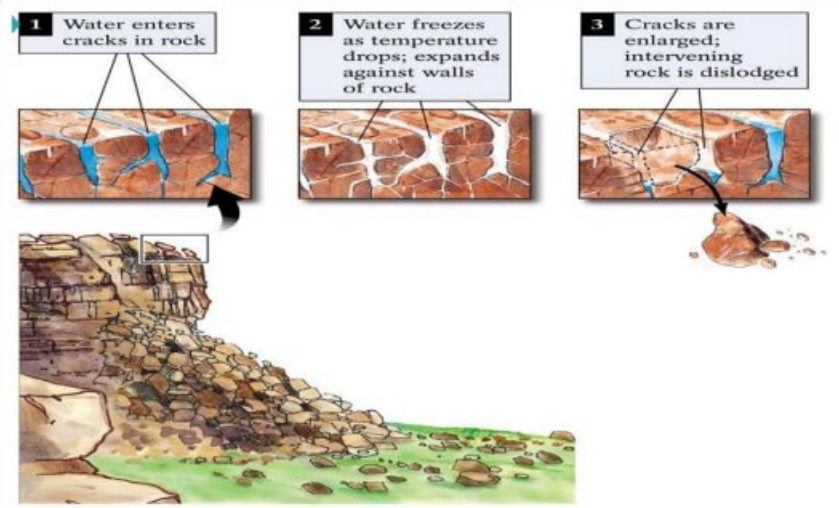
Water penetrates into rocks and reacts with their constituent material.

3. **Freezing and Thawing:-**

When water is trapped into rocks (in cracks) repeatedly freezing and thawing results in forces of expansion and contraction. (When water freezes, the increase in its volume is about 10 %.)



Frost Wedging



Scree Deposits and Talus Slopes

The result of

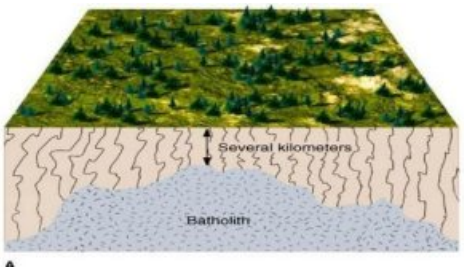
- Mechanical weathering
- Rock falls and slides
- Crushing and abrasion
- Slopes of rock fragments referred as Talus slopes.
- Accumulation of rock fragments referred as Scree deposits

4. Thermal Expansion and Contraction of Minerals:-

Rocks are composed of different kinds of minerals. When heated up by solar radiation each different mineral will expand and contract with surface temperature fluctuations.

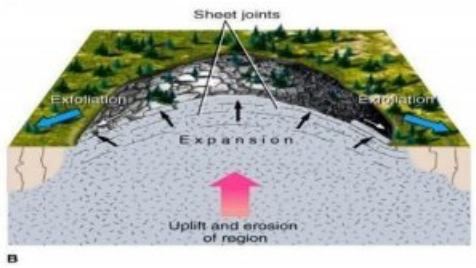
5. Pressure Unloading (or) Pressure Release Jointing:-

There is a reduction in pressure on a rock due to removal of overlying materials. This allows rocks to split along planes of weakness called joints.



6. Crystallization:-

In an arid environment, water evaporates at the surface of rocks and crystals form from dissolved minerals. Over time, the crystals glow (expand their volume) and exert a force great enough to separate minerals grains and break up rocks.



7. Action of Organisms:-

They aids in the physical disintegration of rocks.

8. Thermal Effects:-

The effect of change of temperature on rocks is of considerable importance in arid andsemi-arid regions where difference between daytime and nighttime temperature is often veryhigh. Such temperature fluctuations produce physical disintegration in a normally expected manner.

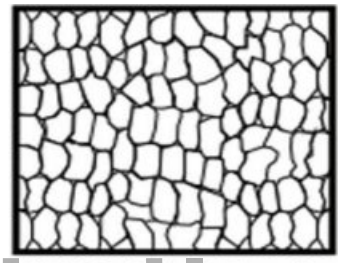
9. Exfoliation:-

Upper layer of rocks get affected due to change in temperature. This phenomenon of peeling off layer from rocks under the influence of thermal is called exfoliation.

Expansion on heating followed by contraction on cooling. When the rock mass islayered and good thickness additional disturbing stresses may be developed into by unequalexpansion and contraction from surface to the lower regions. The rock sometimes is found tobreak off intoconcentric shells.

10. Spheroidal weathering:-

Spheroidal weathering is caused due to the combined effect of mechanical and chemical weathering. This complex type of weathering leads to the breaking down of original rock mass in to spheroid blocks, due to the development of parallel joints by thermal effects.



Chemical weathering:

The chemical decomposition of the rock is called chemical weathering which is nothingbut chemical reaction between gases of the atmosphere and minerals of the rocks.

The chemicalchanges invariably take place in the presence of water generally rainwaterin which aredissolved many active gases from the atmosphere like C02, nitrogen, Hydrogenetc.Theseconditions are defined primarily by chemical composition of the rockshumidity and theenvironmental surrounding the rock under attack.Chemical weathering is essentially a process of chemical reactions between gases of theatmosphere and the surface rocks. For example:

Engineering importance of rock weathering:

As engineer is directly or indirectly interested in rock weathering especially when he hasto select a suitable quarry for the extraction of stones for structural and decorative

purposes. Theprocess of weathering always causes a loss in the strength of the rocks or soil.For the construction engineer it is always necessary to see that:

- ✓ To what extent the area under consideration for a proposed project has been affected byweathering and
- ✓ What may be possible effects of weathering processes typical of the area on theconstruction materials

Types of Chemical Weathering

1. Solution:-

Some rocks contains one or more minerals which are soluble in water to some extent.

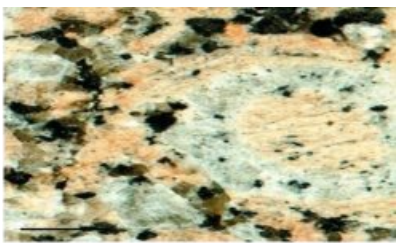
E.g.:- Rock Salt, Gypsum and Calcite

- **Hydration:-**

Minerals absorb water and chemically change the composition of the material.

1) $2CaCO_3 + H_2O + CO_2$ ---------- 2 Ca (HCO_3) 2

2) $CaSO_4 + 2H_2O$ ---------- $CaSO4_2.H_2O$



Eg. granite contains mica. Mica has a weak chemical composition and absorb water. Turns into clay

3. Hydrolysis:-

The process of exchange of ions are called hydrolysis. It is very common process of weathering of silicate minerals, quite abundant in rocks.

Orthoclase + Ion from Water = Silicic Acid

4. Oxidation and Reduction:-

The iron bearing minerals of rocks are generally prone to chemical weathering through the process of oxidation and reduction.

Oxidation:-

The process of addition of oxygen or removal of hydrogen is called oxidation.

Ferrous iron of the minerals is oxidized to ferric iron on exposure to air/ moisture. (Iron + oxygen = Rust)

Reduction:-

The process of removal of oxygen or addition of hydrogen is called reduction.

E.g.:- Reduction of iron oxide to iron.

The effects of oxidation by weathering are easily observed from the color changes produced in iron bearing rocks.

5. Carbonation:-

Carbonation is the process of weathering of rocks under the combined action of atmospheric carbon-di-oxide

E.g.:-Corrosive action over a number of silicate bearing rocks.

C. Biological Weathering [Organic Weathering]

The weathering process related to the activities, if microorganism such as bacteria as well as plants and animals are termed as organic weathering.

E.g.:-

- Animals moving through cracks can break rocks.
- Roots of plants.



Products of Weathering:-

i. **Eluvium:-**

The end product that happens to lie over and above the parent rock.

ii. **Deluvium:-**

The end product has been moved to some distance due to weathering process.

iii. **Regolith:-**

The term used to express all the material Eluvium and Deluvium that covers a parent rock. It forms huge thickness in the suitable environment.

iv. Minerals and deposits:-

i. Clay minerals - Montmorrilonite,Illite

ii. Ores of Aluminium – Bauxite and Laterite

1.2.1 SCALE OF WEATHERING

Scale of weathering refers the rate and intensity of weathering.

It may be less intensive, most intensive or moderate, depending upon the following factors.

1. Nature of weathering agencies involved.
2. Nature and composition of rocks involved.
3. Type of weathering takes place.

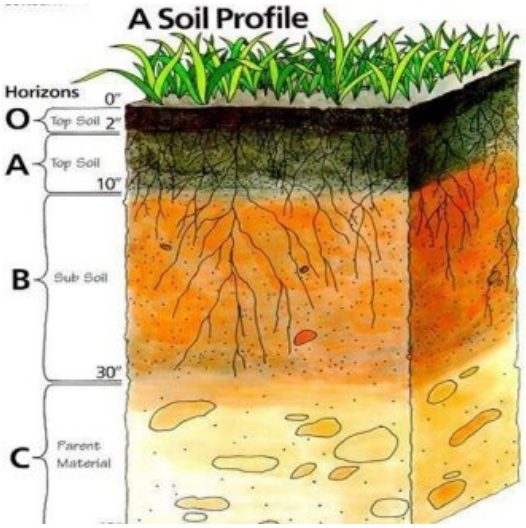
Weather and climate condition of the region

1.2.2 SOILS

- Soils are the products of disintegrated and decomposed rocks.
- Weathering is the key process of the formation of soil.
- Soils are unconsolidated fragments ranging in size 60 micron - 2mm.

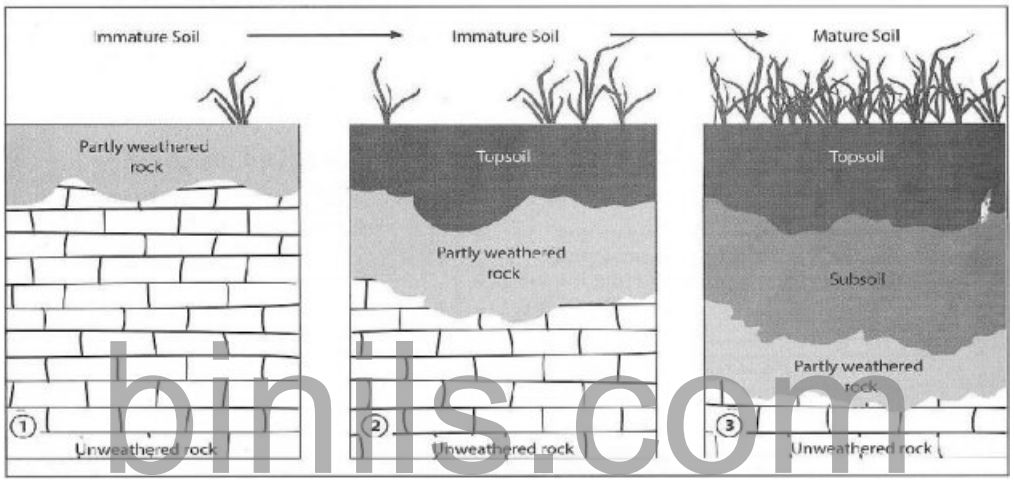
Soil Profile

- ✓ Top layer (consists of loose particles)
- ✓ Second layer (not compacted much)
- ✓ Third layer (compact layer)
- ✓ Last layer (rocky)

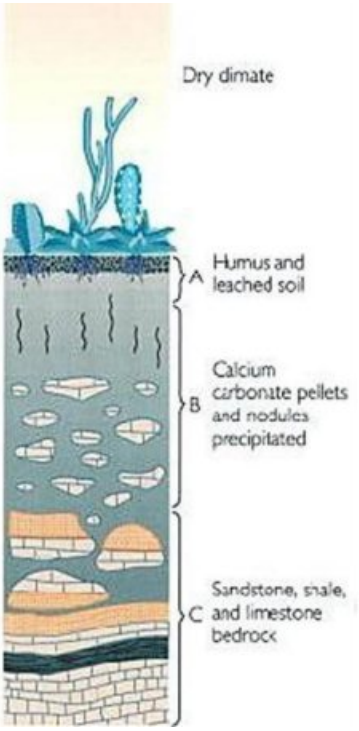


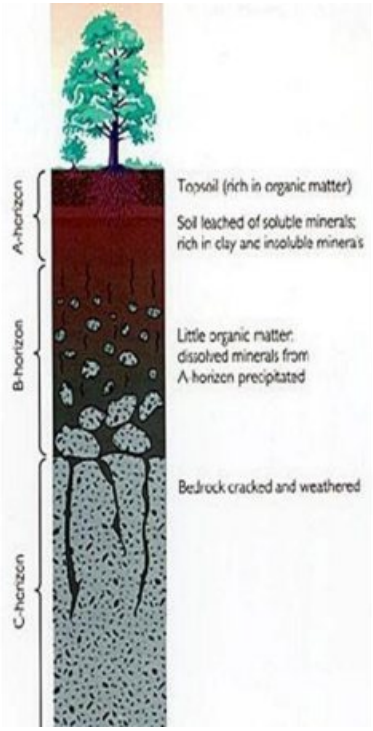
Soil Development

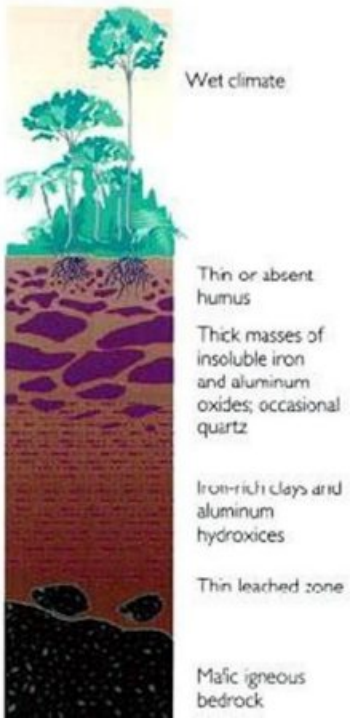
- Soil development from localbedrock.
- Stage 1 Mostly un-weatheredbedrock
- Stage 2 Development of top soil by biologic activity Stage 3 Mature thick and well developed soilhorizons



Different climates produce different soil types







Formation of soil

- Weathering

i. Physical

ii. Chemical

iii. Biological

- Erosion
- Transportation
- Deposition
- Sedimentation

Weathering:-

It is the natural process of disintegration and decay of rocks, due to the impact of various natural agencies like atmospheric gases moisture, sun's heat, wind, running water, glaciers and other organisms and human beings.

Erosion:-

The process of the removal of weathered product by wind, river or any other agents are called erosions.

Transportation:-

It refers movement of eroded particles from one place to another.

Deposition and sedimentation:-

Deposition of particles will take place whenever the velocity of transporting agents like wind is arrested.

Sedimentation is the process of deposition of sediments.

Classification of Soils

Major classifications:-

1. **Cohesive Soil:**Soil particles held under cohesion. E.g.:-Clay soil
2. **Non-Cohesive Soil:**No cohesion involved b/n soil particle. E.g.:-sand
3. **Transported Soil:**The soil particles are transported from the point of origin and deposited somewhere away from their source. E.g.:-River sand
4. **Residual Soil***:* They are also called in–situ-soils. They are formed at there at their source point itself. E.g.:-Pit sand, Lateritic Soil

Based on their composition:-

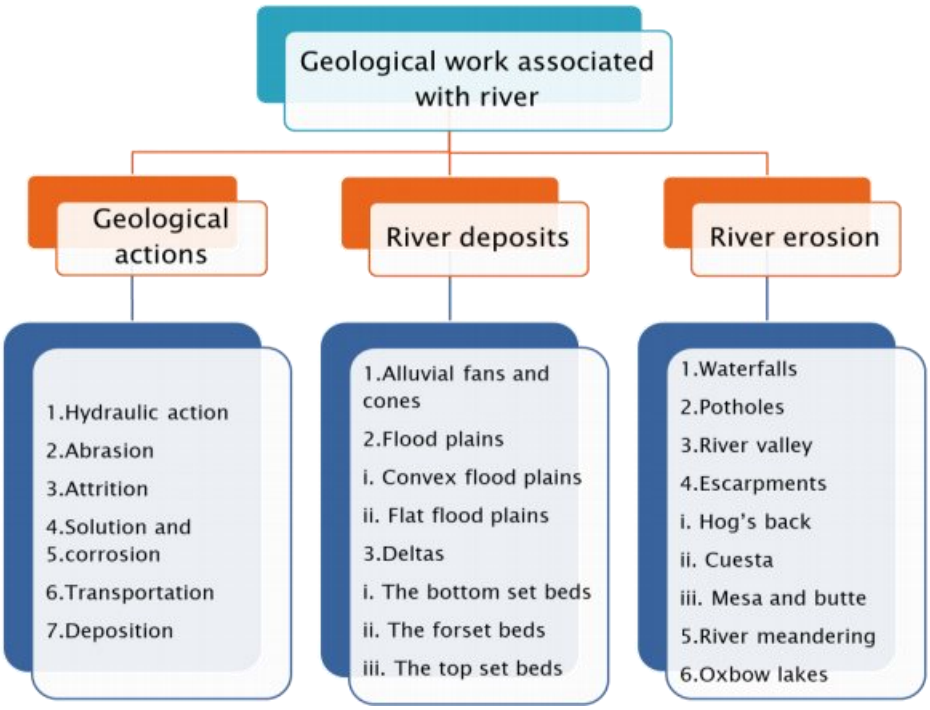
1. **Clayey Soil**–Rich in clay
2. **Sandy Soil** – Rich in sand
3. **Gravelly Sand**–Gravel mixed sandy soil
4. **Clayey Sand** – Clay rich sand
5. **Sandy Clay**– Sand rich in clay
6. **Lateritic Soil** – Rich in laterite
7. **Black Cotton Soil**– Black soil rich in most Montmorrilonite clay
8. **Red Soil** – Red in color rich in iron
9. **Loamy Soil**– Mixture of sand, silt and clay

Based on their places of origins:-

1. **Desert soil:**Light brown soil contains nitrogen and favorable for vegetation if there is water content.
2. **Alluvial Soil:** Formed along river bed.
3. **Coastal sand:** Formed in coastal plains having Saline in character due to the presents of chlorides.
4. **Mountainous soil:** Found in Himalayas.

5. **Peat soil:** Formed due to decaying of vegetable matter, derived from Marshy land.

1.3 LANDFORMS AND PROCESSES ASSOCIATED WITH RIVER



Geological work associated with river:

Geological Actions:-

1. Hydraulic action
2. Abrasion
3. Attrition
4. Solution and Corrosion
5. Transportation
6. Deposition

Hydraulic action:-

Hydraulic action of the river is defined as the process of breaking down of rock masses due to the continuous impact of water moving with appreciable velocity along the channel.

- It is the mechanical removal of material by running water
- High velocity is greater removal of grains from rock

Abrasion:-

- The large boulders and pebbles formed due to the hydraulic action of river roll down, along valley. This mechanical breaking down of bed rocks, due to the impact of wear and tear is known as abrasion.

Attrition:-

- The process of mechanical weathering breaking down of the transported rock fragments, due to the impacts of mutual collusion b/n themselves is described as attrition

Solution and Corrosion:-

- Soluble limestone attacked by running water it makes dilute acids and it is a good solvent of rocks. It makes corrosive effects on rock producing further wear and tear effects.

Transportation:-

- The total quantity of rock waste transported by a stream, in suspension, saltation and solution, constitutes it loads.

Deposition:-

- The velocity of running water decreases transporting capacity of the stream is proportionally reduced. The larger fragments are deposited, while smaller particles are transported to a greater distance.

River Deposits:-

1. **Alluvial fans and cones:-**

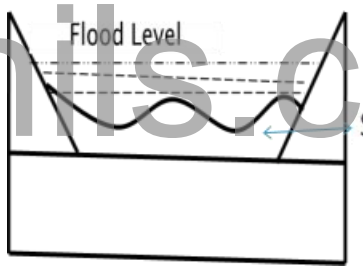
Where the stream enter into plains, the transported sediment like pebbles, gravels, etc deposited at low lands. The rock fragments are arranged like fan like pattern is called alluvial fans.

2. Flood plains:-

Whenever the velocity of river is checked most of the load carried by flood water will be deposited as a thick layer of mud. This deposits are generally plain in nature and hence they are called as flood plains.

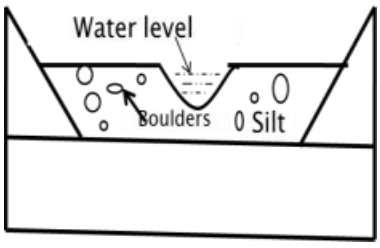
Two types:-

- ✓ Convex flood plains:-



The flood deposit consist mostly of finest sand, silt and clay

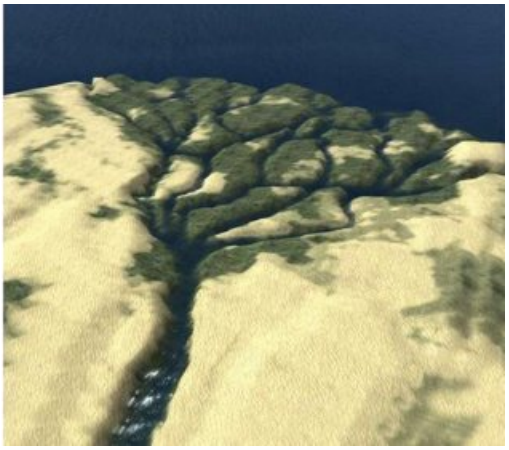
- ✓ Flat flood plains:-



Deposits are made up boulders sand and silt of all grades

3. Delta:-

Deltas are defined as alluvial deposits of roughly triangular shape that are deposited by the rivers at the plains where they enter into the sea.

- **The bottom set beds:-**

It is formed at the base of delta by a gentle sea ward inclination.

- **The forset beds:-**

It shows very steep inclination, towards sea and made up of thick layers of sand and clay.

- **The top set beds:-**

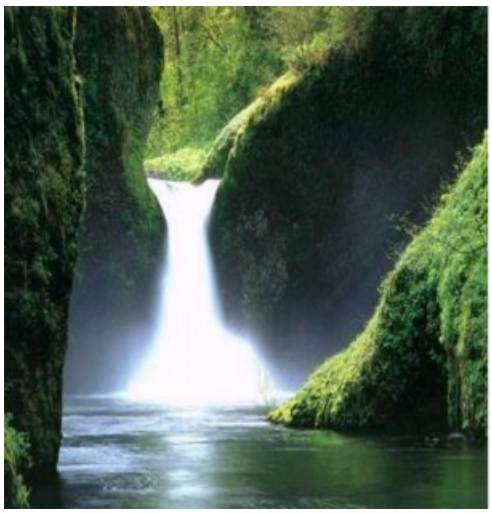
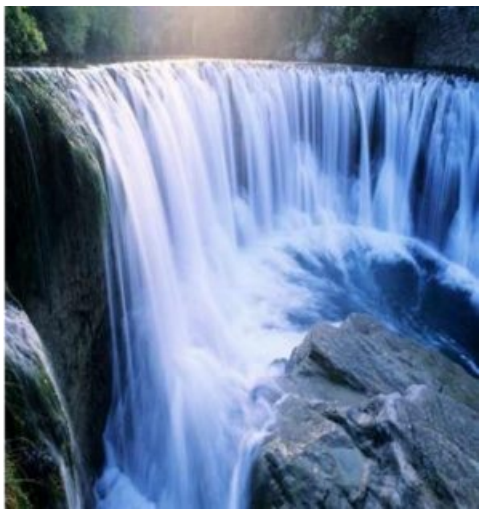
It is a thin layer with gentle slope.

River Erosion

Landforms / Features of river erosion:-

1. **Water falls:-**

When a river flows steep slope, over a vertical slope rock face, it forms a water falls.

2. Pot holes

These are bowl shaped depression, formed due to plucking out of soft rock from river bed by hydraulic action.

- Depression of soft rock are called pot holes.
- Ranges from few centimeters to meters.

3. River Valley

A valley is defined as low land surrounded on sides by various inclined hill slopes and mountains.

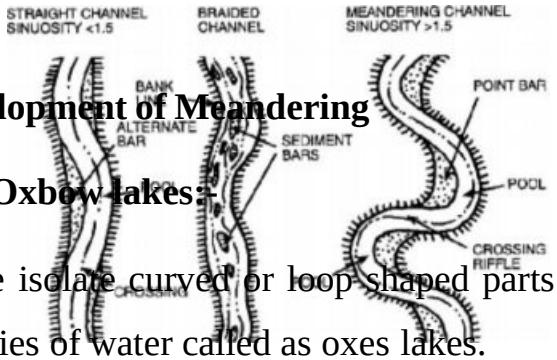
4. Escarpments

During the river erosion, soft rocks are eroded much faster than hard rocks, leaving behind steep slopes on one side and gentle slope on the other. The side with steep is known as escarpments

5. River Meandering:

When a stream flows an along a curved zigzag path, forming loop shaped course in meandering. The process of development of zigzag course by stream is known as River meandering.

- Moderate flow strength
- Low/moderate bank erodability
- Low/moderate sediment supply
- Meanders move downstream



Development of Meandering

The Oxbow lakes:-

There isolate curved or loop shaped parts of a meandering stream often contain some supplies of water called as oxes lakes.

1.4 LANDFORMS AND PROCESSES ASSOCIATED WITH WIND

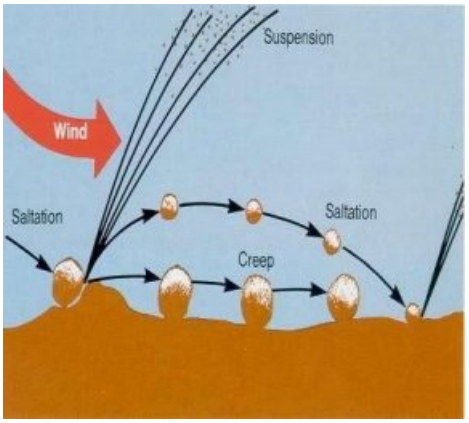
- The earth is surrounded by an envelope of gases called the atmosphere.
- Atmosphere is composed chiefly of gases collectively known as air.
- Air in motion is called wind.
- The movement of the atmosphere in a direction parallel to the earth surface is wind .i.e. the air in motion is called wind whereas the vertical movements of the atmosphere are termed as air currents.
- Wind is one of the major geological agents of change on the surface.

The Entire geological work performed by wind can be studied

1) Erosion
2) Transportation
3) Deposition

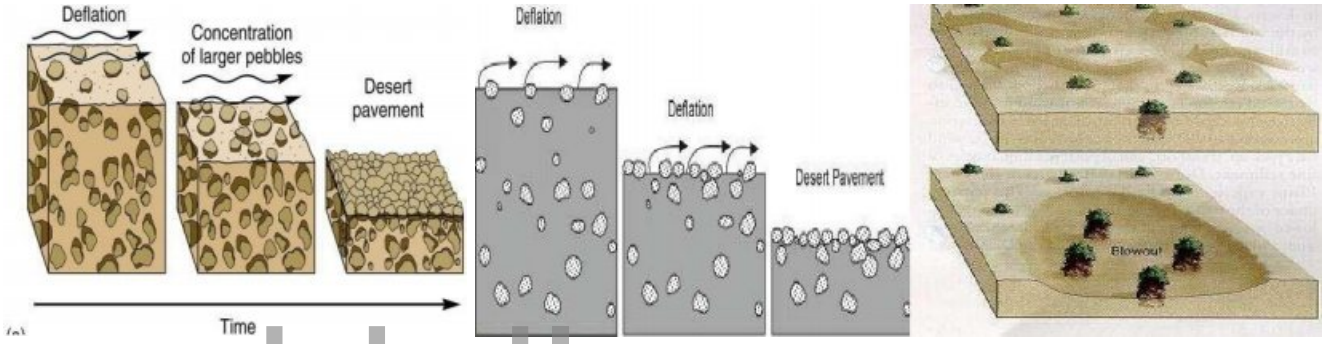
Wind Erosion:-

- Deflation
- Abrasion
- Attrition



a. Deflation [To blow away]

- Wind possesses not much erosive power over rocks [or] over the ground covered with vegetation.
- Wind moving with sufficient velocity over dry and loose sands (or) bare ground covered dust, it remove huge quantity of material from the surface known as deflation.
- In some desert deflation may remove the sand from a particular location to such an exert depression touching the water is known as blow outs.



Deflation - oasis

- Water filled depression known as Oasis is a place where vegetation is grows in desert.
- Stack is another term used for depression created by deflation.
- E.g. Auattarea in Western Egypt.

Deflation – Hammada

- It is a bare rock surface from which thin cover of sand has been blown away by strong winds. E.g. found in deserts


Wind abrasion

Wind is a powerful agent for wear of the rock surfaces when equipped with sand and dust particles.

The load is acquired by the strong winds quite early blowing over sand heaps and loose dry soil.

This type of erosion involves polishing and altering of rock surface by a natural agent like wind, is known as wind abrasion.


Yardangs

- It I an elongated low lying ridges forming overhangs above depression.
- Yardangs are formed in area where rocks of alternate hard and soft rock lying one over other with gentle slopes.


Pedestal rocks

It is known as mushroom rocks. They flat topped rock masses with slender supporting rock stems. The top is commonly referred as overhang and the support on pedestal.

The overhang and the stem are of the same rock that has been eroded by the winds quite unevenly resulting in the mushroom like appearance of the rock mass. They are generally few meters in height.


Ventifacts

- ✓ These are small sized rock fragments having one, two, three or more polished faces.
- ✓ These wind polished fragments are called ventifacts.

b. Attrition of wind

- ➢ The sand grains and other particles that are lifted by the winds and carried away and do not travel in a straight path.

- Their path is determine by their density and velocity of wind.
- It moves in zig – zag paths.

Factors affecting the Wind Erosion:-

1. Nature of region.

- Areas covered by thick vegetation are least affected by winds.
- Marshy lands and saturated soil are not affected by wind erosion.
- Land surface such as dust, silt and sand are easily eroded by wind.

Wind Transportation

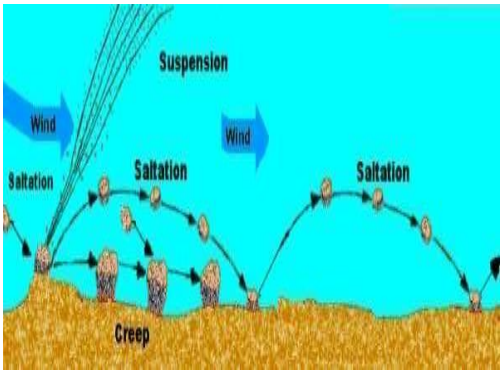
- Wind performs work of Transportation in two ways:

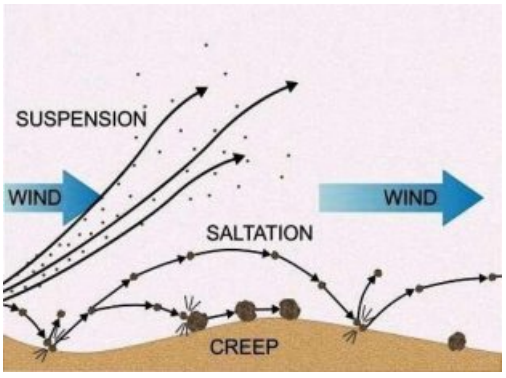
1) Suspension

2) Saltation

1. Suspension

- The light density clay particles may be lifted by the wind from ground and move along with winds is called suspension.





2. Saltation

- The heavier and coarse sediments are lifted up with high velocity and short distance above ground up to 2 m. They picked up and drop again during the transportation process of bouncing and jumping is called saltation.

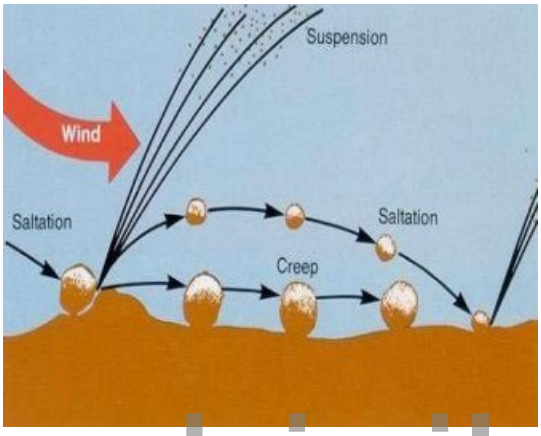
Deposition by Wind:-

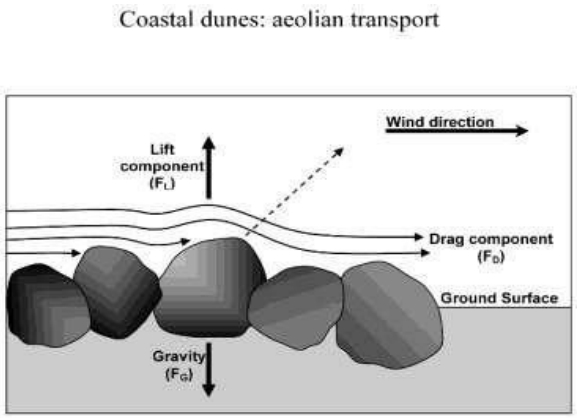
1. Aeolian deposits

Land forms and deposits made by wind-blown sediments are referred as Aeolian deposits.

Two types of Aeolian deposits

- Sand Dunes
- Loess





Types of Aeolian deposits

Sand Dunes

A sand dune is defined as a broadly conical heap of sand with two slopes on either side of ridge or crest.

Its types

- Crescentic dunes Type:- Barchans-Half moon shaped
- Sigmoidal dunes
- Transverse dunes

Types of Sand Dunes

i. Crescentic dunes

The wind ward slope is convex but Leeward concave in outline. This is called cresentic dunes.

Type:-

1. Barchans

This is a type of cresentic dunes developed by wind in the same direction for considerable length of time.

ii. Sigmoidal Dune:-

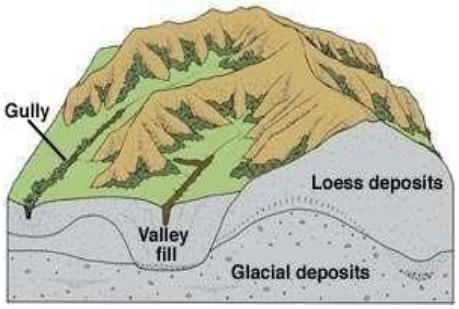
- It is the shape of horns and a curved outline.
- Longitudinal dunes are called as saifs.

iii. Transverse Dune:-

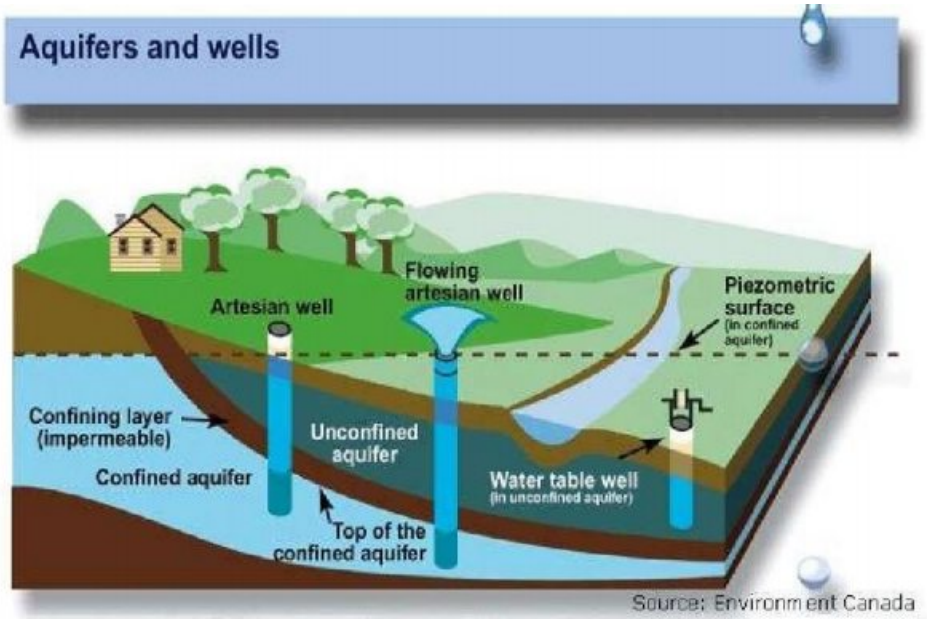
There are generally crescent dunes in nature and formed across the wind.

Loess:

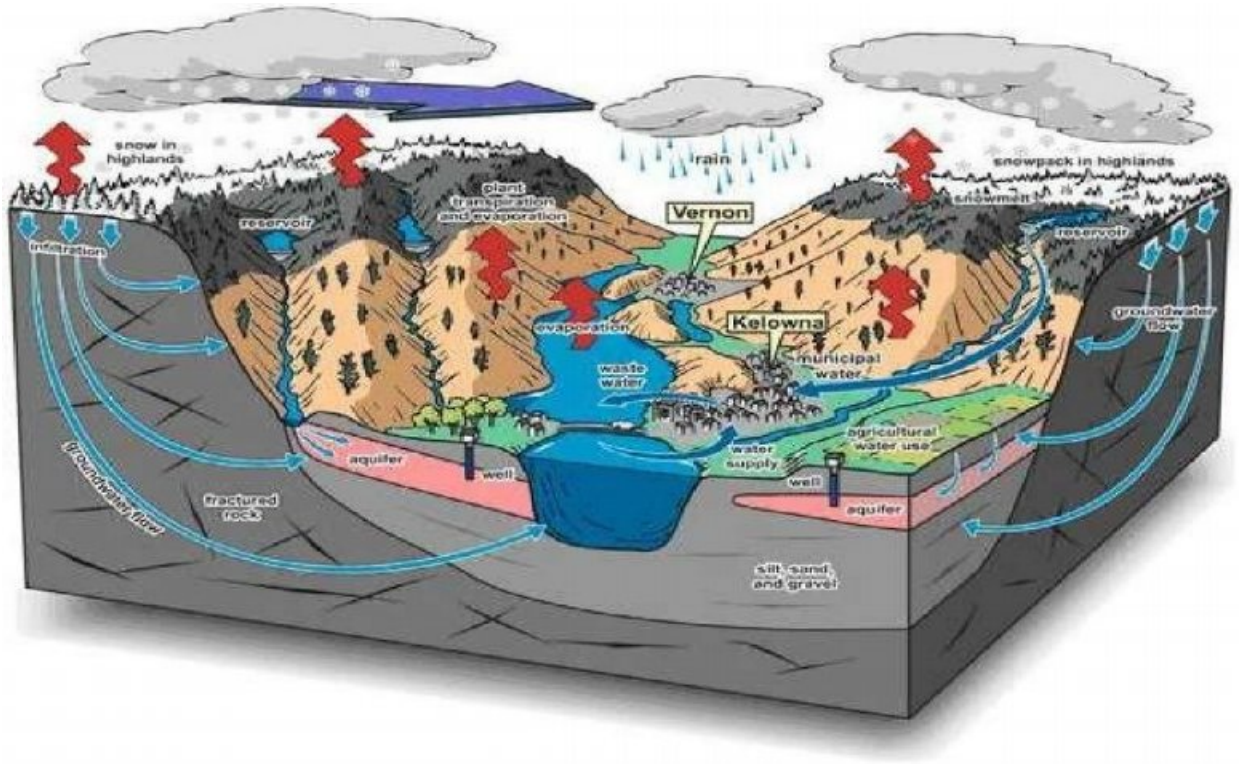
The finest particles of dust travelling in suspension with the wind are transported to a considerable distance. When dropped down under favourable conditions these have been found to accumulate in the different constituents the form of paper-thin laminae, which have aggregated together to form a massive deposit known as Loess.



1.6 LANDFORMS AND PROCESSES ASSOCIATED WITH GROUNDWATER

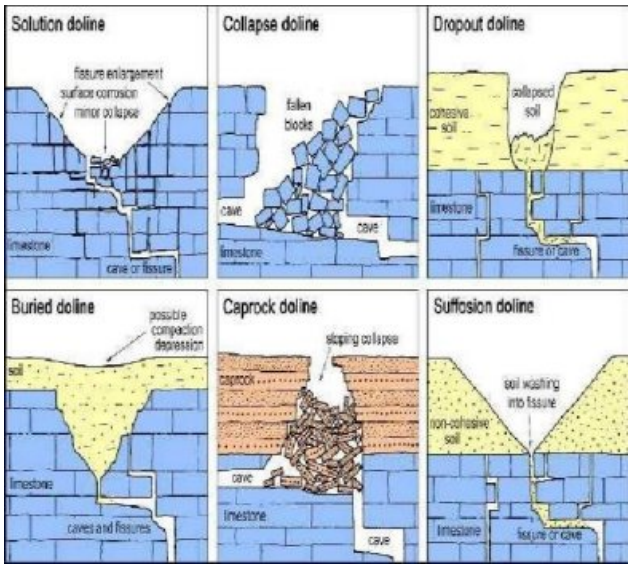


- Ground water like surface water, is also a very powerful natural agent responsible not only for modifying the existing features but also for creating many other geological features on and below the surface of the earth.
- Geological works of ground water may be conveniently studied under two headings namely chemical work and mechanical work
- Water is a great solvent. Groundwater becomes an active agent of dissolution of many rocks like lime stone, dolomites, gypsum, rock salt and the like with which it comes into contact during its downward journey below the surface. It has been observed that water dissolves limestone at a variable rate that depends upon its temperature, composition and above all its carbon dioxide content.
- The dissolution of soluble rocks by groundwater is controlled by a number of factors such as climate, geological structure, topography, porosity and permeability of rocks, composition of rocks, composition of ground water, especially its salts and gaseous content , flow velocity, temperature, pressure, pressure and depth at which the water comes in touch with the rocks.

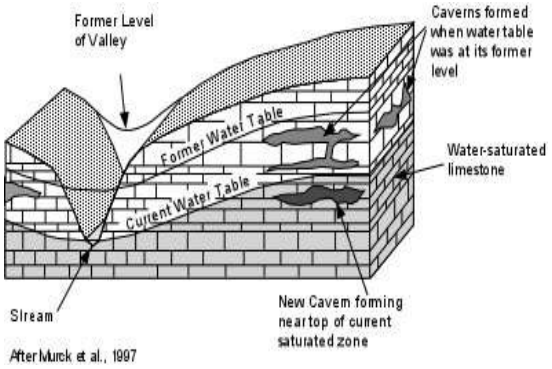


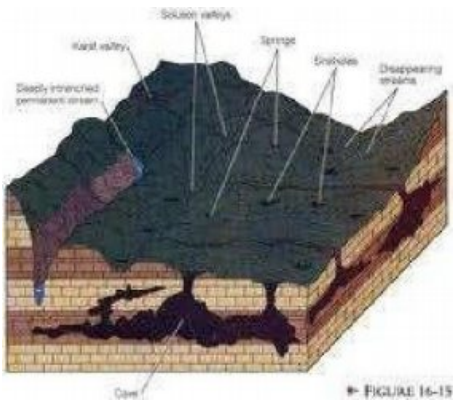
Quite a number of forms are developed due to solvent action of water few are mentioned as below:

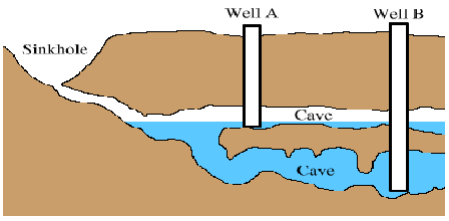
- **Dolines:** These are alsotermed as swallow holes, sink holes and sometimes simply as sinks. A typical dolines is circular or oval depression, which when followed in depth becomes bowl-shaped or cylindrical in cross section.



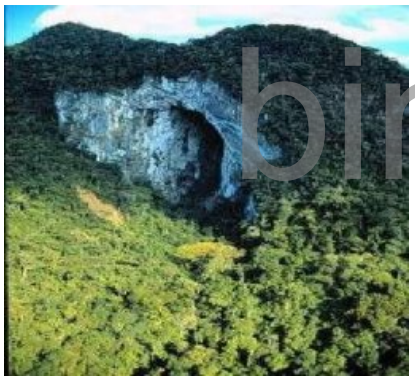
- **Caves:** these may be defined as naturally carved out underground cavities of various dimensions that always have horizontal opening on the surface. They are similar to tunnels with the exception that a cave does not normally have an exit on the other end.

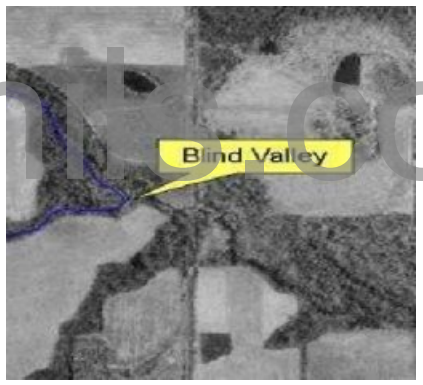






- **Blind Valley:** A blind valley is a valley like feature where a stream flowing through it in the upper reaches suddenly disappears in the lower reaches.



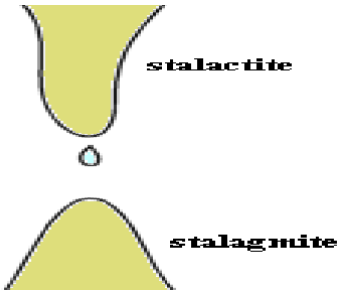


Groundwater is also an active agent of deposition in regions of proper climate and geology. These deposits are typically found to occur in caves and other underground openings and also fissures and crakes in the form of mineral bands, mineral streak or even as distinct mineral layer. Among the minerals very often deposited from the groundwater by precipitation etc. may be mentioned varieties of calcite, silica, fluorite and barite.

The two most commonly known cave deposits are stalactites and stalagmites.

- **Stalactites:** are carbonate projections that hang down from the roof of the caves. They may acquire fantastic shapes like slender rods and cones with flattered bases attached firmly with the roof.



- **Stalagmites:** are also groundwater deposits of carbonate rich droplets from ground upwards.



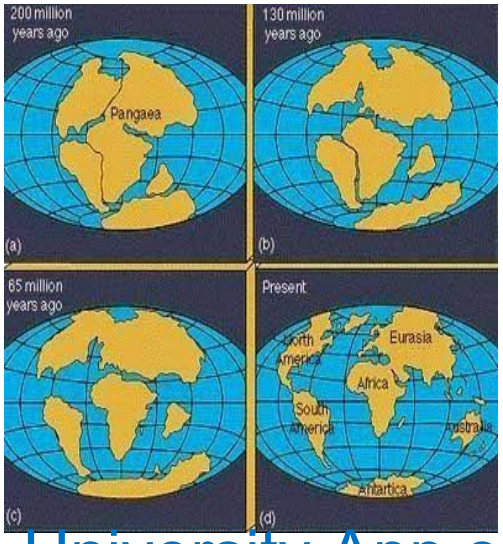
- **Mechanical Work:** Subsurface water is also invariably characterized with some motion due to one or another reason for instances, under the influence of gravity in the zone of aeration and that of hydrostatic head in the Aquifer and underground streams. The velocity of subsurface flow however, is much less when compared to surface water. Hence the mechanical work of subsurface water is more in theory than in practice.

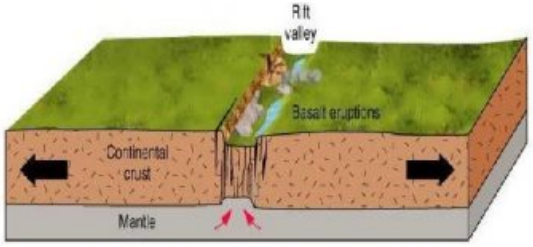
1.7 PLATE TECTONICS

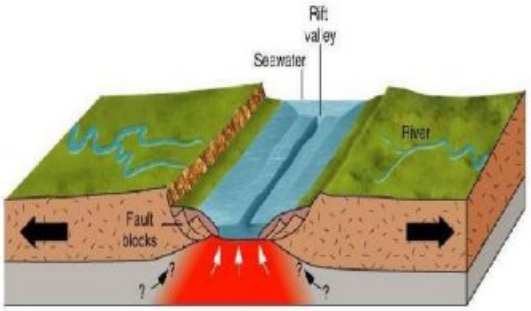
According to this theory, the earth's outer strong layer called lithosphere extending to a depth of 150-200km is divided into several rigid plates. These plates have been in gradual shifting W.R.to each other are called tectonic plates.

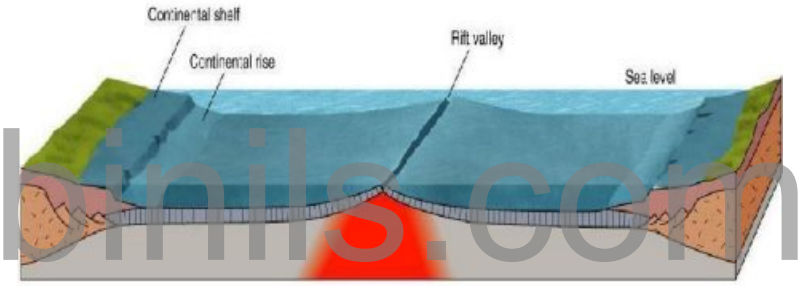
The theory of plate tectonics provides explanations for the past and present day tectonic behaviours of the Earth, particularly the global distribution of mountains seismicity, and volcanism in a series of linear bells, seafloor spreading, polar wandering and continental drift. From several lines of thought and evidences it is learnt that all of the natural phenomena of the earth might be the result of a single basic mechanism, i.e., convection in the mantle.

- The theory of plate tectonics supposes that the sphere of the earth is made up of 7 major and several minor plates which are in constant motion relative to each other.
- The motion of the plates refer to the rigid slabs of the continental and oceanic crust that slides over the plastic zone of asthenosphere of the upper mantle
- A fractures egg shell forms a good analogy to the spherical plates of the earth. These plates are bounded by active linear zones causing volcanism and earthquakes.









Elements of Tectonism

- Seismology permitted an insight into the Earth. As per the seismic data the Earth is composed of a few layers of different composition, density and physical nature.
- The earth consists of three Principal layers, namely crust, mantel and Core.
- Crust is divisible into oceanic and continental crust. The earth's movements involve the upper mantle also in the upper mantle is a layer called low velocity zone which behaves like a fluid. Thus it possesses a plastic flow. The layer is also known as asthenosphere.
- Continental Crust, Oceanic crust and a part of upper mantle constitute a plate which a rigid part of the lithosphere.

- Plates overlie the asthenosphere. Any movement in the underlying asthenosphere affects the plates.

Characteristics of Plates

- A Plate consists of crust and a part of upper mantle.
- Size and Shape of the plates are not constant.
- One large plate may be fragmented into many small plates, many unit to form a large one.
- Plates are spherical of curved and are independent.
- Thickness of plates varies. It is 70 km beneath oceans and 150 km beneath continents.
- Plates are bounded by different boundaries distinguished by the relative motion of the adjacent plates.
- Plates are enclosed by Features like mid-oceanic ridges, oceanic trenches great faults and fold mountain belts.
- The length of the boundary is variable.
- Plates move with respect to each other and to the axis of rotation.
- Plates move with different velocity and in different directions. Even different parts of the same plate move at different velocities.
- Plate margins are subject to deformation .but interior of the plate is free from deformation.
- Plates bearing continental crust will not be consumed at the boundaries.
- Plates and boundaries are not permanent features.

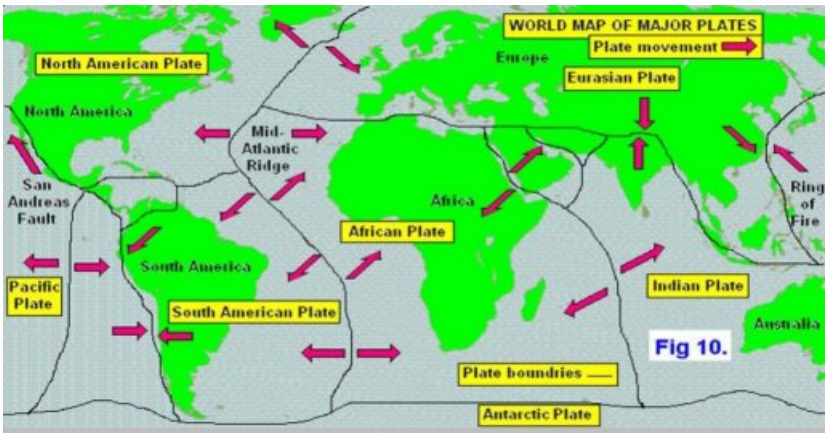
World Plates

Geographical plates of the Earth are recognized as follows. Seven plates are larger and many others are smaller.

Major plates:-

1. The Pacific Plate
2. The North American Plate
3. The South American Plate

4. The African Plate
5. The Antarctic Plate
6. The Indian (Australians) Plate
7. The European/Eurasian Plate



Minor plates:-

1. China Plate
2. Philippine Plate
3. Arabian Plate
4. Iran Plate
5. Nazca Plate
6. Cocos Plate
7. Caribbean Plate
8. Scotia Plate

The collusion may occur in following

1. Two Oceanic Plates
2. One Oceanic & One Continental Plate
3. Two Continental Plate

Plate Boundaries

The surficial trace of the zone of motion is known as plate boundary. The end of the plate is called plate margin. Figure 20.2 shows the boundary and the margin. There are three types of plate boundaries. These are recognized on the basis of the movement associated with the plate junctions.

Theory of Tectonic plate boundary

1. The Diverging plate boundaries
2. The converging plate boundaries
3. The transform fault boundaries

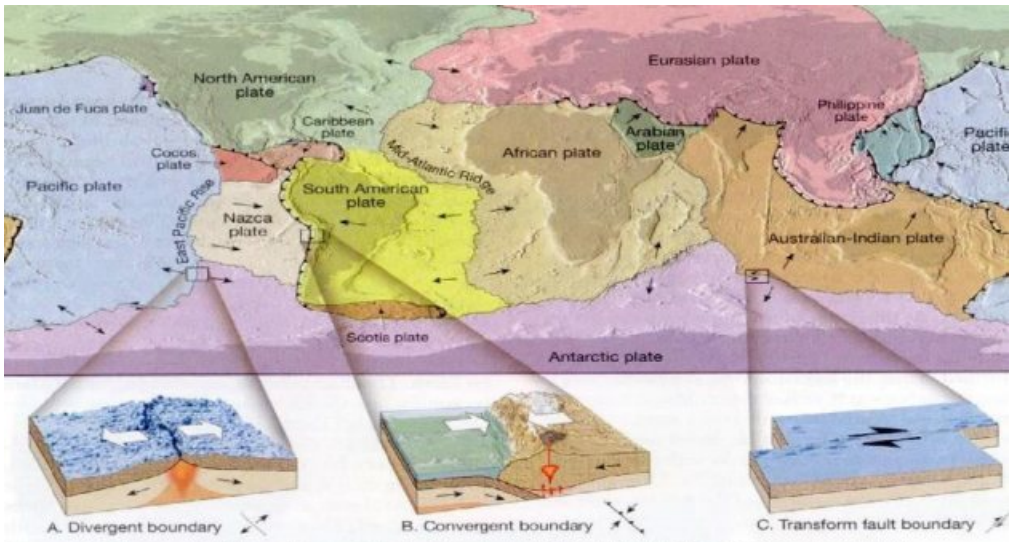


Figure 1.16 Mosaic of rigid plates that constitute Earth's outer shell. (After W. B. Hamilton, U.S. Geological Survey)

The Diverging Plate boundaries

Long the middle of the ocean floor their rises a ridge with a central 'V' shaped valley. The boundary line that separates the two plates runs along the valley bottom. Materials of the two flanks of these mid oceanic ridges move away from each other. This boundary is known as divergent boundary as the plates diverge with reference to the boundary line. But they are never separated. Because new material is poured out continuously and is accreted to the moving plate margins material is symmetrically divided into two halves and mobilised. The symmetry may be produced in this way: A new ribbon of material is added to the margins of separating plates. The rigidity of the material is lower and lower as the centre of the ribbon is approached. Splitting may occur along the line of weak zone. Thus when the ribbon is subjected to tensional forces (because of the mobile plates) it is broken symmetrically as the plane of weakness occupies the central part of the ribbon.

Eg:-

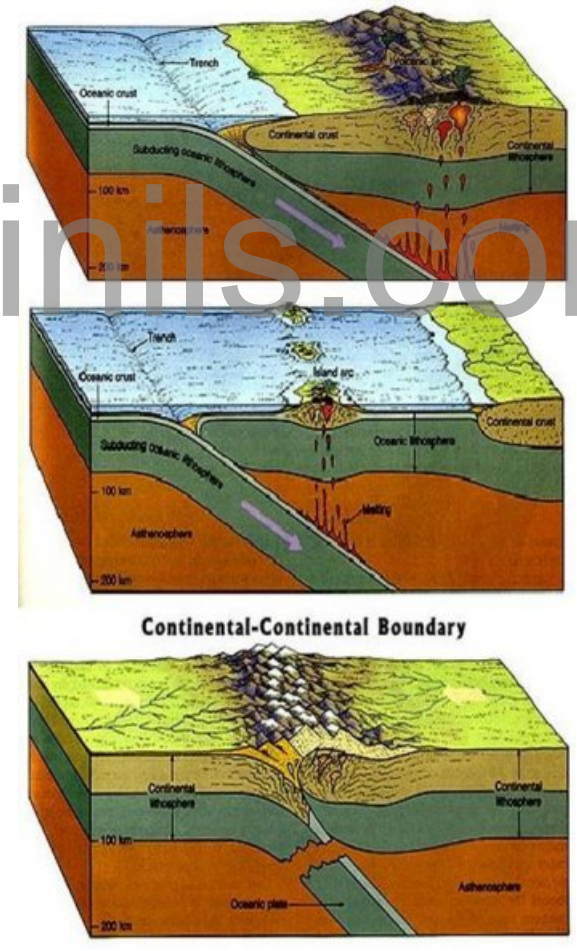
- NA plate VI Eurasian plate.
- Formation of mid Atlantic ridge encircling the globe Arctic Ocean to South Africa.

- Two plates are pulling away from each other.

The Convergent plate boundaries

This boundary is developed as two plates converge towards each other and thus it is known as Convergent boundary. Since land area is lost along this type of boundary, it is known as destructive boundary. For the reason that the material is being sunken at these boundaries they are also known as sinks. Convergent Boundaries are marked by deep sea trenches and fold mountain belts. They may be located along the northern and western border of the Pacific forming Aleutian trench, Japan Trench and Tonga trench and Tonga trench, Western continent slope of the South America forming Eru-Chile trench, Himalayas f India, Mediterranean trench and java trench.

Formation of Himalayas due to convergent movement of plates.



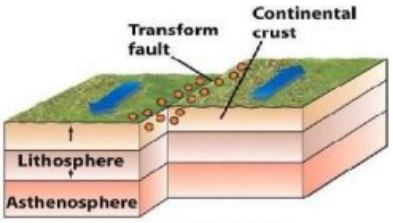
Continental-Continental Boundary

The Transform boundaries

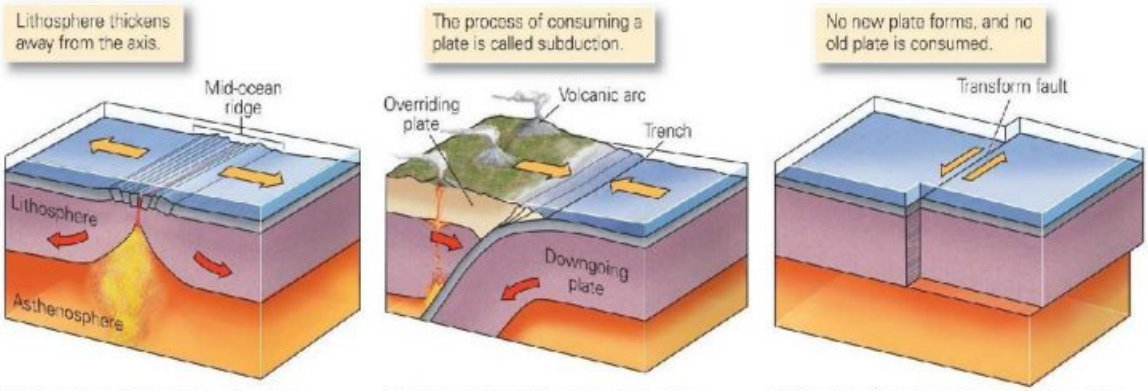
1. Sliding motion of plate, along transform fault boundary.
2. The zones where adjoining plates slide apart each other in a horizontal direction.

Eg:-

California-Transform fault.



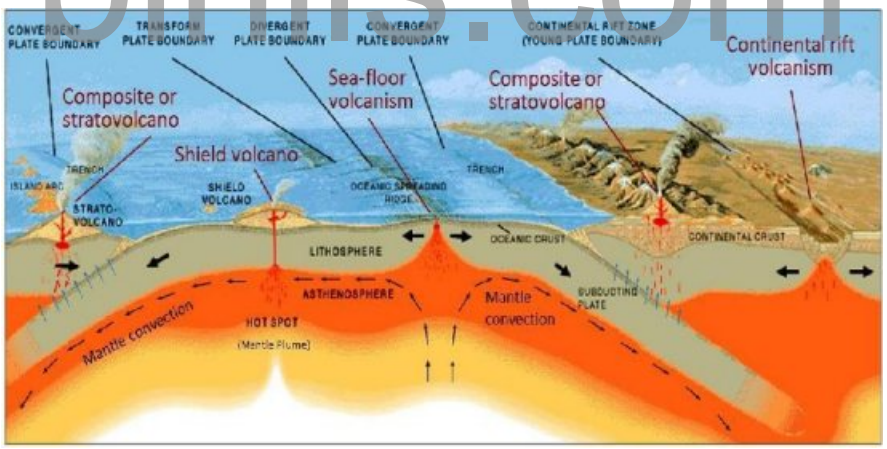
TRANSFORM FAULT BOUNDARY

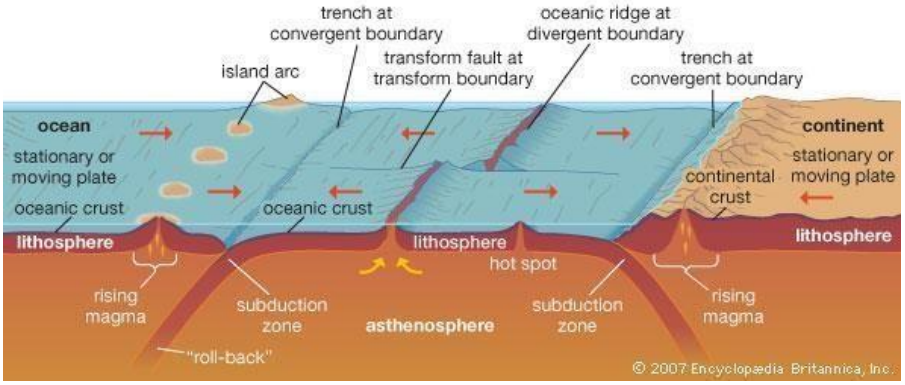


(a) At a divergent boundary, two plates move away from the axis of a mid-ocean ridge. New oceanic lithosphere forms.

(b) At a convergent boundary, two plates move toward each other; the downgoing plate sinks beneath the overriding plate.

(c) At a transform boundary, two plates slide past each other on a vertical fault surface.





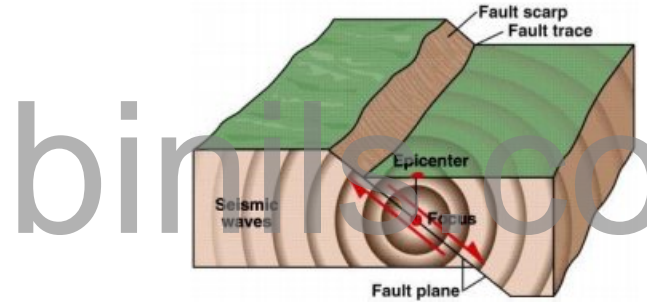
1.8 EARTH QUAKES – SEISMIC ZONES IN INDIA

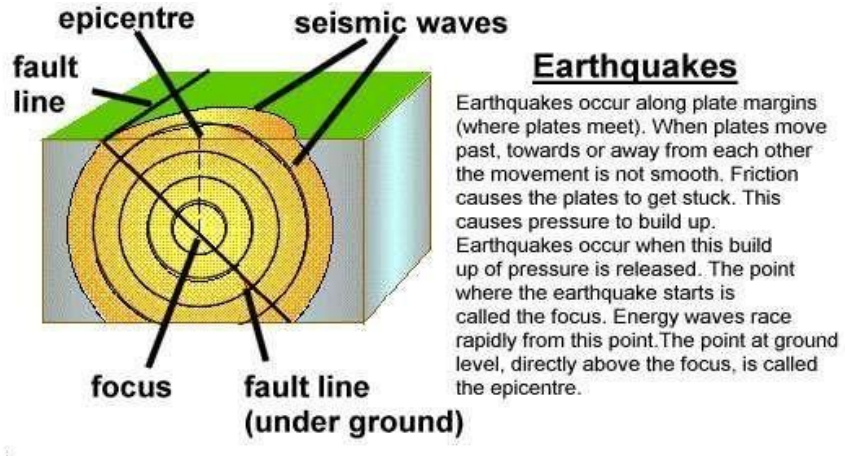
Earth quakes:-

The vibration or shaking of earth crust caused due to movement of either tectonic plates or rock blocks or due to any other natural or artificial causes is called as earth quake.

The physical forces the surfaces are rearranging rock materials by shifting magmas about altering the structures of solid rocks. The adjustment beneath the surface however involve various crystal movements, some of which because of suddenness and intensity produce tremors in the rocks and they are known as earthquake. The science dealing with the study of earthquakes in all their aspects is called seismology.

- Earth quakes generally lost for few seconds only, rarely exceeding one minute.





Important terms involved:

Seismograph: The instrument used to record seismic waves to know the intensity and duration of earth quake.

Seismogram: The seismic record obtained from a seismogram.

Focus: The point where the earth quake starts are called Focus

Epicenter: The point upon the surface of earth, vertically above the focus of an earth quake.

Anticenter: The point which is diametrically opposite to the epicenter is called anticenter.

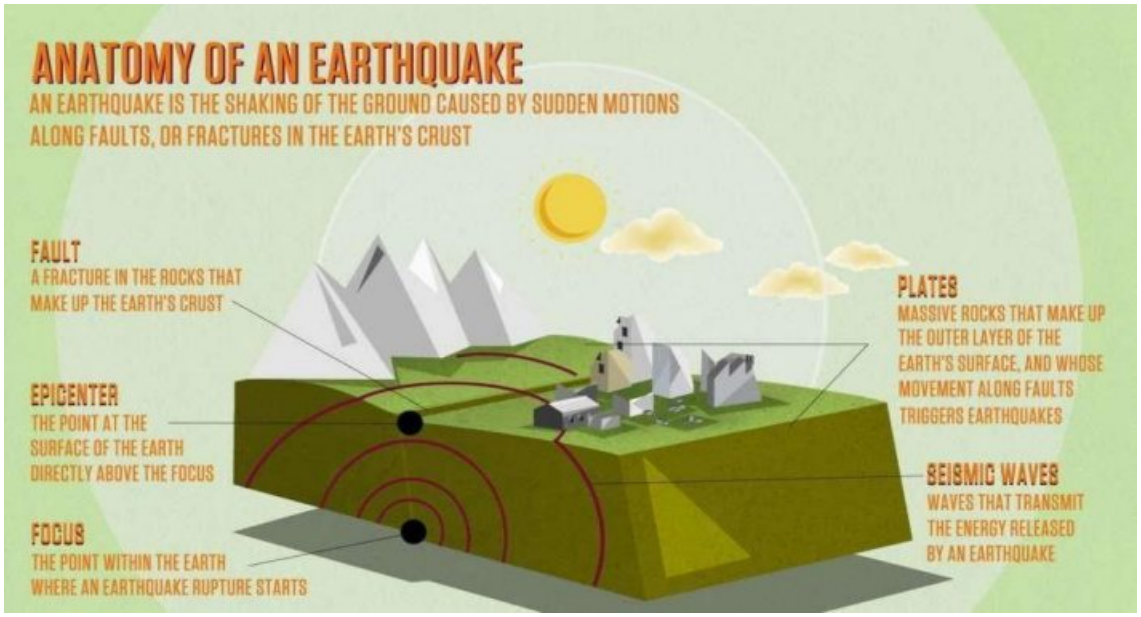
Intensity: Intensity of an earthquake may be defined as the ratio of an earthquake based on actual effects produced by the quakes on the earth.

Magnitude: Magnitude of a tectonic earthquake may be defined as the rating of an earthquake based on the total amount of energy released when the over strained rocks suddenly rebound, causing the earthquake.

Seismic waves: The elastic waves generated from the focus during an earth quake.

Three types of seismic waves:

1. P-Waves (primary waves)
2. S-Waves (secondary waves)
3. L-Waves (surface waves)



P-Waves:

- These are longitudinal waves having short wavelength
- They travel very faster and reach seismic station first

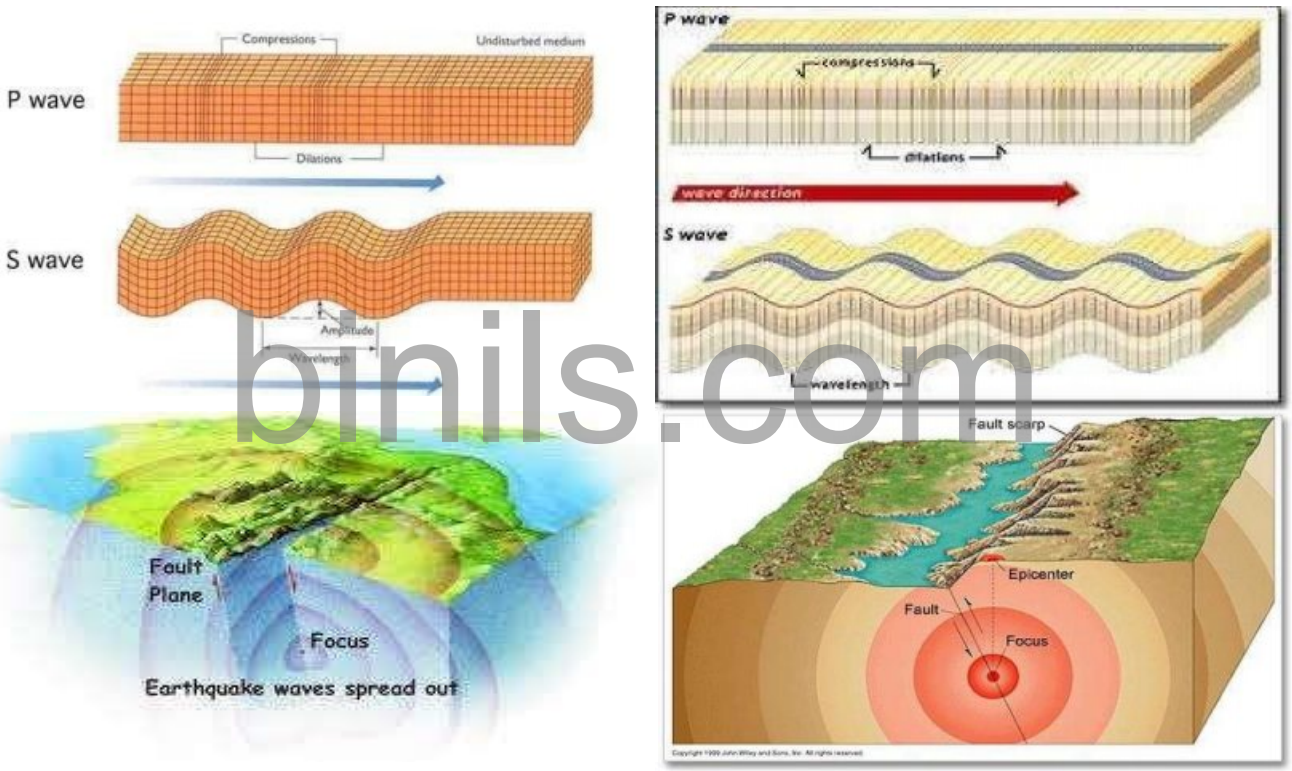
- Their velocity is 1.7 times greater than s-waves
- They passes through solid, liquid, gaseous medium.

S-WAVES:

- These are shear waves which are traverse in nature.
- They travel only in solid medium.

L-WAVES:

- When p and s- waves reached earth surface they are called l- waves.
- Here velocity is much less.



i. **Rayleigh waves:** Complicated waves – makes disaster – at right angled to propagation waves.

ii. **Love waves:** Vibrate and travel of propagation of waves.

iii. **Isoseismal Lines:** Line joining places of equal intensity of earthquake.

Scale of Earthquake:-

1. Ritcher scale (Magnitude based scale)

- Magnitude is expressed in term of amplitude of seismic waves. Recorded in seismogram

5 – Least effect

7 – Moderate

7.50 – 10 – Highly distractive (Disaster)

2. M.M. Scale (Modified Mercalli Scale)

- This is an intensity based scale.

Classification of earthquakes:

1. Depth of focus
2. Intensity & Magnitude
3. Cause of origin

Based on Depth on Focus

1. **EQ based on Depth of focus**

- Shallow focus EQ : focus with in 60km depth
- Intermediate EQ : focus within 300 – 700 km

2. **Based on Magnitude**

CLASS	MAGNITUDE RANGE
A	>7.7
B	7.00 – 7.7
C	6.00 – 7.00
D	5.30 – 6.00
E	<5.30

Based on Causes:-

1. Earth tremors / Feeble EQ
2. Tectonic EQ
3. Volcanic EQ

4. Reservoir Linked EQ

Tremors or Feeble EQ

These are caused due to movement of locomotion engines etc. and are very feeble in nature, not producing and significant effects

Tectonic EQ

Due to movement of tectonic plates, movement of rocks, faulting in rocks etc. They will produce disasters.

Volcanic EQ

Due to volcanic eruption.

Reservoir linked EQ

Due to impounding of water in reservoir of dams.

Earthquake zonings in India:-

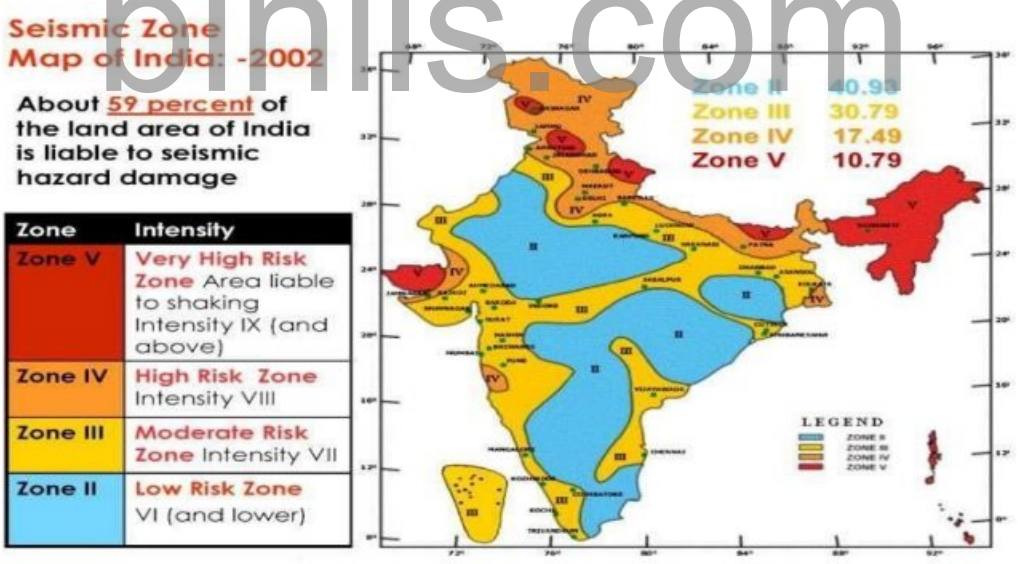


Fig. 1 Seismic zonation and intensity map of India

Zone 5

- Zone 5 covers the areas with the highest risks zone that suffers earthquakes. The IS code assigns zone factor of 0.36 for Zone 5. Structural designers use this factor for earthquake resistant design of structures in Zone 5. The zone factor of 0.36 is indicative of effective (zero period) peak horizontal ground accelerations of 0.36

g (36% of gravity) that may be generated during Maximum Considered Earthquake MCE level earthquake in this zone.

- It is referred to as the Very High Damage Risk Zone. The state of Kashmir, the western and central Himalayas, the North-East Indian region and the Rann of Kutch fall in this zone.
- Generally, the areas having trap or basaltic rock are prone to earthquakes.

Zone 4

- This zone is called the High Damage Risk Zone. The IS code assigns zone factor of 0.24 for Zone 4. The Indo-Gangetic basin and the capital of the country (Delhi), Jammu and Kashmir fall in Zone 4. In Maharashtra Patan area (Koyananager) also in zone 4.

Zone 3

- The Andaman and Nicobar Islands, parts of Kashmir, Western Himalayas fall under this zone. This zone is classified as Moderate Damage Risk Zone. And also 7.8 The IS code assigns zone factor of 0.16 for Zone 3.

Zone 2

- This region is classified as the Low Damage Risk Zone. The IS code assigns zone factor of 0.10 (maximum horizontal acceleration that can be experienced by a structure in this zone is 10% of gravitational acceleration) for Zone 2.