

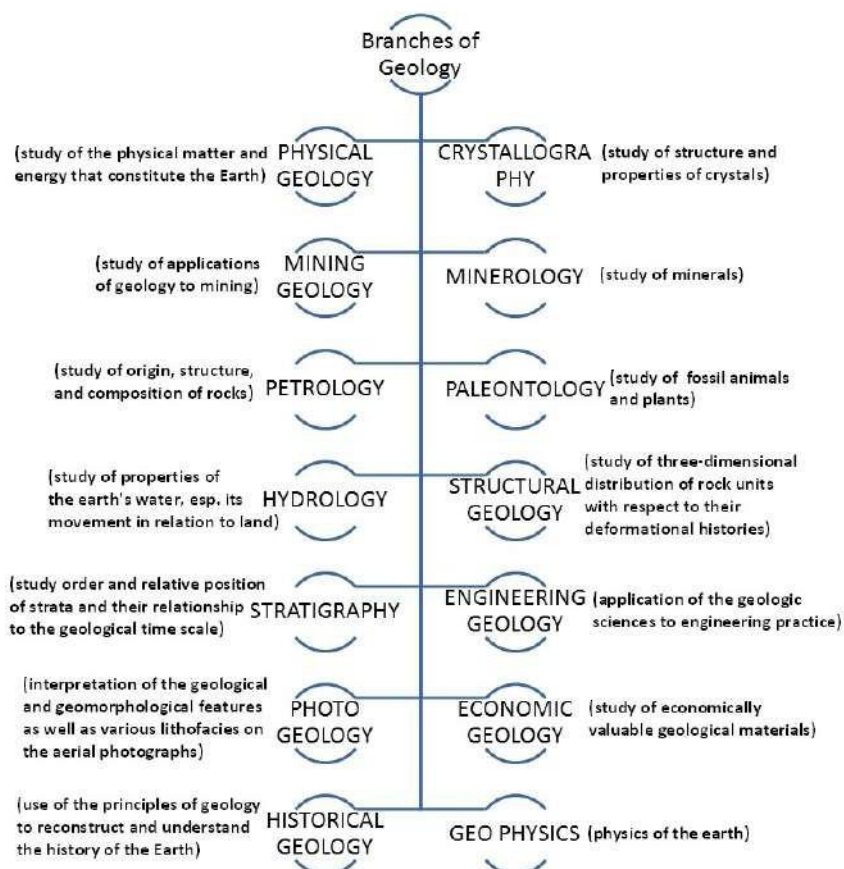
Topic 1: Introduction

INTRODUCTION: (Importance to a Civil Engineer):

The earlier studies of Civil Engineering couldn't see the design of a structure should be preceded by a careful study of its environment, particularly foundations material on which the structure was to be placed. When the St. Francis Dam in Southern California failed in 1928 with a loss of many lives and damages in millions of dollars, the civil engineering profession awoke to the idea that the careful design of a structure itself is not all that is required for the safety of structures. After the failure of St. Francis Dam, the need of environment exploration with proper interpretation of the results was understood by all.

Geology (in Greek, Geo means Earth, logos means study of or Science of) is a branch of science dealing with the study of the Earth. It is also known as earth science. The study of the earth comprises of the whole earth, its origin, structure, composition and history (including the development of life) and the nature of the processes.

Branches of Geology:



Relevance of geology to civil engineering:

Most civil engineering projects involve some excavation of soils and rocks, or involve loading the Earth by building on it. In some cases, the excavated rocks may be used as constructional material, and in others, rocks may form a major part of the finished product, such as a motorway cutting of the site or a reservoir. The feasibility, the planning and design, the construction and costing, and the safety of a project may depend critically on the geological conditions where the construction will take place. This is especially the case in extended 'greenfield' sites, where the area affected by the project stretches for kilometers, across comparatively undeveloped ground. In modest projects or in those involving the redevelopment of a limited site, the demands on the geological knowledge of the engineer or the need for geological advice will be less, but are never negligible. Site investigation by boring and by testing samples may be an adequate preliminary to construction in such cases. The long term economics depends on the engineering safety of the manmade constructions. Durability and maintenance free service of the dams, canals, structures like aqueduct etc. is only possible if engineering safety of them is assured. As every structure is related to rock beneath, proper geological investigations are of utmost importance.

Engineering geology importance:

Engineering geology provides a systematic knowledge of construction material, its occurrence, composition, durability, and other properties. Examples of such construction materials are building-stones, road materials, clays, limestone, and laterite.

The knowledge of the geological work of natural agencies such as water, wind, ice and earthquake helps in planning and carrying out major civil engineering works. For examples, the knowledge of erosion, transportation, and deposition helps greatly in solving the expensive problems of river control, coastal and harbour work and soil conservation.

The knowledge about groundwater that occurs in the subsurface rocks and about its quantity and depth of occurrence is required in connection with water supply irrigation, excavation and may other civil engineering works.

The foundation problems of dams, bridges, and buildings are directly concerned with the geology of the area where they are to be built. In these works, drilling is commonly undertaken to explore the ground conditions. Geology helps greatly in interpreting the drilling data.

In tunnelling, constructing roads, canals, and docks and in determining the stability of cuts and slopes, the knowledge about the nature and structure of rocks is very necessary.

Before starting a major engineering project at a place a detailed geological report, which is accompanied by geological maps and sections, is prepared. Such a report helps in planning and constructing the project.

The stability of the civil engineering structures is considerably increased if the geological features like faults,¹ joints,² folding,³ and solution channels etc. in the rock beds are properly located and suitably treated.

In the study of soil mechanics, it is necessary to know how the soil materials are formed in nature.

For a major engineering project, precise geological survey is carried out and results thus obtained are used in solving engineering problems at hand. The cost of engineering works will considerably be reduced if the geological survey of the area concerned is done before hand.

1- fault: a fracture or fracture zone in rock along which movement has occurred. 2- joint: a fracture in rock along which there has been no displacement. 3- fold: a bend or flexure in a rock unit or series of rock units that has been caused by crustal movements.

Engineering Geologist Vs Civil Engineer:

The engineering geologist presents geological data and interpretations for use by the civil engineer. The civil engineers have to deal mostly with soil and rocks, timbers, steel, and concrete. In a great majority of civil engineering, projects and the designs, involve the soils and rocks almost directly.

Civil engineering is to construct the structure and facilities for transport, water supply, hydropower, flood control, environmental protection, sewage and waste disposal, urban development and more. In above fields, civil engineers construct and maintain waterways, highways, railway, pipelines, dam and reservoirs and tunnels.

BRIEF STUDY OF CASE HISTORIES OF FAILURE OF SOME CIVIL ENGINEERING CONSTRUCTIONS DUE TO GEOLOGICAL DRAW BACKS:

Brief study of case histories of failure of some civil engineering constructions:

With reference to Dams

1. St. Francis Dam
2. Austin Dam
3. Lafayette Dam

Note: Geological studies at the dam site will also suggest which design is suitable for a given geological context. For example, Gravity dam needs very strong and competent foundation rocks; for buttress dams, relatively less strong foundation rocks are enough; arch dam need very strong and stable abutment rocks; for earth dams, even weak foundation rocks meets the requirement.

With reference to Reservoir

1. Jerome reservoir of Idaho
2. Hondo reservoir of Mexico

Note: intense weathering in the rocks upstream causes silting problem. Porosity and permeability of rocks, occurrence of faults, joints and other weak planes cause leakage problems. Ground water conditions also play a major role in influencing leakage. Thus proper studies of geological conditions at any proposed reservoir site will forewarn an engineer of the problems, if any.

With reference to Tunnels

1. Ram-ganga diversion tunnel (Himalaya)
2. Umiam-Barapani tunnel (Meghalaya)
3. Koyna Tunnel (Bombay)

Note: Competence of rocks, associated geological structures like bedding, faults, joints, porosity and permeability of rocks, and ground water conditions are the geological conditions which need to be thoroughly studied to solve such problems.

GEOLOGICAL CONSTRAINTS IN CIVIL ENGINEERING

The geology of an area dictates the location and nature of any civil engineering structures.

Roads and Railways

Problems for a road or railway project may be caused by any of the following geological features:

- Faults
- Junctions between hard and soft formations
- Boundaries between porous and impermeable formations
- Spring-lines
- Fractured granites
- weathered schists²
- Landslip areas
- Areas where beds dip towards the road or railway, as shown in the adjacent diagram.



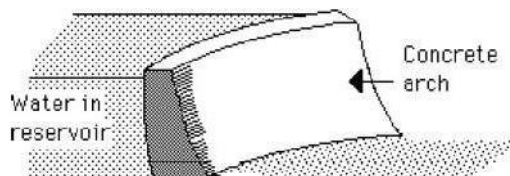
1 - A passage for surplus water from a dam.

2 - A coarse-grained metamorphic rock that consists of layers of different minerals and can be split into thin irregular plates.

Dams:

Geological investigations of a site proposed for construction of a dam must be complete and detailed. Features such as rock-types, geological structures, weathering, fractures and fissures must all be considered. The main considerations are that the material on which the dam rests must be able to carry the weight of the structure without failing. The geology upon which the dam is built must also be impervious¹ to water. The abutments², (the rock faces to which the dam wall is attached) must also be impervious and strong enough to support the dam wall, especially in the case of an arch dam (where more force is transmitted to the abutments).

Left: Cross-section through an arch dam.



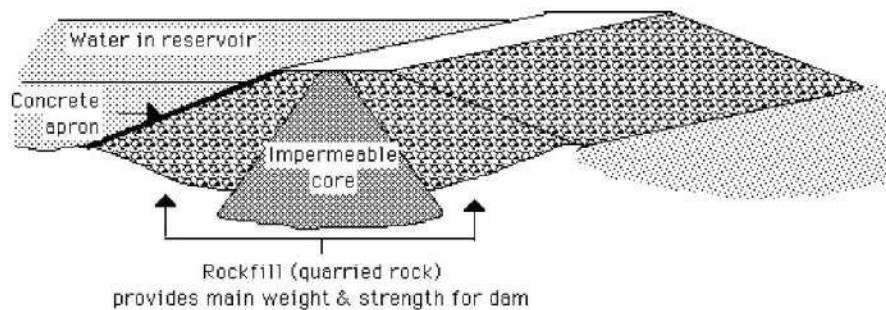
Failure of a dam can be due to many factors including:

- Earthquakes
- A sudden drop in water level
- Inadequate protection of the reservoir side of the dam from wave action
- Insufficient spillway capacity, so that water flows over the whole of the dam surface, with consequent erosion

1 - Not allowing something to pass through; not penetrable. 2 - A structure built to support the lateral pressure of an arch or span, e.g., at the ends of a bridge.

The type of dam selected depends largely on the nature of the surrounding rocks. If they are strong and stable, an arch dam, such as the one shown below can be constructed. This type of dam requires a minimum of construction materials, but the concrete must be of high quality. The Barossa Reservoir Dam (the Whispering Wall), The Roosevelt Dam are examples of an arch dams.

An earth and rock fill embankment dam, as shown in the diagram below must be constructed where the surrounding rocks are not strong enough to support an arch dam. This type of dam is more expensive to build, requiring much more material. The main weight and strength of the dam is provided by compacted quarried rock. The core is made of impermeable material, such as clay, bitumen¹ or concrete.



Cross-section through an embankment dam.

1 - A black viscous mixture of hydrocarbons obtained naturally or as a residue from petroleum distillation.

IMPORTANCE OF PHYSICAL GEOLOGY

This is also variously described as dynamic geology, geomorphology, etc. As the name suggests it deals with:

- (i) Different physical features of the earth, such as mountains, plateaus, valleys, rivers, lakes, glaciers, and volcanoes in terms of their origin and development,
- (ii) The different changes occurring on the earth's surface, like marine transgression, marine regression, formation or disappearance of rivers, springs and lakes,
- (iii) Geological work of wind, glaciers, rivers, oceans, ground water, and their role in constantly molding the earth's surface features, and
- (iv) Natural phenomena like landslides, earthquakes, and weathering.

The main cause for surface changes is weathering. This is a natural phenomenon resulting directly or indirectly due to changes in the atmosphere. It disintegrates and decomposes rocks. This aspect is of special importance from the civil engineering point of view, because color, appearance, strength and durability of rocks are adversely affected by weathering. Thus even granite which is considered ideal for most of the civil engineering works becomes weak and friable on thorough weathering, rendering it useless.

Civil engineers deal with structures like dams which are artificial barriers to the natural flow of rivers. Proper understanding of the geological work of a river and its features will lead to their better utilization for engineering applications

IMPORTANCE OF PETROLOGY

Petrology (Petro = rock, logos = study) deals with the study of rocks. The earth's crust, also called lithosphere, is made up of different petrology types of rocks. Petrology deals with mode of formation, structure, texture, composition, occurrence, types, etc., of rocks. The composition and textural characters of rocks primarily contribute to their inherent strength and durability. Rocks based on their suitability can be used as foundation for dams, for tunneling and materials of construction. Hence this is the most important branch of geology from the civil as engineering point of view.

IMPORTANCE OF STRUCTURAL GEOLOGY

Structural Geology the rocks which form the earth's crust undergo various deformations, dislocations and disturbances under the influence of tectonic forces. The result is the occurrence of different geological structures like folds, faults, joints and unconformities in rocks. The details of mode of formation. Causes. Types, classification, importance, etc., of these geological structures form the subject matter of structural geology. From the civil engineering point of view, it is as important as petrology because these geological structures modify the inherent physical characters of rocks rendering them more suitable or unsuitable for civil engineering purposes. For example, at a dam site sedimentary rocks with upstream dip provide a desirable geological set-up, while the same rocks with downstream dip make the geological set-up most undesirable.

Weathering

Weathering

Weathering is the breakdown of rocks at the Earth's surface, by the action of rainwater, extremes of temperature, and biological activity. It does not involve the removal of rock material.

There are three types of weathering, physical, chemical and biological.

How is erosion different to weathering?

Erosion is the process by which soil and rock particles are worn away and moved elsewhere by wind, water or ice. Weathering involves no moving agent of transport.



Physical Weathering

Physical weathering is caused by the effects of changing temperature on rocks, causing the rock to break apart. The process is sometimes assisted by water.

There are two main types of physical weathering:

- Freeze-thaw occurs when water continually seeps into cracks, freezes and expands, eventually breaking the rock apart.
- Exfoliation occurs as cracks develop parallel to the land surface a consequence of the reduction in pressure during uplift and erosion.

Where does it occur?

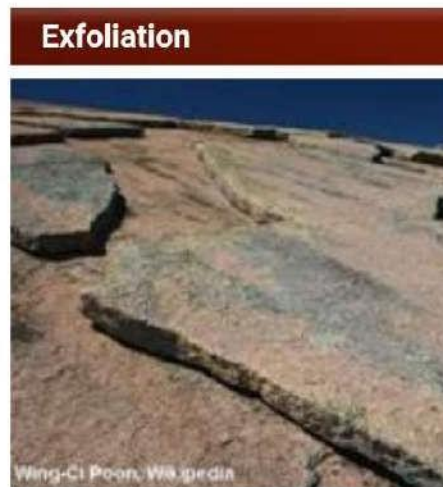
Physical weathering happens especially in places where there is little soil and few plants grow, such as in mountain regions and hot deserts.

How does it occur?

Either through repeated melting and freezing of water (mountains and tundra) or through expansion and contraction of the surface layer of rocks that are baked by the sun (hot deserts).



Find out more about [freeze-thaw](#)



Find out more about [exfoliation](#).

Freeze-thaw

Where does it occur?

In mountainous regions like the Alps or Snowdonia.

How does it occur?

Rainwater or snow-melt collects in cracks in the rocks.



At night the temperatures drops and the water freezes and expands.



The increases in volume of the ice exerts pressure on the cracks in the rock, causing them to split further open.



During the day the ice melts and the water seeps deeper into the cracks.



Rocks broken by freeze-thaw action, Snowdonia

When the rock is finally broken in to small pieces they collect at the bottom of the mountain. The piles of broken rock are called scree.



Scree at Wastwater, Cumbria

View an [animated version of the freeze-thaw process.](#)

Exfoliation

Where does it occur?

Typically in upland areas where there are exposures of uniform coarsely crystalline igneous rocks.

How does it occur?

The rock mass at depth is under high pressure from underlying rocks. It tends to be uniform and lack fractures.



As progressive erosion occurs, the rock mass is subjected to progressively lower pressure of overlying rocks which leads to tension in directions at right angles to the land surface.



This tension is relieved by formation of cracks which follow the land surface - they are relatively flat on plateaus, but can be steep on the flanks of mountains which are called exfoliation domes.



Once the cracks develop, water enters and causes chemical weathering leading to the formation of new low-density minerals. This enhances the cracks and encourages slabs of rock to detach from the surface.



Chemical Weathering

Chemical weathering is caused by rain water reacting with the mineral grains in rocks to form new minerals (clays) and soluble salts. These reactions occur particularly when the water is slightly acidic.

Where does it occur?

These chemical processes need water, and occur more rapidly at higher temperature, so warm, damp climates are best. Chemical weathering (especially hydrolysis and oxidation) is the first stage in the production of soils.

How does it occur?

There are different types of chemical weathering, the most important are:

Solution - removal of rock in solution by acidic rainwater. In particular, limestone is weathered by rainwater containing dissolved CO₂, (this process is sometimes called carbonation).

Hydrolysis - the breakdown of rock by acidic water to produce clay and soluble salts.

Oxidation - the breakdown of rock by oxygen and water, often giving iron-rich rocks a rusty-coloured weathered surface.

Solution



Lupin (Wikipedia)

Malham Cove, Yorks

Find out more on '[Solution](#)'.

Hydrolysis



Peter Loader

Anglesey, N. W

Find out more on '[Hydrolysis](#)'.

Solution

Carbonation

Carbon dioxide in the air dissolves in rainwater and becomes weakly acidic.

This weak "carbonic acid" is able to dissolve limestone as it seeps into cracks and cavities. Over many years, solution of the rock can form spectacular cave systems (see photo).

Note: Stalagmites and stalactites form in caves as water drips from the roof, depositing some of its dissolved calcium carbonate, as carbon dioxide is released into the air.

Acid rain

Polluting gases, like sulphur dioxide and nitrogen oxide dissolve in rainwater to make stronger acids. When this rainwater falls, we get acid rain. This acid attacks many rock types, both by solution and hydrolysis, seriously damaging buildings and monuments.



Cheddar caves, Somerset



Damage to stonework caused by acid rain at Ephesus, Turkey

Hydrolysis

Hydrolysis takes place when acid rain reacts with rock-forming minerals such as feldspar to produce clay and salts that are removed in solution.

The only common rock-forming mineral that is not affected is quartz, which is a chemically resistant mineral. This is why quartz and clay are the two of the most common minerals in sedimentary rocks.

Spheroidal weathering

The weird shapes form as water attacks the rock along joints and cracks, leaving rounded lumps of un-weathered rock.

The iron-rich minerals in the rock have also oxidised to a brown "rusty" colour.



Spheroidal weathering by hydrolysis, Holy Island, Anglesey.



Church carving showing effects of hydrolysis.

Biological Weathering

Living organisms contribute to the weathering process in many ways:



Trees put down roots through joints or cracks in the rock in order to find moisture. As the tree grows, the roots gradually prize the rock apart.



Many animals, such as these Piddock shells, bore into rocks for protection either by scraping away the grains or secreting acid to dissolve the rock.



Even the tiniest bacteria, algae and lichens produce chemicals that help break down the rock on which they live, so they can get the nutrients they need.

Effects of weathering on granite:

Granite is an igneous rock that injects, or intrudes, as magma into Earth's crust and then cools. It consists of four main mineral compounds. Two of these are types of feldspar, a group of silica compounds that constitute the most abundant mineral group on Earth. Plagioclase feldspar is a compound of sodium and silica; potassic feldspar is a compound of potassium and silica. Granite also contains quartz, the second most abundant rock-forming mineral after feldspar. The fourth main mineral compound is mica, which in granite is a silica compound with a crystalline appearance resembling sheets of paper. Muscovite is mica with a high concentration of potassium. Biotite is mica with iron and magnesium. Each of these mineral groups weathers according to its own chemical properties.

1. Cooling

Granite cools slowly within the Earth's crust. Feldspar, quartz and mica crystals form during the cooling. Vertical and horizontal fissures form within the rock mass as it contracts. The fissures expand to larger fractures as the rock cools further.

2. Wind

Wind, water and ice denude the soil and Earth's crust overlying the granite mass, exposing it to the atmosphere. The rock expands and contracts in reaction to changes in temperature. It shatters on the surface and the fractures widen to form crevices.

3. Hydrolysis

Hydrolysis is the chemical weathering of minerals by a mildly acidic water that forms when rains dissolves trace gases in the atmosphere. The reaction of feldspar minerals in granite with rainwater produces kaolinite, white clay known as "China clay" used in the production of porcelain, paper and glass. Kaolinite is most abundant over weathered granite in hot and moist tropical climates. Biotite and muscovite micas also weather by hydrolysis into kaolinite and release iron, potassium and magnesium into the surrounding soil as nutrients.

UNIT-1 PHYSICAL GEOLOGY

①

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, groundwater and sea - relevance to civil Engineering. Plate tectonics - Earthquakes - seismic zones in India.

Geology - Introduction :-

Geology is the branch of science dealing with earth and related subjects.

Definition :-

* It is the science that deals with the study of earth as a whole.

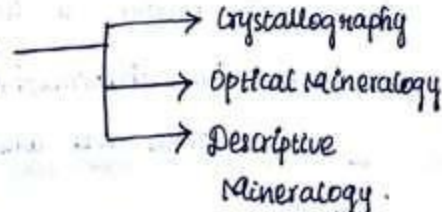
* Engineering Geology may be defined as that branch of applied sciences ^{which} ~~with~~ deals with the application of geology for a safe, stable, economical design and construction of civil Engineering projects.

Geology in Civil Engineering :-

* It enables a civil engineer to understand engineering applications of certain conditions related to the area of construction, which are essentially geological in nature.

* It enables a geologist to understand the nature of geological information that is absolutely essential for a safe design and construction of a civil Engineering project.

Branches in Geology :-

Branches	Description
(i) Physical Geology	<ul style="list-style-type: none">* It deals with the origin, development and ultimate fate of various surface features of the earth and also with its internal structure.* The role played by internal agents and external agents on the physical features of the earth makes major areas of study in physical geology.
(ii) Geomorphology	<ul style="list-style-type: none">* It deals specifically with the study of surface features of the earth, primarily of the land surface.* Detailed investigations regarding development and disposition of mountains, plains, plateaus, valleys and basins. Also various other landforms associated with them fall in the domain of geomorphology.
(iii) Mineralogy	<ul style="list-style-type: none">* Mineralogy is that branch of geology, which deals with formation, occurrence, aggregation, properties and uses of minerals.* Mineralogy <ul style="list-style-type: none">→ Crystallography→ Optical Mineralogy→ Descriptive Mineralogy

Branches	Description
(iv) Petrology	<p>* Formation of various types of rocks, their mode of occurrence, composition, textures and structures, geological and geographical distribution on the earth are all studied under petrology.</p> <p>* Petrology</p> <ul style="list-style-type: none"> → Igneous petrology → Sedimentary petrology → Metamorphic petrology
(v) Historical Geology	<p>* It deals with the past history of the Earth as deciphered from the study of rocks and features associated with them.</p> <p>* Historical Geology</p> <ul style="list-style-type: none"> → Paleo - Geography → Paleontology → Stratigraphy
(vi) Economic Geology	<p>* The branch deals with the study of those minerals, rocks and other materials occurring on and in the earth that can be exploited for the benefit of man.</p> <p>* Includes a wide variety of ores of all the metals and non-metals, building stones, salt deposits, fuels, industrial minerals etc ...</p>

Structure of earth and its composition.

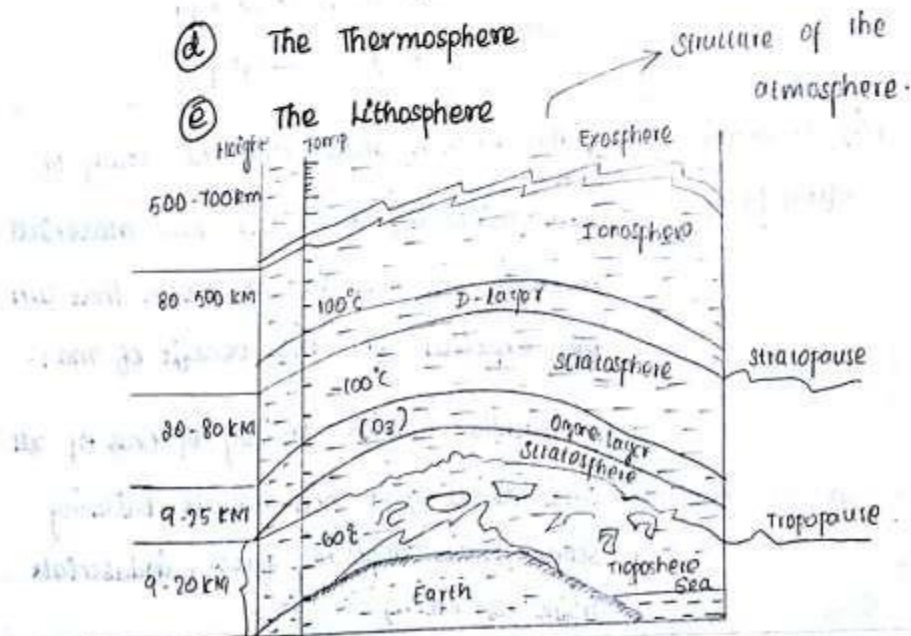
* The shape of the Earth is spheroid with mean equatorial radius of 6378.388 km & polar radius of 6356.912 km.

Atmosphere :-

* The outer gaseous part of the earth starting from the surface and extending as far as 700 km and even beyond is termed as atmosphere.

* Based on the thermal characters the atmosphere is divided into the following layers.

- (a) The Troposphere
- (b) The stratosphere
- (c) The Mesosphere
- (d) The Thermosphere
- (e) The Lithosphere



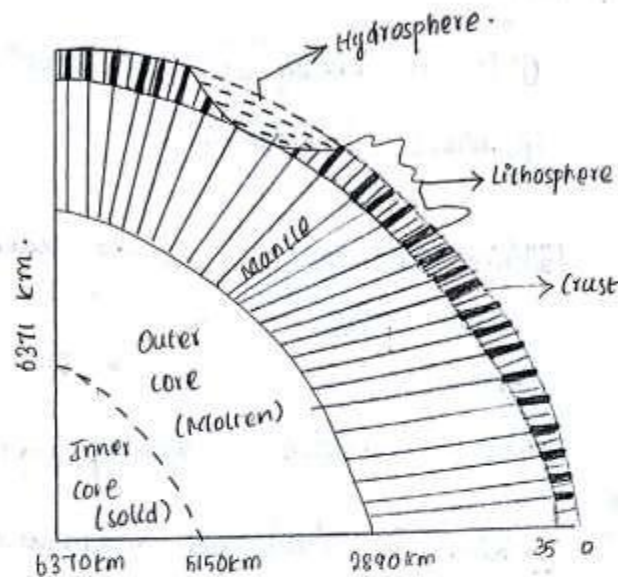
Content	Description
(a) Troposphere	<ul style="list-style-type: none"> * Lowermost zone of the atmosphere rising from the surface of the earth to a height of 11 km. * Its upper boundary called tropopause about 9 km above the poles and at 18 km above the equator.
(b) Stratosphere	<ul style="list-style-type: none"> * Second layer of the atmosphere starting from the tropopause and extending upto an average height of 50 km. * The temperature becomes constant for a height of 20 km (above tropopause) and then starts increasing. * It contains almost the entire concentration of OZONE GAS that occurs above the earth in the form of a well-defined envelope distinguished as the Ozone layer.
(c) The Mesosphere	<ul style="list-style-type: none"> * Third thermal zone of atmosphere which begins at stratopause at about 50 km above the surface and continues up to a height of about 80 km. * It is characterized with a <u>steep fall</u> in temperature that may go to as low levels as 100°C at the upper limit of mesosphere. <p style="text-align: right; color: red; font-size: small;"> Rise/fall @ steep angle. </p>

Content	Description
<p>① Thermosphere</p>	<ul style="list-style-type: none"> * Fourth and the last zone of the atmosphere at about 80 km and extends up to 500 km and beyond. * In this zone, temperature starts rising once again and reaches 1000°C and above. * The IONOSPHERE is a special zone recognized within the atmosphere. Starts from 80 km and extend upwards to variable heights.
<p>② Lithosphere</p>	<ul style="list-style-type: none"> * The term Lithosphere is to include only the uppermost shell of the earth, the crust and a part of the second layer, the mantle up to which the material exists in a definite solid state. * Three specific layers/zone <div style="text-align: center;"> <pre> graph TD A[] --> B[The Crust] A --> C[The Mantle] A --> D[The Core] </pre> </div>

Structure of the earth :-

(4)

Schematic Representation :-



(A) The Crust :-

(i) It is the uppermost solid shell of the earth which has varying thickness in different areas

- (a) under the oceans 5-6 km
- (b) under the continent 30-35 km
- (c) under the mountains 60-70 km

(ii) It extends up to 2900 km from the earth surface.

(I) Crust :-

- (i) upper - continental crust.
- (ii) It consists of all types of rocks like igneous, sedimentary & metamorphic

(iii) Rich in silica & aluminium.

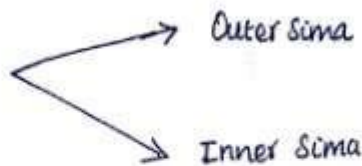
(iv) Its composition is usually granite.

(II) Sima :-

(i) It is known as lower continental crust.

(ii) Thickness is about 22 kms.

(iii) Sima includes
two parts



(iv) Its composition is usually basaltic in nature.

(v) Rich in silica and magnesium.

(vi) Outer sima extends up to a depth of 19 kms.

(vii) Inner sima located at a depth of 19 km and extends up to 33 kms.

(B) The Mantle :-

(i) Materials making the earth become quite different in properties at the base of the crust.

(ii) 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 (change over a short distance

of a material property).

→ A seismologist of Yugoslavia

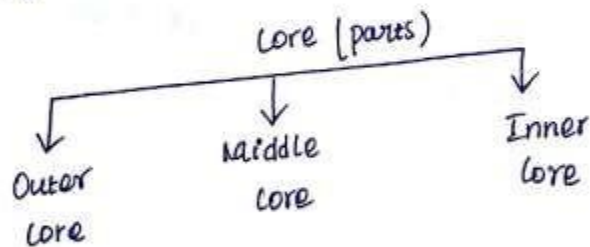
(iii) Mantle is made up of extremely basic material called aptly ultra basic, that is very rich in iron and magnesium but quite poor in silica.

(iv) This zone is characterised with a high density that increases with depth.

(v) In geological literature, it is often referred as α -discontinuity (or) simply as Moho.

(c) The core :-

(i) It separates from the mantle by the Gutenberg weichert discontinuity & extends up to the center of the earth.



(I) Outer core :- liquid like core

(i) Extends of about 1300 kms. +

(ii) It is made of homogenous fluid.

depth \rightarrow 2900 km to 4800 km.

(II) Middle core :-

(i) It is a transition layer.

(ii) Extend from ~~4900~~ ⁴⁹⁸² km to ~~5120~~ ⁵¹⁹¹ km.

(iii) It is of fluid to semifluid state.

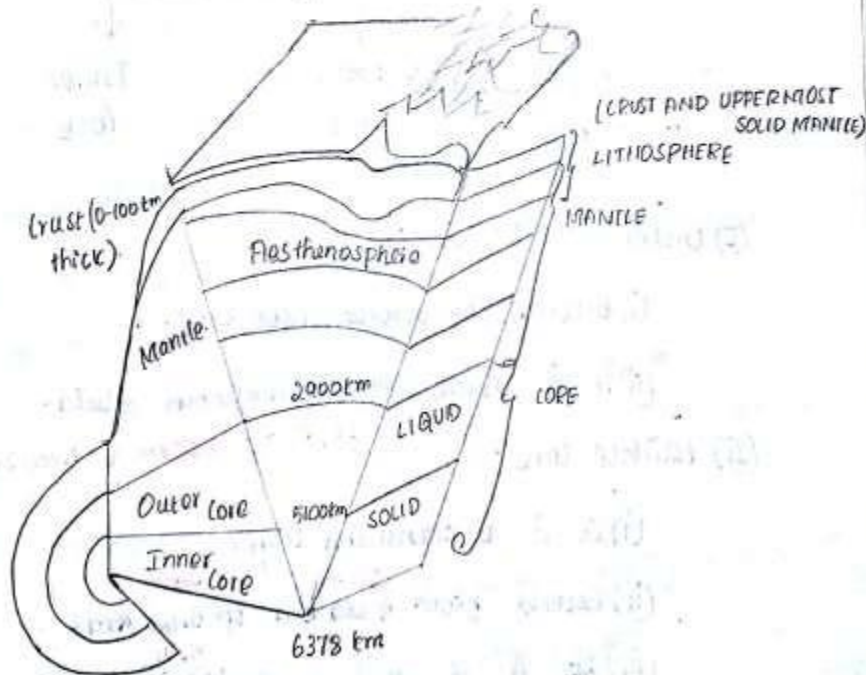
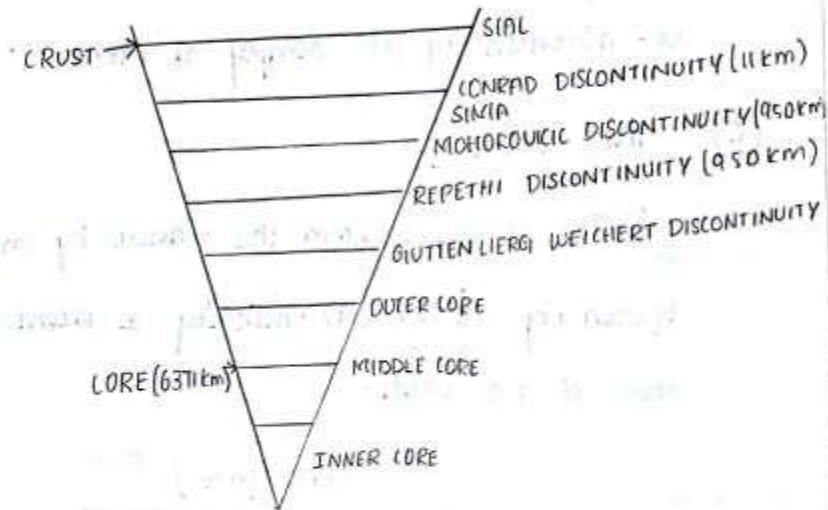
(III) Inner core starts from 4800 km to 6370 km

Solid character

(i) Thickness = 1250 km.

(ii) It is a solid state with density = 18

(iii) Contains certain metallic Nickel & Iron and is called "nife".



Weathering :-

(6)

(i) 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.

(ii) (In other words weathering is the process by which various natural agents, as wind and water act upon exposed rock, causing it to disintegrate to sand and soil.)

Methods :-

(i) Physical weathering / Mechanical weathering

(ii) Chemical weathering.

Physical weathering :-

(i) It is also known as mechanical weathering.

(ii) It is a natural process of in-situ disintegration of rocks into smaller fragments and particles through essentially physical processes without a change in their composition.

(iii) Mechanical weathering is one of the very common geological processes of slow natural rock disintegration in all parts of the world.

(iv) Temperature variation and organic activity (Activity of plants and animals that cause physical weathering of landforms).

Frost Action :-

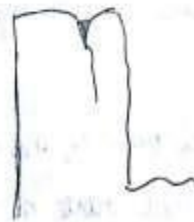
(i) Water on freezing undergoes an increase in its volume by 10%. This expansion is accompanied by exertion of pressure at the rate of 140 kg/cm.

(ii) In areas of intensive cold and humid climates, temperatures often ^{fall} below the freezing point of water repeatedly during ¹ winter months.

(iii) Freezing of water in pots and pools, water pipes and taps, also cracks in concentrated roads causing their bursting & disintegration in many cases is a matter of common observation.



→ (a) Rainwater collects in a crack



→ (b) The temperature falls below 0°C. The water freezes and expands, making the crack bigger.



→ (c) Eventually after repeated freezing and thawing, the rock breaks off.

Thermal Effects (Insolation) :-

(7)

(i) During different weather conditions rocks undergo physical disintegration by another phenomenon related to temperature.

(ii) Rocks like many other solids, expand on heating and contract on cooling.

(iii) Such repeated variations in temperature experienced by a body of rock gradually break into smaller pieces especially in the top layers, by development of tensile stresses developing from alternate expansion and contraction.

Exfoliation :-

(i) The phenomenon of peeling off of curved shells from rocks under the influence of thermal effects in association with chemical weathering is often termed as exfoliation.

Unloading :-

(a) It is also known as sheeting.

(b) Rock masses remain confined from sides but due to relief of pressure from above, they expand upwards, consequently joints develop in them parallel to the uncovered surface dividing them into sheets.

Chemical Weathering :-

(a) It is a process of alteration of minerals whereby the primary minerals (of primary rocks) are converted into new compounds.

Process involved in chemical weathering

- (i) Dissolution
- (ii) Hydration & Hydrolysis
- (iii) Oxidation and reduction
- (iv) Carbonation
- (v) Colloid Formation

Spheroidal weathering :-

(i) It is a complex type of weathering observed in jointed rocks and characterized with the breaking of original rock mass into spheroidal blocks.

(ii) Both mechanical and chemical weathering is believed to actively co-operate in causing spheroidal weathering.

Biological weathering :-

* The weathering process, related to the activities of micro-organisms such as bacteria as well as plants and animals is termed as biological weathering.

Factors Affecting weathering :-

- (a) Nature of the rock.
- (b) climate
- (c) Physical Environment.

The Continental Drift Hypothesis :-

(8)

Assumptions :-

(i) Earth's crust is composed of various individual huge rock masses, called continents.

(ii) These land masses / blocks called continents have been broken from the original single solid crust and are drifting from their initial positions from time to time.

(iii) These solid continental masses of the Earth's crust are thus assumed to be moving over the underlying viscous fluid in the mantle. These masses thus act like floating bodies, which may drift from one place to another under the influence of forces like tidal forces.

(iv) The theory of continental drift was first of all developed by Mr. Alfred Wegener of Germany.

Tectonic Plates :-

(i) The upper part of the Earth is made up of a few large shell-like bodies called plates.

(ii) These plates are made of solid, rigid and cooled rocks of the crust and the mantle.

(iii) Each plate has its own boundaries.

(iv) These plates are thus floating over the dynamic mantle and may move in different conditions.

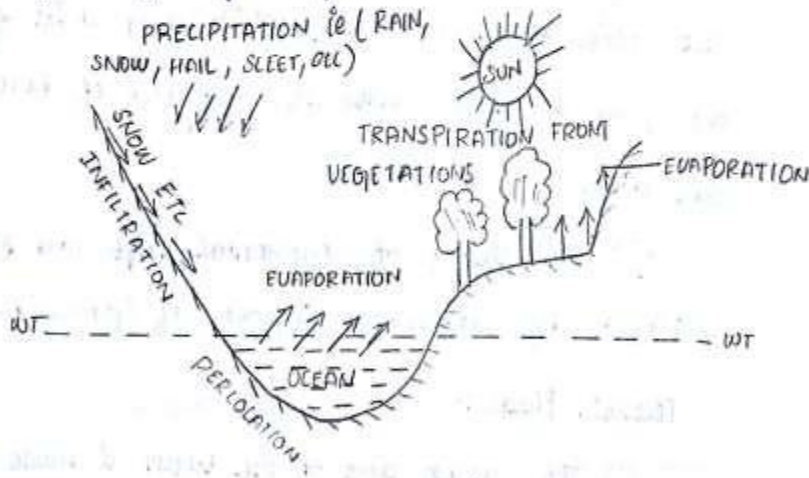
(v) Due to their tectonic movement, these plates are referred to as tectonic plates.

Working of Ground Water :-

* Ground water is the under-ground water that occurs in the saturated zone of variable thickness and depth below the Earth's surface.

Origin of Ground Water :-

* The origin of ground water is carried out through hydrological cycle.



Occurrence of Ground Water :-

* The rainfall that percolates below the ground surface, passes through the voids of the rocks and joins the water table.

The volume of water contained in the ground reservoir, in any localised area, i.e. the water storage capacity of the ground water is dependent upon (9)

- (a) Porosity of the rocks
- (b) Rate at which water is added to it by infiltration.
- (c) Rate at which water is lost from it by evaporation, transpiration, seepage to surface courses and withdrawal by man.

Geological Work of Ground water :-

* The ground water develops openings, running from the ground surface and extending deep into the under-ground rocks, called caves (or) caverns.

* It also develops a number of surface depressions called sinks (or) Dolines.

* Sinks are the circular / oval shaped depressions formed in the ground surface of the underlying water-soluble rocks.

* Caves are formed when the solvent action of ground water is particularly below the surface-

Geological work of water :-

The river originates from the mountain head region and reaches the sea.

Head Region :-

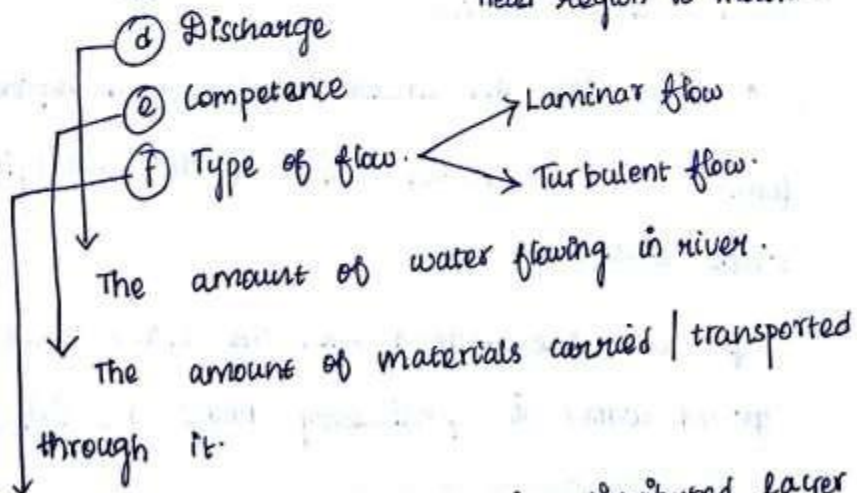
The mountainous region where from the river actually originates and it is called head region.

Sources of stream water :-

- (a) Run off
- (b) Sub surface water.
- (c) Glacial melt water.

Components of River :-

- (a) Channel → The path formed along the course of river
- (b) Velocity → The distance flowed per unit time.
- (c) Gradient → It is the slope of river starting from head region to mount.



Laminar flow → Water moves in undistributed layer fashion

Turbent flow → Water flows in irregular manner due to disturbance.

Stream Erosion :-

(10)

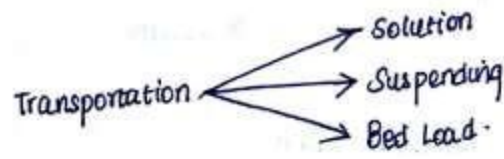
Methods :-

- (a) Chemical action
 - (b) Hydraulic action
 - (c) Abrasion
 - (d) Attrition
- * It includes the solvent and chemical action of water on country rocks.
- * The flowing water hammer the uneven faces of jointed rocks exposed along its channel and remove the joint blocks. This process is called hydraulic action.
- * The flowing water uses rock fragment such as pebbles, gravel and sand.
- * It is the breaking of the transported material themselves due to mutual position collision. It causes rock fragments to become rounder and smaller in size.

Stream Transportation :-

LOAD :-

- * The amount of solid materials transported by a stream called load.



Solution :-

* The amount of ~~materials~~ dissolved materials is carried by a stream.

Suspension :-

* The amount of uneven grains carried by stream.

Bed Load :-

* Huge blocks rocks down due to the hydraulic action at a stream which normally occurs in water falls.

Stream Deposition :-

* The loose rocks materials are transported by stream are deposited where the velocity of flowing of water is reduced.

* The materials which are deposited as sediment is called alluvial deposits.

Depositional Land forms :-

- (i) Alluvial fans
- (ii) Flood plains
- (iii) Natural levees
- (iv) Point bars
- (v) Deltas

Features of Stream Erosion :-

(11)

- (a) Potholes → Circular and deep holes into solid rocks by sand grains.
- (b) Waterfalls → The falling of stream water from a height is called waterfalls. It occurs at places where the stream profile makes a vertical drop.
- (c) Gorges → A narrow deep river valley which is called gorges. It is normally developed in hard rock terrain.

Stream Meanders :-

- (i) The symmetrical S-shaped loops found in the course of a river are called MEANDERS.
- (ii) It grows due to deposition of sediment along slip off side and erosion at the undercut side.

Rivers and Engineering Consideration :

- Rivers requires construction of bridge across them for carrying highways and railways.
- Water power of rivers can be utilized to generate hydroelectric.
- River deposits are the important sources of construction material.

Geological work of wind :-

→ The air currents in motion are called wind.

→ The wind is formed due to pressure difference which is due to change in temperature, wind, volume

Wind Erosion :-

(i) The wind erosion is not restricted to arid and semi arid region.

(ii) Wind thus erode in }
three ways }
Deflation
Abrasion
Attrition.

Deflation :-

* Lifting and removal of loose material by wind is called deflation.

Abrasion :-

* The process in which sand grains are used as tools for eroding rocks is called abrasion.

Attrition :-

* The particle that travels with wind, collide against each other.

* This mutual collision leads to the further break down and the process is called attrition.

Wind Transport :-

* Turbulent wind can easily sweep small dust particles and carry them greater distance in suspension.

* However sands are transported in a series of jumps and rolls along the ground, such processes are called saltation.

Wind deposits :-

* Also called as 'EOLIN' deposit.

* Wind deposit types.

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graph LR; A[Wind deposit types] --> B[Sand dunes]; A --> C[Loess]
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Engg. Considerations :-

* A Sand dune causes major problem for civil Engg, it may travel in any distance and direction may cause bury agricultural land forest and even endanger township.

Geological work of Earthquake :-

→ An Earthquake is a sudden vibration of earth surface by rapid release of energy.

→ This energy released when two parts of rock mass move suddenly in relation to each other along a fault.

Effects of Earthquake :-

- (i) Buildings are damaged.
- (ii) Roads are fissured, railway lines are twisted and bridges are destroyed.
- (iii) Rivers changes their course.
- (iv) Landslides may occur in hilly region.

Earthquake Intensity :-

→ It is a measure of the degree of disturbance caused by an earthquake.

→ It is expressed by a number as given in the earthquake intensity scale.

Seismographs :-

* Seismographs are instruments which detect and record earthquakes.

Earthquake waves (seismic waves).

- (a) Primary waves (P-waves)
- (b) Secondary waves (S-waves).
- (c) Surface waves (L-waves).

Classification of Earthquake :-

(B)

Classification - I → Depending on mode of origin

- Due to Surface causes :- Generated by land slopes and collapse of roof of underground cavities.
- Due to Volcanic causes :- It may also produce earthquake but very feeble.
- Due to tectonic plates :- Most numerous and disastrous.

Classification - II → Depending on depth of focus.

- Shallow Focus :- Depth of focus up to 55 kms.
- Intermediate Focus :- Depth b/n 55-300 kms.
- Deep Focus :- Depth from 300-600 kms.
- Note :- Shallow earthquake are more violent at the surface but affect smaller area.

Earthquake Intensity Scale :-

- (a) ROSSI FOREL SCALE :- It has 9 divisions
- (b) Intensity - I :- Weakest Earthquake
- (c) Intensity - IV :- Cause damage to property
- (d) Intensity - IX :- Strongest Earthquake that cause massive destruction to man-made structure and natural objects.

Richter Scale : Devised by Charles F. Richter an American seismologist.

MAGNITUDE	EFFECTS
2.5	Not felt but recorded
4.5	Local damage
6.0	Can be destructive in popular region
7.0	Major earthquake inflict series damage.
> 8.0	Great earthquake cause total destruction.

Distribution of Earthquake :-

The zones where earthquake occurs are known as seismic belts.

→ Circum Pacific belt : 80% of the world earthquakes occur in this belt.

→ ALPINE HIMALAYAN Belt :- Europe to East Indies

→ RIFT VALLEY region :- East and Central Africa.

Certain Important Earthquakes :-

- (a) The Assam Earthquake (1897)
- (b) The Kangra Earthquake (1905)
- (c) The Bihar Earthquake (1934)
- (d) The Assam Earthquake (1950)

Geological work of sea :-

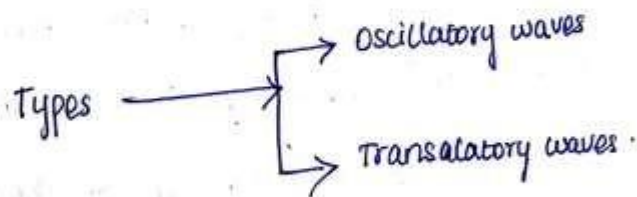
(i) A sea is an extensively developed continuous body of salt water having numerous inland extensions.

(ii) There is generally a sequence of slopes from shore to the sea floor.

(iii) Marine water is spread over more than $\frac{2}{3}$ of the earth surface.

Sea Waves :-

* These may be described as adulatory disturbances on the sea water surface due to strong rushing winds, earthquakes, attraction of sea water by the sun and the moon.



Currents :-

* These are layers (or) strips of sea water that are actually pushed forward in a particular direction.



Marine erosion :-

* Marine water erodes the rocks at the shore and elsewhere with which it comes in contact in a manner broadly similar to that of stream water.

* The work of erosion is accomplished in three ways

(a) Hydraulic Action

(b) Abrasion

(c) Corrosion.

Features due to marine erosion :-

(a) The strength of the sea waves and currents, their magnitude, velocity and duration of operation.

(b) The lithology of the shore (ie) type of rocks, their texture, structure and composition.

(c) The seaward slope of shore line.

(d) The height of the shore line.

(e) The depth and chemical composition of water.

(f) The original profile of the shore line.

Marine deposition :-

There are ~~more~~ two methods of marine deposition-

(a) Shallow water deposits.

(b) Deep water deposits.