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 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 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	* 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	* 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	* Mineralogy is that branch of geology, which deals with formation, occurrence, aggregation, properties and uses of minerals. * Mineralogy → Crystallography → Optical Mineralogy → Descriptive Mineralogy.

Branches	Description
(iv) Petrology	* Formation of various types of rocks, their mode of occurence, composition, textures and structures, geological and geographical distribution on the earth are all studied under petrology. * Petrology → Igneous petrology → Sedimentary petrology → Metamorphic petrology
(v) Historical Geology	* It deals with the past history of the Earth as deciphered from the study of rocks and features associated with them. * Historical Geology → Paleo - Geography → Paleontology → Stratiography
(vi) Economic Geology	* The branch deals with the study of those minerals, rocks and other materials occuring on and in the earth that can be exploited for the benefit of man. * Includes a wide variety of ores of all the metals and non-metals, building stones, salt deposits, fuels, industrial minerals etc ..)

- Structure of earth and its composition.

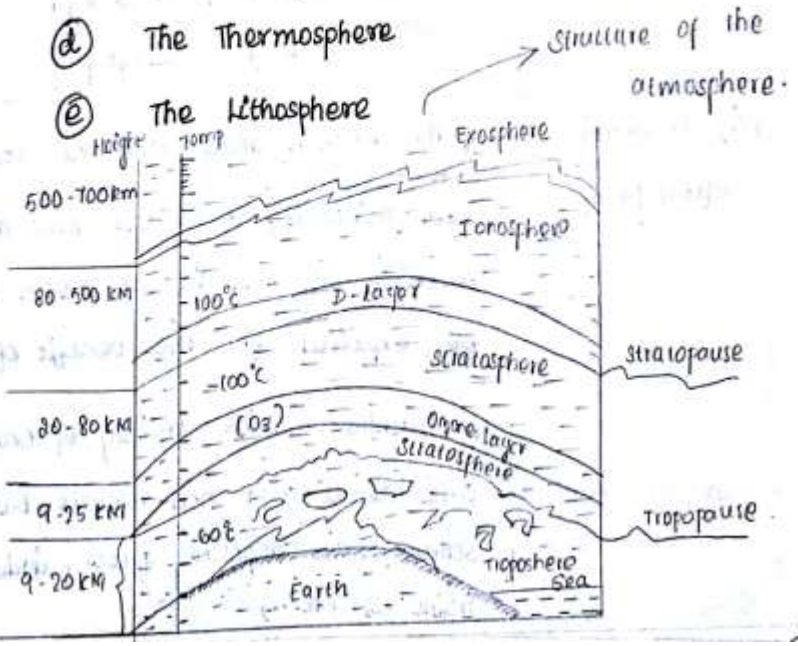
* The shape of the Earth is spheroid with mean equatorial radius of 6378.388 km & polar radius of 6356.912 km.

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 in to the following layers.

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



Structure of the atmosphere.

Content	Description
(a) Troposphere	* 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	* 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	* 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 steep fall in temperature that may go to as low levels as 100°C at the upper limit of mesosphere.

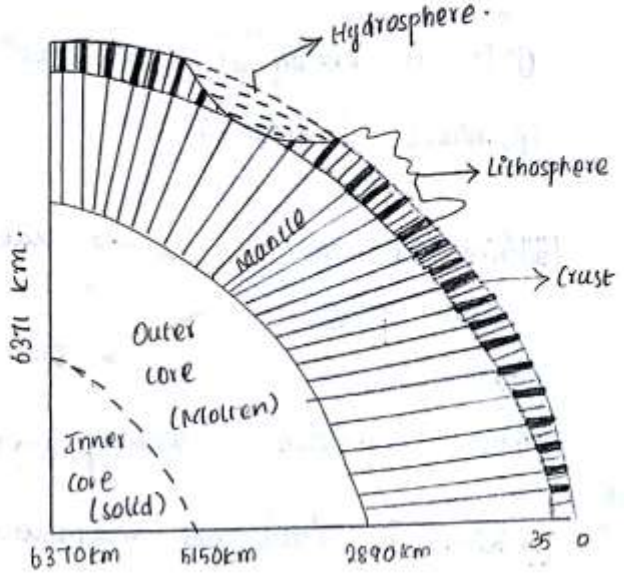
Rise / fall @ steep angle.

Content	Description
(d) Thermosphere	* 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 IONOSPHER is a special zone recognized within the atmosphere. Starts from 80 km and extend upwards to variable heights.
(e) Lithosphere	* 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 The Crust, The Mantle, the core.

(4)

Structure of the earth :-

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) Sial :-

(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 20 kms.

(iii) Sima includes two parts → Outer Sima, Inner Sima

(iv) Its composition is usually basaltic in nature.

(v) Rich in silica and magnesium.

(vi) Outer Sima Extends up to a depth of 19kms.

(vii) Inner Sima located at a depth of 19 km and extends upto 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

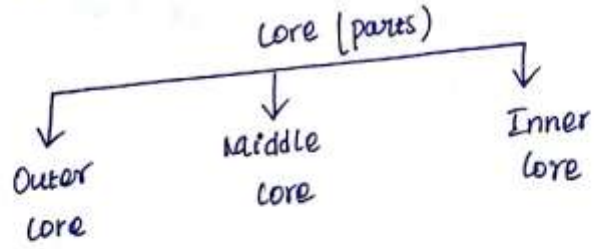
(iii) Mantle is made up of extremely basic material called aptly ultra basic, that is very rich in iron and magnesium but quite poor in silica.

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

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

(c) The core :-

(i) It seperates from the mantle by the Guttenberg 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 → 2900 km to 4800 km.

(II) Middle core :-

(i) It is a transition layer.

(ii) Extend from ~~4900~~ 4982 km to ~~6370~~ 5121 km.

(iii) It is of fluid to semifluid state.

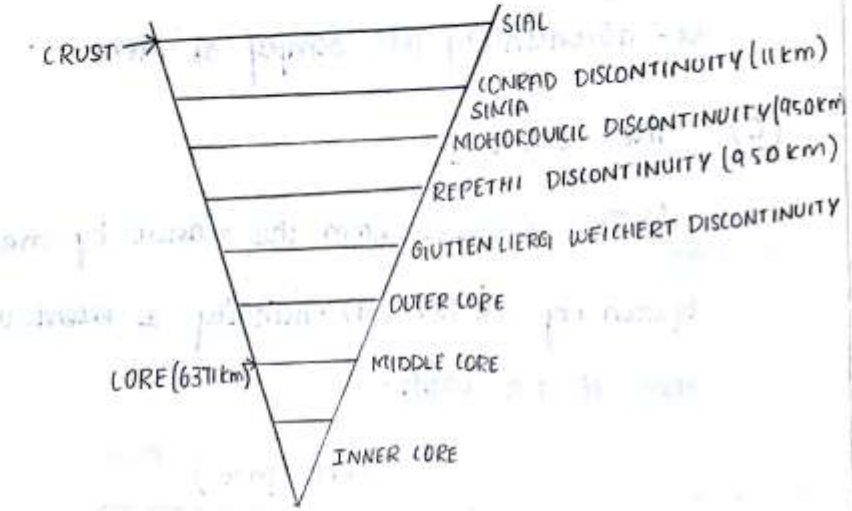
(III) Inner core starts from 4800 km to 6370 km

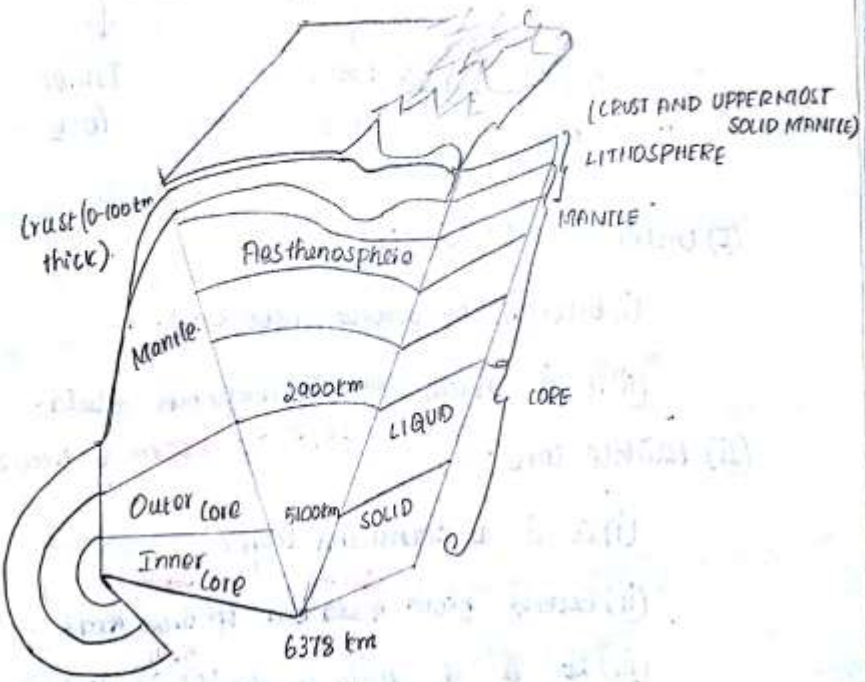
Solid character

(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 in to 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.

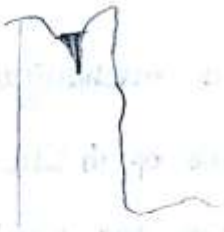
(iv) Temperature variation and organic activity (Activity of plants and animals that cause physical weathering of landforms).

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 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 in to sheets.

Chemical Weathering :-

(a) It is a process of alteration of minerals whereby the primary minerals (of primary rocks) are converted in to 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.

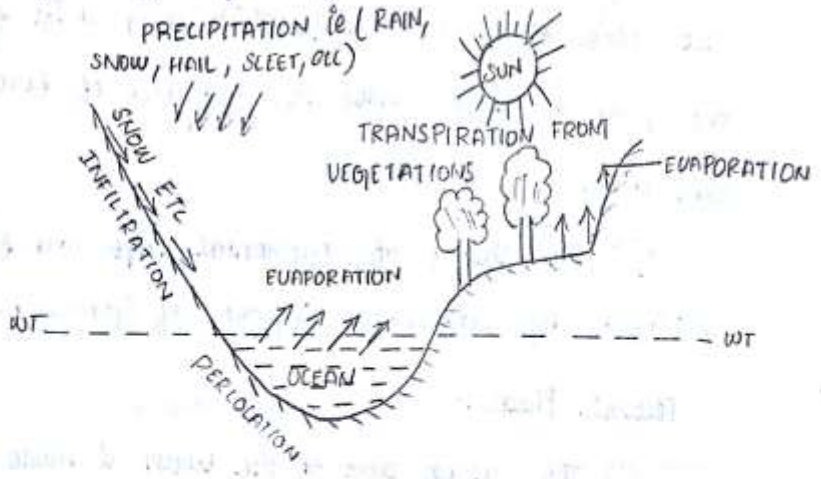
(v) Due to their tectonic movement, these plates are reffered to as tectonic plates.

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.



Occurence of Ground Water :-

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

(9)

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

(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 accurately 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.
(d) Discharge
(e) Competance
(f) Type of flow → Laminar flow
→ Turbulent flow.

The amount of water flowing in river.

The amount of materials carried | transported through it.

Laminar flow → Water moves in undistributed layer fashion

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

(10)

Stream Erosion :-

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 joined rocks exposed along its channel and remove the joint blocks. This process is called hydraulic action.

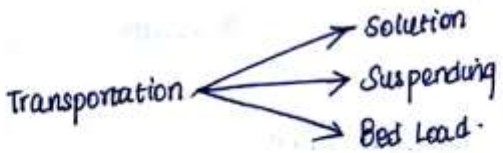
* The flowing water uses rock fragment such as pebbles, gravel and sand.

* 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 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 ation 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 leaves
(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 :-

(12)

* Turbulent wind can easily sweep small dust particles and carry them greater distance is 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 → Sand dunes, Loess

Engg. Considerations :-

* A Sand dune causes major problem for civil Engg, it may travel in any distance and direction may causes burry 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 coarse.

(iv) Landslides may occur in hilly region.

Earthquake Intensity :-

→ It is a measure of the degree of distraction 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 :-

(13)

Classification – I → Depending on mode of origin

- **Due to Surface causes :** Generated by land slopes and collapse of roof of underground caves
- **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 55-300km
- **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 earthquake occur in this belt.

→ AIPINE 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 sequences of slopes from shore to the sea floor.

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

Sea waves :-

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

Types → Oscillatory waves
Types → Translatory waves.

Currents :-

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

* currents → Littoral currents
* currents → Rip currents.

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 mainly two methods of marine deposition.

(a) Shallow water deposits.
(b) Deep water deposits.