AG 3601 ENGINEERING GEOLOGY

Unit 1

units

1. Physical Geology And Geomorphology
2. Mineralogy And Petrology
3. Structural Geology And Rock Mechanics
4. Geoprospecting
5. Geological Considerations And Geohazards

PHYSICAL GEOLOGY AND GEOMORPHOLOGY

Significance of Geology in Civil Engineering; Internal structure of the Earth; Weathering: types, engineering classification of weathered rocks and relevance to Civil Engineering; Fluvial, Marine, Glacial and Aeolian landforms and their importance in Civil Engineering; Plate tectonics and its relevance to earthquakes; Groundwater: types of aquifers, origin, movement and role of groundwater in Civil Engineering constructions.

2-MINERALOGY AND PETROLOGY

Physical and Chemical properties of common rock forming minerals: Quartz family, Feldspar family, Mica (Muscovite, Biotite & Vermiculite), Pyroxene (Augite & Hypersthene), Amphibole (Hornblende), Calcite, Gypsum and Clay minerals and their significance. Formation of Igneous, Metamorphic and Sedimentary rocks; Description of important rocks: Granite, Syenite, Dolerite, Basalt, Quartzite, Slate, Schist, Gneiss, Marble, Sandstone, Limestone, Shale and Conglomerate. Engineering properties of rocks: field and laboratory tests.

3-STRUCTURAL GEOLOGY AND ROCK MECHANICS

Attitudes of beds: Strike and Dip measurements and their relevance to civil engineering; Different types of folds, faults, joints and fractures in rocks and their significance in civil engineering constructions; Geomechanical properties of rocks: Rock Quality Designation (RQD), Rock Mass Rating (RMR) and Geological Strength Index (GSI) and their importance in various civil engineering projects.

4- GEOPROSPECTING

Geological mapping techniques; Remote Sensing: Fundamentals and its role in geological mapping; Geophysical methods for subsurface investigations: Electrical, Seismic & Ground Penetrating Radar (GPR); Subsurface logging and their importance in civil engineering projects.

5-GEOLOGICAL CONSIDERATIONS AND GEOHAZARDS

Geological conditions necessary for designing and construction of important structures: Dams, Reservoirs, Tunnels, Road cuttings and Coastal protection; Landslides: Causes and mitigation; Earthquakes & Tsunamis: Causes and mitigation; Case studies for the above topics.

Physical Geology And Geomorphology

- Physical Geology
- Geomorphology -the study of the physical features of the surface of the earth and their relation to its geological structures.

Geology

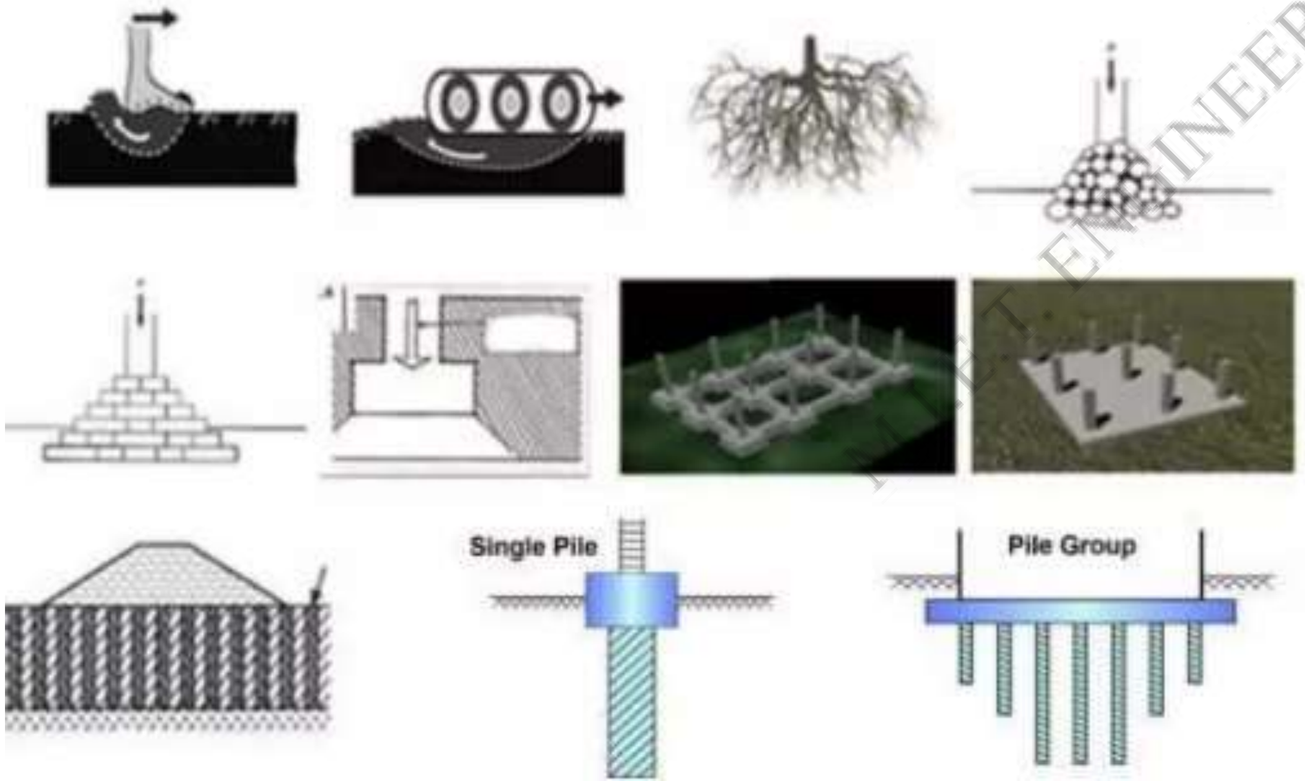
The word geology means 'Study of the Earth. Also known as geoscience or earth science, Geology is the primary Earth science and looks at how the earth formed, its structure and composition, and the types of processes acting on it.

Significance of Geology in Civil Engineering

- Geology helps to identify area susceptible to failures due to geological hazards such as earthquake, landslides, weathering effects, etc. The knowledge about the nature of the rocks is very necessary for tunnelling, constructing roads and in determining the stability of cuts and slopes.

1.

- Geology provides a systematic study of the structure and properties of construction materials and their occurrence.
- The civil engineers need to know the properties of rocks accurately to enable them to consider different rocks for any required purpose that is as a foundation rock, as road metal, as concrete aggregate, as building stones, as the roofing material for decorative purpose.

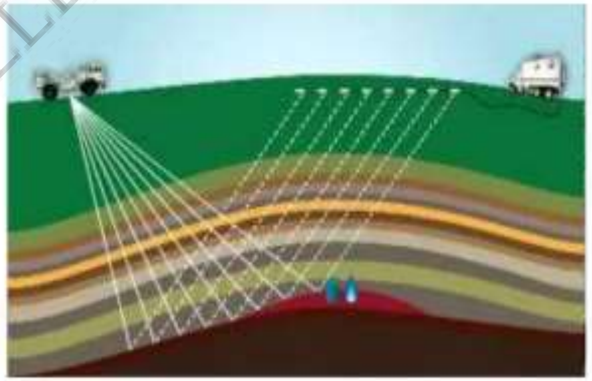


List of Underground Structures:

1. Foundations (Deep & Shallow)
2. Tunnels
3. Pipelines
4. Basements

2.

- The selection of a site is important from the viewpoint of stability of foundation and availability of construction materials.
- Geology provides knowledge about the site used in the construction of buildings, dams, tunnels, tanks, reservoirs, highways and bridges.



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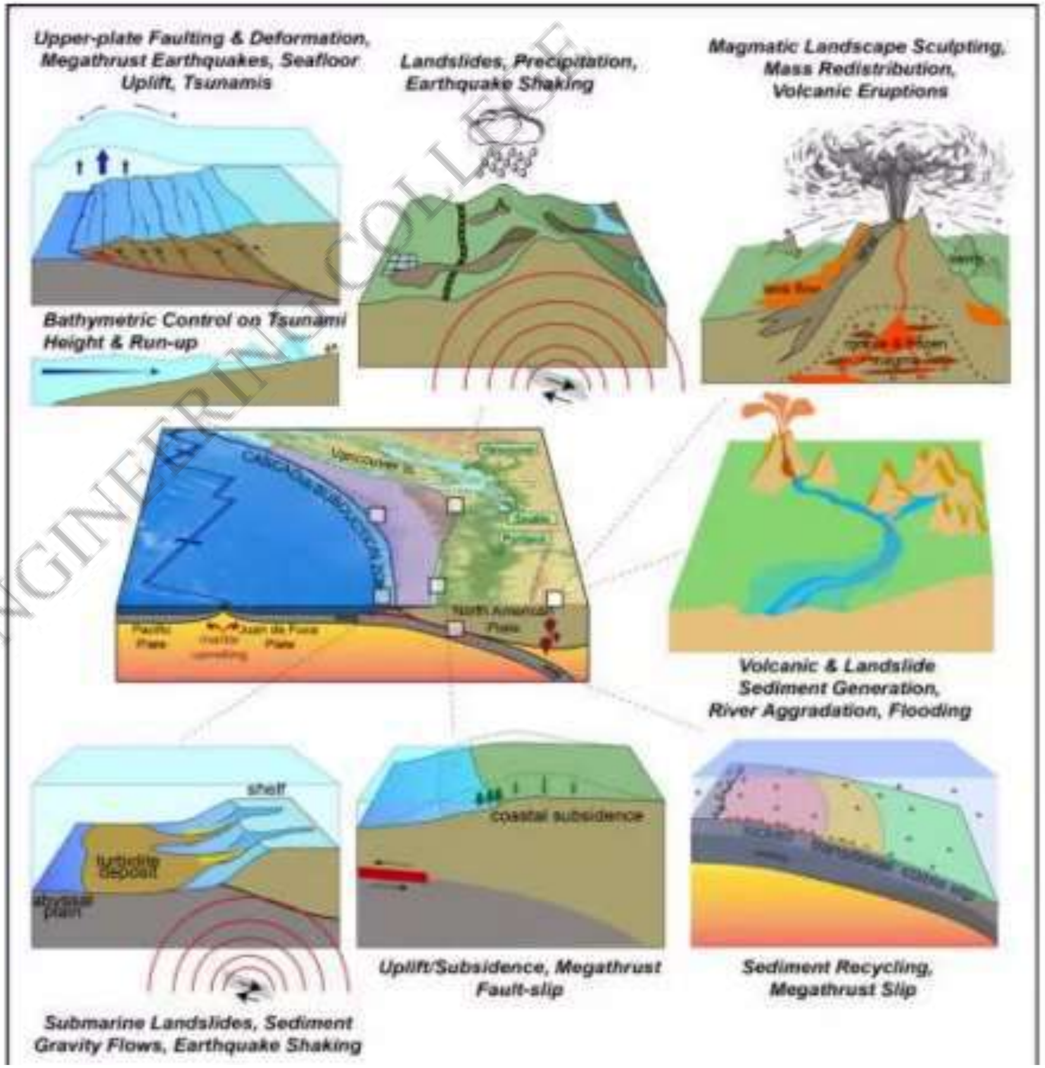

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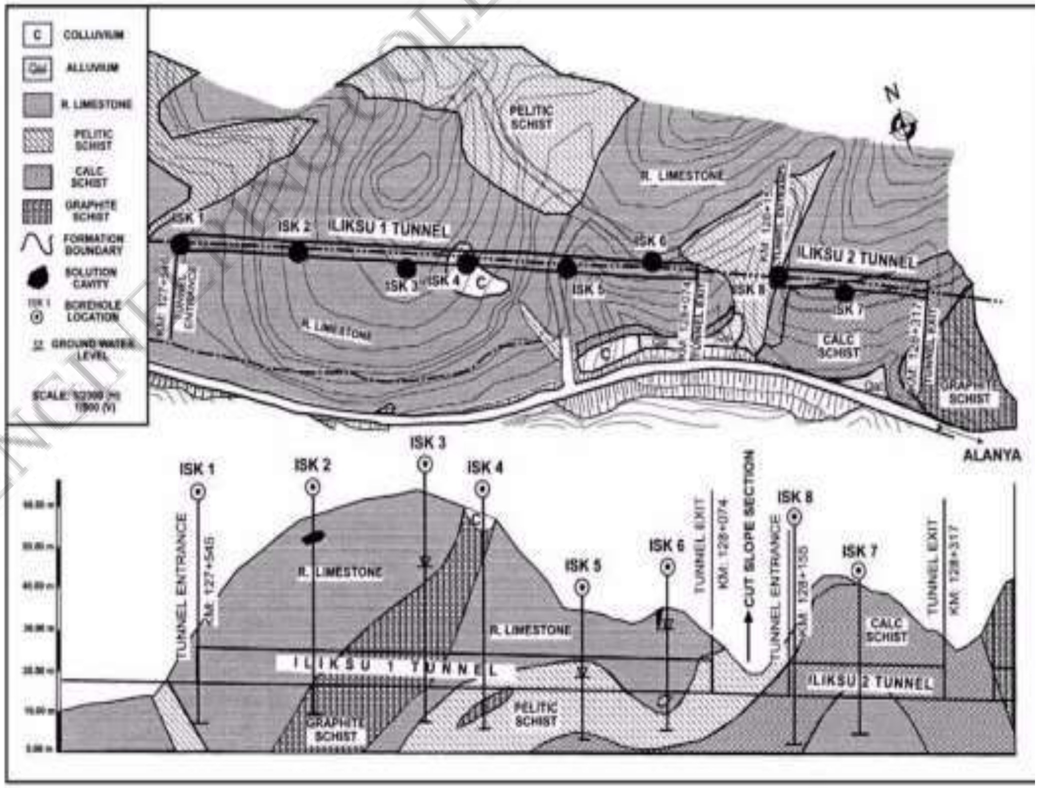
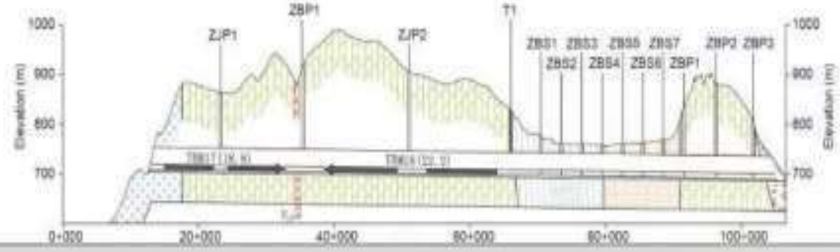
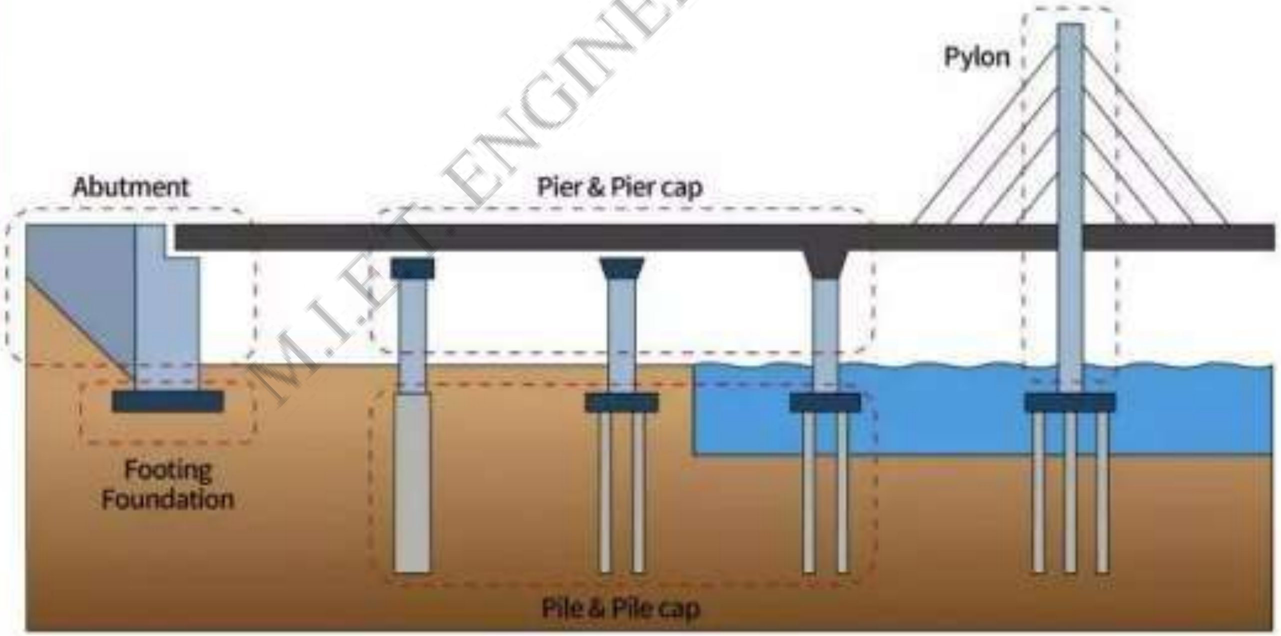




5.

- The foundation problems of dams, bridges and buildings are directly related to the geology of the area where they are to be built.



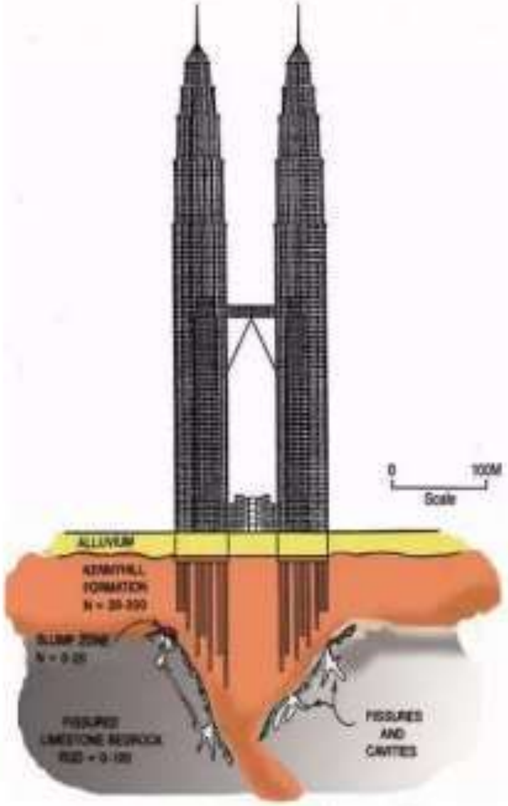
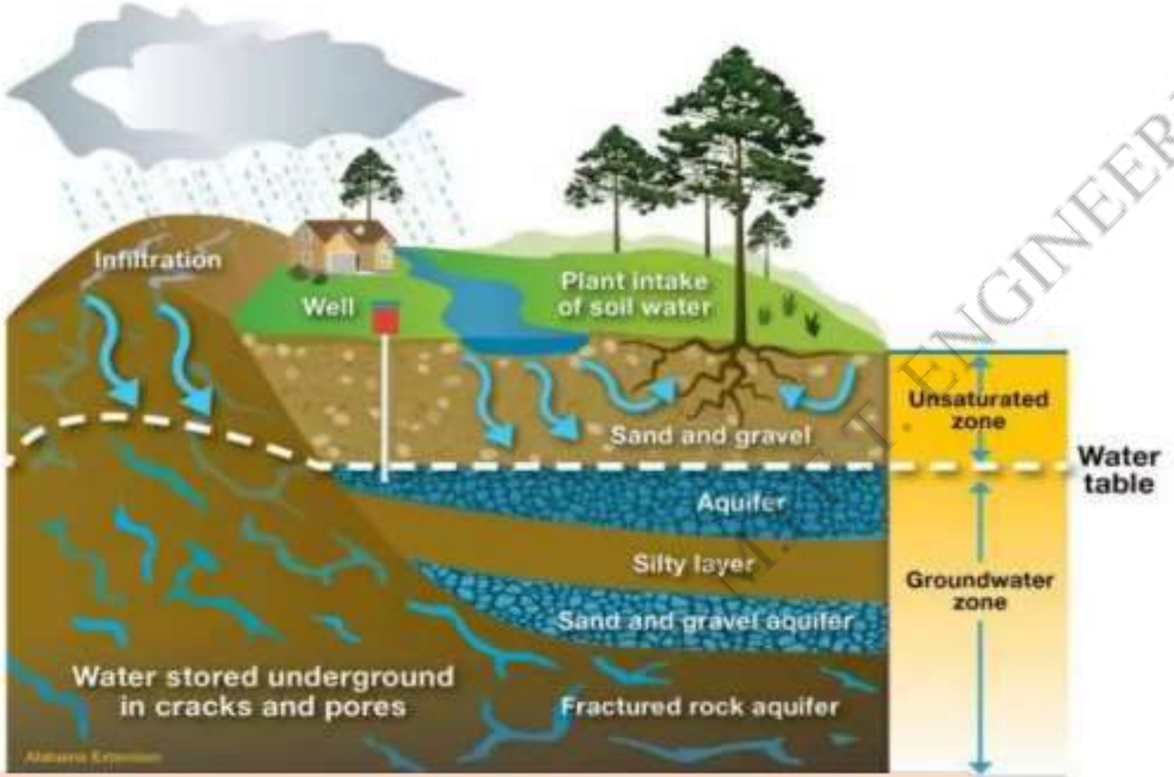


Fig. 1. Petronas Towers Foundation Profile

6. • The knowledge of groundwater is necessary for connection with excavation works, water supply, irrigation and many other purposes. Hydrological maps provide information about the distribution of surface water channels and the groundwater depth.



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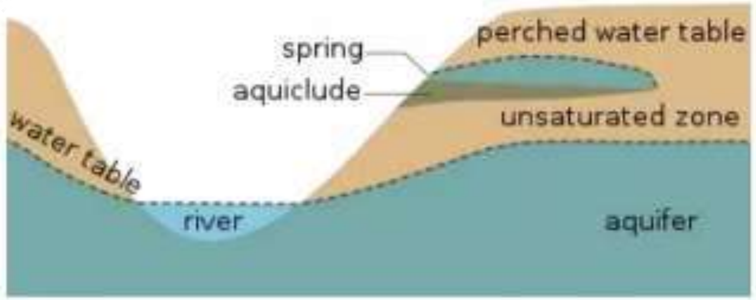
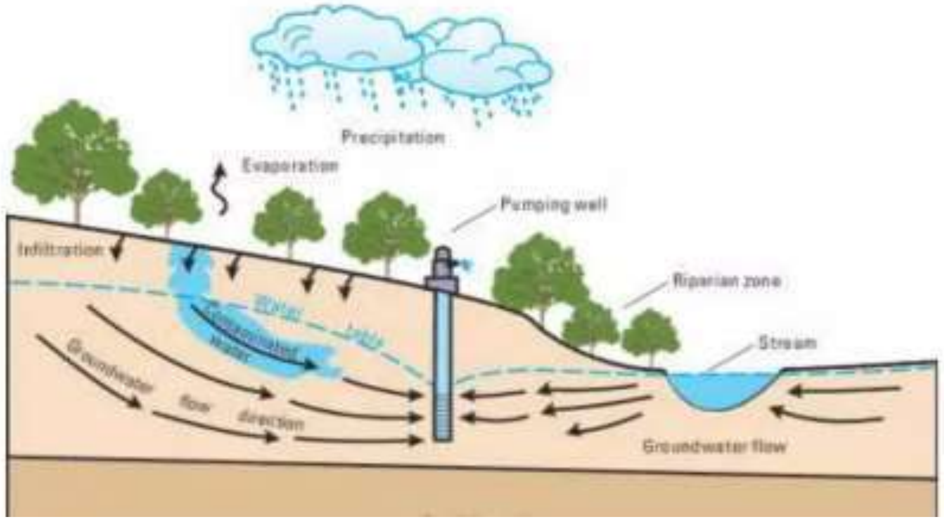
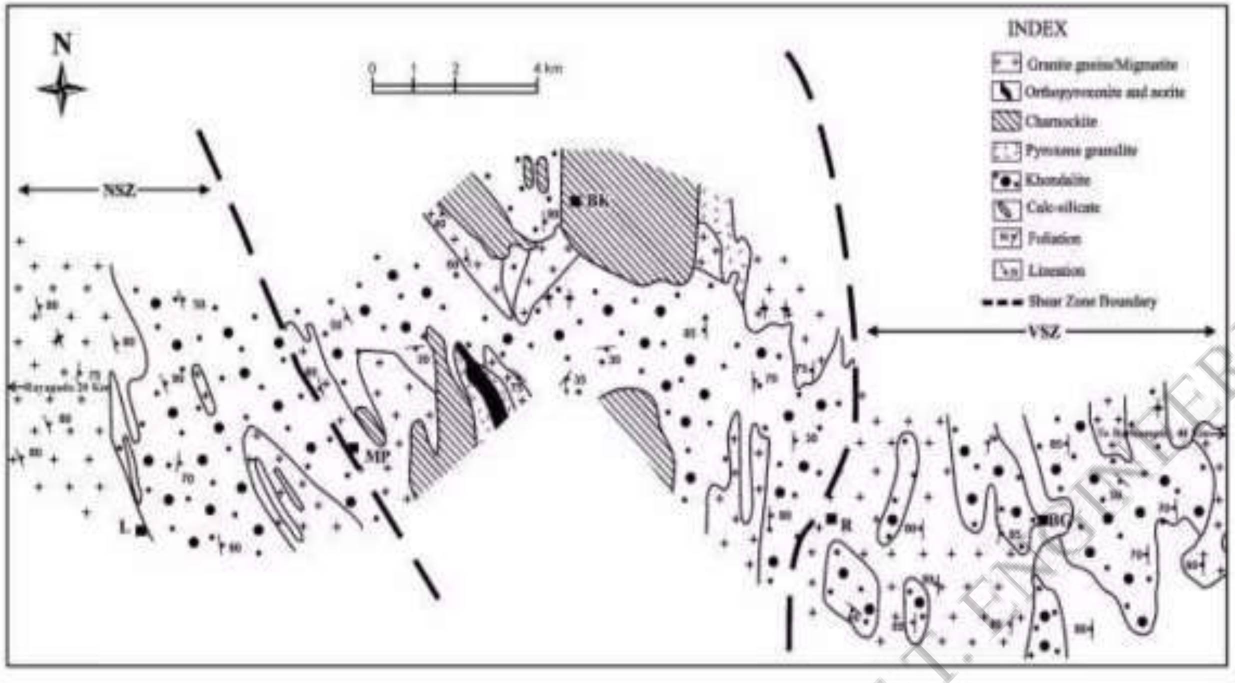
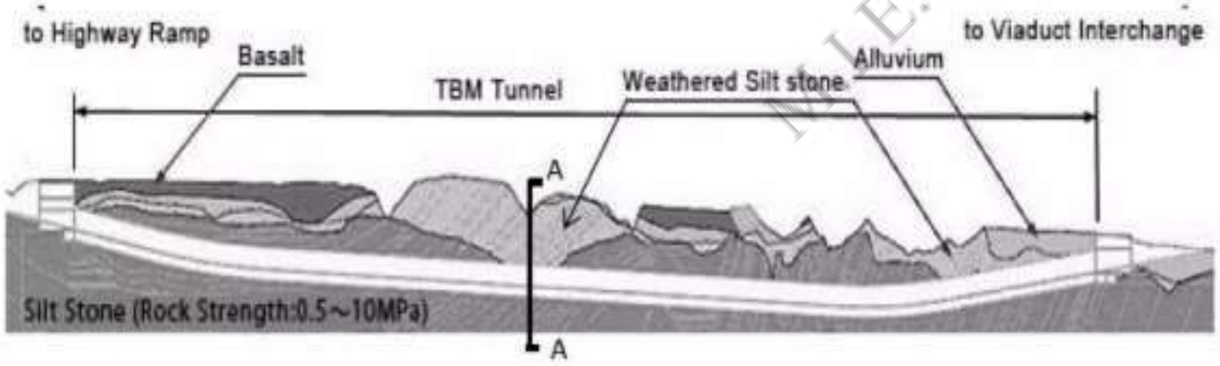




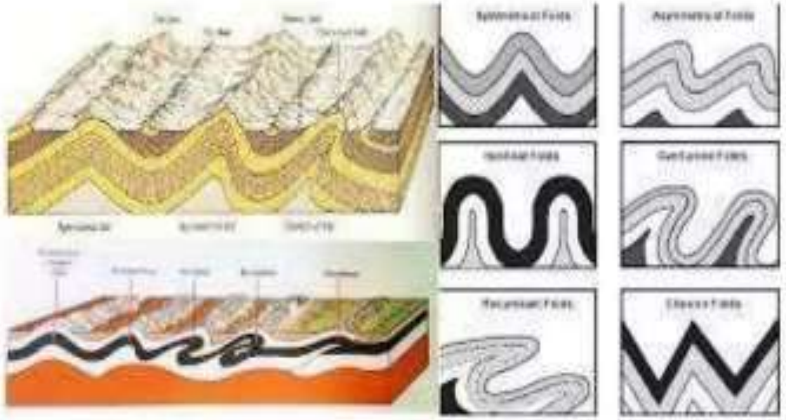
7. • Geological maps help in planning civil engineering projects. It provides information about the structural deposition of rock types in the proposed area.

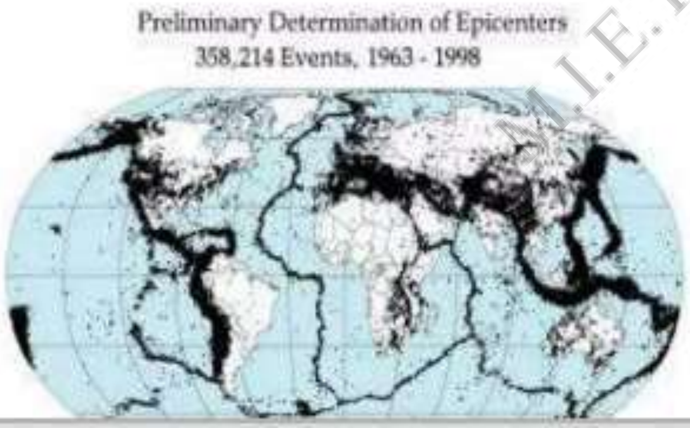




8.

- Geology helps in determining the earthquake-prone areas. If any geological features like faults, folds, etc. are found, they have to be suitably treated to increase the stability of the structure.





9. • The knowledge of erosion, transportation and deposition (ETD) by surface water helps soil conservation, river control, coastal and harbor works.

Erosion Control

River control

Coastal and harbor works

10.

- A geological survey of a site before starting a project will reduce the overall cost.

Summery of Application of Geology in Civil Engineering

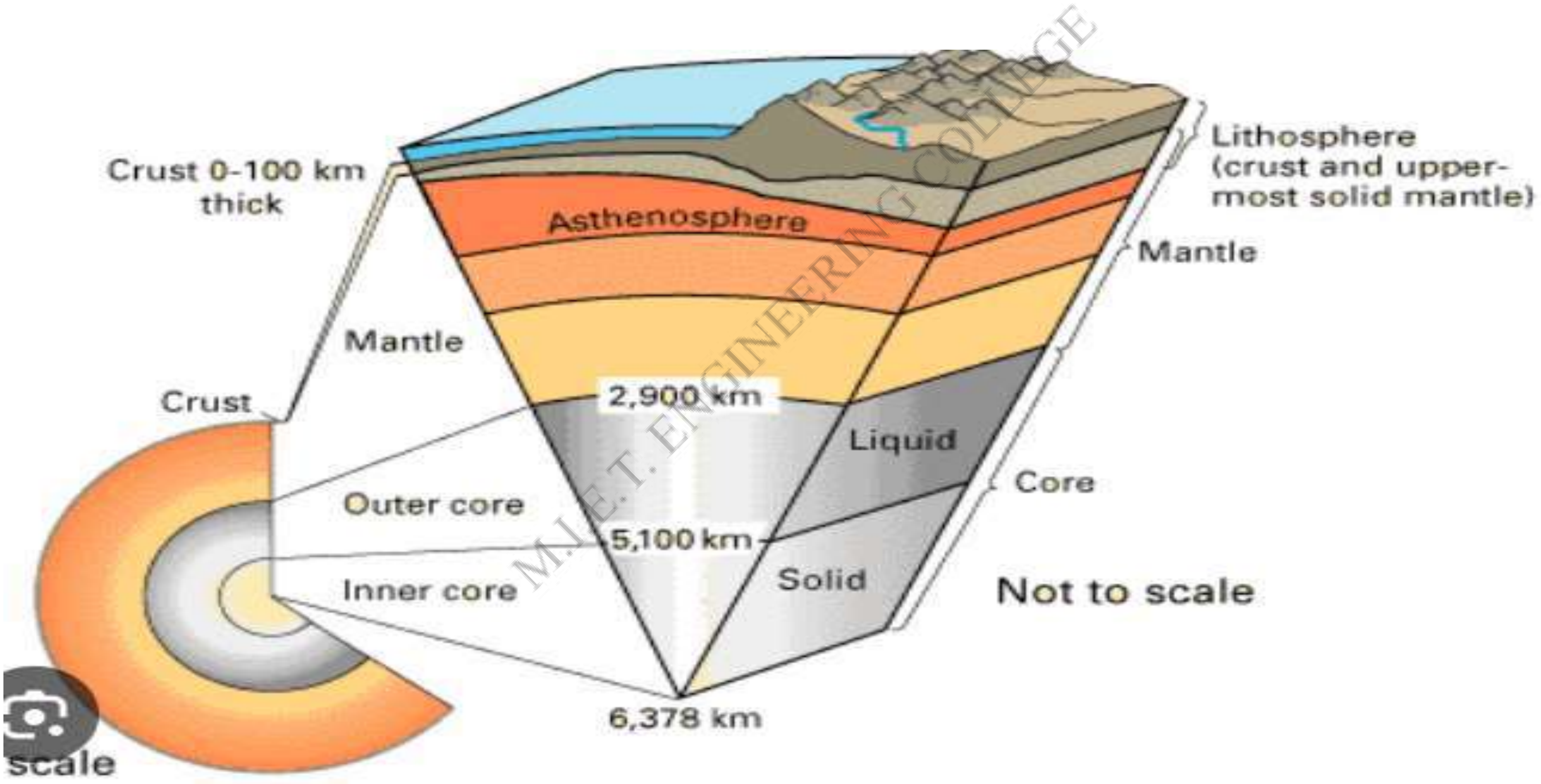
- Site Investigation
- Geomaterial characterization
- Ground water – Hydrology
- Mining
- Foundation engineering
- Earthquake effects on Structures
- Building stones
- Buried structures
- Disaster management- Land slide, subsidence, earthquake etc.

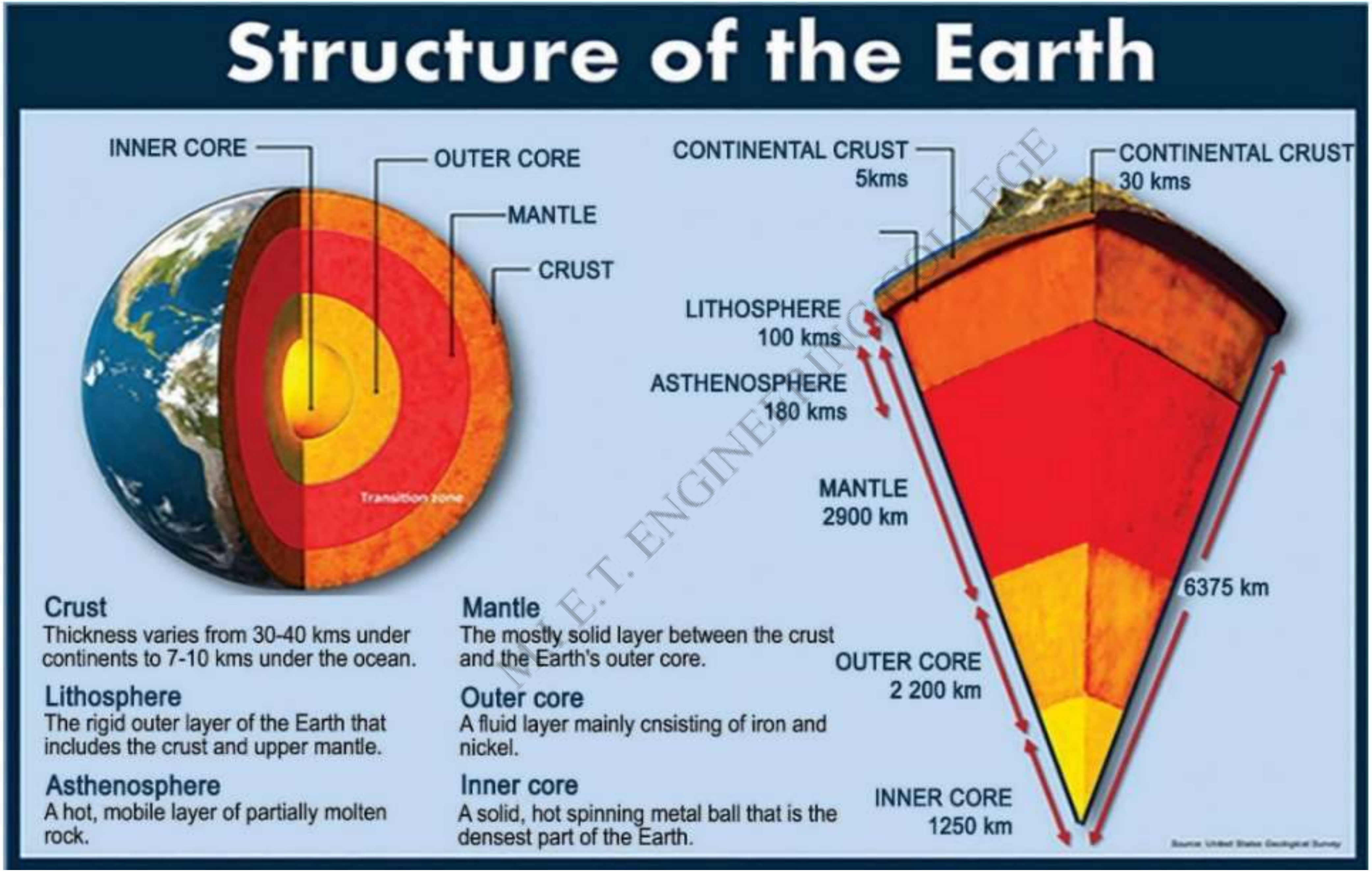
Geological Problems	Engineering Responses
Soft ground and settlement	*Foundation design to reduce and redistribute loading*
Weak ground and potential failure	*Ground improvement & cavity filling; or avoid hazard zone*
Unstable slope and potential sliding	*Stabilize & support slope or avoid landslide hazard prone areas*
Severe river and coastal erosion	*Slow down process with rock/concrete defences*
Potential Earthquake hazard	*Seismic zonation and structural design to withstand vibration and evacuation plan ready*
Potential volcanic hazard	*Delimit & avoid hazard zone, predict eruption, have evacuation plan ready*
Rocks as construction material	*Resource exploration and estimation, testing and exploitation*
Site Survey and Investigation	*Photogrammetry, remote sensing, geophysical, geological and engineering geological investigations*
Natural hazards mitigation	*Flood, coastal hazards, landslides, earthquake, tsunami, volcanism, caving*
Groundwater Exploration	*Hydrological properties of rocky aquifers, groundwater and rock strength*
Rock mechanics and engineering	*Rock mass classification and stresses in rocks*
Strategic storage facility	*Underground storage of oil and gas for emergency*
Nuclear waste disposal sites	*Underground trapment in stable continental areas*

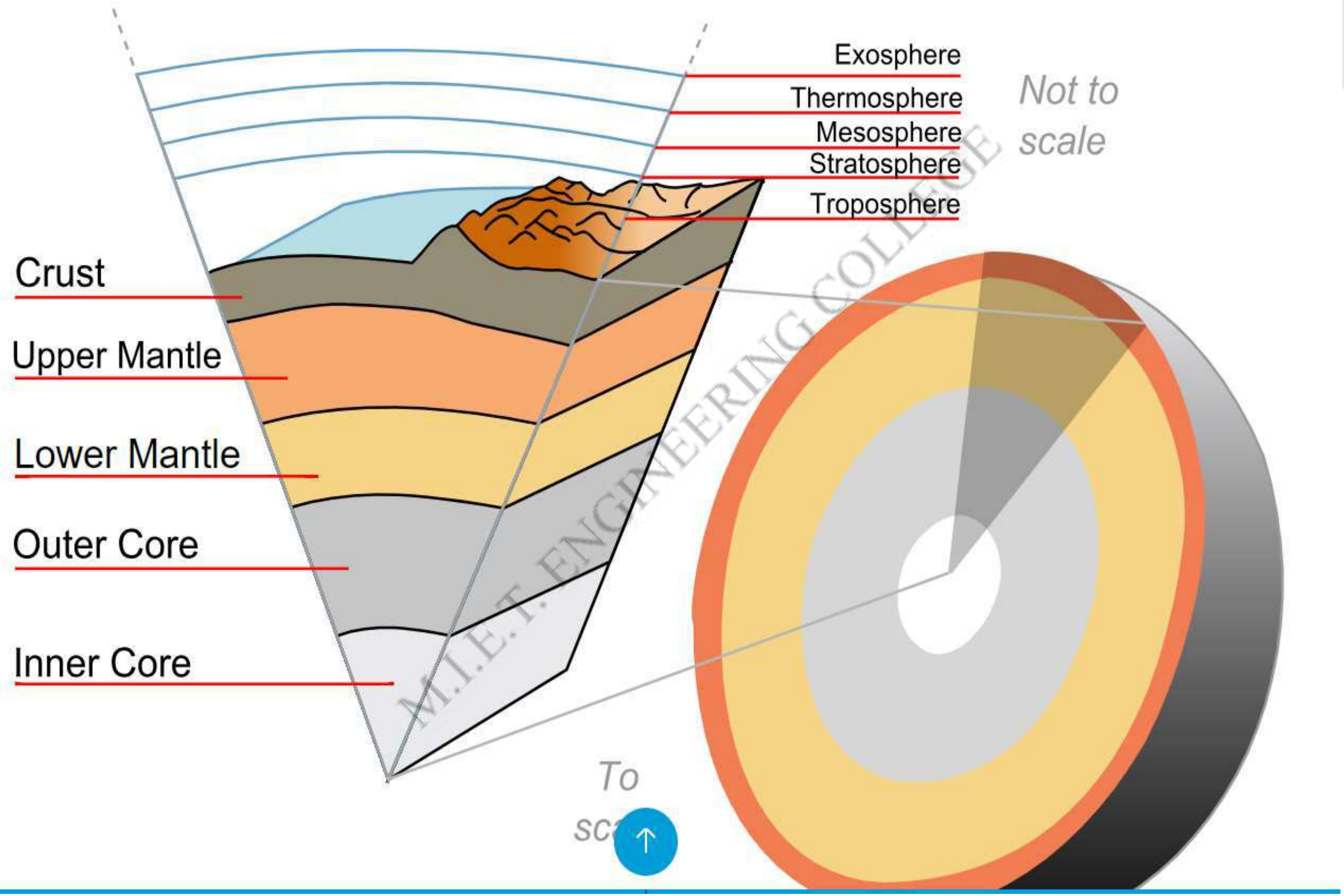
Internal structure of the Earth

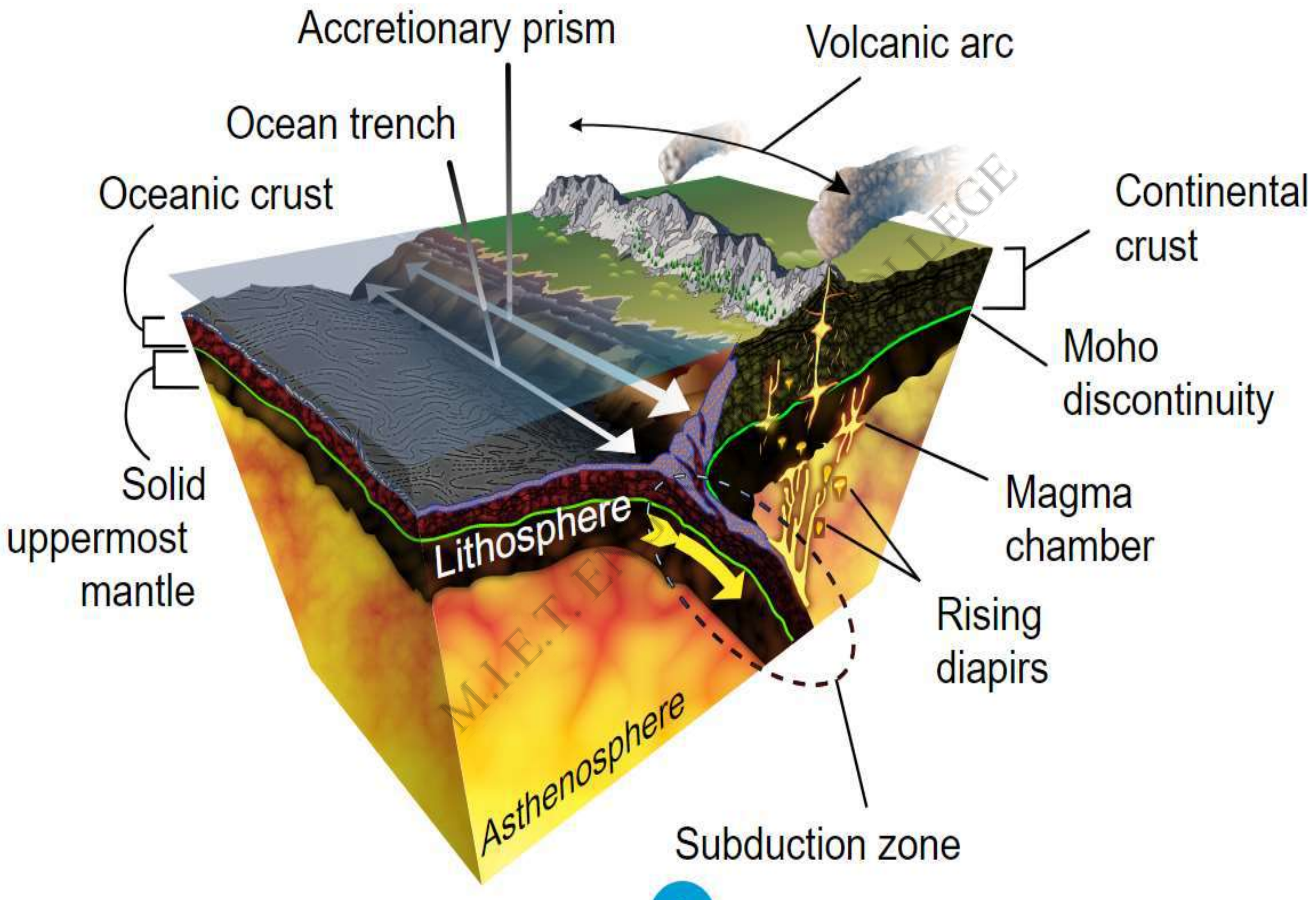
- The structure of the earth is divided into four major components: the crust, the mantle, the outer core, and the inner core.
- Each layer has a unique chemical composition, physical state, and can impact life on Earth's surface.

Internal structure of the Earth




Structure of the Earth
INNER CORE
OUTER CORE
MANTLE
CRUST
Transition zone
CONTINENTAL CRUST
5kms
CONTINENTAL CRUST
30 kms
LITHOSPHERE
100 kms
ASTHENOSPHERE
180 kms
MANTLE
2900 km
6375 km
OUTER CORE
2 200 km
INNER CORE
1250 km
Crust
Thickness varies from 30-40 kms under continents to 7-10 kms under the ocean.
Lithosphere
The rigid outer layer of the Earth that includes the crust and upper mantle.
Asthenosphere
A hot, mobile layer of partially molten rock.
Mantle
The mostly solid layer between the crust and the Earth's outer core.
Outer core
A fluid layer mainly cnsisting of iron and nickel.
Inner core
A solid, hot spinning metal ball that is the densest part of the Earth.


Exosphere
Thermosphere
Mesosphere
Stratosphere
Troposphere
Not to scale
Crust
Upper Mantle
Lower Mantle
Outer Core
Inner Core
To



Accretionary prism
Volcanic arc
Ocean trench
Oceanic crust
Continental crust
Moho discontinuity
Solid uppermost mantle
Lithosphere
Magma chamber
Rising diapirs
Asthenosphere
Subduction zone

The crust

- The crust is the outermost solid part of the earth.
- The thickness of the crust varies under the oceanic and continental areas.
- Oceanic crust is thinner as compared to the continental crust.
- The continental crust is thicker in the areas of major mountain systems.
- The crust is made up of heavier rocks having a density of 3 g/cm3.
- The kind of rock seen in the oceanic crust is basalt.
- The mean density of material in the oceanic crust is 2.7 g/cm3.
- Silica (Si) and Aluminium (Al) are major constituent minerals. Hence it is often termed as SIAL. Also, sometimes SIAL is used to refer to the Lithosphere.

the mantle.

- The portion of the interior beyond the crust is called the mantle.
- It is in a solid-state.
- It has a density higher than the crust portion.
- The thickness ranges from 10-200 km.
- The mantle extends from Moho’s discontinuity to a depth of 2,900 km.
- The asthenosphere is the upper portion of Mantle.
- It is the chief source of magma that finds its way to the surface during volcanic eruptions.
- The crust and the uppermost part of the mantle are called the lithosphere.
- The major constituent elements of the mantle are Silicon and Magnesium and hence it is also termed as SIMA

The Core

- The core-mantle boundary is positioned at the depth of 2,900 km.
- The inner core is in the solid-state whereas the outer core is in the liquid state.
- The core is made up of very heavy material mostly constituted by nickel and iron. Hence it is also called the “nife” layer.

Weathering

- Weathering denotes the process of breaking up, and fragmentation of the rock that creates the surface of the ground and that remains exposed to the weather.
- The process results from forces of weather like rain action, variations in temperature and frost action.

Significance of weathering in civil

- Weathering is also a significant aspect in the civil engineering viewpoint as most of the civil structures are all assembled with rock ,concrete and masonry work.
- It is characterized as an activity of decay, disintegration, and decomposition of stones under the effect of chemical and physical .
- Weathering is due because of different **agents of weathering** like smoke, heat, rain, and a frequent variant of fever throughout nights and days.

Types of Weathering & Erosion

- **Chemical Weathering**
- **Biological Weathering**
- **Physical weathering**

Physical weathering

- Sometimes called mechanical weathering,
- physical weathering is the process that breaks rocks apart without changing their chemical composition.
- These examples illustrate physical weathering: Swiftly moving water. Rapidly moving water can lift

physical or mechanical weathering

- physical or mechanical weathering processes are influenced by some applied forces.
- The applied forces are:
  - Gravitational forces like shearing stress, load, and overburden pressure.
  - Expansion forces due to animal activity or temperature variations.
  - Water pressures regulated by drying and wetting cycles.
- Many of these forces are applied both at the surface and within different earth materials leading to rock breakage.
- Most of the physical weathering processes are caused by pressure release and thermal expansion.

Chemical Weathering

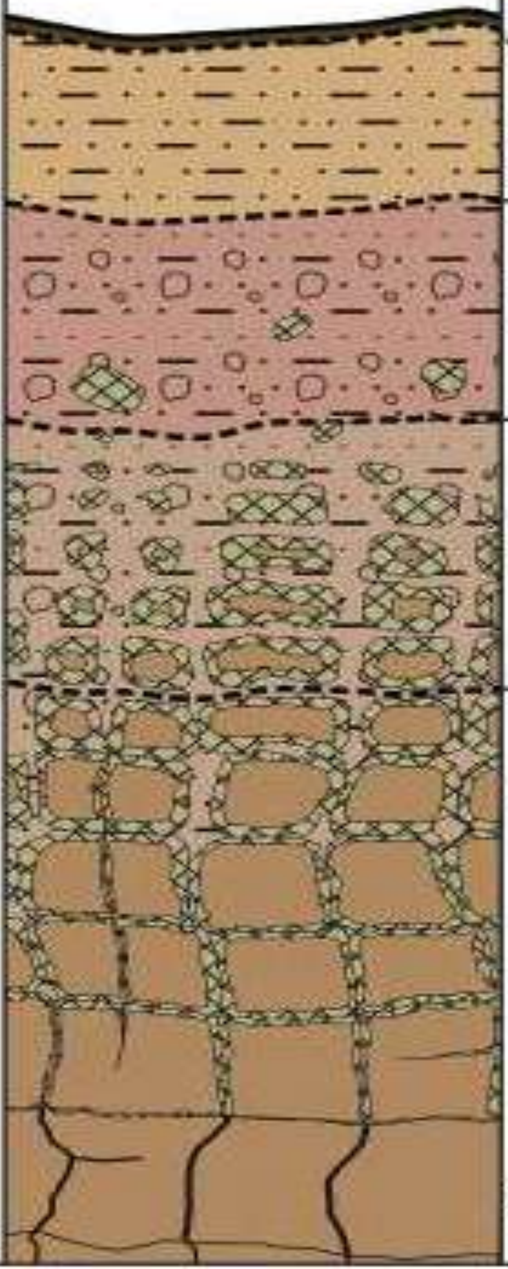
- **Chemical weathering** means the climatic and erosion caused due to the chemical activities.
- Sulfate attack is a typical instance of chemical weathering into the masonry and concrete structures.
- **Chemical weathering** is fundamentally a practice of chemical reactions involving electrons of the air and the top rocks.
- The chemical effects always take place while within the existence of water normally rain -by which can be dissolved many busy pollutants from the air such as Carbon dioxide, Hydrogen, and nitrogen, etc.

Biological Weathering

- **Biological weathering** simply identifies climatic due to creatures -- animals, plants, fungi, and germs such as bacteria. While certain kinds of biological deterioration, like the breaking of rocks by the roots of the tree, can be classified as either chemical or physical, biological purification could be either chemical or physical.

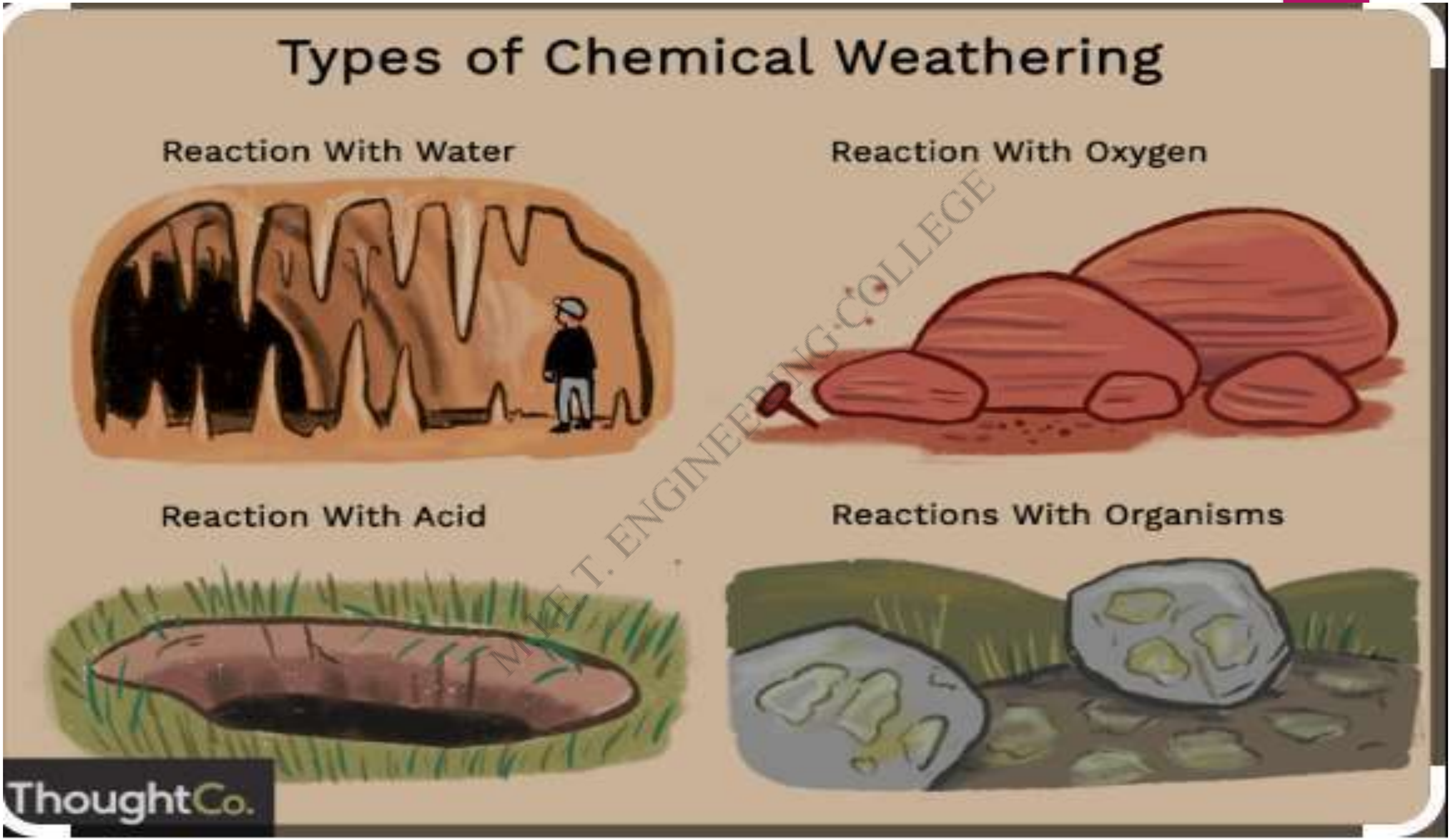
Engineering classification of weathered rocks

- The effects of weathering are to be described using the standard soil and rock description terminology in terms of:
- Colour and colour changes;
- Strength and reduction of strength;
- Condition of discontinuities and their infill; and
- Weathering products



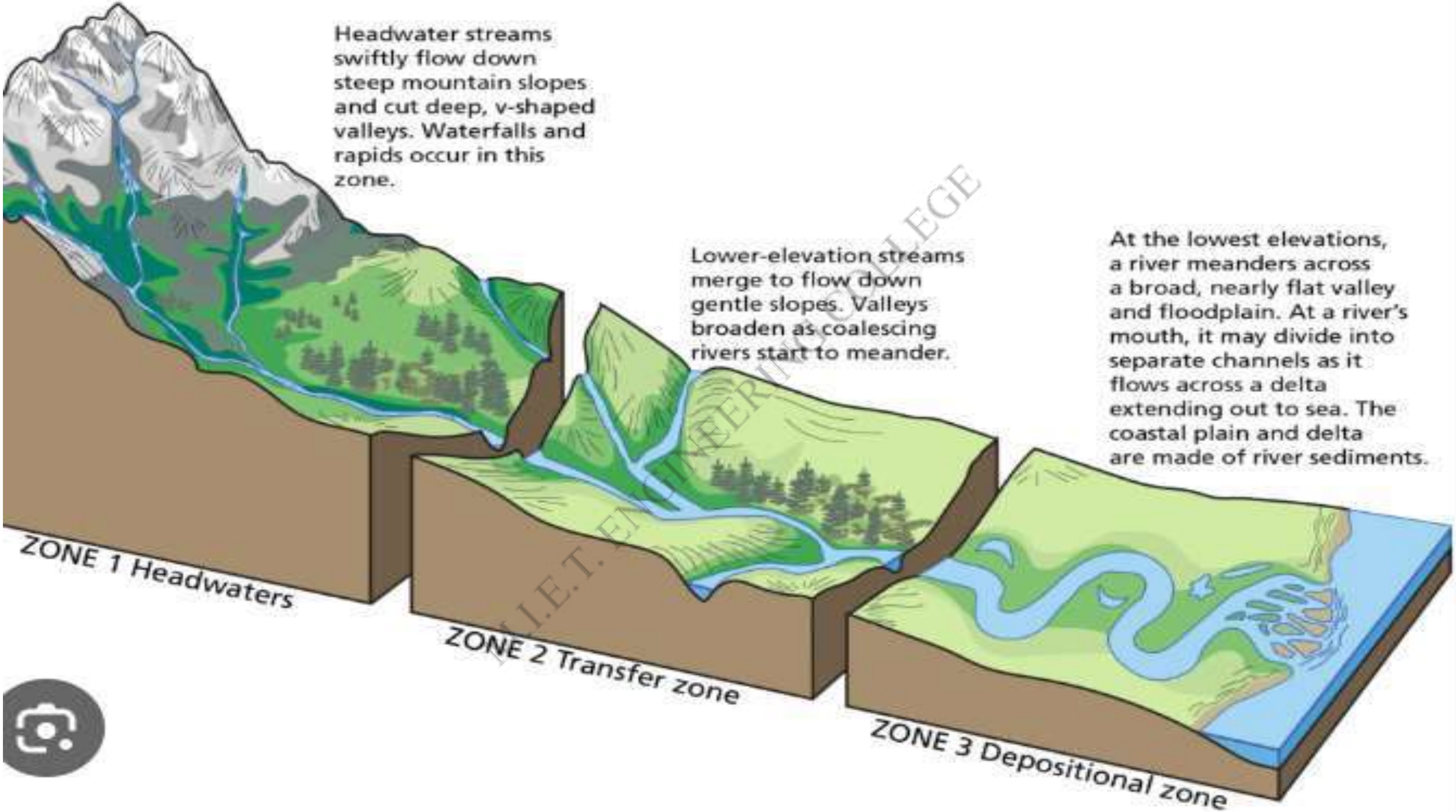
ndicative depth below urface (m)		Rock mass weathering grade	Description (as rock mass for slightly and moderately weathered, and as soil mass for highly weathered to residual soil)
0 0.2		Topsoil	Dark brown, black, sandy clayey SILT with organic matter and man-made material
0.9 - 1.2		Residual soil	Reddish brown to light brown, low sphericity, very angular, sandy clayey SILT of high plasticity
2 - 3		Completely	Reddish brown to red, low sphericity, very angular, clayey silty sandy GRAVEL to gravelly sandy clayey SILT of high plasticity, relict discontinuities (foliation and joints), with in lower part occasionally cobble- and boulder-sized completely decomposed core stones with white kaolin
3.5 - 4.5		Highly	Reddish brown, low sphericity, very angular, clayey silty sandy GRAVEL, relict discontinuities (foliation and joints), with cobble- and boulder-sized completely and partially decomposed core stones consisting of mainly mica and feldspar with white kaolin
5.5 - 8		Moderately Slightly	Light brown, light grey, white, medium- to coarse-sized minerals with phenocrysts, very weak to very strong, schistose and foliated, SCHIST and GNEISS in part migmatized, upwards increasingly weathered leading to core stones surrounded with zone of decomposed intact rock material (hatched), discontinuities discolored (bottom) to filled with completely decomposed and altered intact rock (top), and white kaolin in intact rock and discontinuities, porphyroclasts (garnet) becoming markedly weathered (weaker) starting from moderately weathered


Physical weathering
Freeze and thaw
Wind abrasion
Water abrasion
Chemical weathering
Acid rain on limestone
Rust on rocks
Biological weathering
Plants growing in rock
Human activity
Animal burrowing


Types of Chemical Weathering
Reaction With Water
Reaction With Oxygen
Reaction With Acid
Reactions With Organisms
ThoughtCo.

Fluvial { நதிகள் தொடர்பான } Landforms and Processes

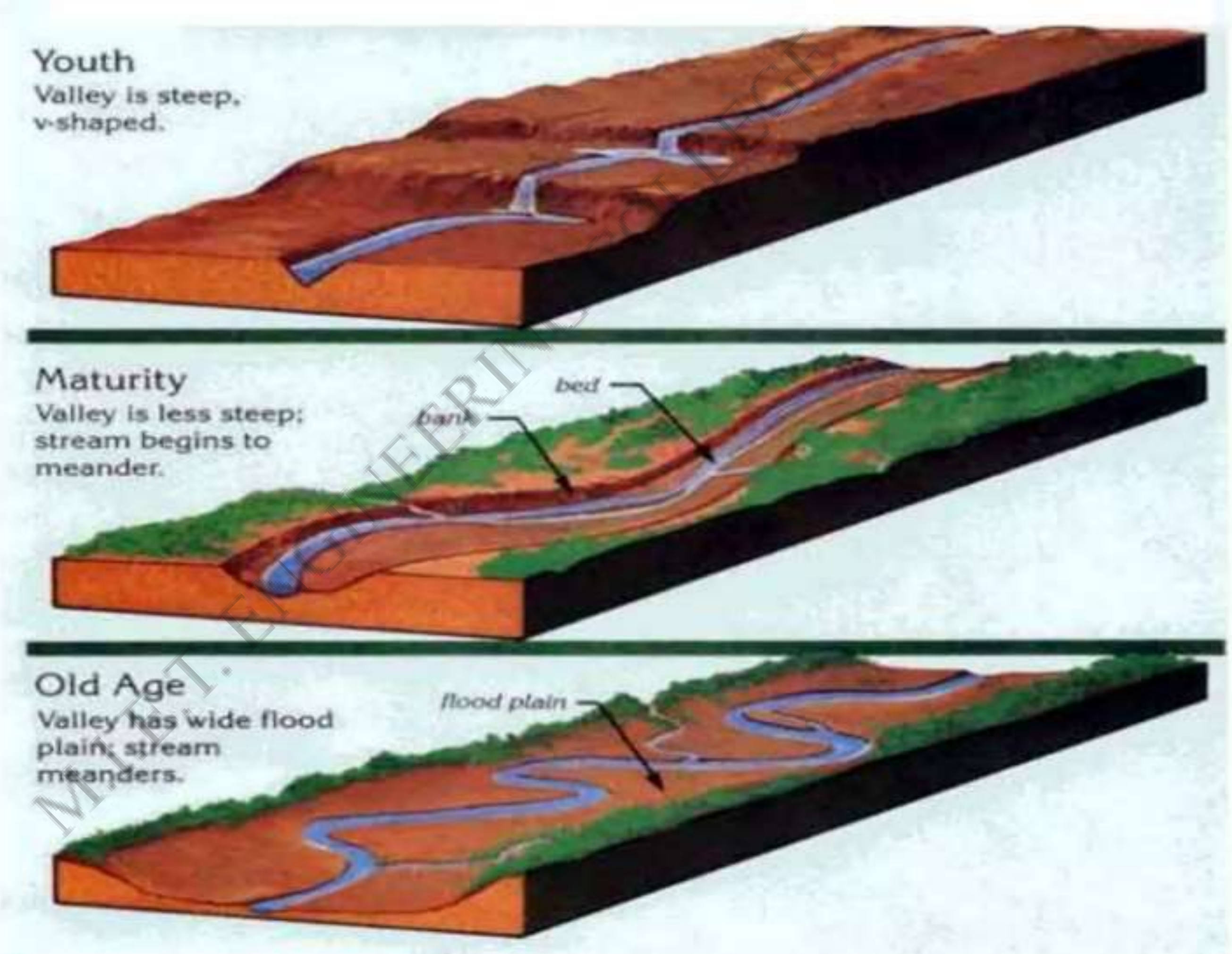
- fluvius (L.): river
- the work of rivers, but also the erosion of soil and rock on hillslopes by running water
- hydrological cycle: orderly scheme to systematically examine and analyze the movement of water through the landscape
- flowing water is the result of net precipitation = total precipitation (input) - evapotranspiration (output or loss)


Headwater streams swiftly flow down steep mountain slopes and cut deep, v-shaped valleys. Waterfalls and rapids occur in this zone.
Lower-elevation streams merge to flow down gentle slopes. Valleys broaden as coalescing rivers start to meander.
At the lowest elevations, a river meanders across a broad, nearly flat valley and floodplain. At a river's mouth, it may divide into separate channels as it flows across a delta extending out to sea. The coastal plain and delta are made of river sediments.
ZONE 1 Headwaters
ZONE 2 Transfer zone
ZONE 3 Depositional zone

- The term fluvial derives from the Latin word *fluvius* that means river.
- Thus fluvial landforms are generated due the flow of rivers.
- They cover an enormous range of dimensions, from small features like rills and streams to large rivers and their drainage basins
- e.g. Nile and Amazon basins.
- Rivers flowing to the oceans drain about 68 % of the Earth's land surface. The fluvial processes landforms by erosion and transport the sediments to new areas where they get deposited to create new landforms

stages:

- Young stage
- Maturity stage
- Old stage



Processes:

- **Erosion** processes include the displacement of bed particles through drag and lift forces; abrasion, causing the wearing away of bed and banks as mobile agencies obtain and remove rock debris

- **Transportation:** processes include the transfer of material in solution and suspension, and by saltation.

- **Deposition:** is the geological process by which sediments, soil, and rocks is added to a landform or land mass.

COASTAL PROCESSES AND LANDFORMS

- coastal areas are an interface between the lithosphere and hydrosphere.
- Coastal areas are unique and typical land masses bordered by the seas and oceans.
- Coastal zones are very sensitive zones.
- The oceans have a great impact on the Earth and its climate.
- Coastal zones are not static but dynamic environments.
- They involve transformation of mass and energy through waves and currents.
- Shorelines are always subjected to both continental and oceanic processes.
- Waves, tides and currents are very powerful geomorphic agents.
- The erosional and depositional work of the sea waves can create many spectacular landscapes along the borders of the continents.
- Studying the coastal landforms are interesting aspects in geomorphology.

the following aspects are highlighted:

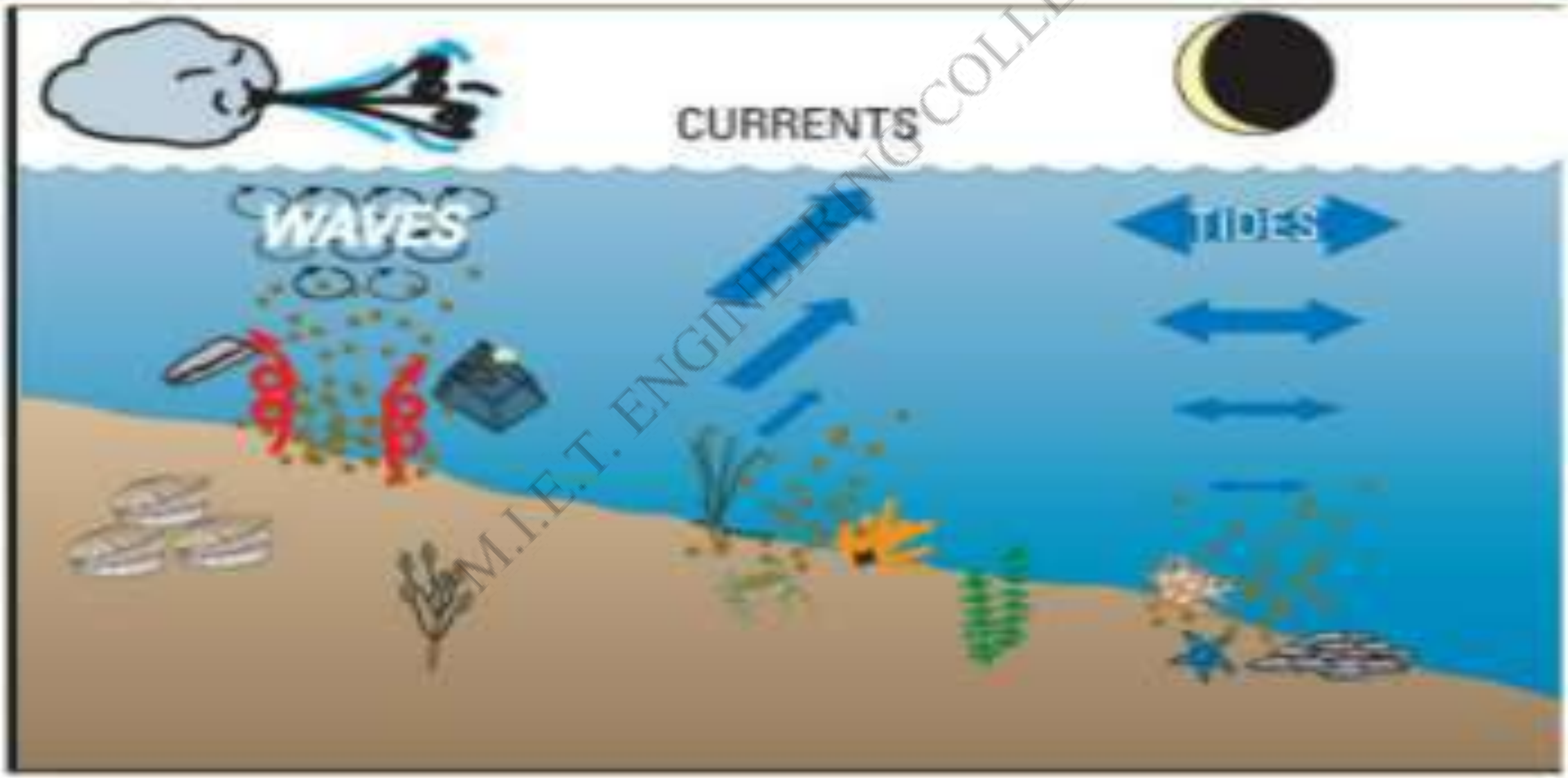
- 1. PROFILE OF COASTAL ZONES
- 2. WAVES, TIDES AND CURRENTS
- 3. COASTAL GEOMORPHIC PROCESSES
- 4. EROSIONAL LANDFORMS
- 5. DEPOSITIONAL LANDFORMS

WAVES, TIDES AND CURRENTS

- Wind provides energy to the waves. Wind causes waves to travel in the ocean and the energy is released on shorelines.
- Tides: The periodical rise and fall of the sea level, once or twice a day, mainly due to the attraction of the sun and the moon, is called a tide.
- Currents: Ocean currents are like river flow in oceans

Motion of the Ocean!

Waves, Currents, and Tides



PROFILE OF COASTAL ZONES

- A Coastline represents the boundary between the continental land masses and the oceanic water masses.
- Coastal belts may be very wide or narrow.
- They also vary with reference to their slope, beach profile, rock types, climate and vegetation.
- The climate of a coast is basically controlled by the land and sea breezes. The climate is also controlled by the humidity of generated by the marine waters.

- a) Backshore region
- b) Foreshore region and
- c) Offshore region

- The backshore is inland of the inter-tidal zone and is usually above the influence of the waves. The nearshore (sometimes called the breaker zone) is where the waves break; the offshore zone is further out to sea and is beyond the influence of the waves.

COASTAL GEOMORPHIC PROCESSES

- Oceans are bodies of dynamic water masses.
- Sea waves are powerful geological agents, acting from the shorelines to the coastal belts.
- Vertical and horizontal movements of water continue to happen both at the surface and at depth at all times.
- Over a period of time, wave action in the surf zone will tend to plane off the entire zone.
- This process is known as marine planation.

- This is a slow process. There are so many other features formed along the coastline due to various hydrodynamic actions of waves on the sea side and aerodynamic actions wind on the landside.
- Sea waves can erode, transport and deposit the marine sediments based on various factors and processes.
- Erosion, transportation and deposition happen on both sides of the shoreline.
- Coastal rocks like cliffs are also subjected to wave actions. Sea cliffs are very unique features seen in some places.

Processes of coastal erosion:

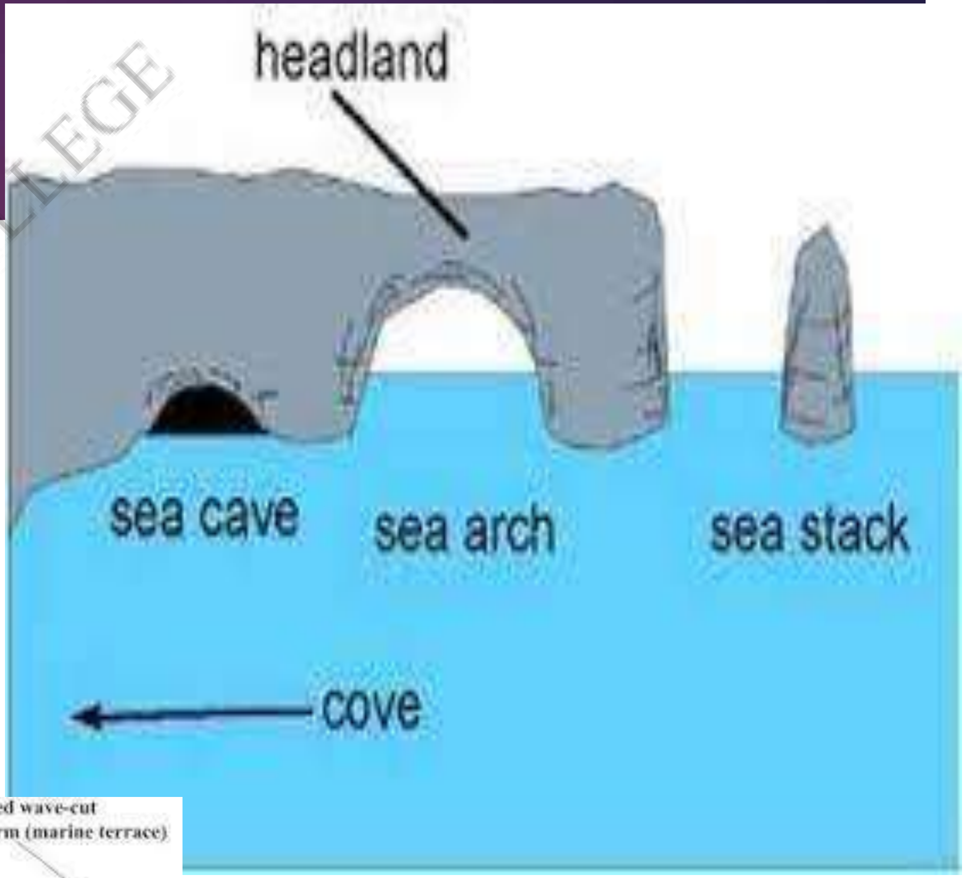
- The combined effect of waves, currents and tides result in a variety of gradational processes acting in the coastal zone.

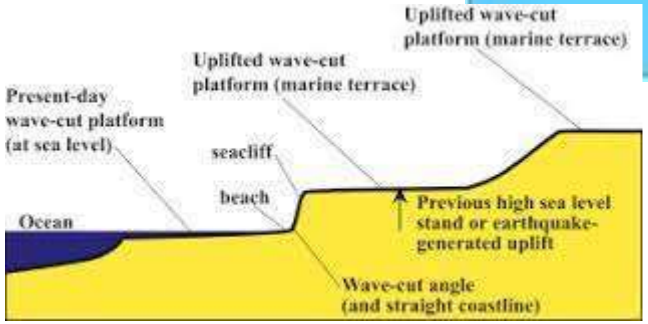
Coastal erosion happens in the form of

- a) hydraulic action,
- b) corrosion (or) abrasion,
- c) attrition,
- d) corrosion (or) solution and
- e) water pressure.

EROSIONAL LANDFORMS

- a) Sea cliffs
- b) Sea caves
- c) Sea Arches
- d) Sea stacks
- e) Wave-cut notches
- f) Wave-built terraces.

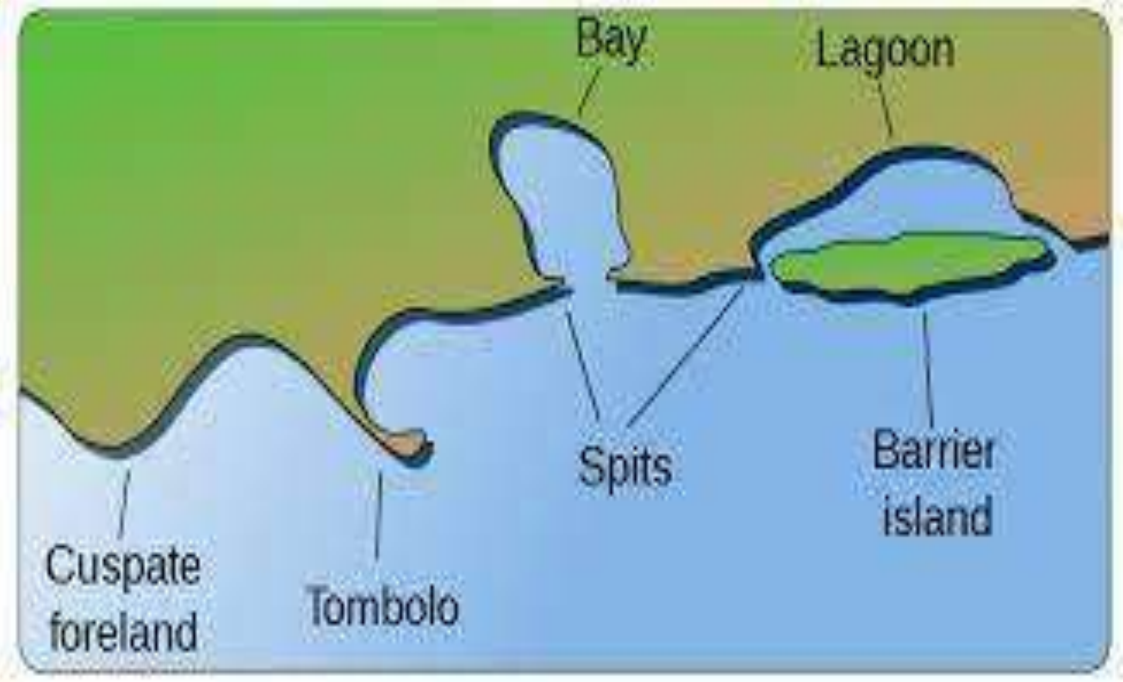




DEPOSITIONAL LANDFORMS

depositional coastal landforms are:

- a) Beaches
- b) Spits and bars
- c) Tombolo
- d) Barrier islands
- e) Mud Flats.



Deltas

- These are bodies of sediments deposited by the rivers when they confluence with the seas.
- Deltas build outward from the shoreline at river mouths.
- There are three kinds of deltas as:
- a) Wave-dominated Deltas
- b) Tide-dominated Deltas
- c) River-dominated Deltas.

Plate tectonics and its relevance to earthquakes


Equator
Pangea
225 million years ago
Equator
Laurasia
Gondwana
150 million years ago
Equator
North America
Europe
Asia
South America
Africa
India
Australia
Antarctica
100 million years ago
Equator
North America
Europe
Asia
Africa
India
South America
Australia
Antarctica
Earth today
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Tectonic Plates

- Tectonic plate (also called lithospheric plate) is a massive, irregularly-shaped slab of solid rock, generally composed of both continental and oceanic lithosphere.
  - The lithosphere includes the crust and top mantle with its thickness range varying between **5-100 km** in oceanic parts and about **200 km** in the continental areas.
  - The concept of Tectonic Plates was first introduced in 1967.
- A tectonic plate may be a **continental plate** or an **oceanic plate,** depending on which of the two occupies the larger portion of the plate.
  - The **Pacific plate** is largely an oceanic plate whereas the **Eurasian plate** is a continental plate.


Tectonic Plates
1. Major Plates
2. Minor Plates
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The Major and Minor Plates

- The Earth's lithosphere is divided into seven major and some minor plates
- Young **Fold Mountain ridges, oceanic trenches,** and/or **transform faults** surround the **major plates.** These include:.
  - **The Antarctic (and the surrounding oceanic) plate**
  - **The North American plate** (with western Atlantic floor separated from the South American plate along the Caribbean islands)
  - **The South American plate**
  - **The Pacific plate**
  - **The India-Australia-New Zealand plate**
  - **The Africa with the eastern Atlantic floor plate**
  - **Eurasia and the adjacent oceanic plate**

minor plates

- **Cocos plate:** Between Central America and Pacific plate
- **Nazca plate:** Between South America and Pacific plate
- **Arabian plate:** Mostly the Saudi Arabian landmass
- **Philippine plate:** Between the Asiatic and Pacific plate
- **Caroline plate:** Between the Philippine and Indian plate (North of New Guinea)
- **Fuji plate:** North-east of Australia
- **Juan De Fuca plate:** South-East of North American Plate

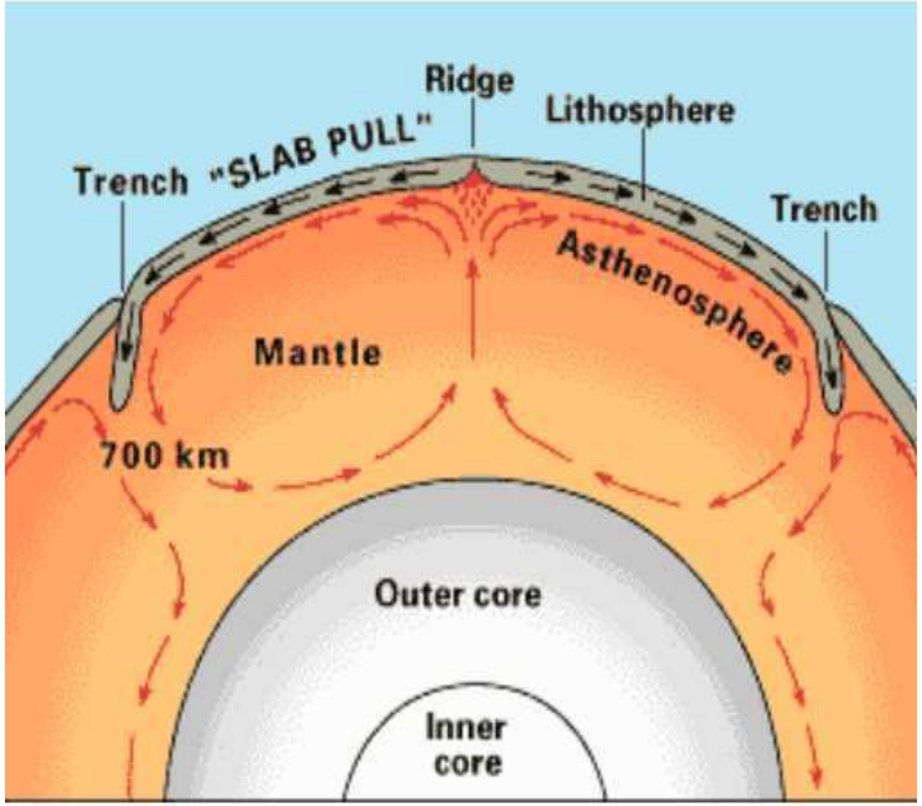
North American Plate
Eurasian Plate
Juan de Fuca Plate
Pacific Plate
Caribbean Plate
Cocos Plate
Arabian Plate
Indian Plate
Philippine Sea Plate
Pacific Plate
African Plate
Nazca Plate
South American Plate
Australian Plate
Scotia Plate
Antarctic Plate

Movement of Plates

- The tectonic plates are not fixed but constantly move horizontally over the **Asthenosphere** as rigid units.
- Sometimes these plates collide, move apart, or slide next to each other which leads to **Earthquakes or Volcanic Eruptions.**
- **Rates of Movement of Tectonic Plates:** The rates of movement of the tectonic plates vary considerably.
  - The **Arctic Ridge** has the slowest rate (less than 2.5 cm/yr), and the **East Pacific Rise,** in the South Pacific (about 3,400 km west of Chile) has the fastest rate (more than 15 cm/yr).

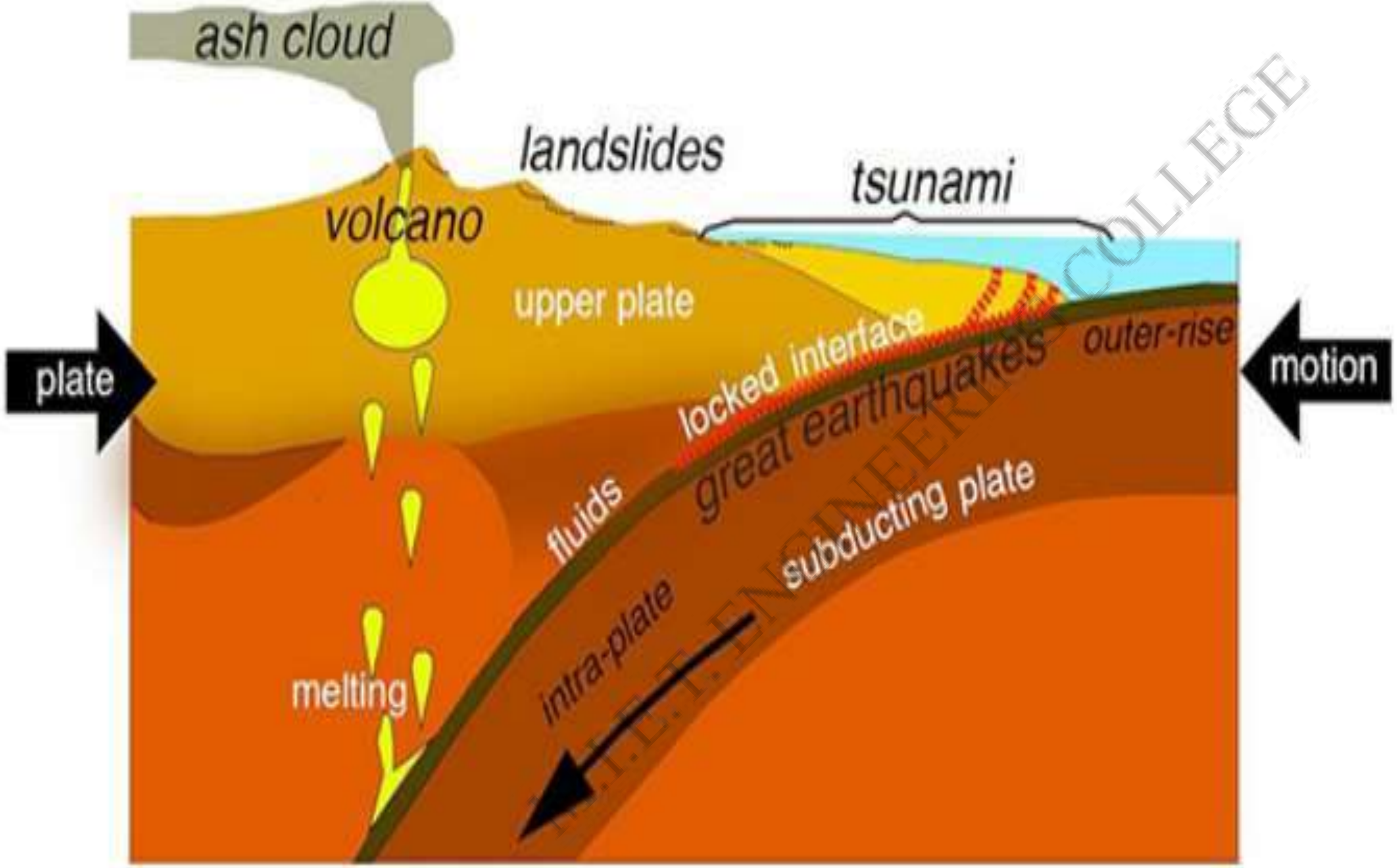
Force for the Movement of Tectonic Plates:

- the rigid plates is believed to be moving in a circular manner.
  The heated material rises to the surface, spreads and begins to cool, and then sinks back into deeper depths.
- This **slow movement of hot, softened mantle** that lies below these rigid plates is the driving force behind the plate movement



Subduction

- It happens when tectonic plates shift, and one plate is pushed under another.
- This movement of the ocean floor produces a **"mineral transmutation"**, which leads to the melting and solidification of magma i.e., the **formation of volcanoes.**
  - In other words, when a "downgoing" oceanic plate is pushed into a hotter mantle plate, it heats up, volatile elements mix, and this produces the magma.
  - The magma then rises up through the overlying plate and spurts out at the surface.


ash cloud
landslides
tsunami
volcano
upper plate
plate
motion
locked interface
great earthquakes
outer-rise
fluids
subducting plate
intra-plate
melting

Boundaries of Plates

1. **Convergent,** where plates move into one another.
2. **Divergent,** where plates move apart.
3. **Transform,** where plates move sideways in relation to each other

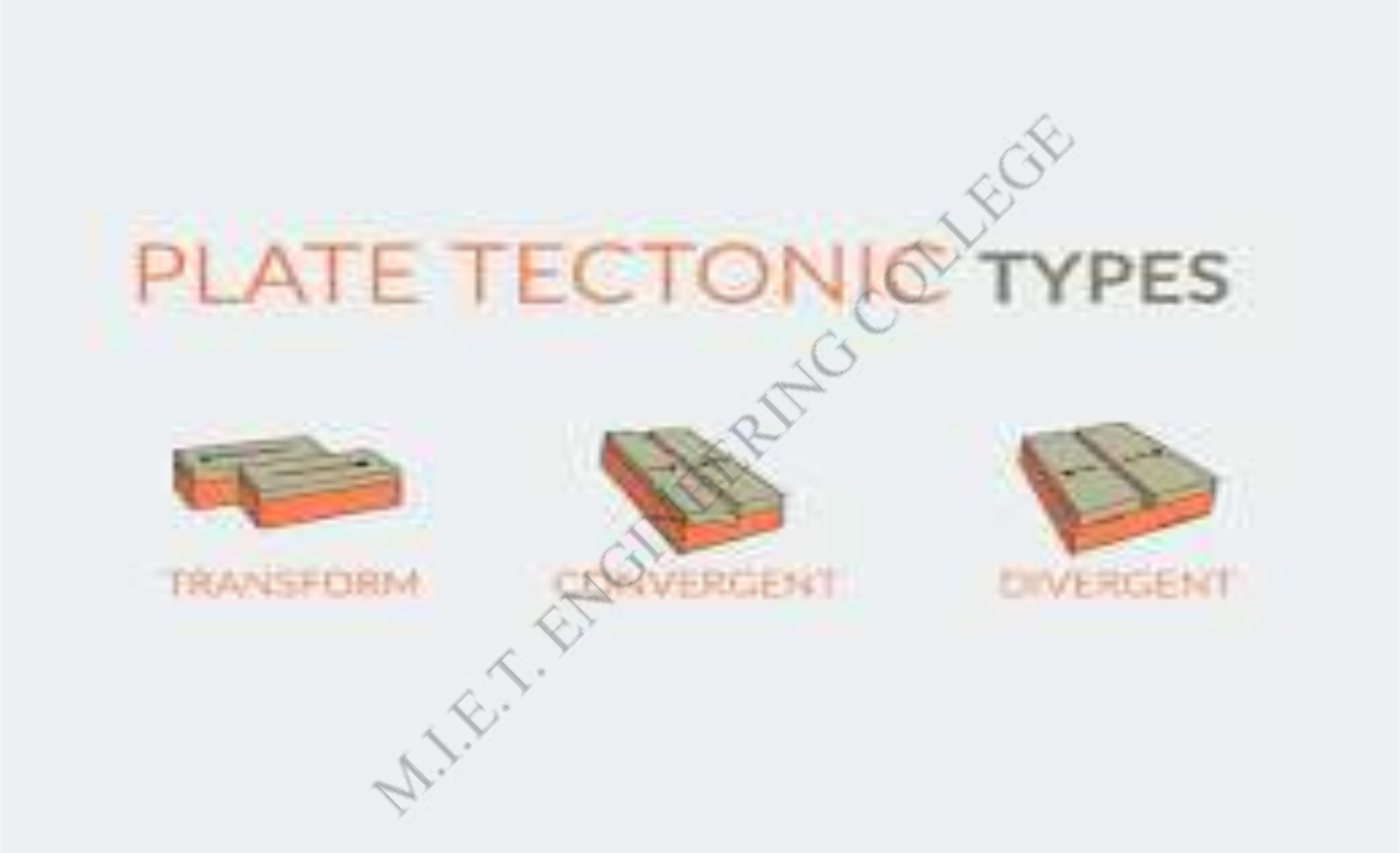


PLATE TECTONIC TYPES
TRANSFORM
CONVERGENT
DIVERGENT

Convergent Boundaries

- A convergent plate boundary is formed when tectonic plates crash into each other. They are also known as **destructive boundaries.**
- These boundaries are often **subduction zones,** where the heavier plate slips under the lighter plate, creating a deep trench.
  - This subduction changes the dense mantle material into buoyant magma, which rises through the crust to the Earth's surface.
  - Over millions of years, the rising magma has been creating a series of active volcanoes known as a **volcanic arc.**

There are three ways in which convergence can occur

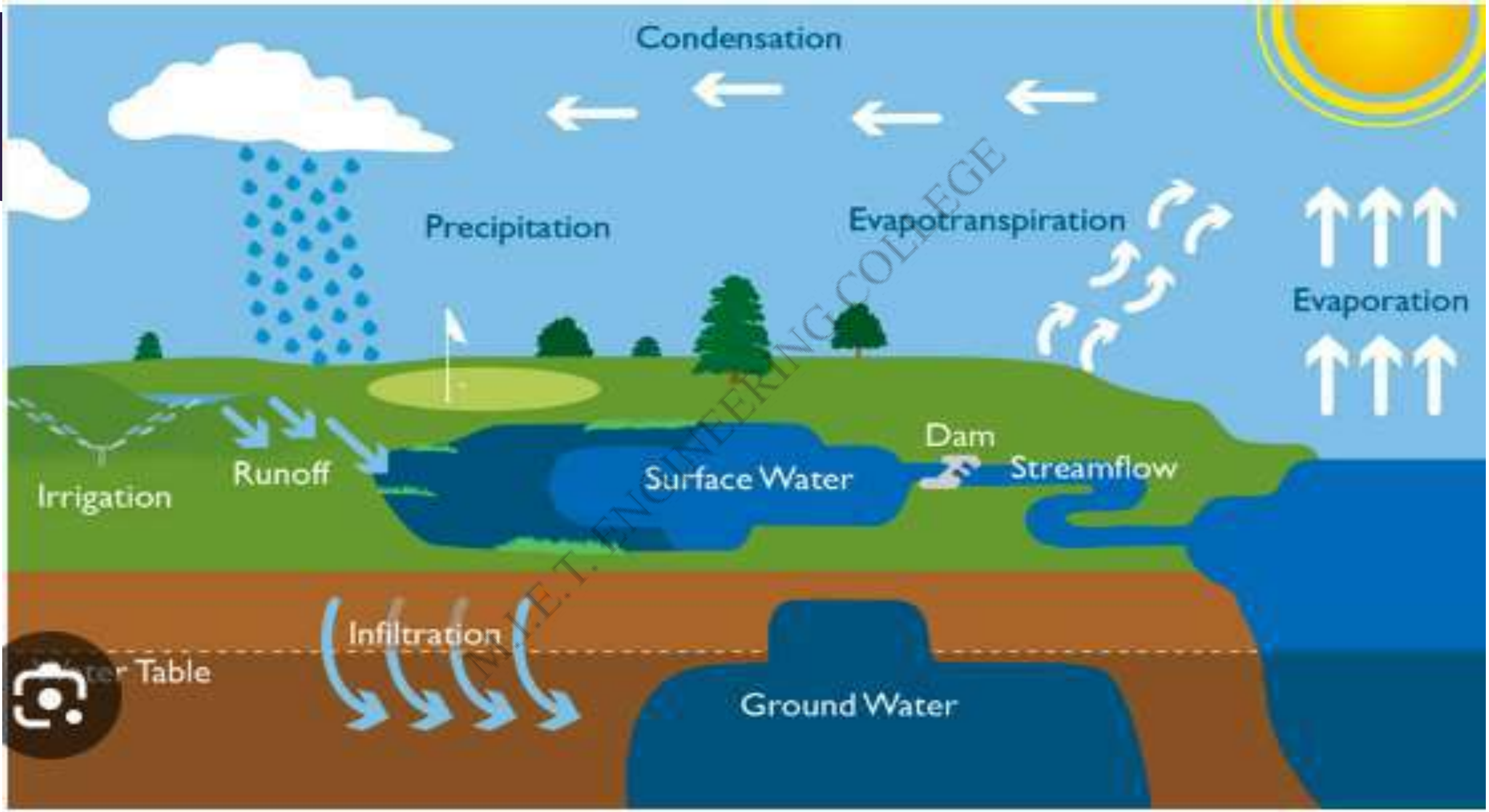
- between an **oceanic and continental** plate
- between **two oceanic** plate
- between **two continental** plates

Divergent Boundaries

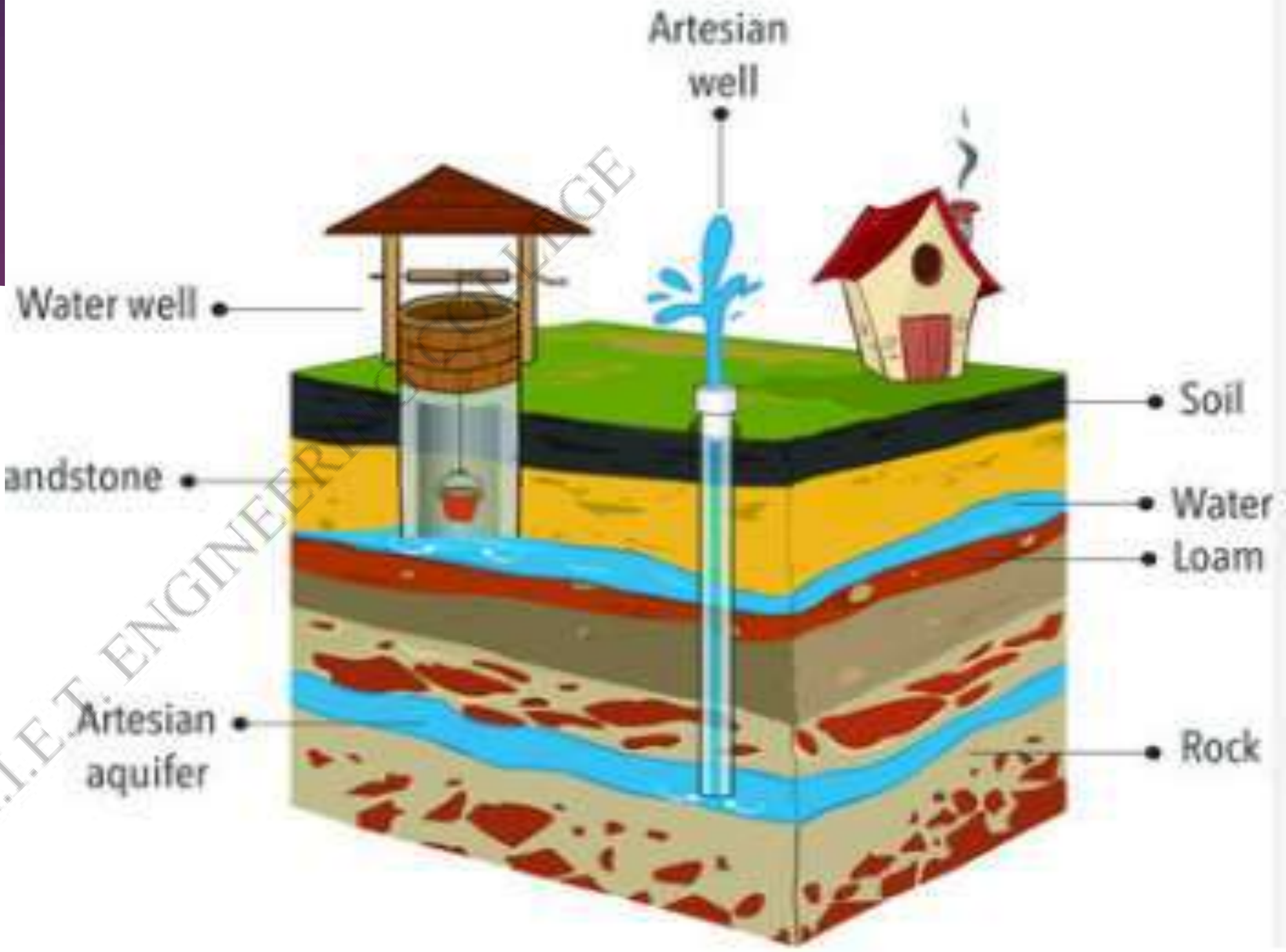
- A divergent boundary is formed by tectonic plates pulling apart from each other. They are known as **constructive boundaries.**
- Divergent boundaries are the site of **seafloor spreading** and **rift valleys.**
- At divergent boundaries **in the oceans,** magma from deep in the Earth's mantle rises toward the surface and pushes apart two or more plates. Mountains and volcanoes rise along the seam. The process renews the ocean floor and widens the giant basins.

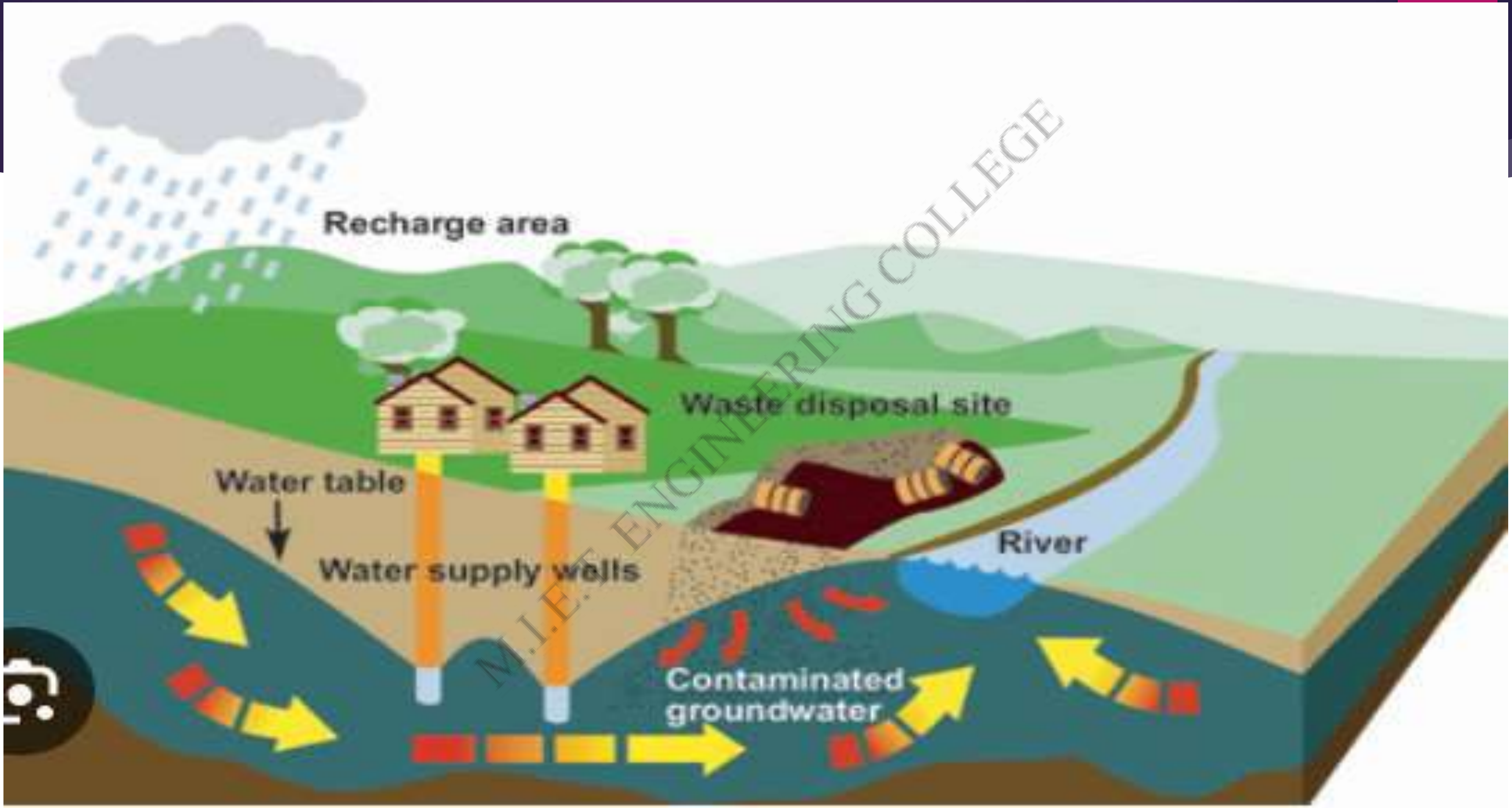
Transform Boundaries

Groundwater: types of aquifers, origin, movement and role of groundwater in Civil


Condensation
Precipitation
Evapotranspiration
Evaporation
Dam
Streamflow
Surface Water
Runoff
Irrigation
Infiltration
Ground Water

Ground water

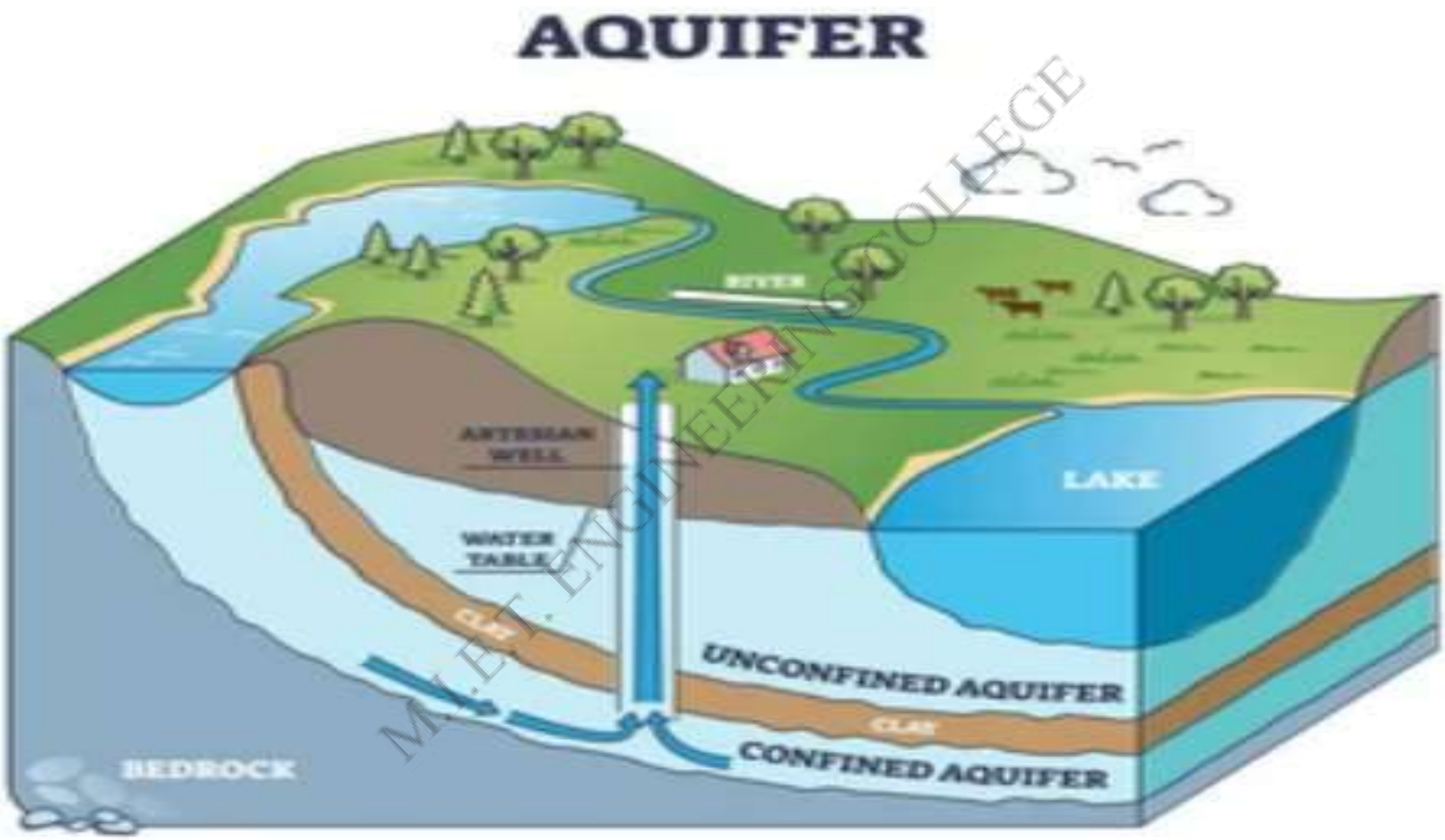




Recharge area
Waste disposal site
Water table
River
Water supply wells
Contaminated groundwater

Aquifer

- An aquifer is an underground layer of porous rocks or permeable rocks that store and retain groundwater levels in the soil.
- The underground aquifer is built with all types of porous or permeable rock materials, such as sand, gravel, or silt, making it a suitable water absorber.
- The rainwater enters the aquifer through the soil and becomes a part of the groundwater. T
- he groundwater from the aquifers then resurfaces from springs and wells. We can also extract the aquifer water with the help of a water well.
- The study of groundwater, aquifer, and their property is known as hydrogeology.


AQUIFER
RIVER
ARTESIAN WELL
WATER TABLE
CLAY
LAKE
UNCONFINED AQUIFER
CLAY
CONFINED AQUIFER
BEDROCK

Properties and Terms Related to an Aquifer

An aquifer forms near the surface and can also range deeper than 9,000 meters or 30,000 feet. The groundwater aquifers closer to the surface are used for irrigation and drinking purposes.

1.hydraulic Head: depth below the natural surface. We can also measure the hydraulic head against the sea level.

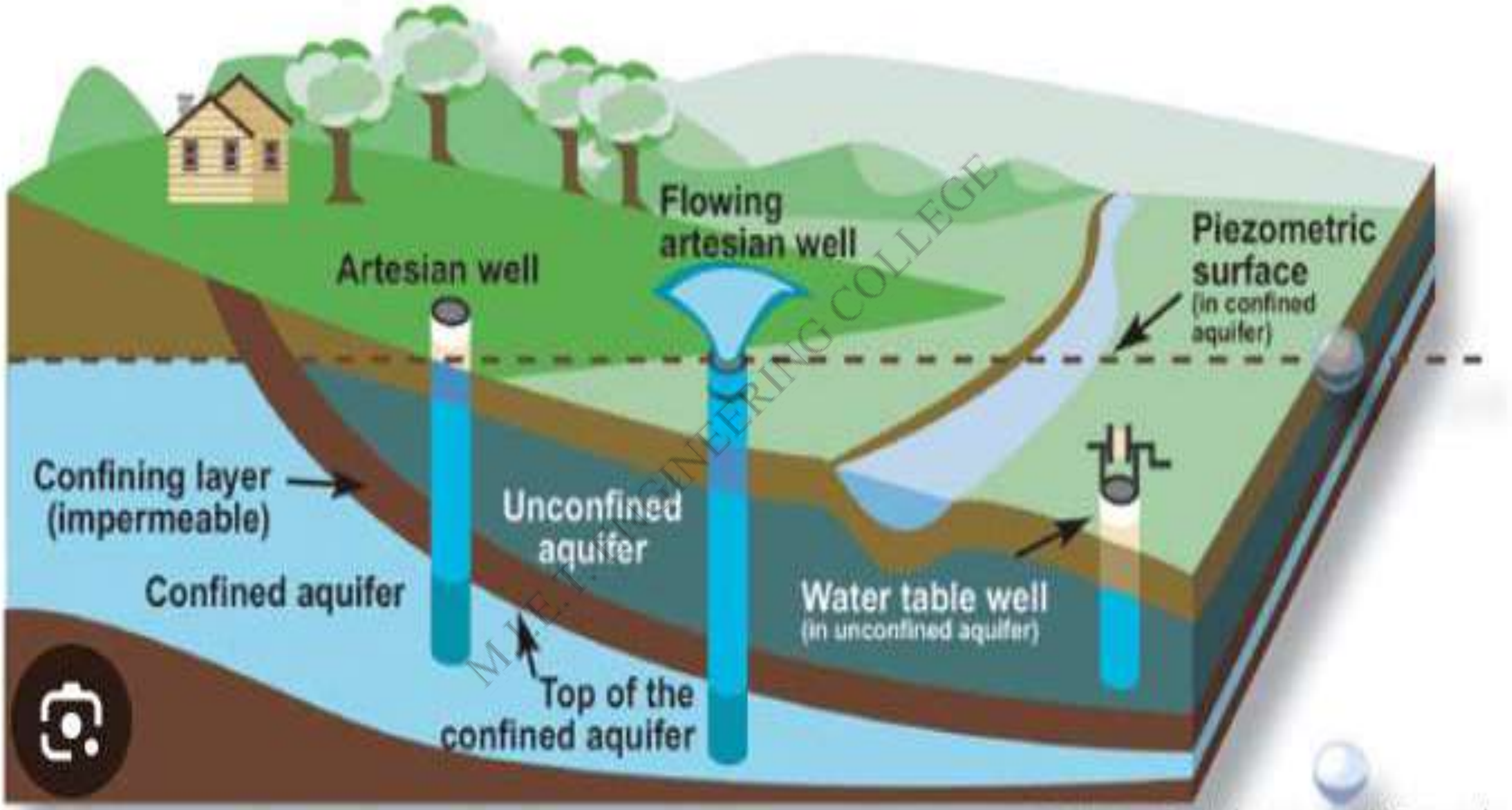
- **2.Hydraulic Gradient**: A hydraulic gradient can be defined as the difference between two hydraulic heads in an aquifer divided by the distance between them
- **3.Hydraulic Conductivity:** Hydraulic conductivity refers to the speed or ease with which water moves through the aquifer.

Types of Aquifers

- Aquifers can be classified into various types depending upon their formation, size, and materials. Let’s discuss each type of aquifer in detail.

Confined Aquifer:

- confined aquifer is an aquifer below the land surface that is saturated with water.
- Layers of impermeable material are both above and below the aquifer, causing it to be under pressure so that when the aquifer is penetrated by a well, the water will rise above the top of the aquifer.

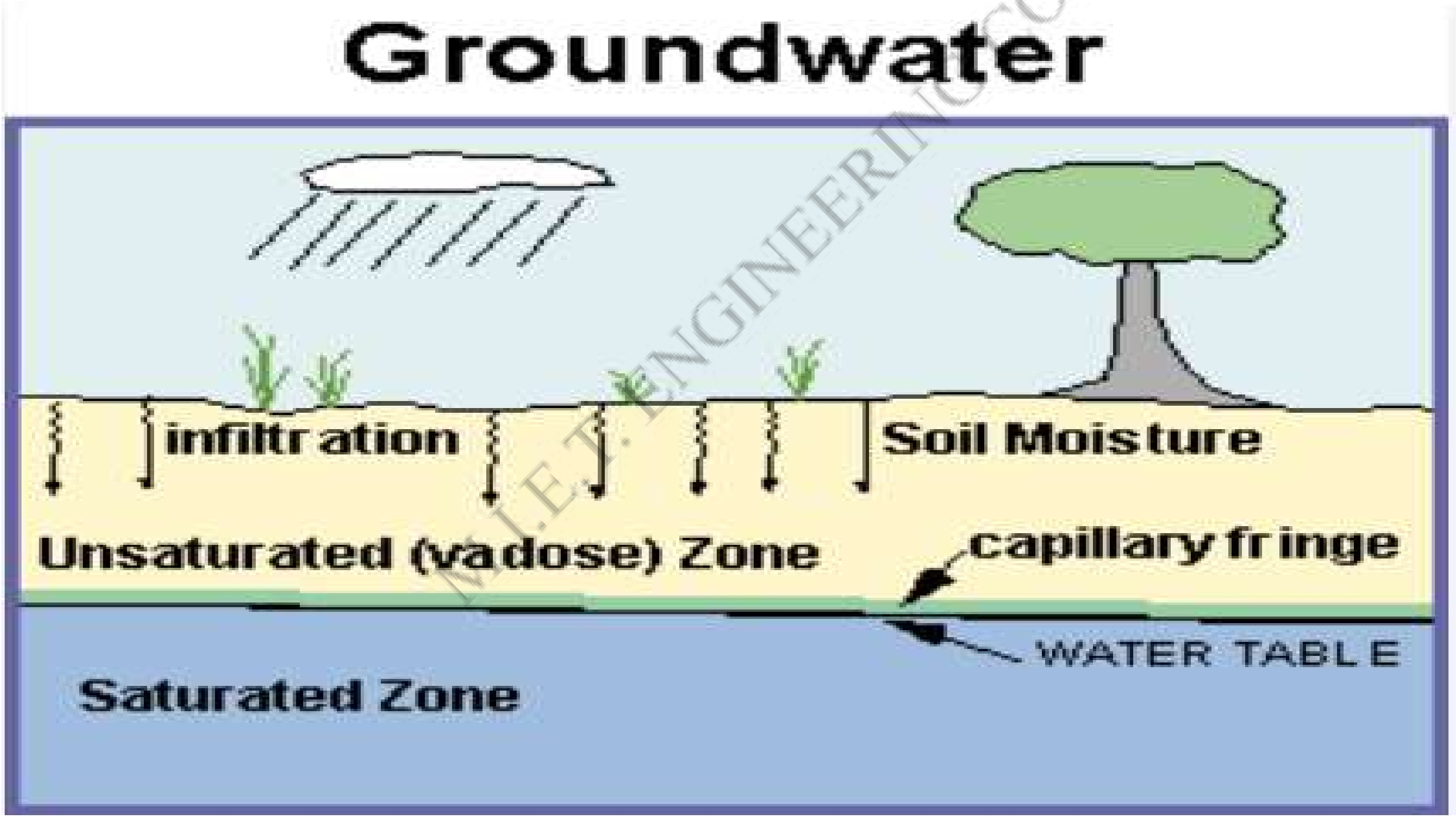


Source: Environment Canada

Unconfined aquifer

- A water table--or unconfined--aquifer is an aquifer whose upper water surface (water table) is at atmospheric pressure, and thus is able to rise and fall.
- Water table aquifers are usually closer to the Earth's surface than confined aquifers are, and as such are impacted by drought conditions sooner than confined aquifers.

Saturated Aquifer and Unsaturated Aquifer



groundwater in Civil Engineering constructions

- A areas with high water tables, the groundwater can seep into the excavation site, making it difficult to maintain stability and work effectively.
- Foundations: Groundwater can affect the design and construction of foundations.