ENGINEERING GEOLOGY

Course code:ACEB05

II. B.Tech II semester

Regulation: IARE R-18

BY

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CO's	Course outcomes
CO1	Understand the role of geology in the design and construction process of underground openings in rock.
CO2	Be able to apply geologic concepts and approaches on rock engineering projects.
CO3	Be able to identify and classify rock using basic geologic classification systems

COs	Course Outcome
CO4	Be able to use the geologic literature to establish the geotechnical framework needed to properly design and construct heavy civil works rock projects
CO5	Have knowledge of design and construction procedures required to safely control rock behavior in underground openings.

MODULE-I

INTRODUCTION OF ENGINEERING GEOLOGY

CLOs	Course Learning Outcome
CLO1	Know the importance of geology in civil engineering.
CLO2	Distinguish weathered rocks from fresh rocks.
CLO3	Understand the effects of weathering on dams, Reservoirs and tunnels.
CLO4	Understand the case histories of failure of some Civil Engineering constructions due to Geological draw backs.

Introduction to Geology:

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

DIFFERENT BRANCHES OF GEOLOGY

1. Physical Geology
2. Crystallography
3. Stratigraphy
4. Mining Geology
5. Mineralogy
6. Paleontology
7. Petrology
8. Historical Geology
9. Structural Geology

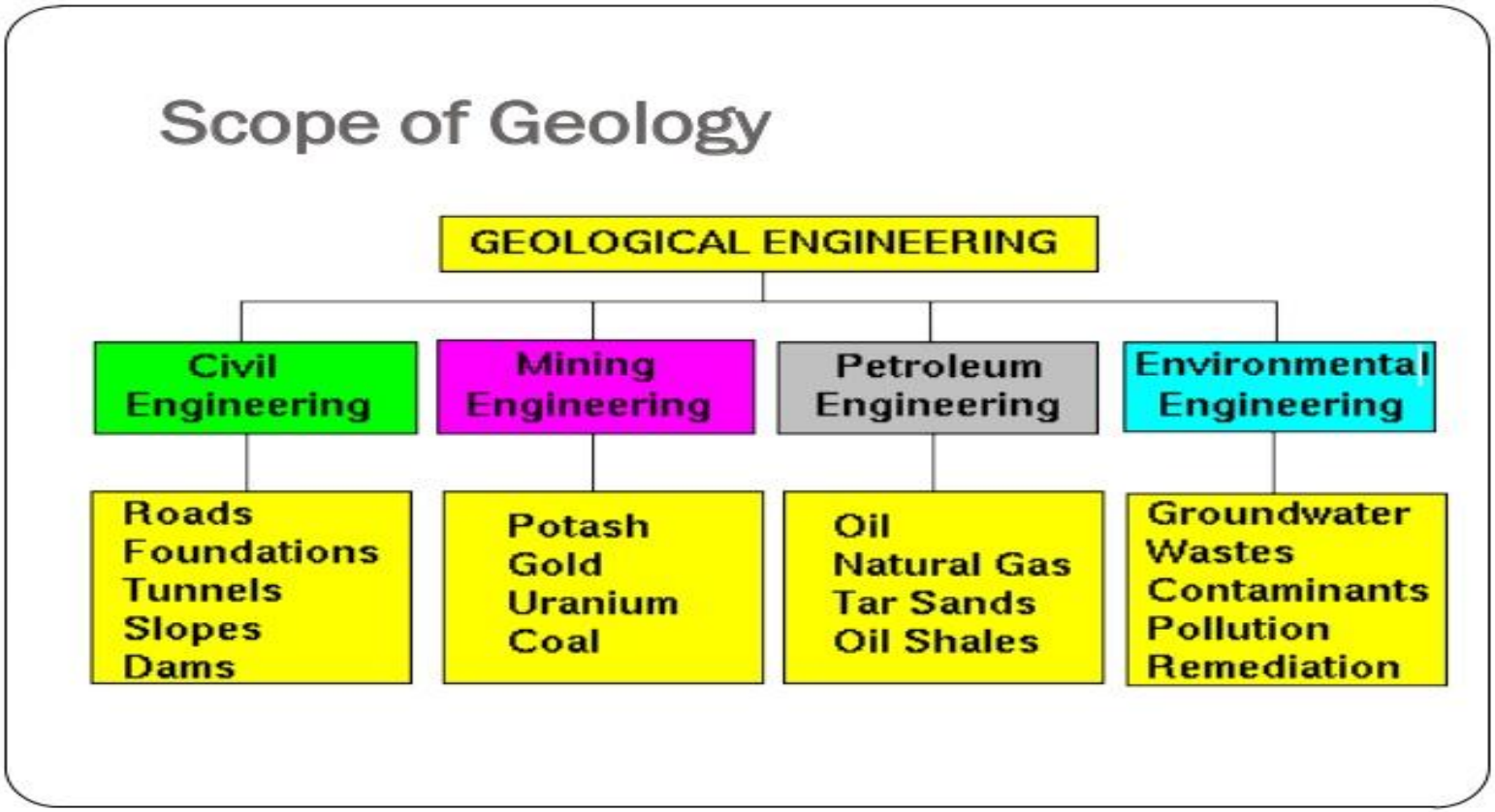
SCOPE OF GEOLOGY

- a)In Civil Engineering:
- Geology provides necessary information about the site of construction materials used in the construction of buildings, dams, tunnels, tanks, reservoirs, highways and bridges.
- Geological information is most important in planning stage, design phase and construction phase of an engineering project.
- b) In Mining Engineering:
- Geology is useful to know the method of mining of rock and mineral deposits on earth's surface and subsurface.

SCOPE OF GEOLOGY

c)In Ground Water:

Resources development geology is applied in various aspects of resources and supply, storage, filling up of reservoirs, pollution disposal and contaminated water disposal.



IMPORTANCE OF GEOLOGY FROM CIVIL ENGINEERING POINT OF VIEW:

Before constructing roads, bridges, tunnels, tanks, reservoirs and buildings, selection of site is important from the viewpoint of stability of foundation and availability of construction materials.

Geology of area is important and rock-forming region, their physical nature, permeability, faults, joints, etc.

Thus, geology is related to civil engineering in construction jobs with economy and success.

The role of geology in civil engineering may be briefly outlined as follows:

- Geology provides a systematic knowledge of construction materials, their structure and properties.
- The knowledge of Erosion, Transportation and Deposition (ETD) by surface water helps in soil conservation, river control, coastal and harbor works.
- The knowledge about the nature of the rocks is very necessary in tunneling, constructing roads and in determining the stability of cuts and slopes. Thus, geology helps in civil engineering.
- The foundation problems of dams, bridges and buildings are directly related with geology of the area where they are to be built.

The knowledge of ground water is necessary in connection with excavation works, water supply, irrigation and many other purposes.

Geological maps and sections help considerably in planning many engineering projects.

If the geological features like faults, joints, beds, folds, solution channels are found, they have to be suitably treated. Hence, the stability of the structure is greatly increased.

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

1. Failure due to earthquake

2. Failure due to landslide

3. Failure due to chemical weathering of foundation rocks (Effect Of Alkali-Silica Reaction, Sulfate & Chloride On Concrete)

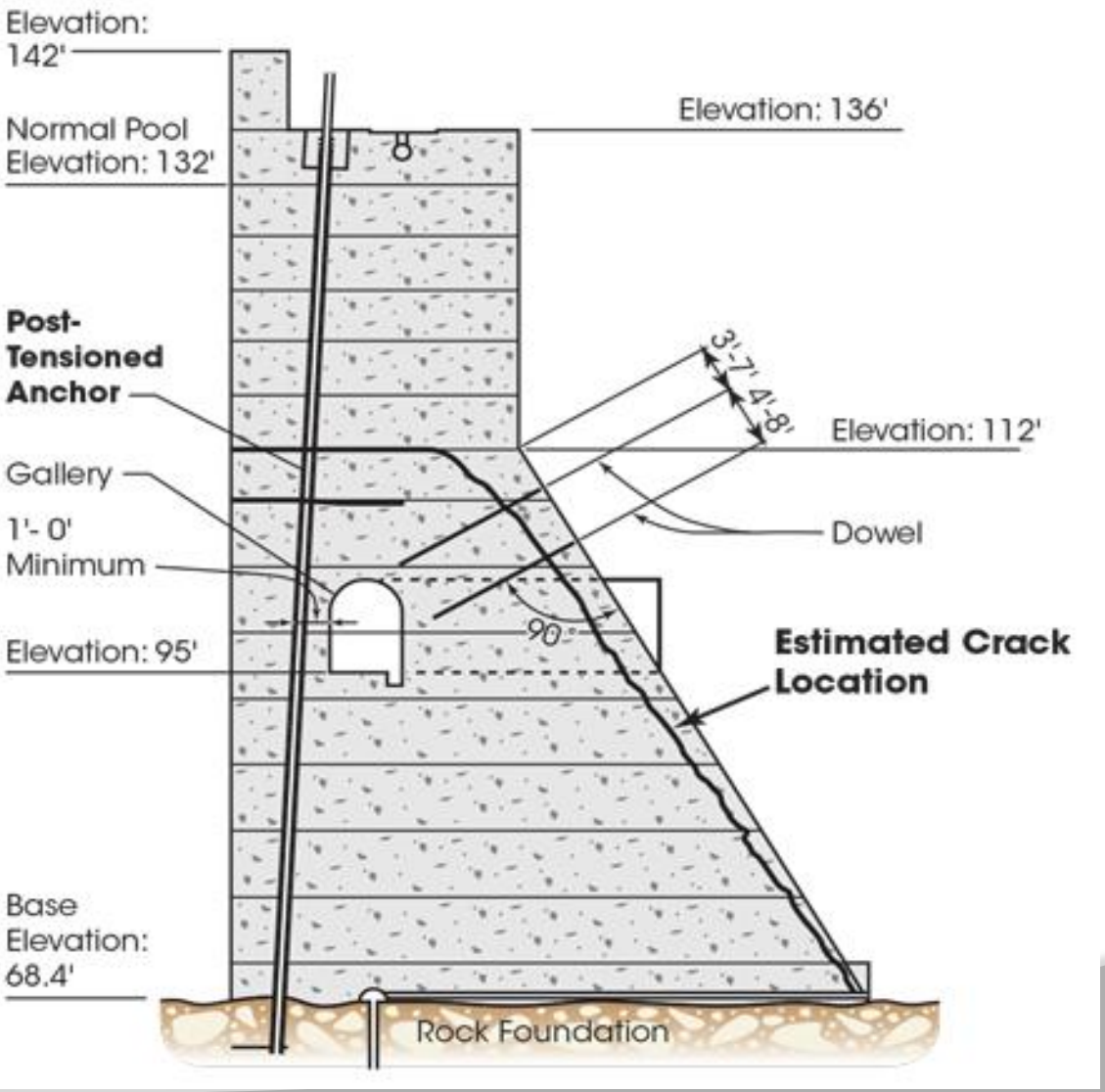
4. Failure due to physical weathering (temperature variations, or by heavy rain, or by physical breaking)

5. Failure due to increase of fractures in geological structures (fault, folds & unconformities)

1. Kaila Dam, Gujarat, India:

- The Kaila Dam in Kachch, Gujarat, India was constructed during 1952 - 55 as an earth fill dam with a height of 23.08 m above the river bed and a crest length of 213.36 m.
- Inspite of a freeboard allowance of 1.83 m at the normal reservoir level and 3.96 m at the maximum reservoir level the energy dissipation devices first failed and later the embankment collapsed due to the weak foundation bed in 1959.

BRIEF STUDY OF CASE HISTORIES OF FAILURE OF SOME CIVIL ENGINEERING CONSTRUCTIONS:



2. Baldwin Dam (USA):

- This earthen dam of height 80 m, was constructed for water supply, with its main earthen embankment at northern end of the reservoir, and the five minor ones to cover low lying areas along the perimeter.
- The failure occurred at the northern embankment portion, adjacent to the spillway (indicated a gradual deterioration of the foundation during the life of the structure) over one of the fault zones.

IMPORTANCE OF PHYSICAL GEOLOGY:

As a branch of geology, it deals with the “various processes of physical agents such as wind, water, glaciers and sea waves”, run on these agents go on modifying the surface of the earth continuously. Physical geology includes the study of Erosion, Transportation and Deposition (ETD).

The study of physical geology plays a vital role in civil engineering thus:

(a) It reveals constructive and destructive processes of physical agents at a particular site.

IMPORTANCE OF PHYSICAL GEOLOGY:

(b) It helps in selecting a suitable site for different types of project to be under taken after studying the effects of physical agents which go on modifying the surface of the earth physically, chemically and mechanically

IMPORTANCE OF PETROLOGY:

- As a branch of geology it deals with ‘the study of rocks’. A rock is defined as “the aggregation of minerals found in the earth’s crust”.
- The study of petrology is most important for a civil engineer, in the selection of suitable rocks for building stones, road metals, etc
- Petrology is the study of the nature of rocks and the processes that form the rocks that comprise the Earth.
- Petrology gives the details of textures, primary structures and minerals of rocks which contribute the physical properties of rocks.

IMPORTANCE OF STRUCTURAL GEOLOGY:

- As a branch of geology, it deals with ‘the study of structures found in rocks’.
- Structural geology is the study of factors such as origin, occurrence, classification, types and effects of various secondary structures like folds, faults, joints and unconformities.
- The primary goal of structural geology is to use measurements of present-day rock geometries to uncover information about the history of deformation (strain) in the rocks.

WEATHERING OF ROCKS:

- The deteriorating effect of weather, climate or atmospheric agencies on rocks may be described as weathering of rocks.
- The different kinds of rocks which are formed under different conditions undergo disintegration and decay when exposed to earth’s surface.

WEATHERING OF ROCKS:

Two important classifications of weathering processes exist

1. **Physical weathering:**

- Mechanical or physical weathering involves the breakdown of rocks and soils through direct contact with atmospheric conditions, such as heat, water, ice and pressure.

Example: Thermal stress weathering can occur in a desert climate that is hot during the day and cold and night. The heating and cooling processes that happen every day put stress onto rocks in the outer layer, causing the outer layers of the rock to start peeling off in thin sheets.

WEATHERING OF ROCKS:

2. Chemical weathering;

Chemical weathering, involves the direct effect of atmospheric chemicals or biologically produced chemicals in the breakdown of rocks, soils and minerals.

Example: when water comes in contact with granite. Feldspar crystals inside the granite react chemically, forming clay minerals. The clay weakens the rock, making it more likely to break.

WEATHERING OF ROCKS:

- Example of this type of weathering is rust formation, which occurs when oxygen reacts with iron to form iron oxide (rust).
- Rust changes the color of the rocks, plus iron oxide is much more fragile than iron, so the weathered region becomes more susceptible to breakage.

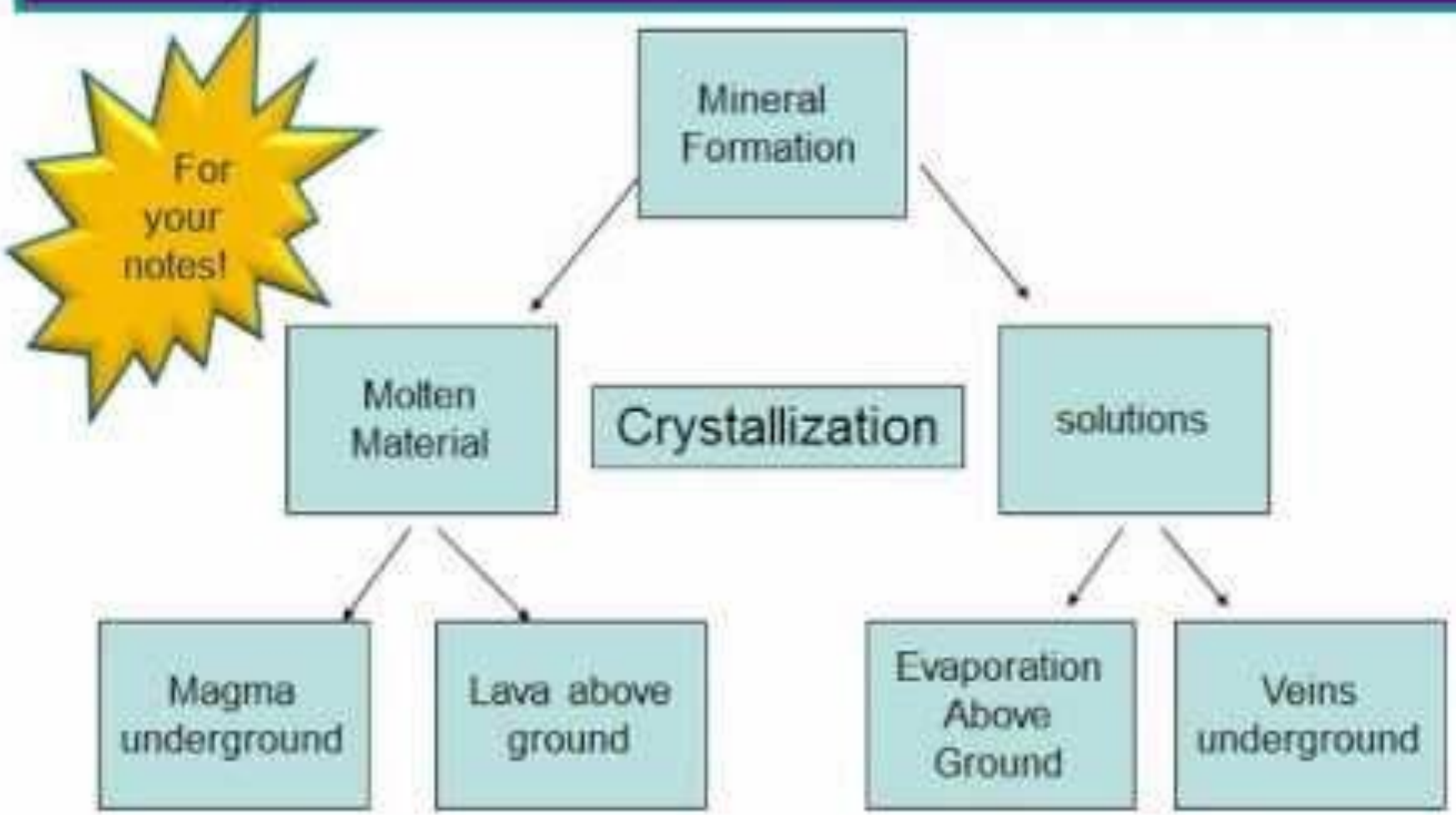
RECOGNITION OF WEATHERED MINERALS

- Weathered rocks usually develop brown, red and yellow colour on the surface.
- Weathered minerals exhibit change in color intensity and strength.
- They lose their natural original shine and fresh appearance.
- They become less transparent or tend to become opaque.

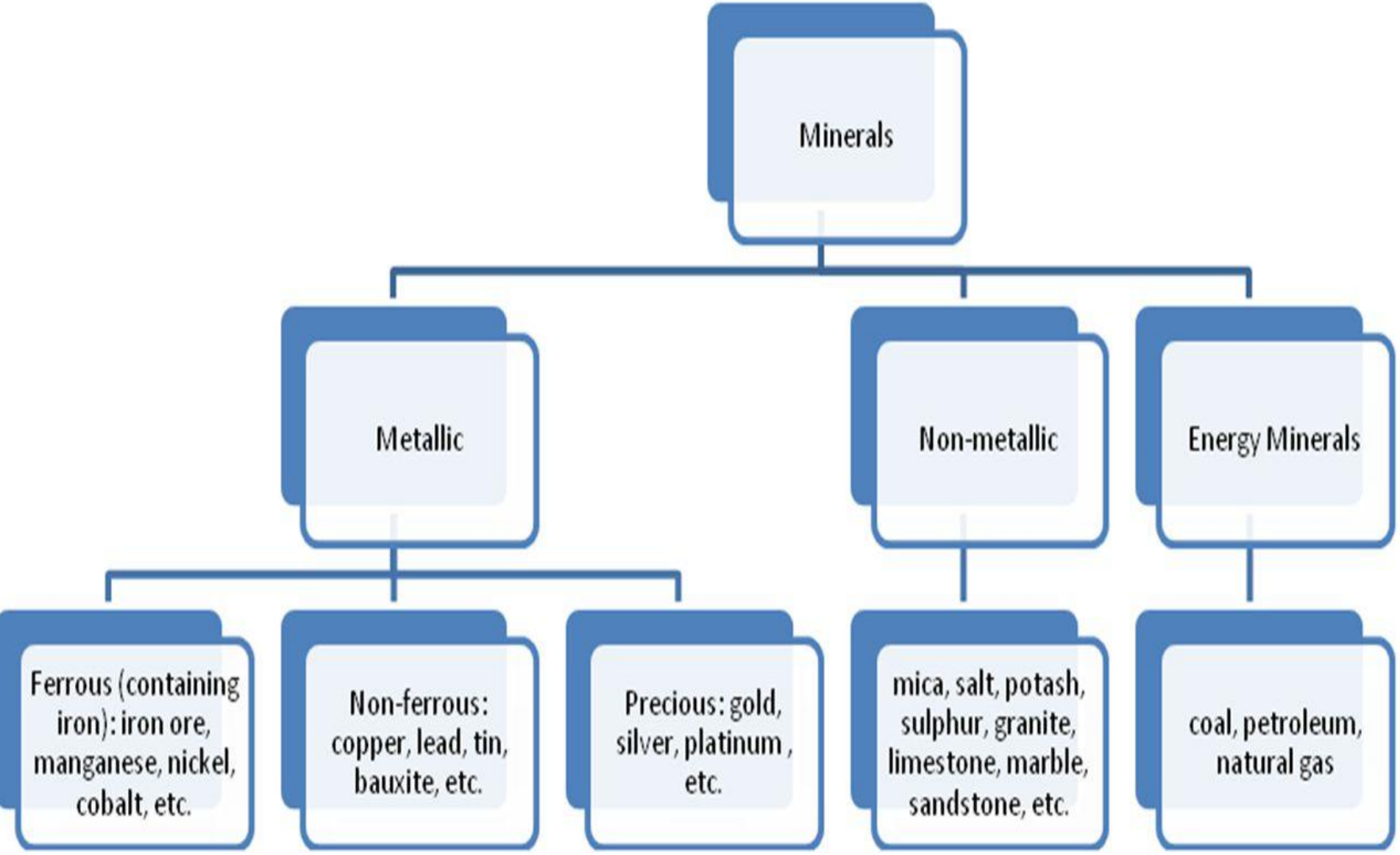
MINERALOGY

- A mineral is, broadly speaking, a solid chemical compound that occurs naturally in pure form.
- Minerals are most commonly associated with rocks due to the presence of minerals within rocks.
- These rocks may consist of one type of mineral, or may be an aggregate of two or more different types of minerals, spacially segregated into distinct phases.

Power Thinking on Mineral Formation



Types of Minerals



Minerals

Quartz

Feldspars

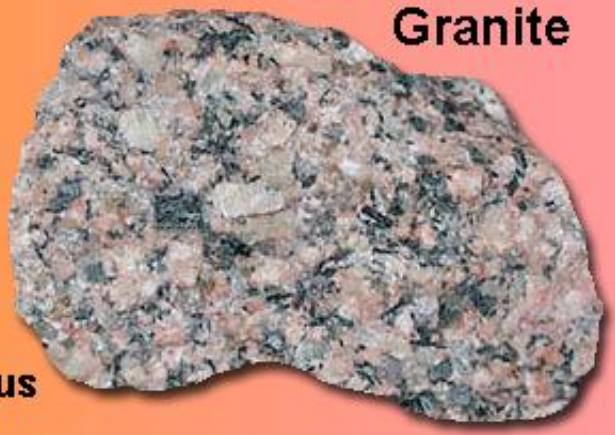
Orthoclase and Plagioclase

Micas

Muscovite and Biotite

Rocks

Igneous



Granite

Sedimentary

Sandstone

Metamorphic

Gneiss

MINERALOGY:

- Mineralogy is a subject of geology specializing in the scientific study of the chemistry, crystal structure, and physical (including optical) properties of minerals.
- Specific studies within mineralogy include the processes of mineral origin and formation, classification of minerals, their geographical distribution, as well as their utilization.

Different methods of study of minerals:

- Methods of study of Minerals Every mineral has its own chemical composition and atomic structure.
- This combination of chemical composition and atomic structure is unique for every mineral. This fact facilitates the study of minerals in different ways.

IMPORTANT DETAILS OF COMMON ROCK FORMING MINERALS:

The Feldspar Group:

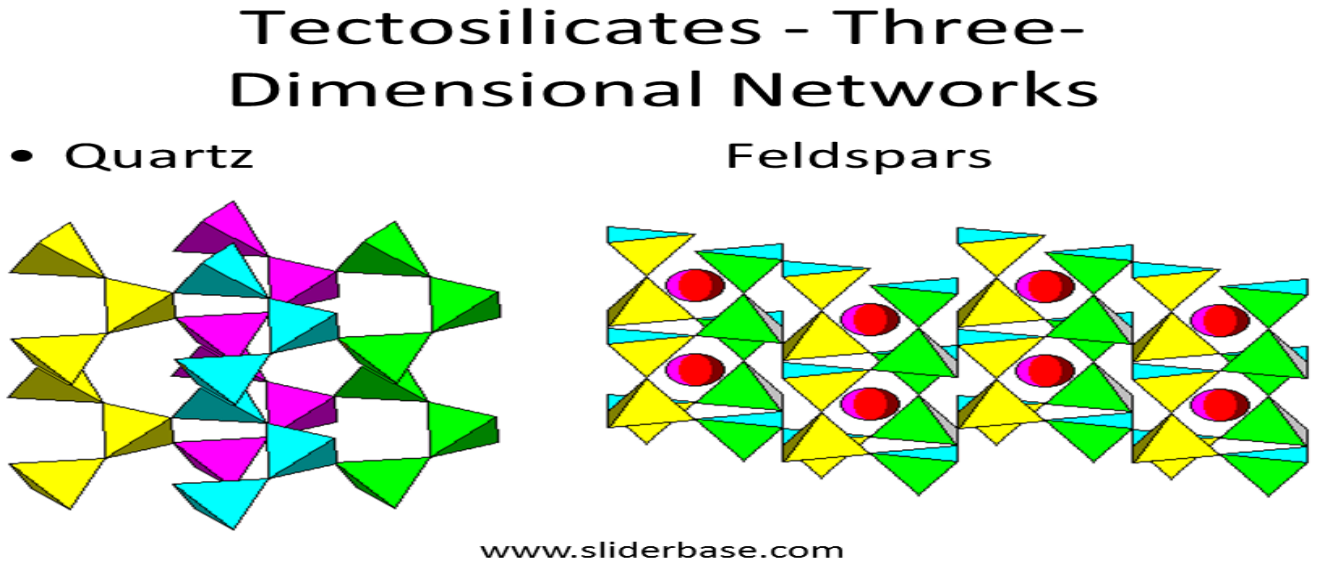
- The term feldspar does not represent any single mineral. It refers to a group of different minerals which possess similar chemical composition, atomic structure and physical properties.
- There are very few rock types which are completely free from feldspar.

Chemical Composition;

All feldspar may be described as aluminum silicates of sodium, potassium, calcium. These are split into two sub groups as alkali feldspars and lime feldspars.

Atomic Structure:

All feldspars are ‘tectosilicates’ in atomic structure. That is the basic unit of the SiO4 tetrahedron in them occurs in a 3- dimensional framework type structure.



Quartz:

It has already stated that next to feldspars, quartz is the most common rock forming mineral. It is a tectosilicate, in its atomic structure the SiO_4 tetrahedral are arranged in the 3- dimensional network pattern.

Response to weathering:

Among different minerals quartz is the most resistant to weathering for the following reasons:

i) Being soluble quartz is not affected by natural waters as they are usually acidic due to dissolved CO_2.

ii) Due to the absence of cleavage and relatively high hardness it is not easily affected by disintegrating forces.


feldspar
quartz
quartz
feldspar

Mica Group:

- Mica is the family name of some similar silicate minerals.
- As rock forming minerals these rank next.

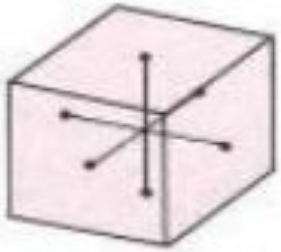
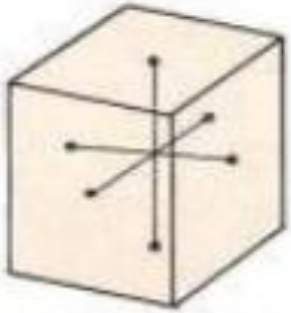
Chemical Composition:

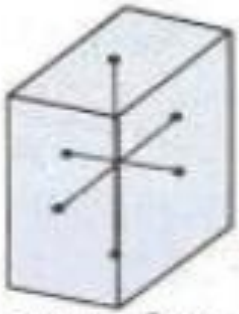
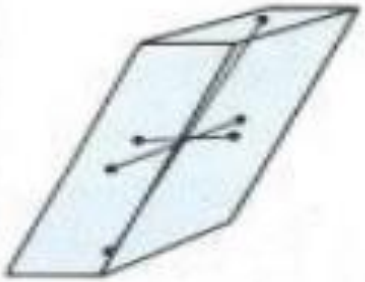
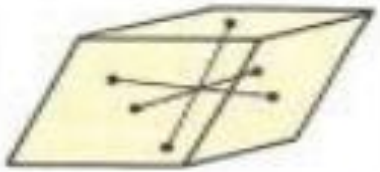
- These are the silicates of aluminum and potassium, together with magnesium.
- The crystalline structure of mica forms layers that can be split or delaminated into thin sheets usually causing foliation in rocks.
- These sheets are chemically inert, dielectric, elastic, flexible, insulating, lightweight, platy, reflective, refractive.

OPTICAL MINERALOGY;

- The study of the interaction of light with minerals, most commonly limited to visible light and usually further limited to the non-opaque minerals.
- Opaque minerals are more commonly studied in reflected light and that study is generally called ore microscopy
- Another application occurs because the optical properties of minerals are related to the crystal chemistry of the mineral -for example, the mineral's chemical composition, crystal structure, order/disorder.
- Minerals are divided into one of six crystallographic systems based upon their symmetry: cubic, hexagonal, tetragonal, orthorhombic, monoclinic, or triclinic.

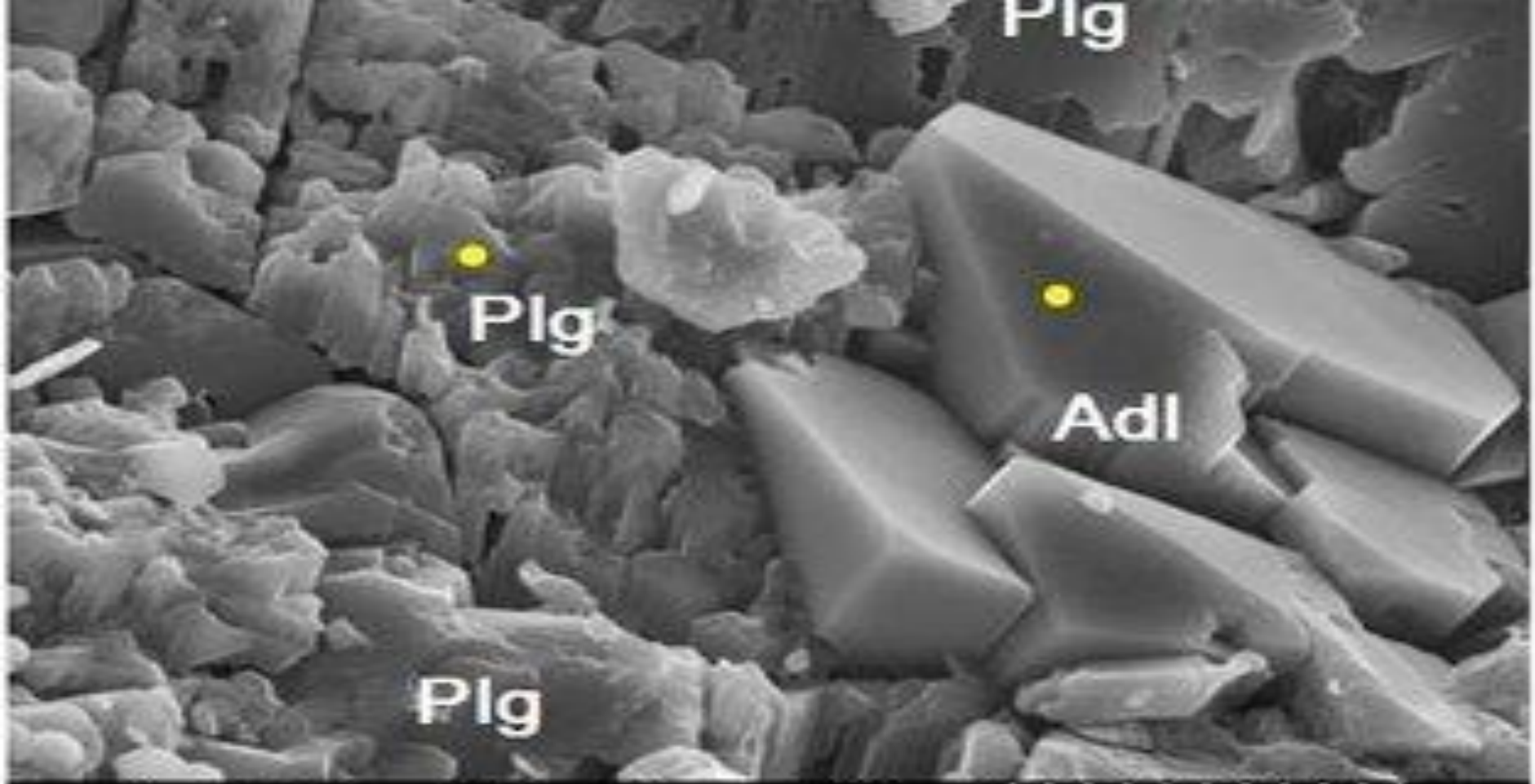
Crystal System (shape)

cubic	tetragonal	hexagonal
 examples: halite galena	 examples: zircon chalcopyrite	 examples: quartz calcite

orthorhombic	monoclinic	triclinic
 examples: sulfur staurolite	 examples: mica gypsum	 examples: feldspar rhodonite

SCANNING ELECTRON MICROSCOPY (SEM)

- The scanning electron microscope (SEM) uses a focused beam of high-energy electrons to generate a variety of signals at the surface of solid specimens.
- The signals that derive from electron-sample interactions reveal information about the sample including external morphology (texture), chemical composition, and crystalline structure and orientation of materials making up the sample.



Element	Weight %	Atomic %
O	51.85	66.67
Al	9.07	6.91
Si	28.42	20.81
K	10.67	5.61

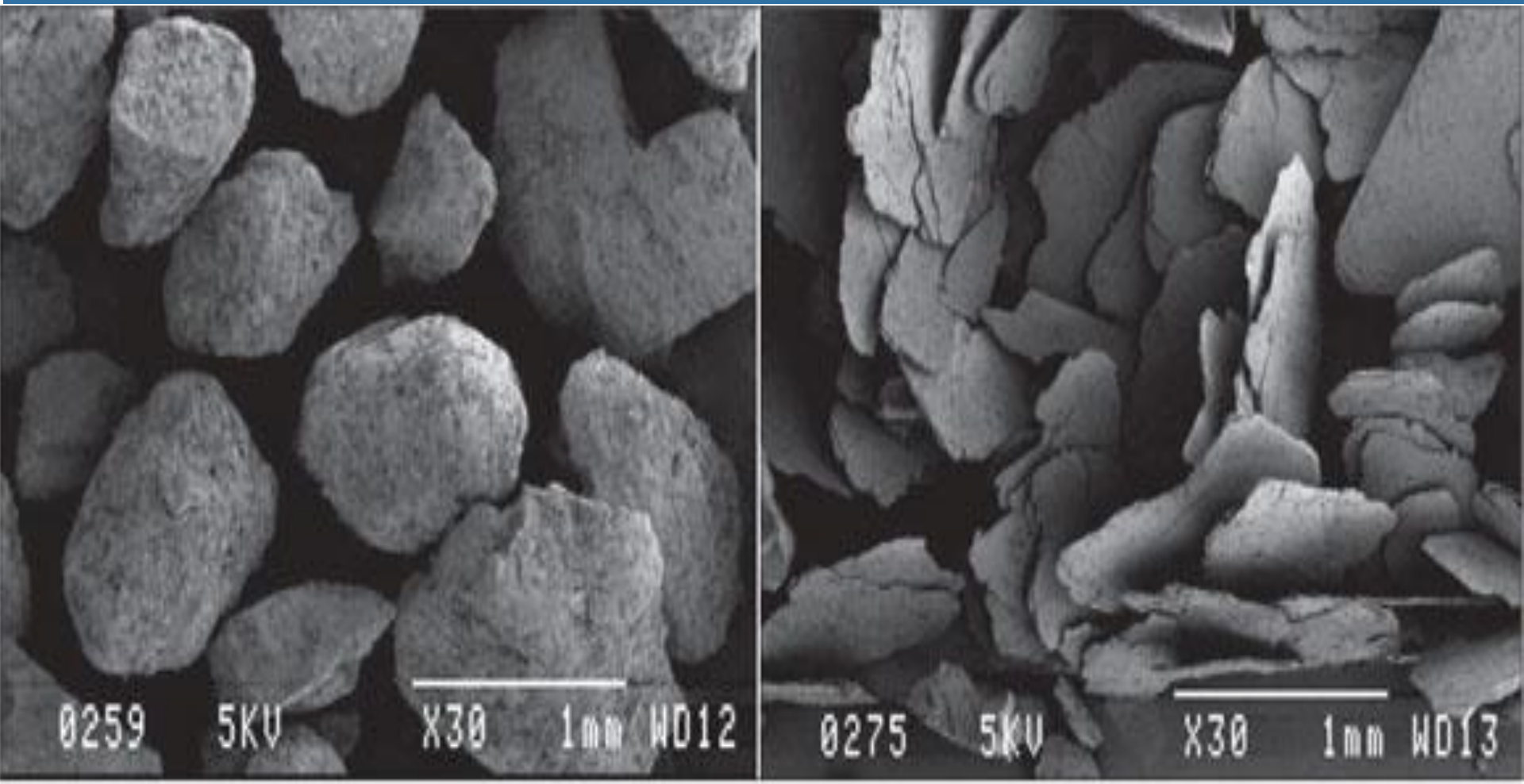


Figure 2 SEM images of +0.425 mm and –2 mm neat gravel soil particles (left) and mica (mus – covite) particles (right)

IDENTIFICATION OF COMMON PRIMARY & SECONDARY MINERALS:

Primary Minerals:

- The primary minerals are those which are formed owing to the crystallization of the molten magma.
- We have already seen that the earth's crust contains dominant amount of oxygen (46.60%) followed by silicon (27.72%).
- In order to achieve neutrality between the negatively-charged oxygen and the positively-charged silicon, there would be a greater tendency for silicon and oxygen to combine to form the basic compound, called the silicon-oxygen tetrahedron (SiO_4).

Feldspars: Feldspars belong to the group of minerals that are light in weight...

Quartz: It is another mineral which is widespread. It is one of the most resistant minerals.

Micas: Micas occur both as primary minerals in igneous rocks and as secondary minerals in altered.

Secondary Minerals:

- The secondary minerals are formed at the earth's surface by weathering on the pre-existing primary minerals under variable conditions of temperature and pressure.
- During weathering, water accompanied by CO_2 from the atmosphere plays an important role in processes, like hydrolysis, hydration
- As a result the primary minerals are altered or decomposed.

Clay Minerals. Clay minerals are ubiquitous and are the most abundant secondary products.

XRD:

- X-ray Powder Diffraction (XRPD) is a versatile technique that can be used to identify any crystalline substances, such as most minerals.
- It can also be used to quantify the proportions of different minerals or indeed many other substances when they are present in a mixture.

MODULE-II

PETROLOGY

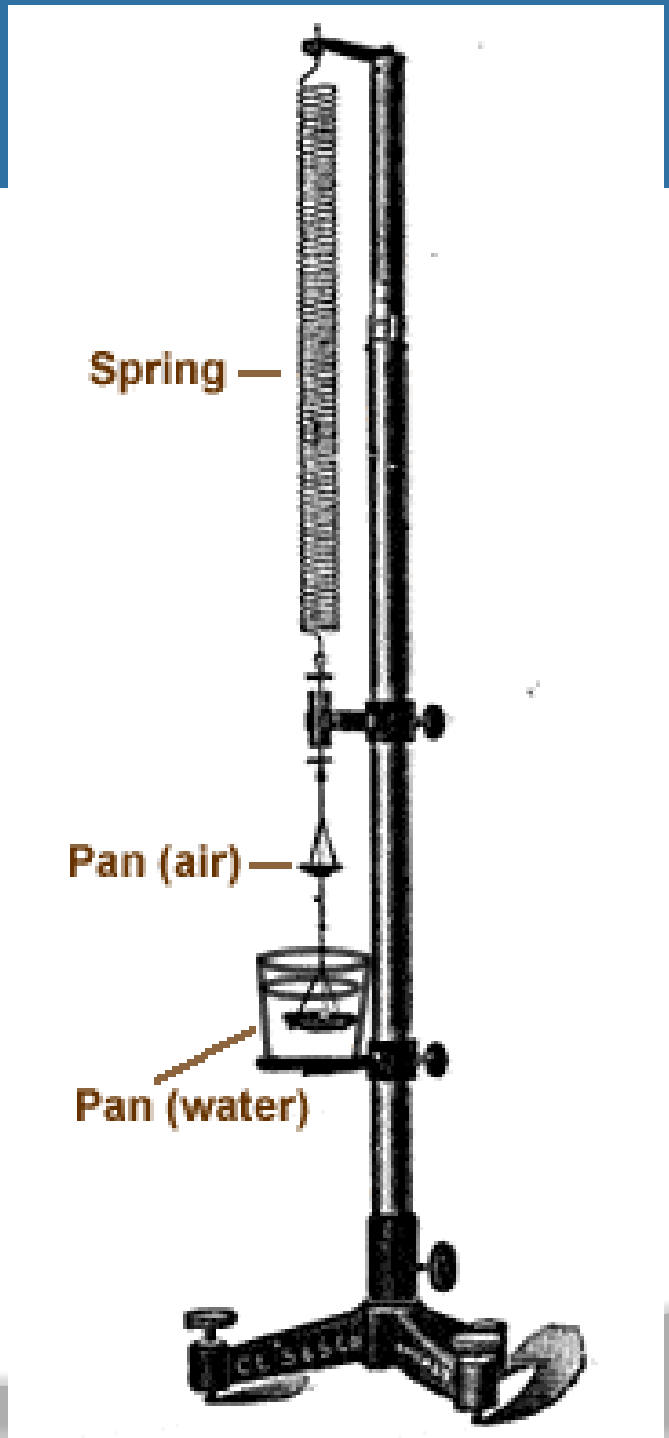
CLOs	Course Learning Outcome
CLO5	Determine the binomial distribution to find mean and variance.
CLO6	Understand the phenomena of real-time problem like sick versus healthy by using Binomial distribution.
CLO7	Determine the Poisson distribution to find mean and variance.
CLO8	Understand the phenomena of real-time problem of predicting soccer scores by using Poisson distribution.
CLO9	Illustrate the inferential methods relating to the means of normal distributions.
CL010	Describe the mapping of normal distribution in real-world problem to analyze the stock market

SPECIFIC GRAVITY(DENSITY)

- It depends on their chemical composition and atomic structure.
- In the laboratory s.g is determined by using either Walker's steel yard or Jolly's spring balance.
- Minerals formed out of weathering due to varying porosity, may show different s.g values.

Example:

Quartz which is crystalline form of silicon dioxide has the higher s.g of 2.7 and opal, the amorphous variety has the lesser s.g of 2.2.


Spring
Pan (air)
Pan (water)

IGNEOUS PETROLOGY:

- Igneous petrology is the study of igneous rocks—those that are formed from magma. As a branch of geology, igneous petrology is closely related to volcanology, tectonophysics, and petrology in general.

Types of volcanic eruption:

The most common type of volcanic eruption occurs when magma (the term for lava when it is below the Earth's surface) is released from a volcanic vent.

1. **Hawaiian Eruption:**

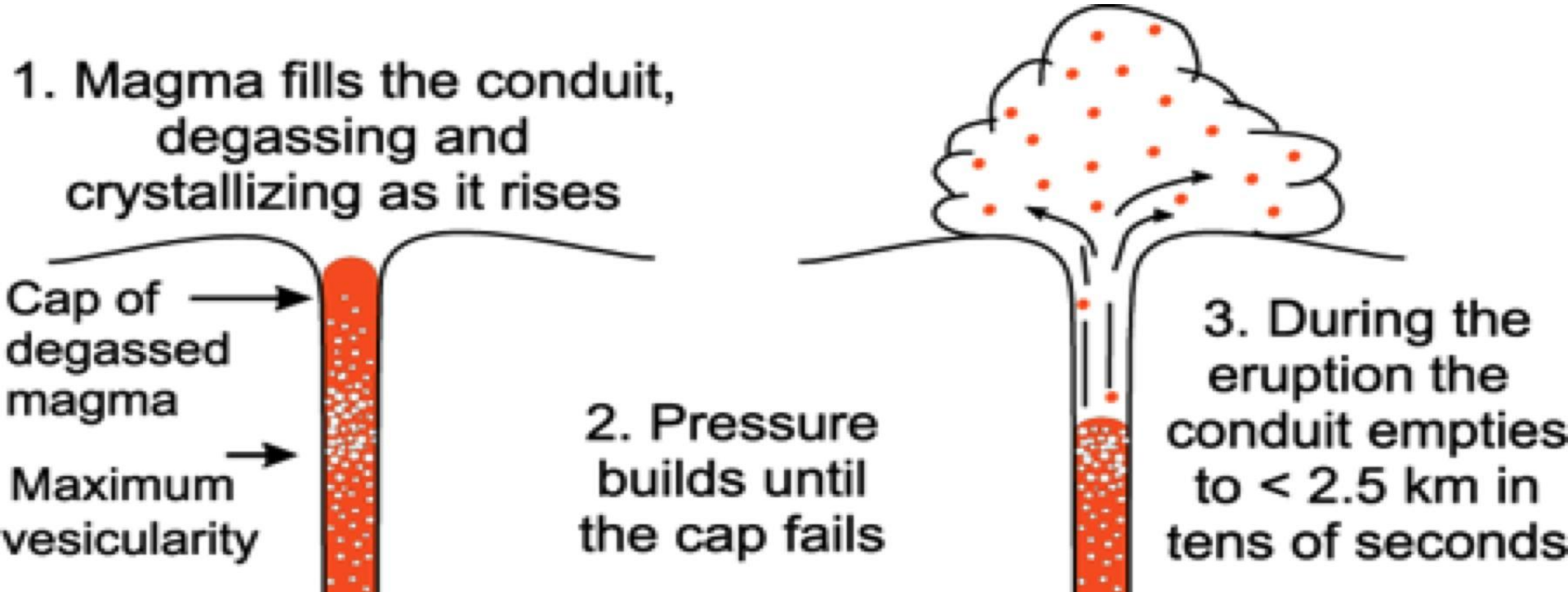
- Fluid basaltic lava is thrown into the air in jets from a vent or line of vents.
- The jets can last for hours or even days, a phenomenon known as fire fountaining.

2. Strombolian Eruption:

- Strombolian eruptions are distinct bursts of fluid lava (usually basalt or basaltic andesite) from the mouth of a magma-filled summit conduit.
- The explosions of lava, which can reach heights of hundreds of meters, are caused by the bursting of large bubbles of gas, which travel upward in the magma-filled conduit until they reach the open air.

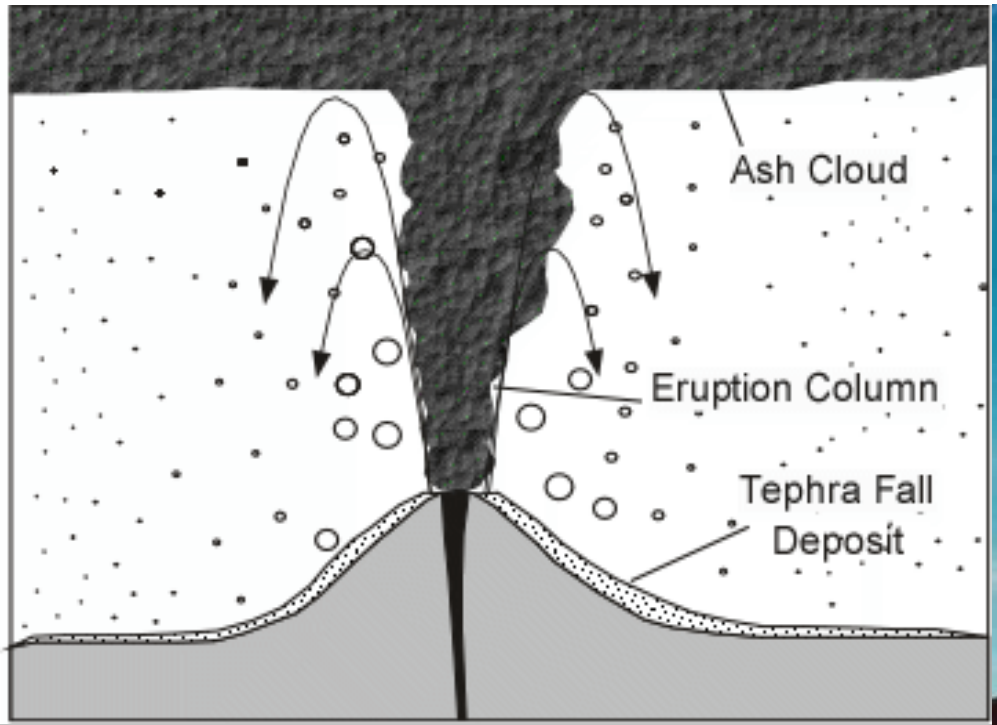
3. Vulcanian Eruption:

- A Vulcanian eruption is a short, violent, relatively small explosion of viscous magma.
- Vulcanian eruptions create powerful explosions in which material can travel faster than 350 meters per second (800 mph) and rise several kilometers into the air.



4. Plinian Eruption:

- The largest and most violent of all the types of volcanic eruptions are Plinian eruptions. They are caused by the fragmentation of gassy magma, and are usually associated with very viscous magmas.
- Ash from an eruption column can drift or be blown hundreds or thousands of miles away from the volcano.



Characteristics of different types of magma:

Basaltic Magma:

- Basaltic magma is made up of 45 to 55 percent silica.
- The temperature of basaltic magma is around 1,000 to 1,200 degrees Celsius.

Andesitic Magma:

- It is probably 800 to 1,000 degrees Celsius. It is made up of 55 to 65 percent silica with average amounts of iron, magnesium, calcium, potassium and sodium.

Felsic Magma:

- Felsic magma is made up of 65 to 75 percent silica.
- reaching 650 to 800 degrees Celsius, and is high in volatile, or unstable, gases and melted rocks.

Ultramafic Magma:

- Ultramafic lava could reach as high as 1,600 degrees Celsius.

Chemical Composition

- The unit cell of any substance will contain one or integral multiple of chemical formula units (Z value).
- Mineral formulas are based on the relationship to unit cell volume and the positions of atoms within the unit cell.

CLASSIFICATION OF IGNEOUS ROCKS ON THE BASIS OF CHEMICAL COMPOSITION:

- Occurrence of igneous rocks can be either intrusive (plutonic) or extrusive (volcanic).

Intrusive:

- Intrusive igneous rocks are formed from magma that cools and solidifies within the crust of a planet.

Extrusive

- Extrusive igneous rocks, additionally referred to as volcanic rocks, are fashioned on the crust's surface due to the partial melting of rocks within the mantle and crust.

CLASSIFICATION OF IGNEOUS ROCKS ON THE BASIS OF CHEMICAL COMPOSITION:

Chemical classification and petrology

- Igneous rocks may be classified in keeping with chemical or mineralogical parameters.
- Chemical: general alkali-silica content material (TAS diagram) for volcanic rock classification used when modal or mineralogic statistics is unavailable:
  - **felsic** igneous rocks containing a excessive silica content, more than 63% SiO2 (examples granite and rhyolite),

- **intermediate** igneous rocks containing among fifty two–63% SiO2 (example andesite and dacite),
- **mafic** igneous rocks have low silica forty five–fifty two% and typically high iron – magnesium content material (example gabbro and basalt),
- **ultramafic rock** igneous rocks with much less than forty five% silica (examples picrite, komatiite and peridotite),
- **alkalic igneous rocks** with 5–15% alkali (K2O + Na2O) content or with a molar ratio of alkali to silica extra than 1:6 (examples phonolite and trachyte).

MINERALOGICAL CLASSIFICATION

The maximum crucial criterion is the phenocryst species, followed by way of the groundmass mineralogy.

Mineralogic contents – felsic versus mafic

- felsic rock, highest content of silicon, with predominance of quartz, alkali feldspar and/or feldspathoids: the felsic minerals; these rocks (e.G., granite, rhyolite) are usually light coloured, and feature low density.
- Mafic rock, lesser content material of silicon relative to felsic rocks, with predominance of mafic minerals pyroxenes, olivines and calcic plagioclase; these rocks (instance, basalt, gabbro) are generally dark coloured, and have a higher density than felsic rocks.
- Ultramafic rock, lowest content of silicon, with greater than 90% of mafic minerals (e.G., dunite).

Composition				
Mode of occurrence	**Felsic**	**Intermediate**	**Mafic**	**Ultramafic**
Intrusive	Granite	Diorite	Gabbro	Peridotite
Extrusive	Rhyolite	Andesite	Basalt	Komatiite

CLASSIFICATION OF SEDIMENTARY ROCKS

classification of sedimentary rocks on the basis of the nature of sediments:-

1. Mechanically Formed Sedimentary Rocks
2. Chemically Formed Sedimentary Rocks
3. Organically Formed Sedimentary Rocks.

1. Mechanically Formed Sedimentary Rocks:

- Previously formed rocks are subjected to me-chanical or physical disintegration and thus the rocks are broken into fragments of different sizes.
- These are called fragmental rock materials or clastic materials which become source materials for the formation of clastic sedimentary rocks.
- These materials are obtained, transported and deposited at suitable places by differ-ent exogenous processes (geological agents) like run-ning water (rivers), wind, glaciers, and sea waves.

Table 8.3 : Classification of Sands by Grain Size

Sand Types	Grain Size (mm)
(i) Very coarse sand	1.0 to 2.0
(ii) Coarse sand	0.5 to 1.0
(iii) Medium sand	0.25 to 0.5
(iv) Fine sand	0.125 to 0.25
(v) Very fine sand	0.0625 to 0.125

2.Chemically Formed Sedimentary Rocks:

- Running water contains chemical materials in suspension.
- When such chemically active water comes in contact with the country rocks in its way, soluble materials are removed from the rocks.
- Such materials are called chemically derived or formed sediments.
- These chemical materials after being settled down and compacted and cemented form chemical sedimentary rocks such as gypsum and salt rocks.

Chemical Sedimentary Rocks

- Chemical rocks form when minerals dissolved in a solution evaporate.
- Limestone and Rock Salt are examples of chemical sedimentary rocks.

3. Organically Formed Sedimentary Rocks:

- The sediments derived from the disintegration or decomposition of plants and animals are called organic sediments.
- These sediments after being depos-ited and consolidated form organic sedimentary rocks.

Organic Sedimentary Rock with Fossils

organic rock

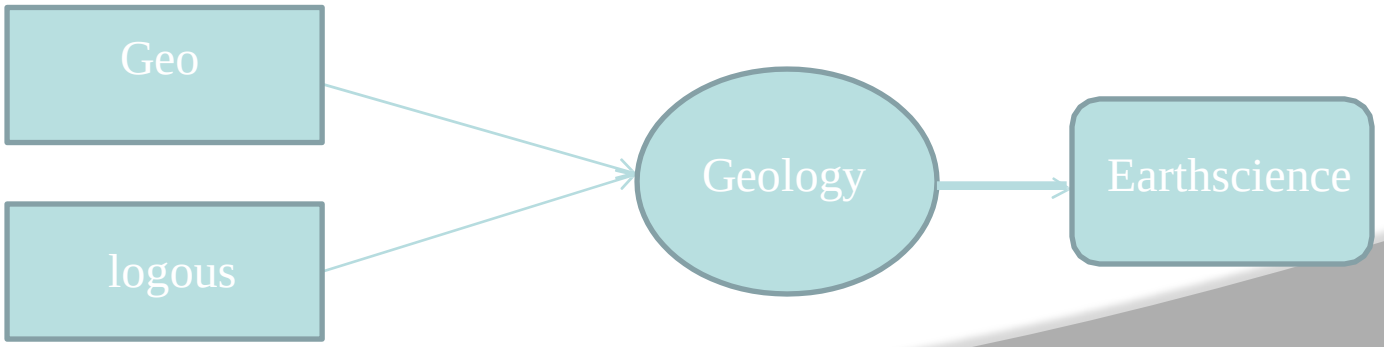
- remains of plants & animals

coal

limestone

Definition:-

- The science which deals with the physical structure and substance of the earth, their history, and the processes which act onthem.
- The geological features of adistrict.
- The geological features of a planetarybody.



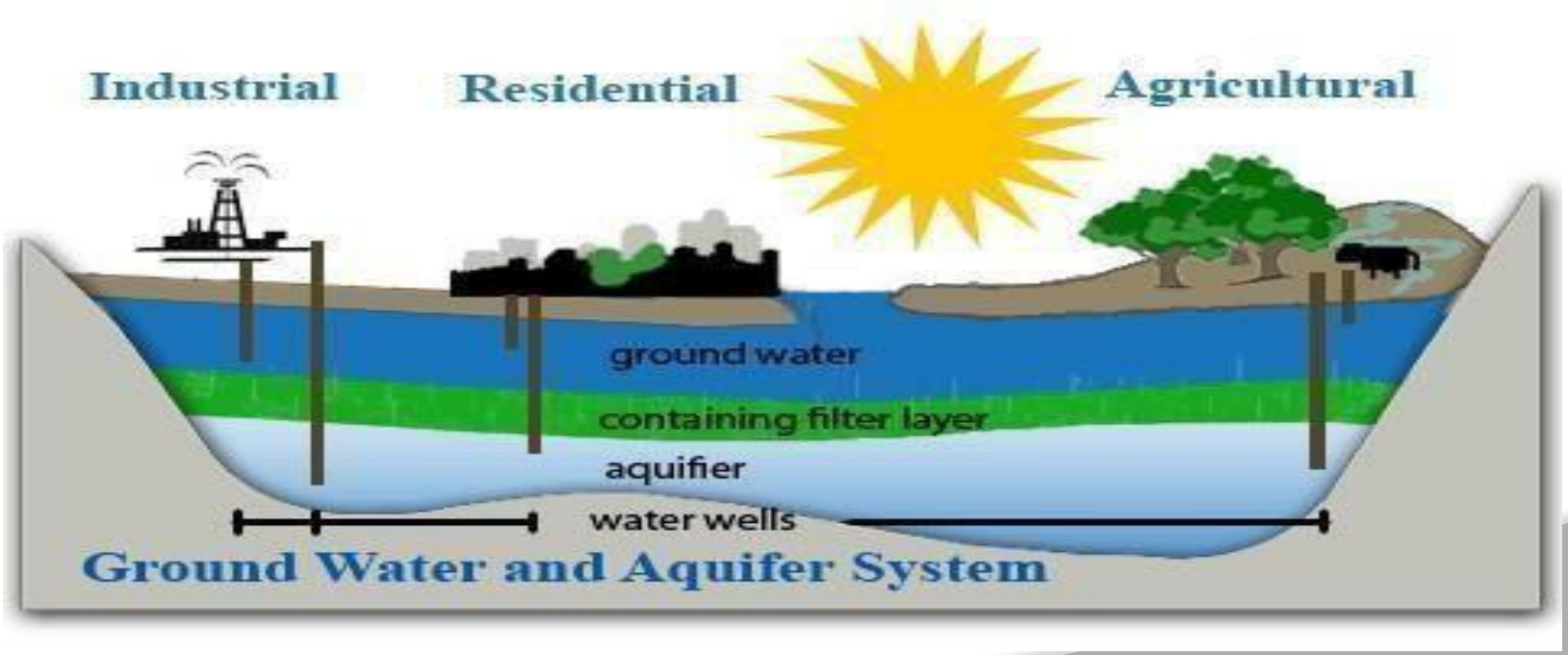
The importance of geology in civil engineering may briefl follows:

- Geology provides a systematic knowledge of construction material, its occurrence, composition, durability and other properties. Example of such construction materialsis building stones, road metal, clay, limestones andlaterite.

- The knowledge of the geological work of natural agencies such as water, wind, ice and earthquakes helps in planningand carrying out major civil engineering works. For example the knowledge of erosion, transportation and deposition helps greatly in solving the expensive problems of river control, coastal and soilconservation.

Contd..

- Ground water is the water which occurs inthe subsurface rocks. The knowledge about its quantity and depth of occurrence is required in connection with water supply, irrigation, excavation and many other civil engineering works.



Contd..

- 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 drillingdata.

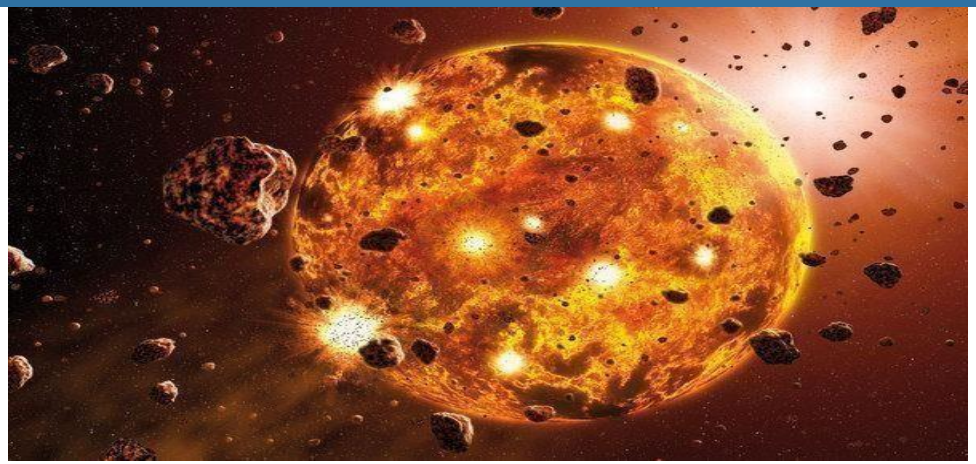
- In tunneling, constructing roads, canals, docks and in determining the stability of cuts and slopes, the knowledge about the nature and structure of rocks is verynecessary.

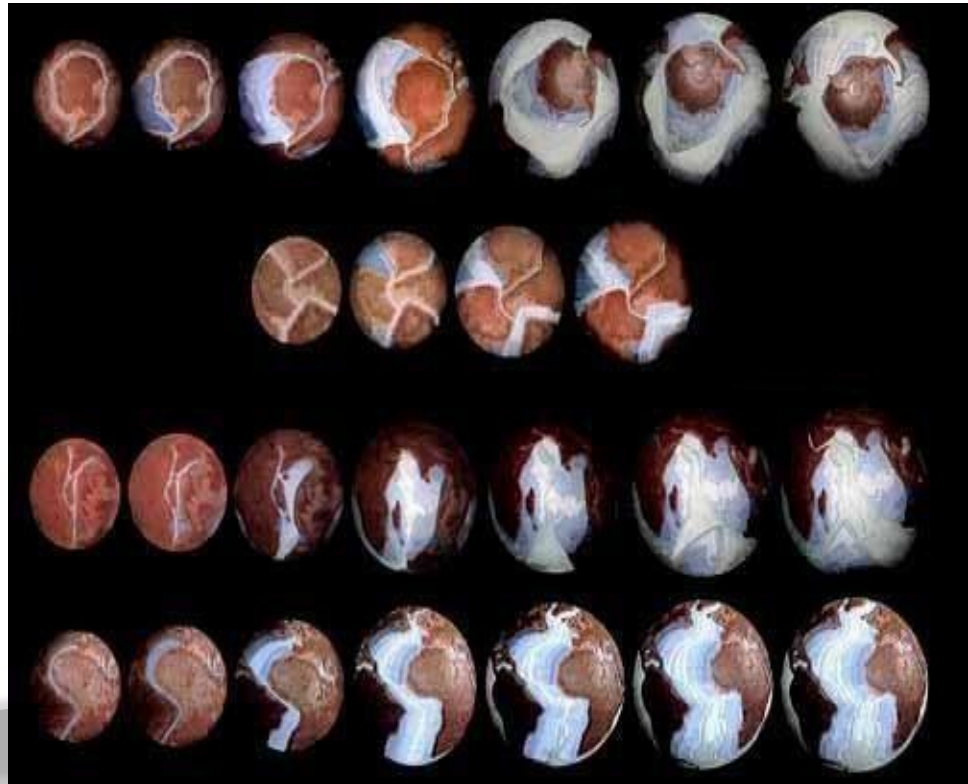
- Before staring a major engineering project at a place, a detailed geological report which is accompanied by geological maps and sections, is prepared. Such a report helps in planning and constructing theprojects.

Physical Geology:

- Physical Geology uses the scientific method to explain natural aspects of the Earth - forexample, how mountains form or why oil resources are concentrated in some rocks and not inothers.

- This chapter briefly explains how and why Earth's surface, and its interior, are constantly changing. It relates this constant change to the majorgeological topics of interaction of the atmosphere, water and rock.





Petrology:-

- Petrology is the branch of geology that studiesthe origin, composition, distribution andstructure ofrocks.
- (from the Greek language : petra-"rock"andlogos-"study")
- “Lithology” was once approximately synonymous with petrography, but in current usage, lithology focuses on macroscopic hand-sample or outcrop-scale description of rocks while petrography is thespecialty that deals with microscopicdetails.

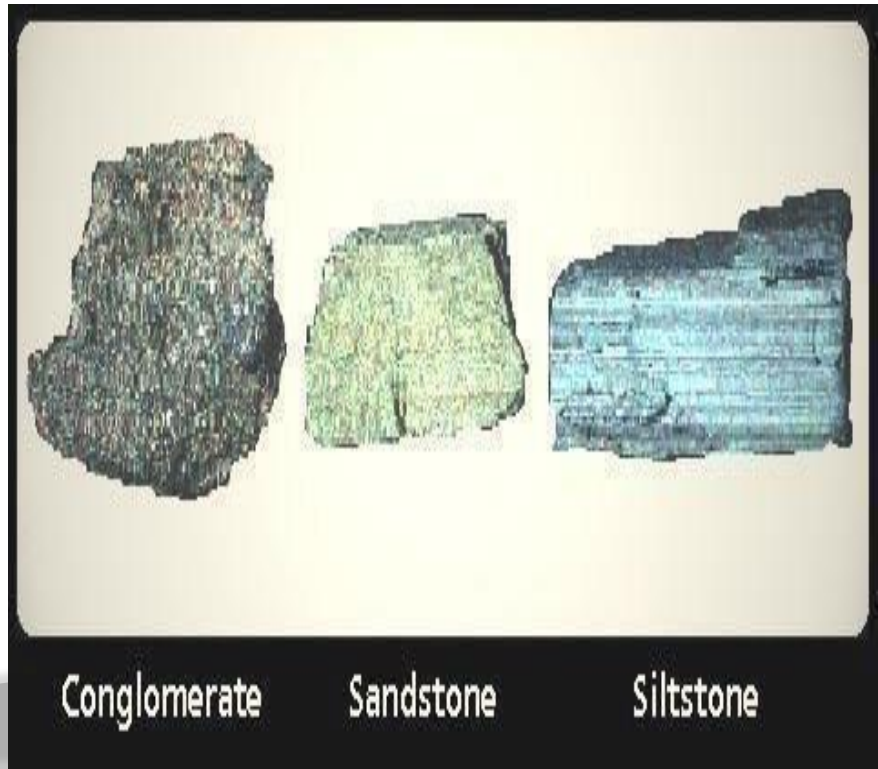
Branches:

- There are three branches ofpetrology,corresponding to the three types ofrocks:

  Igneous, metamorphic, and sedimentary.

- Igneous petrology focuses on thecompositionand texture of igneous rocks (rockssuch as granite or basalt which have crystallized from molten rock or magma). Igneous rocks include volcanic and plutonicrocks.

- Sedimentary petrology focuses on the compositionand texture of sedimentary rocks (rockssuch as sandstone, shale, or limestone which consistof pieces or particles derived from other rocks or biological or chemical deposits, and are usually bound together in a matrix of finer material)



Contd..

- Metamorphic petrology focuses on the composition and texture of metamorphic rocks (rocks such as slate, marble, gneiss, or schist which started out as sedimentary or igneous rocks but which have undergone chemical, mineralogical or textural changes due to extremes of pressure, temperature orboth).

- **Metamorphic rocks** arise from the transformation of existing rock types, in a process calledmetamorphism, which means "change in form". The original rock (protolith) is subjected to heat (temperatures greater than150to 200°C) causing profoundphysicaland/orchemicalchange.

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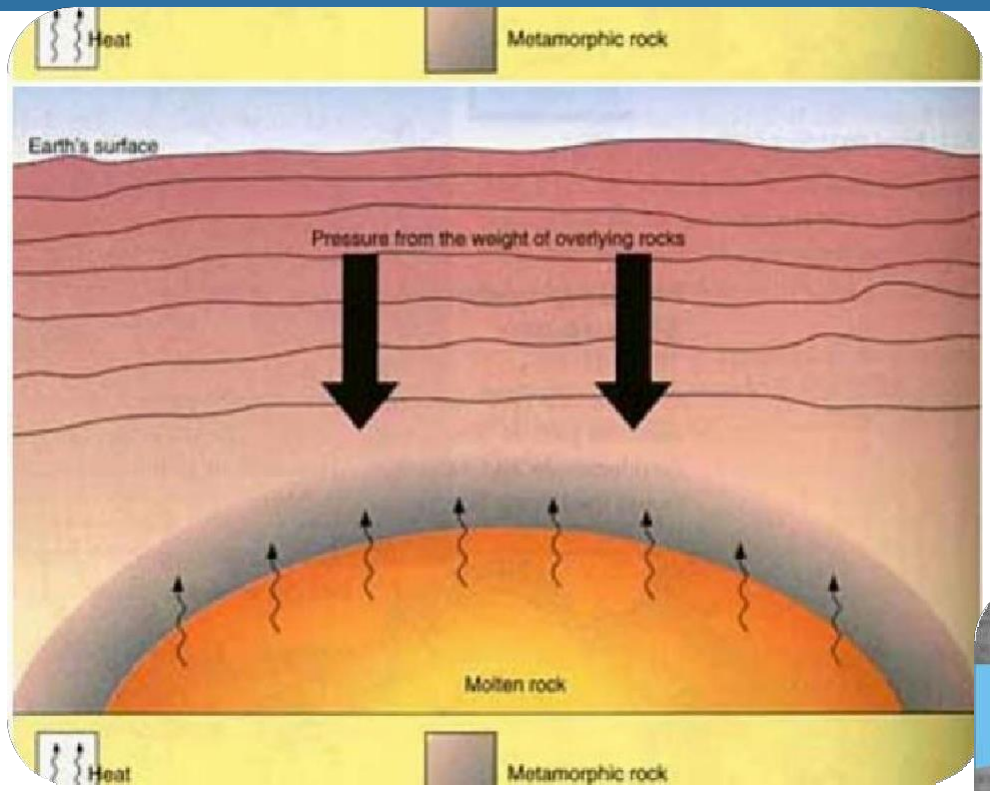
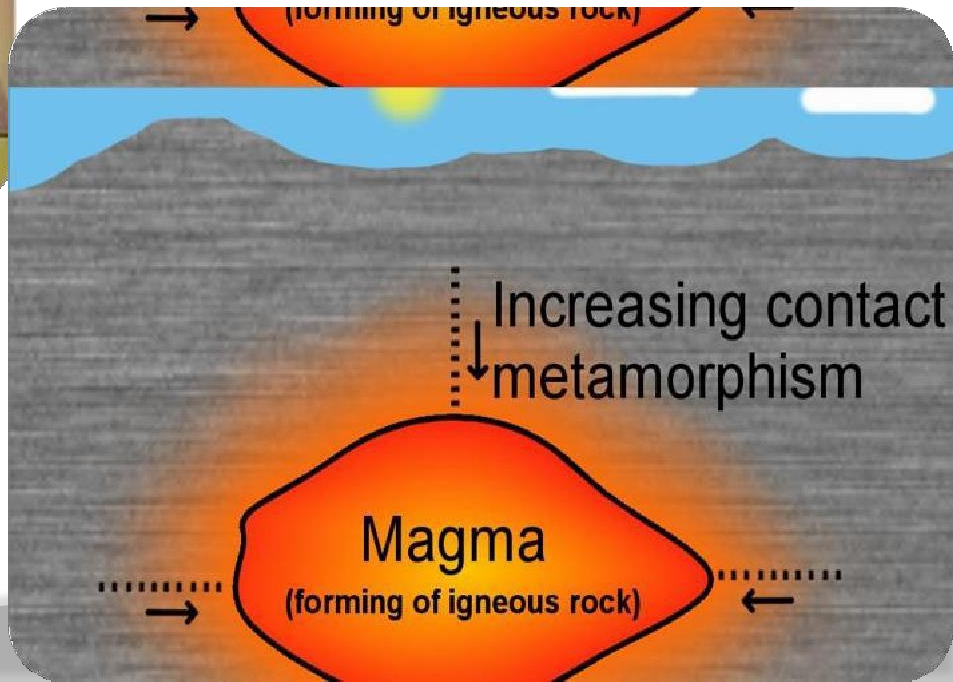
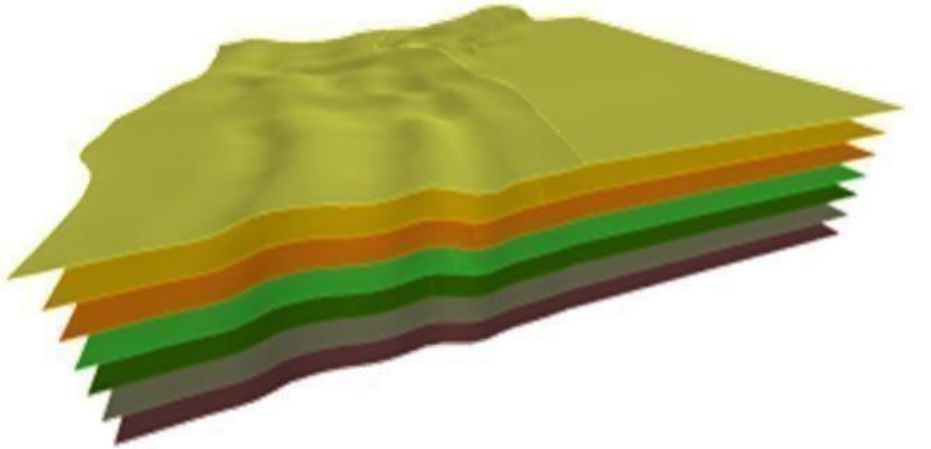

Heat
Metamorphic rock
Earth's surface
Pressure from the weight of overlying rocks
Molten rock
Heat
Metamorphic rock

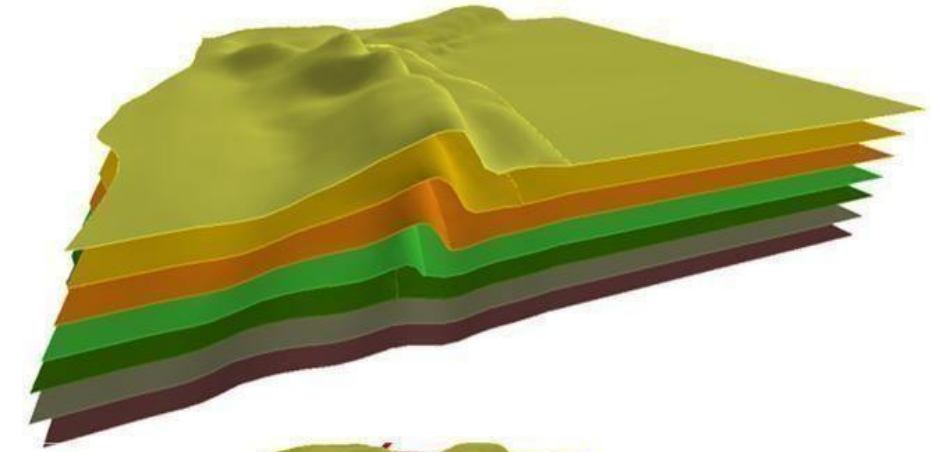

Increasing contact metamorphism
Magma
(forming of igneous rock)

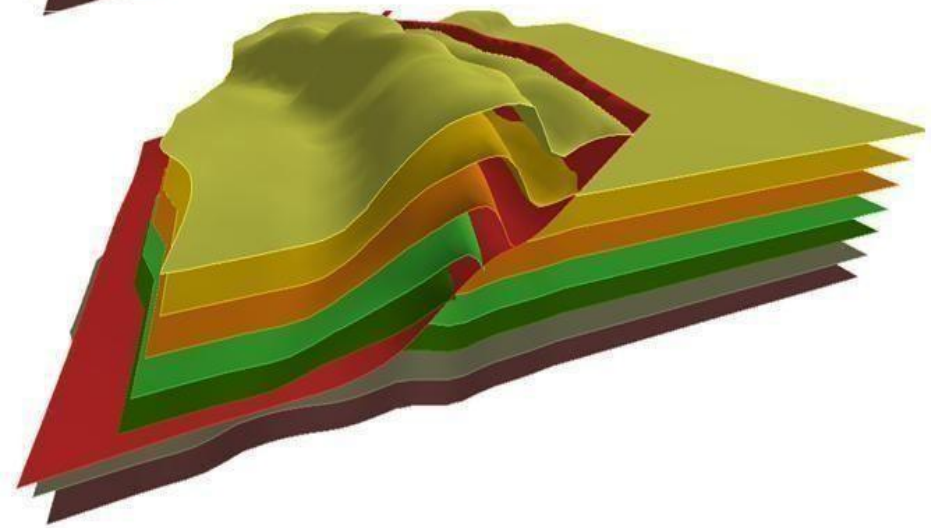
Structural geology:

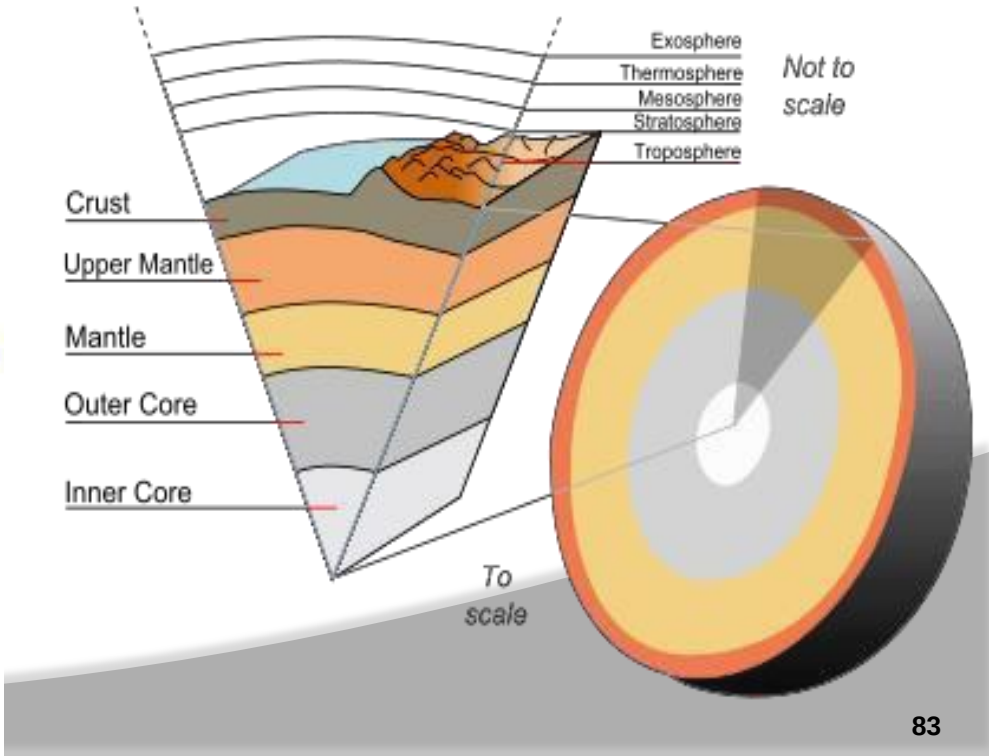
- **Structural geology** is the study of the three- dimensional distribution of rock units with respect to their deformationalhistories.

- The primary goal of structural geology is to use measurements of present-day rock geometries to uncover information about the history of deformation (strain) in the rocks, and ultimately, to understand the stress field that resulted in the observed strain and geometries.







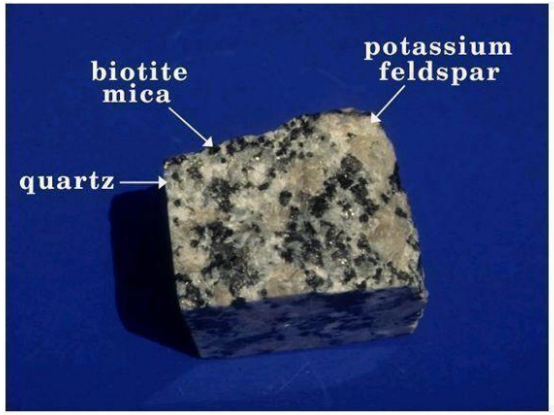

Exosphere
Thermosphere
Mesosphere
Stratosphere
Troposphere
Not to scale
Crust
Upper Mantle
Mantle
Outer Core
Inner Core
To scale

Weathering of Rocks:

- **Weathering** breaks down and loosens the surface minerals of rock so they can be transported away by agents oferosion such as water, wind andice.
- There are two types of weathering: mechanical and chemical.
- Mechanical or physical weathering involves the breakdown of rocks and soils through direct contact with atmospheric conditions, such as heat, water, iceandpressure.
- The second classification, chemical weathering involves the direct effect of atmospheric chemicals or biologically produced chemicals also known as biological weathering in the breakdown of rocks, soils andminerals.

Contd..

Chemical weathering of granite forms the minerals feldspar and quartz. The feldspar reacts with the carbonic acid forming clay. The quartz is resistant to weathering and remains unchanged.



Different Minerals weather at different rates and in different ways.

e.g. Granite

Quartz – hard – physical weathering – sands

Feldspar and Mica – 'softer' – chemical weathering - clays

Excavation:

practices used to construct and modify rock slopes and provides current design and construction guidelines for theiruse.

- The most commonare

1. Blasting (which includes drilling the holes to be filled withexplosives)
2. Ripping
3. Drilling

Blasting

- In any blasting situation, the geologic structure of the rock mass
  be the most important consideration.

- It is practiced most often in mining, quarrying and civil engineering such as dam or road construction. The result of rock blasting is often known as a rockcut.

- Blasting is used for rock excavation on both small- andlarge-scale
  projects. There are two generaltypes:

1. productionblasting
2. Controlledblasting.

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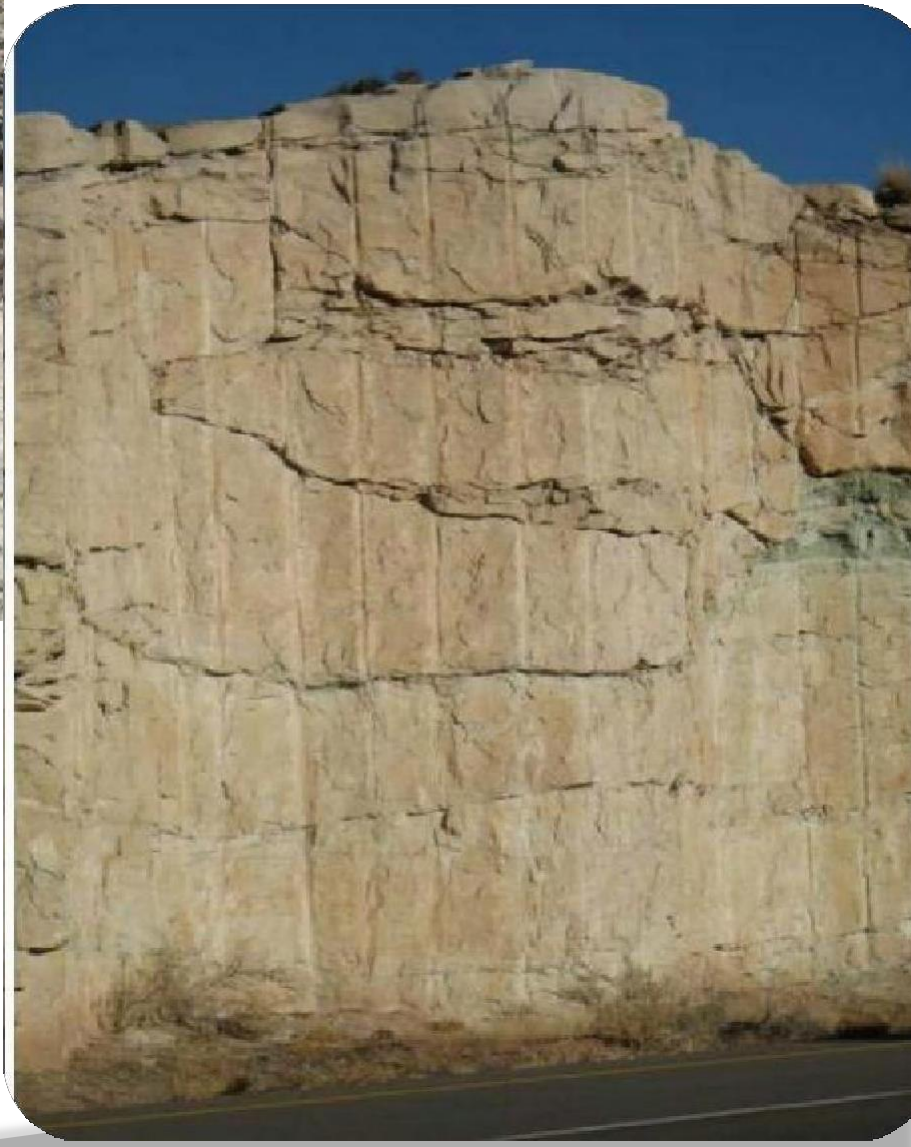


2. RIPPING:

- Uses a tractor with an attached tooth or teeth that is lowered into the rock and dragged to break up material forexcavation.
- The tooth of the ripper can leave scars on the rock surface. The tractor cannot be used on steep slopes because of risk of overturning. Ripping is limited to relatively low densityrocks.

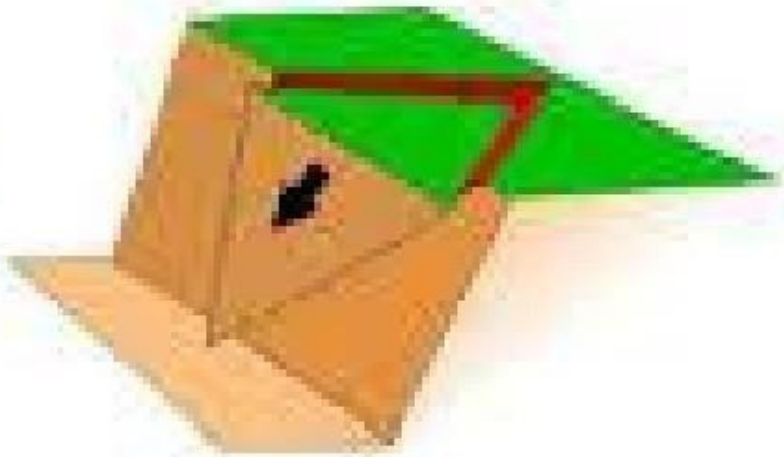
3. DRILLING:

- Blast holes are drilled at various orientations, fromvertical throughhorizontal.
- To create vertical holes, which are used almost exclusivelyin production blasting, rock slope excavation uses two types of drilling:

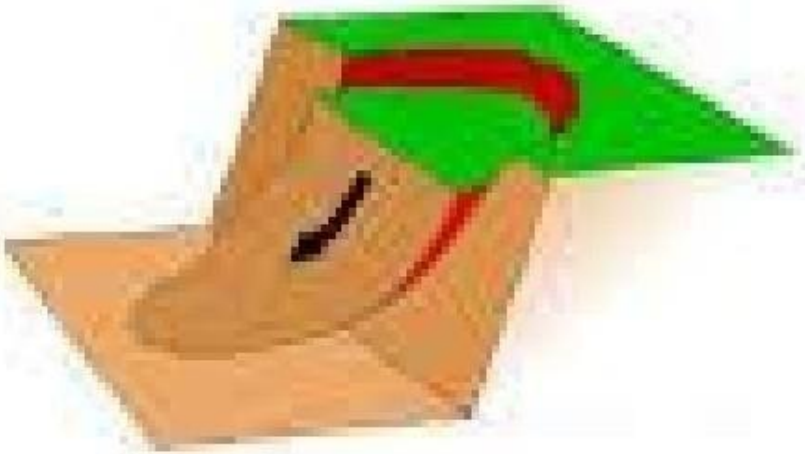
1. Downhole
2. Step drilling

- *Horizontal drilling* is used for both production and controlled blasting because of limited drill rig access or geometry requirements.
- *Angled drilling* can be performed as determined by slope face anglerequirements.

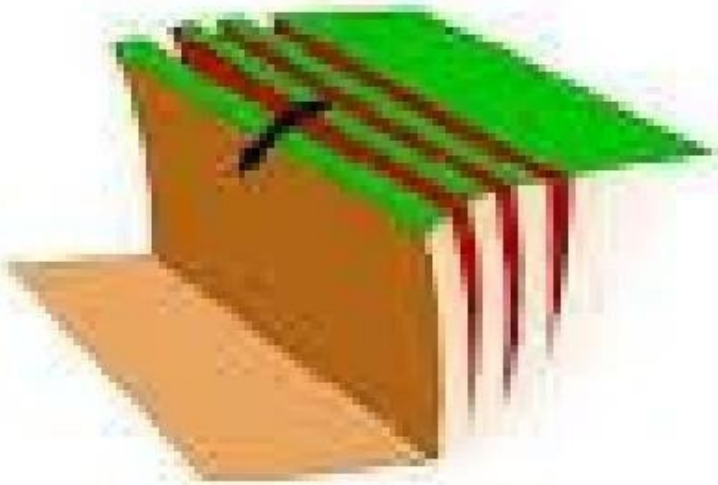
Plane failure



Wedge failure



Circular failure



Toppling failure

MODULE-III
PHYSICAL GEOLOGY AND ROCK MECHANICS

CLOs	Course Learning Outcome
CLO10	Understand the importance of various associated geological structures like folds, faults, joints and unconformities present at site for foundations.
CLO11	Identify subsurface information and groundwater potential sites through geophysical investigations.
CLO12	Understand to select a suitable site for dams and reservoirs to avoid seepage, silting and Tilting.
CLO13	Understand internal geological processes (e.g. faults, earthquakes, volcanoes) and how they affect engineering studies.
CLO14	Locate various subsurface mines and rock bodies by applying geophysical investigations such as Gravity methods, magnetic methods, Electrical methods, seismic methods, radio metric methods and geothermal methods.

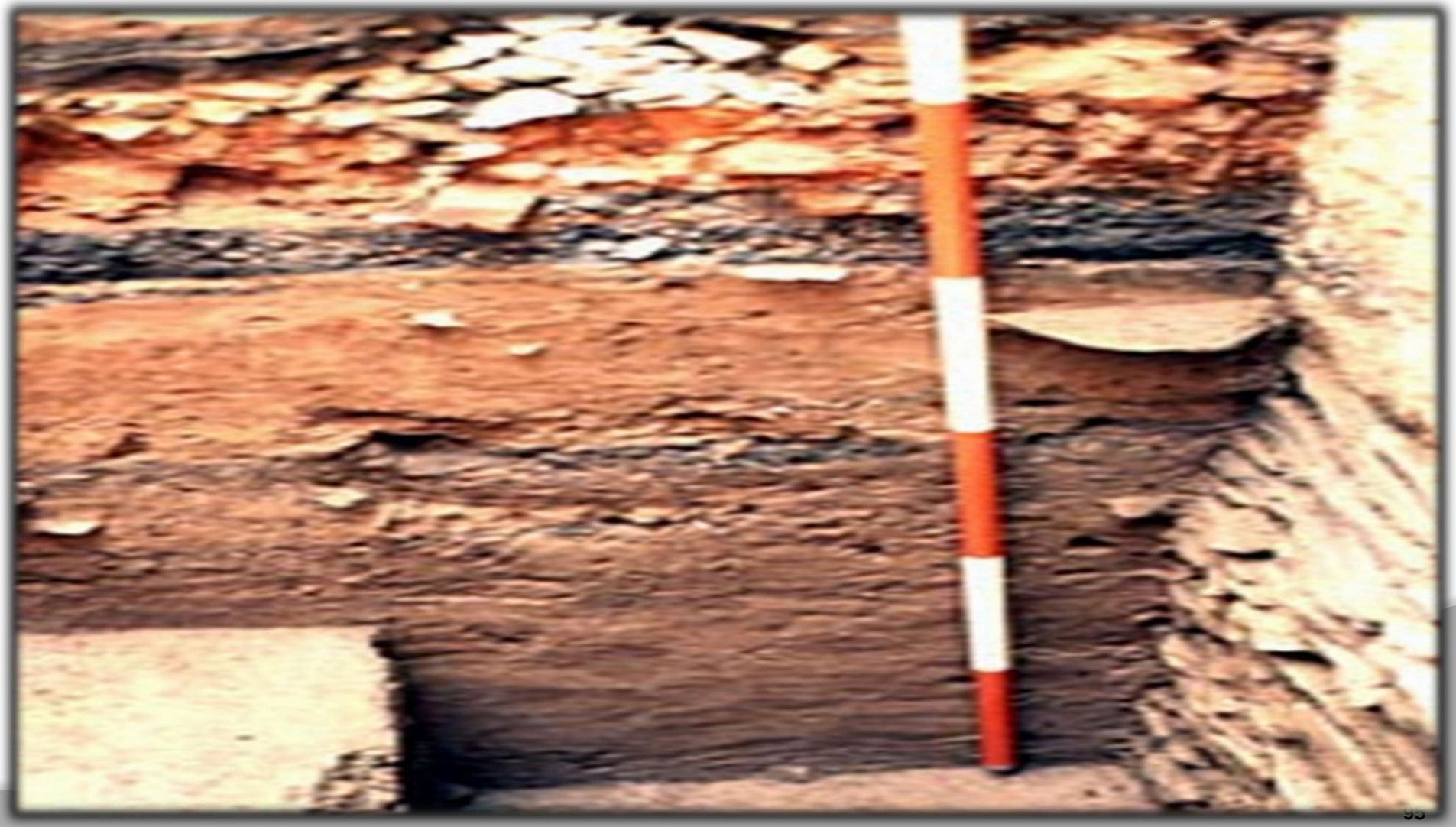
STRATIGRAPHY:

- **Stratigraphy** is a branch of geology which studiesrock layers (strata) and layering(stratification).

- It is primarily used in the study of sedimentaryand layered volcanicrocks.

- Stratigraphy includes two relatedsubfields:

1. Lithologic stratigraphy orlithostratigraphy,
2. Biologic stratigraphy orbiostratigraphy.



1) Lithostratigraphy:

Lithostratigraphy is the geological scienceassociated with the study of strata or rocklayers.

Litho logy:

The **litho logy** of a rock unit is a description of its physical characteristics visible at outcrop, in hand or core samples or with low magnification microscopy, such as color, texture, grain size, or composition.

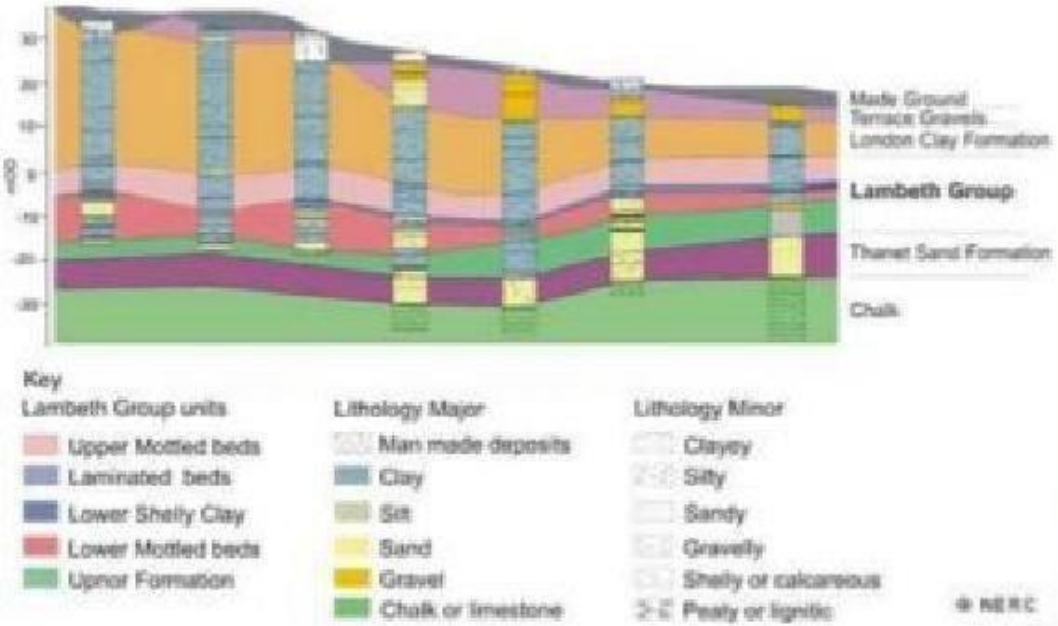
Contd..

Strata:

Strata are layers of rock, or sometimes soil. Innature, strata come in many layers. It is a term in sedimentary and historical geology; the singular is stratum. These layers are laid down as sediment, often in the sea, and are slowly changed by pressure, heat and chemical action into rocks.

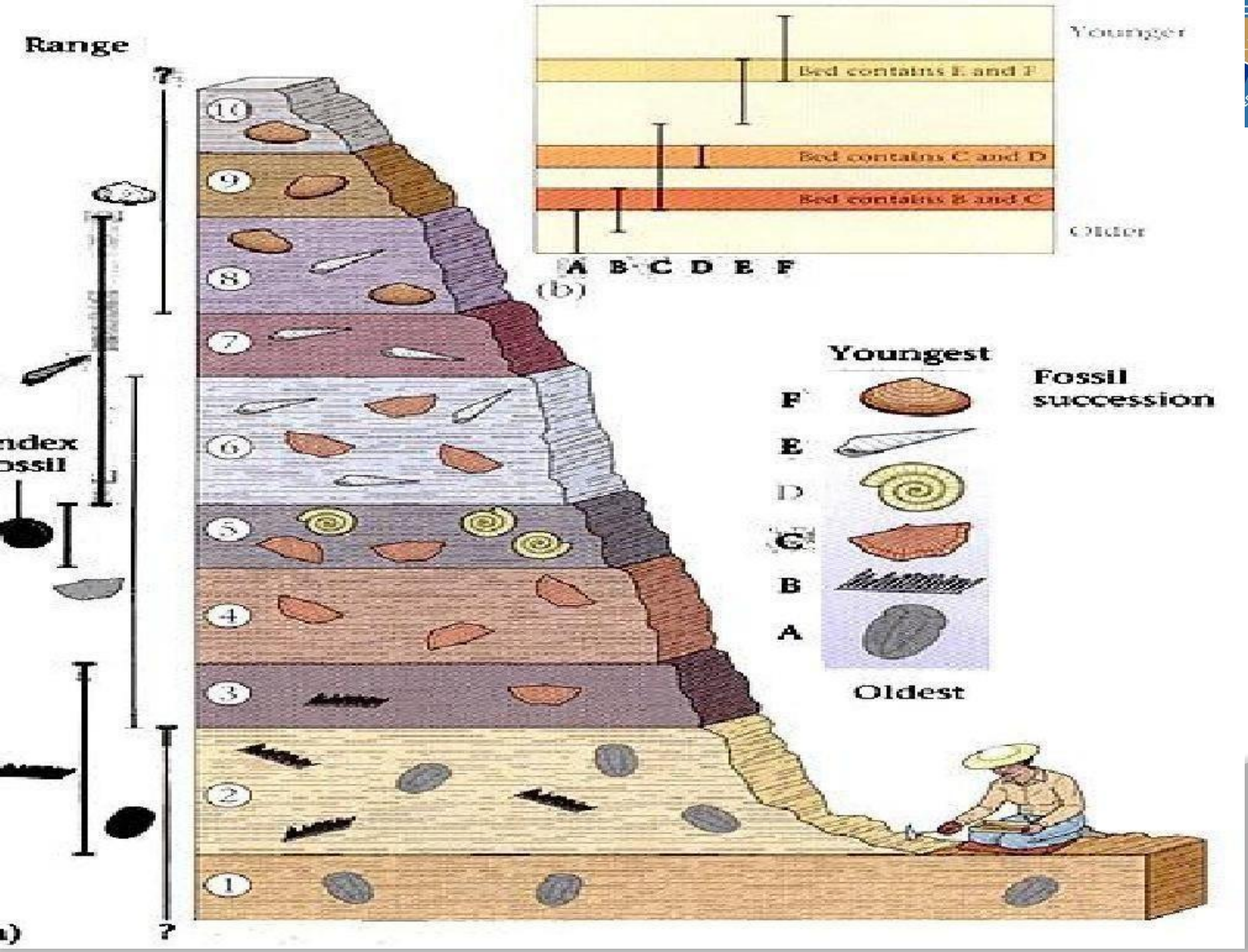
LITHOSTRATIGRAPHY

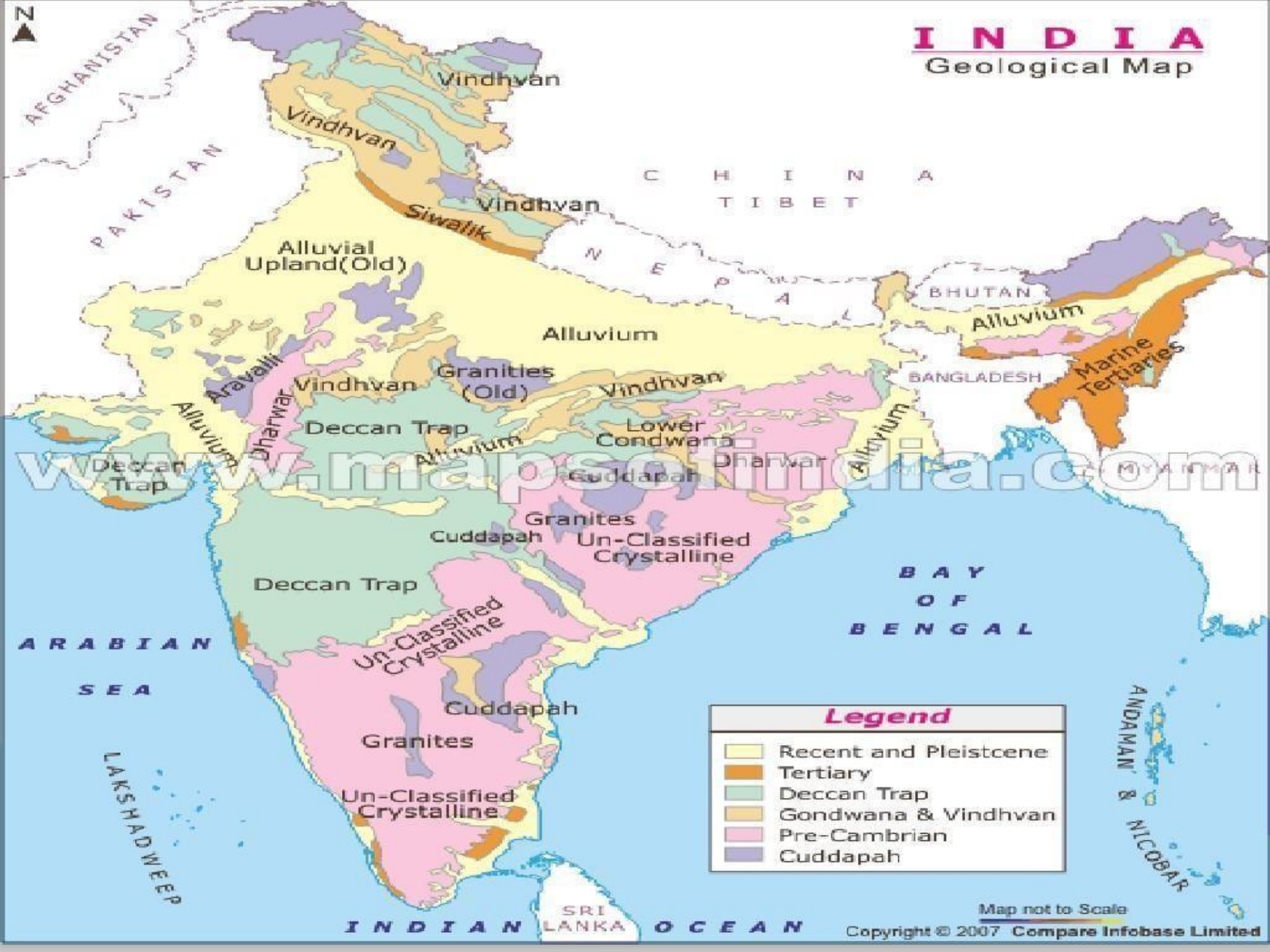
- Subdivision of rock successions into units on the basis of lithology or rock type
- Lithostratigraphical standard units:
  - Supergroup
  - Group
  - Formation
  - Member
  - Bed



2) Biostratigraphy:

- **Bio stratigraphy** is the branch of stratigraphy which focuses on correlating and assigning relative ages of rock strata by using the fossil assemblages contained within them.


Range
Younger
Bed contains E and F
Bed contains C and D
Bed contains B and C
Older
A B C D E F
(b)
Youngest
F
E
D
C
B
A
Oldest
Fossil succession
ndex
ossil
10
9
8
7
6
5
4
3
2
1
?
?
a)



Paleontology

- Paleontology is the study of what fossils tell us aboutthe ecologies of the past, about evolution, and about our place, as humans, intheworld.

- Paleontology incorporates knowledge from biology, geology, ecology, anthropology, archaeology, andeven computer science to understand the processes that have led to the origination and eventual destruction of the different types of organisms sincelifearose.

- It includes the study of fossils to determine organisms' evolution and interactions with eachother and theirenvironments.
- The simplest definition is "the study of ancientlife".
- Paleontology seeks information about severalaspects of past organisms: "their identity and origin, their environment and evolution, and what they can tell us about the Earth's organic andinorganicpast".

MODULE-IV

GEOLOGICAL HAZARDS

CLOs	Course Learning Outcome
CLO13	Understand the structural and lithological considerations for tunnel construction to avoid leakage and falling of rock parts
CLO14	Understanding of impact of engineering solutions on the society and also will be aware of contemporary issues
CLO15	Apply geological principles for mitigation of natural hazards and select sites for dams and tunnels.
CLO16	Possess the knowledge and skills for employability.

GEOLOGICAL TIME SCALE:

- The geological time scale (GTS) is a system of chronological measurement that relates stratigraphy to time, and is used by geologists, paleontologists,and

OUTCROP

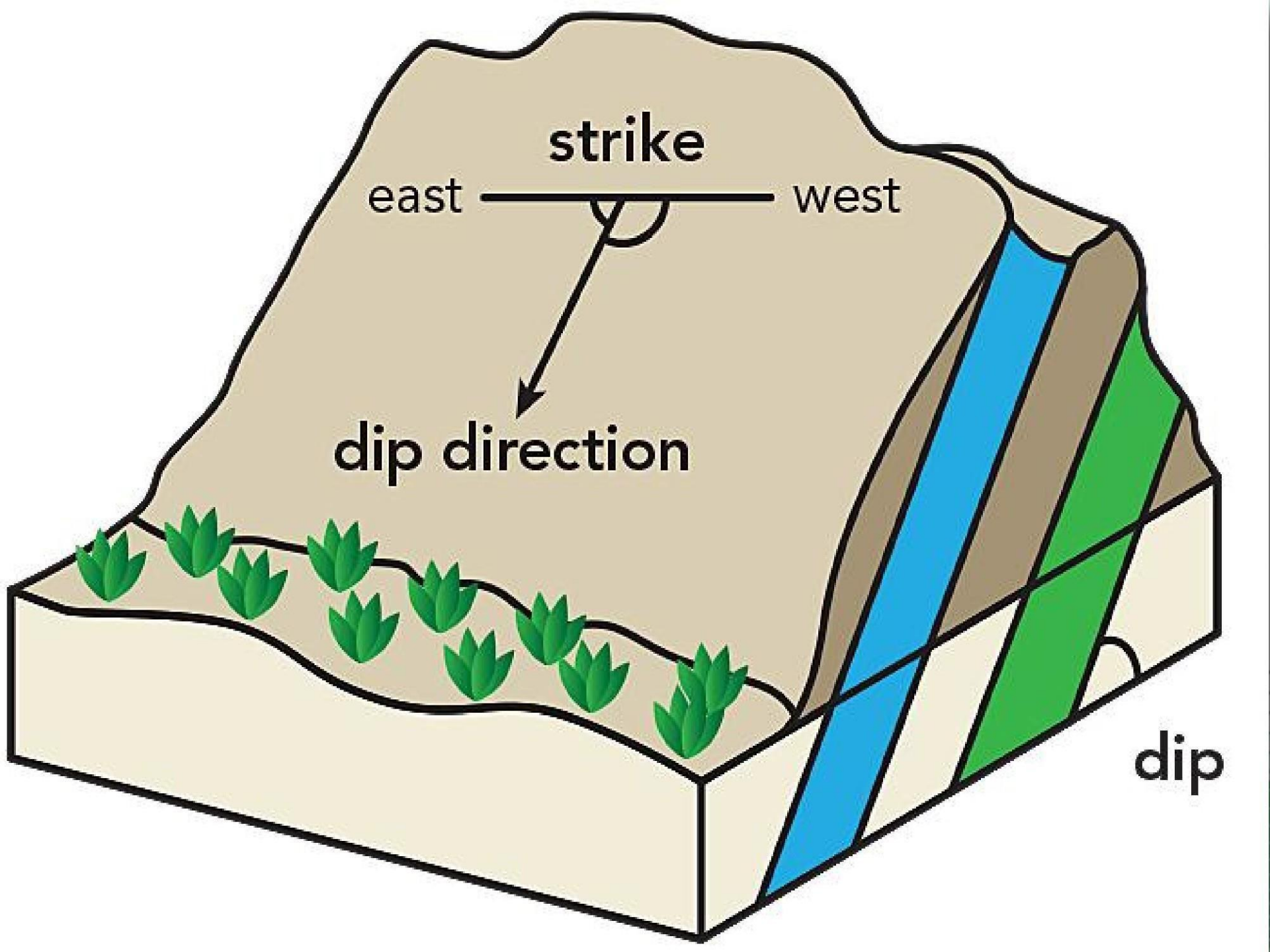
- An outcrop or rocky outcrop is a visible exposure of bedrock or ancient superficial deposits on the surface of the Earth.
- However, in places where the overlying cover is removed through erosion or tectonic uplift, the rock may be exposed, or *cropout*.
- It may also exposed at the Earth's surface due to human excavations such as quarrying and building of transportroutes.

Outcrop

- Any Geological formation exposed on the surface is called an outcrop.

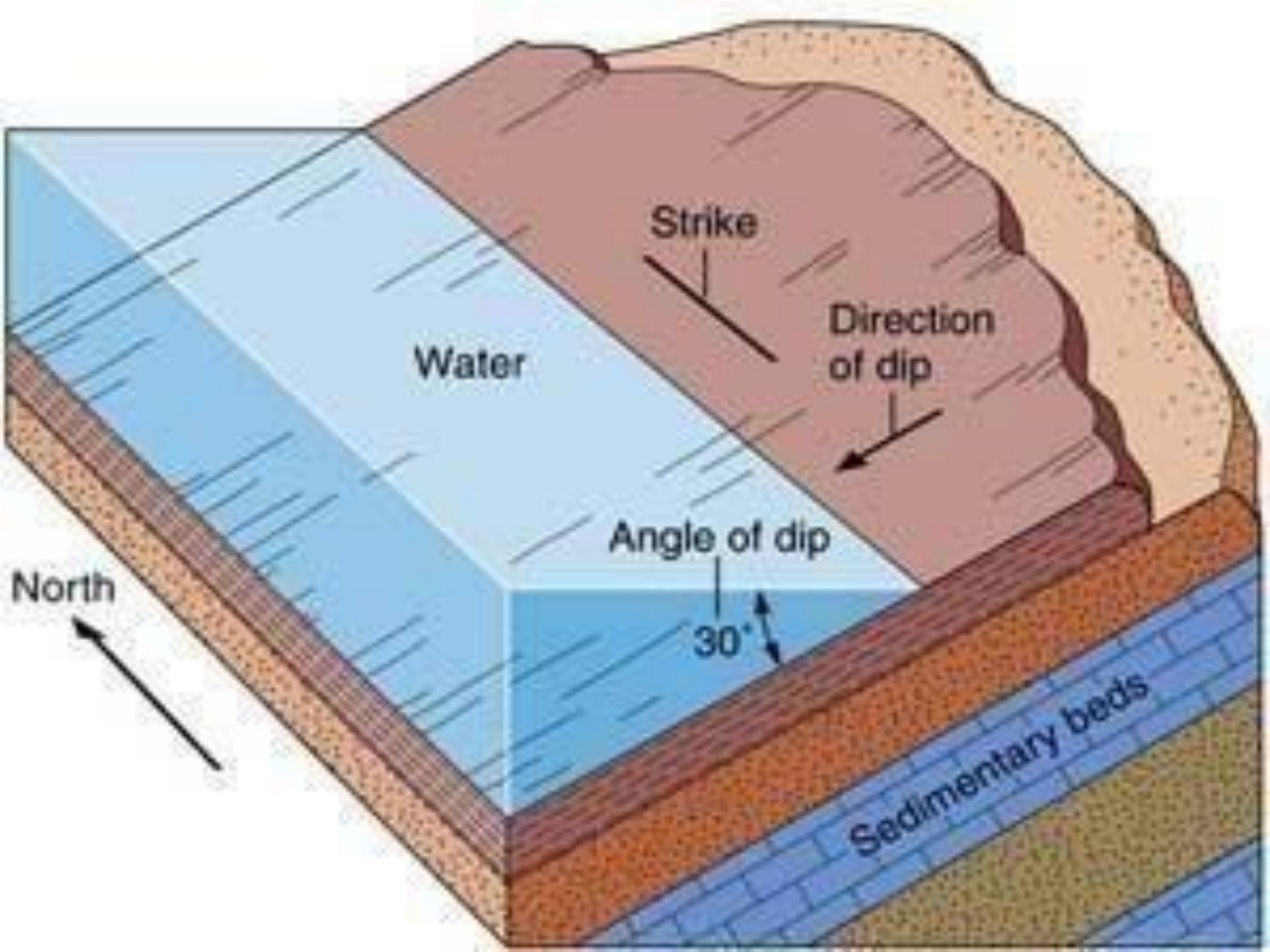
STRIKE AND DIP:

- Strike and dip refer to the orientation or *attitude*of a geologic feature.
- The *strike line* of a bed, fault, or other planar feature, is aline representing the intersection of that feature with a horizontal plane.
- On a geologic map, this is represented with a shortstraight line segment.
- *Strike* (or strike angle) can be given as either a quadrant compass bearing of the strike line or in terms of east or westof true north or south oriented parallel to the strikeline.


strike
east
west
dip direction
dip

DIP:

- Thedipgivesthesteepestangleofdescentofatiltedbed or feature relative to a horizontal plane.
- One technique is to always take the strike so the dip is 90° to the right of thestrike.
- The angle of dip is generally included on a geologic map without the degree sign.


Strike
Direction of dip
Water
Angle of dip
North
30°
Sedimentary beds

FOLDS

- Folds are one of the most common geological structuresfound inrocks.
- When a set of horizontal layers are subjected tocompressive forces, they bend either upwards or downwards.

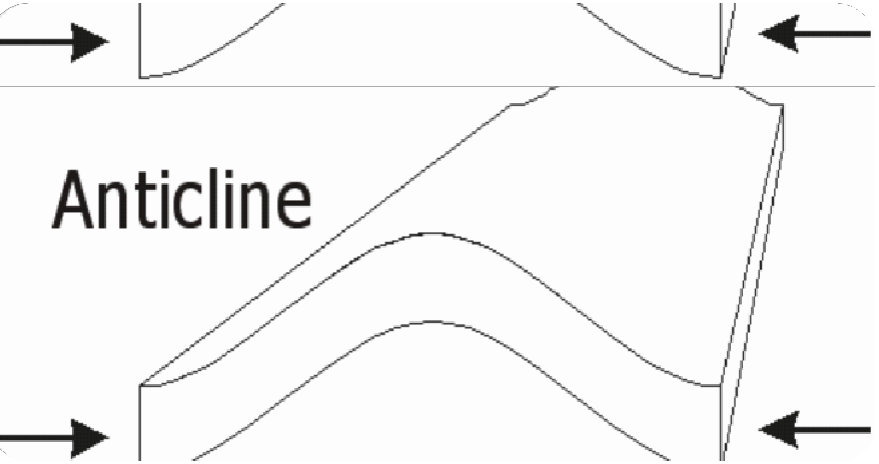
Anticline:

- When the beds are bent upwards, the resulting fold iscalled anticline. This folds is convex upwards.

Anti = Opposite

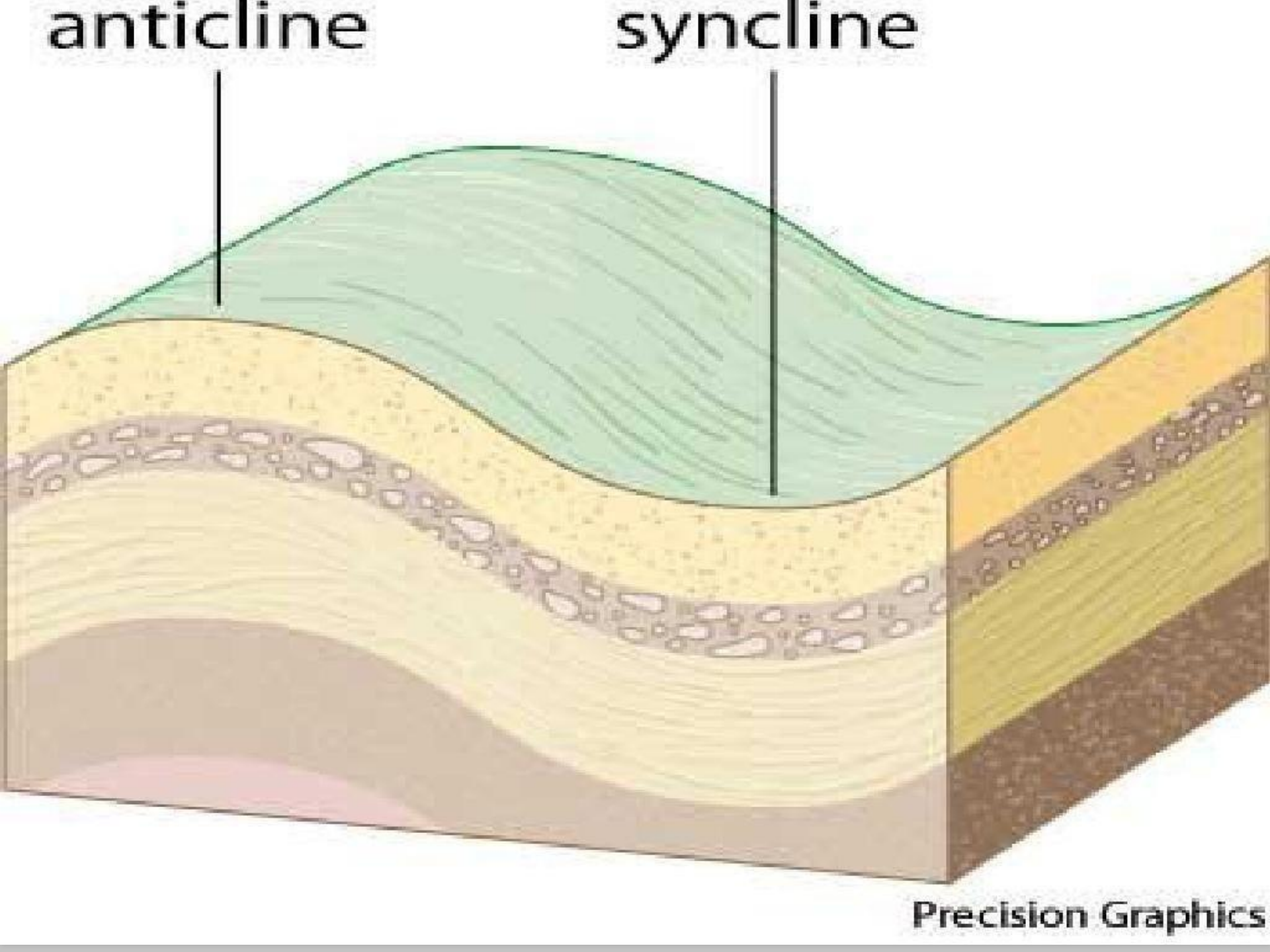
Cline= Inclination

Types of Folds:



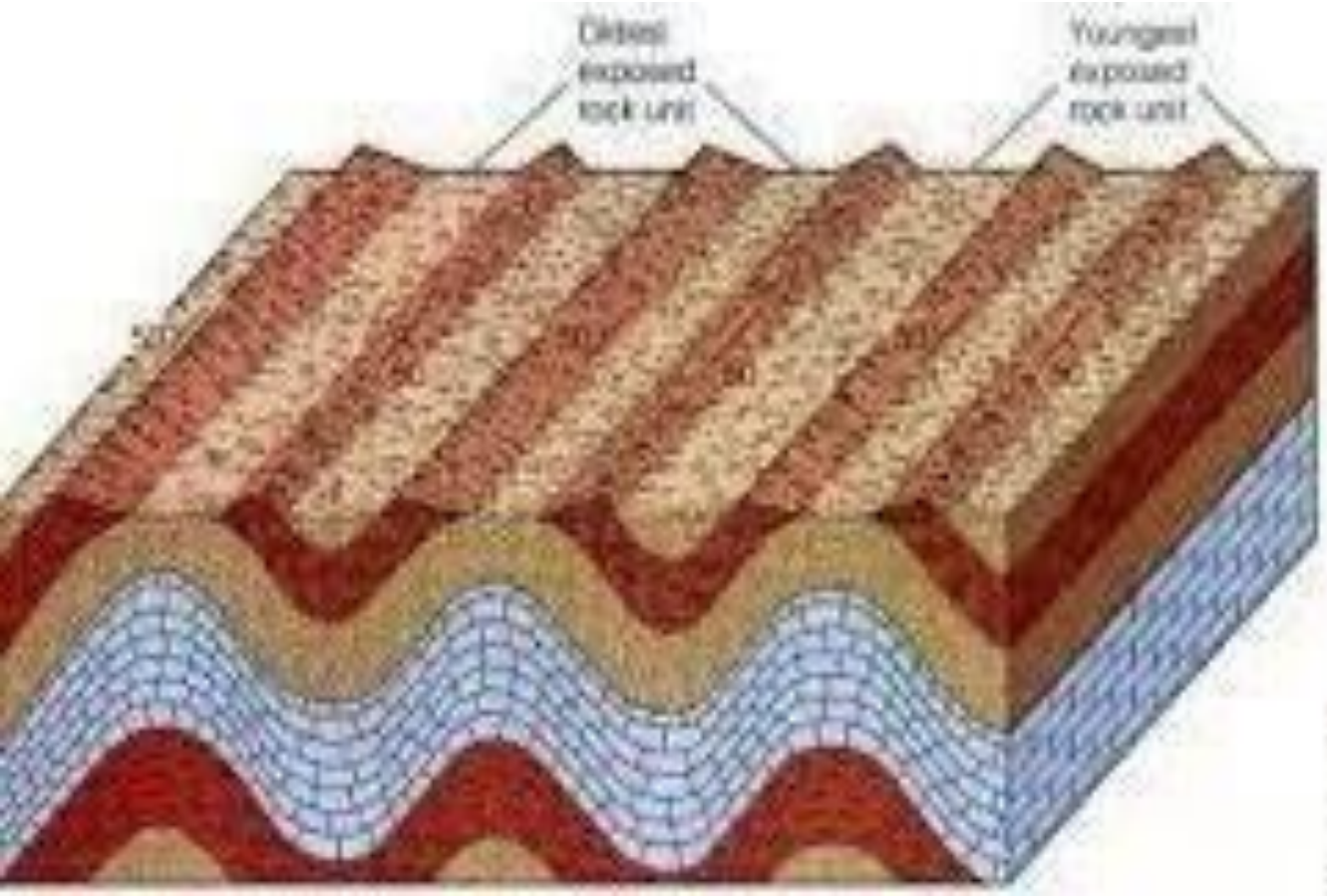
Syncline:

- Syncline is just opposite to anticline in its nature, when thebeds are bent downwards the resulting fold is called syncline.
- This fold is convexdownwards.


anticline
syncline
Precision Graphics

Symmetrical

- When the axial plane divides a fold into two equal halves in such a way that one half is the nature image of another, then such fold is called Symmetricalfolds.

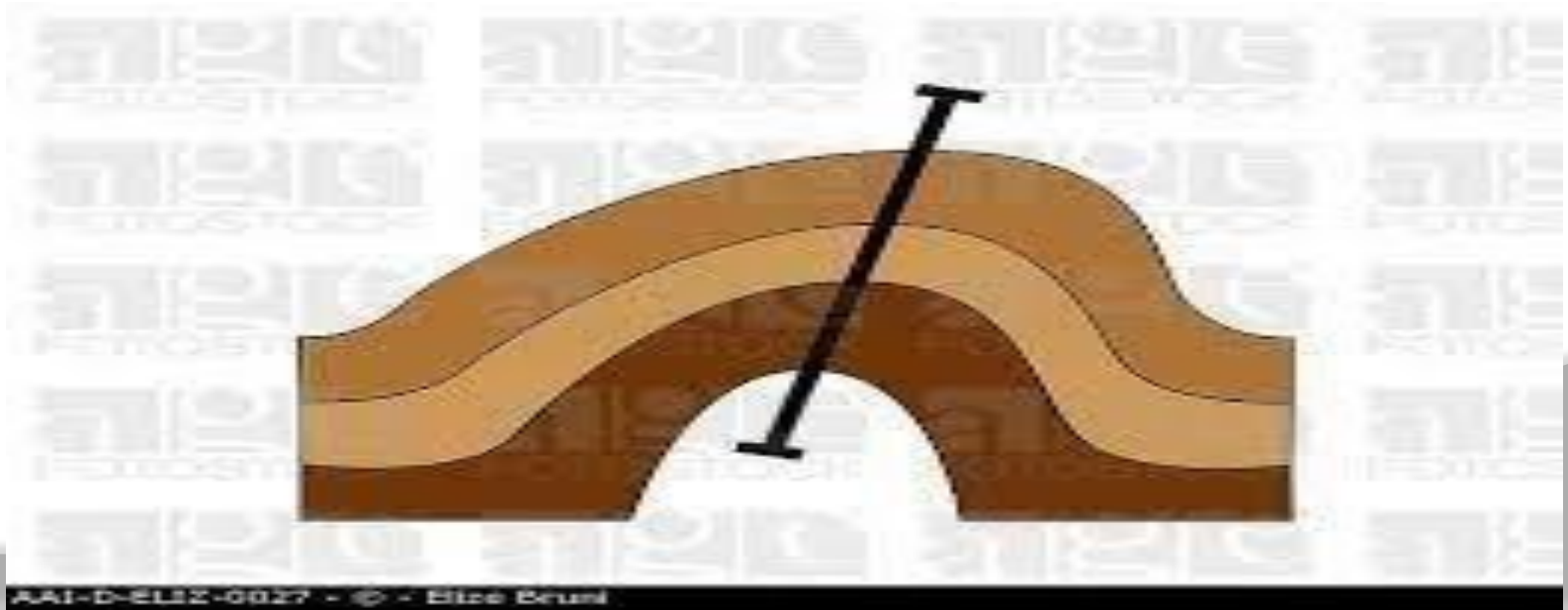


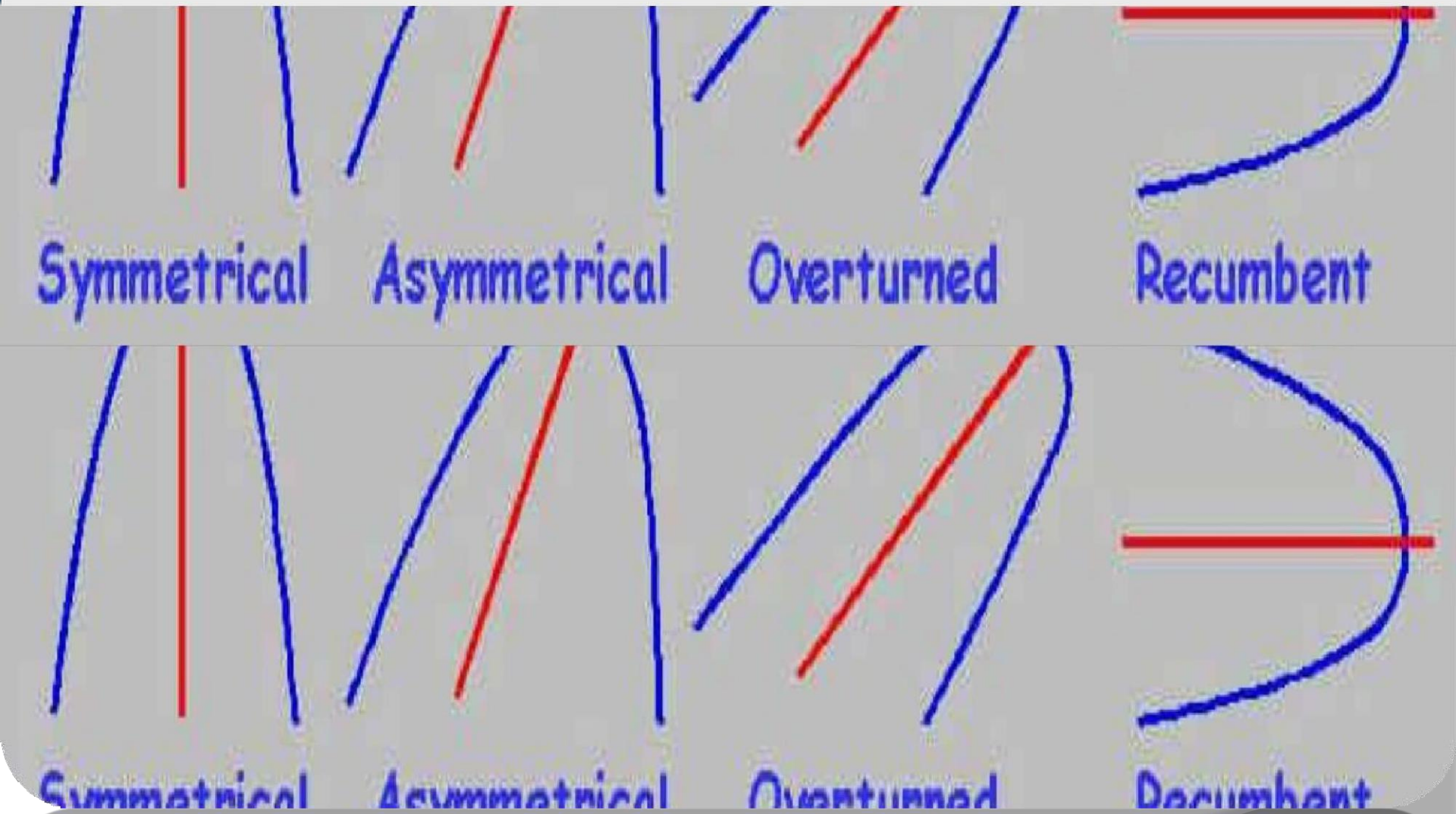
► FIGURE 13-15 Identifying eroded anticlines and synclines by strike and dip and the relative ages of the folded rock layers.

Asymmetrical

Asymmetrical:

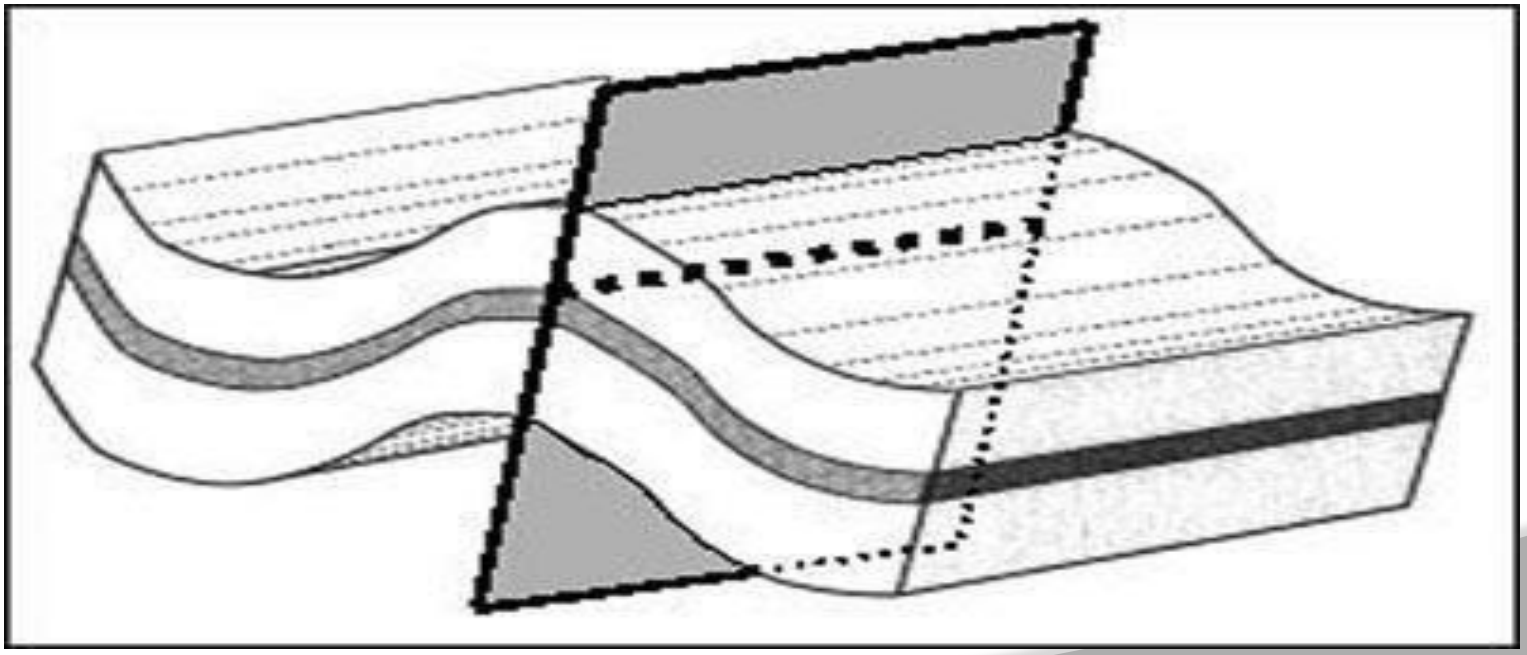
- If the two halves are not mirror images, then the fold is called as asymmetrical fold.
- If the compressive forces responsible for folding are not of the same magnitude, asymmetrical folds areformed.




Symmetrical
Asymmetrical
Overturned
Recumbent
Symmetrical
Asymmetrical
Overturned
Recumbent

Open folds:

- Depending on the intensity of deformation, the beds of the folds may or may not have uniform thickness.
- If the thickness of bed is uniform throughout the fold it is called Openfold.



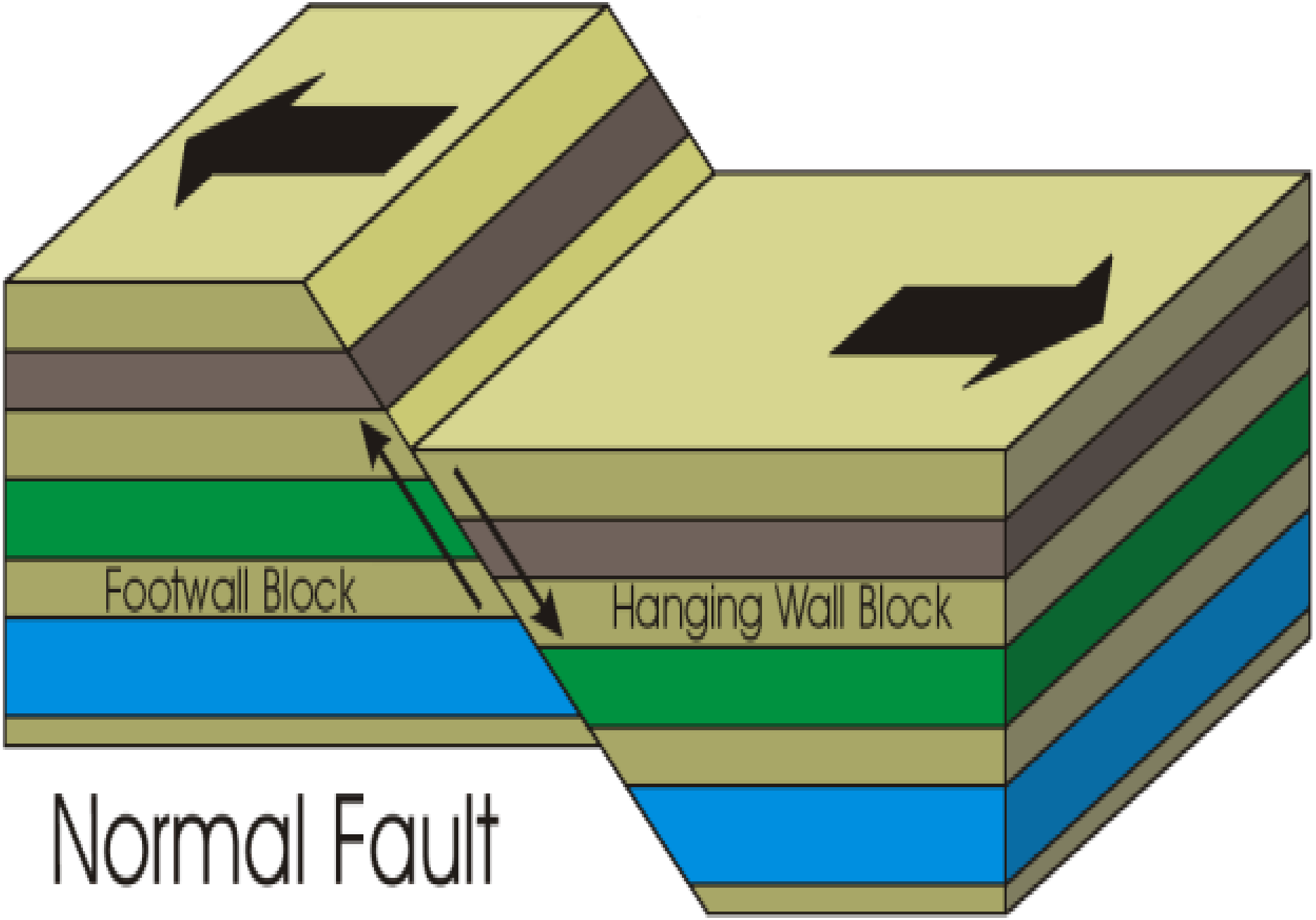
Closed Folds:

- In a fold if the beds are thinner in the limb portions andthicker at crests and troughs, such fold is called a closed fold.

FAULTS:

A fault isafracture or zoneoffractures betweentwo blocks of rock.

- Faults allow the blocks to move relative to eachother.
- This movement may occur rapidly, in the form of an earthquake - or may occur slowly, in the form ofcreep.
- Faults may range in length from a few millimeters to thousands of kilometers.



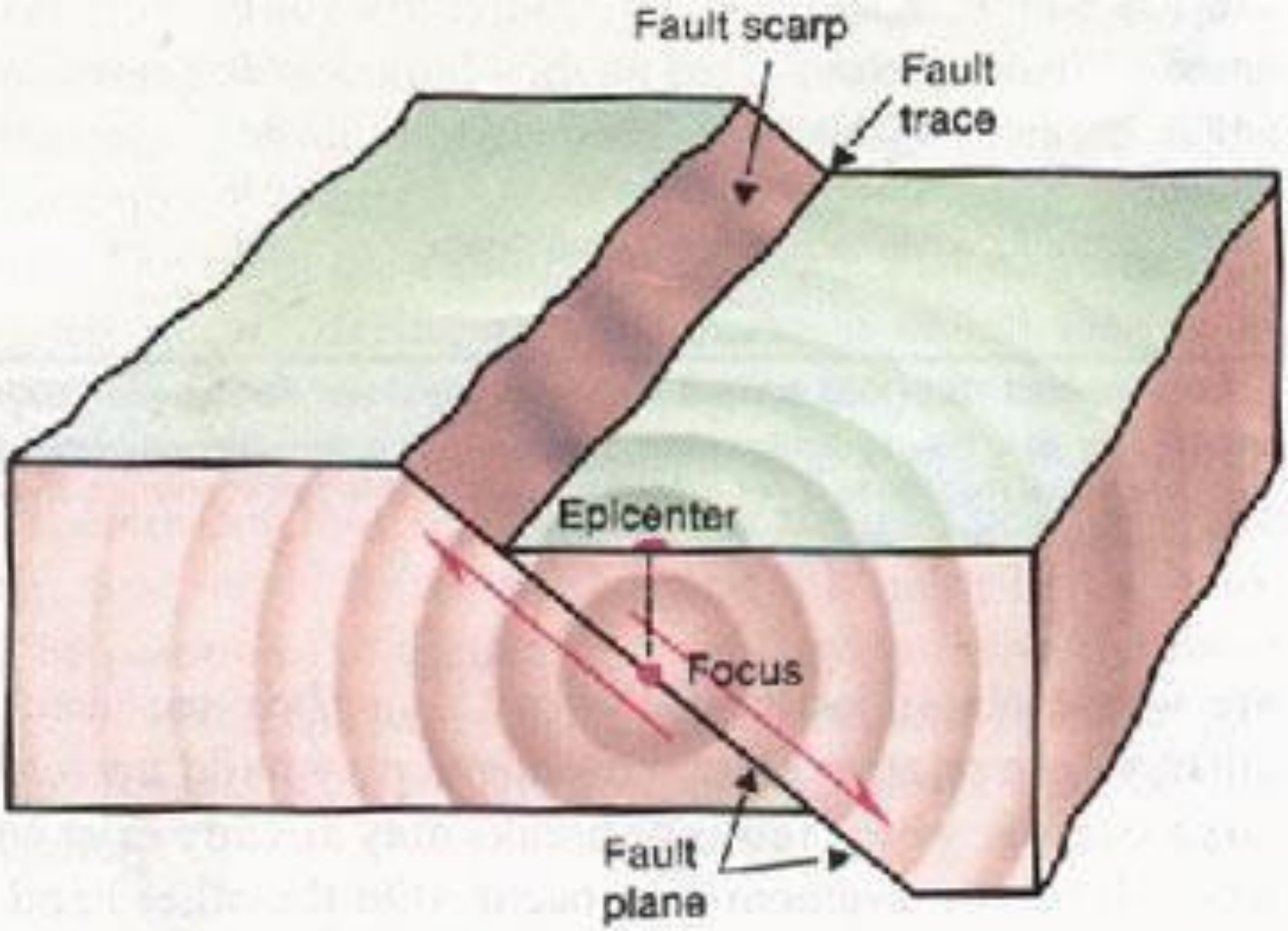
Normal Fault

CAUSES OF FAULTING:

- Faults mainly occur in regions of structuralinstability.
- It may be recollected that faults develop mainly due to shearor

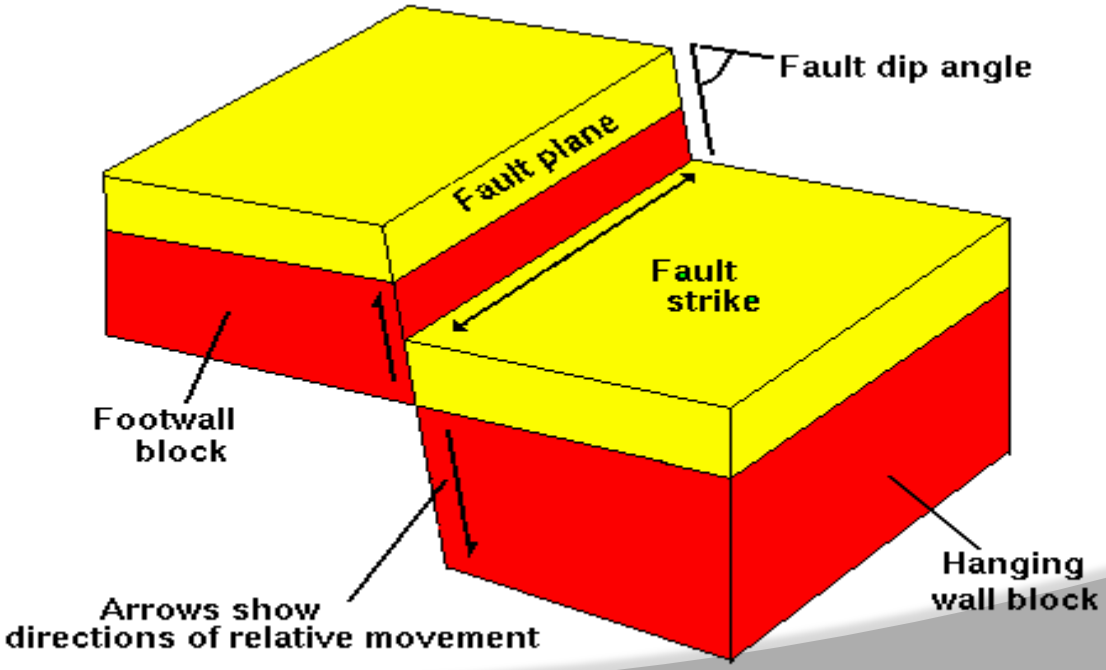
  sliding failures resulting from tensional, compression forces.
- When an earthquake occurs on one of these faults, the rock

  on one side of the fault slips with respect to theother.


Fault scarp
Fault trace
Epicenter
Focus
Fault plane

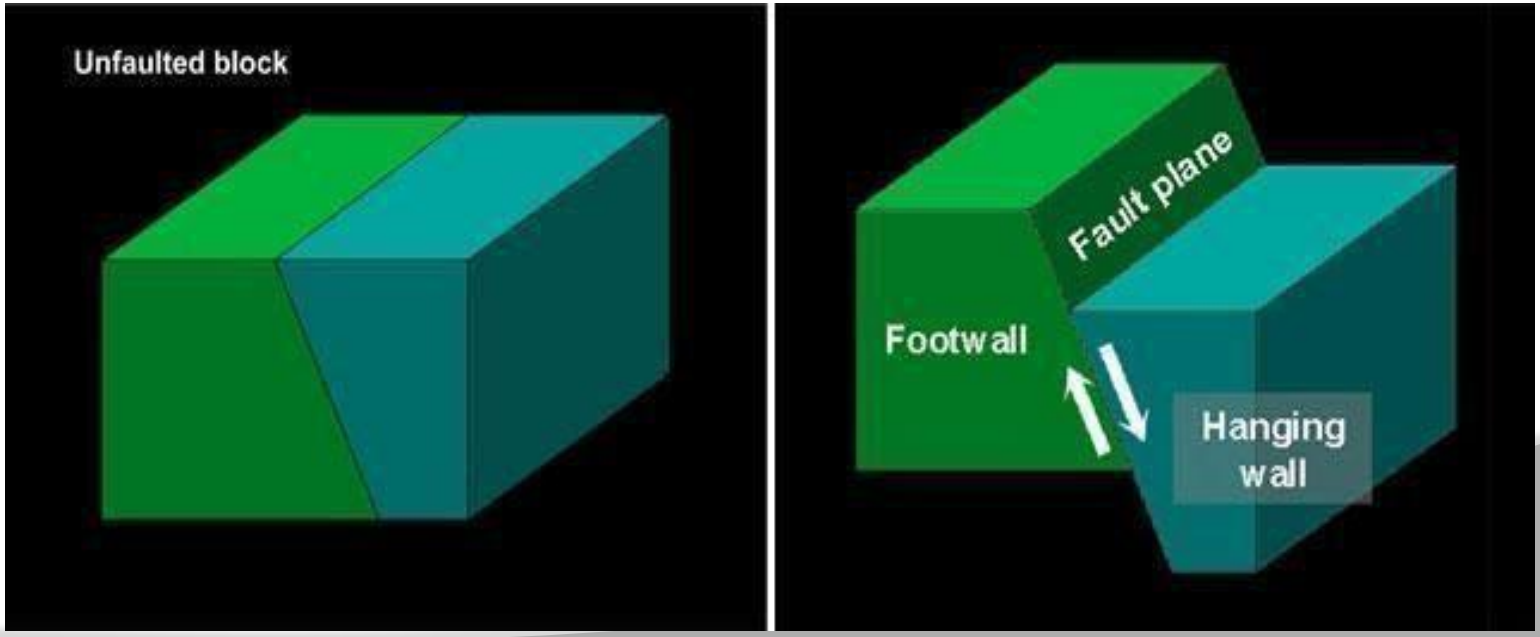
FAULT PLANE:

- This is the plane along which the adjacent blocks are relatively displaced.
- In other words, this is the fracture surface on either side of which the rocks had moved past oneanother.



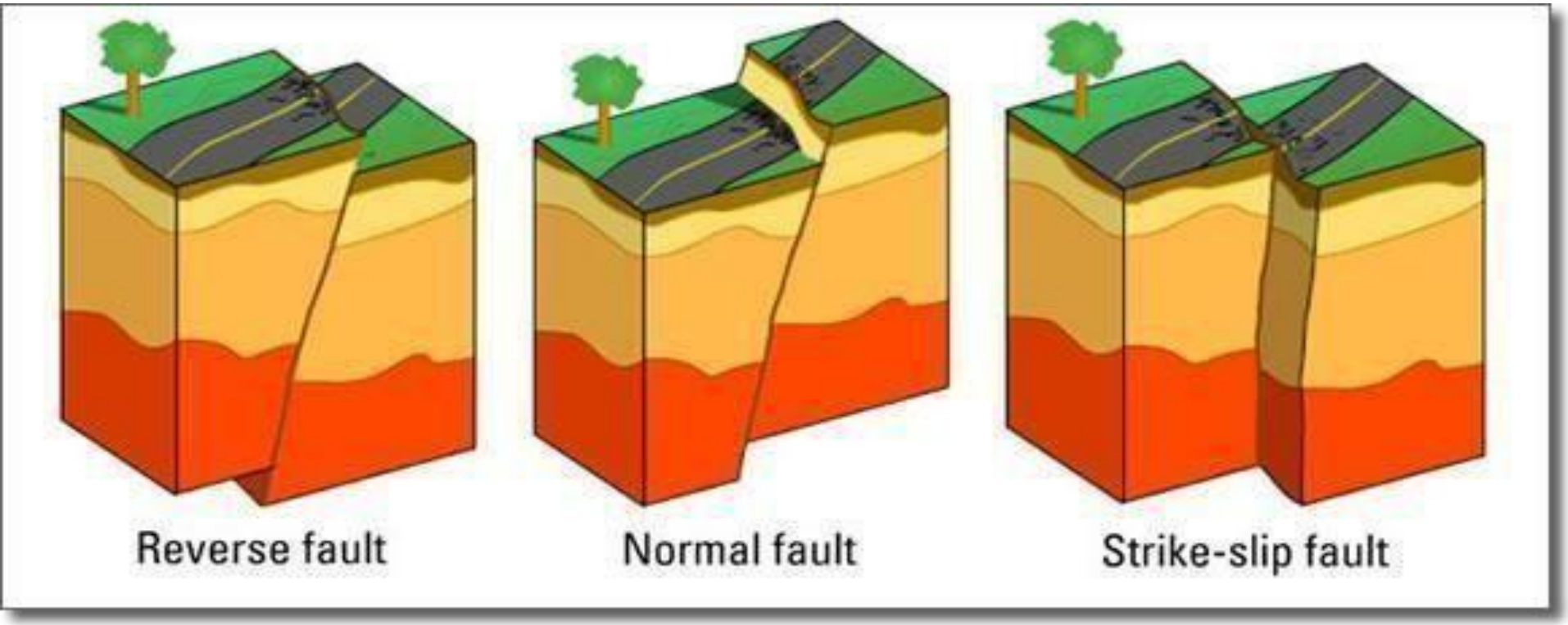
FOOT WALL AND HANGING WALL:

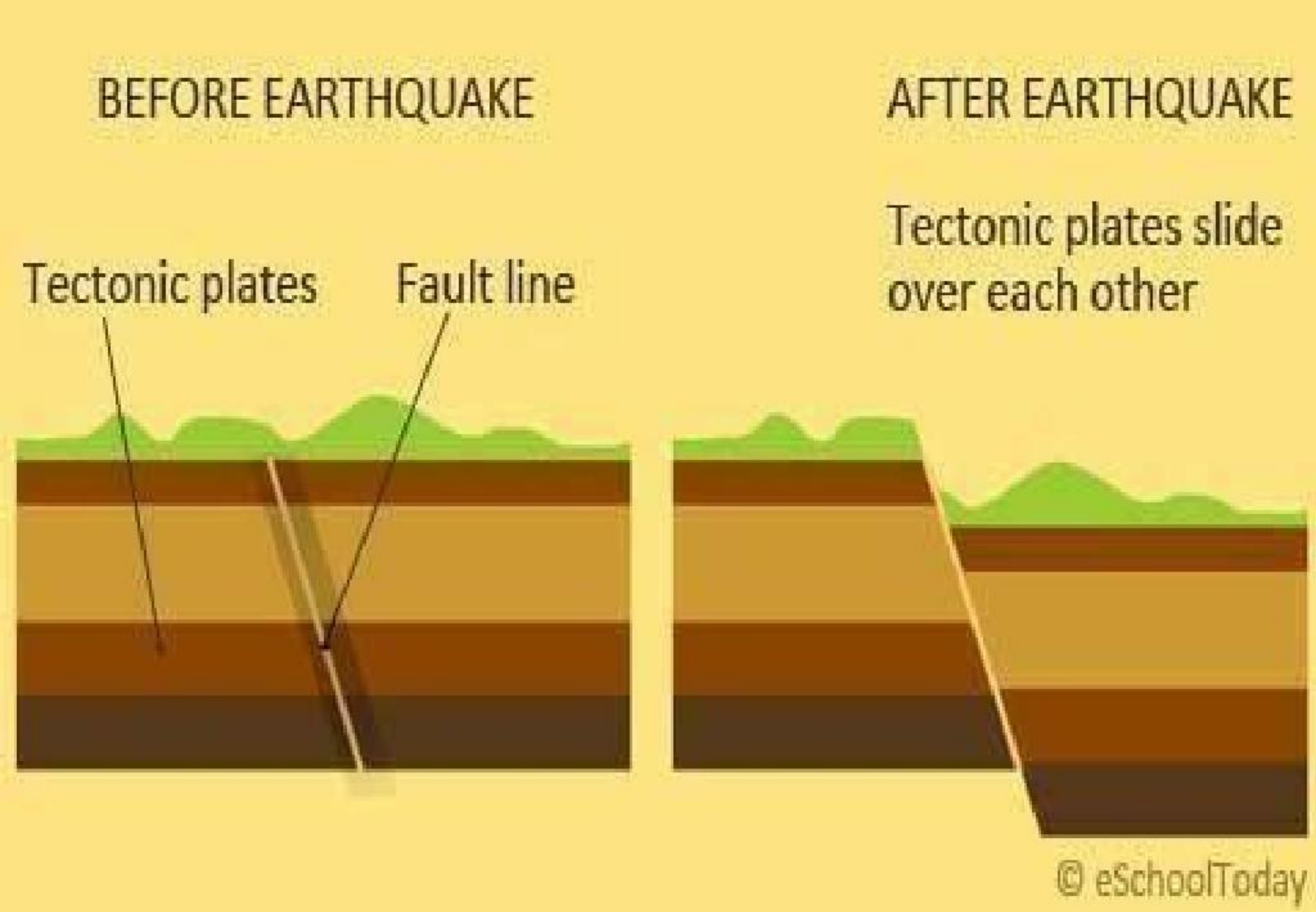
- When the fault plane is inclined the block which lies belowthe fault plane is called “Foot wall”.
- And the other block which rests above the fault plane is called “Hangingwall”.



SLIP:

- The displacement that occurs during faulting is called theslip.
- The total displacement is known as the netslip.
- This may be along the strike direction or the dipdirection.

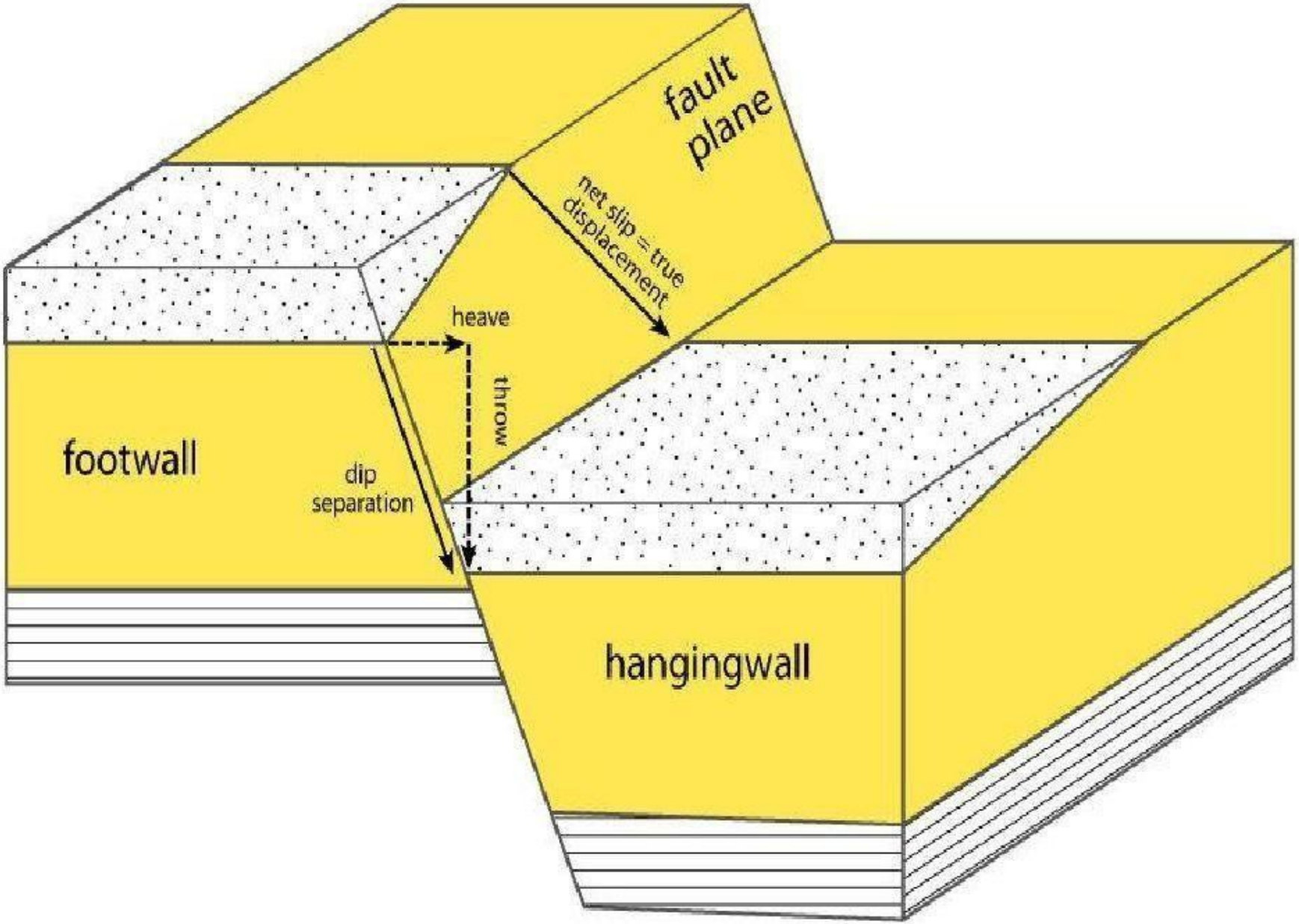



BEFORE EARTHQUAKE
AFTER EARTHQUAKE
Tectonic plates slide over each other
Tectonic plates
Fault line
© eSchoolToday

Parts of a Fault

Heave and Throw

- The **horizontal component of displacement** is called **"heave"** and **the vertical component of displacement** is called **"throw"**
- In vertical faults, there is only throw, but no heave. In horizontal faults, there is only heave, but no throw.


fault plane
net slip = true displacement
heave
throw
footwall
dip separation
hangingwall

MODULE-V
GEOLOGY OF DAM AND RESERVOIR SITE

CLOs	Course Learning Outcome
CLO19	Understanding of impact of engineering solutions on the society and also will be aware of Contemporary issues.
CLO20	Apply geological principles for mitigation of natural hazards and select sites for dams and tunnels.
CLO21	Posses the Knowledge and Skills for employability and to succeed in national and international level competitive examinations.
CLO22	Determination of shear strength of soil using direct shear test and tri-axial test in various drainage conditions.
CLO23	Recognize the behavior of soil in normal, over and under consolidated soil. Understand the concept of dilatancy in sandy soil.

EARTHQUAKES

DEFINITION:

A sudden violent shaking of the ground, typically causing great destruction, as a result of movements within the earth's crust or volcanic action.

A sudden release of energy in the earth's crust or upper mantle, usually caused by movement along a fault plane or by volcanic activity and resulting in the generation of seismic waves which can be destructive.

Sesimic Waves:

Seismic waves are **waves** of energy that travel through the Earth's layers, and are a result of an **earthquake**, explosion, or a volcano that gives out low-frequency acoustic energy.

Seismic waves are studied by geophysicists called **seismologists**. Seismic wave fields are recorded by a seismometer, hydrophone (in water), or accelerometer.ncy acoustic energy.

•The propagation velocity of the waves depends on density and elasticity of the medium.

•Velocity tends to increase with depth and ranges from approximately 2 to 8 km/s in the Earth's crust, up to 13 km/s in the deep mantle.

Classification and causes of Earthquake:

Based on depth of their origin, earthquake are described as
shallow or intermediate or Deep.

•Earthquake with a focus depth less than 60km are called shallow earthquake.
•If the depth more than 60km but less than 300km, they are called Intermediate earthquake.
•Which have focus depth more than 300km, they are called Deep
earthquake.

Based on the causes responsible for their occurrence, earthquakes are described as Tectonic or non Tectonic.

•**Tectonic earthquake** are exclusively due to internal causes, due to disturbances or adjustments of geological formations taking place in the earth's interior, they are les frequent, but more intensive and hence more destructive in nature.

•The **Non Tectonic earthquake** on the other hand, are generally due to external or surfacial causes. This type of earthquake is very frequent, but minor in intensity and generaly not destructive in nature.

Types:

Among the many types of seismic waves, one can make a broad distinction between *body waves* and *surface waves*.

- Body waves travel through the interior of the Earth.

- Surface waves travel across the surface.

- Surface waves decay more slowly with distance than do body waves, which travel in three dimensions.

Includes Primary and Secondary waves:

Primary waves(P-wave):

•Primary waves are compression waves that are longitudinal in nature.

•P waves are pressure waves that travel faster than other waves through the earth to arrive at seismograph stations first, hence the name "Primary".

•These waves can travel through any type of material, including fluids, and can travel at nearly twice the speed of S waves.

•In air, they take the form of sound waves, hence they travel at the speed of sound.

•Typical speeds are 330 m/s in air, 1450 m/s in water and about 5000 m/s in granite.

Secondary waves(S-Waves):

- Secondary waves (S-waves) are shear waves that are transverse in nature.

- Following an earthquake event, S-waves arrive at seismograph stations after the faster-moving P-waves.

- S-waves can travel only through solids, as fluids (liquids and gases) do not support shear stresses.

- S-waves are slower than P-waves, and speeds are typically around 60% of that of P-waves in any given material.

Definition:

•An Earthquake is a sudden and rapid shaking of the ground due to passage of vibrations beneath caused by transient disturbance of elastic or gravitational equilibrium of rocks.

•The scientific study of earthquakes is called Seismology.

•Earthquakes are measured using observations from seismometers.

• Seismic waves are recorded on instruments called seismographs.

•The time, locations, and magnitude of an earthquake can be determined from the data recorded by seismograph stations.

RICHTER MAGNITUDE SCALE:

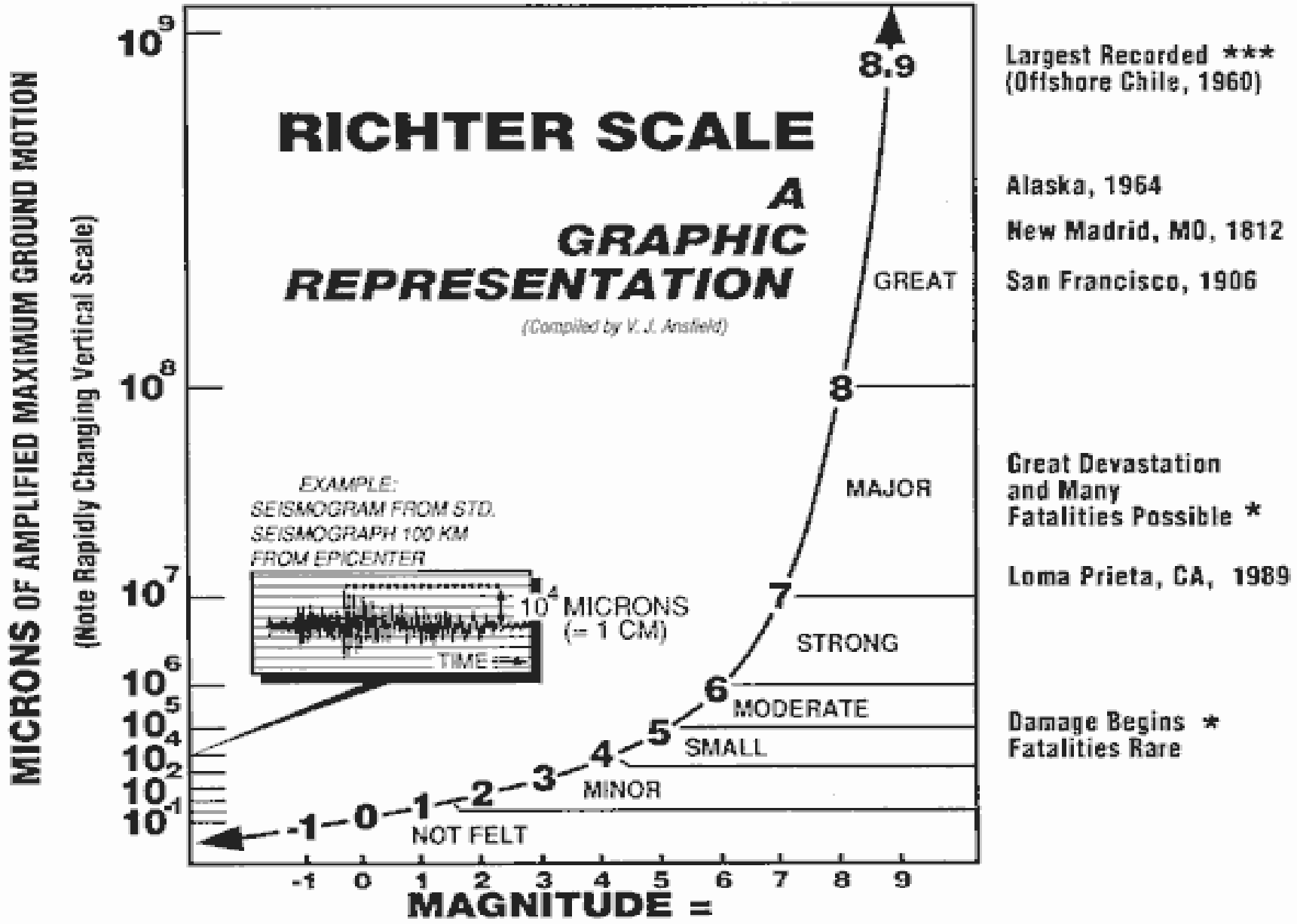
•The Richter magnitude scale was developed in 1935 by Charles F. Richter.

•Earthquakes with magnitude of about 2.0 or less are usually called micro earthquakes; are generally recorded only on local seismographs.

•Events with magnitudes of about 4.5 or greater, are strong enough to be recorded by sensitive seismographs all over the world.

•Great earthquakes have magnitudes of 8.0 or higher.

•On the average, one earthquake of such size occurs somewhere in the world each year.



LOGARITHM (BASE 10) OF MAXIMUM AMPLITUDE MEASURED IN MICRONS **

* EFFECTS MAY VARY GREATLY DUE TO CONSTRUCTION PRACTICES, POPULATION DENSITY, SOIL DEPTH, FOCAL DEPTH, ETC.

** MICRON = A MILLIONTH OF A METER

*** EQUIVALENT TO A MOMENT MAGNITUDE OF 9.5

Man-made Earthquakes:

- The impounding of large quantities of water behind dams disturbs the crustal balance.
- The shock waves through rocks set up by the underground testing of Atom bombs or Hydrogen bombs may be severe to cause earthquake.

CAUSES :

Natural Causes of Earthquake:

- Tectonic Movement
- Volcanic Activity
- Pressure of gases in the interior
- Landslides and avalanches
- Faulting and folding in the rock beds are responsible for causing minor earthquakes.

Man-made Earthquakes:

- The impounding of large quantities of water behind dams disturbs the crustal balance.

EFFECTS:

Destructive Effects:

- Earthquake causes dismantling of buildings, bridge and other structures at or near epicenter.
- Rails are folded, underground wires broken.
- Earthquakes originate sea waves called Tsunamis.
- Earthquakes result in the formation of cracks and fissures on the ground formation.
- The earthquakes cause landslides.
- Landslide due to earthquake may block valleys to form lakes.

SEISMIC BELT:

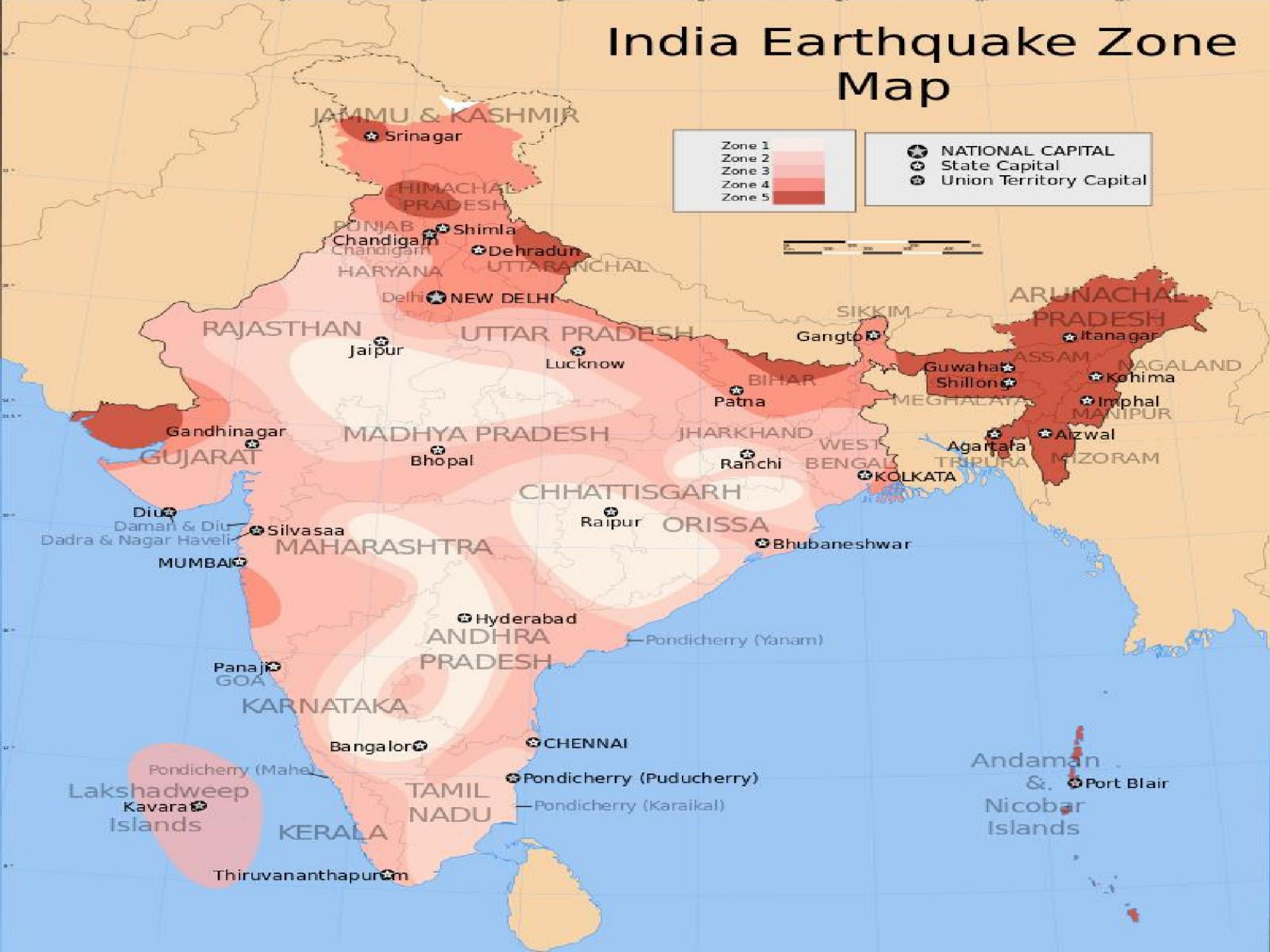
Narrow geographic zone on the Earth's surface along which most earthquake activity occurs.

The outermost layer of the Earth (lithosphere) is made up of several large tectonic plates.

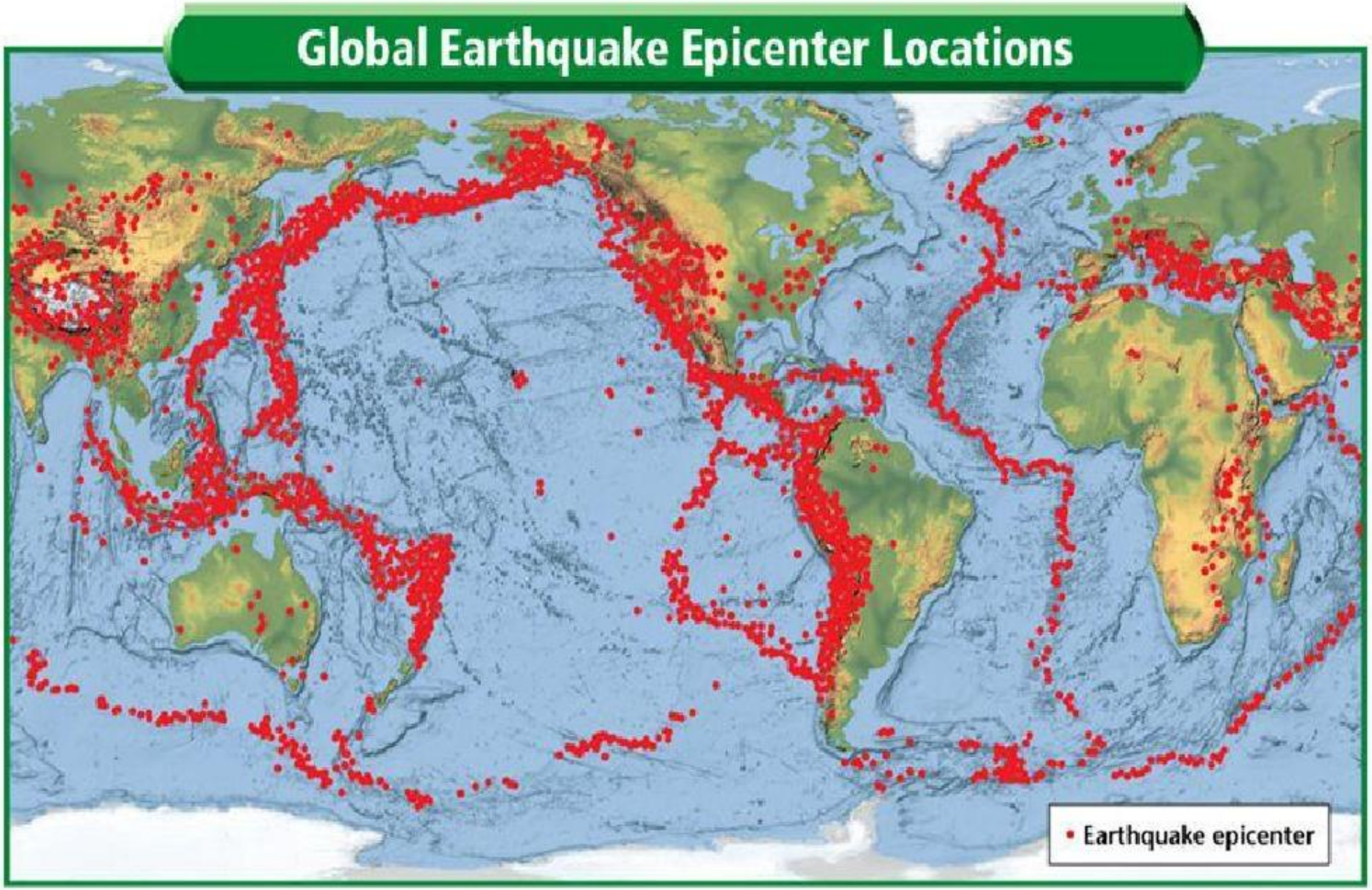
There are three main seismic belts in the world : 1.Circum-Pacific seismic belt

2.Alpine-Himalayan seismic belt 3.Ridge seismic belt

India Earthquake Zone Map



Seismic Belts



SEISMIC WAVES:

•Seismic waves are waves of energy that travel through the Earth's layers, and are a result of earthquakes, volcanic eruptions, magma movement, large landslides and large man-made explosions that give out low-frequency acoustic energy.

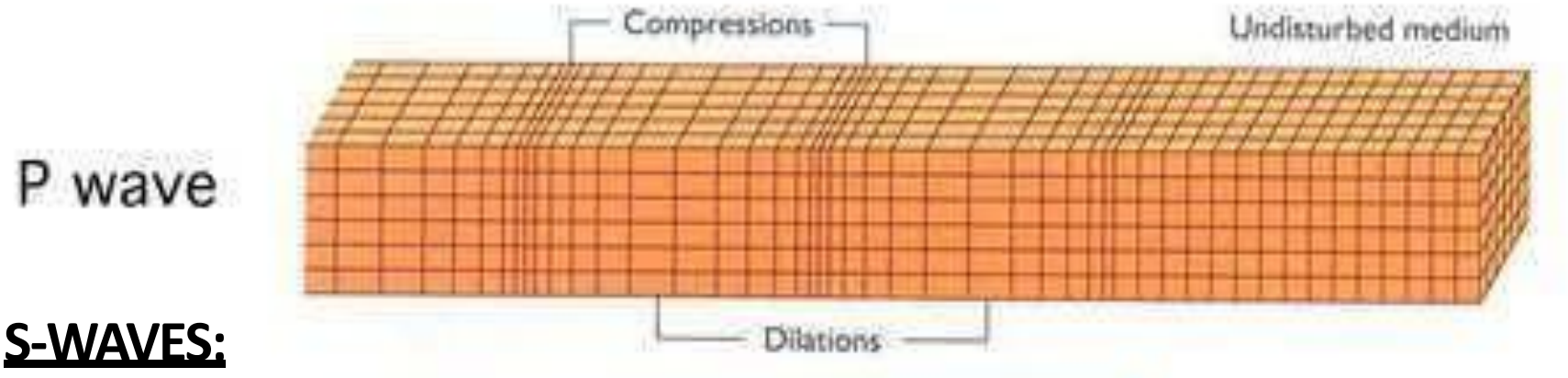
•Seismic wave fields are recorded by a seismometer, hydrophone
(in water), or accelerometer.

P-waves:

•**P-waves** are a type of body wave, that travel through a continuum and are the first waves from an earthquake to arrive at a seismograph.

•Typical values for P-wave velocity in earthquakes are in the range 5 to 8 km/s.

Example: C assignment



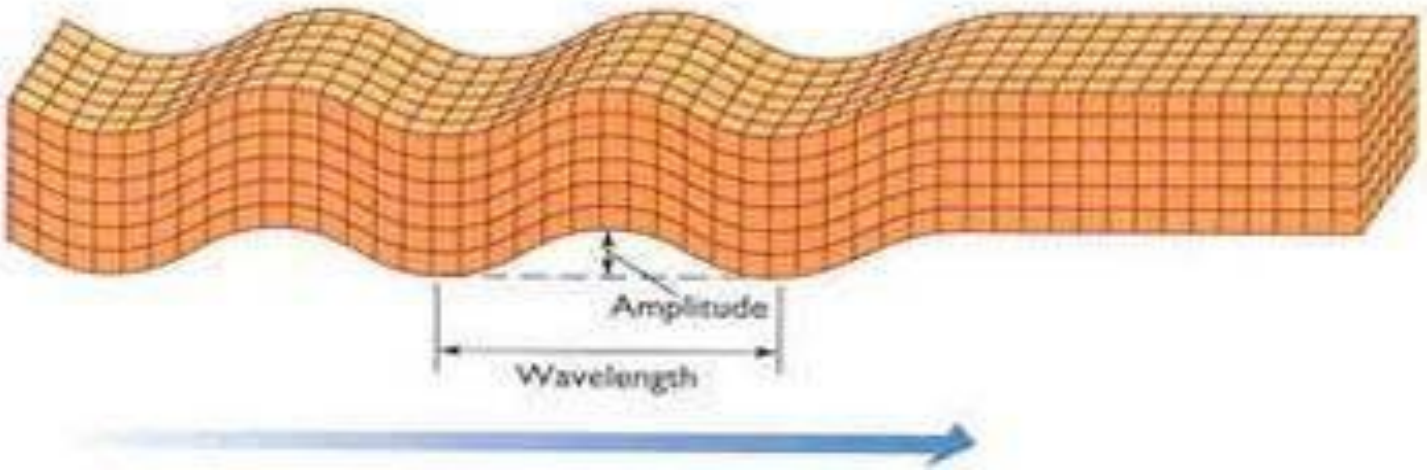
S-WAVES:

•S-waves, secondary waves, or shear waves (sometimes called an elastic S-wave) are a type of elastic wave.

• The S-wave moves as a shear or transverse wave, so motion is perpendicular to the direction of wave propagation.

•Velocity tends to increase with depth and ranges from approximately 2 to 8 km/s in the Earth's crust, up to 13 km/s in the deep mantle.

S wave

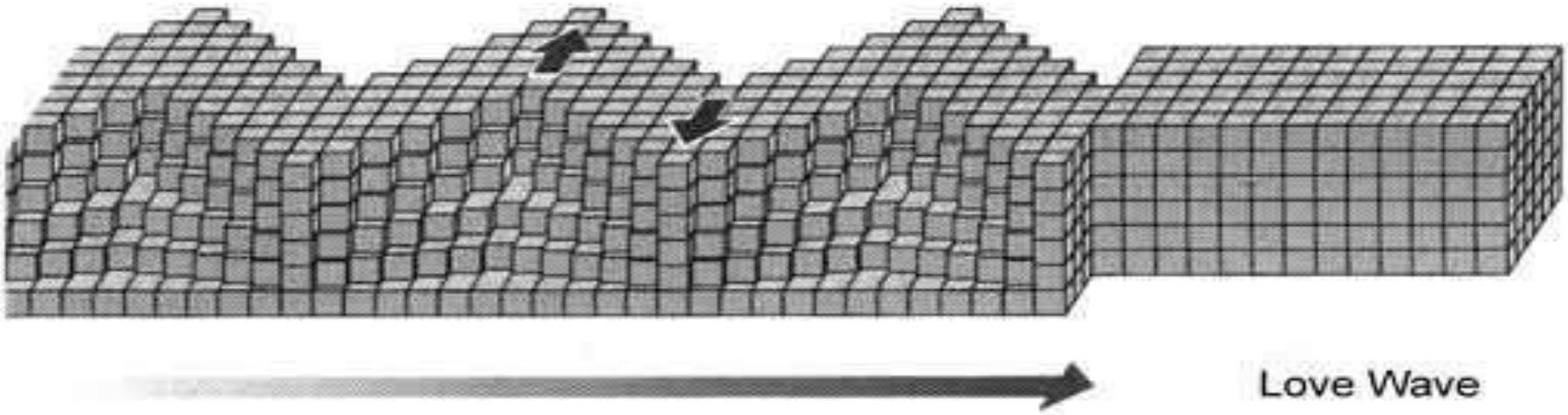


L-WAVES:

•The third general type of earthquake wave is called a surface wave, reason being is that its motion is restricted to near the ground surface.

- Such waves correspond to ripples of water that travel across a lake.

- The typical range of velocities is between 2 and 6 km/second.


Love Wave

ARM flow of control

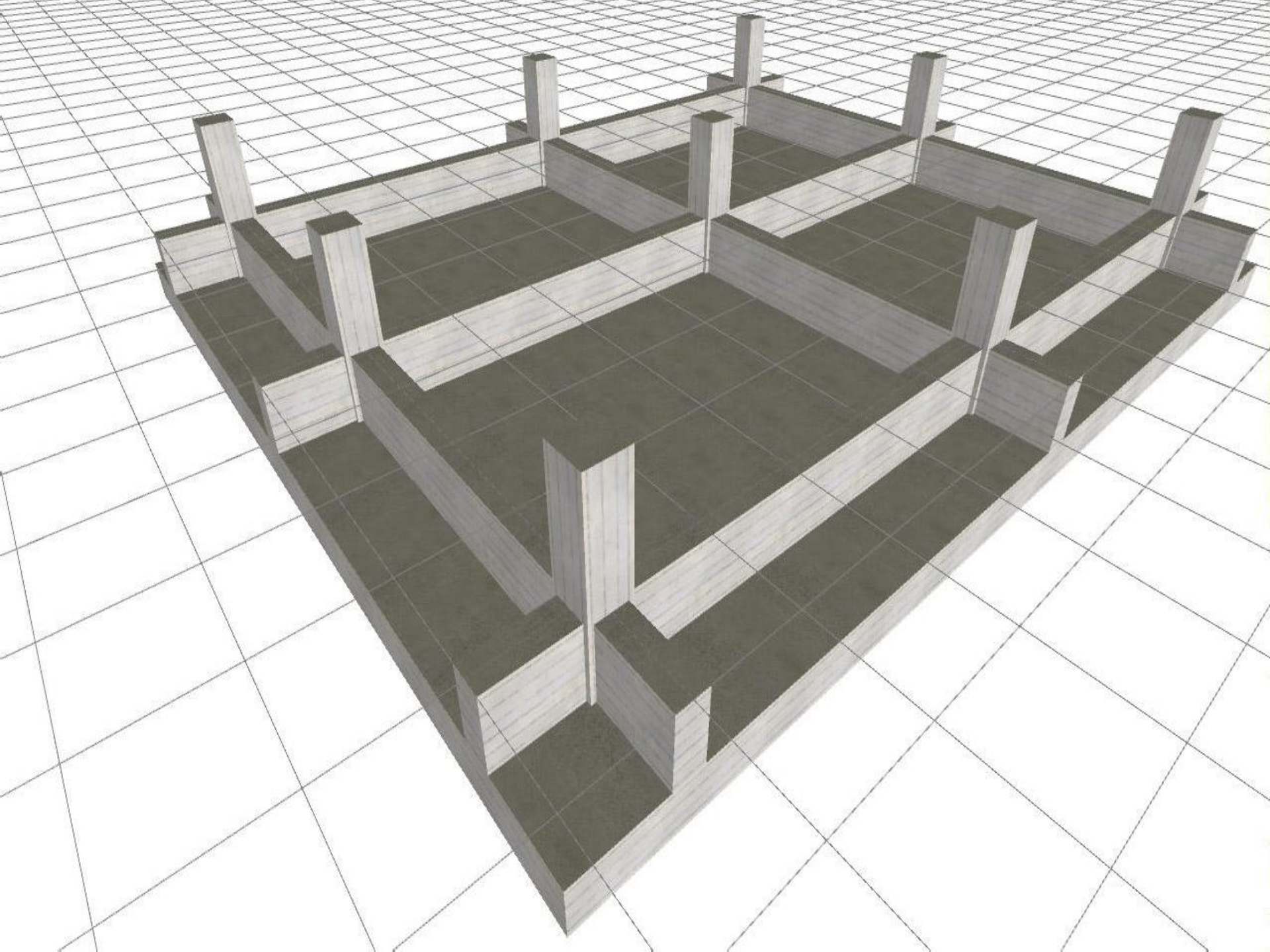
- All operations can be performed conditionally, testing CPSR:
  EQ, NE, CS, CC, MI, PL, VS, VC, HI, LS, GE, LT, GT, LE
- Branch operation:
  B #100
  Can be performed conditionally

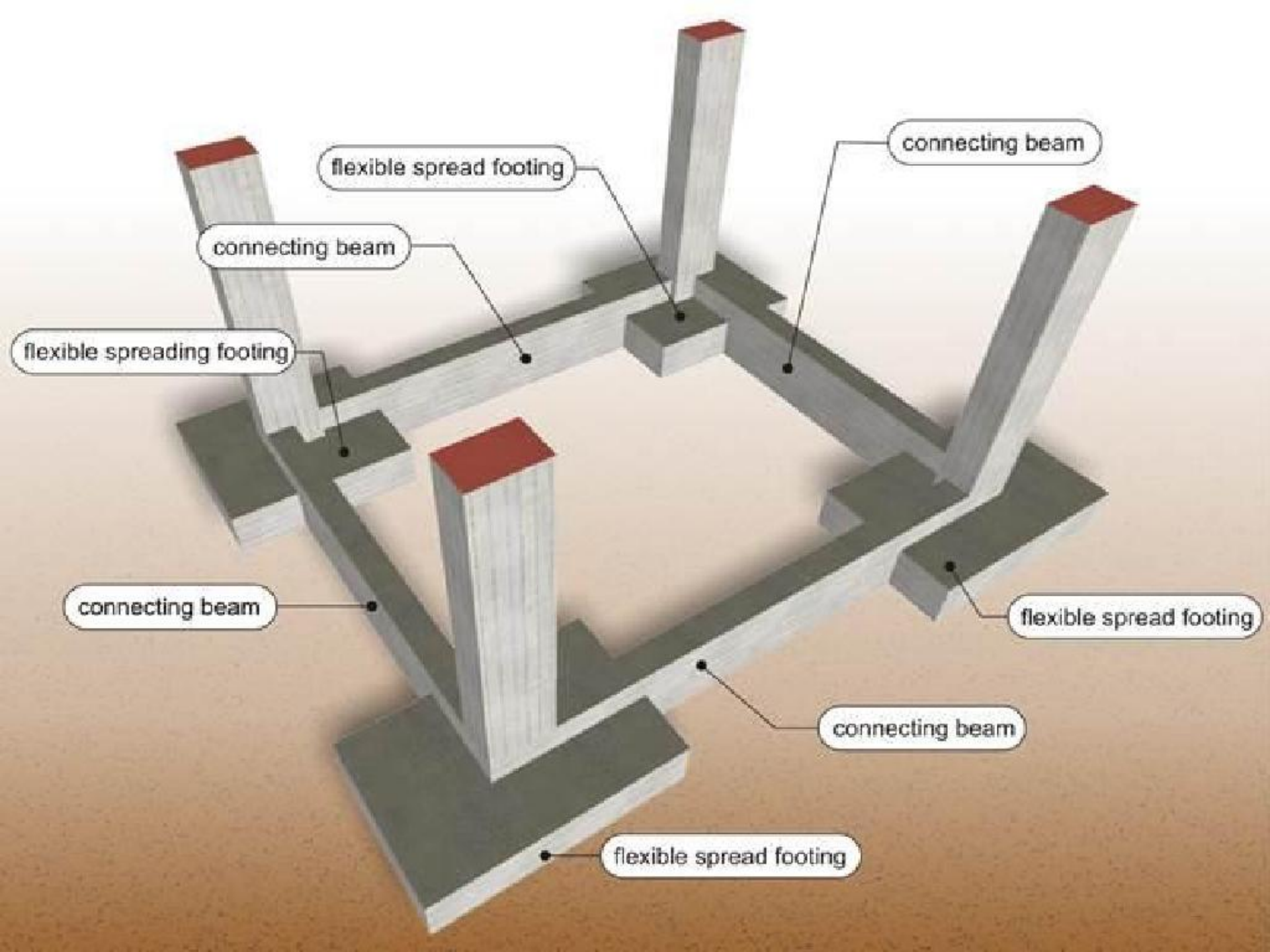
PRECAUTIONS:

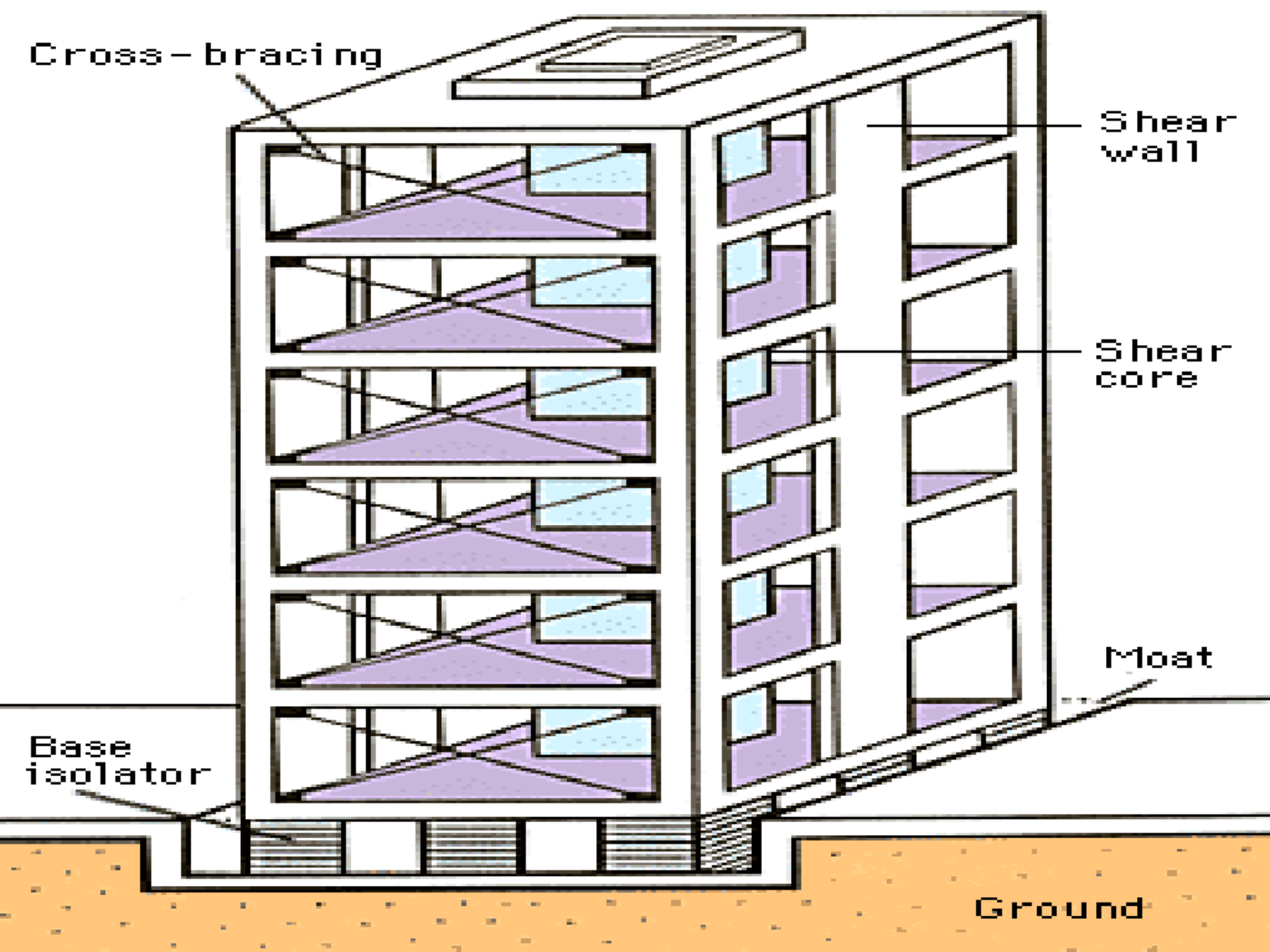
- First do the soil test. Structures will be constructed after testing the soils compaction tendency.
- Design of the structures or buildings should be made by professional engineer.
- Use rods according to the foundation type.
- The rod must provide necessary earthquake resistance to the building or structure.
- Maintain the quality of cement, rod and sand. Provide necessary rod in the joint of foundation and grade beam.
- This helps to provide extra earthquake resistance to the structures or buildings.
- Check column and slab design requirements by the authority.

•For earthquake resistance purposes, there will be no connection in the intersection of beam column.

•Columns of the structures or buildings need to be made strong to provide needed resistance. Column size can be increased from the foundation necessarily.




flexible spread footing
connecting beam
connecting beam
flexible spreading footing
connecting beam
flexible spread footing
connecting beam
flexible spread footing


Cross-bracing
Shear wall
Shear core
Moat
Base isolator
Ground

LANDSLIDES:

•A landslide is the movement of rock, debris or earth down a slope.

•They result from the failure of the materials which make up the hill slope and are driven by the force of gravity.

•Landslides are known also as landslips, slumps or slope failure.

•This is the most destructive and turbulent form of landslide.

•Flows have a high water content which causes the slope material to lose cohesion, turning it into a slurry.

LANDSLIDES HAZARDS:

- Although landslides are primarily associated with mountainous regions, they can also occur in areas of generally low relief.
- In low-relief areas, landslides occur as cut-and fill failures (roadway and building excavations).
- Slope saturation by water is a primary cause of landslides.
- This effect can occur in the form of intense rainfall, snowmelt, changes in ground-water levels.

Natural causes include:

- Elevation of pore water pressure by saturation of slope material
  from either intense or prolonged rainfall and seepage
- Vibrations caused by earthquakes
- Undercutting of cliffs and banks by waves or river erosion
- Volcanic eruptions

Human causes include:

- Removal of vegetation
- Interference with, or changes to, natural drainage
- Leaking pipes such as water and sewer reticulation
- Modification of slopes by construction of roads, railways, buildings, etc