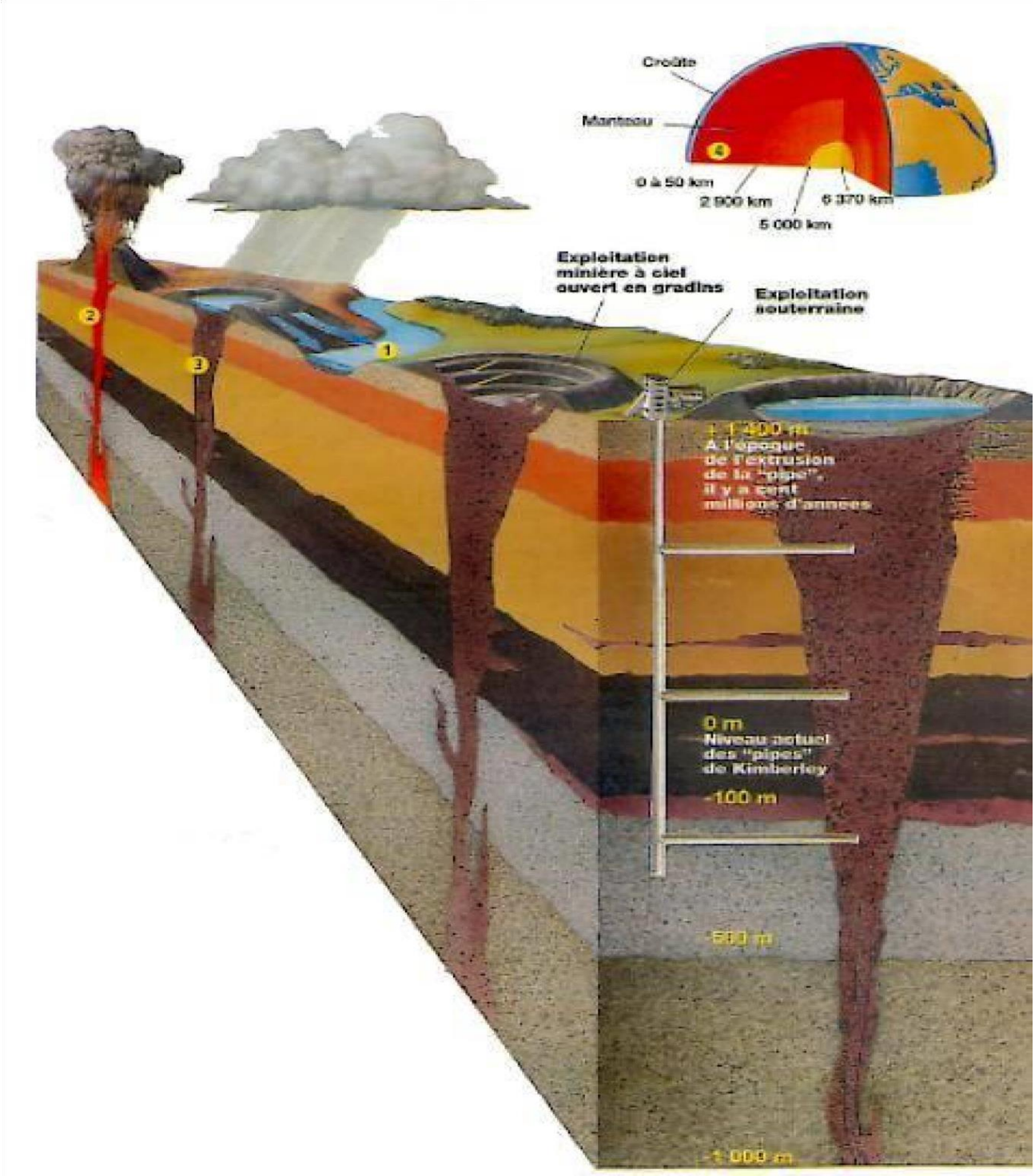
ATRIA INSTITUTE OF TECHNOLOGY
BANGALORE

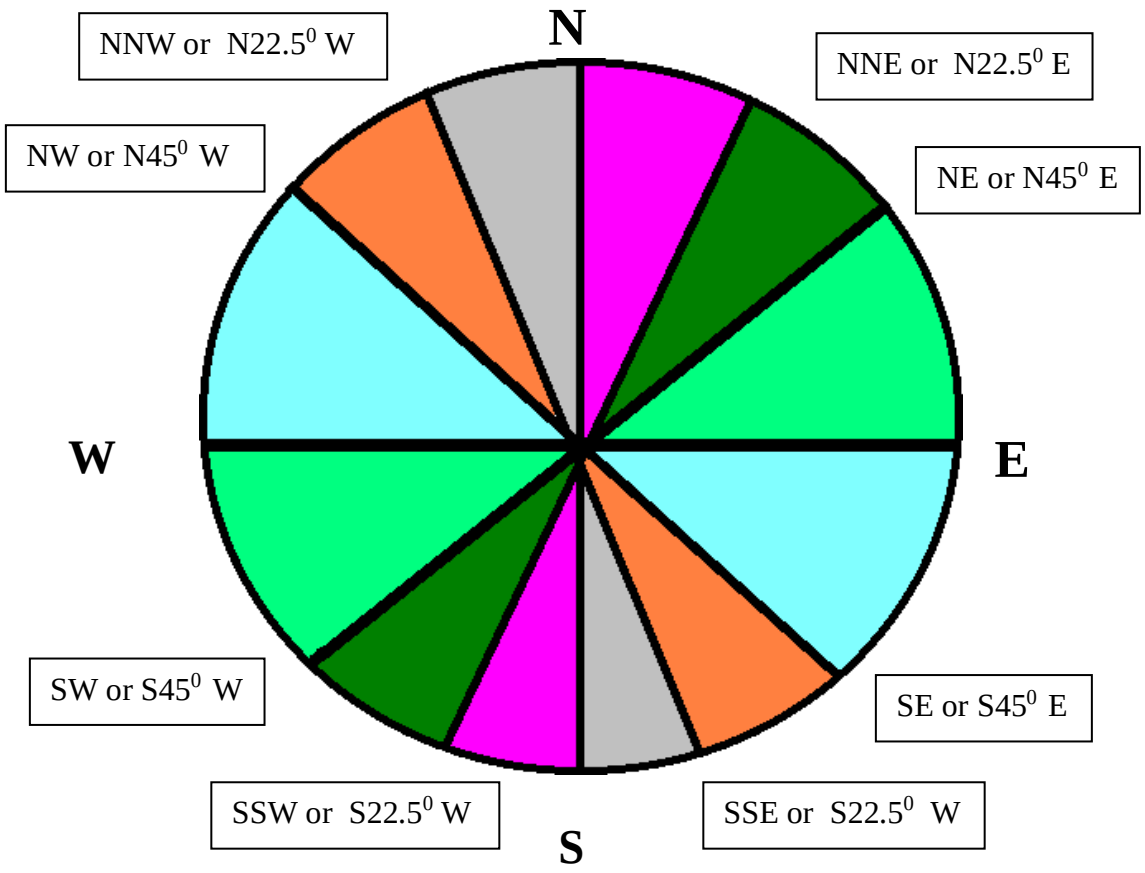
DEPARTMENT
OF
CIVIL ENGINEERING

IV Semester BE Civil Engineering

Engineering Geology
Laboratory Manual

(18CVL47)


Croûte
Manteau
4
0 à 50 km
2 900 km
5 000 km
6 370 km
Exploitation minière à ciel ouvert en gradins
Exploitation souterraine
2
1
3
+ 1 400 m
A l'époque de l'extrusion de la "pipe", il y a cent millions d'années
0 m
Niveau actuel des "pipes" de Kimberley
-100 m
-1 000 m



Due North means North is the direction

ENGINEERING GEOLOGY LABORATORY

18CVL47

B. E. CIVIL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

ENGINEERING GEOLOGY LABORATORY

Course Code	**18CVL47**	CIE Marks	40
Teaching Hours/Week(L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives: This course will enable students

1. To expose the students to identify the minerals and rocks based on their inherent properties and uses in civil engineering,
2. To educate the students in the interpretation of the geological maps related to civil engineering projects.
3. Students will learn the dip and strike, thickness of strata, Bore hole problems related to geological formation related to foundation, tunnels, reservoirs and mining.
4. Students will understand the Field knowledge by visiting the site like problems Faults, Folds, Joints, Unconformity etc.

Experiments

1. Physical properties of minerals: Identification of
   i. Rock Forming minerals - Quartz group, Feldspar group, Garnet group, Mica group & Talc, Chlorite, Olivine, Asbestos, Calcite, Gypsum, etc
   ii. Ore forming minerals- Magnetite, Hematite, Pyrite, Pyralusite, Graphite, Chromite, etc

2. Engineering Properties of Rocks: Identification of
   i. Igneous rocks- Types of Granites, Dolerite, Granite Porphyry, Basalt, Pumice etc
   ii. Sedimentary rocks- Sandstone, Lime stone, Shale, Laterite, Breccia etc
   iii. Metamorphic rocks- Gneiss, Slate, Schist, Marble, Quartzite etc

3. Borehole problems: Determination of subsurface behavior of rocks, their attitude related to foundation, tunnels, reservoirs and mining. Triangular and Square methods. (2 methods)

4. Dip and Strike problems. Determine Apparent dip and True dip. (2 methods)

5. Calculation of Vertical, True thickness and width of the outcrops. (3 methods)

6. Study of Topo sheets and Interpretation, Extraction of Drainage Basin and its Morphometric Analysis. (3Topo sheets)

7. Interpretation and drawing of sections for geological maps showing tilted beds, faults, unconformities etc. (10 Maps)

8. Interpretation of Satellite Imageries. (2 Satellite images)

9. Field work– To identify Minerals, Rocks, Geomorphology and Structural features with related to the Civil Engineering projects.

Course outcomes: During this course, students will develop expertise in;

1. The students able to identify the minerals, rocks and utilize them effectively in civil engineering practices.
2. The students will interpret and understand the geological conditions of the area for implementation of civil engineering projects.
3. The students will interpret subsurface information such as thickness of soil, weathered zone, depth of hard rock and saturated zone by using geophysical methods.
4. The students will learn the techniques in the interpretation of LANDSAT Imageries to find out the lineaments and other structural features for the given area.
5. The students will be able to identify the different structures in the field.

Reference Books:

1. MP Billings, Structural Geology, CBS Publishers and Distributors, New Delhi.
2. B.S. Satyanarayana Swamy, Engineering Geology Laboratory Manual, Dhanpat Rai Sons, New Delhi.
3. LRA Narayan, remote sensing and its applications, UniversityPress.
4. P.K.MUKERJEE, Textbook of Geology, WorldPress Pvt. Ltd., Kolkatta
5. JohnI Plattand John Challinor, Simple Geological Structures,ThomasMurthy&Co, London.

CONTENT

Experiments	
1	Physical properties of minerals: **Identification of Rock Forming minerals**: Quartz group, Feldspar group, Garnet group, Mica group & Talc, Chlorite, Olivine, Asbestos, Calcite, Gypsum, etc. **Identification of Ore forming minerals**: Magnetite, Hematite, Pyrite, Pyrolusite, Graphite, Chromite, etc
2	Engineering Properties of Rocks: **Identification of Igneous rocks** Types of Granites, Dolerite, Granite Porphyry, Basalt, Pumice etc **Identification of Sedimentary rocks-** Sandstone, Lime stone, Shale, Laterite, Breccia etc **Identification of Metamorphic rocks** Gneiss, Slate, Schist, Marble, Quartzite etc
3	Borehole problems: Determination of subsurface behavior of rocks, their attitude related to foundation, tunnels, reservoirs and mining. Triangular and Square methods. (2 methods)
4	Dip and Strike problems. Determine Apparent dip and True dip. (2 methods)
5	Calculation of Vertical, True thickness and width of the outcrops. (3 methods)
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8	Interpretation of Satellite Images. (2 Satellite images)
9	Field work– To identify Minerals, Rocks, Geomorphology and Structural features with related to the Civil Engineering projects.

Sl. No.	Name of the Experiment	Page No.	Marks	Initial of Staff
1	**Mineralogy: Identification of minerals** based on the physical properties: Form, Colour, Streak, Diaphaneity, Lustre, Cleavage, Fracture, Hardness, Sp.Gr. Special properties such as Dil. HCL test, Magnetism, Certain Senses. **Identification of Minerals**: Quartz Group and its Varieties: Rock crystal, Rosy Quartz, Milky Quartz, Amethyst, Smoky Quartz, Orange Quartz, Green Quartz (Fuchsite Quartz) Chalcedony, Agate, Jasper, Chert, Opal. **Identification of Minerals:** Feldspars: Orthoclase, Plagioclase, Microcline, and Kaolin. Mica Group: Biotite Mica, and Muscovite Mica. Carbonate Group: Calcite, Magnesite, Dolomite**.** Ferromagnesium Minerals: Hornblende, Asbestos, Augite, Olivine, Garnet, and Corundum.			
1a	**Identification of Ore Minerals:** Oxide group: Haematite, Magnetite, Pyrrhotite, Limonite, Bauxite, Chromite. Sulphide Group: Galena, Pyrite and Chalcopyrite Sulphate Group: Gypsum			
2 2a	**Petrology:** **Study and Identification of Igneous rocks:** Granite, Syenite, Diorite, Porphyries, Pegmatite, Basalt, and Rhyolite			
2b	**Study and Identification of Sedimentary Rocks:** Breccia, Conglomerate, Shale, Sandstone, Limestone, Laterite.			
2c	**Study and Identification of Metamorphic Rocks:** Slate, Schist, Gneiss, Marble, Quartzite, Charnockite			
3	**Bore hole problems**: Triangle Method & Square Method			
4	**Dip And Strike Problems:** Definition of Dip and Strike, Types of Dips, Solve 4 methods of problems			
5	**Thickness of strata problems** including calculation of vertical, true thickness and its width of out crop.- Solve 4 methods of problems.			
6	Study of Topo sheets and Interpretation, Extraction of Drainage Basin and its Morphometric Analysis. (3Topo sheets)			
7	Interpretation and drawing of sections for geological maps showing tilted beds, faults, unconformities etc. (10 Maps)			
8	Interpretation of Satellite Images. (2 Satellite images)			

Introduction

GEOLOGY is a Branch of Natural science deals with the study of the Earth, It is also known as Earth science. For studying the Earth in detail the subject of geology has been divided into various branches, which are as follows:

1. Mineralogy
2. Petrology
3. Structural geology
4. Civil Engineering geology
5. Mining geology
6. Economic geology
7. Stratigraphy
8. Photo geology
9. Physical geology
10. Hydrology etc.

Intelligent and useful application of geological knowledge to different branches Engineering constitutes the subject matter of engineering geology.

***"Mines generate wealth"*- Kautilya in Arthashastra.**

"Geology is a Fascinating Subject".

" Geology feels pulses of the Earth".

One who applies the geological sciences to engineering practice for the purpose of assuring that the geologic factors affecting the location, design, construction, operation and maintenance of engineering works are recognized and adequately provided for.

The following branches of Geology are important from the subject point of view:

1. Mineralogy
2. Petrology
3. Structural Geology

Chapter 1

Mineralogy

1.1. Introduction:

Mineralogy is a branch of Geology which deals with" the study of minerals". The subject of mineralogy attempts to study the various aspects of minerals.

The study of mineralogy includes the study of:
Physical characters (Physical Mineralogy)
Chemical characters (Chemical Mineralogy)
The Optical properties (Optical Mineralogy)
Mode of occurrence and the formation of minerals {X-Ray Mineralogy)

Due to the advancement of knowledge and improvement in techniques, Mineralogy also includes applied aspects.

A mineral can be defined as a" naturally occurring, homogeneous solid, inorganically formed having a definite chemical composition and ordered atomic arrangement".

According to this definition, a mineral will have the following characters:

1. It must have formed naturally; Minerals prepared in the laboratory by artificial method cannot be called minerals in the true sense.
2. Every mineral will be uniform or homogenous in composition.
3. It must be a solid, but the recent (latest) trend is to include coal and petroleum under minerals. But majority of the minerals are solids.
4. Inorganic processes form the minerals. Very rarely formation of certain minerals like Quartz, calcite etc. has been observed in certain parts of the human body, Even though such substances in the body possess the characters of minerals they cannot be called minerals.
5. Every mineral will have a definite chemical composition.
   For example:- Quartz (SiO_2); Graphite (C); Calcite ($CaCO_3$)
6. Every mineral is characterized by a definite internal atomic arrangement of an atom.

: Physical Properties of Minerals or External Characters of Minerals:

Minerals are characterized by a number of properties that can be observed externally. Such characters are called physical properties. The various physical properties can be studied under the following different headings:

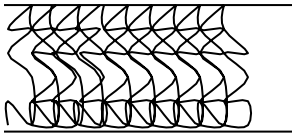
1. Physical properties of minerals depending on Light, Such as Form, Colour, Streak, Diaphaneity, Lustre.
2. Physical properties of minerals depending on state of aggregation, such as Cleavage, Fracture, Hardness.
3. Physical properties of minerals depending on the specific gravity of the mineral.
4. Physical properties of minerals depending on certain senses, such as Taste, Feel and Odour (Smell).
5. Special properties such as Dil. HCL test, Magnetism.

1. Physical properties of minerals depending on Light:

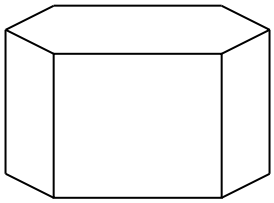
FORM: Minerals assume different shapes, which depend upon the internal structure of the minerals. Different terms have been used to describe the forms of different minerals.

The important terms that are commonly used are:

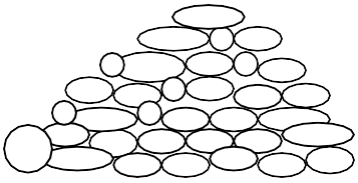
1. Fibrous- when the mineral has a thread like structure. Ex: Asbestos.



2. Columnar: - When the mineral has a thick or thin columnar structure. Ex: Hornblende



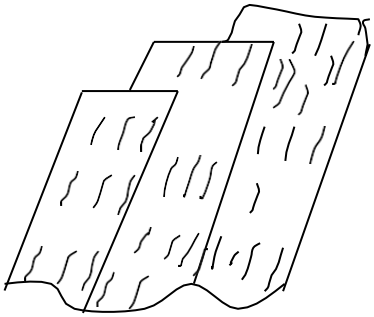
3. Granular-When the mineral has numerous grains, coarse or fine Example: Calcite, Chromite.



4. Crystalline- when the mineral has fine crystals packed together. Ex: Galena, Pyrite.

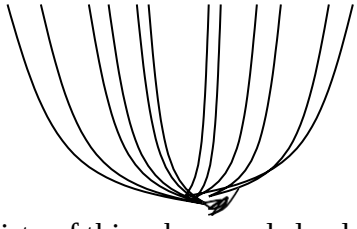
5. Massive- when the mineral has an irregular structure. Ex: Feldspar.

6. Bladed



When a mineral appears to be composed of a blade- like structure. Ex: Kyanite.

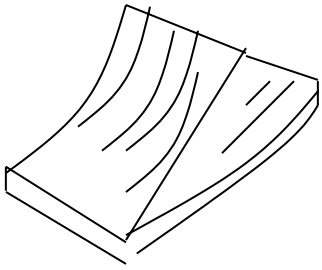
7. Acicular



When the mineral consists of thin, sharp and slender needles as shown in the figure. Ex: Natrolite.

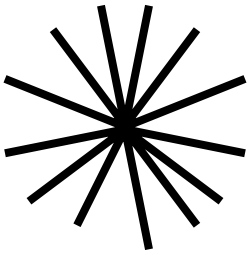
8. Botryoidal - Rounded aggregates of minerals like a bunch of grapes. Example: Chalcedony.

9. Foliated



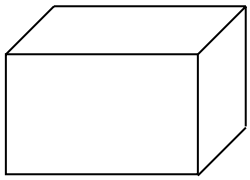
When the mineral consists of thin separable sheets. Ex: Mica.

10.Radiating



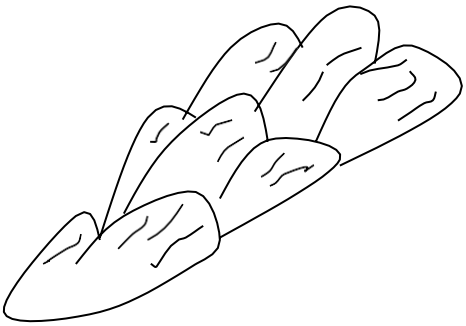
When the fibers or needles are arranged around a central point. Ex: Iron Pyrite.

11) Tabular



The mineral is flat rather than elongated as shown in the figure. Example: Calcite, Orthoclase.

12) Reniform-



When the mineral possesses rounded prominences like those of a Kidney as shown in the figure. Ex: Hematite.

B) Colour: Colour is an important physical property of minerals, which depends upon light. The colour of any mineral depends up on the absorption of some and reflection of others of the colour of white light. If the mineral absorbs all the colour of white light, it appears Black.

If the mineral reflects all the colours of white light it appears, White.
A mineral appears red when it can absorb all the colours of white light except red colour. Similarly, a mineral appears Green when it can absorb all the colours of white light except green colour.

C) Streak: Streak is nothing but the colour of the mineral in its powdery form. Rubbing the mineral against the streak plates can get streak. Some minerals will have the same colour from their massive form also in their powdery form.

For example, Natural gold is Yellow in both in its colour and powder form. There are some other minerals, which have different chloroform their massive form due to their powdery form.
For example, The mineral pyrite which is commonly called as "Fool's Gold" Is yellow in colour in its massive form but it gives a Black streak. Similarly Hematite, the ore of Iron will give Red or Brown Grayish brown in colour but it gives Cherry red Streak.

Table: 1.1 Colour of Streak of Some Minerals

Mineral	Streak
Barite	White
Biotite	Colourless
Chalcopyrite	Black
Chromite	Brown
Galena	Lead-grey
Gold	Natural yellow
Graphite	Black
Gypsum	White
Haematite	Cherry-red
Limonite	Yellowish-brown
Pyrite	Black
Quartz	Colourless
Siderite	White

D) Diaphaneity: Diaphaneity means ability to transmit light. The terms used are:

i) Transparent: when the mineral allows the light to pass through it. In the case of transparent minerals the objects can be clearly seen through such minerals.
Example: Quartz and Calcite (Coloured varieties).

ii) Translucent: When the minerals allow only a part of the light to pass through. The outlines of any object cannot be seen clearly through such a lines of translucent mineral.
Example: Quartz and Calcite (Milky white varieties)

iii) Opaque: When a mineral does not allow any light to pass through. The Objects are not seen through opaque mineral.
Example: Bauxite, Hematite, and Magnetite.

E) Lustre

The Lustre of a mineral is its appearance in a reflected light, which is independent of its colour.
The terms used are:

(i) Adamantine- when a mineral has lustre like Diamond. Example: Zircon, Diamond, Sulphur etc.,
(ii) Resinous- when a mineral has lustre like Grease.
Example: Opal amber and a variety of Zincblende.
(iii) Vitreous- When a mineral has lustre like Glass.
Example: Quartz, Calcite and in many other Silicate Minerals.
(iv) Pearly- when a mineral has lustre like Pearls. Example: Talc. Brucite, Micas etc.
(v) Metallic-When a mineral has lustre like metals. Example: Galena, Pyrite, and Chalcopyrite.
(vi) Silky lustre- Mineral with a Silky shine. Example- Asbestos
(vii) Dull- when a mineral has no lustre. Example- Bauxite.

2. Physical Properties of Minerals Depending On State Of Aggregation

(A) Cleavage: Cleavage of the mineral is its tendency to split along certain parallel planes producing more or less Smooth surface. Cleavage lines are the weaklings or divisional planes in a mineral.

The terms used are:

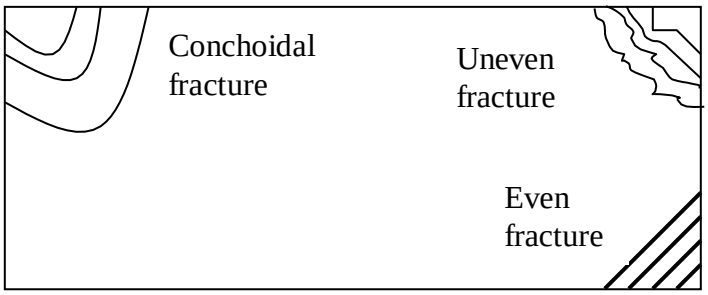
i. Perfect, Good or Distinct- When a mineral can split up with great ease and give a smooth surface.
Example: Mica, Feldspar

ii. Imperfect, Poor, Imperfect or None- When a mineral does not split up with an average force.
Example: Quartz

(B) Fracture: fracture of the mineral may be defined as the appearance of its broken surface, when the mineral is hammered and broken.

The terms used are:

i. Even fracture
ii. Uneven fracture
iii. Conchoidal fracture
iv. Hackly fracture
v. Earthy fracture



(i) Even fracture-Appearance of a mineral in its broken surface is Smooth.
Mineral examples: Chert, Mica.

(ii) Uneven fracture- when the mineral breaks with very rough and coarse surfaces.
Mineral examples: Chromite and various other minerals.

(iii) Conchoidal fracture- when a mineral breaks with curved Surfaces or concentric rings or half-moon shape.
Mineral example: Quartz

(iv) Hackly fracture- when a mineral breaks with irregular Surfaces having sharp edges.
Mineral example: Native copper.

(v) Earthy fracture- when the broken surface is soft and almost smooth.
Mineral example- Chalk.

(e) Hardness: The hardness of a mineral is the resistance it offers to abrasion, which is determined by observing the comparative ease or difficulty in scratching it with another mineral of known hardness. It is always expressed by Moh's Scale of Hardness given below-

Table-1.2 **Moh's Scale Of Hardness**

Standard Mineral and its composition		Hardness Scale	Remarks
Talc	$Mg_3 (Si_4O_{10}) (OH)_2$	1	Can be scratched by a finger nail
Gypsum	$CaSO_4$	2	Can be scratched by a finger nail
Calcite	$CaCO_3$	3	Can be scratched by a copper coin
Fluorite	CaF_2	4	Can be scratched by a iron nail
Apatite	Ca_3 (F, CL, OH) (PO_4)	5	Can be scratched by window glass
Orthoclase	$KALSI_3O_8$	6	Steel pocket knife
Quartz	SiO_2	7	Can be scratched by a Pen knife
Topaz	$Al_2 (SiO_4) (SOH)_2$	8	Can be scratched by a Pen knife
Corundum	Al_2O_3	9	Can be scratched by a Pen knife
Diamond	C	10	Cannot be scratched by a Pen knife

A mineral with lowest hardness is talc and the mineral with the maximum hardness is Diamond. It has been observed that a soft mineral like Talc and Gypsum can be scratched with a Fingernail. A steel knife can cut Apatite and Orthoclase but not Quartz. The average hardness of a normal fingernail may be up to 2.5 whereas the hardness of penknife is 6.5

3. Physical Properties of Minerals Depending on Specific Gravity:

The Specific gravity of a mineral is the ratio of its weight to the Weight of equal volume of water.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{M}{V}$$

Specific gravity is depending on the weight of the specimen

Low - Light minerals (less weight)
Medium - Intermediate minerals (medium weight)
High - Heavy minerals (much weight)

4. Physical Properties of Minerals Depending on Certain Senses Such as Taste, Feel and Odour

1. Taste: The terms used are-
   (i) Alkaline-Taste of soda
   (ii) Bitter-Taste of Epsom salt
   (iii) Cooling- Taste of Saltpeter
   (iv) Saline- Taste of common salt
   (v) Sour- taste of Sulphuric acid

2. Feel: Feel is the sensation upon touching or handling minerals. The terms used are- "Greasy"; "Soapy"; "Rough"; and "Harsh"

3. Odour: Some characteristic smell when rubbed breathed upon heated. The terms used are-
   (a) Arsenical - Like the Odour of Garlic. Example-Orpiment
   (b) Sulfurous - Like the Odour of burning Sulphur. Example-Pyrite
   (c) Argillaceous - Like the Odour of clay.

Special Properties of Minerals: Special properties of minerals such as:
(i) Magnetism; (ii) Reaction with dilute HCL acid

Magnetism:- Only few minerals are attracted by a Bar magnet or Horseshoe magnet. Such minerals are called Ferromagnetic. The most common minerals that attract a magnet are Magnetite, Pyrrhotite, Magnet, etc. Based on the strength of the magnetism, the minerals can be grouped under the following headings.

(i) Highly Magnetic - Examples: Magnetite, Pyrrhotite
(ii) Moderate Magnetic- Example: Siderite, Iron Garnet, Ilmenite, and hematite
(iii) Weakly Magnetic- Example: Tourmaline, spinel, and monazite
(iv) Non magnetic - Example: Calcite, quartz, and feldspars

Reaction with Acid:
Acid Test- Scratch a fresh even surface of the given mineral until grooved and powdered. Certain carbonate minerals react with Hydrochloric acid.
Example: Calcite CaCO3 is got. Add one or two drops of Dilute HCL. Carefully do it. Immediate effervescence (fizzing) confirms Carbonate especially $CaCO_3$**.**

CLASSIFICATION OF MINERALS:

A) Silicate minerals Rock forming minerals	1) Quartz group
	2) Feldspar group
	3) Mica group
	4) Amphibole group
	5) Garnet group
B) Non-silicate minerals Rock forming minerals	6) Carbonate group Calcite, Dolomite, Magnesite.
C) Non-silicate minerals Ore forming minerals	7) Sulphide group: Galena, Pyrite, Chalcopyrite. 8) Oxide group: Hematite, Magnetite, Bauxite, Corundum. 9) Sulphate group: Gypsum, Barytes.

DESCRIPTION OF MINERALS:

1 Quartz Group:

Form - Granular
Colour - (varieties of quartz)
Streak - Colourless
Luster - Vitreous
Cleavage - Absent
Fracture - Conchoidal to uneven
Hardness - 7 [High]
Sp. gr. - Low to Medium.
Chemical Composition - $Si\ 0_2$
Occurrence – widely distributed all over India occurs Beach Sand River sand.

Uses: (1) Manufacture of glass, porcelain
(2) Flux in metallurgical operation
(3) Agates are used as Ornaments
(4) Amethysts are considered as semiprecious stone
(5) Pure quartz crystal shows piezoelectricity

(6) Quartz plates are used in controlling frequencies in radio circuits, radar, Ultrasonic and multiple telephone lines.
(7) Fibre quartz wires are frequently used for transmission of telephone messages. Each minute fibre wire can send large messages.
(8) Quartz is used in refractories
(9) Pure silica is used in ceramics
(10) Pure sand, free from impurities is used in manufacturing Sand paper and Abrassive cloth.

Varieties of Quartz:

1. Crystalline Varieties:

a) Rock crystal or colourless quartz [colourless, transparent]
b) Rosy quartz [Rose colour, Translucent.]
c) Milky quartz [Milk colour, translucent]
d) Grey quartz [Grey colour, translucent]
e) Amethyst [Purple or violet colour, translucent]
f) Smoky quartz [Smoky- yellow or smoky-brown colour, translucent]
g) Orange quartz [Orange colour, translucent]
h) Green quartz [Green translucent colour]

[2] Cryptocrystalline Varieties:
a) Chalcedony [Botryoidal, uniform light colour]
b) Agate [Banded, zebra Agate- zebra colour]
c) Jasper [Blood red colour]
d) Chert [Brick red colour]

[3] Amorphous Varieties:
a) Opal

2. Feldspar Group:

Properties	**Orthoclase**	**Plagioclase**	**Microcline**
Colour Form Streak Lustre Cleavage Hardness Sp.Gr. Chemical composition	Pink Tabular Colour less Vitreous Present 6 (Medium) 2.6 (Medium) Potash feldspar	White Massive Colour less Vitreous Vitreous Present 6 (Medium) 2.6 (Medium) Soda feldspar	Green Tabular Colour less Vitreous Vitreous Present 6 (Medium) 2.6 (Medium) Potash feldspar
Indian Occurrence	Occurs in acidic igneous rocks – granites and pegmatites		
Uses	Used in the manufacture of Sanitary ware and Earthenware. Feldspars are also used in the manufacturing of porcelain bits. Feldspars are also used in the preparation of various types of glazed tiles		

3. Mica Group:

Properties	Biotin Mica (Black Mica)	Muscovite Mica (White Mica)
Form	Foliated	Foliated
Colour	Black	White colour
Streak	Colourless	Colourless
Diaphaneity	Translucent	Transparent
Lustre	Pearly	Pearly
Cleavage	Present	Present
Fracture	Even	Even
Hardness	Medium	Medium
Sp.Gr.	Medium	Medium
Chemical composition	Silicate of Mg, Fe, Al and K with [OH] ions.	Silicate of Al and K
Indian Occurrence	Occurs in igneous and metamorphic rocks	Occurs in igneous and metamorphic rocks
Uses	Lightweight concrete	Used as an insulating material in Electrical Apparatus Mica powders are used in mica bricks, steel plants, lubricants, filter in paints, rubber, plastic materials, wall papers, etc

4. Amphibole Group:

Properties	Hornblende	Asbestos
Form	Columnar	Fibrous
Colour	Dark green	White, Grey, green, etc.
Streak	Colourless	Colourless
Diaphaneity	Opaque	Opaque
Lustre	Vitreous	Silky
Cleavage	Present	Present
Fracture	Uneven	Uneven
Hardness	Medium	Medium
Sp.Gr	High	High
Chemical composition	Complex silicate of Ca, Na, Mg, Fe, Al and (OH) ions.	Hydrous silicate of Mg, Al
Indian Occurrence	Occurs in acidic igneous and Metamorphic rocks	Hassan (Karnataka), Rajasthan, TamilNadu, Andhra Pradesh and Bihar.
Uses	1. Used in the manufacture of cement 2. Rock forming mineral	Extensively used for Insulation, and in the manufacture of Lubricants and paints.

5. Garnet Group:

Properties	Garnet
Form	Crystalline (Cubical blocks)
Colour	Brown
Streak	Colourless
Lustre	Resinous
Hardness	High (7.5)
Sp.Gr.	3.6 to 4.3 (high)
Chemical composition	Silicate mineral of Fe, Mn, Cr, etc.
Indian Occurrence	Jaipur – Rajasthan. Kolar – Karnataka.
Uses	Used in the manufacture of sandpaper, good lustrous Garnets are used as Gems.

6. KAOLIN (China Clay) "Soapy Feel"

Properties	Kaolin
Form	Crystalline
Colour	White
Streak	White
Lustre	Dull
Hardness	2to 2.5 (low)
Sp.Gr.	2.6 [medium]
Chemical composition	Hydrous silicate of Ca, Na, K, Al
Indian Occurrence	Occurs as an alteration product of granites and gneisses.
Uses	Used in the manufacture of potteries, earthenware, sanitary ware, rubber and paints

7. Carbonate Group

Properties	Calcite	Dolomite	Magnesite
Form	Crystalline	Crystalline	Massive
Colour	Pink, white, black, blue	Gray	White
Streak	Colourless	Colourless	White
Lustre	Vitreous	Vitreous	Dull
Hardness	Medium	Medium	Medium
Sp.Gr.	Medium	Medium	Medium
Dil. HCl. test	Bubbles up	No bubbles up	No bubbles up
Chemical composition-	$CaCO_3$	$Ca\ Mg\ (CO_3)_2$	$MgCO_3$
Indian Occurrence	AP, Gujarath, Rajasthan,	Widely distributed all over India	Occurs in ultrabasic igneous rocks
Uses	Used in the manufacture of cement, Bleaching powder, Textile, rubber, paint industries, carrier of insecticide, glass and ceramic industries	1) Used in the manufacture of cement, lime and fertilizers (2) Pure dolomite is a good source of Mg. (3) Refractories, (4) flux in Metallurgical Operations, (5) glass industry.	1) Used for refractory bricks. 2) For furnace lining. 3) In electrical elements.

8. Sulphide Group:

Properties	Galena	Pyrite ("Fools Gold")	Chalcopyrite
Form	Crystalline	Radiating	Crystalline
Colour	Lead gray	Brass yellow	Brass yellow
Streak	Lead gray	Black	Black
Lustre	Metallic	Metallic	Metallic
Hardness	Medium (2.5)	Medium (6.0)	Medium (3.5 to 4)
Sp.Gr.	High (7.58)	High (5.02)	High (4.2)
Chemical composition	PbS	FeS2	CuFeS
Indian Occurrence	Occurs in veins in sedimentary rocks Rajas than, Bihar	Occurs In metamorphic rocks Aimer (Rajasthan) Ingaldhal (Karnataka) Taradevi (Punjab)	Occurs In the metamorphic rocks Rajasthan, Bihar
Uses	Galena is the most important lead ore Containing 66% of lead is found in combined state with zinc. Also used in lead piping	Pyrite is used in the manufacture of Sulphur and Sulphuric acid (H_2SO_4)	Copper ore having 34.5 % of copper.

9. Oxide Group:

Properties	Haematite	Magnetite	Bauxite	Corundum
Form	Massive	Massive	Oolitic	Granular
Colour	Red or Brown	Black	Brown	Brown
Streak	Cherry Red	Black	Same as that of Colour	Colourless
Lustre	Metallic	Metallic	Earthy	Vitreous
Hardness	Medium [5.5 to 6.5]	Medium [6.0]	Low to medium (1 to 3)	High (9)
Sp.Gr	High [5.3]	High [5.18]	Medium	High (4.1)
Chemical Composition	Fe_2O_3	Fe_3O_4	$Al_2O_3 N H_2 O$	$Al_2 O_3$
Indian Occurrence	Occurs in sedimentary and Metamorphic rocks. Bihar, Orissa Madhya pradesh, Karnataka.	Occurs in sedimentary and metamorphic rocks. Bihar, Orissa Madhya Pradesh, Karnataka. Magnetite contains 72.4 % of iron. Used in modern industry as an ore of Iron.	Occurs as an alteration product of Al rich rocks. Gujarat. Maharashtra, Karnataka	Wide Occurrence metamorphism of shale and limestone.
Uses	Haematite Contain 70 % of Iron. Used in modern industry as an ore of iron.		Principal uses of Aluminum are in the manufacture of chemicals, Cement and in refining petroleum.	a) A Few of corundum is used as Gemstones. b) Used as an abrasive.

10. SULPHATE GROUP

Properties	Gypsum	Barytes
Form	Tabular	Tabular
Colour	Colourless, white, also gray, Yellowish or red	White, yellow
Streak	White	White
Lustre	Pearly, silky	Vitreous
Cleavage	Perfect	Perfect
Hardness	2	3.0 to 3.5
Sp.Gr	2.3 (Medium)	4.3 to 4.6(High)
Chemical Composition	$CaSO_4.2H_2O$	$BaSO_4$
Indian Occurrence	Rajasthan, Jammu and Kashmir (J & K), Tamil Nadu, UP, Maharashtra.	A.P, Rajasthan, madras, U.P
Uses	Gypsum is used as a 1) Fertilizer 2) It is also used in the manufacture of cement and plaster of Paris.	Barytes is used in the manu facture of paints, asbestos goods, paper, pottery, etc. It is also used in Sugar industry to refine the sugar.

11 and 12. Staurolite and Talc:

Properties	Staurolite	Talc
Form	Tabular	Flaky, massive, soapy to touch
Colour	Reddish brown	White, Apple green
Streak	Light brown	White
Diaphaneity	Translucent to Opaque	Opaque
Lustre	Vitreous to dull	Opaque
Cleavage	Perfect	==
Hardness	7.5	Perfect
Sp.Gr.	3.7	12.7 to 2.8(very soft, smooth)
Chemical composition	Hydrous silicate of Fe and Al.	Hydrous silicate of Mg
Indian Occurrence	Occurs in metamorphic rocks.	Occurs in metamorphic rocks
Uses	Coloured translucent used as semiprecious stones varieties	Steatite or soapstone is used in many waves Ex—As a lubricant, filler in toilet powder, also in gas burners, furnace linings, etc.

The Standard Format is to be advised while writing The Description of Minerals at the time of identification.

(A) Observation

Name
Form
Colour
Streak
Diaphaneity
Lustre
Cleavage
Fracture
Hardness
Sp. Gr.

(B) Theoretical Information

Chemical Composition (C.C)
Crystal System (C.S)
Indian Occurrences (I.O)
Uses

(C) Note

1] Silicate/ Non-silicate mineral.
2] Rock forming mineral/ Ore forming mineral.
3] Belongs to the group.

Highlights:

Mineralogy [Study of Minerals]

Mineral is defined as naturally occurring homogenous Solid. Inorganically formed having a definite chemical composition and ordered atomic arrangement.

Identification of Minerals on The basis of Physical Properties:

- Form: Shape of a Mineral
  The terms used are
  Granular, Massive, Tabular, Columnar, Foliated, Fibrous, Radiating.
- Colour: Absorption of some and reflection of other Colours of white light.
- Streak: Colour of the mineral in its powder form.
- Diaphaneity: Ability to transmit light.

The terms used are:

1. Transparent	2. Translucent	3 Opaque
Light passes clearly from one end to the other end of the mineral.	Light passes partially from one end to the other end of the mineral.	Light does not Pass through from one end to the other end of the mineral.

- Lustre: Shining of a mineral in its reflected light.

The terms used are

1. Vitreous	Metallic	Pearly	Silky	Dull
(Broken glass	(Metals)	(Pearls)	(Silk)	(No shining)

- Cleavage: Cleavages are nothing but the divisional planes of a mineral

The terms used are:

1. Perfect or present	2. Imperfect or absent
Divisional planes are there	No divisional planes

- Fracture: Appearance of a mineral in its broken surface.

The terms used are

Conchoidal	Even	Uneven
Concentric rings	Smooth	Rough

- Hardness: Means resistance it offers to abrasion.

The terms used are

Low	Medium	High
Possible to scratch by finger nail	Possible to scratch by steel knife	Not possible by both

- Specific Gravity: Based on the weight of the specimen,
  The terms used are

Low	Medium	High
Less weight		Much weight

- Other Characters Such as

a) Dil. Hcl.test – If we touch the mineral with Dil, Hcl the given mineral bubbles up. Because of $CaCO_3$ Examples: calcite.
b) Magnetism – some minerals are attracted by a bar magnet or Horseshoe magnet. Such minerals are called Ferromagnetic Example: Magnetite

1.6. Question: Describe the physical properties, Chemical composition, uses, and crystal system and identify the mineral specimens kept in tray no 1 to 5 - 10 marks (5x2)

Format

Date:

(A) Observation

SL.NO. ---------
SP.NO. ---------
Form/ Habit
Colour
Streak
Diaphaeneity
Lustre
Cleavage
Fracture
Hardness
SP. GR
Name

(B) Theoritical Information

Chemical Composition (CC)
Crystal System
Occurrence
Uses

(C) Note

1] Silicate/ Non silicate mineral.
2] Rock forming mineral/ Ore forming mineral.
3] Belongs to which group.

Example:

Question – Describe the physical properties, Chemical composition, uses, and crystal system and identify the mineral specimens kept in tray no 1 to 5 - 10 marks (5x2)

Sl.no: 1 Specimen no: 1		
A) Observation	Form/ Habit	Crystalline
	Colour	Colourless
	Streak	Colourless
	Diaphaeneity	Transparent
	Lustre	Vitreous
	Cleavage	Absent
	Fracture	Conchoidal
	Hardness	7(High)
	SP. GR	2.65
	Name	Rock Crystal
(B)Theoretical Information	Chemical Composition (C.C)	SiO_2
	Crystal System (C.S)	Hexagonal
	Occurrence	Widely distributed all over the India
	Uses	Used in Microscopes, Glass Industry, Crystals in TVs and Watches and Radios
C] Note	1] Silicate/ Non silicate mineral	Silicate Mineral
	2]Rock forming mineral/Ore forming mineral	Rock forming Mineral
	3] Belongs to which group	Quartz

Excercise:

Question: Describe the physical properties, Chemical composition, uses, and crystal system and identify the mineral specimens kept in tray no 1 to 5 - 10 marks (5x2)

Sl.no: Specimen no:	Properties	Serial No. Specimen No:	Serial No. Specimen No
(A) Observation	Form/ Habit		
	Colour		
	Streak		
	Diaphaeneity		
	Lustre		
	Cleavage		
	Fracture		
	Hardness		
	SP. GR		
	Name		
(B)Theoretical Information	Chemical Composition (C.C)		
	Crystal System (C.S)		
	Occurrence		
	Uses		
C] Note	1] Silicate/ Non silicate mineral		
	2]Rock forming mineral/Ore forming mineral		
	3] Belongs to which group		

Chapter-2
Petrology

The word Petrology is derived from the Greek word Petra means Rock, and Logos means Science.

2.1. Petrology is the branch of Geology deals with the study of rocks. Especially their mode of formation, Composition and uses for all types of engineering works.

The study of petrology is most important for a civil engineering in the selection of suitable rocks for building stones, Road metals etc., Rocks reveal the geological events of our mother earth. Rocks of other planets also decipher the secrets of their geological evolution.

2.2 Definition of as rock:

A Rock is defined as the aggregation of the mineral constituents, which forms the earth's crust. Some rocks may be hard like Granite 0r soft like sand or clay. The hard and resistant substances may be called stones.

Example- Granite, Sandstones, Marble etc., that is why all the stones are rocks, but at the**.** Same time all rocks are not necessarily stones.

2.3. Classification of rocks based on their Genesis:

Broad classification of rocks on the basis of their mode of origin (Ref-Table).

I) Igneous rocks or primary rocks:-

Formed by the consolidation of hot molten material magma.

Example- Granite, Syenite, Diorite, Pegmatite, Dolerite, Basalt.

ii) Secondary rocks or Sedimentary rocks:-

Formed by the consolidification of Sediments in the layered or bedded rocks deposited in the ocean bottom or huge lake etc.,

Examples- Breccia, Conglomerate, Shale, Sand stone, Limestone, Laterite.

iii) Metamorphic rocks:-

Formed by the effects of temperature, pressure of both (by a process is known as 'Metamorphism") on the preexisting rocks.

Examples- Slate, Schist, Gneiss, Marble, Quartzite, Charnockite.

2.4 Table: Classification of rocks based on their Genesis.

Igneous rocks or Primary rocks	**Sedimentary rocks or Secondary rocks**	**Metamorphic rocks or Altered rocks**
Volcanic Examples-Basalt, Trachyte. Hypobyssal Examples-Pegmatite Plutonic Examples-Granite, Syenite, Diorite, Gabbro, Dunite etc.,	Organic Examples-Fossiliferrous Limestone. Chemical Example-Limestone. Mechanical Example-Shale, Conglomerate, Breccia.	Thermal Example-Marble. Dynamic Example-Slate, Schist. Dynamo thermal Example-Quartzite.

Terminology

IGNEOUS ROCKS	**SEDIMENTRY ROCKS**	**METAMORPHIC ROCKS**
or First formed rocks or Primary rocks or Hard rocks or Consolidated rocks	or secondary formed or second formed or soft rocks or unconsolidated rocks	or Altered rocks or Third formed or Hard rocks or Consolidated rocks.

Classification of igneous rocks:

	Over Saturated	Saturated		Under Saturated
	ACID Silica content: SiO_2 >66% with free quartz	INTERMEDIATE SiO_2 55 - 66 %	BASIC SiO_2 44 - 55%	ULTRA BASIC SiO_2 < 44 %
Mineral composition	Q, F, B, H	OF+PF+Hbl	Augite +PF	Olivine and little or no feldspar
Colour	Leucocratic	Mesocratic	Melanocratic	
Specific gravity	2.6-2.7	2.9	3.0	3.1
VOLCANIC (Extrusive)	Rhyolite Dacite Obsidian	Trachyte Andesite Phonolite	Basalt Alkali-Basalt	Limbergite Olivine-basalt
HYPOBYSSAL Minor Intrusive - sill, dyke, Laccolith.	Granite-porphyry Pegmatite	Syenite-porphyry Diorite-porphyry	Dolerite-porphyry Dolerite	
PLUTONIC Major Intrusive-Batholith, Boss	Granite Grano-diorite	Syenite, Diorite Nepheline-Syenite	Gabbro	Dunite Peridotite, Picrite Perkinite.

1.7.Classification of Sedimentary Rocks:

Mode of Formation	Texture and Mineral Composition	Rock types
Mechanically formed or Clastic	1.Rudaceous (Pebbly) ii) Arenaceous (Sandy) iii) Argillaceous (Clayey)	Breccia Conglomerate Sandstone, Shale
Chemically Formed (Precipitation/evaporation/ residual deposits)	Massive ($Caco_{3)}$- Calcite	Limestone
Organically formed	Fossiliferos (Animal remains, Shells, Corals) Calcite	Shell Limestone or Coral Limestone
Sedimentary or Residual Deposits loosely cemented	Concretionary (Clay, Fe2O $_{AL2O3}$	Laterite

Classification of Metamorphic Rocks:

Metamorphic agencies		**Heat**	**Pressure (Stress)**	**Enormous heat and pressure together**
Mode of Formation (Process)		Thermal Metamorphic Rocks	Dynamic Metamorphic rock	Dynamo thermal or Regional Metamorphic rock
Non foliated	Recrystallisation-Granulose	Marble - Quartzite	_____	_____
Foliated	Reorientation Schistose	_____	Chlorite, Schist, Mica Schist	
Banded	Reorientation Gneissose	_____	_____	Gneiss Augen Gneiss

Mode of Origin

1) For Igneous Rocks

Mode of origin	**Acidic**	**Intermediate**	**Basic**	**Ultra basic**
Plutonic	Granite	Syenite Diorite	Gabbro	-------
Hypobyssal	← Pegmatite	Porphyries	→ Dolerite	---------
volcanic	Rhyolite	Trachyte, Andesite	Basalt	---------

(2) For Sedimentary Rocks:

Mode of Origin	**Examples**
1) Mechanical	Breccia. Conglomerate, Shale, Sand stone
2) Chemical	Limestone
3) Organic	Fossiliferos shale, Fossiliferos limestone

(3) For Metamorphic Rocks:

Mode of Origin	Examples
1) Dynamic Metamorphism	Slate, Schist, gneiss
2) Thermal Metamorphism	Marble
3) Dynamo thermal Metamorphism	Quartzite

Parent Rocks to the:

1) Slate, Schist → Shale
2) Marble → Limestone
3) Gneiss → Granite
4) Quartzite → Sandstone

2.10 DESCRIPTION OF IGNEOUS ROCKS:

(A) Description of Plutonic Igneous Rocks:

Properties	**Granite**	**Syenite**	**Diorite**	**Dunite**
Colour	Light colour with White pink tint	Light colour	Light colour	Olive green, yellowish Green, greenish yellow
Grain size	Medium to coarse	Medium to coarse	Medium to coarse	Fine to medium
Texture	Equigranular (E)	Equigranular	Equigranular	Equigranular
Minerals Present	Quartz, Feldspar Biotite, Hornblende	Feldspars, Biotite, Hornblende	Quartz, Feldspars, Hornblende, Biotite	Olivine altering to Serpentine, Chromite, Magnetite
Mode of origin	PAIR	PIIR	PIIR	PUIR
Engineering Uses	a) Granite is one of the most important building stones Specially used fordecoration, monumental and Architectural purposes b) Large blocks of granites are used as building stone c) Smaller blocks of granites are used as Railway ballast or Road metal.	a) Though Syenite is not so common, yet it can be used instead of granite. b) Presence of Feldspar shows beautiful blue and green effect which improves its appearance and hence is used for decorative purposes	Used as a building stone	Used for Ornamental purposes
Group	Igneous rock	Igneous rock	Igneous rock	Igneous rock

(B) Hypobyssal Igneous Rocks:

Properties	**Pegmatite**	**Porphyries**	**Dolerite**
Colour	Light colour (White, pink. Green)	Light colour	Usually dark Being almost black When fresh
Grain Size	Coarse	Medium to coarse	Medium to coarse
Texture	Pegmatitic	Porphyritic	Doleritic
Minerals Present	Feldspars, Quartz, Biotite	Because of Porphyritic texture. It may be Granite porphyry Syenite porphyry Diorite porphyry	Plagioclase. Augite and Hornblende with Some Olivine
Mode of Origin	HAIR	Hypobyssal	Hypobyssal, Basic igneous rock
Engineering Uses	a) The Muscovite mica is used commercially is obtained from pegmatite	----------	Occurs Chiefly in dykes Used as a Road metal
Group	Igneous rock	Igneous rock	Igneous rock

(C) Volcanic Igneous Rocks:

Properties	**Rhyolite**	**Trachyte**	**Pumice**	**Basalt**
Colour	Dirty White with Reddish brown Patches	Dark	Silver Gray when Fresh, Ash grayish White	Dark
Grain Size	Fine	Fine	Fine	Fine
Texture	Vesicular	Trachytic	Vesicular	Vesicular, Amygdaloidal
Minerals present	Same as granite	Same as Syenite	Same as granite	Plagioclase, Augite
Mode of origin	Volcanic Acidic Igneous rock	Volcanic Intermediate Igneous rock	Volcanic Igneous rock	Basic volcanic Igneous rock
Engineering Uses	Used as filler, Abrassive Polisher	--------	Light weight concrete, Tooth powder,	The crushed basalt is used as a road metal

NOTE: PAIR - Plutonic Acidic Igneous Rock.
HIIR - Hypobyssal Intermediate Igneous Rock
PIIR - Plutonic Intermediate Igneous Rock
BVIR- Basic volcanic igneous rock
PUIR-Plutonic ultrabasic igneous rock

DESCRIPTION OF SEDIMENTARY ROCKS:

Properties	**Breccia**	**Conglomerate**	**Shale**	**Sand stone**	**Lime stone**
Color	Light color	Light color (chocolate)	Light (white, pink, black)	Light (red, brown, pink)	Light
Grain size	Rudaceous	Rudaceous	Argillaceous	Arenaceous	Argillaceous
Minerals present	Angular pebbles	Rounded pebbles	Compaction of mud and clay	Quartz, feldspars	Calcite
Cementing material	Siliceous (much quantity quartz)	Ferruginous (because red or brown color)	Siliceous Ferruginous Calcareous	Siliceous Ferruginous Calcareous	Siliceous Ferruginous Calcareous
Mode of origin	Mechanical	Mechanical	Mechanical	Mechanical	Chemical, Organic, Fossiliferous Limestone.
Engineering uses.	a) Used as a building stone b) Used for ornamental purposes	Harder and tougher varieties of conglomerates used as foundation, concrete and railway ballasts.	Used for Bricks and Tile manufacture.	a) Siliceous and ferruginous sand stone are used as a building stone b) Calcareous sand stones are not used as a building stone	**Note:** Depending on the colour of Limestone. The varieties are classified as, 1]Siliceous limestone [Rich in quartz] 2]Ferruginous limestone [Red or brown colour. 3]Calcareous limestone [White colour] Limestone is used in cement industry.

DESCRIPTION OF METAMORPHIC ROCKS:

Properties	Slate	Schist	Marble	Gneiss	Quartzite
Color	Bluish black	Dark	White, gray, red, blue, green and yellow	Alternate layers of dark and light	Light
Structure	Slaty	Schistose	Saccharoidal	Gneissose	Granulose
Minerals present	Very fine grained mixture of quartz, chlorite, Sericite and feldspar.	Flaky minerals such as muscovite, biotite hornblende, chlorite, talc etc. Depending upon the type of flaky mineral present the schist's are described.	Calcite, quartz.	Quartz, feldspar, Biotite, hornblende.	Quartz small amount of mica, tourmaline, graphite and iron minerals
Mode of origin	Dynamic metamorphism Shale (SR) DM ⟶ Slate (MR)	Dynamic metamorphism Shale (SR) DM ⟶ Schist (MR)	Thermal metamorphism Lime stone (SR) TM ⟶ Marble (MR)	Dynamic metamorphism Granite (IR) DM ⟶ Gneiss (MR)	Dynamo thermal metamorphism Sand stone (SR) DTM ⟶ Quartzite (MR)
Engineering uses	<u>Used for</u> a) Flooring Purposes b) For Roofing Materials c) Table tops d) Staircases e) Switch Boards f) It is seldom used as building Stone.	Schist being weak rock, are not use d for important works	a) Coarse grained marbles used for historical, monumental and architectural purposes. b) Extensively used as a building stone for the decoration of columns, stair cases, floors etc. (c) Fine-grained marble used for statues.	Used as a road metal and concrete aggregates	Extensively used as a road metal and concrete aggregates

Rocks:

Format

Describe the Geological properties, uses, and group and identify the rock specimens kept in tray no 6 to 10. (5x4) 20 Marks

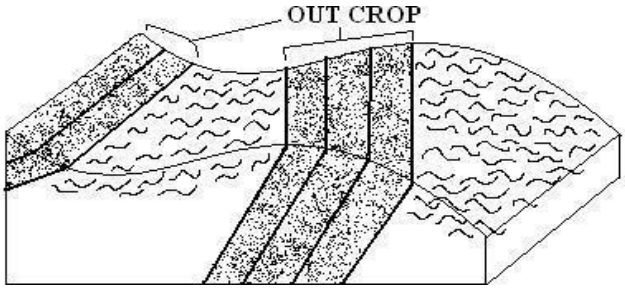
SL.NO	
Specimen NO	
Colour	Leucocratic-Light colour-Felsic Melanocratic-Mafic-Dark colour
Grain Size	Coarse-Grain size is >5mn diameter Medium-Grain size is >mm in diameter Fine-Grain size is < 1mm in diameter
Texture/ Structure	Texture is the mutual relationship among the minerals present in a roc The terms used are - Equigranular, Porphyritic, Pegmatitic, Ophiolitic, Trachytic, Vesicular, and Amygdaloidal
Minerals Present	
Name	
Mode of origin	
Engineering Uses	
Group	

Chapter – 3
Structural Geology Problems

Introduction:

Structural Geology is a branch of Geology deals with the structural deformation undergone by the rocks of the Earth's crust. The structures exhibited by the rocks are developed as the result of internal/external forces (lateral pressure or stress)

Structural Geology is important in Civil Engineering, because the different engineering operations like bridges, tunnels, dams etc., can be built successfully only on a proper foundation for which rock structures must be thoroughly studied.



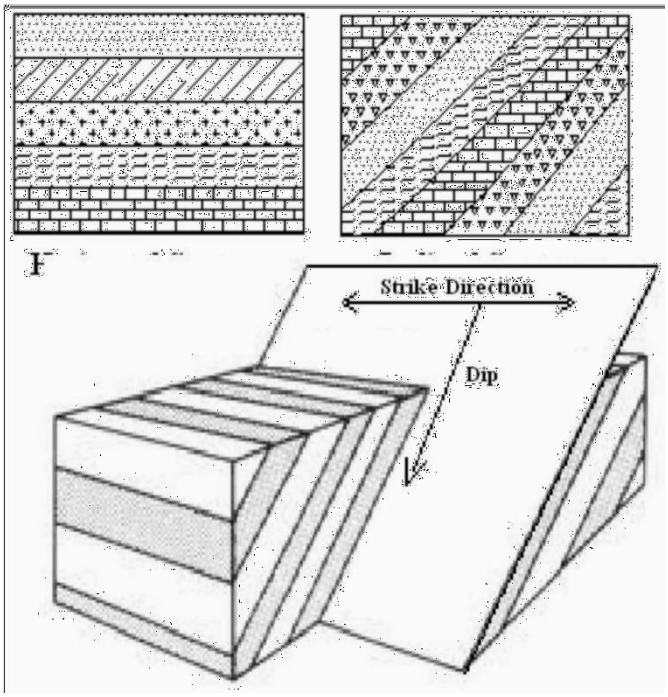
SOME BASIC TERMS

Outcrop

Solid rock is not exposed everywhere on the surface; a thin or thick layer of alluvium or soil often covers it. In certain regions alluvium or soil may be spread for thousands of square kilometer and the bed may not be visible anywhere. In other areas, however, exposures of rocks may be easily seen forming sides of valleys or caps of the hills or even flatlands in fields. An outcrop is the exposure of a solid rock on the surface of the earth.

Bedding

Most sedimentary rocks are deposited under conditions, which favor development of distinct layers form bottom to top. These layers are often easily distinguished on the basis of variation in color, composition and grain size. As it is sedimentary rocks are the most widespread on the surface of the earth, forming more than 75 percent of all the rocks exposed. This layered character; called Stratification or Bedding is, therefore, of fundamental significance in the study of structural features of sedimentary rocks.



Dip and Strike

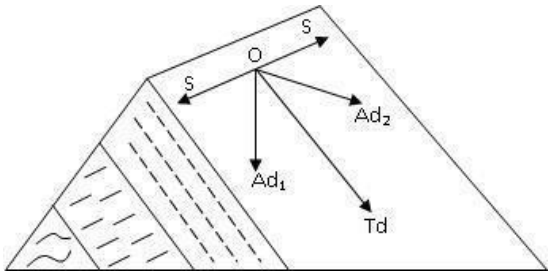
These are two definite quantities by which the position or attitude of a body of rock, especially stratified, is expressed.

Strike: - It is a geographic direction of extension of the layers of rocks and may be explained as the direction of intersection of the bedding plane with a horizontal plane.(SOS)

Dip: - It is defined as the maximum angle of slope of a bed or layer of rock with the horizontal. It is expressed both in terms of degree of inclination and direction of inclination. The amount of dip is the angle between the bedding plane and a horizontal plane.

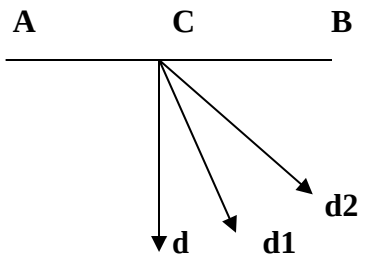
A) **True dip (Td):** The maximum inclination of the strata from the horizontal plane. The inclination of the strata is maximum only in a direction exactly at right angles to the direction of the strike of the strata.

B) **Apparent dip (Ad):** The inclination of the strata in any other direction between the strike and the true dip on either side of the true dip direction. (Note: Td is always greater than Ad)



3.1. DIP AND STRIKE PROBLEMS:

Dip: It is the angle of inclination of a rock bed with the horizontal plane**.**



AB = Strike
Cd = True dip
Cd1**,** Cd2 = Apparent dip

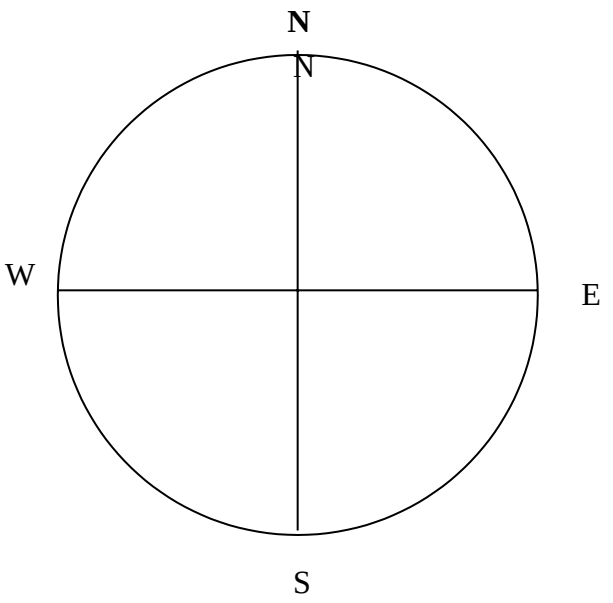
Fig.3.1 Showing Dip and Strike

True dip**:** It is measured at right angles to the strike.
Apparent dip**:** If the angle is measured in any other direction as along Cd1, or Cd2 in the figure, it will have a value less than true dip. Such partial dip angles are called "Apparent dips".

STRIKE: It is the direction of a line formed by the direction of the plane of a bed the horizontal plane. The strike is always at right angles to the true dip**.**

Task: Dip and Strike Problems		
1**.Method** Determination of True Dip Direction [TDD] and True Dip Amount [TDA] ADA = ADD= ADA= ADD= TDD=? TDA=?	**II. Method** Determination of Apparent dip Amount [ADA] TDA= TDD= ADA=? ADD=	**III. Method** Determination of Apparent Dip Direction [ADD] TDA = TDD= ADA = A DD=?

1



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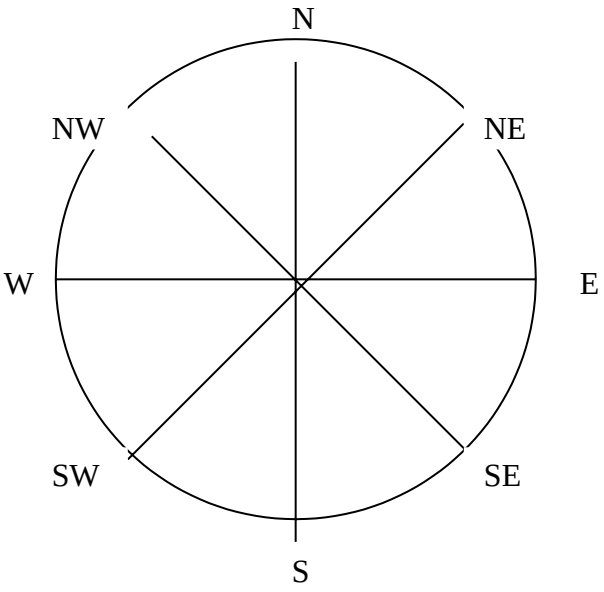

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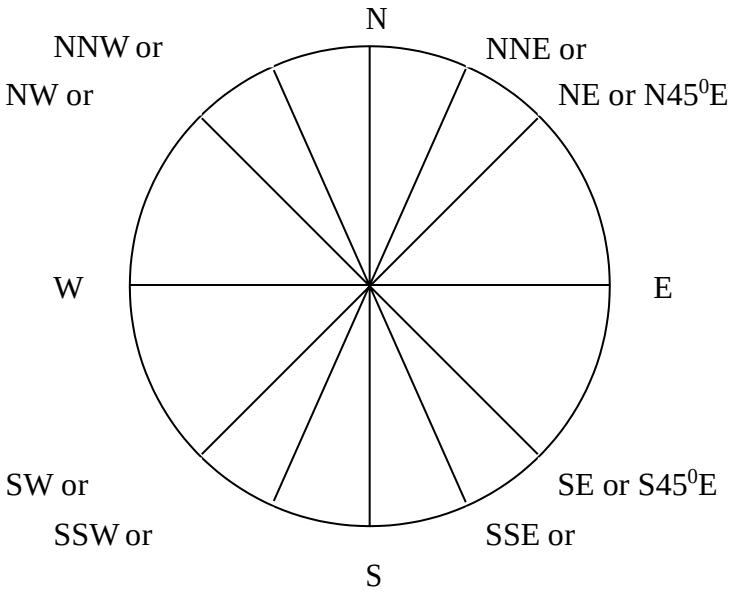


DUE NORTH = North is the direction. Similarly Duesouth.Due east. Due west.
Fig.3.2

1.METHOD: Determination of True Dip Direction [TDD] And True Dip Amount

Problem: A bed of sandstone dips at an angle of 30^0 in a direction of $S30^0E$ and 30^0 along $S15^0W$. Find the amount of true dip.

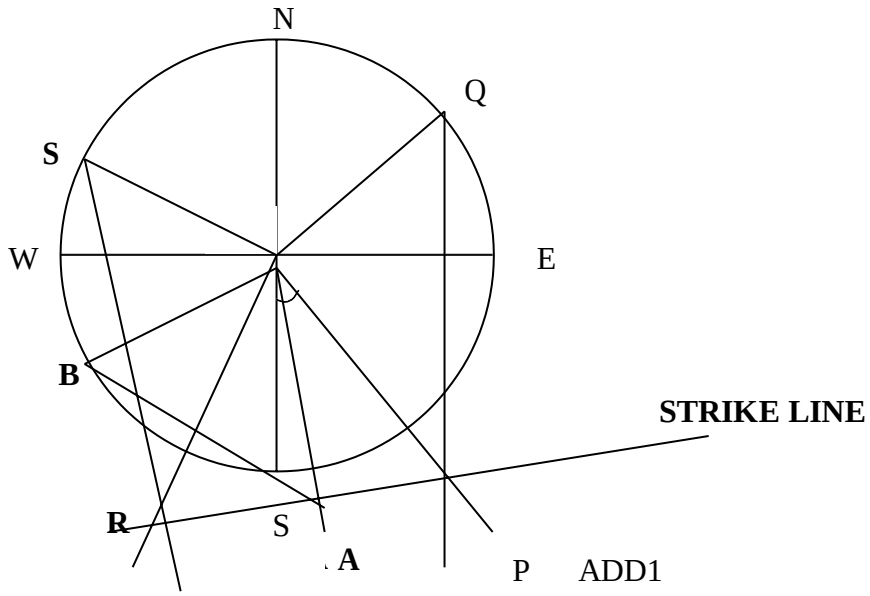


Fig.3.3

Procedure:

1] Draw a Circle by convenient radius and mark N.S.E.W.directions with O as centre.
2] Draw the line OP=S30°E & OR=S15°W.
3] Draw a perpendicular line Op frompfrom point O, which cuts the circle at Q. Now at Q draw a complementary angle [90° - 30°=60°] that cuts the line OP at point P Join PQ.
4] Similarly draw a perpendicular to the line OR from point O, which cuts the circle atS.draw a complementary angle [90° - 30° =60°] which cuts the line OR at point R. Join RS.
5] Now join the points P and R, which is the strike direction.
6] For finding amount of true dip draw a perpendicular from to the linePR which meets the line PR at A join OA.Draw a perpendicular to the line OA from point O, which cuts the circle at B. Join AB. Now angle OAB will give the amount of true dip. And OA is the direction of true dip.

Result-True Dip Amount (TDA)= 30^0
True Dip Direction (TDD) = $S8^0E$

Exercise:

1) The apparent dip of a coal bed is 30^0in a direction of S 30^0E and in a direction of S 58^0W with an apparent dip of 45^0.Find the direction and amount of true dip.

Result - TDA= OAB=49^0
TDD= OA= $S8^0E$

2) A Limestone bed dips 30^0 along $S25^0E$ and dips 33^0 along $N85^0E$. Determine its True Dip.

Result- TDA=OAB=36^0
TDD=OA=$N8^0E$

3) In a dam site a bed of limestone dips 25^0 along N E and 20^0 along NNE Determine its True dip.

Result- TDA= OAB=36^0

TDD=OA=N6^0E

4) A Coal bed dips 30^0 along S30^0W and 38^0 along N60^0W. Determine its True dip.
Result-- TDA=OAB=42^0
TDD=OA=S85^0W

5) At a Dam site a bed of Quartzite dips 28^0 along N20^0E and 34^0 alongS80^0E. Determine its true dip.
Result-- TDA=OAB=38^0
TDD=OA=N68^0E

II Method: Determination of Apparent Dip Amount [ADA]

PROBLEM—Coal seam dips 35^0along S40^0W. Determine the amount of apparent dip in the direction of S 75^0W.

TD.A= 35^0 T.DD=S40 ^{0}W
ADA=? ADD=S75^0W

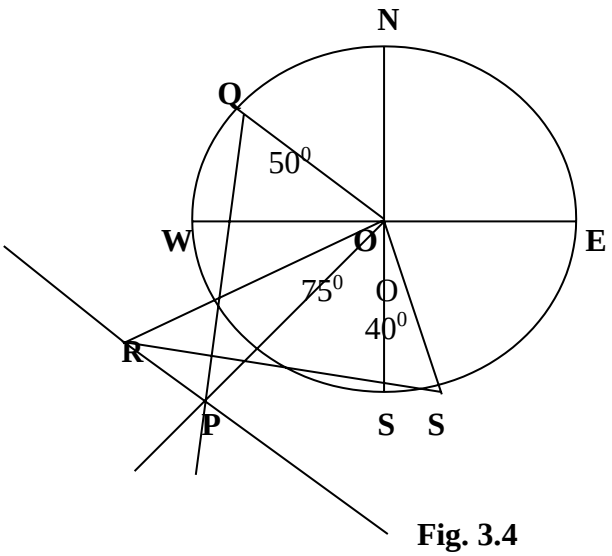


Fig. 3.4

Procedure

1. Draw a circle by convenient radius and mark N.S.E.W. directions with O as centre.
1. Draw a line OP=S40^0 W Draw a perpendicular to the line OP from point O which cuts the circle at Q. Now at Q D raw a complementary angle $90^0 - 35^0=55^0$ which cuts the line OP at point P. Join PQ.
2. From the intersection point P draw a parallel line to the line OQ that is the strike line.
3. Let a line equal to S75^0W which cuts the strike line at point R. join OR – 0R Line.
4. Draw a perpendicular to the line OR from point O, which cuts the circle at S. Join R and S. Measure angle ORS, which is the amount of apparent dip.

Note: ORS should be less than the true dip. Amount given in the problem**.**

Result: ADA alongN70^0W =ORS=30^0

Exercise:

1) Abed of Sandstone dips 40°along east. Determine the amount of dip along N60°E and SE.
   Result--- Apparent dip Amount along SE=3^0
   Apparent dip Amount along$N60^0E=32^0$

2) Abed of Sandstone dips 40^0 along $N60^0$East. Determine the amount of APPARENT dip along $S80^0E$ and $N27.5^0E$
   Result=Apparent dip along$S80^0E=32^0$
   Apparent dip along $N27.5^0E=36^0$

3) A Coal seam is exposed around a colliery. It shows a true dip of 48^0 along $S30^0W$.Determine the amount of inclination along $S10^0E$ and $S60^0W$
   Result=Apparent dip along $S10^0E=40^0$
   Apparent dip along $S60^0W=43^0$

4) In a reservoir site a bed of Quartzite has maximum inclination of 40^0 along $N40^0W$. Find its inclination along North and $N60^0W$.
   Result: Apparent dip along North=23^0
   Apparent dip along $N60^0W=43^0$

III Method: Determination of Apparent Dip Directions- (ADD)

PROBLEM: Coal seam dips 45^0 along S30-^{0}- w. Two inclined tunnels are proposed to have a dip of 28^0. Determine the directions of tunnels. (One direction of apparent dip).

TDA=45 ^{0} TDD=$S30^0$ W
ADA=28^0 ADD=?

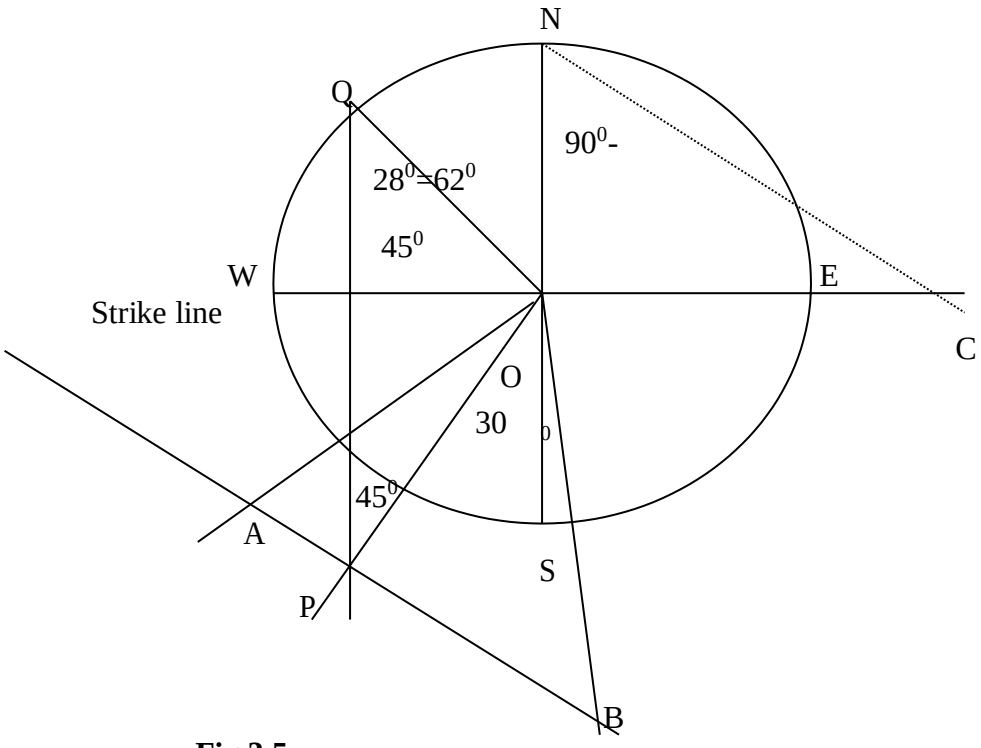


Fig.3.5

Procedure: Point 1, 2 and 3 Similar to the Second method.

4) Select any arbitrary line (Direction) says from north. From point N draw a complementary angle $90^0 - 28^0 = 62^0$ that cuts the East line at point. Now with O as centre OC as radius draw two arcs so that it cuts the Strike line on both the directions at points AB respectively. Join OA and OB.

Note: OA and OB are the directions of apparent dip.

Result= ADD_1, OA=$S30^0E$ ADD_2, OB=$S35^0W$

Exercise:

1) A bed of Shale is found to have a true dip of 45^0 in the direction of N 80^0 E. find the direction along which the bed will have an apparent dip of 36^0.
   Result=ADD1, OA=$N50^0E$ ADD2, OB=$S34^0E$

2) A coal seam dips 45^0 along S 50^0 W. Two inclined tunnels are Proposed to have a dip of 28^0, Determine the direction of tunnels..
   Result=ADD1, OA=28^0 along$S85^0W$
   ADD2, OB=28^0 along$S33^0W$

Chapter-4

BOREHOLE PROBLEMS

(Horizontal Level Ground)

In order to determine the subsurface geology of an area, boreholes are sunk at convenient places in areas such as cultivated lands, forests deserts, alluvium, etc. The surface is completely covered and the outcrops are very few. Such boreholes reveal the presence of economic deposits of coal, petroleum etc. The subsurface geological formations, rock types and their dip and strike can be determined from such borehole data, Which render very valuable information for plans to exploit the hidden treasures.

Bore holes Sunk on Horizontal Ground

Example: Three boreholes are sunk at 3 points of an equilateral triangle whose sides are 480 m each. P is West of Q and R is North of midpoint PQ. Boreholes and R- reach the upper surface of a rich coal seam at 100m, 220m, and 260m depths respectively.

a) Determine the attitude (Dip and strike) of the coal seam.
b) Another borehole is sunk at S, Midpoint of QR. Determine at what depth the borehole S reaches the coal seam

<u>Depth Diagram (Not to Scale):</u>

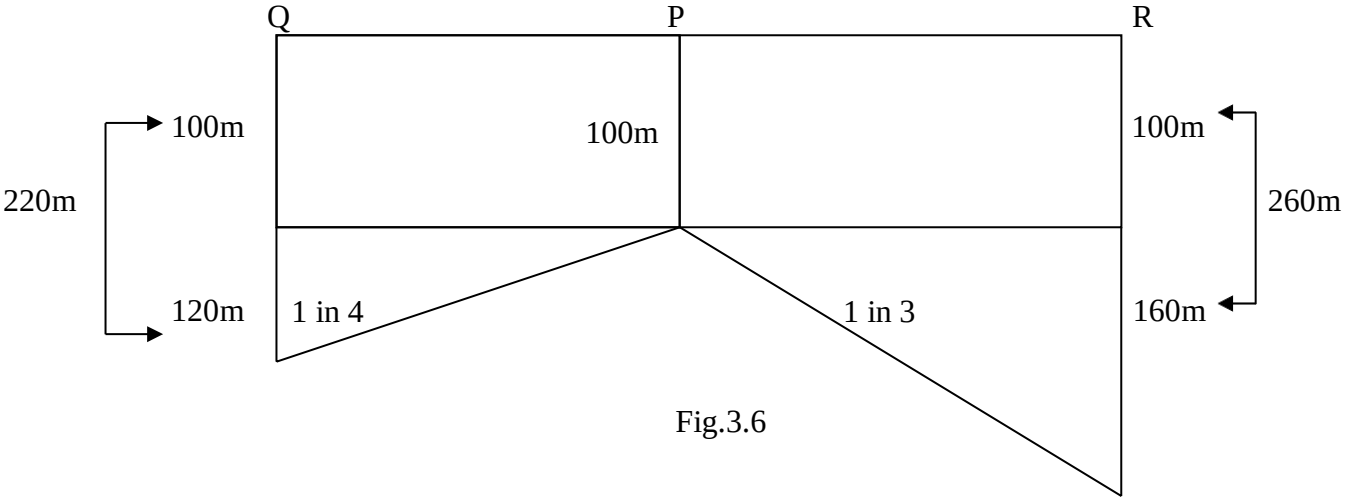


Fig.3.6

Gradient of PQ: 120 / 480=1 in 4
Gradient of PR: 160 / 480 = 1 in 3

Procedure: Construct an equilateral triangle with a suitable scale; Show the positions of the boreholes. The coal seam is reached at point P and Q at 100m and 220m. So the coal seam dips from p to Q. To determine the inclination (gradient) along PQ construct trough sketch depth diagram and determine the gradient It is 120m in 480m. So it is 1 in 4. Similarly construct the depth diagram along PR. It is 160m in 480m i.e. 1 in 3.Take convenient scale and mark 4 units (CMS) along P Q and 3 units (CMS) along P R from P. They are A and B. Join AB and extend. It is the true strike direction (TSD).

Draw a perpendicular to AB from P. It cuts AB at C. Measure PC. it is 2.85 CMS i.e. the gradient is 1 in 2.85. It is true dip.

To determine the direction of true dip, measures the angle CPQ=45^0 .So direction of true dip is the complementary angle from North direction. So (90^0-45^0) 45^0 . So it is N 45^0 E or NE.

True dip 1 In 2.85 along NE.
Strike = SE and NW.

To determine the depth at which the borehole S reaches the coal seam, Join PS it intersects AB line (true strike direction) at T. Measure PT with units selected it is 3 CMS. So the gradient along PT is 1IN 3. Measure PS it is 4.2cms =420m.

Depth Horizontal distance PS X Gradient + Depth of borehole at P
= 420 x 1/3 + 100
=140 + 100 =2
To check whether this calculation is correct or not, let us find out the gradient of coal seam along QR.
Draw depth diagram.
The Gradient is 1 in 12 from Q QS is 240m.

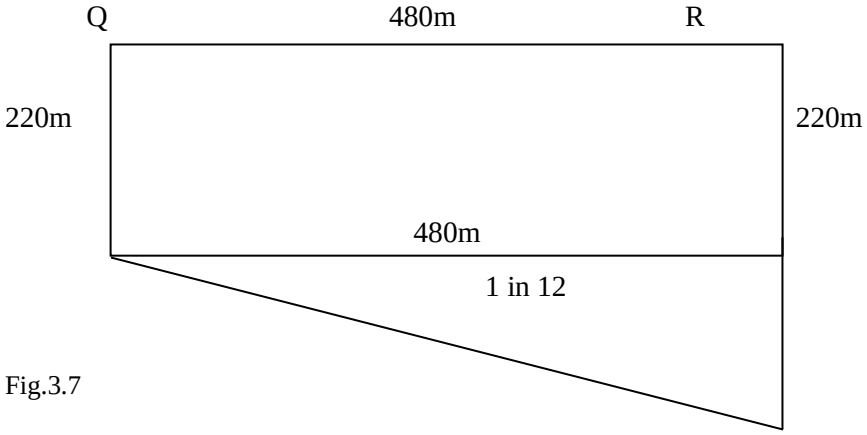


Fig.3.7

Depth= (Horizontal distance X Gradient) + Depth of Borehole Q
= 240 X1/ 12 + 220
= 20 + 220 = 240m

Scale 1CM = 100M
Gradient 1cm = 1unit.

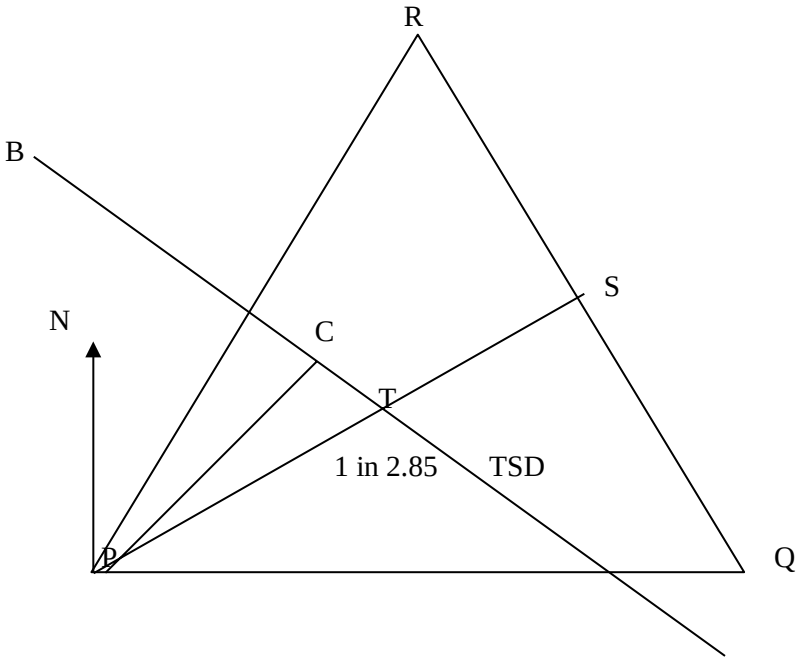


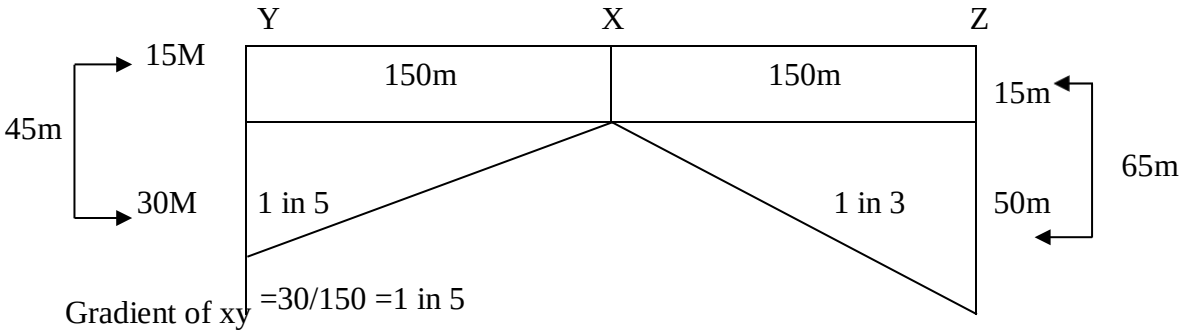
Fig.3.8

2) Three boreholes are sunk at SW, SE, and NW Corners0f Square level ground The Sides of the Square is 150m long. The boreholes are X, Y, Z respectively. The boreholes meet the Coal seam at 15m,in X, 45m in Y, and 60m in Z.

a) Determine the attitude of the coal seam.

b) Fourth borehole is pr0p0sed at P, the NE Corner of the square land. Calculate at what depth, the borehole encounters the coal seam.

Depth Diagram (Not to Scale):



Gradient of xy =30/150 =1 in 5

Gradient of xz = 50/150 = 1 in 3

Fig.3.9

-

Scale 1cm =30m

Gradient Scale 1cm = 1 unit

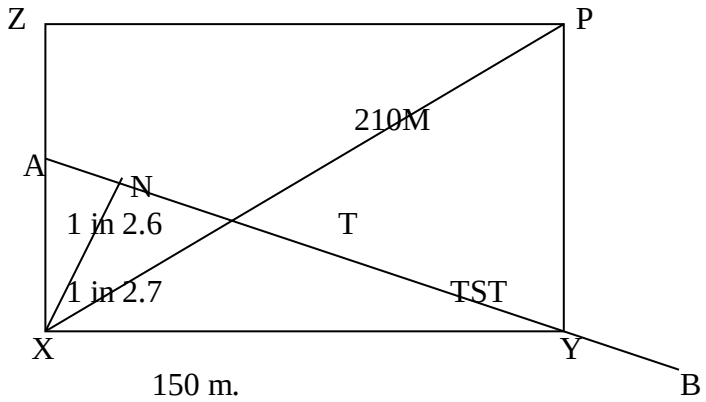


Fig.3.10

True depth = 1 in 2.55 along North 30^0E

Strike = N60^0W and S60^0E

Depth of unknown point P = Horizontal distance X Gradient + depth of borehole at Minimum depth

= 216 x 1/ 2.7 + 15

= 80 + 15 = 95m

EXCERCISE:

1) Three boreholes are sunk at PQR, which lie at the corners of an equilateral triangle on a level ground. The sides of the triangle are 240m. Is situated west of R. AND Is North of midpoint of QR. A Coal seam is met at 30m. at P, 70m at Q And 90m at R.
    a) Determine the true dip and strike of coal seam.
    b) A borehole is proposed at S, the midpoint of QR. Calculate at what depth the proposed borehole reaches the coal seam.

(Answer- True dip 1 in 4,05 along $S17^0$ E
Strike S 73^0 W and N 73^0 E
Depth at borehole S is 80m)

2) Four boreholes are proposed at A, B, C.D at comers of a featureless square land. The sides of the square land are 360m long. A is West of B. and D is South of B. A coal seam is encountered in at 160m, in B at 60m and in D at 240m.
    a) Determine the attitude of the coal seam.
    b) Another borehole is proposed at C. Calculate at what depth it reaches the coal seam.

Answer: True dip 1 in 1,65 along $S35^0$ w
Strike S 55^0 E and N 55^0 W
Depth at bore hole C=360m)

3) Three boreholes are sunk at the corners of an Isosceles triangle. The baseAB is east west 400m. A is west of B. C bore hole is 500m from A and B. and North of midpoint AB. The boreholes touch the oil-bearing stratum in A at 30m, in B 80m and C 130m.
a) Determine the attitude of the oil-bearing stratum.
b) Another borehole is proposed at midpoint of BC. Calculate at what depth the same oil bearing stratum is met.

Answer-(a) True dip 1 in 4.8 along N 23^0 E
(b) Strike N 67^0 W and S 67^0 E
(c) Depth at midpoint BC= 105m.)

4) Boreholes are sunk at the corners of a scalene triangle 0n a featureless ground. AB is 500m, BC is 600m and AC is 400m.B is West of C and A is on the Northern side of BC. The boreholes A, B and C meet a coal seam at 150m, 350m and 250m respectively.
a) Determine the true dip and strike of the coal seam.
b) A bore hole is proposed on BC line due south of A. Calculate at what depth the same coal seam is met in the proposed borehole.

Answer- a) True dip 1 in 2.25 along $S23^0$ W
b) Strike $S67^0$ E and $N67^0$ W
c) Depth in proposed bore hole 285m

4) Three boreholes are sunk at 3 points A B C of an Equilateral triangle whose sides are 600m each. B is west of C and A is North of midpoint of BC. Bore holes ABC reach the coal seam at 20m, 50m and 60m depth respectively.
    a) The attitude of the coal seam.
    b) Another borehole is at D at a distance of 1000m from A. Determine at what depth the borehole D reaches the coal seam.

Answer: Depth in proposed borehole is 89m.-

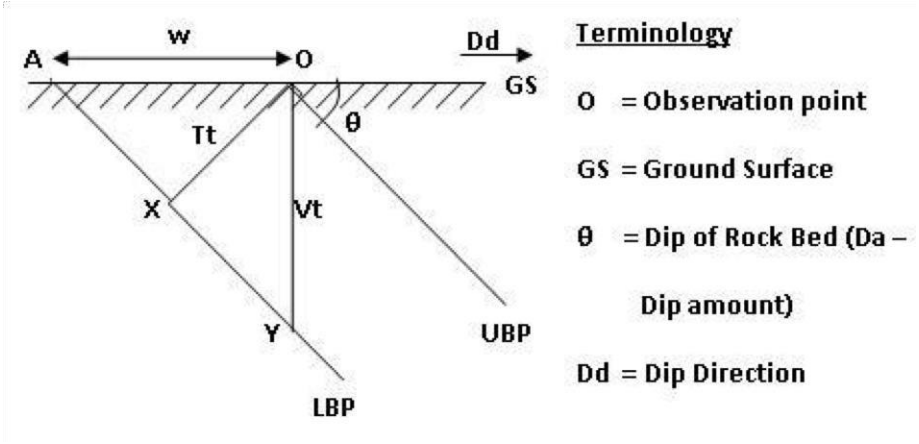
Chapter-5

Thickness Problems

INTRODUCTION

It is often becomes necessary to determine the thickness of rock beds in cases like excavations, quarrying, support and lining of sections of tunnels and canals and for Stabilizing rocky slopes.

Thickness of bed is measured perpendicular to the bedding planes. This is called the **True thickness (Tt)**. Thickness measured vertically downwards between the bedding planes in case of inclined and folded beds is called the **Vertical thickness (Vt).** The beds may be exposed at the surface, so that their thickness is measured directly by a measurement tape. Commonly in most cases, however, direct measurements may not be possible. In such cases, the thickness is worked out from the data obtained from a geological map or field measurement of other parameters such as dip, width of outcrop and nature of the ground surface by drawing the geological sketch graphically to scale and it is called **Graphical method** or calculated with the help of trigonometric expressions called **Mathematical method.**



Note: There may be a slight variation in the answers of the two methods.

From the above figure, True thickness (**Tt**), Vertical thickness (**Vt**), width of the outcrop (**woc**), Dip direction (**Dd**) and Dip amount (**Da**) are interrelated. When some parameters of them are known, the others can be determined by mathematical as well as graphical methods.

The following equations are generally used in mathematical methods.

1. **Tt= W** x **sin θ**
2. **Vt= W** x **tan θ**
3. **Tt= Vt** x **cos θ**

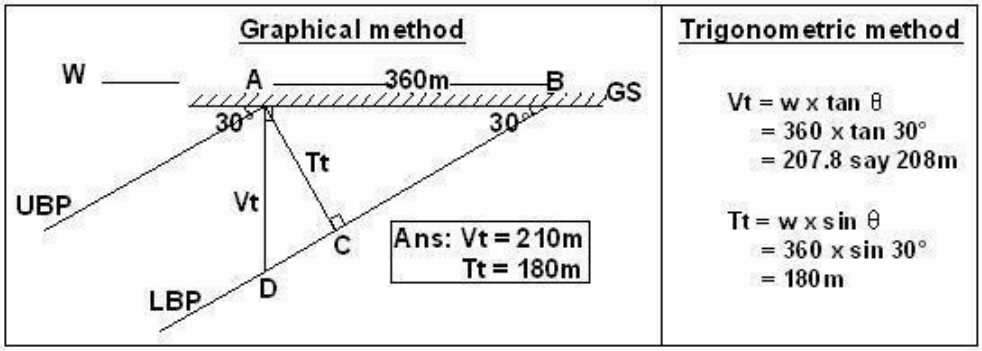
In graphical methods, figures are drawn to a convenient scale to obtain solutions.

On Level Ground

Problem type1: Data given : WOC, DA & DD to determine: TT & VT

1: A coal seam is exposed on horizontal ground. It dips 30^0 towards west. Its width of outcrop is 360m. Determine its true thickness and vertical thickness. (Scale: 1cm= 100 m).

Procedure: Draw a horizontal line. Measure and mark **AB** equal to width of outcrop given. Construct 30^0 angle of **UBP** & **LBP** towards west at **A** and **B** respectively. Draw a perpendicular at **A** to the **LBP** which intersects at **C**. Measure **AC**, it is the True thickness(**Tt**) (From fig, 180m). Draw a perpendicular to **AB** downwards from **A**. It cuts the **LBP** at **D**. Measure **AD**, which is the vertical thickness (**Vt**) (from fig, 210m).

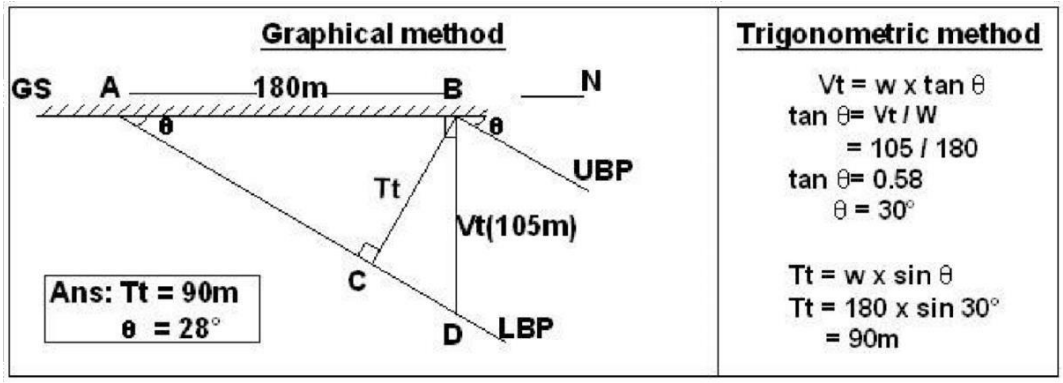


Result:

The True thickness of coal seam, **Tt** = 179m The Vertical thickness of coal seam, **Vt** = 206m

Problem Type 2: Data given: Vt, Woc & Da To determine: Tt, Da

2: A coal seam is exposed on a level ground. It dips towards North. Its width of the outcrop is 180m. A bore hole sunk from its upper bedding plane touches the lower bedding plane at a depth of 105m. Determine its true thickness and amount of inclination. (Scale: 1 cm= 50m)



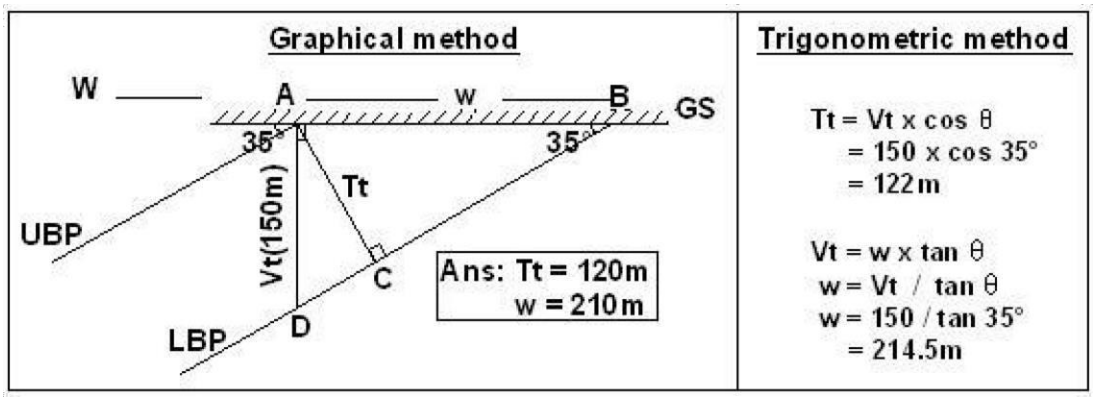
Result:

The True thickness of coal seam, **Tt** = 91m

The amount of inclination (**θ**) of coal seam = 30^0

Problem Type 3:**Data given : Vt, Da & Dd To determine: Tt & w**

3. A vertical bore hole sunk from the upper bedding plane of a shale bed reaches the lower bedding plane at a depth of 150m. It dips 35^0 towards west. Determine its true thickness and width of the outcrop on level ground. (Scale: 1cm = 50m)

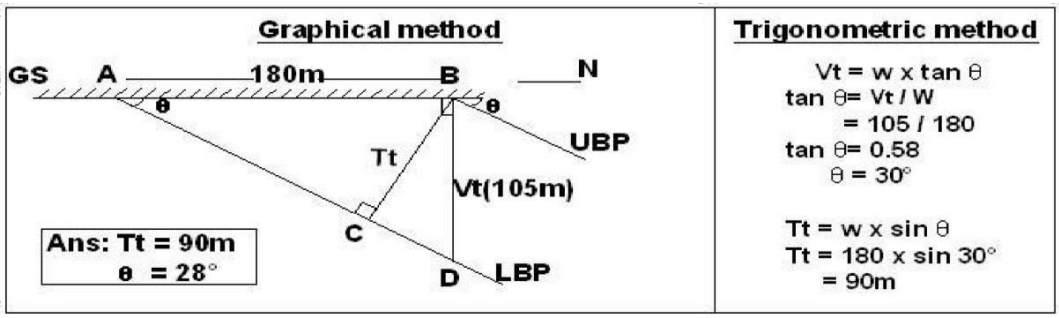


Result:

The True thickness of shale bed, **Tt** = 123m The width of the outcrop on level ground, **w** = 217m

Problem Type 4 :Data given: Tt, Da & Dd To determine : Vt & w

4: On a horizontal tunnel, a bed of sandstone dips 30^0 eastward. Its true thickness is 200m. Determine its vertical thickness and width if the out crop in the tunnel. (Scale: 1cm=100m.)



Result:

The True thickness of sandstone bed, **Vt** = 232m The width of the outcrop in the tunnel, **woc** = 394m

Thickness of strata problems including calculation of vertical, true thickness and its width of out crop.	**4Marks**
Diagram	2
Result	2

EXPERMENT-6
Geomorphology
(interpretation of Toposheets)

INTRODUCTION

Toposheet -In modern mapping, a topographic map is a type of map characterized by large scale detail and quantitative representation of relief, usually using contour lines, but historically using a variety of methods. Traditional definitions require a topographic map to show both natural and man-made features. A topographic map is typically published as a map series, made up of two or more map sheets that combine to form the whole map. A contour line is a line connecting places of equal elevation

Problem 1
Take a Toposheet and select one geomorphology of an area start tracing on better paper later
Bifurcation ratio need to be done

Interpretation of Toposheet	**5Marks**
Trace	**3**
Calculation	**2**

Chapter – 8
Geological Maps

A Student of Geology should have a thorough knowledge in reading a geological map, interpreting the geological features of an area for a specific purpose.

Geological Map

A Geological map always represents the distribution and association of rock types, ores and other economic mineral deposits. The map is usually superimposed on a topographic map of an area.

Topographic Map

A topographic map indicates the ground features like hills, valleys, river courses, roads, railway lines, forests and desert area besides villages, towns, cities, lakes, wells, etc.

Map

Maps are representation of three-dimensional view on two dimensions. Thus the relief of the ground such as depressions and elevations is shown by

1. Shading- Different colours to indicate different altitude with reference to Mean sea level (MSL).
2. HACHURING- only one colour is employed and lines are drawn in the direction of the slope of the ground.
3. Contour: Lines joining all points of equal elevation with some constant intervals.

A contour is invariably in curved line passing through all points of equal altitudes. Each contour is numbered, indicating its positions above or below mean sea level (msl). The difference in height between any two consecutive contours is known as contour interval (ci). It is also known as VERTICAL INTERVAL (VI). The space between the contours is the horizontal distance on the ground in a particular scale. It is known as the Horizontal equivalency (HE). If the contour Interval (C.I,) and the Horizontal Equivalent (H.E) are available, the slope or the Gradient can be calculated.

$$\text{Slope} = \frac{\text{Contour interval}}{\text{Horizontal distance}} \quad \frac{\text{C.I.}}{\text{H.E.}} \quad =$$

When the contours are closely spaced the slope is STEEP, and when the contours are far apart the slope is GENTLE.

Contours remain horizontal and parallel to one another. As they represent different altitudes, they never intersect one another (but in exceptional cases) with the help of the contour; Profile can be drawn in required direction.

Profile

A Profile is a longitudinal section as seen from a side, which shows the rise and fall of the ground between any two points on a map. This is drawn on a Datum line between two end lines with a suitable scale. The height of such profile would be between 4cms and 6 cms.

There are few Geological maps without contours, but they are provided with spot heights or Trigonometrical heights.

Dip and Strike

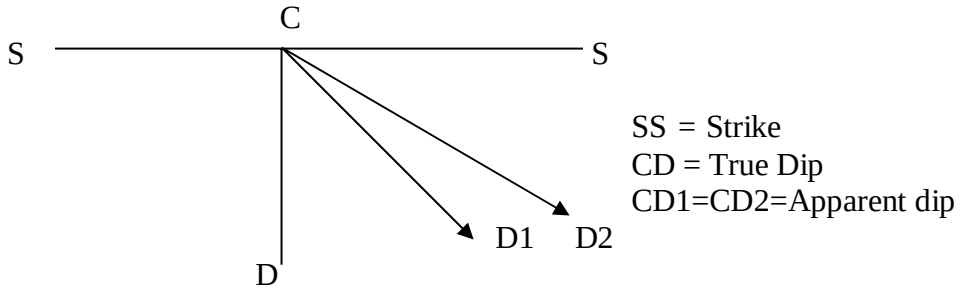


Fig.3.11

Dip and Strike: (Details given in dip and strike Problems)

Bed and a Bedding plane:

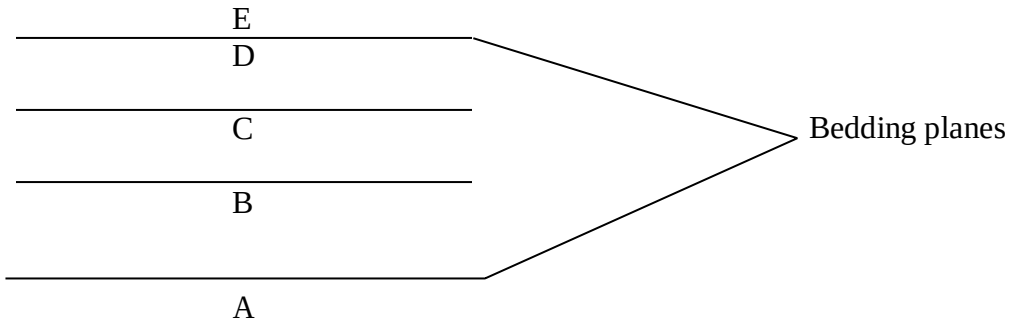


Fig.3.12

ABCDE = Beds

Bedding Planes: the planes, which are separating the different beds.

Folds: When the Sedimentary rocks are subjected to compress ional forces they tend to buckle up or down into a flexure called FOLD.

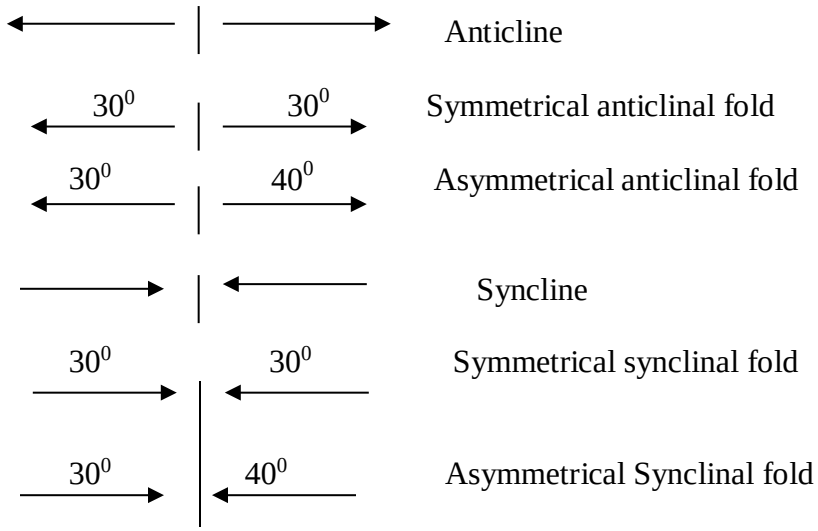


Fig.3.13

Faults: A fault is a dislocation of strata along a plane and the two blocks move in opposite directions- upwards and downwards- and they are called Up throw block and "Down throw" block accordingly.
Unconformities: Border between the two series of beds. Older series deposited at the bottom. Younger series at the top.
Dyke: Dyke is cutting the bedding planes.
Sill: Sill is running parallel to the bedding planes.
Batholith: Irregular shaped igneous intrusion with a narrow top and wide base.

Geological Map: It represents the way in which the rock beds would appear, if a section of the land surface is cut vertically along a certain line. Sections are useful for solving both Stratigraphic and structural problems.

Drawing a Geological Section: From the Geological map a section along a suitable line is constructed to show the geological information in a concise form. The procedure of drawing a section consists of three steps.

i) Drawing a topographic profile
ii) Determination of Dip and Strike of rocks
iii) Construction of Geological Structures

Drawing a topographic profile: Suppose it is required to draw a topographic profile along a X-Y Line on the geological map. The map is first folded along the X-Y Line on a drawing paper. A horizontal line equal to the X-Y Line is drawn, which serves as a base line. to the Geological sections to be made over this line. The folded map is placed and the positions of the various contour lines along X-Y Lines are marked. From these points vertical lines are drawn their length being proportional to the values of corresponding contours as per the scale of the map. Then a Free Hand Curve joins their tops.

Topographic Profile: The vertical lines drawn above the base line are not desired and therefore should be removed.

Determination of Dip and Strike

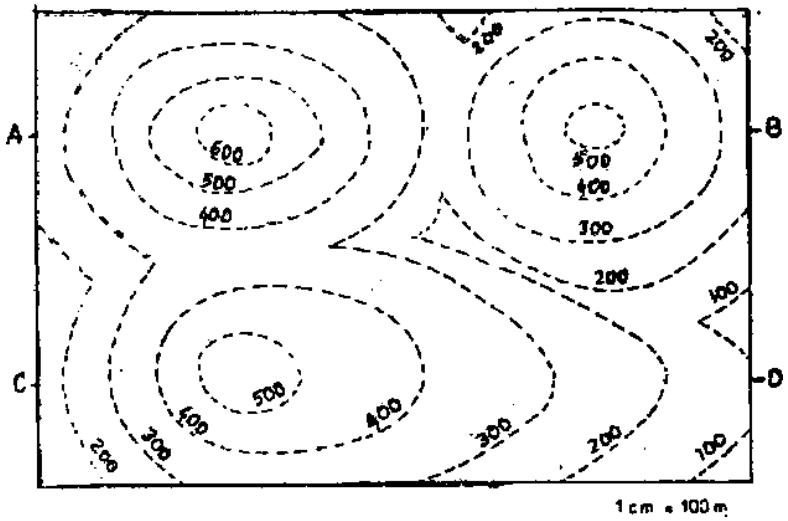
Generally on Geological maps both the contour lines as well as boundaries of rock beds are shown. To determine the dip of a rock bed by graphical method. Such a contour is selected which cuts the particular rock boundary at two points. A line called Strike line joins these two points. Two Strike lines from contours of different values are drawn for the same boundary. Then the distance between them along X-Y Line is measured. And a line having the same length is drawn on the drawing paper somewhere below the profile already made. From one end a perpendicular of length equal to the strike of interval is constructed as per the scale of the map. The angle formed by joining its top with the other end of the line will be the dip angle. And its directions will be from the strike line of higher value to the one that has the lower value. In this way dip of various rock beds shown on the map are determined.

Construction of Geological Structures: Now the map is folded along the X-Y Line and is placed over the base line of the profile. The points of intersection of the boundary lines between different beds and the X-Y Line are transferred. These points are then projected to the surface profile. From these points lines are drawn according to the Dip of the respective boundary surfaces. This is usually done by drawing angles of Dip first at the base line and then drawing parallel lines from the corresponding points at the surface profile. In the section thus constructed, the various structures present are completed as follows:

i) If Unconformity is present, an Undulating Line shows its plane.
ii) If a fold is present, Anticline or Synclinal structures are made accordingly.
iii) If a Fault is present, strata must be shown dislocated along it.
iv) Dykes are shown running vertically. Sills are shown running parallel to the bedding planes.

Exercise:

Map-1: **Contour Map**



Draw a Profile along A B and C D Describe the topography of the area

Note: 1) Use Centimeter graph sheets

2) Horizontal and Vertical Scales are the same

Map- 1: Contour Map

Geological History of the Area:

Topography:

Section along AB: The section along AB shows two hills and three valleys on either side of the hills as shown in graph-1. They have similar slopes on either sides and therefore they are called symmetrical h ills and symmetrical valleys.

Section along CD: The section along CD shows a single hill, It has a steep slope towards west and gentle slope towards East. It is an asymmetrical hill and valleys.

Inference

a) The contours are irregular lines, running almost parallel to one another.

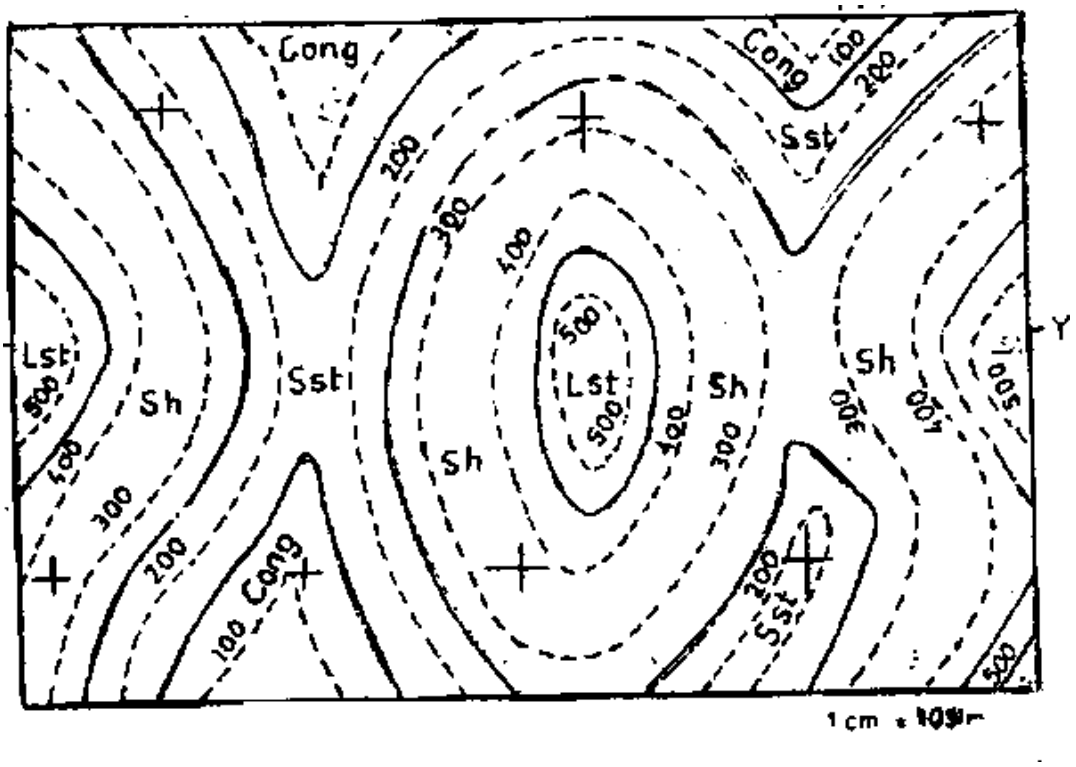
b) When contours of higher value are surrounded by the contours of lower value, it shows a hill feature on the contrary, when a contour of lower value is surrounded by the contours of higher value, it shows a valley features.

c) The contours are helpful in inferring the topography and flow direction of streams.

d) The contours are run at different altitudes, so they never intersect one another.

e) The contours are helpful for drawing the profile of an area along sectional line.

Map 2: Horizontal Strata



1) Draw a cross-section along XY and describe the geological history of the area
2) A dam is proposed outside the eastern border of the map. A horizontal diversion tunnel is planned to divert the river water at an invert level (floor) at 200m up to the western valley of the area. Discuss its feasibility.

Map 2: Horizontal Strata
Geological History of the Area:

1. **Topography:**

It is an undulatory terrain with a series of hillocks & valleys. The minimum and maximum altitude of the given area is of 100m and 500m.

2. **Geology of the area:**

a. Structural features: All the sedimentary rocks indicated in the map as well as in the cross section are deposited as horizontal beds, started by the deposition of sand Stone in the base and followed by Shale and Lime Stone. After certain period of time they were uplifted and exposed to the surface & affected by various geological agents leading to the formation of an undulatory terrain with series of hillocks and valleys.

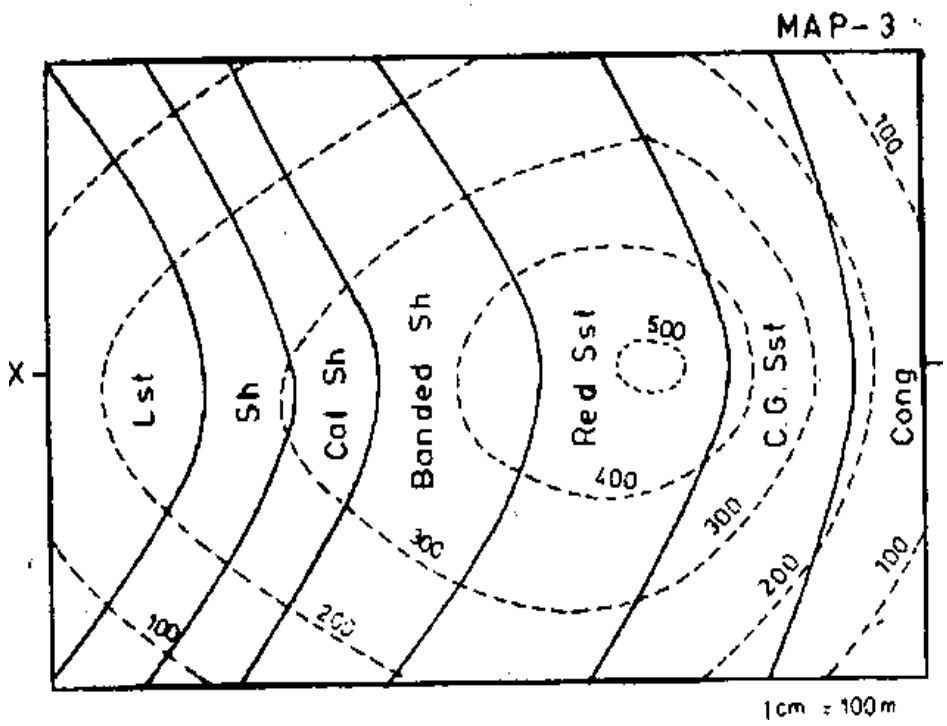
b. Order of Superposition:

Among the beds mentioned in the map & cross section, Sand Stone is the oldest and Lime Stone is the youngest beds. The thickness of the Shale bed is 200m.

3. **Tunnel Proposal:**

The proposed tunnel to divert the water from the proposed dam on the eastern side to the western valley is geologically feasible because it is passing through a single rock formation of Sand Stone.

Map-3: Inclined Strata



1) Draw a geological cross-section along XY and describe the geological history of the area.
2) Determine the Dip and Strike of the formations.
3) Find out the order of Superposition and Vertical thickness of beds
4) A horizontal tunnel is proposed at an altitude of 100m. Discuss its feasibility and suggest suitable precautionary measures.

Map No .3: Inclined Strata

Geological History of the Area:

1) **Topography** : It is a small hillock with gentle slope on the western side and steep slope on eastern side. The minimum and maximum altitude of the given area are 100m and 500m.

2) Geology of the Area

a) **Structural features :** All the beds shown in the cross-section were intially horizontal in nature. Due to various tectonic activities ,these beds were uplifted & tilted. After the upliftment they were affected by various geological agents leading into the formation of a small hillock. The Strike of the bed is parallel to …….The dip direction is towards……..and the dip amount is…..

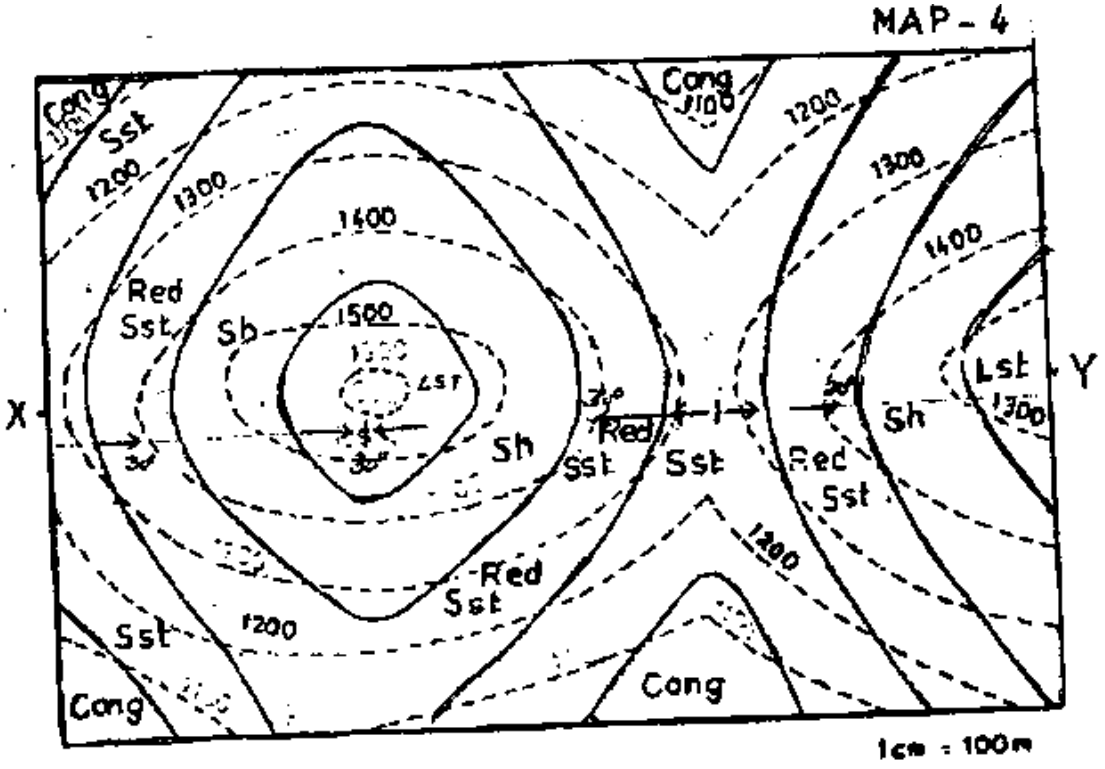
b) Order of Superposition

The oldest bed is Conglomerate followed by coarse grained Sand stone, Red Sand stone, Banded Shale, Calcareous Shale, Shale and the youngest is Lime stone. The thickness of the beds Sand stone=____m , Red Sand stone=____m, Banded Shale=____m, Calcareous Shale =____m, Shale=_m

3) Tunnel Proposal

The proposed tunnel is passing through different types of inclined sedimentary rocks and is not geological feasible.

Map-4: Folded Strata



1) Draw a geological cross-section along XY and describe the geological history of the area
2) Determine Dip and Strike, order of Superposition and thickness of the strata.

Map No.4: Folded Strata

Geological History of the Area :

1) Topography

It is an undulatory terrain with hillocks & valley. The minimum and maximum altitude of the given area is of 1100m and 1600m.

2) Geology of the area

a) Structrual features : The beds indicated in the cross section were intially formed as horizontal beds. Due to earth's dynamic activities, these beds were uplifted and folded, forming into anticlinical & synelinal beds. Later they were affected by various geological process leading to the formation of an undualatory terrain. The strike direction is parallel to .....The dip amount is ……

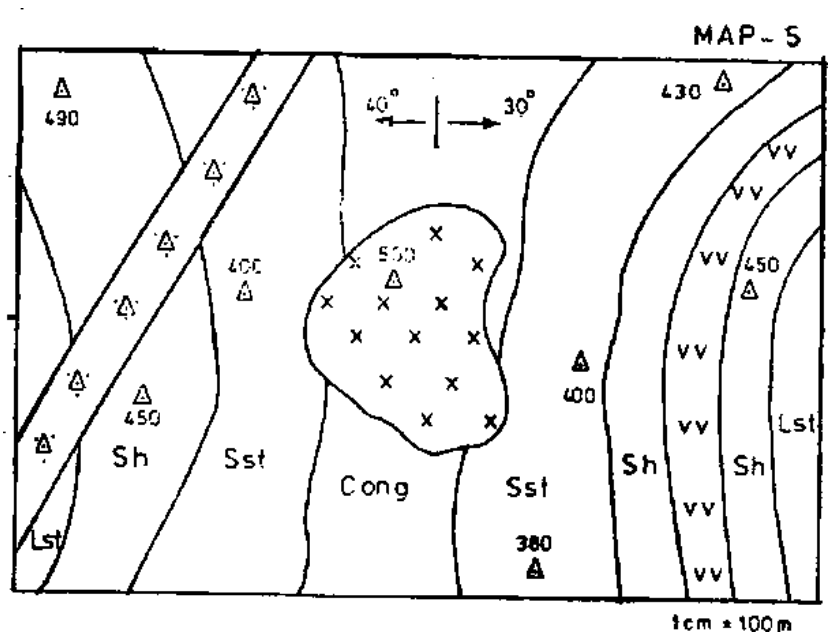
b) Order of Superposition

Conglomerate is oldest bed followed by Sand Stone, Red Sand Stone, Shale and Lime stone is youngest. The thickness of Sand Stone=….m, Red Sand Stone=…m, Shale=….m.

3) Tunnel Proposal

The tunnel proposed is passing through anticlinal & synclinal beds, in addition, at certain position the floor of the valleys is very close to the proposed tunnel site, so it is not geologically feasible.

Map-5: Igneous Intrusions



1) Draw a geological cross-section along XY and describe the geological history of the area.

Map No.5: Igneous Intrusions
Geological History of the Area :

1) Topography

It is an irregular land surface. The minimum and maximum altitude of the given area is 380m and 500m.

2) Geology of the Area

a) Structural features The sedimentary beds which have been shown as inclined beds in the cross section were initially horizontal in nature. Due to various tectomic activities they were uplifted; during up liftment the beds were tilted followed by magmatic intrusions. The magmatic intrusions are of two types : Disordant (Dike and Batholitts) & Cordant (sill).

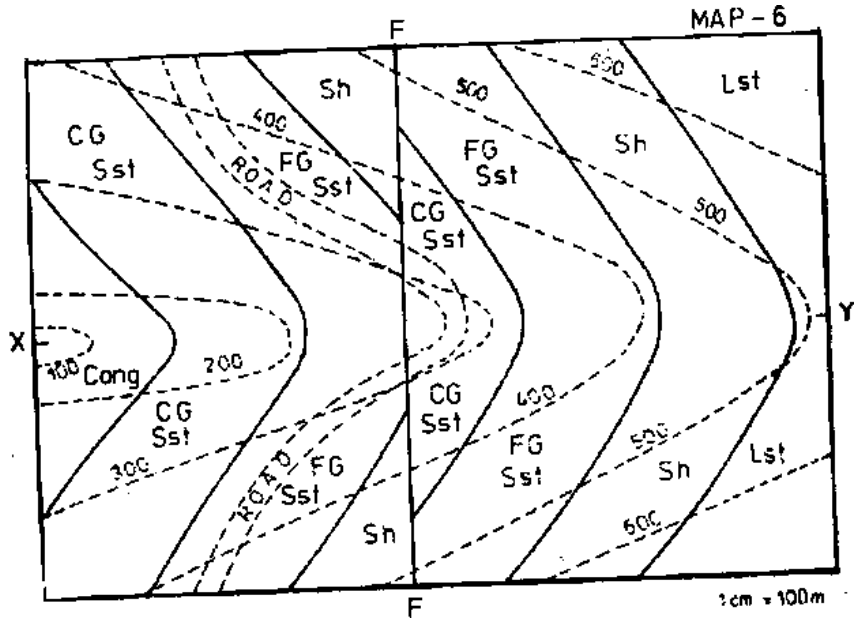
b) Order of Superposition

Conglomerate oldest bed followed by Sand stone, Shale and Lime stone is youngest.

3) Tunnel Proposed:

Inferences: Instead of contours, the spot heights of the area are given. The dip amount and dip direction also mentioned with respect to fold axis.

Map – 6: Faulted Strata



1) Draw a geological cross-section along XY And describe the geological history of the area.
2) Determine the down throw of the fault
3) A road is proposed as shown in the map. Comment upon its feasibility and suggests suitable precautionary measures

Map No.6: Faulted Strata

Geological History of the Area:

1) Topography

It is gently sloping terrain with the minimum and maximum altitudes of 100m and 600m.

2) Geology of the Area

a) Structural features: The rock beds are initially formed as horizontal beds in the sedimentary basin. Due to various geo- tectonic activities, these were folded & faulted has occurred and they were uplifted. After the uplifted these beds were affected by various geological agents & gentle slopes were formed.

The Strike of the beds are parallel to…….The Dip direction is towards ……..and the dip amount is…….

b) Order of Superposition

Conglomerate is oldest bed followed by Coarse Grained Sand Stone, Fine Grained Sand Stone, Shale and

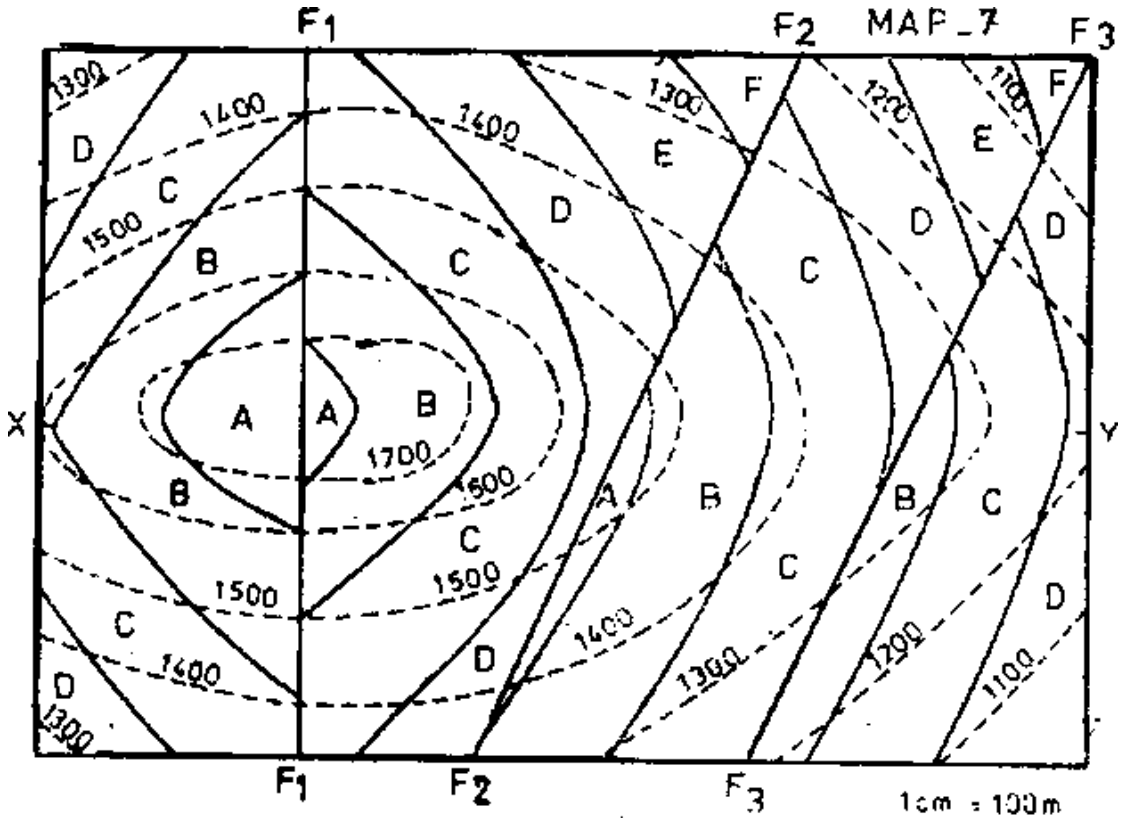
Lime Stone is the youngest. The thickness of beds Coarse Grained Sand Stone=…m, Fine Grained Sand Stone=….m, Shale=…m.

3) Road Proposal

The road proposed is of in Fine grained and coarse grained Sand Stone but at certain places the road will cross the fault. The proposed road site is geologically favorable as it is falling on Fine and Coarse grained Sand Stone.

The problem with road is the water run-off during rainy season. It can be controlled by providing proper drainage system.

Map – 7: Ridge and step Faults



1) Draw a geological cross-section along XY And describe the geological history of the area
2) Determine the up throw sides and downthrown sides of the faults
3) A horizontal tunnel is proposed at an altitude of 1200m. Enumerate the probable geological problems along the tunnel section. Discuss the feasibility of the tunnel.
   Note: Let 1100m be the datum line

Map No .7 : Ridge and step Faults

Geological History of the Area :

1) Topography

It is a small hillock with gentle slope on eastern side and steep slope in western side. The minimum and maximum altitudes of the given area are 1100m and 1700m.

2) Geology of the Area

a) Structural features: The ABCDEF sedimentary were deposited horizontally in the sedimentary basin. Due to orogenic activities, all these beds were uplifted, folded & faulted (F_1, F_2& F_3). After the upliftment the folded and faulted beds were affected by geological agents and it is formed as a small hillock. The Strike of the beds are parallel to…….The Dip direction is towards……..and the dip amount is…….

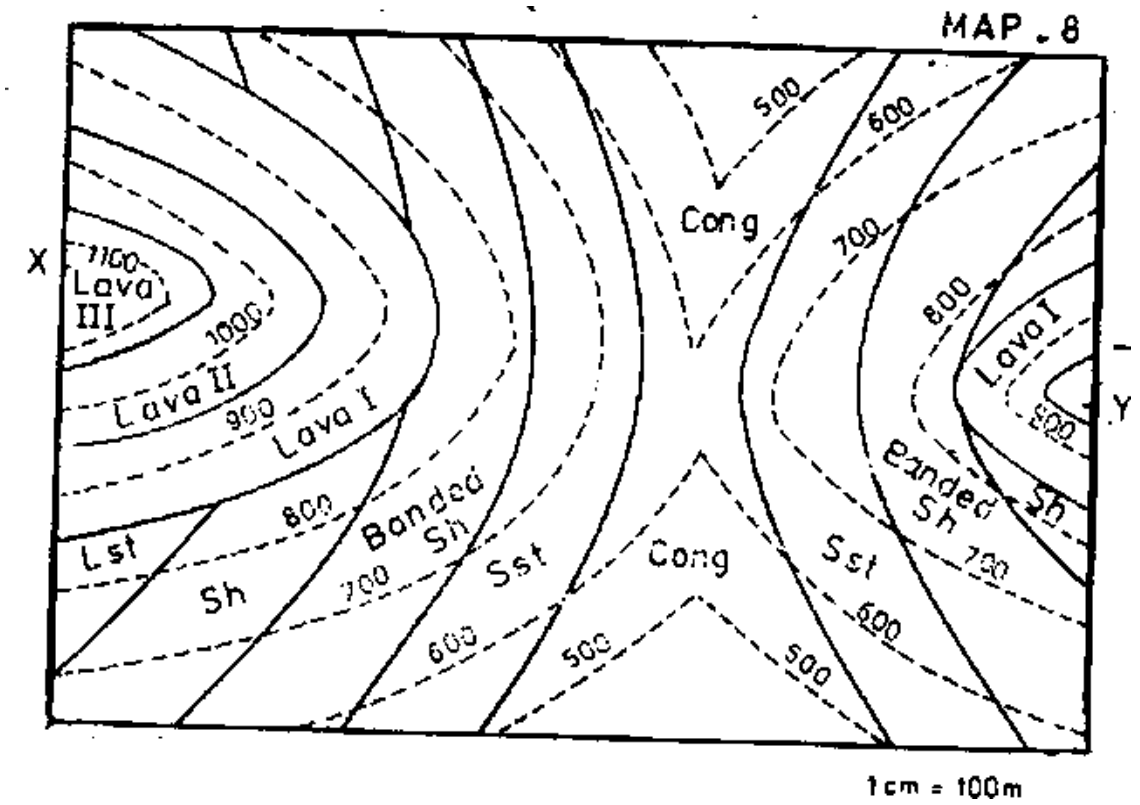
b) Order of Superposition

F is the oldest bed followed by E, D, C, B and A is the youngest bed. The thickness of beds E=…m, D=…m, C=….m, B=…m.

3) Tunnel Proposal

The proposed is passing through different kinds of inclined bed as well as series of rocks, so the proposed tunnel is not geologically favorable.

Map – 8: Graben Fault



1) Draw a geological cross-section along XY And describe the geological history of the area
2) Find out the order of Superposition and Structural details of the formations.
3) A horizontal tunnel is proposed at an invert level of 550m. Discuss its feasibility

Note: Let 500m. be the datum line

Map No.8: Graben Fault

Geological History of the Area :

1) Topography

The given area is a valley. The minimum and maximum altitude of the area is 100m and 450m.

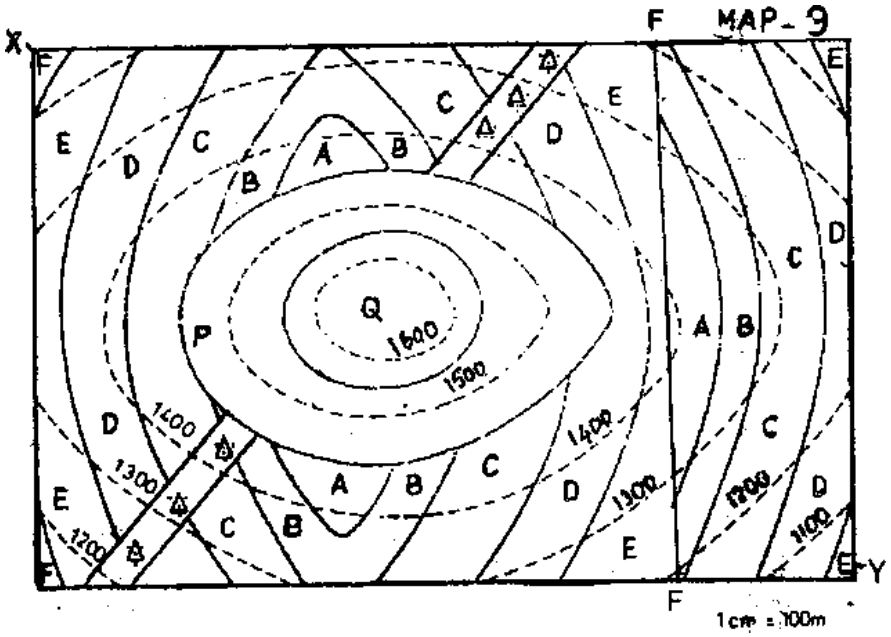
2) Geology of the Area

a) **Structural features:** The beds are initially deposited as horizontal beds in the sedimentary basin. Due to various tectonic activities they were uplifted; during upliftment the beds were folded followed by magmatic intrusions (dyke), followed by series of vertical faults (F_1 & F_2). After uplifted they are affected by various geological agents & a valley has formed. **b) Order of Super position** 'A' is the oldest bed followed by B, C, D, E & F is youngest.

3) Tunnel Proposal

The proposed tunnel is geologically not feasible as it is passing through different rock formation, as well as faults & magmatic intrusion (dyke).

Map – 9: Angular Unconformity



1) Draw a geological cross-section along XY and describe the geological history of the area
2) A horizontal tunnel is proposed along the section at an altitude of 1100m. Discuss the feasibility under the existing structural and geological features.
   Note: Let 1000m. be the datum line.

Map No.9: Angular Unconformity

Geological History of the Area:

1) Topography

The given area is a hillock with minimum and maximum of altitude of 1100m and 1600m.

2) Geology of the Area

a) Structural features: There are two types of sedimentary beds. In the older series older beds A, B, C, D, E, they were initially horizontal in nature, due to tectonic activities these beds were folded and forming into inclined beds followed by fault and magmatic intrusion (dyke). They are uplifted and exposed to surface. Due to various geological agents the beds are eroded. After this process, in the eroded surface the sedimentation process started again with the younger series of bed P followed by Q and they are cemented. Later they are uplifted & exposed to surface of the earth, and then the area is affected by geological agents and the hillock is formed. The Strike of the beds are parallel to……..The Dip direction is towards……..and the dip amount is…….

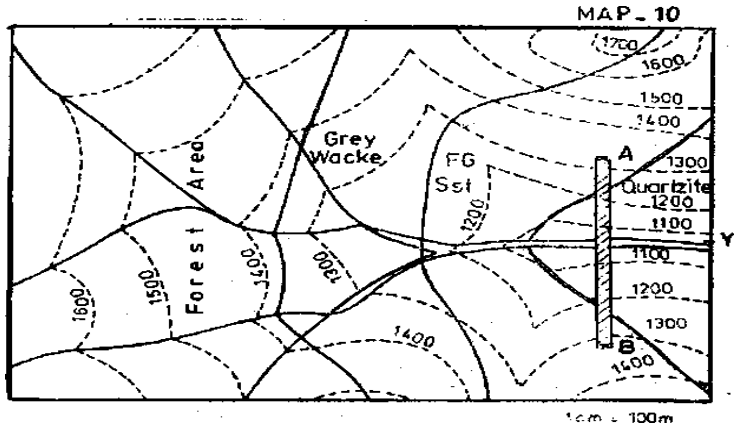
b) Order of superposition:

Bed E is oldest & A is youngest in the Older series & P is the oldest and Q is youngest in the younger series. The thickness of beds B=…m, C=…m, D=…m.

3) Tunnel Proposal

The proposed tunnel is not geologically feasible as it is passing through different inclined beds & as well as magmatic intrusion & a fault (F).

Map – 10: Selection of site for a Dam / Reservoir



1) Draw a geological cross-section along XY and describe the geological history of the area
2) A multi-purpose dam is proposed upto 1300m altitude, across east flowing river at AB. Substantiate your geological views on its suitability. Suggest the precautionary measures in the forest area.
3) Water is stored up to 1295m. level. Show the spread of reservoir water in the map and section. Show the inspection gallery, tailrace and other details.
   Note: Let 1000m. be the datum line.

Map No.10: Selection of site for a Dam / Reservoir

Geological History of the Area :

1) Topography

The given area is a gently sloped terrain with the minimum and maximum altitude is 1100m and 1600m.

2) Geology of the Area

a) Structural features :

The beds are initially horizontal in nature. Due to various tectonic activities these beds were tilted and inclined followed by metamorphism. After these process the entire sequence of beds were uplifted & exposed to the surface of earth crust. The Strike of the beds are parallel to…….The Dip direction is towards……..and the dip amount is…….

b) Order of Superposition

Quartzite is oldest followed by Fine grained Sand Stone & grey wacke is youngest . The thickness of Fine grained Sand Stone = m.

c) Tunnel Proposal

The proposed multipurpose dam across the east flowing river is geologically safe as the position of the dam is exactly falling of on the quartzite rock. In addition to this all the beds are inclined towards the upstream side. Only precautionary measure required to the terrain on the sloppy area which intern, reduces the silt accumulation in the reservoir.

Geological maps, their cross sections and description	**10 Marks**
Cross section	**5**
interpretation	**5**

EXPERIMENT NO: 8

INTERPRETATION OF SATELLITE IMAGERY

Satellite imagery is imageof Earth or other planets collected by imaging satellites. Satellite images have manyapplicationsin meteorology, oceanography, fishing, agriculture,biodiversity,conservation,forestry, landscape, geology, cartography, regional planning, education, intelligence and warfare.

The **interpretation of satellite imagery** and aerial photographs involves the study of various basic characters of an object with reference to spectral bands which is useful in visual analysis. The basic elements are shape, size, pattern, tone, texture, shadows, location, association and resolution.

Less mainstream uses include anomaly hunting, a criticized investigation technique involving the search of satellite images for unexplained phenomena. Images can be in visible colors and in other spectra. There are also elevation maps, usually made by radar images. Interpretation and analysis of satellite imagery is conducted using specialized remote sensing software.

There are four types of resolution when discussing satellite imagery in remote sensing: spatial, spectral, temporal, radiometric and geometric. Campbell (2002) defines these as follows:

- **spatial resolution** is defined as the pixel size of an image representing the size of the surface area (i.e. m^2) being measured on the ground, determined by the sensors' instantaneous field of view (IFOV);
- **spectral resolution** is defined by the wavelength interval size (discrete segment of the Electromagnetic Spectrum) and number of intervals that the sensor is measuring;
- temporal resolution is defined by the amount of time (e.g. days) that passes between imagery collection periods for a given surface location
- **Radiometric resolution** is defined as the ability of an imaging system to record many levels of brightness (contrast for example) and to the effective bit-depth of the sensor (number of grayscale levels) and is typically expressed as 8-bit (0–255), 11-bit (0–2047), 12-bit (0–4095) or 16-bit (0–65,535).
- **Geometric resolution** refers to the satellite sensor's ability to effectively image a portion of the Earth's surface in a single pixel and is typically expressed in terms of Ground sample distance, or GSD. GSD is a term containing the overall optical and systemic noise sources and is useful for comparing how well one sensor can "see" an object on the ground within a single pixel. The resolution of satellite images varies depending on the instrument used and the altitude of the satellite's orbit. For example, the Landsat archive offers repeated imagery at 30 meter resolution for the planet, but most of it has not been processed from the raw data. Landsat 7 has an average return period of 16 days. For many smaller areas, images with resolution as high as 41 cm can be available.[6]

Satellite imagery is sometimes supplemented with aerial photography, which has higher resolution, but is more expensive per square meter. Satellite imagery can be combined with vector or raster data in a GIS provided that the imagery has been spatially rectified so that it will properly align with other data sets.

Viva voce : Basic questions in Engineering geology	**5Marks**

VIVA QUESTIONS IN APPLIED ENGINEERING GEOLOGY

Physical Geology:

1. Weathering:

a. What is weathering ? What is chemical weathering ? Give example

b. Explain spheroid weathering with a figure.

2. Rivers:

a. Explain Recession of waterfalls.

b. Explain formation of OX- bow lakes with figure.

c. Explain Alluvial fan, Delta deposits.

3. Ground Water:

a. What is Water-table ? Why does it fluctuate ?

b. Describe stalactite and stalagmite with figure ?

c. Enumerate favourable factors for selecting a site for sinking a well.

d. Artesian well. b) Spring c) Perched water-table.

4. Earthquakes:

a. What is an earthquake ? …..focus ? …..Epicenter ?

b. Tell the important cause for earthquake.

c. Distribution of Earthquakes in India.

d. Earthquakes Resistance structures.

e. Seismograph – Seismogram.

f. Earthquake Waves.

5. Volcanoes:

a. What is a Volcano ? Volcanic eruption ?

b. What is a geyser ? Thermal springs

c. Volacanic products – solid, liquid & gaseous.

6. Crystallography:

a. What is a crystal and how does it differ from amorphous substance ?

b. Define – Centre of symmetry, Plane of symmetry, Axis of symmetry, Crystal Axes.

c. Give the symmetry characters of any one of the crystal systems.

d. Contact goniameter and its use.

7. Mineralogy

a. Tell the Mohs scale of Hardness.

b. What is cleavage in minerals ? Explain giving examples.

c. What is Diaphaneity ?

d. Tell a mineral which is used as – Lubricant, Talc, abrasive, insulator muscovite, Asbestos, Magnesite refractive material.

e. Minerals in the manufacture of glass –ore of Cu, Cr, Mn, fe,
Cement- Ceramics feldspar
Porcelain- Toilet powders.

8. Petrology:

a. What is a rock ? How many types of rocks are there? How are they distinguished?

b. How are Igneous rocks classifies ?

c. What is the rock used in the construction of Granite Vidhan Soudha.

d. What is the common rock you find around your college ?

e. What is chief rock used in the manufacture of Brick and tiles?

f. What is rock used in the construction of Taj Mahal, Red fort, Vidhana Soudha, , Bangalore, Halebid u & Belur Temples.

g. Rock suitable for carving statues ? Marble. i) Large Monolithic statues ? granite –gomateshwara.

h. Building stones for foundation, super structure flooring, concrete aggragate, Road Metal, Railway Ballast.

9. Structural Geology:

a. What is joint ? Types of joints? Columnar joints ?

b. What is a fold ? Types of folds ? Isoclinal folds, symmetrical folds.

c. What is a fault? Types of faults ? Normal fault, Reverse fault, through fault, Ridge fault, Step faults.

d. How is fault unconformity? Types of unconformity.

e. What is unconformity? Types of unconformity .

f. How is unconformity recognized in the map & field ?

g. What is apparent Dip ? How does differ from True dip ?

h. Describe the compass Clinometer ?

i. What is Inliers ? Outlier ?

j. Explain Dip –Slope and Escarpment slope.

10. Engineering Geology

a. Favourable factors for selecting a Dam site Reservoir site; Tunnel site.

b. What is tunnel ?.... Dam ?

c. What is a Multipurpose Dam ?

d. Explain why soil erosion has to be prevented in the catchment area.

e. Safety and stability of Dam.

f. Water tightness of Reservoir.

General:

a. How is soil formed ?

b. What is a fossil ?

c. How do you distinguish between sill and lava flow?

d. What is the rock you find in and around Lalbagh ?

e. Briefly explain the structure with the help of a figure.

- Porphyritic – Pegmatitic Vascular - Amygdaloidal
- Gneissose - Augen structure Schistose - Flow structure.

f. Suggest a rock for - flooring – foundation – super structure
-Pavement – Interior Decoration

g. Explain Migration of sand dunes and its effects. Briefly tell the preventive measure.

h. Temperature gradient.

i. Foot – wall, Hanging – wall, Hade, and Throw of a fault.

j. Fissure eruption of a volcano.

k. Evidences of sedimentation:- Stratification, Ripple marks, current bedding, graded bedding, rain prints, fossils.

l. Synclinal Hill, Anticlinal valley.

m. Angular unconformity, parallel unconformity.

n .Batholith, Dyke, Sill, Laccolith, Lava flow.

o. How do you distinguish between
Quartz and calcite, corundum and garnet,
Magnesite and Magnetite, granite and gneiss.
Conglomerate and Breccia, granite and Gypsum

p. Rejuvenation of rivers:- River Terraces, Incised Meanders, River capture, Headward erosion.

q. Open wells, Tube wells, Dug- cum-bore wells

r. Confines Aquifer, unconfined Aquifer.

s. Zone of sanitation, Zone of Aeration.

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