ATME College of Engineering

13th K M Stone, Bannur Road, Mysore – 570028

DEPARTMENT OF CIVIL ENGINEERING

(ACADEMIC YEAR 2024-25)

LABORATORY MANUAL

Engineering Geology

SUB CODE: BCV303

SEMESTER: III

INSTITUTIONAL VISION AND MISSION

Vision:

Development of academically excellent, culturally vibrant, socially responsible and globally competent human resources.

Mission:

- To keep pace with advancements in knowledge and make the students competitive and capable at the global level.
- To create an environment for the students to acquire the right physical, intellectual, emotional and moral foundations and shine as torch bearers of tomorrow's society.
- To strive to attain ever-higher benchmarks of educational excellence.

DEPARTMENT VISION AND MISSION

Vision:

To develop globally competent civil engineers who excel in academics, research and are ethically responsible for the development of the society.

Mission of the Department

- To provide quality education through faculty and state of art infrastructure.
- To identify the current problems in society pertaining to Civil Engineering disciplines and to address them effectively and efficiently.
- To inculcate the habit of research and entrepreneurship in our graduates to address current infrastructure needs of society.

Program outcomes (POs)

Engineering Graduates will be able to:

PO1: **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO 1 – Provide the necessary infrastructure for all situations through competitive plans, maps And designs with the aid of a thorough Engineering Survey and Quantity Estimation.

PSO 2 – Assess the impact of anthropogenic activities leading to environmental imbalance on Land, in water & in air and provide necessary viable solutions revamping water Resources and transportation for a sustainable development

Program Educational Objectives (PEOs)

PEO 1 - Engaged in professional practices, such as construction, environmental, geotechnical, structural, transportation, water resource engineering by using technical, communication and management skills.

PEO 2 - Engaged in higher studies and research activities in various civil engineering fields and life time commitment to learn ever changing technologies to satisfy increasing demand of sustainable infrastructural facilities.

PEO 3 - Serve in a leadership position in any professional or community organization or local or state engineering board

PEO 4 - Registered as professional engineer or developed a strong ability leading to professional licensure being an entrepreneur.

Regulations Governing
THE DEGREE OF BACHELOR OF ENGINEERING

ATTENDANCE REQUIREMENT

- Each semester is considered as a unit and the candidate has to put in a minimum attendance of 85% in each subject with a provision of condo nation of 10% of the attendance by the Vice-Chancellor on the specific recommendation of the Principal of the college where the candidate is studying, showing some reasonable cause such as medical grounds, participation in University level sports, cultural activities, seminars, workshops and paper presentation, etc.

- The basis for the calculation of the attendance shall be the period prescribed by the University by its calendar of events. For the first semester students, the same is reckoned from the date of admission to the course as per CET allotment.

- The students shall be informed about their attendance position periodically by the colleges so that the students shall be cautioned to make up the shortage.

- A Candidate having shortage of attendance in one or more subjects shall have to repeat the whole semester and such candidates shall not be permitted to take admission to next higher semester. Such students shall take readmission to the same semester in the subsequent academic year.

INTERNAL ASSESSMENT MARKS

- The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks).
- A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

COURSE DETAILS

Course Name	:	Engineering Geology
Course Code	:	BCV303
Course prerequisite	:	Basic Knowledge on Engineering Geology III semester

COURSE OBJECTIVES

Upon completion of this course, students are expected to:

1. To expose the students to identify the minerals and rocks based on their inherent propertiesand uses in civil engineering,
2. To educate the students in the interpretation of the geological maps related to civilengineering projects.
3. Students will learn the dip and strike, thickness of strata, Bore hole problems related togeological 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.

COURSE OUTCOMES

Upon successful completion of this course, students should be able to:

Subject code: BCV303	**Subject name: Engineering Geology**	
COs	**COURSE OUTCOMES**	**KL***
CO1	Apply geological knowledge in different civil engineering practice.•	AP**
CO2	Acquire knowledge on durability and competence of foundation rocks, and will be able to use the best building materials.	AP
CO3	Students will become competent enough for the safety, stability, economy and life of the structures that they construct	AP
CO4	Able to solve various issues related to ground water exploration, build up dams, bridges, tunnels which are often confronted with ground water problems	AP
CO5	Students will become Intelligent enough to apply GIS, GPS and remote sensing as a latest tool in different civil engineering for safe and solid construction.	AP

Note: * Knowledge Level; ** Apply

Engineering Geology Laboratory			
Course Code	**BCV303**	CIE Marks	50(30+20)
Teaching Hours/Week (L:T:P: S)	0: 0:2:0	SEE Marks	50
Credits	03		

Course objectives:

1. To inculcate the importance of earth's interior and application of Geology in civil engineering in Geo Hazard mitigation and management
2. To create awareness among Civil engineers regarding the resources of earth
3. To provide knowledge on dynamic Geology and its importance in modifying the physical character of rocks which cause rocks suitable or unsuitable in different civil engineering projects such as Dams,bridges, tunnels and highways.
4. To educate the ground water management regarding diversified geological formations, . To highlight the concept of rain water harvesting.
5. To understand the application of Remote Sensing and GIS, Natural disaster and management and environmental awareness. To understand the subsurface using geospatial data
6. To provide decision support on the nature of the basic raw materials used in construction. To provide decision support on Lithological characters and subsurface conditions
7. To describe various geological maps and interpretation of geological data for mining and subsurface investigations.

Sl.NO	Experiments
1	Identification of common minerals based on Physical Properties
2	Identification of rocks used in building construction based on Physical properties
3	Solving Geological maps for suitability for aqua duct
4	Geological maps with inclined beds, suitability for tunnels/ Dams
5	Geological maps with folds, in tunnels/ Dams
6	Geological maps with unconformity , in tunnel/dam project
7	Geological maps with faults in Dams/tunnels project
8	One Day Nearest Field Visit Investigation.

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- Apply geological knowledge in different civil engineering practice.
- Acquire knowledge on durability and competence of foundation rocks, and will be able to usethe best building materials.
- Students will become competent enough for the safety, stability, economy and life of thestructures that they construct
- Able to solve various issues related to ground water exploration, build up dams, bridges,tunnels which are often confronted with ground water problems
- Students will become Intelligent enough to apply GIS, GPS and remote sensing as a latest tool
- in different civil engineering for safe and solid construction.

INTRODUCTION

The Science, which deals with the study of the Earth, is known as Geology. The term **„Geology‟** has been derived from the Greek words. **„Geo‟** means Earth, **„logy‟** means Science.

For study of the Earth in detail, the subject of Geology has been divided in to various branches, which are as follows:-

1. Mineralogy
2. Petrology
3. Geomorphology
4. Geodynamics
5. Structural Geology
6. Engineering Geology
7. Hydro Geology
8. Geo informatics & Environmental Geology

Engineering geology is concerned with the applications of geology to civil, mining and water resources engineering. All the Engineering structures, small or large are constructed either on rocks or soil material. It is essential to study the earth materials in greater details.

Geology is a field science. Geological knowledge is required to locate and exploit mineral resources. Except for water, other resources are non-renewable (for e.g.:- petroleum, coal, metals etc.,). Thus only after discoveries of these precious resources, our civilization have undergone revolution.

In the modern urbanization era, the development of big cities has resulted in the construction of large structures like high risen buildings, fly over‟s, dams etc., Geology helps in designing foundations for these structures and earth materials used in constructions.

Chapter 1

Mineralogy

Definition of a Mineral: A mineral is naturally formed, homogeneous inorganic solid substance, which possess distinctive physical properties, definite chemical composition and definite internal atomic structure.

Physical properties of Minerals: The study of physical properties of minerals is important, since it varies from mineral to mineral. Following are important physical properties.

PROPERTIES DEPEND UPON LIGHT:

a) Colour
b) Streak
c) Luster
d) Transparency (Diaphaneity)

PROPERTIES DEPEND UPON THE INTERNAL ATOMIC STRUCTURE AND MODE OF FORMATION:

a) Habit/Form/Structure

b) Hardness

c) Fracture

d) Cleavage

e) Specific gravity

PROPERTIES DEPEND UPON SENSES:

a) Taste
b) Odor, feel
c) Acid reaction, Double refraction,
d) Magnetism

TOOLS FOR TESTING AND IDENTIFICATION OF MINERALS

1) Hand lens

2) Penknife

3) Magnet

4) Streak plate

5) Dilute HCL (Hydrochloric acid)

PROPERTIES DEPEND UPON LIGHT:

A) COLOUR: The colour shown by a mineral depends upon the absorption of some and the reflection of others of the colored rays. The colour of mineral is one of the most important physical property, some minerals show distinctive colour and are as follows:

Blue : Azurite, Saderiteite,
Green : Flurite, Malachite, Talc, Microcline,
Yellow : Sulphur, Chalcopyrite, pyrite.
Red : Jaspar, orthoclase, Cinnabar, Garnet.
Lead grey : Galena, Graphite.
Colorless : Quartz and Zeolite.

However, the colour of non-metallic minerals vary greatly and the variations of colour in minerals may be due to, Surface alterations,ii)Difference in chemical composition,Presence of impurities,Inclusion of some other mineral matters etc.,

B) STREAK: Streak is the colour of powdered mineral and may be obtained by rubbing the fresh mineral surface on unglazed porcelain plate called “Streak plate”. The streak may be of different colour from the mineral colour. Table showing the different colours in streak of minerals

Mineral	**External Colour**	**Streak**
Calcite	White, blue, grey or blue	White
Fluorite	Green, purple or blue	White
Chalcopyrite	Brass yellow	Greenish black
Galena	Steel grey	Lead grey black
Hematite	Metallic black	Cherry red

C) LUSTURE (LUSTRE): The appearance of the shinning surface of a mineral in reflected light is called luster. The intensity of luster is influenced by transparency, reflectivity and surface structure of the mineral. It is also depends upon the absorption and reflection of ordinary light. The luster of minerals can be divided into two types:

1) Metallic luster. 2) Non-metallic luster.

1) Metallic luster: A mineral having the appearance of a metal reflection. Ex: Galena, Pyrite,

2) Non metallic luster: All minerals dull appearance have a non-metallic luster.

i) Vitreous: Luster shown by broken glasses: Quartz, Feldspars.

ii) Resinous or Waxy: Luster shown by a resin or wax. Ex: Sphalerite, Chlorite.

iii) Greasy luster: Luster shown by a thin layer of oil. Ex: Agate, Mica, Gypsum etc.

iv) Pearly luster: Mineral surface like pearl shine. Ex: Talc, Muscovite, Calcite.

v) **Silky luster:** Luster shown by silk or fiber surface minerals. Ex: Asbestos, Gypsum.

vi) **Adamantine luster:** Brilliant surface reflection. Ex: Diamond.

vii) **Dull or Earthy luster:** When a mineral shows no luster. Ex: Bauxite, Kaolin.

D) TRANSPERANCY: The property possessed by some minerals to transmit light is known as Transparency/ diaphaneity. The terms used to express the varying degrees of this property are

Transparent: When the outlines of an object seen clearly though the mineral, Ex: Rock crystal,

Translucent: A mineral which can transmit light only at edges. Ex: Calcite, Fluorite, Quartz,

Opaque: When no light is transmitted through the mineral. Ex: Hematite, Magnetite, etc.,

PROPERTIES DEPEND UPON INTERNAL ATOMIC STRUCTURE AND MODE OF FORMATION:

Habit/Form/Structure: The characteristic natural internal shape of minerals is called as habit/form. Mineral when formed under favorable physic- chemical conditions occurs as well developed individual crystals, crystal aggregates, with various stages of growth or distorted crystals.

Minerals assume various types of forms which are not necessarily dependent on the crystal characters. These forms are described by various terms as given below:

SI. No.	Habit/Form	Description	Mineral Examples
1.	**Crystalline**	Well developed individual crystals	**Quartz, Calcite**
2.	**Bladed**	Thin elongated flat or tabular, like knife blade	**Kyanite**
3.	**Granular**	Consisting of small crystalline or irregular mineral grains	**Chromite, Olivine**
5.	**Pisolitic**	Consisting of rounded masses about the same size of pices.	**Bauxite**
6.	**Nodular**	Smooth rounded or irregular masses like river gravel/pebble	**Flint**
7.	**Reniform**	kidney shaped masses	**Haematite**
8.	**Botryoidal**	Resembling a bunch of grapes	**Haematite**

9.	**Columnar**	Consisting of column shapes	**Quartz, Berryl**
10.	**Acicular**	Consisting of thin needle like masses	**Pyralusite,**
11.	**Fibrous**	Consisting of thread like fibers, that are rigid	**Asbestos,**
12.	**Dendritic**	Branching like twigs, etc.,	**Pyralusite**
14.	**Flaky**	Extremely thin elastic of flexible and easily separable layers	**Mica**
15.	**Foliated**	Consisting of thin frequently curved twisted, or irregular non –separable layers	**Talc, Chlorite**
16.	**Banded**	Consisting of thin or thick layers of different colour and	**Agate, Jaspar**

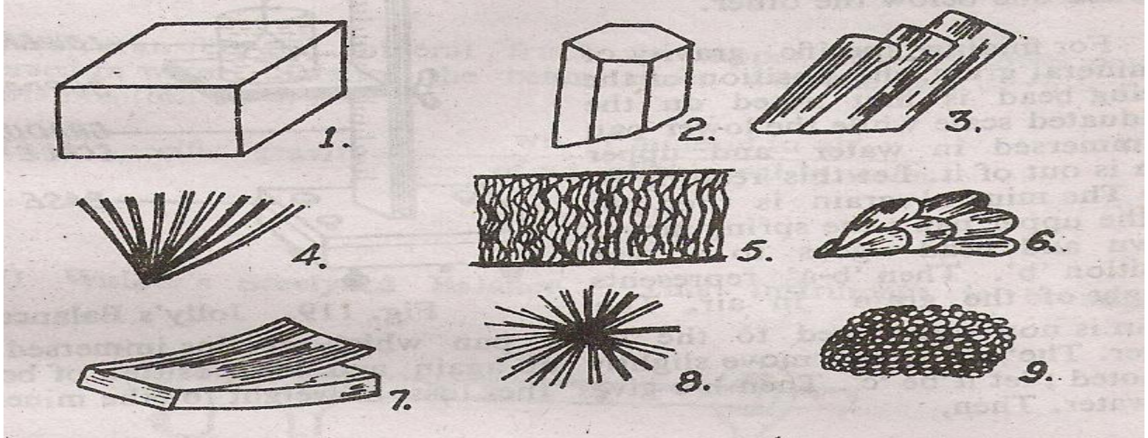


Fig. 118. Some Common Structures in Minerals
1. Tabular 2. Columnar 3. Bladed 4. Acicular
5. Fibrous 6. Reniform 7. Foliated 8. Radiating
9. Granular.

Hardness: Hardness may be defined as the resistance offered by the mineral to scratching, rubbing or breaking. The degree of hardness is determined by observing the comparative easy or difficulty with which one mineral is scratched by the other or by a penknife. Hardness varies from mineral to mineral.

A German mineralogist **Friedrich Moh"s**, was conducted several experiment found that some minerals according to their increasing hardness. This series commonly known as **"Moh"s scale of hardness"** and is as follows.

"Moh‟s scale of hardness"

Grade of Hardness	Moh‟s scale Standard Hardness Minerals	Moh‟s Number	Scratchability
Soft	Talc (Hydrous silicate of Mg) Gypsum($CaSO_4$ $2H_2O$) Calcite ($CaCO_3$)	1 2 3	Easily scratched by fingernail Some difficulty by fingernail Does not scratched by fingernail
Medium	Fluorite (CaF_2) Apatite ($CaPO_4$) Orthoclase ($(KAlSi_3O_8)_6$)	4 5 6	Scratched easily by penknife Some difficulty to penknife Little difficulty to penknife
Hard	Quartz (SiO_2) Topaz ($(AlF)_2$ SiO_4) Corundum(Al_2O_3)	7 8 9	Difficulty to penknife Very difficult to penknife Very difficult to penknife
Hardest	Diamond (C)	10	Scratched by only another Diamond

Fracture: The nature of the broken surface in minerals other than the direction is called fracture. But minerals with very good cleavages break more readily along cleavage planes thus making it difficult to observe the fracture, Common types of fracture.

Conchoidal: The broken mineral surface shows curved concentric shells. Ex: Quartz, Magnesite,
Sub Conchoidal: A lesser degree of curved surface of concentric shells. Ex: Jasper
Hackly: when the mineral breaks with an irregular surface and edges. Ex: native copper,
Uneven: When mineral breaks with a rough irregular surface. Ex: Magnesite, feldspars.
Even: When mineral breaks with a smooth and regular flat surface. Ex: Flint.
Earthy: No fracture surface observed on the minerals surface. Ex: Kaolin, Bauxite.

CLEAVAGE: It is the property of certain minerals to break along certain planes called the cleavage planes. These cleavage planes are always parallel to crystal faces of the mineral. Minerals may split/break in one, two or three directions. The cleavage planes, which run parallel to one another belongs to cleavages. Thus the mineral exhibits one Set, (micas) two sets, (Feldspars) and three sets. (Calcite and Galena)

Basal cleavage: One set of cleavages, which can easily split into sheets. Ex: Muscovite mica.

Prismatic cleav: Two sets of cleavages planes parallel crystal faces. Ex: feldspars

Cubic cleavage: Two sets of cleavages at right angles to each other. Ex: Galena, pyrite

Rhombohedral cleav: Three sets of cleavages at right angles to each other.Ex: Calcite.

Octahedral cleavage: Four sets of cleavages. Planes are parallel to faces. Ex: Fluorite.

Specific Gravity: Minerals vary considerably in weight, some being heavy for their size, others light. The relative weight of a mineral is known as its specific gravity which is a number that expresses the ratio between its weight and the weight of an equal volume of water. Specific gravity can be calculated in the following equation:

Specific Gravity = $W_a / (W_a - W_w)$

Where, W_a = Weight of mineral specimen in air

W_w = Weight of mineral specimen in water

The specific gravity of a mineral depends upon their chemical composition and molecular weight. The most practical method uses are Jolly"s spring yard balance. Beam balance, Walkers steel yard etc., depends upon the size of the minerals. But for practical purposes, specific gravity can be roughly estimated by using the relative terms as

Low (2.5 and less): Less weight. Ex: Graphite.

Medium (3.5 and 3.5): Medium weight. Ex: Quartz, feldspar, Calcite.

High (3.5 above): Heavy weight. Ex: Silver.

III. PHYSICAL PROPERTIES OF MINERALS DEPENDS UPON CERTAIN SENSES AND SPECIAL PROPERTIES:

Taste: When the minerals are soluble in water. Ex: a) saline taste b) Alkaline taste of soda.

Odor: Minerals have characteristic odors rubbed upon or heated. Ex: Sulphurous .

Feel: Smooth, Greasy, Rough are some of the kinds of feel of minerals that may help in their identification. Ex: Talc - Smooth surface, Mica - Greasy surface, Agate - Rough surface, Native copper - Harsh surface

Acid reaction: Certain carbonate minerals reacts with hydrochloric acid. Ex: Calcite.

Magnetism : Some minerals attracts magnet. Ex: Magnetite

MINERAL IDENTIFICATION DATA SHEET

(Description of Minerals)

MINERAL GROUP –

Sl. No	Physical Properties	1	2	3
1.	Chemical Composition	SiO_2	SiO_2	SiO_2
2.	Habit	Crystal, massive	Crystalline	Crystalline
3.	Color	Colorless or white	Smokey	Milky white
4.	Streak	White	White	White
5.	Lustre	Vitreous	Vitreous	Vitreous
6.	Hardness	7	7	7
7.	Cleavage	Absent	Absent	Absent
8.	Fracture	Concoidal	Concoidal	Concoidal
9.	Specific Gravity	2.6	2.6	2.6
10.	Diaphaneity	Transparent to Translucent	Transparent to Translucent	Transparent to translucent
11.	Uses	Glass making & cutting, optical instruments	Watches, pre-stressed concrete	Agro granules
12.	**Name of the Mineral**	**TRANSPARENT QUARTZ**	**SMOKEY QUARTZ**	**MILKY QUARTZ**

Sl. No	Physical Properties	4	5	6
1.	Chemical Composition	$KAlSi_3O_8$	$NaAlSi_3O_8$, $CaAlSi_2O_8$	$K(AlSi_3O_8)$
2.	Habit	Monoclinic	Twinned	Twinned
3.	Color	Orange	Grey	Pink
4.	Streak	White	White	White
5.	Lustre	Vitreous, pearly	Pearly	Vitreous
6.	Hardness	6	6	6
7.	Cleavage	2 sets of perpendicular	2 sets of oblique	2 sets-good
8.	Fracture	even	Even	Even
9.	Specific Gravity	2.6	2.6	2.6
10.	Diaphaneity	Translucent	Translucent	Translucent
11.	Uses	Porcelian, ceramics, pottery bottles	Ceramic industries, binders	Porcelain industries, Ornamental stones
12.	**Name of the Mineral**	**ORTHOCLASE**	**PLAGIOCLASE**	**MICROCLINE**

Sl. No	Physical Properties	7	8	9
1.	Chemical Composition	$CaCO_3$	$CaMgCO_3$	$Ca_2(MgFeAl)_5\,(SiAl)_8$
2.	Habit	Rhombohedral	Rhombohedral	Columnar fibrous
3.	Color	White, grey, pink	White, Grey, Brown	Dark green
4.	Streak	White or grey	White	Pale greenish
5.	Lustre	Pearly	Vitreous	Resinous
6.	Hardness	3	4	5.5
7.	Cleavage	3 sets of oblique	3 sets of oblique	2 sets of oblique
8.	Fracture	Even	Uneven	Uneven
9.	Specific Gravity	2.7	1.8	3.5
10.	Diaphaneity	Translucent	Translucent	Translucent
11.	Uses	Toothpaste, paper, paint, soap, bleaching powder	Refractory, cement, fertilizers	Important rock forming mineral
12.	**Name**	**CALCITE**	**DOLOMITE**	**HORNBLENDE**

Sl. No	Physical Properties	10	11	12
1.	Chemical Composition	$MgCO_3$	$Mg_3(Si_4O_{10})(OH)_2$	$CaSO_4$, $_2H_2O$
2.	Habit	Massive compact	Foliated, Massive	Fibrous
3.	Color	Chalk white	Pale green, silver white	White, snow white
4.	Streak	White	Pale white	Pale white
5.	Lustre	Dull-earthy	Pearly	Resinous
6.	Hardness	4	1.5	2
7.	Cleavage	Absent	Imperfect	One direction
8.	Fracture	Uneven	Even	Uneven
9.	Specific Gravity	3	2.8	2.4
10.	Diaphaneity	Opaque	Translucent	Transparent to Translucent
11.	Uses	Refracting, Furnace lining, Insulator, Crucibles	Paints, paper, Tissue paper, Cosmetics, Insecticides,	Plaster of Paris, Fertilizer, Alkali soils cement
12.	**Name**	**MAGNESITE**	**TALC**	**GYPSUM**

Sl. No	Physical Properties	13	14	15
1.	Chemical Composition	$2H_2O$, CaMg Silicate	$(MgFe)_2SiO_4$	Ca, Mg, $Fe_2Mg(SiO_4)_3$
2.	Habit	Fibrous	Granular	Dodecahedron
3.	Color	Grayish, yellowish	Olive green	Brown, Red
4.	Streak	Pale grayish white	Pale white	White
5.	Lustre	Silky	Resinous	Vitreous to Resinous
6.	Hardness	2.5	6.5	7.5
7.	Cleavage	Perfect	None	None
8.	Fracture	Hackly	Hackly	Uneven
9.	Specific Gravity	3.2	3.3	4.5
10.	Diaphaneity	Opaque	Translucent	Translucent
11.	Uses	Fire proof, Electrical & thermal insulator, Ayurvedic medicine	Gemstone, Insulator Refractories	Gemstone, abrasive
12.	**Name**	**ASBESTOS**	**OLIVINE**	**GARNET**

Sl. No	Physical Properties	16	17	18
1.	Chemical Composition	Al_2O_3	$K(MgFe)(AlSiO_3O_1)(OH)_2$	$H_2KAL_3(SiO_4)_3$
2.	Habit	Crystal	Foliated masses	Flaky
3.	Color	Reddish brown, pink	Dark brown or black	Silver white
4.	Streak	Brownish yellow	White or pale brown	White
5.	Lustre	Adamantine	Vitreous to pearly	Vitreous
6.	Hardness	9	2.5	2.5
7.	Cleavage	None	Perfect, easily separate	Perfect, easily separate
8.	Fracture	Uneven	Even, flexible	Flexible, elastic
9.	Specific Gravity	4.2	3.2	3
10.	Diaphaneity	Opaque	Translucent	Transparent to translucent
11.	Uses	Gemstone & Abrasive	Boiler, Furnace, Window screen	Electric insulator, decorative stone, chimney, gaslight, fancy paints
12.	**Name**	**CORUNDUM**	**BIOTITE MICA**	**MUSCOVITE**

Sl. No	Physical Properties	19	20	21
1.	Chemical Composition	China clay- $H_4Al_2SiO_9$	$Mg_6(SiO_{10})(OH)_8$	$BaSO_4$
2.	Habit	Powdery	Compact, massive	Compact
3.	Color	Dull white	Dull green, Yellow green	White grey
4.	Streak	White	White	White
5.	Lustre	Greasy, pearly	Resinous, waxy	Vitreous
6.	Hardness	1	4	3.5
7.	Cleavage	Nil	Nil	Nil
8.	Fracture	Earthy	Uneven	Uneven
9.	Specific Gravity	2.65	2.6	4.5
10.	Diaphaneity	Opaque	Translucent	Translucent
11.	Uses	Cement stiffener, bricks, glazed tiles filler, ceramic, refractory	Ornamental stones, sources of Asbestos	Paints, pigment, wall paper, glass
12.		**KAOLIN**	**SERPENTINE**	**BARITE**

PHYSICAL PROPERTIES OF ORES

Sl. No	Physical Properties	1	2	3
1.	Chemical Composition	Fe_2O_3	Fe_3O_4	$2F_2O_33H_2O$
2.	Habit	Thick tabular, massive	Crystalline, Massive	Botryoidal & Radiating
3.	Color	Steel grey, reddish brown	Iron black	Reddish brown
4.	Streak	Cherry red, reddish brown	Black	Yellowish brown
5.	Lustre	Metallic	Metallic	Metallic
6.	Hardness	6.5	6.5	5
7.	Cleavage	Oblique cleavages	Nil	Nil
8.	Fracture	Uneven	Uneven	Uneven
9.	Specific Gravity	5.5	5.5	4.3
10.	Diaphaneity	Opaque	Opaque	Opaque
11.	Uses	Manufacture of steel	Ore of Iron	Ore of Iron
12.	**Name**	**HEMATITE**	**MAGNETITE**	**LIMONITE**

Sl. No	Physical Properties	4	5	6
1.	Chemical Composition	$FeCr_2O_4$	Pbs	FeS_2
2.	Habit	Crystalline, Massive	Cubic structure	Crystalline
3.	Color	Black	Lead grey, silver grey	Brass yellow, bright golden yellow
4.	Streak	Brownish black	Grayish black	Greenish black
5.	Lustre	Sub metallic	Black	Metallic
6.	Hardness	5.5	2.5	6.5
7.	Cleavage	Nil	Perfect cubic	Absent
8.	Fracture	Uneven	Even	Uneven
9.	Specific Gravity	4.8	7.5	5
10.	Diaphaneity	Opaque	Opaque	Opaque
11.	Uses	Refractory material, Ore of Chromium	Radio sets, ore of lead alloys	Byproduct of Gold
12.		**CHROMITE**	**GALENA**	**IRON PYRITE**

Sl. No	Physical Properties	**7**	**8**
1.	Chemical Composition	$CuFeS_2$	$Al_2O_32H_2O$
2.	Habit	Crystalline	Pisolitic earthy massive
3.	Color	Golden yellow	Reddish brown, yellowish by iron oxides
4.	Streak	Black to greenish black	White stained red
5.	Lustre	Metallic	Dull
6.	Hardness	4	3
7.	Cleavage	Absent	Nil
8.	Fracture	Uneven	Earthy, Uneven
9.	Specific Gravity	4.3	2.5
10.	Diaphaneity	Opaque	Opaque
11.	Uses	Ore of copper & silver	Ore of aluminum, refractory bricks, porcelain cement
12.		**CHALCOPYRITE**	**BAUXITE**

PETROLOGY

ROCK : Rock is a natural aggregate of mineral grains,. Rocks composed of grains of only one mineral are called monomineralic rocks.

Ex: Marble : Composed of Calcite

Sandstone : Composed of Quartz

Dunite : Composed of Olivine

Rocks composed of grains of two minerals are called **polymineralic/ multi-minerallic rocks.**

Ex: Granite: Composed of quartz, orthoclase, plagioclase, biotite mica, etc,

CLASSIFICATION OF ROCKS:

Rocks are broadly classified into three major groups

a) **Igneous rocks** are derived from solidification of molten material „magma" or „lava". They subjected to different rate of crystallization. Thus, they exhibit different crystalline textures and structures. They are often connected with the interior of the earth‟s crust. They are massive in form and free from fossil remains of ancient animals and plants. Ex: Granite from Magma : Basalt from Lava. These rocks are the fore most rocks to be formed on the earth‟s crust. So they are known as „primary Rocks‟. Even to this day, the igneous rocks are being formed, ., when volcanic lavas are erupted, cooled and solidified.

b) **Sedimentary rocks** are those formed by the weathered, transported and deposited on the oceanic floor in the form of layers. They are also known as „Layered Rocks‟. They are formed under water, they possess evidences of sedimentation viz, stratification, ripple marks, current bedding, graded bedding, mud/sun cracks, rain prints. Fossils etc., Example conglomerate, sand stone, limestone etc.

c) **Metamorphic rocks** are derived from the pre-existing rocks due to intense temperature, pressure or both. These phenomena known as thermal metamorphism, dynamic metamorphism and dynamothermal metamorphism respectively. The rocks subjected to metamorphism, lose their original features and new structures are introduced. Example igneous rock Granite is metamorphosed to form Gneiss, sedimentary rock Limestone is metamorphosed to form Marble.

INDEX PROPERTIES OF ROCKS:

1.Colour 2. a) Grain size b) Texture/Structure
3.a) Essentia minerals (EM) b) Accessory minerals (AM)

4. Mode of formation
5. Cementing material (Sedimentary only) 6. Specific gravity
7. Mode of formation 8. Occurance
9. Uses and importance 10. Name of Rock

Discription of index properties:

Colour : The colour of rocks depends upon their constituent minerals or cementing material

Texture: It is the mutual arrangement of component mineral grains, size , shape.

Textures of Igneous rocks :

Equigranular : It consists of almost equidimensional mineral grains. Ex: Granite, Gabbro.

Porphyritic: It consist of few large, well developed mineral grains. Ex: Granite porphery, etc

Glassy texture: It consists of amorphous surface with rich in silica (SiO_2) and rapid solidification of lava/magma in volcanic igneous rocks. Ex : Rhyolite, Obsidian.

Vesicular/ Amygdaloidal texture : It consist of pores or vesicles due to release of gaseous substances. Later these vesicles are filled with secondary minerals like Quartz, Calcite, Chlorite etc., such texture is called Vesicular or Amygdaloidal texture.

Textures of sedimentary rocks:

Massive : Amorphous or very fine –grained and breaks with concentric curves. Ex : limestone

Fossiliferous: It consists of fossil remains burried,cemented together. Ex : limestones.

Concretionary : Hard and Soft clay with iron oxideor aluminium oxide. Ex : Laterite

Texture of Metamorphic rocks:

Granulose : It consists of interlocking of shapeless grains or crystalline minerals. Ex : Quartzite, Marble.

Schistose : It consists of flaky, foliated grains or layers twisted or curved.

Gneissose : It consists of alternate bands of light coloured and dark coloured mineral. Ex : Gneiss, Augen gneiss.

Grain size : Fine - Grain diameter 1 mm or less

Medium - Grain diameter 1 mm to 5 mm

Coarse -Grain diameter 5 mm and above

Mineral Composition : The combination and proportion of the mineral component in Rock, Mineral compositions can be divided in two types:

Essential minerals : These are essential for description, identification and classification, of Rocks. Ex : Quartz, Feldspar, Mica. Augite, Calcite, Talc, Chlorite……. Etc

Accessary minerals : These may be present/ obsent. Ex: Mica, Magnite, Iron pyrite, Garnet…

Cementing Material : **(Exclusively for Sedimentary rocks)**
Natural binding material deposited in between component sedimentary pebbles, fragments, grains and/or fossil remains.

Specific gravity : Similar to Mineral specific gravity (Refer minerals specific gravity chart)

Special properties : These often form excellent distinguishing features.

Acid Reaction: Carbonate rocks readily react with Dil HCI. Ex : Limestone Marble

Few important Igneous, Sedimentary, Metamorphic Rocks

Igneous Rock

Plutonic Rocks	Hypbyssal Rocks	Volcanic Rocks
a) Granite	a) porphyries	a) Rhyolite
b) Syenite	b) Pegmatite	b) Pumice
c) Diorite	c) Dolerite	c) Basalt
d) Gabbro		d) Obsidian
e) Dunite		

Sedimentary Rocks

Machanically formed sedimentary rocks : a) Conglomerate b) Breccia c) Sandstone d) Shale

Chemically formed sedimentary rocks: a) Lime stone

Organically formed sedimentary rocks : a) Fossil formed Limestone

b) Shell limestone
c) Coral limestone
d) Coal

Metamorphic Rocks

Foliated rocks : a) Talc schist b) Chlorite schist
c) Mica schist d) Hornblende schist
e) Slate f) Gneiss

Non- foliated Rocks: a) Quartzite b) Marbles

ROCK IDENTIFICATION DATA SHEET

IGNEOUS ROCKS

Sl. No.	Phy. Pro. of Rocks	1	2	3
1.	Color	Pink, Reddish brown	Grayish white	White pink, grayish
2.	Texture	Equigranular	Porphyritic	Equigranular
3.	Essential Mineral	Quartz Orthoclase Feldspar	Quartz Orthoclase Feldspar	Orthoclase & plagioclase feldspar
4.	Accessory Mineral	Biotite Mica Hornblende Plagioclase feldspar	Biotite Mica Hornblende Plagioclase Feldspar	Quartz Biotite Mica Hornblende
5	Classification	Plutonic Acidic	Hypabyssal Acidic	Plutonic intermediate
6	Spec. Gravity	2.6	2.6	2.6
7	Crushing strength	Very High	High	High
8	Uses/ Importance	monumental, flooring & wall panels	Flooring & cladding material	Crushed stones for concrete aggregates & road metals
Name of the Rock		**GRANITE**	**GRANITE PORPHYRY**	**SYENITE**

Sl. No	Phy. Pro. of Rocks	4	5	6
1.	Color	Pink, Reddish brown, Brick red, grey	Grayish white	Reddish brown, brick red
2.	Texture	Porphyritic	Equigranular	Porphyritic
3.	Essential minerals	Orthoclase Feldspar Plagioclase Feldspar	Plagioclase feldspar Hornblende	Plagioclase Feldspar Hornblende
4.	Accessory Minerals	Biotite Mica Hornblende Quartz	Quartz Biotite mica	Quartz Biotite Mica
5	Classification	Hypabyssal Intermediate	Plutonic intermediate	Hypabyssal Igneous
6	Spec. Gravity	2.6	2.8	2.8
7	Crushing strength	High	High	High
8	Uses/ Importance	Crushed stone for concrete aggregates, road metals	Dimension stone, concrete aggregates	Ornamental, concrete aggregate, dimension stone
Name of the Rock		**SYENITE PORPHYRY**	**DIORITE**	**DIORITE PORPHYRY**

Sl. No	Phy. Pro. of Rocks	7	8	9
1.	Color	Grey to black	Olive green, greenish yellow	Dark grey to black
2.	Texture	Equigranular	Equigranular	Ophitic
3.	Essential minerals	Plagioclase Feldspar Augite	Olivine	Plagioclase Feldspar Augite
4.	Accessory Minerals	Biotite Mica Hornblende Olivine	Chromite Magnesite Pyrope	Olivine
5	Classification	Plutonic intermediate	Plutonic Ultrabasic	Hypabyssal
6	Spec. Gravity	2.9	3	2.9
7	Crushing strength	High	Medium	Very high
8	Uses/ Importance	Road metal, railway ballast, dimension stone	Ornamental, Dimension stone	Road metals, concrete aggregates, Table tops, paper weight
Name of the Rock		**GABBRO**	**DUNITE**	**DOLERITE**

Sl. No	Phy. Pro. of Rocks	10	11
1.	Color	Dark grey to black	Grayish white, ash grey
2.	Texture	Aphanitic	Vesicular
3.	Essential minerals	Plagioclase Feldspar Augite	Quartz
4.	Accessory Minerals	Hornblende Biotite Mica Olivine	Orthoclase
5	Classification	Volcanic Basic	Volcanic ash
6	Spec. Gravity	2.9	2.4
7	Crushing strength	Low to medium	Low
8	Uses/ Importance	Road metals, fertilizers, floor tiles	Light weight concrete aggregates, Pozzolanic admixture
Name of the Rock		**BASALT**	**PUMICE**

ROCK IDENTIFICATION DATA SHEET - SEDIMENTARY ROCKS

Sl. No.	Phy. Pro. of Rocks	1	2	3
1.	Color	Reddish brown, white, multicolored	Reddish brown, brick red, brown	Reddish brown, brick red
2.	Texture	Clastic (more than 2mm size grained)	Clastic Arenaceous	Clastic fine grained
3.	Mineral composition	Well rounded pebbles of Jasper, Quartz	Quartz, Orthoclase, Muscovite mica	Clay, mud, silt, fine sediments
4.	Cementing material	Fe_2O_3	Fe_2O_3, SiO_2, $CaCO_3$	Fe_2O_3
5	Classification	Mechanically formed, Rudaceous	Mechanically formed clastic Arenaceous	Mechanically formed Argillaceous
6	Spec. Gravity	2.7	2.8	2.6
7	Crushing strength	Medium	Medium	Low to medium
8	Uses/ Importance	Crushed stones for roads, Ornamental, facing stones	Building stones, ornamental, Railway ballast	Bricks, tiles, cement manufacture
Name of the Rock		**CONGLOMERATE**	**SANDSTONE**	**SHALE**

Sl. No.	Phy. Pro. of Rocks	4	5
1.	Color	White, Pink, grey,	Reddish brown, brick red
2.	Texture	Non-clastic, massive	Concretionary porous, fine grained
3.	Mineral composition	Calcite, chert, clay	Clay, Iron oxide, Aluminium oxide
4.	Cementing material	$CaCO_3$	Iron Oxide
5	Classification	Chemically formed	Residual deposited
6	Spec. Gravity	2.7	2.8
7	Crushing strength	Medium	Medium
8	Uses/ Importance	Toothpaste, flux in cement industry, Road metal	Aluminium-rich laterite, ore of iron, road metal
Name of the Rock		**LIMESTONE**	**LATERITE**

METAMORPHIC ROCKS

Sl. No.	Phy. Pro. of Rocks	1	2	3
1.	Color	Grey, banded	Greenish grey	Grey, green, red
2.	Texture	Foliated, Gneissose	Foliated, Schistose	Schistose, fine grained
3.	Essential minerals	Quartz Orthoclase feldspar Plagioclase feldspar	Chlorite, Muscovite, Biotite, Talc, Kyanite	Quartz Sericite
4.	Accessory minerals	Biotite mica Hornblende	Actinolite, Tremolite, Hornblende	Biotite, Muscovite, Talc
5	Classification	Dynamic	Dynamic	Dynamic
6	Spec. Gravity	2.7	3	2.9
7	Crushing strength	Very high	Very low	Medium
8	Uses/ Importance	Road metals, railway ballast, Pillars, slabs	Week nature & cannot be useful for civil works	Roofing, switch boards, mosaic, interior & sanitary works
Name of the Rock		**GNEISS**	**SCHISTS**	**SLATE**

Sl. No.	Phy. Pro. of Rocks	4	5	6
1.	Color	White, pink, red, green, yellow, brown	White, grey, pink, brick red	White, grey
2.	Texture	Non-foliated, granulose	Non-foliated, granulose	Foliated
3.	Essential minerals	Calcite	Quartz	Muscovite mica Chlorite
4.	Accessory minerals	Biotite, Tremolite, Garnet, Talc	Mica, Iron ore	Hornblende, Biotite, Feldspar, Garnet
5	Classification	Thermal	Regional or thermal	Dynamic
6	Spec. Gravity	2.7	2.7	2.6
7	Crushing strength	Medium	Medium	Very low
8	Uses/ Importance	Architectural, Ornamental, Decorative, Monumental, Flooring	Crushed stones, concrete aggregates, railway ballast, glass making, road metals	Cannot be used for civil works because of its week nature, but as slabs
Name of the Rock		**MARBLE**	**QUARTZITE**	**PHYLLITE**

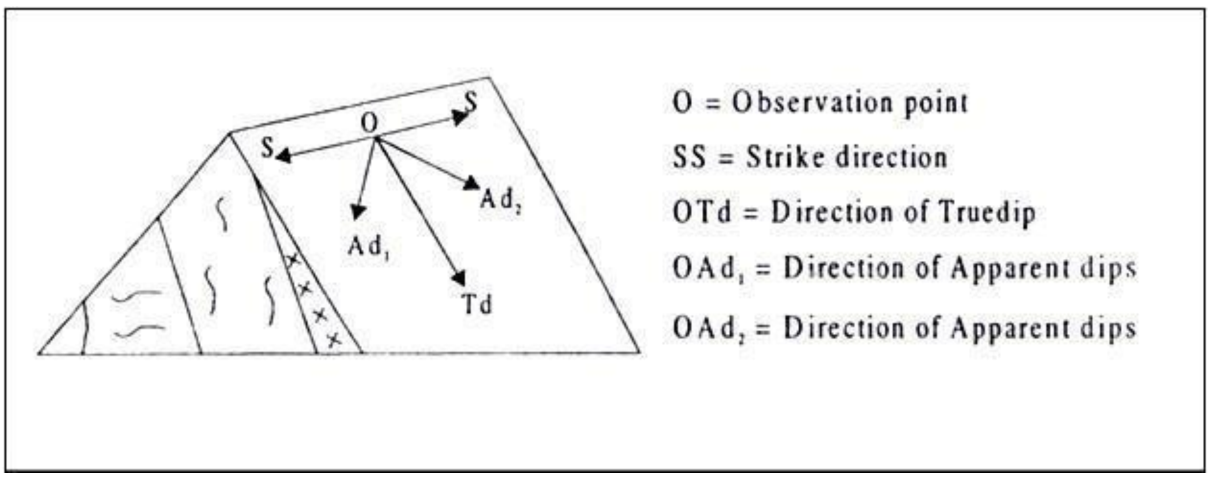
3 Structural Geology

Geological Maps: Geological Map is the computations of dip, strike and other measurable structural parameters of rock masses by geometrical or trigonometric methods. Geological maps are useful to determine the geology of an area, comprising of the rock formations, their three dimensional configuration, thickness and sequence at or below the ground surface, which are the most important geological data for planning and execution of earth works, cuttings, grading, quarrying, underground works and improvement of site conditions, design construction and maintenance of complex engineering structures.

Dip and strike of an outcrop of rocks at the surface are measured with the help of an instrument called „**Compass clinometers**". Dip and strike of underground rock masses are computed from test bore hole data.

Dip: It is an inclination of the rock strata with respect to horizontal plane. It is measured both in the amount of inclination and direction of inclination. There are two types of dips.

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 true dip direction.(Note : Td is always greater than Ad)



Strike : The line of intersection of the inclined strata with the ground surface or an imaginary horizontal plane.

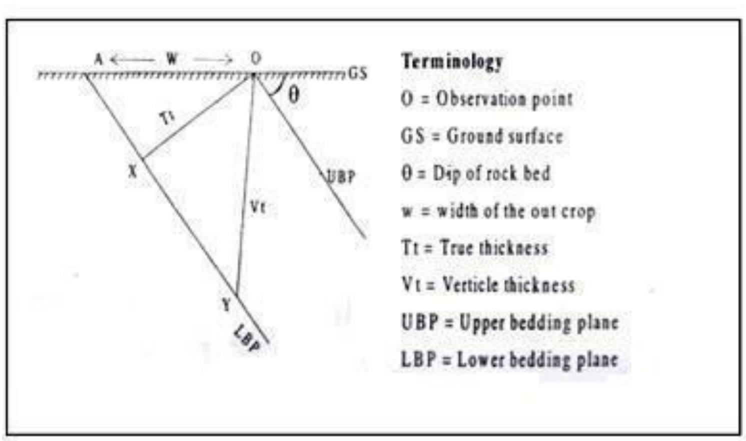
Laboratory Exercises

1. Thickness of Beds (Thickness problem)

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.

i. ***True thickness (Tt):*** Thickness of beds is measured perpendicular to the bedding planes.
ii. ***Vertical thickness (Vt):*** Thickness measured vertically downwards between the bedding planes in case of inclined and folded beds.
iii. ***Width of Outcrop (WoC):*** The beds may be exposed at the surface, so that their thickness is measured directly by a measurement tape.

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 data obtained from a geological map or field measurement by drawing the geological sketch graphically to scale and it is called **Graphical method** Or calculated with the help of trigonometric expressions called the **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 out crop (W), 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 sinθ**
2. **Vt = W x tanθ**
3. **Tt = Vt x cosθ**

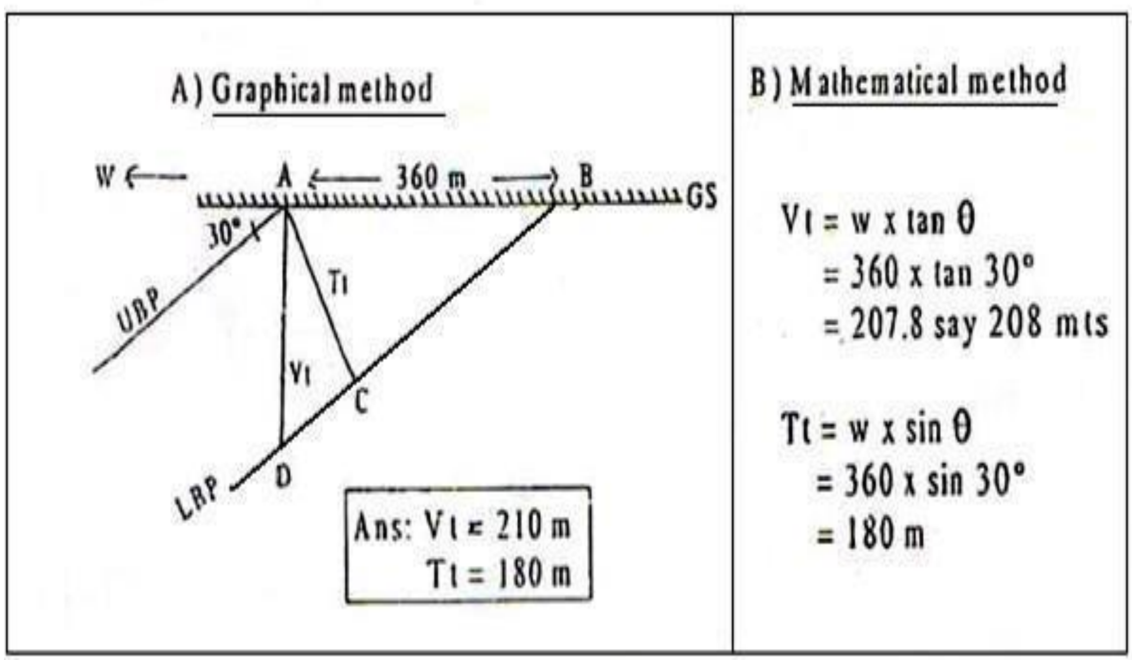
In graphical methods, figures are drawn to a convenient to obtain solutions.

On Level Ground

Type I : Date given – W, (Da) & (Dd)
To determine- Tt & Vt

Example: 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 : 1 cm =100m

Procedure - At a dam site, a bed of sand stone is exposed on horizontal ground: Draw a horizontal line. Measure and mark AB equal to width of outcrop given. Construct 30° angle towards west at A and B. Draw a perpendicular to the lower surface from A. It intersects the Lower
bedding plane at C. Measure AC. It is the True thickness (Tt) (From fig 180m). Draw a perpendicular to AB
downwards from A. It cuts the lower bedding plane at D. Measure AD. It is the vertical thickness (Vt) (from fig .210m)..

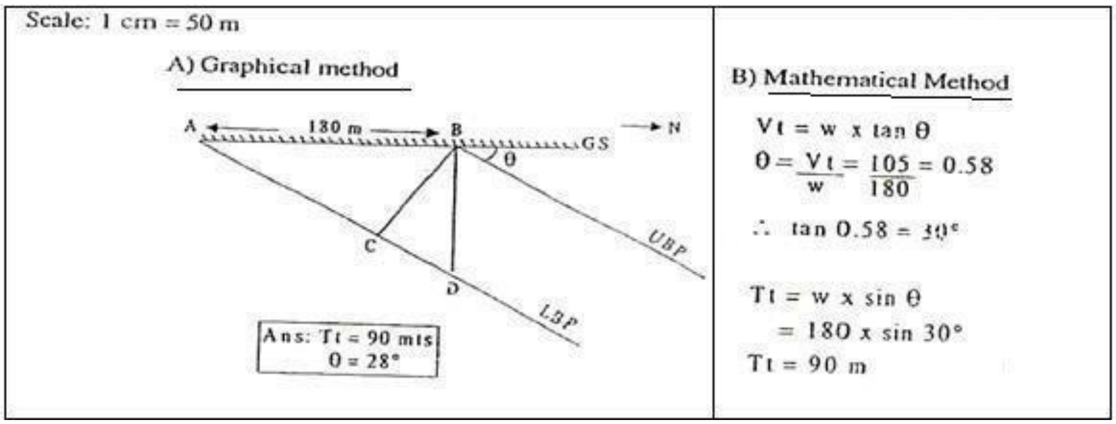


Type II: Date given – Vt + W + (Dd)

To determine –Tt + (Da)

Example : A coal seam is exposed on a level ground. It dips towards North. Its width of the out crop is 180 m. A bore hole sunk from its upper bedding plane touches the lower bedding plane at a depth of 105 m. Determine its true thickness and amount of inclination.

Scale : I cm = 50m

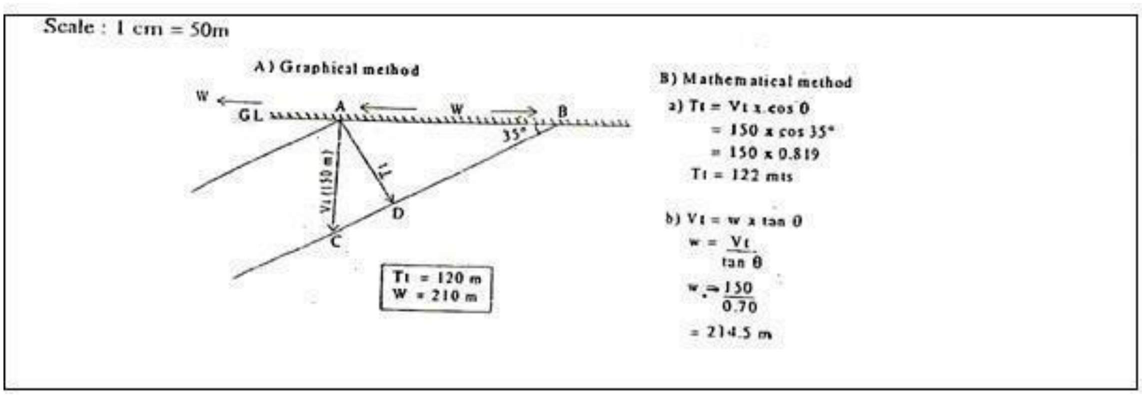


Type III : Data given – Vt & D(a) & (D)

To determine –Tt & W

Example: A vertical bore hole sunk from the upper bedding plane of a shale bed reaches the lower bedding depth of 150m. It dips 35^0 towards west. Determine its true thickness and width of the crop on level ground.

Scale : 1 cm = 50m



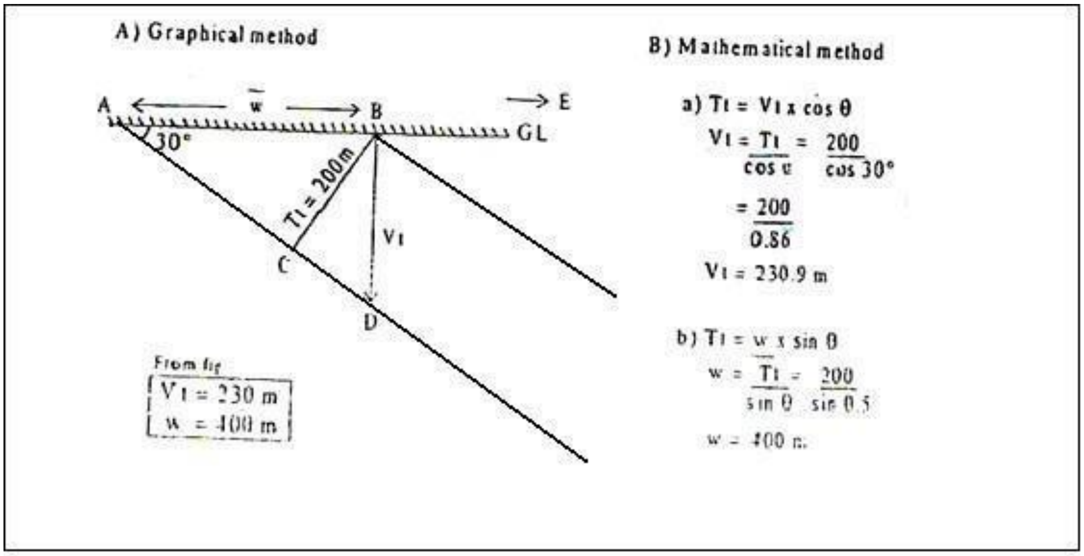
Type IV : Data given – Tt & D(a) & D(d)

To determine: Vt & W

Example: On a horizontal tunnel, a bed of sandstone dips 30^o eastward. Its true thickness is 200m. Determine its vertical thickness and width of the out crop in the tunnel

Scale: 1 cm = 100m.

A) Graphical method B) Mathematical method



PROBLEMS

1) At a dam site, a bed of sand stone is exposed is on horizontal ground, It dips 35^o towards East and its width of out crop is 240m. Determine its true thickness and vertical thickness (Ans: =VT-170m. TT = 140m)
2) A bed of limestone is exposed on a horizontal tunnel, its width of outcrop is 200m and it dips at 25^o Eastward determine true thickness and vertical thickness (TT=85m, VT=93m)
3) A coal seam has a inclination of 28^o along north and its W O C is 180 m find its true thickness and vertical thickness (TT=84m,and VT=96m)
4) A Sandstone layer is exposed on a level ground in reservoir site, A vertical bore hole is sunk and it touches the upper bedding plane at a depth of 50m and its lower bedding plane at 260m, Its W O C is 360 m and dips towards East determine true thickness and amount of its inclination (TT=180, Dip=30^o)

5) A limestone bed has its vertical thickness of 130m and its W O C no level ground is 240m determine its true thickness and amount of dip (TT=114m, Dip=28^o)

6) A bridge site is exposed on a level ground, it dips 40^o North and its true thickness is 180m determine its vertical thickness and W O C (W O C=280m, VT=230m)

7) A bed of shale 60m thick dips 25^o north in a railway cutting , determine its VT and W O C (VT=66m,WOC=142m)

8) A coal seam has vertical thickness of 24m and it dips 30^o south determine its TT and W O C (TT=21m, WOC=42m)

----

1) A coal seam dips 35^o East and slope of 25^o East, it has W O C 240m Determine its TT and VT (VT=48m, TT=36m)
2) A bed of shale Dips 40^oEast and slope of 25^oEast and its W O C is 480m determine iet TT and VT (VT=170m, TT=130m)

----

1) Sand stone bed with a slope of 20^o East and it dips 30^o West, its width of out crop is 150m determine its TT and VT (VT= 130m, VT=110m)

2) A marl bed is exposed with a slope of 20^o South and W O C is 120m Determine its TT and VT (TT=90m, VT=100m)

3) A Conglomerate bed dips 30^o East and Slope of 10^oWest , width of outcrop I 100m, Determine the TT and VT (VT =75m, TT=65m)

4) A laterite is exposed with a slope of 25^oEast and Dip of 35^oWest and W O C is 160m, Determine its TT and VT (TT=170m, VT=140m)

DIP AND STRIKE PROBLEM

Type – I : Date given – Amount and direction of true dip and apparent dip direction.

To determine – Amount of apparent dip.

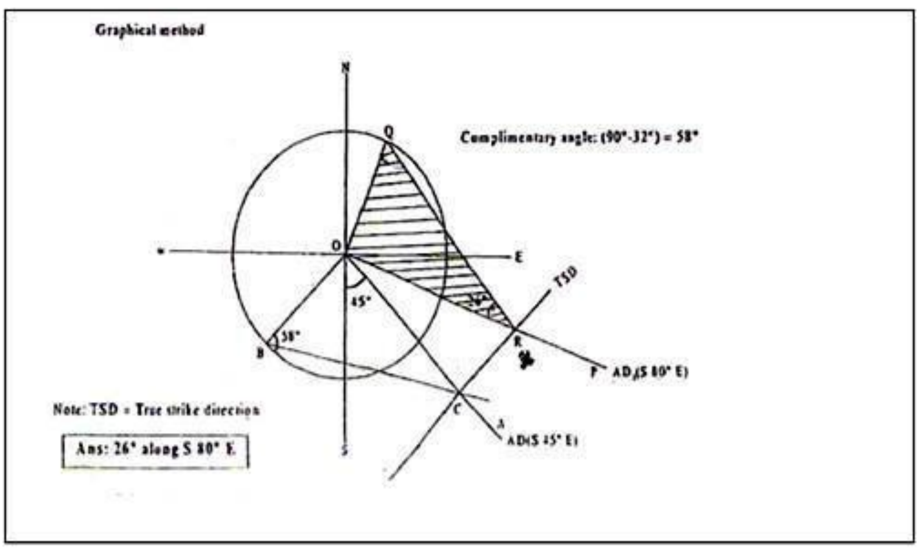
Example : A bed of Shale is dipping maximum of 32º along S-E Find the amount of its inclination along S80º E.

Note: CI = 2.5 cm . Scale: 1 unit= 1 cm.

Graphical method

Procedure : Draw N-S and E-W lines. Let them intersect at O. Draw a **vector circle (2.5 cm. ie.** radius). Draw true dip directional line A along S-E. Draw a perpendicular to OA at O. It cuts the circle at B. Construct complementary angle to true to dip (90º-32º) =58º at B. It cust OA line at C. Draw a perpendicular to OA at C. It is true strike direction (TSD).

Draw apparent dip direction to OA at O. It cuts TSD line at R. Draw perpendicular to OP at O. It cuts the circle at Q. Join QR measure angle LORQ and it is 26º



[Ans: Therefore Amount of apparent dip along S 80º is 26º]

Type-II : Data given -2 apparent dips, amount and direction.

To determine- True dip amount, direction.

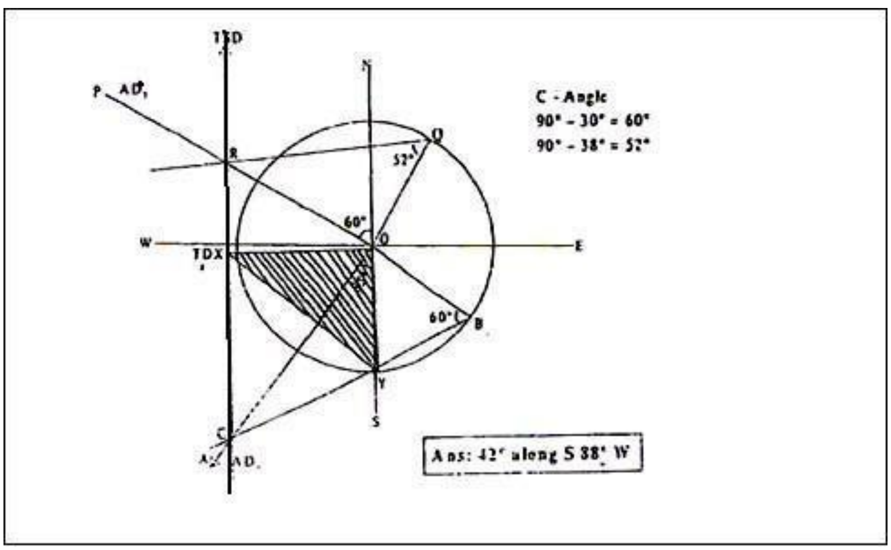
Example: A bed of Sandstone dips 30° along N60° W and 38° along S 25°W.Determine its true dip and strike.

Scale: 1 unit= 1cm.

Procedure : Draw N-S and E-W lines. Let them intersects at O. Draw a vector circle O as its centre with radius (CI = 2.5) 2.5 cm.

Draw OA along apparent dip direction S25° W (AD_1). Draw a perpendicular to it at O. It intersects the circle at B. Construct complementary the given apparent dip (90°-38°) =60° at B. It OA at C. (CB).

Similarly draw OP along apparent dip direction N 60° W (AD_2). Draw a perpendicular to it at O. It cuts the circle at Q. Construct complementary the given apparent dip (90°-38°)= 52° at Q. It cuts OP line at R.It forms the True strike direction (TSD). To determine angle for the direction of true dip, draw a perpendicular to TSD from O. It cuts the TSD line at X. OX is the direction of true dip. Measure angle LSOX. It is S 88° W. To determine the amount of true of true dip along OX deaw a perpendicular to it at O. It cuts the circle at Y. Join xy. Measure LOXY, It is 42°.



[Ans: True dip= 42^0 along S 88° W]

Type III:Data given –True dip amount & direction and Apparent dip amount.

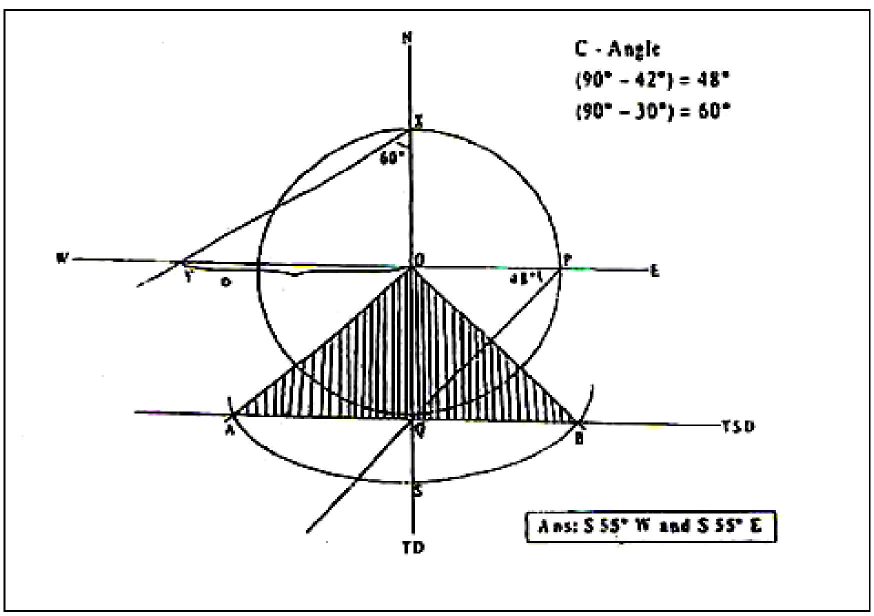
To determine- Apparent dip directions.

Example : A coal seam is overlying Sandstone and has a maximum dip of 42^o towards South. Two inclined tunnels are proposed on the upper bedding plane of Sandstone to have an inclination of 30^o. Determine the directions of the tunnels.

Scale: 1 unit=1 cm.

Procedure: Draw N-S & E-W lines. Let them intersects at O. Draw the vector circle (2.5 cm. as radius).Draw the true dip directional line along OS. Draw a perpendicular to at O. It intersects the circle at P.Construct complementary angle of the true dip (90^o-30^o) =60^0 at P. It cuts OS line at Q. Draw perpendicular to OS at Q. It forms true strike direction (TSD).

To Plot the direction of apparent dip, select ordinarily any suitable direction. Let us take OW. Draw perpendicular to ON. It cuts the circle at X. Construct the complimentary angle of apparent dip (90^o-30^o) =60^o at X. It cuts OW line at Y angle LOYX is 30^o. With O as centre and OY as radius. Draw a Circle to cut TSD line at A and B. Join OA & OB. Measure angle LSOA and LSOB. They are S 55^o W & S 55^o E.



[Ans: Directions of tunnels are S 55^o W and S 55^o E]

Type IV : Data given –Strike, amount & direction of apparent dip

To determine- The amount and direction of True dip.

Example: A limestone formation is striking in a hill side N 35^o W and shows an apparent dip of 22^o in A direction N 80^o W in near by exposure. Find the amount and direction of its true dip.

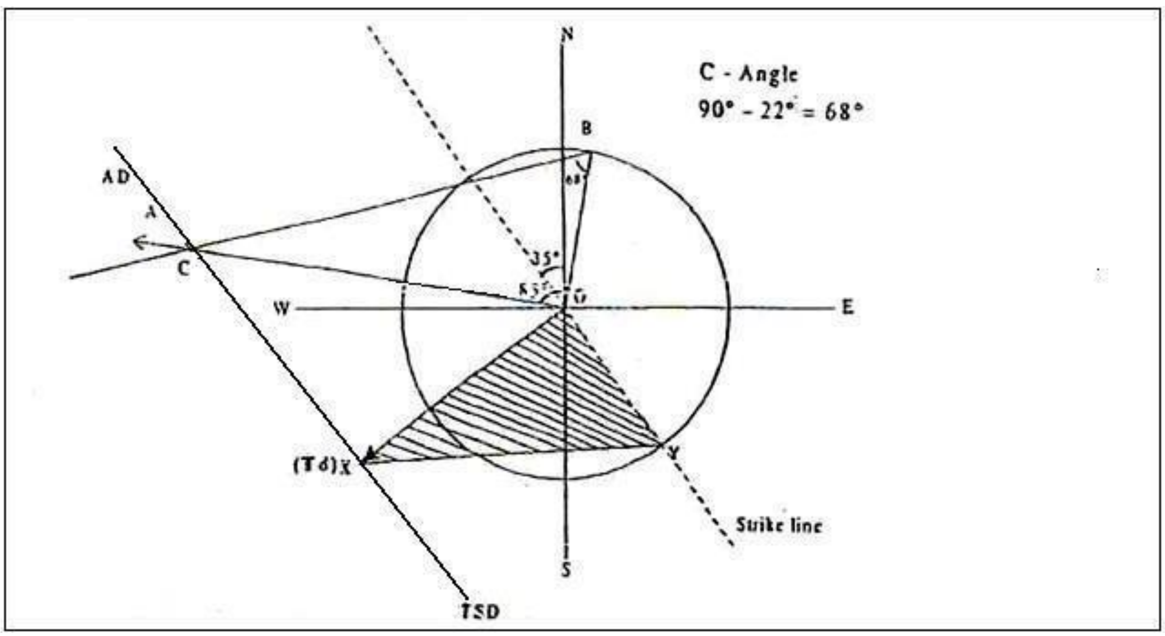
Procedure: Draw NS and EW lines. Draw a circle O as centre (CB-2.5cm.)

Draw the strike direction given N 35^o W.

Draw OA along apparent dip direction of given 22^o along N 80^o W.Draw perpendicular to OA, it cust Circle at B. Construct complimentary angle (90^o-22^o)=68^o at B. It cust OA line at C. Join BC. IS the apparent dip slope.

Draw a lower parallel strike through C.

Draw OX, perpendicular to the strike line with an arrow. OX is the direction to true dip. Draw OX. Perpendicular, it cuts circle at Y. Join YX. YX. is the true dip slope. Measure angle LOXY, which is the amount to true dip. Measure angle LSOX, which is the direction of true dip.



[Ans: True dip = 35^o along S 55^o W]

Problems

1) A bed of limestone dips **35°along S30°E** and **30°along S35°W** find its **True dip** [38°along S16°E]
2) S St formation apparent dip **20°along S85°W** and **30°along S50°E** find **True dip** [50°along S10°W]
3) A coal seam dips **33°along S70°E** and **38°along S20°E** Determine its **True dip** [46°along S60°E]
4) A bed of limestone dips **20°along S25°E** and **25°along N60°E** find its **True dip** [31°along S76°E]
5) A bed of limestone dips **38°along N38°E** and **25°alongN40°W** find its **True dip** [40°along S17°E]
6) A coal seam dips **42°along S70°E** and a tunnel is proposed along **S30°E** find the inclination [35°]
7) A coal seam dips **20°along S50°W** and a tunnel is proposed along **S70°W** find the inclination [19°]
8) A Sand stone dipping **40°along N60°E** find the apparent dip along **S80°E** [32°]
9) A Sand stone dipping **35°along N30°E** find the apparent dip along **N80°E** [25°]
10) A Sand stone dipping **37°along S70°E** find the apparent dip along **S25°E** [27°]
11) A bed has True dip **40°along S80°E** find the directions where amount is **18°**[S13°E &N35°E]
12) A bed has True dip **40°along S40°E** find the directions where amount is **16°**[N31°E &S70°W]
13) A bed has True dip **45°along S30°W** find the directions where amount is **28°**[S88°W &S28°E]
14) A bed has True dip **35°along N45°E** find the directions where amount is **20°**[N14°W&S78°E]
15) A bed has True dip **30°along N35°E** find the directions where amount is **12°**[S76°E&N33°W]

BORE HOLE PROBLEMS

In order to determine the subsurface geology of an area, boreholes are sunk at convenient places. In areas such as cultivated lands, forests, alluvium etc., the surface is completely covered and out crops are rarely exposed. In such places, boreholes reveal the presence of economic mineral deposits, coal, petroleum etc. The subsurface geological formations. rock Types and their dip and strike can be determined from such bore hole data, which render very Valuable information for planning and exploiting the hidden treasures.

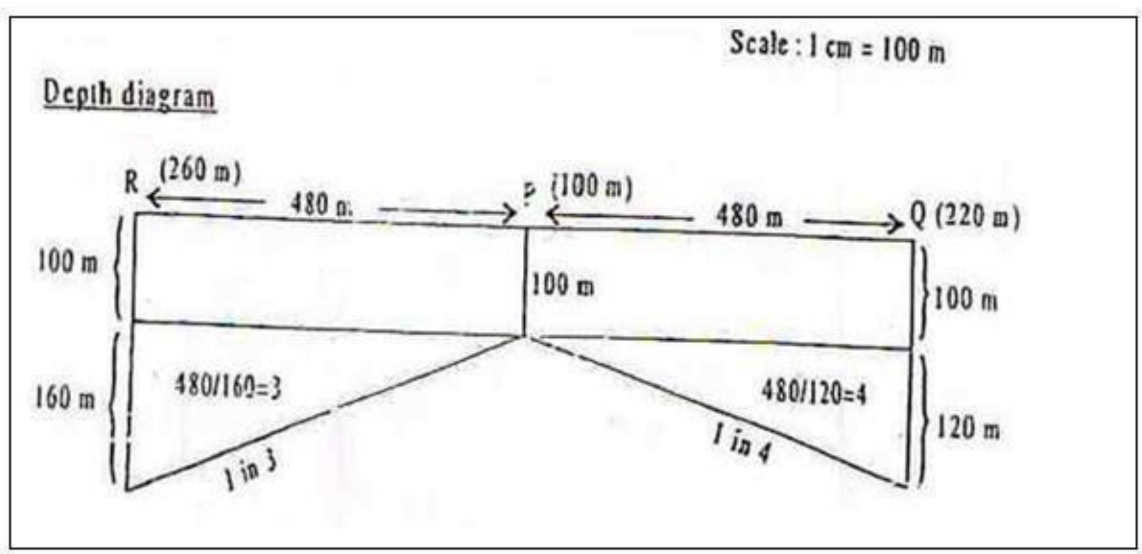
Bore holes sunk on horizontal ground:

Triangular method

Example: Three bore holes are sunk at 3 points of an equilateral triangle, whose are 480m each. P is west Q and R is midpoint PQ. Bore holes P,Q & R reach the upper surface of a rich coal at 100m, 220m and 260m depth respectively.

a) Determine the attitudes (dip and strike) of the coal seam

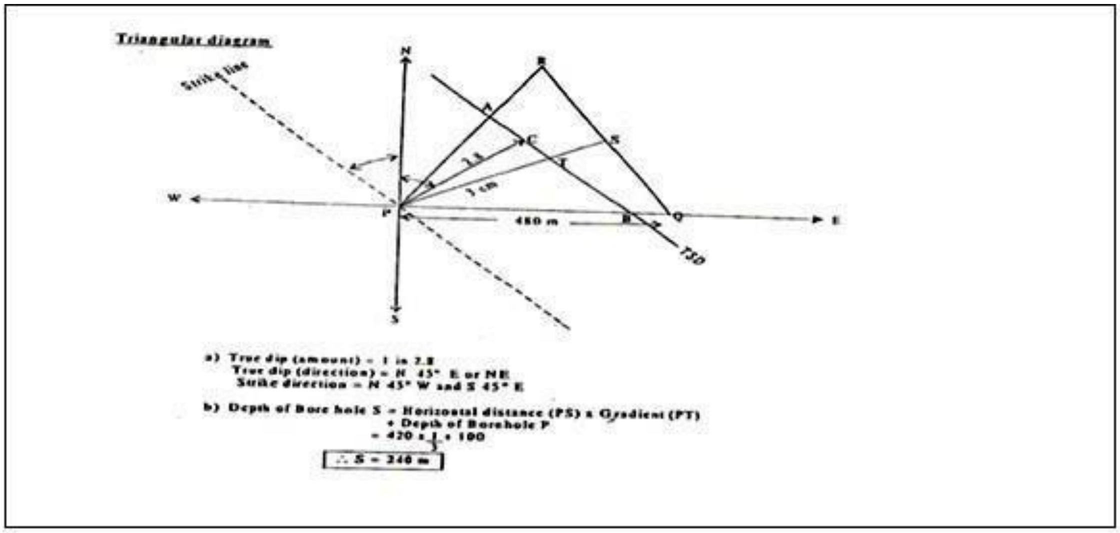
b) Another bore hole is sunk at „S‟ midpoint of QR. Determine at what depth the bore hole „s‟ reaches the same coal seam.



Procedure : Construct an equilateral triangle with suitable scale. Show the position of the bore holes. The coal seam is reached at P and Q at 100m and 220m. So the coal seam dips from P to Q. To determine the inclination (gradient) along PQ. Construct rough sketch depth diagram along and Determine the gradient.It is 120m in 480m. So it is 1 in 4. Similarly construct depth diagram along PR. It is 160 m in 480m. ie. 1in 3. Take convenient scale and mark 4 units (cms) along PQ and 3 units (cm) along PR from P. They are A & B. Join and extend. It is the true strike direction (TSD) Draw perpendicular from P to TSD. It cuts AB line at C. Join and measure PC. It is 208 cm ie. Gradient is 1 in 2.8. It is true dip.

To determine the direction of true dip, measure the angle NPC= 45^{o}. So direction of true dip is the complimentary angle from North direction. So (90^{o}- 45^{o}) =45^{o}. So it is N 450 E or NE.Strike is perpendicular to TD is N 45^{o} W= S 45^{o} E.

To determine the depth at white the bore hole „S‟ reaches the same coal seam, join PS.It intersects AB line (TSD) at T. Measure PT ie. 3cm. So the gradient along PT is 1 in 3. Measure PS (horizontal distance) It is 4.2cm =420m.



Depth of bore holes at S=(Horizontal distance(PS) x gradient(PT)+Depth of bore hole P.

S= (420x1/3)+100

S = 140 + 100

S=240 m

To check, whether this calculation is correct 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.

Depth of borehole at S = (240 x1/12)+220

S =20 + 220

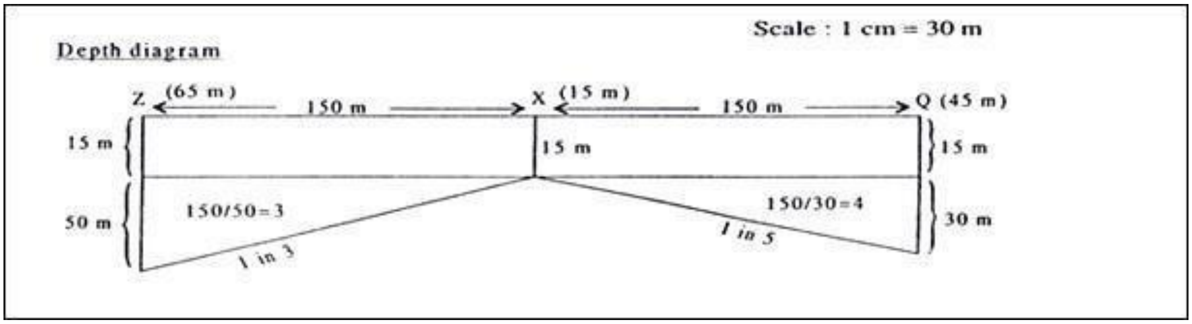
:. S =240m

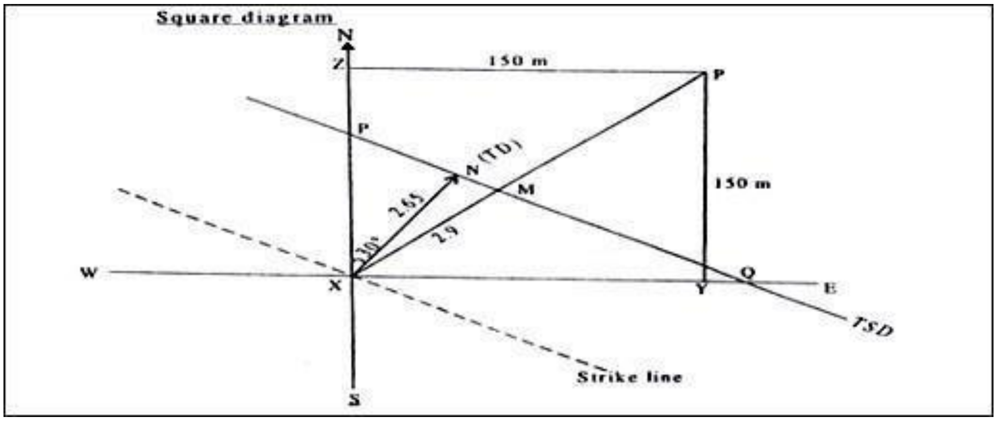
Square method:

Example: Three bore holes are sunk at SW. SE & NW corners of a square level ground. The sides of the square are 150m long. The bore holes are X,Y & Z respectively. The coal seam in Met by the bore holes at 15m is X, 45m in Y and 65m in Z.

a) Determine the attitude of the coal seam.

b) Fourth bore hole P is proposed at the NE corner of the square land. Calculate at what depth the bore hole P is encounters the same coal seam.





True dip = 1 in 2.65 along N30° E, Strike = N60° W and S 60° E.

Let us determine the gradient of coal seam along XP. Join XP, it cuts TSD line at M. Measure XM = 2.9. The gradient is 1 in 2.9 To calculate the depth at „P", measure XP. It is (6.5 x 30m) =195

: Depth at P = Horizontal distance (XP) x gradient (XM) + Depth of bore hole at X.

P = (195x1/2.9) + 15m

P = 82.2 m

EXERCISES

1) ABC are the three bore holes sunk at the three corners of an equilateral triangular grid with sides measuring 1200mts, B is east of C and A is north of midpoint between BC, The depth of coal seam is 100, 180, and 220m at ABC respectively
   a) Determine the attitudes.
   b) Another borehole D is proposed at the midpoint of the triangle, find the depth at D.

2) Three bore holes are sunk at the corners of isosceles triangles. The base AB is east-west 400m. A is west of BC bore hole is 500m from A &B, and North of the midpoint of AB. The bore holes touch the oil bearing stratum in A at 30m. B at 80m. and C at 130m.

Determine the attitude of the oil bearing stratum.

Another bore hole „D" is proposed at midpoint of BC. Calculate at what depth the same oil bearing stratum is met at D.

3) Three bore holes PQR are sunk at three corners of an equilateral triangle on a level ground. The sides of the triangle are 240m. Q is situated west of R & P 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 a coal seam.

b.) Another bore hole is proposed at „S" the midpoint of QR. Calculate at what depth the proposed bore hole reaches the same coal seam.

4) Three bore holes are sunk at the corners of isosceles triangles. The base AB is east-west 400m. A is west of BC bore hole is 500m from A & B.and North of the midpoint of AB. The bore holes touch the oil bearing stratum in A at 30m.B at 80m and C at 130m. **a)** Determine the attitude of the oil bearing stratum. **b)** Another bore hole „D" is proposed at midpoint of BC. Calculate at what depth the same oil bearing stratum is met at D. (Ans: Td = 1 in 4.8 along N 23^{o} E , Strike = N 70^{o} W and S 67^{o} E Depth = 105m)

5) Four bore holes are proposed at ABCD at the corners of a featureless square land. The sides of the square land are 800m long A is North of B and C is East of A, and D is south of C,.A coal seam is encountered in A at 100m, B at 300m and C at 200m depth, respectively

   a) Determine the attitudes of the coal seam.

   b) Find out at what depth of formation is expected in D bore hole

   (Ans: True dip = 1 in 3.6along S 29^{o} E. Strike =N 61^{o} E & S 61^{o} W. Depth: 400m).

Geological Maps

Introduction: Geological maps are plan views of areas on the surface of the earth showing out corps of rocks beneath their trend and structural attitude to scale. Although the rock bodies may be covered by soil, vegetation etc. These maps are usually superposed on topographic maps, which indicate the ground features of the area with contours.

Geological maps represent:

Topography i.e. the configuration (the elevation and depressions) of ground surface

Geological conformation of the area in which the elevations are reduced to the two dimensional horizontal plane of the paper or aerial photo. The elevations are indicated by contour lines or spot levels. Thus geological maps and sections together provides for a three dimensional visualization of the site, geological conditions and an excellent guide to detailed site investigation for engineering construction, both surface and underground and land utilization problems.

Topographic features in Geological maps

1. Topograhy: The principal topographic features deposited in the geological maps are elevations like hills or mountains, depression like valleys. These are inferred by contour values and patterns.

2. Geology: Rock unit - The basic units of geological map are a rock formation, whose boundaries or contacts can be easily recognized. Each rock unit is designated in the map by name or by standard signs or symbols, color or abbreviation and age.

Age of rock formation : (Order of superposition) According to steno‟s law of order of superposition, geologically younger rock beds always occur at the top of a sequence and in the direction of the dip in case of inclined and deformed series.

<u>Geological structures, outcrop patterns, topographic expressions</u>.

Section line (X Y): A long which section is drawn to scale.

Signs and symbols - Dip and Strike.

Sill: Concordant igneous body parallel to bedding plane.

Dyke: Vertical discordant igneous body with straight cut across bedding plane.

Batholiths: Discordant igneous narrow on top (Surface) and wider in deeper level.

Horizontal beds: Bedding planes runs parallel to topographic contours.

Inclined beds / Vertical beds : Straight / curved outcrops cuts contours lines across.

Folded beds: Beds are folded is anticline/synclinal angle towards/away from center the beds.

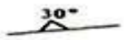
Fault plane (F): Straight heavy shaded line with displacement of beds / Break line with relative displacement

Unconformity: Separation of Older series by younger series.

STEPS FOR DRAWING A CROSS-SECTION

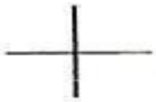
1. Draw a straight line cutting across the contours on the map and mark XY.
2. Take a strip of white paper or graph and place its edge along the XY line.
3. Mark the position and value of every contour that cuts the line XY.
4. Choose a suitable vertical scale, e.g., 1 cm =100 metres, to draw horizontal lines parallel to each other and equal to the length of XY. The number of such lines should be equal or more than the total contour lines.
5. Mark the appropriate values corresponding to the contour values along the vertical of the cross-section. The numbering may be started with the lowest value represented by the contours.
6. Now place the edge of the marked paper along the horizontal line at the bottom line of the cross-section in such a way that XY of the paper corresponds to the XY of the map and mark the contour points.
7. Draw perpendiculars from XY line, intersecting contour lines, to the corresponding line at the cross-section base.
8. Smoothly join all the points marked on different lines at the cross-section base.

Signs and symbols as shown below

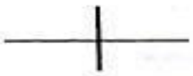


: Dip and Strike

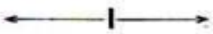
: Amount and direction



: Vertical bed



: Horizontal bed



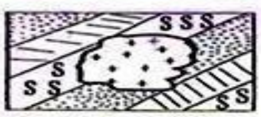
: Anticline

: Syncline

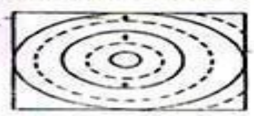
ii) Out crop pattern :

__Sill__ : Heavily shaded, concordant igneous body parallel to bedding plane.

__Dyke__ : Heavily shaded, vertical discordant igneous body with stright or sinuous parallel sides, cut across bedding plane.



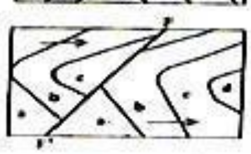
__Batholith__ : Discordant igneous with narrow on top (Surface) and wider in deeper level (depth) . Irregular outline, boundary cuts the bedding planes.



__Horizontal beds__ : Bedding planes runs parallel to topographic contours. Bedding planes and contour lines don't cross each other.

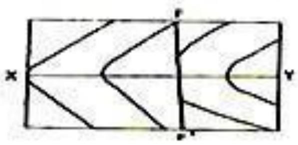
__Inclined beds / Vertical beds__ : Striaght / curved outcrops cuts contours lines across.

__Folded beds__ : Beds are folded in Anticlinal / synclinal at an angle towards the center or away from the centre of the beds.



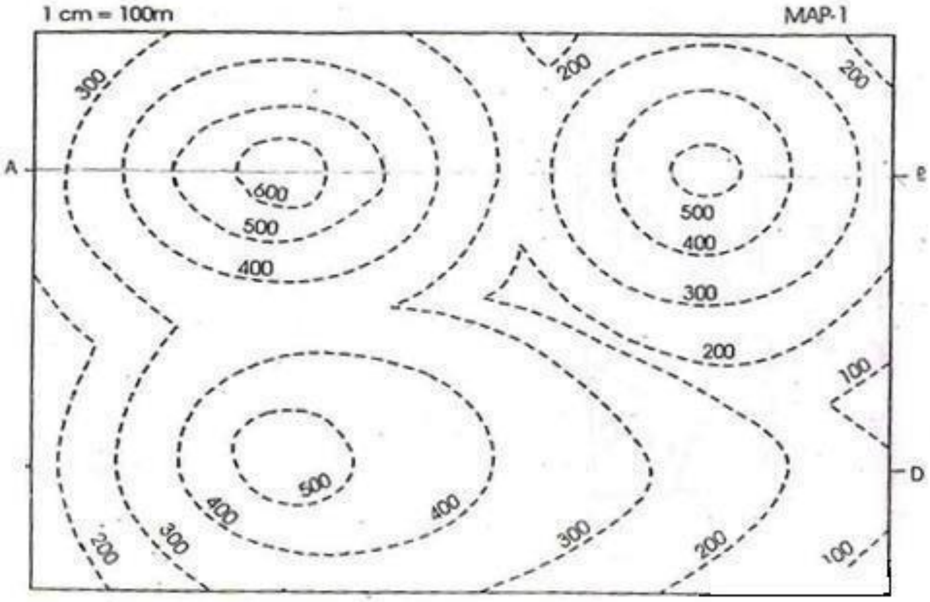
__Fault Plane (F-F')__ : Striaght or Sinuous heavy shaded line with displacement of beds or contacts of different out crops.

__Unconformity__ : Off-set of older (lower) series by younger series. The contact is the erosion surface.



__Section line (XY)__ : Along which section is drawn to scale.

Map no.1:



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

Geological History of Area:

Topography: Section along AB: The section along AB shows two hills three valleys on either side of the hills as shown in fig(i). They have similar slopes on either sides and therefore they are called symmetrical hills 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 a symmetrical hill and valleys.

Inference

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

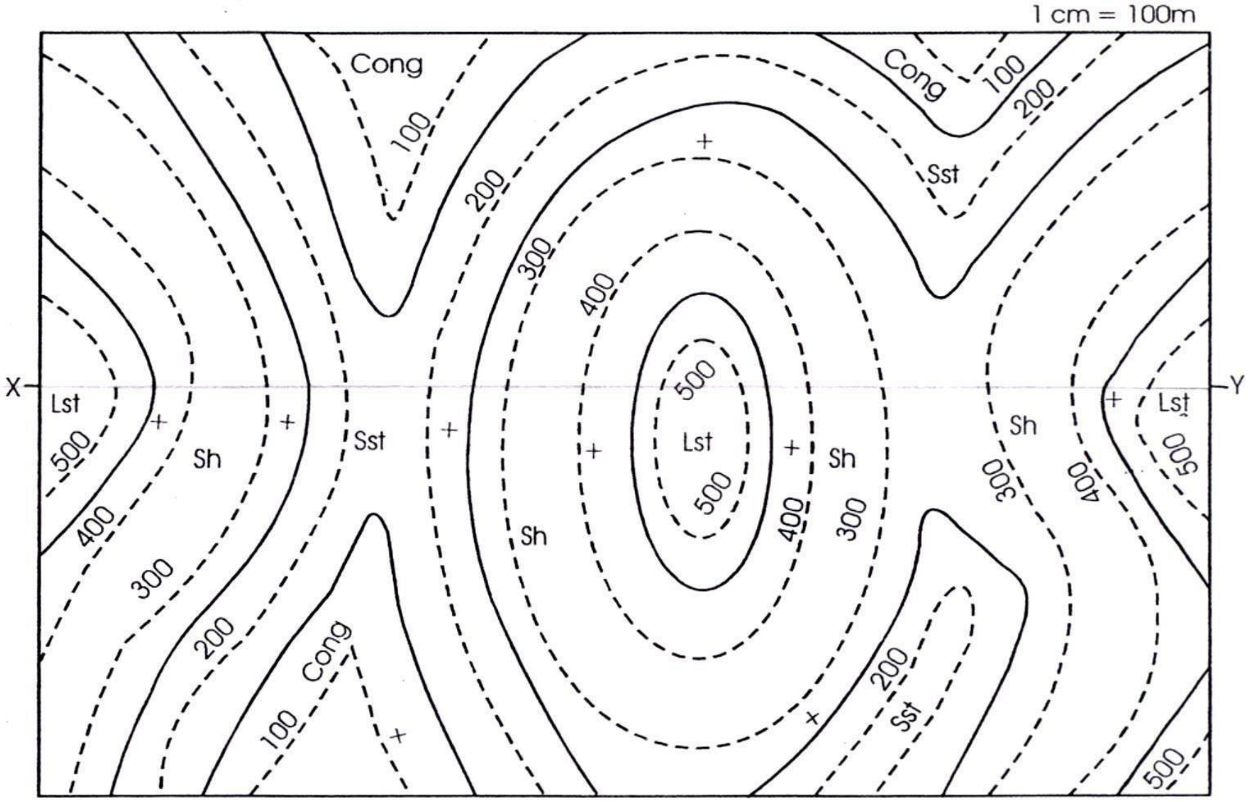
b) When contours of higher value is surrounded by the contours of lower value, it shows a hill feature, on the contrary ,when contours of lower value is surrounded by contours of higher value, it shows a valley features.

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

d) These contours are run at different altitudes, so never intersects one another.

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

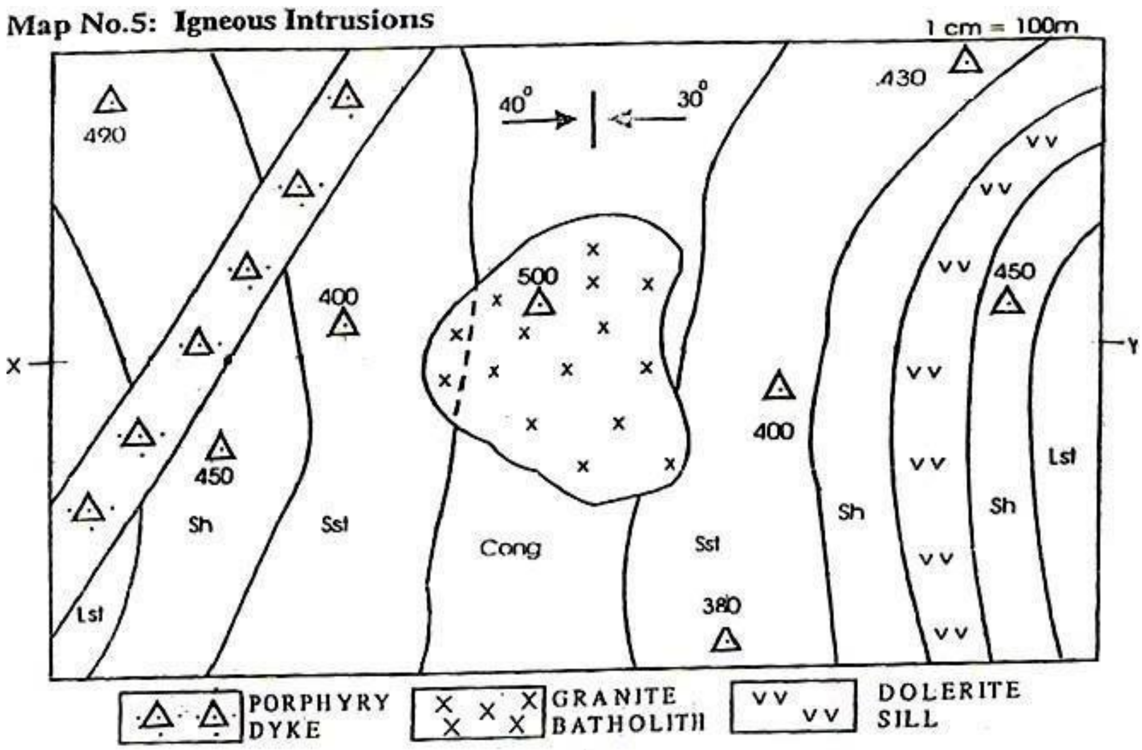
Map no.2: Horizontal Strata



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

b. A dam is proposed outside the eastern border of the map. The horizontal diversion tunnel is planned to divert the river water at an invert level (floor) of 200mts. Up to the western valley in the area. Discuss the feasibility.

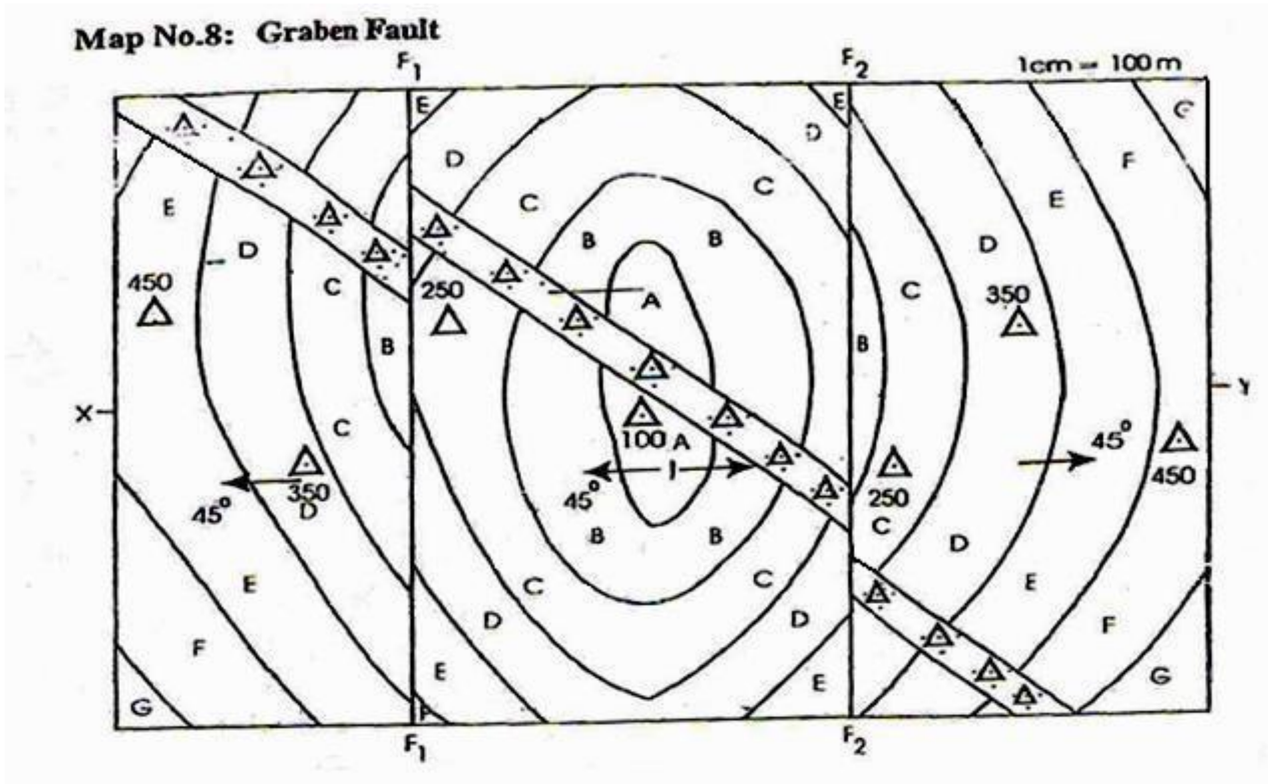
Graphical Method



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

Graphical Method

a) **Draw a geological cross section along XY and describe the geological history of the area**
b) **Determine the downthrow of the fault**
c) **A road is proposed in the map, Comment its feasibility and suggest the precautionary measures**



FF – Faults, Dyke

a) **Draw a geological cross section along XY and describe the geological history of the area**
b) **Find out the order of superposition and structural details**
c) **A horizontal tunnel is proposed at an invert level of 150m. Discuss its feasibility**

Graphical Method

EXPERMENT-6 GEOPHYSICS (Electrical resistivity)

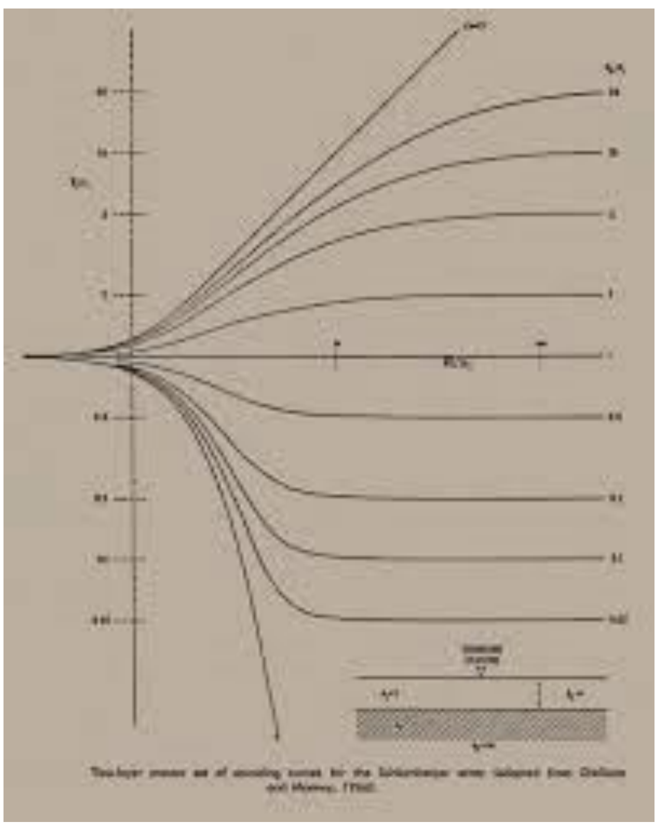
INTRODUCTION

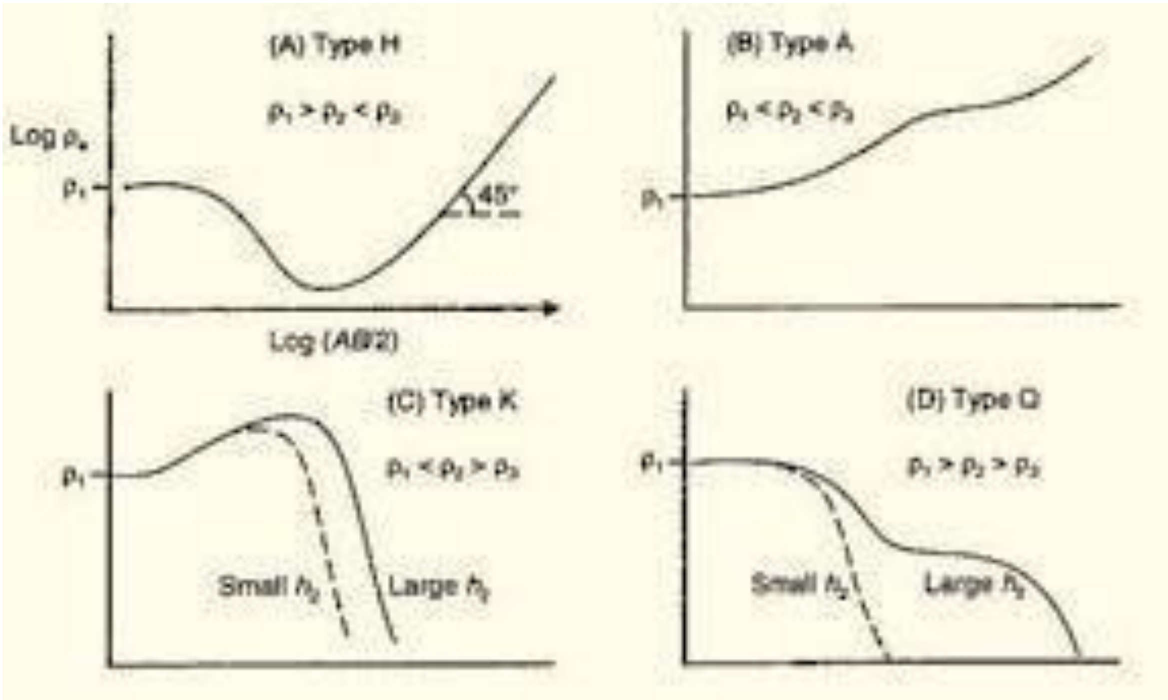
The resistivity method is used in the study of horizontal and vertical discontinuities in the electrical properties of the ground.

● It utilizes direct currents or low frequency alternating currents to investigate the electrical properties (resistivity) of the subsurface.

● A resistivity contrast between the target and the background geology must exist.

In resistivity method of electrical prospecting, an electric field is artificially created in the ground by means of either galvanic batteries (DC) or low frequency AC generators. The energizing current is sent in to the ground by means of two grounded electrodes, called the current electrodes designated as „A" and „B" placed at two selected points. The potential in the area is measured by another two more grounded electrodes 61 called the potential electrodes designated as „M" and „N". Electrical resistivity is defined as the resistance offered by a unit cube ofmaterial for the flow of current through its normal surface. If „L" is the length of the conductor and „A" is its cross-sectional area, then the resistance (R) is defined as R= L/A





Data will be given Electrical resistivity curves drawing and its interpretation for Geotechnical and Aquifer investigations.	**6Marks**
Calculation	2
Graph	2
Result	2

EXPERMENT-7 .1Geomorphology (Toposheet interpretation)
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

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 crystalsystems.

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 theydistinguished?

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.

- Porephyritic – 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, parallelunconformity.

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.

Conglomerato 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.