QMP7.1 D/F

Channabasaveshwara Institute of Technology
(Affiliated to VTU, Belgaum & Approved by AICTE, New Delhi)
(**NAAC Accredited & ISO 9001:2015 Certified Institution)**
NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.

Department of Civil Engineering

ENGINEERING GEOLOGY

BCV303

B.E - III Semester

Lab Manual 2024-2025

Name :_____

USN :_____

Batch :_____ Section :_____

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Aug 2024

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Approved by:

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Dept. of Civil Engg.

“Instructions to the Students”

1. Students should come with thorough preparation for the experiment to be conducted.
2. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.
3. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.
4. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.
5. Practical record should be neatly maintained.
6. They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.
7. Theory regarding each experiment should be written in the practical record before procedure in your own words.

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Course outcomes:

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

1. Apply geological knowledge in different civil engineering practice.
2. Acquire knowledge on durability and competence of foundation rocks, and will be able to use the best building materials.
3. Students will become competent enough for the safety, stability, economy and life of the structures that they construct
4. Able to solve various issues related to ground water exploration, build up dams, bridges, tunnels which are often confronted with ground water problems
5. 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.

Books

1. Engineering Geology, by Parthasarathy et al, Wiley publications
2. A textbook of Engineering Geology by ChennaKesavulu, Mac Millan India Ltd
3. Principle of Engineering Geology, by K.M. Bangar, Standard publishers
4. Physical and Engineering Geology, by S.K. Garg, Khanna publishers
5. Principles of Engineering Geology, by KVGK Gokhale, BS Publications

Reference Books

1. Introduction to Environmental Geology by Edward A Keller, Pearson publications.
2. Engineering Geology and Rock Mechanics B. P. Verma, Khanna publishers
3. Principles of Engineering Geology and Geotechnics, Krynine and Judd, CBS Publications

ENGINEERING GEOLOGY		Semester	3
Course Code	BCV303	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	
Examination nature (SEE)	Theory		

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.

Teaching-Learning Process (General Instructions)

These are sample Strategies; that teachers can use to accelerate the attainment of the various course outcomes.

- Chalk and Talk method.
- Show Video/animation films to explain earth dyanamics and influence of geology in prime civil constructions
- Encourage collaborative (Group Learning) Learning in the class
- Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking.
- Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking process such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Topics will be introduced in a multiple representation.
- Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.

MODULE-1 7 hrs

Introduction, the scope of earth science in Engineering.

Earth's internal structure and composition, internal dynamics and Plate tectonics, Earthquakes - types, causes, so-seismic lines, seismic zonation, seismic proof structures. Volcanic eruption - types, causes. Landslides-causes types, preventive measures; Tsunami – causes, consequences, mitigation. Cyclones - causes and management.

MODULE-2 5 hrs

Earth Materials in Construction

Minerals -Industrial, rock-forming and ore minerals. Physical properties, composition.
Rocks Types, structure/Texture, mineral composition occurrence, properties.
Decorative (facing/polishing), railway ballast, rocks for masonry work, monumental/architecture, Dressing of stones, Requirement of good building stones.

MODULE-3 7hrs

Earth Surface process and Resources

Weathering, type, causes, soil insitu, drifted soil, soil profile, soil mineralogy, structure, types of soil, Black cotton soil v/s Lateritic soil; effects of weathering on monumental rocks. Soil Horizon, Soil Classification by Grain Size.

MODULE-4 7 hrs

Surface and sub investigation for deep foundation

Dip and strike, and outcrop problems(numerical problem geometrical/ simple trigonometry based), Borehole data(and problems), Faults, folds, unconformity, joints, types, recognition and their significance in Civil engineering projects like tunnel project, dam project, Reservoir site,.

MODULE-5 5 hrs

Modern Tools and geophysical methods

Rocks as aquifers, water-bearing properties igneous, sedimentary and metamorphic rocks , coefficient of permeability, factors affecting permeability, Electrical Resistivity meter, depth of water table, (numerical problems), seismic studies.

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl.NO	Experiments 8 hrs
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 use the best building materials.
- Students will become competent enough for the safety, stability, economy and life of the structures 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.

Assessment Details (both CIE and SEE)

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.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

Note: Subject to be taught by Geologist with qualification M. Sc Geology/MPhil/ Ph. D in Geology

Suggested Learning Resources:

Books

1. Engineering Geology, by Parthasarathy et al, Wiley publications
2. A textbook of Engineering Geology by ChennaKesavulu, Mac Millan India Ltd
3. Principle of Engineering Geology, by K.M. Bangar, Standard publishers
4. Physical and Engineering Geology, by S.K. Garg, Khanna publishers
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Reference Books

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2. Engineering Geology and Rock Mechanics B. P. Verma, Khanna publishers
3. Principles of Engineering Geology and Geotechnics, Krynine and Judd, CBS Publications

Web links and Video Lectures (e-Resources):

- **https://www.youtube.com/watch?v=aTVDiRtRook&list=PLDF5162B475DD915F**
- **https://www.youtube.com/watch?v=EBiLLJAxBuU&index=2&list=PLDF5162B475DD915F**
- **https://www.youtube.com/watch?v=sTY-ao4RZck&list=PLDF5162B475DD915F&index=3**
- **https://nptel.ac.in/courses**
- **https://youtu.be/fvoYHzAhvVM**
- **https://youtu.be/aTVDiRtRook**
- **https://serc.carleton.edu/NAGTWorkshops/hazards/events/12262004.html?serc_source=recommendation**
- https://serc.carleton.edu/NAGTWorkshops/visualization/examples/CBezanson.html?sercsource=recommendation
- **https://serc.carleton.edu/NAGTWorkshops/coursedesign/goalsdb/14712.html**
- **https://www.earthsciweek.org/classroom-activities**
- NPTEL materials

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Field Visits
- Quiz/Assignments/Open book test to develop skills
- Encourage collaborative learning in the class
- Demonstration of Geological models and animations
- Hands on experiments with Rock and Minerals

CONTENTS

Chapter 1: MINERALOGY

MINERAL:

Definition: A mineral is a naturally occurring inorganic substance with fixed chemical composition and a regular internal atomic arrangement.

Ex: Quartz – Sio_2 – Hexagonal Crystalline form
Calcite – $CaCo_3$ – Hexagonal – Rhombohedral form

Classification:

Minerals are classified on the basis of chemical composition as follows.

Sl. No.	Name	Examples	Che. Composition
1.	Oxides	Quartz Magnetite	- SiO_2 - Fe_3O_4
2.	Carbonates	Calcite Magnesite	- $CaCo_3$ - $MgCo_3$
3.	Sulphates	Gypsum	- $Caso_4$ $2H_2O$
4.	Sulphides	Iron Pyrites Galena	- Fes_2 - pbs
5.	Silicates	Orthoclase Hornblende	- K Al Si3O8 - Complex Hydrous

Mineral are also classified on the basis of their formations and uses.

1) Rock Forming Minerals:-

Rock forming minerals are those which are found abundance in the rocks of the earth crust.

2) Ore Minerals:-

Ore minerals are those which are of economic values and which do not occur in abundance in rocks.

Physical Properties of Minerals:

Physical mineralogy deals with the various physical properties of minerals the study of which is highly important in the identification of minerals in hand specimens.

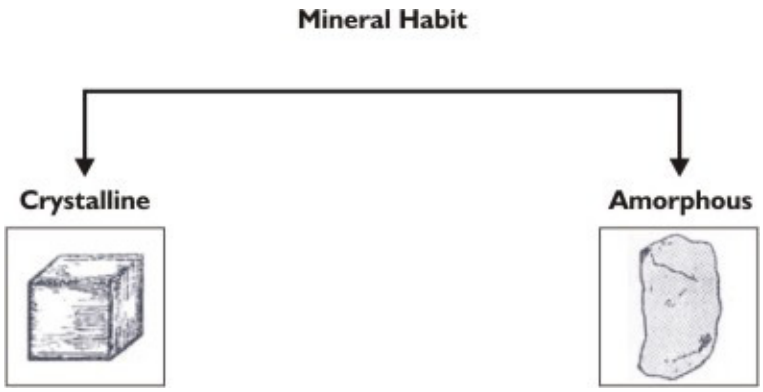
The following are the important physical properties that are helpful in the identification of minerals in hand specimens with the help of some testing tools like Penknife, Magnet, Streak Plate & Dil-HCl.

1. Habit / Form / Structure
2. Colour
3. Streak
4. Luster
5. Cleavage
6. Fracture
7. Hardness
8. Sp. Gravity
9. Diaphaneity

1. Habit / Form:-

Habit / Form is one of the important physical property of minerals, and is defined by its external appearance, which is directly related to is its internal arrangement of their atoms or molecules.

The minerals are divided into two broad divisions. i.e. crystalline, and amorphous based on the internal structure.



1) Crystalline:

Crystalline minerals are those that possess regular internal atomic structure, which under favorable conditions, may be reflected in the development of good geometrical form. Based on the degree of development of crystal faces, the crystalline minerals are further distinguished as:

a) Crystallized b) Crypto crystalline and c) Massive

a) **Crystallized:** Minerals, which show well-developed crystals.

b) **Cryptocrystalline:** Minerals, which show mere trace of crystalline structure are termed cryptocrystalline

c) **Massive:** Amorphous minerals having no definite shape, neither they possess regular internal atomic structure nor good external form.

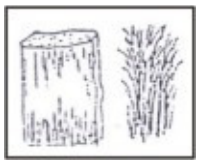
The following are some of the terms used to denote the habits or forms of imperfectly developed crystalline aggregates.

i. Columnar Habit:

A mineral is said to exhibit columnar Habit, when it is developed more along the vertical crystallographic direction resulting in the production of slender columns. The columnar habits are further distinguished as:

1) **Bladed Habit: -** Individual column thin elongated flattened like a knife-blade.

Ex.: Kyanite



2) **Fibrous Habit: -** Consisting of very thin to the size of the fiber.

Ex.: Asbestos

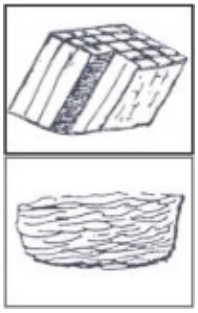
3) **Radiating Habit:-** Needle like columns are radiating from a common center

Ex.: Tourmaline

ii. Lamellar Habit:

A mineral is said to exhibit lamellar habit when developed more along the lateral axes thus producing plates, tablets or leaves.

The lamellar habits are further distinguished as:



1. **Tabular Habit:-** When the lamellae in the form of plates or tablets.

Ex.: Feldspar

2. **Micaceous or foliated Habit: -** When the lamellae are very thin and easily separate.

Ex.: Micas

iii. Granular Habit:

When the mineral is developed equally along the three crystallographic grains, directions producing equidimensional. It is said to exhibit granular habit. The granular habit is further distinguished as course, medium and fine, depending upon the diameter of the grain.

Ex.: Garnet, Chromites, and Hematite.

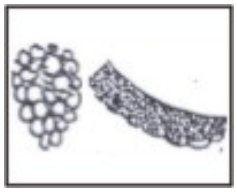
1. **Course granular:** When the diameter of the grain is greater than 5 min.
2. **Medium granular:** When the diameter of the grain range between 5 mm & 1 mm.
3. **Fine granular:** When the diameter of the grain is less then 1 mm.

Forms / Habits of massive minerals:

The following are some of the terms used to describe the imitative forms of the massive minerals.

1) **Reniform Habit:** Kidney shaped, sometimes aggregates.

Ex.: Hematite, Pyrolusite and Limonite

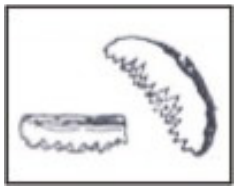


2) **Botryoidal Habit:-** Globular masses so united as to resemble a bunch of grapes.

Ex.: Chalcedony, Hematite

3) **Nodular Habit:-** Spherical, avoid, smooth or irregular masses like river pebbles.

Ex.: Flint, Bauxite

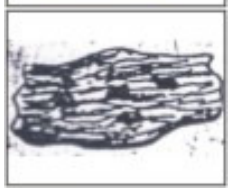


4) **Drusy Habit:-** Small / Large crystal lining the walls of cavities or projecting from an amorphous or banded base.

Ex.: Drusy Quartz.

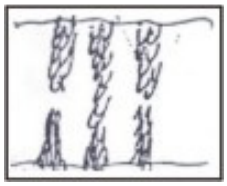
5) **Dendritic Habit:** Branching twigs plant tree like shaped.

Ex.: Pyrolusite



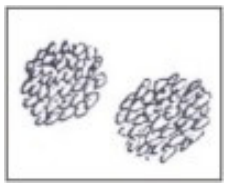
6) **Acicular Habit:-** Consisting of thin or slender needle like members.

Ex.: Actinolite & Stibnite



7) **Stalactite Habit:-** Like pendent columns developed in caves of lime stone areas.

Ex.: calcite

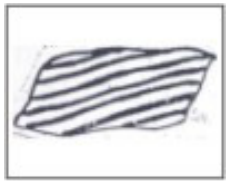


8) **Oolitic Habit:-** Composed of small globular like fish eggs.

Ex.: Oolitic hematite, Oolitic calcite.

9) **Pisolitic Habit:-** Composed of small globules of the size of pea.

Ex.: Bauxite.



10) **Banded Habit:-** Consisting of thin or thick layers of different colours & composition, sometime alternating.

2. COLOUR:

Colour is a distinguishing character of any mineral, the colour is due to the absorption of some and the reflection of the other coloured rays, which is composed in ordinary white light.

The colour of the mineral is mainly depends on its chemical composition some minerals when viewed in different directions show irregular changes in colour hints it is called play of colour.

Ex: Sulphur is yellow due to 'S'

Amethyst is violet due to MNO_2

Smoky quartz is dark gray due to organic impurities.

Descriptive Terminology:

1. White: Milk white, Chalk white, Snow white, Silver white, Grayish white, Dirty White
2. Gray: Steel gray, Dark gray Grayish black, Grayish white.
3. Green: Greenish yellow, Olive green, Parrot green, greenish black.
4. Yellow: Yellowish brown, golden yellow, Brass yellow.
5. Red: Reddish brown, Brick red, Chocolate brown, Brownish black, Pink.
6. Black: Black, Jet black, Charcoal black, Velvet black, Dull black.
7. Colourless: For transparent minerals without any shade/tint.

3.STREAK:

The streak of a mineral is nothing but the colour of its own powder. The colour of the powder may quite often be different from the colour of the mineral in mass. Streak is obtained by rubbing the mineral on a piece of unglazed porcelain plate known as streak plate.

Sl. No.	Mineral with Chem. Comp.	Colour	Streak
1.	Magnetite – Fe_3O_4	Black	Black
2.	Hematite – Fe_2O_3	Steel	Cherry red
3.	Galena – pbs	Lead gray	Black
4.	Chromite – $Fe_2Cr_2O_3$	Dark gray	Brownish black
5.	Iron Pyrite – Fe_2S (Fools Gold)	Bright golden yellow	Black

4. LUSTRE:

The Shining / Brilliance / Reflection of light from the surface of mineral. The luster of minerals varies with the nature of their surface smooth / rough and the quantity of light reflected.

The luster of mineral can be divided into two groups.

a) Metallic.
b) Non-metallic.

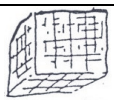
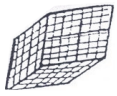
Descriptive Terminology:

Sl. No.	Luster	Description	Mineral Example
1.	Metallic	Shines like polished metals	Galena, Hematite, Graphite magnetite, pyrite
2.	Vitreous	Shines like broken glasses	Quartz, Orthoclase
3.	Silky	Shining like silk thread or cloth	Asbestos, Gypsum
4.	Pearly	Shining like a pearl	Calcite, Muscovite, Talc
5.	Resinous	Shining like wax / resin / grease	Olivine, Chlorite, Agate, Opal, Serpentine
6.	Dull / Earthy	No shining / Earthy	Magnesite, Kaolin, Bauxite
7.	Adamantine	Brilliant luster like Diamond	Diamond, Corundum

5. CLEAVAGE:

Cleavage is the tendency of crystallized minerals to split in a definite planes / directions. These directions are depends on the arrangement of the atoms in a mineral.

Descriptive Terminology: Cleavages are described according to the numbers, directions and intersection of sets of cleavage planes.

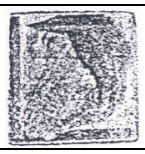
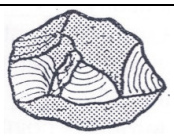
Sl. No.	Cleavage pattern	No of sets	Description & Terminology	Mineral Example
1.		One	Basal Cleavage	Mica, Beryl
2.		Two	<u>Prismatic Cleavage</u> Perpendicular intersection	Orthoclase, Augite, Gypsum
3.		Two	<u>Oblique Cleavage</u> Intersecting at an angle	Hornblende
4.		Three	<u>Rhombohedral Cleavage</u> Intersecting at an angle parallel to rhombic face	Calcite, Dolomite
5.		Three	<u>Cubical cleavage</u> Mutually perpendicular and parallel to cubic faces	Galena, Pyrite, Fluorite

The perfection of parting described as perfect, good, indistinct or poor according to cleavability.

6. FRACTURE:

The fracture is the nature of the broken surface of mineral. The breakage of a mineral in a direction other than that of cleavages. Fracture is described according to the breakage pattern, i.e. the appearance of the broken surface.

Descriptive Terminology:

Sl. No.	Breakage Pattern	Designation & Description	Mineral Example
1.		Even Fracture Mineral breaking with smooth regular almost plane surface	Flint, Hornstone
2.		Uneven Fracture Mineral breaking with an irregular rough surface	Orthoclase, Augite Flint, Magnesite
3.		Concoidal Fracture Concentric undulations or curved concavities resembling the growth lines on a shell	Quartz, Opal, Agate, Flint, Magnesite
4.		Hackly Fracture Breaking with sharp or jagged surface like wood or bone / cast iron.	Asbestos, Gypsum

7. HARDNESS:

Hardness may be defined as the resistance offered by the mineral to scratching or abrasion. The value of hardness (H) is relative, and is expressed by a number.

In 1822 moh, an Australian mineralogist proposed scale of hardness popularly known as ‘moh’s scale hardness. It consists of ten mineral arranged in the order of increasing hardness.

Moh's scale of comparative hardness

Sl. No.	Moh's Standard hardness minerals	Grade of hardness	Scratchability
1.	Talc (Hydrous silicate)	Soft grade	Scratched very easily by finger nail.
2.	Gypsum ($CaSo_4H_2O$)	Soft grade	Scratched with some difficulty by finger nail.
3.	Calcite ($CaCo_3$)	Soft grade	Finger nail does not scratch, but knife scratches very easily.
4.	Fluorite (CaF_2)	Medium grade	Scratched easily by knife.
5.	Apatite ($Ca(po_4)n$)	Medium grade	Scratched by difficulty by knife.
6.	Orthoclase ($KAlSi_3O_8$)	Medium grade	Scratched with great difficulty by knife.
7.	Quartz Sio_2	Hard grade	Knife does not scratch hardness point 8 scratches with great difficulty.
8.	Topaz $(AlF)_2SiO_4$	Hard grade	Hardness point 9 scratches with great difficulty.
9.	Corundum (Al_2O_3)	Hard grade	Hardness point 10 scratches easily.
10.	Diamond (c)	Hardest	Scratched by only another diamond.

8. **SPECIFIC GRAVITY:**

Specific gravity of a mineral is the ratio of the weight of the mineral to that of an equal volume of water.

$$\text{Sp. G.} := \frac{Wa}{Wa - Ww}$$

Where: Wa= Wt. of mineral specimen in air.
Ww= Wt. of mineral specimen in water.
Sp. G. = Specific Gravity.

The specific gravity of minerals depends upon their chemical composition and the state of molecular segregation.

Determination of Specific gravity:

For practical purpose, the specific gravity can be roughly estimated by weighing the mineral in the palm.

Weight	Sp. G.	Value	Min. example
Light	Medium	Sp. G. < 2.5	Gypsum, Opal
Medium	Medium	Sp. G. < 2.5-3.5	Quartz, Calcite, Augite
Heavy	High	Sp. G. > 3.5	Hematite, Pyrite, Galena, Barite

9. DIAPHENEITY:

Diaphaneity is the ability of the mineral to transmit light through it. The following terms are used to describe the varying degree of transmission of light.

Descriptive Terminology:

Sl. No.	Terminology	Explanation with mineral Example
1.	Transparent	When the outline of the objects viewed through the mineral. Ex.: Rock crystal, Selenite etc.
2.	Sub Transparent	When the object are seen physically. Ex.: Calcite, Fluorite etc.
3.	Translucent	When only the thin edges of the mineral transmit light. Ex.: Agate, Chalcedony, Feldspar.
4.	Opaque	When no light is transmitted even on thin sections or edges. Ex.: Ore minerals.

Special properties:

1. **Magnetism:-** A few minerals are attracted by magnet 7 & 8. There are called ferromagnetic. Ex.: Magnetite – Fe_3O_4
   Some other are feebly attached called paramagnetic – Hematite-Fe_2O_3
2. **Acid reaction:-** Certain carbonate mineral react with hydrochloric acid
   Ex.: Calcite – CaCo3
   Minerals are easily identified by acid action by putting few drops of dilute Hcl on the surface of the mineral.
3. **Taste:-** Saline – Taste of common salt Ex. Halite
4. **Feel:-** Feel to touch sensation of touch.
   a) Smooth:- Even non-friction surface-Agate, Flint, Jasper.
   b) Greasy:- Soapy surface-Talc, Gypsum

5. Odour:- Smell emitted when moistened-Kaolin, argillaceous, sulphurous smell of burning sulphur-pyrite.

Description of Minerals
Quartz and its Varieties

Crystalline varieties	Quartz	Smoking Qtz.	Milky Qtz.
Habit / Form / Structure**:**	Commonly crystals sometime with massive	Commonly crystalline	Milk white in colour, greasy luster, Amethyst-Transparent Purple/violet in colour, Rose Quartz=Rose red/Pink in colour, massive. II-Cryptocrystalline varieties Chalcedony-Botryoidal in shape, gray or brown in colour translucent, snow white Blood stone bright green with small spots / Red jasper Agate is a variety with alternating layers of chalcedony having different colours and porosity. The colour bands are parallel to the walls of the cavity Jasper, Opaque, Red, Yellow in colour, due to admixtures of hematite. Dull luster Flint: Gray smoky or brownish black in colour commonly nodular Chert: Massive opaque, Light coloured bedded III- Amorphous variety Opal=Massive, Botryoidal, H-5.5 to 6.5, Sp. Gr-2.2 Colourless, White gray, brown to red, vitreous to waxy luster.
Colour:	Colourless to white	Smokey	
Streak:	White	White	
Luster:	Vitreous	Vitreous	
Cleavage:	Absent	Absent	
Fracture:	Concoidal	Concoidal	
Hardness:	7	7	
Sp. Gravity:	2.655-2.66	2.65-2.66	
Diaphaneity:	Transparent to opaque	Transparent to opaque	
Sp. Properties:	Crystalline habit, Absence of cleavage, though crystalline breaks with sharp cutting edges. Concoidal fracture	Crystalline habit, absence of cleavage though crystalline breaks with sharp cutting edges, Concoidal fracture.	
Chemical Composition:	SiO_2	SiO_2	Occurrence: It is the most common mineral found in all three types of rock ligneous. Sedimentary and Metamorphic.
Crystal system:	Hexagonal	Hexagonal	
Importance / Uses:	Glass making, Glass cutting, Optical instruments, Watches, Prestresed concrete, Industrial and agro granules.	Glass making, Glass cutting, optical instruments, Watches, Prestresed concrete Industrial and agro granules.	

Properties	Orthoclase	Plagioclase	Microcline	Calcite
Habit/Form/ Structure:	Crystals usually short prismatic / Monoclinic	Crystal commonly tabular frequently twinned producing striations on the cleavage surface tri clinic	Crystal usually short prismatic frequently twined also tabular	Crystal are coarse to fine grained compact and stalactite
Colour:	Colourless. Cream, White, White pale yellow, Gray, Flesh red, Pink.	Grayish white. Bluish white. Dark gray. Reddish brown	White, Pale yellow, rarely Red / green.	White, gray, Pink Yellowish, Blue
Streak:	White	White	White	White or Grayish White
Luster:	Vitreous, pearly	Pearly	Vitreous	Pearly=play of colours
Cleavage:	2 sets Perpendicular or Near Perpendicular	2 Sets oblique	2-Sets-good	3 Sets oblique perfect, rhombohedra cleavage
Fracture:	Uneven	Uneven	Uneven	Uneven brittle
Hardness:	6	5-6	6	3
Special Gravity:	2.6	2.62 – 2.76	2.54-2.57	2.71
Diaphaneity:	Transparent to opaque	Transparent to opaque	Translucent	Translucent to opaque
Chemical composition:	$KAlSi_3O_8$	$NaAlSi_3O_8$, $CaAl_2Si_2O_8$	$K(AlSi_3O_8)$	$CaCo_3$
Crystal system:	Feldspar	Feldspar	Tri Clinic	Hexagonal
Special Properties:	Distinguished from the plagioclase by the absence of twin striations and from micro line by the absence of grassing structure.	Distinguished from other feldspars by the presence of stations on cleavage surfaces.	It can be distinguished from orthoclase by its cress-cross twining, deep green colour	Distinguished by its perfect Rhombohedra cleavage and low headiness reacts with Dil.Hcl
Occurrence:	It is prominently constituent of many ligneous rocks like Granites, Syenite pegmatite's, and in metamorphic races in gneisses	It is one of the important rock forming mineral found in ligneous rock. Metamorphic rock	It is common feldspar of igneous pegmatite. Occur as huge crystals.	It is most commonly & widely distributed mineral in the earth crust. It is an imp. Rock forming mineral of Sedimentary & Metamorphic such as Lime stone & Marble
Uses:	Porcelain. Electric insulation filler. Pottery bottles. Ceramics. Binding materials.	Alkali plagioclases are mixed from pegmatite's and used in ceramic industries. Binders.	Used in porcelain industries, and used as ornamental stone	Used in optical instruments. Soil dressing Glass. Toothpaste. Paper Paints. Soap. Bleaching powder.

Properties	**Dolomite**	**Hornblende**	**Augite**
Habit:	Crystals commonly rhombohedra also massive granular	Crystal rare, long columnar fibrous masses also granular	Crystal usually short and thick eight sided
Colour:	White, Gray, Pink, offenly Brown, Black	Dark green to Black	Dark gray, grayish black, Black
Streak:	White	Pale greenish or Grayish white	Grayish White
Luster:	Vitreous	Resinous	Resinous-dull
Cleavage:	3 sets of oblique(R)	2 Sets oblique cleavage	2-Sets almost perpendicular, frequently parting clear
Fracture:	Uneven	Uneven, brittle	
Hardness:	3.5 to 4.0	5-6	5-6
Special Gravity:	Medium 1.7-1.8	3 to 3-4	3.2 - 3.5
Diaphaneity:	Transparent to opaque	Translucent to opaque	Translucent to opaque
Chemical composition:	CaMg(Co3)2	Ca2()MgFeAl)5(SiAl)8	Ca(MgFeAl)SiAl
Crystal system:	Hexagonal(R) system	Monoclinic system	Monoclinic system
Special Properties:	Distinguished from calcite by its relative high hardness. It does not readily react with Dil. Hcl	Long prismatic columnar habit and dark green in colour	Perpendicular cleavage short & thick crystal formation
Occurrence:	It is occurred as assertified deposit along sedimentary rock	Imp rock forming mineral occurring in Igneous & metamorphic rock	Important Rock forming mineral essentially found in Gabbro Dolerite. Basalts.
Uses:	Used as refractory mineral(17000c) Special Cements, Fertilizers.	Important rock forming mineral	Important rock forming mineral

Properties	Magnesite	Talc	Gypsum
Habit:	Crystals are commonly massive compact earthy	Crystal usually foliated massive	Crystal commonly twinned, fibrous or foliated masses
Colour:	Chalk White, Yellowish	Pale green, apple green, silver white	White, snow white, gray, pink yellow
Streak:	White	Pale white	Peal White
Luster:	Dull-earthy	Pearly, greasy	Resinous
Cleavage:	-Nil-	Nil	Nil
Fracture:	Uneven, concoidal	Uneven	Uneven.
Hardness:	3.5 to 4.0	1 to 1.5	2
Special Gravity:	2.9 to 3.0	2.7 to 2.8	2.2 to 2.4
Diaphaneity:	Opaque	Opaque	Translucent to opaque
Chemical composition:	**$MgCo_3$**	**$Mg_3(Si_4O_{10})(OH)_2$**	**$CaSo_4$, $2H_2O$**
Crystal system:	Hexagonal	Monoclinic	Monoclinic
Special Properties:	Recognized by its massive habit acted upon by warm lane Hcl.	Distinguished by its low hardness. Soapy touch. Pearly luster and flexibility	Recognized by its low hardness and resinous luster and fibrous structure
Occurrence:	It may be derived by the alternation of Mg rich rocks in India. Largest deposits are found at the chalk hills of Salem(TN)	It is an alternation product formed by magnesium silicates such as. Olivine. It occurs in schist	It occurs as extensive bed deposits into stratified Limestone shale. In India deposits are found in Nellore Jamnagar, Trichinapally, Punjab.
Uses:	Ore of magnesium, refracting, Furnace lining. Insulator, Crucibles, Mosaic granules, Quick setting cement, Sugar refining fertilizer	Fillers in paints, Paper. Rubber distemper. Cosmetics. Insecticides. Furnace linings. Toilet powder.	Plaster of Paris, Plaster casts. Fertilizer to naturalize alkali soils cement work sheets

Properties	Asbestos	Olivine	Garnet
Habit:	Fibrous, logs compact	Crystal rare, Commonly course to granular masses	Crystalline, dodecahedron (12 rhombic faces). Granular
Colour:	Grayish, Peal green, yellowish	Olive green, greenish yellow	Brown, Red, Black, Wine or Honey brown
Streak:	Pale grayish White	Pale white	White
Luster:	Silky, resinous	Resinous	Vitreous to Resinous
Cleavage:	-Nil-	None	None
Fracture:	Hackly	Uneven, brittle	Uneven
Hardness:	2 to 2.5	6-6.5	6.5 to 7.5
Special Gravity:	2.2 to 3.2	3.2 – 3.37	3.15 – 4.5
Diaphaneity:	Opaque	Transparent Opaque	Translucent to translucent
Chemical composition:	**$2H_2O$, CaMg Silicate**	**$(MgFe)_2SiO_4$**	**Complex silicate, Ca, Mg, $Fe2Mg(SiO_4)_3$**
Crystal system:		Orthorhombic	Isometric
Special Properties:	Distinguished by its asbestos logs, fibrous habit, bad conductor of heat and electricity, sound proof not affected by weather, heat and chemical acid.	Recognized by its granular habit, olive green in colour	Recognized by its crystal forms. Hardness and specific gravity
Occurrence:	Occurs as a deposit	It is found chiefly in the dark coloured igneous rock like Gabbro. Dunite Peridolite and Basalt. The rock dunite entirely made up of olivine only	Widely distributed in granites. Occurs as accuracy mineral in materials like Mica schist. Greisres and in pegmatite's. Found in AP, TN, KA, Rajastan
Uses:	Electrical and thermal installations. Asbestos cement products. Boiler coverings. Furnace and Oven linings, fire proof, ayurvedic medicine	Gem stone. Refractries (Mp-1320^0-1910^0c) spares lug insulator.	Chiefly used as gemstone, abrasive purposes.

Properties	Corundum	Biotite	Muscovite
Habit:	Crystal are common barrel shaped, also massive granular	Crystal rare, usually irregular foliated masses flacky	Crystal are flaky usually lamellar or scaly aggregates
Colour:	Reddish brown, Pink, Bluish White grayish	Dark brown or Black	Colourless or paler shades silver white in black with a dark brown colour
Streak:	Nil	White or pale brown	White
Luster:	Vitreous to adamantine	Vitreous to pearly	Vitreous to Pearly
Cleavage:	None	Perfect, basal, cleavages, easily separate	Perfect, basal, cleavages, easily separate
Fracture:	Uneven to brittle	Uneven, flexible, elastic	Uneven, flexible, elastic
Hardness:	9	2-2.5	2-2.5
Special Gravity:	High 4.2	2.8 – 3.2	2.7 – 3.0
Diaphaneity:	Transparent to translucent	Transparent Opaque	Translucent to translucent
Chemical composition:	**Al_2O_3**	**$K(MgFe)(AlSiO_3O_{10}) (OH)_2$**	**$H_2KAl_3(SiO_4)_3$**
Crystal system:	Hexagonal	Monoclinic	
Special Properties:	Recognized by its higher hardness. Adamantine luster typical barrel shaped crystal	Distinguished from other micas by its dark brown colour	Distinguished from its perfect basal cleavages and paler shades easily separable elastic transparent flakes
Occurrence:	Common mineral usually associated with metamorphic rocks like schist, gneisses etc. General mineral found in Kashmir Abrasive variety in Karnataka. M.P, AP	Most common rock forming mineral, essentially constituted in igneous rock like, granite. Syenite and metamorphic like schist.	It is most widely distributed mineral found in acid ligneous rocks especially in pegmatites also found in metamorphic rocks.
Uses:	Transparent variety are used as gemstone others used as abrasive purposes	Boiler and furnace, Window screen.	Used in electric and electronic insulator ornamental Decorative stone and Gaslight chimneys. Fancy paints.

Properties	Kaolin	Serpentine	Barite
Habit:	The mineral forms fine grained. Compact as well as earthy. Powdery masses	The mineral are compact cryptocrystalline masses coarsely granular	The Crystal are tabular, the aggregates are granular, compact, foliated
Colour:	White, dull white	Yellow green, dull green, white, yellowish pale.	Colourless to white gray also, yellow, brown
Streak:	White	White	White
Luster:	Greasy to touch, pearly	Resinous, waxy, greasy	Vitreous
Cleavage:	Nil	Nil	Perfect
Fracture:	Earthy	Uneven	Uneven
Hardness:	Equals to 1	2.5-4	3-3.5
Special Gravity:	2.6-2.65	2.2-2.7	4.5
Diaphaneity:	Opaque	Transparent to Opaque	Translucent to translucent
Chemical composition:	**China Clay – $H_4Al_2SiO_9$**	**$Mg_6(Si_4O_{10})(OH)_8$**	**$BaSo_4$**
Crystal system:	Monoclinic		Orthorhombic
Special Properties:	Soapy feel. Argillaceous odour when dump powdery masses	Distinguished by its green colour, greasy lustier	It is Distinguished from gypsum by its cleavage and high specific gravity.
Occurrence:	The mineral is formed under the weathering of feldspars of granites and gneisses. Deposits in USSR Eastern Siberia	It is common mineral formed by alteration of rich rock like peridotite Dunites and carbonate rocks	It is common mineral of wide distribution it occurs as gaunge mineral in hydrothermal veins associated with ores of silver, lead
Uses:	Kaolin clays are utilized in the production of refractory materials. Ceramics, porcelain, chinaware, bricks and glazed tiles filler, white cement stiffener.	Massive varieties are cut and used as ornamental stones. While the source of asbestos.	It is used in industry for the manufacture of paints. Pigment, wall paper, glass and insecticides

Ore Minerals

Properties	Magnetite	Haematite	Limonite
Habit:	Crystalline, Octahedron and dodecahedron, also massive granular	Crystalline aggregates thick tabular also massive, reniform	Massive, Botryoidal nodular radiating crystal
Colour:	Iron black	Steel gray when fresh reddish brown when altered	Reddish brown, bluish gray or blackish coating
Streak:	Black	Cherry red, reddish brown	Yellowish brown
Luster:	Metallic	Metallic	Metallic
Cleavage:	Nil in massive varieties, but oblique cleavages in octahedral minerals	Oblique cleavages	Nil
Fracture:	Uneven to sub concoidal	Uneven to sub concoidal	Uneven
Hardness:	5.5-6.5	5.5-6.5	From 1-5
Special Gravity:	High 5.5	5.5	2.7 – 4.3
Diaphaneity:	Opaque	Opaque	Opaque
Chemical composition:	**Fe_3O_4**	**Fe_2O_3**	**$2F_2O_33H_2O$**
Crystal system:	Isometric	Hexagonal	Hexagonal
Special Properties:	Distinguished by its strongly Magnetic, and black colour.	Recognized by its cherry red steak and heavy	Yellowish brown streaks botryoidal radiating cluster alters to ochre
Occurrence:	Available as ore deposits kudremukh, Karnataka.	The largest deposit of Haematite are related to metamorphic rocks associated with limestone	Limonite emerges as a result of the oxidation of ferriferous minerals in the crusts
Uses:	It is an ore of iron	Important ore of iron dye stuff.	Limonite is an important ore of iron

Properties	Chromite	Galena	Pyrolusite
Habit:	Crystalline, Octahedron and dodecahedron, also massive granular	It usually forms grained massive aggregates.	It is usually found in black crystalline or earth masses, sometimes in the form of radially fibrous acicular aggregates
Colour:	Black	Lead gray, silver gray	Black
Streak:	Brownish black	Grayish black	Black
Luster:	Sub metallic	Prominently black	Metallic, Sub metallic
Cleavage:	Nil	Perfect cubic cleavages	Nil
Fracture:	Uneven	Brittle Uneven	Uneven
Hardness:	Equal to 5.5	2 – 2.5	Variable 1-6
Special Gravity:	4.5 - 4.8	7.5	4.7 – 5.0
Diaphaneity:	Opaque	Opaque	Opaque
Chemical composition:	**$FeCr_2O_4$**	**Pbs**	**MNO_2**
Crystal system:	Isometric	Isometric, Cubes	Tetragonal system
Special Properties:	The mineral is weakly magnetic due to iron content, granular habit	Recognized by its colour perfect cleavage, low hardness and a degree of density	Soils the fingers, fibrous acicular radiating aggregates.
Occurrence:	Usually it occurs in ultra basic rocks like dunites. Peridotites and serpentine mined in India S.A. Turkey & Philippine	It is found in venis together with pyrite and other sulphites, mainly in disseminated sedimentary origin of carbonate.	It occurs in the sedimentary origin with psilomelane deposit are located in India, Africa, Brazil
Uses:	Chromite is the only ore of chromium, refractory materials	Most important ore of lead alloys, crystals is need in radio sets.	Most important use of manganese preparation of oxygen minerals salts battery cells.

Properties	Iron pyrite	Chalcopyrite	Bauxite
Habit:	Crystalline, Octahedron and dodecahedron, also massive granular	The crystal are usually of the tetragonal, masses granular, massive	Crystal's commonly pisolitic earthy masses
Colour:	Bradd yellow, Bright golden yellow	Deep bronze yellow, Golden yellow	Dirty white, Reddish brown stained, Yellowish by iron oxides
Streak:	Greenish black	Black to greenish black	White stained red
Luster:	Metallic	Metallic	Dull
Cleavage:	Absence	Absence	Nil
Fracture:	Uneven	Brittle to Uneven	Earthy, Uneven
Hardness:	6 – 6.5	3.5 to 4.0	Variable 1-3
Special Gravity:	5	4.1 to 4.3	2.3 – 2.5
Diaphaneity:	Opaque	Opaque	Opaque
Chemical composition:	**FeS_2**	**$CuFeS_2$**	**$Al_2O_32H_2O$**
Crystal system:	Cubic Isometric	Tetragonal	Massive Amorphous
Special Properties:	Distinguished by chalcopyrite by its paler colour, soluble in HNO_3 higher hardness	It differs from pyrite in its lower hardness and colour	Pisolitic habit, low hardness and earthy luster
Occurrence:	Pyrite is most valuable in the production of sulphuric acid preparation of SO_2. Fertilizer, dye stuff, ink and so on	The origin is associated with sedimentary rock	The formation of bauxite in connected with the weathering of aluminosilicate rocks in a hot climate. The bauxite deposits are of residual sedimentary
Uses:	Making of steel and Iron products.	Chalcopyrite is the most important ore copper its by product & comprise silver	Bauxite is an ore of aluminum refractory bricks oil refining and bauxite cement Ceramics porcelain cement chemicals

PETROLOGY

Chapter – 2 PETROLOGY

Petrology:

Petrology is that branch of geology which deals with the study of rocks, with their mode of formation, composition and the uses for all types of engineering works.

Rock:

Definition:- Rocks are naturally occurring aggregates of mineral grains.

Rocks composed of grains of only one mineral are called Monomineralic rocks.

Ex: Marble:- Composed of calcite
S.St:- Composed of quartz
Dunite:- Composed of olivine

Rocks composed of grains of two / more minerals are called Polymineralic rocks.

Ex: Granite:- Composed of quartz, Orthoclase, Plagioclase, Biotite mica.
Basalt:- Composed of plagioclase, Augite.

Classification of Rocks:

Rocks are the building blocks of the earth's crust and they are classified on the basis of their mode of formation into three major groups as following.

1. Igneous rocks
2. Sedimentary rocks and
3. Metamorphic rocks.

Igneous rocks:-

Igneous rocks are formed by cooling and solidification of magma or lava. There are first formed at very high temperature at a very great depth. The igneous rocks which are formed upon the earth's surface are known as extrusive rocks (lava). The rocks which are formed at a great or moderate depth below the earth surface is known as intrusive rocks (magma).

Forms of Igneous rocks:

The forms of igneous bodies may be studied under the following two headings.

1. Concordant bodies
2. Discordant bodies

Concordant bodies:

The magma, during its upward journey, does not possess enough energy to push, drag or cut through the existing rocks. In such cases, the magma solidifies in the cavities and planes of weakness of the existing rock. Such forms of concordant bodies includes, Sill, Lacolith, Lopolith, Phacolith.

Discordant bodies:

The magma during its upward journey , possesses, a huge energy to push, drag or cut through the existing rock. Such forms of discordant bodies include.
Dyke, Ring dyke / Cone sheets, Volcanic necks and Batholiths.

Classification of igneous rocks:

Igneous rocks may be classified by different scientist by different basis, but on the basis of mode of solidification of magma into the following three types.

1. Plutonic rocks
2. Hypabyssal rocks and
3. Volcanic rocks

Plutonic rocks:

Plutonic rocks are those rocks, which are formed beneath the surface of the earth crust after the solidification of magma. Cools very slowly, thus these are coarsely crystallined rocks.

Hypabyssal rocks:

Hypabyssal rocks are those rocks, which are formed below the earth surface at a short distance, this happens when the magma solidifies in the form of thin sheets or wall like structure usually rocks are medium grained.

Volcanic rocks:

Volcanic rocks are those, which are formed on the surface of the earth. This happen when the magma is forced out on the surface of the earth. Due to a sudden change of pressure and temperature on the ground rapidly cools, thus are fine grained rocks.

Classification Igneous Rocks

Classification	Acid Igneous	Intermediate rocks	Basic rocks	Ultra basic rocks
Base on silica percentage	>66%	66-55%	55-40%	<40%
Based on mode of accurance				
1.Plutoic Igneous rocks	Gray granite Pink granite	Syenite	Diorite	Dunite
2.Hypabyssal Igneous rocks	Pegmatite, granite, porphyries	Syenite porphyry, diorite porphyry	Dolerite	-
3.Volcanic Igneous rocks	Rhyolite, obsidian, pumice	Trachite, Andesite	Basalt	-

Index properties:

The following are the important petrographic characteristic properties helpful in the identification and classifications of rocks in hand specimens by naked eye or with the aid of hand lens and also with some testing tools like pen knife, Magnet, streak plate and Dil.Hcl.

1. Colour
2. a) Texture b) Grain size
3. Mineral composition
4. Cementing Material
5. Specific gravity
6. Special properties
7. Acid reaction
8. Magnetism

1. **Colour:-** The colour of rocks depends upon the colour of their aggregated minerals or cementing materials and is generalized according to the overall shade.

2. **a) Texture:-** The texture is defined as the mutual relationship of the constituent mineral grains their size, shape and etc.

Descriptive Terminology:

1. **Equigranular Texture:-** Equigranular texture are those in which mineral constituents are more or less developed to the same size, megascopically mineral grains shows equal grain size.
   Ex: Plutonic igneous rocks like Granites, Gabbro
2. **Porphyritic Texture:-** When a large crystals called phenocrysts is surrounded by a ground mass called matrix.
   Ex: Hypabyssal Igneous rocks – Porphyries of granite Syenite diorite, dolerite.
3. **Intergrowth** / **Graphics Texture:-** intergrowth texture is mainly formed due to simultaneously crystallization of two minerals more or less in equal proportions. Intergrowth of two minerals generally results in formation of a peculiar texture called graphic texture.
   Ex:- Common Intergrowth in between Quartz & feldspar.
4. **Ophitic Texture:-** Consists of small white grains of plagioclase enclosed wholly or partial in large dark gray irregular grains of Augite.
   Ex:- Dolerite.
5. **Directive texture :-** Directive Texture are formed due to flow of lava during crystallization. It produces bands of layers in which minerals are oriented in a particular direction.
   Ex:- Volcanic Igneous rocks – Rhyolite. Trachite, Andesite.
6. **Glassy Texture:-** Consists of an amorphous surface with or without vesicles some filled with mineral matter sometimes very fine grained.
   Ex:- Volcanic Igneous rocks – Basalts.

2.(b) Grain Size:-

This is the diameter of the component mineral grains, expressed as follows.

Fine grained – grain diameter 1 mm to less.
Medium grained – grain diameter 1 mm to 5 mm.
Coarse grained – grain diameter 5 mm and above.

3. Mineral Composition:

The combination and proportion of the component minerals.

a) Essential minerals – easily identified by necked eye.
b) Accessory minerals – finer particles of deleterious component.

Description of Igneous Rocks

Properties of rocks	Gray Granite	Pink Granite
Colour:	Gray, grayish white	Pink, Flesh red, reddish brown
Mineral composition: **Essential** ⟶ **Accessory** ⟶	Quartz White Orthoclase Plagioclase Biotite mica Magnetite Hornblende	Quartz White Orthoclase Plagioclase Biotite mica Magnetite
Specific gravity:	2.6	2.6
Crushing strength:	Very high	Very High
Occurrence:	Batholith	Batholith
Classification:	Acid igneous Plutonic rocks	Acid Igneous Plutonic rocks
Engineering / Importance:	Building, ornamental, monumental, stone, road metal, concrete Aggregates, railway ballast, window & door sill, pillars, slabs, sinks, paving sets, grinding wheels & sculptures.	Ornamental, monumental, memorial decorative slabs.

Properties of rocks	Syenite	Diorite
Colour:	Multicolor, white pinks, Grayish	Grayish, white, greenish at places.
Texture & grain size;	Equigranular coarse to medium grained	Equigranular coarse to medium grained.
Mineral composition: **Essential** ⟶ **Accessory** ⟶	Orthoclase white / pink	Plagioclase, acid for
	Plagioclase	- Hornblende
	Biotite mica, Quartz, Hornblende	± Orthoclase(White)
	Iron ore	Iron oxide, Apatite
Specific gravity:	2.6	2.8
Crushing strength:	High	High
Occurrence:	Batholith	Dykes and sills
Classification:	Intermediate plutonic ligneous rock	Intermediate Plutonic Igneous rock
Engineering / Importance:	In ornamental and building synenites are considered only after granites.	Ornamental, Road Metal Concrete aggregates.

Properties of rocks	Gabbro	Dunite	Pegmatite
Colour:	Gray to black	Olive green, Greenish yellow	Dull white at places pink
Texture & grain size;	Coarse grained equigranular	Equigranular to medium grained.	Intergrowth or graphic coarse grained
Mineral composition: **Essential** ⟶ **Accessory** ⟶	-Plagioclase -Augite -Hornblende. – biotite -Olivine -Apatite -Magnetite	-Olivine -Chromite -Magnetite -Quartz	-Quartz -Orthoclase (both) -Muscovite mica -Iron ore -Iron pyrites
Specific gravity:	2.8 – 2.9	3	2.6
Crushing strength:	High	Medium	Low
Occurrence:	Plutonic basic Igneous rock	Sill	Sill
Classification:	Intermediate plutonic ligneous rock	Monomineralic Ultra basic Igneous Rock	Acid Igneous hypabyssal rocks
Engineering / Importance:	Ornamental, Concrete aggregates, Railway Ballast	Ornamental	Worked for valuable minerals like quartz orthoclase, muscovite mica atomic minerals beryl

Properties of rocks	Granite porphyry	Syenite porphyry	Diorite porphyry
Colour:	Multicoloured, grayish white at place pink	Pink, reddish brown, brick red, chocolate brown, gray	Reddish brown, brick red.
Texture & grain size;	Porphyritic Texture	Porphyritic texture	Porphyritic texture coarse grained to fine also massive
Mineral composition: **Essential** ⟶ **Accessory** ⟶	Phynocryst- Orthoclase	Phynocryst- Orthoclase (once)	Phynocryst- Plagioclase
	Groundmass -Quartz -Plagioclase -Biotite mica -Hornblende	-Orthoclase -Plagioclase -Reddish brown ±Biotite mica	-Orthoclase -Hornblende -Quartz ±Iron oxide
	Accessory minerals Magnetite	Magnetite	-
Specific gravity:	2.6	2.6	2.8
Crushing strength:	High	High	High
Occurrence:	Hypabyssal Acid Igneous rocks	Hypabyssal sub-acid Igneous rocks	Igneous sub-basic rock
Classification:	Sill	Sill	Sill
Engineering / Importance:	Building, Ornamental monumental, memorial, structural, pillars, slabs, lintels, door steps, aggregates, Railway Ballast, Road metal.	Ornamental, Pillars, Building.	Ornamental, aggregates.

Properties of rocks	Dolerite	Rhyolite	Basalt	Pumice
Colour:	Dark gray to black	Dull white with reddish brown patches	Dark gray to black	Grayish white ash gray
Texture & grain size;	Ophitic texture Fine to medium grained	Fine grained, glassy vesicular	Fine grained, glassy vesicular	Vesicular, glassy
Mineral composition: **Essential** → **Accessory** →	-Augite	-Quartz	-Plagioclase	Quartz
	-Plagioclase	-Orthoclase	-Augite	-Orthoclase
		-Plagioclase		-
		-Mica		-
	-Iron ores			-
	-Olivine	-Hornblende	-Magnetite	-
	±Quartz	-Magnetite	-Iron pyrite	-
Specific gravity:	2.9	2.6	2.9	2.4
Crushing strength:	Very high	Medium	Low to medium	Low
Occurrence:	Intrusive Dyke	Sill	Lava flows	Ash
Engineering / Importance:	Dolerite is called black granite in industry ornamental, Memorial, Road Metal, Kitchen plates, Table tops, Decorative stones, Paper weights, Gift articles etc.	Abrasive, Ornamental, pozzolanic Admixture in concrete	Road metal, concrete, aggregates, kitchen plates used in the manufacture of fertilizers	Light weight concrete aggregates. Pozzolanic admixture, Filler, Tooth powder, Polisher abrasive.
Classification:	Hybabyssal Igneous rock	Acid Igneous rock	Volcanic basic Igneous rock	Ash

Sedimentary Rocks:

Rocks which are formed under water in different situations. There rocks are derived from the consolidation of sediments of the preexisting rock. The distinguished products of pre-existing rocks are transferred by the influence of geological agents like, wind, water and glacier etc. through, the process of erosion, transportation, deposition as a sediment. This sediment deposit into the depressions of the earth, and gets consolidated and cemented to from sedimentary rocks.

Texture of Sedimentary Rocks.

1. **Clastic Texture:-** A sedimentary rocks composed of principally of fragments derived from pre-existing rocks or minerals and transported some distance from their places of origin.
2. **Non-clastic texture:-** Self cemented materials, those rocks which are formed due to physic-chemical process. Such as evaporation and precipitations.

Descriptive Terminology:

1. **Rudaceous Texture:-** Consists of assorted angular / smooth rounded pebbles or fragments of rocks and minerals cemented together.
   Ex: Breccia, Conglomerate.
2. **Arenaceous Texture:-** Consists of sand grains welded or cemented together often porous, bedded. Ex: Sandstone
3. **Argillaceous Texture:-** Consists of fine particles / Flakes of clay, mica welded or cemented, frequently laminated. Ex: Shale.
4. **Amorphous:-** Very fine grained often bedded. Ex: Lime Stone
5. **Fossilferous Texture:-** Consists fossil remains cemented together.
   Ex: Shell Limestone
6. **Concretionary Texture:-** Consists large and small hard of soft clods & clay with iron oxide and Alumina. Ex: Laterites.

Structures in Sedimentary Rocks:

1. **Stratifications:-** The arrangement of sedimentary rock in strata / bedding. It may be indicated by difference in texture, cementation, colour or composition.
2. **Lamination:**- A thin scale / the finest stratification layer in a sediments / sedimentary rocks differing from other layers in colour, composition or particle size. The finest stratification typically shown by shale and fine grained sand stone.
3. **Current bedding** / **Cross bedding:-** Any bedding structure produced by current action, cross stratification resulting from water or air currents of variable direction.
   Ex: Sand Stone.
4. **Gradded Bedding:-** A type of bedding in which each layer displays a gradual change in particle size, usually from coarse at the base to fine at the top.
   Ex: Conglomerate.
5. **Ripple Marks:-** Any feature formed by the action of water current on a sedimentary surface. An irregular feature made by a tidal current in the beach zone, consisting of a small depression extending toward the shore from the side of an abstraction. Ex: Sandstone, Shale.
6. **Sun Cracks** / **Mud Cracks:-** An irregular fracture in a crudly polygonal pattern formed by the shrinking of clay, silt or mud generally in the course of drying under surface conditions.
7. **Rain Prints:** Small depressions with characteristic rim formed by the impact of rain drop.
   Ex: Shale

Cementing Material:

Natural binding material deposited in between component sedimentary pebbles, fragments grains and or fossil remains. The common cementing ,materials are FeO_3, SiO_2 and $CaCo_3$.

Classification of Sedimentary Rock:

Mode of formation	Texture & Mineral Composition	Rock Types
1.Mechanically formed or clastic Sedimentary rock	Rudaceous (Pebbly) Arenaceous (Sandy) Argillaceous (Clayey)	Breccia conglomerate Sandstone Shale(Laminated)
2.Chemically formed Sedimentary rock Precipitation & evaporation (Residue)	Massive ($CaCO_3$)	Limestone
3.Organically formed sedimentary rock(Self cemented)	Fossiliferous (Animal remains shells)	Shell Limestone Coral Limestone
	Fossiliferous (Plant remains)	Coal-peat, lignite Bituminous Anthracite
4.Residual Deposits(Loosely Cemented)	Concretionary, clay Fe_2O_3 +Al_2O_3	Laterites

Descriptions of Sedimentary Rocks:

Properties of rocks	Breccia	Conglomerates
Colour:	Reddish brown Chocolate brown	Reddish brown, white multicoloured
Texture & grain size;	Clastic (pebbly) Rudaceous coarse grained (>2mm dia)	Clastic and coarse grained pebbly (rounded) (>2mm dia)
Min. Composition:	Essential: -Angular fragments of rocks and minerals. (Quartz / Orthoclase)	Smooth rounded pebbles of minerals and rocks
Cementing Material	Fe_2O_3	Fe_2O_3
Crushing strength:	Medium	Medium
Specific gravity:	Medium-2.8	2.7
Classification:	Rudaceous group of mechanically formed Sedimentary rock	Rudaceous group of mechanically formed Sedimentary rock
Special features:	Assorted angular fragments cemented together by Fe_2O_3	Smooth rounded pebbles of rocks and minerals cemented together by Fe_2O_3
Uses:	Ornamental, facing stones.	Ornamental, facing stones.

Properties of rocks	Sand Stone	Shale	Limestone
Colour:	Dull white, reddish, brown, brick red, pink	Reddish brown, brick red, chocolate brown	White, pink, gray, green, black, multicoloured
Texture & grain size;	Clastic Arenaceous (sandy) medium grained 1/10 mm to 2 mm	Clastic fine grained (clayey)	Non-clastic massive fine grained
Mineral composition:	Quartz (Sand particles) Orthoclase (little) little muscovite & mica	Clays, mud, silts fine, sediments	Calcite, chert, Clay
Cementing Material:	Fe_2O_3,SiO_2, $CaCo_3$	Fe_2O_3	$CaCo_3$
Crushing strength:	Medium	Low to Medium	Medium
Specific gravity:	2.8	2.6	2.7
Classification:	Mechanically formed arenaceous group of sedimentary rocks.	Mechanically formed argillaceous sedimentary rocks.	Chemically formed sedimentary rocks.
Special Features:	Sp. /Current bedding ripple marks. Bedded and granular.	Laminated structure soft, Sun cracks, Rain prints	React with Dil. Hcl soft.
Uses:	Building, Ornamental, structural, road, metal, rail road, Ballast, paving set, concrete aggregates	Bricks, Tiles, cement Manufacture	Cement manufacture. Flooring, Ornamental, Tooth paste, Road metal

Properties of rocks	Shell Limestone	Laterite
Colour:	White, dirty white, dark gray	Reddish brown, brick red
Texture & grain size;	Non-Clastic	Concretionary porous, fine grained
Mineral composition:	Shells, Calcite	Clay, Iron oxide, Al_2O_3
Cementing Material:	$CaCo_3$	Iron Oxide
Crushing strength:	Low	Medium
Specific gravity:	2.7	2.6 – 2.8
Special Features:	Fossiliferous, react readily with Dil. Hcl	Concretionary, porous when soft can be cut, sun dried become hard deposited sedimentary rocks
Classification:	Organically formed sedimentary rocks	Residual deposited sedimentary rocks
Important:	Ornamental articles. Table tops. Decorative panels	Building stone, road metal, poor grade Iron ore.

Metamorphic Rocks:

These rocks are formed by the process of conversion called metamorphism, when the pre-existing rocks are subjected to increased temperature. Pressure and chemically active fluids.

Ex: 1. Granites to Gneiss
2. Limestone to Marble
3. Shale to slate
4. Sandstone to Quartzite

Classification of metamorphic Rocks:

Metamorphic Agents		**Temperature**	**Directed pressure**	**Uniform pressure**
Mode of formation and Texture		Thermal metamorphic Rocks	Dynamic metamorphic Rocks	Plutonic Metamorphic Rocks
Foliated rocks Banded	Schistose Texture	-	Talc schist, slate, chlorite schist, hornblende schist	-
	Gneissose Texture	-	Gneiss Augen gneiss	-
Non-foliated rock	Granular texture	Marble Quartzite Serpentine	-	Charnockite Granulite

Description of Metamorphic Rocks:

Properties	Gneiss	Mica schists
Colour:	Gray, banded	Silver white, grayish white, lead gray, brown, black
Texture & grain size;	Parallel orientation (Alternate banded) Fine to medium	Foliated, Schistose, lamellar, elongated
Mineral composition: Essential Minerals Accessory Minerals	- Quartz - Orthoclase(White/Pink) - Biotite -Hornblende. Iron ore	-Muscovite mica -Biotite mica -Granit -Quartz
Specific gravity:	Medium 2.7	2.8-3.0
Crushing strength:	Very high	Very low
Origin / Occurrence:	A foliated rock formed by the regional metamorphism of sandstone. Conglomerate. Granite	A strongly foliated rocks formed by dynamic metamorphism of shale mica, hornblende
Classification:	Dynamic metamorphic rocks	Dynamic metamorphic rocks
Important / Uses:	Building stone. Ornamental stone. Road metal, concrete ballast. Pillars. Slabs	Not fit for building works but worked for extracting valuable minerals like granite, staurolite

Properties of rocks	Talc	Directed pressure	Uniform pressure
Colour:	Greenish white, apple green, yellowish	Greenish black Greenish white	Yellowish white grayish white
Texture & grain size;	Foliated schistose fine grained	Foliated schistose fine grained	Schistose. Flaky aggregates
Mineral composition: Essential Minerals Accessory Minerals	-Talc -Quartz -Mica	-Chlorite -Magnetite -Garnet -Quartz -Iron / copper pyrite	-Quartz -Mica -Plagioclase -Iron ore
Specific gravity:	2.8	2.8	2.8 – 2.9
Crushing strength:	Very low	Low medium	Medium
Origin / Occurrence:	A foliated rocks of dynamic metamorphism rocks	Metamorphism of shale	Metamorphism of Quartz Feldspar
Classification:	Dynamic metamorphic rocks	Dynamic metamorphic rocks	Dynamic metamorphic rocks
Important / Uses:	Being a weak rock is not suitable few important works	Worked for extracting garnet. Magnetite. Ornamental sculpturing	In decoration and Ornamental

Properties of rocks	Slate	Marble	Quartzite
Colour:	Gray, dark gray, black, red	White, pink, green, black, multicoloured	White, gray, pink. Brick red
Texture & grain size;	Schistose, compact fine grained	Granuture fine to coarse grained	Fine to coarse grained
Mineral composition: Essential Minerals Accessory Minerals	 -Clay minerals -Chlorite -Quartz -Feldspars -Mica -Iron pyrite -Magnetite & Hematite	 Calcite($CaCo_3$) -Quartz -Iron ore -Garnet -Serpentine	 Quartz -Mica -Iron ore
Specific gravity:	2.8 – 2.9	2.7	2.7
Crushing strength:	Medium	Medium	High
Origin / Occurrence:	Dynamic metamorphism of shale	Contact or thermal metamorphism of limestone	Thermodynamic metamorphism of sandstone
Classification:	Dynamic metamorphic rock	Thermal metamorphic rocks, reacts with Dil. Hcl	Regional or thermal metamorphic rock
Important / Uses:	Flooring, roofing black boards & slates, mosaic, granules, interior & sanitary works, table tops electrical switch board refrigerator shelves	Architectural Ornamental, decorative, monumental, flooring staircases, statues etc.	Road metal, rail road ballast, glass making

STRUCTURAL GEOLOGY

Chapter-3

Structural Geology

Introduction:

Geologic graphics are helps in determination of the geology of an area comprising of the rock formation, their three dimensional configuration, thickness sequences below the ground surface which are the most important geological data for planning and execution of earth works, cuttings, quarrying, underground works and improvement of site condition, design construction and vital engineering structures.

Dip and strike of outcrop of rocks at the surface are measured with the help of a simple instrument called compass clinometer.

Dip and strike of rock masses underground are computed from test borehole data.

Dip and Strike of Rocks Bed:

Dip – definition:

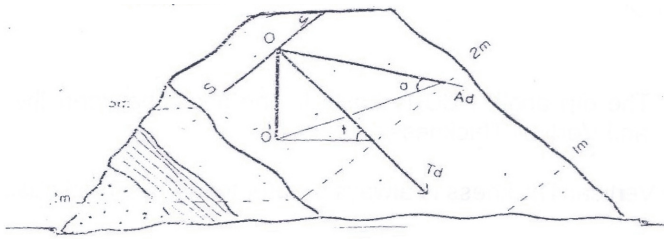
The dip of a bed is defined as its amount of inclination with respect to a horizontal plane, measured in a vertical plane lying at right angles to the strike of the bedding.

Dip is expressed by the amount of inclination and the direction. In dip there are two types.

1. True dip 2. Apparent dip

True dip(Td): The maximum inclination of the strata from the horizontal plane and the direction in which it dips is known as true dip direction (TDD).

Apparent dip (Ad): The line of intersection of the inclined strata with the horizontal plane. Dip and strike are always mutually perpendicular to each other and these can be measured by the instrument called “Compass-Clinometer”.



True dip (Td), Apparent dips (Ad) & Strike (SS)

BORE HOLE PROBLEMS

In order to determine the subsurface geology of an area, bore holes are sunk at convenient places. In areas such as cultivated lands, forests, alluviums etc., the surfaces is completely covered and out crops are rarely exposed. In such places, bore holes 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 borehole data, which render very valuable information for planning and exploiting the hidden treasures.

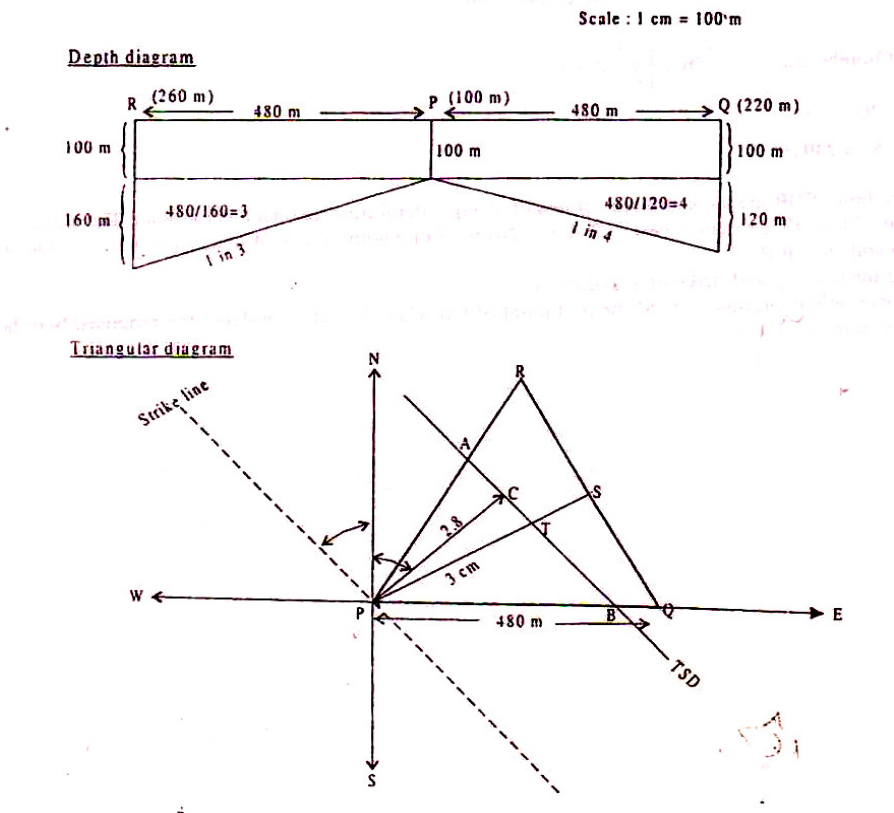
Bore holes sunk on horizontal ground:

Type I - Triangular method

Example: Three bore holes are sunk at 3 points of an equilateral triangle, whose sides are 480m each. P is west Q and R is North of mid point PQ. Bore holes P, Q & R reach the upper surface of a rich coal seam 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' mid point 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 and determine the gradient. It is 120m in 480m. So it is lin4. Similarly construct depth diagram along PR. It is 160m in 480m. i.e. 1 in 3. Take convenient scale and mark 4 units (cms) along PQ and 3 units (cm) along PR from P. They are A & B. Join AB 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 i.e. gradient is l in 2.8. It is true dip.

To determine the direction of true dip, measure the angle NPC = 45°. So direction of true dip is the complimentary angle from North direction. So (90° - 45°) = 45°. So it is N 45^0 E or NE. Strike is perpendicular to TD is N 45° W = S 45° E.

To determine the depth at which the bore hole 'S' reaches the same coal seam, join PS. It inersects AB line (TSD) at T. Measure PT ie., 3 cm. So the gradient along PT is 1 in 3. Measure PS (horizontal distance) It is 4.2 cm = 420 m.

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

= (420 x ⅓) + 100

= 140+ 100

S = 240 m.

To check, wheather 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.

Depth of borehole at S = (~~240~~ x 1/~~12~~) + 220 m

20

= 20 + 220

S = **240 m**

EXERCISES

1) 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 mid point 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.

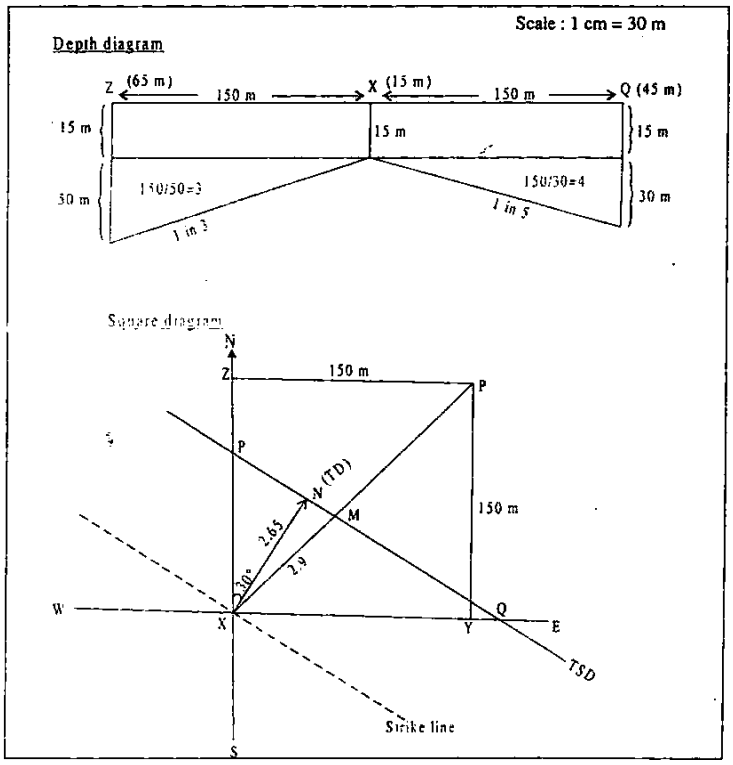
b) Another bore hole is proposed at 'S' the mid point of QR. Calculate at what depth the proposed bore hole reaches the same coal seam

Type II: Square method

Example: Three bore holes are sunk at **SW, SE & NW** comers 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.



Procedure: Draw a square with a convenient scale. Name the corners. Draw a rough sketch of depth diagram to determine the gradients of coal seams from X. It is 1 in 5 along XY and 1 in 3 along XZ. With convenient scale mark 5 units on XY is true strike direction (TSD). Draw a perpendicular to TSD from X. It cuts the TSD line at N. Join XN and measure with units. It is 2.65. The true dip is 1 in 2.65. To determine the direction of true dip, measure angle ZXN = N30°E. Strike is perpendicular to it.

True dip = 1 in 2.65 along N 30° 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 = (195 × 1/ 2.9) + 15m

P = 82.2 m

EXERCISES

1. Three bore holes are sunk at the comers of an isoscales 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 touches 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.

III Dip and strike (underground) and depth problems (Bore hole problems)

1) Three bore holes PQR are sunk at three comers 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. (TD= 1 in 4.05 along S 17° E Strike = S 75° W & S 73° E). (Depth at borehole 'S' is 80m)

2) Three trial bore holes X YZ, X is N 30° E of Y and N 30° W of Z at the apices of an equilateral grid of 900m sides in an engineering construction site intersected a sand stone bed rock at depths 5m, 30m and 25m respectively. Determine (1) The attitude of the bed rock and (2) the depths of the bed rock at station D in the centre of the grid. (Scale: 1cm = 100m)

(Ans: Strike N 80° W, S 80° W, Td = 10° along S 10° W, Depth = 20m).

3) Three bore holes are sunk at the comers of an isoscales 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 touches 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° E)

Strike = N 70° W and S 67° E

Depth = 105 m

4) In a hilly area for an engineering construction three test bore holes X, (70m EL) N 30° E of Y (85m Ei) and Z (90m Ei) east of Y drilled from the corners of an equilateral triangular grid of 900m sides encountered a fault breccia and depths 220m, 135m and 390m respectively. Determine (1) the attitude of fault breccia and (2) the depth at which the fault breccia is met in the bore hole P (75m EL) drilled at the midpoint of XZ. (Scale 1 cm = 100m, 1 unit 1 cm).

(Ans: True dip = 15° along N 70° E, Strike = N 20° W S 20° W Depth = 355m).

5) Four bore hole are proposed at ABCD at the 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 A at 160m, B at 60m and D at 240m depth, respectively.

a) Determine the attitudes of the coal seam.

b) Another bore hole is proposed at C. Calculate at what depth it reaches the same coal seam.

(Ans: True dip = 1 in 1.65 along S 35° W.

Strike = S 85° E & N 55° W. Depth: 360m).

Chapter 4

Dip and strike problems:

DETERMINATION APPARENT DIP AND TRUE DIP

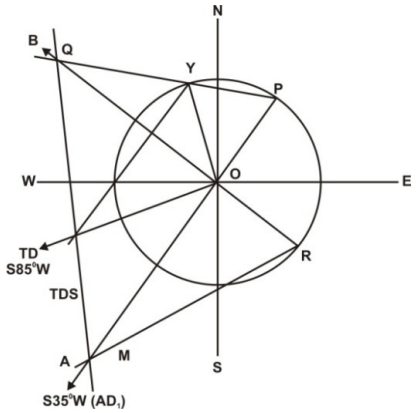
Dip and strike problems are solved by two methods.

1) Graphical method (Geometric)
2) Mathematical method

Type-I: Given the amount and direction of two apparent dips – it is required to find out the amount and direction of true dip.

Example: A bed of sandstone dips 30^0 along S53^0W and 38^0 along N60^0W Determine its true dip.

Graphical Method:



True dip:
Amount - 42^0
Direction - S85^0W

Procedure:

1. Draw north-South and East-West lines. Let them intersect 0. Describe a vector circle-0 as its center with convenient radius (preferably 2.5 cm).
2. Draw OA along apparent dip S35^0W (AD_1). Draw a perpendicular to it at O. It intersects the circle at R. Construct complimentary angle of the given apparent dip (90-30) 60 at R. It cuts OA at M. OMR - 30^0
3. Similarly draw OB along apparent dip N60^0W (AD_2).Draw a perpendicular to it at 0. It cuts the circle at P. Construct complementary angle of the given apparent dip (90^0-38^0) 52 at P it cuts OB at Q. Angle OQP = 38^0 Join MQ. It forms the true strike direction (TSD).
4. To determine the direction of true dip, draw a perpendicular to TSD from 'O' it cuts the TSD line at X.
5. To determine the amount of true dip along OX, draw a perpendicular to it at O. It cuts the circle at Y. Join XY, measure angle OXY. It is 42^0.

True dip – 42^0 along $S85^0W$

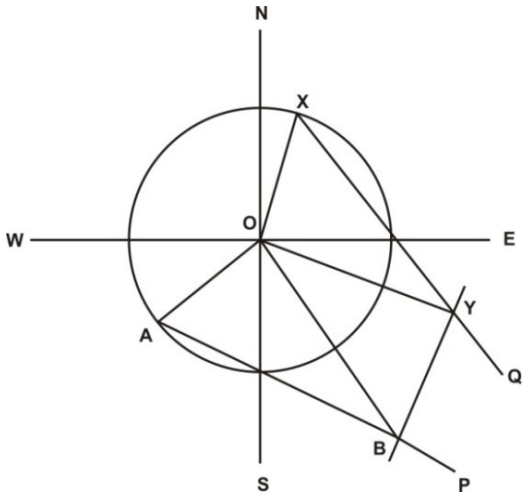
Exercise:

1. At a dam site, a bed of quartzite dips 28^0 along N 20^0E and 34^0 along $S80^0$E. Determine its true dip. (TD=38^0 – N68^0 E).
2. In a colliery, a coal seam dips 33^0 along N 70^0 E and 38^0 along S 20^0W. Determine its true dip, (TD = 46^0 along S 58^0 E).
3. At a railway cutting, a bed of sandstone dips 25^0 along SW and 35^0 along N 60^0 W. Determine its true dip, (TD = 37.5^0 along N 80^0W).
4. At a bridge site, a bed of quartzite shows a dip of 34^0 along north and 38^0 along east. Determine its maximum amount of inclination and its direction, (TD = 46.5^0 –N 60^0E).

Type-II: Given the true amount and direction, and one apparent dip direction – it is required to find out the apparent dip amount.

Example: A bed of shale is dipping maximum of 32^0 along SE. Find the amount of its inclination along S80^0E.

Graphical Method:



Procedure:

1. Draw N-S and E-W line. Let them intersect at O. Draw a vector circle.
2. Draw true dip directional line OP along SE. Draw a perpendicular to OP at O. It cuts the circle at A. Construct complimentary angle of true dip (90^0-32^0) 58^0 at A. It cuts Op line at B. Draw a perpendicular to OP at B. It is true strike direction (TSD).
3. Draw apparent dip direction line OQ. It cuts TSD line at Y. Draw a perpendicular to OQ at O. It cuts the circle at X. Join XY. Measure angle 26^0 = OYX.

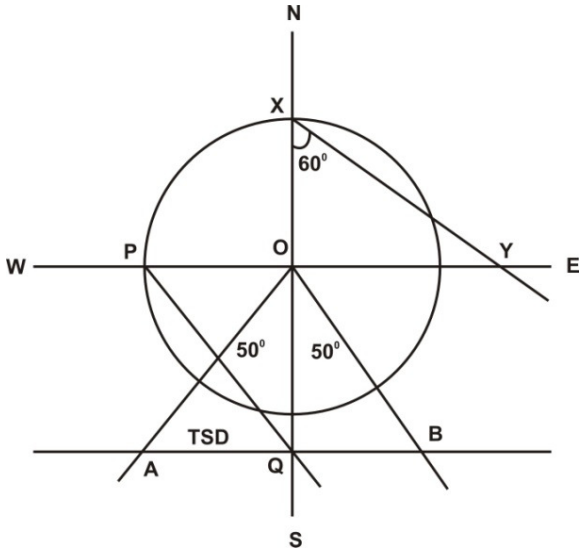
Exercise:

1. A coal seam dips 42^0 along S 70^0E. An inclined tunnel is proposed along S 30^0E along the lower bedding plane of coal seam. Determine the inclination (34^0.6)
2. A bed of limestone has a maximum dip of 45^0 along SW, calculate the amount of inclination along south and S70^0W.
   (South: 35^0.26: S 70^0W= 42^0.18).
3. In a reservoir site a bed of quartzite has maximum inclination of 40^0 along N 40^0W. Find its inclination along North and N 60^0W.
   (North: 23^0.48 : N 60^0W = 39^0.24).
4. A coal seam is exposed around a colliery. It shows a true dip of 48^0 along S 30^0W. Determine the amount of inclination along S 10^0 E and S 60^0W.
   (S 10^0E = 40^0 : S 60^0W = 43^0.83).

<u>Type – III:</u> Given the amount and direction of the true dip and the apparent dip amount-it is required to find out the direction of apparent dip.

Example: A coal seam is overlying sandstone and has a maximum dip of 42^0 towards south. Two inclined tunnels are proposed on the upper bedding plane of sandstone to have an inclination of 30^0. Determine the direction of the tunnels.

<u>Graphical Method:</u>



Inclined tunnels

Along S 50^0E and

Along S 50^0W

Procedure:

1. Draw N-S and E-W lines. Let then intersect at O. Draw the vector circle.
2. Draw the true dip directional line along OS. Draw a perpendicular to it at O. It intersects the circle at P.
3. Construct complementary angle of true dip (90^0-42^0) 48^0 at P. It cuts OS line at Q.
4. Draw a perpendicular to OS at Q. It forms true strike direction (TSD).
5. To plot the direction of apparent dip, select arbitrarily any suitable direction. Let us take OE.
6. Draw perpendicular to OE. It cuts the circle at X. Construct at the complementary angle of apparent dip (90^0-30^0) 60^0. It cuts OE line at Y. Angle OYX is 30^0.
7. Directions of tunnels are S 50^0N and S 50^0 E.

Exercise:

1. A coal seam has a maximum dip of 42^0 towards N 42^0E. Two inclined tunnels are proposed along the lower bedding plane with inclination of $28^{0.}$ Determine the directions. (N12^0W and S 84^0E).
2. At a dam site, a bed of the grained sandstone dips 38^0 along N 70^0E. Determine the directions of the proposed tunnels of 28^0 inclinations. (N23^0E and S 73^0E).
3. In quarry, a bed of limestone has a maximum dip of 40^0 along SW. Two inclined shafts are proposed to have an inclination of 30^0. Determine the direction. (N88^0W: S 2^0W)
4. Determine the directions of apparent dip of 25^0 for a coal seam having max. dip of 35^0 along S 30^0E (S 78^0E : S 18^0W).

Chapter 5

CALCULATION OF VERTICAL, TRUE THICKNESS AND WIDTH OF OUTCROPS.

Thickness of Strata:

Introduction:

Thickness of a bed is the shortest distance between its upper and lower surfaces. In other words, it is the perpendicular drawn to both the surface and it is known as 'TRUE THICKNESS (TT)' when a vertical borehole is sunk on the inclined beds; it reaches the upper and lower surface at different levels. The difference is known as 'VERTICAL THIKNESS (VT). When a bed is exposed on the ground it is an outcrop. An inclined bed as outcropped on a horizontal ground, its upper and lower surface is found parallel to each other. The distance between the two surfaces (bedding planes) is called 'WIDTH OF OUTCROP' (WOC).It is usually measured along the dip direction. Dip of an inclined bed is always expressed by its direction (Dd) and amount of dip (Da).

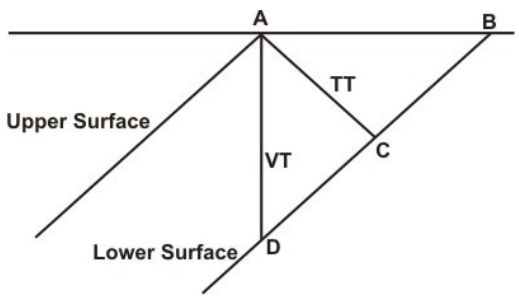
All these factors viz. True Thickness (TT), Vertical Thickness (VT), Width of outcrop (WOC). Dip direction (Dd) and amount of dip (Da) are interrelated. When some of them are known, the other can be determined by mathematical and graphical methods.

The following equations are generally used.

1. TT = W.sin θ
2. VT = W. tan θ
3. TT = VT. Cos θ

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

THICKNESS PROBLEMS:



AB = Width of Outcrop = WOC
AC = True Thickness = TT
AD = Vertical Thickness – VT
ABC = Dip angle D(a)
(Inclination)
West Dip direction D(d)

Note:- 1)The dip angle ABC is equal to the angle between the true thickness and vertical thickness i.e. CAD

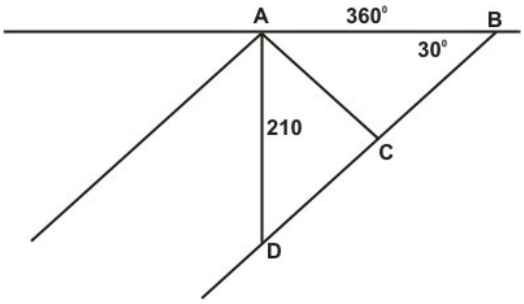
2) Vertical Thickness is always greater than True Thickness.

On Level Ground:

Type-1: Given WOC and dip amount and dip direction. It is required to find out TT & VT.

Example: A coal seam is exposed on horizontal ground. It dips 30^0 westward. Its width of outcrop is 360 m. determine its true thickness and vertical thickness.

Graphical Method:



Scale: 1 cm=100m
TT = 180 m.
VT = 210 m.

Procedure:

Draw a horizontal line. Measure and mark AB equal to width of outcrop given. Construct 30^0 angle westwards at A and B. Draw a perpendicular to the lower surface from A. It intersects the lower surface at C. Measure AC. It is the true thickness = 180m.

Draw a perpendicular to AB downwards from A. It cuts the lower surface at D. Measure AD. It is the vertical thickness = 210m.

Mathematical Method:

a) TT = W.sin D(a)
= 360 x sin 30^0
= 360 x 0.5
= 180 m

b) VT = W.tan D(a)
= 360 x tan 30^0
= 360 x 0.5773
= 207.85 m.
Say 208 m.

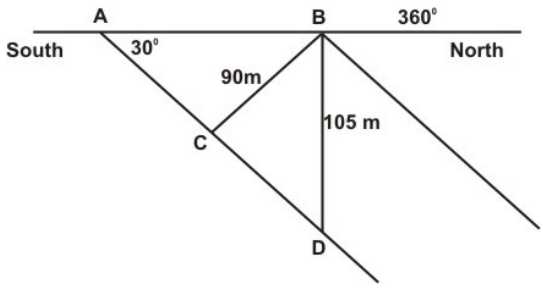
Exercise:

1) At a dam site, a bed of sandstone is exposed on horizontal ground. It dips 35^0 eastwards and its width of outcrop is 240m. Determine its true thickness and vertical thickness (TT = 137.7 m , VT = 168 m).
2) A bed of limestone is exposed on horizontal tunnel. Its width of outcrop is 200m and its dips 25^0 eastward. Determine its true thickness and vertical thickness (TT=84.52m, VT=93.26m).
3) In a colliery, a coal seam has an inclination of 28^0 along north and its width of outcrop is 180 m. determine its true thickness and vertical thickness (TT=84.5m, VT=95.7m).
4) A bed of limestone is exposed in a quarry. Its width of outcrop is 96 m and it dips 40^0 southward. A vertical bore hole is sunk from its upper bedding plane determine at what depth it reaches the lower bedding plane and calculate its true thickness (TT=6.7m, VT=80.55m).

Type-2: Given vertical thickness, width of outcrop and dip direction, it is required to find out TT and dip amount.

Example: A coal seam is exposed on a level ground. It dips northward. Its width of outcrop is 180 m. A borehole 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.

Graphical Method:



Scale: 1 cm = 50m

TT = 90m

D(a) = 30^0

Procedure:

Draw horizontal line. Mark south –north. Measure AB – width of outcrop. Draw a perpendicular at B downward. It is lower bedding plane. Draw upper bedding plane from B parallel to AD. Draw a perpendicular from B to AD. It cuts AD at C. BC is true thickness. Measure BC = 90m.

Measure dip angle = BAD = 30^0

TT = 90m. Dip angle = 30^0

Mathematical Method:

a) VT = W. tan D(a)

Tan D(a) = $\frac{VT}{W} = \frac{105}{180} = 0.5833 = 30^{\circ}\,15'$

b) TT= W.tan D(a)

= 180 x sin $30^{\circ}\,15$

= 180 x 0.5039 = 90.7 m

Exercise:

1. A sandstone layer is exposed on a level ground in reservoir site. A vertical borehole is sunk and touches the upper bedding plane at a depth of 50 m and lower bedding plane at .Determine true thickness and amount of inclination.

   (TT = 181.39m. Amount of dip =$30^{\circ}\,15$)
2. A vertical exploratory drilling for coal seam touches its upper surface at 80 m and the lower bedding plane at 240 m, its width of outcrop is 400 m on a level ground and it dips southwards. Determine its true thickness and amount of dip.

   (TT = 148.55m. Amount of dip = 21.48 say 22°)
3) A westerly dipping limestone bed has its vertical thickness of 130m and its width of outcrop on a level ground is 240 m. Determine its true thickness and amount of dip.

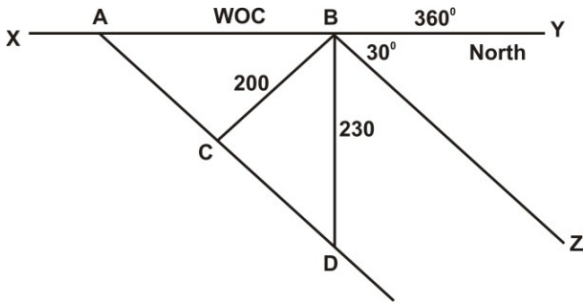
   (TT = 114.30m, Amount of dip = 28.26 say 28°)
4) An exploratory drilling at a tunnel site shows 25 m vertical thickness of southerly dipping sandstone bed and its width of outcrop is 50 m. Determine its true thickness and amount of dip.

   (TT = 22.36 m, Amount of dip 26° 34')

Type - 3: Given true thickness and dip amount and the direction, it is required to find out vertical thickness and WOC.

Example: On a horizontal tunnel, a bed of sandstone dips 30^0 eastwards. Its true thickness is 200 m. determine its vertical thickness and width of outcrop in tunnel.

Graphical Method:



Scale: 1cm = 100m

VT = 230 m
WOC= 400 m

Procedure:

Draw horizontal line XY. Mark B point. Construct YBZ – 30^0 dip angle eastward BZ is upper surface sandstone. Draw a perpendicular to BZ at B downward. Measure 200 m and mark C. BC is true thickness. Draw parallel to BZ from C. It cuts the XY line at A.

Measure AB = width of outcrop = 400 m.

Draw perpendicular to AB at B. It touches the lower surface at D. Measure BD = Vertical thickness = 230 m. VT = 230 m. W=400 m.

Mathematical Method:

a) TT = VT.cos D(a)

$$VT = \frac{TT}{\cos D(a)} = \frac{200}{30^0}.8660$$

= 230.9 m

b) TT = W sin D(a)

$$W = \frac{TT}{\sin D(a)} = \frac{200}{30^0}.5$$

= 400 m.

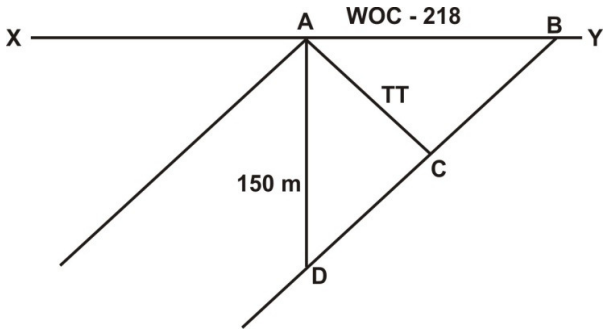
Exercise:

1. At a bridge site, a sill is exposed on level ground. It dips 400 northwards. Its true thickness is 180 m.Determine its vertical thickness and width of outcrop.
   (VT = 234.98 m. (Say 235m). W = 280 m).
2. In a colliery, a coal seam dips 32^0 westwards and true thickness is 2 m determine its vertical Thickness and width of outcrop on a featureless ground.(VT = 2.3 m, W = 3.7 m).
3. A bed of shale of 60 m thick. Dips 25^0 north railway cutting. Determine its vertical thickness and its width of outcrop on a level ground.
   (VT = 66.2 m, W = 141.98 m)
4. During a tunnel excavation, a bed of sandstone is noticed to dip 35^0 eastwards. Its true thickness is 72m.Determine its vertical thickness and its width of outcrop on the horizontal tunnel along the dip direction.
   (VT = 87.9 m, W = 125.53 m).

Type- 4: Given vertical thickness and dip determine TT and WOC

Example: A vertical borehole sunk from the upper bedding plane of shale bed reaches the lower bedding plane at depth of 150 m. It dips 35^0 westwards. Determine its true thickness and width of outcrop on level ground.

Graphical Method:



Scale: 1 cm = 50m.

TT = 125 m.
W= 218 m,

Procedure:

Draw a horizontal line XY. Mark point A. Construct XAZ 350 dip angle westwards. AZ is the upper surface. Draw a perpendicular to XY from A downward. Mark D point at depth of 150 m. Draw a parallel to AZ from D. It cuts XY line at B. BD is lower bedding plane. Measure AB = W = 218 m. Draw a perpendicular to BD A. It cuts BD at AC. AC is true thickness. It is 125 m.

(TT = 125 m, W = 218 m)

Mathematical Method:

$TT = VT \cos\theta = 150 \times 0.8192$
$= 122.87$ m

$VT = W \tan\theta$

$W = \frac{VT}{\tan\theta} = \frac{150}{0.70} = 214.22$m

$= 214.22$m.

Exercise:

1. A coal seam has vertical thickness of 24 m. and it dips 30^0 along south. Determine its true thickness and width of outcrop on level ground.

   (TT = 20.78 m, W = 41.57 m).

2. A bed of sandstone is exposed in a tunnel and it dips 25^0 westwards. An exploratory vertical bore hole sunk touches the upper bedding plane at depth of 10 m and the lower bedding plane at 190 m. its true thickness and width of outcrop on a featureless ground.

   (TT = 163.14 m, W = 386 m).

3. An exploratory vertical borehole reaches the upper bedding plane of oil bearing sandstone at a depth of 150 m and its lower bedding plane at 225 m. it is a conformable bed of series of sedimentary rocks dipping 28^0 westwards. Determine the true thickness and width of its outcrop on level ground.

   (TT = 66.22 m, W = 141 m).

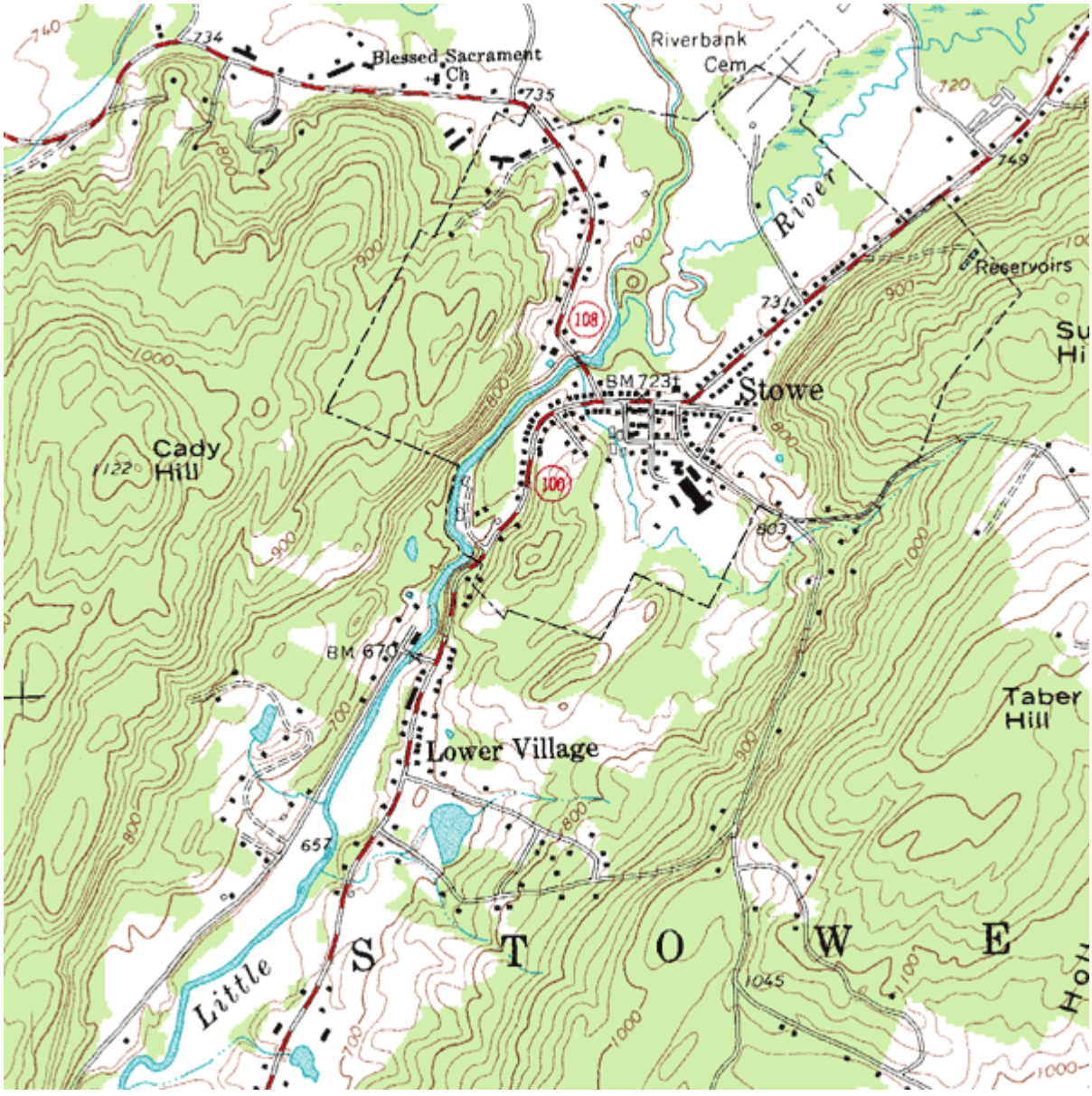
Chapter 6

Study of Topo sheet and interpretation

Introduction

In modern mapping, a topographic map or topographic chart 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 survey 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.



Interpretation of toposheet

1. Identifying the toposheet by the register number given in the left top side of the topo sheet
2. Learn to identify the legend, symbol and scale of the map on the map natural and man made features.
3. Longitudinal and longitudinal grid identification and locating the place district state boundries
4. Mapping the contour elevation, vegetation and drainage
5. Study of land scape and land use pattern of the given toposheet
6. Study of drainage basin , river, stream , lake and pond .

Chapter 7

STRUCTURAL GEOLOGICAL MAPS

Introduction:

Geological maps are plan views of areas on the surface of the earth showing outcrops of rocks beneath, their trend and structural attitude to scale.

A map is described as representation of an area on a plain paper to a scale. The geological map is one which reveals the geological information in terms of topography, litho logy, and geological structure, order of superposition, thickness of beds and geological history of that region. A geological map is a contour map over which geological formations, structures etc. are marked.

Geological maps are prepared by plotting contacts of rock units and other geological parameters such as dip, strike, faults etc., on a plain metric or topographic base map, air photo of the area concerned or on plain paper with contour values.

By a proper interpretation of the nature of the outcrops of rocks and other geological data and drawing vertical sections along required directions analogous to an elevation of a structure in an engineering drawing, the ground conditions can be inferred fairly accurately.

Civil Engineering Importance :

For safe, stable, successful and economical Civil Engineering constructions such as dams, reservoirs, tunnels, etc., detailed geological information is essential. Proper interpretation of a geological map provides all details which a Civil Engineer requires. This study of geological maps is of great importance.

Aim: The purpose of interpretation of the following maps is not to tackle any specific Civil Engineering project but to equip with all necessary geological information, so as to enable the concerned to utilize the same as the required by the context.

Interpretation: In a geological map, normally contours are marked as dotted lines with elevation value and bedding planes, fault planes etc. are marked as continuous lines. The interpretation comprises of details of topography, litho logy, structure and geological history.

Interpretation of Topography:

From the study of contour the information noted is about

1. Maximum height, Minimum height, Surface relief

2. Number of Hills, Valleys, ridges, etc.

3. Nature of slope, whether it is uniform or irregular and steep or gentle

Relevant details:

1. Area in the map indicated by simple rectangles.

2. Hills or Hill ranges

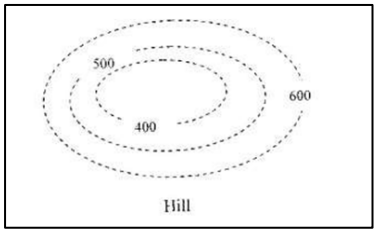
• Closed contour with contour values increasing inwards
• Repeated appearance of the same in a row is Hill Range
• Contours also indicate shape of Hills

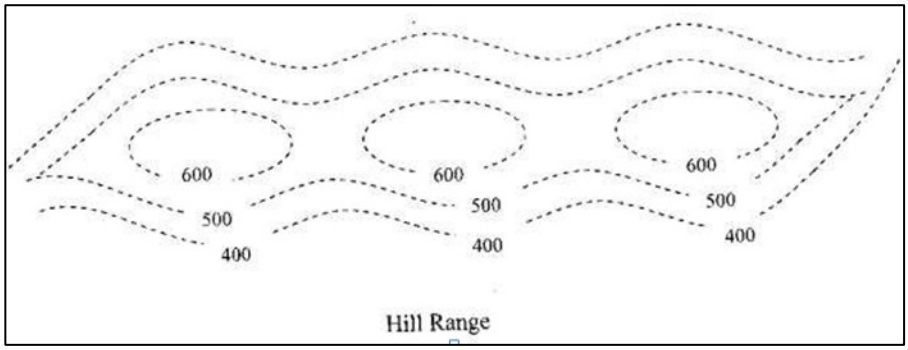
3. (a) Maximum height is the elevation which is more than the highest contour marked in the map. (b) Minimum height is the elevation which is less than the lowest contour marked in the map. (c) Surface relief is the difference between the maximum height and the minimum height.

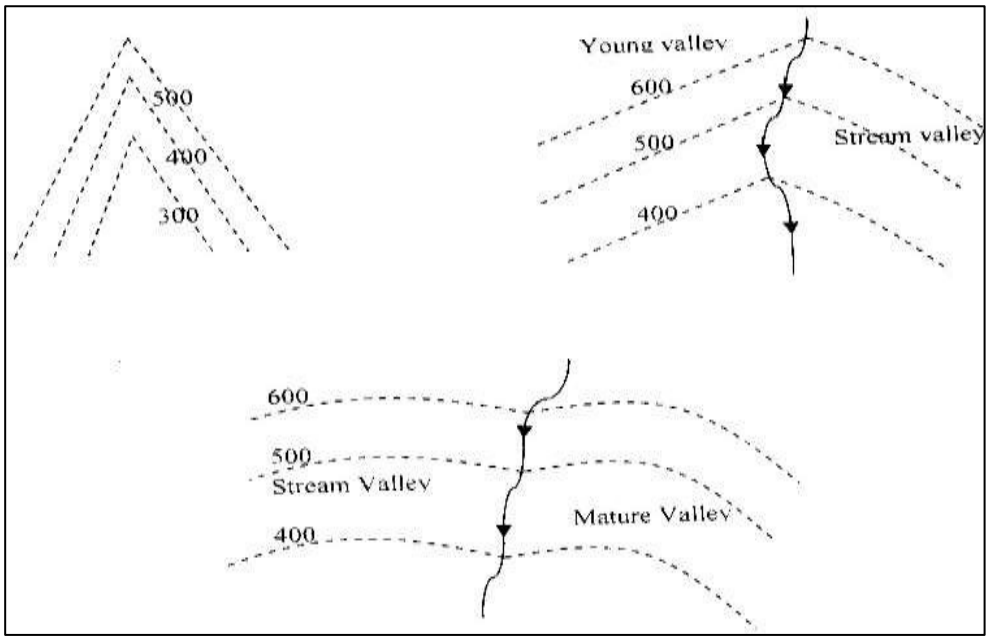
4. (a) Valleys: These are a series of V shaped (sharply bent) contours with successively higher elevation towards the pointed ends (convex side) of the contours.

• The sharpness of bends indicates the stage of valley development

• Young valleys have sharply contours but mature valleys have bluntly curve contour







SIMPLE STRUCTURAL GEOLOGY PROBLEMS

Interpretation of Litho logy and Structure

1. Horizontal Beds: If the bedding planes and associating contours are mutually parallel it indicates beds are Horizontal.

a) Highest elevation is the youngest b) Can't have Strike and Dip

2. Vertical Beds: If the bedding planes appear as straight lines and also cuts across the associating contours, it indicates beds are vertical. Bedding plane itself is their strike direction b) No dip direction but dip amount is 90°

3. Inclined Beds: If the bedding planes are curved and cut across the associating contours, it indicates beds are inclined.

a) Choose any bedding plane which cuts across the same contour minimum at two places. Draw a line passing through. It gives the strike direction of beds.

b) Next check where the bedding planes cut next contour, draw a parallel line passing through this point.

c) If the bedding plane refers to A/B contact and contour passes at the intersection point (where bedding plane, strike line, contour line intersects) is 500 and is called A/B 500. Second value is either A/B 600 or A/B 400.

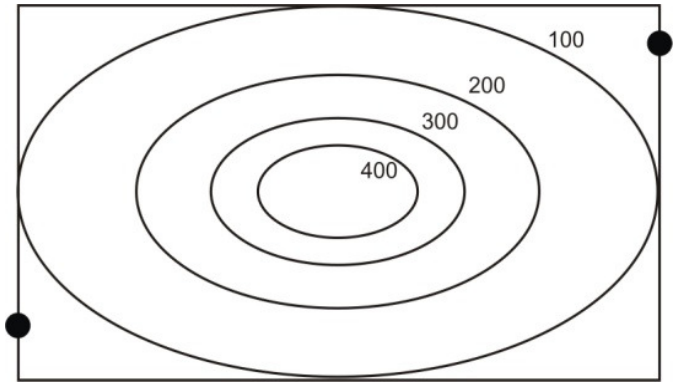
d) A short line perpendicular to the strike line in the decreasing side is the Dip direction.

Dip amount = (contour interval*60)/strike interval.

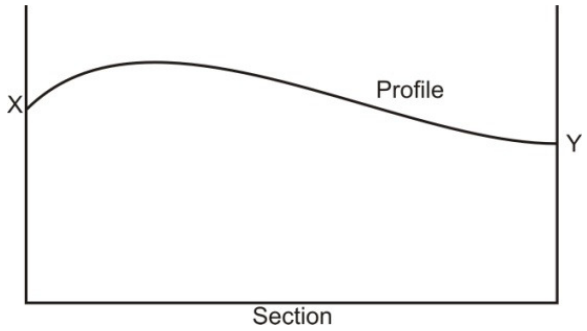
e) Since the arrow head of the dip direction points to successively younger Beds, Order of Superposition is known

f) Strike direction is expressed both with N or S, but dip direction is expressed only either N or S. For example, if N 10° E is dip direction, then strike direction is N 80 ° W or S 80 ° E.

Contour: It is curved line passing all points of equal elevation s. Each contour is numbered (300, 400 etc) indicating its position above or below the mean sea level. There will be constant differences in height between any two consecutive contours known as contour interval (CI) The contours never intersect with each other (But in some exceptional cases). With the help contours a profile can be drawn in drawn in any required directions (XY).



Profile: It is longitudinal section which shows rise or fall of the ground between any two points on a map like X & Y.



There are some maps without contours, but they are provided with triangular spots with height.

FEATURES OF GEOLOGICAL MAPS:

1) **Topography:** It is an outer view of the area. It indicates elevations like hills, Mountains & depressions like valleys. These can be interpreted contour values of the map.

2) **Geology a) Rock Unit:** The basic unit of geological map is a rock formation and subsequent changes in the area i.e. structural formation like dip, folds, faults, unconformity and instructions like dyke, batholiths etc.

3) **Age of rock formation: (Order of super position).**

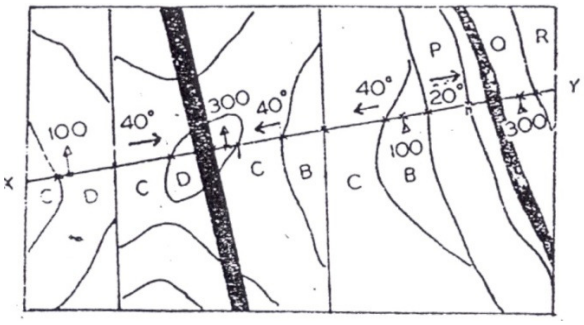
   Geological younger beds occur at the top of the sequence and in the direction of the dip in case of inclined series.

PATTERNS OF GEOLOGICAL MAPS.

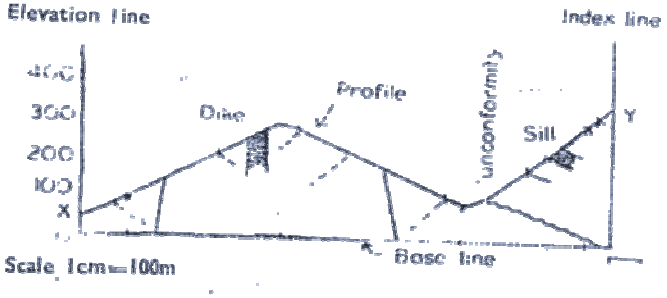
1) Contour: Curved dotted lines or Triangular spots with heights.
2) Bedding planes: Continues bold lines parallel or across the contours
3) Sill: Concordant igneous body runs parallel to bedding planes.
4) Dyke: Discordant igneous body runs parallel to bedding planes.
5) Batholiths: Large discordant body with irregular outline closed output and cut across the bedding planes.
6) Horizontal beds: Bedding planes runs parallel to contours.
7) Folded beds: Bedding planes dipping each other (→I←) and dipping away (←I→) from an anticlincal fold.
8) Fault-plane: A line or plane along which beds are dislocated.
9) Un-Conformity: Determine line between older series and younger series.

Geological Section

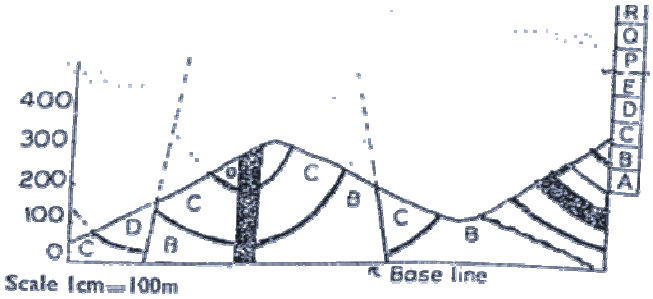
It is evalution draw along required direction (AB or XY) on the map to a scale and it is known as section line.



GEOLOGICAL MAP SCALE 1cm=100m



GEOLOGICAL SECTION



SECTION DRAWING

General Procedure:

1) Draw a base line (XY) on a separate sheet of paper exactly equal in length to the XY on a map.

2) On a strip of paper, keeping on XY line on a map, mark the intersection point of contour lines, fault lines, unconformity line, boundaries of dyke and sill, bedding planes etc and transferred to the section as explained in Sl. No. 4.

3) Draw elevation lines perpendicular to base line at X & Y. Mark the height (100, 200 etc tp next height) on the elevation line at regular intervals according to scale given.

4) Transfer the intersection points of contours to the base line and project them vertically to the corresponding levels in the section referring to the elevation heights. Join all these points by smooth curved line and produce them in the same trend to meet the elevation lines. This line is called “Profile”

5) Transfer the remaining intersection points to the base line and project them vertically on the profile line and draw them as follows.

6) **Faults:** Faults should be drawn from profile to the base line giving inclination (max of 10^0) towards down throw side of the beds.

7) **Unconformity:** From the profile draw in a zig-zag line in the direction of the amount of dip (20^0) of younger series on the map with the help of protractor.

8) **Intrusives:** **a) Sill:** From profile drawn parallel to the bedding planes lying on either side and mark with same sign.

   b) Dyke: From profile draw vertically downwards to meet the base line mark with same sign.

   c) Batholiths: From profile draw to diverging (Widening) lines to meet base line mark with same sign.

9) Bedding planes: From profile points draw the bedding planes in the direction and the amount of dip given on the map from the horizontal at profile point.

In case the direction and amount of dip are not given in the map (contour map) these can be determine by stratum contour method by using formula.

$$= \frac{\text{Counter interval}}{\text{Horizontal distance between strike lines}}$$

Geological report of the Map

This can be interpreted from the map as well as its section together as follows: (See map & Section).

1) Topography: The area show in the map is an undulating ground with two hillocks of 300m high, one at the western side and the other at the eastern side. A valley has been formed in between two hillocks. Erosion of the beds as produced the present undulating topography.

2) Order of superposition: The area consists of two series of beds, the older series consists of 5-beds ABCDE of which A is oldest and the E is the youngest, the younger series consists of 3-beds PQR of which P is the oldest and R is the youngest of all.

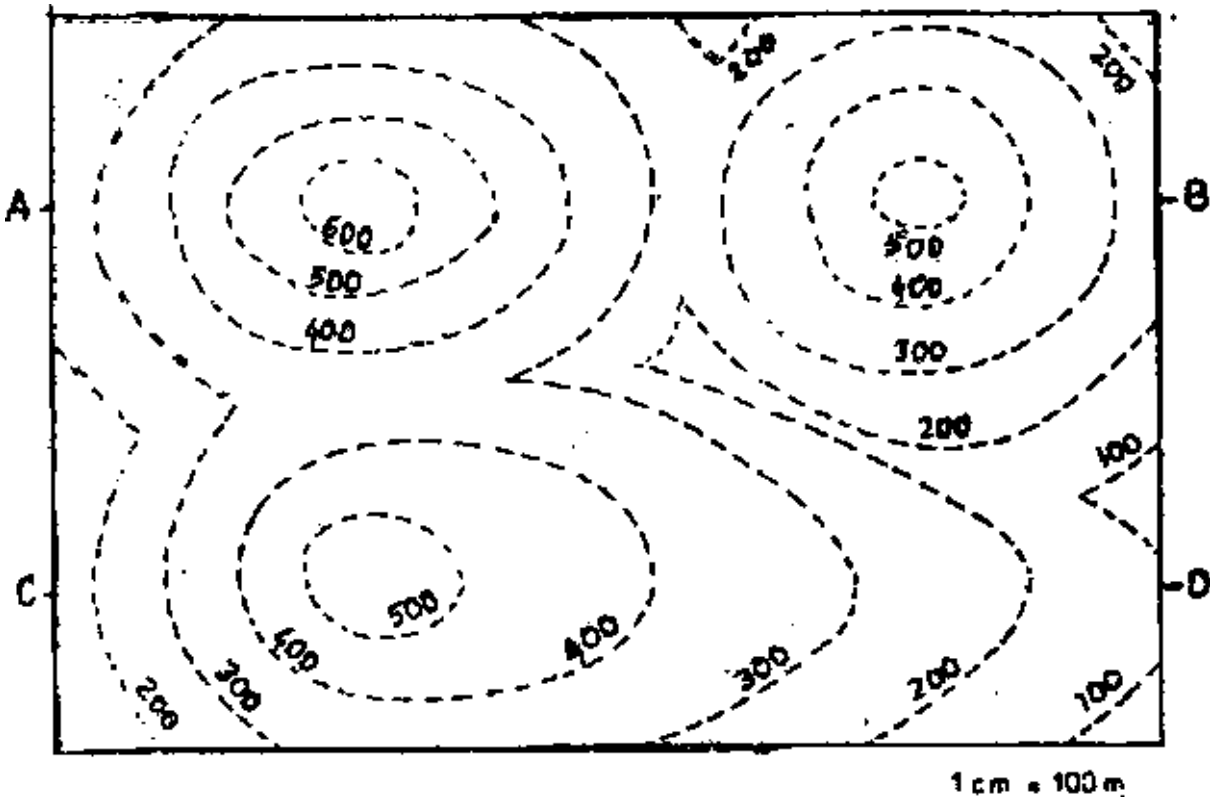
3) Geology of the area: The area consists of two series of confirmable beds (ABCDE and PQR) with an unconformity in between. The older beds have been folded into a symmetrical synclinal bed folds with the limbs dipping towards each other at 40^0. The area faulted two times (F1 & F2) bringing the younger beds in contact with the older beds along the fault planes having a common up throw side between. Thus faults F1 & F2 from a ridge(Horst) type of fault.

The younger beds are dipping eastwards at an angle of 20^0

Intrusions: A dyke is intruded in between two faults. A sill is running through the bed Q. the area is western side is faulted two times and it is not suitable for engineering projects.

Exercise:

Map-1: Contour Map



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

Note: 1) Use Centimetre 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

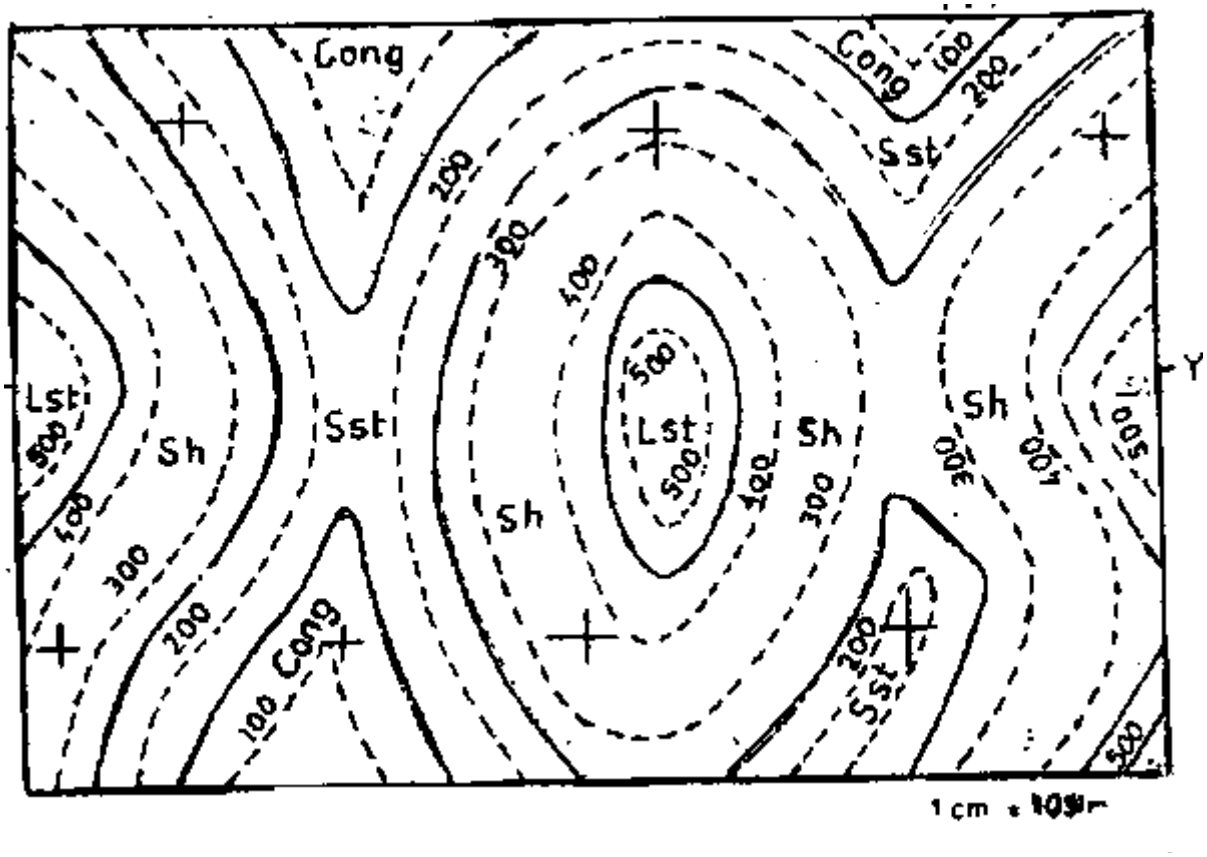
of higher value, it shows a valley features.

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:

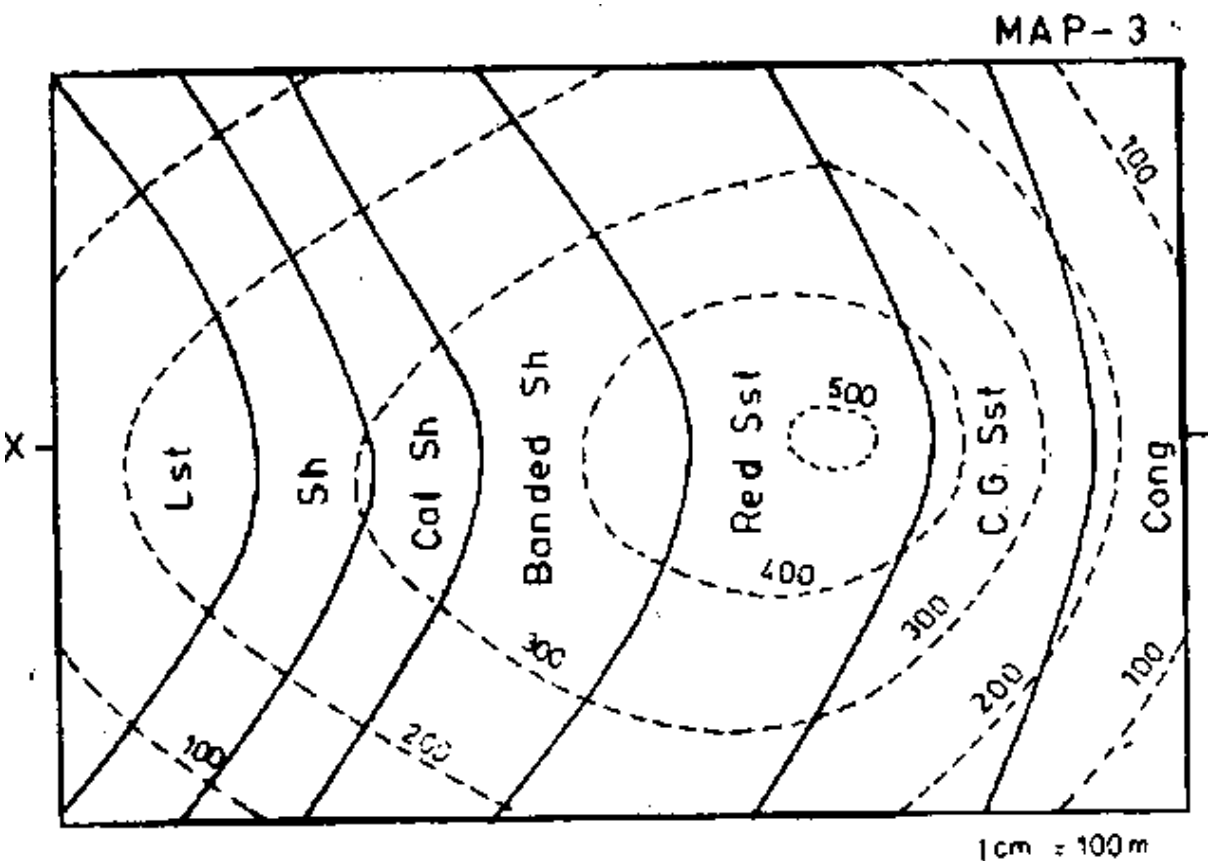
a. Structural features: All the sedimentary rocks indicated in the map as well as in the cross section are deposited as horizontal beds, started by the deposition of sand Stone in the base and followed by Shale and Lime Stone. After certain period of time they were uplifted and exposed to the surface & 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…..

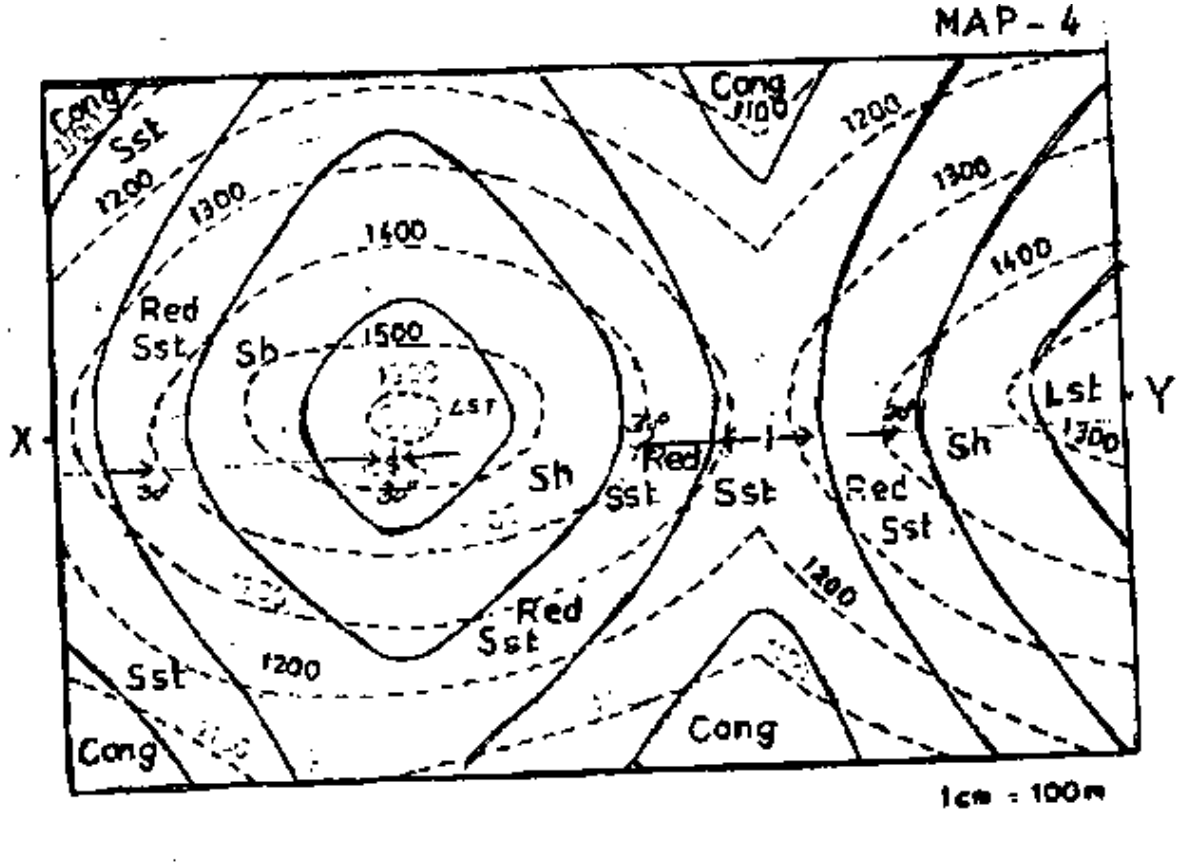
b) Order of Superposition

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 ……

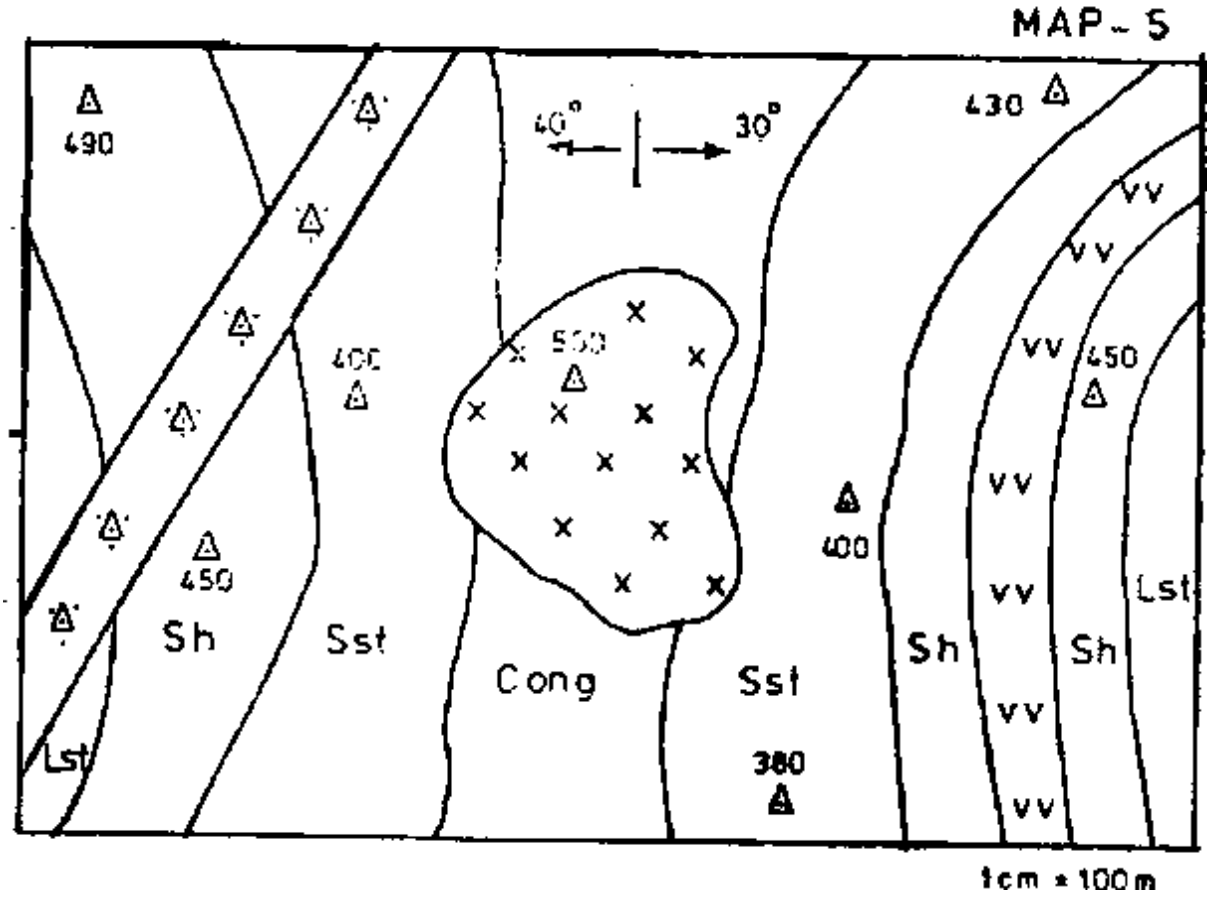
b) Order of Superposition

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 :

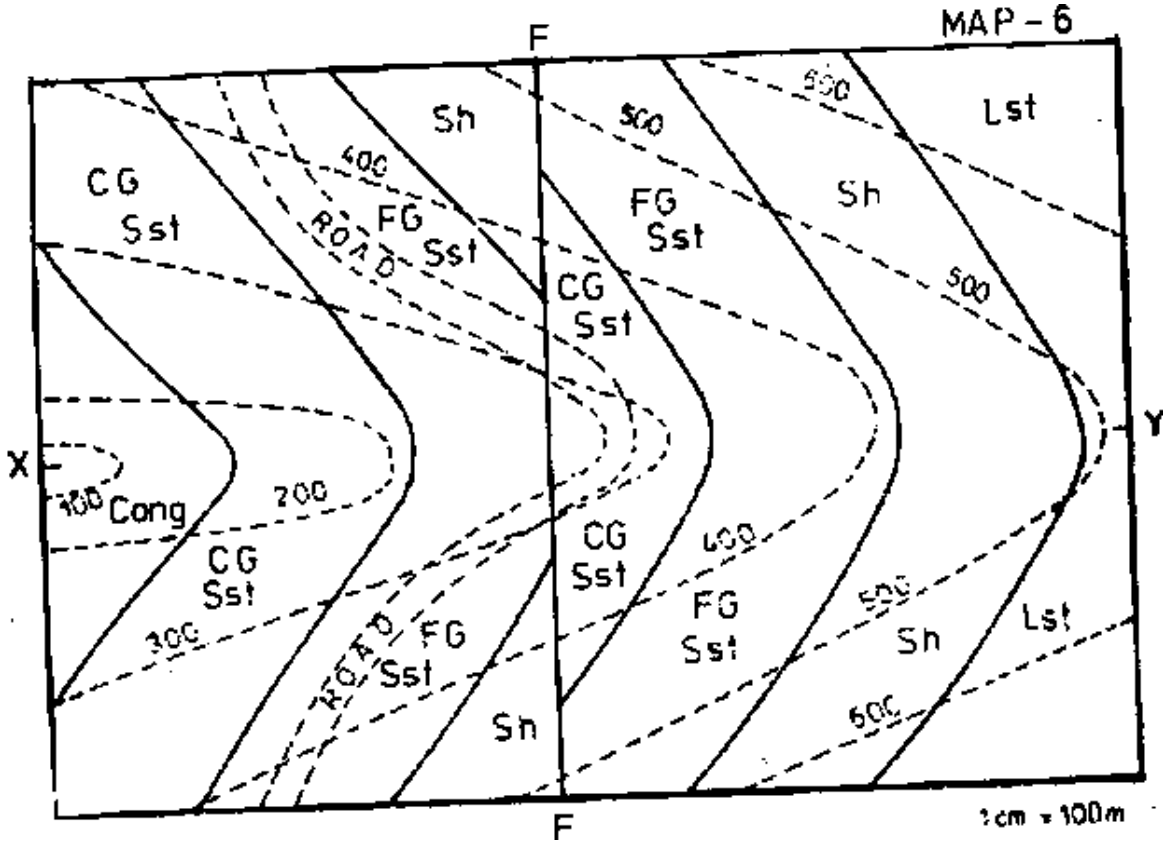
1) Topography
It is an irregular land surface. The minimum and maximum altitude of the given area is 380m and 500m.

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

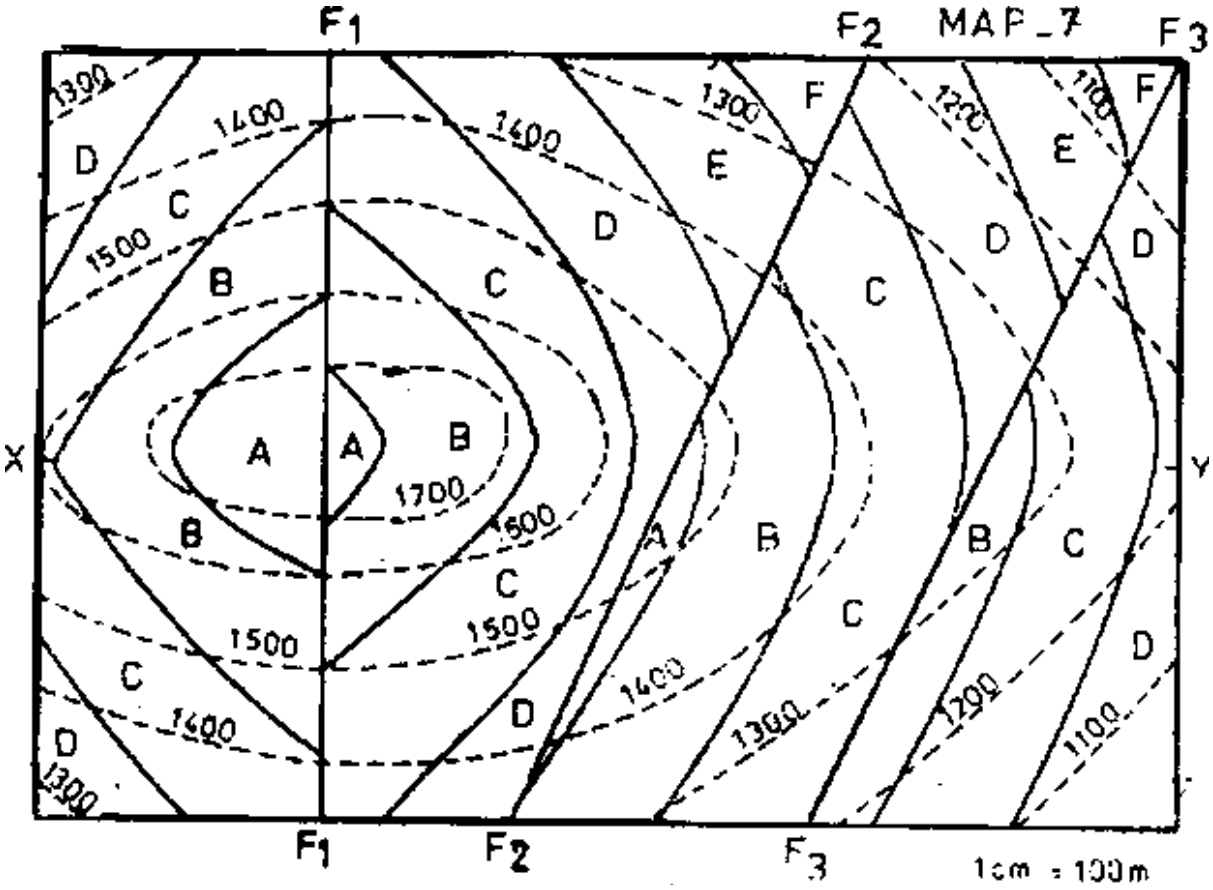
Lime Stone is the youngest. The thickness of beds Coarse Grained Sand Stone=…m, Fine Grained Sand Stone=….m, Shale=…m.

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 (F1, F2& F3). 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…….

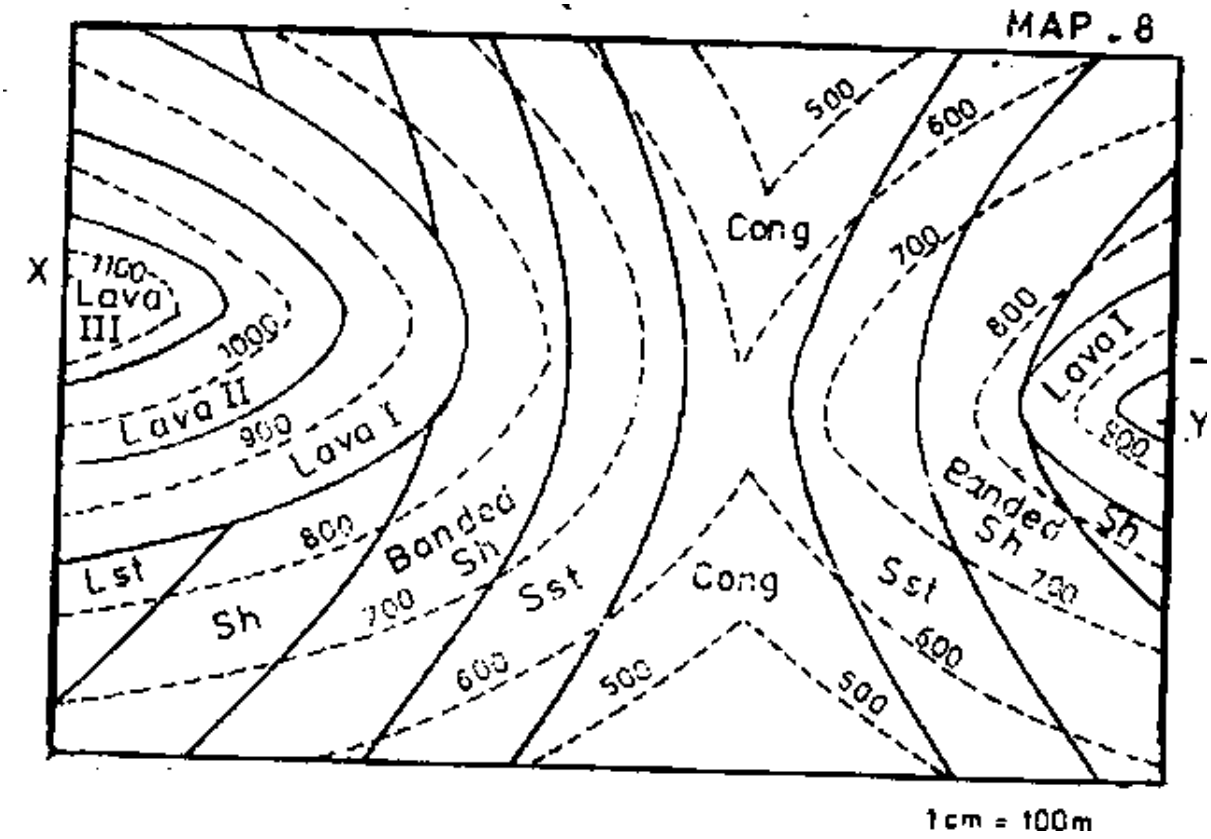
b) Order of Superposition

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

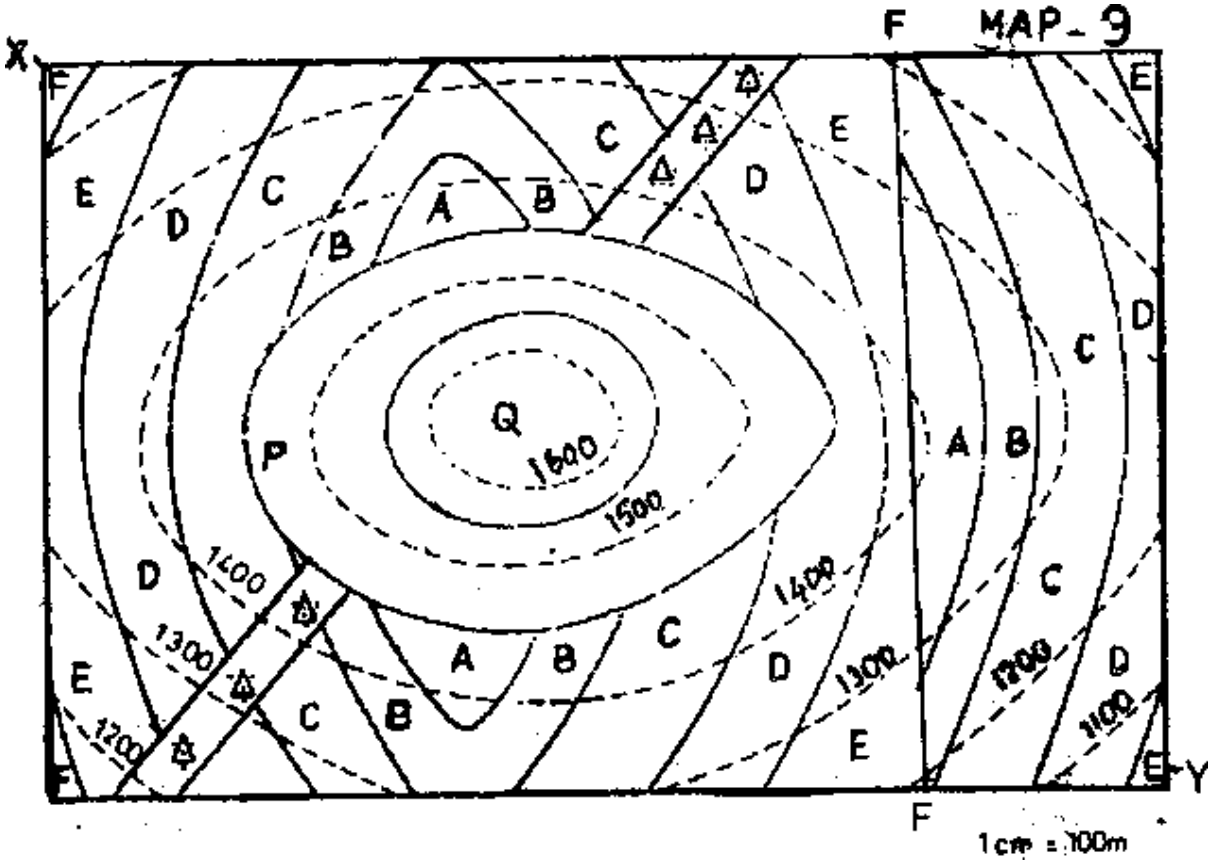
a) **Structural features:** The beds are initially deposited as horizontal beds in the sedimentary basin. Due to various tectonic activities they were uplifted; during upliftment the beds were folded followed by magmatic intrusions (dyke), followed by series of vertical faults (F1 & F2). After uplifted 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…….

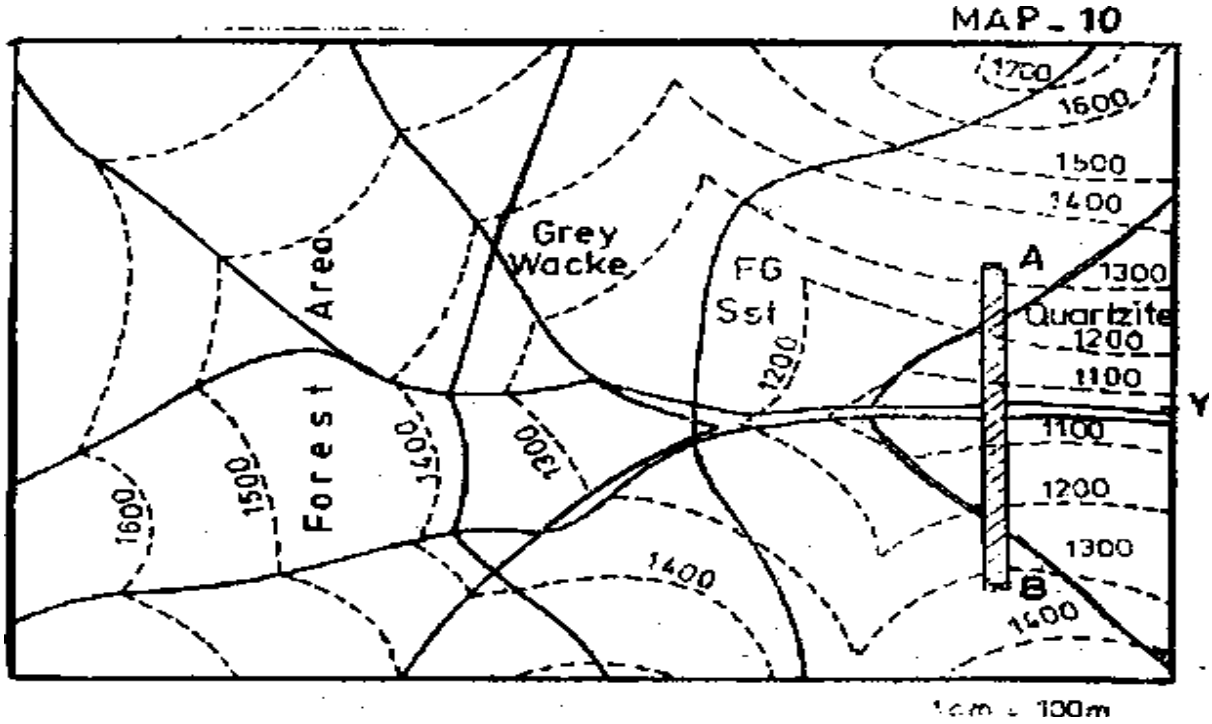
b) Order of superposition:

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.

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 favorable 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) Volcanic products - solid, liquid & gaseous.

d) Distribution of volcanoes.

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 orometer 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 VidhanSoudha.

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 the rock used in the construction of Taj Mahal, Red fort, Fathpur sikri, Vidhana Soudha, A.G. Office, Bangalore, Halebidu & Belur Temples.

g) Rock suitable for carving statues ? Marble.

h) Large Monolithic statues ? granite - gomateshwara.

i) Building stones for foundation, super structure flooring, concrete aggregate, 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 recognised in the map and field.

e) What is inconformity ? Types of unconformity.

f) How is unconformity recognised in the map & field ?

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

h) Describe the compass Clinometer ?

i) What is Inlier ? - 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) Safty and stability of Dam.

f) Water thightness 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
    - Vesicular - 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. Heave 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 uncompormity.

n) Bathililh, Dyke, Sill, Laccoiith. Lava flow.

o) How do you distinguish between.

Quartz and calcite, corundum and garnet.

Magnesite and Magnetite, granite and gneiss.

Conglomerate and Breccia, Talc 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 satination, Zone of Aeration.