



MINING ENGINEERING LAB MANUAL

**MINING GEOLOGY I
(DIPLOMA)
SEMESTER III**

LIST OF EXPERIMENTS

S.No.	Name of the Experiment	Page No.
1.	Study of physical properties of Minerals.	3-13
2.	Study of common igneous rocks.	14-16
3.	Study of common sedimentary rocks.	17-18
4.	Study of common metamorphic rocks	19-22
5.	Study and drawing of Maps & Plans	23-25

EXPERIMENT NO.-1

OBJECT: To Study the physical properties of common rock forming minerals.

THEORY: A **mineral** is a naturally occurring inorganic solid substance that is characterized with a definite chemical composition and very often with a definite atomic structure.

Mineralogy is that branch of geology which deals with various aspects related to minerals such as their individual properties, their mode of formation and mode of occurrence.

Minerals can be described by various physical properties which relate to their chemical structure and composition. Common distinguishing characteristics include crystal structure and habit, hardness, lustre, diaphaneity, colour, streak, tenacity, cleavage, fracture, parting, and specific gravity. More specific tests for minerals include reaction to acid, magnetism, taste or smell, and radioactivity.

PHYSICAL PROPERTIES OF MINERALS:

Minerals can be only identified absolutely by x-ray analysis and chemical tests. The x-ray analysis determines the structure of the mineral and the chemical tests determine the composition of the mineral. Structure and composition are the defining marks of a mineral. Unfortunately for the average collector, these tests require expensive equipment, expert know-how and often destroy the specimen. Fortunately, both structure and composition affect certain physical properties. It is through the proper use of these properties that minerals can reliably be identified. The best physical property is one that will give a unique result for a mineral and will always give the same result, again and again, for any and every specimen of that mineral.

1. COLOUR

Colour is one of the most obvious characteristic of a mineral, but generally not the most useful diagnostic feature. Depending on impurities, individual mineral types may come in a vast variety of colours. For example, ruby and sapphire are differently coloured types of the mineral corundum (Al_2O_3). The red colour of ruby is due to the presence of the element chromium. Sapphires may come in a vast variety of colours; blue is the most familiar colour, but yellow, orange, green, pink, orange and brown varieties are also known. Garnets may also come in a large range of colours, depending on their composition. They can be found with virtually any colour, although blue garnets are exceptionally rare. It is therefore advisable not to rely on colour alone to identify a mineral.

2. CRYSTAL HABIT

Crystal habit refers to the characteristic shape of a mineral unit (either an individual crystal or an aggregate of crystals). Crystals with well-developed faces are referred to as "euhedral"; for example garnet crystals are often euhedral. Minerals may also occur as aggregates of crystals; for example, asbestos is usually found as an aggregate of very fine fibers. The following list gives examples of different crystal habits and examples of common minerals that may exhibit each habit.

- Cubic* - cube shapes
- Octahedral* - shaped like octahedrons, as described above.
- Tabular* - rectangular shapes.
- Equant* - a term used to describe minerals that have all of their boundaries of approximately equal length.
- Acicular* - long, slender crystals.
- Prismatic* - abundance of prism faces.
- Bladed* - like a wedge or knife blade.

3. STREAK

The streak of a mineral refers to the colour of the mark it leaves behind after being rubbed against a piece of unglazed porcelain. Streak is the color produced by a fine powder of the mineral when scratched on a streak plate. Hematite provides a good example of how streak works. While this mineral is usually black, silver or brown-red in hand sample, its streak is always a dark blood-red. Chalcopyrite is usually golden-brown in hand sample, but has a green-black streak. Streak can be used only for minerals with a Mohs hardness of 7 or less, as minerals with a hardness greater than 7 will themselves scratch the streak plate.

4. LUSTRE

Lustre refers to the way in which the surface of a mineral reflects light, and is controlled by the kinds of atoms present and their bonding. It is described by the following terms

1. **Metallic** - looks shiny like a metal. Usually opaque and gives black or dark colored streak.
2. **Non-metallic** - Non metallic lusters are referred to as
 - a. **vitreous** - looks glassy - examples: clear quartz, tourmaline
 - b. **resinous** - looks resinous - examples: sphalerite, sulfur.
 - c. **pearly** - iridescent pearl-like - example: apophyllite.
 - d. **greasy** - appears to be covered with a thin layer of oil - example: nepheline.
 - e. **silky** - looks fibrous. - examples - some gypsum, serpentine, malachite.
 - f. **adamantine** - brilliant luster like diamond.

5. CLEAVAGE

Minerals are composed of atoms, which, for each mineral, have a characteristic arrangement. Weaknesses in the chemical bonds between these atoms cause planes of weakness in the crystal structure. Cleavage is an indication of how well mineral breaks along these planes of weakness, and may be a good diagnostic characteristic. Cleavage may be described as “perfect”, ”good”, “distinct” or ”poor”. In transparent minerals or in thin sections viewed through a microscope, cleavage may be seen as a series of parallel lines.

The number of cleavage planes in a mineral may also aid its identification. Cleavage typically occurs in either one, two, three, four or six directions. Micas easily split along their one plane of cleavage to form thin sheets. Amphiboles exhibit two cleavage planes. Iceland spar, a variety of calcite, cleaves readily along three planes of weakness into distinctive rhombs. Galena breaks along three cleavage planes producing cubic fractions. Fluorite and diamond show cleavage in four directions. Sphalerite exhibits cleavage in six directions. Not every mineral displays cleavage. For example, quartz does not have a weakness in its crystal structure, and therefore does not exhibit cleavage. When a quartz specimen is broken with a hammer, it displays conchoidal (shell-like) fracture.

6. FRACTURE

If the mineral contains no planes of weakness, it will break along random directions called fracture. Several different kinds of fracture patterns are observed.

- Conchoidal fracture - breaks along smooth curved surfaces.
- Fibrous and splintery - similar to the way wood breaks.
- Hackly - jagged fractures with sharp edges.
- Uneven or Irregular - rough irregular surfaces.

7. HARDNESS

Hardness is determined by scratching the mineral with a mineral or substance of known Hardness. Hardness is a relative scale, thus to determine a mineral's hardness, you must determine that a substance with a hardness greater than the mineral does indeed scratch the unknown mineral, and that the unknown mineral scratches a known mineral of lesser hardness.

Hardness is determined on the basis of Moh's relative scale of hardness exhibited by some common minerals. These minerals are listed below, along with the hardness of some common objects.

Hardness	Mineral	Common Objects
1	Talc	
2	Gypsum	Fingernail (2+)
3	Calcite	Copper Penny (3+)
4	Fluorite	
5	Apatite	Steel knife blade (5+),
6	Orthoclase	Steel file
7	Quartz	
8	Topaz	
9	Corundum	
10	Diamond	

8. TENACITY

Tenacity is the resistance of a mineral to breaking, crushing, or bending. Tenacity can be described by the following terms.

- Brittle* - Breaks or powders easily.
- Malleable* - can be hammered into thin sheets.
- Sectile* - can be cut into thin shavings with a knife.
- Ductile* - bends easily and does not return to its original shape.
- Flexible* - bends somewhat and does not return to its original shape. *Elastic* - bends but does return to its original shape.

9. DENSITY (SPECIFIC GRAVITY)

Density refers to the mass per unit volume. Specific Gravity is the relative density, (weight of substance divided by the weight of an equal volume of water). In cgs units density is grams per cm³, and since water has a density of 1 g/cm³, specific gravity would have the same numerical value as density, but no units (units would cancel). Specific gravity is often a very diagnostic property for those minerals that have high specific gravities.

10. MAGNETISM

Magnetic minerals result from properties that are specific to a number of elements. Minerals that do not have these elements, and thus have no magnetism are called *diamagnetic*. Examples of diamagnetic minerals are quartz, plagioclase, calcite, and apatite. Elements like Ti, Cr, V, Mn, Fe, Co, Ni, and Cu can sometimes result in magnetism. Minerals that contain these elements may be weakly magnetic and can be separated from each other by their various degrees of magnetic susceptibility. These are called *paramagnetic* minerals.

Study of physical properties of various minerals:

FELDSPAR

1. Form : Tabular
2. Colour : Pale Pink
3. Streak : White
4. Luster : Vitreous
5. Fracture : Uneven
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 7
9. Specific Gravity : 2.5
10. Occurrence : Adilabad
11. Origin : Igneous
12. Uses : Tiles
13. Name of the Specimen : Feldspar
14. Chemical Composition : $KAlSi_3O_8$

QUARTZ

1. FORM : Amorphous
2. Colour : White
3. Streak : Colourless
4. Luster : Vitreous
5. Fracture : Uneven
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 7
9. Specific Gravity : 3
10. Name of the Specimen : Quartz
11. Occurrence : South India
12. Origin : Igneous
13. Uses : Used as gemstone and in watch industries etc
14. Chemical Composition : SiO_2

OLIVINE

1. Form: : Amorphous
2. Colour: : Yellowish green
3. Streak: : White
4. Luster: : Earthy
5. Fracture: : Absent
6. Cleavage: : Absent
7. Diaphaneity: : Opaque
8. Hardness: : 5
9. Specific Gravity: : 3 to 4.5
10. Occurrence: : Karnataka
11. Origin: : Igneous
12. Uses: : Paints
13. Name of the Specimen: Olivine
14. Chemical Composition: $(\text{Mg, Fe})_2 \text{SiO}_4$

HORNBLLENDE

1. FORM: : Tabular
2. Colour: : Pale Pink
3. Streak: : White
4. Luster: : Vitreous
5. Fracture: : Uneven
6. Cleavage: : Absent
7. Diaphaneity: : Opaque
8. Hardness: : 7
9. Specific Gravity: : 2.5
10. Occurrence: : Adilabad
11. Origin: : Igneous
12. Uses: : Tiles
13. Name of the Specimen : Feldspar

14. Chemical Composition : $KAlSi_3O_8$

MUSCOVITE

1. Form: : Lamellar
2. Colour: : White
3. Streak: : White
4. Luster: : Vitreous
5. Fracture: : Uneven
6. Cleavage: : Absent
7. Diaphaneity: : Transparent in individual layer & opaque as whole
8. Hardness: : 2 to 3
9. Specific Gravity: : 2.5
10. Occurrence: : Gudur
11. Origin: : Metamorphic
12. Uses: : Poor conductor of heat
13. Name of the Specimen : Muscovite
14. Chemical Composition : $KAl_2(AlSi_3)O_{10}(OH, F)_2$

BIOTITE

1. Form: : Lamellar
2. Colour: : Black
3. Streak: : Dark brown
4. Luster: : Vitreous
5. Fracture: : Uneven
6. Cleavage: : Absent
7. Diaphaneity: : Transparent in individual layers & opaque as whole
8. Hardness: : 2 to 3
9. Specific Gravity: : 2 to 3
10. Occurrence: : Nellore
11. Origin: : Metamorphic
12. Uses: : Iron boxes
13. Name of the Specimen: Biotite
14. Chemical Composition: $K(Mg, Fe_3)(AlSi_3)O_{10}(OH, F)_2$

ASBESTOS

1. Form: : Fibrous
2. Colour: : Green
3. Streak: : Colourless
4. Luster: : Silky
5. Fracture: : Uneven
6. Cleavage: : Absent
7. Diaphaneity: : Opaque
8. Hardness: : 4 to 6
9. Specific Gravity: : 3 to 4.5
10. Occurrence: : Cuddapah, Andhra Pradesh

11. Origin: : Metamorphic
12. Uses: : It is used to make sheets
13. Name of the Specimen : Asbestos
14. Chemical Composition : $2\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$

CHLORITE

1. Form: : Granular
2. Colour: : Black and Green
3. Streak: : Colourless
4. Luster: : Metallic
5. Fracture: : Uneven
6. Cleavage: : Absent
7. Diaphaneity: : Opaque
8. Hardness: : 3
9. Specific Gravity: : 3 to 4.5
10. Occurrence: : Karnataka
11. Uses: : Paints
12. Name of the Specimen: Chlorite
13. Chemical Composition: ClO_2

KYANITE

1. Form: : Bladed
2. Colour: : Blue
3. Streak: : Colourless
4. Luster: : Vitreous
5. Fracture: : Uneven
6. Cleavage: : Absent
7. Diaphaneity: : Opaque
8. Hardness: : 6
9. Specific Gravity: : 4.5 to 5
10. Occurrence: : Karnataka
11. Uses: : Abrasive and Ornaments purposes
12. Name of the Specimen : Kyanite
13. Chemical Composition : Al_2SiO_5

GARNET

1. Form : Rhombic
2. Color : Ruby
3. Streak : Light Brown
4. Luster : Earthy
5. Fracture : Absent
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 7
9. Specific : 4.5
10. Name of the Specimen : Garnet
11. Occurrence : Gudur, Andhra Pradesh
12. Uses : Ornaments

13. Chemical Composition : $\text{Fe}_3 \text{Al}_2 (\text{SiO}_4)_3$

TALC

1. Form : Amorphous
2. Colour : White
3. Streak : White
4. Luster : earthy
5. Fracture : No
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 1
9. Specific : 2.5
10. Name of the Specimen: Talc
11. Occurrence : Udaipur, Rajasthan
12. Uses : It is used as talcum powder and in creams etc.
13. Chemical Composition: $\text{Mg}_3 \text{Si}_4 \text{O}_{10} (\text{OH})_2$

CALCITE

1. Form : Bladed
2. Colour : Honey Yellow
3. Streak : White
4. Lustre : Vitrous
5. Fracture : Uneven
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 5
9. Specific : 2.5 to 3
10. Name of the Specimen: Calcite
11. Occurrence : Tamil Nadu
12. Uses : Bombs, gun powders, anti – air craft
13. Chemical Composition: CaCO_3

PYRITE

1. Form : Crystalline
2. Colour : Fool's gold
3. Streak : Black
4. Luster : Metallic to sub - metallic
5. Fracture : Uneven
6. Cleavage Absent
7. Diaphaneity : Opaque
8. Hardness : 6
9. Specific : 3 to 4 5
10. Name of the Specimen: Pyrite
11. Occurrence : Cuddapah, Andhra Pradesh
12. Uses : Paints, Paper industries

13. Chemical Composition: FeS₂

HAEMETITE

1. Form : Amorphous
2. Colour : Dark brown
3. Streak : Brown
4. Luster : Metallic
5. Fracture : Absent
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 7
9. Specific : 6 to 7
10. Name of the Specimen: Hematite
11. Occurrence : Goa
12. Uses : Steel, and iron industries
13. Chemical Composition: Fe₂O₃

MEGNETITE

1. Form : Amorphous
2. Colour : Gray
3. Streak : Brown
4. Lustre : Greasy
5. Fracture : Absent
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 7
9. Specific : 5.5
10. Name of the Specimen : Magnetite
11. Occurrence : Goa, Maharashtra
12. Uses : Iron ore
13. Chemical Composition : Fe₃ O₄

CHROMITE

1. Form : Amorphous
2. Colour : Black
3. Streak : Black
4. Lustre : Earthy
5. Fracture : Absent
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 7
9. Specific : 4.5
10. Name of the Specimen : Chromite
11. Occurrence : Karnataka
12. Uses : Paints, Cr ore

13. Chemical Composition : Fe Cr₂ O₄

GALENA

1. Form : Tabular
2. Colour : Gray and black
3. Streak : Black
4. Lustre : Vitrous
5. Fracture : Even
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 6
9. Specific : 5.5
10. Name of the Specimen : Galena
11. Occurrence : Maharashtra
12. Uses : Ornamental and atomic purposes
13. Chemical Composition : Pbs

PYROLUSITE

1. Form : Amorphous
2. Colour : Black
3. Streak : Black
4. Lustre : Earthy
5. Fracture : Absent
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 7
9. Specific : 6
10. Name of the Specimen : Pyrolusite
11. Occurrence : Adilabad, Vizayanagaram
12. Uses : Maganese ore (steel industries)
13. Chemical Composition : Mno₂

GRAPHITE

1. Form : Amorphous
2. Colour : Gray
3. Streak : Gray
4. Lustre : Sub-Metallic or greasy
5. Fracture : Absent
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 4
9. Specific : 2.5 to 2.8
10. Name of the Specimen : Graphite
11. Occurrence : Anakapalli, Andhra Pradesh
12. Uses : Pencils

13. Chemical Composition : C

MAGNESITE

1. Form : Amorphous
2. Colour : White
3. Streak : White
4. Luster : Earthy
5. Fracture : Absent
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 7
9. Specific : 4.5
10. Name of the Specimen : Magnesite
11. Occurrence : Doddakanya, South India
12. Uses : Magnesium ore, fertilizers
13. Chemical Composition : $MgCO_3$

BAUXITE

1. Form : Concretionary
2. Colour : Reddish Brown
3. Streak : Brown
4. Lustre : Earthy
5. Fracture : Uneven
6. Cleavage : Absent
7. Diaphaneity : Opaque
8. Hardness : 7
9. Specific : 3
10. Name of the Specimen : Bauxite
11. Occurrence : Visakhapatnam, Srikakulam
12. Uses : Aluminum ore
13. Chemical Composition : Al

EXPERIMENT NO 2

OBJECT: Study of common igneous rocks.

THEORY:

- Different types of igneous rocks (volcanic, Hypabasal and plutonic rocks).
- Main factors used in the classification of igneous rocks.
- Order of crystallisation in which minerals are formed.
- Petrogenesis.

PEGMATITE

I Petrography

1. Colour index : Leucocratic (light colour)
2. Mineralogy : a) Essential minerals : Quartz, Feldspars,
b) Accessory minerals: Beryl, tourmaline, apatite
3. Texture : Very coarse grained granular
4. Structure : Pegmatitic

II Petrogenesis

1. Mode of formation : Veins and dykes.
2. Depth of formation : Great depth
3. Conditions of formation : Plutonic conditions (high pressure and high temperature)
4. Name of the rock : **Pegmatite.**

GRANITES

Granites are of two types, based on their colour (a) pink granite, in which the Kfeldspars are more predominant than the plagioclase feldspars. (b) Grey granite, in which the plagioclase feldspars are more predominant than the k-feldspars. They exhibit two distinct types of

- a) Equigranular
- b) Inequigranular (porphyritic).

They are the most abundant rock types among other igneous rocks. In hand specimen, granite is a light colored coarse grained granular rock. It is mainly composed of quartz, feldspars, and micas. Apatite, magnetite, zircon and sphene are found as accessories. The coarse grained texture indicates that the rock is formed under the plutonic conditions.

The systematic description of the granular granite is given in a new format below.

I. Petrography

1. Colour index Leucocratic
2. Mineralogy

- a) essential minerals : quartz, alkalifeldspar and micas
- b) accessory : apatite, magnetite, zircon, sphene, Hornblende and pyroxene.
- 3. Texture : Coarse grained, equigranular.

II. Petrogenesis

- 1. Mode of formation : Big batholiths to small plutonic
- 2. Depth of formation : Great depth (deep seated)
- 3. Conditions of formation : Plutonic conditions (high pressure and high temperature).
- 4. Name of the rock : **Granite**

PORPHYRITIC GRANITE

I. Petrography

- 1. Colour Index : leucocratic
- 2. Mineralogy : quartz, alkali feldspars, and micas.
 - a) Essential minerals : apatite, zircon, magnetite, sphene, Hornblende and pyroxene.
 - b) Accessory minerals : Coarse grained in equigranular
- 3. Texture : Coarse grained in equigranular
- 4. Structure : Porphyritic

II. Petrogenesis

- 1. Mode of formation : Big batholiths to small pluton
- 2. Depth of formation : Great to intermediate depth
- 3. Conditions of formation : Plutonic conditions (high pressure and High temperature.
- 4. Name of the rock : **Porphyritic granite**

DOLERITE

Dolerite is a dark coloured medium grained granular rock. It is mainly composed of labradorite plagioclase feldspar and augite pyroxene. Magnetite, apatite and sphene are found as accessories. The medium grained texture indicates that the rock is formed under hypabyssal conditions.

The systems description of the rock is given in a new format below;

I. Petrography

- 1. Colour index : Melanocratic
- 2. Mineralogy :
 - a) Essential minerals : Labradorite plagioclase and augite pyroxene.
 - b) Accessory minerals : Magnetite, olivine, apatite and sphene.
- 3. Texture : Medium grained.

II. Petrogenesis

- 1. Mode of formation : Dykes

2. Depth of formation : Intermediate (shallow depth)
3. Conditions of formation : Hypabyssal conditions (moderate)pressure and temperature)
4. Name of the rock : **Dolerite.**

BASALT

Basalt is a dark-ash coloured fine grained rock. It is mainly composed of labradorite Plagioclase augite pyroxene. Magnetite, olivine and apatite are found as accessories. Quartz, calcite and zeolites are found as secondary minerals in cavities and vesicles of the rock. The fine grained texture indicates that the rock is formed under volcanic conditions. The systematic description of the rock is given in a new format below.

I. Petrography

1. Colour index : Melnocratic
2. Mineralogy :
 - a)Essential minerls : labradorite plagioclase and augite pyroxene
 - b)Accessory minerals : olivine. Hornblende, magnetite and apatite.
3. Texture : Fine grained
4. Structure : Vesicular and amygdaloidal

II. Petrogeneis

1. Mode of formation : Sills, flows, and dykes
2. Depth of formation : Surface intrusive and extrusives
3. Conditions of formation : Volcanic conditions (low pressure and temperature)
4. Conditions of formation : **Basalt**

EXPERIMENT NO 3

OBJECT: Study of common sedimentary rocks.

THEORY: Description of sedimentary rocks

- Identify the sedimentary rocks
- Recognize the minerals of sedimentary rocks
- Describe the textures & formation of sedimentary rocks.

1. CONGLOMERATE

It is a common rudaceous rock formed under continental environment. It is mainly consolidated with rounded and subrounded pebbles and gravels. These pebbles and gravels are made up of quartz, feldspars and rock fragments. Ferruginous and siliceous cementing materials envelop the pebbles and gravels. In handspecimen, the rock is easily distinguished from breccias by its characteristic rounded pebbles and gravels.

The systematic description of the rock is given below.

1. Clastic /Nonclastic : Clastic
2. Colour : shades of grey, brown
3. Mineralogy : Quartz feldspars, clay, hematite and limonite (goethite)
4. Structure : Rounded rudite
5. Texture
 - (a) Grain size : Coarse grained
 - (b) Grain shape : Rounded to subrounded
 - (c) Sorting : Poorly sorted
6. Nature of matric : Ferruginous and siliceous
7. Name : Conglomerate

2. SANDSTONE

It is most common clastic rock founded in basinal environments such as river, lakes and marginal seas. It is formed due to consolidation of sand particles. The sand particles are mainly made up of rounded quartz grains. In handspecimen, it is in brown or yellow or grey or buff colour, and exhibits medium grained texture.

Sometimes sizegrading and rippling features are seen in it. Well sorting of grains is a characteristic feature of many sandstones. If a sandstone is completely composed of quartz, it is termed as arthoquartzite. If a sandstone contains 75% of quartz and 25% of feldspar, it terms as arkose. If a sandstone has more than 30% of matrix of clay, chlorite and glauconite, it terme as greywacks. A fine grained greywake (sandstone) terms into shale.

The systematic description of the ripple sandstone is given below:

1. Clastic / Nonclastic : Clastic

2. Colour : Brown or yellow or grey or buff
3. Mineralogy : Quartz with little amount of feldspar and Siliceous or ferruginous clays
4. Structure : Ripple marks, arenite
5. Texture :
 - a) Grain size : Medium grained
 - b) Grain shape : Rounded to subrounded
 - c) Sorting : Well sorted
6. Nature of matrix : Siliceous or ferruginous or both
7. Name of the rock : Ripple sandstone

3. SHALE

It is a fine grained argillaceous sedimentary rock that have been formed by the consolidation of beds of mud, clay or silt. The mud and clay are in chlorite, muscovite and quartz. In hand specimen, it has varied colours like grey, brown black or yellow and exhibits fine grained texture and thin layering.

The systematic description of the rock is given below:

1. Clastic / Nonclastic : clastic
2. Colour : Grey brown or black
3. Mineralogy : Chlorite muscovite, kaolin, and quartz.
4. Structure : Thin layering
5. Texture:
 - a) Grain size : Fine grained
 - b) Grain shape : Variable
 - c) Sorting : Poorly sorted
6. Nature of matrix : Ferruginous or siliceous
7. Name of the rock : Shale

4. LIMESTONE

It is a fine grained non clastic sedimentary rock that has been formed by the precipitation of calcium carbonate solutions which are derived from seawater. In hand specimen. It looks grey and exhibits fine grained texture. It is made up of mainly calcite. There are many varieties of limestone. If a limestone is porous with full of foraminiferal shells, it terms as chalk. If a limestone contains shells of brachiopods or Lamellibranchs, it terms as shelly limestone. If a limestone contains high volume percentage of dolomite, it grades into dolomite.

The systematic description of a normal limestone as given below:

1. Clastic / Nonclastic : Non clastic
2. Colour : Grey
3. Mineralogy : Calcite (CaCO₃)
4. Structure : layering
5. Texture:
 - a) Grain size : fine grained
 - b) Grain shape : variable
6. Nature of matrix : Calcareous

7. Name of the rock : Limestone

EXPERIMENT NO 4

OBJECT: Study of common metamorphic rocks.

THEORY:

- Describe the different types of metamorphic rocks
- Describe the mineralogy of different types of rocks

1. SLATE

Slate is a fine grained lowgrade regional metamorphism rock; which is transformed from shale by regional metamorphism. It is characterized by slaty cleavage, along which it splits into thin sheets or layers. State is variable in its colour from grey to black Systematic description of the rock is given below.

1. Colour : Variable (grey yellow green brown or black)
2. Mineralogy : Muscovite, chlorite, feldspar, quartz
3. Structure : Sheet or layers with slaty cleavage
4. Type of metamorphism : Regional metamorphism
5. Conditions of metamorphism : Low pressure and low tempera ture
6. Nature of parent rock : Pelitic (shale)
7. Name of the rock : Slate

2. MARBLE

Marble is either contact (thermal) or regional metamorphic rock transformed from a metamorphosed limestone. It is a coarse grained granular rock commonly exhibits white colour (but some marbles may be in different colours due to impurities). Its colour, texture, soft and smooth surfaces promote the rock into commercial grade in building industry. Systematic description of the rock is given below:

1. Colour : White (rarely pink, shades of green etc)
2. Mineralogy : Calcite
3. Structure : Beds with sacchardial form
4. Type of metamorphism : Contact (thermal) metamorphism
5. Conditions of metamorphism : High temperature and low pressure
6. Nature of parent rock : Limestone
7. Name of the rock : Marble

3. QUARZITE

It is a metamorphosed sandstone formed under either contact or regional metamorphism. In hand specimen, it is rather earthy white to brown in colour and exhibits granular form. It is mainly composed of recrystallized quartz. Its colour, texture, hardness and toughness promote the rock into commercial grade in building industry.

Systematic description of the rock is given below:

1. Colour : Variable (shades of white to brown)
2. Mineralogy : Quartz
3. Structure : Beds with granular form
4. Type of metamorphism : Contact metamorphism
5. Conditions of metamorphism : High temperature and low pressure
6. Nature of parent rock : **Sandstone**
7. Name of the rock : **Quartz**

4. SCHISTS

Schists of many kinds (or varieties) depending upon their colour and composition. All of them have a unique character i.e. Schistosity or foliation. They are common rock type of the Precambrian terrains. In hand specimen they are coarse grained rocks and are in different shades of colours from dark green to brown and also exhibit characteristic foliation. They are mainly composed of phyllosilicates and double chain silicates.

They are derived from either sedimentary or igneous rocks by the regional metamorphism. One of the schists (brown biotite schist) is described in a systematic way for the clear understanding to the student.

1. Colour : Dark brown
2. Mineralogy : Brown biotite, garnet, quartz
3. Structure : Schistose or foliation
4. Type of metamorphism : Medium grade regional metamorphism
5. Conditions of metamorphism : Moderate pressure and temperature
6. Nature of parent rock : Pelitic (shale)
7. Name of the rock : Garnet biotite schist.

5. GNEISSES

Gneisses are of many kinds (or varieties) depending upon their colour and composition.

All of them have a unique character i.e. gneissosity or banding (or lineation). They are common on rock types of the Precambrian terrains. In hand specimen, they are coarse grained rocks with alternate dark and white (light) bands. Each band its own colour and composition. Generally, the white bands is mainly composed of felsic minerals such as quartz and feldspars, while dark band is rich in mafic minerals, such as piroxenes, amphiboles, epidotes, garnets and biotite micas.

They are derived from either sedimentary or igneous rocks by high grade regional metamorphism.

One of the gneisses (quartzofeldspathic gneiss) is described in a systematic way for the clear understanding to the students.

1. Colour : Shades of grayish whits
2. Mineralogy : Quartz, feldspar, biotite, hornblende
3. Structure : Gneissose or banding (felsic and mfic bands)
4. Type of metamorphism : High grade regional metamorphism
5. Conditions of metamorphism : Moderte pressure and high temperature
6. Nature of parent rock : Granite
7. Name of the rock : Quartzo-feldspathic gneiss (peninsular geniss)

IGNEOUS ROCKS					
Name	Formula	H	Color	Fracture/Cleavage	Other Diagnostic Properties
Quartz	SiO ₂	7	colorless, white, gray	conchoidal fracture	glassy, hexagonal crystal form is distinctive when present
Potassium Feldspar (Orthoclase)	KAlSi ₃ O ₈	6	white, pink, buff gray	2 directions at about 90°	exsolution lamellae present in some samples
Plagioclase Feldspar	NaAlSi ₃ O ₈ CaAl ₂ Si ₂ O ₈	6	white, pink, gray, dk gray	2 directions at about 90°	polysynthetic (albite) twinning on best cleavage surfaces
Muscovite (mica)	KAl ₂ AlSi ₃ O ₁₀ (OH) ₂	2-2.5	colorless	1 direction perfect cleavage	color is distinctive
Biotite (mica)	K(Mg,Fe) ₃ AlSi ₃ O ₁₀ (OH) ₂	2-2.5	black	1 direction perfect cleavage	color is distinctive
Amphibole (hornblende)	Ca ₂ (Mg,Fe) ₄ Al[AlSi ₇ O ₂₂](OH) ₂	5-6	dk green, black	2 good cleavages at about 120°	elongate crystals, better cleavage than pyroxene.
Pyroxene	Ca(Mg,Fe)Si ₂ O ₆ (Mg,Fe) ₂ Si ₂ O ₆	5-6	green, gray green, white	2 poor cleavages at about 90°	poor cleavage, stubby crystals
Olivine	(Mg,Fe) ₂ SiO ₄	6.5-7	green, yellow green	conchoidal fracture	glassy, color usually distinctive
SEDIMENTARY ROCKS					
Name	Formula	H	Color	Fracture/Cleavage	Other Diagnostic Properties
Quartz	SiO ₂	7	colorless, white, gray	conchoidal fracture	glassy, hexagonal crystal form is distinctive when present
Calcite	CaCO ₃	3	colorless, white	3 directions not at 90°	rhombic cleavage fragments, reacts (fizzes) with HCl.

Dolomite	$\text{CaMg}(\text{CO}_3)_2$	3.5-4	white, gray, pink	3 directions not at 90°	reacts (fizzes) less vigorously with HCl (compared to calcite) or only when powdered
Kaolinite	$\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$	2	white	1 direction perfect cleavage	sticks to tongue
Hematite	Fe_2O_3	2-6	red, dk red, metallic gray	weak parting, typically not expressed	red streak, specular hematite shows bright gray metallic luster
Limonite	$\text{FeO}\cdot\text{OH}\cdot n\text{H}_2\text{O}$	3.5-4	yellow red	n.a.	yellow-red streak
Halite	NaCl	2.5	colorless	3 directions at 90°	salty taste, cubic cleavage fragments
Gypsum	$\text{CaSO}_4\cdot 2\text{H}_2\text{O}$	2	colorless, white	1 good and 2 poor cleavages	simple twins common in crystals

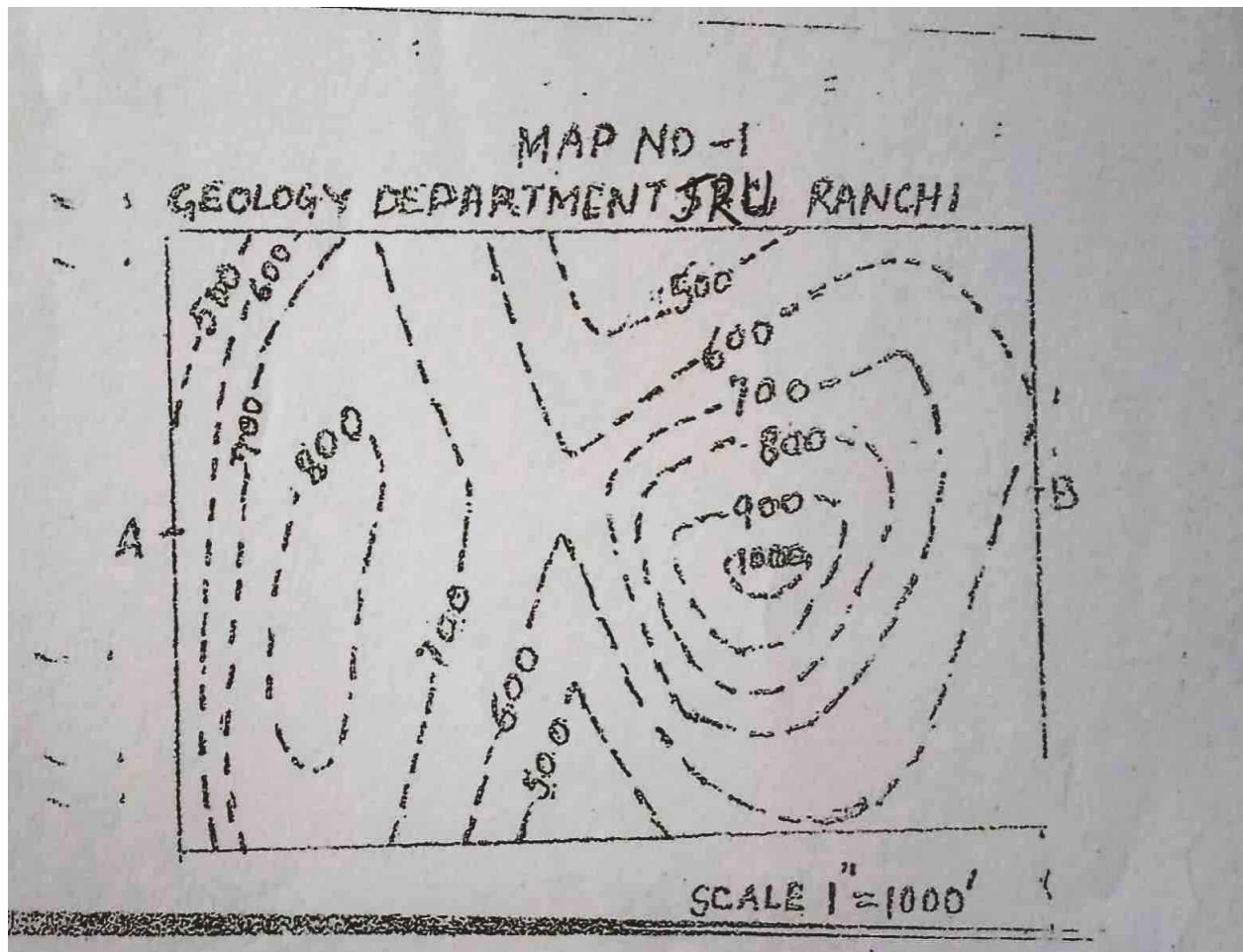
METAMORPHIC ROCKS

Name	Formula	H	Color	Fracture/Cleavage	Other Diagnostic Properties
Talc	$\text{Mg}_3\text{Si}_4\text{O}_{10}(\text{OH})_2$	1	white	1 direction perfect cleavage	greasy feel
Chlorite	$\text{Mg}_5\text{Al}_2\text{Si}_3\text{O}_{10}(\text{OH})_8$	2-2.5	green	1 direction perfect cleavage	color is distinctive
Garnet	$(\text{Fe}, \text{Mg}, \text{Ca})_3\text{Al}_2\text{Si}_3\text{O}_{12}$	6.5-7.5	red, pink, green, black	conchoidal fracture	dodecahedron form common in crystals
Kyanite	Al_2SiO_5	5.5-7	Sky blue to white, also grey, green, black	1 perfect and 1 good direction cleavage	Stubby blades. The long direction of cleavage planes can be scratched with a knife; the perpendicular cannot.
Sillimanite	Al_2SiO_5	6.5-7.5	Colorless to white	1 good cleavage	Small fibers or needles with cleavage perpendicular to long axis.
Andalusite	Al_2SiO_5	6.5-7.5	Usually pink	1 direction good 1 direction poor cleavage	Rod shaped with almost square cross-sections. Chiasmolite cross.
Staurolite	$(\text{Fe}, \text{Mg})_2\text{Al}_9\text{Si}_4\text{O}_{22}(\text{OH})_2$	7	brown	1 direction poor	Interpenetration twins common, elongate crystals
Magnetite*	Fe_3O_4	5.5-6.5	black, metallic	weak parting, typically not expressed	magnetic

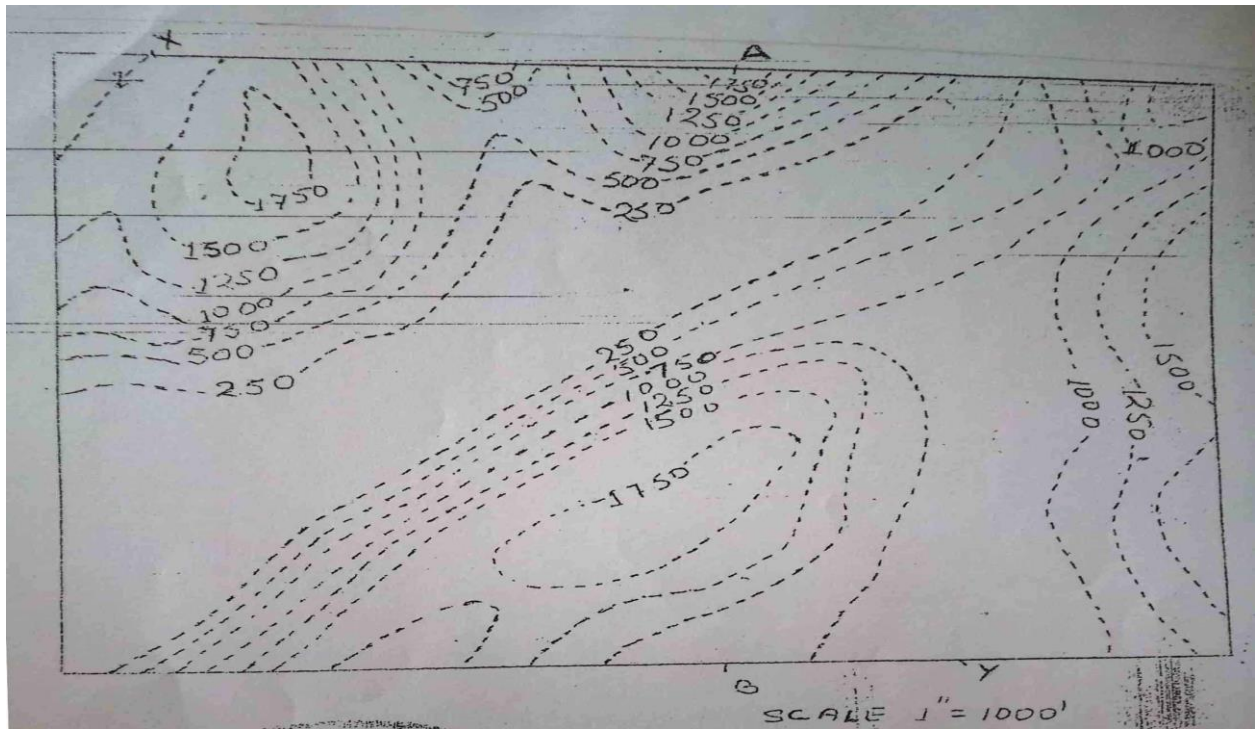
EXPERIMENT NO 5

OBJECT: Study and drawing of maps and plans.

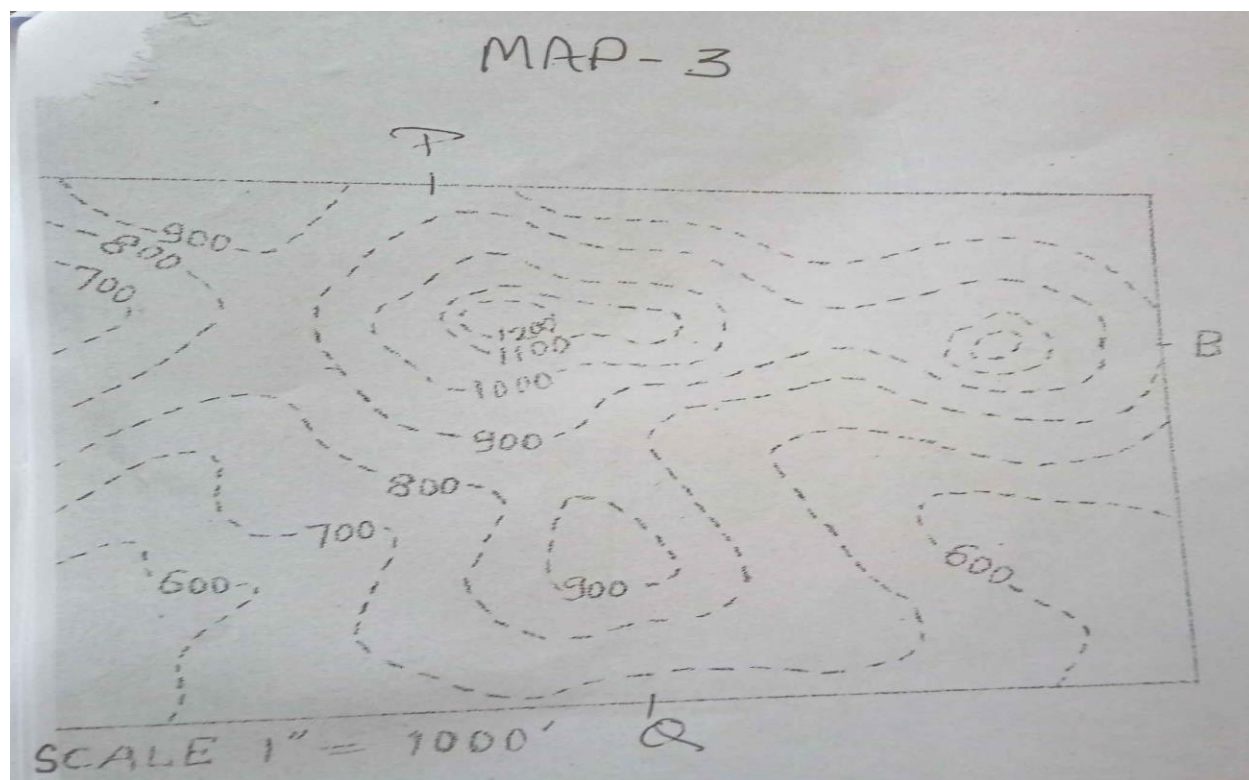
MAP 1



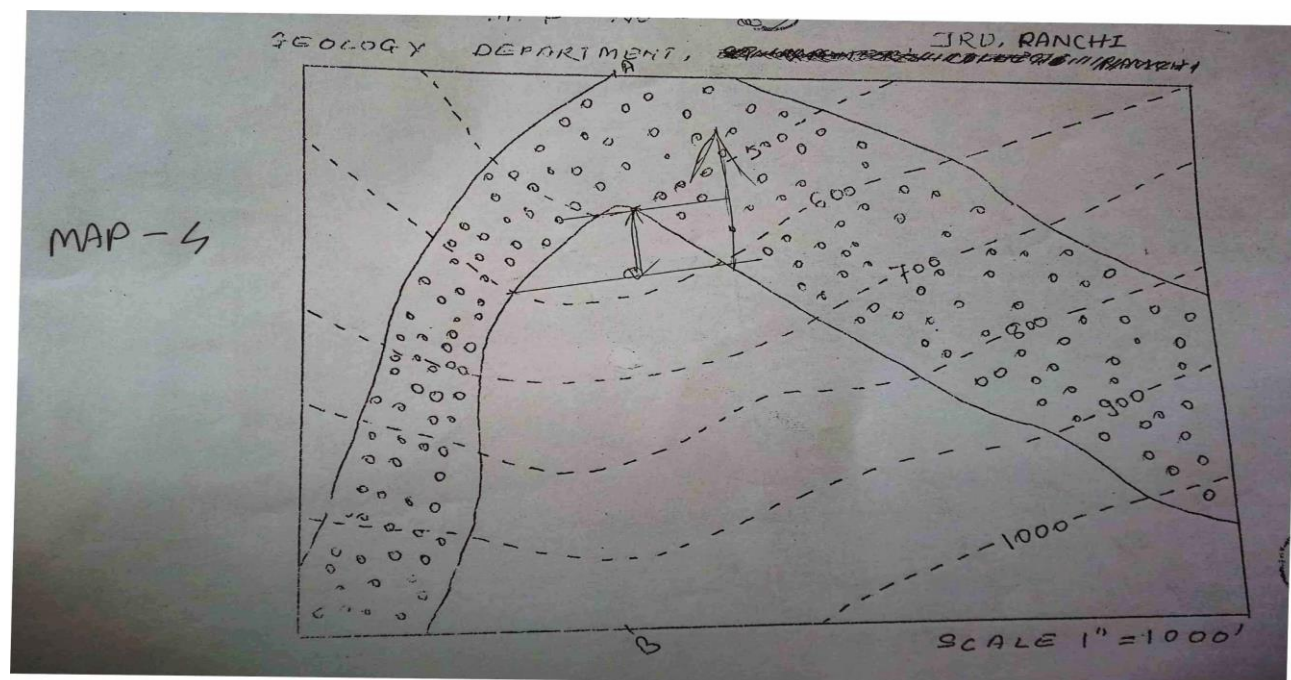
MAP 2



MAP 3



MAP 4



MAP 5

