LAB MANUAL
MINING
GEOLOGY-01

MINING ENGINEERING

Department of Mining Engineering
IIPM School of Engineering & Technology Kansbahal, Rourkela, Odisha

LIST OF EXPERIMENTS

EXPERIMENT NO.-1

OBJECT: To Study the geological maps.

THEORY:

Geologic maps are not like other maps. Geologic maps, like all maps, are designed to show where things are. But, whereas the maps we know best show the distribution of roads or rivers or county boundaries, a geologic map shows the distribution of geologic features, including different kinds of rocks and faults. A geologic map is usually printed on top of a regular map (called a base map) to help you locate yourself on the map. The base map is printed with light colors, so it doesn't interfere with seeing the geologic features on the map. The geology is represented by colors, lines, and special symbols unique to geologic maps. Understanding these features will allow you to understand much of the geology shown in almost any standard geologic map.

Significance of Colored Areas on Geological Maps-

The most striking features of geologic maps are its colors. Each color represents a different geologic unit. A geologic unit is a volume of a certain kind of rock of a given age range. So asandstone of one age might be colored bright orange, while a sandstone of a different age might be colored pale brown. Many geologic units are given names that relate to where their characteristics are best displayed, or where they were first studied. For example, the Briones sandstone was first described in Briones Valley,California. Some geologic units have not yet been named, so those are identified with terms related to the kind of rock in the unit like 'Sandstone and shale,' 'Unnamed sandstone', or 'Undivided shale'.

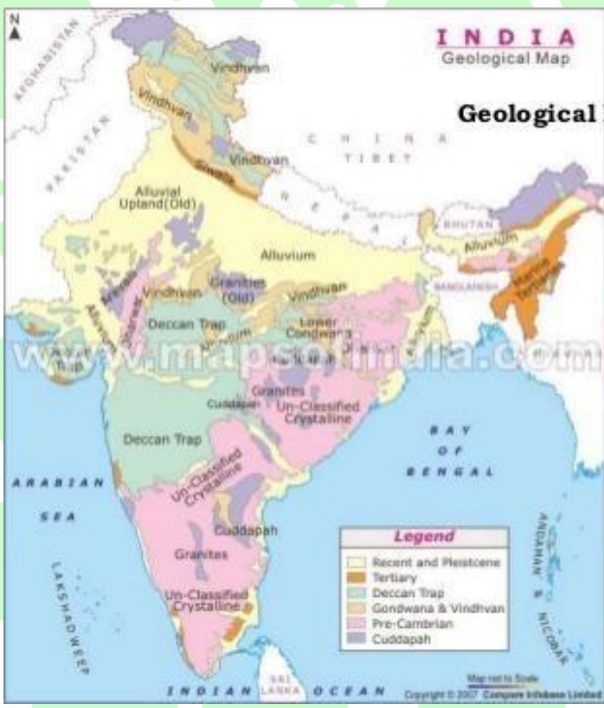
But all units, named and unnamed, have a color on the geologic map, and the area of a given color is the area where that geologic unit is the one at the surface (usually the soil on top of the rocks is disregarded). Geologic units are named and defined by the geologists who made the geologic map, based on their observations of the kinds of rocks and their investigations of the age of the rocks. As more information is gathered, perhaps by other geologists, new geologic units might be defined. These disagreements can be a basis for scientific progress, and illustrate the need for continuing to investigate the geology of an area.

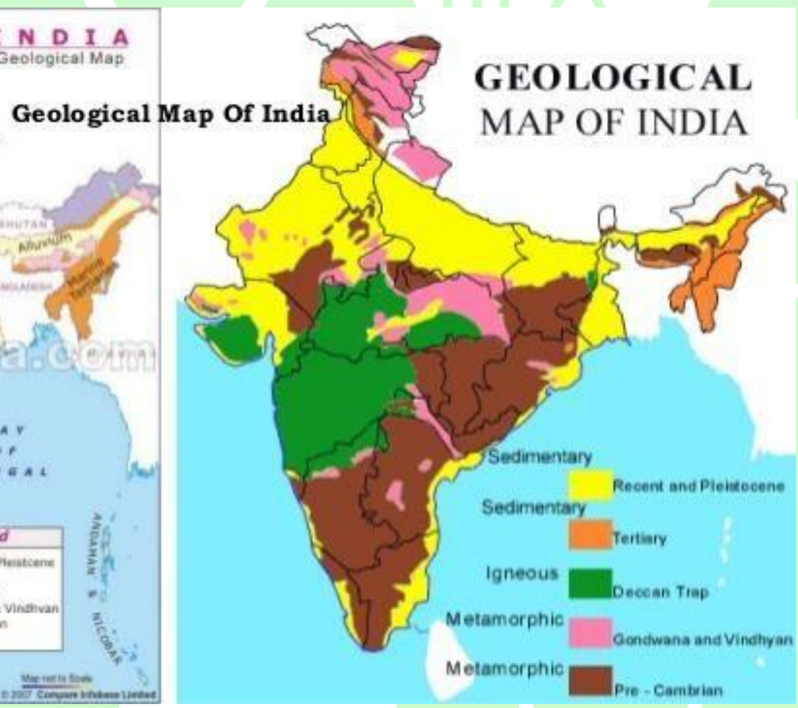
Letter Symbols

In addition to color, each geologic unit is assigned a set of letters to symbolize it on the map. Usually the symbol is the combination of an initial capital letter followed by one or more small letters. The capital letter represents the age of the geologic unit. Geologists have divided the history of the Earth into Eons (the largest division), Eras, Periods, and Epochs , mostly based on

the fossils found in rocks. The most common division of time used in letter symbols on geologic maps is the Period. Rocks of the four most recent Periods are found in the San Francisco Bay area shown on this map, so most letter symbols begin with a capital letter representing one of the four Periods: J (Jurassic - 195 to 141 million years ago), K (Cretaceous - 141 to 65 million years ago), T (Tertiary - 65 to 2 million years ago), or Q (Quaternary - 2 million years ago until today).

Occasionally the age of a rock unit will span more than one period, if the period of many years required to create a body of rock happens to fall on both sides of a time boundary. In that case both capital letters are used. For example, QT would indicate that the rock unit began to form in Tertiary time and was completed in Quaternary time. The few geologic units formed an unknown amount of time ago have letter symbols with no capital letters. The small letters indicate either the name of the unit, if it has one, or the type of rock, if the unit has no name. So Kjm (see 1 on map above) would be the symbol for the Joaquin Miller sandstone (formed in the Cretaceous Period), while Ks (location 2) would be the symbol for an unnamed unit of shale formed in the same Period, and gb (location 3) would be the symbol for gabbro (a dark-colored igneous rock) of unknown age.





EXPERIMENT NO.-2

OBJECT: MINERALOGY-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 is 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 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 though 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 has 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 : $KAl\ Si_3 0_8$

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 : $Sio2$

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: $Mg_3 Si_4 O_{10} (OH)_2$

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: FeS_2

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: Fe_2O_3

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 : $Fe_3 O_4$

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 : $Fe\ Cr_2\ O_4$

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 : Mno_2

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

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

CHALCOPYRITE

1. Form : Tetrahedron,
2. Colour : Brass yellow
3. Streak : Greenish black
4. Lustre : Metallic
5. Fracture : Irregular to uneven
6. Cleavage : Indistinct
7. Diaphaneity : Opaque
8. Hardness : 3.5
9. Specific : 4.1-4.3
10. Name of the Specimen : Chalcopyrite
11. Chemical Composition : $CuFeS_2$

EXPERIMENT NO 3

OBJECT: PETROLOGY-Study of common igneous rocks.

THEORY:

• Different type s of Igenous rocks (volcanic, Hypabasal and plutonic rocks).
• Main factors used in the classification of igneous rocks.
• Order of crytallisation 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: Bery1, 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 coulour (a) pink granite, in which the Kfeldspars are more predominant than the plagioclase feldspars. (b) Grey granite, in which the lagioclase 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. Texure : Coarse grained in equigranular
4. Structure : Porphyritic

II. Petrogenesis
1. Mode of formation : Big batholiths to small plution
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 formal 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 zeolities 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 4

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. Ferrugeneous 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 : Ferrugeneous 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 arthoquarzite. If a sandstone contines 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 greyor buff
3. Mineralogy : Quartz with little amount of feldspar and
Siliceous or ferrugeneous 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 ferrugeneous 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 nd quartz. In hand specimen, it has varied colours like grey, brown black or yellow and exhibits fine grained texure and thin layering.

The systems 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 : Ferrugeneous 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 greyand exhibits fine grained texture. It is made up of mainly calcite. There are many varieties of limestone. It is a limestone is porous with full of foramineral shells, it terms as chalk. If a limestone contains shells of brachiopods or Lamellibranchs, it terms as shelly limestone. If a limestone contains high volums 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 (Ca C03)
4. Structure : layering
5. Texture: a) Grainsize : fine grained
b) Grainshape : variable
6. Nature of matrix : Calcareous
7. Name of the rock : Limestone

EXPERIMENT NO 5

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, hard 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. <u>SCHISTS</u>

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 describe d in a systematic way for the clear understanding to the student.

1. Colour : Dark brown
2. Mineralogy : Brown bioite, 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. <u>GNEISSES</u>

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 handspecimen, 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 puroxenes, 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	concoidal fracture	glassy, hexagonal crystal form is distinctive when present
Potassium Feldspar (Orthoclase)	$KAlSi_3O_8$	6	white, pink, buff gray	2 directions at about 90°	exsolution lamellae present in some samples
Plagioclase Feldspar	$NaAlSi_3O_8$ $CaAl_2Si_2O_8$	6	white, pink, gray, dk gray	2 directions at about 90°	polysynthetic (albite) twinning on best cleavage surfaces
Muscovite (mica)	$KAl_2AlSi_3O_{10}(OH)_2$	2-2.5	colorless	1 direction perfect cleavage	color is distinctive
Biotite (mica)	$K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	2-2.5	black	1 direction perfect cleavage	color is distinctive
Amphibole (hornblende)	$Ca_2(Mg,Fe)_4Al[AlSi_7O_{22}](OH)_2$	5-6	dk green, black	2 good cleavages at about 120°	elongate crystals, better cleavage than pyroxene.
Pyroxene	$Ca(Mg,Fe)Si_2O_6$ $(Mg,Fe)_2Si_2O_6$	5-6	green, gray green, white	2 poor cleavages at about 90°	poor cleavage, stubby crystals
Olivine	$(Mg,Fe)_2SiO_4$	6.5-7	green, yellow green	concoidal fracture	glassy, color usually distinctive

SEDIMENTARY ROCKS					
Name	**Formula**	**H**	**Color**	**Fracture/Cleavage**	**Other Diagnostic Properties**
Quartz	SiO_2	7	colorless, white, gray	concoidal 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	$CaMg(CO_3)_2$	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	$Al_2Si_2O_5(OH)_4$	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	$FeO•OH•nH_2O$	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	$CaSO_4•2H_2O$	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	$Mg_3Si_4O_{10}(OH)_2$	1	white	1 direction perfect cleavage	greasy feel
Chlorite	$Mg_5Al_2Si_3O_{10}(OH)_8$	2-2.5	green	1 direction perfect cleavage	color is distinctive
Garnet	$(Fe,Mg,Ca)_3Al_2Si_3O_{12}$	6.5-7.5	red, pink, green, black	concoidal 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. Chiastolite cross.
Staurolite	$(Fe,Mg)_2Al_9Si_4O_{22}(OH)_2$	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