Catalog

UNIT II

MINERALOGY

2.1 PHYSICAL PROPERTIES OF MINERALS

Physical properties of minerals – Quartz group, Feldspar group, Pyroxene – hypersthenes and augite, Amphibole – hornblende, Mica – muscovite and biotite, Calcite, Gypsum and Clay minerals.

Mineralogy is a branch of geology that deals with the formation, physical, chemical, optical and engineering properties of minerals.

They have specific sub branches such as

- Crystallography
- Optical mineralogy
- Descriptive mineralogy

A naturally occurring inorganic solid that has a definite chemical composition and / or crystal structure.

It is more or less homogeneous defined chemical composition and definite atomic structure.

- Naturally forming solid.
- Inorganically formed.

E.g.:-

i. Ice is a mineral but water is not. → Solid

ii. Mercury and petroleum. → liquid

More than 2500 minerals on earth crust.

States of Mineral:-

- Crystal
- Crystalline
- Amorphous

Their colour, streak, hardness, cleavage, crystal form, specific gravity and lust generally identify minerals. The symmetry elements are:

i) Plane of symmetry
ii) Axis of symmetry
iii) Centre of Symmetry

Formation and Composition

- Minerals come from cooled magma
- 2500 kinds of minerals; some are easy to find and others are rare.

Formation of Minerals:-

Minerals are formed by anyone of the following processes.

1. **Solidification**→ cooling from hot and molten material.

   Solidification → from gases state.

2. Metamorphism → change of composition due to temperature, chemical.

3. Precipitation and evaporation → under favorable temperature.

Physical Properties of Minerals:-

These are diagnostic from identification in the fields.

1. Colour
2. Streak
3. Lusture
4. Hardness

5. Cleavage
6. Fracture
7. Tenacity
8. Special gravity
9. Form/Structure
10. Odour
11. Fluorescence
12. Phosphorescence
13. Magnetism
14. Habit

1. **Colour :-**

- Colour of the mineral is due to the absorption and reflection of light.
- Any minerals that appear white will absorb and reflect all the seven colours of the light.
- Any minerals that appear black will absorb all colours, but reflect none of the colours of light.

2. **Streak:-**

- The colour of mineral powder is called as streak.
- The streak may or may not be the same as that of the mineral's colour
- Color of powder scraped off when it is rubbed against a hard, rough surface
- Streak may be a different color than the mineral itself.

Eg:-

Minerals	Colours	Streak
Quartz	White / colourless	white
Pyrite	Golden yellow	Black
Hematite	Cherry red	Black

3. Lusture :-

Lusture is defined as the shining efficiency of a mineral, due to the intensity of light from its surface.

- The natural reflection of surface.
- The light absorption capacity of mineral.
- The refractive index of minerals.
- The way a mineral reflects light from its surface

Non-metallic luster:

– Don't have much of a reflection; known as glassy, pearly, and dull

Different types of lusture:-

Sl No.	Type of lusture	Represented by	Example
1.	Vitreous lusture	Glassy shine	Quartz
2.	Pearly lusture	Pearly shine	Muscovite
3.	Silky lusture	Silky shine	Asbestos
4.	Metallic lusture	Metallic shine	Magnetite
5.	Adamantine	Diamond like shine	Diamond

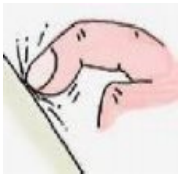
4. Hardness:-

Hardness of a mineral is defined as the resistance against external force of the mineral.

Hardness is a diagnostic and qualitative property of minerals.

Scale of hardness popularly known as Moh's scale.

- The ability to resist being scratched
- Most useful properties for identifying a mineral
- Numbered1-10.
  - 1-Talc-softest
  - 10-Diamond- hardest



The harder white mineral (calcite) scratches the softer one (gypsum).
(Adapted from Jones, 2001: Laboratory Manual for Physical Geology, 3rd edition.)

Moh's scale of hardness

Mineral name	Hardness
Talc	1
Gypsum	2
Calcite	3
Flourite	4
Apatite	5
Feldspar (orthoclase)	6
Quartz	7
Topaz	8
Corundum	9
Diamond	10

Moh's scale of hardness:-

In the scale, the higher hardness minerals will scratch lower hardness minerals .i.e. Diamond will scratch all the nine minerals, but talc will scratch none of the other minerals.

5. Cleavage:-

Cleavage is defined as the direction along which a mineral tends to break with smooth and plane surfaces.

It is the plane of weakness with least cohesion.

Cleavage is a diagnostic property of minerals.

Types of cleavage:-

i. Cubic cleavage: (.E.g.) Galena, Halite

ii. Rhombohedral cleavage: (.E.g.) Calcite

iii. Basal cleavage: (E.g.) Mica

iv. Prismatic cleavage: (E.g.) Natrolite

Further, cleavage of a mineral may be in 1 direction, 2 direction or 3 directions.

(E.g.)

1. Directional cleavage: Mica

2. Directional cleavage: feldspar

3. Directional cleavage: Calcite

6. Fracture:-

Fracture is defined as the appearance of broken surface of a mineral in a direction other than the cleavage direction.

Sl.No	Types of fractures:-	Appearance of broken surface	Example
1.	Even	Smooth and flat	Chert
2.	Uneven	Irregular with minute ridges and depressions	Flourite
3.	Conchoidaol	Concave	Quartz
4.	Splintry	Resembling of broken wood	Kyanite
5.	Hackly	Highly irregular	Native copper
6.	Earthy	Smooth, soft and porus	Chalk

7. Tenacity:-

Tenacity is defined as the resistance of mineral to any external forces that tend to break, bend, cut, crush, or deform it.

Sl.No	Type of tenacity	Description	Example
1.	Brittle	Powdered under hammer.	Calcite
2.	Sectile	Can be cut with a knife.	Talc
3.	Malleable	Can e flattened under hammer.	Tin
4.	Flexible	Can be bent or deformed.	Clay
5.	Elastic	Regain original shape after removal of external force applied	Mica
6.	Plastic	Does not Regain original shape after removal of external force	Clay

8. Specific Gravity:

Where'd' = Density of water = 1

$$\text{Specific Gravity} = \frac{\text{Weight of the mineral in air}}{\text{Loss of weight in water}} \times d$$

9. Form & Structure:-

i. Form:

The internal atomic structure of mineral and the external geometrical shapes together constitute of that mineral.

Types:-

1. **Crystal:** When both internal atomic structure and external geometric forms are perfectly present

   e.g.: calcite

2. **Crystalline:** External geometric form may or may not be present but internal atomic structure is present

   e.g.: Quartz

3. **Amorphous:** Both external geometric formed and internal atomic structure are lacking

e.g.: Obsidian. It is also called powder form.

ii. Structure:-

The physical appearance of mineral in terms of its shape is referred as its structure.

1. **Acicular** : Needle like crystal (e.g.) Natrolite
2. **Bladed** :Blade like (eg) Kyanite
3. **Botryoidal** :Resembling bunch of grapes (eg) Psilomelane
4. **Columnar** :Column like (eg) Beryl
5. **Foliated** :Paper thin sheets like easy separable (eg) Mica
6. **Fibrous** :Made up of fibres (eg) Asbestos, Gypsum
7. **Radiating** : Needle like fibrous crystal, radiating from a common centre (eg) Iron pyrites
8. **Reni form** : Kidney shaped aggregates (eg) Hematite
9. **Tabular** :Flattened – Table like(eg)Calcite, Barite, Feldspar
10. **Lamellar** : Thick leaf like sheets (eg) Vermiculite
11. **Granular** :Densely packed small grains (eg) Chromite
12. **Mammillary** : Rounded grains, overlapping in arrangement (e.g.) Malachite

10.Special properties:-

i. Magnetism

Some minerals are naturally magnetic ink character

a. **Strongly Magnetic** (eg) Magnetite
b. **Feebly Magnetic** Slightly Magnetic (eg) Spinel
c. **Non – Magnetic** (eg) Quartz, Calcite

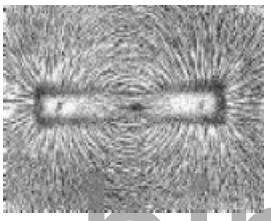
ii. Electricity(Pyroelectricity and Piezoelectricity):

1. **Pyroelectric**: Minerals producing electric charge when heat applied, are called Pyroelectric (eg) Quartz, Tourmaline
2. **Piezoelectricity:** When Pressure applied certain minerals will glow (eg) fluorite.

Fluorescence: When exposed to sun's radiation, certain minerals will glow (eg) Fluorite.

iii. Phosphorescence: Some minerals continue to glow even when bringing to the dark room after exposure to sun's radiation (eg) diamond

- **Magnetite:** Naturally magnetic



- **Halite:** Tastessalty

- **Sulfur:** Smells like rotten egg

iv. Fusibility: It refers temperature of fusion.

v. Transparency : It refers transmission of light of minerals

vi. Translucency: Partial transmission of light through a mineral.

vii. Opaque: No transmission of light through a mineral. (eg) Agate.

Uses of Minerals:-

- Minerals are raw materials used for a wide variety of products from dyes to dishes and from table salt to televisions

2.2 QUARTZ GROUP OF MINERALS

QUARTZ

- ✓ Quartz is an important rock forming mineral. It is found in all types of rocks.
- ✓ Chemically, it is SiO_2.

Varieties of quartz

1. **Polymorphs:** α and β Quartz
2. **Right handed and left handed quartz:**

   If such faces are found to occur on the right upper edge of the prism, then it is called right handed quartz and if they are located on the left side upper edge, then left handed quartz.

3. **Crypto crystalline varieties:**

   When crystallisation is incomplete, then quartz is turned as crypto crystalline varieties of silica. They are

   i. **Chalcedony :** translucent, waxy lustre, massive
   ii. **Agate :** banded, opaque, massive
   iii. **Onyx :** banded agate with different colours alternating evenly.
   iv. **Flint :** dull, opaque variety of chalcedony with conchoidal fracture.
   v. **Jasper :** amorphous variety of silica, dull red or yellow.

4. **Coloured varieties:**

Quartz becomes coloured, when impurities are present. A few common varieties are:

i. **Amethyst :** purple or violet in colour.
ii. **Rose quartz :** Rose colour, due to the presence of titanium.
iii. **Milky quartz :** milky white in colour
iv. **Smoky quartz :** brown or black in colour.

Physical Properties of Quartz group of minerals

Sl.No	Mineral property	Quartz
1.	Crystal system	Hexagonal (Rhombohedral)
2.	Colour	Colourless and various shades of colour
3.	Streak	White
4.	Luster	Vitreous to subvitreous
5.	Hardness	7
6.	Specific gravity	2.65
7.	Cleavage	Absent
8.	Fracture	Conchoidal
9.	Optical properties	Optically positive
10.	Chemical composition	SiO_2
11.	Form / structure	Crystalline, massive
12.	Special properties	a) Piezoelectric and pyroelectric b) Used as abrasive c) Amethyst a variety used as semiprecious, gemstone

2.3 FELDSPAR GROUP OF MINERALS

FELDSPAR MINERLAS

- ✓ It is most abundant of all minerals
- ✓ It is used for making more than 50% by weight crust of earth
- ✓ It is non-metallic and silicate minerals

Chemical composition:

Varieties	Chemical composition
Soda feldspar	$NaAlSi_3O_8$
Potash feldspar	$KAlSi_3O_8$
Lime feldspar	$CaAl_2Si_2O_8$

Crystallization of feldspar:

1. Monoclinic system
2. Triclinic system

Classification / types of feldspar:

1. Crystal system
2. Chemical composition

i. Based on crystal system:

1. Monoclinic feldspars:

a. Orthoclase : $KAlSi_3O_8$

b. Sanidine : $KAlSi_3O_8$

2. Triclinic feldspars:

a. Microcline : $KAlSi_3O_8$

Albite – Anorthite series

ii. Based on chemical composition:

1. Potash feldspar
2. Soda lime feldspar

1. **Potash feldspars:**

i. Orthoclase : $KAlSi_3O_8$

ii. Sanidine : $KAlSi_3O_8$

iii. Microcline : $KALSi_3O_8$

2. **Soda lime feldspars:**

i. Plagioclase feldspars

ii. Isomorphous series

Physical properties of Feldspar Minerals:

(Orthoclase, Albite, Microcline and Anorthite)

Sl.No	Mineral property	Orthoclase	Albite	Microcline	anorthite
1.	Crystal system	Monoclinic	Triclinic	Triclinic	Triclinic
2.	Colour	Colourless or flesh red	White, pink, grey, green, blue	White, pink, red	White or reddish
3.	Streak	White	Colourless	Colourless	Colourless
4.	Luster	Vitreous to subvitreous	Vitreous to pearly	Vitreous	Sub vitreous
5.	Hardness	6	6	6	6
6.	Specific gravity	2.56 to 2.58	2.60 to 2.62	2.54 to 2.57	2.6
7.	Cleavage	2 sets of perfect cleavage	2 sets, perfect	2 sets, perfect	2 sets, perfect
8.	Fracture	-	-	-	-
9.	Optical properties	Optically negative	Optically positive	Optically negative	Optically negative
10.	Chemical composition	$KAlSi_3O_8$	$NaAlSi_3O_8$	$KAlSi_3O_8$	$CaAl_2Si_2O_8$
11.	Form / structure	Crystalline	Crystalline	Crystalline	Crystalline

Sl.No	Mineral property	Orthoclase	Albite	Microcline	anorthite
12.	Special properties	a. Transparent variety Adularia. b. High temperature variety Sanidine. c. Used as ceramic mineral.	a. Used as ceramic mineral. b. Used as an ornamental stone, when polished.	a. Amazon stone a, greenish variety used as semiprecious stone. b. Used as ceramic mineral.	-

2.4 DESCRIPTION OF INDIVIDUAL MINERALS

2.4.1 PYROXENE GROUP

Sl.No	Mineral Property	Hypersthenes (Pyroxene Group)	Augite (Pyroxene Group)
1.	Crystal system	Orthorhombic	Monocline
2.	Colour	Green, greenish black	Variable greyish green or black is predominant
3.	Streak	Colourless	Colourless
4.	Luster	Submetallic	Vitreous
5.	Hardness	5-6	5-6
6.	Specific gravity	3.4-3.5	3.1-3.6
7.	Cleavage	Prismatic	2 sets, perfect
8.	Fracture	Uneven	Uneven
9.	Optical properties	Optically negative	Optically positive
10.	Chemical composition	Silicates of Fe and Mg, with Al in some varieties.	A complex silicate of Ca, Mg, and Fe
11.	Form / structure	Massive form	Crystalline
12.	Special properties	-	-

2.4.2 MICA GROUP

Sl.No	Mineral Property	Hornblende (Amphibole)	Muscovite
1.	Crystal system	Monocline	Monocline
2.	Colour	Black	Colourless or pale yellow
3.	Streak	Colourless	Colourless
4.	Luster	Vitreous to pearly	Vitreous to pearly
5.	Hardness	5-6	2.0-2.5
6.	Specific gravity	3.0-3.4	2.7-3.0
7.	Cleavage	2 sets, perfect	1 set, perfect
8.	Fracture	Uneven	-
9.	Optical properties	Optically negative	Optically negative
10.	Chemical composition	Complex silicates of Ca, Mg and Fe	A complex silicate of K and Al
11.	Form / structure	Crystalline	Foliated / flaky
12.	Special properties	-	Insulator

2.4.3 BIOTITE and CALCITE

Sl.No	Mineral Property	Biotite	Calcite
1.	Crystal system	Monocline	Hexagonal (Rhombohedral)
2.	Colour	Black	White or Colourless
3.	Streak	Colourless	White
4.	Luster	Pearly	Vitreous to sub vitreous
5.	Hardness	2.5-3.0	3
6.	Specific gravity	2.7-3.1	2.71
7.	Cleavage	1 set, perfect	3 sets, perfect
8.	Fracture	-	-
9.	Optical properties	Optically negative	Optically negative
10.	Chemical composition	Complex silicates of Mg, Fe, Al and K	$CaCO_3$
11.	Form / structure	Foliated / flaky	Crystalline
12.	Special properties	Insulator	Iceland spar-transparent variety used in optical instruments

2.4.4 GYPSUM

Sl.No	Mineral Property	Gypsum
1.	Crystal system	Monoclinic
2.	Colour	Colourless, white, grey
3.	Streak	Colourless
4.	Luster	Silky
5.	Hardness	2
6.	Specific gravity	2.3
7.	Cleavage	-
8.	Fracture	Uneven
9.	Optical properties	-
10.	Chemical composition	$CaSO_4.2H_2O$
11.	Form / structure	Fibrous
12.	Special properties	1. For making plaster of Paris. 2. Used as fertilizers. 3. Filler in various materials. 4. Used in cement manufacture

1.5 CLAY MINERALS

Types:

i. Montmorrilonite

ii. Kaolinite

iii. Illite

Bentownite

As far as civil engineering projects are concerned Montmorrilonite clay is likely to pose more complicated problems than the other two types of clay

Engineering properties of clays:-

- Porosity
- Permeability
- Consistency of soils
  - Liquid limit
  - Plastic limit
  - Shrinkage limit
  - Plasticity index
- Activity of clays
- Shear strength
- Swelling
- Shrinkage

i. Porosity:-

Porosity of clay is defined the ratio of pore spaces present in the sample to the total volume of the sample

$a = (v/V) \times 100$

a = porosity of clay, expressed in %

v = volume pores space present in the sample

V = the total volume of clay

ii. Permeability:-

The capacity of strata to transmit water through it is called permeability.

Consistency of soils:-

Consistency denotes degree of firmness of the soil it is related to water content of the soil.

a. Liquid limit (Wl) :-

It is defined as the minimum water content at which the soil is still in the liquid state.

b. Plastic limit (Wp) :-

It is defined as the minimum water content at which a soil will just begin to crumble, when rolled into a thread of 3 mm diameter.

c. Shrinkage limit (W3) :-

It is defined as the minimum or lowest water content at which a soil can still be completely saturated.

d. Plasticity index (Ip) :-

It is defined as the numerical difference between the liquid limit and the plastic limit of a soil.

Ip = W2 – WP

Whenever the plastic limit is greater than the liquid limit, for practical purpose, the plasticity index is considered to be zero.

iii. Activity of Clays (Ac) :-

The activity of clay (Ac) is defined as the ratio of plasticity index to the percentage weight of soil particles of diameter less than 2 microns, present in the clay sample.

$$Ac = \frac{Ip}{Cw}$$

Where, Ac = Activity of clay

Ip = plasticity of index

Cw = % weight of 0.002 mm sized grains present in the sample.

v) Shear Strength:

The shear strength of soil is the resistance to deformation by continuous shear displacement of soil particles.

Engineering Importance:-

Behavior of clay:

1. Swelling property during rainy season

2. Shrinkage during hot summer

Swelling of clay leads to total uplifting of structure and its shrinkage leads to settlement of the structure built on it.

Suppose, the swelling and shrinkage are not uniformly distributed, it leads to unequal settlement of the structure and development of cracks on the structure.

Physical properties of clay minerals:-

Crystal system : Triclinic and Monoclinic

Colour : Colorless, Grey, Brown, etc

Streak : White

Lusture : Dull and Earthy

Hardness 2

Specific Gravity : 2.6

Form : Massive Earthy

Composition : Hydrous Aluminium silicate

Occurrence : occurs as alteration products of alkali feldspars

Uses : Used in the manufacture of Bricks, Tiles, and Ceramic.

Used in manufacture of household utensils and used as filters.