CHAPTER 2

Mineralogy

The study of the characters of minerals is known as mineralogy.

Mineral:-

A "mineral" is a naturally occurring homogeneous substance which has a more or less definite chemical composition and definite atomic structure. The minerals are usually formed by inorganic processes. They possess a set of constant physical properties since the determination of atomic structure and chemical composition requires complex laboratory tests, the more easily recognized physical properties are used in the identification of minerals in the field.

As of today, there are about 4,900 known mineral species, and with the progress of research one or two elements are added every year.

The minerals may be divided into two broad groups:

(i) **Rock – forming Minerals :-** Rock forming minerals are those which are found in abundance in the rocks of the earth's crust. In civil Engineering it is important to have knowledge of the important rock forming types.

Eg: Quartz, Feldspar, Flint, Jasper, Olivine, Hornblende, Muscovite, Biotite, Asbestos, Chlorite, Calcite. Etc.

(ii) **Ore forming Minerals**: - are those which are of economic value and which do not occur in abundance in rocks. The ore – forming minerals are to be understood in detail by the Mining, Metallurgical and Mineral Engineering Professionals. Eg: Haematite, Pyrite, Chromite, Magnetite, Magnesite, Graphite, Galena, Bauxite.

Different Methods of Study of Minerals

According to the mineral definition, every mineral has its own chemical composition and atomic structure and it is unique for every mineral. Common methods of study and identification of minerals are done based on their

(i) Physical properties
(ii) Chemical properties
(iii) Optical properties and
(iv) x-ray analysis.

(i) Study of Physical properties: Physical properties like Color, Form, lustre, Hardness Density (Specific Gravity), cleavage etc., can be studied with simple observations.

(ii) Study of Chemical composition: According to the definition, every mineral which is expected to have its own individual chemical composition, which is not to be found in any other mineral. Therefore, by chemical analysis if composition is known it should be possible to identify the mineral.

(iii) Study of optical properties: In this method of study, the minerals are made very fine (0.03 mm) and fixed over glass

slide by means of canadabalsam .Such skillfully prepared slides are called thin sections. They are studied under petrological microscope. Different optical properties such as interference colors, their order, interference figures, optic sign, twinning, alteration etc., are studied under crossed nicols with the help of some other accessories, if necessary.

(iii) **Study of X-ray analysis:** X-ray analysis make use of the definite atomic structure, found in every mineral. When a beam of x-rays falls on a crystal, it is diffracted by the layers of the atoms within the crystal. In making an x-ray analysis of atomic structure of the crystal, the diffracted x-rays are allowed to fall on the photographic plate and resulting photograph shows a series of spots or lines which form more or less symmetrical pattern. From measurements made on the photograph, the arrangement of the atoms in the crystal can be deduced and also the distances between them. The results of x-ray analysis of minerals reveal their atomic structure, which is distinctive for each mineral. This enables the accurate identification of minerals.

Study of Physical Properties of Minerals

Form:

The form of mineral is defined as its shape. The external shape of mineral reflects the internal arrangement of atoms. When a mineral occurs as a well developed crystal, it is called crystallized. If the growth of the crystals is hampered due to interference of other crystal grains then the resulting form is called crystalline. When just traces of crystalline structures are present, it is called cryptocrystalline. Due to random network of ions or the total absence of crystalline structure, amorphous (or) shape less forms result. Some of the important forms are listed below.

- **Lamellar Form:** Mineral appears as thin separable layers

  Eg: Muscovite, Biotite

- **Tabular Form:** Minerals appears as slabs of uniform thickness

  Eg: Feldspars, Gypsum

- **Fibrous Form:** Mineral appears as fine threads

  Eg: Asbestos

- **Pisolitic Form:** Mineral appears as spherical

  Eg: Bauxite

- **Bladed Form:** Minerals appear as independent blade or lath-shaped grains

  Eg: Kyanite

- **Reni Form:** Kidney-shaped

  Eg: Haematite

- **Massive Form:** No definite shape

  Eg: Graphite, Olivine, Quartz, haematite, Magnesite, Jasper.

- **Nodular Form:** Irregularly shaped compact bodies with curved surfaces

  Eg: Flint

Color: Minerals show great variety of colors and can be identified by their color. Color

wise the minerals are of two types (i) Dark colored minerals and (ii) Light colored minerals.

Streak: The streak of mineral is the color of its powder. Many minerals exhibit a different color in the powder form compared to form of mass. The powder of the mineral is obtained either by scratching the mineral with a pen knife or rubbing it across piece of unglazed porcelain plate called streak plate.

Eg: colorless: quartz, Silver white: Muscovite, Red or reddish brown: Haematite,

Lustre: Lustre is the nature of shining on the surface of the mineral under reflected light. It varies considerably depending upon the amount and type of light reflected.

Based on the type of shining, lustres are grouped as metallic and non-metallic. Metallic lustre is the type of shining that appears on the surface of the metal. Non-metallic lustres are named considering the type of shining that appears in some common materials. Some important non-metallic lustres that are observed mainly in rock-forming minerals are:

- **Vitreous luster:** Glass shine
  Eg: Quartz, Calcite, Feldspar
- **Pearly luster:** Pearl shine
  Eg: Talc, Muscovite(mica)
- **Silky luster:** Silk shine
  Eg: Asbestos
- **Greasy luster:** Grease Shine
  Eg: Graphite, Serpentine
- **Adamantine luster:** Diamond Shine
  Eg: Garnet, Diamond
- **Earthy or Dull luster:** No shining like earth
  Eg: Magnesite, Bauxite

Cleavage: The definite direction or plane along which a mineral tends to break easily is called the cleavage of that mineral. Crystallized and crystalline minerals can have cleavage. Amorphous minerals do not show cleavage. Cleavage, if present , occurs as innumerable planes along which mineral is usually weak. Hence all such parallel planes of weakness are referred to as a set.

Depending upon their atomic structure, crystalline minerals will have 1 set of cleavage (or) 2 sets (or) 3 sets (or) no cleavage.

Eg: 1 set –Talc
2 set- Gypsum
3 set- Calcite
No cleavage- Quartz, Garnet etc.

Fracture: Fracture is the nature of randomly broken surface of mineral. Based on the nature of a broken surface, fractures are described as even fracture, uneven fracture, hackly fracture, and conchoidal fracture.

- **Even Fracture**: If the broken surface of a mineral is plain and smooth, it is called even fracture. **Eg:** Magnesite, Chalk
- **Uneven Fracture**: If the broken surface is rough and irregular. **Eg:** talc, pyrite, haematite, magnetite, bauxite
- **Hackly Fracture**: If the broken surface is very irregular like the end of a broken stick. **Eg:** Asbestos, Kyanite,

- **Conchoidal Fracture**: If the broken surface is smooth and curved. **Eg:** Agate, Flint, Jasper, galena, bauxite.

Tenacity: Tenacity of mineral denotes the degree or character of cohesion. Minerals as shown by their resistance to breaking, crushing or other deformation methods. The different kinds of tenacity are classified as follows

(i) **Brittle**: The mineral breaks into powder

(ii) **Malleable**: The mineral can be beaten into sheets

(iii) **Ductile**: The mineral can be drawn into thin wires

(iv) **Sectile**: The mineral can be cut into thin sheets

(v) **Elastic**: Minerals which spring back after bending.

Mohs' Scale of Hardness:

Hardness may be defined as the resistance offered by the mineral to abrasion or scratching.

In 1882 an Australian mineralogist, Mohs proposed a relative scale for hardness of minerals. The standard set of ten reference minerals used to determine the hardness of any unknown mineral is called Mohs' scale of hardness. The actual minerals of the set and their hardness are as follows:

Mineral	Hardness
Talc	1
Gypsum	2
Calcite	3
Fluorite	4
Apatite	5
Feldspar	6
Quartz	7
Topaz	8
Corundum	9
Diamond	10

Specific Gravity (density): Specific gravity of mineral depends on their chemical composition. and atomic structure. The specific gravity of a mineral is the weight of it to the weight of an equal volume of water. In the laboratory, specific gravity of minerals is determined using either Walker's steel yard or Jolly's spring balance. In determining specific gravity care should be taken to select only fresh (i.e un weathered) minerals free from inclusions, impurities etc,.

The medium density refers to the common rock-forming minerals and higher density refers to the common ore minerals.

- **Low Density:** < 2.5 Sp. Gravity

  Eg: Talc, graphite,

- **Medium Density:** 2.5 to 3.5 Sp. Gravity
  Eg: Feldspars, quartz, flint, jasper, calcite

- **High Density:** > 3.5 Sp. Gravity

  Eg: Barytes, Kyanite, garnet, pyrite, haematite, magnetite, chromite, galena, Pyrolusite,