ENGINEERING GEOLOGY

UNIT – II

MINERALOGY

INTRODUCTION

Nature comprises animals, Plants (organic) and minerals (inorganic). Both animals and plants depend directly or indirectly on minerals for their survival. Human society, in turn, depends heavily on animals and plants. Further, valuable metals and materials are also obtained from minerals. Thus minerals are uniquely important for the human race.

DEFINITION OF A MINERAL

A mineral may be defined as a natural, inorganic, homogeneous, solid substance having a definite composition and regular atomic structure. This means all materials around us cannot be described as minerals.

To call any substance a mineral, the requirements to be fulfilled are:

1. It must have been formed by natural processes; i.e., artificial or synthetic or man-made substances are not eligible to be called minerals.
2. It must be an inorganic substance, i.e., substances of wood or any other organic material cannot be called minerals.
3. It must be homogeneous, i.e., all parts of the minerals should possess the same physical and chemical characters.
4. It must be solid, i.e., gaseous, liquid or semisolid substances are not minerals.
5. It must have a definite chemical composition, i.e., a particular kind of mineral always has the same chemical composition irrespective of its size, shape, origin, occurrence, association, etc.,
6. It must be crystalline, i.e., it should possess an orderly atomic structure. Just as the composition is characteristic of a particular mineral, so is the atomic structure, i.e., chemical composition and atomic structure are specific for every mineral.

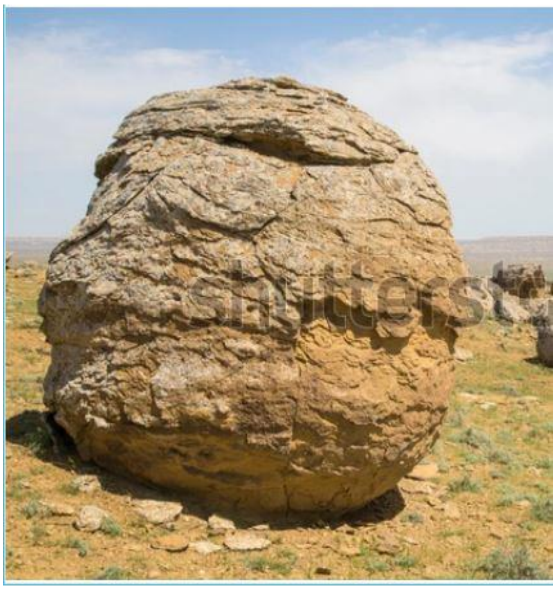
Note: 1. No two minerals can possess the same chemical composition and atomic structure.

2. Under favourable conditions the regular internal atomic structure of minerals results in the development of definite external geometrical shapes, i.e., crystal form.

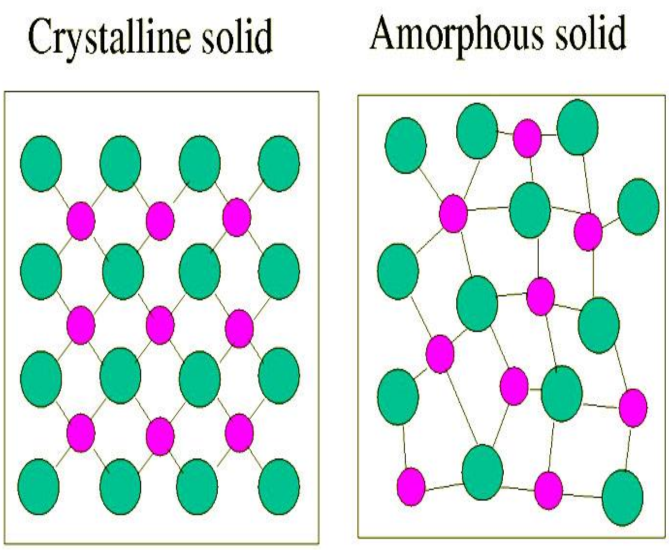
Exceptions for Definition of Mineral

Some substances which are traditionally or generally treated as minerals do not concur with one or another aspect of the definition. However, most of the minerals recognized satisfy the requirements of the given mineral definition. A few exceptions to the mineral definition are as follows:

1. **Artificial Products** – Precious gemstones like diamonds, rubies, sapphires and emeralds are synthetically produces also under controlled laboratory conditions are treated as minerals.
2. **Organic Substances –** Coal, amber, petroleum, natural gas, etc., are also considered as minerals.
3. **Inhomogeneity Minerals** – Amethyst, smoky quartz, citrine, cat's eys, aventurine quartz are some varieties of quartz. Bauxite, coal, etc., are not homogeneous. Kyanite and Fluorite are two typical minerals which do not show uniform colour.
4. **Not Solid substances –** Asphalt, copalite, petroleum, mercury and natural gas are semisolids, liquids or gases are called as minerals.
5. **Do not have definite chemical composition** – Isomorphic group minerals do not have definite chemical composition, but have a definite range of composition. Plagioclase feldspars, garnets, olivines, some pyroxenes, amphiboles, opal, bauxite, psilomelane, limonite, petroleum and natural gas, etc., exhibit this character.
6. **Irregular atomic structure** – Flint, chert, jasper and agate are **cryptocrystalline**, i.e., *they do not have a well-developed crystal structure*. A few others like opal, bauxite, wad, psilomelane, pitch blende and garnierite are typically **amorphous**, i.e., *they do not possess any regular internal atomic structure.*



Cryptocrystalline Form of Rock



MODE OF FORMATION OF MINERALS

Basically there are three kinds of formation of minerals in nature. They are formed from magma or out of secondary processes or under metamorphism.

Magma – Magma is the molten or semi – molten natural material which is found beneath the surface of the earth. It is produced by melting of the mantle or the crust at various tectonic settings.

Lava – Lave is the extrusive equivalent of magma.

- Most of the minerals are formed directly or indirectly out of **magma** during different stages of its solidification. Important and bulk of rock – forming minerals such as Feldspar, Quartz, Pyroxenes, Amphiboles, Micas, Feldspathoids and Olivine are formed in this way. Some precious minerals and Ore minerals like gemstones, garnets, topaz, magnetite, native metals, beryl, apatite, muscovite, fluorspar, lead – zinc ores and tourmaline also are formed from magmatic sources.
- In nature, some minerals are formed from **secondary processes** like weathering, precipitation(due to reaction or evaporation) and deposition. Minerals like calcite, dolomite, bauxite, limonite, wad, serpentine, salts, coal. Petroleum, chlorite, phosphates, bog – iron ore, clays, agate, opal and zeolites are examples of this group.
- Another important mode of formation of minerals is out of **metamorphism**. These minerals are formed under the influence of high temperatures and pressures with or without the active involvement of chemically active solutions. Andalusite, sillimanite, kyanite, staurolite, garnets, chlorite, graphite, talc, cordierite, etc., are examples of this group.
- However, there are some minerals which are formed by different modes. For example ; chlorite, talc and biotite are formed both due to alteration (i.e., weathering) and metamorphism. Similarly, some garnets are primary (i.e., formed out of magma) minerals and some are products of metamorphism.

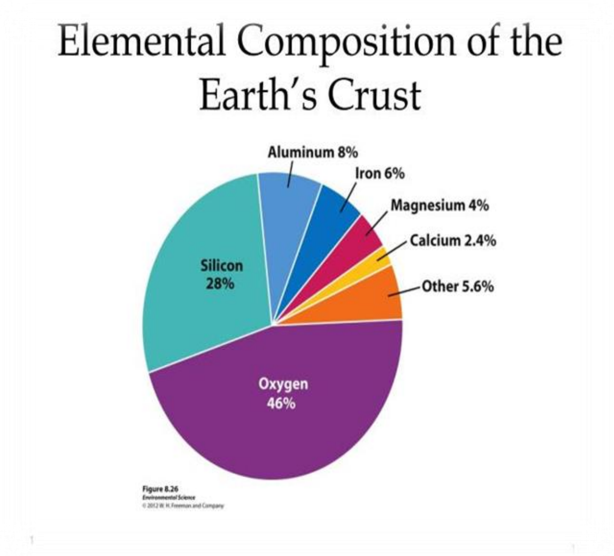
COMMON ROCK – FORMING MINERALS AND THEIR ABUNDANCE

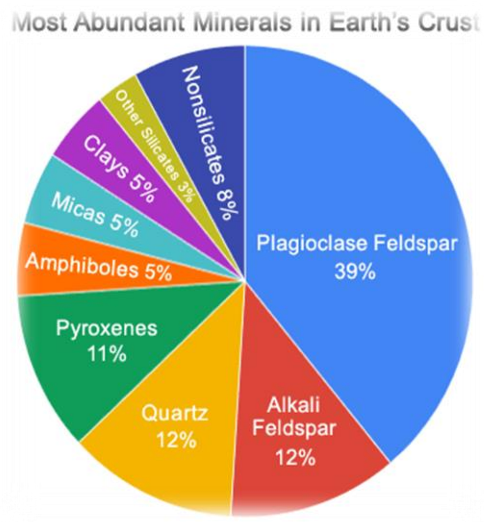
- ✓ Based on their nature and economic importance, all minerals are grouped into "rock – forming minerals" (Eg ; Feldspars, quartz, mafic minerals, biotite mica) and "Economic minerals ".

✓ Some economic minerals serve as sources for extraction of valuable metals and others become useful by virtue of their physical properties. Based on this, economic minerals are further grouped as metallic minerals (Hematite, galena, chromite, etc.,) and Non – metallic minerals (Asbestos, Graphite, Magnesite, etc.,).

✓ Rock – forming minerals are very abundant in the earth's crust. According to an estimate 99.9% of the earth's crust is composed of 20 – 25 rock – forming mineral sonly.

✓ Economic minerals are therefore very scarce. The reason for such occurrence is that the elements that enter into the formation of minerals are derived from the rocks of the outer crust or from magma.





The above diagrams revealing some interesting features, They are:

1. Only nine out of the more than hundred known elements, account for 99.25% of the earth's crust; rock – forming minerals which are very abundant are mainly formed out of these none elements.
2. Oxygen and silicon together constiture 74.4% - therefore, rock – forming minerals are mainly silicates (985 of rock – forming minerals are silicates only).
3. All precious and useful elements such as platinum, gold, silver, copper, manganese, lead, zinc, chromium, nickel and dozens of other elements together represent only 0.436% this explains why economic minerals are scarce.

Civil Engineering Importance of Rock – Forming Minerals

❖ From civil engineering point of view, economic minerals are not relevant and, on the contrary, knowledge of rock – forming minerals is very much necessary because :

❖ The civil engineers need to know the properties of rocks precisely to enable them to consider different rocks for any required purpose, i.e., as foundation rocks, as road metal, as concrete aggregate, as building stones, as flooring or roofing material, as decorative material, etc., All properties of rocks are, in turn, dependent on the properties of their constituent minerals. Thus properties of civil engineering importance such as strength, durability and appearance of rocks can be assessed only with the knowledge of the minerals that form rocks(i.e., rock – forming minerals).

- The economic minerals, since they are scarce, do not influence the properties of rocks and are hence irrelevant from the civil engineering point of view. But, if they happen to occur in large quantities, their economic value will not permit them to be used either as construction materials or as foundation sites.

DIFFERENT METHODS OF STUDY OF MINERALS

According to the definition, every mineral has its own chemical composition and atomic structure. This combination of chemical composition and atomic structure is unique for every mineral. This fact facilitates the study of minerals in different ways. Common methods of study and identification of minerals are based on (i) their physical properties, (ii) their chemical composition, (iii) their optical properties and (iv) their X – ray analysis

Study of Physical Properties

- Physical properties of minerals like colour, shine(lustre), resistance to scratching(hardness), density, Fissility (cleavage, a tendency of some minerals to break in certain preferred directions), etc., can be studied with mere observation and feeling of small mineral specimens.
- These properties are dependent on chemical composition and atomic structure, i.e., if atomic structure and chemical composition remain the same, the resulting physical properties also should be similar.
- Since every mineral invariable possesses its own specific chemical composition and atomic structure, every mineral should possess its own set of physical properties.
- This principle is the basis for the study of minerals by means of physical properties.
- From the civil engineering point of view it is very important to know more about these physical properties by studying different minerals practically.

Study of Chemical Composition

- According to the definition, every mineral is expected to have its own distinctive chemical composition, which is not to be found in any other mineral.
- Therefore, by chemical analysis, if the composition is known it should be possible to identify the mineral.
- This principle is the basis for this type of study of minerals.

Study of Optical Properties

- In this method of study, the minerals are ground very fine (standard thickness is 0.03 mm), such skilfully prepared slides are called thin sections.
- They are studied under a petrological microscope (which has the distinction of having two polarizers one above and the other below the microscopic stage, where this section is held under clips).
- Different optical properties are studied under polarized light and under crossed nicols.
- The properties of minerals like colour, relief, cleavage, shape and plechorism, are studied under polarized light.
- Interference colours, their order, interference figure, optic sign, twinning, extinction, alteration, etc., are studied under crossed nicols.
- The principle which makes this method useful for study and identification of minerals is that; when polarized light passes through thin sections of mineral it is influenced in a characteristic way depending on the chemical composition and atomic structure of the mineral.
- Since every mineral has its own specific chemical composition and atomic structure, the optical properties of every mineral are also distinctive and hence helpful in the identification of the mineral.

X – Ray Analysis

- X –ray analysis makes use of the definite atomic structure, found in every mineral.
- X – rays are similar to light waves but have a much shorter wavelengths, comparable to these distances between atoms in a crystalline mineral.
- When a beam of x – rays falls on a crystal, it is diffracted by the layers of atoms within the crystal.
- In making an x – ray analysis of the atomic structure of the crystal, the diffracted x – rays are allowed to fall on a photographic plate, and the 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.
- In short, results of x – ray analysis of minerals reveal their actual atomic structures, which is distinctive for each mineral. This enables the accurate identification of minerals.

Note:

1. Among the different methods of study made in the identification of a mineral, X – ray analysis is the best, because it is accurate and there is no scope for wrong identification. But the disadvantage is that for x – ray analysis, a lot of infrastructure, costly equipment and accessories are required.
2. Next in the order, from the point of view of correct identification of minerals, is study by optical properties. But this study also has some constraints.

3. Next comes the method of chemical analysis; this is fairly good in giving correct identification of minerals, but this also has some constraints.
4. Lastly, coming to the method of study of minerals by physical properties. This method has so many advantages like time saving, less cost etc., but this also has some disadvantages.

❖ In spite of limitations in the method of study by physical properties, this method is fairly satisfactory in identifying the minerals. Therefore, in the engineering geology laboratory, minerals are identified by this method only.

Mineral Identification

Physical Properties of Minerals

1. Forms and Habits
2. Colour
3. Streak
4. Lustre
5. Fracture
6. Cleavage
7. Hardness
8. Specific Gravity
9. Degree of Transparency
10. Special Properties

Forms and Habits

The form represents the common mode of occurrence of a mineral in nature. It is also called Habit or Structure of minerals. To some extant this is the function of the atomic structure of minerals.

DIFFERENT FORMS & HABITS OF MINERALS

1. **LAMELLAR FORM -** Minerals appears as a thin separable layers.

   Eg : Mica

2. **TABULAR FORM -** Mineral appears as slab of uniform thickness.

   Eg : Feldspar

3. **FIBROUS FORM** – Minerals appears to be made of thin threads.

   Eg : Asbestos

4. **PISOLITIC FORM** – Minerals appears to be made of small spherical grains.

   Eg : Bauxite

5. **OOLITIC FORM** – Minerals appears to be made of still small spherical grains.

   Eg : Lime stone

6. **RHOMBIC FORM** – Minerals appears to be made of rhombic shape.

   Eg : Calcite

7. **GRANULAR FORM** – Minerals appears to be made of innumerable equi-dimensional grain of coarse or medium of grain.

   Eg : Magnetite, Chromite

8. **BLADED FORM** – Minerals appears as a cluster or independent lath shaped grain.

   Eg : Kyanite

9. **BOTRYOIDAL FORM** – Minerals appears as made up of smaller curved faces like bunch of grapes.

   Eg : Hematite, Chalcedony

10. **ACICULAR FORM** – Minerals appears as made up of thin needles.

    Eg : Natrolite, Actinolite

11. **COLUMNAR FORM** – Minerals appears as long slender prism.

    Eg : Quartz, Apatite

12. **PRISMATIC FORM** – Minerals appears as elongated independent crystals.

    Eg : Quartz, Apatite

13. **SPONGY FORM** – Minerals appears as porous

    Eg : Pyrolusite, Bauxite, Pumice

14. **CRYSTAL FORM** – Minerals appears as polyhedral Geometrical shapes

    Eg : Quartz, Amethyst, Pyrite, Galena

15. **MASSIVE FORM** – No definite shape for minerals

    Eg : Graphite, Olivine, Jasper

16. **NODULAR FORM** – Irregular shaped compacted body with curved shape.

    Eg : Flint, Limestone

Colour

Colour is due to the composition. In some others it imparted by the presence of trace element, inclusions, atomic structure.

Great consistency in ore forming minerals. [Idiochromatic]

Less consistency in Rock forming minerals. [Allochromatic]

1. GRAPHITE – Shining Black colour
2. HEMATITE – Dark Steel Grey
3. AMETHYST – Violet
4. CALCITE – White
5. JASPER – Red
6. OLIVINE – Olive Green
7. QUARTZ – Colour less or White
8. ASBESTOS – White, Less commonly green, Yellow, Grey
9. PYROLUSITE – Dark grey, Nearly Black
10. GALENA – Dark Lead Grey
11. BARYTES – White or Pale grey
12. PYROLUSITE – Dark grey, Nearly black

Colour

Determined by the chemical composition of the mineral

Minerals rich in Al, Ca, Na, Mg are often light coloured.

Minerals rich in Fe, Ti, Ni, Cr are often dark in colour

Determined by the atomic structure of the mineral

Atomic structure controls which components of white light are absorbed or reflected

White minerals reflect all components of white light

Black minerals absorb all components of white light

Green minerals reflect green light and absorb the others

Colour

- Colour is not particularly useful as a diagnostic property
- Some minerals show a wide variety of colours
- Quartz can be transparent, white, pink, brown, purple, yellow, orange and even black
- Many minerals show very similar colours
- Calcite, gypsum, Barytes, fluorite, plagioclase feldspar and halite are commonly grey or white in colour

Streak

The colour of a mineral's powder obtained by rubbing a mineral specimen on an unglazed white porcelain tile.

Useful for identifying metallic ore minerals.

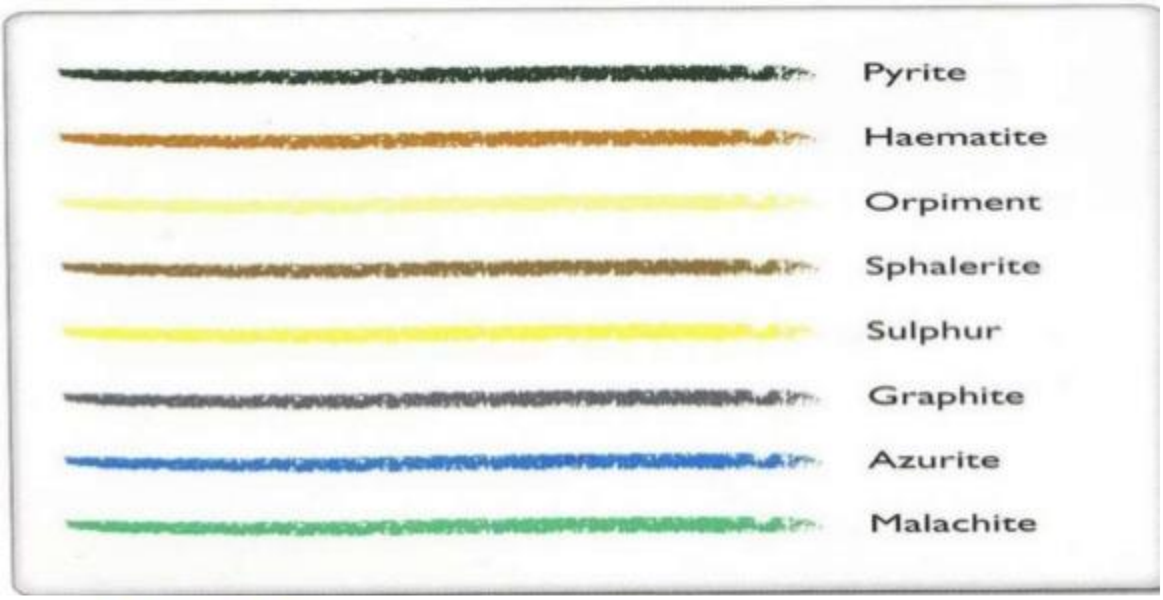
Silicates generally do not mark the tile and have no streak.

White minerals streaked on a white tile will have a white streak

Any minerals harder than the tile (6) no streak.

- HEMATITE gives a cherry red streak.

Metallic Ore Minerals – Characteristic Streaks



LUSTRE

The way in which a mineral reflects light and it is Controlled by the atomic structure of the mineral.

Lustre is the nature of shining on the surface of minerals.

Based on quality or type of shining, lustres are grouped as metallic and non metallic.

1. **METALLIC LUSTRE** – It is the type of shining that appears on the surface of metals.

Eg : Pyrite, Galena, Gold

2. **SUB – METALLIC LUSTRE** – The amount of shining is less compare to metallic lustre.

Eg : Hematite, Magnetite, Chromite

3.**<u>NON – METALLIC LUSTRE</u>**

a. **VITREOUS LUSTRE** – The non – metallic minerals shining like a glass sheet.

   Eg : Quartz, Calcite, Dolomite

b. **PEARLY LUSTRE** – The non – metallic minerals shining like a pearls.

   Eg : Talc, Gypsum, Muscovite Mica

c. **SILKY LUSTRE** – The non – metallic minerals shining like a silk.

   Eg : Asbestos, Satinspar

d. **RESINOUS LUSTRE** – The non – metallic minerals shining like a Resin.

   Eg : Opal, Chalcedony

e. **ADAMANTINE LUSTRE** – The non – metallic minerals shining like a Diamond.

   Eg : Adamantine minerals

f. **EARTHY/ DULL LUSTRE** – The non – metallic minerals shining lie a earth or chalk.

Eg : Kaolin, Magnesite, Bauxite

FRACTURE

The tendency of minerals to break along a flat surface or to break unevenly along a curved surface or irregular surface.

Fracture is a mineral property where the atomic bonding between atoms in crystal structure is perfect with no weakness. When these minerals are stressed they shatter making no two pieces truly the same.

FRACTURE

Fracture occurs in the minerals where bond strength is generally the same in all direction.

Minerals that have fracture do not exhibits cleavage.

Fracture is the Uneven breakage of minerals.

EVEN FRACTURE – The broken surface of the minerals is plain and Smooth.

Eg : Magnesite, Chalk

UNEVEN FRACTURE – The broken surface of the minerals is rough or irregular.

Eg : Sodalite

HACKLY FRACTURE – The broken surface of the minerals is very irregular like broken stick.

Eg : Kyanite, Asbestos, Tremolite

CONCHOIDAL FRACTURE – The broken surface of the minerals is smooth and curved surface.

Eg : Volcanic glass, Opal

SUB CONCHOIDAL FRACTURE – The broken surface of the minerals is smooth and curved nature is less predominate.

Eg : Flint, Jasper, Agate

Cleavage

The definite direction or plane along which a minerals tend to break easily.

It is related to crystallinity only crystalline minerals have cleavage.

Cleavage represents the plane of weakness in atomic structure of minerals.

BASAL – ONE DIRECTION CLEAVAGE – These minerals can be split into a very thin sheet along horizontal plane.

Eg : Muscovite Mica

PRISMATIC – TWO DIRECTION CLEAVAGE – These minerals exhibits two mutually perpendicular sets of cleavage.

Eg : Orthoclash

CUBIC – THREE DIRECTION CLEAVAGE – These minerals exhibits three mutually perpendicular sets of cleavage.

Eg: Halite

CUBIC – THREE DIRECTION CLEAVAGE – These minerals exhibits three mutually perpendicular sets of cleavage with some angles.

Eg: Calcite

Hardness

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

Its is also related to Atomic structure of Minerals.

The chemical composition of mineral appear to have a less influence over hardness.

Hardness

Hardness minerals is studied either as Absolute hardness and Relative hardness.

Absolute hardness means Total hardness.

Relative hardness means comparative hardness.

Hardness

The relative hardness of unknown minerals is determined by scratching it with the minerals of Mohs scale of hardness, starting with the talc and followed by minerals.

RATING	DESCRIPTION
1: VERY SOFT	EASILY CRUMBLES. CAN BE SCRATCHED WITH A FINGERNAIL (2.2)
2: SOFT	CAN BE SCRATCHED WITH A FINGERNAIL (2.2)
3: SOFT	CAN BE SCRATCHED WITH A COPPER PENNY (3.5)
4: SEMI-HARD	CAN BE SCRATCHED WITH A NAIL (5.2)
5: HARD	CAN BE SCRATCHED WITH A NAIL (5.2)
6: HARD	MINERAL WITH HARDNESS OF 6 OR MORE CAN SCRATCH GLASS
7: VERY HARD	CAN BE SCRATCHED WITH A COCRETE NAIL (7.5)
8: VERY HARD	
9: EXTREMELY HARD	USED IN INDUSTRIAL TOOLS FOR CUTTING AND GRINDING
10: THE HARDEST	DIAMOND IS USED TO CUT ALL MINERALS

Specific Gravity (Density)

It is the ratio of the mass of a substance to the mass of a reference substance for the same given volume.

Specific gravity of minerals depends on their chemical composition and atomic structure.

Specific gravity of minerals is determined by using either Walker's steel yard or jolly's spring.

Specific Gravity (Density)

Quartz with silicon dioxide has higher specific gravity of 2.7.

Opal with Amorphous variety has lesser specific gravity2.2 .

Amber as specific gravity nearly equal to water 1.

Platiniridium is the heaviest specific gravity of 22.84.

Rock forming minerals have specific gravity of 2.5 – 3.5.

Ore forming minerals have specific gravity of over 3.5.

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Most sulfides are 4.5 to 6.0

Iron metal is ~8

Lead is ~13

Gold and platinum are 19-22.

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Lead is ~13

Gold and platinum are 19-22.

Degree of Transparency

The resistant offered by materials to the passage of light through them.

Transparency depends on chemical composition.

Ore minerals exhibits opaque.

Degree of transparency is mainly depends on thickness.

Degree of Transparency

Transparent

Muscovite Mica

Quartz

Degree of Transparency

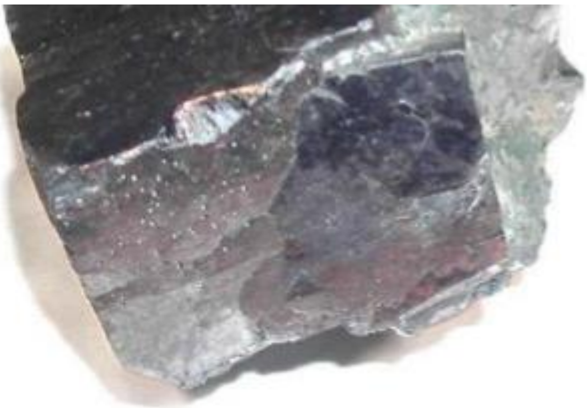
Translucent

Calcite

Agate

Degree of Transparency

Opaque



Galena

Calcite

Special Properties

Some minerals exhibits peculiar characters which enable them to identify easily.

Special Properties

Its very soft (h=1)

It exhibits smooth touch

or soapy feel

Talc

Special Properties

Its low hardness (h=1)

It exhibits black colour

Mark easily on paper.

Graphite

MINERALOGY

Special Properties

Its gives garlic smell

When struck or heated

and freshly broken surface

Realgar

Orpiment

MINERALOGY

Special Properties

It gives a clayey smell

And adheres strongly to the

Tongue.

Kaolin

MINERALOGY

Special Properties

Halite has a saline taste

Halite

MINERALOGY

Special Properties

It strongly attracts by an

Ordinary magnet.

Halite

PHYSICAL PROPERTIES OF THE COMMON ROCK FORMING MINERALS

1. Name of the mineral species with composition and crystal form: **FELDSPAR**

   [Aluminium silicate of K/Ca/Na; Monoclinic (All three axes are unequal in length, and two axes are perpendicular to each other) or Triclinic (All three axes are unequal in length, and none is perpendicular to another)]

   Form: Tabular

   Colour: White/Pale Colour

   Lustre: Vitreous

   Fracture: Even to Uneven

   Cleavage: 2 sets, at right angles

   Hardness: 6

   Density (Specific Gravity): Medium (2.5 – 3)

   Degree of Transparency: Translucent along thin edges

   Special Properties: ---

   Remarks: Most abundant rock forming Mineral

2. Name of the mineral species with composition and crystal form: **QUARTZ**

   [SiO_2, hexagonal]

   Form: Massive (Sometimes as a crystal)

   Colour: Generally colourless or White or any other colour

   Lustre: Vitreous (Shining like glass)

   Fracture: Uneven to Conchoidal (Broken surface is curved and smooth)

   Cleavage: Absent

   Hardness: 7

   Density (Specific Gravity): Medium (2.65)

   Degree of Transparency: Transparent to Translucent

   Special Properties: Horizontal striations on prismatic faces of crystal

   Remarks: 1. Most resistance to weathering, 2. Amethyst is purple or violet in colour, 3. Rock crystal is colourless and transparent

3. Name of the mineral species with composition and crystal form: **JASPER**

[SiO_2, Crypto-crystalline]

Form: Massive

Colour: Red colour common

Lustre: Resinous

Fracture: Con choidal

Cleavage: Absent

Hardness: Nearly 7

Density (Specific Gravity): Medium (2.57 – 2.65)

Degree of Transparency: Nearly Opaque

Special Properties: ---

Remarks: Common as pebbels in conglomerates

4. Name of the mineral species with composition and crystal form: **AUGITE**

[Complex silicate, Monocline]

Form: Massive

Colour: Black

Lustre: Vitreous to sub - vitreous

Fracture: Uneven

Cleavage: 2 sets prismatic, not perfect

Hardness: 5 - 6

Density (Specific Gravity): Medium (3.2 – 3.5)

Degree of Transparency: Nearly Opaque

Special Properties: ---

Remarks: Most common type of pyroxene

5. Name of the mineral species with composition and crystal form: **HORNBLENDE**

[Complex silicate, monoclinic]

Form: Granular or prismatic aggregate

Colour: Dark greenish black

Lustre: Vitreous to sub - vitreous

Fracture: Uneven

Cleavage: 2 sets, Prismatic

Hardness: 5 - 6

Density (Specific Gravity): Medium (3 – 3.5)

Degree of Transparency: Nearly Opaque

Special Properties: ---

Remarks: Most common type of Amphibole

6. Name of the mineral species with composition and crystal form: **ASBESTOS**

[Complex silicate, monoclinic]

Form: Fibrous

Colour: White/pale coloured

Lustre: Silky

Fracture: Uneven to hackly

Cleavage: Present

Hardness:

Density (Specific Gravity): Medium

Degree of Transparency: Thin fibres are Translucent

Special Properties: ---

Remarks: Chrysotile is spinning variety

7. Name of the mineral species with composition and crystal form: **MUSCOVITE**

[Complex silicate, monoclinic]

Form: Lamellar

Colour: Silvery white, Colourless in thin layers

Lustre: Pearly

Fracture: Uneven to hackly

Cleavage: 1 set, basal excellent

Hardness: 2 - 3

Density (Specific Gravity): Medium (2.7 - 3)

Degree of Transparency: Thin layers are completely Transparent

Special Properties: Cleavage is Excellent

Remarks: A very valuable variety of Mica

8. Name of the mineral species with composition and crystal form: **BIOTITE**

[Complex silicate, monoclinic]

Form: Lamellar or flaky

Colour: Dark greenish black or black

Lustre: Pearly

Fracture: Uneven to hackly

Cleavage: 1 set perfect

Hardness: 2 - 3

Density (Specific Gravity): Medium (2.7 - 3)

Degree of Transparency: Only very thin layers are translucent

Special Properties: ----------

Remarks: Common rock - forming Mica

9. Name of the mineral species with composition and crystal form: **OLIVINE**

[$(Mg, Fe)_2 SiO_4$, Orthorhombic]

Form: Massive

Colour: Olive green

Lustre: Dull

Fracture: Uneven

Cleavage: Absent

Hardness: 6 - 7

Density (Specific Gravity): Medium (3.2 – 3.5)

Degree of Transparency: Nearly Opaque

Special Properties: Olive green colour

Remarks: Common unsaturated mineral

10. Name of the mineral species with composition and crystal form: **KYANITE**

[Al_2SiO_5, Triclinic]

Form: Bladed, Radiating Fibrous

Colour: Blue with dark patches

Lustre: Vitreous to Sub - vitreous

Fracture: Uneven

Cleavage: Present, 2 sets

Hardness: Along length (4 – 5); Along width (5.5 – 6.5)

Density (Specific Gravity): Medium (3.6)

Degree of Transparency: Translucent along thin edges

Special Properties: Bladed form

Remarks: A common refractory mineral

11. Name of the mineral species with composition and crystal form: **GARNET**

[$Fe_3Al_2 (SiO_4)_3$ cubic]

Form: Massive or trapezohedron

Colour: Red

Lustre: Vitreous to resinous or adamantine

Fracture: Uneven to sub - conchoidal

Cleavage: Absent

Hardness: 6.5 – 7.5

Density (Specific Gravity): Medium

Degree of Transparency: Translucent along thin edges

Special Properties: Crystal form is very common

Remarks: ----------

12. Name of the mineral species with composition and crystal form: **CALCITE**

[$CaCO_3$, hexagonal]

Form: Rhombic form

Colour: Colourless, White/Pale colour

Lustre: Vitreous

Fracture: Rarely found

Cleavage: 3 sets, well developed cleavage angle = 105^0

Hardness: 3

Density (Specific Gravity): Medium (2.7)

Degree of Transparency: Transparent to Translucent

Special Properties: Reacts with acid vigorously

Remarks: Very common rock forming carbonate mineral

13. Name of the mineral species with composition and crystal form: **TALC**

[$Mg_3Si_4O_{10}.(OH)_2$, Monoclinic]

Form: Foliated or Massive

Colour: White, Pale yellow or pale green, etc.,

Lustre: Pearly

Fracture: Uneven

Cleavage: Present, 1 set

Hardness: 1

Density (Specific Gravity): Medium (2.7)

Degree of Transparency: Translucent along the edges

Special Properties: Soapy feel

Remarks: Very valuable non – metallic economic mineral

14. Name of the mineral species with composition and crystal form: **CHLORITE**

[$(Mg, Fe)_5\ Al(Al,Si)_3O_{10}(OH)_8$, Monoclinic]

Form: Foliated

Colour: Green

Lustre: Pearly

Fracture: Uneven

Cleavage: Present

Hardness: 1.5 – 2.5

Density (Specific Gravity): Medium (2.6 – 2.9)

Degree of Transparency: Nearly Opaque

Special Properties: Green colour

Remarks: ----------------

15. Name of the mineral species with composition and crystal form: **FLINT**

Form: Nodular

Colour: Grey, black, brown, red, white and other colours due to staining

Lustre: Waxy, Dull

Fracture: Conchoidal, Sub-Conchoidal

Cleavage: Absent

Hardness: 6.5 - 7

Density (Specific Gravity): 2.7

Degree of Transparency: Translucent to Opaque

Special Properties: -------

Remarks: Takes good polish

OTHER COMMON ECONOMIC MINERALS

1. Name of the mineral species with composition and crystal form: **PYRITE** [FeS_2, Cubic]

Form: Cubic, Granular

Colour: Brass Yellow

Lustre: Shining, Metallic

Fracture: Uneven

Cleavage: 3 sets, cubic

Hardness: 6 - 7

Density (Specific Gravity): High (5)

Degree of Transparency: Opaque

Special Properties: Brass yellow colour with a greenish black streak

Remarks: Undesirable rock forming mineral

2. Name of the mineral species with composition and crystal form: **HEMATITE** [$Fe_2 O_3$, hexagonal]

Form: Massive

Colour: Steel Grey

Lustre: Metallic to Sub - metallic

Fracture: Uneven

Cleavage: Absent

Hardness: 5 - 6

Density (Specific Gravity): High (5.2)

Degree of Transparency: Opaque

Special Properties: Steel grey colour, Cherry red streak

Remarks: Most common ore of iron

3. Name of the mineral species with composition and crystal form: **MAGNETITE**

[Fe_3O_4, cubic]

Form: Granular

Colour: Black

Lustre: Metallic to Sub metallic

Fracture: Uneven

Cleavage: Absent

Hardness: 5 - 6

Density (Specific Gravity): High (5.2)

Degree of Transparency: Opaque

Special Properties: Strongly magnetic

Remarks:

4. Name of the mineral species with composition and crystal form: **CHROMITE**

[$FeCr_2O_4$, Cubic]

Form: Granular

Colour: Black

Lustre: Sub - metallic

Fracture: Uneven

Cleavage: Absent

Hardness: 5 - 6

Density (Specific Gravity): High (4.5 – 5)

Degree of Transparency: Opaque

Special Properties: Black colour with a brown streak

Remarks: Only Ore of Chromium

5. Name of the mineral species with composition and crystal form: **GALENA**

[PbS, Cubic]

Form: Cubic or rectangular blocks or granular

Colour: Lead Grey

Lustre: Splendent

Fracture: Rarely found

Cleavage: Perfect 3 sets, cubic

Hardness: 2 - 3

Density (Specific Gravity): High (7.5)

Degree of Transparency: Opaque

Special Properties: Marks paper sometimes

Remarks: Only important Ore of Lead

6. Name of the mineral species with composition and crystal form: **PYROLUSITE** [MnO_2, Orthorhombic]

Form: Massive, Spongy

Colour: Dark brownish black

Lustre: Dull

Fracture: Uneven

Cleavage: Indistinct

Hardness: Variable

Density (Specific Gravity): High (4.5 – 5)

Degree of Transparency: Opaque

Special Properties: Soil, the fingers

Remarks: Important manganese ore mineral

7. Name of the mineral species with composition and crystal form: **GRAPHITE** [Hexagonal]

Form: Massive, granular

Colour: Black

Lustre: Shining Greasy

Fracture: Uneven

Cleavage: Present, not distinct

Hardness: 1 – 2

Density (Specific Gravity): Low (2 – 2.3)

Degree of Transparency: Opaque

Special Properties: Marks paper

Remarks: Used in Pencils

8. Name of the mineral species with composition and crystal form: **MAGNESITE** [$MgCO_3$, hexagonal]

Form: Massive

Colour: White

Lustre: Dull

Fracture: Even to Uneven, Sub con-choidal

Cleavage: Absent

Hardness: 4 - 5

Density (Specific Gravity): Medium (3 – 3.2)

Degree of Transparency: Opaque

Special Properties: White colour, Even

Fracture

Remarks: A refractory mineral

9. Name of the mineral species with composition and crystal form: **BAUXITE** [$Al_2O_3 . 2H_2O$, Amorphous]

Form: Pisolitic spongy or Massive

Colour: Dirty White with patches of different colours

Lustre: Dull

Fracture: Uneven

Cleavage: Absent

Hardness: Nearly 4(Variable)

Density (Specific Gravity): Medium (2 – 3.5)

Degree of Transparency: Opaque

Special Properties: Pisolotic Form

Remarks: Only ore of aluminium

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