(20A.1401P) ENGINEERING GEOLOGY LAB

- **PREPARED BY**

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COURSE OUTCOMES

CO 1	**Identify the minerals based on their physical properties**
CO 2	Classify rocks using basic geologic classification system
CO 3	Solve various geological problems
CO 4	Interpret the geological structures in the geological maps and models
CO 5	Ascertain the stability of structures based on the geological aspects

Experiments List as per affiliated University

List of Experiments:

1. Physical properties of minerals: Mega-scopic identification of Rock forming minerals – Quartz group, Feldspar group,
2. Identification of Rock forming minerals Garnet group, Mica group
3. Physical properties of minerals: Mega-scopic identification of Talc, Chlorite, Olivine, Kyanite, Asbestos, Tourmelene, Calcite, Gypsum, etc…
4. Physical properties of minerals: Mega-scopic identification of Ore forming minerals – Magnetite, Hematite, Pyrite, Pyralusite, Graphite, Chromite, etc…
5. Megascopic description and identification of Igneous rocks – Types of Granite, Pegmatite, Gabbro, Dolerite, Syenite, Granite Poryphery, Basalt, etc…
6. Megascopic description and identification of Sedimentary rocks – Sand stone, Ferrugineous sand stone, Lime stone, Shale, Laterite, Conglamorate, etc…
7. Megascopic description and identification of Metamorphic rocks – Biotite – Granite Gneiss, Slate, Muscovite &Biotiteschist, Marble, Khondalite, etc…
8. Interpretation and drawing of sections for geological maps showing tilted beds
9. Interpretation and drawing of sections for geological maps showing faults,
10. Interpretation and drawing of sections for geological maps showing unconformities etc.
11. Simple Structural Geology problems.
12. Strength of the rock using laboratory tests.

List with Additional Experiments

1. Physical properties of minerals: Mega-scopic identification of Rock forming minerals – Quartz group, Feldspar group,
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8. a) Interpretation and drawing of sections for geological maps showing tilted beds

   b) Interpretation and drawing of sections for geological maps showing geological beds
9. Interpretation and drawing of sections for geological maps showing faults,
10. Interpretation and drawing of sections for geological maps showing unconformities etc.
11. Simple Structural Geology problem.

a) Problem on True thickness

b) Problem on Vertical thickness.

12. Strength of the rock using laboratory tests.

MINERALOGY

MINERALOGY

Define Minerals

A mineral is a **naturally-occurring**, **homogeneous**, **solid** with a definite, but generally not fixed, **chemical composition** and an **ordered atomic arrangement**. It is usually formed by in organic processes.

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.

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Forms and Habits

Lamellar Form

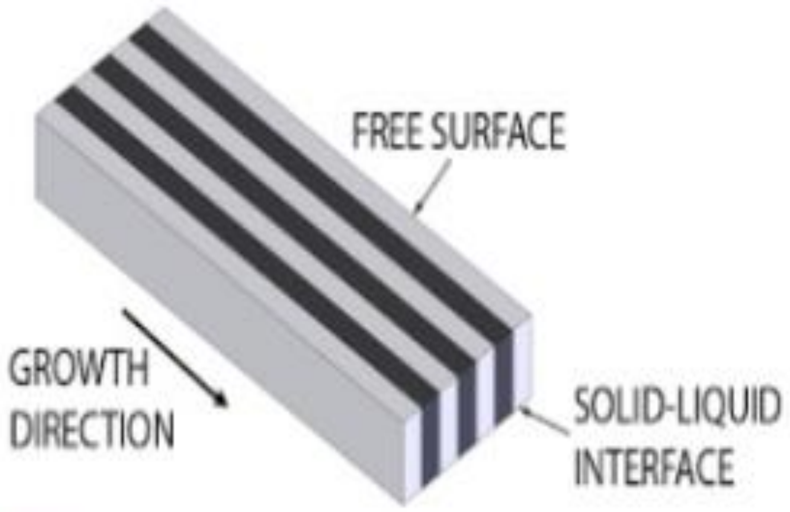
Mica

Minerals appears as Thin separable Layer

MINERALOGY

Forms and Habits

Tabular Form



Feldspar

Minerals appears as slab of uniform Thickness

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Forms and Habits

Fibrous Form

Asbestos

Minerals appears to be made of Thin Thread

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Forms and Habits

Pisolitic Form

Bauxite

Minerals appears to be made of small spherical grain

MINERALOGY

Forms and Habits

Oolitic Form

Lime stone

Minerals appears to be made of still small spherical grain

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Forms and Habits

Rhombic Form

Calcite

Minerals appears to be made of Rhombic Shape

MINERALOGY

Forms and Habits

Granular Form

Magnetite, Chromite

Minerals appears to be made of innumerable equidimensional grain of coarse or medium of grain

MINERALOGY

Forms and Habits

Bladed Form

Kyanite

Minerals appears as a cluster or independent lath shaped grains

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Forms and Habits

Botryoidal Form

Hematite, Chalcedony

Minerals appears as made up of smaller curved faces like bunch of grapes.

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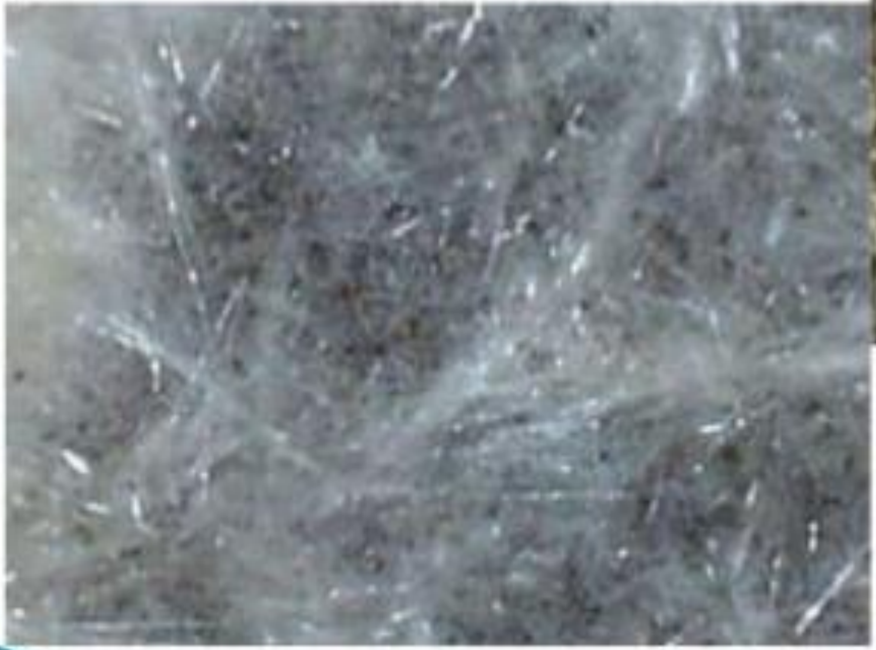
Forms and Habits

Acicular Form



Natrolite , Actinolite

Minerals appears as made up of thin needles.

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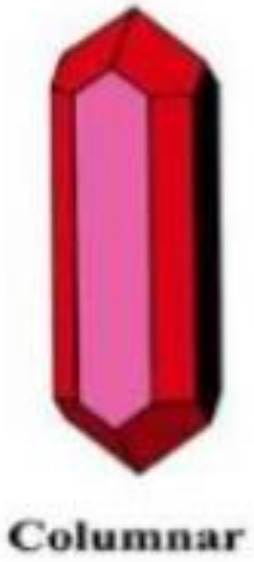
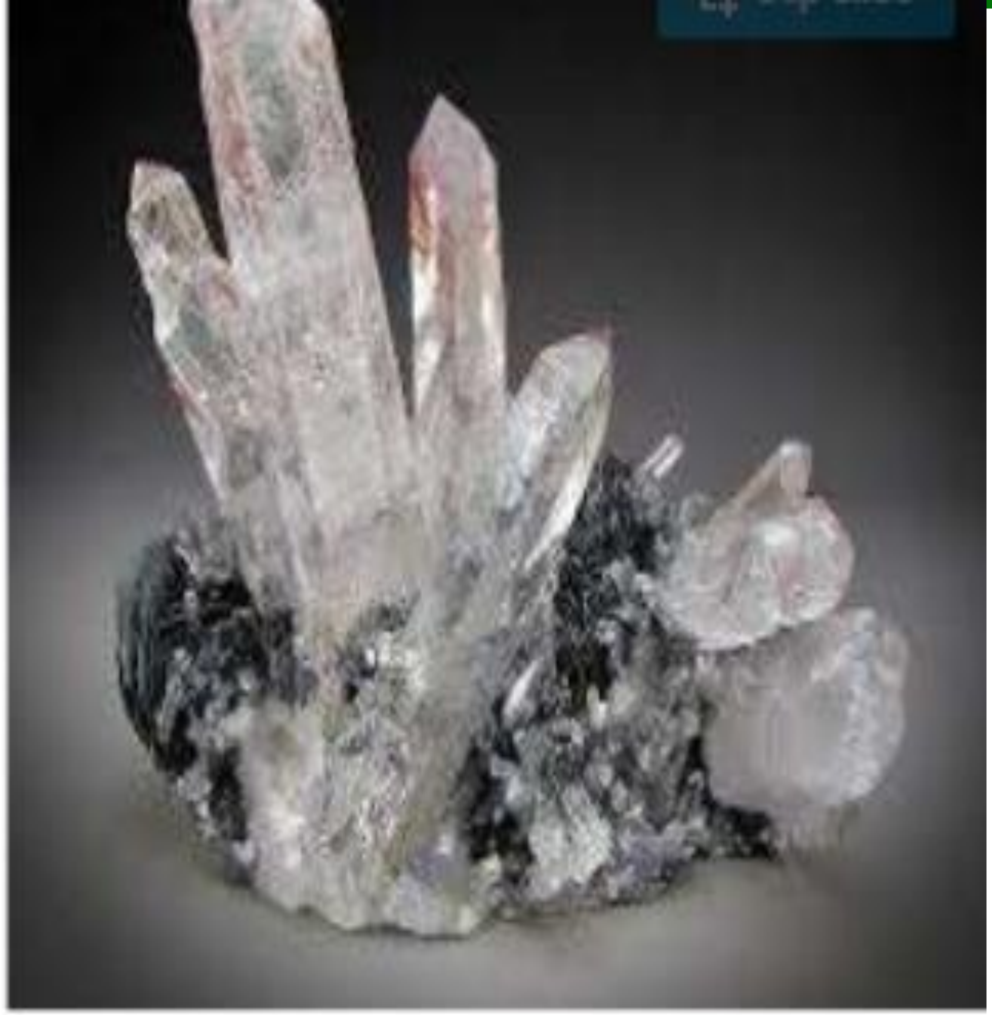
Forms and Habits

Columnar Form





Quartz, Apatite

Minerals appears as Long slender prism.

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Forms and Habits

Prismatic Form

Quartz, Apatite

Minerals appears as elongated independent crystals.

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Forms and Habits

Spongy Form

Pyrolusite, Bauxite, pumice

Minerals appears as porous

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Forms and Habits

Crystal Form

Quartz, Amethyst, Pyrite, Galena

Minerals appears as Polyhedral Geometrical shapes

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Forms and Habits

Massive Form

Graphite, Olivine, Jasper

No Definite shape for minerals

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Forms and Habits

Nodular Form

Flint, Lime stone

Irregular shaped compacted body
With curved surface

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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]

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Colour

Graphite
Shining Black

Hematite
Dark steel Gray

Amethyst
Violet

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Colour

Calcite
White

Jasper
Red

Olivine
Olive Green

Colour

Quartz
Colour less or White

Asbestos
White, less commonly green, Yellow, gray

Pyrolusite
Dark gray, nearly black

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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

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Colour

Determined by the atomic structure of the mineral

<u>Atomic structure controls which components of white light are absorbed or reflected</u>

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

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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

Colour

Examples of colour variation in Fluorite

Colour

All these minerals are grey or white in colour

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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.

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Streak

Haematite gives a cherry red streak

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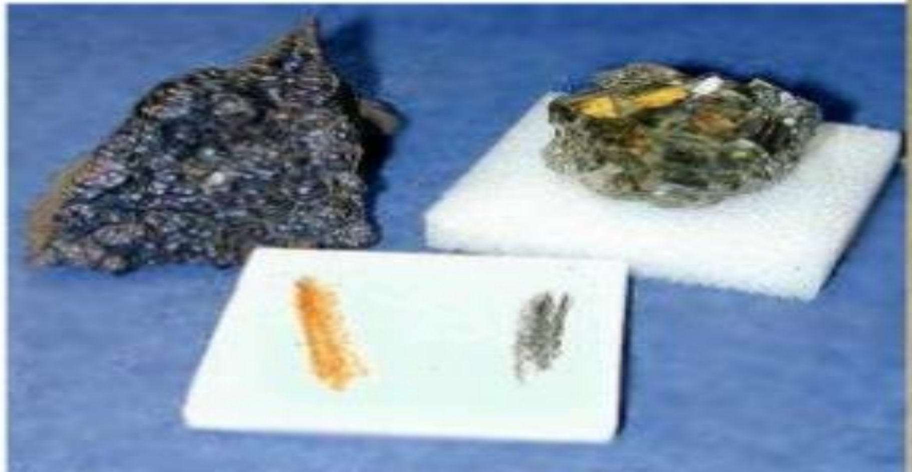
Streak



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Streak

Streak [Streak...can help identify quartz]

BUT

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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.

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LUSTRE

Metalic Lustre

Gelena

Gold

Pyrite

It is the type of shining that appears on the surface of metals.

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LUSTRE

Sub Metallic Lustre

Hematite

Magnetite

Chromite

The amount of shining is less compare to metallic lustre.

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LUSTRE

Vitreous Lustre

Quartz

Dolomite

Calcite

The non metallic minerals shining like a glass sheet

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LUSTRE

Pearly Lustre

Muscovite Mica

Gypsum

Talc

The non metallic minerals shining like a Pearls

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LUSTRE

Silky Luster

Asbestos

Satinspar

The non metallic minerals shining like a silk.

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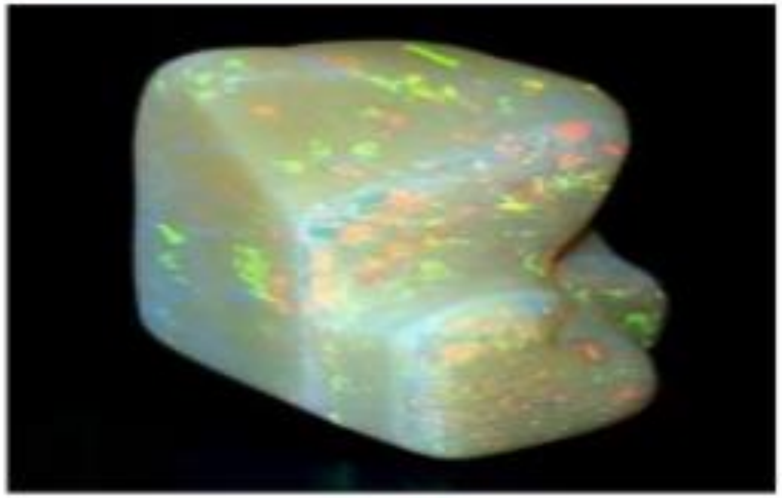
LUSTRE

Resinous Luster



Opal

Chalcedony

The non metallic minerals shining like a Resin.

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LUSTRE

Adamantine Lustre

Adamantine minerals

The non metallic minerals shining like a Diamond.

MINERALOGY

LUSTRE

Earthy or Dull Lustre

Kaolin

Bauxite

Magnesite

The non metallic minerals shining like a Earth or Chalk.

MINERALOGY

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.

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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.

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FRACTURE

<u>Even Fracture</u>

Magnasite

Chalk

The Broken surface of the minerals is plain and smooth.

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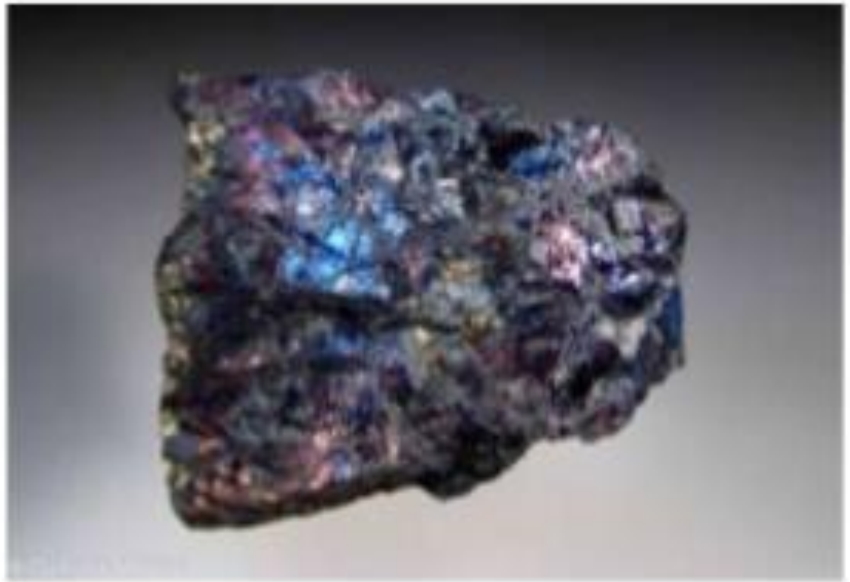
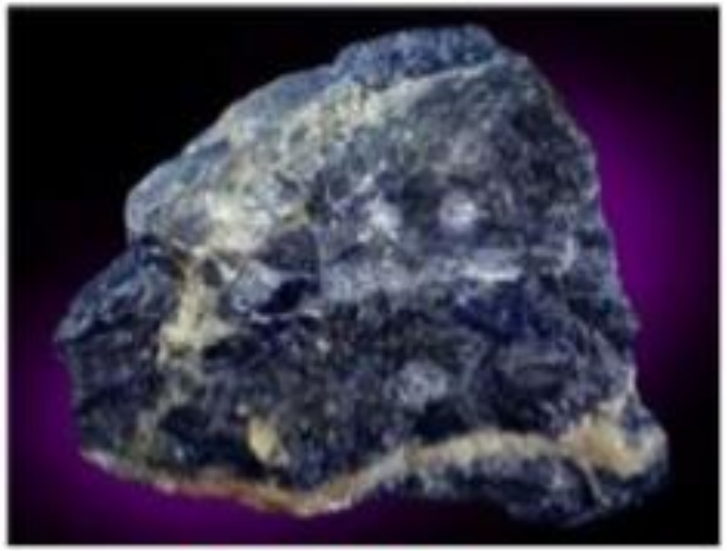
FRACTURE

Uneven Fracture





Sodalite

The Broken surface of the minerals is rough or irregular .

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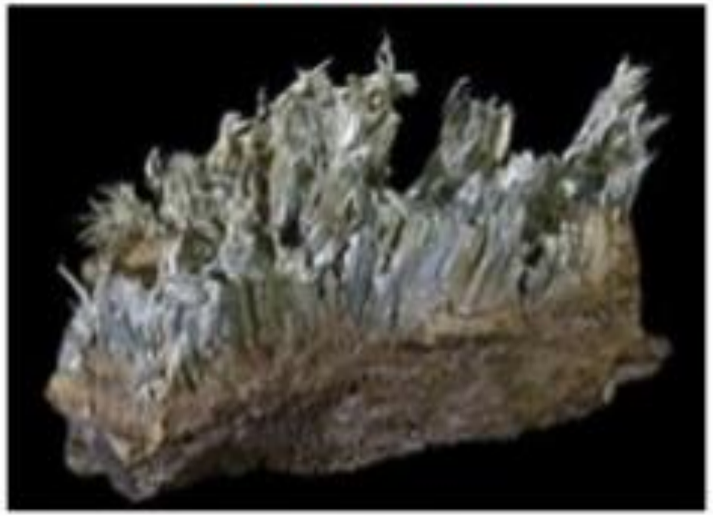
FRACTURE

Hackly Fracture

Kyanite

Asbestos



Tremolite

The Broken surface of the minerals is very irregular like broken stick.

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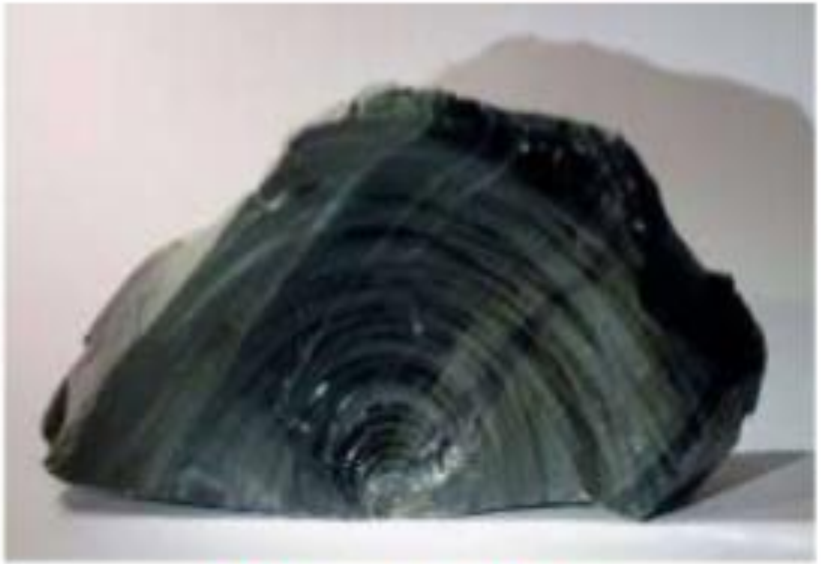
FRACTURE

Opal

Conchoidal Fracture



Volcanic Glass

Volcanic Glass

The Broken surface of the minerals is smooth and curved surface.

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Agate

FRACTURE

Sub Conchoidal Fracture

Flint

Jasper

The Broken surface of the minerals is smooth and curved nature is less predominate.

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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.

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Cleavage

Basal-One direction

Muscovite mica

These minerals can be split into a very thin sheet along horizontal plane

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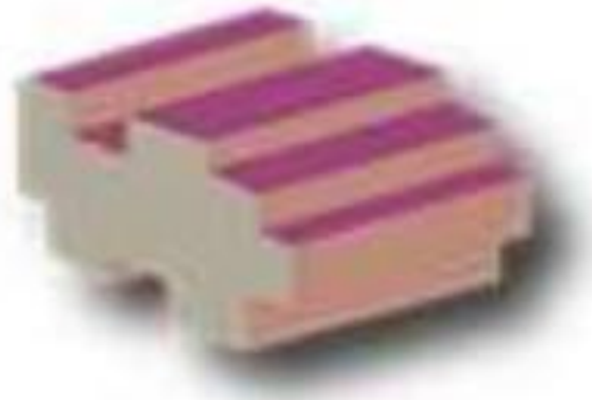
Cleavage

<u>Prismatic-Two direction</u>



Orthoclash

These minerals exhibits two mutually perpendicular sets of cleavage.

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Cleavage

Cubic-Three direction

Halite

These minerals exhibits three mutually perpendicular sets of cleavage.

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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

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.

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Hardness

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

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

MINERALOGY

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.

Specific Gravity (Density)

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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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.

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Degree of Transparency

Transparent

Muscovite Mica

Quartz

MINERALOGY

Degree of Transparency

Translucent

Calcite

Agate

MINERALOGY

Degree of Transparency

Opaque

Calcite

Galena

MINERALOGY

Special Properties

Its very soft (h=1)

It exhibits smooth touch

or soapy feel

Talc

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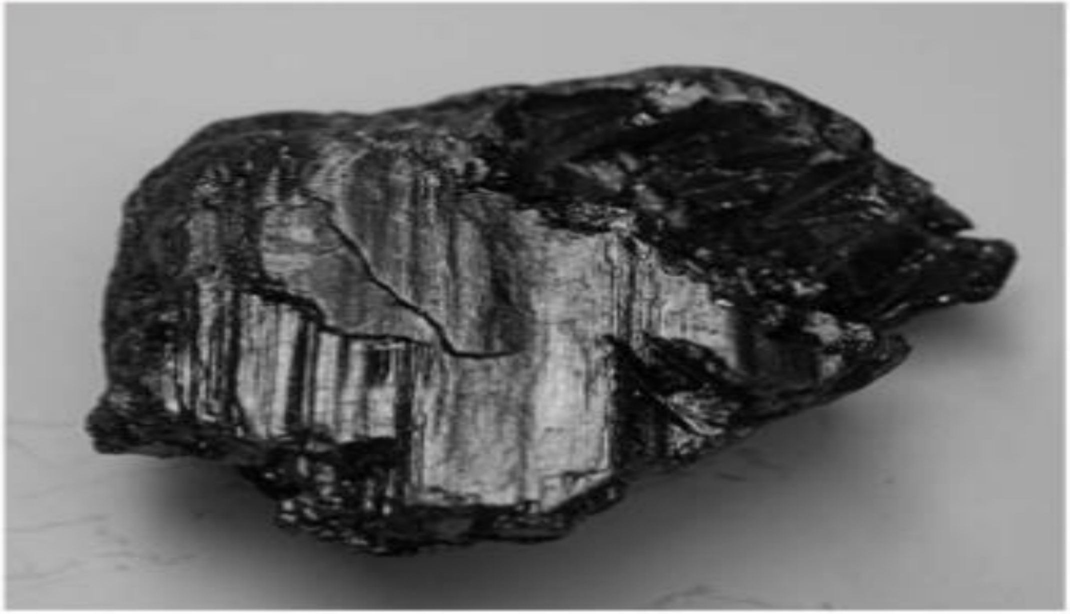
Special Properties

Its low hardness (h=1)

It exhibits black colour

Mark easily on paper.



Graphite

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Special Properties

Its gives garlic smell

When struck or heated

and freshly broken surface

Realgar

Orpiment

MINERALOGY

Special Properties

It strongly attracts by an

Ordinary magnet.

Halite

MINERALOGY

Special Properties

It gives a clayey smell

And adheres strongly to the

Tongue.

Kaolin

MINERALOGY

Special Properties

Halite has a saline taste

Halite

Methods of Study of Minerals

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 invariably 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. For example, any galena mineral irrespective of its place of occurrence, size, shape, association, consistently exhibits lead grey colour, bright metallic shine, opaque character, high density, tendency to break easily along three different directions and is scratched easily by a knife but not by a fingernail. This set of physical properties is never exhibited by any other mineral. Therefore, if such properties are observed in any unknown mineral it must be only galena and no other mineral.

From the civil engineering point of view it is very important to know more about these physical properties by studying different minerals practically.

More details of different physical properties and their importance in identification of minerals are given in later pages of this chapter.

Study of Chemical Composition

According to the definition, every mineral (except in cases of polymorphism, which is explained under Sec. 4.2) 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. For example, if the composition of an unknown mineral is found to be lead sulphide (PbS), then that mineral must be only galena because galena always has the composition of lead sulphide and no other mineral has this composition.

Study of Optical Properties

In this method of study, the minerals are ground very fine (standard thickness is 0.03 mm) and fixed over glass slides by means of Canada balsam. 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 microscope 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 pleochroism, are studied under polarized light. Interference colours, their order, interference figures, optic sign, twinning, extinction, alteration, etc., are studied under crossed nicols, with the help of some other accessories, if necessary.

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. For example, the set of optical properties distinctive of quartz (which are not found as a whole in any other mineral) are: anhedral shape, clear, colourless, no cleavage, transparent, low relief, non-pleochroic, grey or yellow interference colours of the first order, positive uniaxial interference figure, positive elongation, straight extinction, no alteration, etc.

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 wavelength, comparable to the distances between atoms in a crystalline mineral. When a beam of x-rays falls on a crystal (i.e., crystalline mineral), it is diffracted by the layers of atoms within the crystal (just as ordinary light waves are diffracted by an optical grating). 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.

Advantages and Disadvantages By Study of Minerals by Physical Properities

Lastly, coming to the method of study of minerals by physical *properties, it is the most suitable* for the following reasons:

1. The unique advantage is that it makes possible the study of minerals or rocks in the field itself.
2. It does not require any equipment worth mentioning.
3. It does not involve the use of chemicals and it does not need additional facilities.
4. It involves no loss or wastage of material (as it happens in the case of other methods). This enables the mineral to be studied, any number of times.
5. It is the quickest method of identifying the minerals, because with the help of previous knowledge it requires very little time for identification. But in other methods immediate inference is not possible for obvious reasons.
6. It is the cheapest, simplest and least tedious (unlike the other methods of study) method for identification of minerals, i.e., money, energy and time are spent to the minimum extent.

However, the disadvantages in this method are:

1. In some cases even slight variation in chemical composition (due to the presence of trace elements) results in considerable change in colour.
2. Weathering, the universal phenomenon, alters many physical properties significantly and makes identification difficult. Therefore only fresh minerals are easily identified in this way.
3. Further, some minerals when formed under different conditions show slight variations in physical properties.

Physical Properties of Minerals

Table 4.5(a) Physical properties of some common minerals

S. No.	Name of Mineral Species with Composition and Crystal System	Form	Colour	Lustre	Fracture	Cleavage	Hardness	Density (specific gravity)	Degree of Transparency	Special Properties	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1.	**Feldspar** Aluminum silicate of K/Na/Ca; mono- or triclinic	Tabular	White/pale colour	Vitreous	Even to uneven	2 sets, at right angles	6	Medium (25-3.0)	Translucent along thin edges		Most abundant rock-forming mineral
2.	**Quartz** SiO_2, hexagonal	Massive (sometimes as crystals)	Generally colourless or white or any other colour	Vitreous	Uneven to conchoidal	Absent	7	Medium (2.65)	Transparent to translucent	Horizontal striations on prismatic faces of crystals	1. Most resistant to weathering 2. Amethyst is purple or violet in colour 3. Rockcrystal is colourless & transparent
3.	**Agate** SiO_2, cryptocrystalline	Massive (with sharp, parallel colour bands)	Shades of same colour or different colours	Resinous	Conchoidal	Absent	Nearly 7	Medium	Translucent along thin edges	Common as amygdale	Semi-precious mineral
4.	**Jasper** SiO_2, cryptocrystalline	Massive	Red colour common	Resinous	Conchoidal	Absent	Nearly 7	Medium (2.57-2.65)	Nearly opaque		Common as pebbles in conglomerates
5.	**Opal** SiO_2, nH_2O amorphous	Massive or concretionary	Generally milky white	Resinous	Conchoidal	Absent	5-6	Low (2.0-2.2)	Translucent or nearly opaque		Precious mineral
6.	**Augite** Complex silicate, monoclinic	Massive	Black	Vitreous to subvitreous	Uneven	2 sets, prismatic, not perfect	5-6	Medium (3.2-3.5)	Nearly opaque		Most common type of pyroxene
7.	**Hornblende** Complex silicate, monoclinic	Granular or prismatic aggregate	Dark greenish black	Vitreous to subvitreous	Uneven	2 sets, prismatic	5-6	Medium (3.0-3.5)	Nearly opaque		Most common type of amphibole

(Contd.)

(Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
8.	**Asbestos** Complex silicate, monoclinic	Fibrous	White/pale coloured	Silky	Uneven to hackly	Present		Medium	Thin fibres are translucent		Chrysotile is spinning variety
9.	**Muscovite** Complex silicate, monoclinic	Lamellar	Silvery white, colourless in thin layers	Pearly	Uneven to hackly	1 set, basal excellent	2-3	Medium (2.7-3.0)	Thin layers are completely transparent	Cleavage is excellent	A very valuable variety of mica
10.	**Biotite** Complex silicate, monoclinic	Lamellar or flaky	Dark greenish black or black	Pearly	Uneven to hackly	1 set perfect	2-3	Medium (2.7-3.0)	Only very thin layers are translucent		Common rock-forming mica
11.	**Olivine** $(Mg, Fe)_2SiO_4$, orthorhombic	Massive	Olive green	Dull	Uneven	Absent	6-7	Medium (3.2-3.5)	Nearly opaque	Olive green colour	Common unsaturated mineral
12.	**Almandine garnet** $Fe_3Al_2(SiO_4)_3$ cubic	Massive or as crystals of dodecahedron or trapezohedron	Red	Vitreous to resinous or adamantine	Uneven to subconchoidal	Absent	6.5-7.5	Medium	Translucent along thin edges	Crystal form is very common	Most common type of garnet
13.	**Kyanite** Al_2SiO_5, triclinic	Bladed, radiating fibrous	Blue with dark patches	Vitreous to subvitreous	Uneven	Present, 2 sets	Along length (4-5); along width (5.5-6.5)	Medium (3.6)	Translucent along thin edges	Bladed form	A common refractory mineral
14.	**Calcite** $CaCO_3$, hexagonal	Rhombic form	Colourless, white/pale colour	Vitreous	Rarely found	3 sets, well developed, cleavage angle = 105°	3	Medium (2.7)	Transparent to translucent	Reacts with acid vigorously	Very common rock-forming carbonate mineral
15.	**Dolomite** $CaMg(CO_3)_2$, hexagonal	Rhombic form, massive, etc.,	Grey or any other pale colour	Vitreous	Uneven to subconchoidal	Present, 3 sets	3-4	Medium (2.8)	Translucent along thin edges	Less vigorous, reaction with acid	*It is a refractory mineral*

16.	*Talc* $Mg_3Si_4O_{10}(OH)_2$, Monoclinic	Foliated or massive	White, pale yellow, pale green, etc.	Pearly	Uneven	Present, 1 set	1	Medium (2.7)	Translucent along thin edges	Soapy feel	Very valuable non-metallic economic mineral
17.	**Chlorite** $(Mg,Fe)_5$ $Al(Al,Si)_3O_{10}(OH)_8$ monoclinic	Foliated	Green	Pearly	Uneven	Present	1.5-2.5	Medium (2.6-2.9)	Nearly opaque	Green colour	
18.	**Bauxite** $Al_2O_3.2H_2O$, amorphous	Pisolitic spongy or massive	Dirty white with patches of different colours	Dull	Uneven	Absent	Nearly 4 (variable)	Medium (2.0-3.5)	Opaque	Pisolitic form	Only ore of aluminium
19.	**Beryl** $Be_3Al_2(SiO_3)_6$, hexagonal	Hexagonal prisms	Pale green or pale blue	Vitreous to sub-vitreous	Uneven	1 set, basal, very poor	7-8	Medium (2.7)	Translucent along thin edges	Hexagonal prismatic crystals are very common	Emerald is green gem variety
20.	**Apatite** $Ca_5(F,Cl\ PO_4)_3$, hexagonal	Hexagonal prism	Palegreen/ or pale blue	Vitreous to sub-vitreous	Uneven	1 set, basal, very poor	5	Medium (3.2)	Translucent along thin edges	Hexagonal prisms common	1. Resembles with beryl 2. Important phosphate mineral
21.	**Magnesite** $Mg\ CO_3$, hexagonal	Massive	White	Dull	Even to uneven sub-con-choidal	Absent	4-5	Medium (3.0-3.2)	Opaque	White colour, even fracture	A refractory mineral
22.	**Graphite, C** hexagonal	Massive, granular	Black	Shining greasy	Uneven	Present, not distinct	1-2	Low (2.0-2.3)	Opaque	Marks paper	Used in pencils
23.	**Pyrolusite** MnO_2, orthorhombic ?	Massive, spongy	Dark brow-nish black	Dull	Uneven	Indistinct	Variable	High, 4.5-5.0	Opaque	Soils the fingers	Important manganese ore mineral
24.	**Magnetite** Fe_3O_4, cubic	Granular	Black	Metallic to sub-metallic	Uneven	Absent	5-6	High (5.2)	Opaque	Strongly magnetic	

(Contd.)

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
25.	**Hematite** Fe_2O_3, hexagonal	Massive	Steel grey	Metallic to sub-metallic	Uneven	Absent	5-6	High (5.2)	Opaque	Steel grey colour, cherry red streak	Most common ore of iron
26.	**Galena** PbS, cubic	Cubic or rectangular blocks or granular	Lead grey	Splendent,	Rarely found	Perfect 3 sets, cubic	2-3	High (7.5)	Opaque	Marks paper sometimes	Only important ore of lead
27.	**Pyrite** FeS_2, cubic	Cubic, granular	Brass yellow	Shining, metallic	Uneven	3 sets, cubic	6-7	High (5.0)	Opaque	Brass yellow colour with a greenish black streak	Undesirable rock forming mineral
28.	**Chromite** $FeCr_2O_4$, cubic	Granular	Black	Sub-metallic	Uneven	Absent	5-6	High (4.5-5.0)	Opaque	Black colourwith a brown streak	Only ore of chromium
29.	**Chalcopyrite** $CuFeS_2$ tetragonal	Massive	Golden yellow	Metallic	Uneven	Indistinct	3-4	High (4.2)	Opaque	Golden yellow colour with a greenish black streak	Common ore of copper
30.	**Malachite** $CuCO_3$, $Cu(OH)_2$, monoclinic	Massive, botryoidal, fibrous, encrusting	Green	Often silky or dull	Conchoidal	Indistinct	3-4	High (4.0)	Nearly opaque		Common ore of copper