Module -1

Introduction:

Geology is a Branch of Natural science deals with the study of the Earth, It is also known as Earth science. For studying the Earth in detail the subject of geology has been divided into various branches, which are as follows:

1. Mineralogy
2. Petrology
3. Structural geology
4. Civil Engineering geology
5. Mining geology
6. Economic geology
7. Stratigraphy
8. Photo geology
9. Physical geology
10. Hydrology etc.

Application of Earth Science in Civil Engineering Practices

1. **Mapping:** The engineering geologist has to prepare a geological map of the area based on aerial photo and satellite imagery interpretation and field observation. Subsurface geological features are also mapped.

2. **Exploration**: In this stage the engineering geologist explore the area based on exploration techniques. The engineering geologist works from the planning stage. Supervise the exploration works and records the data for further interpretation.

3. **Project Planning**: Project planning is the most important aspect in civil engineering. The civil engineer plans the various stages. The engineering geologists plans and prepares geologic feasibility and developmental parameters reports, which are useful to the civil engineer for planning the project schedule.

4. **Surface water**: The engineering geologist and the civil engineer together prepare surface –water mapping. Both study the volume of total runoff, drainage basin characteristics and sedimentary process in the basin. Weathered areas, silting potential and erosion potential are also estimated before planning any hydraulic structure in the basin.

5. **Groundwater**: Groundwater is the major problem in the majority of civil engineering works. The engineering geologist studies in detail the occurrence, movement, structural controls and hydro geological properties of the rocks. Hydro geological maps are prepared for civil engineering purposes.

6. **Slope Stability**: Geological parameters of possible slide regions are studies

7. **Geological Structures**: Field investigation is carried out for selection of a suitable area. Detailed surface-subsurface studies are conducted and surface and subsurface maps are

prepared. The engineering geologist and the civil engineer conduct in-situ tests for foundation materials, supervise the construction methods and monitor the structure after completion of the work.

8. **Tunneling**: The tunnel site selected is based on a detailed study of the region. The civil engineer and the geologist have to conduct in-situ tests for estimation of weathered zone thickness, depth of hard rock, structural features etc.

9. **Earthquake**: The engineering geologist studies the seismic nature of the project site. He examines the seismic zoning map of the country, evaluates active and inactive faults and keeps the historical record of the earthquake of the region in which the civil engineer will prepare a seismic design of structure.

Geological features of the civil engineering have to be studied a detail before execution of the work. The engineering geologist must work from the exploration stage to the end of the project.

INTERNAL STRUCTURE OF EARTH

Our Earth is a cosmic body. It is one of the nine members of he Solar system of which Sun is the central star. The nine planets constituting the Solar system has been named as Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. In its shape, he Earth is commonly described as a spheroid, it has an equatorial diameter of 12,757.776km and a polar diameter of 12,713.824km and thus has an equatorial bulge.

At present the Earth is the only planet believed to be sustaining life other planets have shown no signs of life on them. For systematic scientific investigations, the earth is commonly differentiated into three parts; they are atmosphere, lithosphere and hydrosphere. Each forms an extensive field of study, volumes of information have been collected about each of these parts during last hundred years or so but findings of last three decades have made our understanding about these parts very clear. Only most important characteristics of these parts have been summarized below.

ATMOSPHERE

The outer gaseous part of earth starting from the surface and extending as far as 700km and beyond is termed atmosphere. Although extending for such great distances, the atmosphere makes only one-millionth part of the mass of earth; this is because of its gaseous composition. It is now fairly established that the atmosphere possesses a layered structure. Their well-defined layers or zones of the atmosphere are surface upward, troposphere, stratosphere and ionosphere.

LITHOSPHERE

It is the solid part of the earth and in a broader sense includes all the solid materials composing the earth from surface downwards, although sometimes-specific terms are used for deeper earth

zones. Recent detailed seismic studies of the body of the earth have shown that it is composed of three well-defined shells, Crust, Mantle, Core.

The Crust: - Is the topmost shell of the earth, which has a thickness of 30-40 km in the continents and 5-6 km in the oceans. There is a striking variation in the materials or rocks, as they are called, composing the crust over the continents and ocean floors. The oceanic crust is made up of heavier and darker rocks called basalts compared to lightcolored and light-density, granitic rocks of the continental crust. When considered as a part of the total structure of the earth, crust makes only an insignificant part represented by a thin layer, similar to the skin of an apple. As regards he chemical composition of the crust, analyses made by Clarke and Gold Schmith, using rocks from different geographic regions of the crust have all shown that when expressed in terms of oxides, the crust has Silica as the most dominant component, its value lying above 50% by volume in the oceanic crust and above 62% in the continental crust. Alumina is the next important oxide, varying between 13-16% followed by Iron Oxides (8%), Lime (6%), Sodium (4%), Magnesium (4%), Potassium (2.5%) & Titanium (2%). The crust itself shows a complicated structure both in make-up and compositional variations.

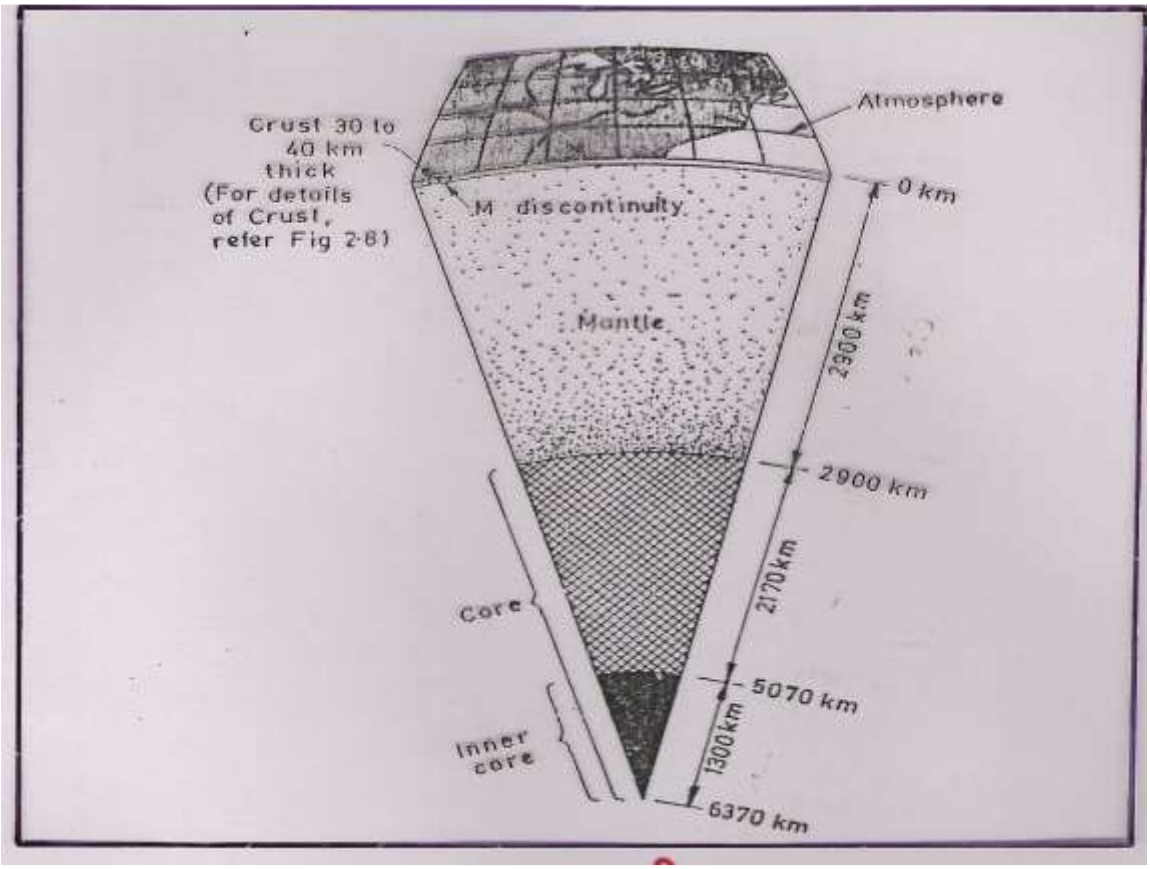


Figure 1.0 INTERNAL STRUCTURE OF EARTH

The Mantle: - At the base of the crust materials of the earth become greatly different in many properties from those overlying them in the crust. These materials appear to form a nearly

homogeneous zone till a depth of 2900 km is reached. This zone of materials lying between crust and a depth of 2900 km is known a MANTLE. It is made up of extremely basic materials, called ultra-basic rocks, which are believed to be very rich in iron and magnesium

but quite poor in silica. Such rock names as Periodotites, Dunite. This One is characterized with a high density, increasing steadily with depth further; the mantle material is believed to be highly plastic in nature. Many of the most important geological process such as earthquakes and formation of mountains are believed to have their origin in this zone.

The Core: - It is the third and the innermost structure shell of the earth, which is clearly marked by the seismic evidence. It starts at a depth of 2900 km below the surface and extends right up to the center of the earth at 6370 km. The material making g the core is found to be from seismic studies only strikingly different from that making the other two shells in one major aspect, in elastic properties. The material has no shear resistance, which makes it nearer to liquid than to a solid body. It has a very high density, above 10gms/cubic centimeter, at the mantle –core boundary. Nothing can be said about the composition of the core. According to one, widely favored view, the core is made up of Iron and Nickel alloy material.

MINERALOGY

Minerals have been defined as naturally occurring substances, mostly inorganic, that are characterized by a definite chemical composition and a definite atomic structure. Since rocks which make up the earth are simply natural aggregates of minerals, a study of minerals is of fundamental importance understands the elements of science of geology. The branch of geology dealing with the study of minerals is designated as Mineralogy. Each mineral is generally characterized with a set of qualities some of which are always distinctive and differentiate it from other minerals. Some of these qualities or properties may be studied from the body of the minerals, its shape, color, shine, hardness etc.; these are termed physical properties. Some other qualities like the behavior towards light require extremely thin sheets or sections of the minerals and are best studied with the help of a microscope. These are termed optical or microscopic properties. A third group of properties involving. These are the physical properties most useful for mineral identification:

HABIT

A mineral may sometimes show a definite and characteristic arrangement in its outer appearance or physical shape. This shape is expressed by the term Habit and is typical in the case of many minerals. A few common habits with examples are given below. Fibrous habit: -When the mineral is made up of fibers, generally separable, e.g. in Asbestos.

Columnar habit: - When the mineral is composed of thin or thick columns, sometimes flattened, e.g. in Hornblende.

Bladed habit: - The minerals appears as if composed of thin, blade like structure, e.g. in Kyanite.

Lamellar habit: - The plates or leaves are separable, e.g. Vermiculite.

Granular habit: - The mineral shows numerous grains packed together, e.g. in Chromite.

Acicular habit: - When a mineral surface is covered by large, conspicuous, overlapping prominences, e.g. in Malachite.

Mammillary habit: - When a mineral surface is covered by large, conspicuous, overlapping prominences, e.g. in Malachite.

Reniform habit: - The rounded prominences exhibit a resemblance to a kidney shape, e.g. in Hematite.

Foliated habit: - When the mineral consists of thin and separable leaves, e.g. in Mica.

Radiating habit: - When the fibers or needles are arranged around a central point, e.g. in Iron Pyrites.

Tabular habit: - The mineral is flat thatn elongated e.g. in Calcite, Orthoclase.

Globular habit: - Or Botryoidally, when the minerals is in the form of bulbous overlapping projections, e.g. in Hematite

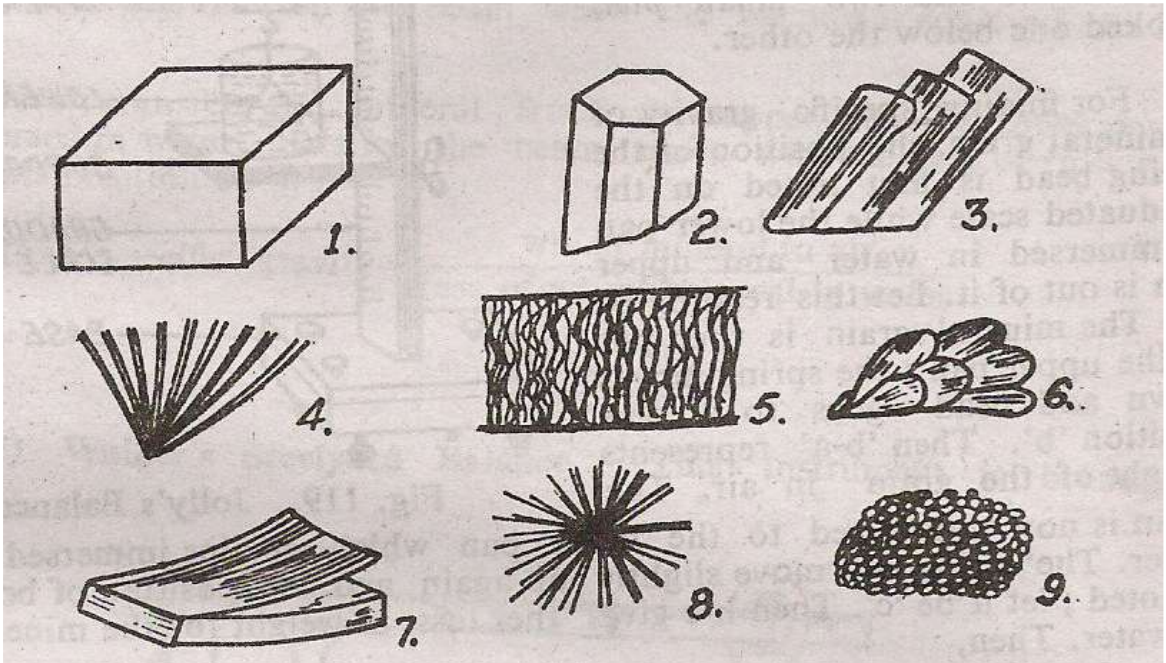


Fig. 118. Some Common Structures in Minerals
1. Tabular 2. Columnar 3. Bladed 4. Acicular
5. Fibrous 6. Reniform 7. Foliated 8. Radiating
9. Granular.

COLOUR

Minerals show great variety of colors. The color of a substance is its appearance in light and depends upon the composition and structure of the substance is its appearance in light and depends upon the composition and structure of the substance. In minerals, colors may be either

of inherent of of an exotic nature; the former is related to the chemical composition and is more diagnostic whereas exotic colors are due to small traces of impurities and may vary within wide limits. Metallic minerals commonly show greater consistency in colors than

the non-metallic minerals. Some minerals show peculiar phenomena connected with color. Of these, the following are interesting and important.

Play of Colors: - It is the development of a series of prismatic colours shown by some minerals on turning about in light. The colors change in rapid succession on rotation, example: Diamond.

Change of Colors: - It is similar to play of colors except that rate of change of colors on rotation is rather slow; each color continues over a larger space in the mineral, ex: - Labradorite.

Iridescence: - Some minerals show rainbow colors either in their interior or on their surface. This termed iridescence.

Tarnish: - Sometimes the surface color is different, rather dull, than the color of the mineral as seen on freshly fractured surface; ex: Chalcopyrite, an ore of copper. Although color is never taken as a conclusive property in the identification of minerals, it is invariably studied first and is generally helpful.

STREAK

The streak of a mineral is the color of its powder. This becomes important in the sense that for some minerals, the color is entirely different from that of their powder. This has been found true in certain or minerals, while most of the other minerals exhibit a white streak: and, streak does not help in distinguishing those minerals. The important minerals offering characteristic color-streak combinations are given in table.

Some minerals with their characteristic color-streak combinations

MINERAL NAME	ORIGINAL COLOR	STREAK COLOR
PYRITE	Brass-Yellow	Greenish Black
CHROMITE	Greenish-Black	Greenish Brown
HEMATIE	Black	Cherry-red

The streak of mineral can be readily observed by scratching it on a streak plate, which is made up of unglazed porcelain or roughened glass. While determining streak for a mineral, care should be taken to scratch it from its obscure part, and to give only a small scratch, producing a small quantity of its powder.

LUSTER

The Shining / Brilliance / Reflection of light from the surface of mineral. The luster of minerals varies with the nature of their surface smooth / rough and the quantity of light reflected. The luster of mineral can be divided into two groups.

i)Metallic. ii)Non-metallic.

DIAPHENEITY:

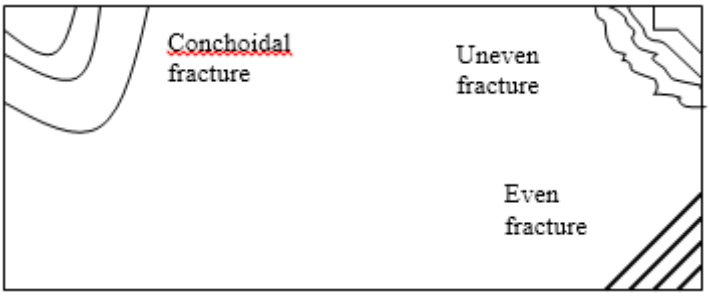
Diaphaneity is the ability of the mineral to transmit light through it. The following terms are used to describe the varying degree of transmission of light.

Descriptive Terminology:

Sl. No.	Terminology	Explanation with mineral Example
1.	Transparent	When the outline of the objects viewed through the mineral. Ex.: Rock crystal, Selenite etc.
2.	Sub Transparent	When the object are seen physically. Ex.: Calcite, Fluorite etc.
3.	Translucent	When only the thin edges of the mineral transmit light. Ex.: Agate, Chalcedony, Feldspar.
4.	Opaque	When no light is transmitted even on thin sections or edges. Ex.: Ore minerals.

FRACTURE:

The fracture is the nature of the broken surface of mineral. The breakage of a mineral in a direction other than that of cleavages. Fracture is described according to the breakage pattern, i.e. the appearance of the broken surface.



(i) Even fracture-Appearance of a mineral in its broken surface is Smooth.

Mineral examples: Chert, Mica.

(ii) Uneven fracture- when the mineral breaks with very rough and coarse surfaces.

Mineral examples: Chromite and various other minerals.

(iii) Conchoidal fracture- when a mineral breaks with curved Surfaces or concentric Rings or half moon shape.

Mineral example: Quartz

Hardness: The hardness of a mineral is the resistance it offers to abrasion, which is determined by observing the comparative ease or difficulty in scratching it with another mineral of known hardness. It is always expressed by Moh's Scale of Hardness given below-

Table-1.1 **Moh's Scale Of Hardness**

Standard Mineral and its composition	**Hardness scale**	**Remarks**
Talc $Mg_3 (Si_4O_{10}) (OH)_2$	1	Can be scratched by a fingernail
Gypsum $CaSO_4$	2	Can be scratched by a fingernail
Calcite $CaCO_3$	3	Can be scratched by a copper coin
Fluorite CaF_2	4	Can be scratched by a iron nail
Apatite $Ca_3 (F, CL, OH) (PO_4)$	5	Can be scratched by window glass
Orthoclase $KALSI_3O_8$	6	Steel pocket knife
Quartz SiO_2	7	Pen knife
Topaz $Al_2 (SiO_4) (SOH)_2$	8	Can be scratched by a Pen knife
Corundum Al_2O_3	9	Can be scratched by a Pen knife
Diamond C	10	Cannot be scratched by a Pen knife

A mineral with lowest hardness is talc and the mineral with the maximum hardness is Diamond. It has been observed that a soft mineral like Talc and Gypsum can be scratched with a Fingernail. A steel knife can cut Apatite and Orthoclase but not Quartz. The average hardness of a normal fingernail may be up to 2.5 whereas the hardness of penknife is 6.5

SPECIFIC GRAVITY

It is defined as the ratio of its weight to the weight of an equal volume of water. Strictly speaking, the weight of water should be taken at 4o C, as the temperature variations bring a slight change in the weight of after of a certain fixed volume. In fact, the specific gravity of a mineral depends upon the weight and spacing of its atoms. A mineral possessing heavier and closely spaced atoms will have a high specific gravity: whereas, a mineral possessing lighter and widely-spaced atoms will have a low specific gravity. The specific gravity of the mineral is thus, in fact a representation of its atomic structures. All minerals have been found to possess a specific gravity varying between 1 to 20: but most of them do have specific gravities varying between 2 to 7.

MISCELLANEOUS

Besides the above properties, minerals may show some specific and rare qualities that often become helpful in their identification. Some of these special properties are explained below:

Magnetism: - Some minerals have natural magnetism in them to an Appreciable Extent. Example is magnetite.

Electricity: - In some minerals heating may develop an electric charge. These are called pyro electric minerals. Examples quartz.

Fluorescence: - A few minerals have the property of glowing or emitting light when they are exposed to radiation. This property is called Fluorescence and mineral fluorite shows this Property.

Fusibility: - Minerals behave differently on heating to elevated temperature. Some Melt easily at lower temperatures whereas other require very high Temperature.

CLASSIFICATION OF MINERALS

A) Silicate minerals Rock forming minerals	1) Quartz group
	2) Feldspar group
	3) Mica group
	4) Amphibole group
	5) Garnet group
B) Non-silicate minerals Rock forming minerals	6) Carbonate group Calcite, Dolomite, Magnesite.
C) Non-silicate minerals Ore forming minerals	7) Sulphide group **Galena, Pyrite, Chalcopyrite.** 8) Oxide group Hematite, Magnetite, Bauxite, Corundum. 9) Sulphate group Gypsum, Barytes.

DESCRIPTION OF MINERALS:

1 Quartz Group

Form - Granular
Colour - (varieties of quartz)
Streak - Colourless
Luster - Vitreous
Cleavage – Absent
Fracture – Conchoidal to uneven
Hardness – 7 [High]
Sp. gr. – Low to Medium.
C C - $Si\ 0_2$

Occurrence– widely distributed all over India occurs Beach Sand, River sand.

Uses: (1) Manufacture of glass, porcelain
(2) Flux in metallurgical operation
(3) Agates are used as Ornaments
(4) Amethysts are considered as semiprecious stone
(5) Pure quartz crystal shows piezoelectricity
(6)Quartz plates are used in controlling frequencies in radio circuits,radar,ultrasonic and multiple telephone lines.
(7) Fibre quartz wires are frequently used for transmission of telephone messages. Each minute fibre wire can send large messages.
(8) Quartz is used in refractories
(9) Pure silica is used in ceramics
(10)Pure sand, free from impurities is used in manufacturing Sand paper and Abrasive cloth

Varieties of Quartz:

Crystalline Varieties

a) Rock crystal or colorless quartz [colorless, transparent]
b) Rosy quartz [Rose colour, Translucent.]
c) Milky quartz [Milk colour, translucent]
d) GREY quartz [Grey colour, translucent]
e) Amethyst [Purple or violet colour, translucent]
f) Smoky quartz [Smoky- yellow or smoky-brown colour, translucent]
g) Orange quartz [Orange colour, translucent]
h) Green quartz (Green translucent] colour,)

[2] Cryptocrystalline Varieties

a) Chalcedony [Botryoidal, uniform light colour]
b) Agate [Banded, zebra Agate- zebra colour]
c) Jasper [Blood red colour]
d) Chert [Brick red colour]

[3] Amorphous Varieties

a) Opal,

2. Feldspar Group

Properties	Orthoclase	Plagioclase	Microcline
Colour	Pink	White	Green
Form	Tabular	Massive	Tabular
Streak	Colour less	Colour less Vitreous	Colour less Vitreous
Luster	Vitreous	Vitreous	Vitreous
Cleavage	Present	Present	Present
Hardness	6 (Medium)		
Sp.Gr.	2.6 (Medium)	6 (Medium)	6 (Medium)
Chemical		2.6 (Medium)	2.6 (Medium)
composition:	Potash feldspar		
		Soda feldspar	Potash feldspar
Occurrence	Occurs in acidic igneous rocks – granites and pegmatites		
Uses	Used in the manufacture of Sanitary ware and Earthenware. Feldspars are also used in the manufacturing of porcelain bits. Feldspars are also used in the preparation of various types of glazed tiles		

3. Mica Group

Properties	Biotin Mica (Black Mica)	Muscovite Mica (White Mica)
Form	Foliated	Foliated
Colour	Black	White colour
Streak	Colourless	Colourless
Diaphaneity	Translucent	Transparent
Lustre	Pearly	Pearly
Cleavage	Present	Present
Fracture	Even	Even
Hardness	Medium	Medium
Sp.Gr.	Medium	Medium
Chemical composition-	Silicate of Mg, Fe, Al and K with [OH] ions.	Silicate of Al and K
Occurrence.	Occurs in igneous and metamorphic rocks	Occurs in igneous and metamorphic rocks
Uses	Lightweight concrete	Used as an insulating material in Electrical Apparatus Mica powders are used in mica bricks, steel plants, lubricants, filter in paints, rubber, plastic materials, wall papers, etc

4. Garnet Group

Properties	**Garnet**
Form	Crystalline (Cubical blocks)
Colour	Brown
Streak	Colorless
Lustre	Resinous
Hardness	High (7.5)
Sp.Gr.	3.6 to 4.3 (high)
Chemical composition-	Silicate mineral of Fe, Mn, Cr, etc.
Occurrence	Jaipur – Rajasthan. Kolar – Karnataka.
Uses	Used in the manufacture of sandpaper, good lustrous Garnets are used as Gems.

5. Amphibole Group

Properties	Hornblende	Asbestos
Form	Columnar	Fibrous
Colour	Dark green	White, Grey, green, etc.
Streak	Colorless	Colorless
Diaphaneity	Opaque	Opaque
Lustre	Vitreous	Silky
Cleavage	Present	Present
Fracture	Uneven	Uneven
Hardness	Medium	Medium
Sp.Gr	High	High
Chemical composition-	Complex silicate of Ca, Na, Mg, Fe, Al and (OH) ions.	Hydrous silicate of Mg, Al
Occurrence	Occurs in acidic igneous and Metamorphic rocks	Hassan (Karnataka) Rajas than, TamilNadu, Andhrapradesh and Bihar
Uses	1.Used in the manufacture of cement 2.Rock forming mineral	Extensively used for Insulation, and in the manufacture of Lubricants and paints.

6. KAOLIN (CHINA CLAY)

"Soapy Feel"

Properties	Kaolin
Form	Crystalline
Colour	White
Streak	White
Lustre	Dull
Hardness	2to 2.5 (low)
Sp.Gr.	2.6 [medium]
Chemical composition-	Hydrous silicate of Ca, Na, K, Al
Occurrence	Occurs as an alteration product of granites and gneisses.
Uses	Used in the manufacture of potteries, earthenware, sanitary ware, rubber and paints

7. Carbonate Group

Properties	Calcite	Dolomite	Magnesite
Form	Crystalline	Crystalline	Massive
Color	Pink, white, black, blue	Gray	White
Streak	Colorless	Colorless	White
Lustre	Vitreous	Vitreous	Dull
Hardness	Medium	Medium	Medium
Sp.Gr.	Medium	Medium	Medium
Dil. HCl. test	Bubbles up	No bubbles up	No bubbles up
Chemical composition-	$CaCO_3$	$Ca\ Mg\ (CO_3)_2$	$MgCO_3$
Occurrence	A.p.Gujarath, Rajas than,	Widely distributed all over India	Occurs in ultra basic igneous rocks
Uses	Used in the manufacture of cement, Bleaching powder, Textile, rubber, paint industries, carrier of insecticide, glass and ceramic industries	Used in the manufacture of cement, lime and fertilizers Pure dolomite is a good source of Mg. Refractories, flux in metallurgical Operations, glass industry.	Used for refractory bricks. For furnace lining. In electrical elements.

8. Sulphide Group

Properties	Galena	Pyrite ("Fools Gold")	Chalcopyrite
Form	Crystalline	Radiating	Crystalline
Colour	Lead gray	Brass yellow	Brass yellow
Streak	Lead gray	Black	Black
Lustre	Metallic	Metallic	Metallic
Hardness	Medium (2.5)	Medium (6.0)	Medium (3.5 to 4)
Sp.Gr.	High (7.58)	High (5.02)	High (4.2)
Chemical composition-	PbS	FeS2	CuFeS
Occurrence	Occurs in veins in sedimentary rocks Rajas than, Bihar	Occurs In metamorphic rocks Aimer (Rajasthan) Ingaldhal (Karnataka) Taradevi (Punjab)	Occurs In the metamorphic rocks Rajasthan, Bihar
Uses	Galena is the most important lead ore Containing 66% of lead is found in combined state with zinc. Also used in lead piping	Pyrite is used in the manufacture of Sulphur and Sulphuric acid (H_2SO_4)	Copper ore having 34.5 % of copper.

9. Oxide Group

Properties	Haematite	Magnetite	Bauxite	Corundum
Form	Massive	Massive	Oolitic	Granular
Colour	Red or Brown	Black	Brown	Brown
Streak	Cherry Red	Black	Same as that of Colour	Colourless
Lustre	Metallic	Metallic	Earthy	Vitreous
Hardness	Medium [5.5 to 6.5]	Medium [6.0]	Low to medium (1 to 3)	High (9)
Sp.Gr	High [5.3]	High [5.18]	Medium	High (4.1)
C.C.	Fe_2O_3	Fe_3O_4	$Al_2O_3 N H_2 O$	$Al_2 O_3$
Occurrence	Occurs in sedimentary and Metamorphic rocks. Bihar Orissa Madhya pradesh, Karnataka.	Occurs in sedimentary and metamorphic rocks. Bihar, Orissa Madhya Pradesh, Karnataka.	Occurs as an alteration product of Al rich rocks. Gujarat. Maharashtra, Karnataka	Wide Occurrence metamorphism of shale and limestone.
Uses	Haematite Contain 70 % of Iron. Used in modern industry as an ore of iron.	Magnetite contains 72.4 % of iron. Used in modern industry as an ore of Iron.	Principal uses of Aluminum are in the manufacture of chemicals, Cement and in refining petroleum.	a) A Few of corundum is used as Gemstones. b) Used as an abrasive.