N.B.K.R. INSTITUTE OF SCIENCE & TECHNOLOGY:: VIDYANAGAR

(AUTONOMOUS)

CIVIL ENGINEERING

Academicc Year: 2021-2022

Class-Semester: II.B.TECH-I **Branch: Civil Engineering**

Course Code: 20CE2104 **Course Name: Engineering Geology**

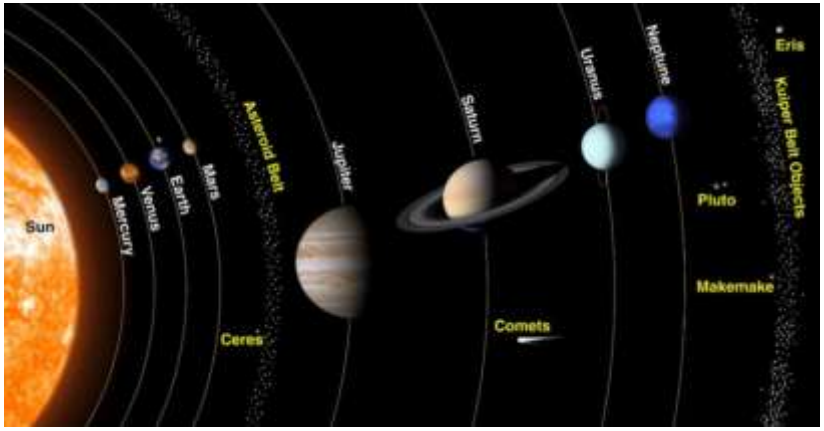
Unit I (Introduction, Branches of geology, scope and importance of geology in civil engineering and Basics of Mineralogy)

Teacher: Dr.U.CHANDRA BHASKARA REDDY

Contents…….

- **Introduction to Geology**
- **Scope of geology in GSI and NIRM**
- **Role of engineering geology in civil engineering**
- **Physical properties of minerals**
- **Physical Identification of minerals**

Unit-I Introduction to Geology



Definition:

The science explain about the Earth in terms of its origin,evolution,morphology,composition,geography etc. is defined as geology.

Geo=Earth and logy =study. So study on the earth is known as geology.

- The word Geology is derived from the Greek "Gea" the earth and "logos" the science, thus it is "Earth Science".

- Geology is the science study of the solid earth ,that examines the earth, its form and composition and the changes has undergone and is going.

- Geology deals with about our physical environment, different geological structures, understanding many processes that operate beneath and upon its surface.

This extensive study of the Earth is subdivided into many branches as main and allied branches.

Main branches of geology:

- ✓Petrology
- ✓Mineralogy and Crystallography
- ✓Physical geology
- ✓Structural Geology
- ✓Stratigraphy
- ✓Sedimentology
- ✓Geological mapping
- ✓Plaeontology

Allied branches of geology:

✓Engineering Geology

✓Geophysics

✓Geochemistry

✓Economic geology

✓Mining&Petroleum geology

✓Hydrogeology

✓Environmental geology

✓Marine geology

✓Remotesensing or photogeology

✓Volcanology etc.

Scope of Geology in GSI

✓Creation and updation of national geoscientific data.

✓Mineral resource assessment,

✓Air-borne and marine surveys,

✓Conducting multifarious geo- technical, geo-environmental studies.

✓Study on natural hazards, glaciology and seismotectonics etc.

✓Geothermal and desert geological studies.

Scope of Geology in NIRM

INFRASTRUCTURE Projects

- Understand the nature of hard rock to design controlled blast to excavate hard rock for the construction of underground station.
- Feasibility study for hard rock excavation.
- Blasting near residential area and sensitive areas.

HYDROELECTRIC PROJECTS

- Rock feasibility Studies.
- Detail Project Report (DPR-Geology) Preparation.
- In-Situ Stress Measurement.
- Measurement of Deformability and Shear Strength Parameters.
- Analysis of cross tunnels and pillar stability.
- Design of excavation methodology for extraction of caverns with minimum damage to the rock mass.
- Detection of Cracks using GPR and Seismic Studies.
- Micro seismic studies of powerhouse site.
- Monitoring of underground structures.

NUCLEAR POWER PROJECTS

- Seismotectonic investigations for nuclear installations, as per IAEA and AERB guidelines.
- Lineament Analysis- Preparation of lineament map from the analysis of different satellite images and survey of India Top sheets.
- Active Fault Mapping - Mapping potentially active faults and extracting information on history of movement are major input to seismic hazard evaluation.
- Paleoseismic studies - Identifying the paleoearthquakes as part of seismic hazard assessment of an area.
- Construction stage engineering geological investigations.
- Rock mass damage control at strategic locations.

Underground Metal Mine works

- Study of stability of crown and rib pillars.
- Evaluation of stability of mine shafts.
- Determining the cap rock dimensions.
- Blast design for optimum production.

Underground Coal Mines

- Subsidence studies and prediction.
- Geophysical investigations to detect the old workings.
- Assessing the feasibility or workability of coal seams under difficult ground conditions.
- Optimization of pillar dimensions in steeply dipping seams.

Role of Engineering Geology in Civil Engineering

Engineering Geology has been simply defined as the application of geology to engineering practice to understand the geological factors which influence the location, design, construction and maintenance of engineering works- Fred Bell 1992.

Understanding of geology and geologic principles is vital to the practice of geotechnical and civil engineering works.

Role of Engineering Geology in Civil Engineering

In a major engineering project, geological reports might be carried out through specialize in geology, geophysics or engineering (with a detailed knowledge of ***soil or rock mechanics***).

However, an engineer will have overall supervision and responsibility for the project.

Therefore, the civil engineers must have enough understanding of geology for the following reasons:

- Engineer can recognize common rock types and simple geological structures, and other geological information for preliminary investigation of a project.

- Most civil engineering projects involve some excavation of soils and rocks, or involve loading the earth by building on it.
- In some cases, the excavated rocks may be used as constructional material, and in others, rocks may form a major part of the finished product, such as a motorway cutting or the site for a reservoir.
- The feasibility, the planning and design, the construction and costing, and the safety of a project may depend critically on the geological conditions where the construction will take place.

MINEROLOGY

Origin of minerals

- By the cooling down of magma, atoms are linked into crystalline patterns and subsequently different **minerals** are formed.
- Normally mineral formation takes place in the depths of the earth's crust and upper mantle.

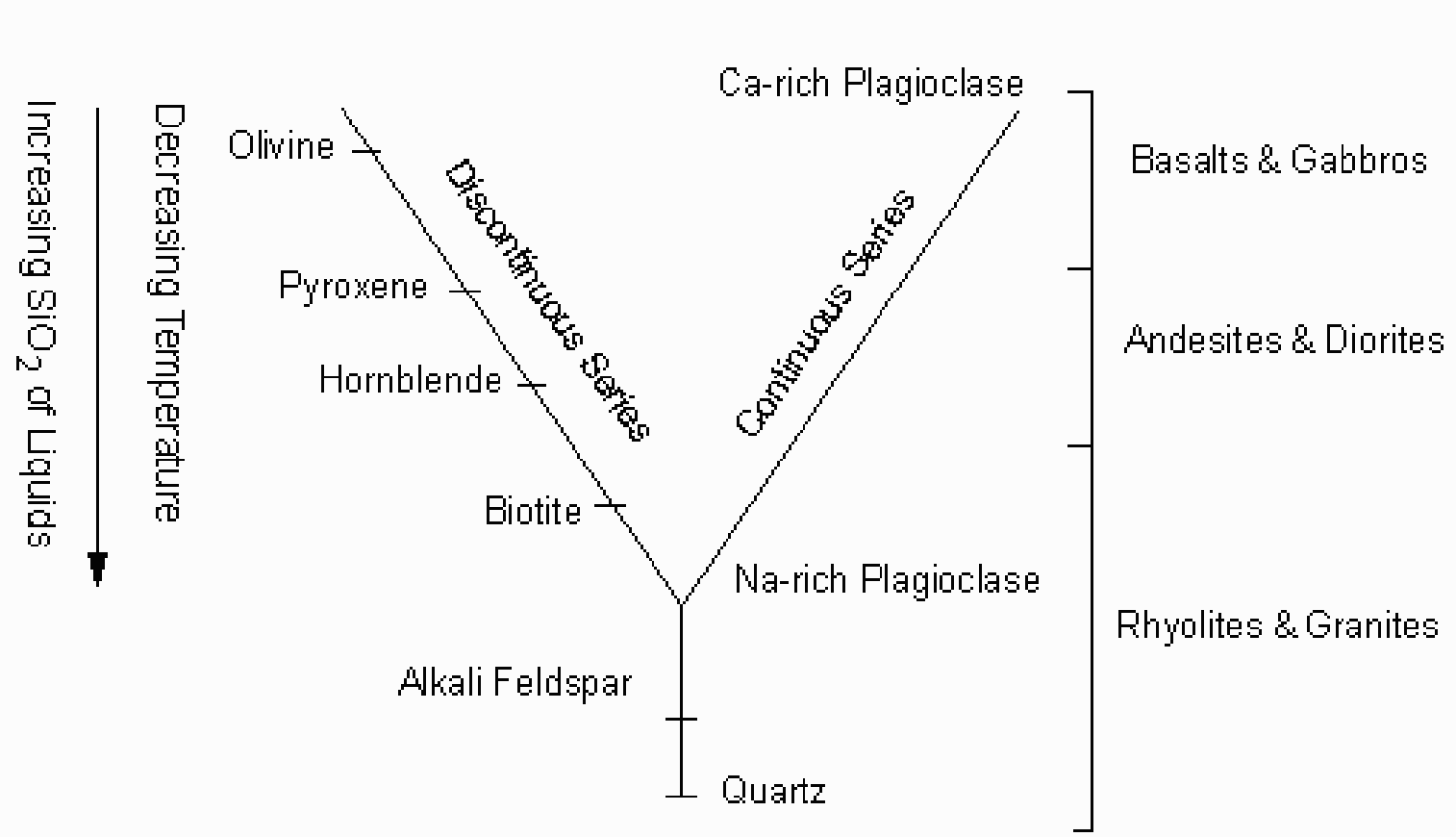
- Magma is extremely hot liquid and semi-liquid mixture of minerals located under Earth's surface.

- There are three basic types of magma:
  1. **Mafic or Basaltic magma** (1000^{o}C to 1200^{o}C) is high in iron, magnesium, and calcium but low in Silica (SiO_2 45-55 wt%) content potassium and sodium.
  2. **Intermediate or Andesitic** (800)^{o}C to 1000^{o}C) magma has moderate amounts in Silica (SiO_2 55-65 wt%) and other minerals.
  3. **Felsic or Rhyolitic** magma(650^{o}C to 800^{o}C) is high in Silica (SiO_2 65-75wt%), potassium and sodium but low in iron, magnesium, and calcium.

Bowen found by experiment that the order in which minerals crystallize from a basaltic magma depends on temperature.

1. As a basaltic magma is cooled Olivine and Ca-rich plagioclase crystallize first.
2. Upon further cooling, Olivine reacts with the liquid to produce pyroxene. And plagioclase.
3. Ca-rich plagioclase react with the liquid to produce less Ca-rich plagioclase.
4. Olivine and Ca-rich plagioclase are removed from the liquid, it will be more SiO_2 rich.

Crystallization of the common silicate minerals from a magma
by N.L.Bowen



Bowen reaction series

Classification of minerals

Based on chemical composition minerals are classified as

1. Native elements:(Gold-Aurum, Copper, Silicon)
1. Silicates:
   - ✓ Quartz group-(SiO_2)
   - ✓ Feldspar group
     - Orthoclase-KAlSi3O8,
     - Plagiolase–NaAlSi3O8–CaAl2Si2O8
   - ✓ Mica group
     - MuscoviteMica-$KAl_2(AlSi_3O_{10})(F,OH)_2$
     - BiotiteMica-$K(Mg,Fe)_3(AlSi_3O_{10})(F,OH)_2$
   - ✓ Amphibole group
     - Hornblende(Ca,Na)23(Mg,Fe,Al)5(Al,Si)8O22(OH,F)
   - ✓ Pyroxene group-XYZ_2O_{6-} (WhereX=Na^+,Ca^{2+}, Mn^{2+}, Fe^{2+}, Mg^{2+}, Li^+; Y= Mn^{2+}, Fe^{2+}, Mg^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Ti^{4+}; and Z= Si^{4+}, $Al^{3+.)}$ and
   - ✓ Olivine group-$(Fe,Mg)_2SiO_4$).

Classification of minerals

3. Oxides:(Magnetite-Fe3O4,Hematite-Fe2O3,Ruby Al2O3:Cr)
4. Carbonates:(Calite-CaCO3,Malachite-$Cu_2[(OH)_2CO_3]$,Azurite-$Cu_3[OHCO_3]_2$ (Copper carbonate,Rhodochrocite-MnCo3)
5. Sulfides:(Galena-Pbs,Stibinite-Sb2S3,Pyrite-FeS2)
6. Sulfates:(Barite -$BaSO_4$,Gypsum-$CaSO_4 2H_2 0$
7. Halides:(Halite,Fluorite)
8. Phosphates:(Apatite-$Ca_5(PO_4)_3(F,Cl,OH)$,Turquoise-$CuAl_6(PO_4)_4(OH)_8\ 4H_2O$

Mineral Classification(based on economic value)

Based on economic value minerals are classified as

✓**Rock forming minerals**

1. Quartz
2. Feldspars,
3. Amphiboles,
4. Micas,
5. Olivine,
6. Garnet,
7. Calcite,
8. Pyroxenes.

✓ **Ore forming minerals**

1. Galena
2. Graphite
3. Diamond
4. Hematite
5. Halite
6. Chalcopyrite
7. Chromite
8. Sphalerite
9. Sulphur

Other minerals as

✓ **Clay minerals**

1. Kaolinite
2. Montmorillonite
3. Illite

Mineral identification methods

To identify the minerals, various methods can be used such as

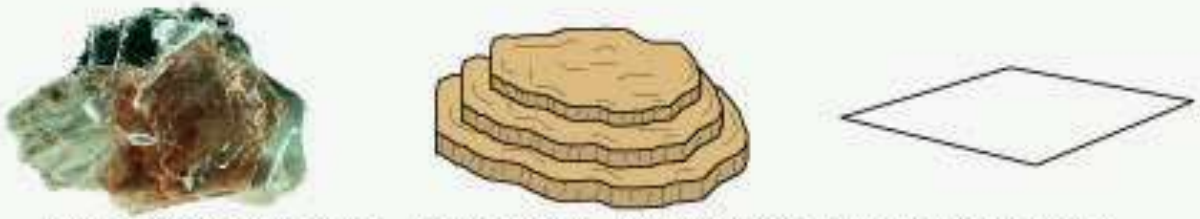
- ✓By physical properties
- ✓By chemical analysis
- ✓By optical propeties
- ✓By X ray difraction(XRD)
- ✓By Scanning electron microscopy(SEM) analysis
- ✓By Cathodo luminescence (CL)
- ✓By X-ray fluoroscopy (XF) etc.

Physical Properties of minerals

- Minerals can be identified by their physical characteristics or properties.
- The physical properties of minerals are related to their chemical composition and bonding.
- Some diagnostic properties, such as a mineral's hardness, specific gravity are more useful in their identification.

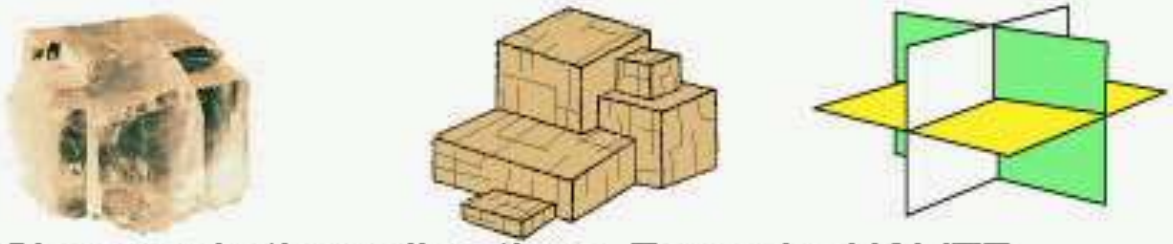
I.Based of cohesion and elasticity

a. Cleavage
b. Fracture
c. Hardness
d. Tenacity



Cleavage in one direction. Example: MUSCOVITE

Cleavage in two directions. Example: FELDSPAR



Cleavage in three directions. Example: HALITE

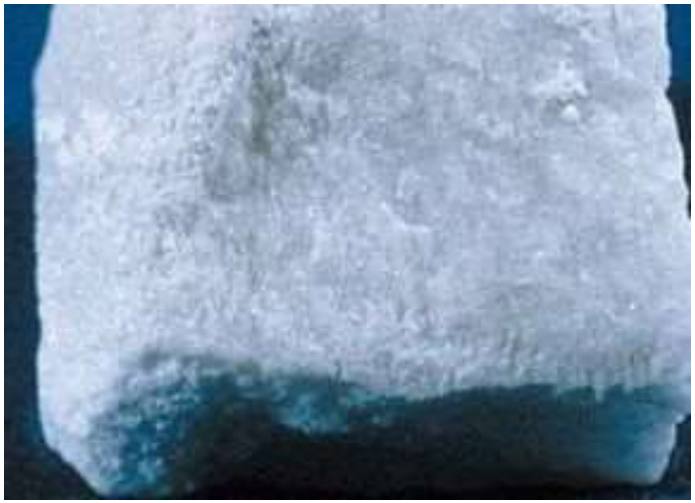
Cleavage in two directions. Example: CALCITE

The most common fracture types are

- ✓Conchoidal and sub conchoidal
- ✓Uneven
- ✓Hackly or Jagged
- ✓Splintery or fibrous
- ✓Glassy

Conchoidal

Sub conchoidal

Uneven fracture

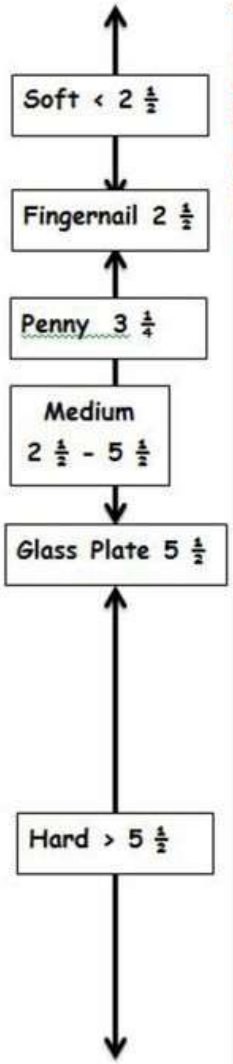
Hackly or Jagged fracture

Splintery or fibrous fracture

Even fracture

Mohs' Hardness Scale (Relative Hardness)

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



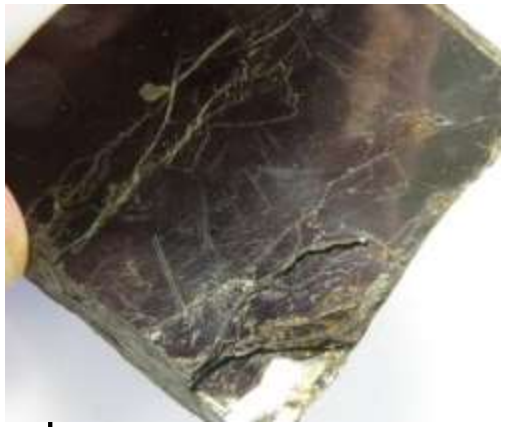
II **Based on light and general optics**

a. Color

b. Streak

c. Luster

d. Trasnsparency



III Based on Specific gravity

a. High specific gravity minerals

b. Medium specific gravity minerals

c. Low specific gravity minerasl

IV Based on heat/electricical conductivity/magnetism

a. Heat obseorbers

b. Magnetic minerals

c. Electrical conductors\resisters

Rose Quartz: The pink variety of quartz

Amethyst: The purple variety of quartz

Aventurine: A sparkling translucent quartz

Citrine: The yellow to orange quartz

V Based on feel

a. Harsh or smooth

b. Smell or odor

c. Taste

VI Based on form or crystal habit

a. Cubic

b. Hexagonal

c. Monoclininc

d. Prismatic

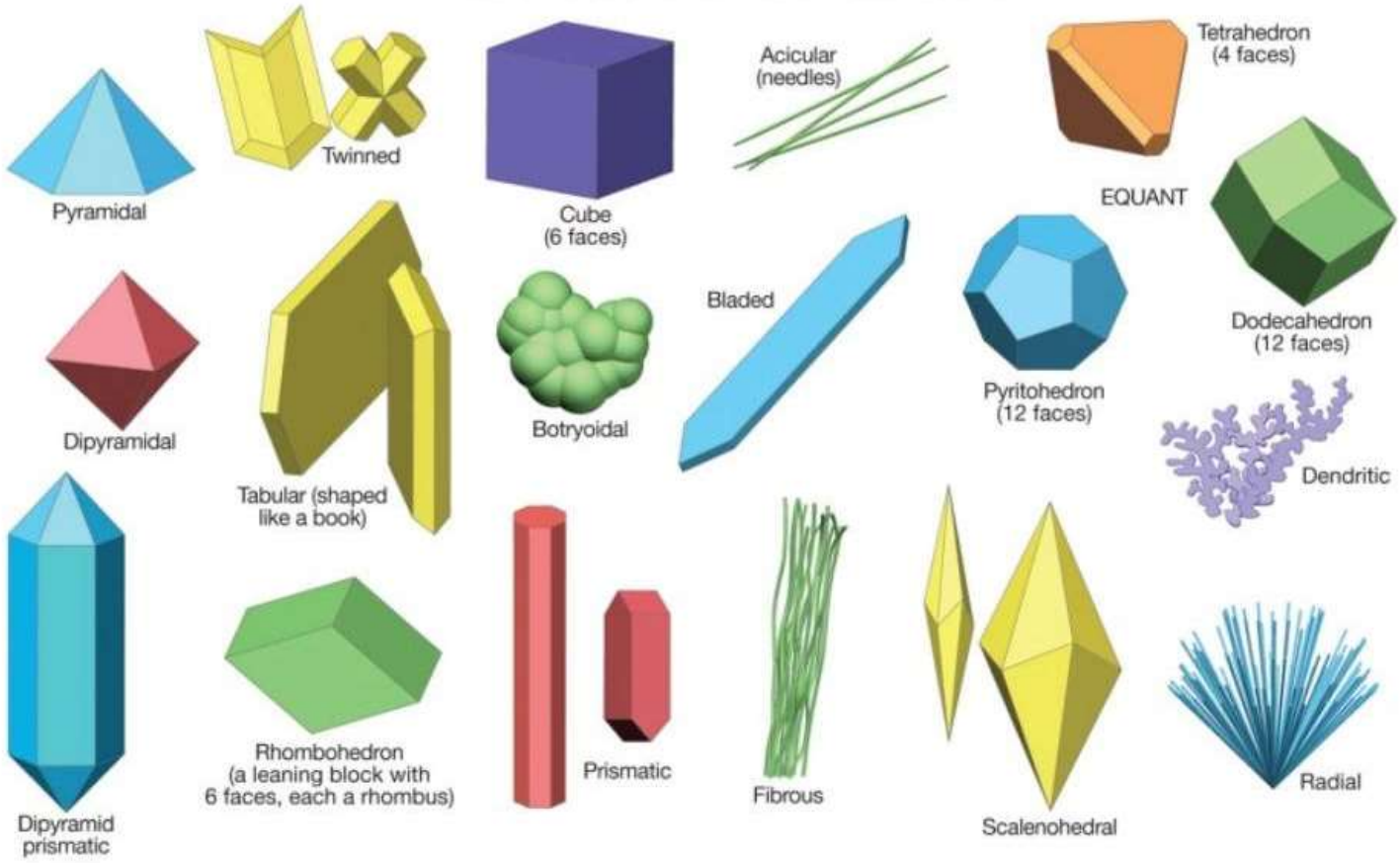
e. Fibrous

f. Botrioydal

g. Oolitic

h. Pisolitic

Crystal Habits (General Forms and Combinations)



Identification of Rock-forming Minerals by Physical properties

Physical Property	Mineral Name: Quartz
Color	Common colors are clear, white, gray, purple, yellow, brown, black, pink, green, red.
Streak	colorless/white
Luster	Vitreous
Diaphaneity /Transparency	Transparent to translucent
Cleavage	absent
Fracture	Conchoidal
Hardness	7
Tenacity	Brittle
Specific Gravity	2.6-2.7
Form/Crystal system	Massive/granular/crystalline/Orthorhombic
Diagnostic property	Conchoidal fracture, glassy luster, hardness 7.
Name of the Mineral	Quartz
Chemical Composition	SiO_2
Mode of origin/occurrence	Found in acidic igneous rocks, metamorphic rocks and sedimentary rocks.
Uses	Glassmaking,foundrysand,hydraulic fracturing proppant and gemstones.

Quartz

Physical Property	Mineral Name: Olivine
Color	Olive green, yellow to bright green and brownish green to brown
Streak	colorless/white
Luster	Vitreous
Diaphaneity /Transparency	Translucent/opaque
Cleavage	Poor
Fracture	Uneven
Hardness	6.5-7
Tenacity	Brittle
Specific Gravity	3.2 - 4.4
Form/Crystal system	Massive/granular/Orthorhombic
Diagnostic property	Green color, Dull to vitreous luster, conchoidal fracture,
Name of the Mineral	Olivine
Chemical Composition	$(Mg, Fe)_2 SiO_4$ Ca, Mn
Mode of origin/occurence	Most olivine found at Earth's surface in dark-colored igneous rocks.
Uses	Gemstones, a declining use in bricks and refractory sand

Olivine-Normal

Olivine-Gemstone

Physical Property	Mineral Name: Feldspar
Color	White, gray, flesh pink, reddish, yellow, green etc.
Streak	white
Luster	Vitreous, Pearly on some cleavage faces.
Diaphaneity/Transparency	Translucent
Cleavage	Perfect in two directions. Cleavage planes usually intersect at or close to a 90 degree angle.
Fracture	Uneven
Hardness	6
Tenacity	Brittle
Specific Gravity	2.5-2.6
Form/Crystal system	Tabular/Triclinic or Monoclinic
Diagnostic property	Cleavage planes usually intersect at or close to a 90 degree angle. Pearly on some cleavage faces.
Name of the Mineral	Feldspar
Chemical Composition	$KAlSi_3O_8$ $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$
Mode of origin/occurrence	Found in Intrusive and extrusive igneous, and metamorphic rocks.
Uses	Used as decorative stone, moon stone, ceramics.

Orthoclase Feldspar

Plagioclase Feldspar

Physical Property	Mineral Name.: Garnet
Color	Typically red, but can be orange, green, yellow, purple, black or brown.
Streak	colorless
Luster	Vitreous
Diaphaneity/Transparency	Translucent
Cleavage	Absent
Fracture	Uneven
Hardness	7-8
Tenacity	Brittle
Specific Gravity	3.5-4.3
Form	Cubic, Massive
Diagnostic property	Cleavage absent, red in color.
Name of the Mineral	Garnet
Chemical Composition	$X_3Y_2(SiO_4)_3$ $X=(Fe^{2+}, Ca^{2+}, Mg^{2+}, Mn^{2+})$ $Y=(Fe^{3+}, Al^{3+}, Cr^{3+})$
Mode of origin/occurrence	Garnets are found in metamorphic, igneous, and sedimentary rocks.
Uses	Used as Abrasives, Blasting, Water jet Cutting, , and Gemstone.

Garnet

Physical Property	Mineral Name: Biotite Mica
Color	Black, dark green, dark brown
Streak	white to gray
Luster	Pearly
Diaphaneity /Transparency	Translucent
Cleavage	Perfect
Fracture	Uneven
Hardness	2-3
Tenacity	Malleable
Specific Gravity	2.7-3.4
Form	Lamellar
Diagnostic property	Pearly luster
Name of the Mineral	Biotite Mica
Chemical Composition	$K(Mg,Fe)_{2-3}Al_{1-2}Si_{2-3}O_{10}(OH,F)_2$
Mode of origin/occurrence	Found in crystalline igneous rocks, such as granite, diorite, gabbro, peridotite and pegmatite. It also occur in metamorphic rocks, mainly in schist and gneiss.
Uses	Mica is used as a filler and extender in paints, as an additive to drilling muds, as an inert filler and mold-release agent in rubber products, and as a non-stick surface coating on asphalt shingles and rolled roofing.

Biotite Mica

Physical Property	Mineral Name : Muscovite Mica
Color	white
Streak	white
Luster	Pearly
Diaphaneity /Transparency	Translucent
Cleavage	Perfect
Fracture	Even
Hardness	2-3
Tenacity	Malleable
Specific Gravity	2.8-2.9
Form	Lamellar
Diagnostic property	Pearly luster, Lamellar form
Name of the Mineral	Muscovite Mica
Chemical Composition	$K\,Al_2(AlSi_3O_{10})(OH)_2$
Mode of origin/occurrence	Muscovite is found in igneous, metamorphic and sedimentary rocks.
Uses	Muscovite mica is used to manufacture a variety of products such as joint compound, paint, drilling mud, plastics, rubber, asphalt roofing and cosmetics.

Muscovite Mica

Physical Property	**Mineral Name: Hornblende** (Amphibole group)
Color	Black, dark green, dark brown
Streak	White
Luster	Vitreous
Diaphaneity/Transparency	Opaque
Cleavage	Perfect
Fracture	Uneven
Hardness	5-6
Tenacity	Brittle
Specific Gravity	2.9-3.5
Form	Prismatic
Diagnostic property	Dark green color
Name of the Mineral	Hornblende
Chemical Composition	$(Ca,Na)_{2-3}(Mg,Fe,Al)_5(Al,Si)_8O_{22}(OH,F)_2$
Mode of origin/occurrence	Hornblende is an important constituent in acid and intermediate igneous rocks such as granite, diorite, syenite, andesite and rhyolite.
Uses	Cut, polished hornblende named as "black granite" for use of building facing, floor tiles, countertops and other architectural uses.

Hornblende

Physical Property	Mineral Name:Kyanite
Color	Pale blue
Streak	White
Luster	Vitreous, sometimes pearly
Diaphaneity /Transparency	Translucent
Cleavage	Perfect
Fracture	Hackly
Hardness	4-6
Tenacity	Brittle
Specific Gravity	3.6-3.7
Form	Bladed
Diagnostic property	Bladed Form
Name of the Mineral	Kyanite
Chemical Composition	Al_2Sio_5
Mode of origin/occurrence	Kyanite found in metamorphic rocks mainly in schist and gneisses.
Uses	It used in the manufacture of refractory bricks, mortars and kiln. For foundries, the molds that are used for casting high temperature metals are often made with kyanite.

Kyanite

Physical Property	Mineral Name: Gypsum
Color	white, gray, yellow, red, brown.
Streak	White
Luster	vitreous, silky, sugary
Diaphaneity/ Transparency	Transparent to Translucent
Cleavage	Perfect
Fracture	Even
Hardness	2
Tenacity	Brittle
Specific Gravity	2.3
Form	Massive/Crystalline/Monoclinic
Diagnostic property	Less Hardness
Name of the Mineral	Gypsum
Chemical Composition	$CaSO_4 \cdot 2H_2O$
Mode of origin/occurrence	Gypsum is found in layered sedimentary deposits in association with halite, anhydrite, sulfur, calcite and dolomite
Uses	Gypsum uses include manufacture of wallboard, cement, plaster of Paris, soil conditioning, a hardening retarder in Portland cement.

Gypsum

Physical Property	Mineral Name: Asbestos
Color	Grey,green
Streak	White
Luster	Silky
Diaphaneity /Transparency	Opaque
Cleavage	Perfect
Fracture	Hackly
Hardness	2.5
Tenacity	Flexible
Specific Gravity	3-3.2
Form	Fibrous
Diagnostic property	Fibrous form, Silky luster
Name of the Mineral	Asbestos
Chemical Composition	$Mg_3Si_2O_5(OH)_4$
Mode of origin/occurrence	It occurs chiefly in association with massive serpentine.
Uses	Due to its resistance to the effects of heat and fire it is widely used in roofing, ceiling tiles, cement pipes and other building materials. Asbestos fabrics were used for safety apparel and for such items as theatre curtains and fire stop hangings in public buildings.

Asbestos

Physical Property	Mineral Name: Calcite
Color	White, gray, red, green, blue, yellow, brown, orange
Streak	White
Luster	vitreous
Diaphaneity /Transparency)	Transparent to Translucent
Cleavage	Perfect (rhombohedral)
Fracture	Even
Hardness	3
Tenacity	Brittle
Specific Gravity	2.7
Form	Rhombohedral or Hexagonal
Diagnostic property	React with acid.
Name of the Mineral	Calcite
Chemical Composition	$CaCO_3$
Mode of origin/occurrence	Calcite is the principal constituent of limestone and marble.
Uses	Calcite used as a construction material, abrasive, agricultural soil treatment, construction aggregate, pigment, pharmaceutical and more.

Calcite

Physical Property	Mineral Name: Talc
Color	White
Streak	Pale green
Luster	Pearly
Diaphaneity/Transparency	Translucent to opaque
Cleavage	Perfect
Fracture	Even
Hardness	1
Tenacity	Brittle
Specific Gravity	2.7-2.8
Form	Massive
Diagnostic property	Soapy feel, low hardness.
Name of the Mineral	Talc
Chemical Composition	$Mg_3Si_4O_{10}(OH)_2$
Mode of origin/occurrence	Talc is most often found in the metamorphic rocks.
Uses	Used as a filler and anti-stick coating in plastics, ceramics, paint, paper, roofing, rubber and in cosmetics.

Talc

Physical Property	Mineral Name:Augite (Pyroxene group)
Color	Dark green,black,brown.
Streak	White to gray to very pale green
Luster	Vitreous on cleavage and crystal faces. Dull on other surfaces.
Diaphaneity /Transparency)	Opaque
Cleavage	Present, Prismatic in two directions.
Fracture	Uneven
Hardness	5.5-6
Tenacity	Brittle
Specific Gravity	3.2 to 3.6
Form/Crystal system	Prismatic/Monoclinic
Diagnostic property	Two cleavage directions intersecting at slightly less than 90 degrees.
Name of the Mineral	Augite
Chemical Composition	$(Ca,Na)(Mg,Fe,Al)(Si,Al)_2O_6$
Mode of origin/occurrence	Augite is a rock-forming mineral that commonly occurs in mafic and intermediate igneous rocks such as basalt, gabbro, andesite, and diorite.
Uses	No significant commercial use.

Augite

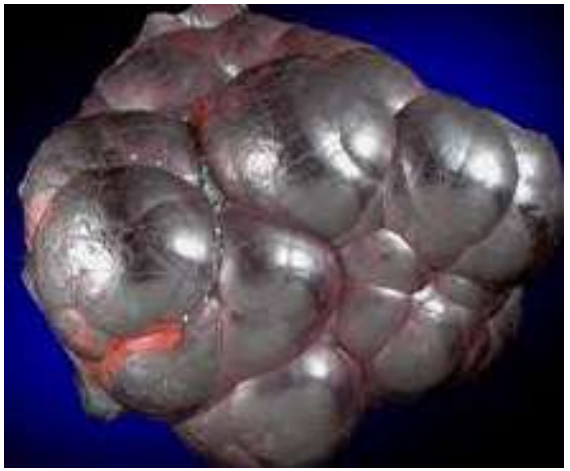
Identification of Ore-forming or Economic Minerals by Physical properties

Physical Property	Mineral Name: Magnetite
Color	Black to silvery gray
Streak	Black
Luster	Metallic-Sub metallic
Diaphaneity/Transparency)	Opaque
Cleavage	Absent
Fracture	Uneven
Hardness	5-6.5
Tenacity	Brittle
Specific Gravity	5.2
Form	Massive
Diagnostic property	Strongly Magnetic
Name of the Mineral	Magnetite
Chemical Composition	Fe_3O_4
Mode of origin/occurrence	It found in igneous, metamorphic and sedimentary rocks.
Uses	As Iron ore and powdered magnetite is often mixed with a liquid to produce a thick, high density slurry. The abrasive known as "emery" is a natural mixture of magnetite and corundum. Small amounts of magnetite used as a micronutrient in fertilizers, pigment in paints, and as an aggregate in high-density concrete.

Magnetite

Physical Property	Mineral Name: Hematite
Color	Red- reddish brown- black
Streak	Red, Cherry red.
Luster	Sub-metallic
Diaphaneity/Transparency	Opaque
Cleavage	Absent
Fracture	Uneven
Hardness	5-6.5
Tenacity	Brittle
Specific Gravity	5-5.3
Form	Massive
Diagnostic property	Streak is cherry red.
Name of the Mineral	Hematite
Chemical Composition	Fe_2O_3
Mode of origin/occurrence	It is a common rock-forming mineral found in sedimentary, metamorphic, and igneous rocks at locations throughout the world.
Uses	Used as Iron ore, and to produce pigments, heavy media separation, radiation shielding, ballast, and many other products.

Hematite-Cherry red Streak



Physical Property	Mineral Name: Galena
Color	Lead grey
Streak	Black
Luster	Sub-metallic
Diaphaneity/Transparency	Opaque
Cleavage	Perfect(Cubic)
Fracture	Uneven
Hardness	2-3
Tenacity	Brittle
Specific Gravity	7.4-7.6
Form	Cubic
Diagnostic property	Black streak, High specific gravity
Name of the Mineral	Galena
Chemical Composition	PbS
Mode of origin/occurrence	It is found in igneous and metamorphic rocks.
Uses	Galena is a very important mineral because it serves as an ore for most of the world's lead production. It is also a significant ore of silver.

Galena

Physical Property	Mineral Name: Bauxite
Color	White, brown or yellow
Streak	usually white but iron stain can discolor
Luster	dull, earthy
Diaphaneity /Transparency	Opaque
Cleavage	Absent
Fracture	Uneven
Hardness	1-3
Tenacity	Brittle
Specific Gravity	2-2.5
Form	Pisolitic
Diagnostic property	Low specific gravity, pisolitic form
Name of the Mineral	Bauxite
Chemical Composition	**$Al_2O_3.2H_2O$**
Mode of origin/occurrence	Formed from a lateritic soil that has been severely leached of silica and other soluble materials in a wet tropical or subtropical climate.
Uses	It is the primary ore of aluminum. Calcined alumina is crushed, separated by size and used as an abrasive.

Bauxite

Physical Property	Mineral Name: Chalcopyrite
Color	Brass yellow
Streak	Greenish black
Luster	Metallic
Diaphaneity/Transparency	Opaque
Cleavage	Poor
Fracture	Uneven
Hardness	3.5-4
Tenacity	Malleable
Specific Gravity	4.1-4.3
Form	Massive
Diagnostic property	Greenish black streak
Name of the Mineral	Chalcopyrite
Chemical Composition	$CuFeS_2$
Mode of origin/occurrence	Chalcopyrite deposits are found in hydrothermal veins, void fillings and replacements in limestones, contact metamorphic deposits and magmatic separations.
Uses	Important ore of copper.

Chalcopyrite

Physical Property	Mineral Name: Pyrite
Color	Brass yellow to dull brass
Streak	Greenish black to brownish black
Luster	Metallic
Diaphaneity/Transparency	Opaque
Cleavage	Poor
Fracture	Uneven, often conchoidal
Hardness	6-6.5
Tenacity	Malleable
Specific Gravity	4.9-5.2
Form	Cubic
Diagnostic property	Color,streak,specific gravity.
Name of the Mineral	Pyrite
Chemical Composition	FeS_2
Mode of origin/occurrence	Chalcopyrite deposits are found in hydrothermal veins, void fillings and replacements in limestones, contact metamorphic deposits and magmatic separations
Uses	Important ore of copper

Pyrite

Physical Property	Mineral Name: Graphite
Color	Steel gray to black
Streak	Black
Luster	Metallic, sometimes sub metallic or earthy.
Diaphaneity/Transparency	Opaque
Cleavage	Perfect in one direction.
Fracture	Even.
Hardness	1-2
Tenacity	Brittle
Specific Gravity	2.1-2.3
Form	Massive/Hexagonal
Diagnostic property	Color, streak, slippery feel, low specific gravity.
Name of the Mineral	Graphite
Chemical Composition	C
Mode of origin/occurrence	It is a native element mineral found in metamorphic and igneous rocks.
Uses	Used to manufacture heat and chemical resistant containers and other objects. Battery anodes. A dry lubricant. The "lead" in pencils.

Graphite

Clay minerals and their Physical properties

Clay mineralogy in its relation to the physical properties of soils, shale's, and other poorly consolidated rocks is an essential factor in a wide variety of engineering problems.

✓**Clay minerals** are hydrous aluminum phyllosilicates, variable amounts of iron, magnesium, alkali metals, alkaline earths, and other cat ions found on or near **planetary Earth surface environments**.

✓They form in soils and sediments by diagenetic and hydrothermal alteration of rocks.

✓Water is essential for clay mineral formation and most clay minerals are described as hydrous alumino silicates.

On basis of lattice structure, clay minerals classified into three major groups as

- ✓The Kaolinites
- ✓The Montmorillonites
- ✓The Illites

Kaolinite is a clay mineral, with the chemical composition $Al_2Si_2O_5(OH)_4$. It is an important industrial mineral. It is a layered silicate mineral, with one tetrahedral sheet of silica(SiO_4) linked through oxygen atoms to one octahedral sheet of alumina (AlO_6) octahedra.

Montmorillonite is a very soft phyllosilicate group of minerals that form when they precipitate from water solution as microscopic crystals, known as clay. It is named after Montmorillon in France.

Illite is an altered product of muscovite and feldspar in weathering and hydrothermal environments. It is common in sediments, soils, and argillaceous sedimentary rocks as well as in some low grade metamorphic rocks.

Physical Property	Mineral Name:Kaolinite
Color	White to cream, sometimes red, blue or brown tints from impurities and pale-yellow
Streak	White
Luster	Pearly to dull or earthy.
Diaphaneity/Transparency	Opaque
Cleavage	Perfect in one direction.
Fracture	Even.
Hardness	2-2.5
Tenacity	Flexible
Specific Gravity	2.16-2.68
Form	Clayey Massive
Diagnostic property	Color, streak, slippery feel, low specific gravity.
Name of the Mineral	**Kaolinite**
Chemical Composition	$Al_2Si_2O_5(OH)_4$
Mode of origin/occurrence	Kaolinite clay occurs in abundance in soils that have formed from the chemical weathering of rocks in hot, moist climates.
Uses	Used in ceramics and main component of porcelain.

Kaolinite

Physical Property	Mineral Name:Montmorillonite
Color	White, pale pink, blue, yellow, red, green
Streak	White
Luster	dull or earthy.
Diaphaneity/Transparency	Translucent
Cleavage	Perfect in one direction.
Fracture	Even.
Hardness	1-2
Tenacity	Flexible
Specific Gravity	1.7-2
Form	Compact lamellar masses
Diagnostic property	Compact lamellar masses
Name of the Mineral	**Montmorillonite**
Chemical Composition	$(Na,Ca)_{0.33}(Al,Mg)_2(Si4O10)(OH)_2 \cdot nH_2O$
Mode of origin/occurrence	Clay minerals are very common in soils, in fine-grained sedimentary rocks such as shale, mudstone, and siltstone and in fine-grained metamorphic slate and phyllite.
Uses	It is also used as a soil additive to hold soil water in drought-prone soils, used in the construction of earthen dams and levees, and to prevent the leakage of fluids. It is also used as a component of foundry sand and as a desiccant to remove moisture from air and gases.

Montmorillonite

Physical Property	Mineral Name:Illite
Color	Grey-white to silvery-white, greenish-gray
Streak	White
Luster	Pearly to dull
Diaphaneity/Transparency	Translucent
Cleavage	Perfect
Fracture	Even.
Hardness	1-2
Tenacity	Flexible
Specific Gravity	2.79-2.8
Form	Lamellar masses
Diagnostic property	Lamellar masses
Name of the Mineral	**Illite**
Chemical Composition	$K_{0.65}Al_{2.0}[Al_{0.65}Si_{3.35}O_{10}](OH)_2$
Mode of origin/occurrence	An altered product of muscovite and feldspar in weathering and h ydrothermal environments. It is common in sediments, soils, and argillaceous sedimentary rocks as well as in some low grade metamorphic rocks
Uses	Indicator of metamorphic grade in clay-bearing rocks.

Illite

Questions

1. Can you define geology and describe the branches of geology?
2. What do you understand the role of engineering geology in civil engineering?
3. How the mineral can be defined, what are the various physical properties which are used in the identification of minerals?
4. Give the physical properties which helps to identify in the field for the following minerals. (a) Quartz (b) Calcite (c) Hornblende (d) Biotite (e) Galena (f) Hematite