UNIT-3 PETROLOGY

Classification of rocks, distinction between igneous, sedimentary and metamorphic rocks. Engineering properties of rocks.
Description, occurrence, Engineering properties, distribution and uses of granite, Dolomite, Basalt, Sandstone, Limestone, Limestone, Shale, Quartzite, Marble, Slate, Gneiss and schist.

Rocks:

(i) Defined as aggregates of minerals.
(ii) Forms major part of earth crust.
(iii) Quartzite and marbles contain only one mineral but most are composed of variety of different mineral.

Classification of rocks:

Rocks are broadly classified into three groups. They are

(a) Igneous rocks
(b) Sedimentary rocks
(c) Metamorphic rocks.

Igneous rocks:

(i) Formed by cooling and solidification of magma.
(ii) Magma is a hot viscous siliceous melt, contains water vapour and gases.
(iii) Magma comes from great depth below earth surface, it is composed of O, Si, Al, Fe, Na, K.
(iv) When a magma comes out upon the earth surface such magma is called lava.

Chemical composition:

- (a) $\text{SiO}_2$ - 40 - 70 %
- (b) $\text{Al}_2\text{O}_3$ - 10 - 20 %
- (c) $\text{Ca}, \text{Mg}, \text{Fe}$ - 10 %

Based on chemical composition magma is classified into 2 groups:

- **Acid Magma**
  - (a) $\text{Si}, \text{Na}$ and $\text{K}$ (rich)
  - (b) $\text{Ca}, \text{Mg}$ and $\text{Fe}$ (poor)

- **Basic Magma**
  - (a) $\text{Ca}, \text{Mg}$ and $\text{Fe}$ (rich)
  - (b) $\text{Si}, \text{Na}$ and $\text{K}$ (poor)

Nature of magma:

(i) Liquid portion: Melt

(ii) Solids: Any Silicate minerals

(iii) Volatiles: Dissolved gases in melt, including water vapour, $\text{CO}_2$ and $\text{SO}_2$.
Crystallization of magma:

(i) Cooling results in systematic arrangements of ions.
(ii) Silicate minerals resulting in crystallization forms in a predictable order and develop distinct texture and structure.

Basic classification:

Volcanic Rocks / Extrusive Rocks:
* Rocks formed from lava on earth surface.

Plutonic Rocks / Intrusive Rocks:
* Rocks formed from magma at deep seated layer in earth.

Hyphabyssal Rocks:
* Rocks formed close to surface of earth.

Texture:
* Overall appearance of a rock based on the size, shape and arrangement of interlocking minerals is called texture.

Factors affecting crystal size:
1. Rate of cooling:
   * Slow rate → Fewer but large crystal.
   * Fast rate → Many small crystal.
* very fast rate forms crystals.

3. 7.6% of SiO₂ present.

3. Dissolved gases.

**Types of Igneous Texture:**

Based on visible crystallinity:

**Aphanitic:**

(i) Fine grained texture.
(ii) Rapid rate of cooling.
(iii) Microscopic crystals
(iv) May contain vesicles.

**Phaneritic:**

(i) Coarse grained texture.
(ii) Slow cooling.
(iii) Large, visible crystals.

**Glassy Texture:**

(i) Very rapid cooling of lava.
(ii) Resulting rock is called obsidian.

Based on variation in crystal size:

**Porphyritic Texture:**

(i) Large crystals (phenocrysts) are embedded in a matrix of smaller crystals (ground mass).
Equigranular Texture:

* All crystals are of same size.

In equigranular Texture:

* Some of the crystals are larger than others.

Based on crystal size:

* Coarse grained texture - crystal size > 2 mm.
* Medium grained texture - crystal size (2 - 0.06 mm).
* Fine - grained texture < 0.06 mm.

Other type of texture:

Pegmatitic Texture:

* Coarse grained
* Crystallization of granitic magma.

Pyroclastic Texture:

(i) Rock fragments thrown out during volcanic process are called pyroclastic.

(ii) Depending on size they are ash, lapilli and volcanic bombs.

Structural Features:

Primary Structures: Structures formed at the time of formation of rock.
<table>
<thead>
<tr>
<th>Objective</th>
<th>Description</th>
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<tbody>
<tr>
<td>(i) Columnar Joints</td>
<td>Due to shrinkage polygonal cracks develops divide to polygonal. Ex: Basalt, Rhyolite.</td>
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<td>(ii) Flow Structure</td>
<td>Presence of parallel layers/bands/streaks due to flow.</td>
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<td>(iii) Pillow Structure</td>
<td>Overlapping of parallel layers pillows like surface on rocks.</td>
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<td>(iv) Rift and Grain</td>
<td>It refers to a direction, easiest direction to break is rift and other is grain.</td>
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<td>(v) Vesicular structure</td>
<td>Holes present in rocks due to escape of gases.</td>
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<td>(vi) Microphytic structure</td>
<td>Holes filled with volatile material.</td>
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<tr>
<td>(vii) Arbicular structure</td>
<td>Appears like spheroidal.</td>
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<tr>
<td>(viii) Ropy and Blocky structure</td>
<td>Lava is more mobile (ie less viscous but are smooth and shiny surface) Ropy refers to waviness, blocky represents the broken/fragment surface of rocks.</td>
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Secondary Structure:
These are formed due to various stress on primary rocks.

(a) Sheeting: One set of joints parallel to ground surface
(b) Shear Zones: Joints due to shear force.
(c) Mural Joints: Three set of joints dividing rock into cubical rocks.
(d) Fault Joints: Formed due to shear displacement b/w rocks.

Forms of Igneous rocks (Intusive rock):

(a) Concordant forms
(b) Sills
(c) Poccolith
(d) Laccolith
(e) Discordant forms
(f) Dykes
(g) Volcanic necks
(h) Batholiths
(i) Lapolith
classification of igneous rocks:

Based on colour Index:

i) Leucocratic - Light colour
ii) Mesocratic - Medium colour
iii) Melanocratic - Dark colour

Based on mode origin:

i) Plutonic
ii) Hypabyssal
iii) Volcanic

Based on mineralogical composition:

a) Acidic rock: Over-saturated (>66.1)
   Eg: Granite & Rhyolite
b) Intermediate rock: Saturated (50-66.1)
   Eg: Dacite and Andesite
c) Basic rock: Under-saturated (40-50.1)
   Eg: Gabbro and basalt
d) Ultra basic rock: Under saturated (>40.1)
   Eg: Peridotite, Komatite & Peridotite
Properties of Igneous rocks:

(i) Sp. gravity: 2.6 - 3.3

(ii) Density (Dry): 3.6 - 3.3 (g/cc)

(iii) Porosity: 1 - 2.1

(iv) Permeability: $(1 \times 10^{-7}) - (1 \times 10^{-10})$

(v) Compressive Strength: 100 - 300 kPa

(vi) Tensile Strength: 4 - 13 kPa

(vii) Shear Strength: 4 - 12 kPa

(viii) Modulus of rigidity: 0.3 - 1.1 $\times 10^6$ kPa

Uses:

(a) Structural purpose: (Beams, columns, roofing material, unctol and sill).

(b) Masonry

(c) Monuments

(d) Flooring

(e) Aggregates, ballast

(f) Switch boards

(g) Pavement materials

(h) Kitchen flat forms

(i) Table top frame
Sedimentary rocks:

(i) These are called secondary rocks as they form from igneous and metamorphic rocks.

(ii) They are also called stratified rocks as they form in layers.

(iii) These rocks amount 5-8% of volume of the crust.

(iv) They occupy 75% of area of the land.

Mode of formation of sedimentary rocks:

(a) Clastic rocks (Mechanical form)

(b) Diagenesis

(c) Matrix

(d) Cement

Classification of sedimentary rocks:

1. Clastic rocks
2. Non-clastic rocks

Clastic rocks:

(i) Clastic rocks are mainly comprise of broken fragments of older rock.

(ii) Also known as terrigenous rocks
(iii) The broken fragments of pre-existing rocks ranging in size from minute particles to very large boulders.

(iv) Clastic rocks

(v) Some other clastic rocks

(i) Arkose

(ii) Graywacke

Non-clastic sedimentary rocks:

(i) Those sedimentary rocks which are formed by chemical precipitation of minerals, from water (or) by accumulation of remains of animals and plants.

Non-clastic sedimentary rocks

Chemically formed rocks

(a) Carbonate rocks
(b) Salt rocks
(c) Ferruginous rocks
(d) Silicious rocks

Organically formed rocks

(a) Bio-chemically formed rocks
(b) Organically formed rocks
Structural features of sedimentary rocks:

1. Mechanical structure.
2. Chemical structure.

Metamorphic rocks:
(i) Metamorphic rocks are formed from older rocks when they are subjected to increased temperature, pressure and shearing stresses.

Sources:
- Igneous rocks
- Soils
- Other metamorphic.

Factors affecting metamorphic:

(a) Temperature
(b) Pressure
(c) Chemically, fluids and gases.

Effects of metamorphism:

(a) Recrystallization.
(b) Plastic deformation.
(c) Granulation.
(d) Metasomatism.
Types of metamorphism:

1. Contact metamorphism
2. Dynamic metamorphism
3. Dynamothermal metamorphism
4. Metasomatism

Granite:

a. Origin: Plutonic
b. Colour: Leucocratic (light colour)
c. Texture: Phaneritic, porphyritic
d. Essential min.: Quartz and feldspar
e. Accessory min.: Mica / Hornblende
f. Varieties: Granite are named according to the main accessory minerals.

g. Example: Biotite (rich) - biotite granite
   Hornblende (rich) - hornblende granite
h. Occurrence: Commonly occur as major intrusive bodies such as batholiths and stocks.

Dolerites:

a. Origin: Hypabyssal
b. Colour: Melanocratic
CE6301 ENGINEERING GEOLOGY

@ Texture : Ophitic and porphyritic

@ Essentially minerals : Calcic plagioclase

@ Accessory minerals : Augite, Olivine & Iron Oxide

@ Occurrence : Sills and dykes

@ Uses : Crushed stone & Ornamental stone.

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** BASALT :**

@ Origin : Volcanic igneous rocks ( intrusive rocks )

@ Colour : Melanocratic

@ Texture : Fine grained

@ Essential mineral : Calcic, Plagioclase, Feldspar

@ Accessory mineral : Augite, Olivine, hornblende & Iron Oxide

@ Varieties : Olivine rich - basanite

... Olivine free - Zephrite...

@ Occurrence : (i) Occurs oceanic divergent boundaries

(ii) Occurs at Oceanic hotspots

(iii) Mantle plumes and hotspots beneath continents

@ Uses : (i) As an aggregate in construction

(ii) Slabs of basalt were used in floor tiles, building veneer & monuments
**SANDSTONE:**

a. Origin: Mechanically formed.
b. Texture: Clastic (fine to medium grained).
c. Structure: Mechanical structure.
e. Types:
   i. Based on types of building material.
   ii. Based on mineralogical composition.
f. Uses:
   i. Masonry material.
   ii. Pavement material.
   iii. Flooring material.
   iv. Wall facing material.

**LIMESTONE:**

b. Texture: Non-clastic.
d. Types: Chalk, shelly, limestone, argillaceous limestone.
e. Occurrence:
   - Bio-thermal formation.
   - Bio-stromal & limestones.
   - Pelagic limestone.
Shale:

- **Origin**: Composition and consolidation of silted clay minerals
- **Texture**: Fine grained
- **Mineral composition**: Quartz, clay minerals, oxides of iron
- **Structure**: Fissility/lamination
- **Types**: (i) Based on origin, (ii) Based on mineralogical composition, (iii) Based on predominant group

Uses:

- (i) Manufacture of bricks
- (ii) Plays a source for paraffin

Gneiss:

- **Nature**: It is coarse grained, irregularly banded, metamorphic rocks of light in colour
- **Texture**: Coarse crystalline texture
- **Structure**: Gneissic
- **Mineral composition**: Quartz, feldspar, mica, pyroxenes
- **Types**: Ortho-gneiss, para-gneiss and banded
Uses: (i) Roofing material
     (ii) Monuments
     (iii) Flooring materials

Quartzite:

(a) Nature: Formed by recrystallization of pure sandstone
(b) Texture: Granular
(c) Structure: Granulose
(d) Mineral composition: Quartz, mica, feldspar and some amphiboles
(e) Types: Orthoquartzite and paraquartzite
(f) Uses: (i) Crushed quartzite is used in railway ballast
         (ii) Decorative stones

Marble:

(a) Nature: Recrystallized from limestone
(b) Texture: Fine to coarse grain
(c) Structure: Granulose
(d) Mineral composition: Calcite, olivine, serpentine, garnet
(e) Types: Pink marble, white marble and black marble
(f) Uses: Used formatting sculpture & building stone
SLATE:

(a) Nature: Fine grained metamorphic rocks

(b) Texture: Fine grained

(c) Structure: Slate

(d) Mineral: Mica, chlorite, oxide of iron, composition

(e) Uses: (i) Roofing slates
(ii) Slate tile used in interior and exterior
(iii) Electrical insulators, fireproof material, switchboard, electrical motor

SCHIST:

(a) Nature: Foliated metamorphic rocks, flaky and platy minerals arranged in illite, sub illite layers, bands

(b) Texture: Coarsened crystalline, porphyroblastic, lineation

(c) Structure: Schistose

(d) Mineral: Mica, chlorite, hornblende, tremolite

(e) Uses: Rarely used as building material in flooring and ornament decoration