Topic 2: MINERALOGY

Mineral:

A mineral may be defined as a natural, inorganic, homogeneous, solid substance having a definite chemical composition and regular atomic structure.
To call any substance a mineral, the requirements to be fulfilled are:

1. It must have been formed by natural process
2. It must be homogeneous, i.e. All parts of the minerals should possess the same physical and chemical characters
3. It must be inorganic substance, i.e., substances of wood or any other organic material cannot be called mineral
4. It must be solid, i.e. gaseous, liquid or semisolid substances are not minerals.
5. It must have a definite chemical composition.
6. It must be crystalline.

Importance of study of minerals:

From civil engineering point of view, studies of minerals are very important because:

1. The civil engineers need to know the properties of rocks precisely to enable them to consider different rocks for any purpose, i.e. foundation rocks, as road metal. As concrete aggregate, as building stones, as flooring or roofing materials , as decorative material etc.
2. The economic minerals, since they are scarce, do not influence the properties of their constituent minerals, and hence irrelevant from the civil engineering point of view. But, if they happen to occur in large quantities, their economic value will not permit them to be used as construction materials or as foundation sites.

Thus properties of civil engineering importance such as strength, durability and appearance of rocks can be assessed only with the knowledge of the minerals that form rocks.

Engineering Significance of Rock Forming Minerals

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

1. *Study of physical properties*
2. *Study of chemical composition*
3. *Study of optical properties*
4. *X-ray analysis*

Physical Properties

Over 4,000 minerals are known to man, and these minerals are identified by their physical and chemical properties. The physical properties of minerals are determined by the atomic structure and crystal chemistry of the minerals. The most common physical properties are crystal form, color, hardness, cleavage, and specific gravity.

Crystals
Cleavage and Fracture
Color
Hardness
Streak
Luster
Specific Gravity
Tenacity
Acid Test
Magnetism
Fluorescence

Crystals

One of the best aids in the identification of a mineral is its crystal form (external shape). A crystal is defined as a homogenous solid possessing a three-dimensional internal order defined by the lattice structure.

Crystals developed under favorable conditions often exhibit characteristic geometric forms (which are outward expressions of the internal arrangements of atoms), crystal class, and cleavage. Large, well-developed crystals are not common because of unfavorable growth conditions, but small crystals recognizable with a hand lens or microscope are common.

Minerals that show no external crystal form but possess an internal crystalline structure are said to be massive. A few minerals, such as limonite and opal, have no orderly arrangement of atoms and are said to be amorphous.

Crystals are divided into six major classes based on their geometric form: isometric, tetragonal, hexagonal, orthorhombic, monoclinic, and triclinic. The hexagonal system also has a rhombohedral subdivision, which applies mainly to carbonates.

Cleavage and Fracture

After minerals are formed, they have a tendency to split or break along definite planes of weakness. This property is called cleavage. These planes of weakness are closely related to the internal structure of the mineral, and are usually, but not always, parallel to crystal faces or possible crystal faces. Minerals may have one, two, three, four, or six directions of cleavage. These cleavage forms are (1) cubic, (2) octahedral, (3) dodecahedral, (4) rhombohedral, (5) prismatic, and (6) pinacoidal. Minerals that break easily along these lines of weakness yield shiny surfaces. Many crystals do not cleave, but fracture or break instead. Quartz, for example, forms well-developed crystal faces but does not cleave at all; instead it fractures or breaks randomly with a conchoidal fracture.

Color

The color of a mineral is the most important identifying characteristic for the amateur mineralogist. Many minerals exhibit various colors; the varieties are mainly due to impurities or a slight change in chemical composition. For example, calcite can be white, blue, yellow, pink, or fluorescent. Surface tarnish may have changed the color of the specimen; therefore, a fresh surface should be examined.

Hardness

The hardness (scratchability) of a mineral can be measured by its resistance to scratching or abrasion. Mohs scale is a set of 10 common minerals chosen for comparative hardness. The minerals are arranged in order of increasing hardness; each mineral will scratch all that precede it, and be scratched by all that follow it. Mohs scale (1-10) is as follows:

- *talc*
- *gypsum*
- *calcite*
- *fluorite*
- *apatite*
- *orthoclase*
- *quartz*
- *topaz*
- *corundum*
- *diamond*

Streak

The streak of a mineral is the color of the powder produced when the mineral is rubbed against an unglazed porcelain plate or other fine-grained, hard, abrasive surface. The color of a particular mineral may vary, but the streak is generally constant. The streak may be the same color as the mineral or an entirely different color, but the streak of all white minerals, including calcite, is white.

Luster

Luster refers to the brightness of light reflected from the mineral's surface. The main types of luster are metallic and nonmetallic. Some of the more important nonmetallic lusters are:

Adamantine: brilliant, like that of a diamond.

Earthy: dull, like kaolin.

Silky: having the sheen of silk, like satin spar, a variety of gypsum.

Greasy: oily appearance.

Resinous: waxy appearance, like sphalerite.

Vitreous: the appearance of broken glass, like quartz.

Nacreous (pearly): like mother of pearl; for example, pearly luster on fossil gastropods and cephalopods.

Specific Gravity

The specific gravity (relative density) of a mineral is its weight compared to the weight of an equal volume of water; thus, a mineral with a specific gravity of 4 is four times heavier than water. Special instruments are needed to measure the specific gravity.

Tenacity

Tenacity is the measure of a mineral's cohesiveness or toughness. Tenacity terms are:

Brittle: breaks or powders easily; for example, pyrite or marcasite.

Ductile: can be drawn into a wire; for example, copper.

Elastic: bends and resumes its original position or shape when pressure is released; for example, biotite or muscovite.

Malleable: can be hammered into thin plates or sheets; for example, gold or copper.

Sectile: can be cut or shaved with a knife; for example, gypsum or galena.

Acid Test

When carbonates (especially calcite) are treated with cold, dilute hydrochloric acid, they will effervesce, foam, and bubble, and give off carbon dioxide gas. When sulfides, such as galena, pyrite, and sphalerite, are treated with dilute hydrochloric acid, they will give off the rotten-egg odor of hydrogen sulfide.

Study of chemical compositions:

According to the definition, every mineral is expected to have its own distinctive chemical composition, which is not to be found in any other mineral.

Therefore, by chemical analysis, if the composition is known it should be possible to identify the mineral.

This principle is the basis for this type of study of minerals. For example, if the chemical composition of an unknown mineral is found to be lead sulphide, then that mineral must only be Gelena, because it only has the composition of lead sulphide and no other mineral has this composition.

Study of Optical properties:

In this method, the minerals are ground very fine and fixed over glass slides by means of *CANADA BALSAM.* Such skillfully prepared slides are called thin sections.

They are studied under a petrlogical microscope.

The properties of minerals like colour, their order, interference figures, cleavage, shape, etc are studied under crossed nicols, with the help of some other accessories, if necessary.

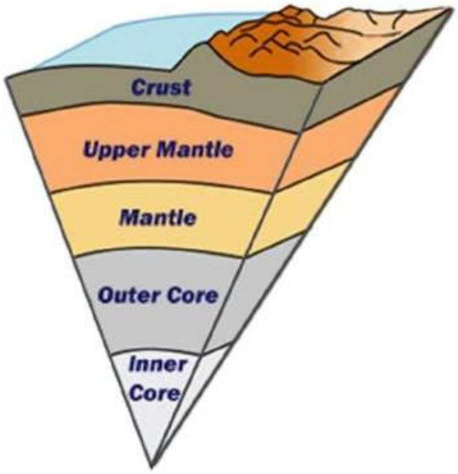
X-ray Analysis:

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 wave length, comparable to the distances between atoms in a crystalline mineral. When a beam of X-rays falls on crystal, it is diffracted by layers of atoms within the crystal. In making an x-ray analysis of atomic structure of the crystal, the diffracted x-rays are allowed to fall on photographic plate, and the resulting photograph shows a series of spots or lines which form more or less symmetrical pattern. X-ray analysis of minerals reveals their actual atomic structures, which is distinctive for each mineral. This enables the accurate identification of minerals.

Petrology:

Shell structure of earth:

The interior structure of the Earth is layered in spherical shells. These layers can be defined by their chemical and their rheological properties. Earth has an outer silicate solid crust, a highly viscous mantle, a liquid outer core that is much less viscous than the mantle, and a solid inner core.



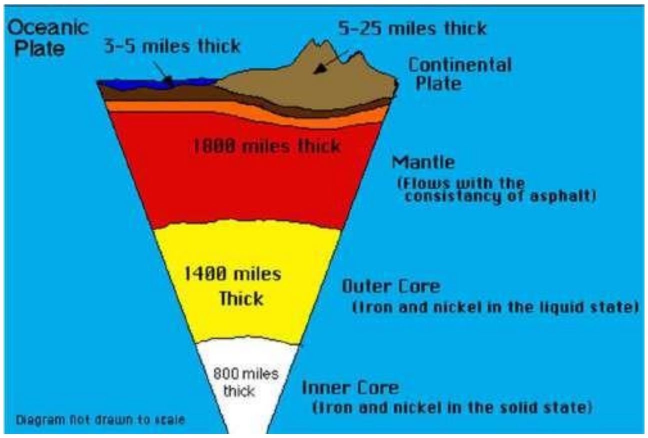
Structure of earth:

The crust of earth is made up of different kinds of rocks. The thickness of crust is approximately 35Km. this rocky crust is known as **Lithosphere.**

The earth crust is uneven with many depressions and elevations.

These depressions are filled with water and are called lakes, seas and oceans. This discontinuous body of water in association with the lithosphere is called the **Hydrosphere**.

On land masses of the lithosphere and in water bodies of hydrosphere, all living creatures exist, this is called **Biosphere**. All these, in turn are enveloped by a layer of air which is called the **Atmosphere.**



Definition of a Rock:

Rock or stone is a natural substance, a solid aggregate of one or more minerals or mineraloids. The solid mineral material forming part of the surface of the earth and other similar planets, exposed on the surface or underlying the soil.

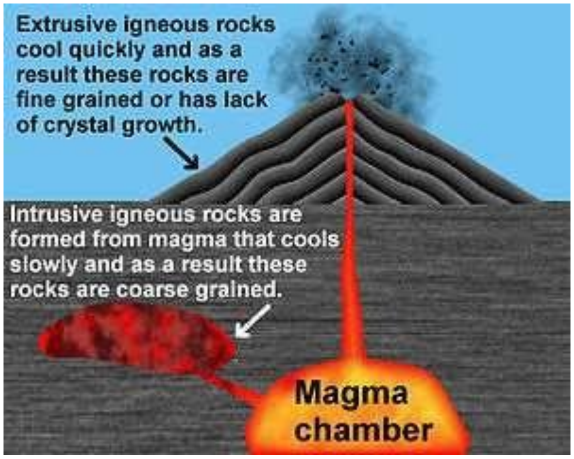
A rock can be simply defined as *"an aggregate of minerals".*

Classification of Rocks:

Using color, texture, and mineral composition, geologists can classify a rock according to its origin. A rock's origin is how the rock formed. Geologists classify rocks into three major groups: **igneous rock, sedimentary rock,** and **metamorphic rock**.

Igneous rock:

Igneous rock is formed through the cooling and solidification of magma or lava. The magma can be derived from partial melts of existing rocks in either a planet's mantle or crust. Typically, the melting is caused by one or more of three processes: an increase in temperature, a decrease in pressure, or a change in composition. Solidification into rock occurs either below the surface as intrusive rocks or on the surface as extrusive rocks. Igneous rock may form with crystallization to form granular, crystalline rocks, or without crystallization to form natural glasses.



Igneous rocks are also geologically important because:

- Their minerals and global chemistry give information about the composition of the mantle, from which some igneous rocks are extracted, and the temperature and pressure conditions that allowed this extraction, and/or of other pre-existing rock that melted;
- Their absolute ages can be obtained from various forms of radiometric dating and thus can be compared to adjacent geological strata, allowing a time sequence of events;
- Their features are usually characteristic of a specific tectonic environment, allowing tectonic reconstitutions in some special circumstances they host important mineral deposits (ores): for example, tungsten, tin, and uranium are commonly associated with granites and diorites, whereas ores of chromium and platinum are commonly associated with gabbros.

Sedimentary Rocks:

Sedimentary rocks are types of rock that are formed by the deposition and subsequent cementation of that material at the Earth's surface and within bodies of water. Sedimentation is the collective name for processes that cause mineral and/or organic particles (detritus) to settle in place. The particles that form a sedimentary rock by accumulating are called sediment. Before being deposited, the sediment was formed by weathering and erosion from the source area, and then transported to the place of deposition by water, wind, ice, mass movement or glaciers, which are called agents of denudation.

Sedimentation may also occur as minerals precipitate from water solution or shells of aquatic creatures settle out of suspension.

The sedimentary rock cover of the continents of the Earth's crust is extensive (73% of the Earth's current land surface, but the total contribution of sedimentary rocks is estimated to be only 8% of the total volume of the crust. Sedimentary rocks are only a thin veneer over a crust consisting mainly of igneous and metamorphic rocks. Sedimentary rocks are deposited in layers as strata, forming a structure called bedding. The study of sedimentary rocks and rock strata provides information about the subsurface that is useful for civil engineering, for example in the construction of roads, houses, tunnels, canals or other structures. Sedimentary rocks are also important sources of natural resources like coal, fossil fuels, drinking water or ores.

Metamorphic rocks:

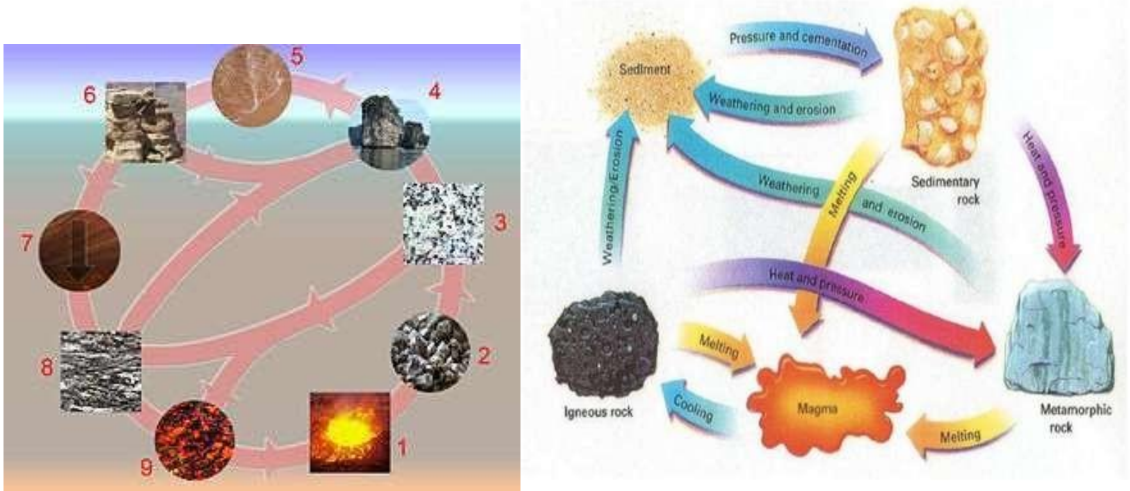
Metamorphic rocks arise from the transformation of existing rock types, in a process called metamorphism, which means "change in form". The original rock (protolith) is subjected to heat (temperatures greater than 150 to 200 °C) and pressure (150 megapascals (1,500 bar))[clarify],causing profound physical and/or chemical change. The protolith may be a sedimentary, an igneous, or even an existing type of metamorphic rock.

Metamorphic rocks make up a large part of the Earth's crust and form 12% of the Earth's current land surface. They are classified by texture and by chemical and mineral assemblage (metamorphic facies). They may be formed simply by being deep beneath the Earth's surface, subjected to high temperatures and the great pressure of the rock layers above it. They can form from tectonic processes such as continental collisions, which cause horizontal pressure, friction and distortion. They are also formed when rock is heated up by the intrusion of hot molten rock called magma from the Earth's interior. The study of metamorphic rocks (now exposed at the Earth's surface following erosion and uplift) provides information about the temperatures and pressures that occur at great depths within the Earth's crust. Some examples of metamorphic rocks are gneiss, slate, marble, schist, and quartzite.

Rock Cycle:

The rock cycle is a basic concept in geology that describes the time-consuming transitions through geologic time among the three main rock types: sedimentary, metamorphic, and igneous. As the adjacent diagram illustrates, each of the types of rocks is altered or destroyed when it is forced out of its equilibrium conditions. An igneous rock such as basalt may break down and dissolve when exposed to the atmosphere, or melt as it is subducted under a continent. Due to the driving forces of the rock cycle, plate tectonics and the water cycle, rocks do not remain in equilibrium and are forced to change as they encounter new environments.

The rock cycle is an illustration that explains how the three rock types are related to each other, and how processes change from one type to another over time. This cyclical aspect makes rock change a geologic cycle and, on planets containing life, a biogeochemical cycle.



A diagram of the rock cycle.

1 = magma; 2 = crystallization (freezing of rock); 3 = igneous rocks; 4 = erosion; 5 = sedimentation; 6 = sediments & sedimentary rocks; 7 = tectonic burial and metamorphism; 8 = metamorphic rocks; 9 = melting.

Forms of Igneous rock:

Igneous rocks are formed in two forms

1. Intrusive igneous rocks
2. Extrusive igneous rocks

Intrusive igneous rocks:

Intrusive, or plutonic, igneous rocks form when magma cools slowly below the Earth's surface. Most intrusive rocks have large, well-formed crystals.

Examples: granite, gabbro, diorite and dunite.

The most common forms of intrusive igneous bodies as observed in the field are:

Dyke, sill, laccolith, lopolith, bysmalith, phacolith, chonolith,volcanic neck or plug, batholiths etc.,.

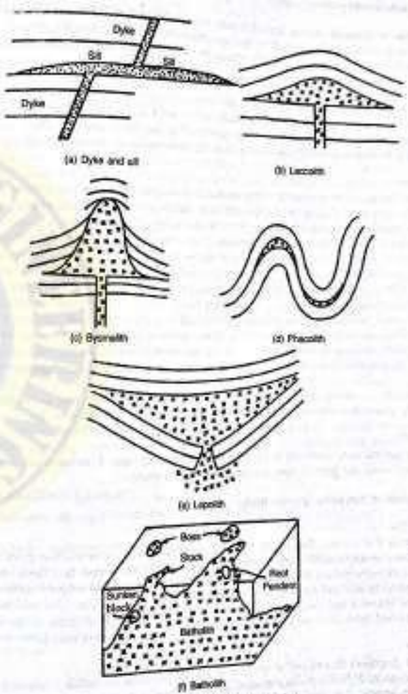
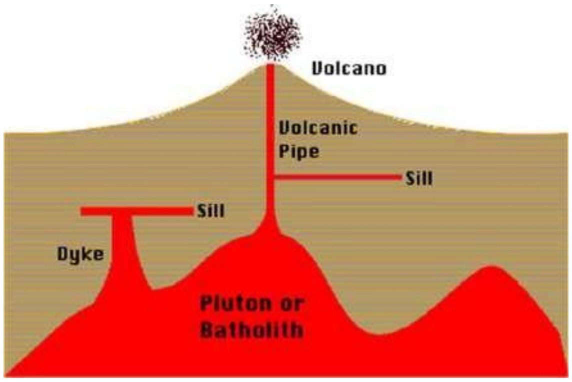


Fig. 6.1 Forms of intrusive igneous rocks

Dykes:

A dyke (or dike) in geology is a type of later vertical rock between older layers of rock. Technically, it is any geologic body which cuts across: flat wall rock structures, such as bedding. Massive rock formations, usually igneous in origin.

Dikes can be either magmatic or sedimentary in origin. Magmatic dikes form when magma intrudes into a crack then crystallizes as a sheet intrusion, either cutting across layers of rock or through an un-layered mass of rock. Clastic dikes are formed when sediment fills a pre-existing crack.



Sills:

A sill is a sheet-like intrusion that is concordant with external layering such as bedding or metamorphic foliation. Sills are formed from magma injected along planes of weakness represented by layering in rocks and are distinct from dykes that cut across layering (i.e. are discordant).

An intrusive mass of igneous rock which consolidated beneath the surface and has a large horizontal extent in comparison with its thickness.

FORMS OF EXTRUSIVE IGNEOUS ROCKS:

Lava Flows

On eruption of a volcano, lava simply flows on the surface and on consolidation gives rise to lava flows. These closely resemble sills in shape. Based on surface appearance, lava flows are described as block lava and ropy lava. Block lava is less mobile and has a rough and irregular surface. The ropy lava is more mobile and has a wrinkled but smooth and shining surface. The vesicles are more numerous, spherical and small in ropy lava flow and they are few and irregular in block lava flow. These physical differences occur because ropy lava comes out hotter and with lesser volatiles.

Pyroclasts

The rock fragments thrown out at the time of volcanic eruption are called pyroclasts. These are described variously, based on size and shape. Bigger and angular fragments are called volcanic blocks. If they are somewhat rounded they are known as volcanic bombs. Smaller fragments are called lapilli.

Classification of Igneous rocks:

- **i) Classification based on silica percentage**
- **ii) Classification based on silica saturation**
- **iii) Classification based on depth of formation**

Classification based on silica percentage:

The chemical composition of a rock is generally expressed in terms of different (oxides like SiO2 AL2O3, Fe2O3, FeO, Mg0 and C20. Among different oxides silicon dioxide is always predominant in rocks. Since silica percentage is also responsible for the formation of different minerals and their associations, it serves as a suitable basis for the classification of igneous rocks. When silica content exceeds 66%. The igneous rock is called as **acidic;** when it is 52-66%, the rocks are called **intermediate**. **The basic rocks** have 45-52%. In **ultrabasic rocks**, the silica content is less than 45%.

Acidic rocks

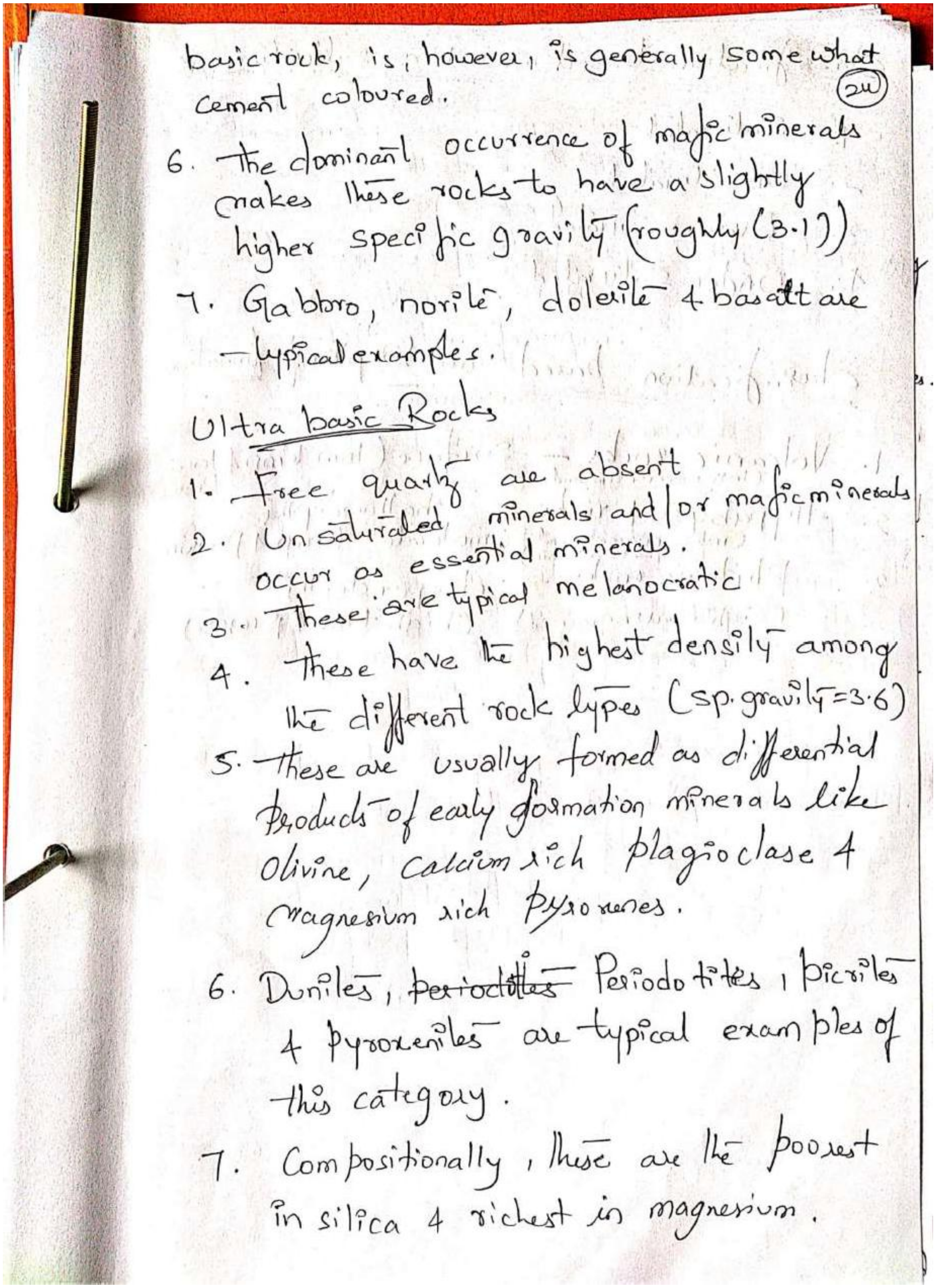
1. These rocks are compositionally rich in silica, alumina 4 alkalies, but poor in calcium, magnesium 4 iron (Mafic)
2. They are composed of quartz, alkali feldspar 4 muscovite mica – representing late stage of crystallization of magma.
3. They are leucocratic because these are rich in pale coloured minerals 4 poor in dark coloured Mafic minerals.
4. They have characteristically free primary quartz 4 are always devoid of unsaturated minerals like olivines 4 feldspathoids.
5. They are relatively lighter 4 have high melting points.
6. Granites 4 many Pegmatites are typical examples of this group: Granites have 70% (or) more of silica content. Sometimes, pure white primary quartz veins composed of 100% silica also occurs in nature.

Intermediate Rocks

1. These rocks may be lacking in free quartz completely (or) may be having very little of it.
2. These are mainly composed of alkali feldspars with a few acessory minerals of the mafic kind.
3. These are leucocratic (or) mesocratic
4. Syenite is a typical example of this group - potash feldspar is the predominant constituent of this rock.

Basic Rocks

i) In these rocks, mafic minerals occur as essential minerals, i.e., they occur as important constituents.
ii) Quartz and olivine are generally absent, or any one of them may occur in small quantities.
iii) Feldspars are of the plagioclase type
iv) Silica + alkalies are less + Calcium, magnesium + ferrous iron are more in content when compared with acidic rocks.
v) Dolerite + gabbro, belonging to this group, are typical melanocratic i.e., black coloured, Basalt, another typical

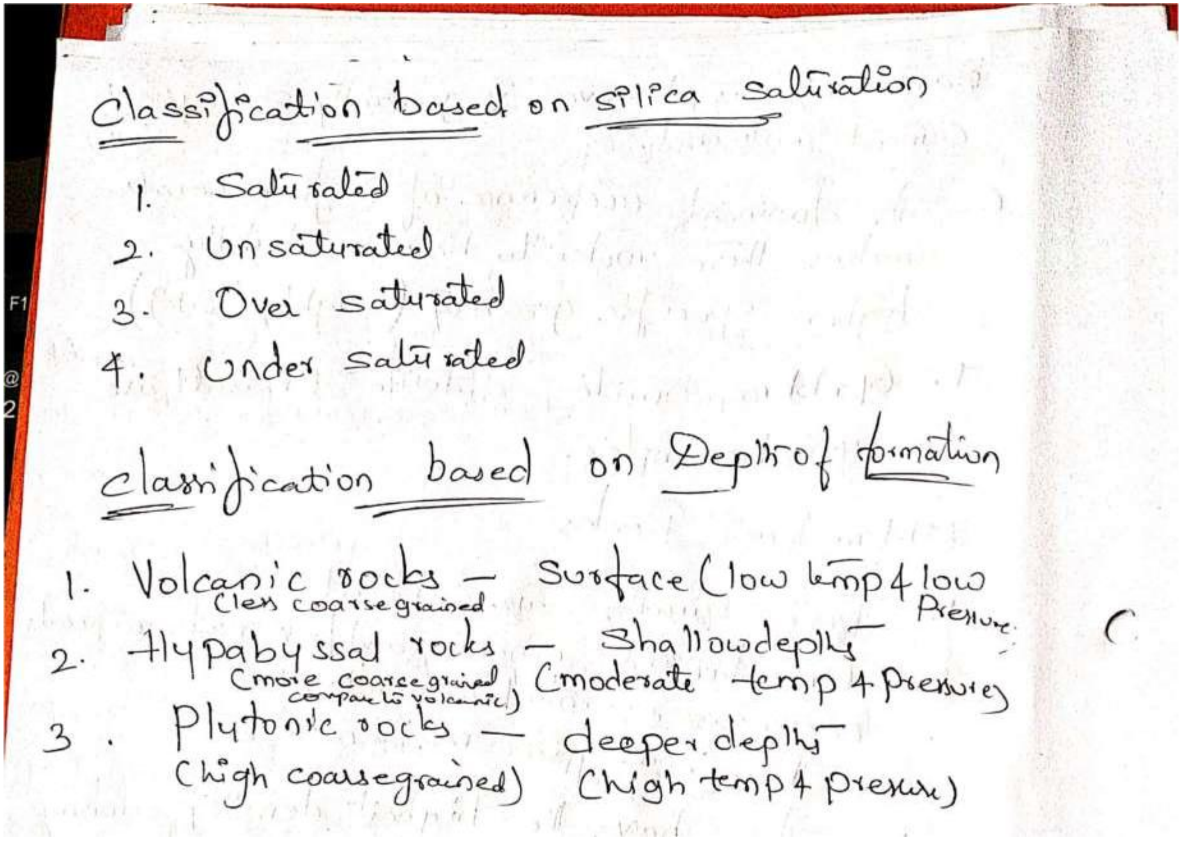


basic rock, is, however, is generally somewhat cement coloured.

6. The dominant occurrence of mafic minerals makes these rocks to have a slightly higher specific gravity (roughly (3.1))
7. Gabbro, norite, dolerite 4 basalt are typical examples.

Ultra basic Rocks

1. Free quartz are absent
2. Un saturated minerals and/or mafic minerals occur as essential minerals.
3. These are typical melanocratic
4. These have the highest density among the different rock types (sp. gravity = 3.6)
5. These are usually formed as differential products of early formation minerals like olivine, calcium rich plagioclase 4 magnesium rich pyroxenes.
6. Dunites, ~~periodtites~~ Periodotites, picrites 4 pyroxenites are typical examples of this category.
7. Compositionally, these are the poorest in silica 4 richest in magnesium.



Classification based on silica saturation

1. Saturated
2. Unsaturated
3. Over saturated
4. Under saturated

classification based on Depth of formation

1. Volcanic rocks — Surface (low temp & low Pressure)
   (less coarse grained)
2. Hypabyssal rocks — Shallowdepth
   (more coarse grained compare to volcanic) (moderate temp & pressure)
3. Plutonic rocks — deeper depth
   (high coarsegrained) (high temp & pressure)

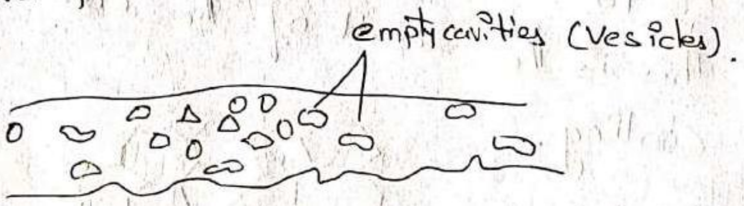
Structure & Texture of Igneous rocks

Structure

Vesicular structure

This structure is due to the porous nature, commonly observed in volcanic rocks, & is attributed to the following reasons.

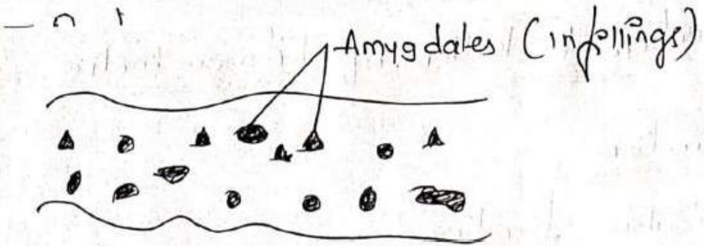
- Magma is an intimated mixture of rock melt and gases.
- Eruption of any volcano is accompanied by the flow of such melt on the surface.
- Then, the gases being lighter, move upwards and as they escape into the atmosphere create cavities of various sizes & shapes near the surface of lava flow. These cavities are called vesicles.



- Vesicles if plenty, make rock hollow & less strong
- Vesicles are interconnected with fractures, the rock becomes permeable too & behave like aquifer.

Amygdaloidal structure

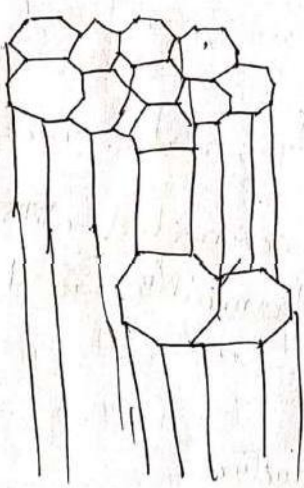
The vesicles, which are empty to start with in vesicular structure, are ~~[illegible]~~ subsequently filled up by the deposits of surface waters or hydrothermal solutions. Such infillings are called amygdales.



When cavities filled with amygdales the Vesicular structure is known as Amygdaloidal structure.

Columnar Structure

In this structure, the volcanic igneous rock appears to be made up of numerous parallel polygonal prismatic columns, bundled together. This is the result of the contraction of lava during cooling.



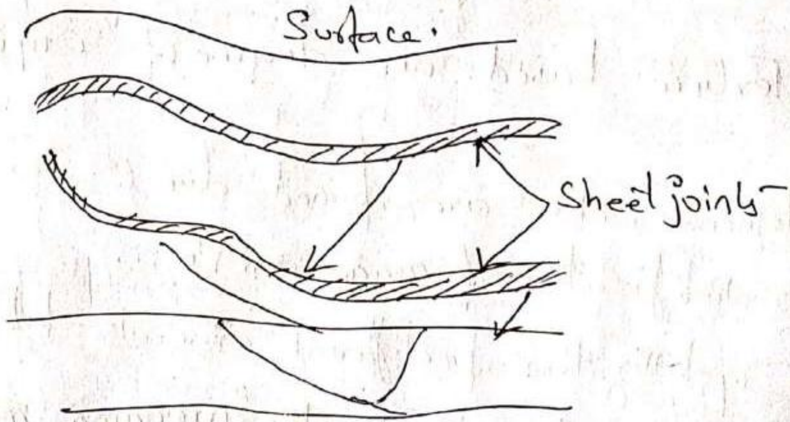
columnar structure.

Ideal conditions produce hexagonal columns. But irregularities in the spacing of cooling centres produce ~~hexagonal~~ Prisms ~~columns~~ of three or four (or) more number of sides. This feature bears a resemblance to mud cracks.

Sheet structure

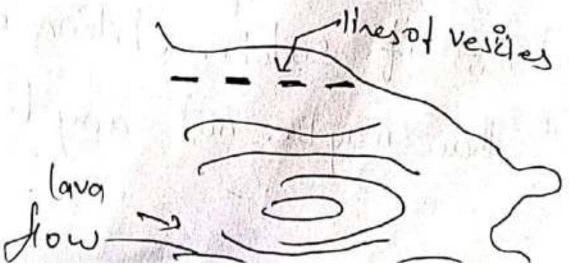
In this structure, the rock appears to be made up of a no. of sheets, because of the development of nearly horizontal cracks. This is the effect of erosion over rocks formed at depth.

When erosion takes place, the overlying rocks (or) strata disappear, ultimately exposing plutonic rocks on the surface. In this process the earlier pressure no longer remain & this release (or) disappearance of pressure results in the development of joints or cracks, roughly parallel to the surface. These are sheet joints.



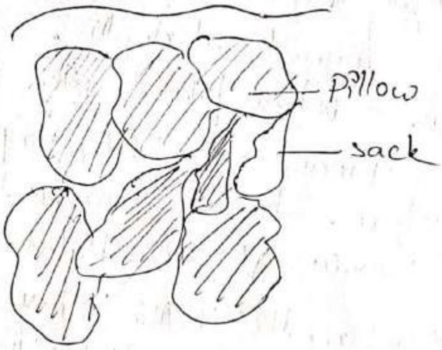
Flow structure

This structure refers to linear and nearly parallel feature occuring in volcanic rocks which develop ~~asaconsequence~~ as a consequence of the lava flow.



Pillow structure

In this structure, the volcanic igneous body appears as a pile of numerous overlapping pillow(or)sacks.



Common Texture of Igneous rocks

Texture based on degree of crystallinity.

Igneous rocks are formed due to cooling & solidification of magma (or) lava.
Crystallization of different minerals takes place when the respective molecules in magma move to their centres of crystallization & arrange themselves in a definite pattern. If reasonable time is available, Crystallization of different minerals takes place from the melt giving rise to a rock. But if sudden chiling of lava occurs, then there may be not any time for crystallization,

i) Holocrystalline → holo - complete

ii) Holo hyaline - glassy (or) ~~amphor~~ amorphous

iii) Hemi crystalline → hemi - half (Partly crystalline & Partly glassy)

Thus preceeding three crystallization give rise to three textures of igneous rocks.

Texture based on Granularity

① Depending on the physical conditions that had prevailed during the crystallization of magma, mineral grains occur in different sizes. The presence of volatiles, low viscosity, slow cooling & great pressure help to grow large minerals. The absolute sizes of minerals vary widely.

If minerals in the rocks are big enough to be seen by naked eye, then the texture is described as phaneric texture.

If minerals in the rock are too fine to be seen seperately by naked eye, the texture is described as aphanitic texture.

When the mineral grain size is more than 5mm, the texture is called as Phaneric - coarse.

When the grain size is less than 1mm & 5mm the texture is called Phaneric - medium.

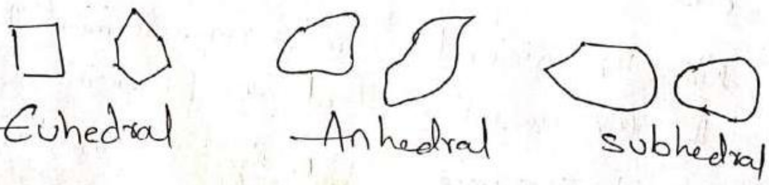
When the grain size is recognizable as less than 1mm then Phaneric - fine.

Similarly, the aphanitic texture is also classified as micro-crystalline, cryptocrystalline & glassy.

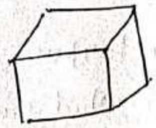
When grain is recognizable under microscope, the texture is called aphanitic - microcrystalline.
If the rock is amorphous & minerals are not recognizable under the microscope, then the texture is aphanitic glassy
If the minerals had undergone only very incipient growth, & are not distiguishable under the microscope but affect the polarized light giving hazy outlook under crossed Nicols, the texture is called aphanitic - cryptocrystalline.

Texture based on shapes of crystals

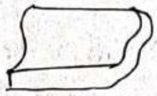
When the minerals are completly bounded by crystal faces, it is called 'euhedral'; when crystal faces are absent, it is called "anhedral", & when only a part of the mineral is bound by crystal faces it is called "subhedral".



Minerals based on their shapes are described as equidimensional (or) platy (or) prismatic (or) irregular.



Equidimensional



Platy

Prismatic

Irregular

Texture based on Mutual relation of Constituent minerals of Rock

Equigranular texture: minerals present are approx. of same size

Inequigranular texture: rocks having this type of texture are not composed of same sized minerals.

Porphyritic texture: In this two sizes (larger + smaller) (Phenocrysts and ground mass) minerals grains occur. rock is known as Phorphyry.

Poikilitic texture: In this type smaller mineral grains are enclosed in b/w or in the larger ones without any order.

Ophitic texture: this type commonly occurs in dolerites, under microscope. In this augite mineral grains enclose small laths (regular grains) of Plagioclase-feldspar

Seriate texture: This is uncommon inequigranular texture in which grain sizes of minerals vary gradually from smallest to largest.

Intergranular texture: this is also observed under microscope in rocks like basalts. In this Intergranular (or) regular shaped Plagioclase feldspar grains form a network & polygonal shaped spaces left are filled with augite, olivine & iron oxides

~~Graphic texture~~

Interlocking texture: In this texture, the different minerals are closely interlinked (or) mutually locked with one another. It develops when a melt solidifies. only igneous rocks have this type of texture.

Graphic texture: This is an intergrowth texture formed due to eutectic crystallization in which two minerals are formed simutaneously.

texture is also classified

Suitability of Igneous Rocks for constructions:

From Civil Engineering point of view, the very purpose of studying Petrology is to get concept about what makes some rocks very competent & other less competent.

- Among various types of rocks, igneous rocks are inherently very competent & desirable for different civil engg. purposes.

No rock possesses all the desirable properties so as to make it ideally suitable for various types of construction.

For foundation purposes of heavy construction – rock should be very strong & be able to withstand substantial loads.

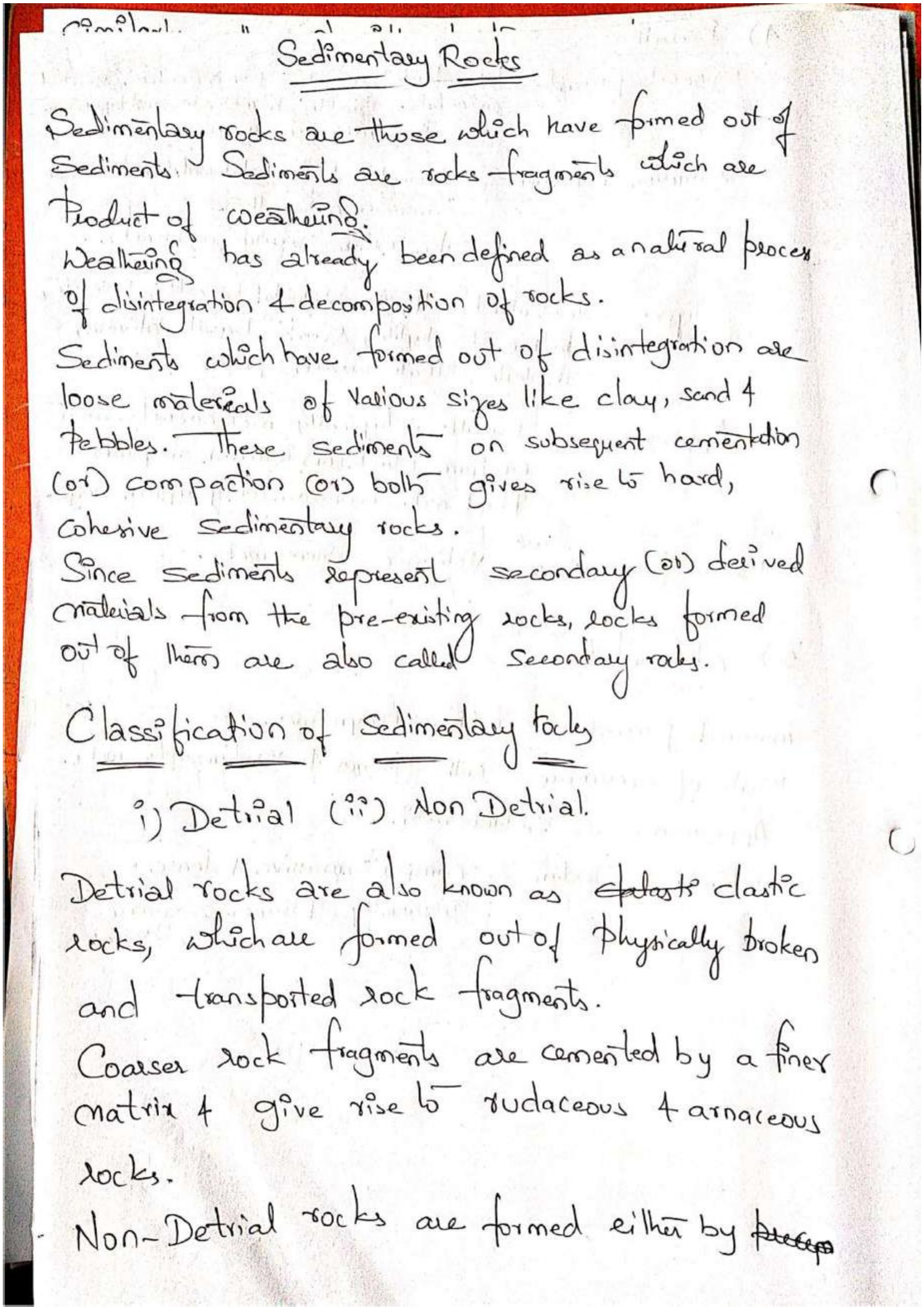
For superstructure of considerable magnitude, rocks should be easily workable & be ~~able~~ available in plenty, & should be durable.

For Roofing purposes, rocks should be resistant to weathering

For flooring purposes, rocks should be able to with stand wear & tear, i.e., they should be resistant to abrasion.

For face work, rocks should have pleasant colour, attractive appearance & ability to take good polish.

- Igneous rocks in general & 'Granite' in particular meets these requirements to a very satisfactory extent



Sedimentary Rocks

Sedimentary rocks are those which have formed out of Sediments. Sediments are rocks fragments which are Product of weathering.

Weathering has already been defined as a natural process of disintegration & decomposition of rocks.

Sediments which have formed out of disintegration are loose materials of various sizes like clay, sand & pebbles. These sediments on subsequent cementation (or) compaction (or) both gives rise to hard, cohesive sedimentary rocks.

Since sediments represent secondary (or) derived materials from the pre-existing rocks, rocks formed out of them are also called Secondary rocks.

Classification of Sedimentary rocks

i) Detrial (ii) Non Detrial.

Detrial rocks are also known as ~~clasti~~ clastic rocks, which are formed out of physically broken and transported rock fragments.

Coarser rock fragments are cemented by a finer matrix & give rise to rudaceous & arnaceous rocks.

Non-Detrial rocks are formed either by [illegible]

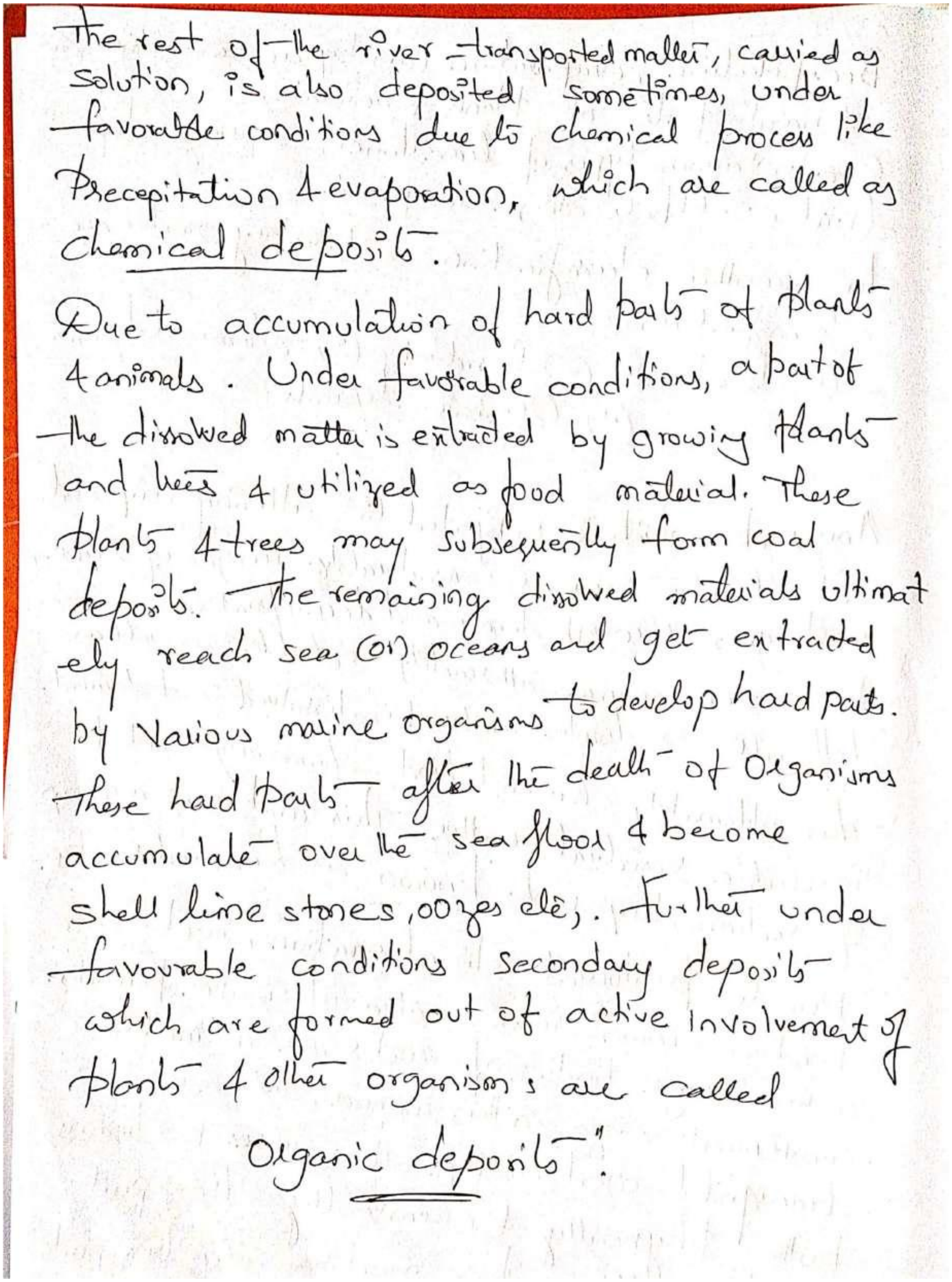
Precipitation, evaporation (or) by accumulation ③ of hard parts of plants & animals.
Coals, various types of limestones, Springs deposits flint, salt beds etc., are formed.

In another classification sedimentary rocks are classified as

① Detrial ② Residual ③ chemical deposits
④ Organic deposits.

Any rock which is subjected to altering dry and wet climates over a considerably length of time, undergoes through decay and decomposition.
As a consequence, all readily soluble as well as difficult to dissolve material is dissolved and leached.
This ultimately leaves behind chemically inert & insoluble residual matter. This makes up a group of sedimentary rocks known as Residual Rocks.

Due to prolonged disintegration, rocks are broken down into smaller & smaller particles.
When large bodies of rocks are reduced to convenient size in this manner, they are transported mechanically. Thus, rivers & streams both physically & chemically transport rock matter. The mechanically transported sediments subsequently cemented or compacted to give rise to another group called Detrial rocks.



The rest of the river transported matter, carried as solution, is also deposited sometimes, under favorable conditions due to chemical process like Precepitation & evaporation, which are called as chemical deposits.

Due to accumulation of hard parts of plants & animals. Under favorable conditions, a part of the dissolved matter is extracted by growing plants and trees & utilized as food material. These plants & trees may subsequently form coal deposits. The remaining dissolved materials ultimately reach sea (or) oceans and get extracted by various marine organisms to develop hard parts. These hard parts after the death of organisms accumulate over the sea floor & become shell lime stones, oozes etc,. Further under favourable conditions secondary deposits which are formed out of active involvement of plants & other organisms are called

Organic deposits".

STRUCTURE AND TEXTURE OF SEDIMENTARY ROCKS

- *STRATIFICATION*
- *CEMENTING MATERIAL*
- *FOSSIL OCCURRENCE*
- *RIPPLE MARKS*

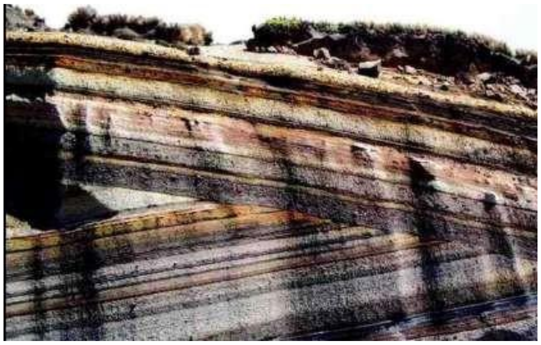
- *MUD CRACKS OR SUN CRACKS*

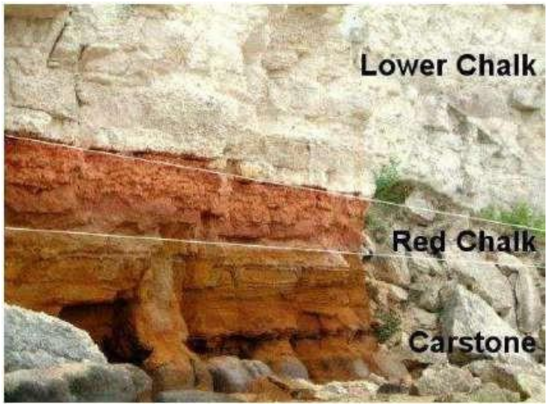
- *RAIN PRINTS OR MARKS*

- *TRACKS AND TRAILS*
- *PECULIAR FORMS*
- *CONCOIDAL FRACTURE*

STRATIFICATION

• STRATIFICATION refers to the way sediment layers are stacked over each other, and can occur on the scale of hundreds of meters, and down to sub-millimeter scale. It is a fundamental feature of sedimentary rocks.





- Stratum- bed, strata means beds
- Stratification is also known as bedding
- When the thickness of individual beds is very thin then it is known as Lamination
- Bedding plane is the plane of contact between two adjacent beds of strata.

Cementing material

Cementation, in geology, hardening and welding of clastic sediments (those formed from pre-existing rock fragments) by the precipitation of mineral matter in the pore spaces. It is the last stage in the formation of a sedimentary rock. The cement forms an integral and important part of the rock, and its precipitation affects the porosity and permeability of the rock. Many minerals may become cements; the most common is silica (generally quartz), but calcite and other carbonates also undergo the process, as well as iron oxides, barite, anhydrite, zeolites, And clay and minerals

Fossil occurrence

- Fossils have been defined as “relicts and remnants of ancient plants and animals preserved inside the rocks by natural processes”
- Remains of plants and animals, when they get buried under sediments, become fossilized.
- Not all animals and plants become fossils, only with hard parts become fossils under favourable conditions.

Mud cracks

- Water or sea or lake, depending on different conditions covers the gently sloping sides on and off.
- When such a wet surface is not covered, it dries up and develops vertical polygonal cracks which are wedge-shaped downwards.

Ripple marks

- In shallow bodies, the waves and currents on the surface of water produce impressions in the form of minor undulations on the loose and soft sediments which lie at the bottom. These are known as ripple marks.

Rain prints or marks

- Rain prints or marks develop under the same conditions as those of mud cracks and are preserved on surface of some rocks.

Tracks and trails

- Tracks and trails are the markings indicating the paths of some animals or organisms, over a soft sediment, which is able to take and retain the impression.
- Footprints of animals or birds may occur the same way.

Peculiar forms

- Nodular , concretionary, pisolitic, oolitic, stalactitic.
- These forms occurs only in sedimentary rocks.

NODULAR

CONCRETIONARY

PISOLITIC

OOLITIC

STALACTITIC

Metamorphic Rocks

Metamorphic rocks are geologically classified as one of the major groups of rocks which have been formed out of metamorphism of Pre-existing Igneous & sedimentary rocks.

Orthometamorphic — from Igneous rocks
Parametamorphic — from Sedimentary rocks
Polymetamorphic — Metamorphism of Metamorphic rock

Note:
When a rock undergoes metamorphism more than once, the process is called Polymetamorphism.

(Meta – change
Morph – form)

In Petrology, it indicates the effect of temp., Pressure & chemically active solutions over the texture, minerals & composition of parent rocks.

Igneous & Sedimentary rocks which serve as Parent rocks are formed under a certain physico-chemical environment, i.e., at the time of their formation, they were in equilibrium with their surroundings in terms of temperature, pressure & chemically active fluids.

Granite $\xrightarrow{changes}$ Granite gneiss
Peridotite → Serpentine & talc schist
Gabbro → hornblende schist
Sandstone → quartzite, limestone → marble
Shale → Slate.

+ Metamorphic Agents

Temperature, Pressure & chemically active fluids are the agents of metamorphism.

Generally all these act together & cause Metamorphism. But some times, any one or two of them may dominate & play an active role.

Temperature :

The source of ~~te~~ temperature which is responsible for metamorphism is either due to depth (or) contact with magma. The metamorphic changes mainly take place in the temperature range of 350–850°C. The temperature rise also increases the chemically activity in rocks & facilitates rxn's during metamorphism.

Pressure :

The Pressure which causes metamorphism is of two different kinds, namely, uniform Pressure & direct pressure.

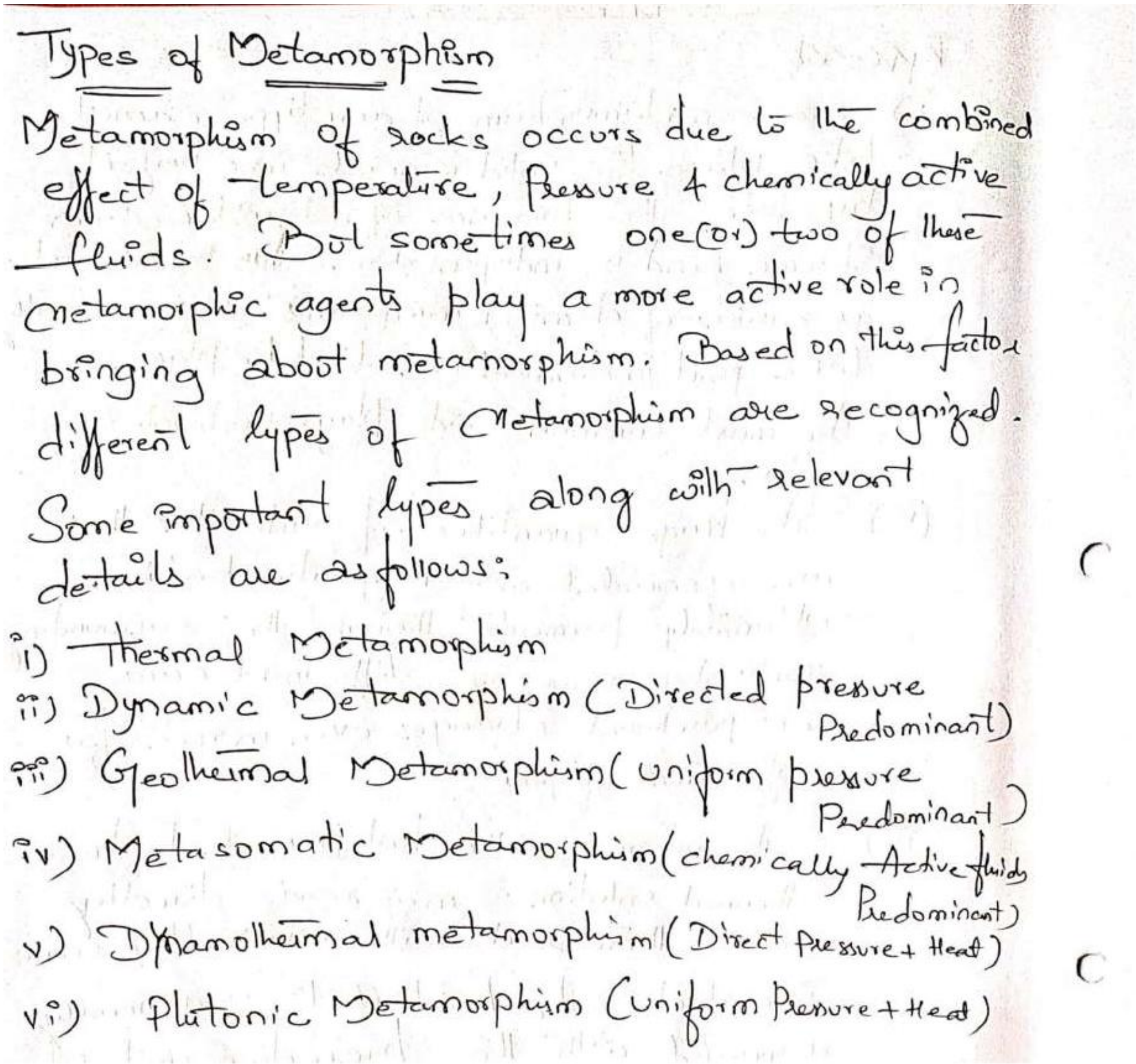
Chemically Active fluids :

Chemically active fluids play a key role in different ways in causing metamorphism.

i) Since metamorphism of any type cannot take place for solid minerals in a perfect dry state, the presence of a liquid medium of some kind is indispensable. Thus liquids act as carriers of chemical components that actually take part in chemical rxns to take place. The most common liquid plays such role is water.

(ii) The huge quantities of volatiles that are associated with magmatic bodies ultimately permeate through the surrounding rocks by means of diffusion & cause compositional changes even in rocks far off from magma

(iii) The magma (or) the hot juvenile hydro-thermal solutions may react directly with those rocks with which they come in contact. The heat that is generally associated with the preceding contents plays a positive role in accelerating the rxns.



Types of Metamorphism

Metamorphism of rocks occurs due to the combined effect of temperature, Pressure & chemically active fluids. But sometimes one (or) two of these metamorphic agents play a more active role in bringing about metamorphism. Based on this factor different types of Metamorphism are recognized. Some important types along with relevant details are as follows:

i) Thermal Metamorphism
ii) Dynamic Metamorphism (Directed pressure Predominant)
iii) Geothermal Metamorphism (uniform pressure Predominant)
iv) Metasomatic Metamorphism (chemically Active fluids Predominant)
v) Dynamothermal metamorphism (Direct Pressure + Heat)
vi) Plutonic Metamorphism (Uniform Pressure + Heat)

Structure of Metamorphic rocks

- **Gneissose Structure**

- If the rock consists of **equi-dimentional** minerals ***along with platy and prismatic minerals***, which can **easily be segregated** and **altering bands** are formed.
- Foliation and lineation of **platy and prismatic minerals** take place.
- Such a texture or arrangement of minerals is called **Gneissose structure**.

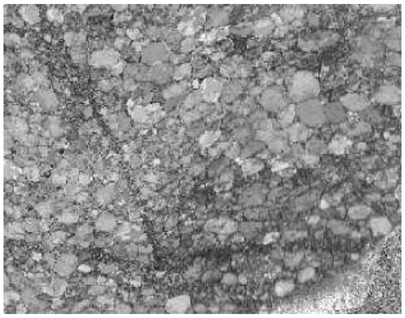
Schistose Structure

- If the rock consists of **only prismatic or platy minerals**, then **no segregation takes place.**
- **Only foliation or only lineation** occurs.
- Such a texture or arrangement of minerals is known as **Schistose structure**

Granulose Structure

- If the rock is **composed predominantly of equidimensional minerals**, then **neither segregation nor foliation** takes place, **absence of platy or prismatic minerals**.
- Such a texture is called G**ranulose structure.**

Cataclastic Structure



- It is produced under the influence of direct pressure in the upper zones of earth's crust.
- In some rocks, more resistant minerals may remain unaffected, while the softer minerals are powdered to fine material.
- This result in appearance similar to porphyritic texture and is called **Porphyroclastic structure**.

Classification of Metamorphic rocks

- Metamorphic rocks are classified as para-metamorphic or ortho-metamorphic rocks based on whether they have been formed out of sedimentary or igneous rocks.
- In different way, metamorphic rocks can be classified on their physical appearance, i.e., as massive or foliated.
- This is independent of kind of metamorphism or parent rock involved.
- However this classification reflects the mineral content and structure clearly.

Foliated rocks

- The process of metamorphism which is accompanied by pressure, induces alignment of constituent minerals in rock.
- The alignment or orientation of minerals takes place perpendicular to the direction of the greatest stress.
- When platy, lamellar, bladed or flaky minerals occurs in rocks, they orient themselves parallel to each other and obviously perpendicular to the direction of the greatest stress.

Such rocks are called as foliated rocks, the process is known as foliation.

Massive or non-foliated rocks

The three important type of rocks which come in this type of category are:

- Quartzite
- Marble
- Hornfels

Of these quartzite is formed out of thermal, dynamic or dynamo-thermal metamorphism.

Hornfels is formed through thermal metamorphism.

Marble is a result of thermal metamorphism of limestone**.**

UNIT- 2

MINEROLOGY

Minerals :-

* Inorganic substances which has more / less definite atomic structure and chemical composition.

* It has constant physical property which are used in the identification of mineral in the field.

* Minerals → Rock forming mineral
→ Ore forming mineral.

Mineral Group	Examples
Oxides	Quartz, magnetite, haematite, etc.
Silicates	Feldspar, mica, hornblende, Augite, olivine, etc.
Carbonates	Calcite, dolomite, etc.
Sulphides	Pyrites, galena, sphalerite, etc.
Chloride	Rocksalt, etc.

Physical Properties :-

* Physical properties can be determined by inspection (or) by simple test.

* It can also determined by hand specimen.

* The chief physical properties are colour, streak, lustre, hardness, habit, cleavage, fracture, odour, tenacity, specific gravity and crystal forms.

* Correct identification are made of with polarizing microscope.

Colour :- It occur due to certain wavelength of light by atoms making of crystals. On a basic of colour of a mineral, may belong to anyone of three types.

→ IDIOCHROMATIC :- Shows a current constant colour appear metallic crystal.

Ex :- Copper.

→ ALLOCHROMATIC :- Shows variable colours, appear non-metallic ex :- Quartz.

→ PSEUDOCHROMATIL :- Shows false colour. Some minerals viewed in different directions shows irregular changes in colour.

① Play of colour :- Change in rapid succession on rotation

Ex : diamond.

② Change of colour :- Rate of change of colours on rotation and intensity is low.

Ex : Labrodorite.

③ Iridescence : Shows rainbow colours in interior/ exterior surface.

Ex :- Limonite, Hematite.

④ Tarnish : Change of original colour due to oxidation.

Ex :- Bornite.

Streak :-

* The streak of the mineral is the true colour of the mineral is quite helpful in Identifying mineral.

* The streak is obtained by rubbing a mineral against an unglazed porcelain plate.

Ex :- Magnetite, black in colour and give blackish brown colour as streak.

Lustre :-

* General Appearance of a mineral surface of reflected light.

① Metallic : Metallic appearance ex. Magnetite, Hematite.

② Sub-Metallic : Feebly displayed metallic lustre

Ex :- chromite.

③ Adamantine : Hard brilliant lustre

Ex : Diamond.

④ Vitreous Lustre : Lustre exhibited by broken glass

Ex :- Quartz, gypsum.

⑤ Pearly Lustre : Lustre exhibited by pearls.

Ex :-Talc, calcite.

⑥ Silky Lustre :- Lustre exhibited by silk fibres.

Ex :-Asbestos.

⑦ Resinous Lustre : Exhibited by resin

Ex :- Sphalerite, Nephiline.

⑧ Greasy Lustre :- Lustre exhibited by grease

Ex :- Talc.

⑨ Dull (or) Earthy :- No lustre said to earthy lustre

Ex :- Kaolin.

Hardness :-

Hardness of mineral depends on chemical composition.

Determined by rubbing / scratching a mineral of unknown hardness against one of known hardness.

Cleavage :-

* It is defined as a tendency of mineral break more easily with smooth surface along plane of weak bonding.

* Cleavage →
  - Perfect
  - Good
  - Poor
  - Indistinct.

Fracture :-

* The nature of the surface of the mineral is called as fracture.

* Fracture →
  - Even fracture
  - Uneven fracture
  - Conchoidal fracture
  - Hacky fracture
  - Earthy fracture.

Specific Gravity :-

* Its number which represent the ratio of weight of the mineral to the weight of an equal volume of water.

Quartz group :-

Introduction :-

* It is an important rock forming mineral next to feldspar.

* It is a non-metallic refractory mineral.

* It is a silicate group.

Physical properties :-

ⓐ Crystal System : Hexagonal.

ⓑ Habit : Crystalline / Amorphous.

ⓒ Fracture - Conchoidal

ⓓ Hardness - 7

ⓔ Specific Gravity - 2.65 - 2.66 (Low)

ⓕ Streak - No

ⓖ Transpareny - Transparent / semi-transparent / opaque

Polymorphism Transformation

Quartz → Tridymite → Crystotallite → Melt.

Coloured varieties :-

* Pure quartz is always colourless and transparent.
* Presence of impurities the mineral showing colour

ⓐ Amethyst : Purple / violet.

ⓑ Smoky quartz : Shades of grey.

ⓒ Milky quartz : Light brown, pure white, opaque.

ⓓ Rose quartz : Rose.

Crypto crystalline forms of Quartz :-

ⓐ Chalcedony : Amorphous, waxy lustre.

ⓑ Agate : A banded, variety having different colours.

ⓒ Jasper : Dull red, yellow, massive.

ⓓ Flint : Dark grey, conchoidal fracture.

ⓔ Opal : Amorphous

Quartz family members :-

ⓐ Primary : Recrystallization process (Si, Al, Fe).

ⓑ Secondary : Precipitation (chalcedony, opal, chert, flint).

Occurrence :-

*It occurs in all types of rocks like igneous, metamorphic and sedimentary rocks.

Uses :-

(i) Used as semi-precious stone.

(ii) Form of sand in construction.

(iii) Used as abrasive in industries

(iv) used for making watches.

(v) Piezoelectric crystal for frequency state.

FELSPAR GROUP :-

(i) It is most abundant of all minerals.

(ii) It is used for making more than 50% by weight crust of earth.

(iii) It is non-metallic and silicate minerals.

CHEMICAL COMPOSITION :-

(i) Potash feldspar $KAlSi_3O_8$

(ii) Soda lime feldspar $NaAlSi_3O_8$ / $CaAl_2Si_2O_8$

Varieties of Potash Feldspar :-

ⓐ Orthoclase
ⓑ Sanidine
ⓒ Microline

Soda lime Feldspar :-

ⓐ Albite
ⓑ Oligoclase
ⓒ Andecine
ⓓ Amarthitite
ⓔ Labrodorite.

CRYSTAL SYSTEM :- Monoclinic, triclinic

ⓐ HABIT :- Tabular (crystalline)

ⓑ CLEAVAGE :- Perfect (2-directional).

ⓒ FRACTURE :- Concholdal / uneven

ⓓ COLOUR :- white, grey, pink, green, red.

ⓔ LUSTRE :- Vitreous

ⓕ HARDNESS :- 6-6.5

ⓖ SPECIFIC GRAVITY :- 2.56 -2.58 (low)

ⓗ STREAK :- No

ⓘ OCCURENCE :- Igneous rock

ⓙ USES :- ceramics, glass, tableware, enamels, electric porcelain & false teeth.

POTASH FELDSPAR :-

ⓐ ORTHOCLASE :-

ⓑ CRYSTAL SYSTEM :- Monoclinic

ⓒ COLOUR :- Flesh red

ⓓ CHEMICAL COMPOSITION :- $KAlSi_8O_8$

ⓔ USES :- Ceramic semiprecious.

~~SODA LIME FELDSPAR~~

MICROLINE :- ~~Triclinic~~

ⓐ CRYSTAL SYSTEM :- Triclinic ~~Whitish / pinkish white~~

ⓑ COLOUR :- Flesh red

ⓒ CHEMICAL COMPOSITION :- $KAlSi_8O_8$

ⓓ USES :- Ceramic semiprecious.

~~ⓔ~~ SODA LIME FELDSPAR :-

ALBITE :-

ⓐ CRYSTAL SYSTEM :- Triclinic

ⓑ COLOUR :- Whitish / Pinkish white

ⓒ CHEMICAL COMPOSITION :- $NaAlSi_3O_8$

ⓓ USES :- Ceramic, Ornamental stone.

ANORTHITE :-

ⓐ CRYSTAL SYSTEM :- Triclinic
ⓑ COLOUR :- White
ⓒ COMPOSITION :- $CaAl_2Si_2O_8$ (90%), $NaAlSi_3O_8$ (10%)
ⓓ USES :- Ceramic, Ornamental stone
ⓔ OCCURENCE :- All types of rocks.

PYROXENES GROUP

ORTHOPYROXENE :-

(i) ENSTATITE ($MgSiO_3$)
(ii) HYPERTHENE [$(Mg, Fe)SiO_3$]

CLINOPYROXENE :-

(i) AUGITE [$(Ca, Na)(Mg, Fe, Al)(Al, Si)_2O_6$]
(ii) DIOPSIDE [$CaMgSi_2O_6$]
(iii) HEDENBERGITE [$CaFeSi_2O_6$]

AUGITE :-

ⓐ CRYSTAL SYSTEM :- Monoclinic
ⓑ HABIT :- Crystalline
ⓒ CLEAVAGE :- Good (Prismatic cleavage)
ⓓ FRACTURE :- Conchoidal
ⓔ COLOUR :- shades of greyish green and black
ⓕ LUSTRE :- Vitreous
ⓖ HARDNESS :- 5-6
ⓗ SPECIFIC GRAVITY :- Medium.

ⓘ STREAK :- White

ⓙ OCCURENCE :- Ferromagnesian mineral of igneous rock (Andes

ⓚ USES :- Rock forming mineral

ⓛ COMPOSITION :- $[(Ca, Na)(Mg, Fe, Al)(Al, Si_2O_6)]$

ⓜ TRANSPARENCY :- Translucent/opaque

AMPHIBOLE GROUP

- These are closely related to pyroxene group.
- It shows double chain silicate structure.
- Rich in calcium, magnesium, iron oxide and Mn, Na, K and H.

Classification :-

ⓐ Orthorhombic

ⓑ Monoclinic

(i) Hornblende
(ii) Tremolite
(iii) Actinolite.

MICA GROUP :-

(i) Form sheet like structure.

(ii) Can be split into very thin sheets along one direction.

(iii) Aluminium and magnesium are rich.

(iv) Occupy 4 % of earth crust.

(v) shows basal cleavage.

Classification :-

Light Mica :-

ⓐ Muscovite - $KAl_2(AlSi_2O_{10})(OH)_2$ - Potash Mica

ⓑ Paragonite - $NaAl_2(AlSi_3O_{10})(OH)_2$ - Soda Mica

ⓒ Lepidolite - $KLiAl(Si_4O_{10})(OH)_2$ - Lithium Mica-

Dark Mica :-

ⓐ Biotite - $K(Mg \cdot Fe)_3(AlSi_3O_{10})(OH)_2$ · (Fe Mag mica)

ⓑ Phogopite - $KMg_3(Al_3Si_3O_{10})(OH)_2$ - (Mag Mica)

ⓒ Zinwaldite - Complex Li - Fe mica.

IRON OXIDE MINERALS :-

MAGNETITE :-

ⓐ CRYSTAL SYSTEM :- Cubic

ⓑ HABIT :- Crystalline, massive / granular

ⓒ FRACTURE :- Uneven

ⓓ CLEAVAGE :- Absent

ⓔ LUSTRE :- Metallic

ⓕ HARDNESS :- 6-7

ⓖ Sp. gravity :- 5.18 (high)

ⓗ STREAK :- brown

ⓘ COMPOSITION :- Fe_3O_4

ⓙ Transparency :- Translucent

ⓚ Occurence :- As neccossary in igneous rocks

ⓛ Uses :- It is important ore of iron.

HEMATITE :-

ⓐ Crystal system : Hexagonal

ⓑ Habit : Massive

ⓒ Cleavage : Absent

ⓓ Fracture : Uneven

ⓔ Colour :- Reddish brown to black.

ⓕ Lustre :- Metallic

ⓖ Hardness :- 5-6

ⓗ Sp. Gravity :- 5.26 (high)

ⓘ Streak :- dark red

ⓙ Composition :- Fe_3O_3

ⓚ Varieties :- Red other

ⓛ Transparency :- Translucent

ⓜ Occurence :- Thick beds of sedimentary rocks

ⓝ Uses :- As iron ore and pigments.

PYRITE :-

ⓐ Crystal System :- Cubic
ⓑ Habit :- Cube / Granular
ⓒ Cleavage :- Absent
ⓓ Fracture :- Conchoidal
ⓔ Colour :- brass, Yellow
ⓕ Lustre :- Vitreous
ⓖ Hardness :- 6-6.5
ⓗ Sp. Gravity :- 5.02
ⓘ Streak :- Greenish / brownish black
ⓙ Transparency :- Translucent
ⓚ Ocurence :- Common sulphide minerals found in hydrothermal veins of metamorphic rock.
ⓛ Uses :- Used in manufacture of sulphuric acid.

SIDERITE :-

ⓐ Crystal System :- Hexagonal
ⓑ Habit :- Crystalline, fibrous also granular
ⓒ Cleavage :- Perfect
ⓓ Colour :- light to dark brown
ⓔ Lustre :- Vitreous.
ⓕ Hardness :- 3.5-4
ⓖ Sp. Gravity :- 3.96 (medium)
ⓗ Composition :- $FeCO_3$
ⓘ Transparency :- Translucent
ⓙ Uses :- In steel industries

CARBONATE MINERAL :-

CALCITE :-

ⓐ Crystal system :- Hexagonal
ⓑ Habit :- Tabular
ⓒ Cleavage :- Perfect
ⓓ Fracture :- Even
ⓔ Colour :- Milky white, grey, green, yellow, etc
ⓕ Lustre :- Vitreous
ⓖ Hardness :- 3
ⓗ Sp. Gravity :- 2.71 (low)
ⓘ Streak :- Colourless
ⓙ Composition :- $CaCO_2$
ⓚ Transparency :- Transparent
ⓛ Uses :- Used for manufacture of cement & lime. It is also used as a fertilizer.
ⓜ Ocurrence :- Rock forming mineral in sedimentary rocks.

CLAY MINERAL GROUP :-

(i) These are phyllosilicates minerals.
(ii) Essentially hydrous aluminium silicates.
(iii) These are common weathering products.
(iv) Very common in sedimentary rock.

CLASSIFICATION :-

There are four group

1. Kaolin
   - (a) Kaolinite.
   - (b) Dicttite
   - (c) Nacrite
   - (d) Halloysite.
2. Smectite
   - (a) Montmorillonite
   - (b) Nontronite
   - (c) Hectorite.
3. Illite
4. chloride.

Kaolinite :-

* It is formed by weathering of aluminate - silicate minerals. The feldspar rocks are comonly weathered to kaolinite.

(a) Crystal system :- Triclinic

(b) Habit :- Massive

(c) colour :- White sometimes brown

(d) cleavage :- Perfect.

(e) Fracture :- Even

ⓕ Streak : - - -

ⓖ Cleavage : Imperfect

ⓗ Lustre : Waxy / dull

ⓘ Fracture : conchoidal

ⓙ Hardness : 2·25

ⓚ Sp. Gravity : 2.25 (low)

ⓛ Transparency : Translucent

ⓜ Composition : $Al_2 Si_2 O_5 (OH)_4$

ⓝ Ocurence : Secondary mineral formed by alteration of alkali feldspar.

ILLITE :-

* The illite clay have a structure similar to that of muscovite. They form by alternate minerals like muscovite and feldspar.

* Chemical composition :- $(K, H) . Al_2 (Si\,Al)_4 O_{10} (OH)_2 XH_2O$

* Uses :- Oil Industry.

CHLORIDE :-

ⓐ Crystal system : Foliated monoclinic

ⓑ Habit : Foliated

ⓒ Colour : Grey, Green

ⓓ Streak : White

ⓔ Cleavage : Good

ⓕ Fracture : Even

ⓖ Lustre : Vitreous.

(h) Sp. Gravity :- Low

(i) Hardness :- 2-3

UNIT PETROLOGY

Classification of rocks, distinction between igneous, sedimentary and metamorphic rocks. Engineering properties of rocks. Description, ocurence, Engineering properties, distribution and uses of granite, Dolerite, Basalt, Sandstone, Limestone, Laterite, Shale, Quartzite, Marble, Slate; Gnesis 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

ⓐ Igneous rocks

ⓑ Sedimentary rocks

ⓒ 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, Mg, Na and K.

(iv) When a magma comes out upon the earth surface such magma is called lava.

Chemical composition :-

ⓐ SiO_2 - 40-70 %

ⓑ Al_2O_3 - 10-20 %

ⓒ Ca, Mg, Fe - 10 %

Based on chemical composition magma is classified into 2 groups.

Magma
- **Acid Magma**
  - ⓐ Si, Na and K (rich)
  - ⓑ Ca, Mg and Fe (poor)
- **Basic Magma**
  - ⓐ Ca, Mg and Fe (rich)
  - ⓑ Si, Na and K (Poor).

Nature of magma :-

(i) Liquid Portion : Melt

(ii) Solids : Any silicate minerals

(iii) Volatiles : Dissolved gases in melt, including water vapour, CO_2 and 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.

HYPABYSSAL ROCKS :-

* Rocks formed closed 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.

② % of SiO_2 present.

③ Dissolved gases.

TYPES OF IGNEOUS TEXTURE :-

Based of visible crystallinity :-

Aphanitic :-

(i) Fine grained texture.

(ii) Rapid rate of cooling.

(iii) Microscopic crystal

(iv) May contain visicles.

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 > 2mm.
- * 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.

Objective	Description
(i) Columnar Joints	Due to shrinkage polygonal cracks develops divide to polygonal. Ex:- Basalt, Rhyolite.
(ii) Flow Structure	Presence of parallel layers / bands / streaks due to flow.
(iii) Pillow Structure	Overlapping of ~~parallel layers~~ pillows like surface on rocks.
(iv) Rift and Grain	It refers to a direction, easiest direction to break is rift and other is grain.
(v) Vesicular Structure	Holes present in rocks due to escape of gases.
(vi) Miarolytic Structure	Holes filled with volatile material.
(vii) Arbicular Structure	Appears like spheroidal.
(viii) Ropy and Blocky Structure	→ lava is more mobile (ie less viscous but are smooth and shiny surface) Ropy refers to waveness, blocky represents the broken / fragment surface of rocks. Blocky lava is less mobile (ie less viscous, irregular surface, vesicles are few & irregular)

Secondary Structure :-

These are formed due to various stress on primary rocks.

ⓐ Sheeting : One set of joint parallel to ground surface

ⓑ Shear Zones : Joints due to shear force.

ⓒ Mural Joints : Three set of joints dividing rock in to cubical rocks.

ⓓ Fault Joints : Formed due to shear displacement b/n rocks.

Forms of Igneous rocks (Intusive rock) :-

ⓐ Concordant forms

ⓑ Sills.

ⓒ Paccolith.

ⓓ Laccolith

ⓔ Discordant forms.

ⓕ Dykes.

ⓖ Volcanic necks.

ⓗ Batholiths.

ⓘ Lapolith.

classification of igneous rocks :-

Classification
- → Based on colour Index
- → Based on mode origin
- → Based on mineralogical composition.

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 :-

ⓐ Acidic rock : Over saturated (>66%)

Eg: Granite & rhyolite.

ⓑ Intermediate rock : Saturated (50-66%)

Eg: Dacite and Andesite.

ⓒ Basic rock : Under saturated (40-50%)

Eg: Gabbro and basalt.

ⓓ Ultra basic rock : Under saturated (>40%)

Eg: Picrite, Komatit & Periodtite.

Properties of igneous rocks :-

(i) Sp. gravity : 2.6 - 3.3

(ii) Density (Dry) : 2.6 - 3.3 (g/cc)

(iii) Porosity : 1 - 2 %

(iv) Permeability : $(1 \times 10^{-7}) - (1 \times 10^{-12})$.

(v) Comp. Strength : 100 - 300 Mpa.

(vi) Tensile strength : 4 - 13 Mpa.

(vii) Shear strength : 4 - 13 Mpa.

(viii) Modulus of rigidity : $0.2 - 1.1 \times 10^{6}$ Mpa.

Uses :-

ⓐ Structural purpose : [Beams, columns, roofing material, lintel and sill).

ⓑ Masonry

ⓒ Monuments

ⓓ Flooring

ⓔ Aggregates, ballasts.

ⓕ Switch boards

ⓖ Pavement materials.

ⓗ Kitchen flat forms.

ⓘ 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 :-

ⓐ Clastic rocks (Mechanical form)

ⓑ Diagenesis

ⓒ Matrix

ⓓ Cement.

Classification of sedimentary rocks :-

① Clastic rocks

② Non-Clastic rocks

Clastic rocks :-

(i) Clastic rocks are mainly comprise of broken fragment 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
- → Rudaceous
- → Arnaceous
- → Argillaceous.

(v) Some other clastic rocks.

(i) Arkose
(ii) Graywacks.

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
  - ⓐ carbonate rocks
  - ⓑ Salt rocks
  - ⓒ Ferruginous rocks.
  - ⓓ silicious rocts.
- → Organically formed rocks
  - ⓐ Bio-chemically rocks.
  - ⓑ organically formed rocts.

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 :-

ⓐ Temperature

ⓑ Pressure

ⓒ chemically fluids and gases.

Effects of metamorphism :-

ⓐ Recrystallization.

ⓑ Plastic deformation.

ⓒ Granulation.

Metasomatism.

Types of metamorphism :-

① contact metamorphism → Pyrometamorphism, → Plutonic metamorphism

② Dynamic metamorphism.

③ Dynamothermal metamorphism.

④ Metasomatism.

Granite :-

ⓐ Origin : Plutonic

ⓑ Colour : Leucocratic (light colour)

ⓒ Texture : Phanertic, porphyritic

ⓓ Essential min. : Quartz and feldspar.

ⓔ Accessory min. : Mica / Hornblende

ⓕ Varieties : Granite are named according to the main accessory minerals.

ⓖ Example : Biotite (rich) - biotite granite.
Hornblende (rich) - hornblende granite.

ⓗ Occurence : commonly occur as major intrusive bodies such as batholiths and stocks.

DOLERITES :-

ⓐ Origin : Hypabyssal

ⓑ Colour : Melanocratic

ⓒ Texture : Ophitic and porphyritic

ⓓ Essentially minerals : Calcic plagioclase

ⓔ Accessory minerals : Augite, Olivine & Iron Oxide.

ⓕ Occurence : Sills and dykes.

ⓖ Uses : Crushed stone & Ornamental stone.

BASALT :-

ⓐ Origin : Volcanic igneous rocks (Extrusive rocks).

ⓑ Colour : Melanocratic

ⓒ Texture : Fine grained

ⓓ Essential Mineral : Calcic, Plagioclase, feldspar.

ⓔ Accessory mineral : Augite, Olivine, hornblende & Iron Oxide.

ⓕ Varieties : Olivine rich — basanite

Olivine free - Zepherite.

ⓖ Occurence : (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 :-

ⓐ Origin : Mechanically formed.

ⓑ Texture : Clastic (Fine to medium grained)

ⓒ Structure : Mechanical structure.

ⓓ Mineral composition : Quartz , feldspar , mica , garnet , magnetite

ⓔ Types : (i) Based on types of building material.
(ii) Based on minerological composition.

ⓕ Uses : ~~(iii)~~
(i) Masonry
(ii) ~~Calcareous 60~~ Pavement material
(iii) Flooring
(iv) Wall facing material.

Limestone :-

ⓐ Origin Bio-chemically and mechanically.

ⓑ Texture Non-clastic

ⓒ Mineral composition calcite , dolonite , quartz , feldspar minerals

ⓓ Types chalk , shelly , limestone , argillaceous limestone

ⓔ Occurence Bio-thermal formation.
Bio-stromal limestones
Pelagic limestone.

(f) Uses : (i) ~~Manufacture of bricks~~ Primary source in limestone.

(ii) In metallurgical industries as flux.

Shale :

(a) Origin : Compaction and consolidation of siltd clay minera

(b) Texture : Fine grained

(c) Mineral composition : Quartz, clay minerals, oxides of iron.

(d) Structure : Fissibility / lamination.

(e) Types : (i) Based on origin.

(ii) Based on minerological composition.

(iii) Based on predominant group.

(f) Uses : (i) Manufacture of bricks.

(ii) Plays a source for paraffin.

GNEISS :-

(a) Nature It is coarse grained, irregularly banded, metamorphic rocks & light in colour.

(b) Texture Coarse crystalline texture.

(c) Structure Gneissose

(d) Mineral composition Quartz, feldspar, mica, pyroxenes.

(e) Types Ortho-gneiss, para gneiss and banded.

(f) 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) Min~~Int~~eral composition : Quartz, mica, feldspar & some amphiboles.
(e) Types : Orthoquartzite and paraquartize.
(f) Uses : (i) Crushed quartzite is used is railway ballas
(ii) Decorative stones.

MARBLE :-

(a) Nature : Recrystallised by 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 formaking sculpture & building stone.

SLATE :

ⓐ Nature : Fine grained metamorphic rocks

ⓑ Texture : Fine grained

ⓒ Structure : Slate

ⓓ Mineral composition : Mica, chloride, oxide of iron.

ⓔ Uses : (i) Roofing slabs.

(ii) Slate tile used in interior and exterior.

(iii) Electrical insulators, fire proof material, switch board, electrical motor.

SCHIST :

ⓐ Nature : Foliated metamorphic rocks.

Flaky and platy minerals arranged in $\parallel^{le}$ / sub $\parallel^{le}$ layers / bands.

ⓑ Texture : Coarsed crystalline, porphyroblastic, lineation.

ⓒ Structure : Schistose.

ⓓ Mineral composition : Mica, chlorite, hornblende, tremolite, actinolite, Kyanite.

ⓔ Uses : Rarely used as building material in flooring and garden decoration.