SWAMI VIVEKANANDA SCHOOL OF ENGINEERING & TECHNOLOGY

MADANPUR,BBSR

LECTURE NOTES

ON

MINE GEOLOGY-I

YEAR & SEMESTER:2ND YEAR & 3RD SEMESTER

BY-Dr. ALOK RANJAN MAHANANDA

LECTURER IN DEPARTMENT OF MINING ENGINEERING

(i) Erosion :-

The breaking down of the rocks due to physical forces associated with the natural agencies, followed by removal of the disintegrated rock fragments and particles, and the sum total of the process is defined as erosion.

(ii) Transportation :-

It is the process by which the weathered materials are removed from the site of their formation by various geomorphic agents.

(iii) Deposition :-

Weathering :- To change in appearance because of the effect of the sun, air, water and wind. glacier.

1. Geological action of river :-

A river is defined as the body of flowing water of any shape and size, A geological action of river is known as fluvial cycle. It includes three process.

(1) Erosion (2) Transportation (3) Deposition

(1) Erosion :- The erosion caused by running water. also it is devided into two types.

(a) mechanical erosion.
(b) chemical erosion.

(a). Mechanical erosion :-

This is because of the physical forces associated with the running water and it includes the following process.

(i) Hydraulic action (ii) Abrasion (iii) Attrition (iv) cavitation

(i) Hydraulic action :-
The swiftly flowing water hammers the uneven faces of the joints rock exposed along channel and removed to joint rock is called hydraulic action.

(ii) Abrasion :-
The flowing water carries the rock fragment such as pebbles, gravel and sand which is act as a tool of destruction which scratch and grinding the side and floors of the valley. this is known as abrasion.

(iii) Attrition :-
It is the breaking of transported material themselves due to mutual collision. the attrition causes the rock fragment to became more rounded and smaller in size.

(iv) Cavitation :-
This is because of presence of air bubbels which creat a whirling action at the time of penitration water through the existing pores and fissures and the small sand particles along with the air bubbles play a major role in widening the cavities.

* Factors help the mechanical erosion :-
(i) Hydraulic gradient.
(ii) Climate
(iii) Nature of the bed rock.
(iv) Hardness of the transported materials.

(b) Chemical erosion :-
It is also known as solution or corrosion during this process of materials get dissolved in the water of the river and are transported in solution.

* Factors which help the chemical erosion :-
(i) solubility of the river bed.
(ii) dissolving action of water due to the presence of (carbon)

(2.) Transportation :-
There are two types of transportation.
(a) Mechanical transportation (b) Chemical transportation.

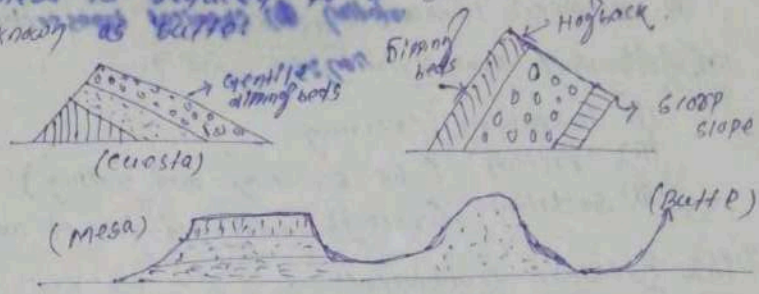
(a). Mechanical transportation :-
(i) Suspension (floating)
(ii) Traction (by creeping and rolling)
(iii) Saltation (through lifts and falls of materials)

(b). Chemical transportation :-
It is through the process of saltation usually in the form of carbonates, sulphates and calcium, sodium, potassium, magnesium etc.

(3.) Deposition :-
It is the last geological action of river where by the materials transported gets accumulated in an appropriate site.
The fluvial cycle of river includes generally four stages, such as, initial, youth, mature and old stage

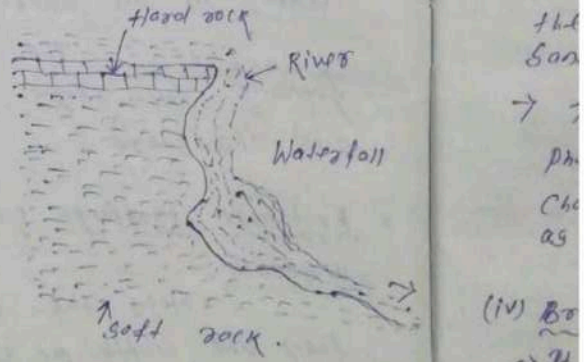
* Erosional landforms produced by river :-
(i) Strath :-
When the width of the valley is greater than the width of the river, the valley is known as Strath.
(ii) Cuesta :-
In a region of sub-horizontal beds a gentle slope is developed along the gentle stepedips of strata such a landscape is known as cuesta.
(iii) Mesa :-
An Isolated tuble-land area with steep sides.

(iv) Butte :- With continued erosion of the sides a mesa is reduced to a smaller flat-topped hill known as butte.



(v) Hog back :- It is a cuesta where the dip slope and the scrap slope are both approximately 45°.

(vi) Potholes :- 'pot holes' are the circular and deep holes, cut into solid rock by sand grains and pebbles swirling in fast eddies. They are commonly found on the channel floors.



(vii) Waterfalls :-

The falling of stream water from a height is called waterfall. while stream profile makes a vertical drop.

* Important depositional features produced by river :-

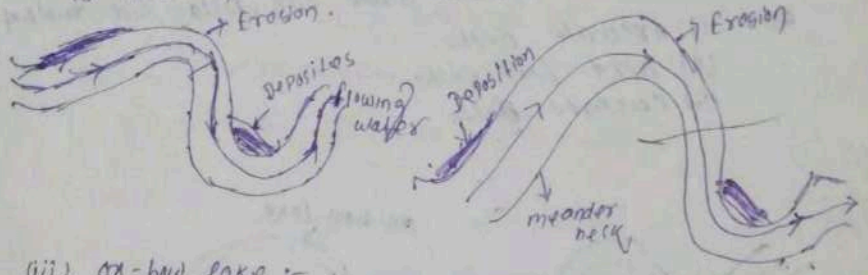
(i) Alluvial fans :-

When stream flow abruptly from steeper to gentler gradients, as at the base of a mountain or ridge. the huge quantities of materials

carried by the river [illegible] to a board, low [illegible] alluvial fans.

(ii) Meandering river :-

The river flows across the flood plain in broad sweeping curves, known as meanders. The water flows faster around the act side of the bend and is slow on the inner curve.



(iii) Ox-bow lake :-

→ A meander grows untill it becomes blub-shaped with a narrow neck. due to the coarse of time the meander neck is filled up by silted and sandy materials.

→ Therefore a meander loop get abandoned phenomenon is called as 'cut-off'. the abandoned channel thus constitute a loop shaped lake known as an 'ox bow lake' or 'horse-shoe lake'.

(iv) Braided River :-

→ It is a phenomenon of dividing and reuniting the river channel.

→ In such cases, the river flows in a number of narrower channels, separated by particular sand and gravel bars which may again meet the main channel some where down stream.

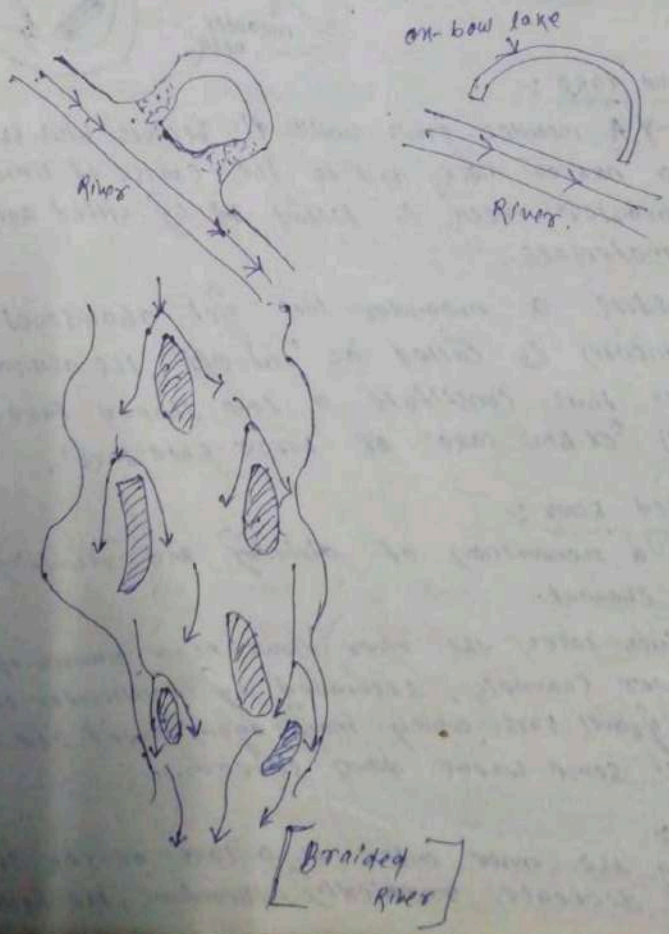
(v) Delta :-

→ When the river enter to a lake or sea its velocity decrease rapidly, therefore, the heavier

material is laid down first and the finer material is carried further out.

→ Thus the load brought by the river gets deposited at its mouth, which gives rise to what is known as a 'delta'. These deposites are triangular in outer line and resemble the Greek letter 'Δ' (Delta)

→ on the basis of the shape like deltas, are classified as (1) Arcuate Delta
(2) Bird-foot Delta
(3) Cuspate Delta.



* Geomorphic features produced by wind action :-

Wind action is clearly visible in semi-arid and arid regions. But it [illegible] in deserts. Aeolian topography is created by the geological action of wind. which is divided into three stages are called.

(1) Erosion (2). Transportation (3) Deposition

(1) Erosion :- The erosion caused by wind blowing. The wind accomplishes erosion by three types.

(i) Deflation (ii) Abrasion (iii) Attrition.

(i) Deflation :- Deflation is the process of removal of the soil loose or rock particle along the course of the blowing wind. This process well in dry region with little or no rain falls.

(ii) Abrasion :- It is the sand blast action of wind with sand against the rocks. the loose particles that are blown away by the wind. they move on some rock surface they bring about a scarring of the surface.

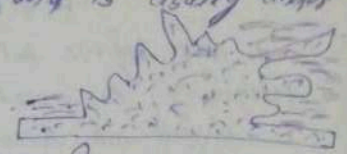
(iii) Attriation :- Attriation is the grinding action of which on transist wind blone particles often collided with one another. such mutual collision brings about a further grinding part of the particle.

* Erosional feature produced by wind action :-

(1) Hamada :- Due to deflation. when the loose particles are burnt away, only the hard mantle is left behind which is known as hamada.

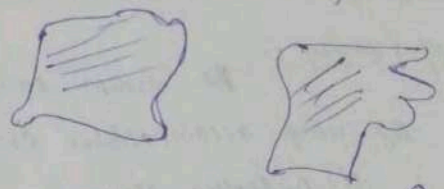
(ii) Yardang :- A grooved or furrowed topography from

Produced by wind abrasion which is elongated in the direction of prevailing winds and is usually cusp out. It known as yardangs.



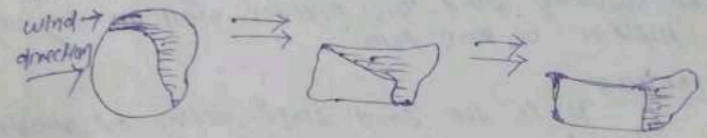
(iii) Pedestral rock :-

A wind rock cap standing on a slender rock column, produced because of wind abrasion is known as 'pedestral rock'.



(iv) Ventifacts :-

These are the pebble faceted by the abrasive effects of wind blown sand. Ventifacts with one smooth surface is called as 'Einkanters' and with three smooth face as left, it is called zwei-kanter.



(v) Honey-comb structure :-

Rock consisting of hard and soft parts get differential abrasion and the resulting feature is known as honey-comb structure.

(vi) Blow-outs :-

These are broad-shallow caves in hills, broad-shallow depression in deserts.

(2) Transportation :-

Wind transportation totally depends on wind-velocity. There are three types of transportation (i) Traction (ii) Saltation (iii) Suspension.

(i) Traction :- where particles are removed through rolling and creeping.

(ii) Saltation :- Here the particles, which are too heavy to remain in suspension and ~~slightly~~ to be transported in traction.

(iii) Suspension :- very light particle like dust and smoke move with the wind quickly but settle very slowly to remain in suspension in the air.

{3} Deposition :-
Wind formed deposits is called deposition. wind is an excellent agent for sorting of materials according to their size, shape or weight. pebbles and boulders can not be carried away.
wind deposits takes two general form as,
(i) sheets (ii) piles.

(i) Sheets :- 'sheet deposites' are the dust deposits laid down on the large area.

(ii) piles :- But 'piles' deposites' include the various type of dunes which accumulate from sand and silt carried in saltation.

* Depositional features produced by wind-action :-

(i) Sand hill :- mounds of sand whose surface is irregular is called sand hill. The shape of dune is controlled by.
→ Amount of sand supply.
→ wind velocity
→ constancy of wind direction.
→ Amount and distribution of vegetative cover.

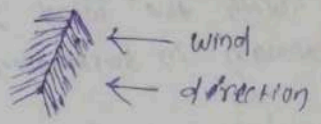
(ii) Sand dune :- when a mead mound is in the form a a round hillock or a ridge with a crest, it is cal

Sand dune.

Types of sand dunes

(i) Transverse dune :-

Elongated dunes form at right angle to the prevailing wind.

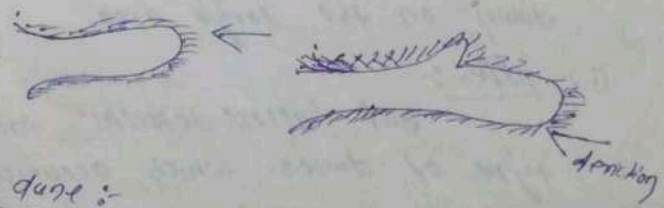


(ii) fore dune :-

Ridge like deposites of wind borned sand formed along the coast of sea or lakes.

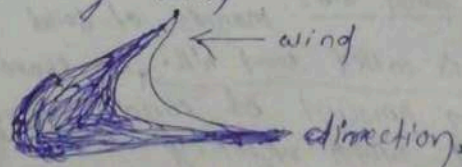
(iii) Longitudinal dunes :-

Elongated ridges of sand found to lie parallel to the direction of blowing wind. They may extend up to 90 kms.



(iv) parabalic dune :-

These are the parabalic shape. their horns points towards the direction of wind opposite to that of the blowing wind



Mineral:- A 'mineral' is naturally occurring homogenious substance which has definite chemical composition and definite atomic structure. The minerals are usually formed by inorganic processes.

The minerals may be devided into two broad groups;

① Rock forming minerals
② Ore forming minerals

"Rock forming minerals" are those which are found in abundance in the rock of the earth crust. "Ore forming minerals" are those which are of economic value and which do not occur in abounddance in rock.

- Few percent of valuable mineral.

Metalic Mineral:- Minerals from which we obtain metals are metalic mineral. have their own ductile etc. [illegible] it have their appearance.

Non metalic mineral:- Don't we obtain metal. But it not ductile.

Mineral
- Crystaline
- Crystaline
- Amorphos

Crystalz:- In this process the minerals are well developed in internal atomic structure and external form.
Example - quartz

Crystaline:- In this process the minerals are well developed internal atomic structure but not external form.

Amorphos:- In this case both the internal atomic structure and external form are not developed.

Physical properties of minerals:

Physical properties of minerals can be determined readily by inspection or by simple test. Because the physical properties are determined in hand specimens. The chief physical properties are colour, streak, lustre, hardness, habit, cleavage, fracture, feel, tenacity, fluorescence, magnetism, specific gravity and crystal form.

Or

① Light :- Colour, lustre, streak,
② state of aggregate :- form, hardness, fracture, cleavage
③ Sense :- feel, smell, test.
④ Special properties :- Magnetism, electrism, etc.

Colours :- It is the appearance of mineral in reflected light.

Ex :- olivine shows olivine colour.
Pyroxine shows white colour.

Streak :- It is the colour of the powder of the minerals.

Ex :- ① Talke show white streak.
② Hemalite show cherry read streak.

Lustre :- The 'lustre' may be defined as the general appearance of a mineral surface in reflected light. The various type of lustre are as follows.

(a) ① Metallic lustre :- Minerals which have the appearance of a metal, are said to a "metallic lustre", Ex :- gold, pyrite and galena.

(b) ② Non-metallic lustre :- The feebly metallic displayed metallic lustre is called the

Hardness
1
2
3
4
5
6
7
8
9
10

submetallic lustre. E.g:- Chromite and hematite

③ Adamantine lustre :- A hard brilliant lustre like that of a diamond is called adamantine lustre, E.g:- transparent corussite.

④ Vitreous Lustre :- It is the lustre exhibited by the broken glass, eg:- quartz (Mineral)

⑤ Pearly Lustre :- It is the lustre exhibited by the pearls, eg:- muscovite, talc and calcite.

⑥ Silky Lustre :- It is the lustre exhibited by the silk fibres, eg:- gypsum.

⑦ Resinous Lustre :- It is the lustre exhibited by the resin, eg. sphalerite.

⑧ Greasy Lustre :- It is the lustre exhibited by the grease, eg. talc and nephaline.

⑨ Dull or earthy Lustre :- Minerals showing no lustre are said to possess dull or earthy lustre, eg. chalk and kaolin.

Hardness :-

It is the resistance of the mineral towards stress or scratch. There is a scale called mohs hardness scale. In this scale there are ten minerals which are arranged in the order of their increasing hardness.

Mohs Scale of hardness

Hardness	Mineral	Remark
1	Talc	Scratched by a finger nail.
2	Gypsum	
3	Calcite	Scratched by a knife.
4	Fluorite	
5	Apatite	
6	Orthoclase	Scratched by knife.
7	Quartz	
8	Topaz	
9	Corundum	Not Scratched by knife.
10	Diamond	

Form/Habit :- Habit of a mineral may be defined as the size and shape of the crystal. The chief habits shown by minerals are as follows.

① Acicular :- Mineral showing needle like crystal, for example, natrolite.

② Fibrous :- Minerals showing an aggregate of long thin fibres, for example, asbestos and satinspar.

③ Foliated :- It occurs as foliated aggregates containing thin separable sheets, for example, muscovite biotite.

④ Bladed :- Mineral showing bladed habit occurs as small knife blades, for example, kyanite.

⑤ Tabular :- Mineral showing broad flat surface, for example, felspar.

⑥ Columnar :- minerals showing columnar crystals, for example, tourmaline.

⑦ Botryoidal :- mineral showing aggregate of rounded masses bunch of grapes. eg. chalcedony.

⑧ Reniform :- mineral showing kidney shaped form eg- kidney-iron-ore.

⑨ Granular :- mineral which occur as aggregate of equidimensional grains, for example, chromite.

⑩ Pisolitic :- minerals occurs as aggregates of rounded grains of a pea size, for example ; bauxite

⑪ Oolitic :- minerals showing an aggregates of bodies resembling fish roe.

⑫ Massive :- When non-crystalline minerals occur as structure (निरवयव) - less mass, their form is described as "massive" for example flint (चकमक पत्थर)

Cleavage :- It is the plane of weakness. broken easily with smooth surface along planes of weak bonding. It may be ① Pinacoidal → one set of cleavage.
② Rhombic → 3 " " "
③ octahedral → 4 " " "
④ Prismatic →

Fracture :- The nature of broken surface is called fracture. The common type of fracture are as follows.

① Conchoidal :- It is a curved fracture surface showing concentric lines like a shell. quartz and glass are show conchoidal fracture.

② Even fracture :- It is a fracture surface which is almost flat. flint shows even fracture.

③ Uneven fracture :- It is a fracture surface which is irregular and rough. A large number of minerals show uneven fracture.

④ Hackly fracture :- It is a surface fracture which is rough with sharp and jagged points. Native metal show hackly fracture.

Feel :-
Feel is the sensation often upon touching or handling minerals. The different type of feel are "greasy", "rough" and "harsh", the example of greasy feel is talc.

Magnetism :- A few minerals are attract by a magnet. of these minerals magnetite and pyrrhotite are the most common example.

Specific gravity is a number which represent the weight of a mineral and the weight of an equal volume of water. Thus a mineral with specific gravity 4.0 is four times as heavy as water. The specific gravity of common silicate mineral is about 2.65.

$$\text{Specific gravity} = \frac{W_1}{W_1 - W_2}$$

Where,

W_1 = weight of the mineral in air.

W_2 = weight of the mineral water.

Common ore forming minerals :-

(i) Quartz : SiO_2

Crystal system - Hexagonal
Cleavage - Absent
Hardness - 7
Sp. gr - 2.65
Fracture - Concoidal
Luster - Vitreous
Colour - Colourless
Habit - Massive

Occurrance :- quartz occurrance in most igneous, metamorphic and sedimentary rock. Some sandstones and quartzites are composed allmost entirely of quartz.

use :-

(i) In the form of sand it is used as construction material.

(ii) Quartz is used as a flux in industries.

(iii) Quartz is used as oscillators in electrical equipment such as watch.

2. Felspar group :-

The felspar are the most abundant of all minerals. They fall into two main groups : (i) K-Na felspar, are called "alkali felspar", and (ii) Ca-Na felspar, called "plagioclase feespar".

Form – generally tabular.
Colour – White, grey, pink, green
Lustre – vitreous
Streak – white
Hardness – 6.
Cleavage – good
Fracture –
Sp. gr – 2.25

Occurrence :-

The alkile felspar which include orthoclase and albite, have a similar occurrence. They are commonly found in igneous rock such as granite, pegmatites, syenites and trachytes.

Use :-

3. Muscovite : $KAl_2(AlSi_3O_{10})(OH)_2$

Form – Tabular crystals, foliated.
Colour – colourless
Lustre – pearly or silky
Streak –
Hardness – 2
Cleavage – perfect basal
Fracture –
Sp. gr – 2.76 – 2.88

Occurrence :-

Muscovite is a characteristic mineral of granites and granite pegmatite.

Use:-

(i) Muscovite used as a dielectric in electrical industries.

(ii) Muscovite is also used for heat resistants supports and windows.

4⇒ Biotite : $K(Mg, Fe)_3 (AlSi_3O_{10})(OH)_2$

Form – Irregular foliated masses. (Rectangular shapes)
Colour – dark green, brown.
Lusture – Pearly
Streak –
Hardness – 3
Cleavage – Perfect basal.
Fracture –
Sp. gr. – 2.8 to 3.2

Occurrence :-

Bothite is found in granite, syenites and schists.

5⇒ Chlorite group : $(Mg, Fe, Al)_6 (Al, Si)_4 O_{10}(OH)_8$

Form – Foliated masses.
Colour – Green of various shades.
Lusture – Vitreous or dull.
Streak –
Hardness – 2 - 2½.
Fracture –
Cleavage – Perfect basal
Sp. gr – 2.6 - 3.3

Occurrence :-

Chlorite is a common mineral in low grade metamorphic rocks, such as Chlorite schists.

6) Olivine Group : $(Mg, Fe)_2 SiO_4$

Form - Granular
colour - Yellow green or olivine
Lustre - vitreous
Streak -
Hardness - 6½ - 7
Fracture - Conchoidal
Cleavage -
Sp. gr. - 3.27 to 4.37

Occurrence :-

Olivine occurs mainly in the dark coloured igneous rocks such as gabbro, peridotite, and basal.

7) Calcite : $CaCO_3$

Form - Tabular
Colour - White to colourless.
Lustre - Vitreous
Streak - ~~Gre~~ white
Hardness - 3
Fracture - even
Cleavage - perfect
Sp. gr - 2.71

Occurrence :-

The origin of calcite may be igneous as in intrasive carbonatites, sedimentary such as limestone and metamorphic as in marbles. Calcite are also found in various rock.

Use :-

The most important use of calcite is for the manufacture of the cement and lime. Calcite is also used as flux in the smelting of ore and as a fertilizer.

8 ⇒ Dolomite: $CaMg(CO_3)_2$

Form - granular or massive.
Colour - White
Lustre - Vitreous to pearly
Streak -
Hardness - 3½ - 4
Fracture -
Cleavage - Perfect rhombohedral.
Sp. gr. - 2.85

Occurrence :-

Dolomite occurs as extensive sedimentary rock

Use :-

① As a building and ornamental stone.
② In the manufacture of refractory bricks furnace linings.

9 ⇒ Tourmaline : $Na(Mg,Fe)Al_6(BO_3)_3Si_6O_{18}(OH)_4$

Form -
Colour - black, Brown, colourless, pink, green and blue.
Lustre - Vitreous to resinous
Streak -
Hardness - 7 - 7½
Fracture -
Cleavage - very poor
Sp. gr. - 3.0 to 3.25

Occurrence :-

Tourmaline occurs commonly in granite-pegmatites or in some granite which have undergone metasomatism by boron rich fluids.

Use :- It is used manufacture of pressure gauges.

10 => Pyrite : FeS_2

Form - Massive or granular.
Colour - brass yellow.
Lusture - metallic
Streak - greenish or brownish
Hardness - 6 - 6½
Fracture - conchoidal
Cleavage -
Sp. gr. - 5.02

Occurrence :-
Pyrite is the most common mineral. It is found in hydrothermal veins, contact metamorphic deposite and as an accessory mineral in sedimentary rocks.

Uses :-
It is used for the manufacture of sulfuric acid.

11 => Chalcopyrite : $CuFeS_2$

Crystal system - Tetragonal
Form - Massive and compact.
Colour - brass yellow
Lusture - Metallic
Streak - greenish black.
Hardness - 3½ - 4
Fracture - uneven
Cleavage - Poor
Sp. gr. - 4.28

Occurrence :- It is the most commonest copper mineral. It is

found in hydrothermal veins.

Uses :- An important ore of copper.

12 => Galena : PbS

Crystal system - cubic

form - often cubic crystals and also massive.
Colour - lead grey
Lustre - bright metallic
Streak - lead grey
Hardness - 2½
Fracture - stepped fracture.
Cleavage - perfect cubic
Sp. gr. - 7.4 - 7.6

Occurrence :-

Galena is commonly found in hydrothermal sulphide veins associated with pyrite, chalcopyrite etc. It is also associated with silver mineral.

Uses :-

An important ore of lead and silver.

13 => Sphalerite : ZnS

Crystal system :-

Form - massive
colour - yellow, brown to black.
Lustre - resinous.
Streak - brown to yellow
Hardness - 3½ - 4
Fracture - conchoidal
Cleavage - Perfect
Sp. gr. - 3.9 to 4.1

Occurrence :-
Sphalerite occurs in hydrothermal veins. It is often associated with galena and other sulphides.

Uses :-
principal ore of zinc.

14 ⇒ Hematite : Fe_2O_3

crystal system :- hexagonal
form - massive
colour - reddish brown to black
Lustre - metallic to dull
Streak - dark red
Hardness - 5 - 6
Fracture -
Cleavage - absent
Sp. gr. - 5.26

Occurrence :-
It is found in metamorphosed sediments and contact metamorphic deposits.

Uses :-
Mainly iron ore.

15 ⇒ Magnetite : Fe_3O_4

crystal system :- cubic
form - massive or granular
colour - iron-black
Lustre - metallic to dull
Hardness - 5 to 6
Fracture -
Cleavage - absent
Streak - black
Sp. gr. - 5.18

Occurrence :-

Magnetite is a high temperature mineral. It occurs in igneous rocks.

Uses :-

Magnetite is an important ore of iron.

1. Layers of atmosphere
a. (Convex concave

-: Petrology :-

Petrology :- It is the branch of geology which deals with the study of rock science is known as petrology. It is devided into two parts,

(i) Petrogenesis
(ii) Petrography

Petrogenesis :- It is include origin and mode of occurrence as well as natural history of rocks.

Petrography :- It deals with the classification and description of rocks.

Rock :-

Rock is defined as aggregates of minerals.

classification of rock :-

According to mode of origin all rock are catagorised into three parts.

(i) Igneous / primary rocks
(ii) Sedimentary / secondary rocks.
(iii) Metamorphic rocks.

Igneous Rocks :-

These are the rocks formed by the solidification of magma either underneath the surface or above it. accordingly they are devided into two groups :

(a) Intrusive bodies (b) Extrusive bodies.

(a) Intrusive bodies :
Which are formed underneath of the surface of the earth.

(b) Extrusive bodies :-
These are due to the consolidation of magma above the surface of the earth. These are also known as volcanic rocks. It is of two types,

(i) Plutonic rocks (ii) Hypabyssal rocks

(i) Plutonic rocks :-
Which are formed at very great depth.

(ii) Hypabyssal rocks :-
Which are formed at shallow depth.

Important features of igneous rocks :-
i) Generally hard, massive, compact with interlocking grains.
ii) Entire absence of fossils.
iii) Absence of bedding planes.
iv) Enclosing rocks are baked.
v) Usually contain much feldspar.

* Volcano :- A volcano is an opening in the earth's crust through which Lava, Volcanic ash and gases escape. (A mountain typically conical, having a crater or vent through which Lava and ash has been erupted.

Magma :- Magma is a hot viscous, siliceous melt from the earth containing water vapour and gases. It comes from great depth bellow the earth's surface. It's composed mainly of O, Si, Al, Fe, Ca, Mg and K.

Lava :-
When a magma comes out upon the earth's surface, it looses its gases. Such a magma is called 'Lava'.

Chemical composition of igneous rock:

Acid and Basic rocks:

The composition of igneous rocks depends upon the composition of the magma from which they are originated. Magmas are divided into two broad groups: (i) Acid magma (ii) Basic magma.

Acid magma:

The "acid magma" is rich in Si, Na and K, and poor in Ca, Mg, Fe.

Basic magma:-

The "basic magma" on the other hand, is rich in Ca, Mg and Fe, and poor in Si, Na and K.

On the basic of the silica percentage present, igneous rocks are classified into the following groups.

(i) Ultrabasic rocks:- These contain less than 45% silica, e.g. peridotite.

(ii) Basic rocks:- These contain silica left 45% and 55%, e.g. gabbro and basalt.

(iii) Intermediate Rocks:- These contain silica left 55% and 65%, eg. diorite.

(iv) Acid rocks:- These contain silica more than 65% silica; eg. granite.

Acid rocks:

In general, acid rocks are light in colour, low in specific gravity. It is also called the "Basic rocks" eg. granite.

Basic rocks:

Dark in colour, relatively high in specific gravity and contain mainly silica poor minerals such as olivine, pyroxene, biotite and little or no quartz. It's also called 'mafic' rocks.

* Texture of igneous rock :-

'Texture' means the size shape and arrangement of mineral grains in a rock. The grain size of an igneous rock depends on the rate of cooling of magma. In general slower is the rate of the cooling, the coarser is the grain of the rock. In the study of texture four points are considered. These points are:

(i) Degree of crystallization
(ii) Size of grain
(iii) Shape of crystals.
(iv) Mutual relation btn mineral grain.

(i) Related Degree of crystallization :-

On the basis of degree of crystallization texture of igneous rock devided into the following groups:

(a) Holocrystalline texture.
(b) Holohyaline texture.
(c) Hemicrystalline texture.

(a) Holocrystalline texture :-

When the rock is made up entirely of crystals. Its texture is described as "holocrystalline".

(b) Holohyaline texture :-

When the rock is entirely of glassy material. Its texture is called "holohyaline texture".

(c) Hemicrystalline texture :- When a rock composed partly of crystals and partly of glass. The texture called "hemicrystalline".

(ii) Size of grain :-

The size of grain in igneous rock varies considerably. The slow cooling gives crystals time to grow to size greater than 5 mm. On rapid cooling the mineral grain crystallize quickly which are generally less than one millimeter in size. In some lavas, the cooling is so rapid that they fail to crystallize and "glassy texture" results. Igneous rock whose constituent mineral grains can be seen with the naked eye are described as 'phaneric', while those whose mineral grains are too small to be seen with the naked eyes are called "aphantic".

* The texture of 'phaneric' rock sub-devided into three parts;

(a) coarse grained texture :-

If the grains of a rock more than 5mm in diameter, it's texture is said to be "coarse grained".

(b) medium grained texture :-

If this size the grains lies in between 5 mm, the rock is denoted as medium grained.

(c) fine grain texture :-

The diameter of the size less than 1 mm. The texture of the rock is called fine grain texture.

* The texture of 'aphanitic' rock sub-devided in to two parts;

(a) If the mineral grains are can be distinguish under a microscope, the rock said to be microcrystalline texture.

(b) Cryptocrystalline texture :-

the crystals are very small and there are not visible under the microscope but their presence can be felt as they react to the polarized light.

(iii) Shape of crystals :-

The grain of an igneous rock are called 'euhedral', if they show well developed crystal faces, and if the crystal faces are partly developed, they are described as "subhedral". The term "anhedral" is used for those grains in which crystal faces are absent.

(iv) Mutual relations of grains :-

It is also devided into four parts such as;

(a) Equigranular texture.
(b) Inequigranular texture.
(c) Directive texture.
(d) Intergrowth texture.

(a) Equigranular texture :-

Igneous rocks containing mineral grain of more or less equal size are said to have an equigranular texture. It is of following types;

(i) panidiomorphic texture :-

When most of the grains are euhedral. the texture of the rock is called 'panidiomorphic' and these texture generally found in lamprophyres.

(ii) Hypidiomorphic texture :-

When most of the crystals are subhedral the texture it is called hypidiomorphic.

(iii) Allotriomorphic texture :-

When most of the mineral are an-hedral. The texture is called Allotriomorphic.

(d) The crystals of these fine grained are commonly anhydral or sub-hedral. Such texture is called microgranular texture.

(e) orthophyric texture :-
Some highly felspathic rocks possess a fine grained panidiomorphic texture. The texture is called orthophyric.

(f) Inequigranular textural :-
Igneous rocks showing variations in the size of mineral grains are said to have the inequigranular texture.

* Common igneous rock types :-

1. Granite :-

Nature :- Plutonic rock, Acidic, light coloured.

Mineral composition :- Essential minerals are K-felspar and quartz.

Texture :- Textures vary from fine to very coarse. Equigranular texture is common

Varieties :- Granites are named according to the main accessory minerals such as, biotite granite, hornblende granite etc.

occurrence :- Granites commonly occur as major intrusive bodies such as batholiths and stocks. The granites are considered to be the result of crystallizing from melts at relatively low temperature.

2. Diorite :-

Nature :- plutonic rock, composition intermediate between acid and basic.

Mineral composition :- principal mineral is plagioclase feldspar. Hornblende is the dark colored dark mineral. Biotite is also present. Pyroxenes are rare. mafic minerals are present in sufficient the amount to give the rock a dark appearance.

Texture :- Equigranular, coarse to medium grained.

occurance :- Diorite occurs as marginal facies of granite. may also occure as stocks and lacco.

3. Gabbro :—

Natural :- plutonic rock, basic. dark coloured.

Mineral composition :- plagioclase minerals feldspar and mafic minerals are present in equal amount. olivines are also present in most gabbro. Accessory minerals are Biotite, hornblende and ilmenite.

Texture :- Equigranular. coarse to medium grained.

Occurrence :- Gabbro occures in all form of intrusive igneous bodies.

4. Basalt :-

Nature :- volcanic equivalent of gabbro. composition basic to ultra basic. Dark coloured.

Mineral composition :- Essential minerals are augite and iron oxide. olivine is also present.

Texture :- Fine grained to glassy. porphyritic texture common.

occurrence :- Basalts are the most abundant of the volcanic rocks and form extensive lava flows. Basalt is widely found forming many small dykes.

5. Rhyolite :-

Nature :- Fine grained rock. volcanic equivalent of granite. Acidic. of light coloured.

Mineral composition :-

Mineral composition of rhyolite is similar to that of granite. Essential minerals are alkali feldspar and quartz.

Texture :- fine grained

occurrence :- Rhyolites commonly occur in lava flows.

6. Pegmatites :-

Nature :- Extremely coarse grained. commonly associated with granites their composition is usually granite.

Mineral composition :- It contains common minerals found in granites but they are of extremely large size. These minerals are quartz, feldspar and mica.

Texture :- Extremely coarse grained and irregular. The constituent minerals are 2cm or more than in size.

occurrence :- Pegmatites are closely related to generally to large masses of plutonic rocks. They may be found as dense dykes or veins. traversing the plutonic and igneous rock.

* **Sedimentary Rocks:-**

These rocks have been derived from the pre-existing rocks, through the process of erosion, transportation and deposition by various natural agencies like, wind, water glacier, etc. The loose sediments, which are deposited undergo the processes of compaction and the resulting product are known as sedimentary rocks.

* **Classification of Sedimentary rocks:-**

On the basis of place of formation, sedimentary rocks, which are devided into two parts,

(i) sedentary rocks (Residual deposites)
(ii) Transported.

(i) **sedentary rocks:-**

That are the residual deposites, formed at the site of the pre-existing rocks from which they have been derived. These are not formed by the process of transportation.

(ii) **Transported:-**

In which case the disintegrated and decomposed rock materials are transported from the place of their origine and get deposited at a suitable site. According to mode of transportation of deposited these rocks are sub devided in to three types,

(a) mechanically deposited. (clastic rocks)
(b) chemically deposited.
(c) organically deposited.

Sedimentary

Important features of sedimentary rocks :-

(i) Generally soft.
(ii) Fossils common.
(iii) Stratification, lamination, cross-bedding, ripple marks mud-cracks etc. are the usual structures.
(iv) quartz, clay minerals, calcite, dolomite, hematite are the common minerals.

Epigenesis : physical comparison of something (especially with respect to the size and shape of the constituents of a substance)

* Formation of sedimentary rocks:-

The formation of sedimentary rocks takes place in three stages:

(i) Weathering and erosion of preexisting rocks.
(ii) Sedimentation.
(iii) Lithification and diagenesis.

(i) Weathering and erosion of preexisting rocks:-

During weathering and erosion, the pre-existing rocks and their constituent minerals are broken down. The material thus product is called 'sediment'. The sediments are usually transported and deposited in areas of accumulation by the action of water, glacier and wind action. During transportation the sediments are deposited according to size. Bigger rocks such as gravel, they settel first. sands are next and clay are depositied in last.

(ii) Sedimentation:-

The process of accumulation of sediments at a site of deposition is called "sedimentation". Sedimentation is the intermediate stage in the formation of sedimentary rocks.

(iii) Lithification and Diagenesis:-

'Lithification' is a process by which soft or loose sediments are converted into hard and firm rocks. This process is called "consolidation" during this process many more physical or chemical changes takes place within the sediments. such

changes are called "diagenetic" changes and the process is described as "diagenesis". It is of three process.

(a) compaction.
(b) cementation.
(c) Recrystallization

* Common sedimentary rock types:-

1. Conglomerate:-

Nature:- Consolidated gravels. Colour variable.

Mineral composition:- Rounded pebbles are set in a fine grained sandy matrix. The matrix commonly consists of sand. and it is cemented by silicat and iron oxide.

Texture:- Very coarse grained.

2. Sandstone:-

Nature:- Arenaceous, colour variable according to the type of cementing minerals. Rocks having calcite as their cementing material are light in colour.

Mineral composition:- Quartz is the chief mineral constituent. small amount of feldspar, mica garnet, etc. It may occur cementing material Silica, calcite, iron oxide clay.

Texture:- It composed sub angular to rounded sand grains. The texture of sandstone is 'coarse grained' when the grain is 2 to 0.5 mm.

3. Shale :-

Nature :- Argillaceous. colour variable. shales are often soft and scratched by a knife.

Mineral composition :- shales are composed mainly of clay minerals like kaolinite and illite. small amount of other mineral like quartz, mica and chlorite.

Texture :- very fine grained with grain size less than 0.01mm.

4. Limestone :-

Nature :- calcerious rocks. formed chemically or organically generally white, grey or cream coloured. often contain fossils.

Mineral composition :- calcium carbonate is the chief constituent. magnesium carbonate is also present in variable amount. silt and clays are present as impurities

Textual :- Limestone is a fine grained rocks. it is commonly compact and massive.

5. Dolomite :-

Nature :- Dolomites resemble limestones.

Mineral composition :- The chief constituent of dolomite rock is dolomite mineral. It may also contains some calcite

Stress - Force per unit area

* Metamorphic Rocks :-

These are formed by the alteration of pre-existing rocks by the action of temperature, pressure and chemical active fluids and gases.

* Important features of the metamorphic rocks :-

(i) Generally hard, interlocking grains and bedded.
(ii) Fossils are rarely preserved in rocks of sedimentary origin except slates.
(iii) Foliated, gneissose, schistose, granulose, slaty etc are the common structure.
(iv) Common minerals are sillimanite, kyanite, cordierite, garnet and graphite etc.

* Process of metamorphism :-

The process which operate together in the effected rock to bring about metamorphism are,
(i) granulation (ii) plastic deformation (iii) Recrystallization (iv) metasomatism.

(i) granulation :-

Pressure shatters rocks and the fracture is so great that the rock are partially melted. This process where crushing of rocks takes place without loss of cohesion, is called "Granulation". (सुसंगत)

(ii) Plastic deformation :-

When a solid is subjected to stresses its shape changes. on the removal of the stresses if the solid does not regain its original shape, it is said to be "plastic deformation".

(iii) Recrystallization :-

It means, either the formation

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(iii) Recrystallization :-

It means either the formation

new mineral or formation of new crystals of the pre-existing minerals. Recrystallization causes mineralogical and textural changes in rocks during metamorphism.

(iv) Metasomatism :-

"Metasomatism" is the process, in which the original composition of the rock are changed primarily by the addition or removal of mineral. This changes is caused by the movement of hydrothermal fluids through rocks occurring under high temperature and pressure.

* Textures of metamorphic rocks :-

(i) crystalloblastic texture :-

The holocrystalline texture of metamorphic rock is called the "crystalloblastic texture". This texture developed due to recrystallization of minerals grains in the solid medium. The crystals showing perfect crystal outline, are called the "idioblasts" while those which do not have any definite shape, are termed as "xenoblasts".

(ii) porphyroblastic texture :-

When idioblasts occur as large crystals embedded in a fine grained groundmass, the texture is called "porphyroblastic texture".

(iii) Granoblastic texture :-

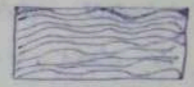
In the metamorphic rock if the major constituents are granular or equidimensional, the texture is named "granoblastic".

(iv) Palimpest texture :- The remnant texture of the parent rock found preserved in the metamorphic rocks, is called "palimpest texture".

* Structure of metamorphic rocks :-

(i) Cataclastic structure :-

It is found in rocks such as crush breccias and mylonites. It formed mainly under the influence of shearing stresses in the upper zone of the earth crust. Harder constituent of minerals rocks are broken into pieces while softer one are crushed to powder.



(ii) Maculose structure :-

The spots in the spotted rocks are due to the development of bigger crystals of some minerals within the fine grained groundmass. This structure is called the "maculose structure".

(iii) Slaty structure :-

The slaty structure is caused due to the parallel orientation of (platy) flaky minerals, mainly mica and chlorite slaty rocks split readily into thin sheets.

(iv) Schistose structure :-

A foliated rocks which is coarse grained and it is largely composed of flaky and platy minerals is called "schist". The foliation of schists is called "schistosity".

(v) Gneissose structure :-

In rocks that have been recrystallization under condition of high grade metamorphism, the light and dark minerals may segregate into alternate bands parallel to the schistosity. Such a coarse grained metamorphic rocks showing banded appearance is called "gneiss" and its structure is called the "Gneissose structure".

(vi) Granulose structure:-
Granulose structure is produced product due to predominance of equidimensional mineral such as quartz, feldspar, and calcite.

(vii) Hornfelsic structure:-
Hornfelsic structure is characteristic of contact metamorphic rocks is called "hornfels". A hornfels is dark, compact, and fine grained rocks.

* Some common metamorphic rocks:-

(1) Slate:-
Nature:- slates are dark coloured exceedingly fine grained low grade metamorphic rocks.

Mineral composition:- slates are composed of a very fine grained mixture of mica and chlorite with some quartz and feldspar.

Texture:- slates are very fine grained rocks which show slaty cleavage.

2. Phyllite:-
Nature:- A phyllite is a fine grained foliated lustrous rock.

Mineral composition:- It consists of chlorite, muscovite and quartz.

Texture and structure:- It is a fine grained rocks foliated structure. It split easily with an uneven surface.

3. Schist :-

Nature :- It is coarse grained metamorphic rocks. well developed foliation. The rock may be easily broken.

Mineral composition :- mica-schists consists essentially of quartz and mica usually moscovite or biotite.

Texture and structure :- It is coarse grained rocks. They splits easily into thin sheets along the planes of schistosity.

Origin :- Schists are generally the product of regional metamorphism.

4. Gneiss :-

Nature :- A gneiss rock is a coarse grained, banded metamorphic rock having poor schistosity. A gneiss has usually a light colour.

Mineral composition :- quartz and felspar occur together in light coloured bands. Generally quartz and felspars predominate over micaceous minerals.

Texture :- Gneisses are coarsed grained rocks having gneissose structure.

5. Quartzite :-

Nature :- A quartzite is a hard and siliceous metamorphic rocks having granular texture.

Mineral composition :- quartzite are composed essentially of quartz with small amount of

mica, tourmaline and iron minerals.

Texture :- A quartzite is a compact rock of interlocking quartz grains. Its structure is granulose.

origin :- quartzite are derived from sandstones by high grade metamorphism.

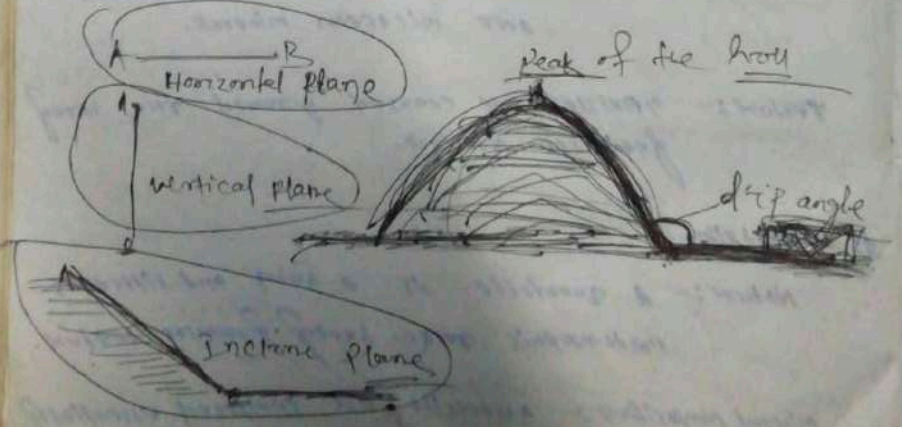
b. Marble :-

Nature :- A marble is crystaline calcarious metamorphic rock having granular texture. marbles are generally white.

Mineral composition :- A marble is composed of grains calcite.

Texture :- The marble show granulose structure.

origin :- marble are formed as a result of metamorphism of lime stones.

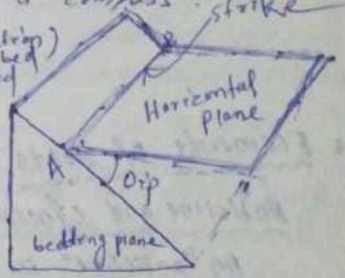


Structural Geology

What is dip ?

The angle of inclination of a rock bed with horizontal plane is called "dip". It is measured in a plane perpendicular to the strike. The dip is a vector quantity. The dip angle is measured with a clainometer and deriction is measured with a compass.

(Dip is a vector quantity → Magnetude and Direction)
Dip varies from (0 to 90°). for Horizontal bed Dip = 0°. and Vertical bed Dip = 90°



(True dip > Apparent dip)

Types of dip :-

These are of two types,

(i) True dip
(ii) Apparent dip

'AB' = strikeline

(i) True dip :-

The "true dip" is defined as the maximum angle of dip on a rock bed. It's measured to the direction at right angles to the strike.

(ii) Apparent dip :-

A dip measured in any other deriction than the true dip is called "apparent dip". An apparent dip will always have a value less than the true dip.

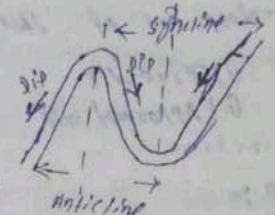
Strike :-

The strike may be defined as the derition of the line formed by the intersection of a bedding plane and a horizontal plane. Strike is scalar quantities. The strike is always at right angles to the true dip direction (Dip and strike are at right angle to each other) It's always (N-S direction)

* Folds :-

"Folds" may be defined as any wavy undulation in the rock beds. The rock is generally horizontal. They are best displayed by the sedimentary rocks. The size of folds vary greatly. It has two parts crest (convex) is the top part and trough (concave) is the bottom of the part.

* Elements of folds :-



Anticline and Synchline :-

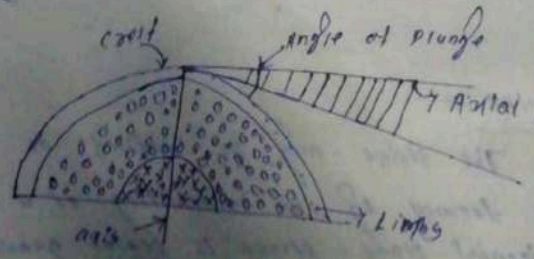
An "anticline" is up-fold where the limbs dip away from each other. A "synchline" is a down-fold. where the limbs dip towards the axis of the fold on either side.

Crest :-

The highest point on the anticline is called the "crest".

Trough :- The lowest point on the synchline is called "trough".

* Part of the fold :-



Limbs:- The sloping sides of a fold form coast to trough are called the "limbs".

Axial plane:- It is an imaginary plane which devides a fold into two equal halves (

Axis of fold:-
An "axis of fold" is defined as the line of intersection between the axial plane and the surface of any of the other constituent rock bed.

Plunge of fold:-
Folds having inclined axes are called "plunging folds". The angle of inclination of a fold axis is with horizontal is called "angle of plunge". The direction in which this axis is inclined called the angle direction of plunge.

Types of fold:-
Folds have been classified into various type, on the following basis:-

(a) Appearance of cross-section,
(b) Symmetry of fold,
(c) Interlimb-angle,
(d) Attitude of fold,
(e) mechanism of fold,
(f) origin: (i) Tectonic-origin (ii) Non-tectonic-origin
(g) Thickness of limb,
(h) Special types.

(a) Appearance in cross-section :-
The following types of folds have been recognised, on this basis.

(i) Antiform :- Any upwardly convex structure is termed as an antiform.

(ii) Synform :- Any upwardly concave structure, i.e., flexure in the form of a trough is known as Synform.

(iii) Anticline :- It is generally convex upwards where the limbs commonly slope away from the axial plane.

(iv) Syncline :-
It is a fold which is concave upward and the commonly dip towards the axial plane. Younger beds are found towards the center of the curvature of the fold.

(v) Anticlinorium :-


(Anticlinorium)

A large anticline with secondary folds of smaller size developed on it.

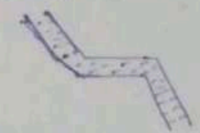

(Synclinorium)

(vi) Synclinorium :- It is a large Syncline with secondary folds of smaller size developed on it.

(vii) Anticlinal bend or monocline :- It is due to local
(viii) steepening of a bed, where of they sudden increase in the dip of a bed which is originally horizontal to near a vertical position.

(vii) Structural bench or structural terrace :-

In case of a dipping bed, due to local flattening of the beds, at a particular step. there original dip without any change in the direction of dip. These are also known as "structural bench".



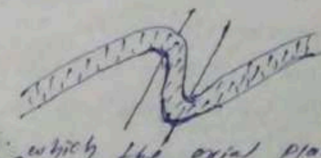
B. Symmetry of fold :-

Six types of folds have been recognised on the basis of symmetry of fold, as follows;

(i) Symmetrical fold :-

When the axial plane is vertical and bisects the fold, the fold is said to be a symmetrical or upright fold.

(ii) Asymmetrical fold :- If the axial plane has dip, the fold is described as "inclined or asymmetric fold". In this case both the limbs dip at different angles and the axial plane cannot devided the fold into two symmetrical halves.



(iii) Recumbent fold :-

It is an overturned fold, in which the axial plane is horizontal or more nearly so.

(iv) Isoclinal fold :- When the limbs have the same amount of dip, towards the same direction, it is known as Isoclinal fold.

(v) over-turned fold :- These are also known as "over folds". Here the axial plane is inclined and both the limbs dip in the same direction.

Faults

Fault:- A fault may be defined as a fracture along which blocks of rock have been displaced relative to each other.

Fault terminology:-

Fault plane:- The fracture surface along which relative movement has taken place, is called a 'fault plane'.

Hade:- The 'hade' of a fault is the angle of inclination of fault plane measured from vertical. It includes both the angle and direction.

Dip:- The dip is the angle ~~of~~ ~~fault~~ fault plane makes with a horizontal surface.

Strike:- The 'strike' of a fault is the direction of its continuity on the ground surface.

Throw:- The vertical component of the displacement of fractured rock blocks, is called throw of fault. The side of which the strata appear to have thrown down is called 'down thrown side' and thrown on up is called "up thrown side".

Heave:- The horizontal component of the displacement of a fault is called the 'heave'.

Net slip:- The total displacement measured along the fault plane is called the "net slip". It has two component. Strike slip and dip slip.

Dip slip :-
Dip slip is the movement parallel to the direction of dip of the fault plane. The movement which is parallel to the strike of the fault is called strike slip.

Fault scarp :- It is a cliff formed initially along the up-thrown side of a fault.

Hanging wall :- If the fault plane is not vertical, the block of rock lying above it is known as hanging wall.

Foot wall :- The block how the fault plane is known as foot wall.

Fault zone :- Most of the fault planes are associated with a zone of crushed rock. This zone is called "fault zone".

* Classification of faults :-

*(A) On the basis of apparent movement the faults are classified in two groups : (i) Normal - fault (ii) Reverse fault.

(i) Normal fault :- A "normal fault" is one in which the hanging wall appears to have moved downward relative to the foot wall. In this case the fault plane dips towards the down-thrown side. Generally normal faults are produced by tensional force and they are also called 'gravity faults'. Normal faults

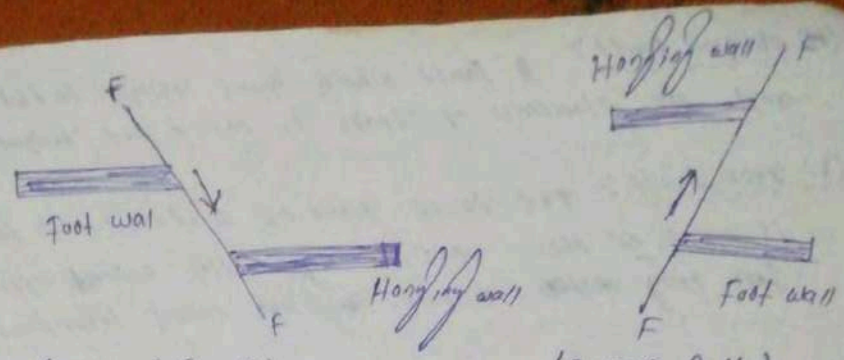
Revers
the
relat
plane
fault

(B) on
fault
(i)
(ii)

(i) Dip fa
to th

(ii) Strike
Stream

(iii) Bed
along
perpen



Reverse fault :- A "reverse fault" is one in which the hanging wall appears to have moved upward relative to the foot wall. In this case the faults plane dips towards the up-throw side. The reverse faults are generally high angle fault.

(B) on the basis of relationship b/w the strike of a fault. The faults are classified into 5 groups:
(i) Dip fault (ii) Strike fault (iii) bedding fault
(iv) Oblique fault (v) Tear fault.

(i) Dip fault :- A fault which strikes approximately parallel to the dip direction of beds, is called the dip fault.

(ii) Strike fault :- A fault which runs parallel to the streak of strata, is called streak fault.

(iii) Bedding fault :- A bedding fault is one which occurs along a contact b/w beds of different or same lithology.

(iv) Oblique fault :- A fault which runs oblique to the strike and dip directions of strata is called the "oblique fault".

(v) Tear fault :- The fault plane of a strike-slip fault is more or less vertical and often extends for long distance. They are called tear fault.

(c) On the basis of the degree of dip, the faults are classified into two groups,

(i) Low angle faults (ii) High angle fault.

(i) High angle fault :- The 'high angle faults' are those which have a dip greater than 45°. Normal faults are commonly high angle faults.

(ii) Low angle faults :- The low angle faults which are those which have a dip less than 45°. Thrust faults are commonly low angle fault

(iii) Thrust fault :- It is a low angle reverse fault.

Joints

* **Joints:-** When rock masses are subjected to tensional or compressional forces, regular or irregular fractures develop in them. Such fractures has been no relative displacement are called joints. Joints occur in almost every type of rock. They may be vertical, inclined or even horizontal.

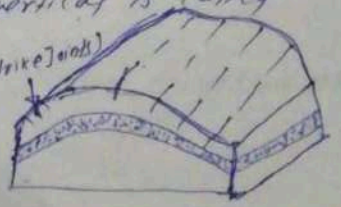
* **Description:-**

Joint set:- A series of parallel joints is called 'Joint set'.

Joint system:- Two or more joints sets intersecting each other, produced a joint system.

conjugate system:- Two sets of joints nearly at right angles to one another, produced by the same stress system. is known as conjugate system.

master joint:- A persistent joint or sets which may be horizontal or vertical is called 'master joint'.



* **Classification of joints:-**

Depending on the mode of formation, the joints are classified in to two groups;

(i) Tension joints (ii) shear joints

(i) **Tension joints:-** 'Tension joints' are those which are formed as a result of tensional force. These joints are relatively open and rough and irregular surface.

(ii) **shear joints:-** 'shear joint' are those which are

(i)

(ii)

(iii)

(iv)

(v)

(vi)

(vii)

(viii)

(ix)

(x)

(xi)

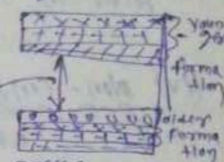
(xii)

Unconformities

Unconformities :- Major break in sedimentation are called unconformities. It is erosional and non-depositional surface which separates younger series of rocks from the older series.

How to developed or formation :-

The formation of an unconformities may be defined as several types given bellow:

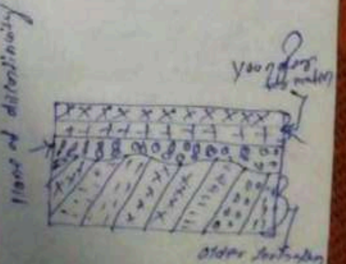


(i) The formation of older rocks.
(ii) Breaking in deposition
(iii) Erosion/~~and~~ weathering of older rocks.
(iv) The formation of younger succession of beds above the surface of erosion.
(v) conglomorates ~~or~~ surface. (which are more or loss rounded surface)
(vi) second set of younger formation.

Classification of unconformities :-

~~The have~~ unconformities have been classified into several types :

(i) Angular unconformity ~~ies~~.
(ii) Disconformity
(iii) Local unconformity ~~ies~~
(iv) Non-conformity
(v) Blended unconformity



(i) Angular unconformity :-
If the beds under (beneath) the erosion surface are ~~[illegible]~~ tilted so that their is an angular discordance (angle) between the younger and older beds the contact is called an angular unconformity.

(ii) Disconformity :-
The rock beds on opposite sides of a "disconformity" are parallel. Disconformity occurs when the strata of older series have not been tilted or deformed in any way before the younger rock beds were deposited above them.

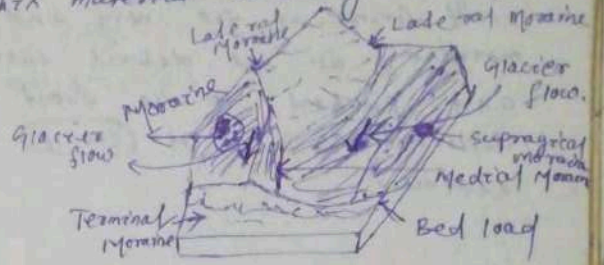
(iii) Local - unconformity :-
It is also known as 'non-depositional' unconformity. It is similar to disconformity, but it is local in extent. The time involved is also short.

(iv) Non - conformity :-
When bedded sedimentary rocks overlie the non bedded igneous mass, the structure is called "non conformity".

(v) Blended unconformity :-
It is a surface of erosion, which may be covered by a thick residual soil that grades into the underlying bed rock.

What is Moraine?

A moraine is material left behind by a moving glacier. This material is usually soil and rock (debris)



Moraine form:-

Glaciers transport all sorts of dirty and boulders that build up to form moraines.

Types of moraine:-

Moraines are devided into four main catagories,

(1) lateral moraine.
(2) medial moraine
(3) supraglacial moraine.
(4) terminal moraine.

(1) Lateral moraine:-

Lateral moraines are formed at the side of the ice flow. The unconsolidated debris can be deposited on top of the glacier.

(2) Medial moraine:-

A medial moraine is a ridge of moraine that runs down the centre of a valley. It forms when two glacier meet and the debris on the edges of the adjacent valley sides join and are carried on top of the enlarged glacier.

(3) Supraglacial moraine:-

Supraglacial moraines are created by debris accumulated on top of glacial ice. This debris can accumulated due to ice flow towards the surface in the ablation zone. melting of the surface

ice that [illegible] the glacier [illegible]

4. Terminal or end moraine :-
It forms at the very end of a glacier. A terminal moraine, all the debris that was scraped up and pushed to the front of the glacier is deposited as a large clump of rocks, soil and sediment.

Unit-4 Element of Crystallography

Crystallography :-
It is a branch of mineralogy which deals with the study of crystal and their growth, external shape and internal structure. most minerals are crystalline while a few are Amorphous (Non-crystalline).

Crystal :-
A solid which possesses (प्राप्त करती) a regular geometrical shape, is called a "crystal". A crystal is bounded by faces, which are parallel to the planes of atoms in the crystal structure. (In addition to face, crystals contains edges and solid angles arranged in a regular order. "edges" are formed where two adjacent faces meet and a "solid angle" is formed where three or more edges emet meet.

Zone :- In many crystals a group of faces are arranged in such a manner that their intersecting edges are parallel to each other. Such faces constitute a "zone".