Paper - V Unit - 6

Folds

Paper V

Folds are defined as bends or curvatures in crustal rocks. Folds are formed by stresses to which rocks have been subjected from time to time in the past history of the earth. Folds may develop in any type of rocks. Fold may have any shape, from simple curvature to complex flextures having complicated geometrical patterns. Thus the bending of rock strata due to compressional forces acting tangentially or horizontal towards a common point or plane from opposite directions is known as folding. The shape and extent of folding ultimately depend on the combined action of a number of factors like the nature, magnitude, direction and duration of the compressional stresses and also on the character of rocks, subjected to such a process.

In general; the phenomenon of folding indicates an effort of the rocks to adjust themselves with changed stress conditions. As a result the rocks are bent into series of archs and troughs. → Folds may be defined as a curved or zig-zag structure shown by rock beds. (wavy undulations in the rock beds)

Folds are best displayed by stratified formations – such as sedimentary rocks. They are also observed in volcanic layered rocks and in metamorphic rocks.

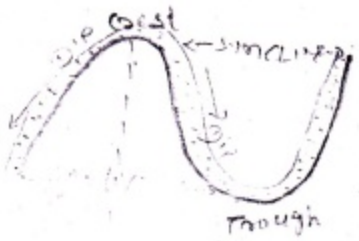
Parts of a fold:- (Terminology of during fold)

In the descriptive study of the folds, following terms are commonly used:- They are best explained with reference to vertical section of a typical fold.

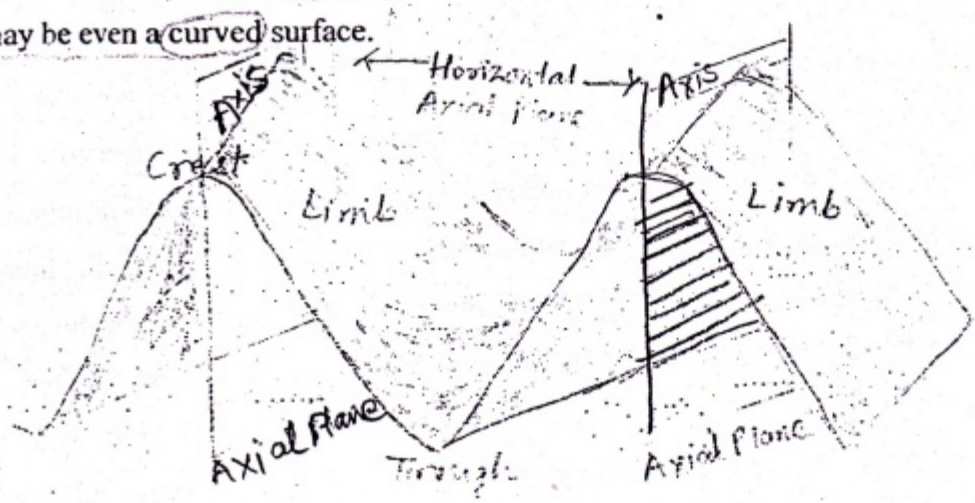
1) Limb:- Limbs are the sloping sides of a fold. from crest to trough are called the limb An individual fold has two limbs. In a series of folds, the central limb is common to any two adjacent folds. Thus it is the stretch of rocks beds lying at the sided of crests and troughs.

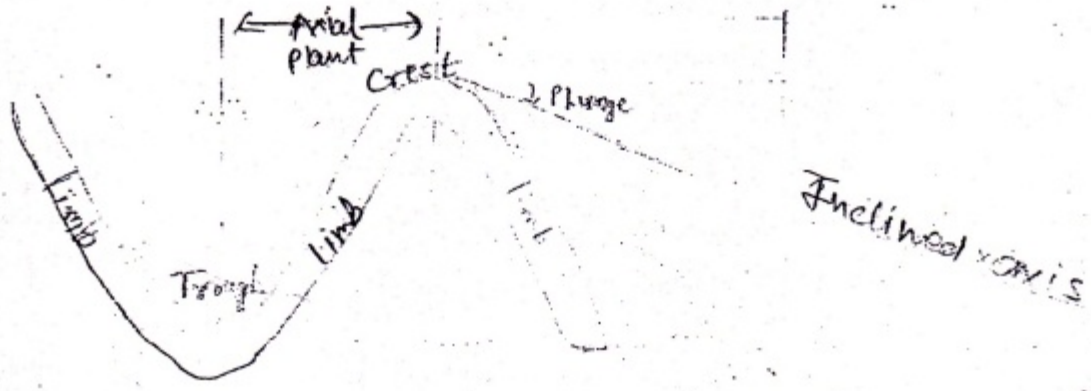
The wavy undulations are formed of a series of alternate crests and troughs.

2) Crests and Trough:- A typical fold is divided into two parts – up arched and down arched bends. The highest part of the curvature is called the crest part and the lowest part of the curvature is termed as the trough. There is a separate crest for each bed. The crest on trough may or may not coincide with the axis of the fold.



3) Axial Plane - Axial plane is an imaginary plane divides the fold as symmetrically as possible. Any point on the axial plane is at equidistant from both the limbs. Depending upon the nature of the fold, its axial plane may be vertical, inclined or horizontal on it may be even a curved surface.





4) Axis:- Axis is defined as the intersection of the axial plane and the surface of the bed with the bed of the fold. It may be horizontal, inclined or vertical.

5) Hinge:- This term is similar to axis. The hinge of a fold is the line of maximum curvature in the folded bed. It is the line along which the amount and direction of dip change. It is characterized by orientation and position.

6) Plunge:- The axis of a fold may be horizontal, inclines or vertical. If the axis is inclined, the angle of inclination of the fold axis with the horizontal line is termed as plunge of the fold. It is measured in terms of degree and direction of inclination just like the dip of the strata.

7) Pitch:- The angle between the axial plane and vertical line is termed as pitch of the fold. If the axial plane is upright (vertical), pitch coincides with plunge.

Classification of folds:-

Folds show a variety of forms, some may be simple and others may be complicated. A great majority of folds are simple or complex modifications of two simple types known as anticlines and synclines.

Folds have been classified into various types on the following bases:-

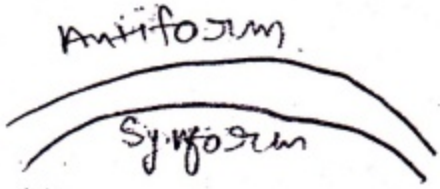
1) Appearance in cross-section
2) Position of axial plane (symmetry of fold)
3) Thickness of limb (behavior with depth)
4) Inter limb angle (degree of compression)
5) Attitude of the fold (position of the axis)
6) Mechanism of folding
7) Origin
8) Special types

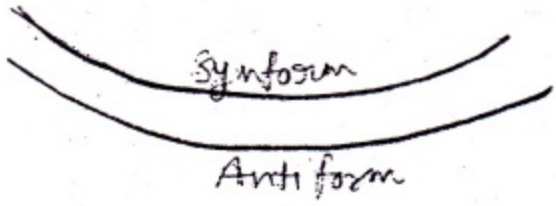
1) Appearance in cross-section:-

Following types of folds have been recognized on this basis-

Antiform:- Any upwardly convex structure.

Synform:- Any upwardly concave structure. i.e. flexture in the form of a trough is known as synform.





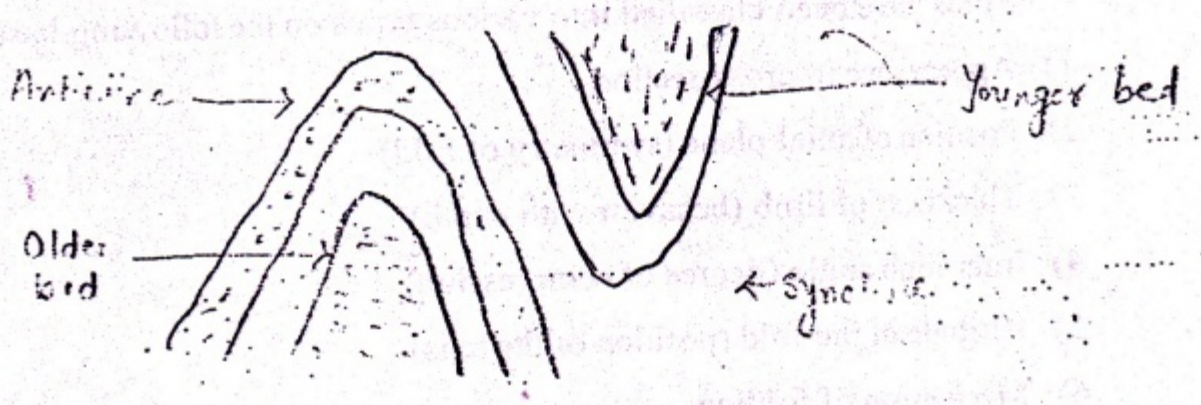
Anticlines:

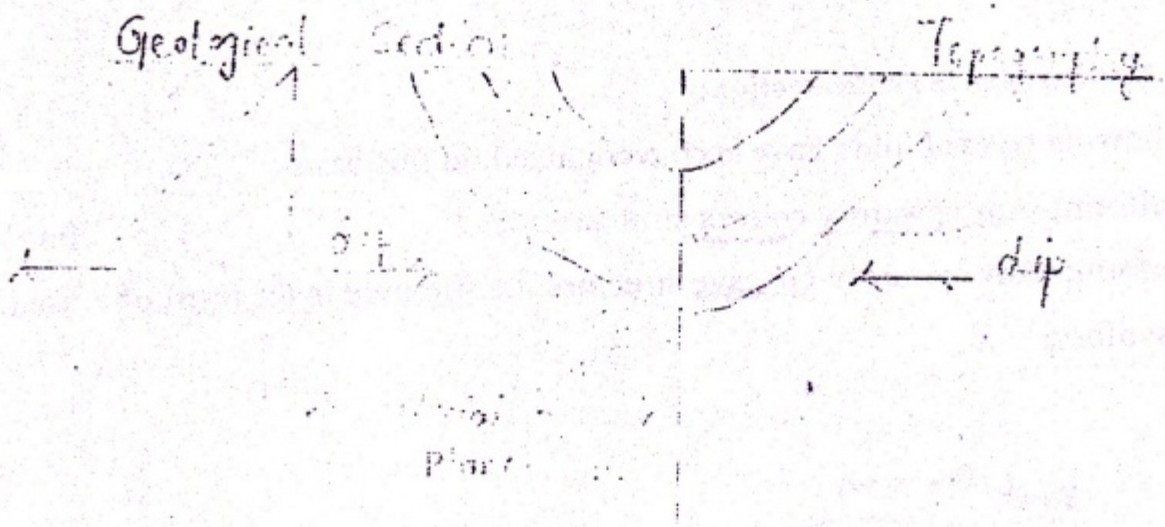
Anticlines are defined as those folds in which

- The strata are uparched i.e.stratas is convex upwards.
- The limbs dip away from each other with reference to axial plane.
- Older beds occur towards the centre of curvature of the fold.

Synclines are defined as those folds in which

- The strata are downarched i.e. strata are concave upwards.
- The limbs commonly dip towards the axial plane,
- Younger beds are found at the centre of curvature of the fold.





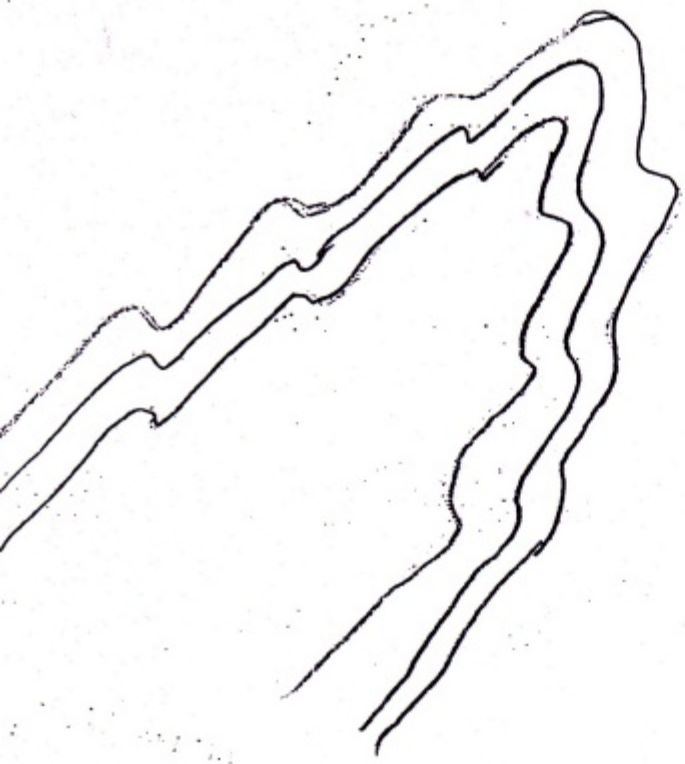
Anticlinorium:-

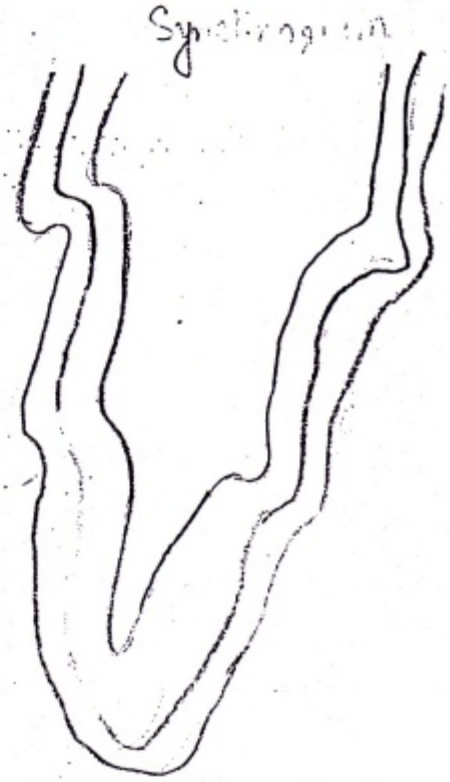
A large anticline covering several kilometers. The trend is anticlinal with secondary folds of smaller size developed on it.

Indian Example:- Champaner series, Shivrajpir area repeated folding in a roughly E-W direction, second generation of folds show N-S direction. The series consist of rocks like conglomerates, sandstones, limestiones, shales, phyllites, slates, quartzites.

Synclinorium:-

It is a large syncline with limbs showing numerous anticlines and synclines. i.e. limbs are thrown into many minor undulations.





2) Symmetry of fold:

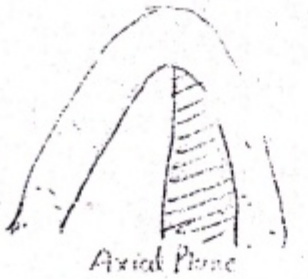
Position of Axial plane

Depending upon the nature and direction of compressional stresses, the axial plane of a fold may acquire horizontal, inclined or vertical position and symmetry of fold varies as to this position. Following are the types recognized on the basis of symmetry of fold.

Symmetrical Fold:-

When axial plane is vertical and bisect the fold, the fold is said to be a symmetrical or upright fold. They may be of anticlinal as well as synclinal nature and accordingly both the limbs dip equally either opposite or towards as the case may be.

A "Symmetrical fold" is one where the two limbs dip at the same angle but in opposite directions.



Symmetrical fold

Asymmetrical fold

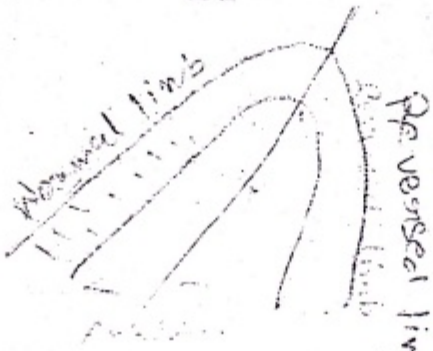
Asymmetrical Fold:-

The fold in which the axial plane is inclined is known as asymmetrical fold. In this case both the limbs dip at different angles and the axial plane cannot divide the fold into two symmetrical parts. There may be asymmetrical anticlines as well as synclines.

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 but at different angles.

Over folds indicate severe degree of folding. One of the limbs occurs in the normal position while the other limb appears to have been rotated and completely over turned from its usual position. This limb is called reversed limb. There may be over turned anticlines as well as synclines. Such folds are also known as inverted folds.



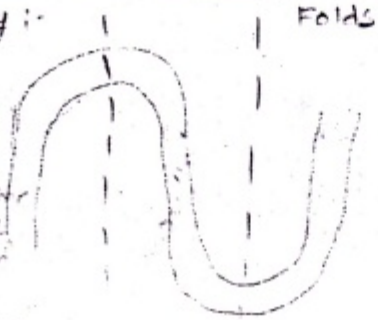
Recumbent fold :- The folding is so intense that both the limbs become almost horizontal. In this case the axial plane also becomes nearly horizontal & the lower limb gets overturned.

Isoclinal Fold:-

In an overturned fold when both the same amount of dip has in the same direction, it is known as isoclinal fold. Axial planes here are parallel to each other. As to the position of the axial planes, there may be horizontal, inclined or vertical isoclinal folds.

Non Plunging :- Folds that have parallel limbs are called isoclinal

The axes of fold may be horizontal or inclined. Anticline & syncline whose axes are horizontal are called isoclinal.



Paper 5 Unit 6

FAULT

MAJOR STRUCTURES.

When over rocks are involved in the crystal deformation variety of structures are likely to produced within the body of rocks. The types of structures developed depend on the following factors.

1. The kind of the rock mass involved.
2. The amplitude and direction of force
3. The kind of the force.

In general structures are divided into two chief groups.

1. Primary structures.
2. Secondary structures.

Primary structures are due to.

(a) Igneous action :- i.e. structures produced due to igneous activites such as dykes, sills, Laccoliths, batholiths in various shapes and sizes.

(b) Sedimentation :- i.e. structure produced due to sedimentation such as stratification, lamination, ripplemarks, current bedding etc.

Secondary structures are due to.

(a) Heat, pressure and chemical action such as foliation, lineation gneissose and schistose structures etc.

(b) Crystal deformation such as faults, folds etc. all these are due to crystal deformation upheaval, subsidence etc.

subsidence etc

CAUSES OF CRYSTAL DEFORMATION:-

The crust of the earth in all its parts is never in a state of rest. Different forces of varying intensities are constantly operating either to disturb or to restore equilibrium. Forces are thus operating to produces stresses in the crust whatever the forces may be that set up stress in the crust, the most important and effective are the direct stresses of tension and compression or the tangential stresses both by tension and compression.

Types of stresses:-

TENSIONAL STRESS:- (Tensile stress)

A body is said to be under tension when external forces from two sides tend and pull it a part.

← [TENSION] →

Tension causes the tensile stress by which rock masses are pulled apart rocks are _____, elongated or broken into blocks and shifted or displaced.

COMPRESSIONAL STRESS:- [Compressive stress]

A body is said to be under compression when external forces from two sides tend to push it inside.

two sides tend to push it inside

→ COMPRESSION ←

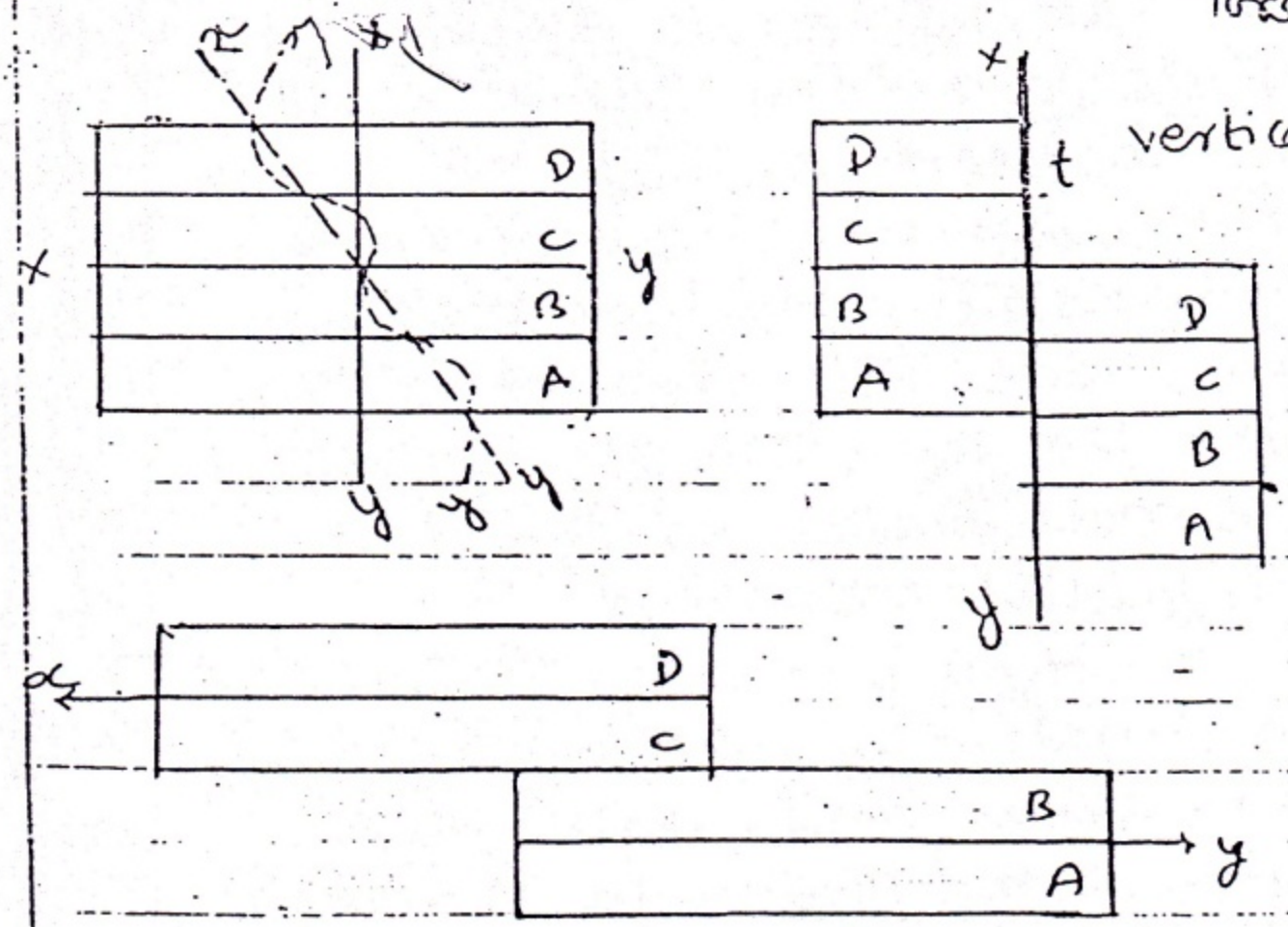
compression causes the compressive stress by which rock masses are squeezed compressed, flattened and some times broken in such way to over ride one another.

As a result of crystal movement in many regions we find that the great thickness of strata have been tilted, bend or displaced, so that they are now found in inclined folded or faulted conditions. sedimentary beds that were once laid down on the floor of the sea are now found as folded and ~~fted~~ faulted mountains

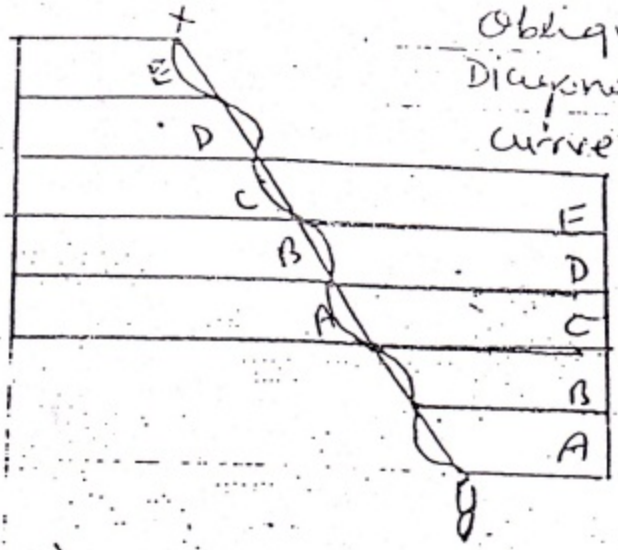
Himmatnagar sandstones, and shales as well as vindhyan sand stones and shales are found stratified with horizontal attitude but in Aravalli mountain range and Himalayan mountain range rocks are found to be tilted, folded and faulted with various attitudes

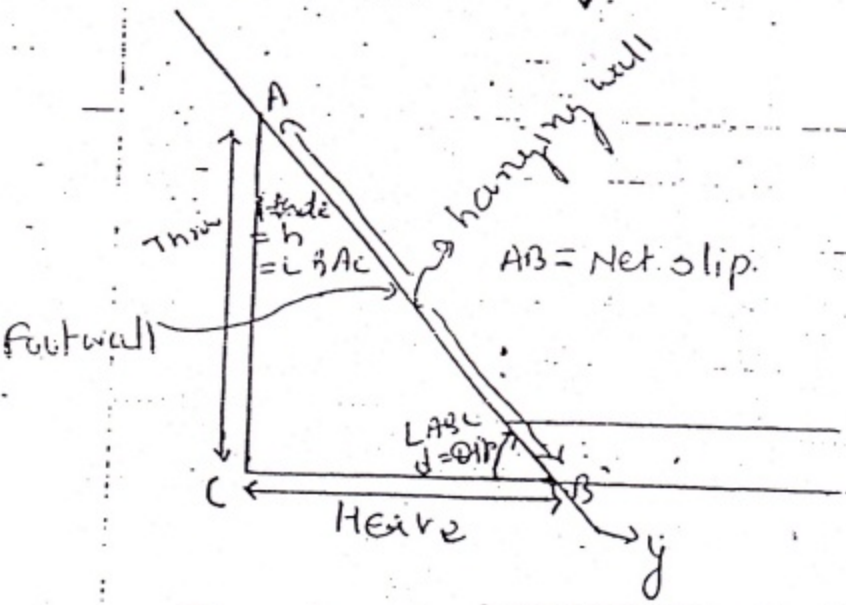
STRUCTURES

- Primary
  - Igneous
  - sedimentation
- secondary
  - Heat, pressure & Chemical action
  - Crustal deformation
    - Tension
    - Compression
    - shear
    - Torsion

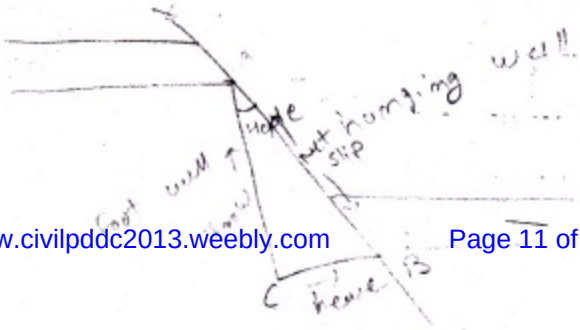


Oblique
Diagonal fault plane
curved fault surface.





xy = Faultplane
= Fault surface
AB = Net slip
AC = THROW
BC = Heave
∠ABC = Dip of the fault
∠BAC = Hade of the fault.



FAULTING.

When ever rock formation can not adjust themselves to crustal movements under differential stresses mainly of the tensile types they develop fractures in the direction of forces and may break with relative movement on either side of the fracture. Such a fracture with appreciable displacement is called fault.

A fault is called fracture or a displacement or a dislocation on either side of which there is a relative movement of the strata.

Or

Faulting is the phenomenon in which there is a relative displacement of rocks along the breaking plane.

Attitude :- Divisional

All types of igneous sedimentary and metamorphic rocks may be found dislocated by faults. Such fractures may vary in displacement from a fraction of a centimetre to many metres. or kms. They also vary in depth some of them extend for hundreds of kms. e.g. The great Rift valley of Africa.

The movement displacement may be horizontal, vertical, oblique or curved.

As a result of movement the strata on either side of a fault are elevated

expressed relative to the other side comes in contact with the or beds.

As a result of faulting various features characteristic of fault are found to observed in the field

FAULT PLANE:- The plane along which the displacement takes place is called a fault plane such a plane may not necessary be a smooth surface but may be curved irregular. Hence it is better called fault surface.

SLICKEN SIDES :- Usually the fault surfaces are highly polished because of the friction caused due to the displacement of rocks. Some times it may also happen that during the actual displacement the rocks may polish groove, or scratch the surfaces of walls. Such surfaces are commonly known as slickensides.

FAULT BRECCIA :- When displacement takes place in equigranular rocks are crushed along the fault surface as a result the coarse fragments and fine rock material get cemented together to form fault breccia. As the fragments are crushed it is also called

crushed breccia. The fragments then produced may be angular, sub-angular or irregular and may be cemented by ferruginous siliceous or calcareous fine matrix as the case may be

(x) FAULT ZONE :-

Some times number of fractures are developed due to continued tensional stresses and the displacement occurs in parallel or sub parallel planes. Thus instead of a single fracture. There may be two or more fracture consisting of closely spaced parallel faults forming a fault zone. Usually such planes show slicken sided surface or they are found filled with fault breccia.

(xi) HANGING WALL and FOOT WALL :-

As a result of faulting relative displacement takes place Hence one part is placed at a higher position in comparision to the other. The block above the Fault plane is called the Hanging wall. And the block below the fault plane is called the foot wall. Vertical fault has neither the foot wall nor the hanging wall.

DOWN THROW SIDE and UP THROW SIDE :-

The block which has gone down due to the displacement is called down throw side or block and that which has gone up is called up throw block. Both the blocks may operate moving more than the other or one may remain stationary and the other operate. It should be remembered that younger beds comes in CONTACT WITH OLDER BEDS on the down throw side of a fault.

(*) **HEAVE:-** Heave is the horizontal displacement of the fault. In the diagram BC is the heave. Heave varies as to the dip of the fault. If the dip is less heave is more and viceversa. In case of a vertical fault heave is nil.

The hori. dis. between the displaced ends of the faulted stratum is known as heave

(*) **THROW:-** Throw is the vertical displacement of the fault. The vertical distance between the displaced ends of the faulted stratum is known as throw.

as the throw of the fault. In the diagram AC is the throw.) Throw varies as to the dips of the throw. Throw fault. (If the dip is less throw is less & if the dip is more throw is more. In case of Horiz. fault throw is nil.)

(5) SLIP :- Slip is the actual displacement of the fault. It is expressed in terms of net slip. In the Diagram AB is the net slip.

(6) DIP :- Dip is the angle that the fault plane makes with the horizontal. In the diagram it is denoted by ∠ABC.

(7) HADE :- Hade is the angle that the fault plane makes with the vertical, In the diagram it is denoted by ∠BCD.

Thus when fault plane is vertical heave and hade are nil when the fault plane is horizontal. dip and throw are nil. If the fault plane dips at 45° heave and throw are equal. If the dip is less than 45° Heave is greater than throw and with dip less than 45° throw is greater than the heave.

CLASSIFICATION :-

Faults may be classified in two ways: one on the basic of their geometry and the other on the basic of their genesis

gneiss.

Geometrical Classification:-

Geometrical classification is based simply on the geometry of the faults; i.e. on the dip & strike relations of the strata in which faults are found.

Strike Fault:- (longitudinal fault)

This is a type of faulting in which displacement takes place parallel to the strike of the strata. As a result of strike fault repeatition or omission of the beds takes place. strike fault sare found in Ambajie and ABU Road Areas.

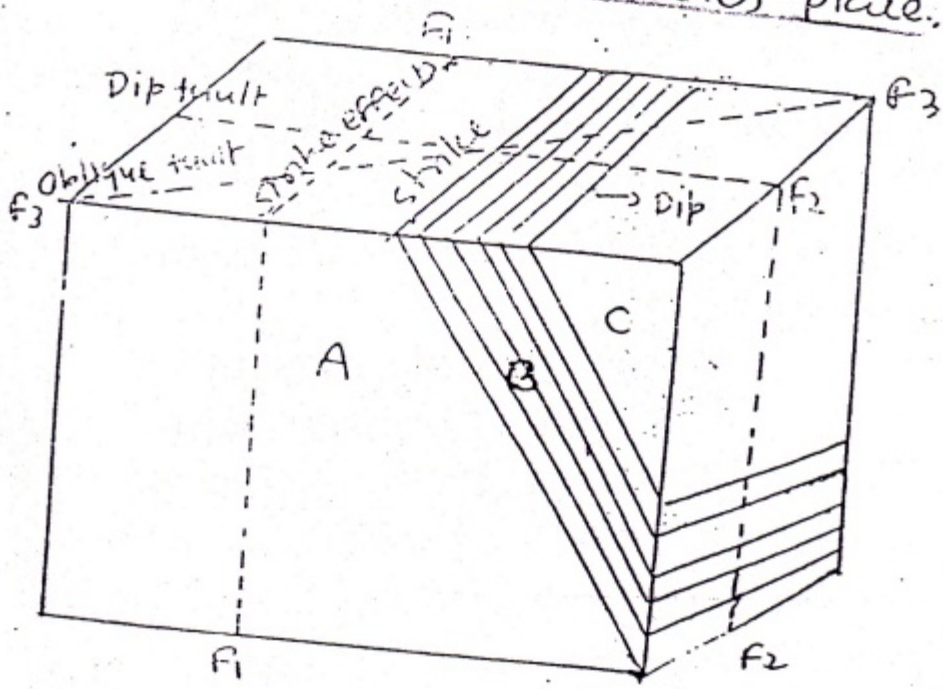
Dip Fault:-

This is a type of faulting in which displacement takes place parallel to the dip of the strata. As a result of dip fault lateral shifting takes place. when a dip faults affects an anticline construction occurs. when it affects an anticline construction occurs. when it affects the syncline widening of the strata occurs. This type of faulting directly cuts across the strike of the strata. Dip faults occurs in salt range area.

→ A fault which runs oblique to the strike & dip directions of strata is called the 'oblique fault'.

Oblique or Diagonal Fault:-

This is a type of faulting in which displacement takes place neither in the strike direction or on the dip direction of the strata. or Partly in the dip direction as a result of diagonal fault lateral shifting of the strata takes place.



In the above figure fault outcrop shown.

$F_1 - F_1$ = Strike fault
$F_2 - F_2$ = Dip fault
$F_3 - F_3$ = Oblique fault.

Effects are not shown

Beds → C → Dip offset
B →

Genetic classification :-

Genetic classification is based upon the origin of the fault i.e. Faults may be grouped according to how they have been formed either by tension compression or by shearing or by torsion. In addition to the intensity of stresses their direction should also be considered As to this different types of faults are grouped broadly into two types.

Normal faults :-

In the formation of normal faults having wall goes down relative to the foot wall. It is infact very difficult to establish which parts actually moved down or up. such as they are many possibilities concerning the actual movement.

foot wall up
hanging wall down
hence - down.

① The foot wall may remain stationary and hanging wall goes down.

② The hanging wall may remain stationary and footwall goes up.

Both the blocks may move down hanging wall more than the foot wall.

Both the blocks may move up foot wall more than the hanging

wall

In normal faults the fault surface is essentially inclined and the dip of the fault plane may range from more than the hori. to almost vertical. They may also range in length from a centimetre to many kms and may have a net slip of hundreds and thousands of metres.

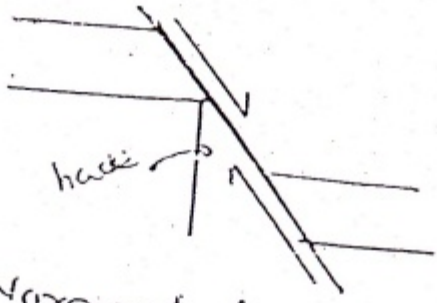
Normal faults are mainly produced due to tensile stresses and hence they are also known as tensional faults. In case of normal faults hanging wall goes down wards and for that reason they are also termed as gravity faults.

All normal faults always hades towards down throw side i.e. the dislocated bed shale slipped down on that side of a fault plane towards which the fault plane is inclined.

Normal faults usually indicate an extension of the surface area.

Depending upon the attitude of dip and strike of the strata they are further subclassified into normal dip fault, normal strike fault & normal oblique fault.. (P.T.O.)

→ A 'Normal fault' is one in which the hanging wall appears to have moved downward relative to the foot wall. In this case the



Normal fault.

2. Reserved faults :-

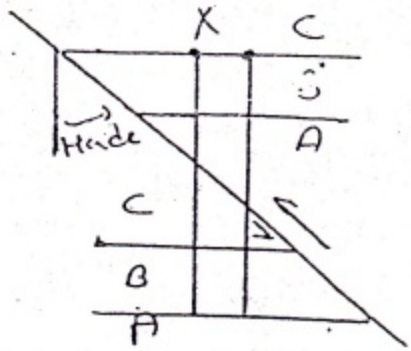
This type of faulting is just ~~reserve~~ reverse to the normal fault features and hence the name. Here the displacement takes place in the upward direction i.e. Hanging wall moves up in comparision to the footwall slide on the hanging wall block are pushed up causing them to over-ride one another.

Compression plays an important role in the formation of reversed fault. Due to compressional stresses, one portion is pushed over the other. Hence such faults are also known as compressional faults.

Reversed faults always hade towards the upthrow side i.e. the dislocated beds have slipped up on that side of a fault plane towards which the plane is inclined.

In case of ~~reverse~~ reversed fault there is always the reduction of the area and repeatation of strata occurs in case of reversed faults for example if a hole is drilled at x as shown in the diagram, beds are found repeated on both the sides of a fault plane.

Depending upon the attitude of the dip & strike of strata reversed faults have further been classified into reversed dip fault reversed strike fault and reversed oblique fault.



Reversed fault..

Strike slip fault – the movement is essentially horizontal along the strike of fault. These faults usually have very steep to vertical dips.

high angle - which have deep gouge 45°. (normal fault)

low angle - which have dip less 45°. (thrust fault)