FOLD

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Introduction

- The word fold was used by Hall (1815) for the first time to explain the rock structures.
- Van Hise (1894) contributed on the geometry of folds, while Willis (1891) worked out their mechanics.
- Fold is a wave like structure which is formed by bending or flexuring of any type of planes or layers in igneous, sedimentary and metamorphic rocks due to compressional force.
- Folds are best displayed by stratified formations.

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What are folds?

- Folds may be defined as undulations or bends or curvatures developed in the rocks of the crusts as a result of stresses on these rocks.

➤ The bending of rock strata of plastic nature due to Compressional forces acting horizontally toward a common point or plane from opposite directions is known as fold.
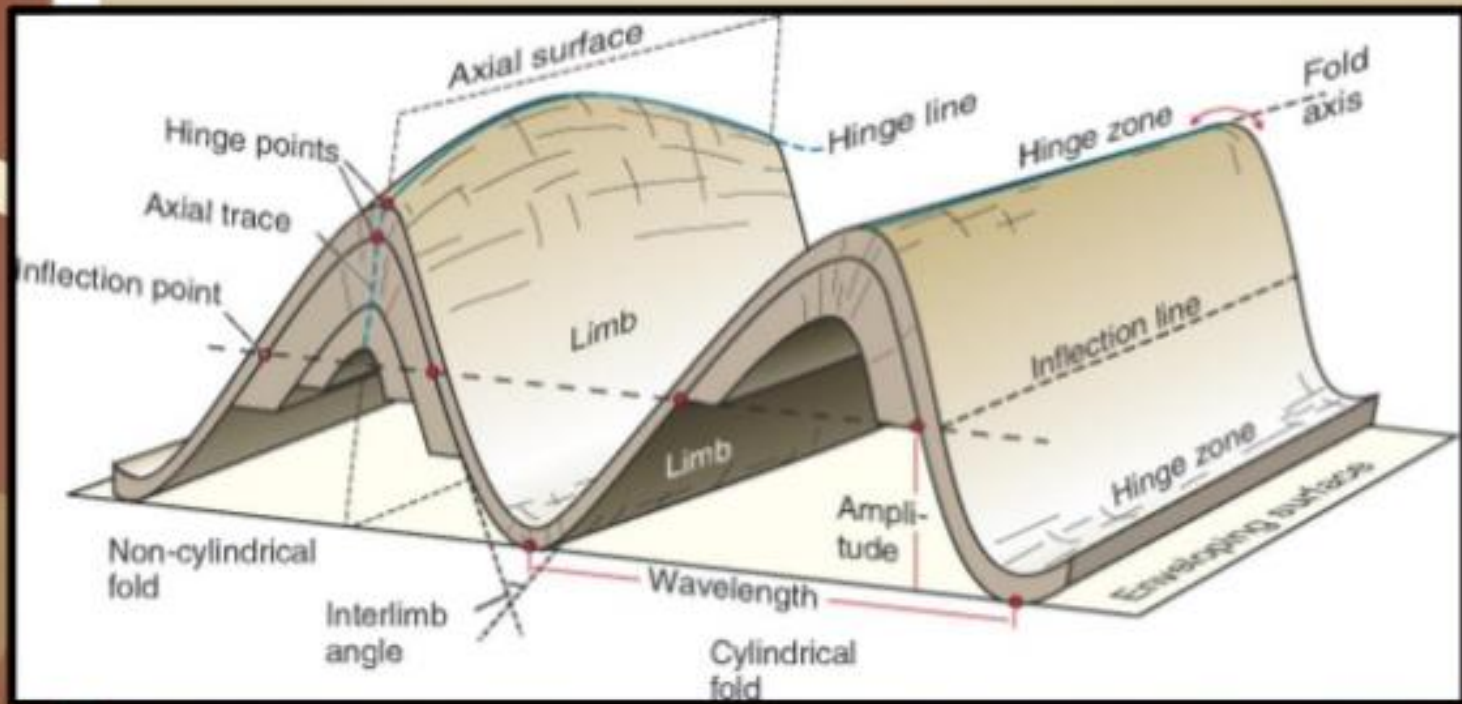
Or

➤ Folds may be defined as undulation, bending or curvatures in rocks of the crust's as a result of stresses.

➤ Folds are one of the most common geological structures found in rocks.

➤ a set of horizontal layers are subjected to compressive forces, they bend either upward or downward.

# Parts of the folds

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Parts of the folds

Terms used to describe the shape of the folds are:

- **Limbs**: these are side or flanks of the folds.

- **Hinge**: in a folded layer, a point can be found where curvature is maximum and one limb ends and the other starts at this point. This point is called hinge point.

- **Hinge line**: when the rocks occur in the sequence and all the hinge points are joined ;the resultant line us called hinge line.

- **Axial planes**: it is the imaginary plane that passes through all points of maximum curvature in folded sequence. It may be vertical, horizontal or horizontal in nature.

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- **Axis of the fold**: it may be defined as a line parallel to the hinge line of a fold. Or it may be defined as line of intersection of a axial plane of a fold and with any bed of the fold.

- **Plunge of the fold**: the axis of the fold may be horizontal, vertical or inclined with respect to other parts of the fold. The angle of inclination of the fold axis with the horizontal as measured in a vertical plane. In other words fold axis is a line and plunge is the angle which this line makes with horizontal.

- **Crest and trough**: the line running through the highest points in a uparched fold is called crest. Similarly line running through the lowest point in a downarched fold is called trough.

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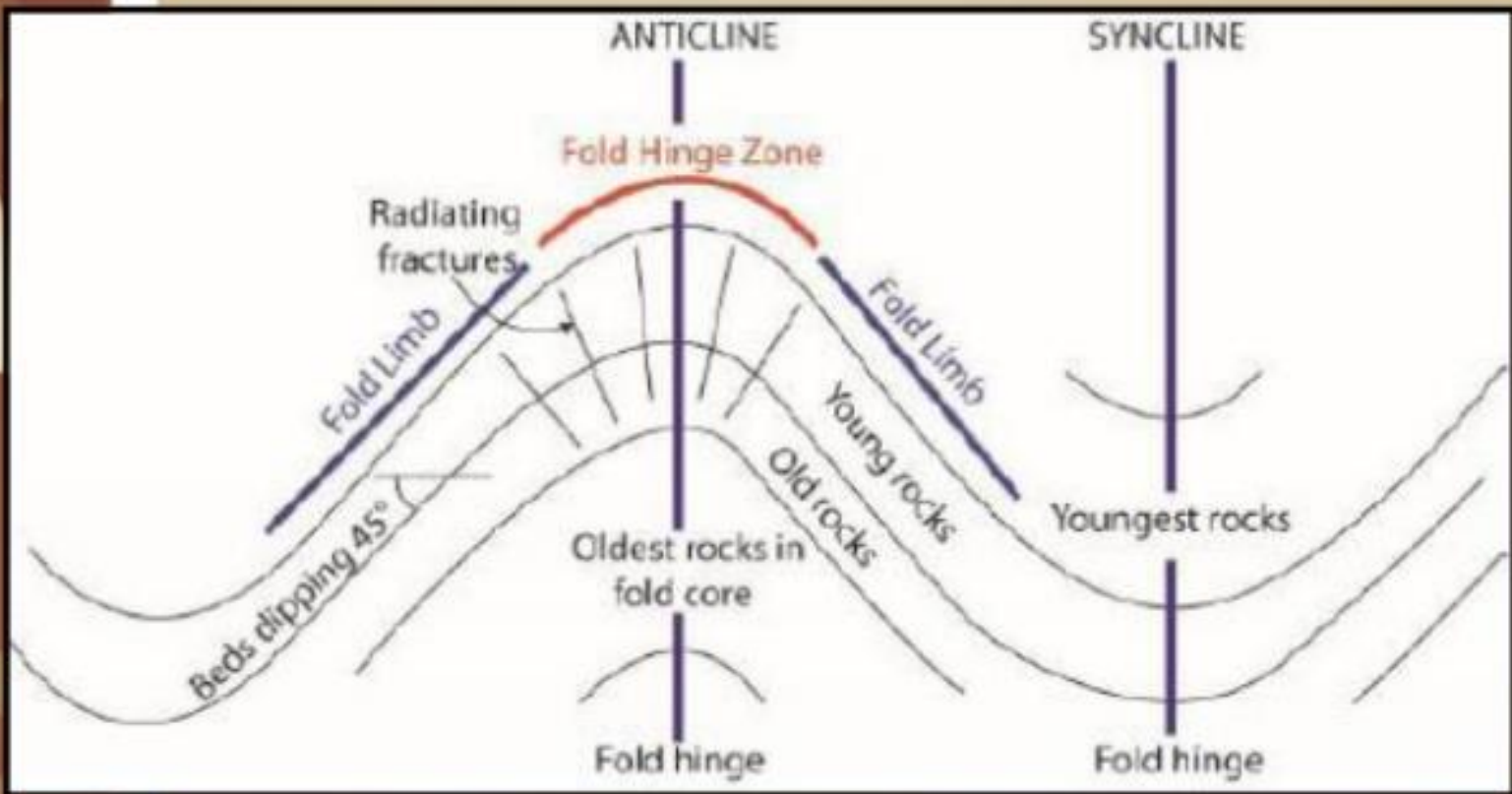
Classification of fold

Basis of classification:

1. Fold Closure
2. Symmetry
3. Plunge of fold axis
4. Orientation of axial plane
5. Direction of younging relative to fold closure
6. Nature of hinge line
7. Interlimb angle
8. Shape of hinge
9. No of hinges
10. Geometrical elements (Dip isogons, axial plane thickness & Orthogonal thickness)
11. Superposition of fold

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5. Classification on the basis of direction of younging relative to fold closure

- Anticline
- Syncline
- Anticlinorium
- Synclinorium
- Synformal anticline
- Antiformal syncline

Anticline,

Syncline,

synclinorium

anticlinorium

synformal anticline

antiformal syncline

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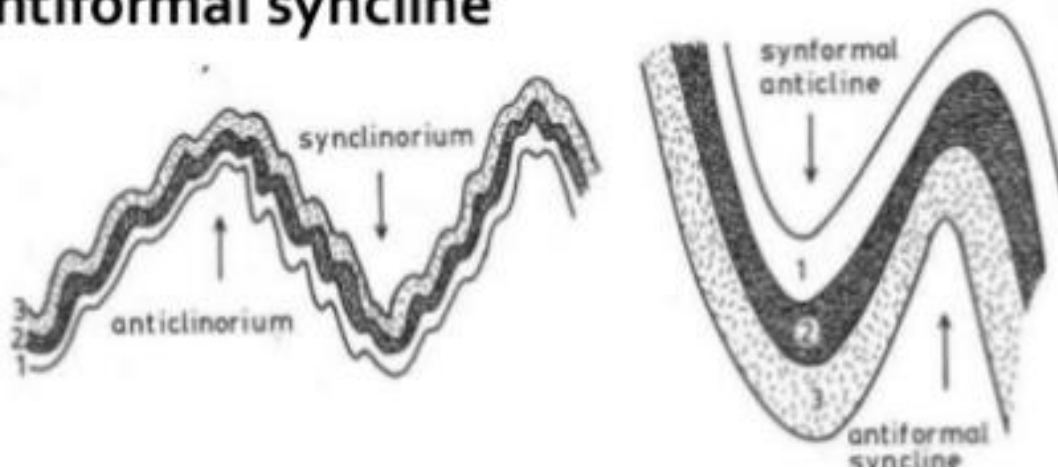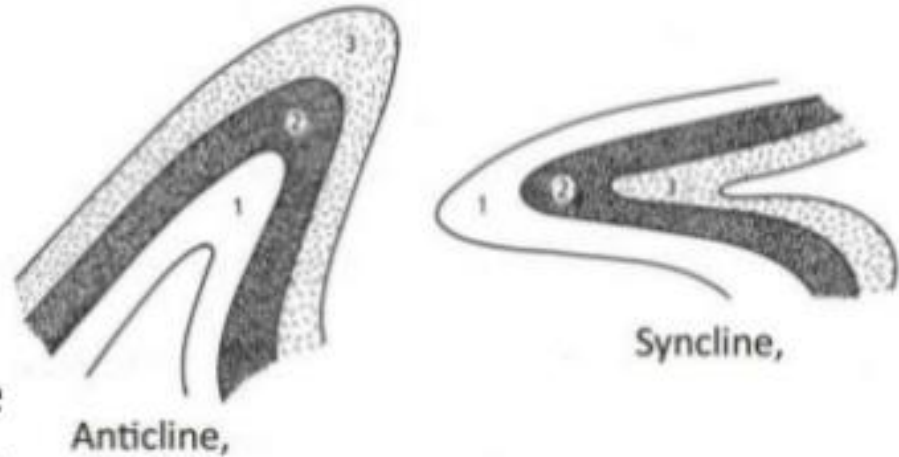
Syncline

➢ The word syncline is a Greek word which means "together inclined".

➢ It may be define as a fold that is convex downward.

➢ In this kind of folds the two limbs dip toward each other.

➢ So its means that the younger rocks are at the center and older are at limbs.

This photo showing syncline

Anticline.

➢ The word anticline is a Greek word which means "opposite inclined". it may be define as a fold that is convex upward; it may also be defined

as a fold that has older rocks in the center and the younger are at limbs.

➢ In this type of fold,

the limbs are dip away from each other.

An anticline expose during road cut at new jercy USA

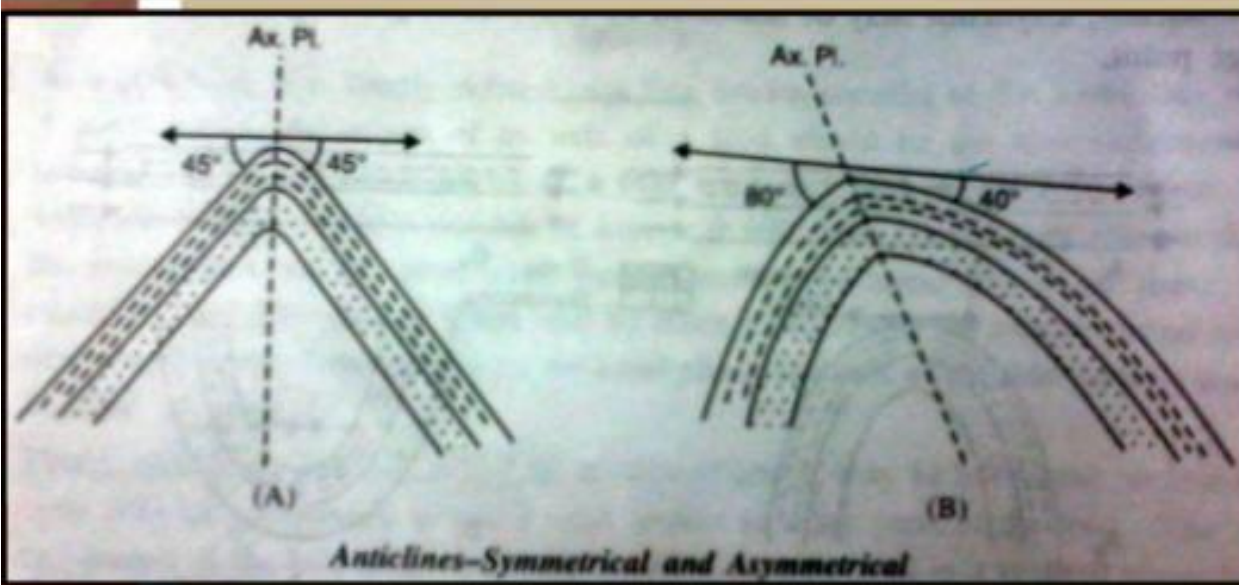# Classification on the basis of axial planes

- **Symmetrical folds**: the axial plane is essentially vertical. The limbs are equal in length and dip equally in opposite direction. In short, two limbs are essentially mirror images of each other. It may be anticline or syncline.

- **Asymmetrical folds**: all those folds, anticlines or synclines, in which the limbs are unequal in length and dips unequal on either side from the hinge line.

- **Overturned folds**: fold with the inclined axial planes in which both the limbs are dipping essentially in the same direction. In some cases, due to extreme compression from opposite sides reverse the general dip conditions – anticline limbs dip towards each other and the synclinal limbs dip away from each other. Such type of fold is called **fan fold**.

- **Isoclinal folds**: may be defined as groups of folds in which all the axial planes are essentially parallel i.e. all the component limbs are dipping at equal amount. They may be made up of series of anticlines and synclines.
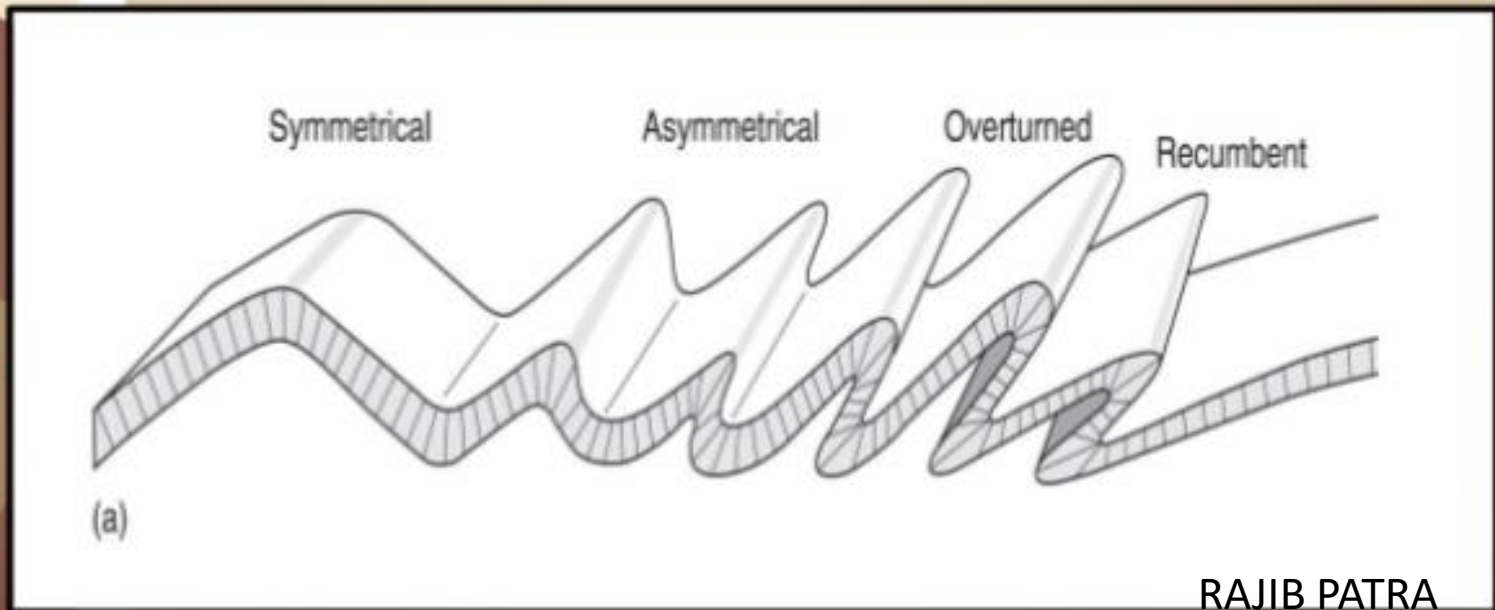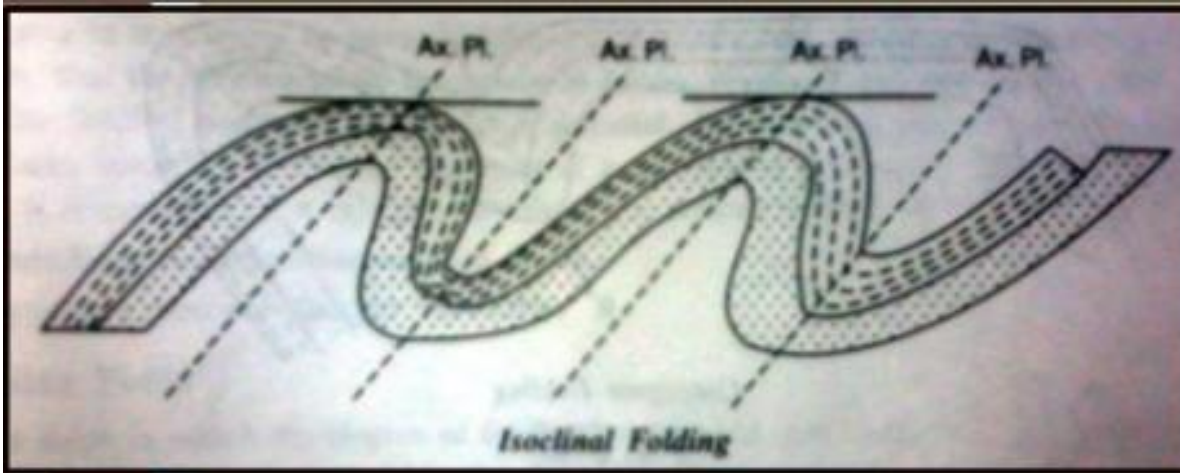
Symmetrical fold

➤ That type of fold in which the axial surface is essentially vertical.

➤ The term upright is also used.
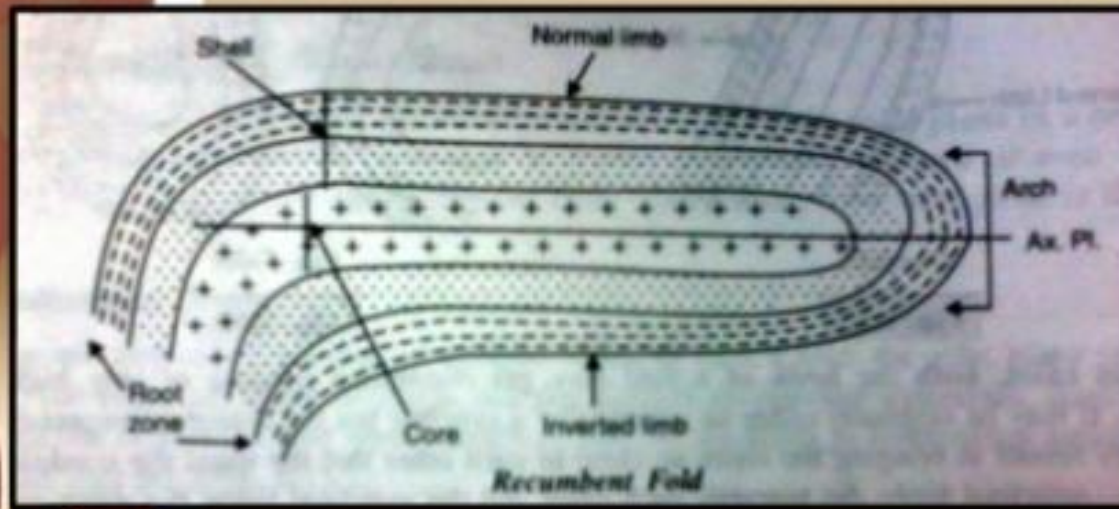
➤ In symmetrical folds no limb is steeper then other.

This photo showing symmetrical fold

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Ax. Pl.
45° 45°
(A)

Ax. Pl.
80° 40°
(B)

Anticlines—Symmetrical and Asymmetrical

N
60°
Normal Limb
Reserved Limb
Overfold

Fan Folds

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Isoclinal Folding

Symmetrical   Asymmetrical   Overturned   Recumbent

(a)
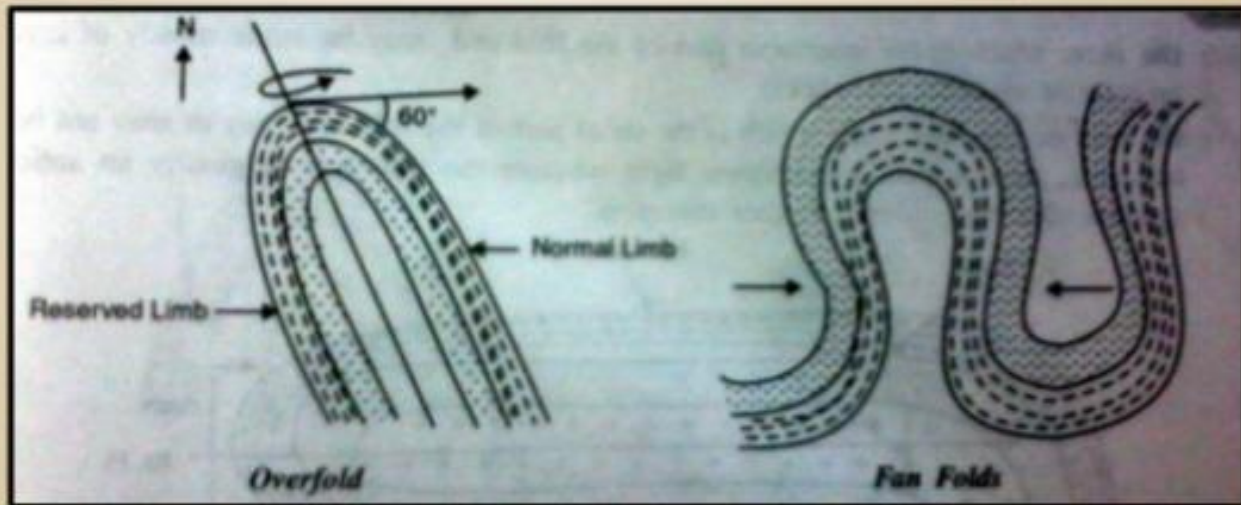
Recumbent Fold

Recumbent folds: may be defined as extreme type of overturned folds in which the axial plane acquire almost an horizontal attitude. Parts of this types of folds are:

➢ **Arch**: zone of curvature corresponding to crest and trough

➢ **Shell**: outer zone made up of sedimentary formation.

➢ **Core**: innermost part of the fold and mostly formed of crystalline igneous or metamorphic rocks.

➢ **Root zone**: basal part of the fold. It is not easily traceable; once traced can show whether the fold was anticline or syncline that has suffered further inversion.

Recumbent fold

➢ A recumbent fold is one in which the axial plane is essentially horizontal.

➢ These types of folds are produce when the deformation is intense.

➢ And one fold lies on the top of next fold so that the axial plane become sub horizontal.

➢ Such kind of fold can be found in alps mountains.

This photo shows recumbent folding.

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Isoclinal fold

> An isoclinal fold, from the Greek word meaning "equally inclined", refers to folds in which the tow limbs dip at equal angles in the same direction.

Chevron fold

> chevron fold is one in which the hinges are sharp and angular.

Box fold

> A box fold is one in which the crest is broad and flat. Two hinges are present, one on either side of the flat crest.

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Classification on the basis of plunge

- **Plunging fold**: any fold in which fold axis is NOT HORIZONTAL i.e. it makes an angle with the horizontal, may be termed as plunging folds.

- **Non-plunging fold**: any fold in which fold axis is essentially HORIZONTAL i.e. it doesn't makes an angle with the horizontal, may be termed as plunging folds.
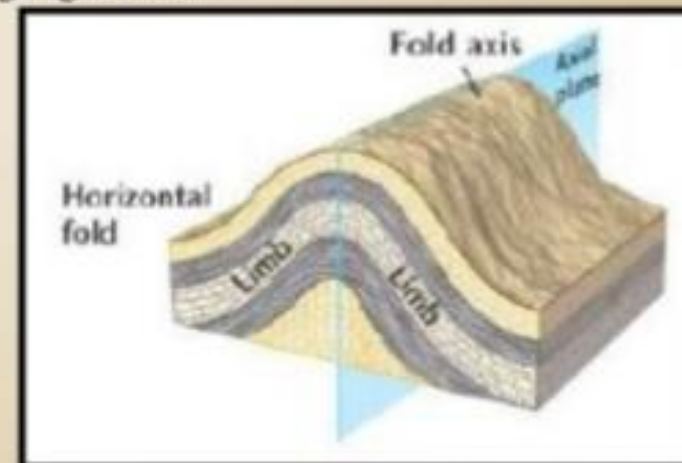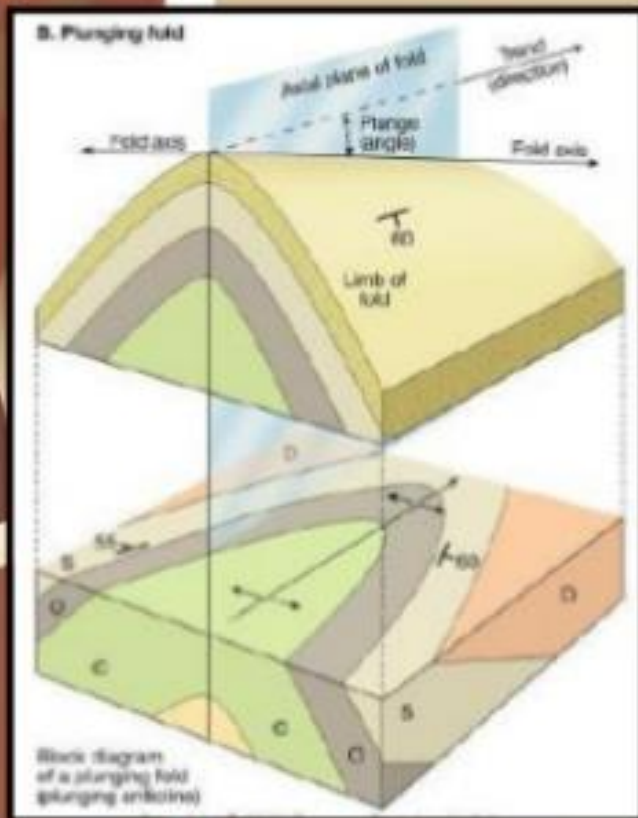
This photo shows chevron folding

This photo shows box folding

This photo shows isoclinal folding

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Fan fold

➤ A fan fold is one in which both limbs are overturned.

➤ In the anticlinal fan fold, the two limbs dip toward each other; in the synclinal fan fold, the two limbs dip away from each other.

Anticline   Syncline

This diagram shows fan folding

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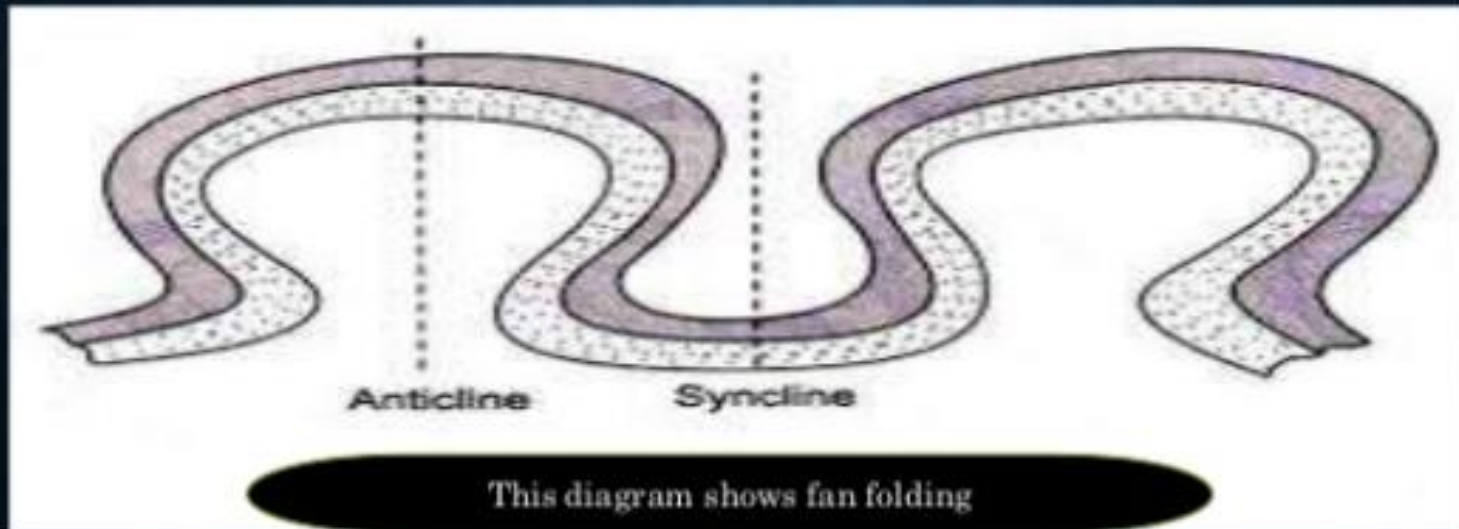
Fluety's Classification based on Amount of Plunge of Fold & Dip of Axial Plane
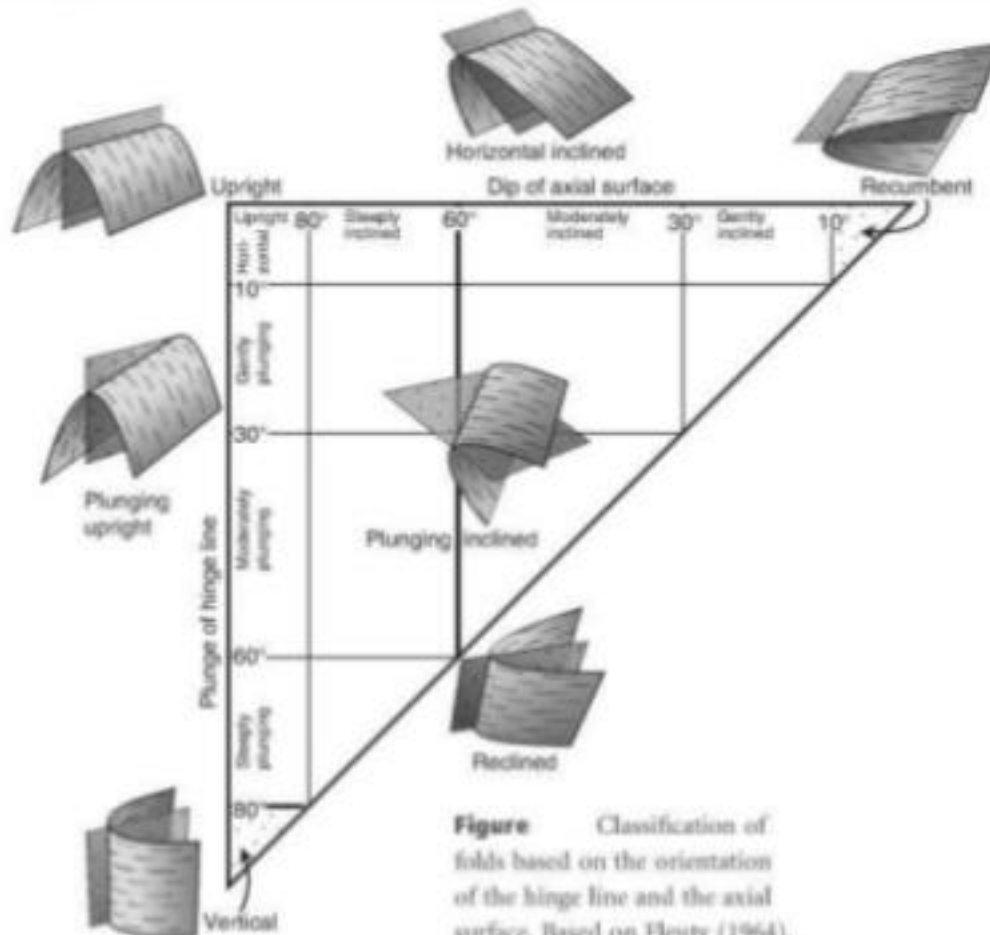
Figure Classification of folds based on the orientation of the hinge line and the axial surface. Based on Fleuty (1964).

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6. Classification on the basis of nature of hinge line

- **Cylindrical** – generated by moving a line parallel to itself
- **Non-cylindrical** – cannot generated by moving a line parallel to itself
- **Conical** – a non cylindrical fold whose shape is approximately a part of a cone.

(a) Cylindrical fold

(b) Non-cylindrical fold

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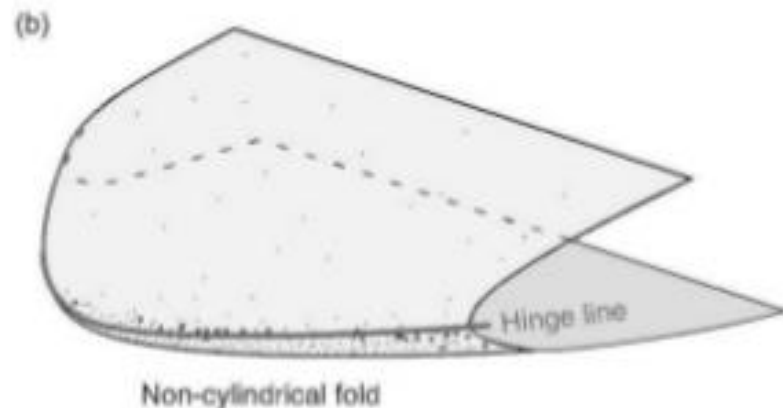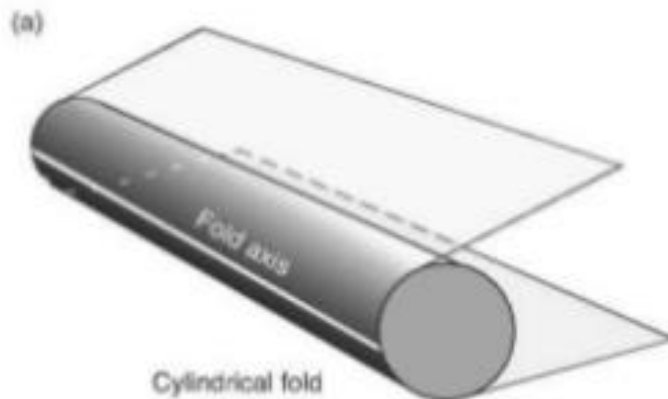
7. Fluety's classification on the basis of interlimb angle

Given by Fluety (1964)

- **Gentle fold** - interlimb angle between 180-120°
- **Open fold** - interlimb angle between 120-70°
- **Close fold** - interlimb angle between 70-30°
- **Tight fold** - interlimb angle < 30° but > 0°
- **Isoclinal fold** – with subparallel limb.
- **Fan Fold** – with negative interlimb angle.

Gentle 120° · Open 70° · Closed 30° · Tight 10° · Isoclinal 0° · Elastica

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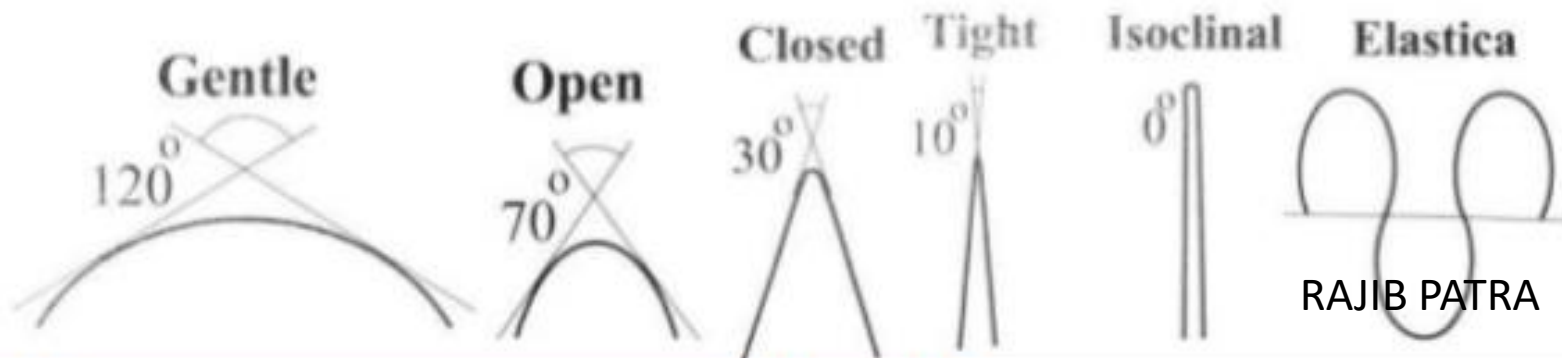
8. Classification on the basis of shape of hinges

- **Round-hinged or broad hinge fold** – broad hinge zone compared to limb.
- **Chevron fold** – straight limbs and sharp hinge.
- **Arrow-head fold** – sharp hinge and curved limbs.
- **Cuspate fold** – 1 set of closure with sharp hinge other with round.
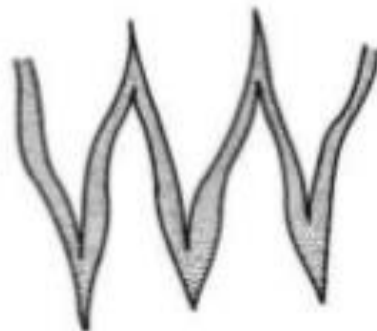
Chevron folds,   Arrow-head folds   Cuspate folds

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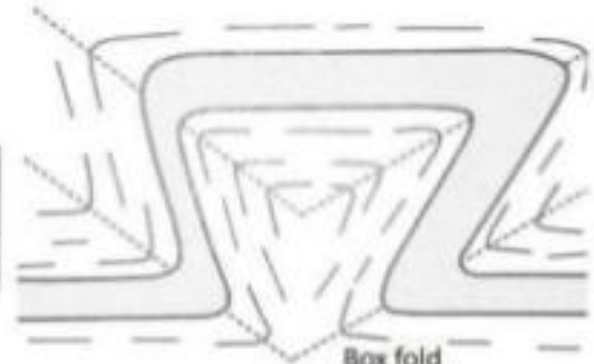# 9. Classification on the basis of number of hinges

- **Single hinged fold** – single hinge
- **Conjugate fold** – double hinged fold with sharp hinge
- **Box fold** – double hinged with rounded hinges.
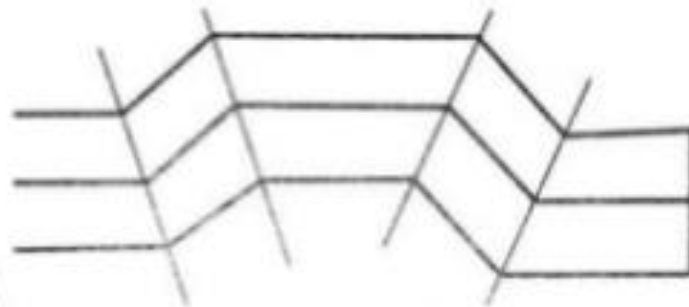
Single hinged fold   Conjugate fold   Box fold

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10. Geometrical classification of fold

Given by John G. Ramsay in 1967 based on dip isogons, axial plane thickness and orthogonal thickness.

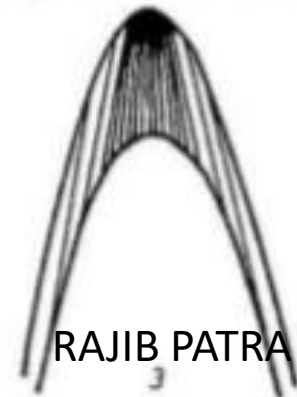- Class 1
    - Class 1A
    - Class 1B
    - Class 1C
- Class 2
- Class 3

Class 1, convergent isogons

1A

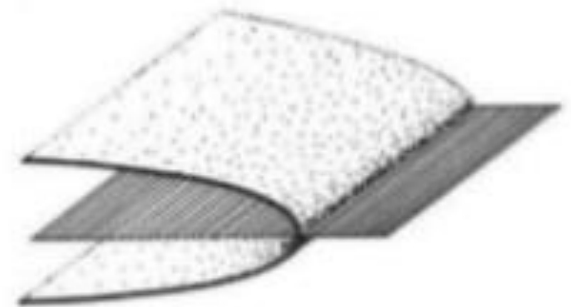1B, Parallel

1C

Class 2

2, Similar
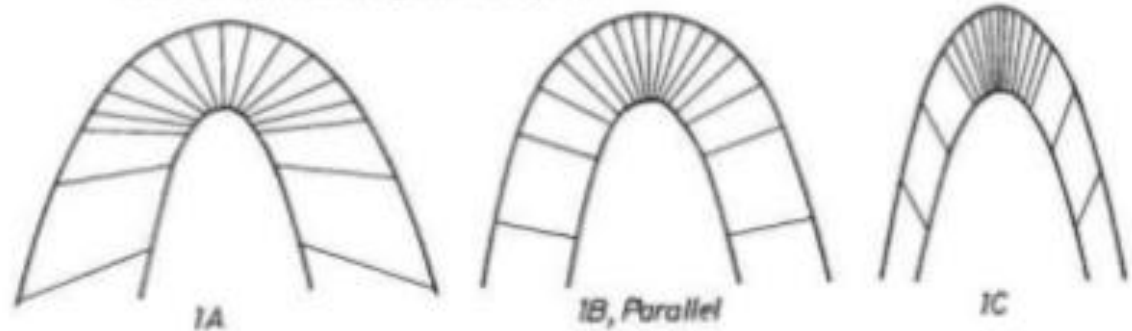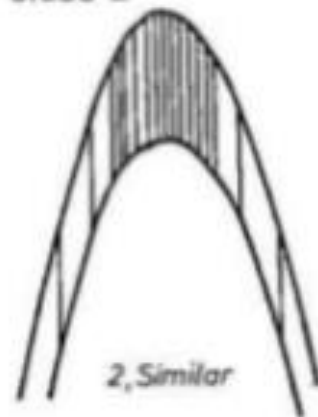
Class 3, divergent isogons

3

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4. Classification of fold on the basis of orientation of axial plane
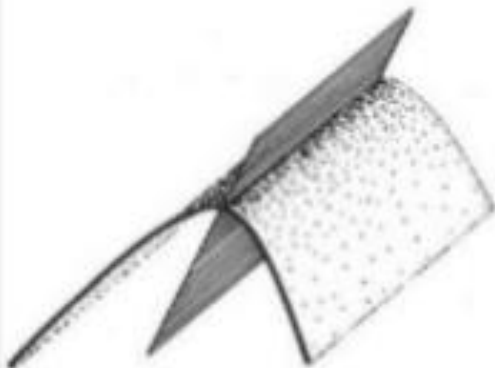
- Upright fold
- Recumbent fold
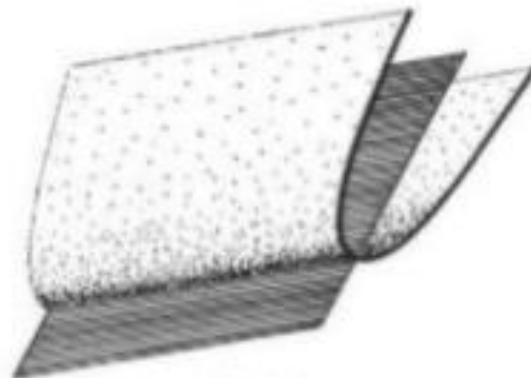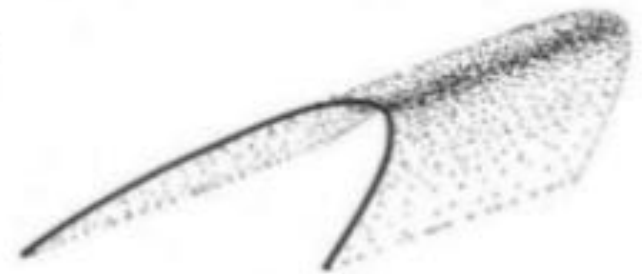- Inclined fold
- Reclined fold
- Overturned fold
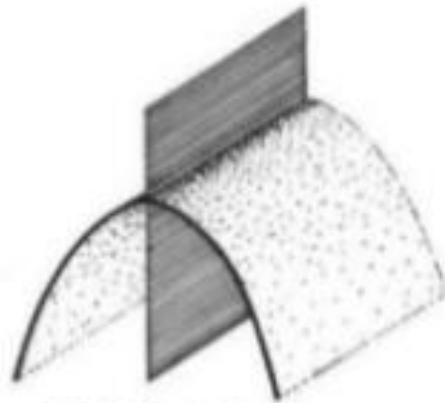
Upright fold,

recumbent fold,

inclined fold

reclined fold

overturned fold

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3. Classification of fold on the basis of plunge of fold axis
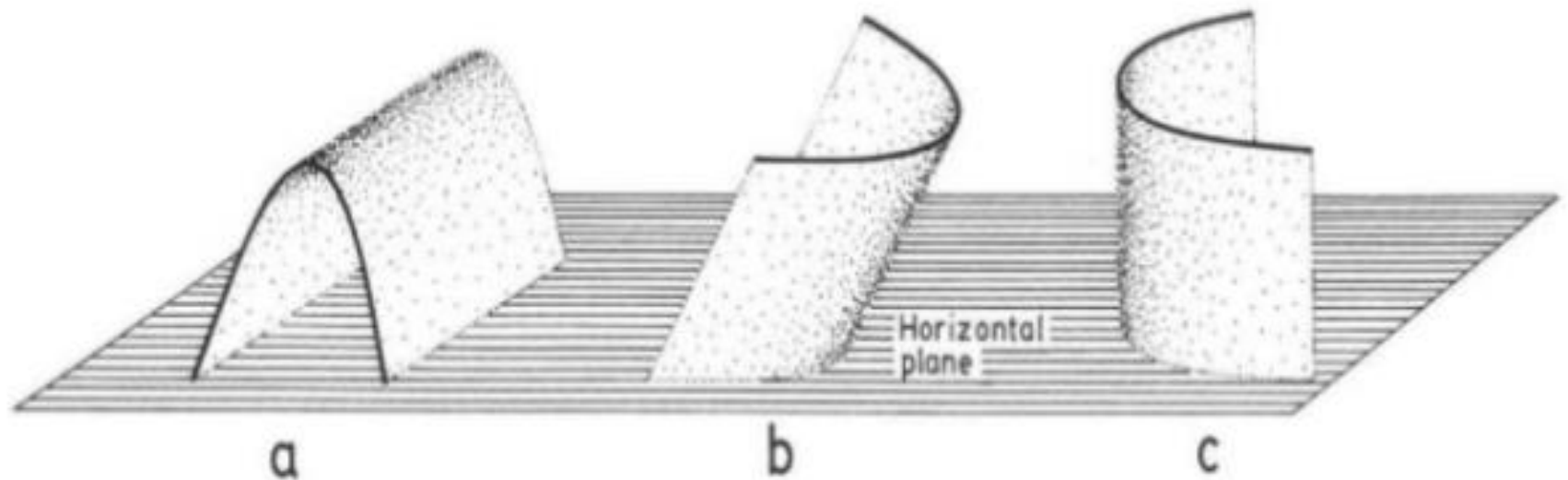
- Horizontal fold
- Plunging fold
- Vertical fold

Fig. (a) Horizontal, (b) Plunging, (c) Vertical

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