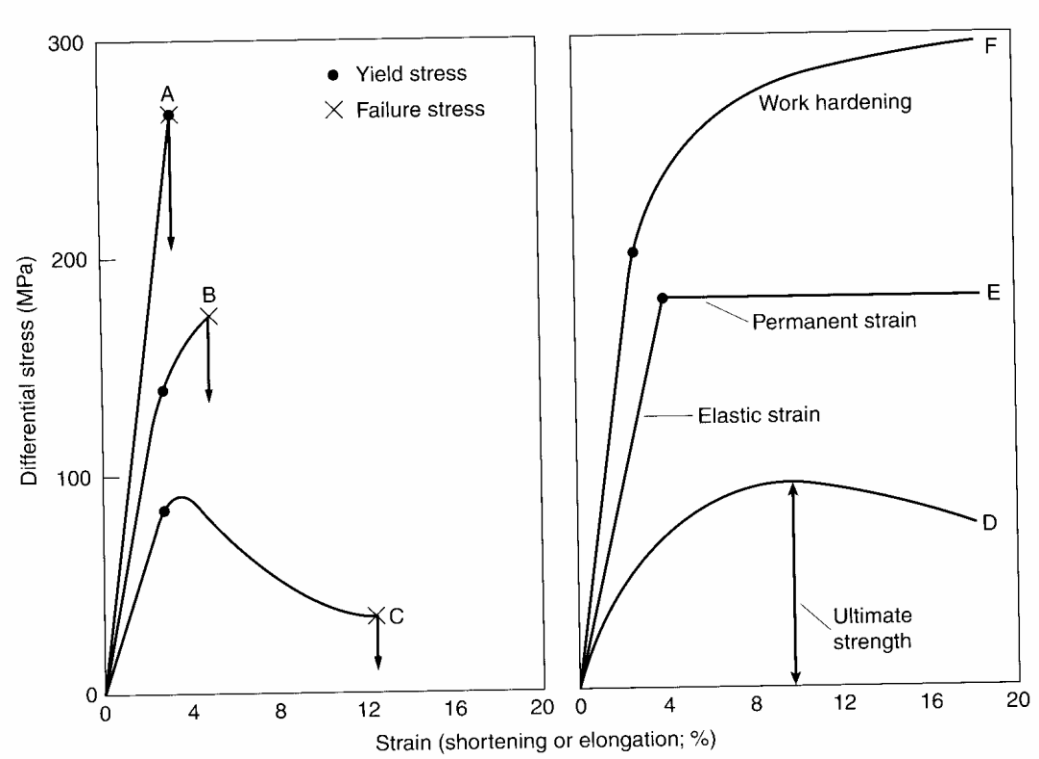
ES2105: Earth Science Lab 2

Outcrop Patterns

Lecture 2: Rock Deformation (Manifestation of rock deformation)

Reference: Marshak & Mitra, Chapter 11
Twiss & Moores, Chapter 10

• **Failure:** Rock is unable to support stress increase without permanent deformation



Non-linear behavior between stress and strain

Brittle Failure – Rock breaks to form continuous fractures resulting in the loss of cohesion.

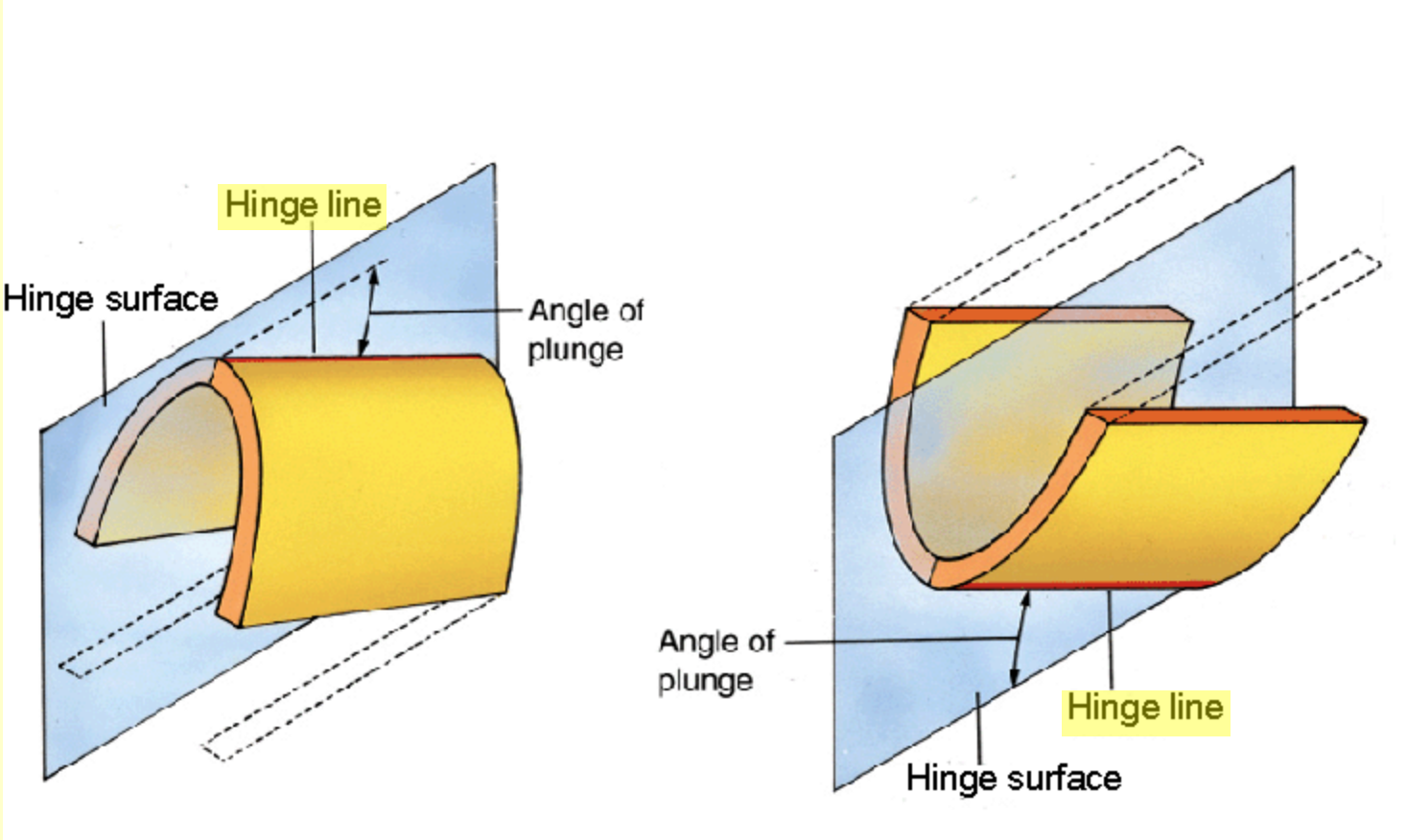
Ductile Failure – Rock deforms permanently without losing cohesion.

Brittle Failure – 1. Development of new fracture in an intact rock

2. Slip on a pre-existing fracture in a previously fractured rock

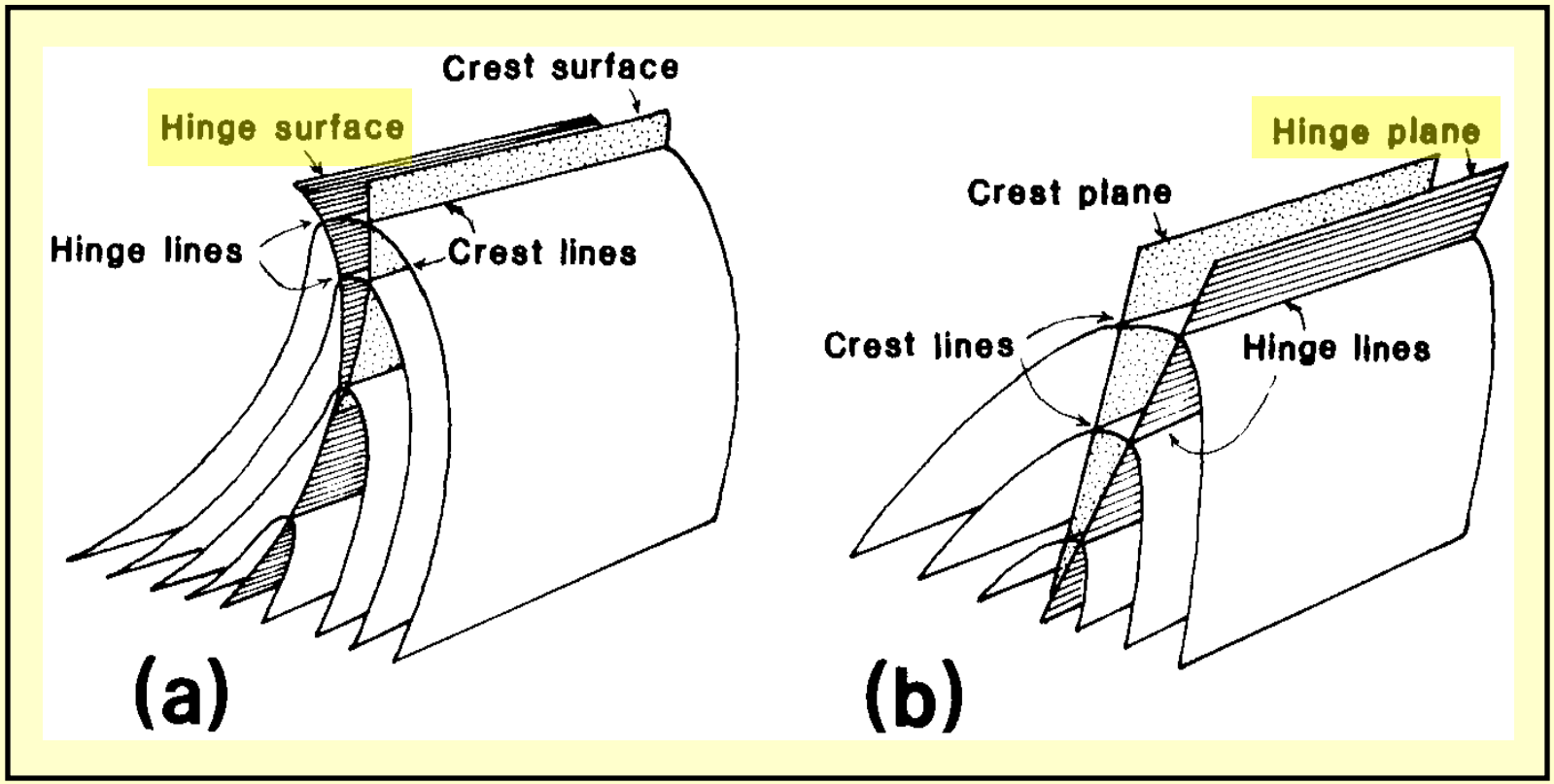
- **Fold-** Structural feature that is formed when layers of rocks are bent or curved.

Fold Geometry



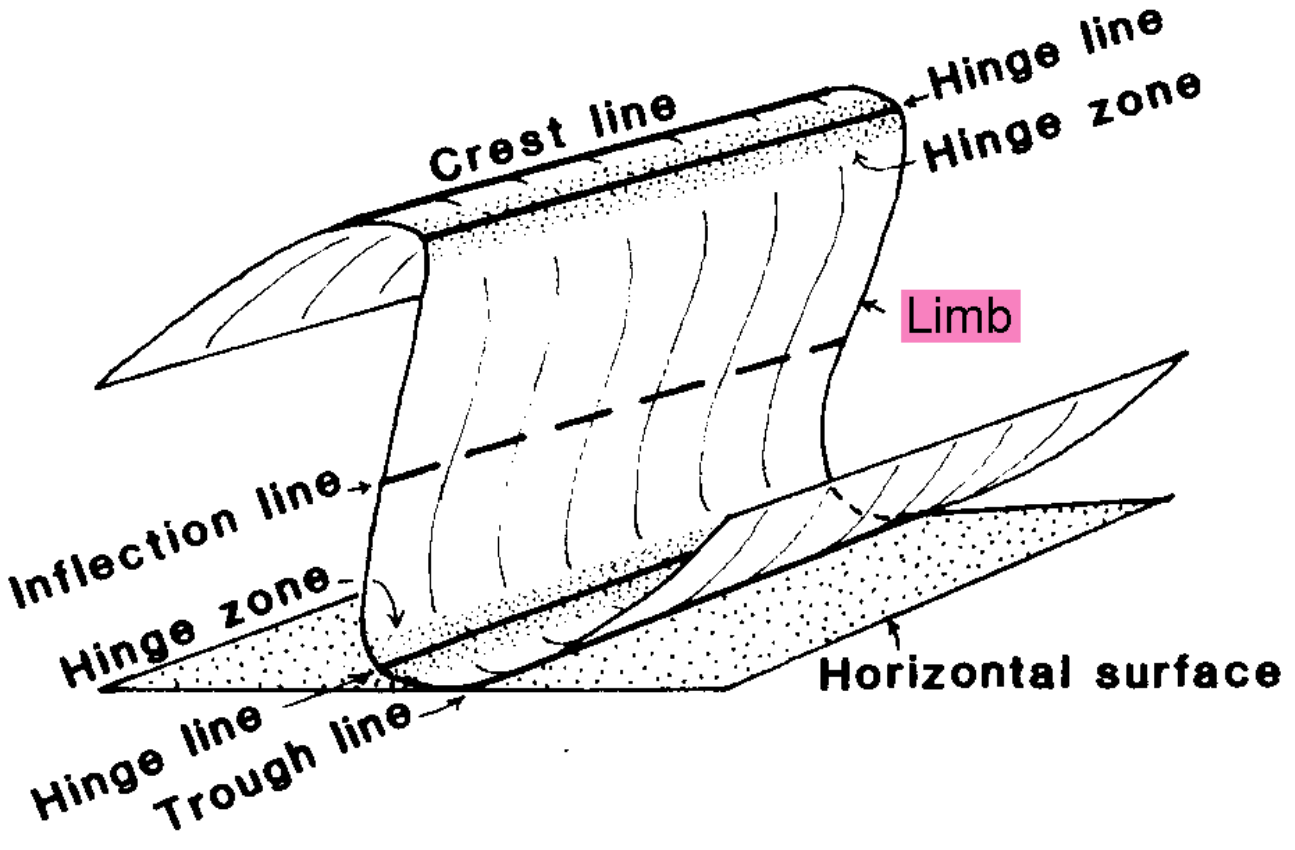
Hinge line: The locus of all points with maximum curvature (smallest radius of curvature)

Fold Geometry

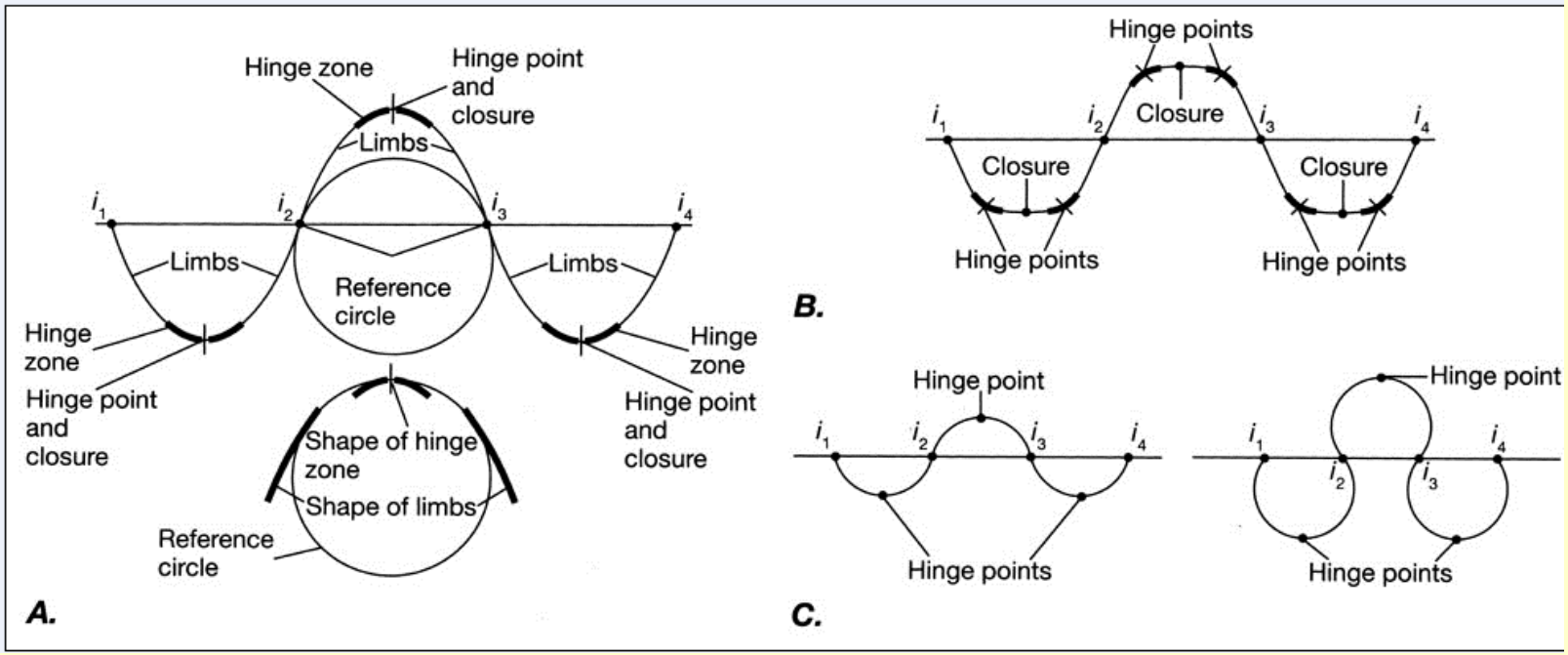


Hinge surface: A surface containing the hinge lines of successive folded surfaces within a single fold. If the surface is planar, it is referred to as a hinge plane.

Fold Geometry



Inflection line: Line at which surface changes from convex to concave.



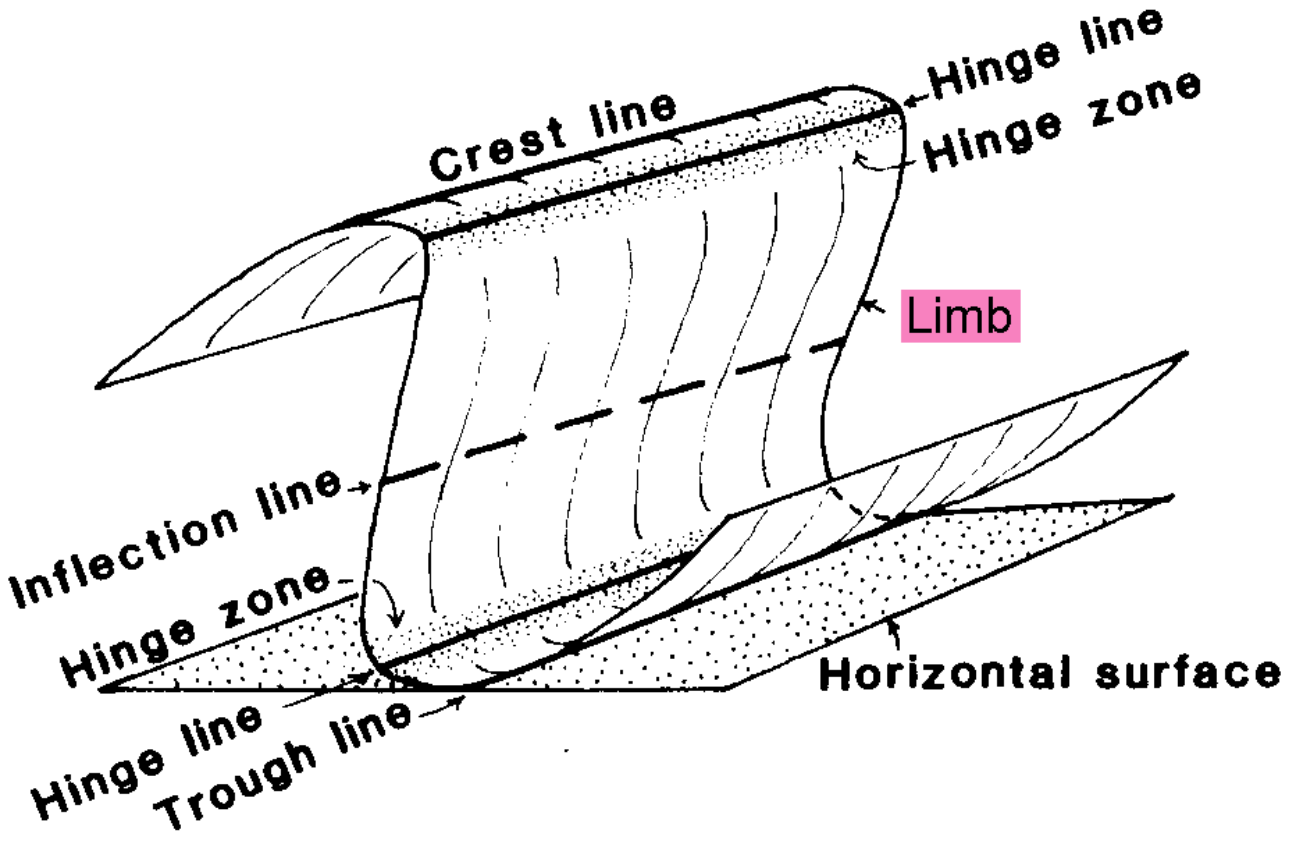
(Twiss & Moores Chapter 10)

Reference Circle: Tangent to two inflection points.

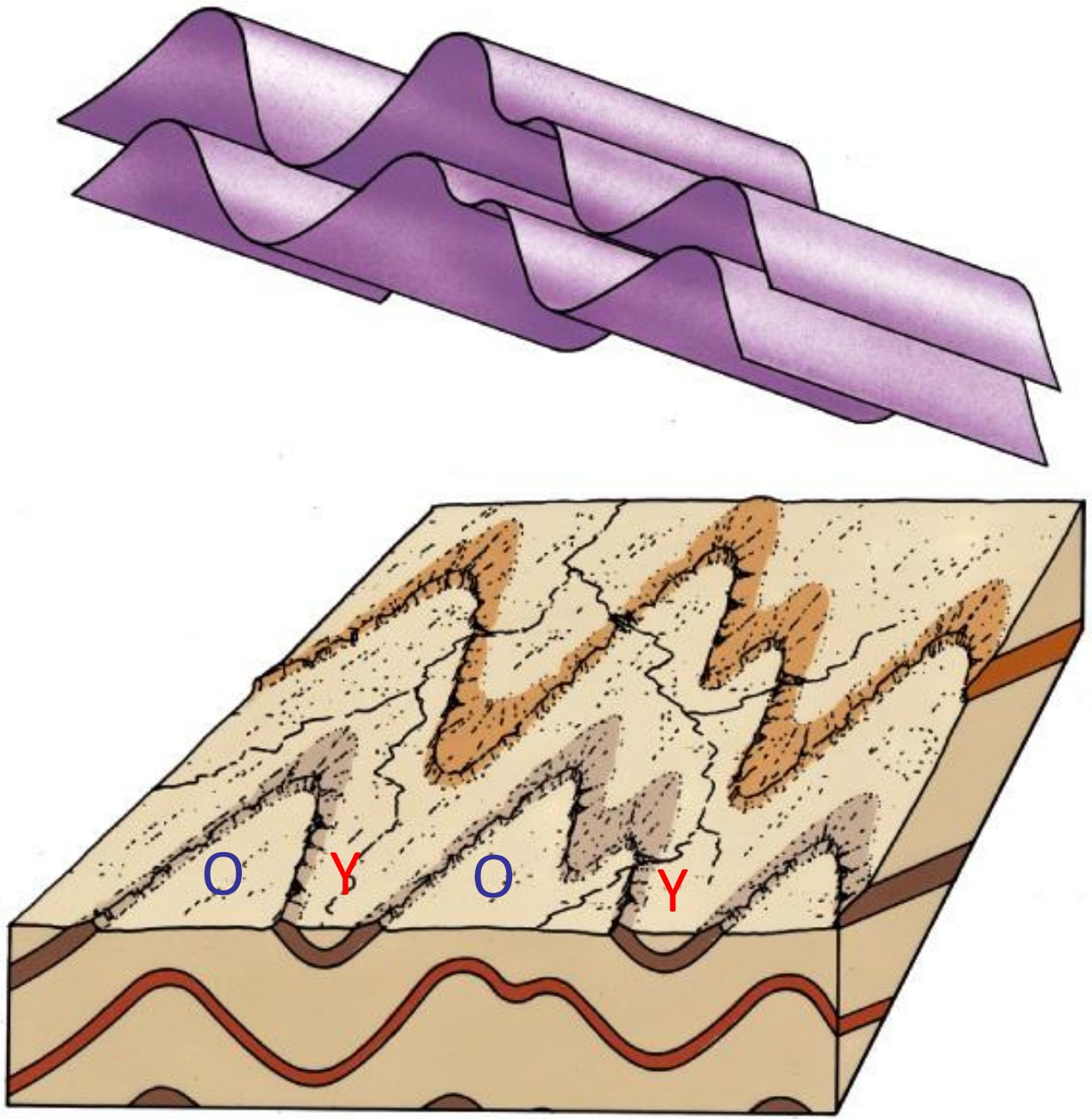
Hinge zone: Curvature > Reference circle

Limbs: Curvature < Reference circle

Fold Geometry

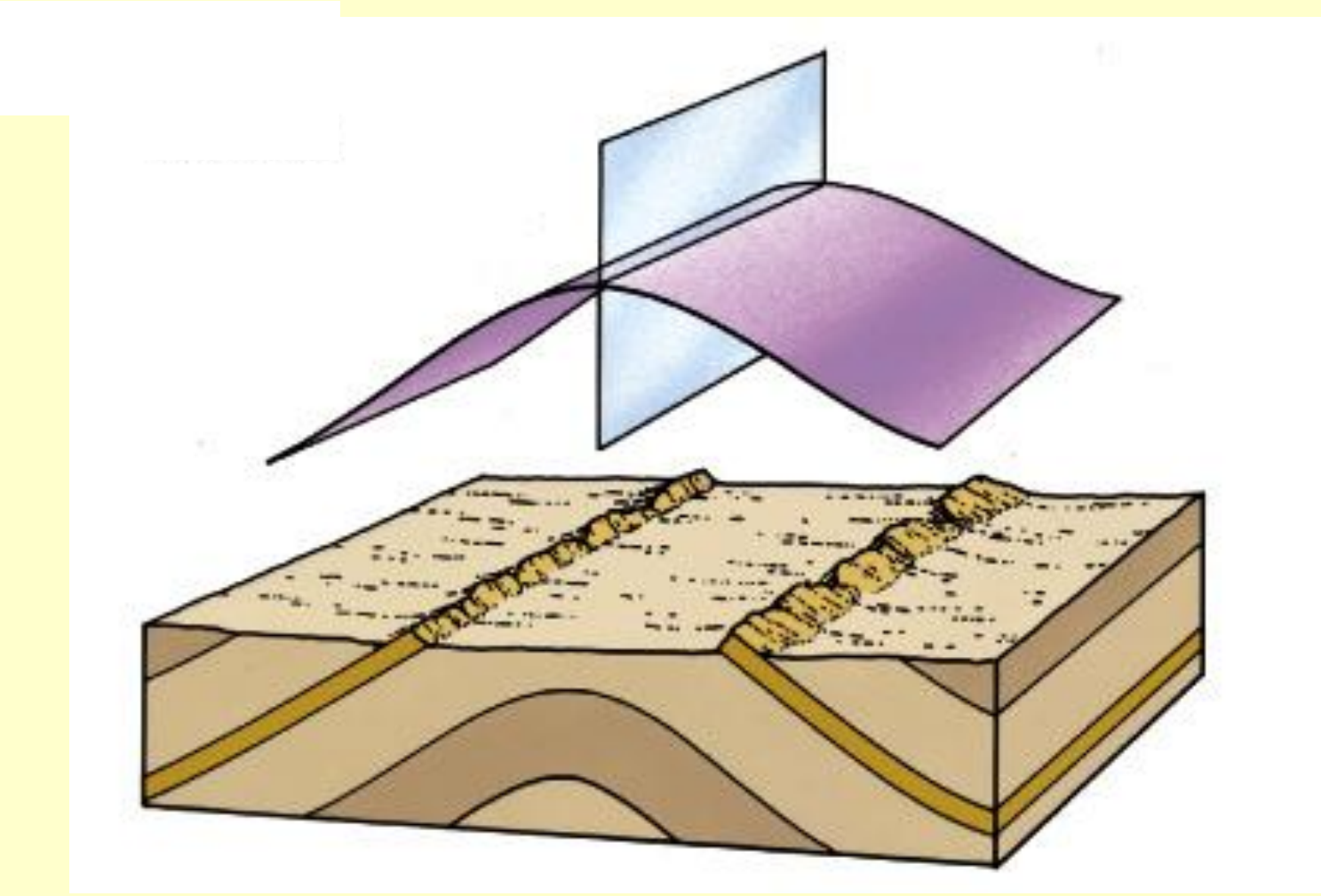


Fold Limb: Area of the folded surface between hinge zones where the surface has a large radius of curvature.

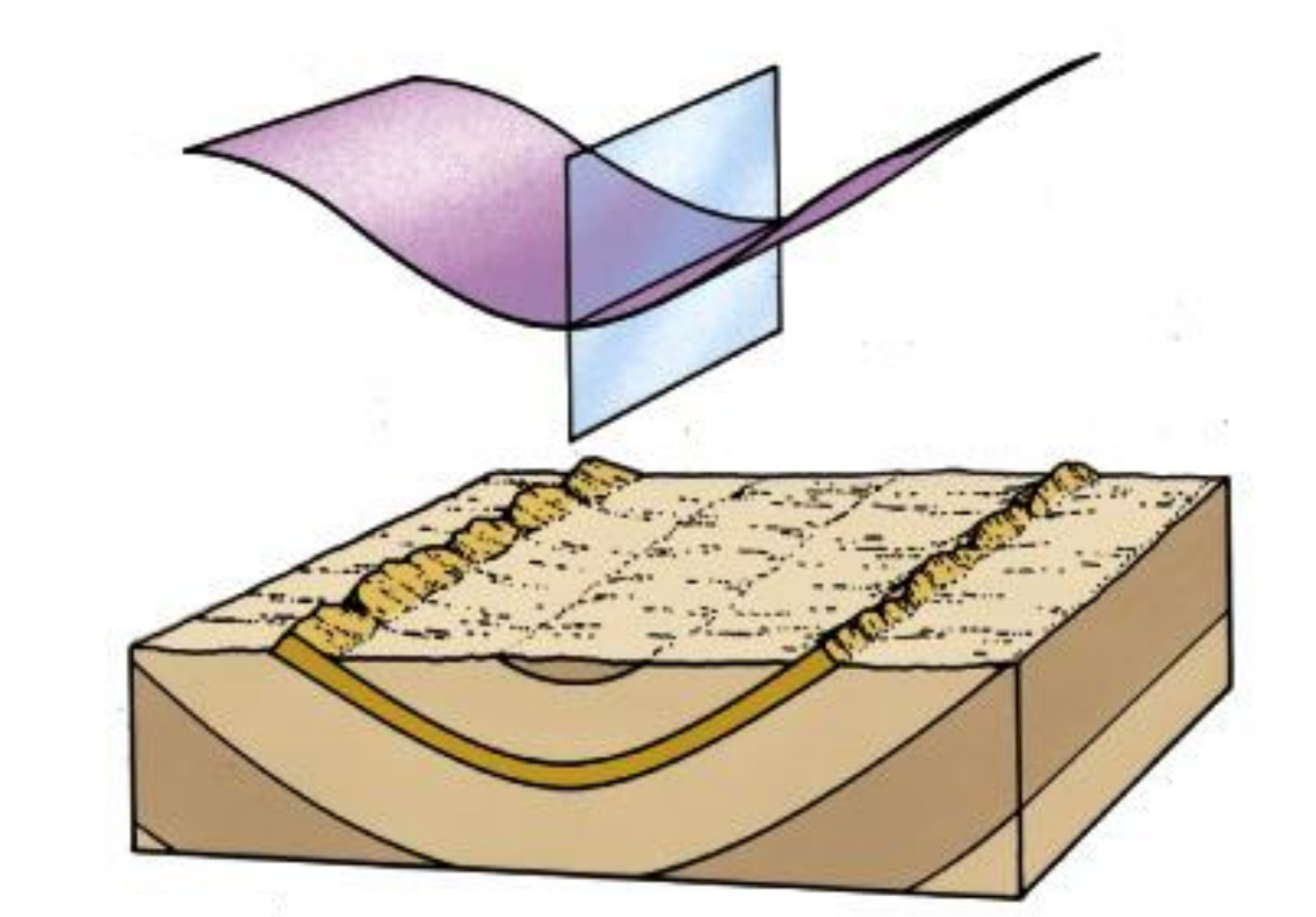

O
Y
O
Y

A. Closure:

Antiform: Fold closing upward and limbs dip *away* from the hinge line



Synform: Fold closing downward and limbs dip *toward* the hinge line.

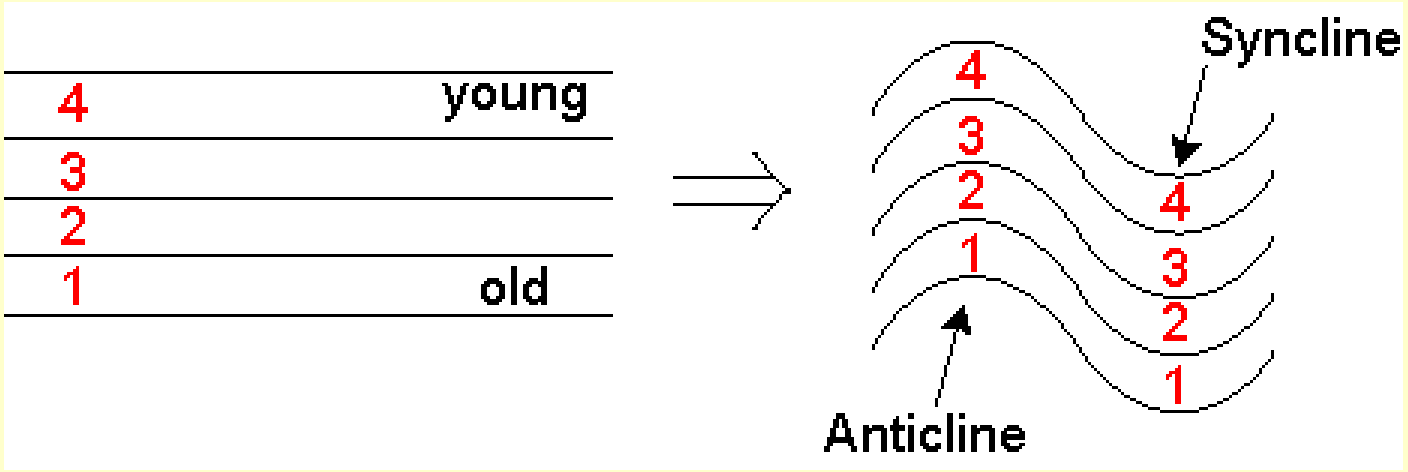


Neutral folds: Fold closing sideways (left or right)

Anticline & syncline – have very restricted usage and depend on stratigraphic younging direction (i.e. facing) of the folds.

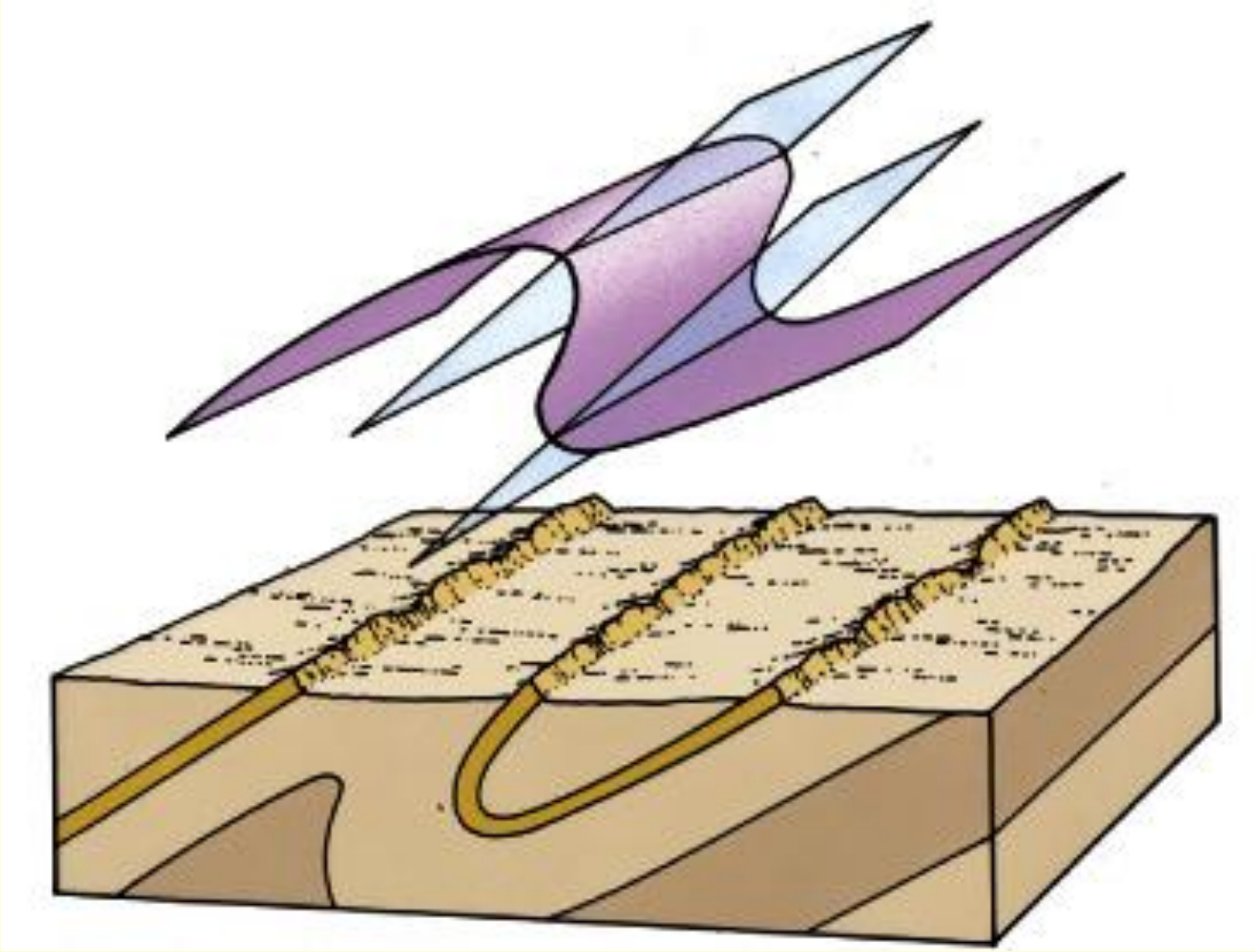
Anticline has the oldest unit of the folded sequence it its core.

Syncline has the youngest unit in the folded sequence it its core.



Folds

Overturned folds



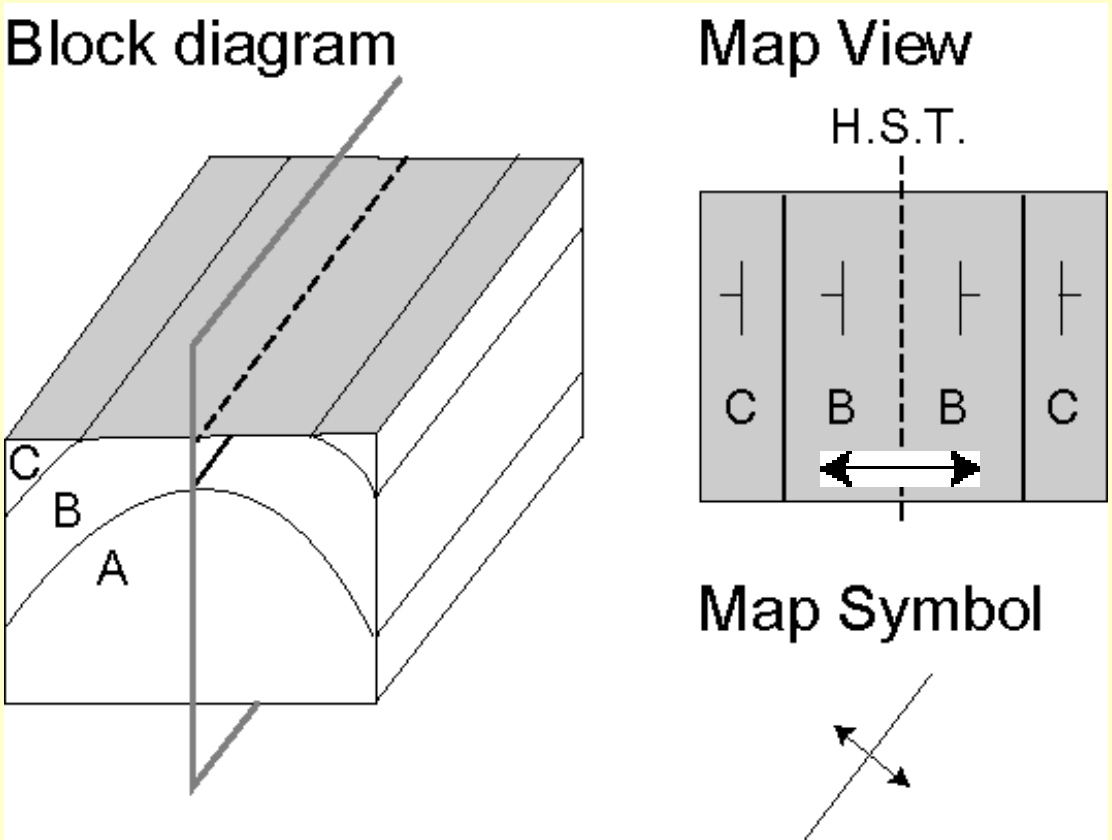
Orientation of folds

Hinge Plane: Strike, dip

Hinge line: Plunge, Bearing

Antiform

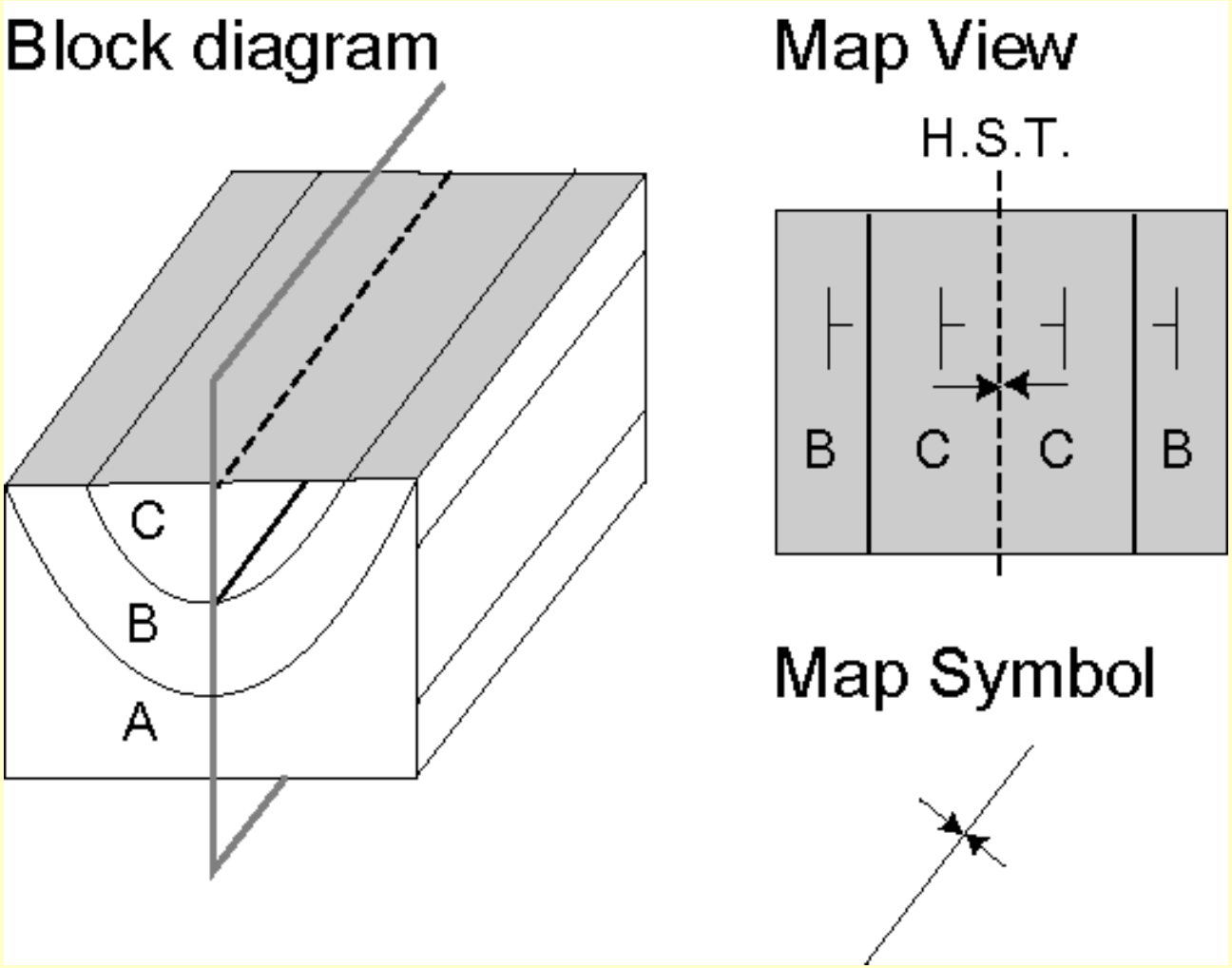
Non plunging fold



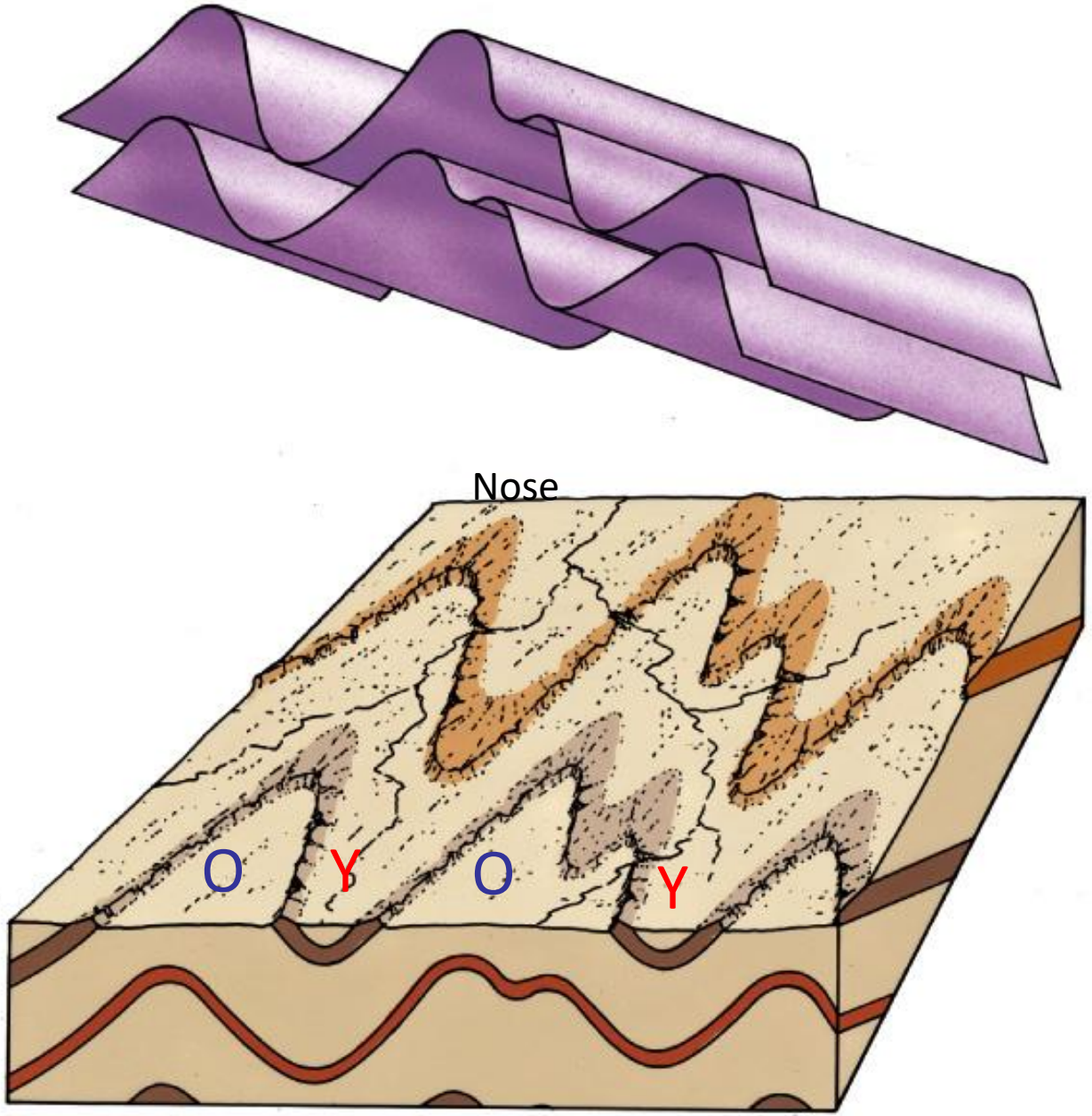
Symmetric repetition of beds

Orientation of folds

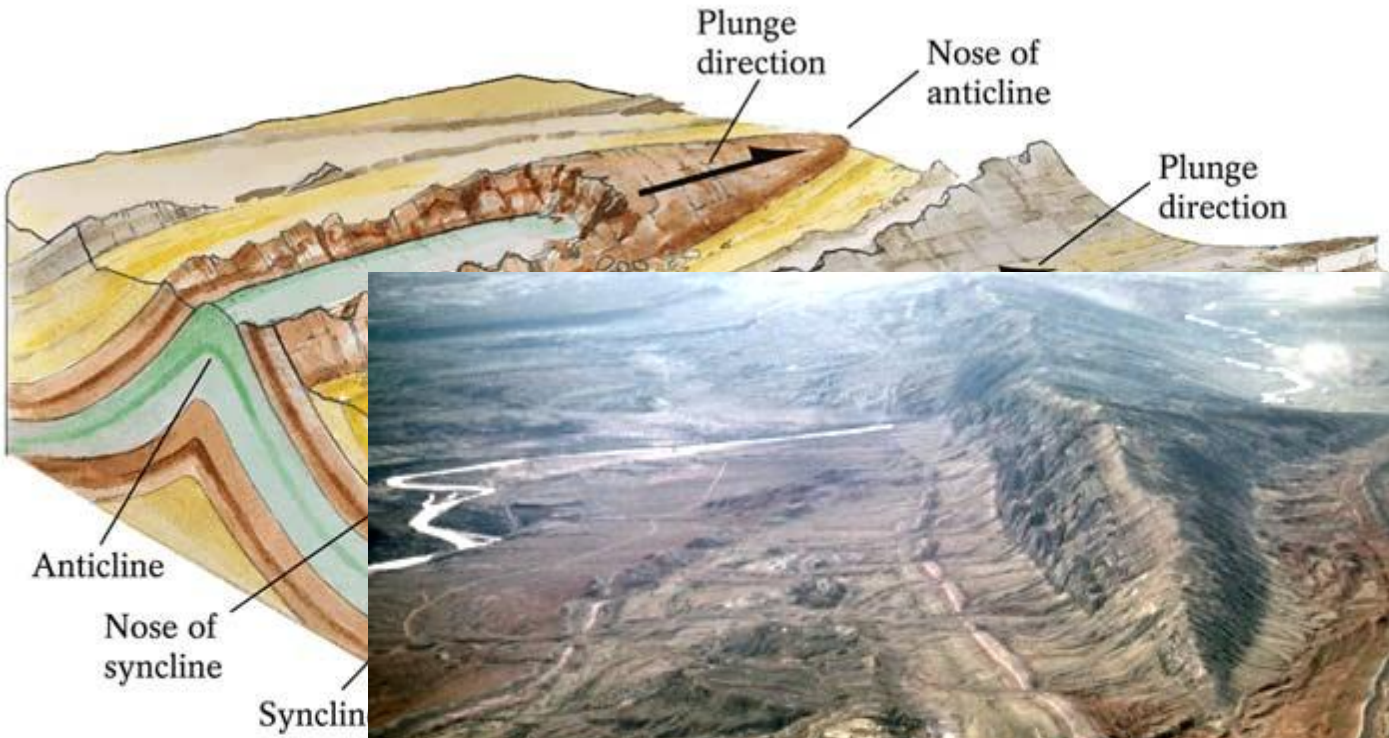
Synform

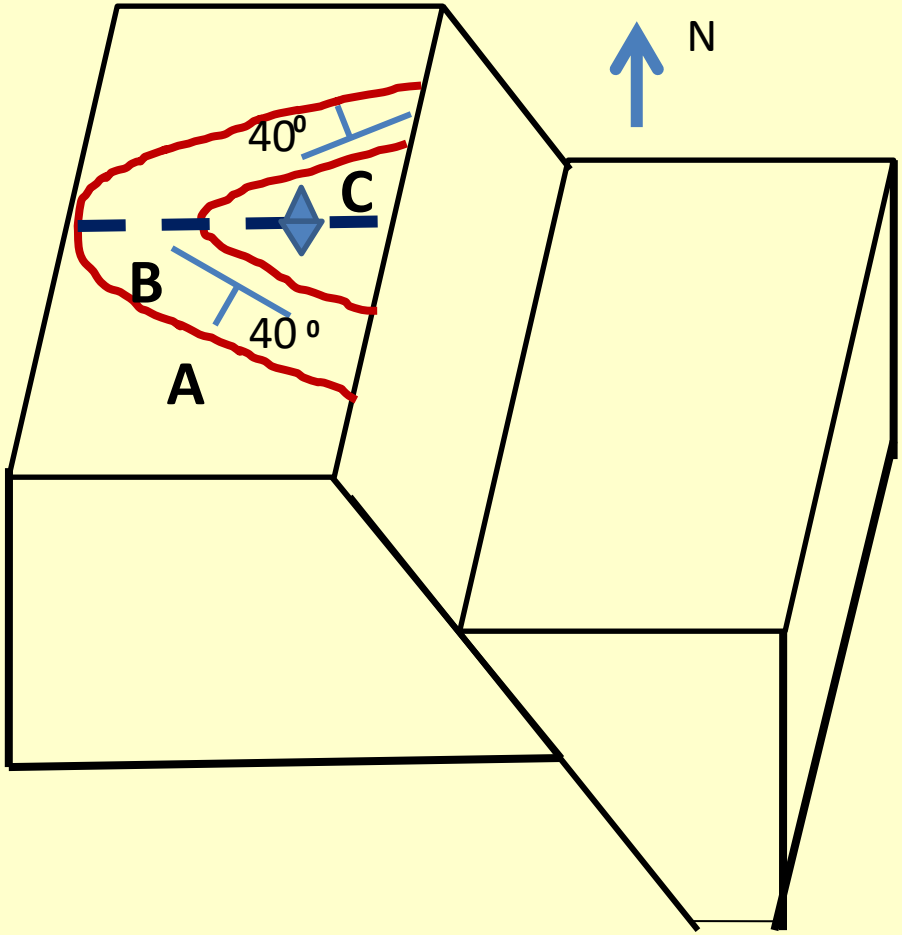


Plunging Fold: has an inclined hinge line

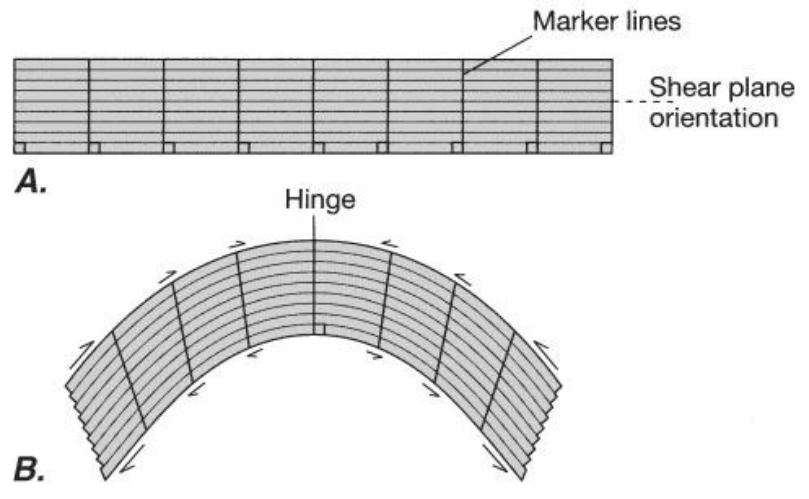


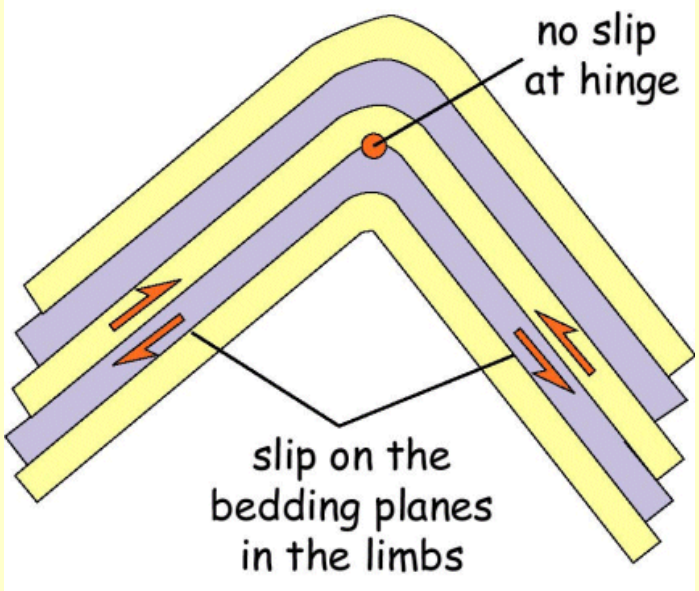
Plunging Folds




N
40º
C
B
40 º
A

Flexural Shear/Flexural Flow





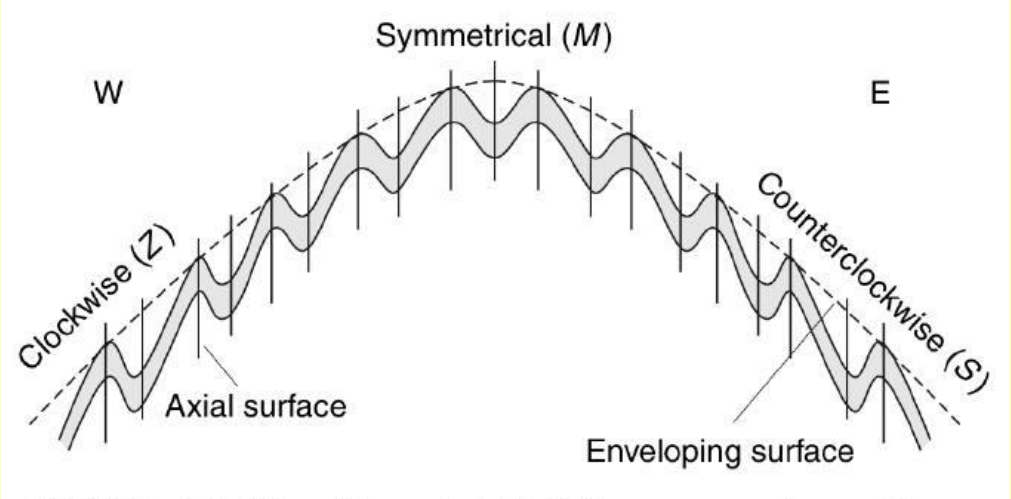
Thickness of the layer measured perpendicular to the shear planes is constant.

Flexural Flow: Folding accommodated by simple shear parallel to the layer, there is no lengthening & shortening, respectively, of the outer & inner arc of the fold.

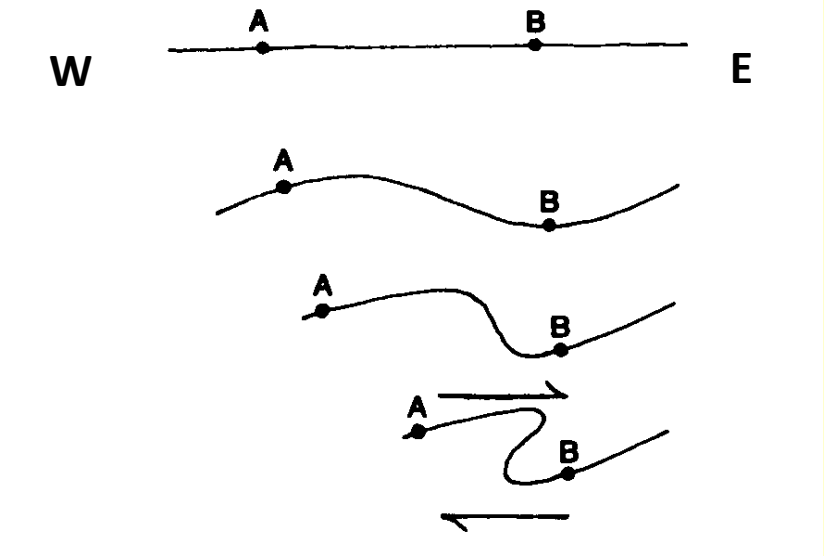
Flexural shear folding occurs if the layer is less competent/ has strong planar mechanical anisotropy/ strong foliation parallel to the layer.

Fold vergence

Vergence: The direction toward which the fold is turned.



- **Minor folds verge toward antiformal hinge surface & away from synformal hinge surface**



Sense of shear