

# GY403 Structural Geology Lab

Geological Attitudes and 3D Block  
Diagram Interpretation

# Terminology & Definitions

- Azimuth: compass direction of a line measured relative to north=0, east=090, south=180, west=270 (increases clockwise from north).
- Bearing: compass direction of a line in quadrant format (ex. N30W, S20E)
- Trend: azimuth or bearing direction of a line (ex. 330 or N30W). A vertical line has no definable trend.
- Strike: trend of the horizontal line contained in a geological plane (ex. bedding). By convention strike lines are recorded to a north quadrant (0-90; 270-360)
- Inclination: angle measured from a line of plane to the horizontal in a vertical plane. The maximum possible angle is 90. Planar structures have inclinations that are termed "true dip". Linear structures have an inclination that is termed "plunge".
- Dip: inclination angle measured on a geological plane. If the angle is measured perpendicular to strike it is a "true" dip, otherwise the angle is an "apparent" dip. Apparent dips are always less than the true dip.
- Plunge: inclination of a line measured from the line up to the horizontal in a vertical plane.
- Trace: intersection of a plane with the horizontal map surface. For example the axial trace is the intersection of the axial plane with the map surface. If the map surface is horizontal the trace is also the strike line of the plane.
- Rake (Pitch): angle between a line contained in a plane and the strike line of the plane. A rake angle needs to be followed by the quadrant end of the strike line from where the rake was measured (ex. 33SW in a plane that is oriented N50E, 60SE). The maximum possible angle is 180.

# Attitude (Orientation) of Geological Structures

- Geological structures that can be measured are either geometric “planes” or “lines”.
- Planar: geological structures such as bedding, faults, joints, axial planes are planar geometries.
- Linear: geological structures such as fold hinges, elongated minerals, cleavage/bedding intersection are linear geometries

# Planar Attitudes

- A plane's attitude in 3D space is determined by measuring 2 non-parallel lines that lie within the plane.
- Strike and Dip: strike is the trend of the horizontal line that lies in the geological plane. By convention this trend is always recorded to a north quadrant. The trend can be either azimuth or bearing format.
- The dip is the maximum angle of inclination of the plane. Because the dip trend is always perpendicular to the strike only the quadrant direction (NE, SE, NW, SW) is needed for the dip.
- Azimuth Example: 050, 68SE. The north end of the strike line is trending at azimuth 050. The true dip inclination angle is 68 degrees trending at 140 azimuth (southeast quadrant 90 degrees from strike). The two non-parallel lines that define the plane are the strike line (azimuth=050, plunge=0), and the dip line (azimuth=140, plunge=68).
- Quadrant Bearing example: N30W, 55SW. The north end of the strike line is trending 330 azimuth (=N30W), and the dip line is trending 240 azimuth (SW quadrant 90 degrees from strike). The plunge of the dip line is 55.

# Other Planar Attitude Conventions

- Right-Hand rule: rather than reading the strike to a north quadrant (NE: 0-90; NW: 270-360) the strike trend is recorded in the azimuth direction such that the true dip (incline) of the plane is to the observers right. This removes the need for a quadrant direction for the dip.
- Example: A strike and dip of 310, 55SW would be measured as 130, 55.
- Note that a right-hand rule measurement appears no different than a bearing and plunge for a line so the note-taker must be careful to distinguish planar from linear data.

# Other Planar Attitude Measurement Conventions

- Dip Trend and Angle: Because the strike of a plane always has a trend 90 degrees from the dip trend, one may simply record the dip trend and dip angle of a plane. The strike can always be calculated as the line trending perpendicular to the dip trend.
- As with the right-hand rule, the note-taker must be careful to distinguish planar from linear data.

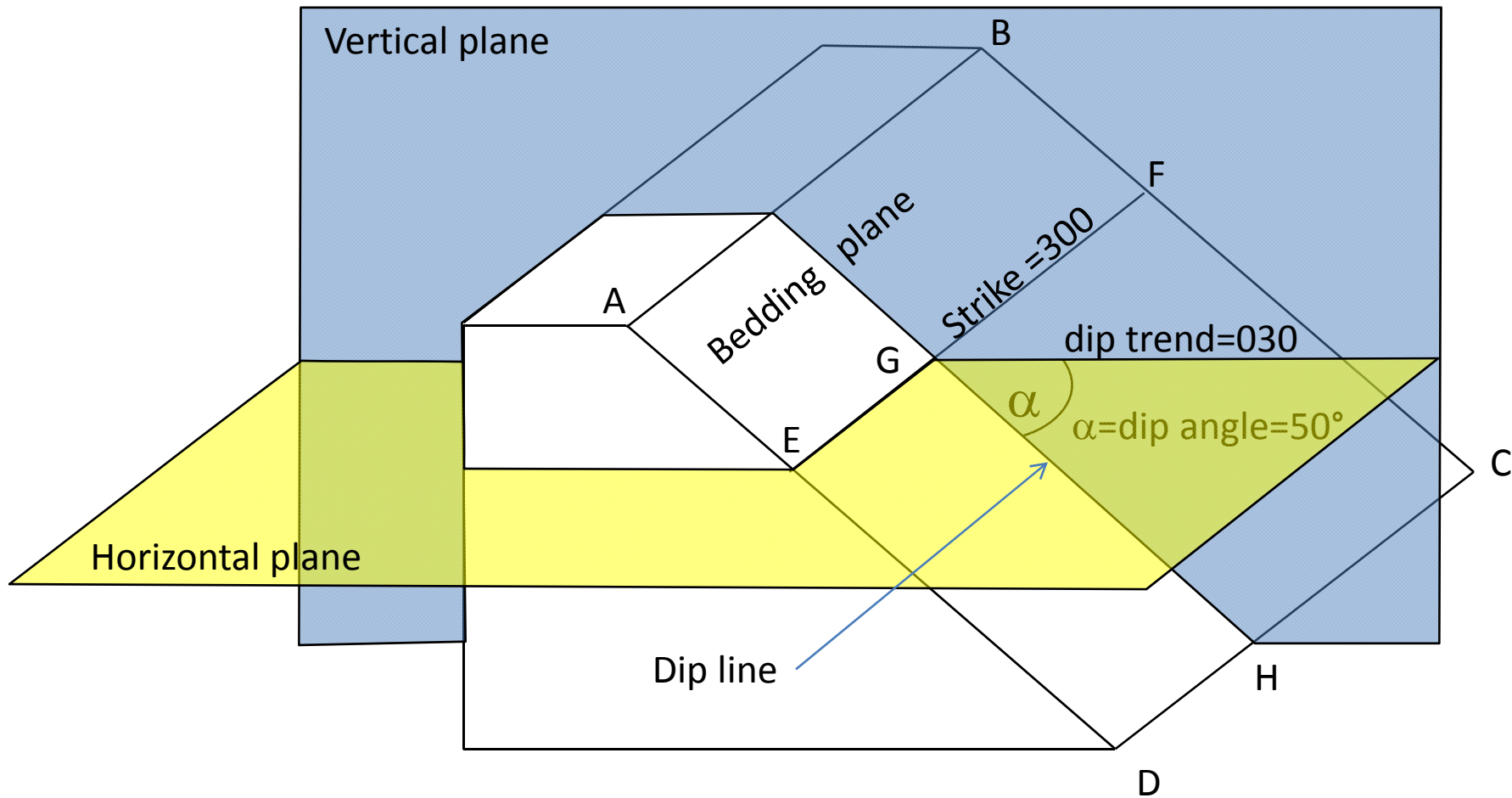
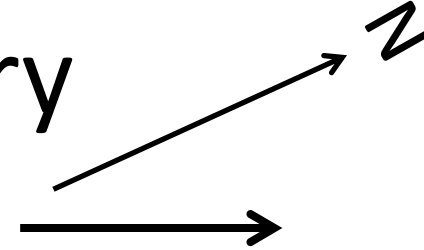
# Planar Geometry

Strike & Dip: 300, 50NE

Right-Hand: 300, 50

Dip line trend and plunge: 030, 50

030 azimuth



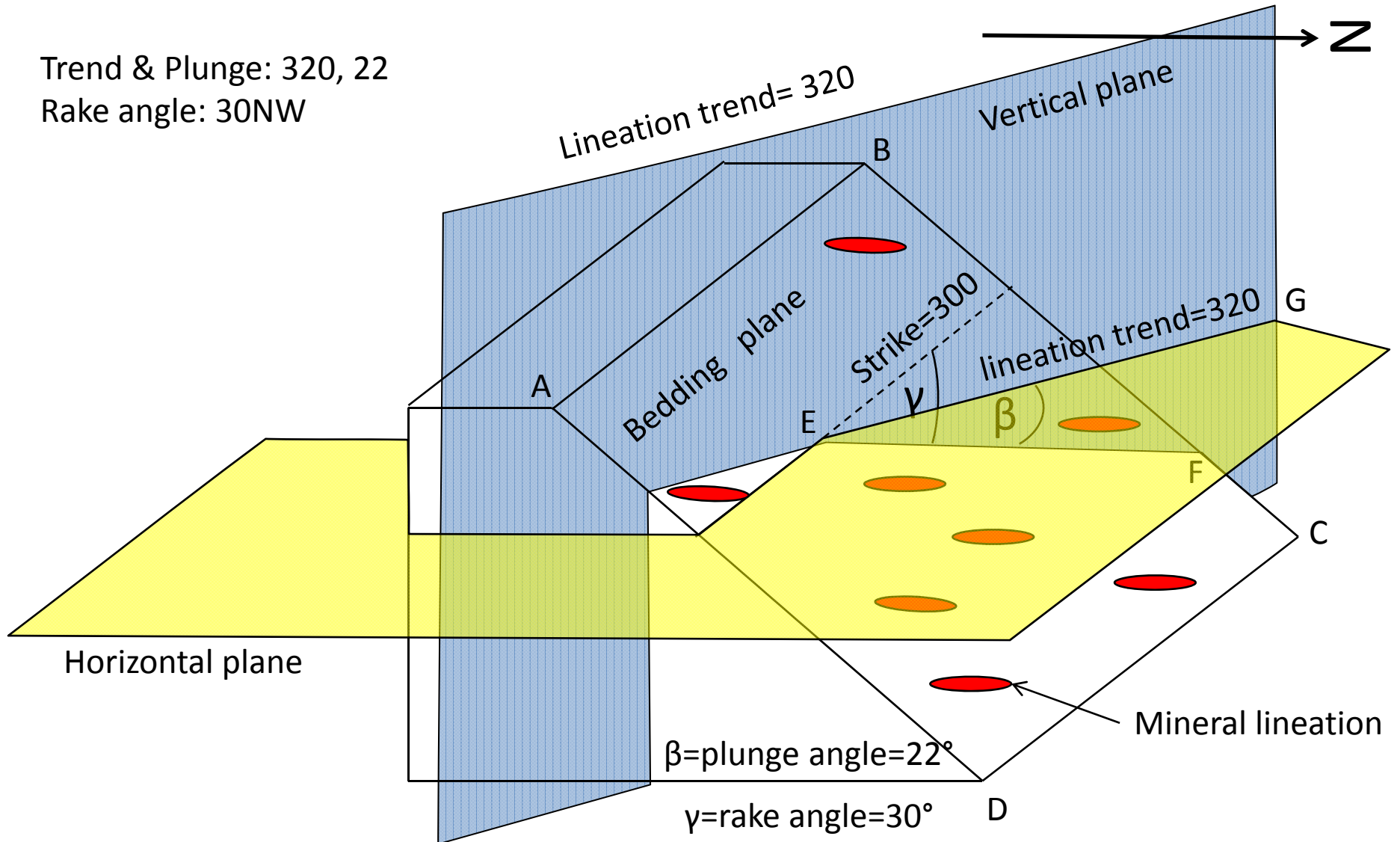
# Linear Attitude

- Linear attitudes are specified by a bearing (trend) and plunge measurement. Note that no quadrant direction is needed therefore 2 numbers completely specify the attitude.
- Example: 220, 15 (line is trending at azimuth 220, and the plunge incline is 15 degrees).
- Note that a line may trend in any azimuth direction (0-360).
- Note that a line plunging 90 degrees (vertical) has no definable trend.

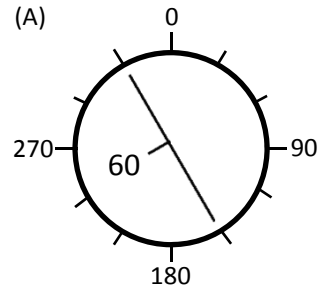


# Linear Geometry

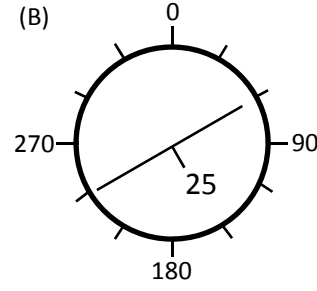
Trend & Plunge: 320, 22  
Rake angle: 30NW



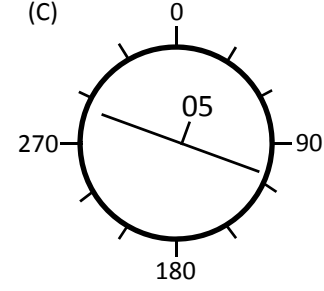
# Planar Attitude Examples



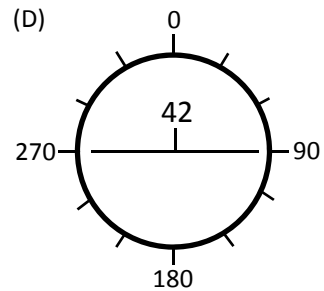
330, 60SW



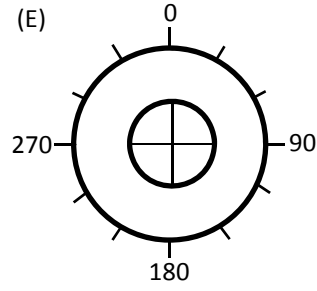
060, 25SE



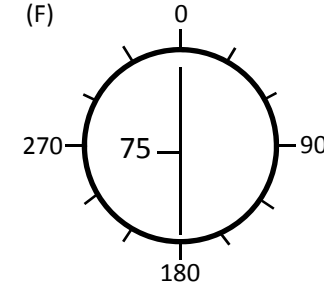
290, 05NE



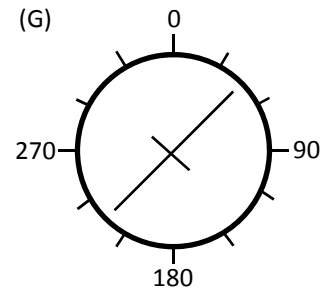
090, 42N -or- 270, 42N



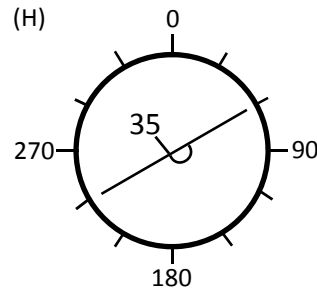
horizontal



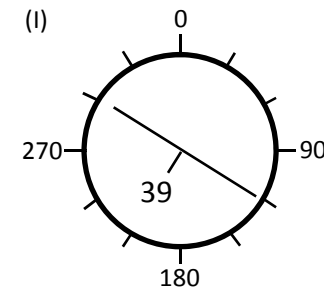
000, 75W



045, 90

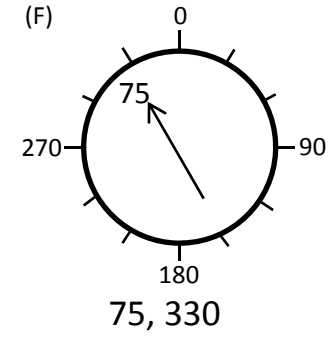
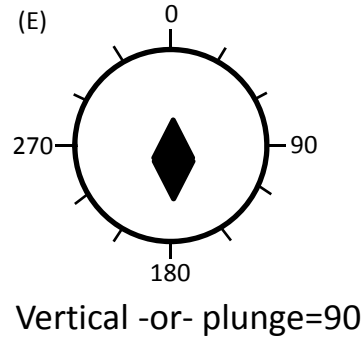
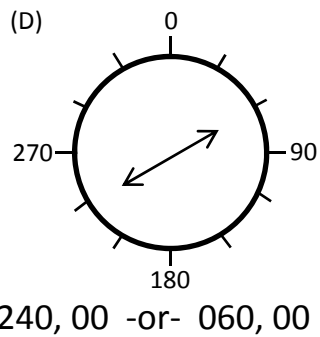
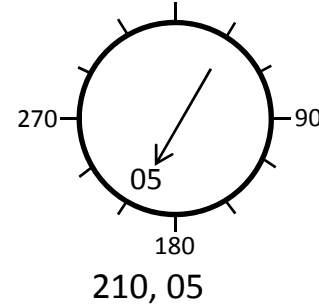
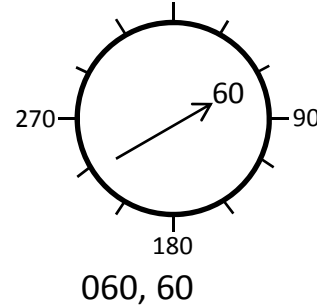
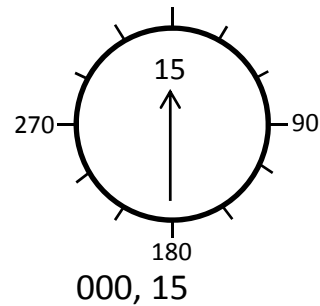


060, 35NW OT



Rt. hand rule: 120, 39


# Linear Attitude Examples



Note: all above linear attitudes are in “azimuth, plunge” format, except (F) that is in “plunge, azimuth” format.

# Geologic Time


Young



Old

Period	Symbol
Quaternary	Q
Tertiary	T
Cretaceous	K
Jurassic	J
Triassic	Tr
Permian	P
Pennsylvanian	P

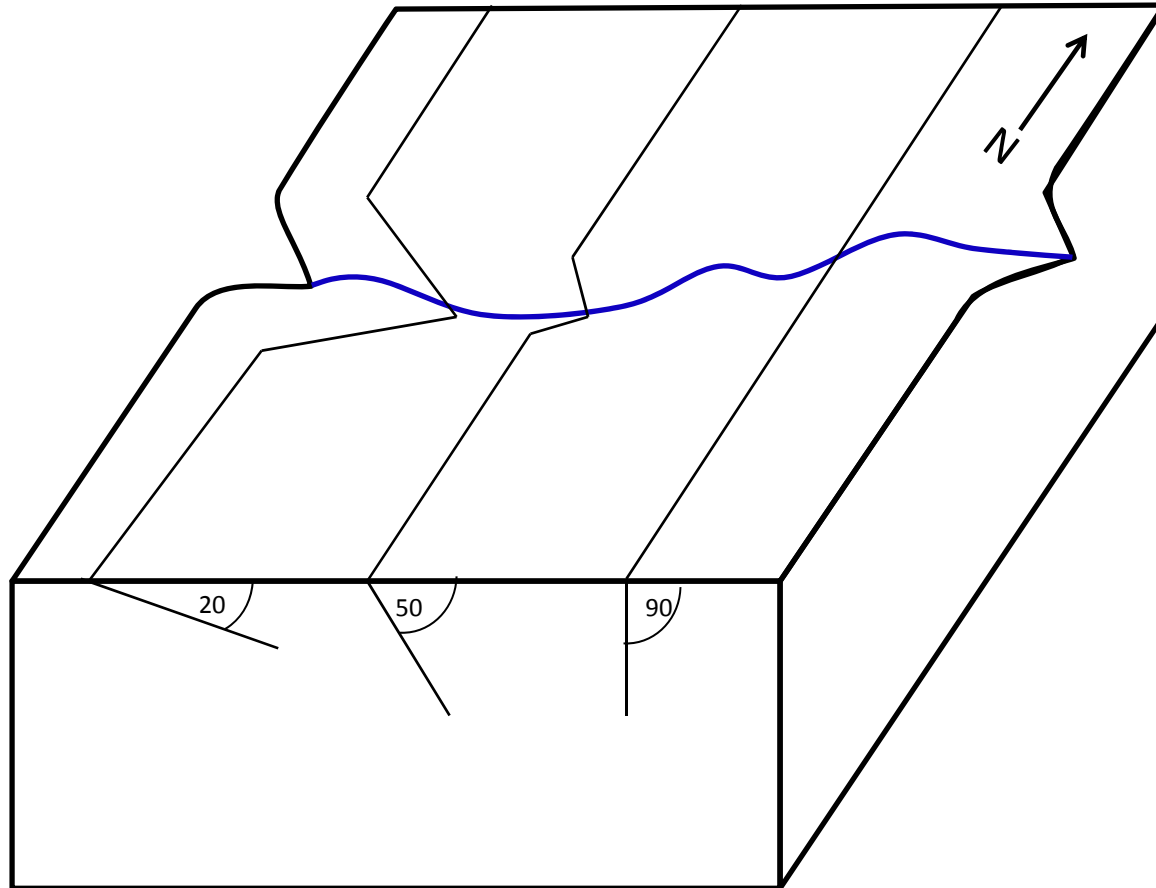
Young



Old

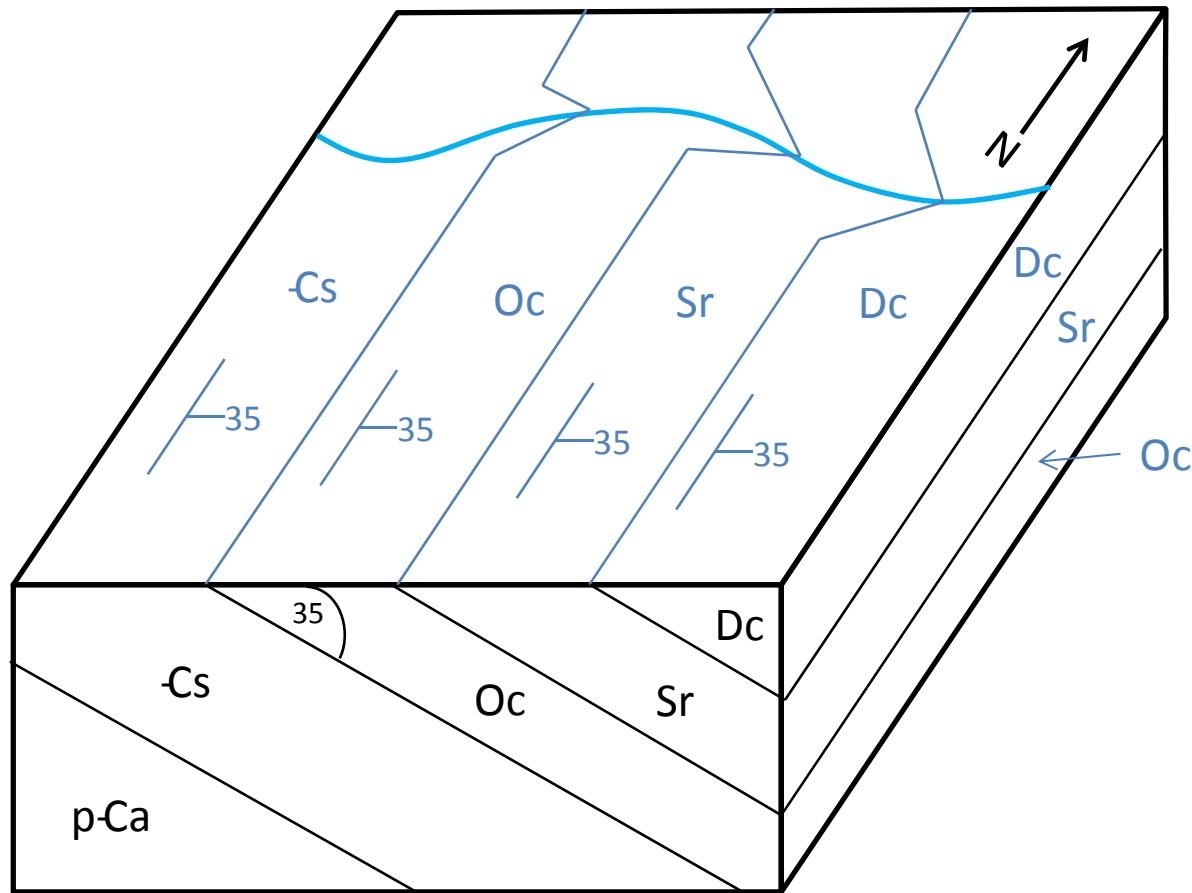
Period	Symbol
Mississippian	M
Devonian	D
Silurian	S
Ordovician	O
Cambrian	-C
Precambrian	p-C

# Rule of “V’s” for Geologic Contacts Crossing Stream Valleys



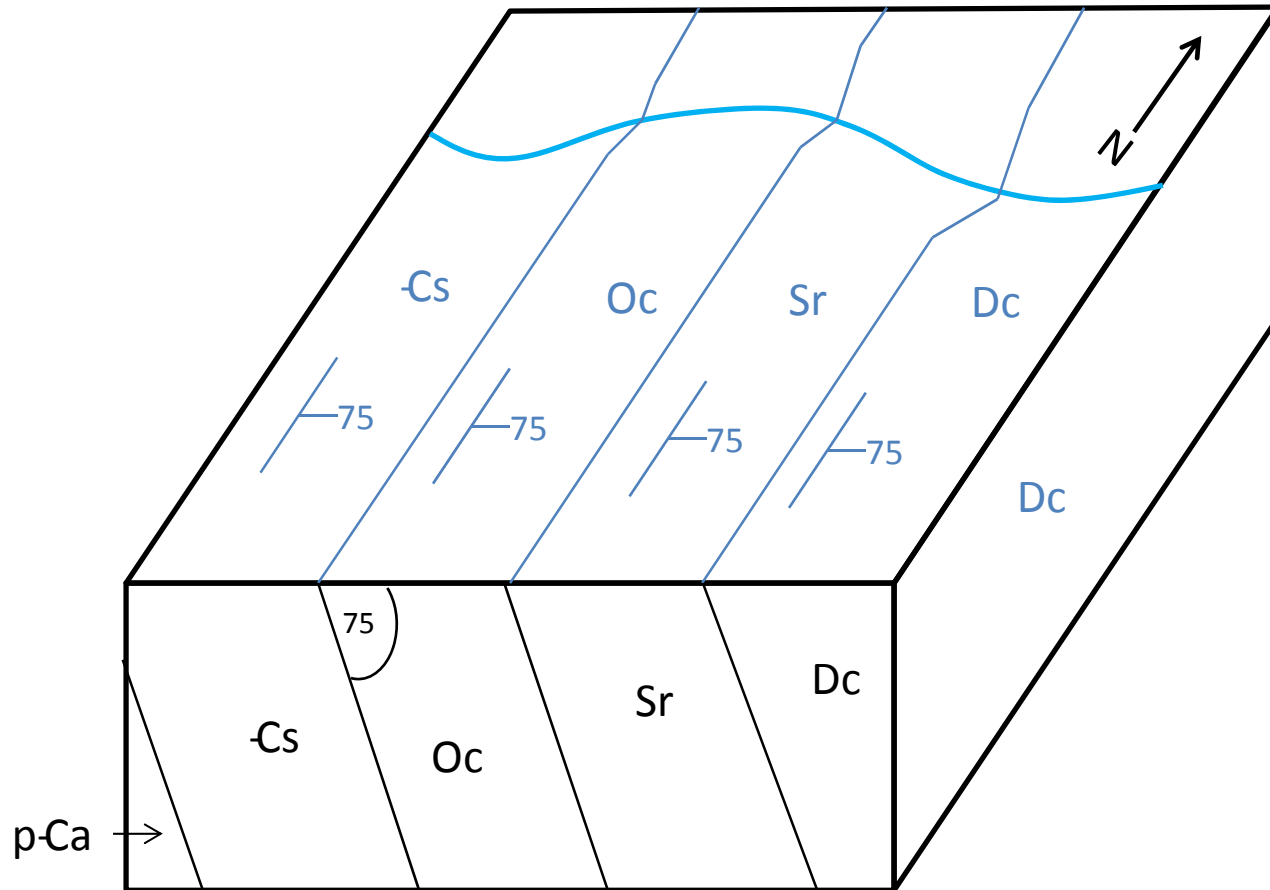
- “V” in dip direction is less pronounced with larger dip angle
- A vertical bed shows no “V”

# Bedding Strike & Dip Symbols



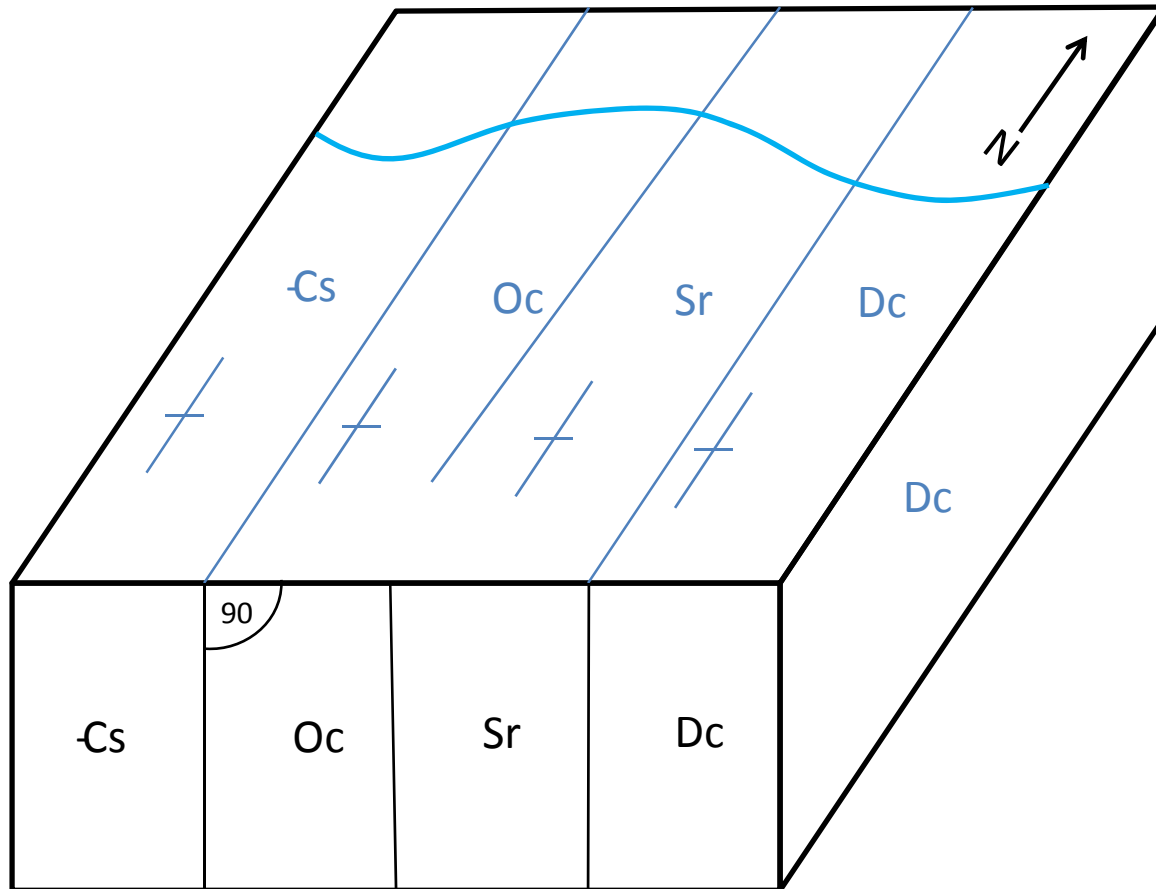
- Unless strata is overturned dip should be toward younger beds
- Strike is parallel to contact
- Dip angle is measured in plane perpendicular to strike
- Stream valley produces a contact "V" that points in dip direction

# Bedding Strike & Dip Symbols



- “V” in dip direction is less pronounced with larger dip angle

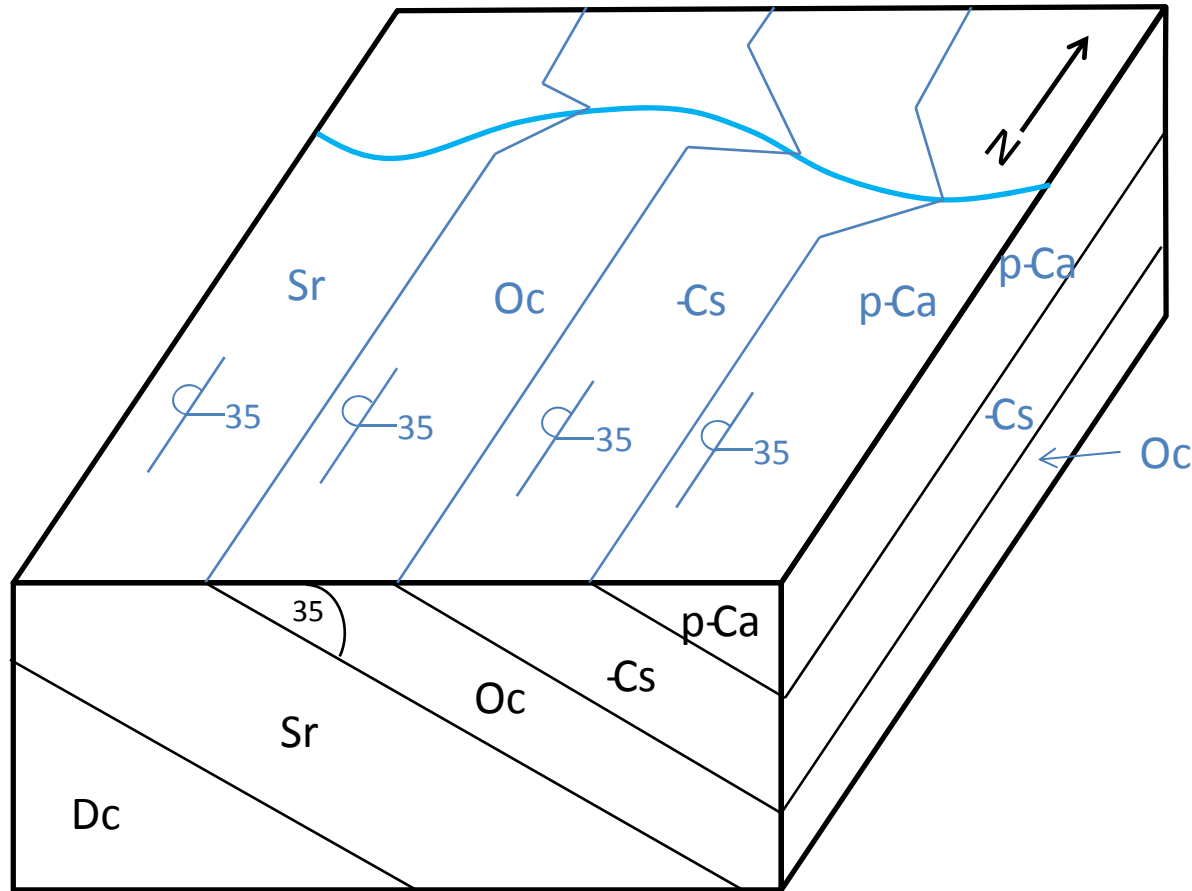
# Bedding Strike & Dip Symbols



- Vertical beds have no “V” across a stream valley
- Note the special symbol for a vertical planar attitude

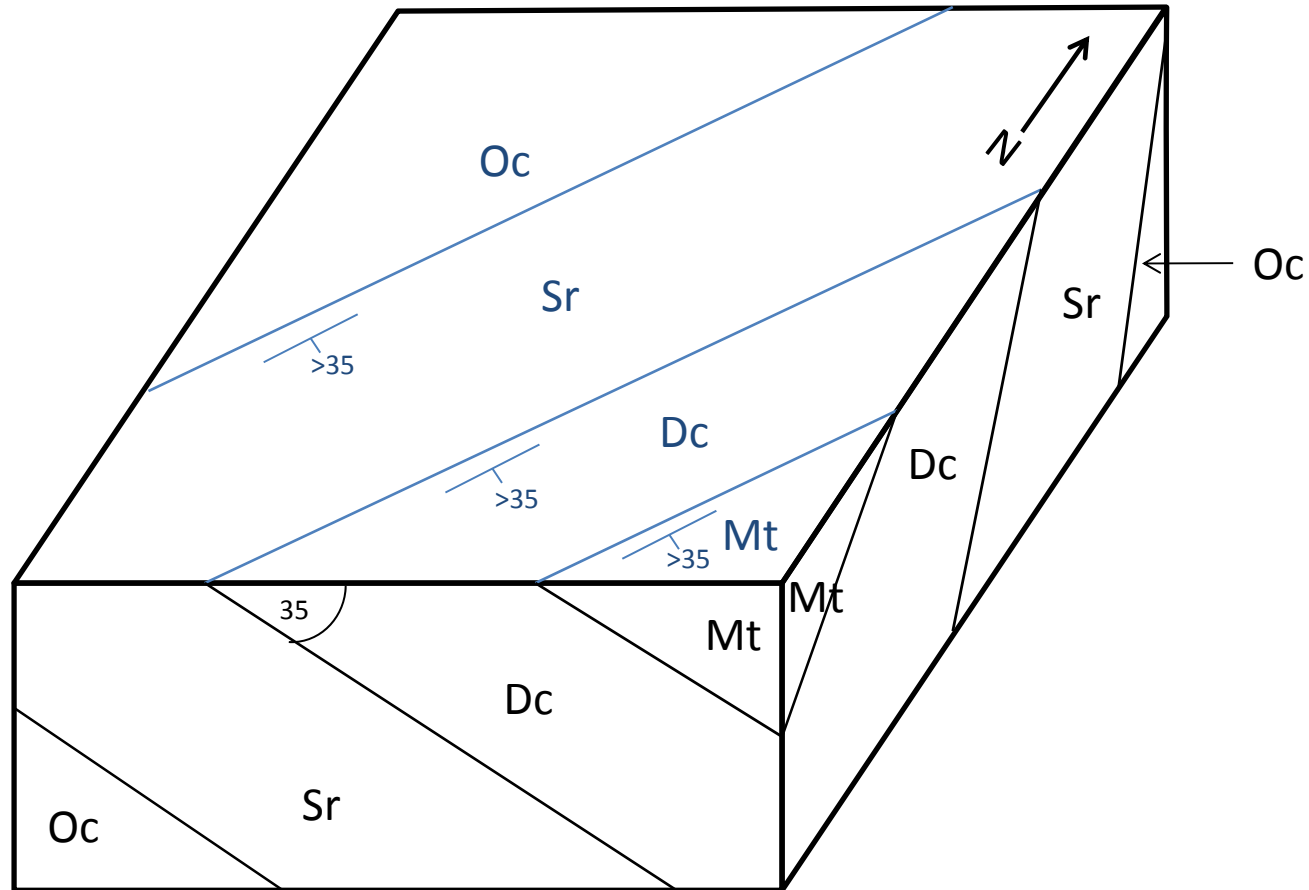


# Bedding Strike & Dip Symbols



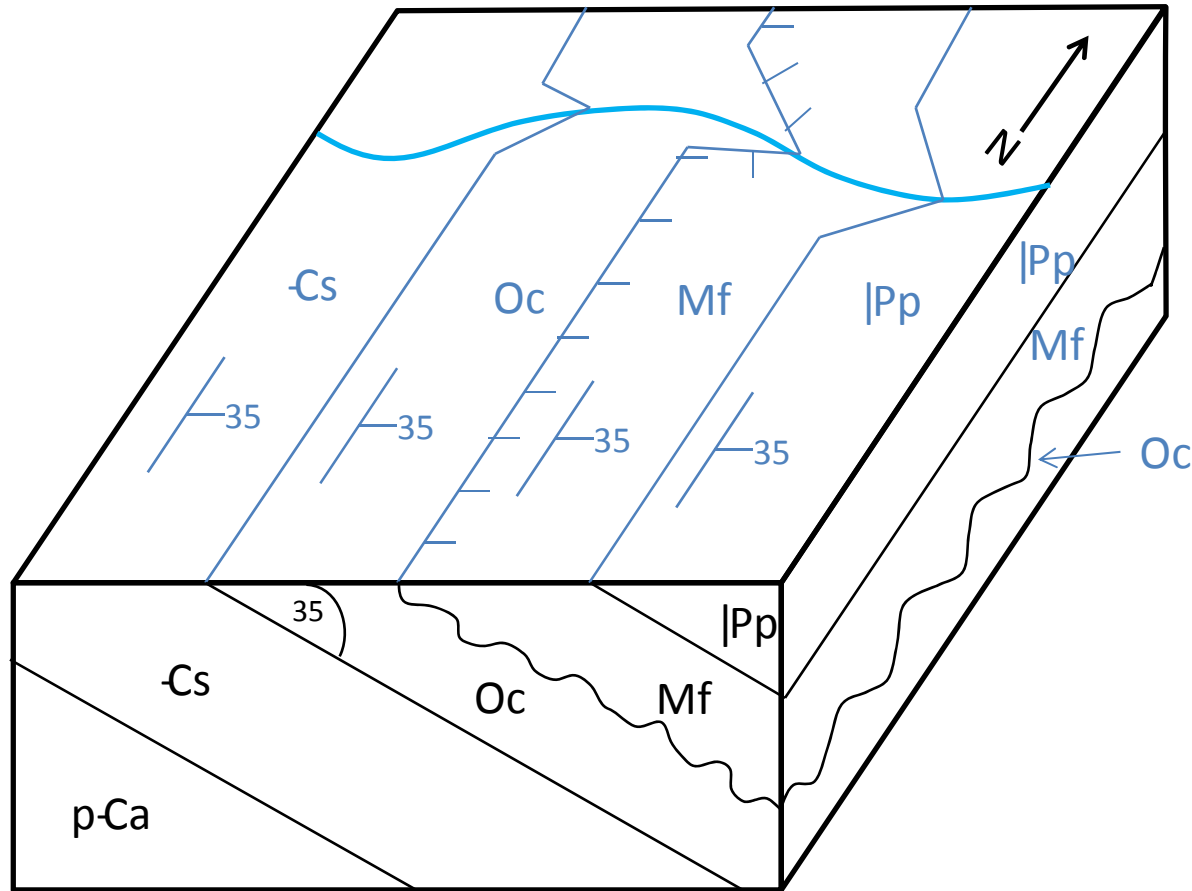
- Note the overturned symbol and that the dip direction is toward older beds

# Apparent Dips



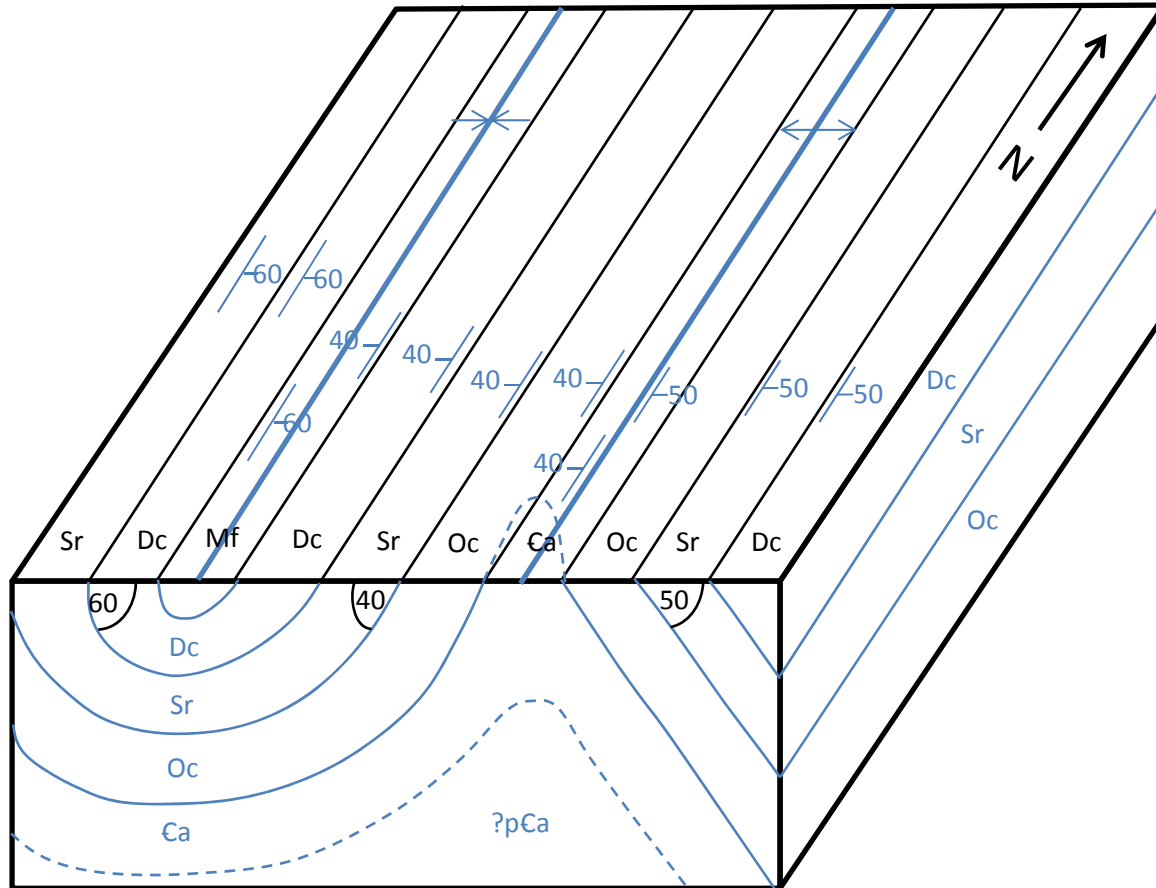
- Note that the 35 degree angle on the front face must be an apparent dip because the contacts on the map surface are clearly not perpendicular to the front face. The true dip must therefore be  $>35$  degrees.

# Unconformable Contacts



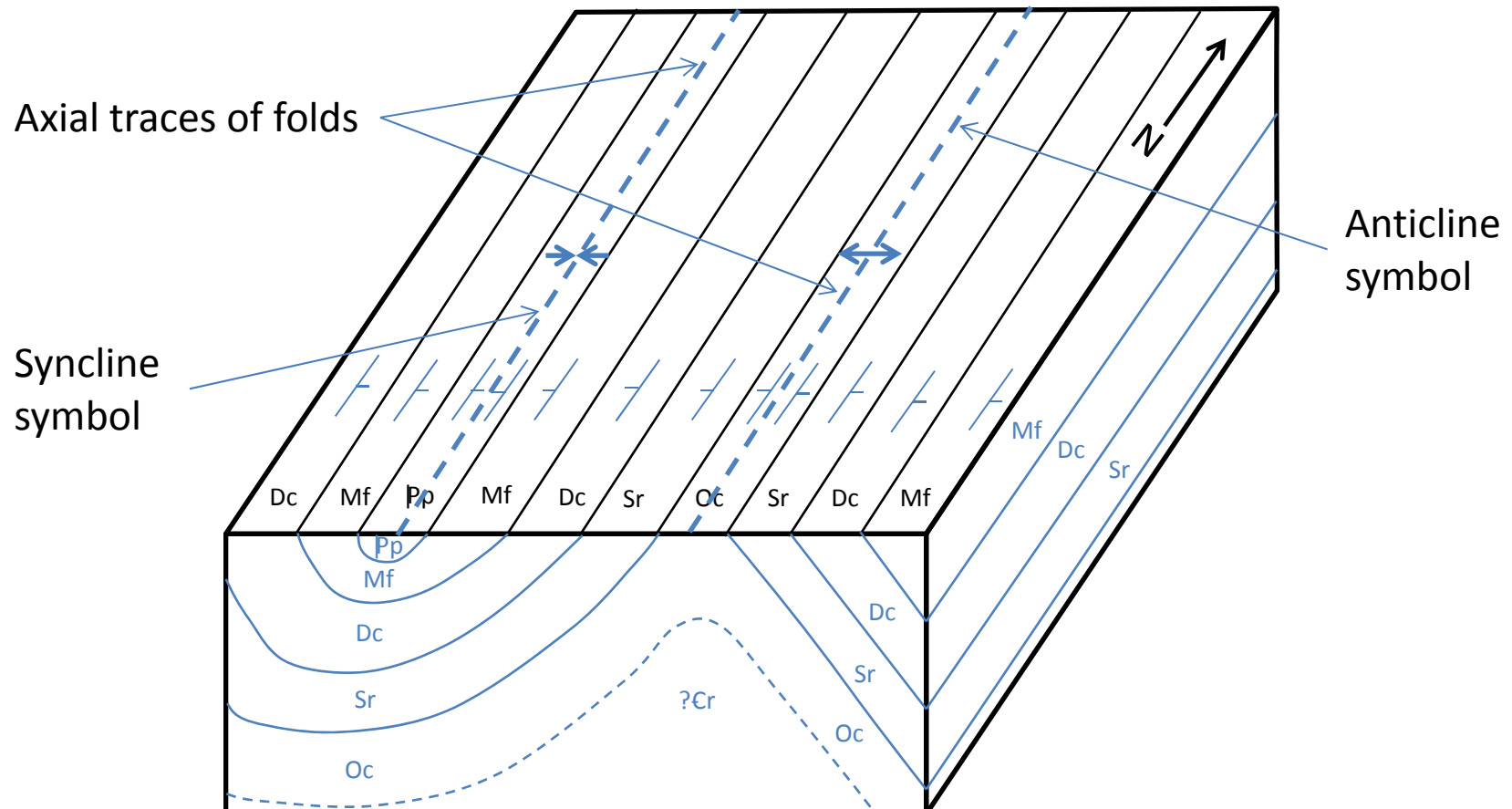
- Unconformities are marked by hachures on the map surface on the younger side of the contact; in a cross-section view by an irregular contact line depicting erosional relief.
- Note the missing Silurian & Devonian formations producing the disconformity

# Folding and 3D Blocks



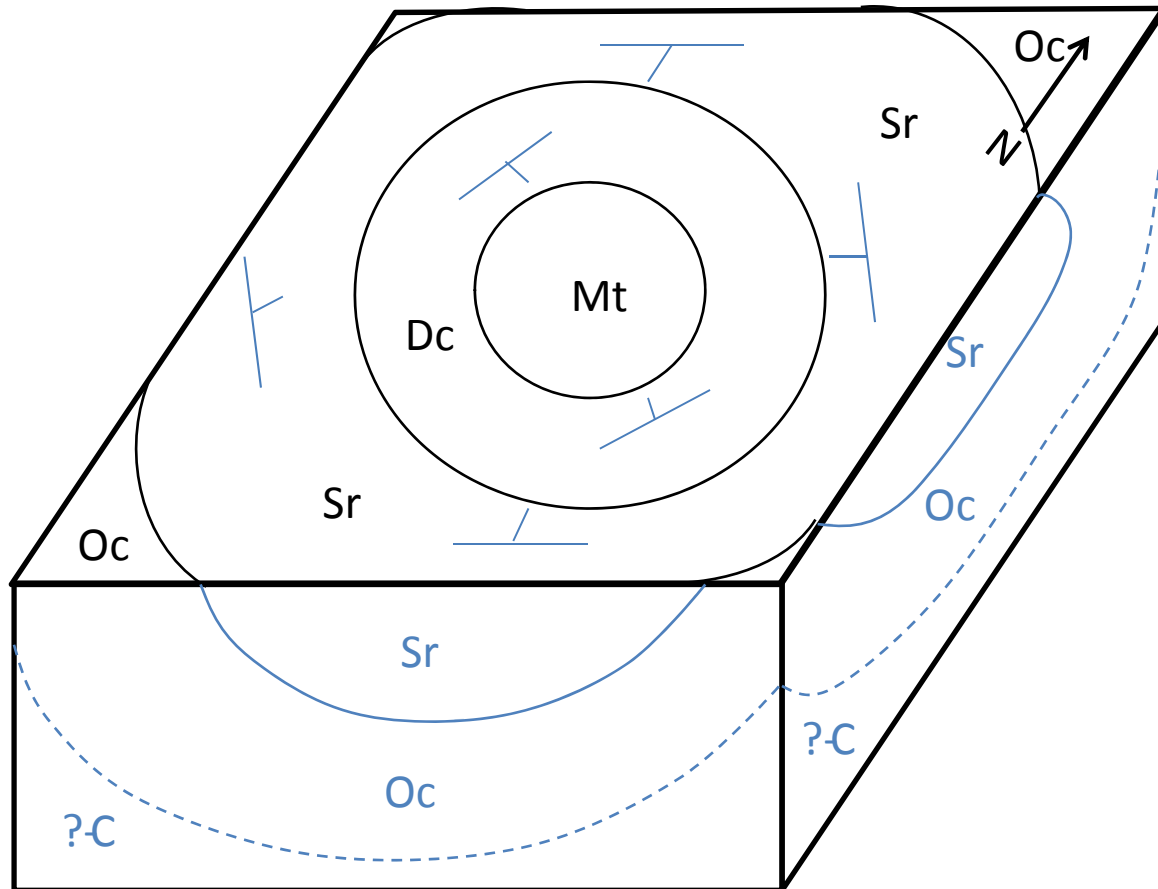
- Typical fold problem presentation- add strike & dip symbols, complete contacts on sides of block, add anticline and syncline symbols. Problem solution is in blue color. Use dashed line and “?” for speculative contacts and age labels.

# Non-plunging Anticlines & Synclines



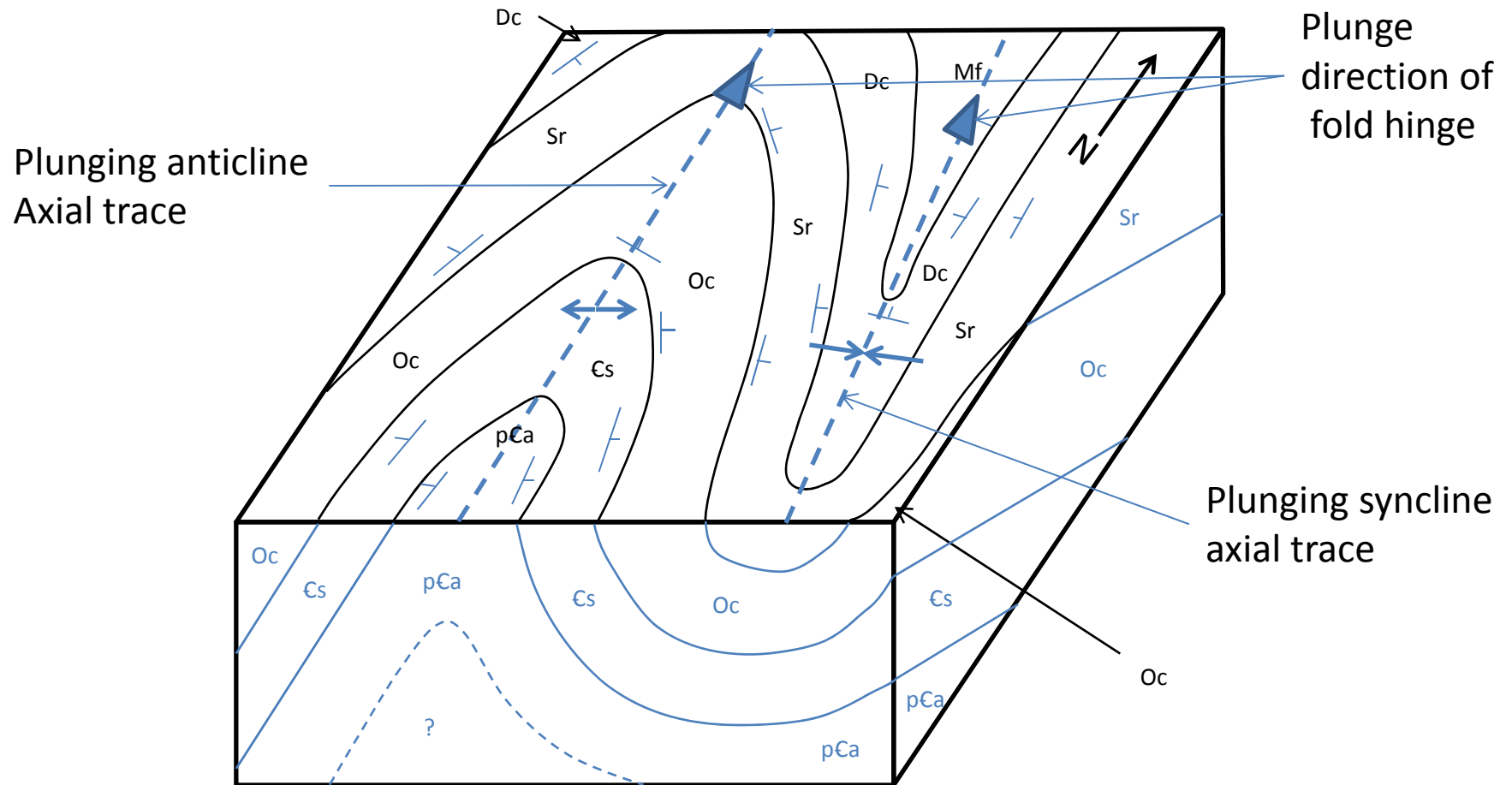
- Note that the anticline has the oldest strata in the core of the structure, and the syncline has the youngest, and note the axial trace symbols for anticline and syncline.
- Because there are no overturned beds the strata always dip in the younging direction.
- Non-plunging folds have straight contact lines in the map view (horizontal) surface.
- Vertical sides of the block diagram perpendicular to the axial traces of folds may contain curved contact lines.

# Geologic Domes and Basins



- This example is a basin because the youngest strata are in the core (center).
- Note that dip direction is toward the core of the basin, which is also toward younger beds.
- Strike direction is “tangent” to the curved contacts in domes & basins.

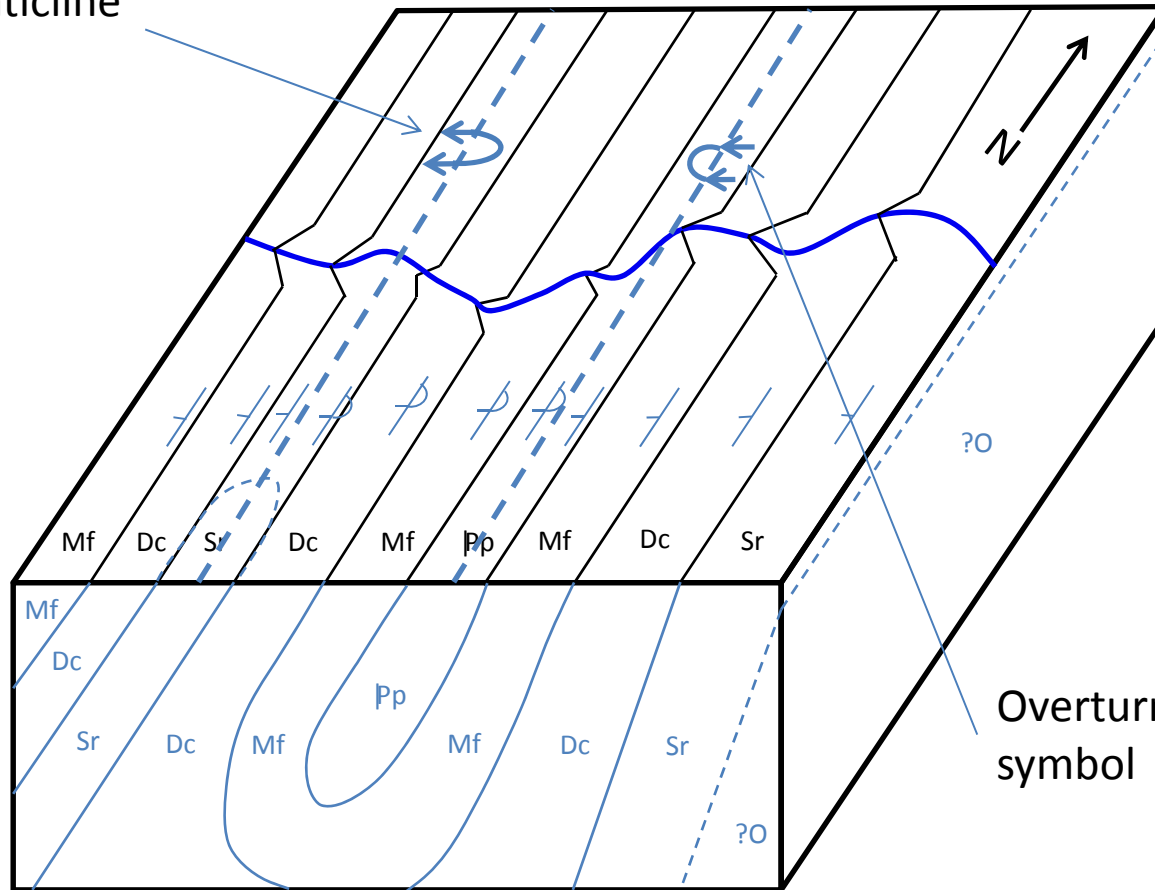
# Plunging Folds



- Note that anticlines still have oldest strata in the core of the structure, vice versa for synclines. Dip direction is away from anticline core, toward syncline core.
- Plunge direction always points with the “V” direction of the contact in the anticline, opposite the “V” in contacts for the syncline.

# Overturned Folds

Overturned anticline symbol



Overturned syncline symbol

- Overturned folds have one limb containing overturned strata.
- The above anticline & syncline pair share an overturned limb.
- Note the overturned symbols for the anticline & syncline



# Fault Classification

- Dip-Slip Faults
  - Hanging wall down = Normal dip slip
  - Hanging wall up = Reverse dip slip
- Normal faulting accommodates lateral stretching
- Reverse faulting accommodates lateral compression
- Strike-slip faults
  - Right-handed offset across fault contact = Right-lateral (dextral)
  - Left-handed offset across fault contact = Left-lateral (sinistral)
- Fault slip that combines both dip-slip and strike-slip components is oblique-slip.





