

Name: _____

Lab day: Tuesday Wednesday Thursday

ENVG /SC 10110-20110L Planet Earth Laboratory

Laboratory #8: Structural Geology – Thinking in 3D

<http://www.nd.edu/~cneal/PhysicalGeo/Lab-Structural/index.html>

Readings: Laboratory Manual at the lab web site:

110 points total.

Tools needed for this lab: scissors, **protractor**, ruler, pencil, and an eraser!!!

Introduction: This week we continue our shift from the study of minerals and rocks to the study of geologic and topographic maps. Geologists use maps to (1) simplify data in a systematic fashion for easier understanding of geologic features that are large (or small but complex) in scale, (2) to study geologic features when they cannot study them directly in the field, (3) to simplify the transfer of information between researchers.

We will use three types of maps: **geologic maps, geologic cross-sections, and block diagrams**. Geologic maps illustrate the geology at the earth's surface, or how the geology would look from the air if it was possible to remove all vegetation, soil and regolith. Geologic cross-sections illustrate how the geology would look if we could take a cross-section through the earth's surface; road-cuts through hills are an example of a geologic cross-section. Block diagrams are a combination of geologic maps and cross-sections, illustrating both surface features and cross-sections through the earth.

Structural geology is the study of the ways in which rocks or sediments are primarily arranged and secondarily deformed on the Earth. **Stress** (force per unit area) may deform (or **strain**) rocks either by bending (seen as **folds**) or breaking (as in **faults**). The geometry of folds and faults is controlled by the amount of force involved, the direction of the applied force (compressional, tensional, and shearing), and by the types of rocks involved (some rocks are more likely to perform plastically than others). **A number of the important terms used in structural geology are defined on the last 3 pages of this lab handout.**

Also, check out the lab website for more hints and information.

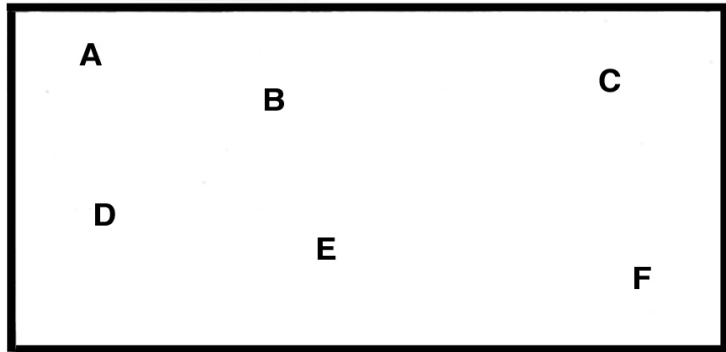
USE A PENCIL FOR THIS LAB!

BE SURE TO LABEL THE BACK OF EACH BLOCK WITH YOUR NAME AND LAB DAY

Part I Symbols for Strike and Dip (see Figs. 14.3 & 14.4, page 241, in your Lab Manual).

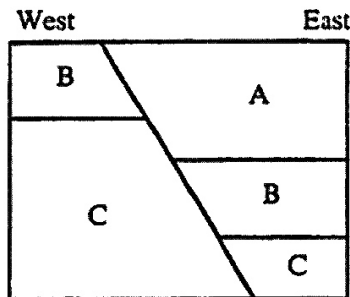
1) Using the symbols on the last 3 pages of this handout, and using your protractor/ruler, draw the appropriate symbols for the following attitudes (see Pages 8 & 9 of this lab). Assume **NORTH** is at the top of the page (6

- A. Strike: NW, Dip: NE
- B. Strike: NE, Dip: SE
- C. Horizontal bedding
- D. Strike: N, Dip: W (but overturned)
- E. Strike: NE, Dip: NW
- F. Strike: SW, Dip: vertical

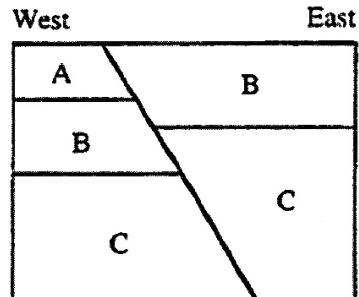


Part II Faults in Cross-Section and Map View (e.g., Fig. 14.11, Page 246, in your Lab Manual).

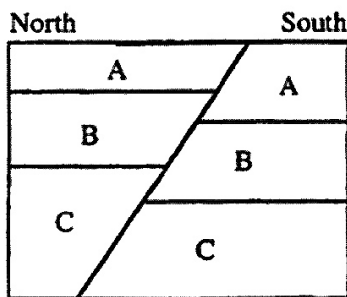
- 1) For each of the following three cross-sections and one map view of faults:
- a) Draw arrows indicating how the blocks either side of the fault have moved (the arrows should be drawn *next* to the fault face). (4 points – 1 point for each diagram)
 - b) Indicate (*if possible*) the direction of dip of the fault plane (i.e., north, south, east, west). If you can't tell, say so! (4 points)
 - c) Identify the type of fault the diagram represents (normal, reverse, right or left-lateral strike-slip). (4 points)



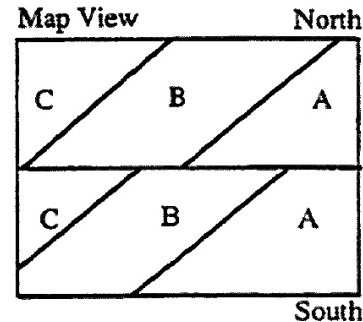
dip direction:
type of fault:



dip direction:
type of fault:



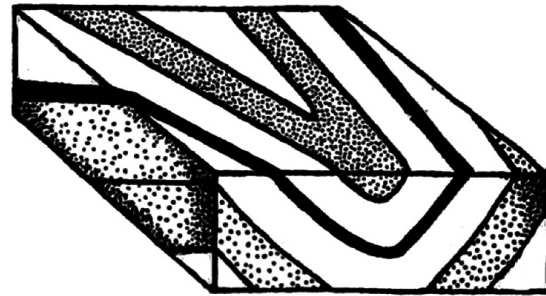
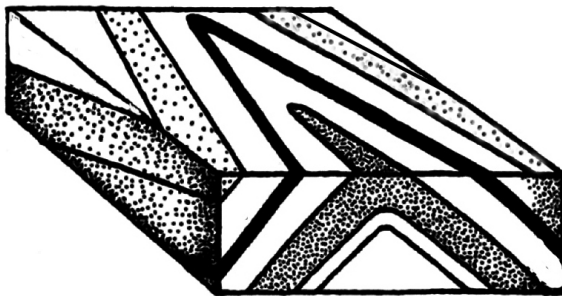
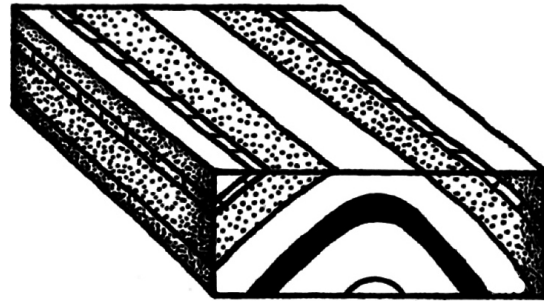
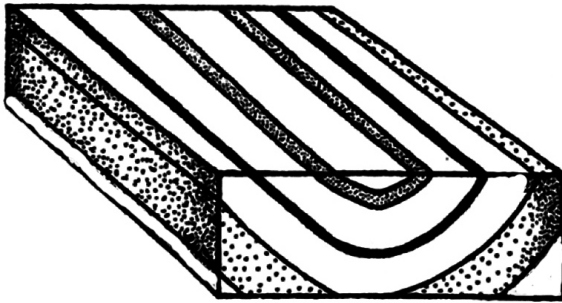
dip direction:
type of fault:



dip direction:
type of fault:

Part III Folds and Faults in Block Diagrams (see Fig. 14.9, page 245, in your Lab Manual).

- 1) **Label** the block diagrams below, indicating whether they are synclines, anticlines, plunging synclines and plunging anticlines (1 point each). Then **label** which bed(s) is/are oldest and which is/are youngest as seen in each block diagram. (3 points each) Assume the beds are not over-turned. (16 points total).



2) The following questions are also drawn from your lab manual.

Complete the blank sides in the two block diagrams (5 pts each). See Figure 14.5 (page 242) of your Lab manual for an example. Also look at Figures 14.9 and 14.10, page 245, in your lab manual Use a protractor to measure the angles of beds and the fault where appropriate. Lowest numbers (i.e., 2) correspond to the oldest rocks. Answer the following questions:

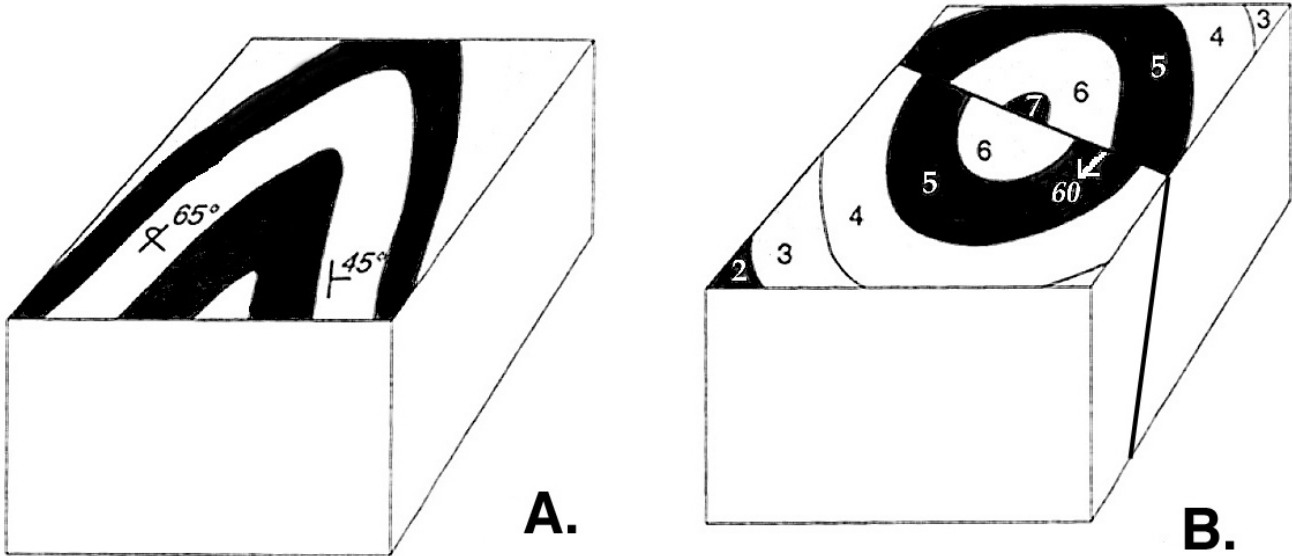
- a) In Figure A, what geologic structure is shown? HINT: Draw in the axial plane on the upper surface before you start.

(3 pts)

(see Fig. 14.9, page 245 in your lab manual)

- b) What kind of fault is shown in Figure B, and what kind of geologic structure does the fault cross-cut? (see Fig. 14.10, page 245, in your lab manual). Bed 7 is the youngest, bed 2 the oldest. NOTE THAT THE WAY TO REPRESENT THE DIP OF A FAULT IS SHOWN IN THIS DIAGRAM.

(2 pts for the structure; 2 pts for the fault)



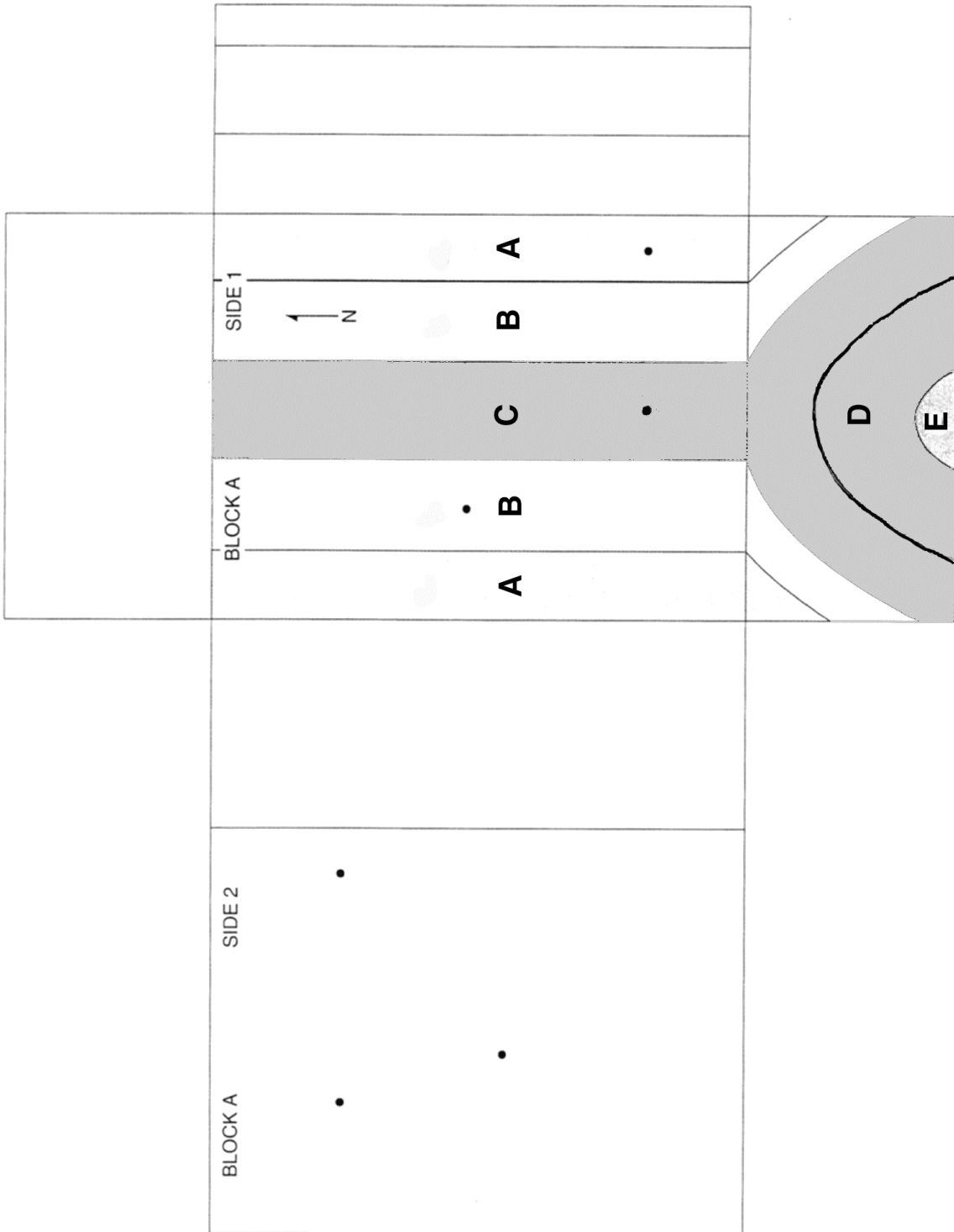
3) The following questions are drawn from your lab manual. The questions refer to the block diagrams on pages 6 and 7 of this handout. **Cut out the diagrams before starting the problems.** Assume no overturned beds. **MAKE SURE YOUR NAME AND LAB DAY ARE CLEARLY WRITTEN ON THE BACK OF EACH BLOCK DIAGRAM.**

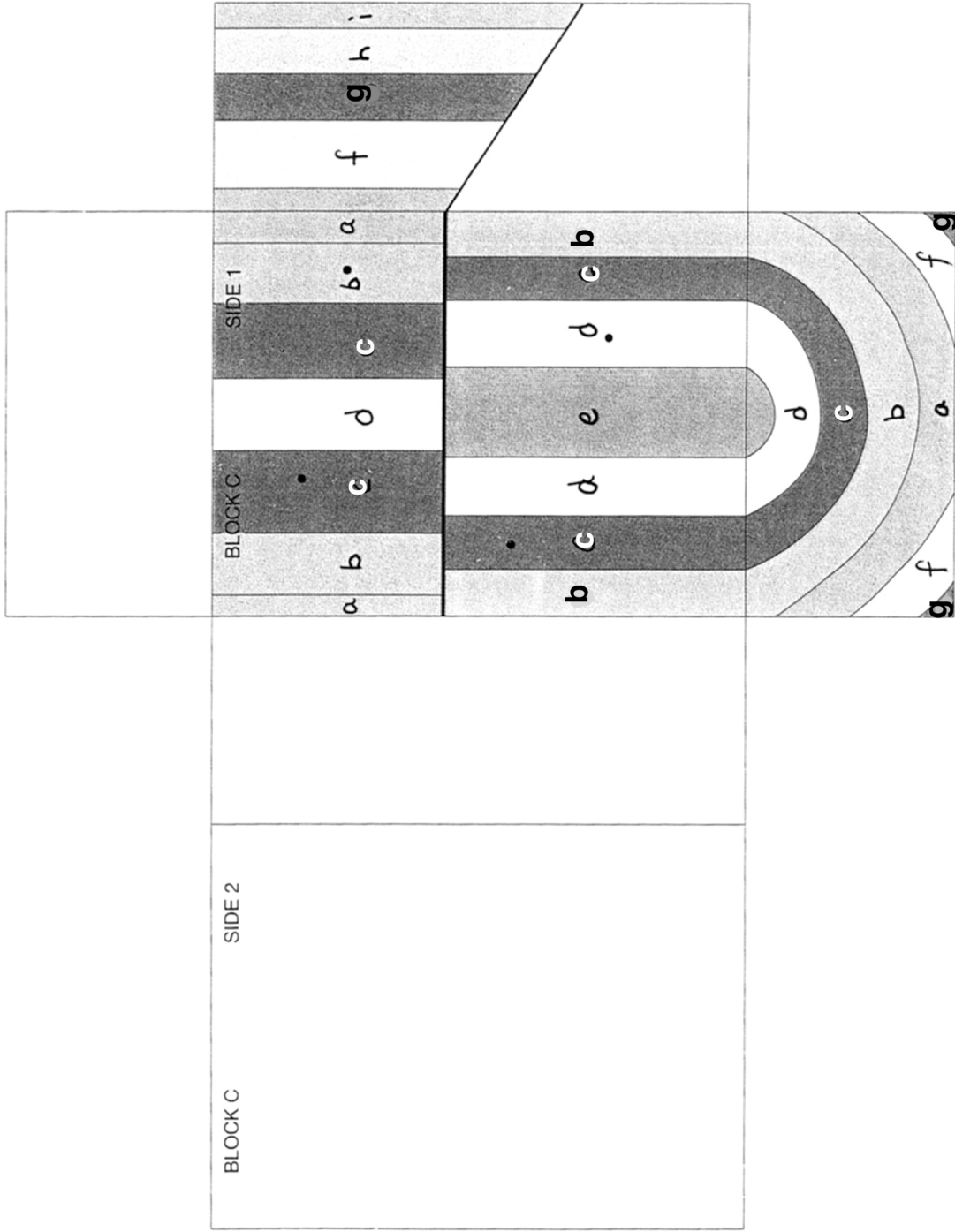
3a) Refer to **Block A** with Side 1 up (26 pts Total)

- i) Fill in the **blank faces** on the sides and bottom (Side 2) of the block. In order to keep track of the layers I have labeled them as “A”, “B”, “C”, etc. Be sure to include these labels when filling in the blank faces. (10 pts.)
- ii) Put **strike** and **dip** symbols at the spaces indicated with dots on Sides 1 and 2. (6 pts)
- iii) Illustrate the position of the **axial surface** of the fold by sketching its trace on the top of the block. The trace is an imaginary line that outlines the axial surface. The axial surface most nearly divides a fold into two equal parts). (2 pts)
- iv) Label all **oldest** and **youngest** beds present on Sides 1 and 2 on the block. Make sure the T.A.s and I will be able to find your answers. (6 pts)
- v) What **type of fold** is this (as seen from Side 1)? *Label the type of fold right on the block.* Make sure the T.A.s and I will be able to find your answer. (2 pts)

3b) Refer to **Block C** with Side 1 up (32 pts Total). **NOTE:** The color block in your lab manual is incorrect.

- i) Fill in the **blank faces** on the sides and base of the block. Be sure to include these labels when filling in the blank faces. (20 pts)
- ii) Put **strike** and **dip** symbols at the spaces indicated with dots on Side 1. (4 pts)
- iii) Give a **dip symbol** with **angle of dip** for the fault on the block. (2 pts)
- iii) Indicate the **relative movement** of the fault by placing **arrows on opposite sides** of the fault on the side faces. (2 pts)
- iv) Label the **hanging wall** and **footwall** on the top and side faces right on the block. (4 pts)





Definitions:

Strike: The angle between true North and the horizontal line contained in any planar feature.

Dip: The maximum angle by which a planar feature deviates from the horizontal, always measured in the plane that is perpendicular to the strike.

Map Symbols:

strike & dip of inclined layer



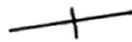
horizontal layer



strike & dip of an overturned bed



strike of vertical layer



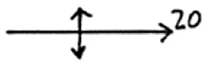
anticline



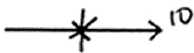
syncline



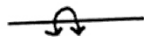
plunging anticline



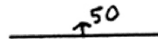
plunging syncline



overturned fold



fault trace



Structural Geology

Structural geology: study of the ways in which rocks or sediments are primarily arranged and secondarily deformed on the Earth.

Stress: force per unit area

- compressional stress:
- tensional stress:
- shear stress:

Strain: change in shape, length or volume of a mass when forces are applied to it.

Attitude: orientation of planar surfaces with respect to horizontal.

1.Strike: direction of line of intersection of an inclined plane and a horizontal plane. Note: strike lines are horizontal.

2.Dip: acute angle between a horizontal plane and an inclined plane, measured perpendicular to strike and expressed as an amount/angle and direction. The inclined plane can be a lithologic unit, fault or other geologic feature that has the dimensions of a plane.

- apparent dip: any dip that is not measured perpendicular to strike; the apparent dip will be less than the true dip.

Symbols used on maps:

\oplus - horizontal layer

$35^\circ /$ - strike and dip of inclined layer

$90^\circ \perp$ - strike of vertical layer with top to the left

$\swarrow 55$ - strike and dip of overturned layer

True Thickness (TT): layer thickness measured perpendicular to upper and lower surfaces.

Apparent Thickness (AT): layer thickness measured at some angle, other than perpendicular, to upper and lower surfaces.

Outcrop: exposure of bedrock.

- outcrop width: exposure of a specific unit in outcrop.

Contact: boundary between adjacent rock units.

Folds

Parts of a fold:

Limb: side of a fold

Axial surface: imaginary surface connecting points of maximum curvature from which limbs bend in successive layers through a fold.

Axis: imaginary line connecting points of maximum curvature on a fold.
Intersection of a folded surface and the axial surface.

Axial trace: line of intersection of an axial surface and the earth's surface.

Types of folds:

Anticline: fold in which layering is concave toward older rocks in the center of the structure.

Syncline: fold in which layering is concave toward younger rocks in the center of the structure.

Symmetry of folds:

Symmetrical: dip angle of both limbs is the same with respect to the axial surface.

Asymmetrical: dip angle of both limbs is different with respect to the axial surface.

Overtured: axial surface inclined, both limbs dip in the same direction, but usually at different angles.

Inclination of folds:

Non-plunging: fold axis horizontal.

Plunging: fold axis not horizontal, amount of plunge is the angle between the axis and a horizontal plane.

Dome: circular anticline; strata dips away from the center.

Basin: circular syncline; strata dips into the center.