Structural Geology – Laboratory 9

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(Name)

Geologic maps show the distribution of different types of structures and rock stratigraphic units generally on a topographic base such as a quadrangle map. Key structures that are commonly shown include (1) bedding attitudes, (2) anticlines, (3) synclines, and (4) faults.

A bedding attitude is defined as the strike and dip of a bed. Strike is the direction of a line produced by the intersection of an imaginary horizontal plane with an inclined bed. From previous laboratories you should know that based on the Principle of Original Horizontality sedimentary beds are originally deposited as a series of horizontal layers one on top of another. Such beds would have an infinite number of strike lines as the intersection of an imaginary horizontal plane with a horizontal bed is an infinite number of lines oriented from 0^o to 360^o (Figure 1).

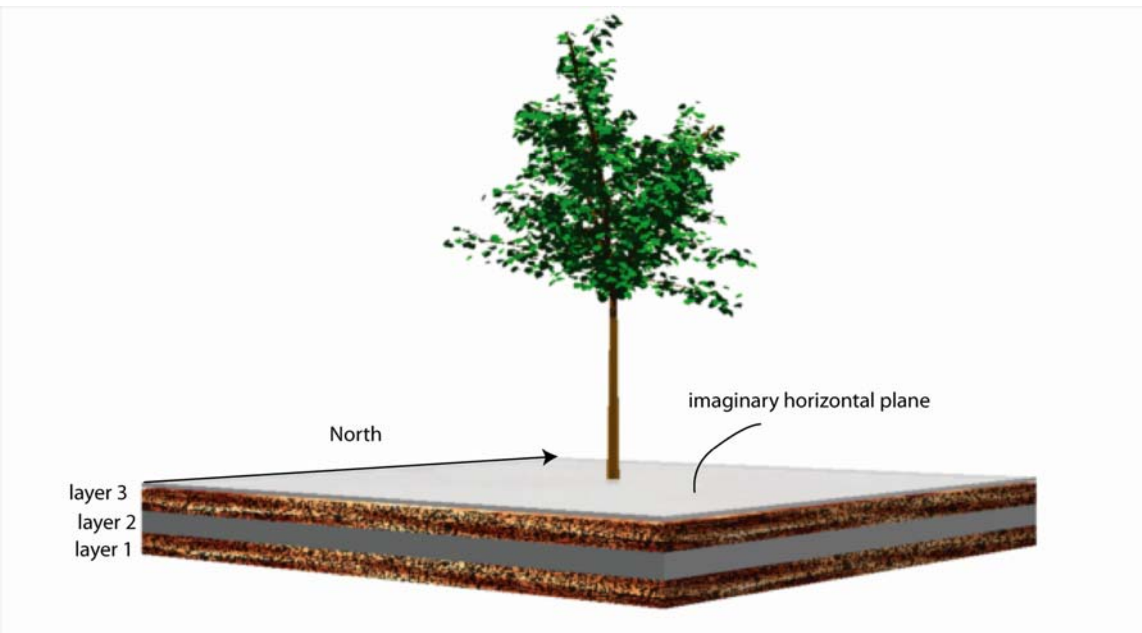

Figure 1. Three layers stacked one on top of the other. Based on the Principle of Superposition layer 1 is older than layer 2 and layer 2 is older than layer 3. Based on the Principle of Original Horizontality none of the three layers have been deformed as the angle between the imaginary horizontal plane and their current orientation is 0°. Note the position of geographic north.

In contrast, if a bed is inclined relative to the horizontal, then its intersection with an imaginary horizontal plane produces one and only one line (Figure 2). The direction of this line is the strike of the bed.

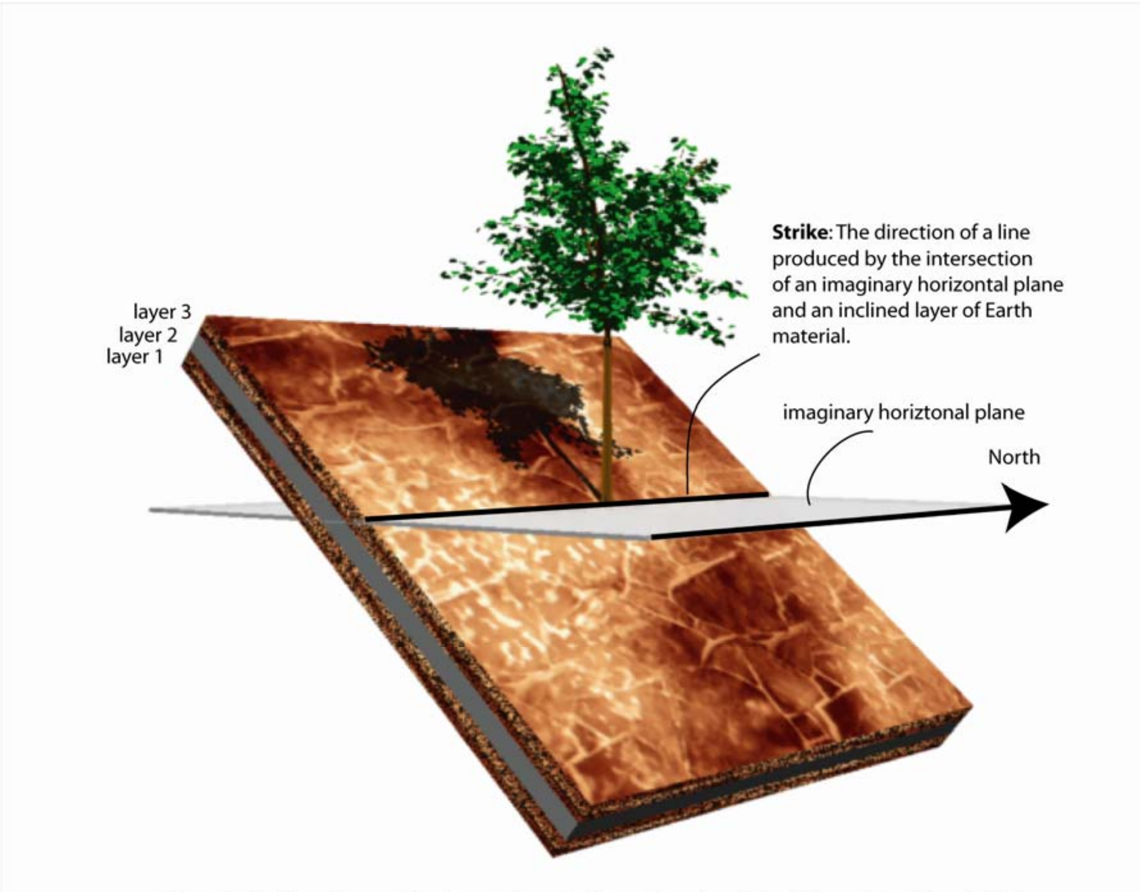

Figure 2. The three layers of sediment shown in Figure 1 are here tilted 40o east. In this orientation each layer intersects the imaginary horizontal plane to form a line. The direction of this line is the strike of each of the three layers.

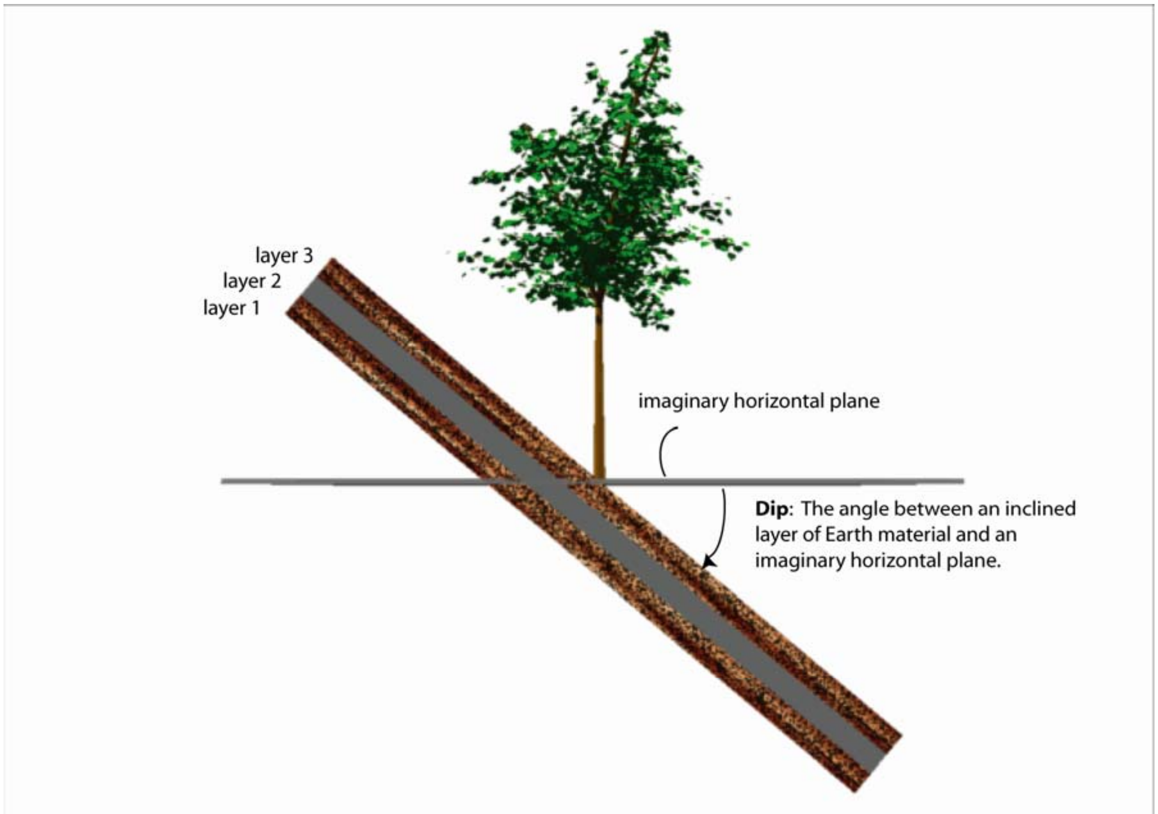

Figure 3. Dip is always measured in a vertical plane oriented at 90° to the strike.

Dip is the angle between the imaginary horizontal plane and the inclined bed measured in a plane oriented at 90^{o} to the strike line (Figure 3).

In all of the above illustrations strike and dip is defined for an inclined layer such as a bed or lamination or rock stratigraphic unit (e.g., a member or formation). However, the orientation of any planar surface can be expressed by its strike and dip. For example, the orientation of a fault or foliation surface is commonly given as its strike and dip.

Geologists use a Brunton or Silva compass to measure strike and dip. The various parts of the standard Brunton compass are shown in Figure 4. When using the compass to determine the attitude of a plane the edge of the compass is placed against the inclined surface and then the bulls-eye bubble is centered. In this configuration the compass lies in a horizontal plane and its edge is parallel to the line produced by the intersection of the imaginary horizontal plane and the inclined surface or layer. The sighting armature points in the direction that this line is oriented, and this direction is read directly off the compass. During today's lab you will learn how to measure the attitude of a layer using the Bruton or Silva compass.

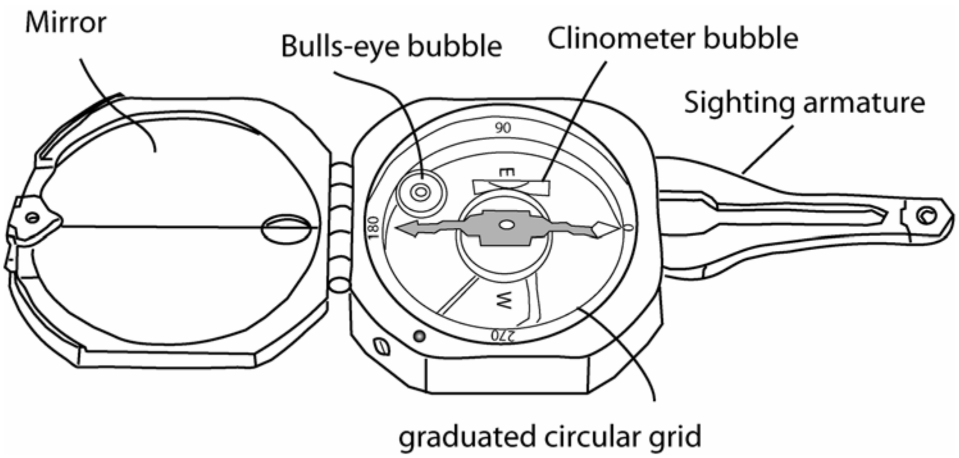

Figure 4. The standard Brunton compass and its most essential parts.

Once the attitude of a bed is determined it is entered into a field notebook and then is plotted on a quadrangle map at the location that it was collected. Geologists across the globe have agreed that on all geologic maps the attitude of a bed will always be represented by the same symbol. This symbol is shown in Figure 5. The quadrant notation that is commonly used to express the strike of a layer is illustrated in Figure 6.

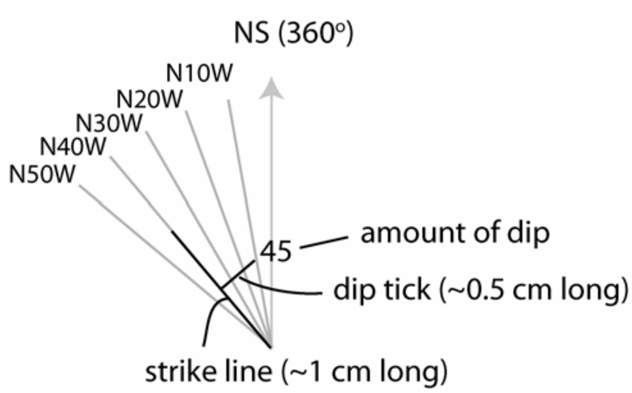

Figure 5. The conventional map symbol and its meaning.

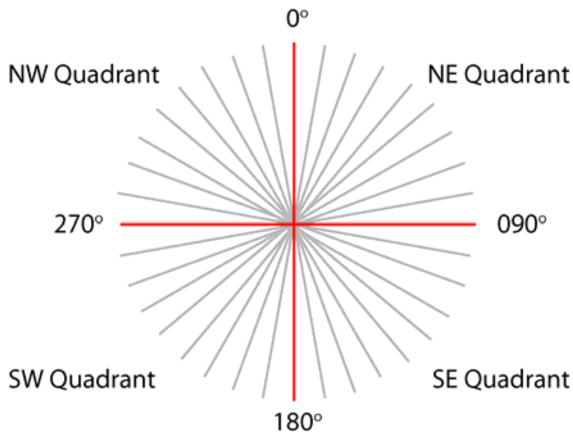

Figure 6. The quadrants used in communicating geographic direction. Grayed rays are for every 10^{o} segment.

Using the inclined boards provided by your instructor measure a strike and dip, and then record it in the following box.

Measured strike and dip goes here.

Assume that the attitude that you measured in laboratory today was collected at location 1 on the map shown as Figure 7. Please plot it using your protractor.

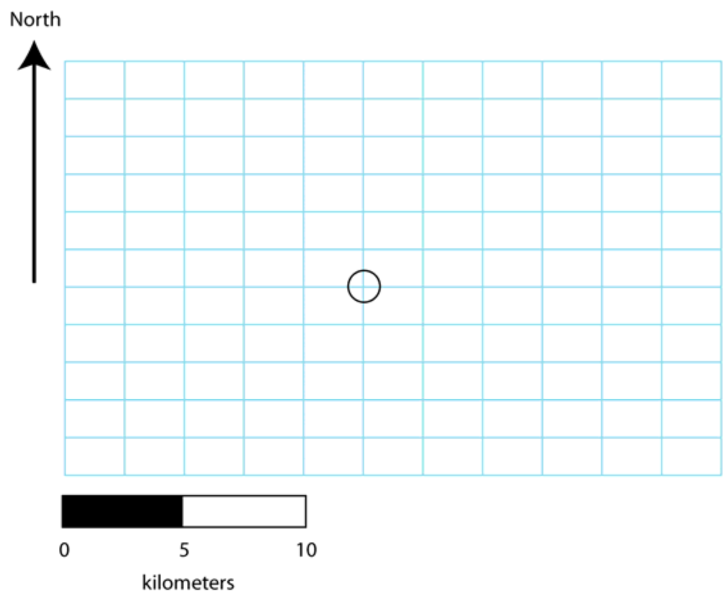

Figure 7. The circle marks location 1. Note the scale and the North arrow.

The concept of strike and dip is fundamental to the development of geological maps as it allows a geologist to represent the 3D orientations of planes on 2D sheets like quadrangle maps. Below we will consider the 3D geometry of two common folds: anticlines and synclines

Anticlines

An anticline that has not been modified by erosion would look something like the crest of an ocean wave approaching the shore but frozen in time (Figure 8(A)). The hinge line of any fold is the locus of the points of maximum curvature of a given layer in the fold (see Figure 8(A)). A cross-section of a fold is a view of a vertical slice of the fold that is oriented at right angles to the hinge line (see Figure 8(B)). Note that in Figure 8(B) below that the layers converge upward. The surface (in 3D) separating the purple from the green layer is referred to as a contact. Geologists would say that a contact is a 3D surface separating Earth material of differing lithologic aspect (Figure 8).

The bisector of a fold divides it into two symmetrical parts called the limbs of the fold (see Figure 8(B)). In 3D the bisector and the hinge line define the axial surface, the plane that subdivides the fold in 3D into two symmetrical parts (compare Figure 8(A) and (B) below). When an anticline is eroded, the older layers always occur in the center of the fold with younger layers occurring on opposite sides (see Figure 8(C) below).

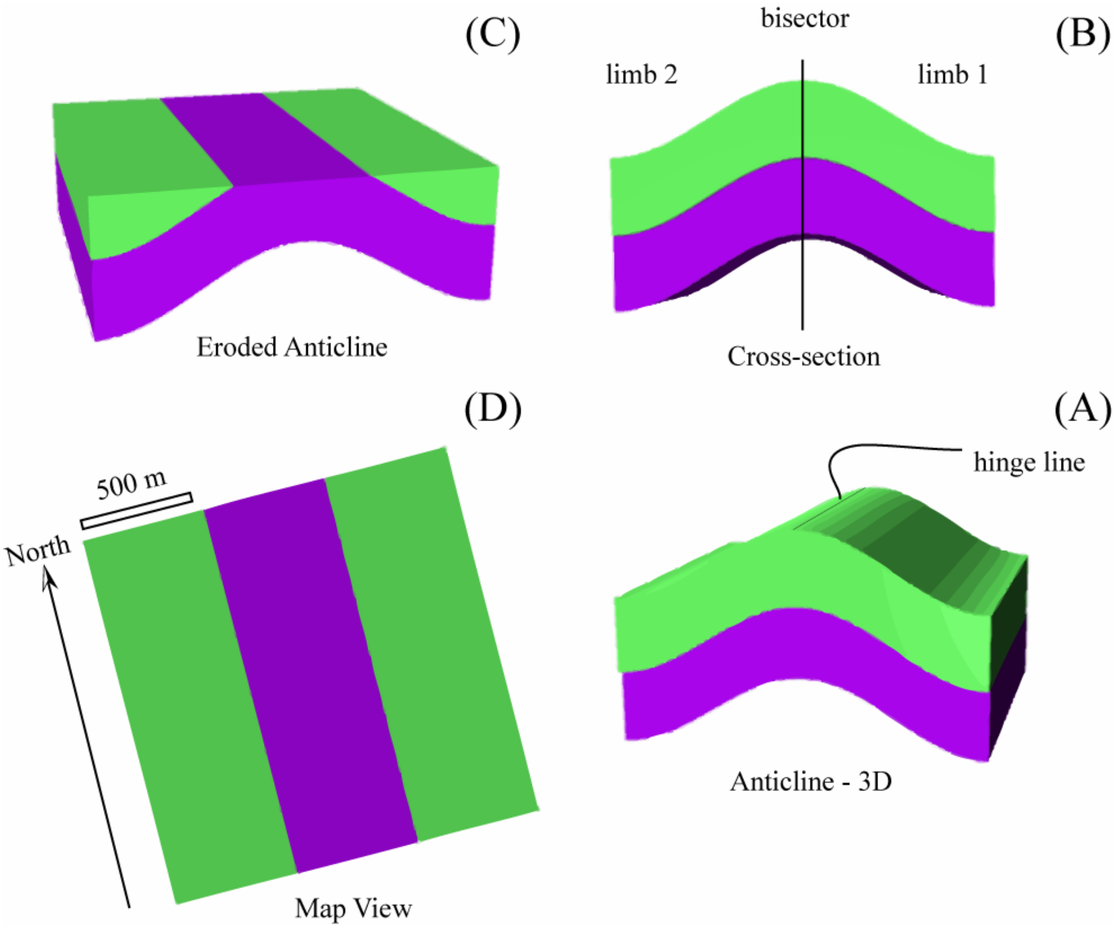

Figure 8. Different views of an anticline.

The map symbols for an anticline and syncline are shown in Figure 9. Note that in map view bedding dips away from the trace of the axial surface of an anticline while it dips toward the trace of axial surface in a syncline.

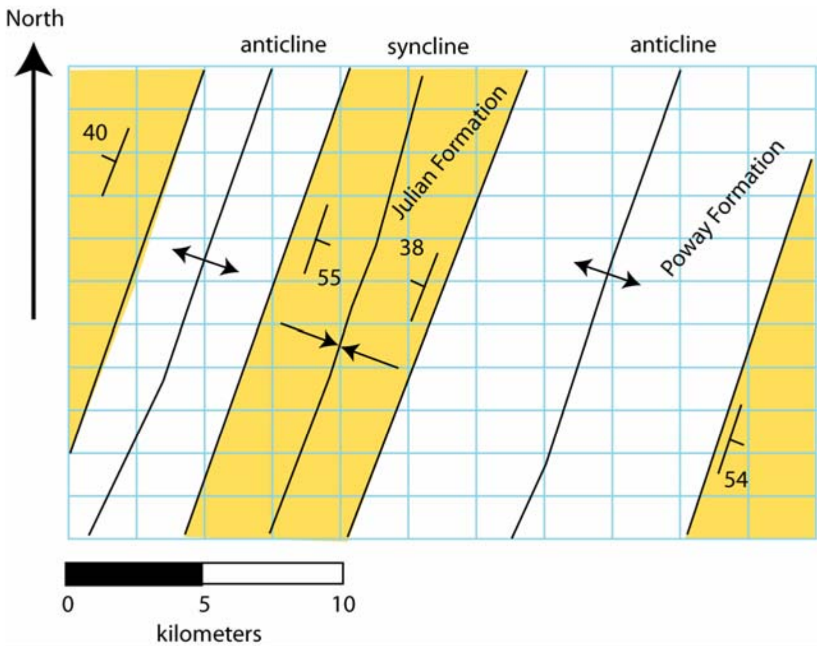

Figure 9. Conventional fold symbols used on geologic maps. Note the different forms of the symbols used to show the positions of synclines and anticlines.

With the above as background please answer the following questions.

(1) What is the dip of the limbs of the anticline as seen in Figure 8(B) below?

(2) The top of the view labeled Figure 8(C) is horizontal. Using Figure 8(D) below determine the strike of the limbs of the fold?

(3) In Figure 8(C) and (D) below draw in the proper map symbol for the attitudes of the two limbs of the fold.

(4) In the views labeled Figure 8 (C) and (D) sketch in the map symbol for an anticline.

(5) Please write below a complete definition of an anticline based on your answers to the previous 4 questions.

Synclines

A syncline that has not been modified by erosion would look something like the trough of an ocean wave approaching the shore but frozen in time (see Figure 10(A)). The hinge line of any fold is the locus of the points of maximum curvature of a given layer in the fold (see Figure 10(A)). A cross-section of a fold is a view of a vertical slice of the fold that is oriented at right angles to the hinge line (see Figure 10(B)). Note that in Figure 10 (B) that the layers converge downward.

The bisector of a fold divides it into two symmetrical parts called the limbs of the fold (see Figure 10(B)). In 3D the bisector and the hinge line define the axial surface, the plane that subdivides the fold in 3D into two symmetrical parts (compare Figure 10(A) and (B)). When a syncline is eroded, the younger layers always occur in the center of the fold with older layers occurring on opposite sides (see Figure 10(C)). With this as background please answer the following questions.

(1) What is the dip of the limbs of the syncline as seen in Figure 10(B) below?

(2) The top of the view labeled Figure 10(C) is horizontal. Using Figure 10(D) below determine the strike of the limbs of the fold?

(3) In Figure 10(C) and (D) below draw in the proper map symbol for the attitudes of the two limbs of the fold.

(4) In the views labeled Figure 10(C) and (D) sketch in the map symbol for a syncline.

(5) Write below a complete definition of a syncline based on your answers to the previous 4 questions.

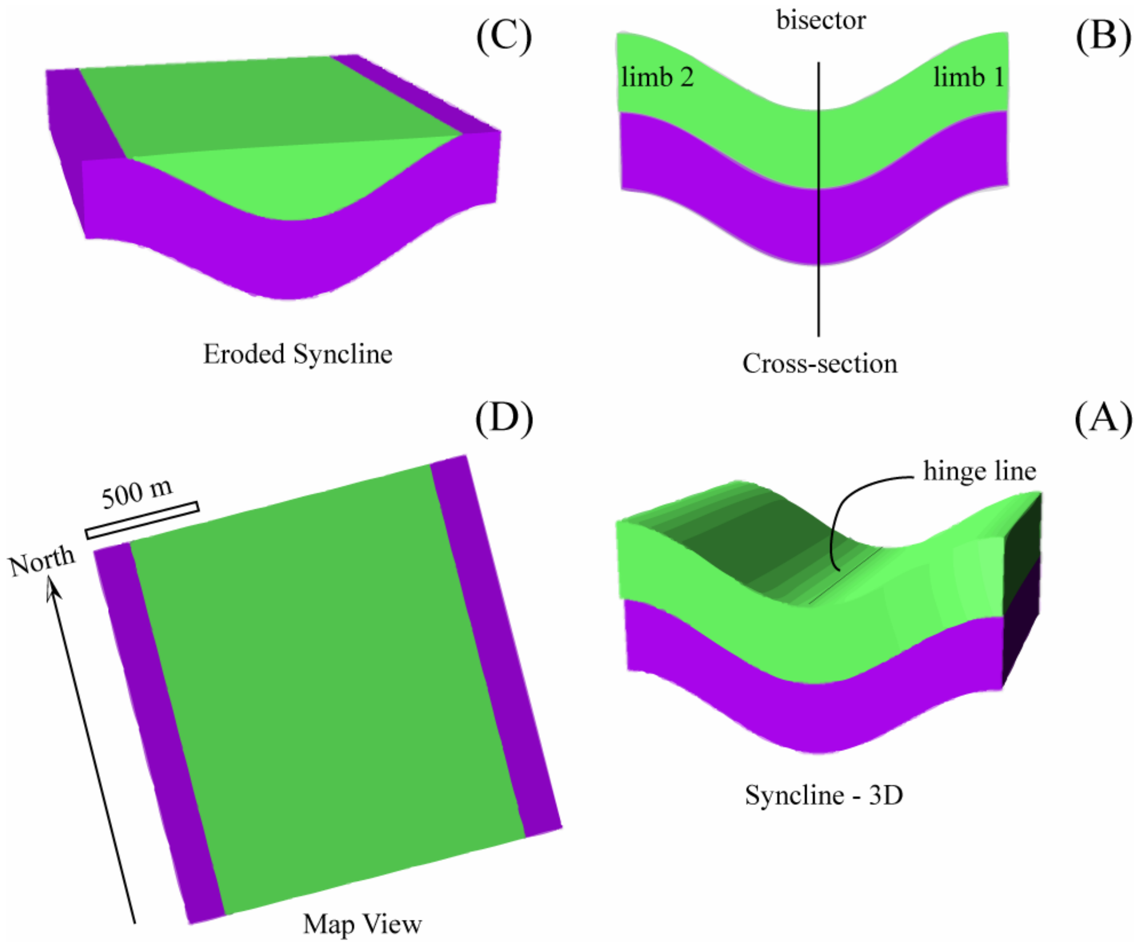

Figure 10. Different views of a syncline.

Working with Geologic Maps

Below is a geologic map showing the position of two outcrops in which the attitude of bedding was measured (Figure 11). At location 1, bedding has an attitude of N60E, 60SE. At location 2 bedding has an attitude of N60E, 60NW. Using your protractor please plot these data using the conventional map symbol for bedding. Note that both bedding attitudes were collected from the same San Diego Formation and that the SDSU Formation crops out between these two areas.

(1) From the bedding attitudes that you have plotted can you determine which formation is older than the other.

(2) Given your answer what kind of a structure separates the two areas that the bedding attitudes were determined.

(3) Draw in the conventional map symbol for the structure that you identified in (2) above.

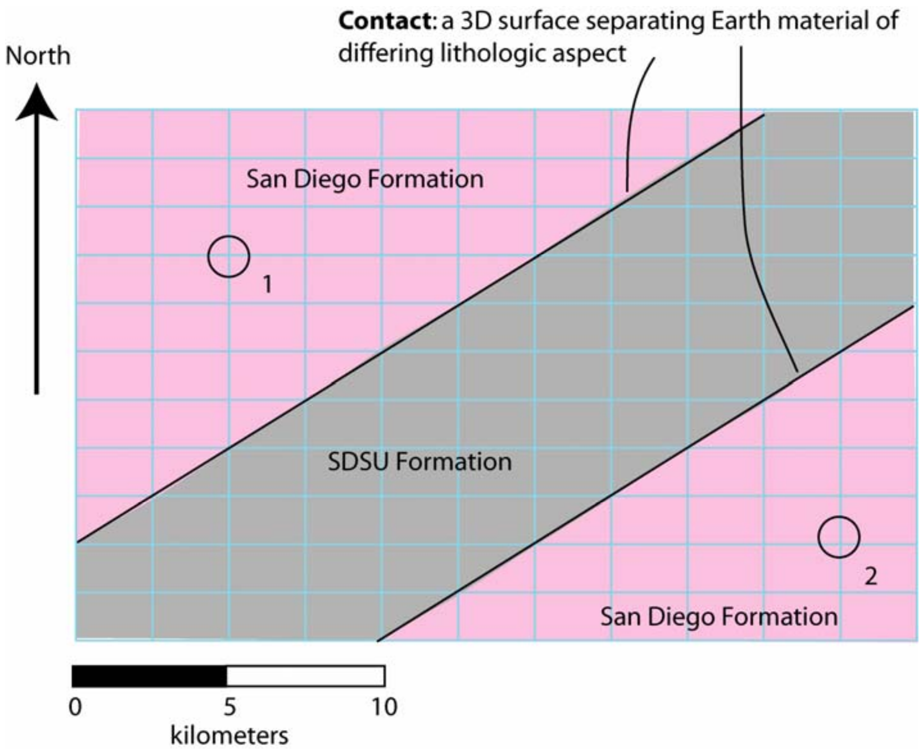

Figure 11. Geologic map showing the position of two locations at which bedding attitudes were measured.

Let's look at another example. Below is a geologic map showing the position of two outcrops in which the attitude of bedding was measured (Figure 12). At location 1, bedding has an attitude of N60W, 40SW. At location 2 bedding has an attitude of N60W, 30NE. Using your protractor please plot these data using the conventional map symbol for bedding. Note that both bedding attitudes were collected from the same SDSU Formation and that the San Diego Formation crops out between these two areas.

(1) From the bedding attitudes that you have plotted can you determine which formation is older than the other.

(2) Given your answer what kind of a structure separates the two areas that the bedding attitudes were determined.

(3) Draw in the conventional map symbol for the structure that you identified in (2) above.

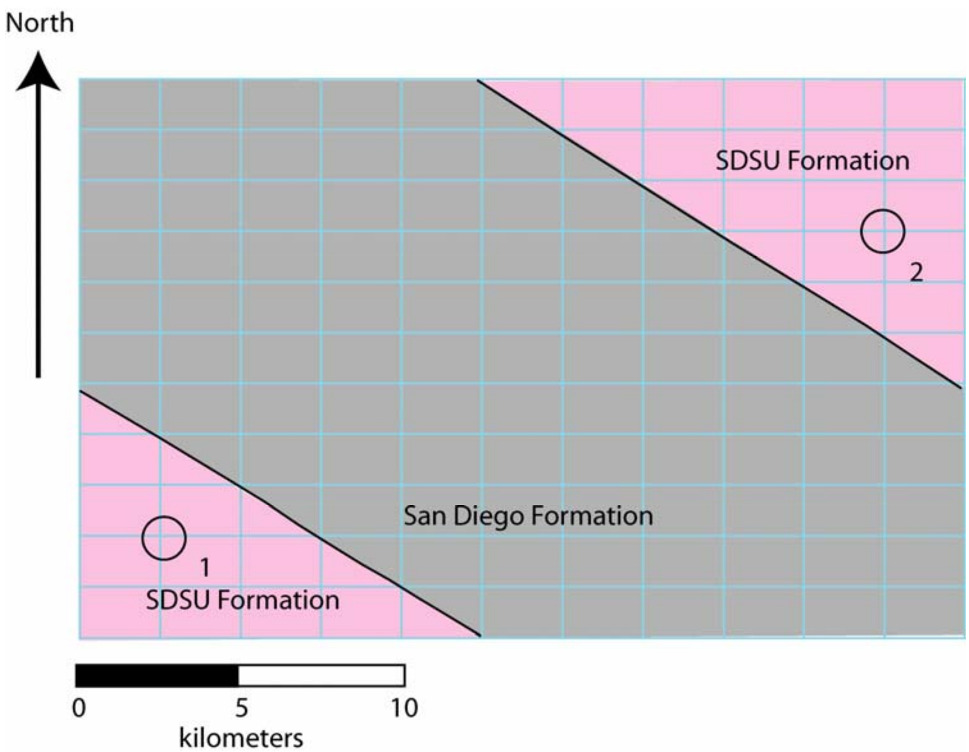

Figure 12. Geologic map showing the positions of two bedding attitudes measured in the SDSU Formation.