



# GEOLOGIC STRUCTURES

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## Introduction

**Structural geology** is the study of the ways in which rocks or sediments are arranged and deformed on the earth. It involves all three rock types: **igneous**, **sedimentary**, and **metamorphic**. We will focus on sedimentary rocks throughout this class. Sedimentary rocks are deposited in horizontal layers. Any rock unit that is recognizable and mappable in the field is called a **formation**. Formations can include different rock types (so long as the entire package can be distinguished from adjacent formations). Sometimes formations are further subdivided into **members**. The boundaries between formations are called **contacts**. These boundaries can be depositional, erosional, or structural. Ask your TA for more information on this topic.

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Generally, geologists can only see the rocks that are at the earth's surface. This two dimensional view of rock distribution is called the **map view**. A **geologic cross-section** is a view of a vertical slice of the earth, like you might see at a road cut or a stream cut. A **block diagram** is a combination of those two representations and gives a 3-D view of formations and contacts. It looks like a block, and shows a map view on top, and a cross-sectional view on each of its visible sides. A cross-sectional view can reveal details of a structure not visible in map view, such as cross bedding. Ask your TA what cross bedding can show us.



Cross bedding in North Dakota

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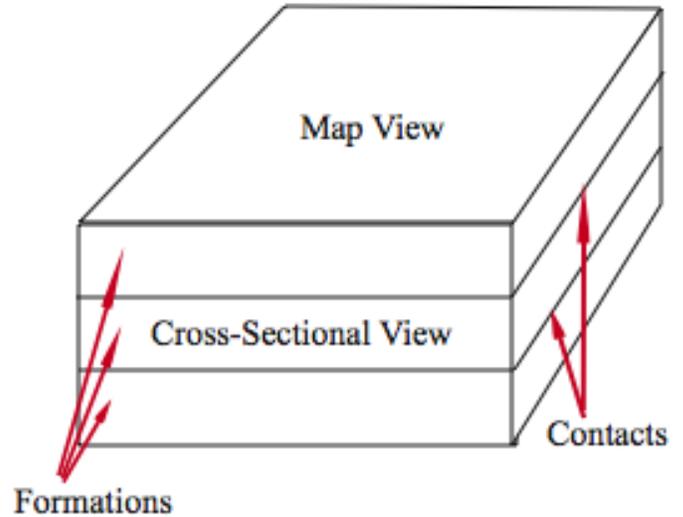
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## Block Diagrams & Nomenclature

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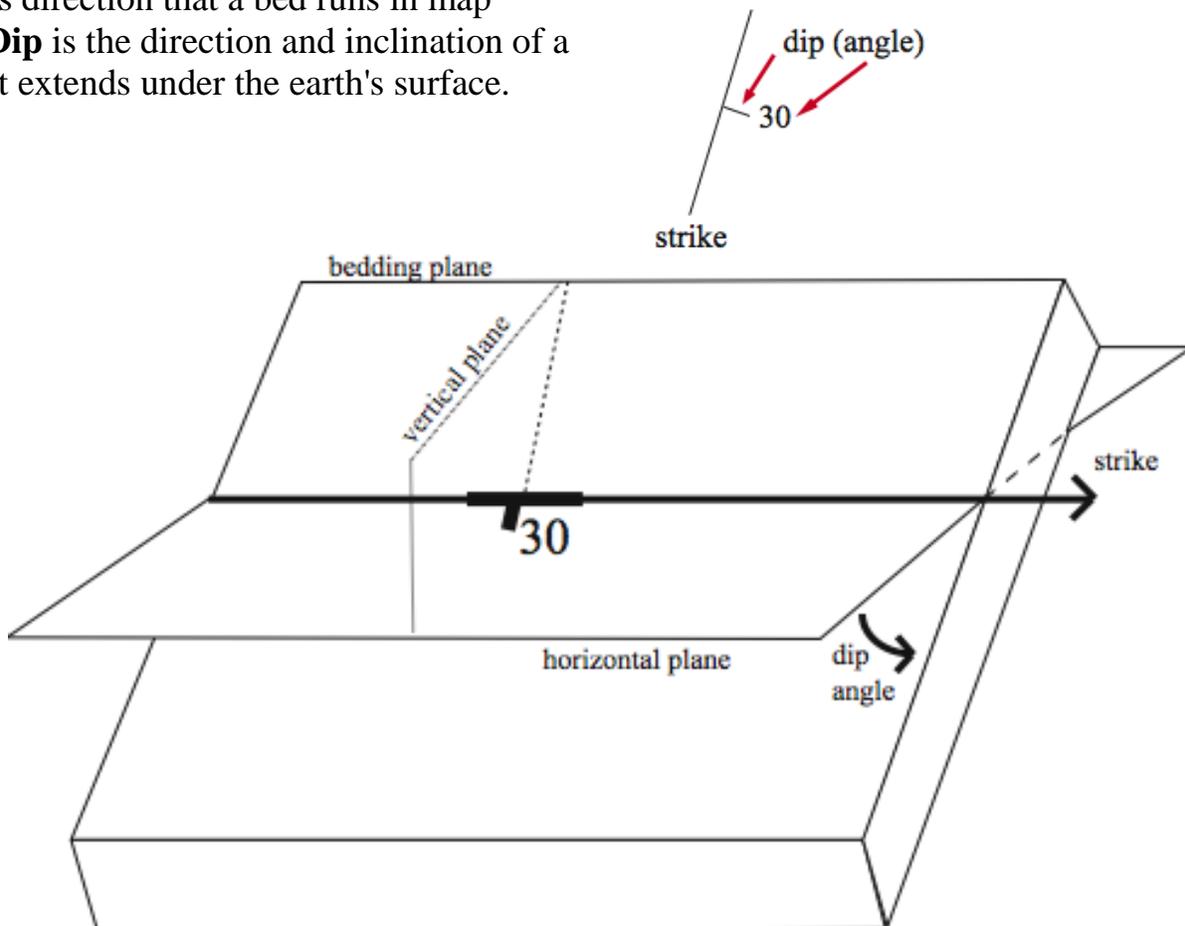
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To the right, there is a representation of a generic block diagram. Think of a block diagram as being similar to a square slice of cake, cut and then lifted out of the cake so that the various layers can be examined. As was mentioned earlier, the upper surface of the diagram represents the map view, that is how the structures appear from above. The sides of the diagram show the vertical arrangement of formations with respect to one another.



Stress may cause deformation of rock beds, resulting in tilted, folded, or faulted beds. The way a bed is oriented relative to a horizontal plane is referred to as the **attitude** of the bed. The attitude consists of two components: strike and dip. **Strike** is the compass direction that a bed runs in map view. **Dip** is the direction and inclination of a bed as it extends under the earth's surface.

The **dip angle** is the angle that a bed makes with a horizontal surface. The dip angle can range from 0-90°, which a horizontal bed having no dip (0°) and a vertical bed having a 90° dip. On a map, the strike and dip are represented by a strike-dip symbol.



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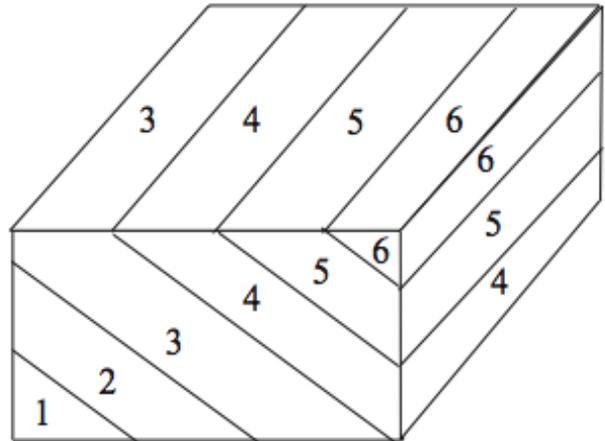
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## Basic Tilt & Fold Structures

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Rocks deform into certain structures that we see again and again. These structures leave distinctive patterns on block diagrams. The simplest example of such a situation has rocks dipping (tilting) in only one direction. Geologists simply call this structure **inclined beds**. When looking at examples of structures, we will number the rock layers to indicate their relative ages; the later numbered "1" being the oldest. Note the position of the oldest layer.

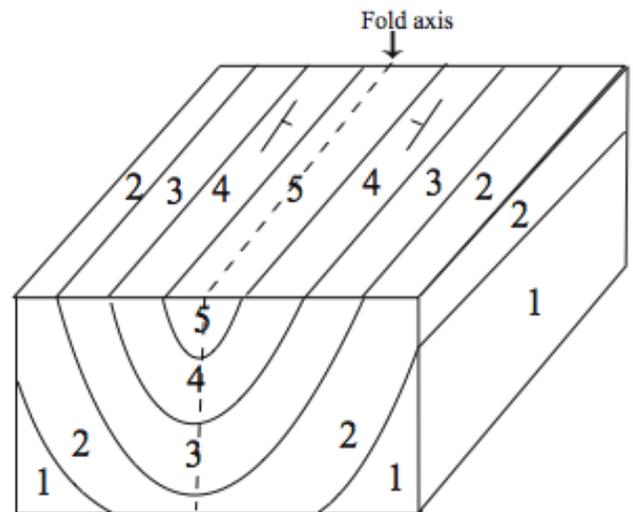


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More elaborate structures may develop in such a way as to cause folding. If the resulting fold is trough-shaped, the structure is called a **syncline**. Note that the youngest rocks are in the center. Can you explain why?

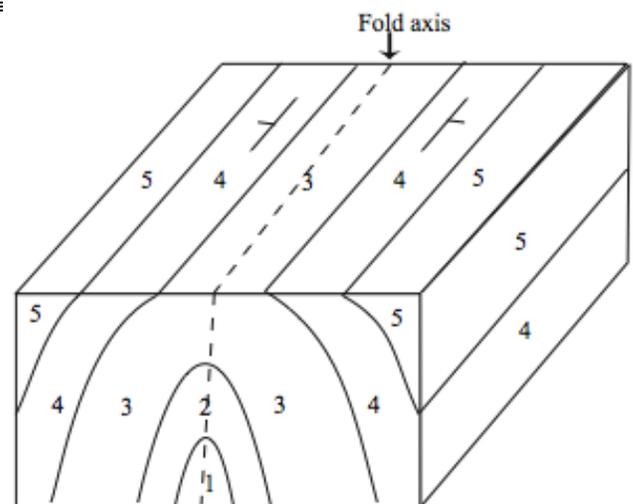
Note that the rocks are bent around an imaginary line called a **fold axis**. All geological folds have such a fold axis.



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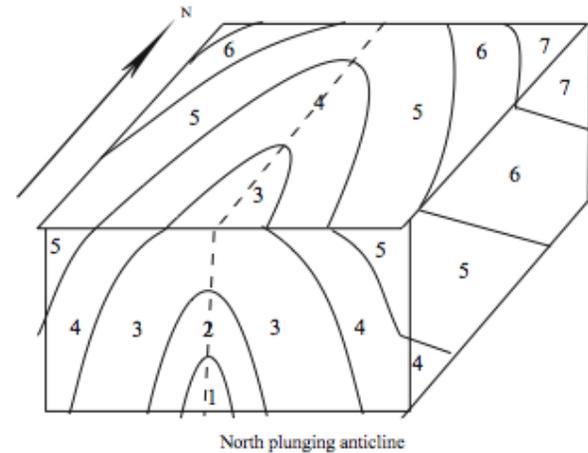
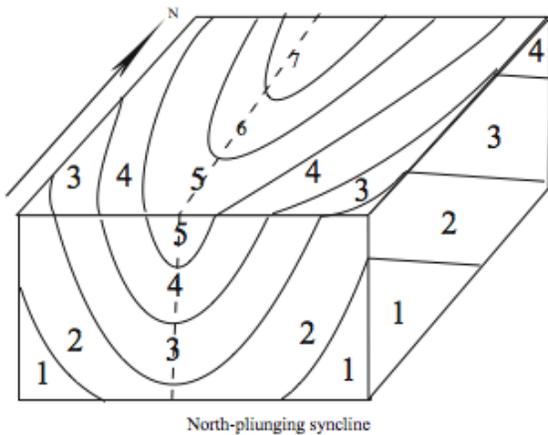
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If the rocks are folded into an arch shape, the resulting structure is called an **anticline**. Contrary to the syncline, the rock beds dip away from the fold axis, and the older rocks are situated in the center. Make sure that you know why & note that *they are not necessarily the absolute oldest rocks in the sequence*. In these examples, the fold axis is horizontal, and the structures leave a symmetrical, repeating pattern of parallel formations in map view.



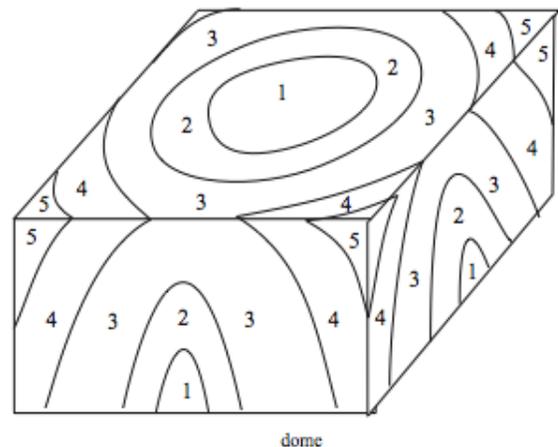
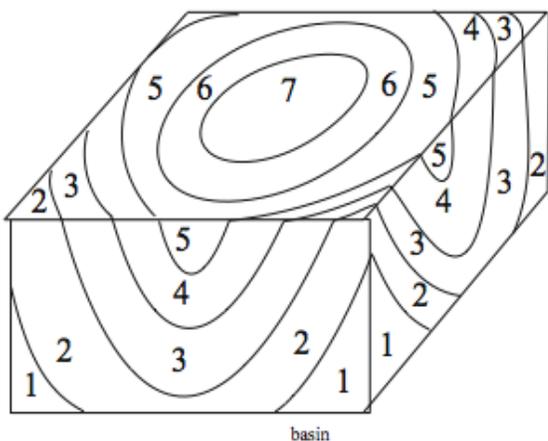
# Plunging Fold Structures

Often folds can also be tilted. This results in fold with a nonhorizontal, inclined fold axis. Such a fold is said to **plunge**. Compare the block diagrams on this page with those on the previous page. First, note that the side of the cross-sectional view that faces you is essentially the same whether the fold plunges or not.



**Basins** and **domes** exhibit circular structures in map view. You can think of a basin as a syncline that plunges in all directions at once. That is, at any point on the structure, the dip of a bed is towards the center. Like synclines, basins contain the youngest rocks in the center. Any cross-section of a basin will resemble the end cross-section of a syncline.

Similarly, you can think of a dome as an anticline that plunges in all directions. That is, the beds dip away from the center in all directions. Like anticlines, the oldest exposed rocks are in the center. Note also, that any cross-section of a dome resembles the cross-section of an anticline.



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## From 2-D to 3-D

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In geology, sometimes the only information we get about a geologic structure is from the map view. This information usually comes from aerial photographs, and from hiking over the topography. From this limited information we try to deduce, or interpret, what the structure looks like *below* the surface of the Earth.

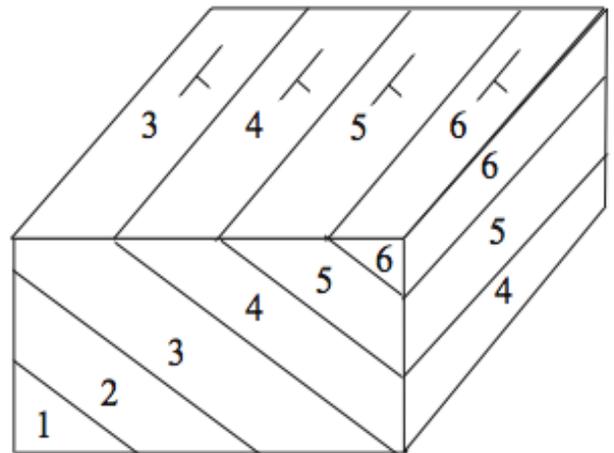
In this lab, we will be trying to interpret what a geologic structure looks like in cross-section using only the patterns that the formation make in the map view as a guide. In the course of doing so, there are two important, but simple, rules to remember:

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### 1) *Older beds dip towards younger beds*

In the figure to the right, the direction of dip (as indicated by strike-slip symbols, as well as graphically in the cross-sectional view) is in the same sense as the progression of beds from older to younger.

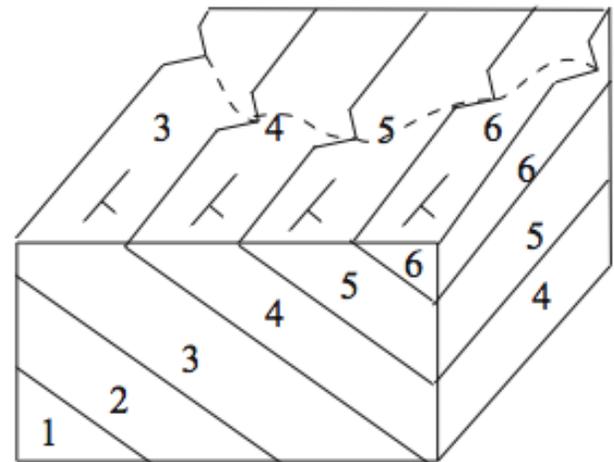


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### 2) *In map view, the "V" cut by a stream into the surface points in the direction that a bed is dipping*

Examine the diagram to the right. Notice that the watercourse running across this area has formed "V"-shaped grooves in the surface (think about "V"-shaped canyons worn out of rock by rivers to picture this better). The points of these "V"s are oriented in the same direction as the dip of the beds that they cut. Be careful not to confuse this rule with the so-called rule of "V"s used on topographic maps. In this lab, the idea of using a stream to determine the dip of a rock layer will only be applied to flat-lying terrain.

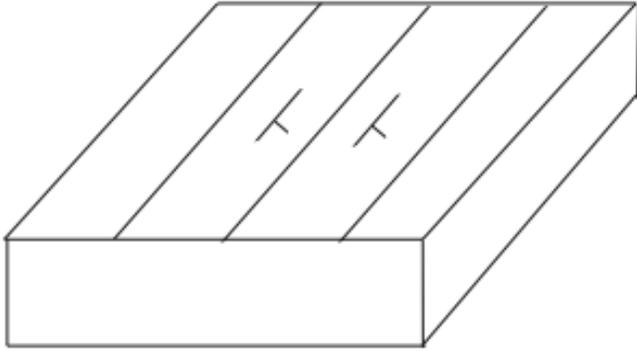


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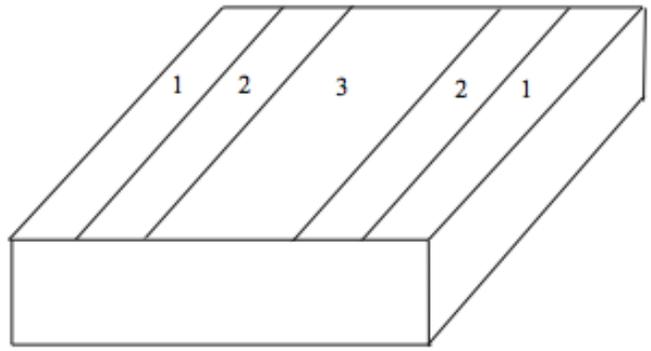
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## Laboratory Exercise

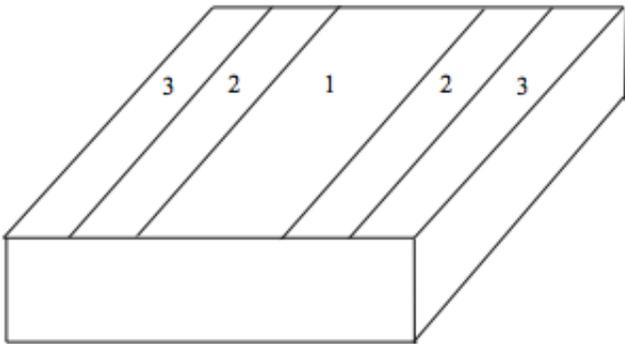
Fill in the cross-sections on the block diagrams and name the structures. Interpret the two blank sides of each block diagram using the information given in the map view. If rock layers are numbered in the map view, you must correctly number the rock layers in the cross-sections. Also add the correct strike and dip symbols for each block diagram if it is not already done.



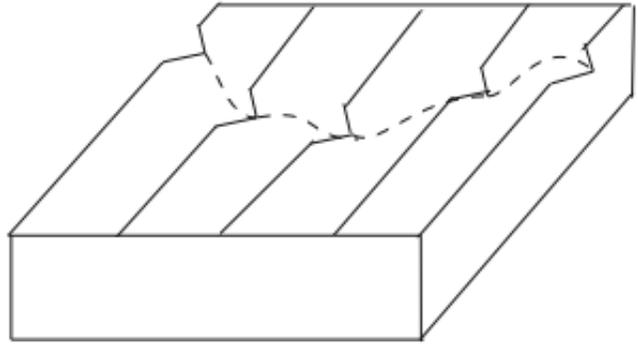
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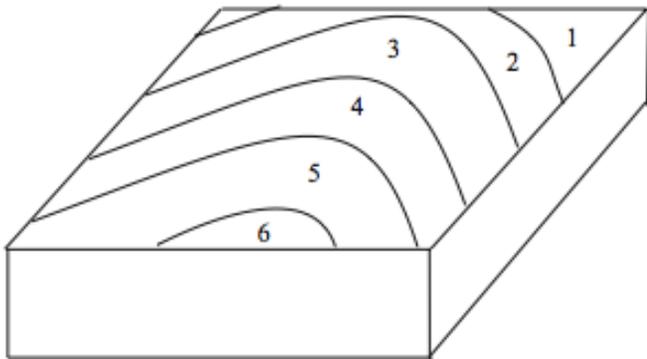
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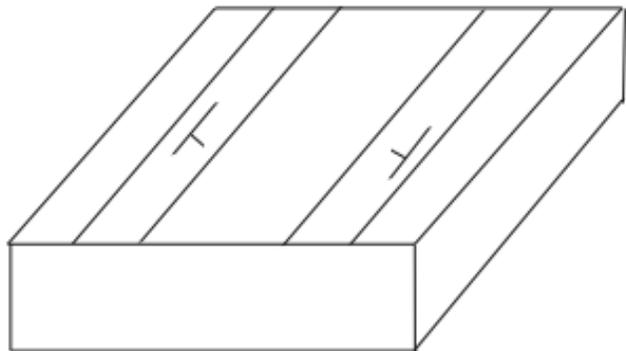
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## Laboratory Exercise Continued

