**Geological Visualization Tools and Structural Geology**

Geologists use several visualization tools to understand rock outcrop relationships, regional patterns and subsurface geology in 3D and 4D.

**Geological maps** are topographic maps on which different rock types are represented. An upcoming lab will be entirely devoted to studying geologic maps.

**Cross sections** are vertical “slices” into the earth that are used to interpret the geology at depth. The geological data (contacts, dips of formations, etc.) are projected from the surface into the cross section to predict what might be down there. Often, data from drilling projects or seismic surveys are used to construct cross sections.

**Block diagrams** are a combination of geologic maps and cross sections. They are three-dimensional representations of a block of the earth that can aid in the exploration for mineral resources and the interpretation of the cause or meaning of geological features.

**Structural geology** is the study of how geologic units (bodies of rock or sediments) are deformed relative to their original orientations or positions.

*Uniformitarian principles such as superposition and original horizontality help a geologist keep track of the geometry of a structure in space (3D). Knowing the different ages of rock bodies keeps track of the fourth dimension, time.*

**Attitude** is the geometric orientation of a geological feature.

**Planar Features**

**Strike** is the compass bearing of a line formed by the intersection of an imaginary horizontal plane (e.g. a map) and an inclined planar geological feature (e.g. sedimentary beds, metamorphic fabrics).

**Dip** is the vertical angle perpendicular to strike between the imaginary horizontal plane and the inclined planar geological feature.

The attitude of a planar feature is shown on the map with a strike line and dip tick:

![Diagram of Attitude](image)

The longer line is the strike, measured in degrees from geographic north. The dip is perpendicular to strike, and is a vertical angle quantified with its measurement in degrees.
Linear Features

**Plunge** is the vertical angle between the inclined linear feature and an imaginary horizontal plane.

**Trend** is compass bearing in the direction of the plunge of the linear geological feature.

Some Types of Structures

**Faults** are fractures or breaks in rocks on which movement has occurred

**Offset** is the amount of movement or displacement that has occurred on a fault.

The fault block **above** the fault is the **hanging wall**.
The fault block **below** the fault is the **footwall**.

**Normal faults**: the hanging wall moves **down** relative to the other side of the fault, while the footwall moves **up** relative to the other side of the fault. Rule of thumb – puts younger rocks against older rocks.

**Reverse and Thrust faults**: the hanging wall moves **up** relative to the other side of the fault, while the footwall moves **down** relative to the other side of the fault. Rule of thumb – puts older rocks on top of younger rocks.

**Strike-slip faults** are vertical faults and there are two main types:

- **Right lateral** means that as you look across the fault, things on the other side have moved to the right relative to your position.

- **Left lateral** means that as you look across the fault, things on the other side have moved to the left relative to your position.

**Folds** are ductilely deformed rock layers. **Antiform** folds are convex towards the top, and **synform** folds are concave towards the top.

An **anticline** is an antiform with the oldest rocks are in the middle.
A **syncline** is a synform with the youngest rocks in the middle.

A **dome** is a regional scale antiform structure, and a **basin** is a regional scale synform structure.

Parts of a Fold

1. **Hingeline** or **axis** is a line running along the fold apex, the most deformed part of a fold. The **axial plane** is made up of all the axes of the different deformed layers in a fold.
2. **Limbs** are the relatively less deformed parts of the fold on either side of the apex.
Using geological structures to interpret deformational conditions:

STRESS AND STRAIN

**STRESS** is defined as the force applied to something per unit area:

\[ \text{Stress} = \frac{F}{A} \]

Stress is the *cause* of deformation.

**STRAIN** is the amount of deformation something has gone through relative to its original shape.

*Strain is the result of stress.*

Geologic structures are strain markers that with careful observation and interpretation can tell a geologist what kind, how much and for how long an area was under stress during its geologic history.

They also provide clues as to how the different processes of earth deformation work

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**Plate Tectonics** is the large scale process that is the ultimate cause of most of the deformation seen in rocks on Earth.

Through careful observing, mapping and measuring of geologic structures, the geologic history, including plate tectonic history, of a given region may be worked out.
Creating and Drawing Faults

1. You have four (4) different clays. Take each one out of the container and make four rectangular sheets.

2. Designate a Period for each clay sheet and put them in the proper order according to the principle of superposition.

3. Draw a legend below, showing color designations for each time period.

4. With your clay block, slice an inclined (not vertical) fault plane. With this fault plane, create either a normal or reverse fault scenario. Draw and color a block diagram (not a cross-section) of the faulted clay block below, and label the hanging wall and the footwall. Be sure to use the colors you defined in your legend above, indicate the sense of movement with arrows, and title your creation “normal fault” or “reverse fault”.
USING AND INTERPRETING BLOCK DIAGRAMS

For this exercise you will use photocopies of Cardboard Models 1, 2, 3, 5 and 6 from your lab book. You may fold the models into blocks if it helps you solve the three-dimensional aspects of the questions. Please fold the sheets into blocks, do not cut them, and when you are finished, staple them back to your lab.

Follow the instructions and answer only the specific questions from the lab book about each model below.

Cardboard Model 1
This model shows a pale yellow sandstone formation striking due north and dipping 25° to the west. A second formation (gray shale) strikes due north and is vertical (dip angle = 90°). Provided are a complete geologic map (the top of the diagram) and three of the four vertical cross sections (the south, east, and west sides of the block diagram).

4a. Note that both the yellow sandstone and gray shale formations have the same thickness, but the yellow sandstone makes a much wider band on the geologic map (top of block). Why?

4b. What kind of unconformity is present in this block diagram, and how can you tell?

Cardboard Model 2
This model is slightly more complicated than the previous one. The geologic map is complete, but only two of the cross section are available.

5. Finalize Cardboard Model 2 as follows. First, complete the north and east sides of the block. Notice that the rock units define a fold. This fold is an antiform, because the strata are convex upward. It is nonplunging, because its axis is horizontal. On the geologic map, draw strike and dip symbols to indicate the attitudes of formation E (grey formation) at points I, II, III, and IV. Also draw the proper symbol on the map (top of model) along the axis of the fold (refer to Figure 10.3).

6. How do the strikes at all four locations compare with each other?

7. How does the dip direction at points I and II compare with the dip direction at points III and IV? In your answer, include the dip direction at all four points.
**Cardboard Model 3**

This cardboard model has a complete geologic map. However, only one side and part of another are complete.

8. Finalize Cardboard Model 3 as follows. Complete the remaining two-and-a-half sides of this model, using as guides the geologic map on top of the block and the one-and-a-half completed sides. On the map, draw strike and dip symbols showing the orientation of formation C at points I, II, III, and IV. Also draw the proper symbol along the axis of the fold (refer to Figure 10.3).

9. How do the strikes of all four locations compare with each other?

10. How does the dip direction (of formation C) at points I and II compare with the dip direction at points III and IV? *Include the dip direction at all four points in your answer.*

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**Cardboard Model 5**

This model shows a plunging synform. Two of the sides are complete and two remain incomplete.

16. Finalize Cardboard Model 5 as follows. Complete the north and east sides of the diagram. Draw strike and dip symbols on the map at points I, II, III, IV and V to show the orientation of layer G. *Synforms plunge in the direction in which the fold opens* (refer to rules, Figure 10.11). Draw the proper symbol along the axis of the fold to indicate its location and direction of plunge.

17. What is the *trend and plunge* of the fold axis?

   Trend:  
   Plunge:

   If H is the oldest formation, what type of fold is it?

   If H is the youngest formation, what type of fold is it?
Cardboard Model 6
This model shows a fault that strikes due west and dips $45^\circ$ to the north. Three sides of the diagram are complete, but the east side is incomplete.

18. Finalize Cardboard Model 6 as follows. At point I, draw a strike and dip symbol showing the orientation of the fault. On the west edge of the block, draw arrows parallel to the fault, indicating relative motion. Label the hanging wall and the footwall. Complete the east side of the block. Draw arrows parallel to the fault, indication relative motion. Now look at the geologic map at points II and III. Write U on the side that went up and D on the side that went down. At points IV and V, draw strike and dip symbols for formation B.

19. Is the fault in this model a normal fault or a reverse fault? Why?

20. On the geologic map, what happens to the contact between units A and B where it crosses the fault?

21. There is a general rule that, as erosion of the land proceeds, contacts migrate downdip. Is this true in this example? Why?

22. Could the same offset along this fault have been produced by strike-slip motion?