GEOLOGIC MAPS

PURPOSE: To be able to understand, visualize, and analyze geologic maps

Geologic maps show the distribution of the various igneous, sedimentary, and metamorphic rocks at Earth's surface in plan view. The contacts between different geologic formations and the various structures that occur in the rocks are typically superimposed upon the contour lines of topography in the map area.

Geologic cross sections often appear with geologic maps. They are diagrams illustrating the distribution of geologic units in the vertical dimension along a line through the map area. They may also show the topographic profile of the land surface.

Map Explanations or **Keys** are also found accompanying geologic maps. The formations are presented and described in chronological sequence, with the oldest unit at the bottom and the youngest unit at the top.

Geologic maps make use of specific **map symbols** to relate important information. Illustrations of common structure symbols and fault/fold relations are on pages 2 and 3.

Useful items on geologic maps:

- The **symbol** for a geologic unit, labeled on the map and in the explanation, begins with the capitalized symbol for the geologic period (or era), followed by lowercase letters that designate the name of the formation.
  for example, the Ordovician Swan Peak Formation is labeled "Osp"

- **Contact lines** on a map separate and mark the boundary between two adjacent geologic formations.

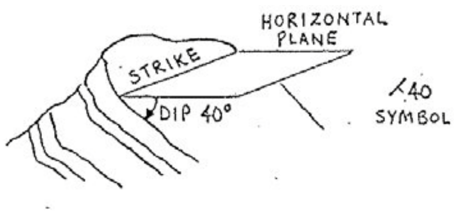
- **Outcrops** are those places where a geologic formation is exposed at the Earth's surface. Three factors control the width of a formation's outcrop on a geologic map: 1) the formation's thickness; 2) the slope of the land in the area of an outcrop; and 3) the dip angle of the beds in the formation.

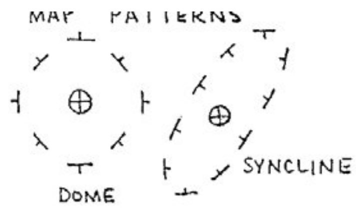
- The **dip angle,** measured in degrees, is the maximum angle between an imaginary horizontal plane and the sloping bedding plane of sedimentary strata.

- The **direction of dip** is the compass bearing that the rock units are tilted towards, measured downwards from the horizontal.

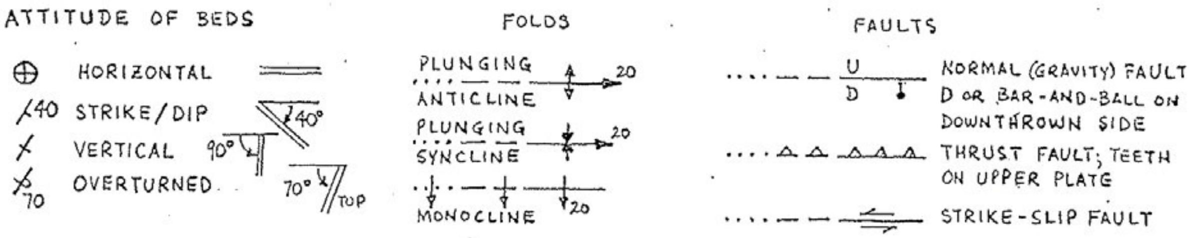
- The **line of strike** is the direction of the intersection of an imaginary horizontal plane and a tilted bedding plane or contact. The **direction of strike** is always at a right angle to the direction of dip.

- **Fold symbols** are a line along the crest of an anticline, trough of a syncline, or the inflection along a monocline. The type of fold is indicated by arrows across this line: pointing outward for an anticline, inward for a syncline, and in the direction of the step down for a monocline.

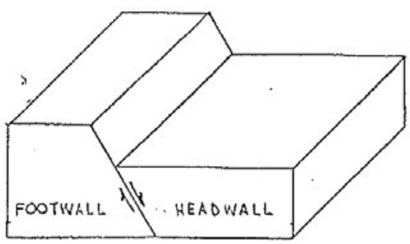




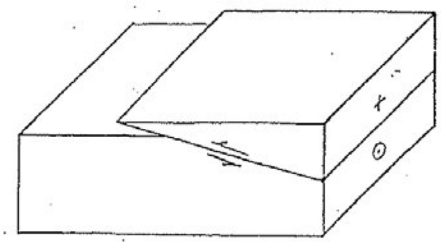
STRIKE/DIP AND OTHER SYMBOLS USED ON GEOLOGIC MAPS



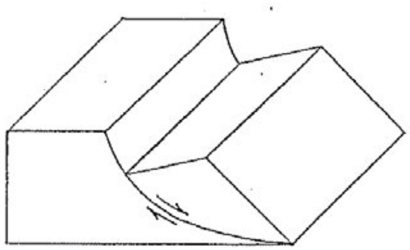
DOTTED FOLD OR FAULT : COVERED BY YOUNGER STRATA; DASHED: LOCATION APPROXIMATE



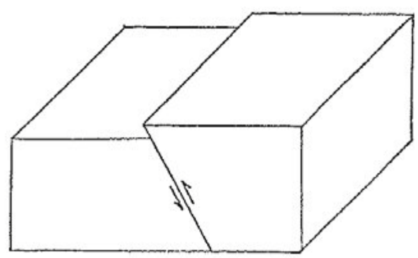
NORMAL (GRAVITY) FAULT



LOW-ANGLE REVERSE (THRUST) FAULT

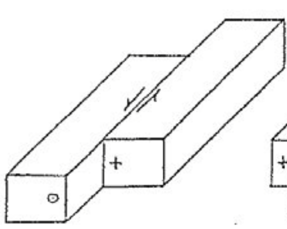


LISTRIC (SLUMP-LIKE) NORMAL FAULT

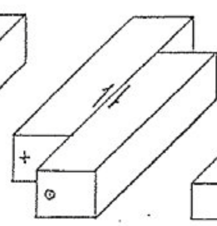


HIGH-ANGLE REVERSE FAULT

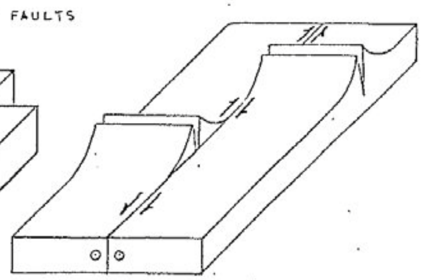
STRIKE-SLIP FAULTS



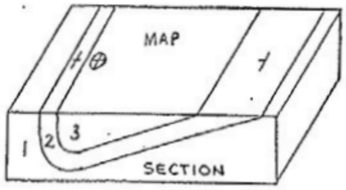
LEFT-LATERAL



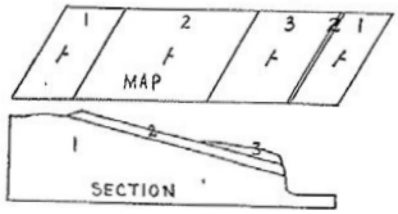
RIGHT-LATERAL



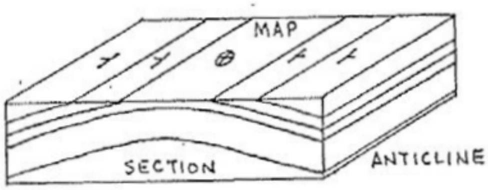
TRANSFORM (RIGHT-LATERAL IN MIDDLE HERE)
AT OFFSETS OF SPREADING RIDGES

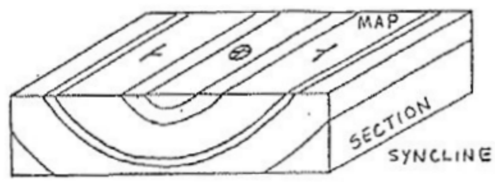


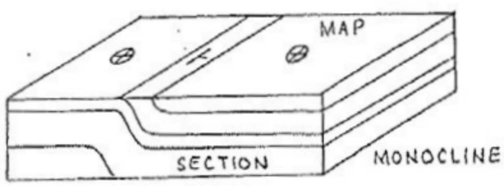
EFFECT OF DIP ON WIDTH OF OUTCROP

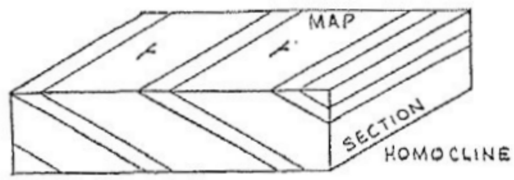


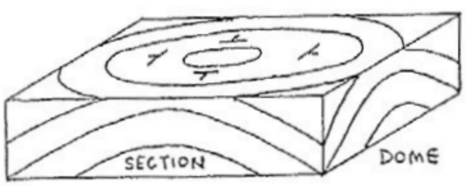
EFFECT OF TOPOGRAPHY ON WIDTH OF OUTCROP

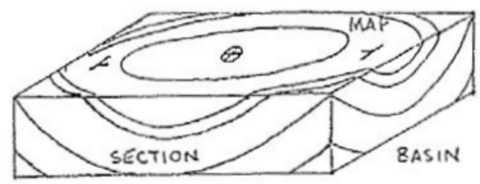


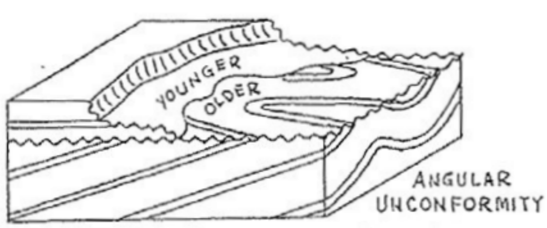




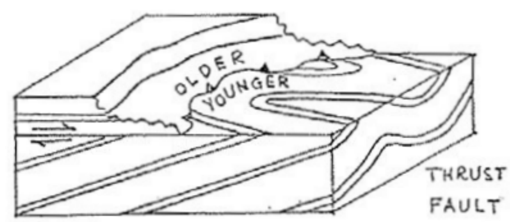








OVERLYING, YOUNGER STRATA PARTLY REMOVED BY LATER EROSION



OLDER STRATA, ABOVE THRUST SURFACE, PARTLY REMOVED BY LATER EROSION

BLOCK DIAGRAMS ILLUSTRATING FOLDS, AN ANGULAR UNCONFORMITY, AND A THRUST FAULT.

Exercise Part 1 (do before lab)**: Visualizing Geology in 3-D with online program**
tasks/questions in italics will be graded

We are going to explore the block-diagrams provided on the previous pages in 3-D by exploring this site: Go to http://visible-geology.appspot.com
Click on "Visualize", then click on "View Models". We'll begin by looking at blocks that have already been created, then later we can explore building our own block models.

1. a) Select "normal fault". Rotate the model so that you observe the block from all angles. *Draw a small sketch of the normal fault from both a top view and a side view. Label the footwall and the hanging wall (aka "headwall"):*

b) Select "reverse fault". Rotate the model so that you observe the block from all angles. *Sketch the reverse fault from a top view and a side view, labeling the footwall and the hanging wall:*

c) Compare the two sets of drawings you just made. *Explain how you differentiate the two faults from each other based on your illustrations.*

2. a) Select "syncline" and rotate the model so that you observe the block from all angles. Now, select "anticline" and rotate the model. Finally, select "plunging anticline" and do the same.

b) *Sketch here the top and a side view of a syncline and the plunging anticline, label the oldest strata and the youngest strata on you diagrams:*

c) *Describe the similarities and differences between these two folds and how you use the ages of the rock layers to differentiate them.*

Next, hit the “back” button on your browser and go back to the Visible Geology starting page to clear things and start over with a new block by clicking again on “Visualize”.

This time stay on “Create Geology”, and select “Geologic Beds” and create a new geology block with at least 3 layers of your choosing. Edit the 3 layers to fit the block, the total is 86 units high, so for example: layer 1 = 32, layer 2 = 24, and layer 3 = 30 units to fill the whole block.

3. Now create a dome, selecting the “Domes and Basins” icon. Begin by setting the radius at 30, and then “Add Dome Event” to deform your block. The events are incremental, so you should do 3 events in a row to make the pattern really visible. Rotate the block so that you observe it from all angles. Play around with the radius to see how it affects your dome.

4. Geologic maps often display patterns that are far more complex than those we have seen so far in these block models. Geologists spend a lot of their time and brain-power trying to unravel the events that created the complex geology we observe in the landscape. You will now create some very complex map patterns.

a) Folding folds. Create a simple fold in your basic layered block model: 000 strike, 90 dip, 000 rake, and under “More Options”: 90 period, 20 amplitude. Examine your block from all angles. It should look very familiar. Now, simply change the strike to 045 and the dip to 70 and add new folding event.

Examine your block diagram. When looking at just the top, like in a Geologic Map, *what previous structure in this exercise does the pattern roughly resemble?*

Now lets add a 3rd folding event. Change the strike to 090, the dip to 50, and the period to 30. Sketch here the top (map view) and the east-side (cross section view):

a) Click on “Geologic History”, and delete these three folding events to get back to your simple layers. Go back to “Create Geology” and let’s begin by tilting the beds at the default dip of 45 degrees. Now, go back to the Create Geology menu and add a “Simple Unconformity” using the default settings. This block should look familiar.

Continuing to build on this tilted model, let’s go ahead and fault it as well. Click on “Fault”, and go with a strike of 30 and a dip of 35, and under More Options, make it have a slip of 25.

Finally, add a folding event to this block. Make the fold strike 060, have a dip of 90, and (under More Options) have a period of 090. Whew! You can go back to “Geologic History” to remember your 4 deformation events.

Please sketch here the map view and the east-side cross-section view.

Which line is the fault? *Can you put a symbol on it showing which side is down along the fault line? Which line is the unconformity? Can you label it? Extra bonus if you can correctly label the oldest to youngest beds in your deformed block.*

5. Keeping your complicated block model, open the “Explore” tab at the top right. In this menu, you can make cross-sectional views (like at the sides of your block) in any direction you want—it is nifty.

Now, drill a borehole in the middle of your block. Check it out. This is the amount of information an exploration geologist generally receives to work from. Imagine trying to interpret the complicated geologic history of an area with such a narrow tube of rock! With a few more boreholes, and geologic training, you could do it!

Exercise Part 2: Inspecting Geologic maps in the lab room

<u>Sugar House</u>

1. Focusing on the bedrock underlying the Wasatch Mtns of the eastern 1/3 of map...
   a) What type of fold structure parallels Parley's Canyon (northeast part of map)?

   b) Compare (list) the bedrock ages along the axis of the fold, versus to the south along the limb, towards Mill Canyon—which is older?

2. Observe the fault that lies parallel to the mountain front in the southern part of the map, within the yellow "Qu" map unit.
   a) Which side of the fault, *generally*, is down-thrown? What type of fault is this?

   b) The fault is shown as cross-cutting and offsetting the Qu map unit. How old is the fault activity?

<u>Bright Angel Arizona</u>

3. Looking at the contact lines shown between Paleozoic geologic units, relative to the topographic contours--what is the general dip or tilt of the bedrock units?

4. Taken on the south side of Grand Canyon, what is the thickness of the Paleozoic rocks exposed?

5. What type of unconformity exists between the Zoroaster Granite, the Bright Angel, and the Tapeats formations south of Bradley Point (in east-central part of map)?

6. Observe the Pipe fault where it crosses the small drainage south of Isis Temple (west-central part of map):
   a) Constrain the geologic age of the Pipe fault, considering the geologic formations it does and does not cross-cut:

b) Considering the direction that the fault line “Vs” as it crosses the drainage, what direction does this fault surface dip?

c) What kind of fault is this?

<u>Flaming Gorge</u>

7. North of the Uinta fault, which runs east-west through the center of the map area…
   a) What rock types (not specific unit names) form the high plateaus, ridges, and steep cliffs, such as the “Boars Tusk” and the steep cliffs in Horseshoe Canyon?

   b) What *bedrock* type underlies the broader valleys, such as Antelope Flat and Lucerne Valley?

   c) Hypothesize why this would be:

8. a) The rock south of the Uinta fault is of what geologic age? Compare this to the age range of rocks immediately north of the fault:

   b) Using the symbols along the fault line, which side of the fault is up-thrown?

   c) Based upon these observations, what type of fault is the Uinta fault?

   d) Due to movement on the Uinta fault, the rocks north of the fault are broadly bent into what type of fold?

9. Based upon your observations from question 8, and using cross cutting relations, constrain the geologic timing of Uinta fault activity as best you can. Explain your reasoning!