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# Lab 9: **GEOLOGIC MAPS I; THE INTERPLAY BETWEEN TOPOGRAPHY AND GEOLOGY**

Geologic maps depict the intersections of geologic surfaces (bedding planes, faults, intrusive contacts, etc.) with surface topography. Such intersections are, of course, nothing more than lines in a 2-D map view, but the way in which a line crosses or is parallel to a topographic contour must directly reflect the orientation of the plane it represents. Conversely, the orientation of a plane (strike and dip) controls how it will intersect topography and thus how a line used to represent it crosses or parallels topographic contours. To successfully make or interpret geologic maps, it is absolutely essential to be able to "read" and thoroughly understand this interplay between topography and geology. The best map readers (and makers) are people who can mentally visualize 3-D planes from 2-D lines on maps and vice-versa. This can be a difficult task, but is facilitated by understanding a few basic concepts, and by practice with block diagrams, simple maps and cross sections.

Todays lab serves as an introduction to visualizing lines on geologic maps as planes in space. Calculation of strike and dip from topography/bedding surface intersections are dealt with in a later lab.

## I. Horizontal strata

The simplest relations to visualize are those involving the intersection of topography with horizontal beds. A map of a perfectly flat, horizontal area underlain by horizontal beds would show a single unit (Fig. 1a).

In contrast, on a slope of uniform gradient, horizontal beds crop out as a series of parallel units in map view (Fig. 1b). The line that represents the intersection of a surface with topography is technically called the **trace** of the surface; Figure 1b shows the trace of two contacts. Note that the thicknesses of the units in map view (called the **apparent thickness**) are governed by the slope; shallow slopes produce greater apparent thicknesses than steeper slopes.

Two slopes that intersect to form a valley yield a V-shaped pattern when underlain by horizontal units (Fig. 1c). Note that the V must always point upstream (just like the contours do) if the units are horizontal. Again note the difference between true and apparent thicknesses.

From diagrams 1b and 1c it should be apparent that the map trace of a horizontal plane must always mimic contours; *a horizontal contact can never cross a contour line.*

II. Uniformly dipping strata or planar surfaces

Units having parallel strikes and uniform dips intersect a flat topography to produce a pattern like that in Figure 2a; a series of parallel, linear bands. Notice that the trace of the contacts in map view must parallel the strike of the units. Why must this always be true? Because, by definition, a contacts' strike is the line of intersection of the contact with a horizontal plane which, in this case, is coincident with the flat, horizontal topography.

The same pattern results from dipping beds on a uniform slope, however *the trace of a unit contact will differ from its strike, if the strike is not parallel to the contours* (huh? see Fig 2b). This is just a precise way of saying that an inclined plane intersecting a sloping surface will produce a trace that tracks up and down a slope. This concept will later allow us to deduce attitudes of planar surfaces from their intersections with contours.

A dipping surfaces that intersect a valley produce a V-shaped map pattern, *unless the dip is vertical* (Fig 3). A vertically dipping surface always has a straight map trace, regardless of the topography it intersects. Notice the map patterns in figure 3; the direction the V points depends not only upon the direction the beds dip, but also upon the steepness of the dip relative to the slope of the valley floor (compare bottom diagram with others). If a surfaces dips more steeply than a valley floor slopes, the V **will always** point toward the direction of dip. Notice the opposite is true when a dipping surface crosses a ridge (E and W parts of block diagrams). A surface dipping downstream at an angle less than the slope of the valley will always V in a direction opposite the dip direction, or up-valley. Also notice that the V is more drawn-out when the beds dip shallowly than when they dip steeply. This is a qualitative measure of the amount of dip.

Finally, notice that the V's in the Figure 3 are symmetric; apparent bed thicknesses and trace lengths are the same on both side of the valley. A symmetric V is produced only when: 1) the valley itself is symmetric and 2) the strike of the beds is precisely perpendicular to the slope of the valley floor. This is, of course, not the usual circumstance and most V's in map view are thus asymmetric (eg. see fig. 2c).

One last thing can be observed from fig. 2c; *the map trace of a dipping surface does not cross contours when its strike is parallel to the contours,* as on the north side of the valley.

Determining Strike and Dip Directions from Map Patterns

From the above discussion of the rule of V's for dipping beds, it should be apparent that a rough approximation of *direction of dip* can be made noting whether a V points up or down valley. What about the strike? By definition, strike is always perpendicular to dip and is the line of intersection of a horizontal plane with the surface in question. If a dipping surface crosses valleys and ridges we can construct **strike lines** to precisely determine strike and dip directions.

A **strike line** (also called a structure or stratum contour) is a line connecting two or more points on a surface (eg. a bedding plane or fault) that are at the same elevation (Fig. 4). By drawing a line between two points on a surface that are at the same elevation you defined the intersection of a horizontal plane with the surface, and thus the strike of the surface. Strike lines are labeled by elevation. For example the 400 ft. strike line in figure 4 connects the 2 exposed points on the basal contact of the stipled unit that are at 400 feet elevation. Because a planar surface can have only one strike, *all strike lines on a surface must be parallel if the surface is planar*. Non-parallel strike lines on a surface indicate the surface is not planar. Folded beds need not have parallel strike lines, nor need erosional unconformities.

Strike lines are the easiest way to determine the strike and dip directions of contacts and faults, and provide a quick check on whether surfaces are planar. They are also a powerful predictor of where a contact should intersect topography when mapping, if the strike and dip of a contact are known.

Finally, the spacing between strike lines of different elevation is a function of the steepness of dip. Steeply dipping surfaces have more closely spaced strike lines than shallowly dipping ones in areas of uniform slope.

# EXERCISES

Map 1

1) Is the topography of this area a ridge or valley?

2) Which way do the beds dip?

3) Draw 200-700 ft strike lines on the limestone/mudstone contact.
Is this contact a planar surface?
What is the strike of this contact?

4) Do all units on this map have the same strike?

5) Do the beds dip shallowly or steeply?

6) Draw a cross section from B to A.

Map 2

1) What are the topographic features one would encounter when walking SE to NW across this area?

2) Does the conglomerate rest on top of or underneath the sandstone?

3) Construct strike lines on all contacts where possible on both sides of the fault. What are the strike and dip directions?

Are the contacts between all units planar and parallel?

4) Examine the spacing of your strike lines with respect to the slope of the valley floor on either side of the fault. Do the units dip similar amounts on both sides of the fault?

5) Draw strike lines on the fault. Which way does the fault dip?

6) Assuming a negligible component of strike-slip, what is the motion on the fault?

7) Is this a normal fault or a reverse fault?

8) Draw a cross section from B to A.

9) List the sequence of events that gave rise to the geology of this area.

Map 3 - This map should test your interpretive skills!

1) Examine the topography of the area carefully and mentally note the position of the drainages, hills, and ridges.

2) Construct strike lines on the base of the coarse sandstone in the three areas it is exposed. What are the strike and dip directions of the coarse sandstone?

3) What does the coarse sandstone unit rest on at each of the three areas where it's exposed?

What does this tell you about the basal contact of the coarse sandstone?

4) Construct strike lines on the remaining contacts on both sides of the fault. Are the beds everywhere planar?

5) Which way do these beds dip in most of the SW quarter of the map?
Which way do they dip elsewhere?

6) Assuming the superposition of units on the map is representative of relative age, what is the oldest unit exposed?

7) What sort of structure is needed to explain the dip directions and map pattern of the units below the coarse sand on either side of the fault?

8) Draw strike lines on the fault. Which way does it dip? Does it dip steeply?

9) Assuming a negligible amount of strike-slip movement, which side moved up? Is this a reverse or normal fault?

10) What is the age of the fault?

11) Draw a cross section from A to B.

12) List the sequence of events that gave rise to the geology of this area.

For those wishing further practice in this sort of thing, you are encouraged to explore the Hypercard program called HyperMap 1 that is installed on the Macintosh computers in Rooms 106 and 107. It ask the same sort of questions as above about 6 different maps, and supplies feedback on your answers. It's a great interactive way to hone your interpretive skill and practice visualizing in 3-D. See one the T.A.s or me if you'd like to use it and don't know how to get started.

Maps 4 and 5

1) Make 4 cross sections in the spaces left empty around the perimeter of each map. Give this some thought before blithely filling these boxes in. In particular, the dip of a unit in cross section depends on the how the cross section is oriented relative to the strike of the unit. Maximum dip (= the "true dip") is seen only in sections that are perpendicular to strike. All other sections will show "apparent dips" which are always less than the true dip. When done properly, the maps and sections could be cut out to form a block diagram.

2) List the sequence of events that gave rise to the geology on each map.

Fig. 4

Geologic map and cross section of 4 units that strike N-S and dip W. 300 and 400 foot strike lines for the basal contact of the stipled unit are shown. The 300 foot strike line is W of the 400 foot strike line, as it must be if the units dip W. Parallel strike lines could be drawn for the upper contact of the stipled unit (at 500) and the upper contact of the conglomerate (at 200 and 300), indicating all contacts are planar and parallel.