Geology 350

LAB 2: GEOLOGIC STRUCTURE FROM TOPOGRAPHIC MAPS

OBJECTIVES:

This lab exercise is designed to help you recognize the expression of geologic structure on topographic maps. Specifically, you will be:

a. mapping topographic features suggestive of recent strike-slip faulting
b. using drainage patterns to infer structural control or lack thereof
c. determining strike and dip of beds from topography
d. identifying fold types from their topographic expression, and mapping the trend and plunge of fold axes

MATERIALS:

soft dark (2H) pencil
eraser
colored pencils
ruler
protractor

MAPS:

San Andreas Rift Zone 1:37500 maps (xerox handout compiled from Bolinas, Double Point, and Inverness CA 7.5' quads)
Point Reyes, CA 15' quad
Soda Canyon, CO 15' quad, and portion reproduced with this lab
Millheim, PA 15' quad
Orbisonia, PA 15' quad
Milton, WV 15' quad
Waldron, AR 15' quad

RECOGNIZING FEATURES SUGGESTING RELATIVELY RECENT STRIKE-SLIP FAULTING

POINT REYES 15' AND SAN ANDREAS RIFT ZONE 1:37500 MAPS

Before the geology on either side of the San Andreas fault was mapped, its existence was inferred from its topographic expression: the pronounced long linear aligned strike valleys that mark its trace. The San Andreas is not a single, discrete break; instead, movement typically occurs along a several parallel branches (fault splinters) that define the San Andreas Rift Zone. These branches are not all equally active, nor are their traces equally obvious. To define the width of the zone, and to determine the most active traces, we need to map minor topographic features suggestive of recent faulting: sag ponds, linear depressions, linear scarps, offset/deflected streams, anomalous ridges (e.g., ridges in the middle of a valley bottom), etc. The US Geological Survey in fact did this sort of mapping along the San Andreas fault from Cape Mendocino to the Monterey area as part of its study of Bay Area geologic hazards. I've posted an example of this mapping.

a. **Overview:** Examine carefully the topography along the rift zone and the adjacent slopes on the 1:37500 strip maps. Look for features characteristic of strike-slip faulting. I suggest that you also look at the Point Reyes 15' quad which is less detailed, but provides a larger overview.

b. **Mapping fault traces:** On the strip map, use **red** lines to mark all inferred fault traces. Use a solid red line where the traces are accurately located, dashed lines where less accurately located, and question-marked lines where uncertain.

c. **Specific evidence:** With blue arrows, point out the features you used to locate or recognize fault traces and write a *brief* explanation next to each arrow to show what you saw there. See the posted USGS maps for an example.

I suggest that you spend no more than a half-hour on this exercise. You can check your mapping with my posted map. **You do not have to turn these maps in.**

INFERRING STRIKE AND DIP OF BEDDING FROM TOPOGRAPHY AND DRAINAGE PATTERNS

Bedrock geologic structure is often strongly reflected in topography, especially where layered rock units differ significantly in their resistance to erosion. Resistant units (e.g., conglomerates, sandstones, cherts, and volcanic flows) form cliffs or ridges, while weaker units (e.g., shales and, in humid areas, limestones) form benches or valleys. **Cliff-and-bench** topography typically occurs where flat-lying or very gently-dipping units have been incised by streams. Where rock layers are more steeply tilted, the resistant units form asymmetrical linear ridges called **cuestas**. The steep side of the cuesta is the eroded edge of the bed, while the gentle slope is formed by the bedding surface. Hence the strike and dip of the rocks forming a cuesta is obvious: the strike parallels the length of the ridge, while dip is in the direction of gentler slope. Where the beds are very steeply tilted, the resistant units form symmetrical linear ridges called **hogbacks**. In a hogback, the eroded edge of the bed and the bedding surfaces form equally steep slopes, and we cannot determine the direction of dip of the units from topography alone. Prominent linear ridges in curving or zig-zag patterns indicate eroded plunging folds. For further information refer to the handout on topography and geologic structure.

Stream patterns are important tools in inferring geologic structure. The randomly-branching tree-like **dendritic** pattern suggests lack of appreciable structural control, either because the beds are nearly flat-lying or because they all are similarly resistant to erosion. A **parallel** pattern commonly develops on moderately tilted depositional or erosional surfaces. **Pinnate** and **rectangular** patterns are typical of areas where joints or faults create weaker zones in flat-lying or otherwise relatively uniform materials. **Trellis** or **recurved trellis** drainage patterns usually reflect folds. Refer to the handout on drainage patterns for more information.

The exercises below are designed to develop your ability to recognize geologic structure from topography and drainage patterns. This skill is of great value in geologic mapping.

1. SODA CANYON, COLORADO 15' QUAD

   a. What name would you give the stream pattern? ______________________________

   b. What does this pattern indicate about presence or absence of marked structural control?

   ____

   c. What do you infer the general attitude of the bedding is (i.e., what is the overall strike and dip)?

   ____

   d. What is the evidence for your inference?

   ____

   ____

   e. Note the relatively flat, evenly sloping ridge crests in the NW corner of the map? What is the most probable origin of these flat surfaces (i.e., what do they represent?) What alternative explanation can you suggest?

   ____

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Do not spend more than 20 min on this. You can check your answers with my posted ones. **You do not have to turn this exercise in.**

2. MILLHEIM, PENNSYLVANIA 15' QUAD

The Millheim quad covers an area of deeply eroded folded rocks in the Valley-and-Ridge province of the Appalachians. Long-continued erosion has etched out valleys in the weaker rocks, leaving the resistant rocks to form cliffs and hold up the ridgecrests. This differential erosion has created a topography which strongly reflects the geologic structure.

a. Place a tracing-paper overlay over the *top half* of the Millheim quad. It should extend from the northern margin of the map down to about the town of Coburn. Mark the top corners of the quadrangle on your overlay.

Now, starting at the top of the map, trace in soft dark pencil the **base of each resistant unit** you can recognize (i.e., draw a line along the break in slope at the base of each resistant unit).

How many *different* resistant units did you discover? _________

b. I have drawn for you a topographic cross-section along a line extending from the red "m" (small print) in the "6 m" at the top margin of the map, down through the first leg of the first "N" in "Thick Mountain". The cross-section ends at the stream called Cherry Run.

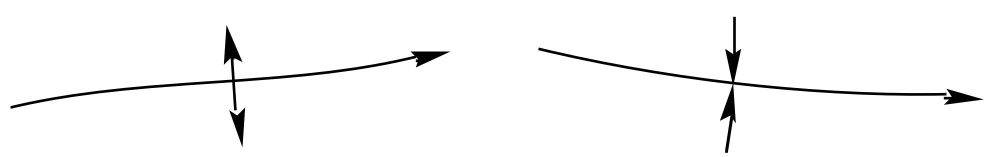
Use the topography shown on the map, together with the topographic cross-section to determine the strike direction and dip direction of the resistant bed at the following locations:

1) near Schreckengast Gap
2) on S side Nittany Mtn.
3) on N side Brush Mtn. near Wolfs Store Gap
4) on S side Shriner Mtn. near Fox Gap
5) on N side Woodward Mtn. near Woodward Gap
6) in vicinity of First Green Knob

Put strike and dip symbols on your overlay at these points.

c. Using your overlay as a guide, sketch on the topographic cross-section the *top and bottom* of the bed whose strike and dip you have been determining. The top and bottom of this bed should pass through the appropriate breaks in slope in the profile. When you have got the bed drawn in as you think best, shade it in lightly with a blue pencil. You now have the beginning of a geologic cross-section, constructed entirely from the topography on the map.

d. Using your strike and dip symbols, the topography, the cross-section, and the topography as a guide, use a blue pencil to draw in the *fold axes* of all folds you can recognize on your overlay. Use the proper symbols for anticline and syncline, being sure to indicate the direction each axis plunges. Remember that a fold axis runs the full length of the fold.



anticline syncline

arrow on end shows direction of plunge of fold

This is an important exercise; I suggest you devote at least an hour to it. You can check your work against my posted answers. We will go over the cross-section together in class. **You do not have to turn this exercise in.**

3. (30) ORBISONIA, PENNSYLVANIA 15' QUAD

Note: because we have only two copies of the Orbisonia quad, you will have to use it in lab; it cannot be checked out for home use.

My sketch below shows the main ridges on the Orbisonia map. I would like you to draw on it the axes and plunges of all the synclines and anticlines you can recognize on the map.

The Orbisonia quad also cover an area of deeply eroded folded rocks in the Appalachians. The beds here dip more steeply than they did on the Millheim quad, hence the structure may be harder to decipher. You will have to look for more subtle indications of dip than you did previously; in particular you will need to look for asymmetry in some of the smaller, lower ridges. I suggest that you start by carefully scrutinizing the area between Shade Gap, Pleasant Hill School, Center School, and Neelyton. I would start by putting down some strike and dip symbols on the map; only then would I start on the fold axes.

4. (30) MILTON, WEST VIRGINIA 15' QUAD

Drainage patterns can often tell us a great deal about the presence or absence of appreciable structural control in an area. For example, a *dendritic* stream pattern suggests lack of such control, and may may indicate that the beds are flat-lying; alternatively, it may simply mean that the beds are all nearly equally resistant to erosion, and hence no particular structural pattern appears. In flat-lying or relatively uniform materials, joints or faults may create weak zones in the rocks which streams can exploit, and the drainage pattern will reflect this control. The purpose of this exercise is to help you develop your eye for stream patterns.

a. (8) Look carefully at the topography on the map. Do you see any pronounced differences in rock resistance? (Hint: are there any particularly large ridges alternating with valleys such as you saw on the Millheim and Orbisonia quads? Is there any cliff-and-bench topography?) Based on your observations, what do you think the most likely geologic structure here is?

structure: ____

evidence: ____

b. (10) Note the black lines that divide the Milton quad into nine rectangles. Place a piece of tracing paper over the rectangle forming the SE corner of the map and trace with dark pencil *all* the stream channels in it. Trace also the center line of small valleys which lack blue lines.

c. (5) Do you see any preferred orientation of the stream segments in this area, or do they appear to be more-or-less randomly oriented? If you think they show preferred orientation(s), what are the compass directions?

Orientation? ____

d. (5) Do you think there is any structural control of this drainage pattern? Give the reasoning for your answer. If you think that there *is* control, what is the most likely cause?

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____

e. (2) What name would you apply to the drainage pattern you mapped? ____________________

5. (40) WALDRON, ARKANSAS 15' QUAD

In my sketch below I have shown and labeled the chief ridges on the topographic map.

a. On the sketch, draw in in green the axes of all the anticlines and synclines you can recognize, indicating direction of plunge. I suggest that you put some strike and dip symbols on the beds before you draw in the axes.

b. Draw in any *obvious* faults in red. (Don't waste your time looking for small or subtle faults.)

c. Name the drainage pattern you see centered on Waldron: ________________________________

CAUTION: the area between Henry Mtn. and Peanut Mtn./Buffalo Mtn. *is not* a fold; it is cut by several faults you will not be able to map.