

## Physical Geology 101 Laboratory Interpreting Geology Maps

**Introduction & Purpose:** The purpose of this laboratory is to gain a working knowledge and skill to read geology maps. Students will learn to read a geology map for the purpose of understanding surface and subsurface structural relations and geologic history that may include a record of rock forming events, mountain building deformation, and the relationship between geology and topography

### Part I. Review Taking Strike and Dip

**Directions:** Use the Compass and Inclinator, provided by your instructor, to determine the strike and dip of two inclined boards that are setup in the classroom. **Note:** Use the boards labeled "X" and "Z".

1. What is the strike and dip of the board labeled "X" strike: \_\_\_\_\_ dip: \_\_\_\_\_

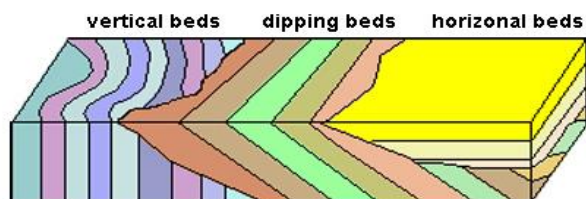
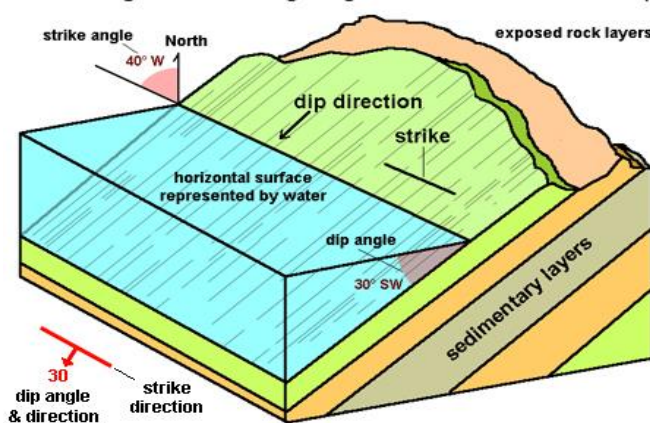
2. What is the strike and dip of the board labeled "Z" strike: \_\_\_\_\_ dip: \_\_\_\_\_

### Part II – Reading and Interpreting a Simplified Geologic Map

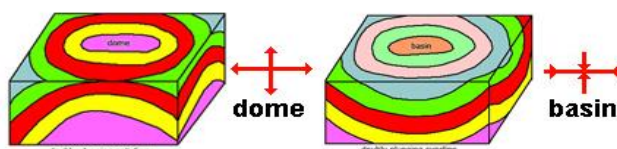
**Introduction:** A geologic map is a greatly scaled-down, two-dimensional abstract representation of the surface geology, structure, and relief of a geographic region of Earth, or even another terrestrial planet. A geologic map typically includes most information found on a topographic map, but most importantly, includes color-coding regions and symbols that denote rock units, contacts, and other structural information. Additionally, all the geologic color-coding and symbols are explained in the legend on a geologic map, including topographic and cardinal information.

#### Common Geologic Map Symbols

Describing orientation of geologic features with strike and dip



beds inclined straight up    strata inclined at an angle    flat-lying strata



Rock Unit Boundaries - contacts between rock units of different age and/or different composition

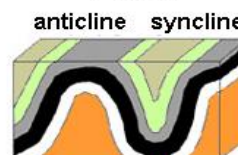


— contact certain  
--- contact inferred



.... contacts inferred beneath sedimentary cover

#### FOLDS



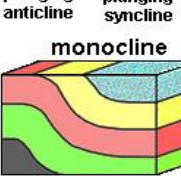
anticline    syncline

plunging folds



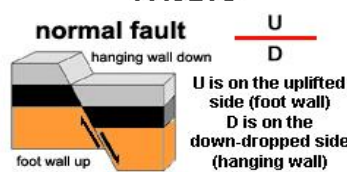
plunging anticline    plunging syncline

monocline

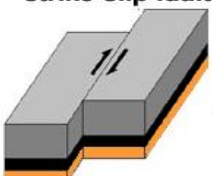


arrow points in fold dip direction

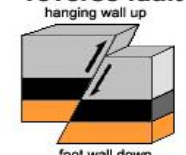
#### FAULTS



normal fault



strike-slip fault



reverse fault



thrust fault

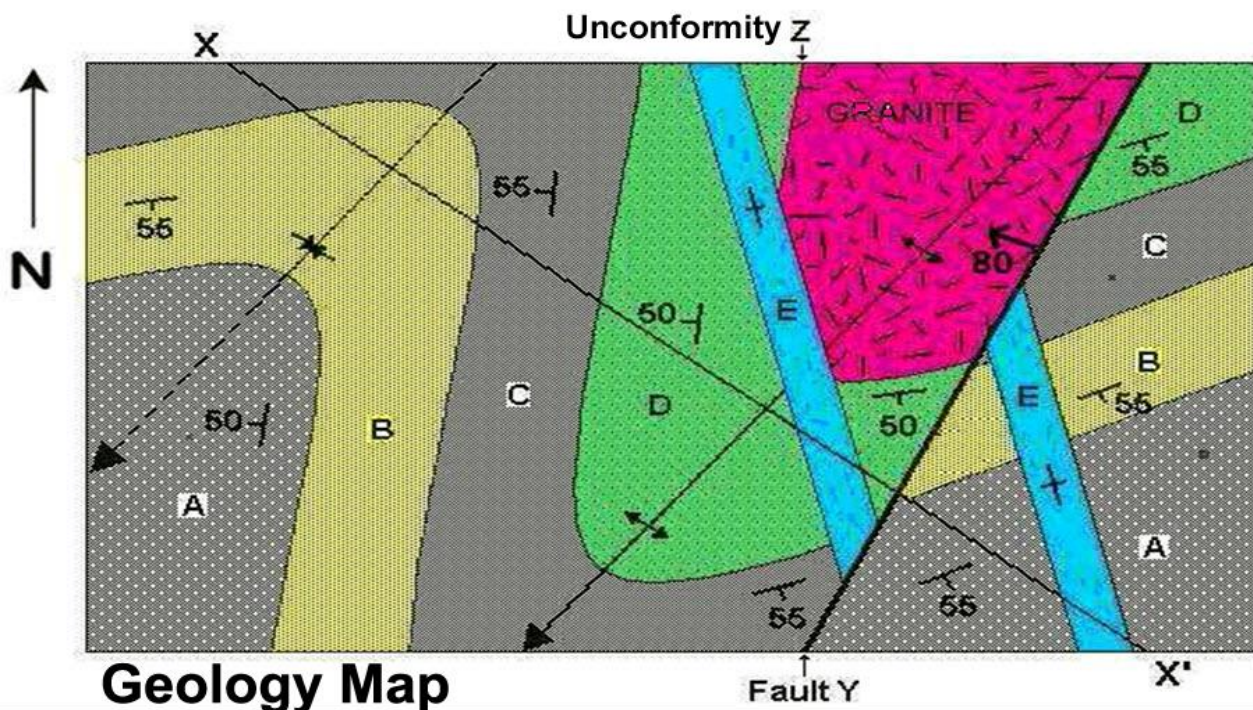
U  
D  
U is on the uplifted side (foot wall)  
D is on the down-dropped side (hanging wall)

half arrows show direction of fault motion

triangles on upper plate (hanging wall)

triangles on upper plate

**Directions:** The simplified geology map below contains several geologic features that include the following: Sedimentary beds "A", "B", "C", and "D"; Basalt dike "E"; Granite pluton; Fault "Y"; and Unconformity "Z". Please note that the illustration below is a map view (horizontal ground surface) and not a vertical cross-section. Use the map below to answer the list of questions:



- 1) What is the *oldest* rock unit on this map? \_\_\_\_\_
- 2) What is the *youngest* rock unit on this map? \_\_\_\_\_
- 3) Which structural rule(s) (1 through 13) best helped you answer questions 1 and 2?

Structure Rule(s) \_\_\_\_\_

- 4) Which is the *youngest* geologic feature: Dike "E", the Granite pluton, or Fault "Y"?

Answer : \_\_\_\_\_

- 5) Which is the *oldest* geologic feature: Dike "E", the Granite pluton, or Fault "Y"?

Answer : \_\_\_\_\_

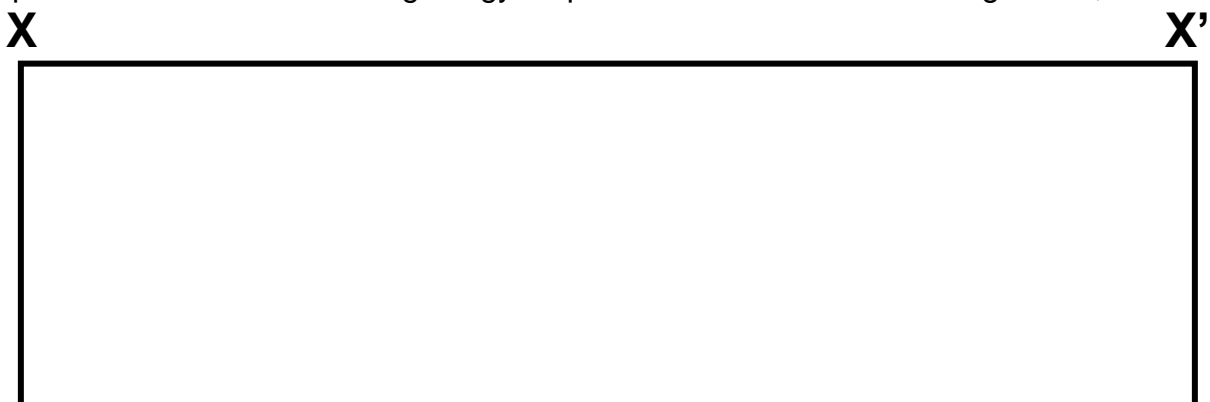
- 6) Which stratigraphic principle best helped you answer questions 35 and 36?

Answer : \_\_\_\_\_

- 7) Which of the following is the correct temporal order of the geologic features on this map? (The oldest one being the first in the order.) Circle the correct letter – a through f

- a) "A", "B", "C", "D", "E", "Z". Granite, "Y"
- b) "D", "C", "B", "A", "E", "Z", Granite, "Y"
- c) "D", "C", "B", "A", Granite, "Y", "E", "Z",
- d) Granite, "Z", "A", "B", "C", "D", "E", "Y"
- e) Granite, "E", "Z", "Y", "A", "B", "C", "D",
- f) Granite, "Z", "D", "C", "B", "A", "E", "Y",

- 8) What is the strike and dip of Fault "Y"? Answer : \_\_\_\_\_
- 9) Which side of Fault "Y" is the hanging wall? The side with the granite? Or without the granite?  
Answer : \_\_\_\_\_
- 10) What type of fault is Fault "Y" if the slickenside grooves are horizontal (parallel to strike)?  
Answer : \_\_\_\_\_
- 11) What type of fault is Fault "Y" if the slickenside grooves are vertical (parallel to dip)?  
Answer : \_\_\_\_\_
- 12) What is the strike and dip of Dike "E" ? Answer : \_\_\_\_\_
- 13) What type of fold occurs in the **western** part of map? (fold with axis through rock unit "A")  
Circle the correct answers whether it's 1) an anticline or a syncline AND 2) whether its horizontal or plunging.  
Answer: The fold is a(n) anticline / syncline and it is horizontal / plunging.
- 14) What is the strike and plunge of the fold axis located in western part of map?  
Answer: The strike of the fold axis is \_\_\_\_\_ and it is plunging towards the \_\_\_\_\_
- 15) What kind of dips do the limbs of the fold located in western part of map have?  
Low-angle dips? Moderate dips? Or High angle dips? Circle one.
- 16) What type of crustal force caused the folding and faulting? Assume that the fault has vertical-grooved slickensides (parallel to dip). Tension, compression, or shear? Circle one
- 17) What were the horizontal directions were the crustal forces being applied to create the foldi shown on the map? NW-SE? NE-SW? N-S? or W-E? Circle one.
- 18) What type of unconformity is "Z"? Answer : \_\_\_\_\_
- 19) When did the folding event occur?  
Answer: The folding event occurred after \_\_\_\_\_ , but before \_\_\_\_\_
- 20) What is the tectonic setting most likely to have formed this deformed rock package?  
Divergent? Convergent? Or Transform? Circle one.
- 21) Complete a cross section of the geology map for transect X – X". NW is right side; SE is left.



### Part III – Reading and Interpreting the Devil’s Fence Quadrangle Geology Map

**Directions:** Do a general examination of the entire geologic map of the Devil’s Fence Quadrangle. Carefully examine the various rock units represented by the colored regions and related map symbols on the map that portray the surface geology of this area in Montana. Note their shape, aerial extent, and the larger structural patterns formed by spatially- associated outcropping rock units. Use the explanation to the left of the map to decipher the rock units, in terms of formation name, age, and lithology, and structural. Also use the explanation to the left of the map to decipher the structural relations of the various formations, including strike and dip, folding, and faulting. Finally, answer the following questions, based on your analysis of the Devil’s Fence Quadrangle.

- 1) Verbal scale for this map? (bigger map) One inch of map is equal to \_\_\_\_\_ miles of real ground.
- 2) What is the contour interval? \_\_\_\_\_ ft.      3) This map covers \_\_\_\_\_ square miles.
- 4) What are the minimum and maximum elevations for this area? Min = \_\_\_\_\_ ft. Max = \_\_\_\_\_ ft
- 5) Does this area have gentle or rugged topography (relief)? \_\_\_\_\_
- 6) What topographic feature does the "Devil’s Fence" represent? Valley? Mountain peak? Ridge?
- 7) Does the location and orientation of the Devil's Fence topographic feature (question 6) correspond to specific location and orientation of underlying geologic rock unit(s)? Hint: Underlying geology (nature of rock formations and structures like folds and faults) very commonly controls the overlying topography. Answer: \_\_\_\_\_  
\_\_\_\_\_
- 8) List the major types rock types exposed in this area, such as sandstone, schist or granite. Include at least six rock types. List at least one rock type from each of the three major rock groups.  
\_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.
- 9) List the total age range of the rock formations? \_\_\_\_\_ Period to \_\_\_\_\_ Period
- 10) Find the Colorado Formation unit on the map. What its age? \_\_\_\_\_ Period
- 11) This rock formation forms the center of what general type of geologic structure, such as a fold or fault? Hint: notice the "V" shaped pattern of rocks) \_\_\_\_\_.
- 12) If you answered “fold”, is it a syncline or an anticline? \_\_\_\_\_ Horizontal or plunging?
- 13) What information did you use to tell whether it was a syncline or an anticline? \_\_\_\_\_  
\_\_\_\_\_
- 14) How could you tell whether it's a horizontal or plunging fold? \_\_\_\_\_  
\_\_\_\_\_



- 15) Find the Greyson Shale Fm on the map. What's its age? \_\_\_\_\_ Period
- 16) This rock formation forms the center of what general type of deformational geologic structure?  
Hint: notice the upside down "V" shaped pattern of rocks) \_\_\_\_\_.
- 17) If you answered "fold", is it a syncline or an anticline? \_\_\_\_\_ Horizontal or plunging?
- 18) What information did you use to tell whether it was a syncline or an anticline? \_\_\_\_\_  
\_\_\_\_\_
- 20) What is the general strike (bearing) of the fold axes across the map? \_\_\_\_\_
- 19) How could you tell whether it's a horizontal or plunging fold? \_\_\_\_\_  
\_\_\_\_\_

Which direction are the folds plunging? North or south? \_\_\_\_\_

- 21) How many distinct folds are found in this geologic map? Hint: Way more than two!! \_\_\_\_\_
- 22) Which two compass directions did the deviatoric stresses come from to cause the folding? \_\_\_\_\_
- 23) What type of fault is the Horse Gulch Fault if the west side is the hanging wall and it has vertical slickenside grooves in the fault zone? Note the age difference between formations across the fault.

Answer : \_\_\_\_\_

- 24) What type of fault cuts across the Devil's Fence (between the letters "F" and "E")? Note the fault is steeply dipping towards the northeast and it has vertical slickenside grooves in the fault zone. Also note the NW direction that the folded limb is dipping across the faulted region.

Answer : \_\_\_\_\_

- 24) Determine the timing of the regional folding event. **Note:** Folding must have occurred **after** the youngest folded rock unit BUT **before** the oldest non-folded rock unit. So to determine the age of the folding event, you will need to determine the following rock formation ages:

a) Name and age of YOUNGEST ROCK that is FOLDED?

Formation name: \_\_\_\_\_ Age: \_\_\_\_\_ Period

b) Age of OLDEST ROCK that is NOT FOLDED?

Formation name: \_\_\_\_\_ Age: \_\_\_\_\_ Period

c) Age of folding? Folding occurred between \_\_\_\_\_ Period and \_\_\_\_\_ Period

- 25) What type of rock makes up the Sagebrush Park stock? \_\_\_\_\_

- 26) What's the age of the Sagebrush Park stock? \_\_\_\_\_ Period

**27)** Determine the timing between the intrusion of the Sagebrush Park stock and the regional folding event. Did the intrusion occur **BEFORE**, **DURING**, or **AFTER** the folding? **Note:** To confidently answer the above question, you will need to know both, the age of folding and the age of intrusion.

a) Age of folding event? \_\_\_\_\_ Period

b) Age of Sagebrush Park intrusion? \_\_\_\_\_ Period

Based on the above noted ages, did the intrusion occur **BEFORE**, **DURING**, or **AFTER** the folding?

c) Sagebrush Park stock intruded the sedimentary rock package \_\_\_\_\_ the folding.

**28)** Based upon your study of the geology and structure of the Devil's Fence region, what was the most likely tectonic plate boundary setting (**divergent, convergent, or transform**) that would generate the combination of folding, reverse faulting and granodiorite intrusions?

**Answer:** \_\_\_\_\_ **Why?** \_\_\_\_\_

**29)** If you picked convergence, was it subduction-related, or was it a continental collision scenario

**Answer:** \_\_\_\_\_ **Why?** \_\_\_\_\_

**30)** If you picked subduction, was it ocean-ocean subduction, or was it ocean-continental?

**Answer:** \_\_\_\_\_ **Why?** \_\_\_\_\_

## **Part IV - Geologic Map Laboratory Reflection**

**Directions:** Write a 120-word minimum reflection of the lab activity, explaining its purpose, the methods used, the results obtained, and a brief personal reflection of what you enjoyed and learned about doing this geologic map lab (3 points possible). Answer the following 3-point question reflection set below.

1) *What was the purpose of this lab? What did you actually discover and learn during this lab?*

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2) *What did you enjoy most about this lab? Also, what was challenging or thought-provoking?*

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3) *What are your comments about the design and execution of this lab? What's good? Bad?*

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