# Geoscience 202 Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Intro to Geological Structures** Learning Partner\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Fall 2017** Learning Partner\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**In class exercise: Map and cross-section on igneous/metamorphic terrain**

Map: Norwegian Bay Quadrangle, St. Louis County, Minnesota by R.L. Bauer

Minnesota Geological Survey Miscellaneous Map Series M-59

Activity: You will have two class periods to answer the questions on the sheets. Each person must write down her or his answers, but you need to work together. You are encouraged to ask any TA or instructor questions during the class period.

Background: This is one of Basil’s favorite geological maps – it is an example of an outcrop map. It clearly separates its observations from its interpretations, and it is a fascinating area. It has faults, folds, fabrics, and an intrusion, so it will require that you synthesize all that you have learned this far in the semester.

Step 1: Topography

As per usual, you first have to understand the base map and the topography.

1. What is the scale of the map? If you didn’t have a scale bar on the bottom of the map, list two ways you could figure it out anyway?
2. Why is NS dimension of the map larger than the EW dimension of the map?
3. How much distance in reality does 1 cm on the map represent?
4. What is topographic contour interval? Describe, in words, the overall topography of the area (e.g., flatter than a pancake, Sierra Nevada-like topography, etc.)?
5. What is the highest point and lowest point on the map? Give the location in latitude and longitude.
6. What are the contours in Lake Vermillion (that is, what does it mean that a lake has contour lines in it)?

Step 2: Geomorphology

After you understand the topography, it is important to understand how the topography formed.

1. Look at the description of the Quaternary geological units. What deposited them (or, how were they deposited)?
2. What is the topographic shape of the Quaternary deposits, relative to the topography on the rest of the map?
3. What is the dominant geomorphic agent (wind, water, ice, etc.) in this area?

Step 3: With your hands; gesture the subsurface geology.

# Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Learning Partners\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 4: Bedrock geology - Lithology

Use the “Description of Map units” to read the rock descriptions.

1. This is an important part of this map: *It is an outcrop map rather than a standard geological map.* The grey outline tells you were rock actually outcrops (See “Area of Outcrop” at bottom of map symbol) – where there is color, but not grey, the extent of the unit is inferred. Outcrop maps are better than standard geological maps. Why?
2. Find the Proterozoic unit; there isn’t much of it. (Look in the south-central portion of the map.) Why is it interpreted as a dike?
3. A diabase (*dia* = two, in this context) has two dominant minerals (to make a basaltic composition). What are those two minerals?
4. There are two main lithologies that make up most of the bedrock. One is Avbs. What is it?
5. A strike and dip symbol is used for this unit. What does it designate?
6. A lineation symbol is used for this unit? What does it designate?
7. The other main lithologies is Avwt. What is it? What is a “tonalite” (look at page 140 in your fieldbook if you have it) – what are the relative percentages of quartz, plagioclase, and alkali feldspar?
8. A strike and dip symbol is used for this unit. What does it designate?
9. How does this strike & dip symbol for Avwt differ from that used for Avbs?
10. The Avad unit has a limited areal extent, but is quite important to understand. Briefly described at where it outcrops S of the Vermillion fault.

Step 5: Bedrock geology – Geological Structures

1. You will notice that there are folds in both Avwt and Avbs. What, exactly, is folded?
2. There are different symbols and different labels of folds. In general, folds are labeled by the order they formed with F1 as the oldest fold, F2 is the second oldest fold, etc.. In this case, there are three fold generations, so F3 is the youngest fold. There are three F3 folds, but they are all similar to each other: What kind of folds are they?
3. Look in the NW corner of the map. How can you tell that the F2 fold is older than the F3 fold? You may want to look at Figure 2 in the lower part of the map.
4. There are three main faults on the map: Black Bay fault, Vermillion fault, and Haley fault. Describe each:
   1. Black Bay fault (use the offset F3 fold):
   2. Vermillion fault
   3. Haley fault (this is tricky):
5. Do you see an exposure of any of these faults anywhere (Note: This is a huge advantage of an outcrop map)?
6. What is the geomorphology of the fault zones, generally?
7. The Vermillion fault is thought to have ~17 km of offset. Are you going to be able to see any single offset feature on both sides of the fault on just this map? Why or why not?
8. Look at the northern and southern margin of the Wakemup bay pluton. Is it conformable or unconformable or can’t you tell?
9. If it is conformable, what would you call it (in terms of geometry)?
10. If it is unconformable, what would you call it (in terms of geometry)?
11. Look at the Avad unit where it is located right in the middle of the Wakemup Bay tonalite (On the border between sections 24 and 19). What is the approximate orientation of this unit (use the relation between topography and contacts)?
12. What unit is topographically below the Avad unit?
13. What is the relation of the Avad and Avbs units (on the border of sections 24 and 19) to the Wakemup Bay pluton?
14. How does this section of the map help tell you whether the Wakemup Bay pluton is conformable or unconformable?

Step 6: Cross section

Make a cross-section (NS oriented) that goes from the Vermillion fault, to the S end of the map (S of Haley fault), that explains the geometry inferred from the map (So, don’t worry about going very deep).

In addition to the data for the top of the pluton, we did a geophysical (gravity) survey to determine the depth to the bottom of the pluton. The gravity data shows the subsurface extent of the tonalite (it is technically an isopach map of the thickness of the pluton).

Using the surface geology and the gravity data, make an interpretation of what the pluton looks like on a cross-section oriented ~NS across the middle of the pluton.

Note that this exercise will thus be similar to your lab this week on the Tuolumne intrusive suite, Sierra Nevada batholith, California.