LABORATORY 5: Campus Geologic Mapping Project

I. *Mesoscopic Structure* Symbols (outcrop scale)

(A) *Bedding/compositional layering* (S_0)

Bedding contacts are primary sedimentary structures. They may be associated with other primary sedimentary structures such as *crossbedding*, *graded bedding*, and *ripple mark*s. An outcrop may contain multiple layers that differ in composition, however, is the layers have been recrystallized by metamorphism you cannot assume that this represents bedding unless you recognize primary features. In this case you should use the term compositional layering.

(B) *Foliation* or *Cleavage* (S_1)

Foliation is a preferred alignment of mineral grains in a rock. The microscopic occurrence of this property is termed cleavage because it will impart a pronounced parting to the rock if struck by a hammer.

(C) *Lineation* (L_1)

Mineral lineation is the parallel alignment of mineral grains.

Intersection lineation is a streaky lineation caused by the intersection of cleavage or foliation with compositional layering (S_0)

(D) *Fold Hinge* (F_1)

The hinge consists of the points of maximum curvature along a single folded surface.

Fold symmetry relates to the shape of an asymmetric fold viewed in the down plunge direction of the hinge. The shape will appear as a "Z", "S", or "M", and should be noted. The symmetry is related to megascopic folding of same generation

(E) *Axial plane* (AP_1)

The axial plane is the plane that contains multiple hinge line points along the fold profile. Typically this is measure by aligning a clipboard with the imaginary plane that contains several hinge lines in a fold profile. You must be able to see significant three-dimensional relief on the outcrop surface to be able to accurately measure the axial plane attitude.

(F) Joints

The number of joint surfaces exposed at a given outcrop is often a very large number so it is not usually possible nor desirable to measure every single occurrence. Instead you should look for *joint sets*- two or more joints with similar orientation. Often there are only two or three sets at a given exposure. The orientation pattern of joint sets can often delineate the orientation of the principal components of the stress field that caused the fracture system to develop.

II. *Megascopic Structure Symbols (map scale)*

(A) *Depositional contacts* and *igneous contacts*

For depositional contacts use a normal line width (i.e. #0 rapidograph pen).

An *Unconformity* may be indicated by hachures on the young side (upper) of the unconformable surface, however, since unconformities are depositional contacts you must use a normal width line (i.e. #0 rapidograph) for the contact.

(B) *Fault Contacts*

Use a thick line width (#2 rapidograph) to distinguish faulted contacts from other contacts. In general, any symbols used with a fault contact are placed on the hanging wall side of the fault. Fault contacts with teeth on the hanging wall traditionally represent low-angle *reverse fault* (*thrust*) contacts.

Normal fault (*hanging wall* down) contacts should have hachures on hanging wall side of the contact. A "U" and "D" is often used to distinguish the upthrown and downthrown fault blocks. Most normal faults dip steeply. If the fault dips 90°, use the "U" and "D", and put hachures on the downthrown block.

Reverse fault (hanging wall up) contacts are plotted with the teeth symbols on the hanging wall block. If a reverse fault dips at a low-angle it is termed a thrust fault.

A *strike-slip fault* is plotted with arrows on opposite sides of the fault contact, and these arrows should accurately describe the sense of motion on the fault.

(C) *Megascopic Fold*s

The axial trace of a fold should be plotted as a thick line (i.e. #2 rapidograph) weight. If the fold hinge is not horizontal, an arrow on the axial trace should indicate the direction of the plunge. Symbology on the axial trace should indicate the difference between an antiform and a synform.

An *Asymmetric fold* is a fold where one limb is significantly longer than the other. This produces a “Z” or “S” symmetry when viewed in profile. A symmetric fold, one with equal length limbs appears as an “M” shape. These folds are also termed *neutral* folds.

An *Overturned fold* contains a limb which has been rotated more than 90 degrees from the original horizontal attitude. If the limb is composed of bedding, the bedding is overturned on the overturned limb (i.e. younger beds are encountered at depth).

A *Recumbent fold* is a fold with a horizontal axial plane.

Dome and *Basin* fold structures are indicated by circular contacts. Domes will have older strata in the core of the structure, whereas basins will contain younger strata in the core.

A *Doubly-plunging* fold contains a hinge line that gradually changes attitude. The map pattern of contacts will be elliptical in this case. An elliptical pattern of contacts with older strata in the core of the structure is a doubly-plunging anticline; younger strata in the core indicates a doubly-plunging syncline.

(D) *Antiform*, *Synform*, *Anticline*, and *Syncline*

Remember that the term antiform and synform describe the geometry indicated by structure data- and nothing more. An antiform is a structure in which the limbs of the fold dip away from the axial trace on the map. A synform contains limbs which dip toward the axial trace. In cross-section profile an antiform is concave down, and synform is concave up.

Anticline and syncline terminology can be used only when age relationships are known. Anticlines have older strata in the core of the structure (map or cross-section view), whereas a syncline must have younger strata in the core of the structure.

Note that it is possible for there to exist an *antiformal syncline*, a structure which is concave down in profile, but contains younger material in the core of the structure. The opposite structure, a *synformal anticline*, can and does exist in highly deformed terranes.

(E) Several deformational phases may produce complex "*superposed*" folding that produces fold structures such as an antiformal syncline or synformal anticline.

III. Pace and Compass Traverse

(A) *Pace length* calculation

1. Make multiple pace counts over known distance measured with tape measure.
2. Average the pace count values and divide into the known distance to give a distance per pace value (usually feet per pace).
3. Calculate the average of the pace count trials and standard deviation. Use the average for subsequent distance calculations and the standard deviation as a confidence limit on your estimate.
4. Write the pace count average down in your field notebook and use it to calculate distances from pace totals along *traverse legs*.

(B) *Traverses* are made to mark the progress of moving across a map area. If the scale of the map is not sufficiently large, or a map area lacks landmarks, a traverse will be made to locate stations. Each leg of a traverse is made along a constant azimuth. The distance is calculated using a pace count.

(C) A *closed traverse* is made when the end of the traverse is at the same point as the beginning. Since the error inherent to azimuth and pace measurements inevitably cause the closed traverse to not "close" when plotted on paper, these traverses must be corrected using the vector defined by the starting and ending points as plotted on the map. The correction should be calculated as below:

1. Determine the magnitude and direction of the vector described by the "gap" between the first and last point of the closed traverse. The direction of this error vector should be in the sense of travel from the endpoint of the last leg, to the start of the traverse.

2. Divide the magnitude of the error vector by the number of legs of the traverse. For example, if the error magnitude was 75 feet, and there were three legs to the closed traverse, then this increment value would be 25 feet.

3. Starting with the end of the first leg of the traverse (station 2), displace the plotted position of the station in the direction of the error vector by a distance equal to the leg # times the increment calculated in (2). For leg #1 this distance would be 25 feet, leg #2 50 feet, etc.

4. When (3) is applied to the last leg of the traverse the new position of the last station of the traverse should be directly on the origin point (station 1) of the traverse. This, in effect, "closes" the traverse. Attitude data that was collected at the various stations should now be plotted at the corrected station positions.

NOTE: If you have already completed the pace length calculation and statistics in a previous course you can use that value for this exercise.

EXERCISE 5: Geologic Map and Structural Analysis

General Instructions for Lab 5 (5A & 5B)

In this exercise you will collect field data with which you will construct a geologic map. In addition to the geologic map, you will analyze the attitude data with the stereonet. You may want to review the use of the Brunton Compass (Pocket transit), and the organization of field notes in your lecture text.

The class will meet outside the Life Sciences building near the parking lot for orientation. Marked on the campus property adjacent to the Life Sciences building will be several stations that are the targets for the pace and compass traverse. At each station will be a model that simulates a bedding plane. Your team will measure the attitude of bedding with a pocket transit at each station and record that information into a notebook. On the bedding plane surface will be a pebble lineation simulated by a strip of masking tape. You are to measure that attitude as a plunge and bearing/azimuth. As your team moves from station to station, you are to measure the azimuth of the direction of travel, and record the pace count. This allows you to later plot and correct a closed traverse of all stations. At the beginning of the lab period I will give a brief lecture on the use of the Brunton Compass and the calculation of a pace count. Make sure that you understand the below steps before beginning the problem:

1. Calculation of your pace count including percent error for distance measurement (you may have already completed this step in a prior course).
2. Setting of magnetic declination on the Brunton compass.
3. Measurement of azimuth direction from station to station with Brunton compass.
4. Calculation of distance between two points with pace count.
5. Measurement of strike and dip of bedding.
6. Measurement of plunge and bearing of pebble lineation.
7. Determination of plunge and bearing of pebble lineation on steeply-dipping surface with a rake angle.

You will turn in the following products for this problem:

Exercise 5A Geologic Map and Stereonet Analysis

<u>Problem 1</u>: Plot the structure data collected at each station on the closed traverse. Use the adjusted position of the stations- not the original position. The following geologic information was collected at stations 1 through 8 along the campus traverse. You can assume that no exposure was encountered along the traverse between stations (but that does not mean that contacts cannot project between stations!):

Station 1: Contact between the Cambrian siltstone to the southwest and Ordovician limestone to the northeast.
Station 2: Contact between the Ordovician limestone to the southwest and the Silurian sandstone to the northeast.
Station 3: Contact between the Silurian sandstone to the southwest and the Devonian shale to the

northeast.
Station 4: No formation contact observed. Bedding measured was in the Silurian sandstone.
Station 5: Contact between Cambrian siltstone to the northwest and Precambrian schist to the southeast.
Station 6: Contact between Cambrian siltstone to the southwest and Precambrian schist to the northeast.
Station 7: Contact between Silurian sandstone to the southwest and Ordovician limestone to the northeast.
Station 8: Contact between Ordovician limestone to the southwest and Cambrian siltstone to the northeast.

Use the following information for plotting the geologic map and constructing a legend:

Formation	Lithology	Pattern	Color
Devonian	shale	dashed	brown
Silurian	sandstone	dotted	red
Ordovician	limestone	blocked	blue
Cambrian	siltstone	dotted & dashed	orange
Precambrian	schist	"use your imagination"	green

You should try to project contacts so that the entire map area is covered by one of the above color and pattern combinations. Use a dashed contact line to indicate approximate contacts. If a fold structure is indicated by the exposure pattern, draft the axial trace and antiform/synform megascopic structure symbols appropriate for the structure (don't forget about overturned bedding symbols). Use a #0 rapidograph pen for depositional or igneous contacts, and a #2 rapidograph pen for fault contacts and megascopic fold structural symbols. Your geologic map should contain all of the elements that are discussed in your lecture text (i.e. scale, title, geographic and magnetic north, and explanation). Scale: 1 inch = 100 feet.

Problem 2: For the stereonet portion of problem one, plot bedding as great circles (Beta diagram). Plot pebble lineations as filled triangles. If a fold structure is indicated by the data, also plot the following:

- Best visual fit of hinge point labeled "hinge" as a filled circle
- Axial plane of the fold as a great circle labeled as "axial plane" in red color
- Interlimb angle of the fold plotted as measured along the great circle perpendicular to the hinge point. Plot this great circle and the two points used for measuring the interlimb angle in blue.

Report the attitude of the hinge, axial plane, and the interlimb angle value as answers.

Exercise 5B Geologic Map and Stereonet Analysis

Problem 1: Plot the structure data collected at each station on the closed traverse. Use the adjusted position of the station on the closed traverses- not the original position. The following geologic information was collected at stations 1 through 9 along the campus traverse. You can assume that no exposure was encountered along the traverse between stations (but that does not mean that contacts cannot project between stations!):

Station 1: Contact between the Cambrian siltstone to the northwest and Ordovician limestone to the southeast.
Station 2: Contact between the Precambrian gneiss to the northwest and the Cambrian siltstone to the southeast.
Station 3: Contact between the Precambrian gneiss to the north and the Cambrian siltstone to the south.
Station 4: Contact between the Precambrian gneiss to the northeast and the Cambrian siltstone to the southwest.
Station 5: Contact between Ordovician limestone to the northeast and Silurian sandstone to the southwest.
Station 6: Contact between Precambrian gneiss to the east and Cambrian siltstone to the west.
Station 7: Silurian sandstone bedding encountered.
Station 8: Contact between Devonian shale to the northwest and Mississippian chert to the southeast.
Station 9: Contact between Silurian sandstone to the northwest and Devonian shale to the southeast.

Use the following information for plotting the geologic map and constructing a legend:

Formation	Lithology	Pattern	Color
Mississippian	chert	triangles	gray
Devonian	shale	dashed	brown
Silurian	sandstone	dotted	red
Ordovician	limestone	blocked	blue
Cambrian	siltstone	dotted & dashed	orange
Precambrian	schist	wavy lines	green

You should try to project contacts so that the entire map area is covered by one of the above color and pattern combinations. Use a dashed contact line to indicate approximate contacts. If a fold structure is indicated by the exposure pattern, draft the axial trace and antiform/synform megascopic structure symbols appropriate for the structure (don't forget about overturned bedding and/or limb symbols). Use a #0 rapidograph pen for depositional or igneous contacts, and a #2 rapidograph pen for fault contacts and megascopic structural symbols such as a fold. Your geologic map should contain all of the elements that are discussed in your lecture text (i.e. scale, title, geographic and magnetic north, and explanation). Scale: 1 inch = 100 feet.

Problem 2: For the stereonet portion of problem one, plot bedding as great circles (Beta diagram). Plot pebble lineations as filled triangles. If a fold structure is indicated by the data, also plot the following:

- Best visual fit of hinge point labeled “hinge” as a filled circle
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- Interlimb angle of the fold plotted as measured along the great circle perpendicular to the hinge point. Plot this great circle and the two points used for measuring the interlimb angle in blue.

Report the attitude of the hinge, axial plane, and the interlimb angle value as answers.