

LAB Exercise #2

Stereographic Projections

GOAL: Stereonets are a convenient and common way to represent structural orientation data. This lab will give you practical experience using stereonet to plot your structural data. In this lab you will get experience plotting by hand and using software for the problem set.

Below are some examples of stereonet from the *Journal of Structural Geology*:

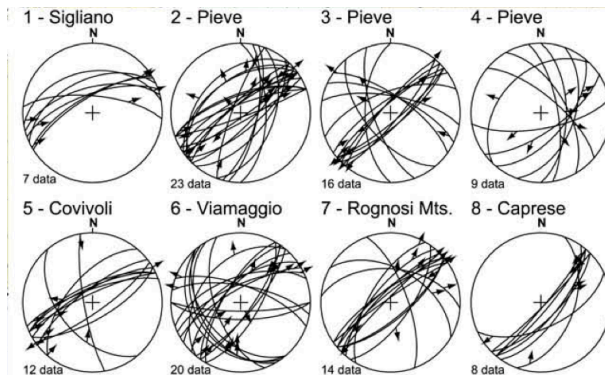


Fig. 2. Fault-slip data collected at selected sites of measurements along the main transverse faults in the Northern Apennines.
Bonini, 2009

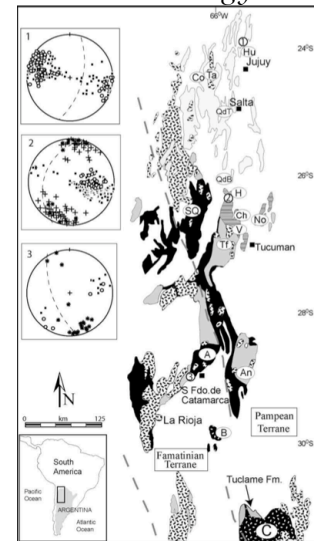


Fig. 1. Structural data from the Pampean Terrane.
Pinan-Llamas & Simpson, 2009

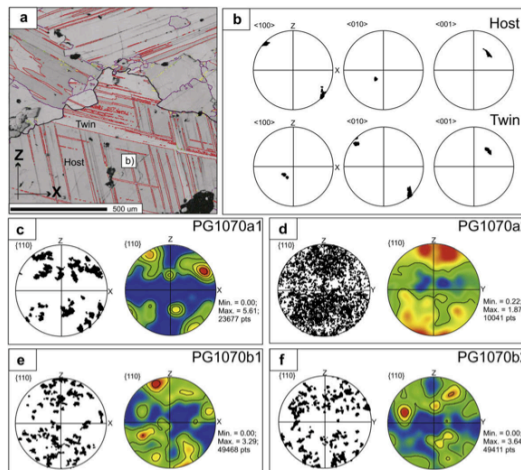


Fig. 7. Scattered data and contoured pole figures showing twin plane data.
Hildyard et al., 2009

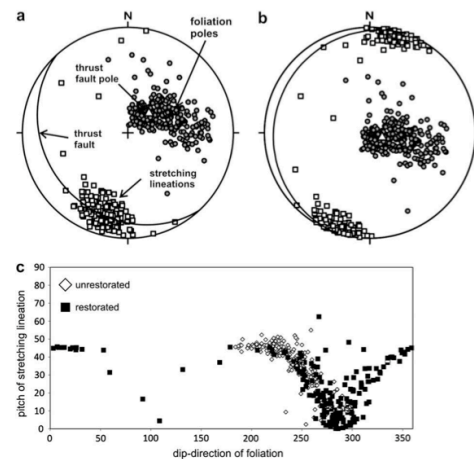


Fig. 4. a) Orientation data for stretching lineation and foliation b) Restored orientation data projection c) Pitch/dip-direction correlation diagram
Vitale & Mazzoli, 2009

Setting Up Your Stereonet

Stereonet plotting by hand is usually done using a piece of tracing paper over a stereonet from a book.

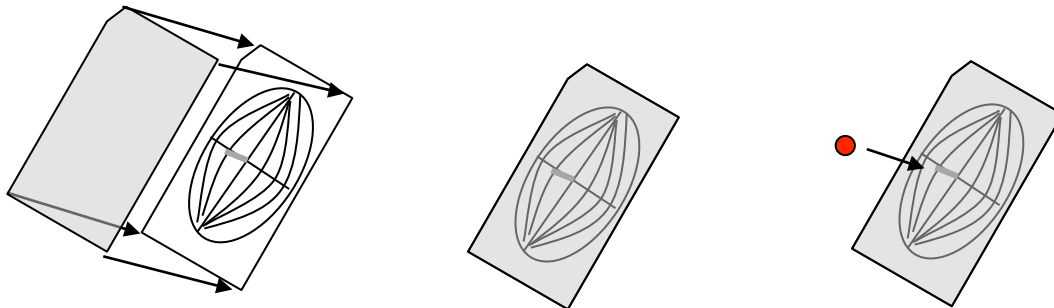
You will need:

- A piece of tracing paper for every stereonet problem
- A blank stereonet (attached to this lab)
- A thumbtack
- A thumbtack protector

Place the thumbtack through the center of the blank stereonet so that the sharp end is exposed on the printed side of the stereonet.

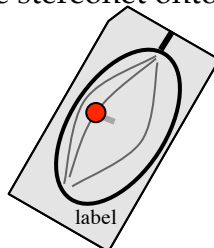


Place a piece of tracing paper over the stereonet and punch a hole in its center with the sharp end of the thumbtack. Place the thumbtack protector over the sharp end of the tack.



Label the tracing paper with your name, the date, and a description of the problem you are working on. There is nothing worse than a great stereonet that solves a problem, but you just aren't sure which problem!

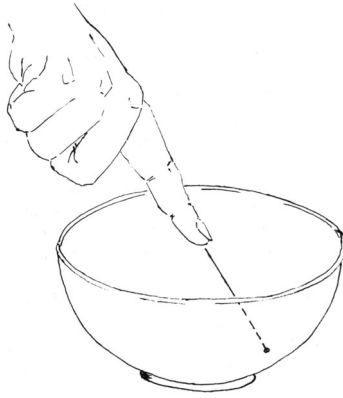
Trace the outer circle of the stereonet onto the tracing paper. Make a tick mark at north.



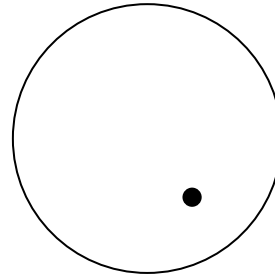
You are now ready to begin plotting lines, planes, and poles.

Plotting Lines and Planes

The stereographic projection of a line is simply a point, so plotting the representation of the point will be pretty easy. Imagine that the finger below is a linear feature. It intersects the bowl at a single point, as shown in the view from above. A stereonet is essentially the view of the bowl from above.



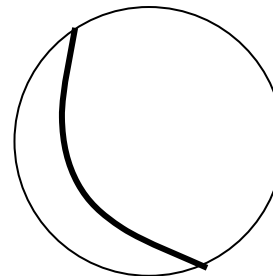
From above...



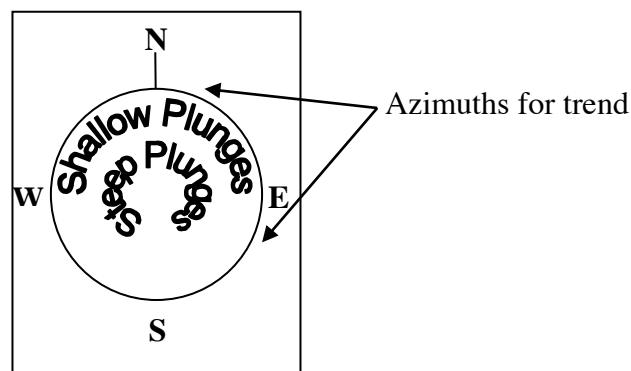
The same is true for planes:



From above...

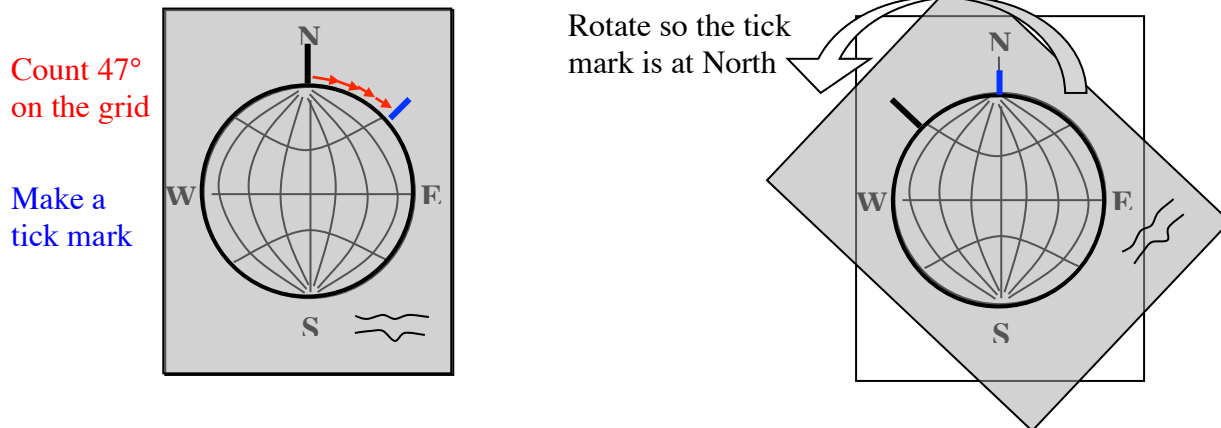


To start plotting a line, visualize the problem. The grid marks along the outer circle of the stereonet represent azimuths. Points closer to the outer circle will have shallow plunges (close to zero) and points near the center will have steep plunges. Where do your lines lie?

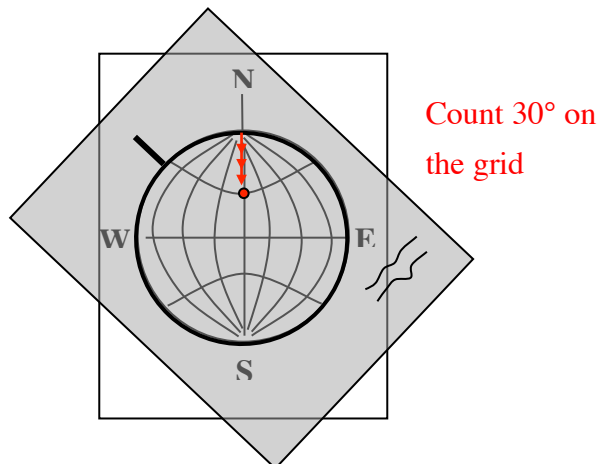


Plotting Lines

To plot the point representation of the line, you'll need to first find the azimuth that represents the line's trend. Count the grid marks to find the trend of the line and make a small tick mark along the outer circle (bold grid lines are spaced 10° , thin grid lines are at 2° spacing). Then, rotate the tracing paper so that the tick mark on your tracing paper is aligned with the North mark on the Stereonet.



Now, you'll need the line's plunge. Remember that shallower plunges plot near the edge of the stereonet. start at North on the stereonet and count grid squares along the straight line that connects North and South.



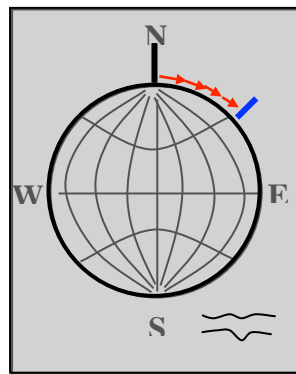
Plotting Planes

The stereographic projection of a plane is a line. Successfully representing a plane on your stereonet will therefore require you to draw a line. Since there are only two straight lines on the stereonet, it's likely that the line representing your plane will be a curve as well! Remember how the strike and dip of a plane are simply the trend of the strike line and the plunge of the dip line? Well, plotting planes will be similar to plotting lines for exactly this reason.

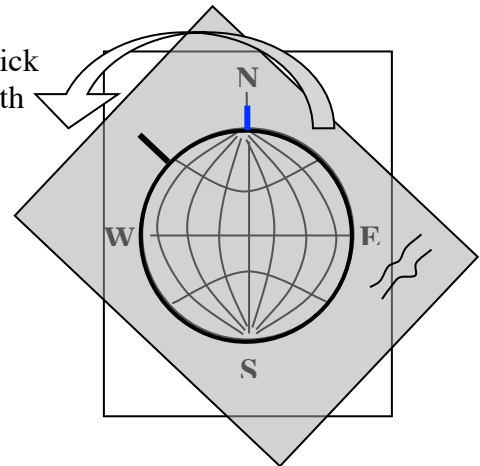
You begin by setting up your stereonet. Next, visualize the problem. Steeply dipping planes will run close to the center of the stereonet and shallow dipping planes will be closer to the outer circle. Make a tick mark at the plane's strike and then rotate your stereonet so that this mark is aligned with north. This is the same as plotting the trend of a line.

Count 47°
on the grid

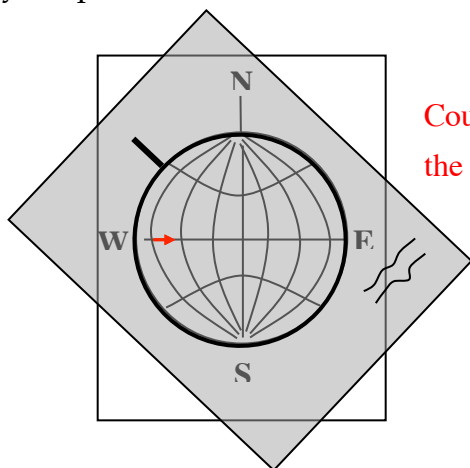
Make a
tick mark



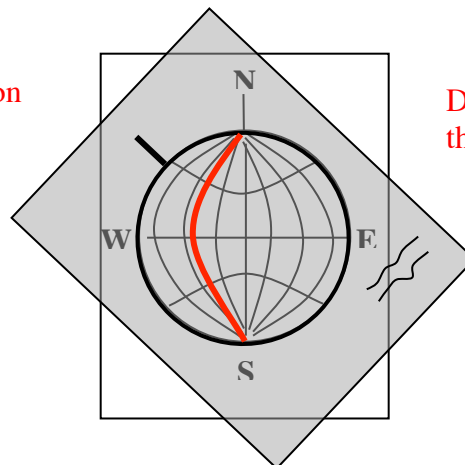
Rotate so the tick
mark is at North



When plotting the plunge of a line, you counted inward on the line that connects North-South. However, the dip direction is 90° away from the strike direction. If your plane is east-dipping, count grid squares inward from the East side of the straight line that connects East-West on the stereonet. If your plane is west-dipping, start on the west side. You can't just draw a point here. You draw a line tracing out the "great circle" path going through this point. From this point, draw along the curved line that connects your point to North and South.



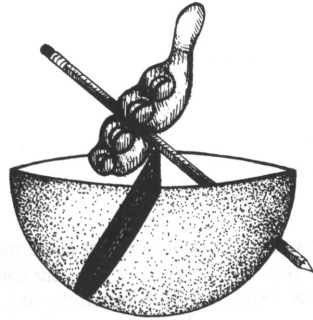
Count 30° on
the grid



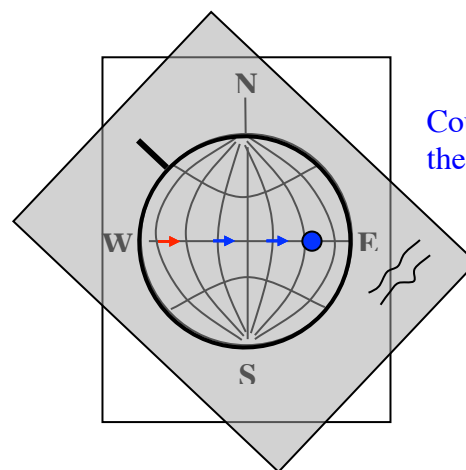
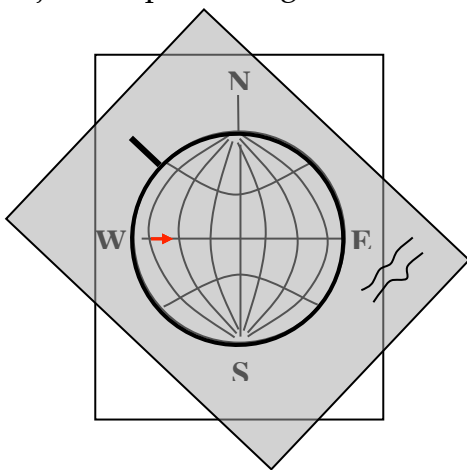
Draw great circle
through this point.

Plotting Poles

It can sometimes get very messy to plot a lot of lines on the stereonet, but we may still want to represent a lot of planes. For this reason, we plot "poles" to planes. A pole is simply a line that passes exactly perpendicular to a plane. Each plane has exactly one pole in the lower hemisphere of a stereonet (and one in the upper, but we always plot the lower one).



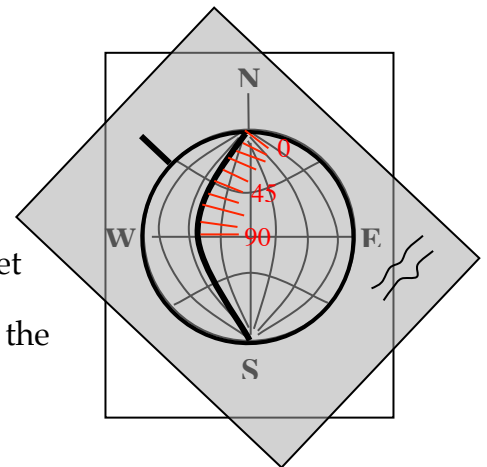
To plot the pole of a plane, follow the directions for plotting a plane until you get to the step where you are about to draw the great circle. Your stereonet should look like the left side of the pictures below. Since the pole should be exactly 90° away from the plane, just keep counting 90° more along the grid squares.



Count 90° more along the East-West line

Calculating Rake

We use rake to describe the angle between a plane and lineations on that plane. For example, we can describe the orientations of slickenlines on a fault surface. Rake is simply the angle between the strike direction and the lineation trend. You can figure this out simply on a stereonet by just counting the grid squares along the great circle line. Rakes of 0° are at North and South, while a rake of 90° is in the middle.



Determining the Trend and Plunge of a Line from a stereonet

In some cases, you will need to read off the trend and plunge of a line from a stereonet.

- 1) Rotate the tracing paper such that the point representing the 3-D line is along the North-South axis of the stereonet.
- 2) To determine the plunge, count the grid squares between North and the intersection point.
- 3) Make a tick mark on your tracing paper on top of the North from the stereonet. To find the trend, rotate the tracing paper back to normal, being careful not to lose track of the tick mark you just made. The trend is the azimuth of the tick mark.

Determining the Strike and Dip of a Plane from a stereonet

- 1) Rotate the tracing paper such that the two ends of the great circle that represents the plane are at North and South.
- 2) To determine the dip, count the grid squares from east or west
- 3) Make a tick mark on your tracing paper on top of the North from the stereonet. To find the strike of the plane, rotate the tracing paper back to normal, being careful not to lose track of the tick mark you just made. The trend is the azimuth of the tick mark.

Intersection of two planes

In 3-D, two planes will intersect in a line.

- 1) Visualize the problem
- 2) Plot each plane
- 3) On the stereonet plot, the two great circles should intersect at a point.
- 4) Follow the directions for determining the trend and plunge of a line on the stereonet.

Apparent Dip Calculations.

Stereonet make it easy to calculate apparent dips. In an apparent dip problem, you are looking at a cross section of the fault that is not taken perpendicular to the strike of the feature you are interested in. For example, suppose you are looking at bedding planes exposed in a quarry wall.

- 1) Plot the plane of the feature you are viewing (i.e., bedding planes)
- 2) Plot the plane that represents your viewing angle (i.e., quarry wall orientation).
- 3) The apparent dip is the same as the plunge line of intersection between these two planes. (See above)

True Dip from Two Apparent Dips

Sometimes, a bed will be exposed in two quarry walls, but you can't determine the true strike or dip at either one of them.

- 1) Plot each apparent dip observation as a 3-D line: For the line's trend, use the bearing of the observation. For the line's plunge, use the apparent dip that you measured.
- 2) Rotate the tracing paper until you can draw a great circle that passes through both these points.
- 3) Use the method above for determining the strike and dip of this feature.

LAB Exercise #2

Stereographic Projections

Instructions - Complete the following exercises using the correct stereonet.

Attach results on separate sheets of paper in order with your name and problem number included on each. Do not write answers on this handout. If needed, use a separate sheet of paper for additional details. Some problems will require answers using hand drawn stereonets and computer generated stereonets. You may use the software to check all answers before submission. All problems should be logically organized and clearly described upon submission.

You will need:

Blank equal angle and area stereonet

1 Thumbtack

tracing paper (take extra sheets)

Work in pencil and erase errors

Stereonet program. Go to EPS116 Links webpage for Allmendinger software download.

PART A – Complete in lab. Will be graded before leaving.

Problem 1: Plot planes and lines with an **equal angle** stereonet on separate sheets of tracing paper and with the Stereonet program. Print the Stereonet results. On tracing paper and printed results label each plane and pole as 1a, 1b, 1c, etc. (24 pts: 1pt each by hand and 0.5 pt each by software).

Plotting planes

Plot each of the following Bed orientations as great circles on the same tracing paper overlay. Label each plane. Be sure you visualize each plane as you plot it!

- | | |
|-----------------|----------------|
| a) S25°W, 44°NW | e) 234°, 18°NW |
| b) S14°E, 85°SW | f) 227°, 01°NW |
| c) N83°W, 43°NE | g) 270°, 38°N |
| d) N72°E, 06°SE | h) 000°, 90°E |

Plotting Lines

Plot each of the following lineations (plunge/trend) as points on the tracing paper.

- | | |
|---------------|---------------|
| i) 32°, 087° | m) 86°, 270° |
| j) 43°, 217° | n) 59°, N60°E |
| k) 12°, N12°E | o) 59°, S60°E |
| l) 88°, 092° | p) 59°, N60°W |

Problem 2: Plotting poles from planes Plot the following planes as poles on an **equal angle** stereonet. Complete exercise on one sheet of tracing paper and using the stereonet software. Label all poles a-h on the results. Turn in the tracing paper and printed results. (12 pts; 1pt each by hand, 0.5 pt each with software)

- | | |
|-----------------|----------------|
| a) 205°, 44°NW | e) 234°, 18°NW |
| b) S14°E, 85°SW | f) 040°, 90°SE |
| c) N83°W, 43°NE | g) 270°, 38°N |
| d) 072°, 6° SE | h) 180°, 90° |

Part B – Complete by due date.

Problem 3: (22 pts) Revist question 4 from Lab 1. Complete exercise by hand using an **equal angle** stereonet and with the software. Attach tracing paper and print out software results. Do not write answers to questions on this document, use a separate piece of paper and compile all results in an organized manner.

Imagine that you discover a previously unreported fault on the Berkeley campus. During field mapping, you recorded the trend and plunge of 4 different and overprinted sets of slickenlines. When you sit down to write the paper that will make you famous, you find something wrong. Here is the information from your field notes:

Fault Surface Strike/Dip: N39°W, 47°E

Slickenline lineation 1 Plunge/Trend: 47°, N51°E

Slickenline lineation 2 68°, due N

Slickenline lineation 3 47°, N51°W

Slickenline lineation 4 34°, due N

- Assuming that you recorded the planar attitude of the fault surface correctly, determine which lineation measurements are impossible. In other words, **which lineation(s) cannot possibly lie in the specified plane**. This time, support your statements with a well constructed stereonet. (6 pts)
- Assuming the measurement of lineation 1 is correct, **what is its rake?** (4 pt)
- Assuming the measurement of lineation 1 is correct, **is the fault a strike-slip fault or a dip slip fault?** (4 pt)
- After your last mistake, you return to the outcrop on campus and re-measure the lineations. This time, you get the correct ones from the previous set plus two additional sets. **What is the difference in angle (difference in rake) between these two lineations?** (3 pts)

Slickenline lineation b1 Plunge/Trend: 11°, N29°W

Slickenline lineation b2 Plunge/Trend: 44°, N29°E

- Calculating apparent dip from true dip*

It turns out that your fault is also exposed during excavation of the foundation for the new Institute for Waterballoon Science on campus. The excavation wall is vertical and trends N20°W. **What is the apparent dip of the fault?** Hint: plot both planes and estimate from intersection (5pts)

Problem 4: *Calculating true dip from apparent dip* Complete exercise with software using an **equal angle** stereonet. Print results and show calculation on a separate paper.

Interesting outcrops of Claremont chert are exposed in the two other walls of the excavation. According to Nick Swanson-Hysell, there shouldn't be any Claremont chert anywhere near campus, so your discovery is quite significant. Nick asks for the strike and dip of the formation so that he can have his 101 students include it on their maps. Unfortunately, you can't get a good measurement of the strike or dip. Instead, you measure the apparent dip in two vertical walls. **What is the true dip of the Claremont chert formation?** (10 pts)

Wall 1: Strike: S48°W. Dip: Vertical. Apparent dip of Chert: 23°.

Wall 2: Strike: N55°W, Dip: Vertical. Apparent dip of Chert: 34°.

Problem 5: *Chevron folds (Figure 10.25 p.293 in Twiss and Moores 2nd ed.)*

One limb of a chevron fold is oriented N23°E, 57°SE, and the other limb is oriented S12°E, 71°SW. They have roughly planar limbs and most of the deformation occurs in the fold axis. Complete with the software using an **equal angle** stereonet to plot the fold limbs and answer questions. Print results and clearly label the answers.

- a) What is the plunge and trend of the fold hinge? (6 pts)
- b) What is the inter-limb angle? (6 pts)

Problem 6: Cylindrical folds (*p. 278-9 in Twiss and Moores 2nd ed.*) Plot all results using the stereonet software with an **equal area**. Answer questions clearly on the printed results (20 pts). Note the different stereonet projection.

If the beds or foliations in a region have undergone cylindrical folding and we plot their attitudes on the net, the planes tend to intersect at a point (or several points), called the **β -axis**; it coincides with the trend and plunge of the fold axis in the region.

This diagram, called a β -diagram becomes very crowded when there are a large number of planar data. Hence it is generally more convenient to plot the poles to the planes, rather than the planes themselves. This is called a π -diagram. If the fold is cylindrical, the points plotted will be distributed along a great circle on the stereonet. This arc, called a girdle, has a pole normal to it, which is the fold axis.

Use the data below to construct β and π -diagrams on two separate figures and answer the following questions:

S45°W, 80°NE	N27°E, 41°SE	N50°E, 44°SE	130°, 40°SW
N3°W, 55°E	S75°E, 60°SW	097°, 60°SW	180°, 50°W
112°, 70°SW	N68°E, 60°SE	N60°E, 70°SE	S20°W, 70°NW
N25°W, 60°NE	155°, 48°SW	S82°E, 44°SW	S40°W, 90°
18°, 42°SE		N65°E, 44°SE	N82°E, 50°SE

- How many fold axes are present? (4 pts)
- What is the trend and plunge of each fold axis? (8 pts)
- What is (are) the angle(s) between the fold axes? Remember, the angle between two axes is measured in the plane that includes both axes. (8 pts)