

**The University of Sydney School of Geosciences Geos3008 and
Macquarie University Department of Earth and Planetary Sciences GEOS307**

**ORIENTATION ANALYSIS: INTRODUCTION TO STEREOGRAPHIC
AND EQUAL-AREA PROJECTIONS**

OBJECTIVES: Structural investigations often involve the collection of a large database of three dimensional orientation measurements. In this quick exercise you will practice techniques for plotting 3D orientations of planes and lines on an equal-area projection.

You are all hopefully by now familiar with stereographic projections (or at least vaguely remember them!). **Planes** form great circles on an equal-area projection. There is a minimum of 3 measurements needed to define any plane: the **strike** of the plane, the **dip** of the plane and the **dip direction**. This information is described in order by using the following notation: 323/45/N. Planes can also be plotted as **poles**, defined as the line oriented exactly perpendicular (90°) to the plane. **Lines** form dots on an equal-area projection. Two pieces of information are required to describe the orientation of a line in 3 dimensions: the **trend** (or azimuth) of the line, and the **plunge** of the line. We commonly write a line as plunge towards the trend (e.g. 23 towards 323 or 23→323). Note that for lines the direction of plunge is coded in our choice of azimuth so we do not include a letter like we do for planes. Lines can also be described by their **pitch** within a plane e.g. (30° N within 323/45/N). Pitch is defined as the angle a line makes from horizontal measured within a specified plane.

PART 1. The faults listed below have slickenlines formed on their surfaces. Often, structural geologists identify different sets of structures based on orientation. Plot the data. How many different sets of faults and slickenlines can you identify? Below you are given the orientation of some lines as a pitch, others as a trend and plunge.

<u>Fault Surface</u>	<u>Slickenline</u>	<u>Slickenline</u>
070/46/S	25→096	
077/43/S		30°W
069/41/S	19→093	
079/37/S	17→234	
068/36/S		21°W

Calculate the orientation of the pole to each of the fault planes.

GEOMETRIC ANALYSES OF FOLDED ROCKS

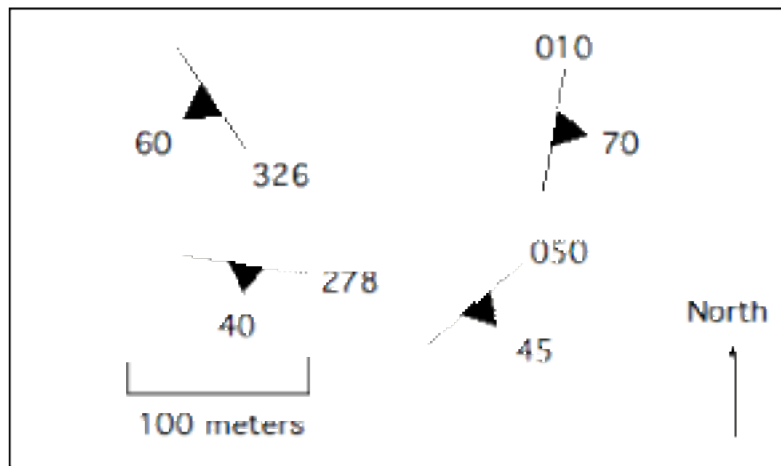
OBJECTIVES: Folded rocks and related lineations and foliations form one of the most spectacular styles of deformation visible in the Earth's crust. To understand how folds form and how they relate to structures around them we must first determine fold geometry as accurately as possible. In this practical exercise, we will examine how to plot, manipulate, and analyse large collections of 3D structural measurements.

FOLD GEOMETRY AND ORIENTATION: From Lectures you should know all the geometric components needed to accurately describe the geometry of folds such as the orientations of the fold axis, axial plane, and other factors that influence fold shape such as interlimb angle. Often structural geologists are not able to directly measure structural features on large-scale folds such as the axis. This exercise is to show you methods of determining the orientation of a fold's axis and to show you the geometric relationships between folds and other types of structures.

β -Diagrams. A simple method of determining the orientation of the axis of a cylindrical fold using structural data is to construct a β -diagram. The axis of the fold (β -axis) is found by plotting the orientations of the surface (eg. bedding or foliation planes) that are affected by the fold as great circles on an equal-area net. The point of intersection of all the great circles represents the axis of the fold. However, because most folds are not perfectly cylindrical, the great circles will not intersect perfectly at a point. This technique can be used to determine if different folding events have affected an area.

π -Diagrams. A more frequently used method of determining the orientation of the fold axis that is better suited to large quantities of data is the π -diagram. To use this technique you must plot folded planar structures (bedding or foliation) as poles on an equal-area net. Next, draw the great circle that best fits the plotted poles. Finally, the pole to the best-fit great circle represents the fold axis. The axial plane of a fold is usually measured directly in the field. However, it is also possible to calculate its orientation on a π -diagram given certain information. Note that the axial plane must contain the fold axis. You must also know the horizontal azimuth of the axial trace (defined as the line of intersection between the Earth's surface and the axial plane) measured on a geological map. To determine the orientation of the axial plane of a fold find the great circle that connects the fold axis with the azimuth of the axial trace.

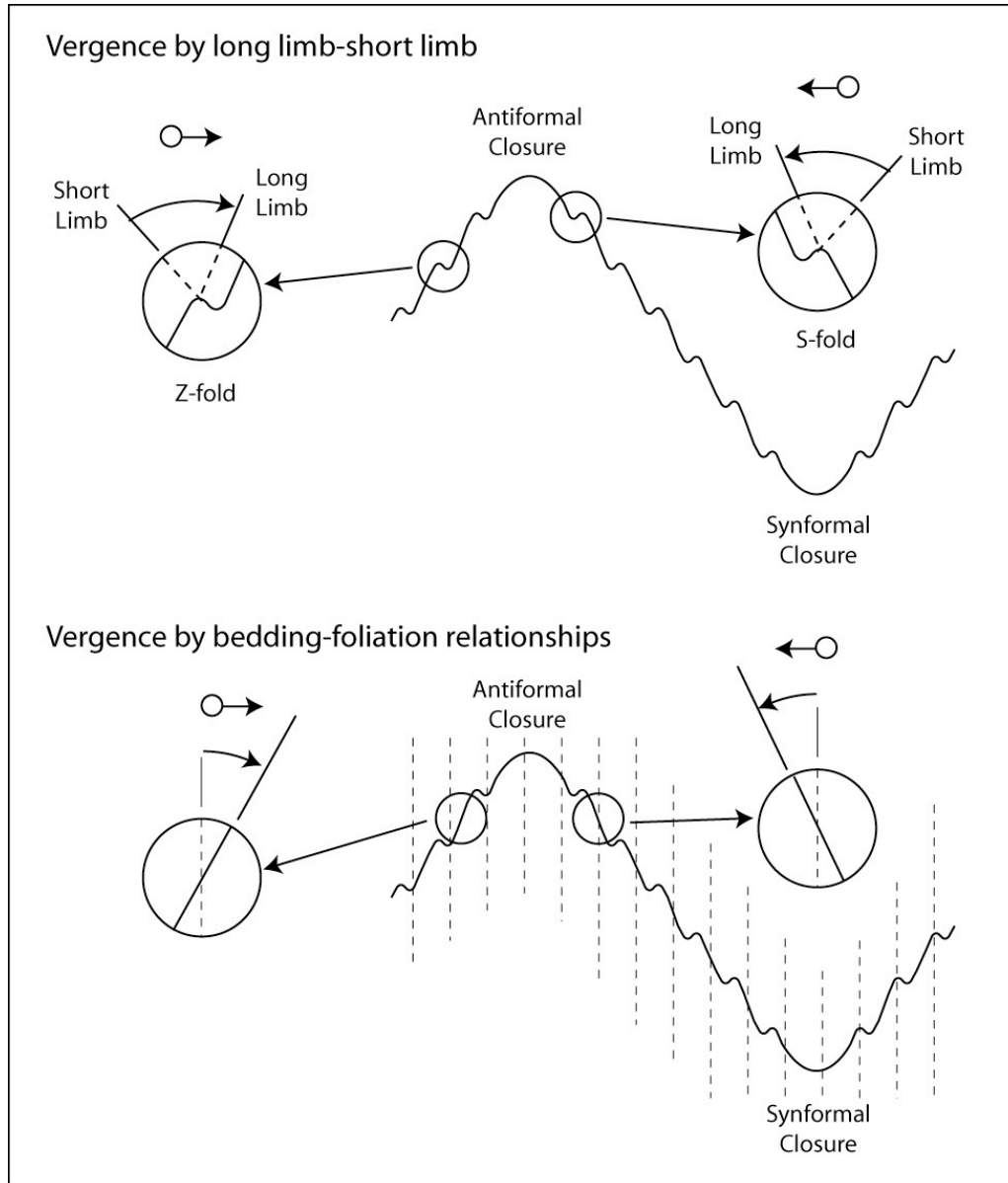
PART 2. Construct a β -diagram for the following map pattern. Is the region folded? If so, what is the orientation of the fold axis?



PART 3. Construct a π -diagram for the map. What is the orientation of the π -axis? Does it coincide with the β -axis?

VERGENCE IN FOLDED ROCKS

The analysis of vergence (direction to the nearest antiformal fold closure) is very important when mapping in folded terrains. It will allow you to better understand the regional-scale structures. There are two important techniques for determining vergence that will be of use to you on this field trip. These are (i) bedding-foliation relationships, and (ii) short limb-long limb or Z-S-M relationships (see below).



TIME TO GO INTO THE FIELD

Examine the folded psammite layer in the air photograph provided:

- 1) Is the fold symmetric or asymmetric?
- 2) What is the vergence direction?
- 3) What is the size of the fold? (hint: use the scale)

We will walk over to the fold shown in the air photograph. In your groups make about 30 measurements of bedding around the fold (that's ~10 measurements per person in your group). Plot the data as poles to bedding onto an equal-area stereonet. Conduct a π -analysis of the folded data.

- 4) What is the orientation of the π -analysis?