LABORATORY 4: Contoured Stereograms

I. Types of Stereonets

a) Equal-angle stereonet

1. Also termed *Wulff* net.

2. Maintains angular relationships within the projection plane of the stereonet. For example, if the small circle intersection of a cone with the lower hemisphere is plotted, on an equal-angle net the shape of this surface will project as a perfect circle.

b) Equal-area stereonet

1. Also termed *Schmidt* net.

2. Maintains the proportion of the lower hemisphere surface projected to the plane of the net. In other words, no preferred alignment of data will be apparent if the data are truly random.

c) For the plotting of a large number of structural data elements, we must use the equal area net to remove any bias when interpreting the average trend of the data. For this reason most structural geologists will carry the equal area net with them in the field.

d) Note that the types of problems worked in previous laboratory exercises can be solved with either net. In effect, both nets preserve the angular relationships between lines and planes in three dimensional space, however, when these elements are projected to the two dimensional plane of the net diagram they are somewhat distorted on the equal area stereonet.

e) Be aware that you cannot plot data with one type of net, and then measure angular relationships or rotate data with the other type.

II. Constructing contoured stereonets.

a) A typical detailed structural analysis of an area will often yield hundreds if not thousands of attitude measurements on a variety of planar and linear structures. This is particularly true of deformed metamorphic terranes that may display several generations of structural elements at a given exposure.

b) If large numbers of data are plotted on a net, the diagram may become overwhelmed by the number of plotted data, making it difficult to interpret for structural trends. In this case it is necessary to contour the data rather than plot individual points or great circles.

c) The point at which it becomes necessary to contour structural data depends not only on the number of observations, but also on other factors such as the degree of clustering, etc. In practice most geologists contour the data when more than 50-100 data are plotted.

d) Since constructing a contour diagram requires a great deal of repetitive plotting, it is an excellent task for a computer. Although you will initially construct several diagrams by hand to learn the fundamentals, in future labs the actual construction of the diagram will be a task for the computer.

e) Steps for constructing a contoured stereogram

1. Plot all of the data on the stereonet. Planar data should be plotted as poles.

2. Transfer the plot constructed in (1) to the *Kalsbeek counting net*. Use of the counting net will be demonstrated in class.

3. Count the number of points or poles that fall within a given six-sided polygon on the counting net. Write this number at the center point of the polygon. The center point is termed the *counting node point*.

4. Remember to count points near the primitive at the diametrically opposed counting nodes. Note that a given point may be counted up to three separate times.

5. On a separate sheet of paper the count node values are recalculated as a percentage of the total number of data:

percentage = (count node value)/(total number of points) x 100

For example, if the total number of data is 233, and a count node tally was 15, its recalculated percentage would be:

percentage = (15)/233 x 100
percentage = 6.4

Usually the percentages are rounded to the nearest whole number. This value represents the percentage of the total data that fell within the one percent area of the lower hemisphere centered around the counting node point.

6. After calculating the percentage values for every node on the counting net, the percentages are contoured as you would contour any other distribution of values.

There are no specific rules for contouring stereograms, however, you should follow the below general guidelines:

a. Pick a contour interval that produces at least 5 distinct contour levels on the stereogram.

b. If several types of data are plotted on separate stereograms for comparison, use the same contour interval for each, otherwise, it is not valid to compare structural trends.

c. Always indicate the contour interval levels below the stereogram.

d. If poles to planar data are contoured, make sure that this is mentioned in your legend or title on the stereogram.

7. The student should note that if a contour line intersects the primitive, the same contour line should intersect the primitive at the diametrically opposed position on the primitive.

III. Interpretation of Stereograms

a) The plotting of data on the stereonet has as a goal the determination of structural trend. For example, the attitude of the fold hinge of a large structure may be evident when regional data is plotted.

b) Plotting data on the stereonet may have a purely statistical goal. For example, a geologist may know from experience that bedding in a region generally strikes NE, and generally dips at a moderate angle to the SE, but what is the best single estimate of the average attitude of bedding?

c) Stereograms are used to determine the attitude of these basic structural orientation distributions:

1. Uniform or *Random Distribution*: this distribution proves that there is no preferred orientation of data. This would be represented by points or poles uniformly distributed on the stereonet.

2. *Point maximum*: this is a tight grouping of points about a particular point on the net. If the data plotted is linear, the center of gravity of the point maxima is considered to be the average attitude of linear data. If the data is poles to planes, the center of gravity of the point maximum is 90° from the great circle representing the average attitude of the planar data.

3. *Great circle girdle*: if the plotted points tend to line up along a great circle, the vectors representing the plotted points tend to lie within a plane. If the data plotted are poles to planes, the great circle along which the poles align is 90° from the hinge of the fold.

4. *Small circle girdle*: if plotted points align along a small circle girdle, the vectors that represent the points lie within a conical surface that intersects the lower hemisphere along a small circle.

IV. Analysis of Folding with Stereograms

a) There are two fundamental types of fold geometries:

1. *Cylindrical*: produced by moving a line parallel to itself so as to sweep out the surface. This line is termed the fold axis, and is parallel to the hinge of the fold. Cylindrical folds produce great circle girdle distributions when poles to planar structures are plotted on the stereonet.

2. *Conical*: conical fold geometry can be modeled by rotating a line about a rotational axis. The line that is rotated is at some angle other than 90° from the rotational axis. The surface thus formed is a cone, and this conical surface intersects the lower hemisphere along a small circle.

b) Properties of Cylindrical Folds

1. If planar readings from a cylindrical fold surface are plotted on the stereonet, where the great circles tend to intersect defines the hinge attitude. This is rarely done with large data sets because the large number of intersections is difficult to interpret. This type of diagram is referred to as a *Beta (&) diagram*.

2. If poles to the folded surface are plotted, the great circle along which they align is the plane perpendicular to the hinge line of the fold. In addition, the two point maxima that occur along this great circle trace can be considered to be the poles to the limbs of the fold. This type of stereogram where poles to the folded cylindrical surface are plotted is termed a *Pi (B) diagram*.

3. If a lineation existed within a surface, ripple marks within bedding for example, and that surface is later folded into a cylindrical surface, the lineation will have an attitude that keeps a constant angle with the hinge of the fold. This is true if the fold was produced by a *flexural-slip* mechanism. If the mechanism was instead *passive-slip*, the pre-existing lineations would be deformed so as to lie within a plane. They would then plot along a great circle.

c) Properties of Conical Folds

1. If poles to the folded surface of a conical fold are plotted, they fall along a small circle. The apical angle of the cone containing the poles is the supplementary angle of the folded conical surface. The axis of the cone will be the center of the small circle trace on the stereonet.

2. Remember that the trace of the intersection of a cone with the lower hemisphere on the equal area net is not a circle but is instead an elliptical geometry.

V. Problems Associated with Fold Analysis on the Stereonet.

a) Always remember that it is impossible to determine whether or not a fold structure is an *antiform* or a *synform*. This is only possible when the data is plotted on a geologic map.

b) Although you can plot the limb attitudes from a fold girdle, you cannot directly measure the interlimb angle until you have additional information that describes the attitude of the axial plane. If the fold is described as *upright* you may assume that the axial plane dips steeply. A *recumbent* fold has a horizontal or nearly horizontal axial plane.

c) An *isoclinal* (both limb are parallel) fold will plot as a point maxima.

d) The pattern produced by a parallel fold as compared to a chevron fold is different even if they both have the same hinge and axial plane attitudes, and the same interlimb angle.

e) The *symmetry* of the pattern of contours on the stereogram is correlated to the actual symmetry of the fold limbs.

EXERCISE 4A: Contoured Stereograms and Interpretation of Folded Data.

Generate all stereonet diagrams with a radius of 3.5 inches. Label all interpreted and/or calculated geometries on the stereonet, as well as reporting attitudes in the upper left corner of page.

Problem 1: The below data were measured along the limbs of a fold:

N74°W,36°SW	N40°E,60°SE
N30°W,45°SW	N03°W,65°SW
N79°E,40°SE	N53°E,50°SE

plot the following on separate stereonet diagrams:

(1A) $-diagram (great circles) and estimated hinge attitude
(1B) B-diagram (poles) and estimated hinge attitude

Problem 2: With the map in Figure 4-1, and the below data:

ATTITUDE OF FOLIATION	RAKE OF MINERAL LINEATION
(A) N37°E,30°SE	42°SW
(B) N00°E,40°E	11°S
(C) N23°W,60°NE	04°NW
(D) N55°W,70°SW	07°NW
(E) N85°W,40°SW	87°SE

Determine the following on separate plots:

(2A) Determine the plunge and bearing of mineral lineations at stations (A)-(E) with the stereonet.

(2B) Using appropriate structure symbols for foliation and mineral lineation, plot the above data on the Figure 4-1 map. Plot the axial trace of the fold on the map and report its attitude.

(2C) With the stereonet, find the attitude of the fold hinge and the full axial plane attitude. Do this by plotting a B-diagram. Determine the angle between the hinge and each mineral lineation. Of the following possibile types, flexural-slip or passive-slip, is the most likely deformational mechanism?

Problem 3: Below are several attitudes for poles to bedding from a fold structure. Using a stereonet to plot a B-diagram, determine the axis of folding, and whether the fold is conical or cylindrical.

16°,N10°E	47°,N16°W	37°,N75°W
38°,N02°W	50°,N49°W	24°,N82°W

Problem 4: With the following foliation data in Table 1A, construct a contoured stereonet. The foliation data were obtained from a large mesoscopic fold. This problem should be completed manually. You should turn in the following plots:

(4A) Construct a plot of the poles to the below planar data, including the number of poles per one percent area of the lower hemisphere as calculated from the counting net.

(4B) Construct a plot of the poles per one percent area converted to a percentage of the total number of poles. Also include the contours of density percent on this plot. Label the contour interval and total number of observations on the bottom center of the plot. Use your own discretion in determining the contour interval, but strive for 4-6 discreet levels. Label the point that represents the hinge of the fold with a B, and plot the great circle girdle perpendicular to the B point. Report the hinge attitude as estimated with the B method.

TABLE 1A- S_1 foliation data from Toxaway Gneiss basement and Tallulah Falls cover sequence.				
N24E,39SE	N11W,35NE	N28E,41SE	N32E,44NW	N38E,58NW
N58E,12NW	N21W,67NE	N23E,34SE	N34E,34SE	N23E,36SE
N33E,28SE	N43E,31NW	N69E,24NW	N14E,28SE	N13E,39SE
N34E,29SE	N19E,33SE	N64E,24NW	N42E,25SE	N63E,22NW
N38E,43NW	N23E,44SE	N29E,38SE	N33E,32SE	N31E,21NW
N32E,26SE	N34E,64SE	N49E,29SE	N32E,31SE	N21E,42SE
N22E,26SE	N42E,36NW	N29E,37SE	N11E,44SE	N62E,58NW
N37W,22NE	N7E,56SE	N12E,22SE	N38E,21NW	N18E,57SE

TABLE 1A- S_1 foliation data from Toxaway Gneiss basement and Tallulah Falls cover sequence.				
N34E,61SE	N14E,41SE	N81W,19NE	N22E,39SE	N16E,24SE
N38E,28NW	N34E,77SE	N12E,37SE	N12E,26SE	N63E,59NW
N9E,32NW	N23E,24SE	N14E,26SE	N21E,79SE	N27E,24SE
N37E,45SE	N34W,25NE	N26E,16SE	N2W,19NE	N34E,38SE
N19E,27SE	N25W,19NE	N24E,24SE	N22E,14SE	N19E,37SE
N14E,76SE	N74E,19NW	N23E,42SE	N48E,28NW	N31E,51NW
N18E,69SE	N11W,32NE	N32E,48SE	N42E,22NW	N51E,41NW
N43E, 62SE	N43W,41NE	N32E,48SE	N23E,28SE	N39E,23NW
N12E,64NW				

Problem 5: The following data in Table 2A are foliations collected in the Blue Ridge of north Georgia. Note that the data are listed in azimuth and dip format. With these data:

(5A) Plot the poles to foliation and raw number of poles per one percent area. Visually estimate the "best-fit" great circle girdle that passes through the poles.

(5B) Plot contours of the percent density of data, including the percent density values used for contouring on the plot. Label the contour interval, and the number of data used for the plot, centered below the stereonet. Determine the attitude of the hinge of the fold affecting this data by plotting the great circle girdle, and label the pole to this great circle as "HINGE" on the net. Indicate whether or not this fold is symmetrical or asymmetrical.

You will be required to use the "freeware" computer program, NETPROG, to complete this problem. The procedure for producing hard copy output on the computer will be demonstrated in lab. The program can output all necessary elements of the problem so you should not have to draft anything with a rapidograph for this problem.

TABLE 2A- Foliation data collected from the Blue Ridge of northern Georgia.					
016,54NW	039,33NW	051,55SE	067,38SE	058,38SE	014,64NW
024,49SE	042,64SE	068,16NW	029,57NW	022,39NW	024,39NW
028,56NW	039,12NW	001,18NW	017,67SE	012,52NW	038,39NW

TABLE 2A- Foliation data collected from the Blue Ridge of northern Georgia.

052,34NW	003,53NW	011,62NW	022,69NW	034,22NW	001,69NW
016,13NW	052,48NW	056,41NW	026,68NW	021,33NW	058,23NW
062,55SE	022,63NW	016,40NW	079,51NW	063,27NW	024,19NW
014,52NW	023,33SE	039,44NW	014,68NW	019,51NW	024,26SE
052,39SE	007,67NW	044,63NW	043,28SE	063,23SE	038,24NW
029,41NW	029,54NW	048,14SE	024,61NW	043,03NW	022,42NW
011,49NW	058,54NW	353,32SW	017,67NW	024,54NW	012,59NW
054,73NW	012,46NW	027, 39NW	011,66NW	024,46NW	041,75SE
027,33NW	023,29NW	016,38NW	026,41NW	028,47SE	013,47NW
037,36NW	030,14SE	023,06SE	052,36SE	052,27NW	027,48NW
028,33NW	065,19SE	018,27NW	032,52SE	042,72NW	022,58SE
028,18NW	030,24SE	019,67NW	027,41SE	062,28NW	023,47SE
020,17SE	025,17SE	023,62NW	011,68SE	293,39SW	019,55NW
008,07NW	035,28SE	016,73NW	027,52SE	291,34SW	027,63NW
025,34NW	032,12SE	021,56NW	068,56SE	041,29NW	030,23NW
021,34SE	038,62NW	047,23NW	009,48NW	023,25NW	295,30NW
012,28SE	043,62NW	026,48SE	019,51NW	022,25NW	020,10NW
024,7NW	024,70NW	066,22SE	021,68NW	027,34NW	020,03NW
029,25NW	007,47NW	047,22SE	013,73NW	020,15NW	022,15NW
032,46NW	027,21NW	047,16NW	023,44NW	023,21NW	000,10E
034,47NW	032,64NW	048,42NW	019,63NW	023,19NW	000,03W
022,37NW	052,34SE	051,21NW	023,72NW	025,11NW	015,10NW
012,62NW	021,43SE	026,39NW	038,24NW	022,16NW	025,01NW
019,57NW	022,68NW	061,24NW	030,52NW	320,01SW	016,32SE
019,71NW	051,61NW	027,26NW	002,29NW	016,11NW	019,02NW
007,51NW	049,73NW	028,24NW	017,68NW	025,14NW	030,36NW

TABLE 2A- Foliation data collected from the Blue Ridge of northern Georgia.					
029,36NW	043,82NW	042,46NW	012,79NW	025,18NW	042,54NW
036,32NW	074,51NW	008,69NW	033,11SE	010,15NW	039,11NW
014,43NW	054,53NW	017,74NW	022,41NW	018,19NW	047,36NW
010,84NW	020,17SE	012,51NW	022,43NW	049,64NW	043,42NW
031,27SE	016,44NW	018,89NW	037,24NW	013,88NW	056,20SE
024,16NW	014,44SE	048,54NW	027,37NW	022,19SE	018,52NW
064,69NW	048,24NW	0 38,06NW	038,06NW	025,12SE	

Problem 6: Given the below data in Table 3A, find attitude of the lower Ordovician Mascot Dolomite before deposition of the middle Ordovician Chickamauga Limestone. An angular unconformity separates the two lithologies. You may use the computer program to help solve this problem. "Eyeball" an average orientation (center of gravity) to poles for the Chickamauga to determine the rotation for the Mascot formation. Then rotate the Mascot data to its pre-unconformity orientation by moving each pole about the rotational axis, and then re-plot the pole. The attitude of the Mascot data prior to deposition of the Chickamauga can be determined from the center of gravity of the rotated Mascot poles. It is recommended that you use the computer program to accomplish the above rotation step. You should turn in on separate plots:

(6A) The poles to the Chickamauga data along with the visually selected center of gravity of the data. Using a line and arrows, indicate the path that the center of gravity pole would follow if the plane it represents were rotated to a horizontal attitude. Report the attitude of the axis of rotation, and the amount of rotation necessary.

(6B) The poles to the Mascot data in the current post-unconformity attitude, and the pre-unconformity attitude. Use a cross for attitudes before rotation, and a triangle for attitudes after rotation.

(6C) Plot the rotated pre-unconformity poles determined in (6B), and the center of gravity of the poles. Convert the center of gravity pole to a strike and dip and report that as the final answer. Also plot the great circle 90° from the center of gravity pole.

TABLE 3A- Data for problem 6.

Mascot Bedding		Chickamauga Bedding	
Strike	Dip	Strike	Dip
N67E	19SE	N35E	28SE
N72E	24SE	N42E	23SE
N63E	17SE	N34E	33SE
N65E	21SE	N38E	26SE
N68E	16SE	N40E	32SE
N62E	18SE	N37E	22SE
N64E	19SE	N33E	27SE
N61E	22SE	N39E	31SE
N69E	20SE	N36E	2SE
N66E	15SE	N41E	30SE

EXERCISE 4B: Contoured Stereograms and Interpretation of Folded Data.

Problem 1: With the below Table 1B bedding data construct a contoured stereogram. Find the following:
(a) Hinge attitude.
(b) Axial plane attitude given that the axial trace is N50E.
(c) Fold interlimb angle.

Table 1B: Bedding				
N 17.0 E 64.0 E	N 62.0 E 66.0 W	N 36.0 E 82.0 E	N 36.0 E 82.0 E	N 60.0 E 73.0 W
N 69.0 E 68.0 W	N 65.0 E 72.0 W	N 9.0 E 51.0 E	N 9.0 E 51.0 E	N 90.0 E 50.0 W
N 15.0 E 53.0 E	N 9.0 E 60.0 E	N 80.0 E 50.0 W	N 80.0 E 50.0 W	N 75.0 E 54.0 W
N 14.0 W 43.0 E	N 19.0 E 59.0 E	N 74.0 E 68.0 W	N 74.0 E 68.0 W	N 65.0 E 61.0 W
N 7.0 W 52.0 E	N 26.0 E 65.0 E	N 47.0 E 80.0 W	N 47.0 E 80.0 W	N 2.0 E 51.0 E
N 2.0 W 46.0 E	N 24.0 E 70.0 E	N 52.0 E 76.0 W	N 52.0 E 76.0 W	N 21.0 E 64.0 E
N 17.0 W 49.0 E	N 34.0 E 77.0 E	N 57.0 E 80.0 W	N 57.0 E 80.0 W	N 5.0 E 58.0 E
N 20.0 E 66.0 E	N 35.0 E 74.0 E	N 75.0 E 62.0 W	N 5.0 E 58.0 E	N 45.0 E 90.0 W
N 5.0 E 58.0 E	N 87.0 W 42.0 E	N 84.0 E 56.0 W	N 73.0 E 57.0 W	

After plotting the poles to bedding, use the counting net to manually count the percent concentration nodes. Plot the node values that are non-zero, and then the 2% contours. Plot answers (a), (b), and (c) on the same diagram. All work must be inked with “0" rapidograph pen.

Problem 2: The below Table 2B data have been collected from folded Paleozoic rocks in the Picuris Range of North New Mexico. Using the stereonet application “NETPROG” plot the data as poles to bedding along with the percent concentration node values. Contour the diagram at a contour interval of 2% using a Gaussian calculation scheme. Given that the axial trace of folds has been measured from geologic maps to be N19W in this region, calculate the following and plot on the stereonet:

(a) Hinge attitude
(b) Axial plane attitude
(c) Fold interlimb angle

On a second sheet of paper discuss the symmetry of the fold as shown by your contour pattern.

Table 2B: Picuris Bedding				
N 05 E 60 E	N 36 W 65 W	N 05 W 26 E	N 30 E 10 E	N 41 W 63 W
N 22 W 56 E	N 21 W 27 W	N 18 W 64 E	N 30 E 13 E	N 20 W 57 E
N 00 E 62 E	N 65 E 20 E	N 40 W 60 W	N 22 W 39 E	N 15 W 51 E
N 15 W 65 E	N 22 E 13 W	N 32 W 75 E	N 15 W 34 W	N 13 W 58 E
N 47 W 30 E	N 09 W 73 E	N 11 W 76 E	N 18 E 20 E	N 19 W 60 E
N 38 W 35 E	N 03 W 52 E	N 35 W 50 W	N 40 E 15 E	N 06 W 71 W
N 15 W 58 E	N 24 W 52 W	N 11 W 42 W	N 16 W 50 E	N 20 W 53 W
N 18 W 41 W	N 25 W 90 W	N 20 W 75 E	N 02 E 54 E	N 18 W 84 E
N 30 W 15 E	N 11 W 79 E	N 32 W 76 E	N 15 W 45 W	N 34 W 73 E
N 20 W 46 E	N 35 W 80 E	N 10 W 79 E	N 14 W 55 E	N 18 W 37 W

N 60 W 30 E	N 05 E 65 E	N 21 W 31 W	N 27 W 24 W	N 12 W 32 E
N 10 W 10 W	N 20 W 16 W	N 19 W 47 W	N 22 W 20 W	N 30 W 83 E
N 13 W 28 W	N 13 W 63 W	N 18 W 49 W	N 15 W 55 E	N 09 W 77 E
N 05 W 23 W	N 23 W 37 W	N 03 W 15 E	N 21 W 62 W	N 20 W 44 E
N 00 E 39 W	N 06 E 25 W	N 34 W 71 E	N 08 W 55 E	N 11 W 46 W
N 09 E 28 W	N 36 W 64 E	N 36 W 28 W	N 41 W 58 E	N 47 W 7 W

Problem 3: Table 3B contains foreset bedding readings from the Red Mt. Formation near Birmingham, AL. The Red Mt. Formation is a Silurian sandstone unit affected by folding. Assume that all of the readings were taken from the same outcrop where primary bedding has been measured as N38E, 44SE. Construct the following diagrams using NETPROG:

(a) Plot the poles to foreset beds as a contoured stereonet plot with contour interval of 4%, beginning at 2%. Also plot the percent concentration node values, and the great circle representing the primary bedding attitude. Use the least-squares vector fit to calculate the mean attitude of the foreset poles. Convert the average foreset pole to a strike and dip, and report the answer as the average foreset attitude in the current (deformed) state.

(b) Determine the rotation axis, amount of rotation, and sense of rotation assuming that primary bedding should be put back to its original horizontal position. Use the rotation option in NETPROG to process the rotation, save the results to a different file, and then load this file into NETPROG. You should then see the rotated poles to foresets. In addition to the rotated poles to foresets, plot the following:

1. Percent concentration nodes
2. Contours of rotated data starting at 2%, with a 4% interval (same as in (a))
3. Least-squares vector fit to the rotated foreset poles representing the average attitude of the poles to foresets during deposition.
4. The great circle representing the actual strike and dip of the average foreset attitude during deposition.
5. Plot the point representing the true dip plunge and bearing of the rotated average foreset, and report the bearing as the paleocurrent direction.

Table 3B: Foreset Attitudes				
N 25.0 W 51.0 E	N 37.0 W 47.0 E	N 40.0 W 50.0 E	N 32.0 W 64.0 E	N 35.0 W 65.0 E
N 23.0 W 49.0 E	N 48.0 W 40.0 E	N 44.0 W 47.0 E	N 33.0 W 61.0 E	N 39.0 W 62.0 E
N 29.0 W 43.0 E	N 32.0 W 52.0 E	N 50.0 W 46.0 E	N 39.0 W 60.0 E	N 42.0 W 60.0 E
N 36.0 W 40.0 E	N 27.0 W 65.0 E	N 37.0 W 54.0 E	N 41.0 W 56.0 E	N 48.0 W 55.0 E
N 21.0 W 61.0 E	N 29.0 W 61.0 E	N 42.0 W 52.0 E	N 46.0 W 52.0 E	N 50.0 W 56.0 E
N 29.0 W 57.0 E	N 31.0 W 55.0 E	N 51.0 W 50.0 E	N 29.0 W 75.0 E	N 39.0 W 68.0 E
N 31.0 W 49.0 E	N 37.0 W 52.0 E	N 29.0 W 69.0 E	N 33.0 W 70.0 E	N 40.0 W 65.0 E

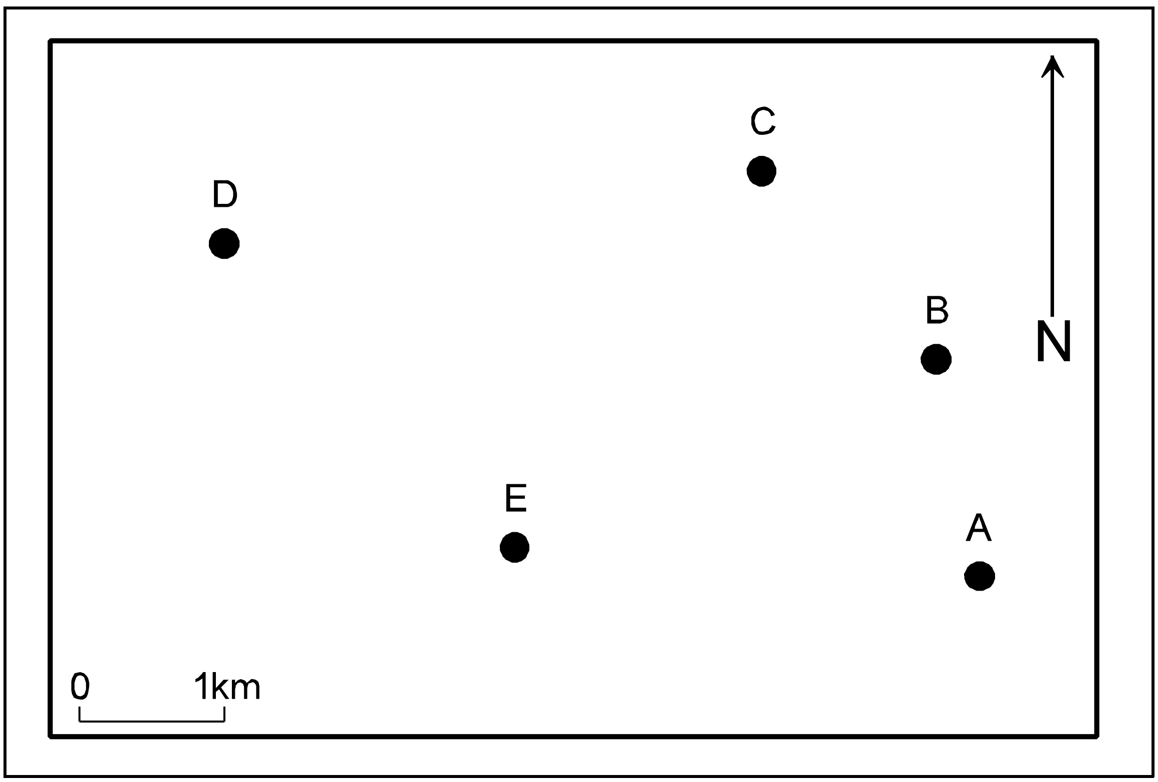

Figure 4-1: Map for problem 2B.

COUNTING NET

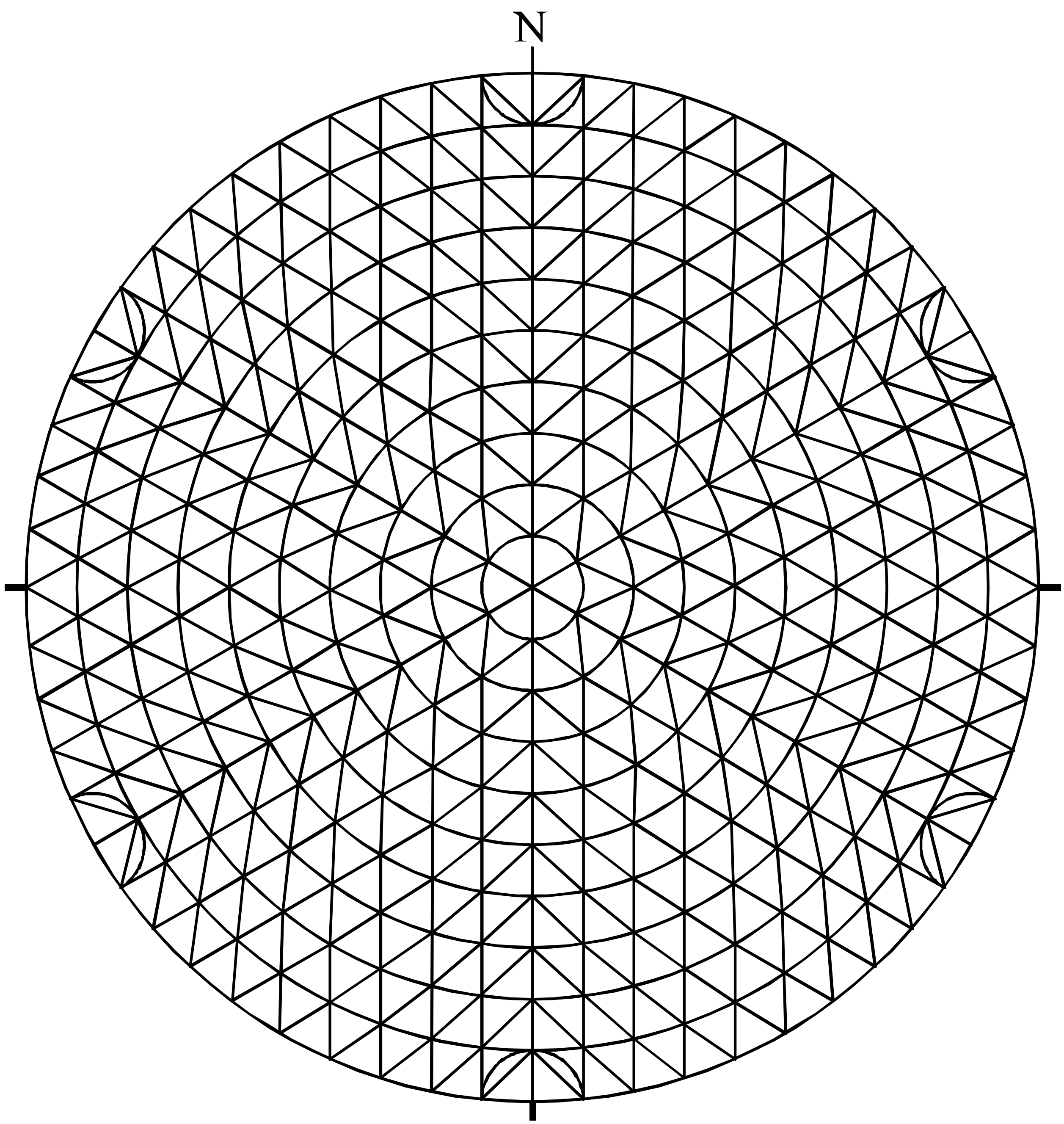

Figure 4-2: Counting net (equal area).