

# Biemsderfer plotter for field recording of structural measurements on equal area nets

Donald U. Wise\*

*Department of Geosciences, University of Massachusetts, Amherst, MA 01003, USA*

Received 24 June 2004; received in revised form 14 September 2004; accepted 27 October 2004

Available online 25 April 2005

## Abstract

The Biemsderfer plotter is a pie-shaped template anchored by a thumb-tack at the center of an equal area net. A 90° angle between its two arms allows one side to be laid parallel to the strike of a plane while the pole is plotted as a dot along the other arm. Variations for use with lineations are equally simple. Its chief virtue is field-friendly ease of producing hard-copy equal area plots while the geologist is still able to make further observations on the outcrop about each data class. These plotters may be low-tech tools but their use with some of the strategies described commonly produces a quantum leap in the quality of recognition and recording of field structural data.

© 2005 Elsevier Ltd. All rights reserved.

*Keywords:* Biemsderfer; Plotter; Equal area; Stereonet

## 1. Introduction

Though simple, the equal area net is among the most important tools of structural geology. This is especially true for presentation of large amounts of field data. Typically, a list of measurements is recorded in a field notebook and then plotted by hand or typed into a computer at a later time. With the advent of smaller, more powerful, and more rugged computers, such data are increasingly recorded digitally in the field but only infrequently are they plotted there. Though powerful, these methods remain somewhat restrictive in adaptability to the wide variety of data types typical of any field area, in complexity of their programs, in steep learning curves, and in cost to equip entire classes. Above all, any attempt to make even the simplest annotation on these field plots typically involves fighting through computer interfaces. It is much easier to make the annotations directly onto a field-available paper copy.

Unfortunately, the traditional paper method of equal area plotting is not especially field-friendly. It usually involves a central thumb-tack or a moveable ring that allows rotation of a wind-whipped sheet of tracing paper overlying a

stationary net. However, a little-known, field-friendly, low-tech alternative has been used by small groups for over half a century.

## 2. Biemsderfer plotter

George Biemsderfer (1916–1993), then a faculty member at Franklin and Marshall College and later chief geologist of Bethlehem Steel, proposed (1949) a reversal of the method whereby the plotting paper remained stationary while a template of the net rotated. The plotter (Fig. 1A) is a 90° pie-shaped piece of plastic or cardboard with arms equal in length to the radius of the net and a hole for a thumb-tack at its center. Marks are scribed at 10° intervals along each arm with spacings traced off along the N–S or E–W axes of the net. (Remember, the name equal area net does *not* mean equal spacing along its primary axes.)

Several variations of the plotter are possible. Biemsderfer's original design with 90° at the ends of each arm (Fig. 1A) plots only poles to planes. An updated, right-hand-rule version has a pointer on only one arm to indicate azimuths of lineations or strikes of planes (Fig. 1B). The scale along this arm, designed for the plunge of lineations, has zero at its end whereas the other arm, designed for pole plotting, has 90° at its end. The relative positions of the two arms are set

\* Tel.: +1 413 253 5342; fax: +1 413 254 1200  
E-mail address: dwise@geo.umass.edu.

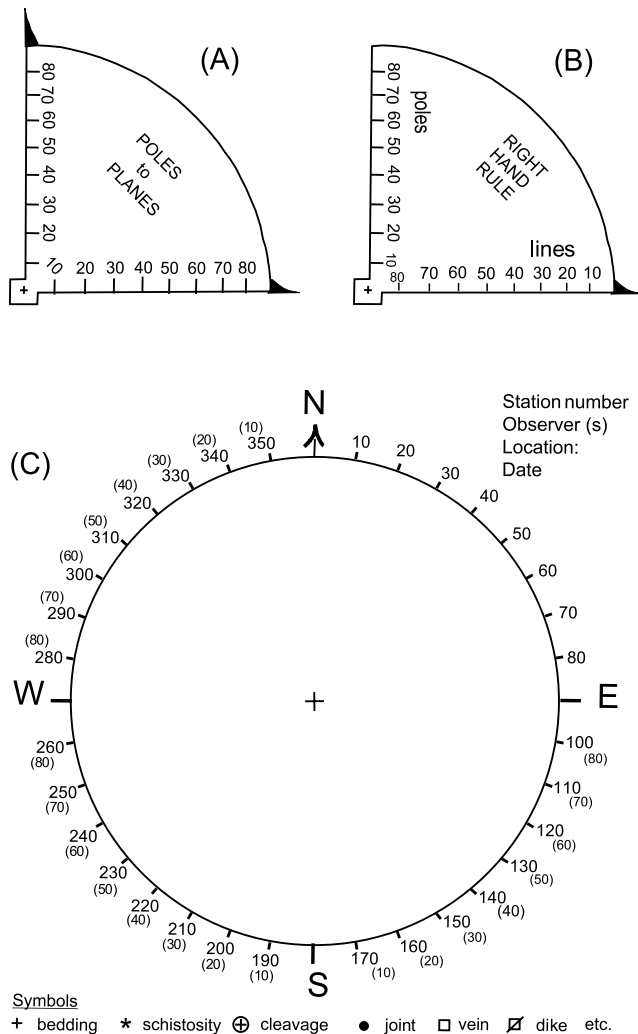


Fig. 1. (A) Original Biemserfer plotter with scale set for poles to planes. (B) Updated plotter with pointer on one arm for either strike of planes or azimuth of lineations and scale set for plunge of lineations. Poles to planes are plotted along the other arm using the right-hand-rule. (C) Azimuth and quadrant annotated equal area circle for use with the Biemserfer plotter. Multiple photocopies of enlargements are recommended for field use, being certain that circle and plotter retain the same percent enlargement.

for automatic use of the right-hand-rule, namely when looking in the direction of that azimuth, the plane dips to the right and its pole lies in the opposite quadrant. The easiest way of producing strong, waterproof field copies of these plotters is to photocopy them onto overhead projection transparency sheets and cut them out with scissors. These transparent copies of circle and plotter also can be used with an indelible pen and an overhead projector for classroom demonstrations.

Plotting is done on photocopies of a data sheet featuring a plain circle with azimuths marked at 10° intervals (Fig. 1C). Some possible symbols are indicated on the sheet. Colored pencils and a bit of imagination can generate many more symbols, each of which should be recorded as used for a legend specific to each sheet. A thumb-tack through the center of the plotter provides the axis of rotation. A bit of

rubber eraser on the tack tip prevents scratched wrists and minimizes field loss of the plotter.

For more efficient fieldwork, I use a homemade, hard-back folder, closed with a large rubber band to protect its contents in transit but hinged to open, book-like, on the outcrop. Small clips anchor the net on one face of the folder with the data-recording page on the opposing side. A rear pocket holds spare plotters as well as new and used pages. All pages are punched for later insertion into a 3-ring notebook wherein net and data sheets for each station are stapled together.

### 3. Beginner student exercise

Strike and dip of a plane and measurement thereof are among the most fundamental concepts and skills required of all beginning structural geology students. I have always introduced these concepts at the very first lab with immediate introduction to the Brunton compass. After the students have a bit of compass practice, I introduce them to the simplest aspects of an equal area net, using tracing paper and dealing only with great circles and associated poles. The students are then introduced to the plotter with particular stress placed on the fact that *poles must plot in the quadrant opposite the direction of dip*.

After about an hour of these preliminaries we adjourn to the nearest outcrop to measure joint orientations. Pairs of students alternate every five measurements between a compass reader and a recorder who writes down each measurement and immediately plots it. In this way, students see poles beginning to cluster on the net and recognize any stray points that need rechecking. They also get practice with the compass and confidence in the accuracy of their readings. The faculty member can check their progress and accuracy with a glance at the net. For homework, each student contours his/her net by hand, a procedure that every structure student should do once before resorting forever to the black box of a computer. This use of the plotter for the first lab forces students to start thinking in terms of map directions, azimuths, and compass coordinates. Later in the course, students can be introduced to more complicated uses of the net, by that time a somewhat familiar tool.

### 4. Advanced use of the plotter

For more advanced students and professional levels of field work, the plotter can be invaluable. For larger field parties, two or three persons can do the compass work while one can keep up with them in recording and plotting the data. When working alone, one can measure and record for 5- or 10-min periods before stopping to plot each new data increment. The following procedure can be used to describe an outcrop.

- (1) A plot is produced as an integral part of the measuring process using different symbols and/or colors for each data type, the more distinctions the better. A key for each symbol is placed at the bottom of the sheet. Fold axes, mineral lineations, etc., can be linked to their associated planar features by assigning the same number to paired points on the plot while annotations of age relationships or other properties can be made on the margins with lines drawn to specific data points.
- (2) As the plot evolves, multiple data clusters should begin to appear. For smaller or more diffuse clusters there can be a question of whether these represent distinct populations, statistical noise, or conjugate sets of planes merging into a poorly defined double cluster. At this point, the observer can make additional measurements and examine details of the features in an attempt to settle such questions *while still on the outcrop*. Such selective sampling obviously invalidates any statistical meaning of numerical values of contours representing higher or lower density populations. However, what is absent is some kind of a sampling grid or traverse line, but these distinctions would be pseudo-statistical anyhow.
- (3) Once clusters for all structural elements have been identified on the plot, each cluster can be encircled and assigned a letter. Then for each lettered cluster, a written description can be made of its spacing, average orientation, surface characteristics, mineralogy, etc.
- (4) A third pass over the outcrop records age relationships and possible stress and/or strain significance among the data classes. This is the opportunity to seek out the most critical age relationships and associations among all the features. Sketches, digital photos, and collection of a few oriented samples are appropriate at this stage.
- (5) Finally, even though it may seem like a waste of field time, a paragraph or two should be written about the plot while evidence is fresh in one's mind. This summarizes key structural features and relationships, possible stress or strain significance, and a tentative deformational history.
- (6) Later in the lab, the written measurements can be entered into a computer by keyboard. Alternatively, the net can be scanned and points digitized from the screen to read orientation data directly into the computer without ever having made any written field record, a risky but time-saving method.

## 5. Conclusions

It has been my pleasure to use these field plotting methods for over a half century and to introduce them to several generations of students and colleagues. The difference in results using these methods represents a quantum leap when compared with the typical practice of

merely recording structural measurements in the field and plotting them at a later time, either by hand or by computer. Ramsay and Huber (1987, pp. 678–681) emphasize field plotting.

“Beginners often produce a map which is just a series of locality numbers. All the data are placed in the field book and little or none on the map. Such a record is practically useless and the geologist who uses such a technique is unlikely to see many of the major geological and structural problems of the region. These will only emerge when he begins to plot his data and he may then find it necessary to return to the terrain or leave the problem in an unsatisfactory and unresolved state.”

Plotting and refining data on the outcrop forces one to identify, describe, and seek interrelationships among all the features while critical observations are easily made. The summary paragraphs written on the outcrop commonly find their way into final manuscripts. Examination of outcrops in this way is time consuming and not useful for simple traverse-style geologic mapping at every station. However, I have found that at the beginning of a mapping project, an in-depth study of this type for one or two of the largest and best exposures in the area allows one to recognize most of the potential structural elements of that area and to get some idea of how these features might relate to one another. Using this information, standard traverse methods through the area then can be done with much greater efficiency and sophistication. Alternatively, a line of such detailed stations allows the changing orientation and character of many structural elements to be traced across an area. The study by Freedman et al. (1964) used the plotter and a line-of-detailed-stations technique to do one of the first regional separations of multiple phases of folding across a region, the lower Susquehanna Piedmont of Pennsylvania. For broader regional structural studies, a network of such stations provides the kind of detailed reconnaissance needed to correlate multiple features and establish tentative domain boundaries throughout the area.

Biemsderfer plotters may be low-tech tools, but their use can force a far more rigorous examination, understanding, and recording of outcrop structural data than the use of any other method with which I am familiar.

## Acknowledgements

Reviews by Juliet Crider, Michael Williams, and ‘Anonymous’ provided helpful refinements of the manuscript. The plotter originated at Franklin and Marshall College in Lancaster, Pennsylvania, while refinements in design and field techniques for its use evolved both there and at the University of Massachusetts at Amherst.

**References**

- Biemsderfer, G.K., 1949. A new tool for plotting points on the equal area net. *Proceedings of the Pennsylvania Academy of Science* 23, 72–75.
- Freedman, J., Wise, D.U., Bentley, R., 1964. Pattern of folded folds in the Appalachian Piedmont along Susquehanna River. *Geological Society of America Bulletin* 75, 621–638.
- Ramsay, J.G., Huber, M.I., 1987. *The Techniques of Modern Structural Geology*. Vol. 2. Folds and Fractures. Academic Press, New York. 700pp.