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Mean-Dip Maps - Indicators of Deformation Intensity

(A contribution to geometrics)

by

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ABSTRACT

Mean-dip maps are graphic displays of the relative dip of bedding, schistosity, axial planes of folds, or other planar fabric elements throughout map areas. Such maps show the relative intensity of deformation resulting from each upright fold event and make possible delineation of tectonic boundaries. Construction of a mean-dip map consists of four steps: (1) subdivision of a structure map into subareas which are reasonably homogeneous with respect to the strike of the planar element; (2) calculation of the arithmetic mean of dips within each subarea; (3) plotting each mean-dip value at the median areal center of its respective subarea; (4) freehand contouring of the resulting distribution of mean dips. A mean-dip map of the Red Ives area of northern Idaho is shown as an example of how tectonic boundaries are emphasized by the construction described above.

INTRODUCTION

The purpose of this paper is to describe the construction of mean-dip maps, as exemplified by work done in the Red Ives area of northern Idaho. A mean-dip map is a graphic display of the relative dip of bedding, schistosity, axial planes of folds, or other planar fabric elements throughout the map area. Such a visual display augments standard techniques of structural analysis, and makes possible delineation of tectonic boundaries. Mean-dip maps of poly-deformed rocks show the relative intensity of deformation resulting from each upright fold event.

A small number of descriptive statistical techniques, such as stereonet diagrams, have been extensively applied to the analysis of folded rocks. In reviewing recent advances in statistical fold analysis, Whitten (1966, p. 545-596) suggests that more effort should be made in developing new analytical tools.

One statistical method reviewed by Whitten (p. 572-575) is the construction of isopleth maps for structural fabric data (Agterberg, 1961). Agterberg constructed isopleth maps for mean strike of schistosity, mean trend of minor folds, and mean plunge of minor folds. This paper extends Agterberg's method to the construction of mean-dip maps of bedding and other planar elements.

METHODS

Construction of mean-dip isopleth maps, herein called mean-dip maps, consists of four steps:

1. Subdivision of a structure map into subareas reasonably homogeneous with respect to the strike of beds.

2. Calculation of the arithmetic mean of the dips, disregarding bearing, within each subarea.

3. Plotting of each mean dip value at the median areal center of the dip measurement locations within its respective subarea.

4. Freehand contouring of the resulting distribution of mean dips.

The only difficult step is the subdivision of the map into reasonably homogeneous domains. In areas of complexly folded rocks, subdivision by the criterion of homogeneity is more useful than subdivision into a regular grid, because differences in mean dip between adjacent areas of different tectonic trend are thus emphasized. In a fold belt of constant trends, however, subdivision is made using a grid system. Where folds have complex patterns and small wavelengths and where fabric data are limited, the criterion of homogeneity can be used only as a guide. Large homogeneous domains should be

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subdivided to provide sufficient points for eventual contouring. The minimum allowable number of data points included per subarea depends on the variability of trends in that area. In the example (Fig. 1) I have attempted to draw boundaries so that at least four dips were included in each subarea.

EXAMPLE

Figure 1 is a mean-dip map of the Red Ives area on the St. Joe River, Shoshone County, Idaho. This map has been constructed in the manner described above.

The Red Ives area straddles the tectonic boundary between the polymetamorphic terrane of complex fold trends to the south and west and the Idaho-Montana thrust belt to the north and east. The area of complex fold trends is characterized by horizontally-directed flow folds, refolded by upright and inclined folds of several trends. The thrust belt is characterized by high-angle reverse faults and upright isoclinal, fault-related folds, which refold recumbent isoclinal folds. A preliminary report describing the structural petrology and silicate paragenesis of the Red Ives area has been written (Greenwood, 1966). A description of the Idaho-Montana thrust belt east of the area shown in Figure 1 is in progress (Nord). A detailed report on the geology of the St. Joe River basin, including the Red Ives area, is in preparation (Reid and Greenwood).

The tectonic boundary between the simple isopleth patterns of the thrust belt and the complex isopleth patterns to the south and west is clearly shown in Figure 1.

The zones of dominant northwest, northeast, and north-south fold trends are shown by the mean-dip isopleth patterns in the southwest part of the Red Ives area.

Trends of mean-dip isopleths in Figure 1 can be related to deformational events of those trends and the zones of dominant structural control of the several deformational events can thereby be discerned from a mean-dip map.

GENERAL CONSIDERATIONS

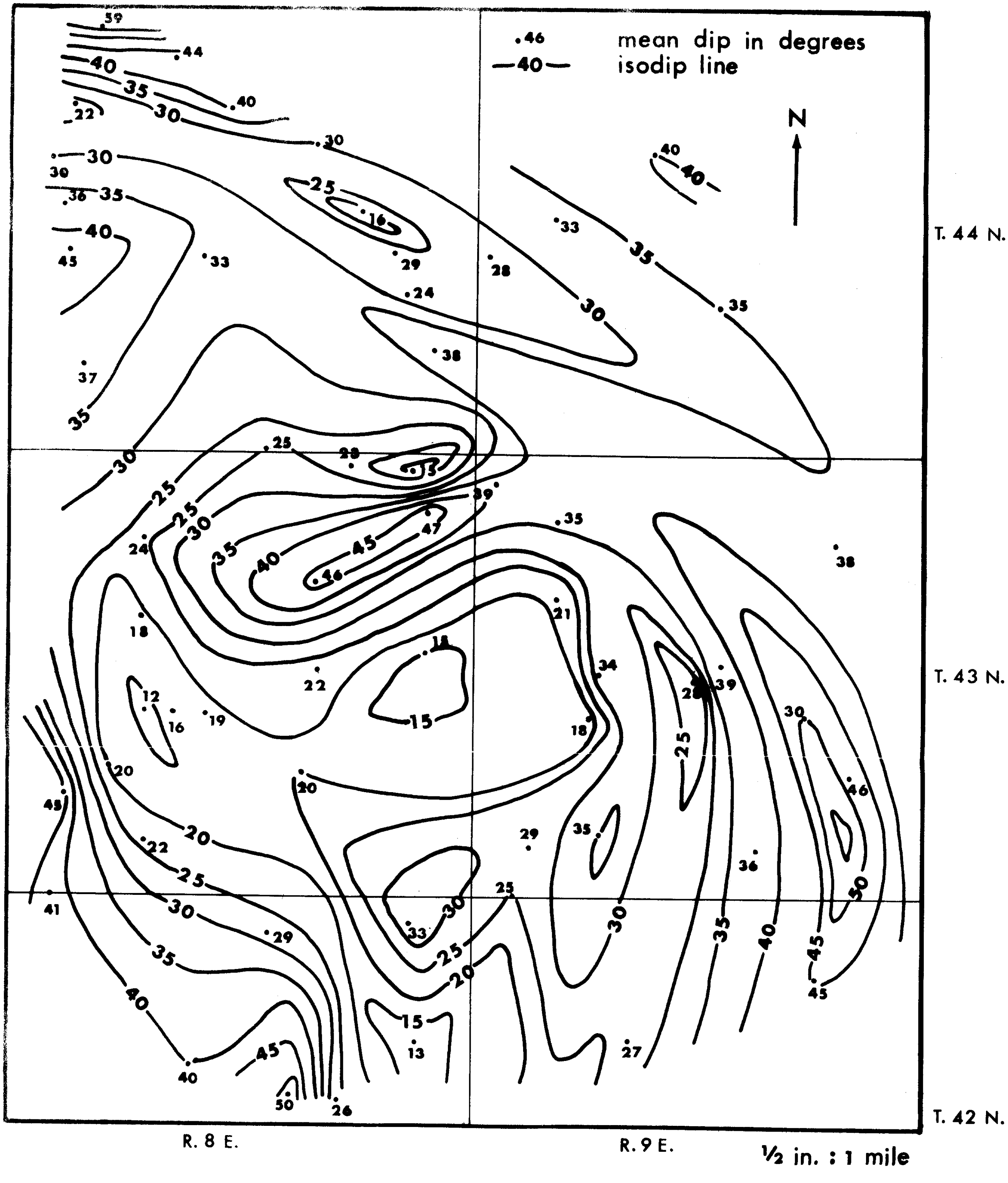
When interpreting mean-dip maps, consideration should be made of the effect of rock competency on fold symmetry. As an example, a quartzite unit in a schist terrane might show up as a mean-dip minimum because folds tend to be more open in the relatively competent quartzite. Open folding produces lower mean dips than closed folding because of the increased probability of measuring flat dips in the nose of open folds.

It can be readily seen that the effects of recumbent isoclinal folding are minimized on mean-dip maps. Upright folds will produce higher mean dips than inclined folds with the same symmetry and wave length. Therefore, mean-dip maps conveniently emphasize the effects of upright refolding of recumbent isoclinal folds.

FIGURE 1

MEAN—DIP MAP OF RED IVES AREA

SHOSHONE COUNTY, IDAHO



SUMMARY

In summary the mean-dip map is a tool designed to assist in the interpretation of fold belts, especially polydeformed terranes. The construction of Figure 1 emphasizes differences in the dips related to different tectonic trends. In areas of constant trend, subareas are assigned by a grid method. In such an area of constant trend, the distribution of mean-dip isopleths might reveal nodes of deformation intensity. Abrupt truncation of regional isopleth patterns indicates probable tectonic lineaments and possible boundaries of tectonic blocks.

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