Journal of Structural Geology, Vol. 8, No. 2, pp. 205 to 207, 1986
Printed in Great Britain

0191-8141/86 $03.00 + 0.00
Pergamon Press Ltd.

A comparison of Sanderson's and Panozzo's strain measurement methods using calcite grain boundaries from the Variscan fold and thrust belt in Ireland

PHILIP M. TRAYNER

Department of Geology, University College, Cork, Ireland

(*Received* 15 *February* 1985; *accepted in revised form* 6 *November* 1985)

Abstract—Two methods of determining strain from the two-dimensional preferred orientation of lines by Sanderson and Panozzo are compared using grain boundaries in limestones from S Ireland. The Panozzo method utilizes the orientations and lengths of lines whereas the Sanderson method uses only the orientations. The Panozzo method is shown to be more sensitive to inhomogeneous deformation or dubious data than the simpler method of Sanderson.

IN A recent paper, Panozzo (1984) presented a new method for determining the two-dimensional strain from the preferred orientation of lines. This method projects sets of lines (or line segments) onto an axis and measures their resultant lengths. The axis is then rotated in increments through 180° and the procedure repeated. At each of the n increments of rotation the total projection $A(\alpha)$ is calculated by summing up the projection of all the lines. The major and minor axes and the ratio of the two-dimensional strain ellipse are obtained from the maximum and minimum values of the total projection $A(\alpha)$. The method is sensitive to the length and orientation of lines but not to their position in the XY plane. Panozzo considered the method to be particularly suitable for strain determinations from initially random grain-boundary distributions in polycrystalline rocks, and compared it with the method of Fry (1979) which uses the change of relative position of centre points as a measure of strain. Panozzo did not, however, refer to the similar technique of Sanderson (1977) which treated line segments as unit vectors, summed them, and used the vector mean as an indicator of the strain. The Sanderson method is only sensitive to the orientation of lines and does not use line lengths in the calculations.

This short note makes a comparison of the Sanderson and Panozzo methods using orientation data obtained from the geometry of grain boundaries in deformed Lower Carboniferous limestones from Castlemartyr, County Cork. The limestones contain a fabric parallel to a strong cleavage, axial planar to the regional folds (Trayner 1985). The fabric is the result of a Variscan strain which acted on a pervasively recrystallized limestone mosaic; recrystallization has obscured all evidence of the diagenetic fabrics as described in undeformed micrites by Schwarzacher (1961).

Grain boundaries were traced from scanning electron photomicrographs (Fig. 1) and the data digitized using an APPLE II microcomputer. Short programs have been written to analyse the data by the methods outlined in Sanderson (1977) and Panozzo (1984). The results are shown in Table 1. All data sets were tested for a significant preferred orientation using a Rayleigh Test prior to making strain determinations. Although both methods will produce results for any data set, in practice these are not significant, according to the Rayleigh Test for strains less than 1.2:1. The two strain determination methods give comparable results for the strain ratio, but differ considerably on the orientation of the principal strain axes.

The Sanderson method produces a single angle for the X-axis of the strain ellipse and is thus easy to interpret. The Panozzo method does not produce such clear-cut results. Since the maximum and minimum values of the total projections define the major and minor axes of the strain ellipse, the resolution of the axes depends on the number of increments chosen for the total projection. In this example increments of 10° were chosen and hence the principle axes are defined as lying within a 10° interval. A smaller increment interval would naturally be advantageous, but is not practical on an APPLE II microcomputer as it required approximately 15 minutes running time to produce results for 10° intervals.

The exact X-axis angle defined by the Sanderson method lies within the 10° interval established by the Panozzo method for samples SEM 42, 43 and 49. However, there are discrepancies between the two methods for samples SEM 46, 47 and 48. This highlights one of the problems with the application of the projection method. The maximum and minimum total projection values should always be 90° apart and define the major and minor axes of the strain ellipse. Only samples SEM 42 and 49 adhere to this condition. The remainder of the samples have major and minor axes separated by angles ranging from 80 to 110°. This possibility is not considered by Panozzo (1984), but probably reflects either (1) departures from an initially random distribution or (2) inhomogeneous deformation. In this respect the Panozzo method is important in that it recognizes a departure from homogeneously strained data, or indi-

* Present address: Dept. of Geology, University College, Cardiff, CF1 1XL, U.K.

Table 1. Strain determinations using methods of Sanderson (1977) and Panozzo (1984). Chance of significance refers to the results of the Rayleigh test and indicates the likelihood that the data is not part of a uniform distribution

Sample number	Grain boundary length Mean (μm)	Std. Dev.	Chance of significance	Sanderson (1977) Strain ratio	Direction of X-axis	Panozzo (1984) Strain ratio	Direction of X-axis	Direction of Y-axis
SEM 42	7.20	3.55	99%	1.49	0	1.52	0–10	80–90
SEM 43	6.89	3.61	99%	1.31	0	1.32	0–10	90–100
SEM 46	9.45	4.52	99%	1.32	138	1.34	120–130	40–50
SEM 47	8.23	4.29	95%	1.22	156	1.18	160–170	50–60
SEM 48	7.74	4.02	99%	1.29	144	1.25	130–140	30–40
SEM 49	9.02	3.78	99%	1.45	138	1.32	130–140	40–50

cates a dubious data set. There is no such indication of inhomogeneity from the simpler and hence less sensitive Sanderson method. Without recourse to further methods it is not possible to state which, if either, of these two methods gives the 'correct' measurement of strain, but the Panozzo method should be used in preference to Sanderson's method to highlight inadequacies in any data set. The Sanderson method remains as a quick and simple calculation with the potential for obtaining results in the field with a pocket calculator, but results should always be carefully checked upon return to the laboratory.

Acknowledgements—I should like to thank Mark Cooper and two anonymous referees whose comments have greatly improved this paper.

REFERENCES

Fry, N. 1979. Random point distribution and strain measurements. *Tectonophysics* **60**, 89–105.

Panozzo, R. 1984. Two-dimensional strain from the orientations of lines in a plane. *J. Struct. Geol.* **6**, 215–221.

Sanderson, D. J. 1977. The analysis of finite strain using lines with an initial random orientation. *Tectonophysics* **43**, 199–211.

Schwarzacher, W. 1961. Petrology and structure of some Lower Carboniferous reefs in northwestern Ireland. *Bull. Am. Ass. Petrol. Geol.* **45**, 1481–1503.

Trayner, P. M. 1985. The stratigraphy and structure of parts of east county Cork and west county Waterford. Unpublished Ph.D. thesis, National University of Ireland.

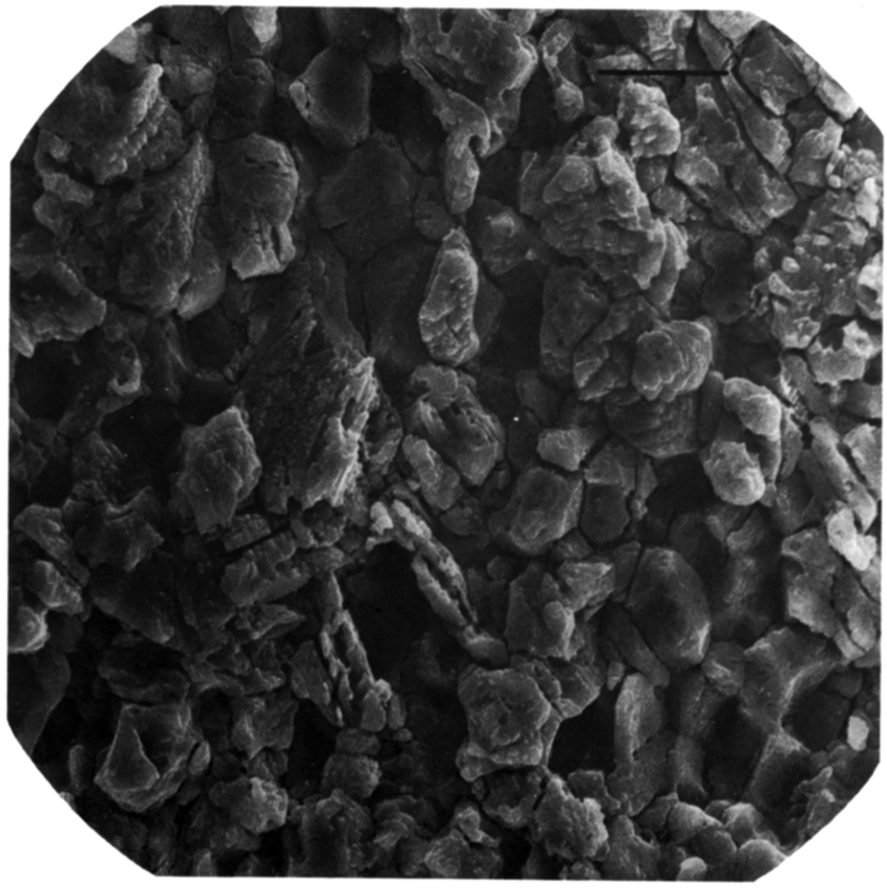

Fig. 1. Scanning electron photomicrograph of limestone (SEM 43). Scale bar = 10 μm.