Journal of Structural Geology, Vol. 10, No. 5, pp. 529 to 530, 1988
Printed in Great Britain

0191–8141/88 $03.00 + 0.00

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Strain analysis in rocks with pretectonic fabrics: Discussion

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(*Received* 29 *January* 1988; *accepted* 23 *May* 1988)

Wheeler (1986b) presents an algebraic solution to the determination of strain in rocks with a pretectonic fabric. The basic concepts illustrated in his figs. 1 and 2 represent an advance on the approach of Matthews *et al.* (1974), but we feel that Wheeler's contribution could be clarified by some further observations. In an earlier paper Wheeler (1986a, p. 268) found that two types of fabric ellipsoid could be used to describe deformed fabrics in rocks such as conglomerates, but that fabric ellipses on section planes determined from section plane data were not the same as sections through either fabric ellipsoid. Yet as a prerequisite for methods described in the paper currently under discussion, Wheeler (1986b, p. 891), it is assumed that the fabric ellipsoid "has been determined".

Our purpose here is to illustrate the problem plaguing two- vs three-dimensional fabric data. To do this we need to go back to the basic assumptions behind fabric analysis. Wheeler states that "if the initial fabric results from some non-tectonic process then it may still be thought of as the result of 'virtual strain' imposed on a random distribution". In other words, it is assumed that a primary sedimentary fabric can be described using an average ellipsoid. We disagree. If primary sedimentary fabrics were analogous to strained random fabrics, no fabric would ever become asymmetric during deformation because none could be distinguished from a random fabric deformed in stages, one 'virtual', the other real (this was precisely the point of discussion between Siddans 1981 and De Paor 1981). As illustrated in Fig. 1, non-coaxial strain increments do not affect a fabric's symmetry. Let path 3 represent a co-axially accumulated deformation D, whereas paths 1 and 2 involve an initial compaction (or virtual strain) followed by tectonic strain with different principal directions resulting in the same deformation. The fabric developed is a function of D; it is a state function, not a path function. If this were not so, by reversing the direction of path 3 and following a circuit as in Fig. 1(b), one would arrive at the origin with residual fabric as the fabric developed on paths 1 and 2 would not be negated by the inverse deformation -3. Repeated circuits would lead to a build up of residual fabric, and after many laps, one would end up with an undeformed mylonite!. By *reductio ad absurdum*, we conclude that ellipse fabrics are path independent. An analogous argument in thermodynamics leads to the rejection of perpetual motion machines. Perhaps the geological equivalent is still discussed because crystallographic fabrics are often found to be path dependent. However, they involve non-conservative processes such as recrystallization. All homogeneous transformations are independent of deformation path, so it is invalid to represent or simulate initial sedimentary fabrics by imposing a 'virtual strain' on a random data set.

To represent a pebble fabric, consider the envelope surface within which pebble ellipsoids would lie if translated to a common origin and enlarged or reduced to a standardized pebble volume. Such a surface would be spherical for a uniform or random distribution and spheroidal for a compacted random fabric. Wheeler suggests that it would be ellipsoidal with the shape of a virtual strain ellipsoid for any primary fabric, but we argue that it would be arbitrary in shape. In the case of a waterlain sediment, it might be guitar-shaped with the

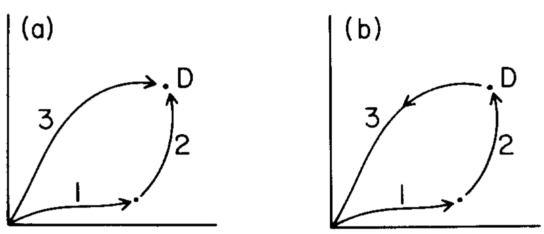

Fig. 1. (a) Flinn plot of deformation paths 1 + 2 and 3, leading to the same strain D (see text). (b) Reversal of path 3 leads to a 'round the clock' deformation loop.

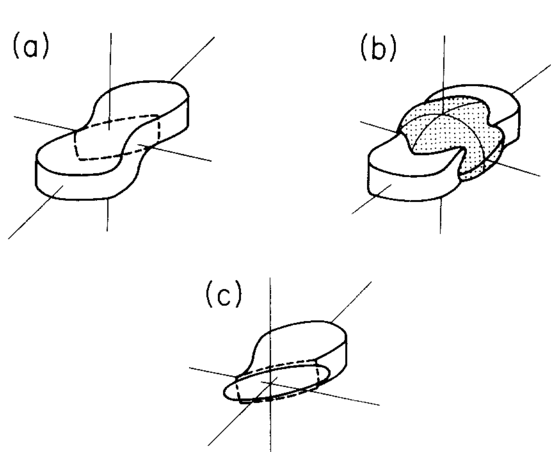

Fig. 2. Guitar-shaped envelope to primary pebble fabric (dashed line is a TV screen shaped section of the envelope surface). (b) Best-fit ellipsoid to the envelope surface. (c) Best-fit ellipse to the envelope section. Note that this is not necessarily a section of the ellipse in (b).

long-axis oriented downstream and the flat side parallel to bedding. The intensity of a primary fabric need not vary as the radii of an ellipsoid because the process of sedimentation is not an homogeneous transformation. In a section through the fabric's envelope surface, the envelope line could be any shape such as a TV screen or a dumbell. By least squares, it is possible to fit an ellipsoid to the guitar and an ellipse to the screen or even the dumbell, but there is no reason why the best-fit ellipse to any of these shapes should be a section of the best-fit ellipsoid! The conclusion we draw is that primary sedimentation fabrics are not well-represented by average ellipses or ellipsoids (Fig. 2). In contrast, Wheeler concludes that one should not carry out any two-dimensional strain studies.

It must be emphasized that the two- and three-dimensional problems discussed above only apply to methods that use average ellipsoids. Techniques of Dunnet & Siddans (1971), De Paor (1981, 1988) and Lisle (1985) require initial fabric symmetry but not elliptical average shape. They yield sound two-dimensional results and it is perfectly valid to combine such two-dimensional strain ellipses to yield three-dimensional ellipsoids; fabric ellipsoids alone are impossible to determine from two-dimensional data. We do, however, acknowledge that there are cases where two-dimensional methods break down and Wheeler's techniques might prove useful. The problem of competence contrast requires careful consideration of three-dimensional fabric by serial sectioning of specimens. Heterogeneously strained objects in a specimen would follow different paths in Fig. 1 and all could not return to zero simultaneously. Wheeler's three-dimensional approach might be usefully extended to deal with such competence contrasts.