in the N and the one S of 62°) are likely to have their origin in old Precambrian rocks of similar metamorphic chronologies (Talwani & Eldholm, 1972). The probable trend of the considered fault zone in the Norwegian Sea region makes it reasonable to suspect that the two gravity features concerned (and which are more than 500 km apart) originally were better lined up and much closer together than at present.

Following the new development in the fault problem of Northern Britain it seems to be a practically impossible task to find corroborative evidence in the Devonian succession exposed on land. Thus, the amount of displacement which according to geophysical evidence may well have been of the order of 500 km (i.e. a Palaeozoic equivalent to the San Andreas Fault) implies that E Shetland is to be correlated with regions in Inverness-shire which are now nearly devoid of Devonian strata. Therefore, it appears to me that Mykura's arguments actually have no direct relevance to the problem under consideration. There appears to be little doubt that further details about the displacement along the Great Glen Fault have to come from geophysics and off-shore geological data.

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KARSTEN M. STORETVEDT

University of Bergen
Geophysical Institute
Department of Geomagnetism
Allégt. 70
N-5014 Bergen – Universitetet
Norway
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The assumption of constant volume in the extrapolation of 2-dimensional strain data to 3-dimensions: a discussion of Thakur (1972)

SIR – The assumption that there is no volume change during deformation is often made in order to simplify tectonic problems, and may be justified in many cases. Recently Thakur (1972) has used this assumption to convert a 2-dimensional strain estimate into a 3-dimensional one.

Assuming constant volume, if two principal strains, $X = 1+e_1$ and $Y = 1+e_2$, are known ($e_1 \geqslant e_2 \geqslant e_3$), then the third principal strain ($Z = 1+e_3$) may be calculated, since

$$Z = (XY)^{-1}. \tag{1}$$

For a volume change Δ, Z is given by

$$Z = (1+\Delta)(XY)^{-1}, \tag{2}$$

Δ is termed the dilation and, for example, a 10% volume reduction is expressed as $\Delta = -0.1$.

Let us consider the effect of volume change on Thakur's estimate of Z. Firstly we must clear up some confusion in the nomenclature used by Thakur. He states that 'λ_1, λ_2, λ_3, represent principal extensions' and uses these symbols in the text as the lengths of the principal axes of the finite strain ellipsoid produced from a unit sphere. Thus his symbols are not the principal quadratic elongations which are usually referred to by λ_1, λ_2, λ_3 (Ramsay, 1967; Jaeger, 1969). However, in labelling his Figure 2(*b*),

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Thakur reverts to the usual convention of using λ for quadratic elongation. In view of this confusion I have considered both interpretations in discussing the effects of volume change. I have calculated Z from X and Y for different dilations using equation (2), and hence the strain ratios a = X/Y and b = Y/Z and the parameter k = (a−1)/(b−1).

(*a*) Assuming X = 1.64 and Y = 0.8, i.e. interpreting Thakur's λ_1 as X and λ_2 as Y, we get:

Δ	1+Δ	Z	a	b	k
0	1.0	0.76	2.05	1.05	21
−0.2	0.8	0.61	2.05	1.31	3.4
−0.4	0.6	0.46	2.05	1.74	1.42
−0.6	0.4	0.30	2.05	2.67	0.63
−0.8	0.2	0.15	2.05	5.34	0.24

(*b*) Assuming X = $\sqrt{1.64}$ and Y = $\sqrt{0.80}$, i.e. interpreting Thakur's λ_1 and λ_2 as quadrate elongations:

Δ	1+Δ	Z	a	b	k
0	1.0	0.87	1.43	1.03	14
−0.2	0.8	0.70	1.43	1.28	1.54
−0.4	0.6	0.52	1.43	1.72	0.60
−0.6	0.4	0.35	1.43	2.55	0.28
−0.8	0.2	0.17	1.43	5.26	0.10

Thus the 3-dimensional strain estimate is very sensitive to changes in volume, as can be seen from the effect on the b and k parameters above. The amount of dilation accompanying deformation is likely to vary. Ramsay & Wood (1973) estimate a volume reduction of 10–20 % on the basis of density changes between mudstones and slates. For the deformation of crystalline rocks the volume change may be expected to be less, but Patterson & Edmond (1971) have detected dilations of up to 20 % during experimental deformation of various crystalline materials.

The assumption of constant volume is not a satisfactory method of extrapolating 3-dimensional strain data from a 2-dimensional analysis. Thakur's method of using stretched tourmaline crystals as strain indicators must be applied in other planes, not only XY, in order to determine the 3-dimensional finite strain state. Such 3-dimensional analysis would also allow his other assumption, that cleavage is the XY plane, to be checked.

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DAVID J. SANDERSON

Department of Geology
The Queen's University
Belfast
N. Ireland

19*th September* 1973

SIR – There is no confusion in my nomenclature. It is stated in the Introduction to my paper that X, Y and Z represent measured ellipsoid axes from deformed sphere of

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radius r, X = r $(I+e_1)$, etc., and λ_1, λ_2 and λ_3 indicate principal extensions meaning principal quadratic extensions. The symbols λ_1, λ_2 and λ_3 nowhere have been used in the text for representing the lengths of the principal axes of the finite strain ellipsoid produced from a unit sphere, as has been pointed out by Sanderson. On p. 447, the values of principal strains, λ_1 and λ_2 (e.g. $\lambda_1 = 1.30$, $\lambda_2 = 0.75$, etc.) indicate the principal (quadratic) extensions. These values were computed from the change in unit lengths for 3 line elements of stretched tourmaline crystals, using the method (Ramsay, 1967, p. 81). It is also clearly stated on p. 448 that the values of principal strains, $\lambda_1 = 1.64$ and $\lambda_2 = 0.80$ represent the values measured along X and Y axes. These values of principal strains indicate principal (quadratic) extensions, and not the lengths of X and Y axes of strain ellipsoid.

Sanderson's derivation for the 3-dimensional strain estimate for the change in volume with respect to variation of b and k parameters is theoretically valid. However, it may be added that in naturally deformed rocks, where deformation is controlled by other thermodynamic parameters, the amount of dilation may vary depending upon the various types of tectonic environments.

I never postulated that the assumption of constant volume is valid in all cases for analysing 3-dimensional strain from 2-dimensional data. This assumption can be used in some specific cases only, where other evidence, like deformation features, suggest that no volume change occurred during deformation. For example, in the Molare region the dislocated parts of tourmaline crystals, showing sharp margins, indicate a brittle rupture; and recrystallization, which could bring about dilation, was not accompanied during the stretching of tourmaline crystals.

V. C. THAKUR

Wadia Institute of Himalayan Geology
Delhi University Campus
Delhi – 110007, India

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