

CORRESPONDENCE

Phases of deformation in North Wales

SIR,—I submit this letter in reply to Dr Bromley's letter criticising my recent paper (Lynas, 1970) concerning polyphase deformations in North Wales. I deal with each of his criticisms in turn.

1. Dr Bromley points out that S_1 steepens in dip to the north (my own notations defined in the paper (Lynas, 1970) are used here) and eventually becomes the north-easterly trending sub-vertical cleavage (S_2) developed in the major F_2 fold, the Dolwyddelan syncline. All authors seem in agreement that the Dolwyddelan syncline is a Caledonian structure. Dr Bromley states that 'nowhere . . . is there any evidence that the low angle slaty cleavage either dies out away from the Harlech Dome or that it is overprinted by the Caledonian slaty cleavage of Snowdonia'. This is a moot point, and it may be that evidence has yet to be found. No one would claim that complete and exhaustive work has yet been done between the Dolwyddelan area and the Migneint area to the south.

2. Dr Bromley is concerned about the crystalline rocks which are affected by the low angle S_1 . The extent to which concentric shear can have been effective in deforming competent bodies is unknown in this instance, and this deformational process may have been more powerful than initially realised. Whilst there is no doubt that the metamorphic spots produced by the Tan-y-Grisiau microgranite (and similar spots clearly seen in the bed of the Afon y Foel in Cwm Hafod y rhedrwydd further east) in the pelitic rocks surrounding the intrusion, are deformed strongly by the S_1 low angle cleavage, there is no absolute criterion which can be used to show that the intrusion pre-dated the formation of S_1 . As Bromley (1969, p. 390) mentioned, Fearnside's (Fearnside & Davies 1944, p. 269) concluded that 'the growth of spots took place in slate that was already cleaved'. However, Wilcockson's remarks (in discussion of Fearnside & Davies 1944, p. 275) suggested that the intrusion was more likely to be before the S_1 formation.

Valid arguments can be raised for both theories. It may be that the development of S_1 was approximately synchronous with the intrusion (as already suggested by Harper (1967) though he apparently referred to a later D_2 metamorphic event). Thus the metamorphic minerals, now represented by the flattened spots, may have been deformed whilst they were growing at about the same time as the acid magma was forcing its way into the upper crust. The Tan-y-Grisiau microgranite may in fact be an offshoot from a much larger mid-Caradocian intrusion, centred below the Harlech Dome, which was responsible for the formation of the Dome, and produced the sub-vertical stress field necessary for the formation of S_1 . This theory is of course exceedingly hypothetical, but can be used to explain most of the problems raised by Dr Bromley.

The second (D_2) deformation (Caledonian) which produced the strong F_2 folds and S_2 planes in Snowdonia would almost certainly have totally destroyed any pre-existing planar fabric caused by volcano-tectonic doming. Hence, an earlier quaquaversal structure has not been and is not likely to be, recognized around the Snowdonia volcanic dome.

3. Dr Bromley states that a post- S_1 NNE-SSW vertical cleavage is to be seen affecting the rocks south of Blaenau Ffestiniog, and that this is axial planar to major NNE-SSW folds. This agrees with my own observations in the Migneint area to the east, except that the cleavage (S_2) is usually not well developed, occurring only as an intersection lineation (S_1 - S_2 intersection) on the flat-lying S_1 planes. However, I am not in a position to argue that this cleavage does not, as Dr Bromley states, die out northwards. I would, however, question how it is possible to differentiate a NNE-SSW vertical cleavage (described above) from a similarly oriented presumed earlier cleavage which Dr Bromley records as developing from the flat-lying S_1 planes of Ffestiniog and the Migneint. If pillaring in the Ffestiniog area is, as I believe the evidence shows, equatable with L_2 (S_1 - S_2 intersection lineation), and the effects of the deformation which produced this structure 'die out northwards in the ground between Ffestiniog

and Dolwyddelan', I would further question how the pillaring joints of Dolwyddelan and the Nantlle area, which Dr Bromley seems to suggest are genetically related to the L_2 lineation described, can be equated with the pillaring of the Ffestiniog slates. Thus, the pillaring joints to the north cannot be related to L_2 of the Migneint.

I am not the first or the only author to note the quaquaversal nature of the S_1 slaty cleavage to the Harlech Dome, and also the Berwyn Dome. Rast (1969, p. 324) has described 'a cleavage earlier than the main cleavage (which) appears to be related to the (Harlech) dome'. In the same paragraph, he suggested that the main cleavage (S) developed when the ductility contrast between the dome and surrounding rocks ceased to exist. Dewey (1969, Fig. 9) also appeared to recognize more or less quaquaversal slaty cleavages around the Harlech Dome and, to a lesser extent, the Berwyn Dome. A major problem has been to explain the remarkable relatively flat-lying S_1 planes which can be seen to dip off the flanks of the Harlech Dome. This cannot be explained except in terms of a vertical maximum principal stress, and this in turn cannot be explained unless substantial vertical uplift of the Harlech Dome is envisaged. Far from being untenable, this hypothesis remains the only one put forward so far which is capable of adequately explaining the genesis of S_1 . D_2 structures are, however, more simply explained by horizontally directed compressive stress acting from the WNW and ESE with the resultant maximum principal strain being sub-vertical—a deformational style quite different from D_1 . It is difficult to see how this generally accepted stress field could produce the flat-lying S_1 cleavage around the Harlech Dome.

This worthwhile criticism by Dr Bromley serves to show again that insufficient detailed work and correlation between known areas has been carried out, particularly with regard to the complex, interfering and poorly understood deformational fabric elements.

References

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28th July 1971

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