Tan y Grisiau

[SH 683 454]

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Highlights

This locality displays excellent examples of deformed contact-metamorphic spots in cleaved Tremadoc siltstones and pelites. The contact spots provide a means of dating the Tan y Grisiau microgranite intrusion in relation to the deformation of North Wales that was imposed during the Caledonian Orogeny. In addition, the spots and cleavage are important in the measurement and analysis of the strain imposed in southern Snowdonia during the orogeny, and this has an important bearing on the postulated Tremadoc Thrust Zone'.

Introduction

The site provides an example of deformed metamorphic spots in Tremadoc Series siltstones and pelites within the contact aureole of the Tan y Grisiau microgranite. The microgranite, which lies 700 m south-east of the site, has a roof area, estimated by Campbell *et al.* (1985) to measure about 10 km by 5 km, dipping beneath the site at about 20°. The aureole extends at least 1 km on this north-west side. Dark metamorphic spots are flattened in the plane of the north-dipping cleavage and are extended down dip.

Areas adjacent to the Tan y Grisiau intrusion have been the subject of numerous structural studies, of which the work of Fearnsides (1910) and Fearnsides and Davies (1944) are notable early examples. To the south-west of the micro-granite lies the Tremadoc Thrust Zone, a band of crush belts and high strain which may be olistostromic. A detailed petrological study of the granite was presented by Bromley (1963) who also contributed to a series of later papers (Bromley, 1969, 1971; Lynas, 1970a, 1973; Fitch *et al.,* 1969), which were concerned with the structural relationships of the granite and its host rocks. The interpretation of the flat-lying cleavage favoured by Lynas (1970a) was combined with the thrust model of Fearnsides and Davies (1944) in the general structural interpretation of Coward and Siddans (1979).

Recent work by Campbell *et al.* (1985) has modified the general model of Coward and Siddans (1979), and has confirmed the view that low-angle cleavage around Tan y Grisiau is equivalent to the upright main cleavage elsewhere in North Wales. Smith (1987, 1988) has cast doubt on previous interpretations of low-angle discord-ances to the west of Tan y Grisiau. Instead, he suggests that the Tremadoc Thrust Zone (Fearnsides, 1910) may be an olistostrome.

Description

The Tan y Grisiau GCR site consists of an exposure of metasediment illustrating representative examples of the deformed contact spots. Within the exposure, Tremadoc sediments dip to the north at ˜45°, with a single cleavage dipping at a slightly steeper angle in the same direction. Numerous, black contact-metamorphic spots appear throughout the sediments and different concentrations of spots help define the bedding. The spots are mainly oval in shape and generally have a maximum diameter <0.01 m, although some approach 0.02 m. Cordierite was the original mineral forming these rounded spots which now have a retrogressive mineralogy of chlorite and sericite. Occasional angular spots which are lath-or diamond-shaped may have had andalusite as a precursor.

Strain can be estimated using a combination of cleavage and joint surfaces on which various sections of the strain ellipse can be measured. The spots here are flattened in the cleavage and have x-axes which plunge down the cleavage surface toward the north. A grain-shape fabric in the matrix has the same orientation. Joint surfaces in a variety of orientations allow an accurate picture of the strain ellipsoid to be obtained. An average axial ratio (*x:y:z*:) of 1.72:1:0.67 has been calculated at the site using 30 spots (Smith, 1988).

Several thin (<0.01 m) veins cross-cut the sediments and some possess symmetrically disposed colour zoning, produced by hydrothermal alteration, which may extend up to 0.04 m into the surrounding rock. Occasionally these veins contain euhedral quartz, calcite, and minor pyrite. The veins, and the retrogressive mineralogy of the spots, are the consequence of an expulsion of volatiles from the granite during the latter stages of its crystallization.

Interpretation

Two aspects of the geology of the Tan y Grisiau area have provoked controversy in the literature:

1. the relative age of the microgranite intrusion with respect to the regional deformation of the surrounding rocks; and
2. the age of the low-angle cleavage in the aureole and elsewhere on the southern margin of Snowdonia.

Both these age relationships are crucial to the interpretation of the structural development of the area between Snowdonia and the Harlech Dome. The chosen site provides an example of the orientation relationships and strain data available for such investigations.

The accepted age of the Tan y Grisiau microgranite, with respect to deformation, has progressively changed during the course of a prolonged period of investigation. Early workers considered it to be post-tectonic (Jennings and Williams, 1891), whereas Fearnsides and Davies (1944) considered it to be post-cleavage, but to pre-date the Tremadoc Thrust (Fearnsides, 1910). Shackleton (1953) considered the intrusion to be truly synorogenic. However, more recent research has demonstrated that the intrusion pre-dated the cleavage because the contact-metamorphic spots are deformed within the plane of the main cleavage (Bromley, 1969; Coward and Siddans, 1979), an interpretation confirmed by a minimum age of 477 ± 20 Ma obtained for the granite by Fitch *et al.* (1969).

The aureole of the microgranite is characterized by a low-angle, northerly dipping cleavage which is developed only in Cambrian and Ordovician strata along the northern flank of the Harlech Dome. Lynas (1970a, 1973) interpreted this flat-lying cleavage as the product of a deformation which preceded that forming the main cleavage elsewhere. Coward and Siddans (1979) suggested that this fabric was related to the development of the Tremadoc Thrust Zone. However, the interpretation of this flat-lying cleavage as a low-angle manifestation of the steeply dipping main phase (that is, late Silurian–early Devonian) cleavage elsewhere (Bromley, 1971), has been confirmed by recent work (Campbell *et al.* , 1985; Smith, 1987, 1988).

Campbell *et al.* (1985) reassessed the model of Coward and Siddans (1979) and, while they still preferred a 'thin-skinned' interpretation of structural evolution, modified it so that the subsurface extension of the Tan y Grisiau micro-granite played a dominant role in thrusting. In their model, the microgranite body acted as a rigid block over the roof of which the bulk of Snowdonia was ramped during the main Caledonian deformation. This provided an explanation for both the shallow dip of the main cleavage and the northerly dipping extension direction indicated by the contact spots and mineral grain elongation. In addition, the low angle between cleavage and bedding was thought to have facilitated dislocation along the Tremadoc Thrust Zone where shear-strain was at a maximum.

Recent work by Smith (1987,1988) has reassessed the evidence for the existence of the Tremadoc Thrust Zone and favours a pre-deformation explanation for the features previously attributed to thrusting; features such as crushing, faulting, bed repetition, and high strain associated with the zone. A strain study, which included investigation of the deformed contact spots of the microgranite aureole, indicated relatively low strain with the exception of a narrow zone of intense prolate strains in the Rhyd area, a 7 km-long strike to the south-west. Smith (1987, 1988) considered these unusually high strains to be related to compression against the rigid subsurface extension of the microgranite, but high strains being achieved without detachment along a specific thrust plane; an assessment recently confirmed by radiometric methods.

In addition, the siltstones and shales have a low-angle cleavage found extensively along the northern flank of the Harlech Dome. This cleavage and the related Tremadoc Thrust Zone have been the subject of some controversy. It is now agreed that the cleavage at the site is a variation on the main-phase regional cleavage whose low angle of dip is a local deflection related to the presence of the underlying microgranite intrusion. One interpretation (Campbell *et al.,* 1985) sees

the low angle and local high strain as results of a thrust ramp which transported Snowdonia south-eastwards over the rigid block during the main deformation phase. However, Smith (1987) denies the presence of any discrete thrusting, but accepts that the angle of cleavage and its intensity has been controlled by the presence of the micro-granite. Although the measurement of the deformed contact spots at this site have provided further important data for the nature of the Caledonian strain, measurements of similar spots in the contact aureole over a wider area would enable the effect of the pre-deformation intrusion to be seen in a wider context.

Conclusions

This locality shows excellent exposures of Tremadoc (early Ordovician Period) siltstones and shales which have been affected by baking by a later igneous intrusion, the Tan y Grisiau micro-granite. Contact spots, a product of the baking, have developed within the altered zone (aureole) around the Tan y Grisiau microgranite intrusion. These spots may be seen to be deformed, which is evidence of tectonic deformation after the emplacement of the microgranite. The deformed spots have played an important role in resolving the debate about the age of the intrusion relative to the formation of the main Caledonian cleavage.

The microgranite was emplaced around 470 million years before the present. This is consistent with a date of around 400 million years for the main Caledonian mountain-building event, including the low-angle cleavage, which deforms the spots in the granite aureole. The unusual cleavage here has been interpreted as due to Snowdonia being pushed (thrust) southwards over the buried microgranite mass.

References