Rhosneigr

[SH 317 734]

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Highlights

Rhosneigr provides a locality at which deformation on a variety of scales in the Ordovician cover sequence can be examined close to the underlying basement. The site provides unrivalled examples of strain variation around small-scale folds.

Introduction

The folded Ordovician greywacke sequence (the Nantannog Formation, of Arenig age) exposed at Rhosneigr is characterized by well-exposed minor folds. As minor folds can rarely be observed in the Lower Palaeozoic succession elsewhere in North Wales, Rhosneigr provides an important locality for their study. Folds of sandstone units are demonstrably non-cylindrical on a variety of scales. Excellent cleavage fans can be observed in the mudrock units surrounding the folded sandstone layers (Figure 4.9).

The Ordovician rocks of Anglesey were studied by Greenly (1919) who presented illustrations of the minor folds at Rhosneigr — see Figures 261 and 262 in Greenly (1919). It was not until Shackleton (1954) erected a general model for North Wales that the Lower Palaeozoic cover on Anglesey was reconsidered from a structural viewpoint. Whalley (1973) presented a thesis devoted entirely to a structural study of the Rhosneigr locality. A study of structures in the Lower Palaeozoic of Anglesey, including a description of Rhosneigr was undertaken by Bates (1974) who, like Shackleton (1954), emphasized the importance of basement control on deformation in the cover. The Rhosneigr locality was also mentioned in the paper of Barber and Max (1979).

The excellent degree of exposure at the site has allowed theoretical models of cleavage formation to be developed. In addition to the work of Whalley (1973), detailed studies include those of Knipe and White (1977) and White and Knipe (1978) which are of international significance in the study of cleavage formation. The site has also appeared in field guides (Barber *et al.,* 1981; Bates and Davies, 1981).

Description

The GCR site consists of an area of wave-cut platform located to the west of the town. Some of the features of interest are illustrated by stereographic projection (Figure 4.10) and by line drawing (Figure 4.11).

An Ordovician greywacke sequence is deformed by upright folds on a variety of scales. Cleavage dips steeply to the north-west, as generally does bedding, but at moderate angles. The dominant sense of vergence is therefore toward the southeast. The greywacke sequence is dominated by shales, with folds delineated by discontinuous sandstone beds, generally <0.3 m thick. Knipe and White (1977) defined two types of fold based on scale:

1. macrofolds with a wavelength >10 m and
2. meso-(parasitic) folds with a mean wavelength –0.5 m.

Two scales of non-cylindricity (fold axis curvature) can also be identified:

1. individual fold axes curve markedly within a single exposure for example, at [SH 3163 7319] and
2. a general change in the plunge of folds is seen along the strike of the outcrop (Figure 4.10).

Individual mesofolds have divergent cleavage fans in the surrounding mudrocks while the cleavage refracts strongly through sandstones as convergent fans of series of spaced fractures perpendicular to bedding. Locally, cleavage in the shales is parallel to the outside arcs of the folded sandstones, defining a triangular zone of weak cleavage orientation, the finite neutral point of Ramsay and Huber (1987, p. 461). (Figure 4.11) shows the pattern of cleavage displayed by the folds. A detailed account of the cleavage pattern is provided by Knipe and White (1977).

Exposed folded sandstone surfaces display fracture sets that are disposed symmetrically about fold hinges. At one location [SH 3163 7319], minor quartz slickensides on sandstone bedding surfaces suggest that some flexural slip was involved in fold development. Elsewhere, small quartz-filled fractures indicate extension in the outer arc of sandstone beds during folding.

Irregularly spaced rusty fractures can be observed in the mudrocks which appear to postdate the cleavage. They are generally subvertical and often strike approximately parallel to cleavage, but their orientation and spacing are very irregular. They occasionally reach widths of a centimetre and many contain a breccia of pelite fragments. At [SH 3172 7338], folded sandstone beds are displaced along these rusty fractures, dominantly in a sinistral sense, by up to 1 m. A minor occurrence of *en échelon* quartz veining at [SH 3186 7350] is compatible with the sinistral displacement on the subvertical fractures. The fractures are also associated with small-scale thrusting of fold pairs (see Greenly, 1919; Figure 263).

Interpretation

The Ordovician of Anglesey lies unconformably on the Precambrian Mona Complex, many of the contacts being faulted. The majority of work on Anglesey has concentrated on the basement lithologies and their deformation. The general consensus is that this deformation was Precambrian in age (Roberts, 1979). However, as stated above, other workers have suggested that the Ordovician and Gwna Mélange were deformed together, for the first time, during the later stages of the Caledonian Orogeny (Barber and Max, 1979).

Shackleton (1953, 1954) stressed the importance of basement control on deformation of the Lower Palaeozoic cover in North Wales. He also emphasized the absence of a major decollement between cover and basement. The pattern of fold and cleavage orientations indicated to Bates (1974) that pre-existing structural trends in the Mona Complex dictated the deformation pattern in the Ordovician succession. However, the orientation of structures and degree of deformation at Rhosneigr are similar to those observed in similar lithologies on mainland North Wales where, presumably, the basement at depth had a much reduced influence on deformation in the cover.

In particular, it is interesting to note that, despite the close proximity (a few hundred metres) of the basement, the non-cylindrical nature of minor folds at Rhosneigr is compatible with the periclinal form of major folds in Snowdonia. The implication is clearly that, although the basement may have controlled the orientation of structures, the style and degree of deformation were controlled largely by processes acting within the cover. This is compatible with the 'thin-skinned' model of structural evolution (Coward and Siddans, 1979; Campbell *et al.,* 1985) and the strike-slip model of Woodcock (1984a).

Strike-slip or oblique-slip transpression during the Caledonian Orogeny may be used to explain the structures seen at Rhosneigr (see below), particularly considering its location close to faults on which major strike-slip motion has been proposed (Nutt and Smith, 1981). The rusty fractures on which sinistral displacement is apparent could with some certainty be ascribed to strike-slip movement, and a slight angle between axial traces and the strike of cleavage (Knipe and White, 1977) could be attributed to an earlier oblique-slip during the main deformation. However, considering the small-scale examples of basement faults passing up into the Ordovician cover sequence on Anglesey (see Ogof Gynfor above), perhaps the recently developed models of Smith (1988), Wilkinson (1988), and Wilkinson and Smith (1988) offer the most suitable explanation of the structure. Thus strike-slip movements on reactivated basement fractures may have provided, in a transpressional regime, the local heterogeneous strain manifested by the obliquity of cleavage to the axial planes and the late sinistral fractures.

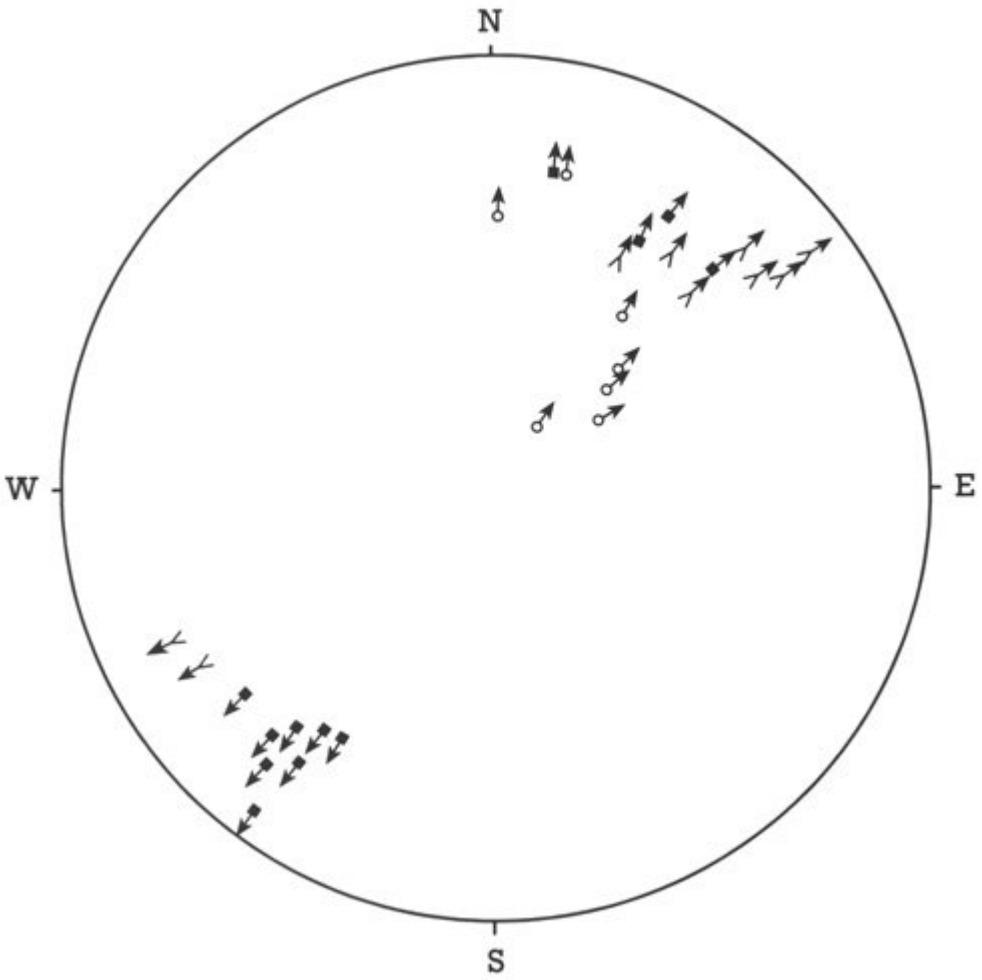
Minor folds are rarely seen in the Lower Palaeozoic rocks of North Wales. The excellent exposure of the minor folds at Rhosneigr has made them suitable for detailed theoretical studies (Whalley, 1973; Knipe and White, 1977; White and Knipe, 1978). Knipe and White (1977) produced a detailed study of strain distribution in natural folds using a symmetrical meso-anticline from Rhosneigr, and later (White and Knipe, 1978) used slate from the site in the development of a model to explain cleavage initiation.

Conclusions

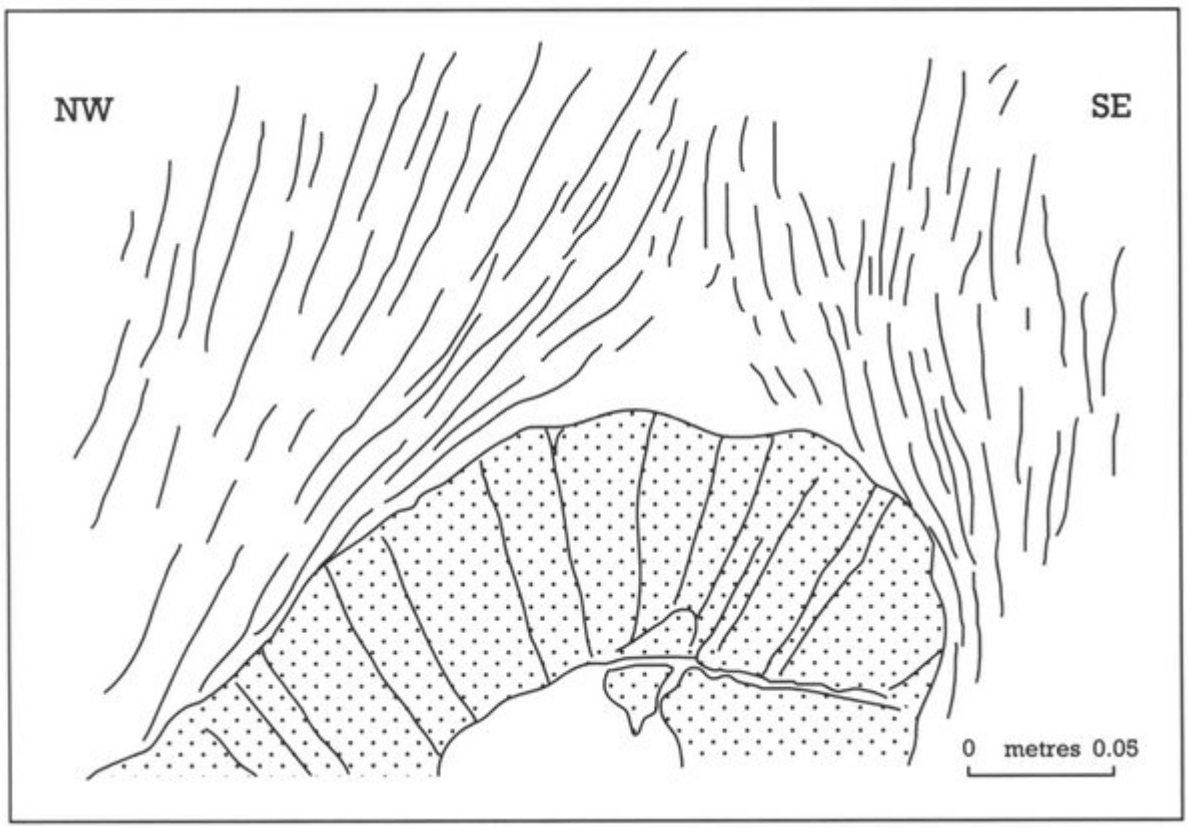
The Rhosneigr site, with its alternations of hard sandstones and soft mudstones, provides an excellent example of small-scale, non-cylindrical folding. This folding occurred during the Caledonian mountain-building phase, affecting a sequence of Ordovician sedimentary rocks. With its wealth of minor folds which are uncommon elsewhere in North Wales, the site provides an important locality at which the morphology of such folds can be compared with that of the major Caledonian folds. The outcrops here, very close to the underlying crystalline Precambrian basement, provide a location at which the influence of basement control on Caledonian deformation can be assessed, by comparison with localities on the Welsh mainland where the cover was thicker and the structures that were developed were presumably further away from the influence of the ancient basement. Here the structures are similar to those seen further south in North Wales, and therefore are not thought to be greatly influenced by the Precambrian basement. This is an important issue in the interpretation of the Caledonian structure of Wales. The quality of these outcrops has enabled a detailed theoretical analysis to be undertaken on the basis of the relationship between cleavage and folding, and this has made a significant international contribution to studies of the origin of cleavage (Whalley, 1973; Knipe and White, 1977; White and Knipe, 1978).

References

(Figure 4.9) Rhosneigr, Anglesey. Tight minor folds in thin sandstones exemplify the intensity of the deformation in north-west Wales. The enclosing slates have been the subject of studies on the nature of slaty cleavage and strain variations around folded layers (penknife, centre, is 6 cm long). (Photo: J. Treagus.)



(Figure 4.10) Equal-area stereographic projection of the plunge of minor fold axes at Rhosneigr. The site measurements are represented by the head of the arrow, and are divided into three subareas; circles = central, squares = NE and Vs = SW.



(Figure 4.11) Rhosneigr. Line-drawing illustrating the strong cleavage refraction associated with the hinge of a meso-scale fold delineated by sandstone surrounded by pelite. A photograph of this fold appears in Ramsay and Huber (1983, figure 10.18).