North Clarach

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Highlights

The folds in the Llandovery Series (Lower Silurian) sedimentary rocks at the North Clarach site have unusually complicated geometrical relationships with the cleavage, which makes the site particularly important for research into the relative timing of these two types of structure. The site also provides clear, small-scale examples of cleavage transection, a phenomenon of topical research interest in the Welsh Basin. This phenomenon has implications for the understanding of the plate tectonic setting of the basin.

Introduction

This site consists of a wave-cut platform, submerged at mid- and high-tide, showing folded and cleaved turbiditic sandstones, siltstones, and mudstones of the Aberystwyth Grits Formation. These sedimentary rocks have been described by Wood and Smith (1958), and Cave and Haim (1986). The principal points of interest here are the examples of repeated (or progressive) folding and of various geometrical relationships between folding and cleavage. Cleavage transects some folds, is axial-planar to others, and locally is itself apparently folded. The platform at Clarach has been mapped at a scale of 1:50 by Mrs R. Johnson, formerly of University College of Wales, Aberystwyth. Her map is reproduced in simplified form as (Figure 4.14). The structures displayed in the platform were briefly commented on by Fitches and Johnson (1978).

Description

A clearly recognizable example of a fold transected by cleavage is found at the northern end of the site (Locality 1, (Figure 4.14)). The fold is a periclinal anticline with an upright, N–S axial plane and hinge line which plunges gently north and south. Cleavage, which is well defined in the shale layers, strikes obliquely to the axial plane in a clockwise sense and dips to the WNW at a lower angle.

Several other examples of folds transected by cleavage are exposed on the platform, notably at Locality 2 where cleavage cuts both limbs of an open anticline on the western limb of a larger syncline.

Around Locality 3, where the rocks are conspicuously cut up by a complex of small faults, many of which are eroded out as gullies, several small folds appear to deform the cleavage. These folds, with metre-scale wavelengths, are close to tight structures on variable, but mostly N–S, upright axial planes. They are unusual for their very steep plunge. Cleavage in shale beds is nearly parallel to the bedding and appears to pass round the fold hinges. The precise disposition and pattern of cleavage throughout a particular fold has not been determined because of the feeble, often ill-defined nature of the cleavage, the difficulties of distinguishing it from compactional bedding-plane fabrics, and the problems of sampling these fissile rocks for sectioning.

Two stages of folding can be demonstrated around locality 4 where, immediately north of a conspicuous gully, an open anticline trends N–S. To its west, a very gentle, saucer-like periclinal syncline trends approximately NNW–SSE. The syncline has been superimposed on the anticline, causing a gentle plunge depression in the anticlinal hinge. The cleavage in this area bears no simple geometrical relationship to either of the folds, and it appears to transect both structures.

Interpretation

The reasons for the variable orientations of the folds, the superimposition of folds on each other, and the different geometrical relationships between folds and cleavage are subjects of ongoing investigation and are not yet completely understood. One interpretation of all these phenomena is that the folds and cleavage, and possibly some of the small faults as well, are due to accommodation in the core of a major anticline. In this case the variable attitudes and overprinting relationships of the folds, and the incongruent relationships between cleavage and folds could be explained by complex stress reorientations during progressive tightening of the host structure.

A second interpretation is that the structures were caused by progressive deformation accompanying transpression along the N–S Llangranog–Glandyfi Lineament, the central part of which is likely to pass through the area a short distance inland from North Clarach. Craig (1985, 1987) has described how, further south in the lineament, folds developed at different times during displacement along the zone; refolding, as seen at North Clarach, can be produced as early formed folds rotate to a new alignment with respect to stress axes in the transpression zone. Similarly, cleavage does not necessarily develop contemporaneously with folds in transpression zones. It can precede, follow, or form at the same time as folds, leading to the various types of geometrical relationships (superimposed folds, transecting cleavage) observed at North Clarach.

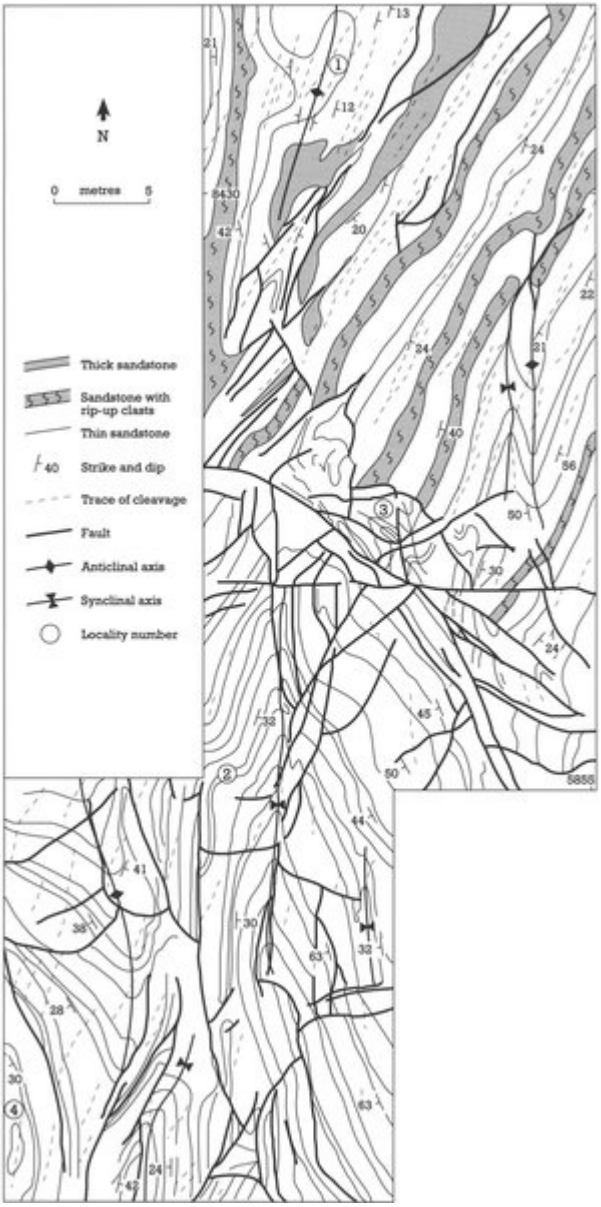
A third interpretation of the apparently disorganized geometrical relationships between folds and between folds and cleavage, based on studies elsewhere, is that these structures developed in unlithified or only partly lithified sediments, which might have produced initial irregularities of bedding planes.

Conclusions

The North Clarach site contains examples of structures which are important in understanding the sequence of events and processes which characterize the Caledonian mountain-building episode in this region. Here are seen folds which have been refolded, and also complicated relationships between folds and cleavage. Contrasting relationships are seen: folds are present with associated cleavage (very fine, closely spaced, parallel fractures), which parallels the planes which bisect fold limb-pairs (that is, the cleavage is axial planar). In other examples, the cleavage cuts across (transects) the fold axial plane, whereas in other situations folds are seen to deform, and therefore apparently post-date, the cleavage. These relationships have been explained in various ways: as the product of the progressive tightening of the major fold in which the site lies, as a product of progressive adjustment in relation to a major structural lineament nearby, and finally, as being due to various irregularities in the sedimentary rock pile that were present before deformation commenced.

This site is important and it is likely to yield important evidence on folding and cleavage-forming processes, the timing of deformation with respect to lithification of the host sediments, and on the regional structure of west Central Wales.

References



(Figure 4.14) North Clarach. Fold–cleavage–fault relationships on wave-cut platform (modified from map produced by R Johnson, University College of Wales, Aberystwyth, 1977). Localities 1–4 referred to in the text.