Cwm Rheidol

[SN 7005 7955]–[SN 7114 7920]

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Highlights

This site illustrates the morphology and style of small-scale folds which are parasitic to major folds produced during the Caledonian Orogeny; folds on this scale are uncommon in most parts of the Welsh Basin. The site also exhibits the poor cleavage characteristic of west Central Wales, and provides examples of pencil cleavage.

Introduction

The Cwm Rheidol site has been chosen to represent a profile through a series of small-scale folds, developed on the limb of a major fold, the Plynlimon Dome, in a section of Lower Silurian sedimentary rocks. The structures at this site have not been described in the literature, although they resemble those discussed by Tremlett (1982), Craig (1985), and Cave and Haim (1986) in other parts of Central Wales. The Lower Silurian rocks of this region are described by Cave and Haim (1986).

Description

The 1 km-long track section exposes a 400 m-thick succession of well-bedded sandstones, siltstones and mudstones. The succession is the 'right way up' on the evidence of the cross-lamination and ripple-marks which abound in the section. The sheet dip over the whole section is about 20° to the WNW, consistent with its position on the south-west flank of the Plynlimon Dome. The Silurian sedimentary sequence has here been shortened by 17–23%.

Folds occur on several scales, with wavelengths ranging from *c.* 400 m down to 0.10 m; most are in the range 1–10 m (Figure 4.12)A. The folds are upward-facing, according to younging evidence, have upright NNE–SSW axial planes, plunge gently to moderately to the SSW, and are symmetrical or Z-folds in down-plunge profile. The variation in amount of plunge (horizontal to 40°SSW), obtained from stereograms of bedding (Figure 4.12)B, of cleavage-bedding intersections (Figure 4.12)D and direct measurements of fold hinges, is probably due to non-cylindrical fold morphology, although there are indications of two distinct plunge populations.

The folds range from open to close, locally becoming tight with interlimb angles of less than 40°. Anticlines typically have rounded open profiles, whereas most of the synclines are close to tight with narrow hinge zones. This geometrical pattern resembles the cusp-and-lobe, or mullion structure described elsewhere by Sokoutis (1987) and Ramsay and Huber (1987, p. 397). On a smaller scale, cusp-and-lobe style structures are commonly developed in sandstone beds and are clearly seen on many bedding planes; wavelengths are usually in the 0.02–0.10 m range. These small structures, which have nucleated on sedimentary ripple structures in the sandstones in several instances, resemble the cusp-and-furrow described and illustrated by Cave and Haim (1986, Plate 17).

Most folds have Class 1B (parallel) geometry (Ramsay, 1967), but in some of the tighter anticlines and in most synclines the mudstone and siltstone layers have been slightly thickened in hinges to give a Class 1C geometry.

Cleavage is ubiquitous in the siltstones and mudstones, but is uncommon in the sandstones. This fabric is seen at outcrop in fine-grained rocks as closely spaced (0.5–2 mm) surfaces which anastomose and are rough to smooth. Similar cleavage, elsewhere in the region, is seen under the microscope to comprise spaced surfaces along which pressure solution has taken place and very fine phyllosilicates are weakly aligned. The cleavage planes braid around large, detrital quartz grains and large chlorite–white mica stacks which are aligned in bedding. The cleavage in sandstones is poorly developed and widely spaced (more than 0.01 m in most instances).

The cleavage refracts strongly through layers of different ductility. It shows the fanning relationships to folds expected of layer-parallel buckle-folding processes. Statistically, from stereograms, the cleavage strikes 020° and dips 86°E (Figure 4.12)C. Cleavage appears to be essentially axial planar to the folds — compare (Figure 4.12)B, C and D. A pencil cleavage, produced by the intersection between cleavage planes and the strong bedding fabric, is common in the section. Some 400 m from the western end of the site (Figure 4.12), a crenulation cleavage, oriented 023/36°E, overprints the main cleavage. Several bedding planes are striated by fine ridges and grooves which plunge WSW–WNW on westerly-dipping fold limbs, or ENE–ESE on easterly dipping limbs.

Interpretation

The folds in this section have orientations and symmetries consistent with their position in the south-west flank of the Plynlimon Dome, one of the major periclinal Caledonian folds of the Welsh Basin. The variation in plunge implies either non-cylindrical fold shapes or perhaps two populations of folds (Figure 4.12)A and B. The cusp-and-lobe morphology observed at various scales is considered to be due to strong contrasts in ductility of the layers, the sandstones having the greater rigidity. The presence of large-scale structures with this form, the synclines being the cusps, may imply that the section is underlain by a thick rigid layer.

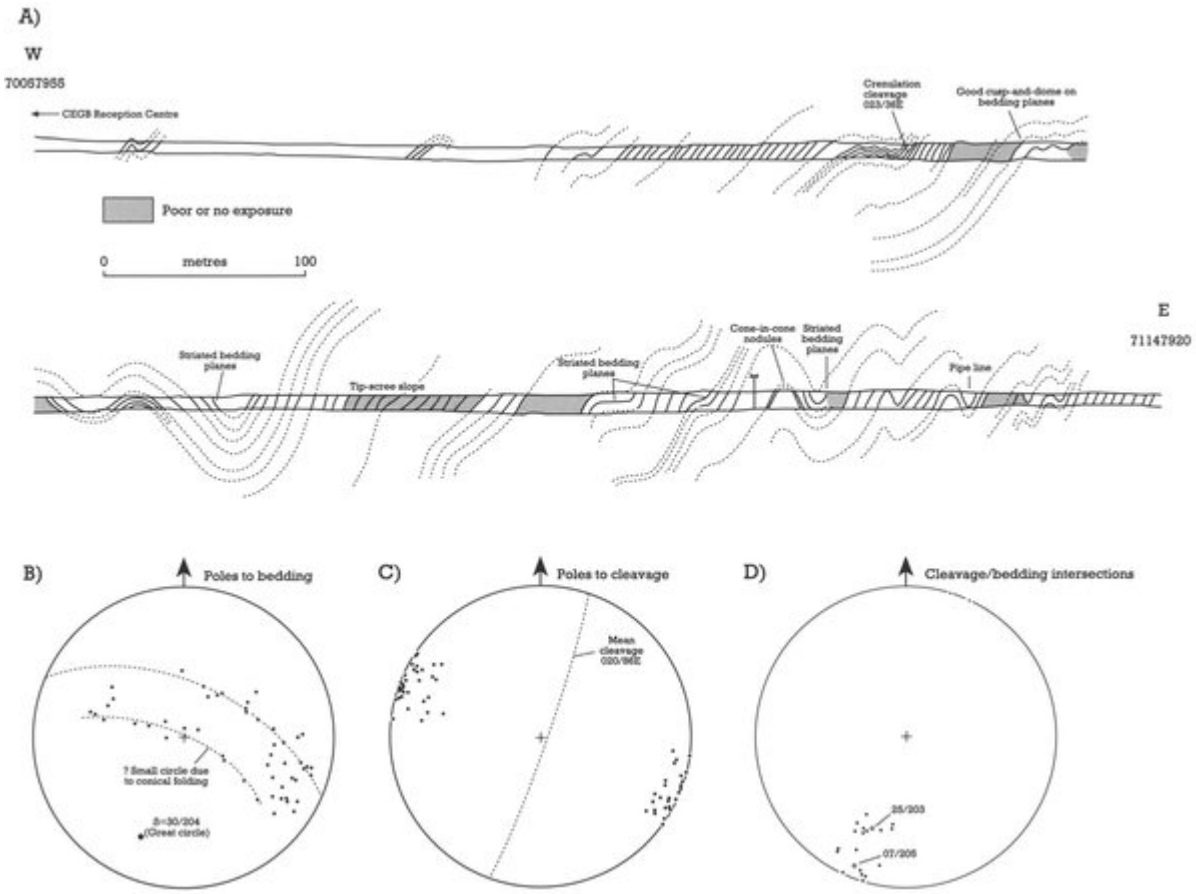
Measurements and calculations made from (Figure 4.12)A reveal that the amount of horizontal shortening accomplished by the folding ranges from 17.5% in the west and centre of the section to 28% in the east. These figures are similar to those obtained by Craig (1985) by measurements of distorted concretions on the Cardigan Bay coast.

The cleavage in the section is typical of the spaced anastomosing fabric which is widely developed in central Wales. Its microscopic characteristics have been described by Craig (1985), for example. The pencil cleavage, caused by intersection of bedding fissility and cleavage, is also found extensively in central Wales, as described by Craig (1985) from the Cardigan Bay coast. Cleavage in the Cwm Rheidol section is parallel with, or fans, with respect to the axial traces of the folds in steep surfaces, and stereo-grams reveal that the fold hinges lie in the cleavage; the hallmark of axial-planar cleavage (Figure 4.12)A–C.

Conclusions

The Cwm Rheidol site provides an almost continuously exposed, 1 km-long profile through Silurian sedimentary rocks (around 440 million years old) that were folded and cleaved during the Caledonian Orogeny (around 400 million years ago). Continuous profiles of this length are exceptionally rare, so the site offers an unusual opportunity to examine the styles, sizes, and orientations of small folds, which themselves are not common in the Welsh Basin. The site shows evidence of at least two phases of Caledonian deformation, the main folding, with associated cleavage (fine, very closely spaced, parallel fractures), and a later wider-spaced cleavage which locally cuts the early set. Moreover, the quality and length of the exposures enables accurate determination of the amounts of crustal shortening responsible for folding; that is, by how much the Earth's crust was compressed and shortened by Caledonian earth movements with consequent vertical extension of the crust. It is very rarely possible elsewhere in the Welsh Basin to make such determinations. This is therefore a valuable cross-section through the south-western flank of the Plynlimon Dome, one of the major periclinal folds of Wales.

References



(Figure 4.12) Cwm Rheidol. (A) Section along track showing bedding attitudes in siltstones and mudstones. Parts (B), (C) and (D) are equal-area stereographic projections of poles to bedding, poles to cleavage, and cleavage-bedding intersections respectively. (B) Dashed lines show great circle and small circle limits of the distribution and the large filled circle gives the pole to the great circle. (C) Dashed line represents mean cleavage attitude. (D) The two mean plunges of the cleavage-bedding intersections (open circles) can be seen to lie on the mean cleavage of (C) as does the pole to the bedding readings in (B).