Limestone Haws to High Pike Haw, Coniston

[SD 279 966]–[SD 255 940]

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Highlights

This site provides the only location for demonstrating the important folding that occurred at the end of mid-Ordovician volcanicity. Folded Borrowdale Group volcanics are spectacularly overstepped by the later sediments. The locality also exposes late-Caledonian strike-slip faults, which abruptly turn into thrusts along incompetent shales.

Introduction

This classic area includes outcrops in the upper part of the Borrowdale Volcanic Group and the overlying sedimentary rocks, now assigned to the Windermere Group (Ordovician–Silurian). The extinction of the Borrowdale 'volcano', an event almost certainly related to partial closure of the Iapetus Ocean, near the end of the Ordovician (Williams, 1975; Moseley, 1977), was followed by, or was contemporaneous with, the intrusion of the Ordovician component of the Lake District batholith (Firman and Lee, 1986; Soper, 1987). It is likely that these events resulted in uplift, folding, and erosion before the Late Ordovician Coniston Limestone was laid down unconformably upon the volcanics.

The best documented of these pre-Coniston Limestone Formation folds is the Ulpha Syncline, recognized by Aveline *et al.* (1888), Mitchell (1956a) and Firman (1957), mapped by Numan (1974) and discussed by Soper and Numan (1974), Soper and Moseley (1978), and, more recently, by Branney and Soper (1988). This major E–W trending fold has assumed some importance as being an indication of Late-Ordovician compression, clearly pre-dating the late-Caledonian deformation represented by cross-cutting cleavage. Branney and Soper (1988), however, have removed the effects of later cleavage-related deformation and rotated the fold limbs to their pre-Coniston Limestone attitudes. The resulting fold is a weak monoclinal flexure which they consider more compatible with bending that would have been associated with foundering of the volcanic pile.

The final closure of Iapetus resulted in continental collision, and strong folding and cleavage across the whole of the Lake District. The major fold, affecting the Coniston area, was the Wrynose anticline, the south-east limb of which extends 8 km from Wrynose Pass to Coniston Water and has resulted in the steep south-easterly dips in both the Borrowdale Group volcanics and the lower part of the Windermere Group (Mitchell, 1940; Soper and Moseley, 1978) seen here.

Subsequent to the folding, the latest adjustments to the closing of Iapetus were by strike-slip faulting, often sinistral in displacement (Soper and Hutton, 1984). In the Lake District (Moseley, 1972), the large faults, such as the Coniston Fault, are north-trending with sinistral displacement, but an important north-west-trending set with dextral displacement are particularly well seen along the Borrowdale–Windermere Group boundary. Many of these faults turn into low-angle thrusts above the volcanics, particularly utilizing the fissile black shales of the Skelgill Beds.

Description

Faulting near Limestone Haws and the Walna Scar Track

[SD 279 965] and (Figure 3.14)A

The volcanic structures, in this area, are difficult to determine, the lithology being mostly ignimbritic breccia of probable laharic origin (Yewdale Breccia Formation), with little indication of the dip. The breccia is overlain by the Long Sleddale Member, a tuffaceous sandstone with occasional brachiopods, followed by members of the Coniston Limestone Formation (Moseley, 1983, 1984). At High Pike Haw, a fold (the Ulpha Syncline) in the Yewdale Breccia is overstepped

by the Coniston Limestone. Dips in the latter are steep, generally between 60° and 80° to the ESE. This sequence is overlain, discordantly, by the Skelgill Member (Llandovery Series), and could easily be interpreted as an unconformity. However, the Skelgill Member, where well exposed, is seen to be much thicker than the space available in the narrow marshy gully between the Coniston Limestone Formation and the Browgill Beds (Figure 3.14A), and this implies the presence of a strike fault. The Skelgill Member comprises black, highly incompetent graptolitic mudstones, known from many outcrops across the Lake District to be followed by thrusts, subparallel to bedding. The discordance, therefore, is attributed to thrusting rather than to an unconformity. It is noticeable that the dip faults, clearly seen above the Walna Scar track, probably small wrench faults, terminate at this horizon and the suggestion is that they are linked wrench-thrust faults (Soper and Moseley, 1978).

Faulting from Flask Brow [SD 270 960] to Ashgill Quarry [SD 269 954]

(Figure 3.14)B and (Figure 3.14)C

In the area between Torver Beck and Ashgill Quarry, there are approximately ten dip faults which displace the Borrowdale Group–Coniston Limestone Formation junction. They have northwesterly trends and are likely to be dextral wrench faults with strike-slip displacements of up to 100 m. Most of the faults do not cross the Skelgill Member outcrop but are believed to rotate into thrusts, as described above. Between the Torver Beck tributaries [SD 276 962] and Ashgill Quarry (Figure 3.14)B and (Figure 3.14)C; Moseley, 1983) the junction between the Borrowdale Volcanic Group and the Applethwaite Member (Coniston Limestone Formation), can be seen to be displaced. The fault at the south-west end of Ashgill Quarry is, however, different in that it does, also, displace the Skelgill Member, by some 70 m (Figure 3.14)C. A strike fault seen in the quarry (Figure 3.14B) also displaces the member.

The Caradoc unconformity at High Pike Haw

At [SD 260 950], the Coniston Limestone Formation (Windermere Group) oversteps the Ulpha Syncline — see (Figure 3.15); based on Soper and Numan (1974) and Branney and Soper (1988). In so doing, it cuts across more than 600 m of the Borrowdale Volcanic Group, including the Yewdale Breccia, Yewdale Bedded Tuff, and the Tilberthwaite Tuff Formations (Mitchell, 1940; Soper and Moseley, 1978; Soper, 1987; Branney and Soper, 1988). (Figure 3.4) shows form lines for bedding in the principal areas of exposure in the volcanics, and strike and dip values for exposures in the clearly unconformable Coniston Limestone Formation.

The north limb of this fold strikes 045°, with moderate to steep dip south-east, while the south limb has an average N–S strike, dipping moderately east, with variations due to medium-scale folding. The fold has a plunge gently to the ENE, has an interlimb angle of 115°, an amplitude of 4 km and a half wavelength of 8 km. The cleavage also strikes ENE, some 20°–30° anticlockwise of the fold axial-plane trace. The overstepping Coniston Formation has a constant north-easterly strike and moderate south-easterly dip, clearly oblique to that in the Borrowdale Group volcanics (particularly around [SD 265 950]), but it shares a common cleavage orientation with those rocks.

Interpretation

The Ulpha Syncline is the one fold structure in the Borrowdale Volcanic Group that can be clearly demonstrated to pre-date the Coniston Limestone Formation (Windermere Group). Cleavage of late-Caledonian age, equally clearly, cross-cuts both the fold and the unconformity. The phase of Late Ordovician folding demonstrated by the syncline has been credited with considerable importance in the history of the Lake District (Soper and Numan, 1974) and has been used to support the hypothesis that the closure of Iapetus essentially occurred in the Ordovician (Murphy and Hutton, 1986). The demonstration, however, by Branney and Soper (1988) that this fold was an open monocline, before Windermere Group sedimentation, has reduced its significance; it is now associated with Borrowdale Group volcanotectonic faulting and block-tilting connected with caldera collapse.

It is quite clear that most of the NW-trending faults that cut the Borrowdale Volcanic Group and the Coniston Limestone Formation do not displace the early Silurian Skelgill Beds and higher formations. From the relationships seen, it seems most likely that the faults must be linked strike-slip/thrust structures. Thus the site demonstrates that one of the

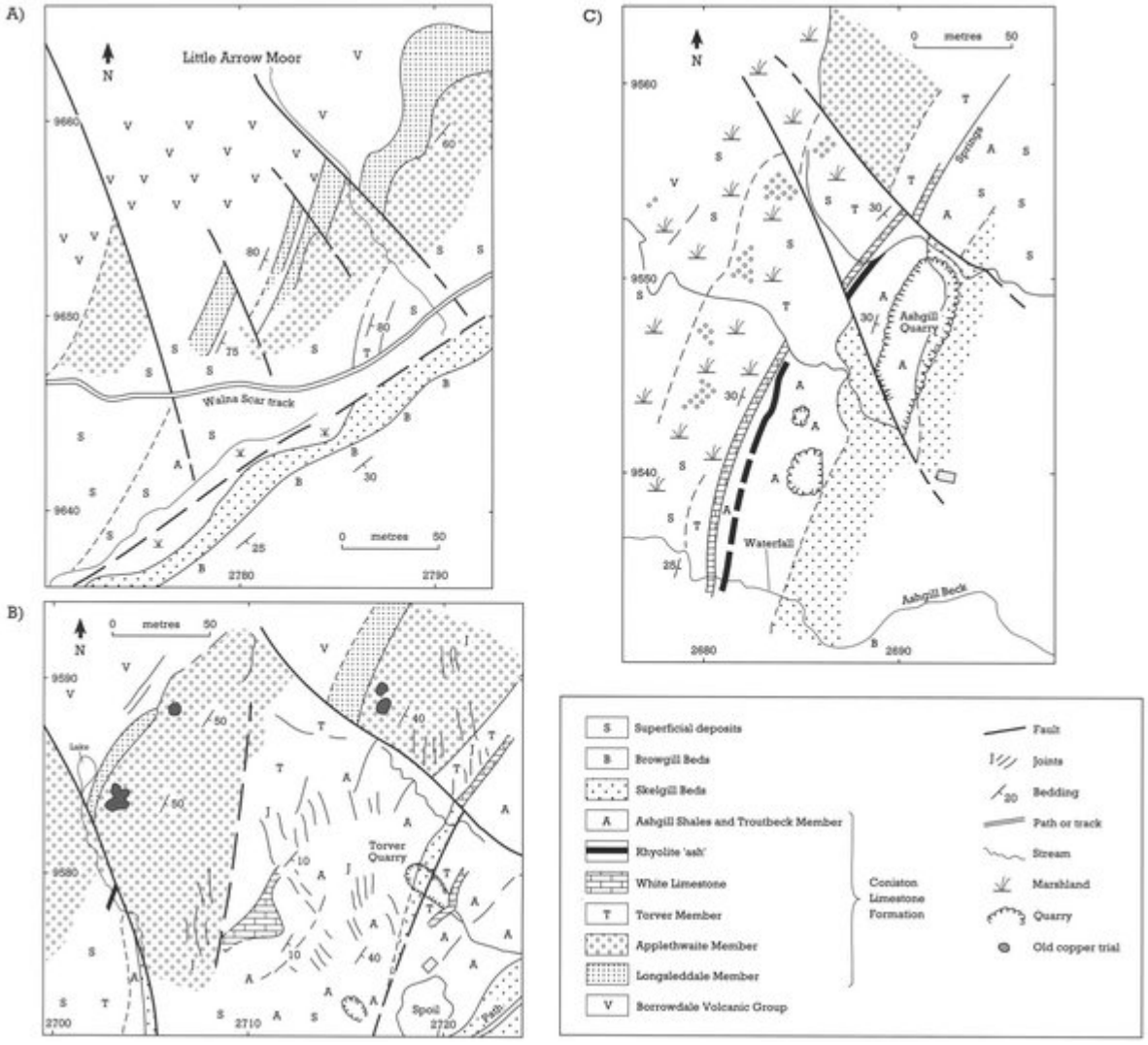
pre-Coniston (Limestone Formation) fold structures in the Borrowdale Group is not a significant tectonic structure but rather of volcanotectonic origin. Some of the late, northwest-trending faults in this area terminate as thrust structures within the bedding.

Conclusions

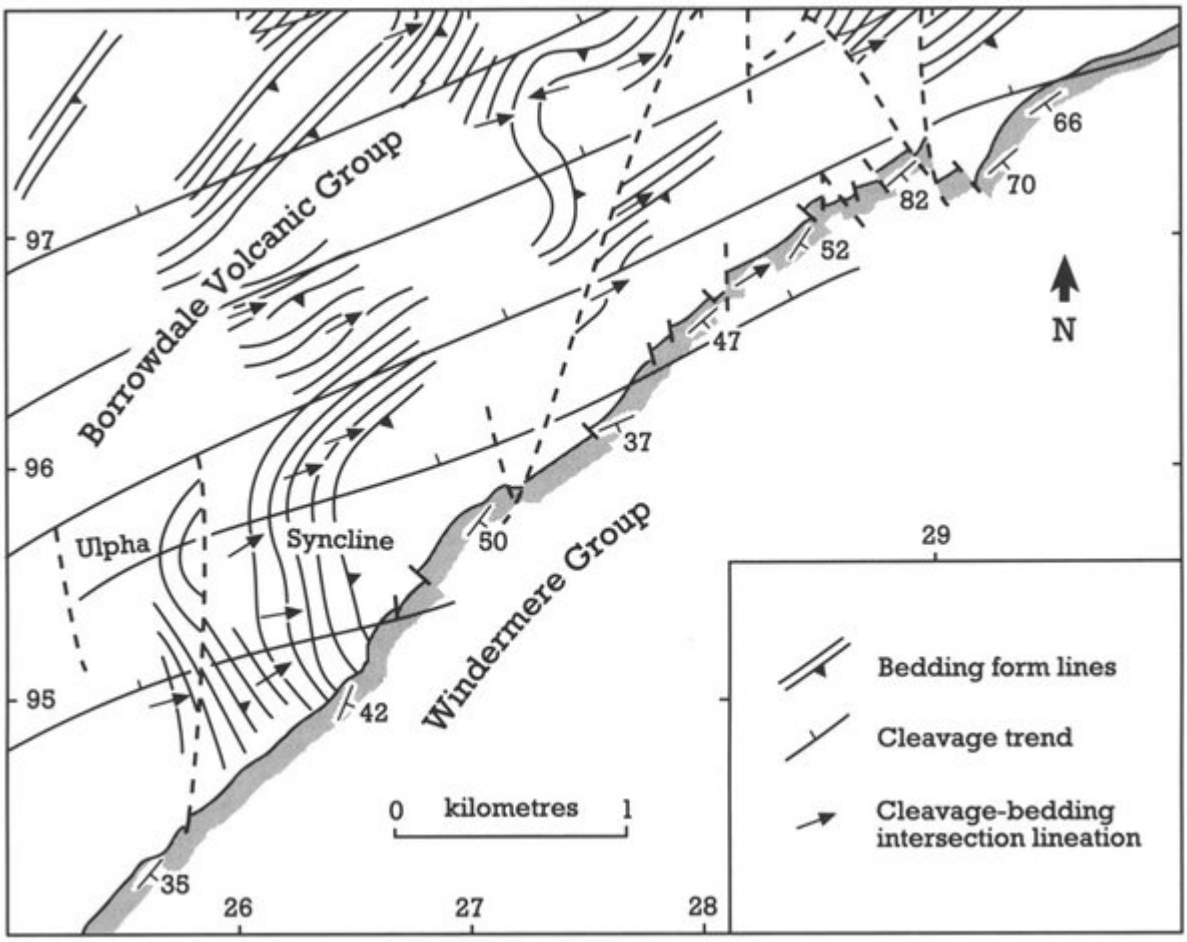
The Ulpha Syncline is an important structure that was produced as the result of Ordovician volcanic events. It has considerable bearing on hypotheses regarding the history of closure of Iapetus Ocean. The principal locality is important as the only area where the unconformity of the Coniston Limestone Formation (Windermere Group) with the underlying folded Borrowdale Group volcanics can be demonstrated. Adjacent localities are important, not only for providing a rare opportunity to examine and demonstrate the displacement of the NW-trending faults, but also for the clear evidence that these strike-slip faults must pass upwards into low-angle thrusts.

Formerly, folding in the Borrowdale Group volcanics was taken to be evidence that the Iapetus closed, with associated compression, during the Ordovician Period (around 450 million years before the present). However, current thinking assigns this deformation to movements connected with the collapse of the main lava chamber of an ancient volcano.

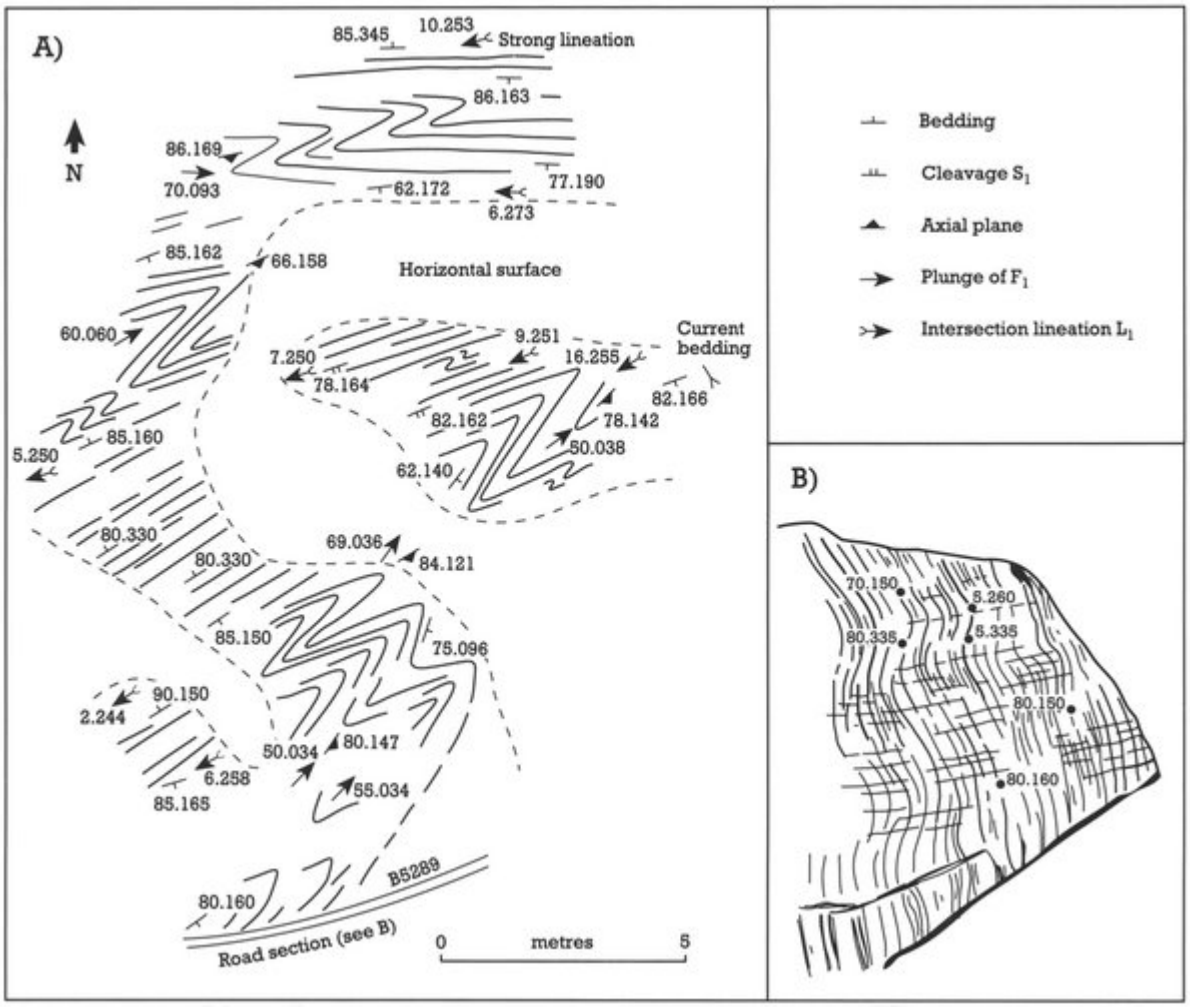
References



(Figure 3.14)A, B, and C (on pages 80 and 81) Geological maps illustrating the nature of the faulting in three areas within the Limestone Haws–High Pike Haw, Coniston site (after Moseley, 1990, Figure 52B, C and D). (A) South side of Little Arrow Moor. (B) Area around Torver Quarry. (C) Area around Ashgill Quarry.



(Figure 3.15) Structural map of the Ulpha Syncline at Torver High Common (after Soper and Numan, 1974; Soper and Moseley, 1978, figure 24).



(Figure 3.4) Skiddaw Group exposures, near Buttermere. (A) is a horizontal surface. (B) Vertical roadside section in (A) looking towards 060°. Three fold phases are represented in these exposures. The steep plunge of the folds represents the dip of a limb fold, initiated during F_0. The D_1 phase is represented by the tight ENE–WSW folds and related cleavage, and D2 by open recumbent folds and crenulation cleavage which can only be viewed on vertical surfaces, where the other two phases cannot be seen (after Moseley, 1981, and notes by D. Aldiss B.Sc. thesis, Birmingham University, 1974).