Tebay Cuttings

[NY 6079 0075]–[NY 6074 0140] and [NY 6090 0180]–[NY 6104 0239]

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Introduction

This site consists of two of a number of substantial cuttings created where roads and a railway are confined within the narrow Lune Gorge, near Tebay village, about 16 km NNE of Kendal, Cumbria (Figure 3.49). The accessible cuttings border the west side of the A685 road, 2–4 km south of Tebay. They expose the Coniston Group (Windermere Supergroup), a thick lower Ludlow (Gorstian) sequence dominated by sand turbidites.

The history of study and nomenclature of the Coniston Group, including the primary work of Sedgwick (1845) and that of Marr (1927), has been detailed by Kneller *et al.* (1994). The upper boundary of Sedgwick's Coniston 'Grits' lies just up-section to the north from the Tebay cuttings.

The Coniston Group has two formations, the Latrigg and Moorhowe, dominated by laminated mudstones, separating three sandstone-rich formations, the Gawthwaite, Poolscar and Yewbank (Kneller *et al.,* 1994). King (1992) recognized the upper three formations at Tebay, the Poolscar in the southern roadcut, the Yewbank in the northern cut, and the intervening Moorhowe in the valley between them. However, new mapping by Soper (pers. comm., 1997) shows that the Moorhowe Formation thins eastward and disappears before reaching the Lune Gorge. The Coniston Group at Tebay does contain some intervals of laminated mudstones, but these do not correlate with the Latrig or Moorhowe formations, and they have not been given formal lithostratigraphical status. This uncertainty does not detract from the importance of the roadcuts as continuous sections through the main lithologies of the regionally extensive Coniston Group.

Description

The Coniston Group lies entirely within the *nilssoni–scanicus* biozones of the Gorstian Stage (Kneller *et al.,* 1994; Cocks' *et al.*, 1992). However, this biostratigraphical assignment relies on regional correlation, as fossils are rare in the Tebay sections. Graptolites from the north end of the northern roadcut have indicated only a broadly Ludlow age (R.B. Rickards, pers comm., 1997).

The Coniston Group typically comprises four main lithofacies, interbedded in differing proportions in the sandstone-rich and sandstone-poor formations respectively (King, 1992). All four lithofacies (labelled B, C, D and E following the scheme of Pickering *et al.,* 1989) are interpreted as turbiditic or related deep-marine sediments and can all be observed in a 35 m thick section in the northern roadcut (Figure 5.74).

Facies B sandstones

Fine- to very fine-grained sandstone in medium to thick beds, but lacking the upward grading into mudstone that characterizes Facies C, occur sporadically throughout the section (e.g. at 1.5 m; (Figure 5.74)). Such beds are massive to cross-laminated, and usually eroded by the base of the succeeding sandstone bed.

Facies C sandstone–mudstone couplets

The predominant facies in the sandstone-rich intervals of the Coniston Group comprises medium to thick beds of fine- to very fine-sandstone grading up into mudstone (e.g. between 5 m and 7.5 m; (Figure 5.74)), deposited from high concentration turbidity flows. The beds typically preserve Bouma divisions T_a to T_d, with thin hemipelagic muds of division T_e sometimes discernible. The transition from sandstone to mudstone is usually rapid. Bed bases may preserve flutes and grooves, whose mean direction in the Tebay area indicates palaeoflow towards WSW By contrast, ripple

cross-lamination shows a mean southward palaeoflow. Divergence between flow indicators at the base and in the body of turbidite beds is common throughout the Coniston Group (Kneller *et al.,* 1991).

Fades D siltstone–mudstone couplets

About a third of the logged section (Figure 5.74) comprises thin to medium beds of siltstone or very fine-sandstone grading up to mudstone (e.g between 8 m and 9.5 m). This facies forms an important component, together with Facies E, of the sandstone-poor formations of the Coniston Group farther west such as the Moorhowe, and constitutes most of the Bannisdale Formation that overlies the Coniston Group. Cross-lamination, indicating mean southward palaeoflow, is common in the sandstone intervals of this facies but they may be also massive. The transition from sandstone to mudstone is often rapid, or proceeds through fading ripples of sand, grading down-current into mud. In the logged section (Figure 5.74) Facies D turbidites typically occur as intervals 0.5 m to 5 m thick between intervals of Facies C turbidites. Individual beds of Facies D also punctuate intervals of the hemipelagic Facies E (e.g. between 17 m and 19 m); see (Figure 5.75).

Facies E mudstones

The characteristic facies of the sandstone-poor intervals of the Coniston Group is this dark grey, finely laminated, graptolitic, carbonaceous silty mudstone. This facies has been described extensively from other Lower Palaeozoic sequences, often by the term 'laminated hemipelagite' (e.g. Dimberline *et al.,* 1990; Kemp, 1991). The distinctive lamination is defined by alternation of carbonaceous laminae with silty mud laminae. The average thickness of each silty mud–carbon couplet in the Coniston Group is between 0.3 mm and 0.4 mm (King, 1992). However, this spacing increases to about 0.8 mm in the upper parts of the group, by increase in thickness of the silt-mud component. Intervals of this 'expanded' hemipelagite occur between 17 m and 19 m in the logged Yewbank Formation section (Figure 5.74). The hemipelagic mudstone is interbedded with isolated thin beds of Facies D turbidites (Figure 5.75).

Interpretation

The Tebay sections are interpreted in terms of sporadic turbidity currents advancing from the north-east or north over a marine basinal plain.

There are two conflicting hypotheses for forming the Facies E mudstones. Kemp (1991) said they represent very fine-grained turbidity flows that deposited discontinuous films of algal organic material in intimate association with clay and fine silt. In this hypothesis, a number of carbon and silty mud laminae are deposited during one event, and their continuity is then enhanced by later compaction. According to Dimberline *et al.* (1990) Facies E records the background lamina-by-lamina rain of fine-grained sediment that would have accumulated in the marine basin in the absence of direct input from turbidity flows. This background sedimentation was itself spasmodic, with the lamination reflecting fluctuation in either or both organic productivity and silt supply. An attractive hypothesis is that this fluctuation represents an annual climatic cycle of high warm-season productivity with high wet-season sediment run-off (Dimberline *et al.,* 1990) similar to that described from recent basins on the California Borderland (Thornton, 1984). Estimates of the lamination frequency in the Brathay Formation of the Lake District, using graptolite biozonation and its chronometric calibration (King, 1992), suggest a periodicity of 3 or 4 years. A near-annual driving influence is not precluded by this observation, given the potential for erosion and non-preservation of laminae. A persuasive observation in favour of the hemipelagic rather than turbiditic origin of Facies E in the Coniston Group is the remarkable continuity and vertical regularity of the lamination, once it is expanded by thicker silt laminae (King, 1992). On either hypothesis, the lack of bioturbation in Facies E implies a sparse or absent benthic fauna, and probable dysaerobic to anaerobic bottom waters.

The remaining three facies are all uncontroversially interpreted as the products of intermittent deposition from turbidity currents. Facies D siltstone–mudstone couplets derive from low-concentration turbidity currents, flowing approximately southwards as they overwhelmed the Tebay area. These currents were intermittently active both during times of quiescent deposition of Facies E mudstones and during the more energetic periods of Facies C deposition. Facies C sandstone–mudstone couplets derive from high-concentration currents carrying mostly fine or very fine sand. Each flow

probably originated north-east of the Tebay area, and initially flowed WS'W, parallel to the mean direction of flute and groove marks. However, later parts of each flow tended to flow southward, as indicated by the ripple cross-lamination in the T, divisions of the turbidite beds. A bounding slope to the north or north-west of the basin may explain this discrepancy, either by the influence of solitary waves relected off the slope (Kneller *et al.,* 1991; King, 1992), or by deflection of the whole flow by the slope, as suggested in the Welsh Basin (Clayton, 1993). The Facies B sandstones are also interpreted as the products of high-concentration turbidity flows. These beds are commonly amalgamated with overlying beds of Fades B or C, and they probably lack their muddy beds tops due to erosion by the succeeding current, rather than by non-deposition.

The Coniston Group turbidites were deposited during the collision of the Eastern Avalonian microcontinent, on which they rest, with the edge of the Laurentian continent represented by the Southern Uplands of Scotland to the northwest. Soper and Woodcock (1990) regarded the Coniston Group as sand supplied from Laurentia onto the underthrusting margin of the Avalonian continent. The increasing sediment accumulation rate during Windermere Supergroup deposition was interpreted by Kneller (1991) and Kneller *et al.* (1993) as the signal of flexural subsidence of the north-western edge of the Avalonian lithosphere, in a foreland basin due to thrust loading of Laurentia. Isotopic evidence implies that the source of the Coniston Group sediments may not have been locally from Laurentia, but from its collision zone with Baltica, some distance to the north-east (McCaffery and Kneller, 1996).

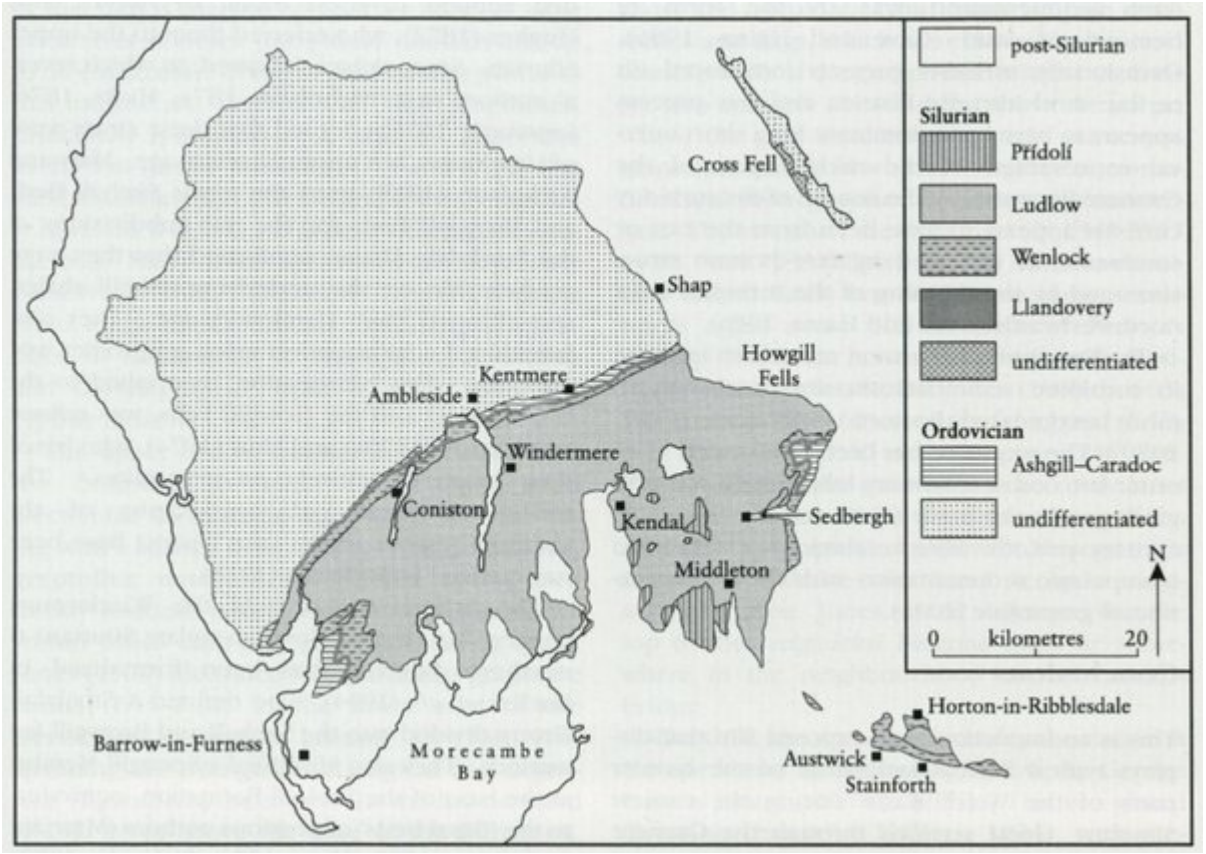
Locally, the Coniston Group turbidity flows seem to have been directed axially into the asymmetric foreland basin, with a relatively steep north-western slope and a more gentle slope on its south-eastern margin. Palaeocurrents in the Howgill Fells, to the south-east of Tebay, suggest the complication of an intrabasinal south-west facing slope here (King, 1992). Flows were deflected by, or reflected off, these bounding slopes to give the observed divergence of basal and intrabed flow indicators. Periods of high sand input, producing the three sandstone-rich formations, alternated with periods dominated by mud input, either controlled by sea-level variation or tectonic controls on sediment supply.

The Tebay GCR site typifies the turbidite deposition that accounts for the greatest thickness of Ludlow Series deposits in the Lake District Basin. It complements three sites in later Ludlow and P■ídolí rocks of the Lake District, at Hills Quarry, Benson Knott and The Helm, which record the progressive shallowing of the basin when flexural subsidence waned in late Silurian time. The Ludlow Series turbidites at Tebay also offer an instructive comparison with the contemporaneous turbidites of the northern Welsh Basin (at GCR site Ty'n-y-Ffordd Quarry), with the storm-influenced deposits on the Welsh Basin margin (Mithil Brook and Cwm Blithus) and with the shallow marine deposits of the Midland Platform (e.g. sites in the Ludlow area).

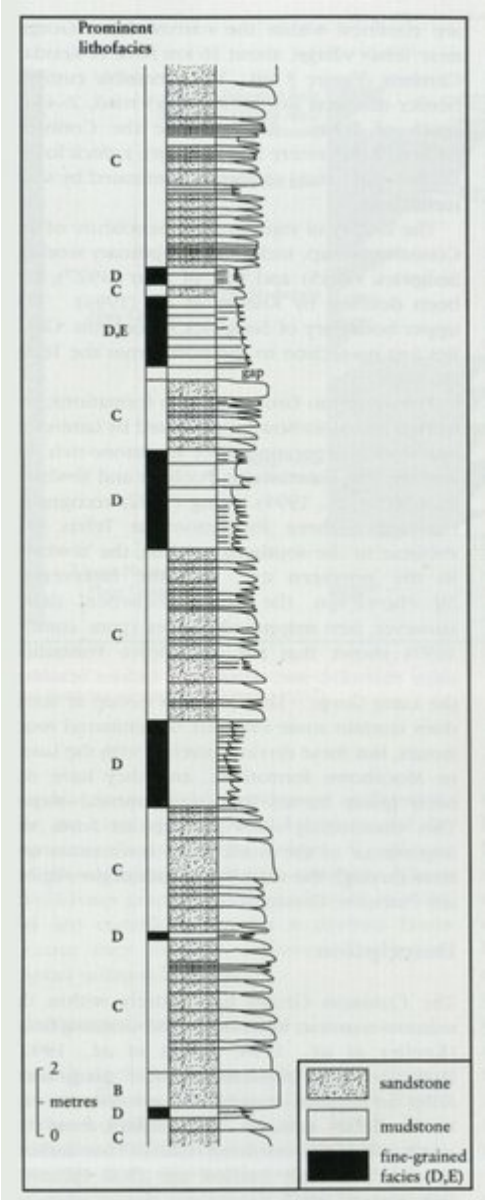
Conclusions

This site is primarily of sedimentological and palaeogeographical significance. The Tebay roadcuts offer accessible, clean, continuous exposures of the mainly turbiditic Coniston Group. Although their strata cannot yet be dated precisely within the Gorstian, they superbly illustrate the typical turbidite and hemipelagite facies deposited in the Lake District Basin during Ludlow time.

References



(Figure 3.49) Outline geological map of the Lake District and Howgill Fells (modified after Rickards, 1989a).



(Figure 5.74) Lithological log of the Yewbank Formation, Coniston Group, in the northern Tebay roadcut, Cumbria, between numbered fence post 33 at [NY 6098 0194] and post 66 at [NY 6102 0206] (modified from King, 1992). The prominent lithofacies (B, C, D and E; see text) follow the scheme of Pickering et al. (1989).

(Figure 5.75) Coniston Group, Gorstian Stage, Tebay Cutting, Cumbria. The photograph shows laminated hemipelagic mudstones with intercalated turbidite, comprising a silt-mud interlaminated base overlain by homogenous mud; dark interval on staff = 10 cm. (Photo: N.H. Woodcock.)