Torver–Ashgill

[SD 276 955]

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Introduction

This site is located in the western part of the Lake District, near Coniston (Figure 3.49). It comprises the nearly continuous stream sections of Torver Beck [SD 2763 9617]–[SD 2847 9545] and Ashgill Beck [SD 2700 9532]–[SD 2757 9484], together with considerable rock exposure in the intervening ground that includes the disused Banishead quarries [SD 2782 9600]. Historically, the Wenlock strata of the Lake District were studied in particular by Marr (1878, 1892, 1916, 1927). More recent revision of the lithostratigraphy and biostratigraphy of these rocks has been made through, notably, the work of Rickards (1969, 1970b, 1978, 1989a), Kneller (1990) and Kneller *et al.* (1994).

The Wenlock succession of the Torver–Ashgill site displays the three component formations (of Kneller *et al.,* 1994) — Brathay, Birk Riggs, and Coldwell — typical of the western and central Lake District. Additionally, Torver and Ashgill becks offer exposure through the underlying Stockdale Group (Llandovery Series) down into the Dent Group (Ashgill Series, upper Ordovician), and upsequence into the overlying Wray Castle Formation and Coniston Group (Ludlow Series).

Thus, the Wenlock succession characteristic of the western and central parts of the Lake District can be examined here both in its own right and in its regional stratigraphical context. The site also contains a nearly complete suite of Wenlock graptolite biozones, which enable long-range correlation.

Description

The structure hosting the Wenlock succession is relatively simple (British Geological Survey, 1998). Beds, which form part of the Windermere Supergroup, strike NE–SW and dip to the south-east at between 40° and 60° (Figure 4.59). A cleavage cuts fine-grained lithologies, dipping north-west at about 60°. The Park Gill Thrust follows the top of the Wenlock succession, but the amount of structural repetition here is minor. Sub-vertical faults, mostly north-trending, cause some displacement.

The Brathay Formation, the Brathay Flags of Marr (1878), makes up the lower 160 m of the Wenlock succession. Although the formation was originally defined at Brathay Quarries (see GCR site report), Kneller (1990) proposed an alternative type section in Ashgill Beck [SD 2711 9525]. The typical lithology of the formation is dark grey laminated siltstone. The lamination comprises couplets of muddy quartzose silt overlain by carbonaceous mudstone, on a scale of about 3 couplets to a millimetre. However, the basal 10–30 m of the formation is transitional from more homogeneous grey siltstones at the top of the underlying Browgill Formation (Llandovery Series). It contains burrow mottling, diffuse at the base, and better-defined higher up, together with intercalated bands of the laminated siltstone facies. This basal unit is termed the Dixon Ground Member (Kneller *et al.,* 1994).

Rickards (1969) established eight graptolite biozones in the Brathay Formation, ranging from *centrifugus* to *lundgreni* (Figure 4.60). The *ellesae* Biozone was not verified by him, but he thought it unlikely that it is missing. This biozonation allowed the recognition of subtle, but laterally continuous, lithological markers in the Brathay Flags. A 10 cm calcareous nodule horizon occurs at the top of the *centrifugus* Biozone, about 15 m above the top of the Dixon Ground member, which lies entirely in this biozone. Graptolites are preserved flattened rather than as pyrite replacements above the middle of the *murchisoni* Biozone, and thin turbiditic sandstones occur in the *riccartonensis* Biozone. Above this level, the siltstone grain size gradually increases, thin mud turbidite beds appear, and carbonate nodules increase in frequency and size. Rare shelly fossils — crinoids, corals and brachiopods — become more common up through this part of the succession. Bentonitic clays occur sporadically through the whole of the Brathay Formation.

The Birk Riggs Formation, in part the Grit Band 1 of Aveline and Hughes (1872) and the Lower Coldwell Beds of Marr (1878), is characterized by thin to very thick sandstone–mudstone couplets. The sandstone is fine- to medium-grained quartz-rich wacke. Sandstone-rich facies is interbedded with a sandstone-poor facies comprising thin-bedded graded siltstone–mudstone couplets, intercalated with intervals of laminated siltstone persisting from the Brathay Formation. The laminated siltstone yields graptolites that place the Birk Riggs Formation within the *lundgreni* Biozone (Rickards, 1969, 1970b).

The Birk Riggs Formation has both its thickest development (360 m) and its type locality, Birk Riggs [SD 2797 9537], within the Torver–Ashgill site. The formation thins both south-westward and north-eastward, in which latter direction it pinches out east of Lake Windermere. Flute and groove moulds suggest palaeoflow to the N–NE, and ripple cross-lamination flow to the S–SE (Kneller, 1990; McCaffrey, 1991).

The top of the Wenlock succession is marked by the Coldwell Formation, the Coldwell Beds of Aveline and Hughes (1872) and the Middle Coldwell Beds of Marr (1878). This unit was named after Cold Well Quarry, which is part of the Brathay Quarries GCR site, but the alternative type section proposed by Kneller (1990) lies within the Torver–Ashgill site, east of Birk Riggs [SD 2808 9536]–[SD 2814 9529]. Here the Coldwell Formation is 30 m thick, although it thickens north-eastward to over 80 m. The formation is distinguished by two units of pale blue-grey calcareous siltstone separated by dark grey lami nated siltstone similar to that in the Brathay Formation. The lower and upper calcareous siltstones have been distinguished as the Randy Pike Member and High Cross Member respectively (Kneller, 1990; Kneller *et al.,* 1994). The High Cross Member itself contains significant intercalations of laminated siltstone.

The Randy Pike Member of the Coldwell Formation contains a shelly fauna comprising the trilobite *Delops obtusicaudatus* and the bivalve *Slava interrupta,* together with crinoid ossicles, brachiopod fragments and orthoconic nautiloids. Laminated siltstone intercalations in the Randy Pike Member yield graptolites characteristic of the *nassa* Biozone, as does the central siltstone unit of the formation (Rickards, 1970b). Graptolites of the *ludensis* Biozone are found immediately below the High Cross Member and a *nilssoni* Biozone fauna (lowest Ludlow Series) in a laminated siltstone 3 m from its top (Rickards, 1970b; Kneller, 1990). The shelly fauna in the High Cross Member is more sparse than in the Randy Pike Member. The biozonation of the Coldwell Formation shows that it spans the highest two Wenlock graptolite biozones and just extends into Ludlow time (see, for example, Cocks *et al.,* 1992).

The top of the Coldwell Formation coincides with the base of the 300 m thick Wray Castle Formation (*nilssoni* Biozone, Ludlow Series), characterized by further laminated siltstone units with subordinate graded mudstone beds.

Interpretation

The depositional character of the Wenlock succession was influenced by two main factors: the amount of sand and coarse silt being supplied to the depositional basin and the degree of oxygenation of the marine bottom waters.

No sand reached the Lake District Basin during early Wenlock (Sheinwoodian) time. The base of the Wenlock coincides with the beginning of a transition from the oxic conditions recorded by the thoroughly bioturbated mudstones of the Browgill Formation (Llandovery Series), through the dysaerobic deposits of the Dixon Ground Member to the anaerobic conditions that characterize the bulk of the Brathay Formation. This environment is implied by the lack of bioturbation in the laminated siltstone together with the sparse or absent benthic fauna. There has been some debate as to whether the laminated siltstones were deposited lamina by lamina as a hemipelagic sediment, or by low-concentration turbidity flows that produced internal parallel lamination (see Marr, 1927; Rickards, 1964; Dimberline *et* W., 1990; Kemp, 1991). This debate is discussed more fully for the typical Brathay Formation deposits in the River Rawthey GCR site report.

The amount of land-derived silt supplied to the basin increased through Wenlock time, culminating in the burst of sand-rich deposition that gave rise to the Birk Riggs Formation within the *lundgreni* Biozone. This sand was transported and deposited by medium- to high-concentration turbidity flows (McCaffrey, 1991). These flows probably travelled axially along troughs in the submarine topography, with the discrepant cross-lamination palaeoflows being due to reflection off bounding topographical slopes (Kneller *et al.,* 1991). These south-east directed slopes and apparent direction of sediment supply have been taken to indicate the first influx of Laurentian sediment across a rapidly-closing Iapetus

Ocean (Soper and Woodcock, 1990). However, the original provenance of the Birk Riggs sediment was most probably from the Avalonia-Baltica side of the Iapetus Ocean, recycled through the Scandian (Baltica–Laurentia) collision zone (McCaffrey *et al.,* 1992; McCaffrey and Kneller, 1996).

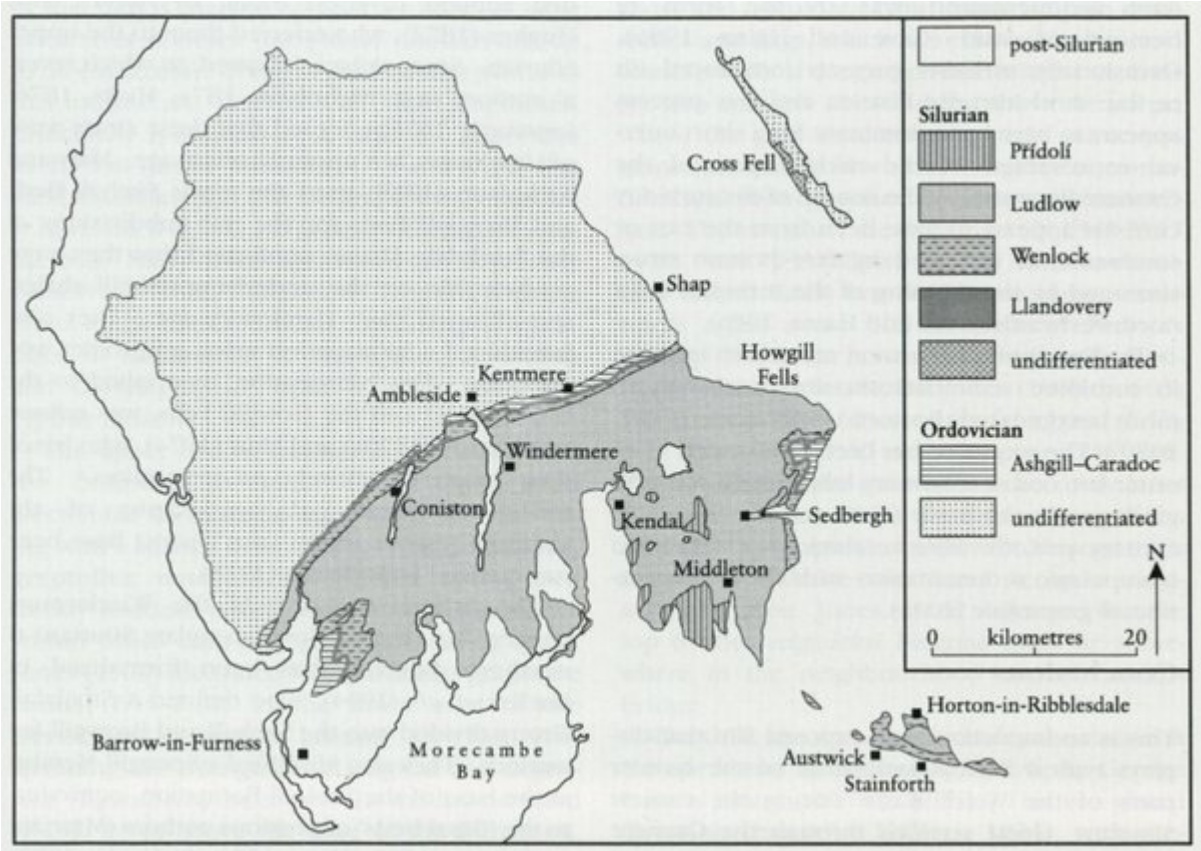
The calcareous horizons of the Coldwell Formation coincide with well-established global falls in sea level (Kemp, 1991). The lowstands resulted in oxygenation of the bottom waters of the Lake District basin, allowing the establishment of a low-diversity shelly benthos. The laminated siltstone horizons record intervening highstands, and the transition to the overlying Wray Castle Formation the return to more persistent anaerobic conditions during early Ludlow time.

The Torver–Ashgill site is very closely linked to the nearby, historically important Brathay Quarries site, which has similar lithostratigraphical units of Wenlock age exposed, though less completely so. Other related northern England sites include the River Rawthey in the Howgill Fells and, to a lesser extent, Arcow Quarry in the Horton-in-Ribblesdale area.

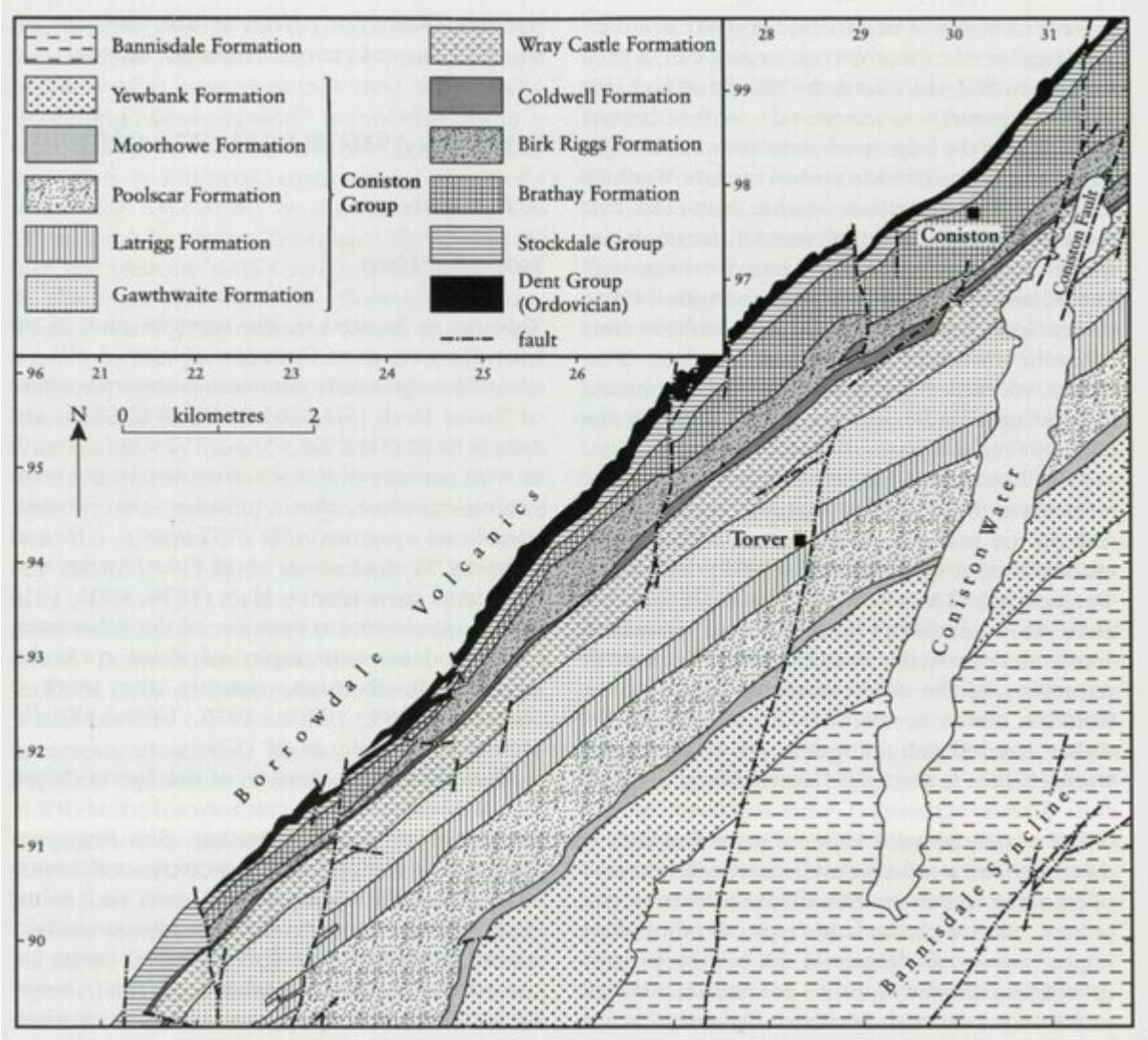
Conclusions

The Torver–Ashgill site provides high-quality sections through the typical Wenlock succession of the western and central Lake District. It can be studied here in the context of a continuous succession from late Ordovician (Ashgill) to late Silurian (Ludlow) strata. The biostratigraphical control is excellent, and allows regional and international correlation of the Wenlock sequence. The site includes the revised type localities for the three regionally important formations of Wenlock age, the Brathay, Birk Riggs and Coldwell formations. The Birk Riggs Formation records the first pulse of sand-rich sediment supplied to the Lake District Basin, and provides crucial evidence in the ongoing debate about the timing of closure of the Iapetus Ocean.

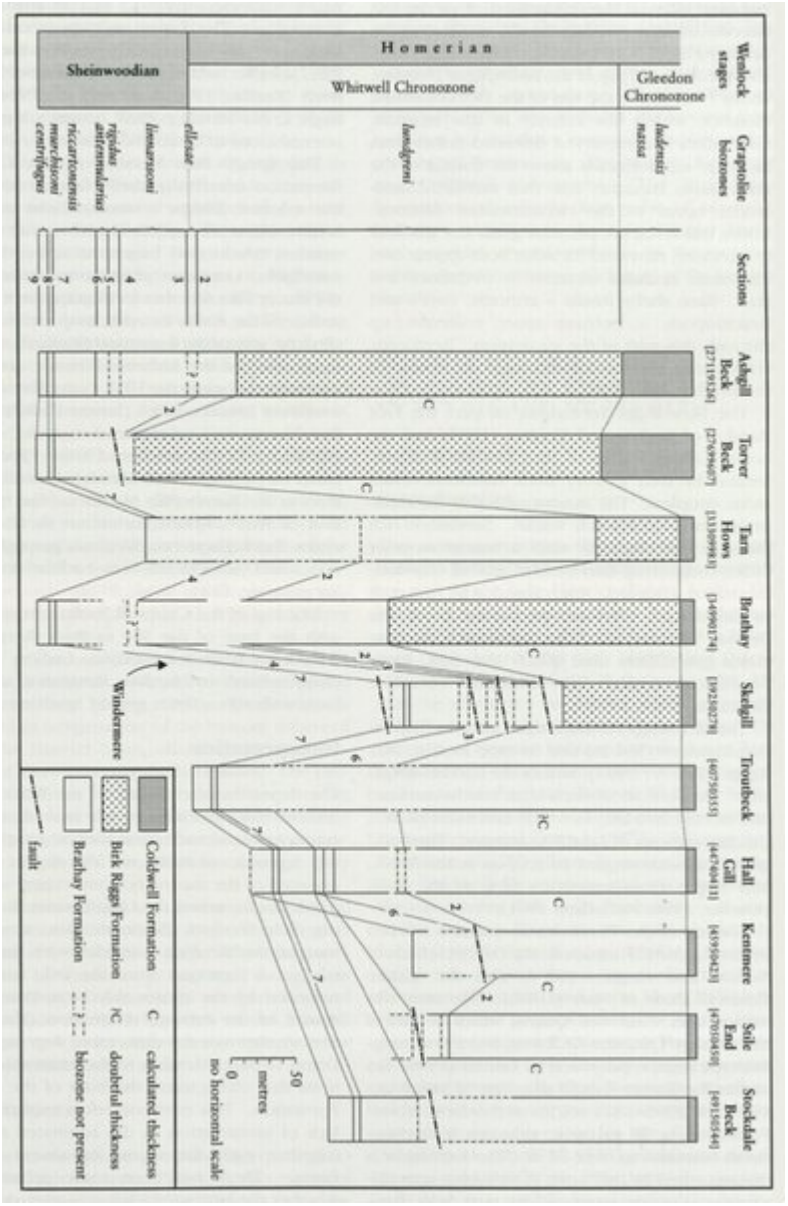
References



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



(Figure 4.59) Lithostratigraphical map of the Windermere Supergroup around Coniston Water, south-west Cumbria (after Kneller et al., 1994).



(Figure 4.60) Torver–Ashgill. Logs of the best exposed Wenlock sections across the Lake District, with tie-lines indicating the correlation of graptolite biozones (after Rickards, 1969, 1989a, with revision of lithostratigraphy after Kneller et al., 1994).