Benson Knott

[SD 5470 9414]

Potential GCR Site

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Introduction

Benson Knott is a hill 3 km north-east of Kendal, Cumbria (Figure 3.49). Outcrop is widespread within a 500 m radius of the hill top [SD 5470 9414], particularly on the western and northeastern slopes. All these exposures are now included within the Kirkby Moor Formation, which here is of upper Ludfordian, Ludlow Series age.

The formation name has its origins as the 'rocks of Kirkby Moor' (Sedgwick, 1852), which lay above the Ireleth (later Bannisdale) Slates. The term 'Kirkby Moor Flags' was used in this sense by Marr (1878), Blackie (1933) and Furness *et al.* (1967). However, the separate discrimination of Transition Beds comprising the lower part of Sedgwick's Kirkby Moor rocks (Aveline and Hughes, 1872, 1888; Marr, 1892) led to the definition of the Underbarrow Flags underlying a stratigraphically more restricted Kirkby Moor Flags (Shaw, 1971a, b; Moseley, 1984; see (Figure 5.76)). The present usage of Kirkby Moor Formation (Lawrence *et al.,* 1986; Kneller *et al.,* 1994) therefore corresponds only to the upper part of Sedgwick's unit. The Underbarrow and Kirkby Moor units have been grouped as members within a Kendal Formation (Moseley, 1984) and, together with the Bannisdale Formation, as formations within a Kendal Group (King, 1994).

Shaw (1971a) recognized a separate Scout Hill Flags unit above the Kirkby Moor Flags, on the basis of a lvtidoli fauna and a reddening (which may, however, be secondary). On Benson Knott the lithofacies of the Scout Hill Flags is identical to that of the Kirkby Moor Formation, and Kneller *et al.* (1994) recommended disuse of the name Scout Hill Flags. However, a distinctive facies in the Scout Hill Flags at The Helm is given member status within the upper part of the Kirkby Moor Formation.

The Kirkby Moor Formation diachronously overlies the Underbarrow Formation see (Figure 5.77), represented at the Hills Quarry site [SD 5960 8803]. The upper boundary of the Kirkby Moor Formation (as currently defined) is not preserved, but the formation is at least 1050 m thick.

Description

A typical section of the Kirkby Moor Formation at Benson Knott (Figure 5.80), (Figure 5.82) has beds with three lithofacies (King, 1992, 1994), herein numbered to match lithofacies shared with Hills Quarry and The Helm.

2. *Bioturbated graded fine siltstones and sandstones* form beds 0.5 to 10 cm thick, grading up into mudstone. Bed bases are sharp, often with groove marks and load structures. The beds are strongly affected by *Chondrites* bioturbation, especially in the mudstone tops, giving an irregularly laminated appearance to the rock. The sandstone and siltstone intervals weather to a buff colour, reflecting a carbonate cement. Lithofacies 2 is subordinate within the Kirkby Moor Formation but dominates the Underbarrow Formation.
3. *Thin- to medium-bedded graded sandstones* occur in beds 5 to 30 cm thick. Beds are sharp-based and comprise moderately sorted, micaceous fine sand grading up into silt and clay. The sandstone intervals preserve planar lamination, low-angle cross-lamination, ripple cross-lamination and occasional convolute lamination. Mudstone tops are often bioturbated. This lithofacies increases in frequency through the Underbarrow Formation and into the Kirkby Moor Formation, but remains subordinate to lithofacies 4.
4. *Thick-bedded stratified sandstones* occur as beds 20 to 200 cm thick, comprising fine-grained micaceous sandstone that may grade up into mud. Beds are often amalgamated. They show the same range of internal structures as lithofacies 3, although convolute lamination is very common, and some beds may be massive. Internal mud clasts

occur infrequently. Low-angle hummocky cross-stratification and symmetrical ripple cross-lamination are widespread. Some mud tops are bioturbated, often by vertical *Skolithos* burrows. Bed bases can be planar, but are usually erosive or loaded. Beds of lithofacies 4 vary laterally in thickness, and occasionally pinch out e.g. [SD 5465 9418].

Fossils in the Kirkby Moor Formation occur as shelly lenses within or at the base of beds of lithofacies 3 and 4. About two-thirds of the species found in the Kirkby Moor Formation also occur in the underlying Underbarrow Formation. However, individuals are more numerous, particularly brachiopods, gastropods and ostracods, and there is a marked increase in species of ostracods and bivalves. The fauna at Benson Knott includes the ostracod *Neobeyrichia confluens* and the trilobites *Acastella prima* and *Homalonotus knightii.* The rock is determined as of upper Ludfordian age, thus correlating with the Whitcliffe Group of the Welsh Borderland (Shaw 1971a, b). However, the base of the Kirkby Moor Formation is regionally diachronous, ranging down into the lower Ludfordian near Kentmere (Lawrence *et al.,* 1986) and rising well into the upper Ludfordian near Hills Quarry in the south-east (Shaw 1971a, b).

Interpretation

The Kirkby Moor Formation shows abundant sedimentological and faunal evidence of its shallow marine origin, thus contrasting with the deeper marine origin of the majority of the underlying sediments of the Windermere Supergroup. The diachroneity of the base of the Kirkby Moor Formation implies that it was deposited inboard of the outer shelf Underbarrow Formation and, in turn, the deeper water Bannisdale Formation (see (Figure 5.81)). These environments prograded rapidly southwards through late Ludlow and P■ídolí time, as the Lake District marine basin was transformed first into an alluvial plain and, by the mid-Devonian, into an eroding upland.

The graded beds of lithofacies 2 are the product of deposition from dilute waning flows, probably turbidity flows generated by storm suspension of sediment (King, 1994). However, the abundant medium- to thick-bedded sandstones (lithofacies 3 and 4) suggest an environment of higher energy and greater sediment supply than the underlying Underbarrow Formation, where lithofacies 2 is dominant. Deposition of lithofacies 3 and 4 above storm wave base is suggested by the preservation of symmetrical ripples and associated cross-lamination. The hummocky cross-stratification typical of lithofacies 4 is the product of combined oscillatory and unidirectional flows generated by large storms (King, 1994). On this hypothesis, the graded beds of lithofacies 3 and 4 were formed by fallout of storm-mobilized sediment above storm wave base, probably on the mid- to inner shelf (see (Figure 5.81)). This environmental model is supported by the abundant shelly fauna and the nature of the bioturbation. The increase in abundance and diversity of gastropods and bivalves suggest shallower water than in the Underbarrow Formation (Shaw, 1971a, b).

Abundant convolute lamination at Benson Knott is usually confined within one depositional unit and shows no consistent sense of overturning. It is probably the product of instability during sedimentation, perhaps triggered by earthquakes (King, 1994).

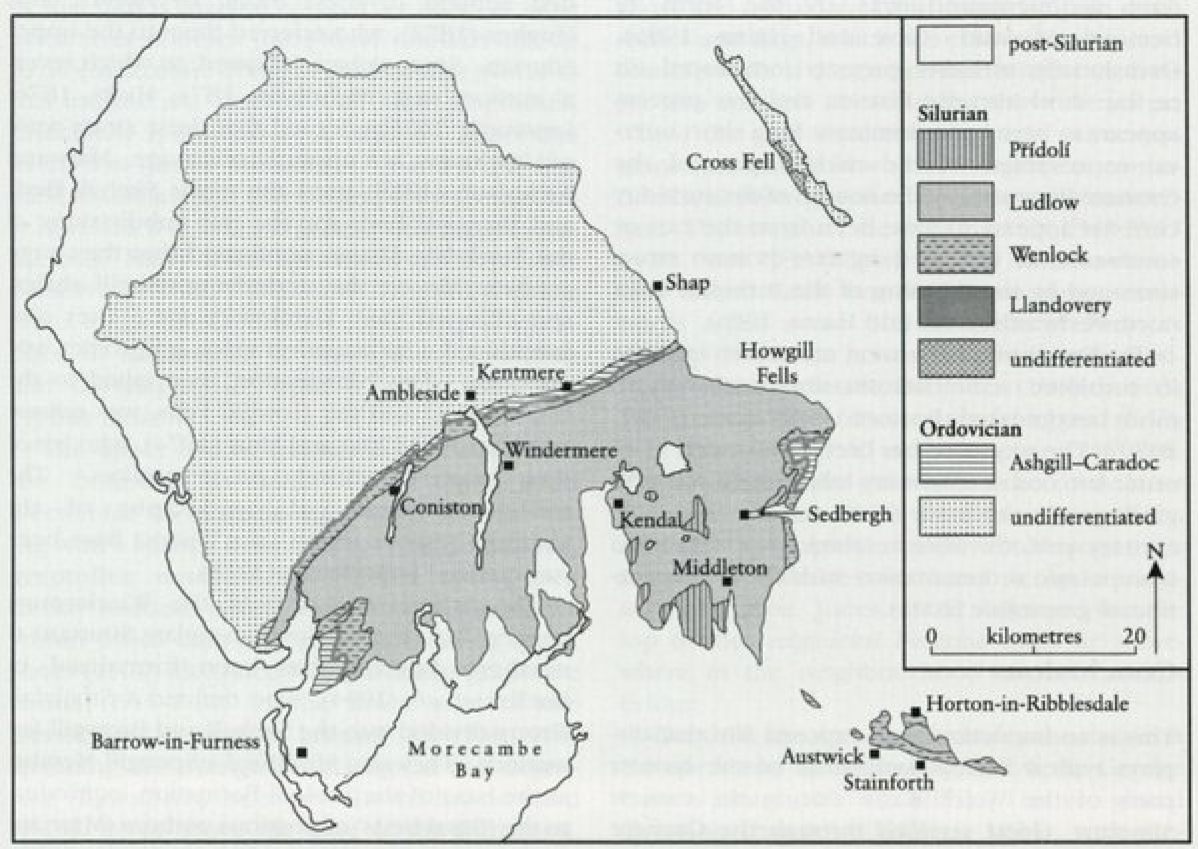
Benson Knott is proposed as a GCR site, together with Hills Quarry and The Helm, in order to show the diachronous progradation of shallow and marginal marine environments during the late Silurian demise of the Lake District depositional basin (Figure 5.81).

Conclusions

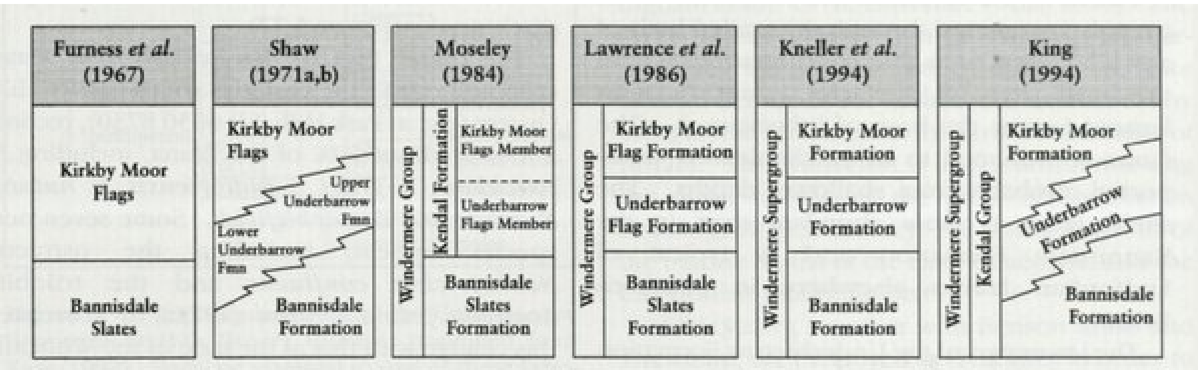
Benson Knott provides extensive, accessible and fossiliferous exposures of typical Kirkby Moor Formation, the uppermost formation of the marine Silurian succession in the Lake District Basin. This late Silurian shallowing of the Lake District Basin is an important stage in the compressional geological history that culminated in the uplifted Caledonian mountain belt.

It is an important reference site with considerable research potential, particularly for investigation of storm-induced sedimentary processes and their associated faunal relationships.

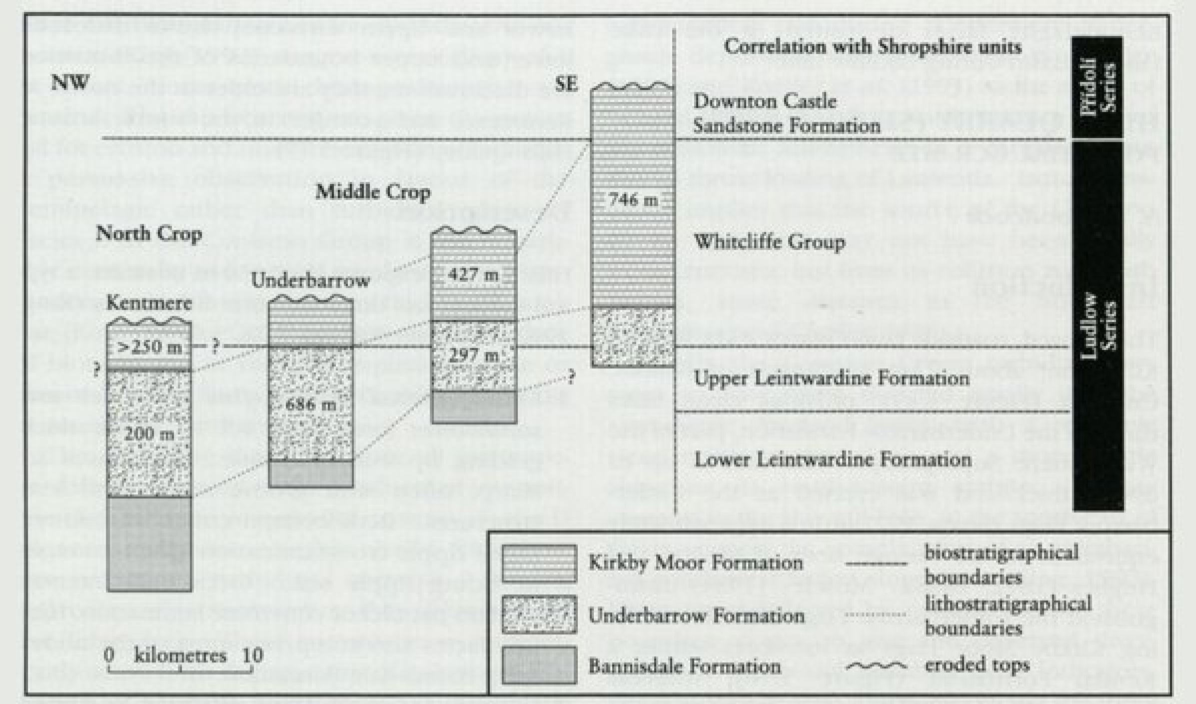
References



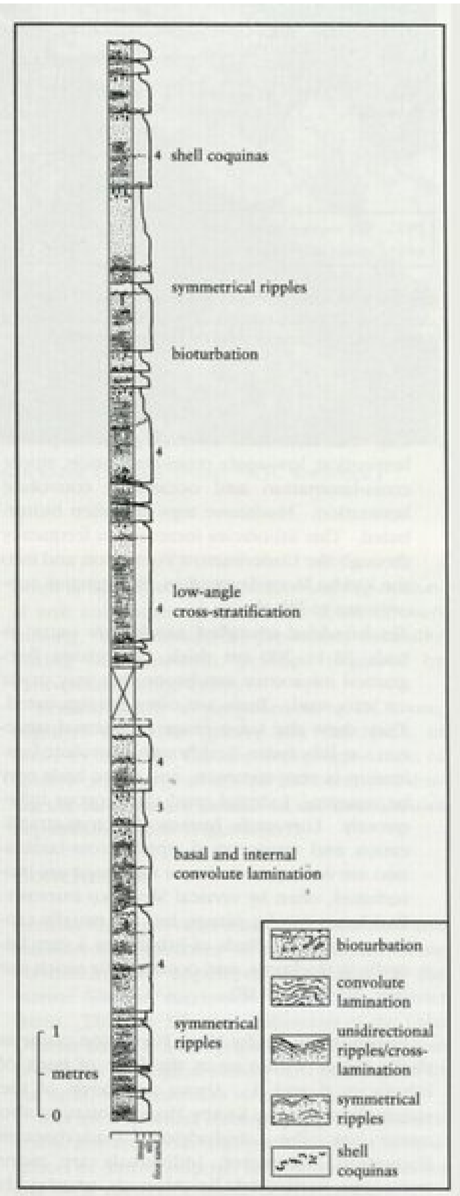
(Figure 3.49) Outline geological map of the Lake District and Howgill Fells (modified after Rickards, 1989a).



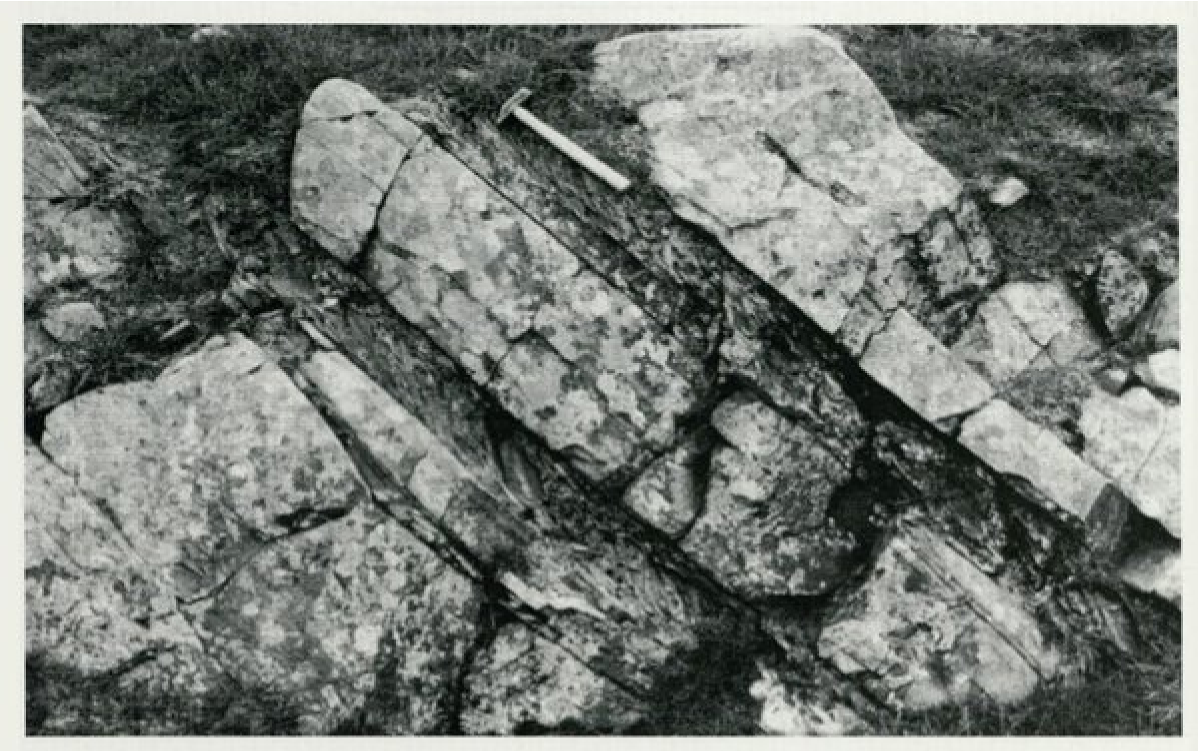
(Figure 5.76) Evolution of lithostratigraphical nomenclature in the Kendal Group, upper part of the Windermere Supergroup (after Lawrence et al., 1986). This nomenclature is relevant to Ludlow Series sites at Hills Quarry and Benson Knott, and to the P■ídolí site at The Helm, Cumbria.



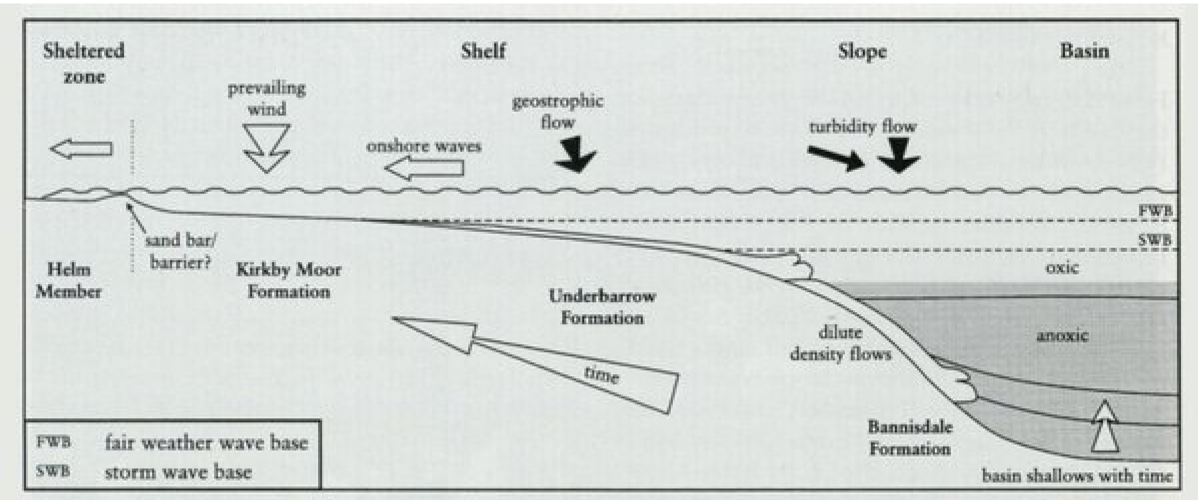
(Figure 5.77) Diagram illustrating the diachroneity of the lithostratigraphical units of the Kendal Group (after King, 1994).



(Figure 5.80) Representative log of the Kirkby Moor Formation at Benson Knott, Cumbria (at [SD 5465 9418]; modified from King, 1992). Beds are assigned to lithofacies 2 to 4 (see text); lithofacies 2 and 3 match similar facies in the Underbarrow Formation (see GCR site report for Hills Quarry). At Benson Knott lithofacies 3 and 4 are prominently developed but lithofacies 2 (which dominates in the Underbarrow Formation) is subordinate.



(Figure 5.82) The Kirkby Moor Formation at Benson Knott, Cumbria. (Photo: N.H. Woodcock.)



(Figure 5.81) Hypothetical reconstruction of the northern margin of the Lake District Basin and its associated depositional environments, for formations spanning the Ludfordian-early P■ídolí time interval (after King, 1992). No absolute depths or scale are implied.