

Kendal Group succession, Windemere Supergroup, late Ordovician to Silurian, Northern England

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Introduction



Thinly interbedded, turbiditic mudstone, siltstone and fine-grained sandstone of the Bannisdale Formation seen here south-east of Raw Ghyll near Staveley [4550 9914]. Bedding is picked out especially by the lines of small cavities produced by the preferential weathering of carbonate-rich concretions in the mudstone layers. The hammer is 37 cm long. (P223342).

The lithostratigraphical succession above the Coniston Group is only informally associated within a Kendal Group. It is dominated by the very thick succession (up to 4.5 km) of fine-grained sandstone, banded siltstone, silty mudstone and rare hemipelagite that makes up the Bannisdale Formation.

The banding is the result of grading from siltstone (or less commonly from fine sandstone) to mudstone upwards through very thin turbidite beds no more than a few centimetres thick (P223342). The siltstones and fine sandstones are commonly affected by convolute lamination, caused by small-scale dewatering, and this feature, together with ripple cross-lamination, appears to become more abundant towards the top of the formation. The mudstones may contain small calcareous or phosphatic nodules. Interbedded turbidite sandstones are locally common towards the base of the formation and in places, particularly in the south-west of the Lake District outcrop, create a transitional boundary with the underlying Coniston Group; the proportion of sandstone decreases upwards. Localised sandstone members have been previously defined in this transitional interval, but their wider application has proved difficult. The hemipelagite component of the formation represents the continuing background sedimentation and contains graptolites, though the biostratigraphical ranges that they indicate suggest some diachroneity. The age of the formation's base has been variously described as lying between the Gorstian *scanicus* Biozone and the base of the Ludfordian *leintwardinensis* Biozone; there is a consensus that the top of the formation ranges up into the *leintwardinensis* Biozone. There is a noticeable increase in bioturbation in the highest beds.

Lithostratigraphy is poorly defined in the upper part of the Kendal Group, above the Bannisdale Formation. In particular, the previous recognition of an Underbarrow Formation, intervening between the Bannisdale Formation and the overlying Kirkby Moor Formation, is unsatisfactory since it brings together a variety of disparate, localised facies variations. These probably represent stages in the depositional transition from the Bannisdale to the Kirkby Moor formations, and are best regarded as local members of one or other of those two units.

The most securely defined unit is the Kirkby Moor Formation, which comprises several hundred metres (at least) of thickly bedded (up to about 1 m) fine-grained sandstone, the beds having little internal structure apart from convolute lamination produced during dewatering. There are sporadic channelised bedforms and in a few cases a shelly lag deposit is seen at the base of a bed. There is a little more variation in the lowest 100 m, where the formation is more thinly bedded and finer grained than average. In this part of the formation, thin beds of siltstone and fine-grained sandstone are parallel- and cross-laminated, with sporadic developments of larger scale, hummocky cross-stratification. A shelly fauna suggests an age equivalent to the younger part of the Ludfordian *leintwardinensis* graptolite Biozone, with the possibility that the top of the formation ranges up into the Pridoli.

The highest beds of the Windermere Supergroup have previously been termed the Scout Hill Formation, but the definition has been principally on faunal grounds. However, at this Pridoli level the faunas are strongly facies-controlled and parts of the Scout Hill unit are lithologically indistinguishable from the Kirkby Moor Formation, apart from a widespread secondary reddening. One distinctive member of thinly bedded siltstone (the Helm Member) might usefully be preserved as a component of the Kirkby Moor Formation, but the remainder of the Scout Hill Formation is best subsumed therein. The result is a Kirkby Moor Formation that extends well up into the Pridoli, and is affected by secondary reddening in its higher part. The Helm Member probably occupies a high stratigraphical level within the Kirkby Moor Formation as thus defined.

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