Ordovician and Silurian Rocks

The Ordovician Period is currently regarded as having extended from about 495 to 443 million years ago. The Silurian Period is believed to have extended from 443 to 418 million years ago.

Currently protected sites of Ordovician and Silurian rocks within the AONB

SSSI/GCR Name/Grid Ref

Harthwaite Sike/Harthwaite Sike [NY 702 247]

Keisley Quarry/Keisley Quarry [NY 714 238]

Melmerby Road Section/Melmerby Road Section [NY 623 383]

Pus Gill/Pus Gill [NY 696 256]

Swindale Beck/Swindale Beck [NY 688 275]

Ordovician and Silurian rocks are also exposed within a number of areas scheduled as SSSIs that are not specifically designated for Namurian rocks within the Geological Conservation Review.

RIGS

Knock Pike, Flagdaw [NY 687 285]

Durham County geological sites

Pencil Mill, Lunedale [NY 848 296]

Ordovician and Silurian rocks in Great Britain

The Ordovician and Silurian rocks found in Great Britain were deposited mostly within a deep ocean, known to geologists as the Iapetus Ocean. This ocean lay between two huge continents which, during Ordovician and Silurian times were rapidly converging. Thick layers of mud accumulated on the ocean floor, together with substantial amounts of muddy sands, deposited from vigorous turbidity currents carrying sediment from the adjoining continental shelves. Enormous crustal stresses, resulting from the movement of the two continents, caused widespread subsidence of the ocean basins, substantial volcanic and other magmatic activity and repeated deformation of the sediments deposited. As the continents eventually collided, destroying the Iapetus Ocean early in Silurian times, the muds were eventually compressed to form hard mudstones and slates; the muddy sands were compacted to form the sandstones we know today as greywackes.

Great Britain's Ordovician and Silurian rocks are important on a regional, national and international level. As the original, or 'type', areas for these two geological periods, the British Ordovician and Silurian successions remain important standards for the description and interpretation of rocks of these periods throughout the world.

Ordovician and Silurian rocks in the AONB

The Ordovician and Silurian rocks of the AONB are considered together in this document as they share many geological similarities and occur closely associated in small, rather complexly faulted exposures. Their outcrop occupies only 221 hectares or 0.1% of the surface area of the AONB, but hosts the type localities for several Ordovician and Silurian fossils.

The most extensive outcrops of these rocks occur along the foot of the North Pennine escarpment where, as a result of uplift along the Pennine Fault System, they are exposed beneath the Carboniferous rocks which make up the greater part of the North Pennines. This belt of Ordovician and Silurian rocks is generally known by geologists as the Cross Fell Inlier. A variety of rock types within this area can be correlated with similar rocks of the Lake District, notably parts of the Ordovician Borrowdale Volcanic and Dent groups, and the Silurian Windermere Supergroup.

Outcrops of Ordovician rocks, believed to be equivalent to the Skiddaw and Borrowdale Volcanic groups of the Lake District, are exposed beneath basal Carboniferous rocks in the Teesdale Inlier.

Elsewhere in the AONB and adjoining areas, Ordovician and Silurian rocks are known to occur at depth beneath younger rocks and have been proved beneath the Carboniferous rocks in a small number of boreholes. The North Pennines may be regarded as a platform composed mainly of Ordovician and Silurian rocks, upon which Carboniferous rocks have been deposited.

In order to name, map and interpret the rocks formed during intervals of geological time, geologists subdivide the succession of rocks into individually recognisable Formations which comprise rocks with physical and perhaps chemical, features that distinguish them from other formations. Two or more geographically associated formations with notable features in common may be combined in a Group, which in turn may be further combined within a Supergroup.

Ordovician rocks

Within the AONB, the earliest Ordovician rocks comprise sedimentary rocks closely resembling, and of the same age as, the Skiddaw Group rocks of the Lake District.

The Kirkland Formation contains mudstones interbedded with many thick bands of tuff (volcanic ash) and lavas and gives a lithological sequence quite distinct from that of the wholly sedimentary Murton and Catterpallot formations. Graptolites within the mudstones have enabled identification of the Kirkland Formation as having been deposited during a period of volcanic activity that pre-dated the Borrowdale Volcanic Group (BVG).

At Pencil Mill, at the foot of Cronkley Fell in Teesdale, soft, pale coloured slightly metamorphosed slates, crop out within the Teesdale Inlier. Rare graptolite fossils collected from these rocks confirm their correlation with the Skiddaw Group slates of the Lake District.

The Skiddaw Group rocks were folded, uplifted and eroded before the accumulation of tuffs and volcanic sandstones of the Studgill, Knock Pike and Harthwaite formations. These are the equivalent of the thick succession of lavas and volcanic sediments, known in the Lake District as the Borrowdale Volcanic Group (BVG). Within the AONB outcrops of BVG rocks are confined to several small, mainly fault-bounded blocks along the foot of the North Pennine escarpment, together with a tiny isolated outcrop in the banks of the River Tees at the foot of Cronkley Fell.

All of these Ordiovician rocks were further folded and eroded before being submerged by a shallow sea in which the Dent Group (formerly known as the Coniston Limestone Group) formed. It would be difficult to subdivide the relatively monotonous series of limestone, mudstone and siltstones were it not for the rich variety of shelly fossils that provide a detailed biostratigraphy.

The lowest part of the Dufton Shale Formation between Millburn Beck and Roman Fell is known as the 'Corona beds' after the commonly occurring brachiopod Trematis corona.

At the top of the Ordovician succession in the AONB, the Keisley Limestone, in and around Keisley quarry, is the best example of an Ordovician carbonate mudbank in England. It has yielded a varied range of shelly fossils, including trilobites.

The currently accepted classification of the Ordovician and Silurian rocks of the AONB is shown in the table above.

Silurian rocks

During the Silurian Period mudstones and siltstones were deposited in rather deeper waters than those of late Ordovician times. Within the AONB outcrops of Silurian strata are restricted to heavily faulted ground along the foot of the North Pennine escarpment. Graptolite fossils, found in these rocks, enable correlation with the Lake District and Howgill Fells, and show that a considerable, if not complete, sequence of these rocks is present in the AONB.

The oldest beds of the Skelgill Formation lie at the entrance to Keisley Quarry. Younger beds are seen in isolated exposures in Great Rundale Beck and Swindale Beck, Knock. The lower part of the Browgill Formation is exposed in Swindale Beck.

The Brathay Formation is exposed in Swindale Beck and also downstream from Keisley Bridge.

Impact on the landscape

The distinctive landscape of the Cross Fell Inlier reflects the varied nature of the exposed Ordovician and Silurian rocks. Most distinctive and conspicuous are the steep-sided rather conical hills, such as Knock Pike and Dufton Pike, which mark the outcrops of Ordovician volcanic rocks. These are topographically more reminiscent of the landscape associated with the equivalent rocks of the Lake District than of the typical North Pennines hills.

The Ordovician slates and volcanic rocks of the Teesdale Inlier are almost everywhere concealed beneath a substantial mantle of glacial deposits and have comparatively little direct effect upon the area's landscape.

Impact on biodiversity

Limestones outcrops, such as the Keisley Limestone, support a flora similar to that of the Carboniferous limestones of the North Pennines. Outcrops of other rocks within the Cross Fell Inlier are commonly partly mantled by glacial or later deposits. In these areas the natural vegetation is characteristic of much of the outcrops of other non-calcareous rocks of the North Pennines.

Economic use

A variety of Ordovician and Silurian rocks have been worked in small quarries in the Cross Fell Inlier. Keisley Quarry produced limestone for burning in kilns and stone for local use.

Other quarries, such as Knock Pike Quarry, yielded volcanic rock for use as road stone. The soft Skiddaw Group slates exposed at Cronkley Mill, in Upper Teesdale, were formerly worked for the making of slate pencils, known locally as 'Widdies'.

There are no quarries currently working the area's Ordovician and Silurian rocks.

Wider importance

Although these rocks occupy a comparatively restricted surface outcrop within the AONB, they include a variety of rock types representative of significant parts of the British Ordovician and Silurian successions. These rocks provide important evidence of the Ordovician and Silurian geology of both Europe and North America.

The AONB includes the type localities for several Ordovician and Silurian fossils.

Conservation issues

Several individual sites are currently protected as SSSIs (see below). Monitoring of their condition by, or on behalf of, English Nature should ensure that they are conserved in a condition appropriate to their importance as geological features. Other exposures of these rocks within the AONB are not currently perceived to be subject to any significant

threats, apart from those normally associated with natural outcrops and stream sections.

Selected references:

Arthurton and Wadge, 1981; Burgess and Wadge, 1974; Burgess and Holliday, 1979; Dunham, 1990; Rushton, Owen, Owens and Prigmore, 1999: Stone et al, 2010.

Figures

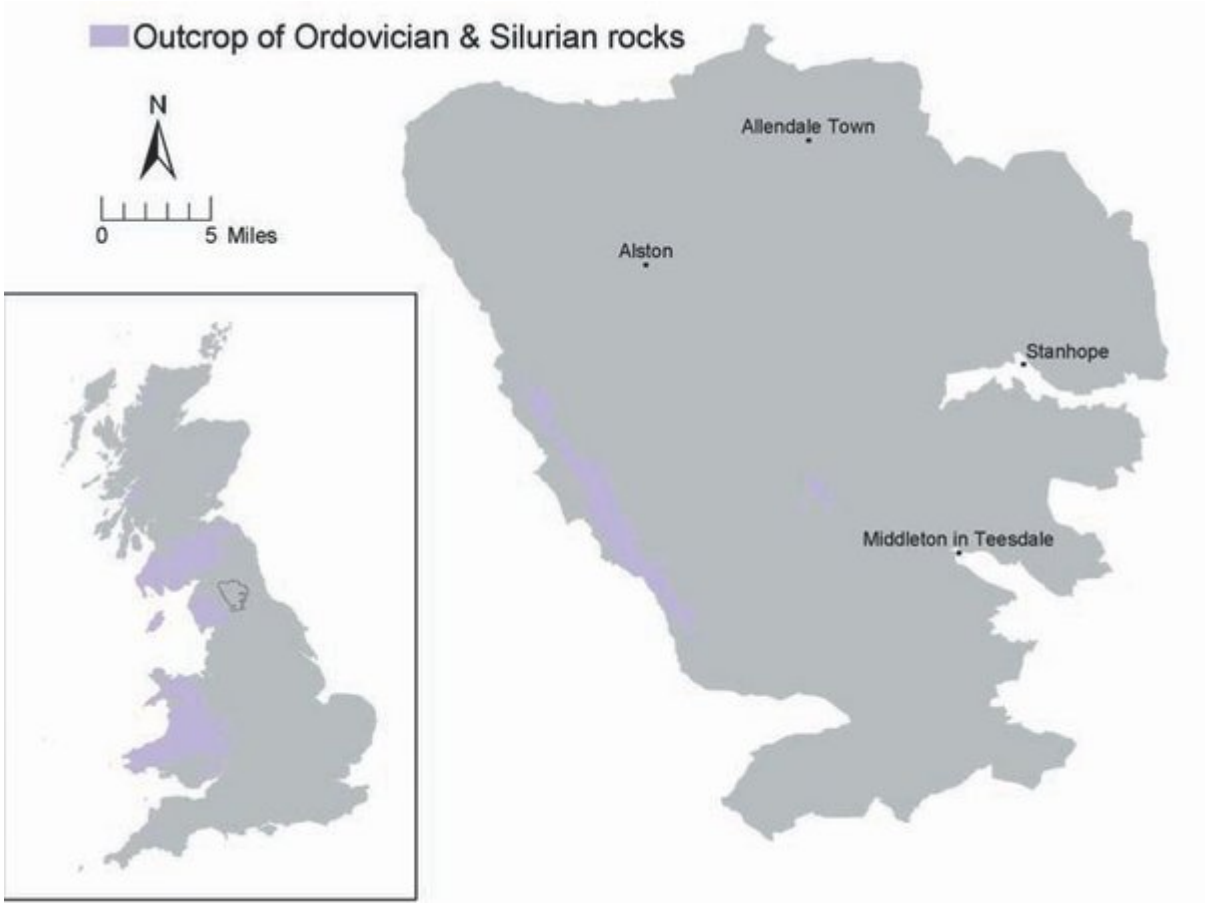
(Figure 8) Outcrop of Ordovician and Silurian rocks

(Figure 9) The currently accepted classification of the Ordovician and Silurian rocks of the AONB is shown in the table above.

(Figure 10) Keisley Limestone Quarry, Dufton. © S. Clarke, BGS, NERC.

(Figure 11) Knock Pike and Dufton Pike. © B. Young, BGS, NERC.

Full references



Outcrop of Ordovician and Silurian rocks

Period	Group		Formation	Main Rock Types
SILURIAN	WINDERMERE SUPERGROUP		Brathay	Dark bluish grey, laminated graptolitic mudstones and siltstones with sporadic calcareous nodules
		Stockdale	Browgill	Pale greenish grey unfossiliferous mudstone with a few thin black graptolitic mudstone beds, succeeded by red mudstone
			Skelgill	Dark brown to black shaly or blocky mudstones
ORDOVICIAN		Dent	Ashgill Formation	Calcareous mudstone with beds and lenses of decalcified limestone; shelly fauna
			Swindale	Mid-grey calcareous mudstones, with bands and lenses of greenish grey fine grained limestone commonly decalcified at outcrop to brown rottenstone
			Dufton Shale	Dark grey, partly calcareous siltstones and mudstones, with thin bands or lenses of silty limestone
		Borrowdale Volcanic	Harthwaite	Volcanic sandstone and siltstones and tuffs
			Knock Pike	Lapilli-tuff and tuff
			Studgill	Lapilli-tuff and volcaniclastic sandstone
		Skiddaw	Kirkland	Mudstones interbedded with many thick bands of tuff (volcanic ash) and lavas
			Murton	Siltstones and mudstones with some sandstones
			Catterpallot	Siltstones and interbedded sandstones

The currently accepted classification of the Ordovician and Silurian rocks of the AONB is shown in the table above.

Keisley Limestone Quarry, Dufton. © S. Clarke, BGS, NERC.

Knock Pike and Dufton Pike. © B. Young, BGS, NERC.