

# Carboniferous rocks of Northern England - lithostratigraphical province

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## Introduction

The Northern England Province encompasses the area between the Southern Uplands and the Craven Fault System (Figure 3); it includes the Northumberland and Stainmore troughs, the Tweed and Solway basins, the Alston and Askrigg blocks and the Manx-Lake District Block (Figures 7-15). During Westphalian times this area formed the northern part of the Pennine Basin.

The Northumberland Trough has a Tournaisian succession distinct from the rest of the province. Along the southern margin of the Southern Uplands Massif, the earliest Carboniferous strata are of *continental and peritidal facies*, very similar to the Inverclyde Group of the Midland Valley of Scotland. This group name and some component formations have been extended into the northern part of the Northumberland Trough. Within the Northumberland Trough the Inverclyde Group is overlain by the Border Group of early Visean age.

Elsewhere, the *continental and peritidal facies* 'cornstone' subfacies is preserved only in local basins in the deformed Lower Palaeozoic rocks that formed the Devonian continental landmass. The distribution, adjacent to the Pennine-Dent and Lake District boundary faults suggests that they were preserved in half-grabens that formed during the initial stages of extension in the Late Devonian-early Carboniferous. Local formation names are used for each isolated basin. The *continental and peritidal facies* 'cementstone' subfacies is associated with deposition in epicontinental basins with a limited marine influence. The evaporite-bearing succession marks the initial marine transgression with deposition in sabkha environments along arid shorelines. An increasing marine influence and transgression is denoted by the deposition of peritidal carbonates. Only within the Stainmore Trough has sufficient lithostratigraphical variation been identified to warrant *continental and peritidal facies* strata being assigned to a group, namely the Ravenstonedale Group.

South of the Northumberland Trough, the remainder of the province comprised basins and highs both of which formed largely distinct and isolated areas of deposition until Asbian times, each with different formational nomenclature. However, each structural entity showed a consistent development in facies in time from *open marine, platform and ramp carbonates facies* to cyclical *mixed shelf carbonate and deltaic ('Yoredale') facies*. Strata of the former are assigned to the Great Scar Limestone Group and strata of the latter to the Yoredale Group. During Namurian times, the Millstone Grit Group (*fluviodeltaic ('Millstone Grit') facies*) extended over the Askrigg Block, and subsequently, during Westphalian times the Pennine Coal Measures Group (*fluviodeltaic ('Coal Measures') facies*) extended across the entire province. 'Barren Measures' (*alluvial ('Barren Measures') facies*) of late Westphalian age, have been assigned formation names within the Warwickshire Group.

## **Ungrouped formations of continental and peritidal facies in the Craven Basin**

The Late Devonian to Visean *continental and peritidal facies* is restricted to localised areas of deposition at the northern margin of the Craven Basin. The deposits have been attributed a stand-alone formational name, with a geographical range limited to the known extent of the sub-basin. The SFC Committee did not consider these isolated deposits warranted group status.

[Stockdale Farm Formation](#)

## **Inverclyde Group (INV)**

The Inverclyde Group (Paterson and Hall, 1986) (Figure.7) of *continental and peritidal facies* comprises strata directly equivalent to the group of the same name present in the Midland Valley of Scotland (see Section 4.2 above), where the type area occurs at Greenock in the Inverclyde District (see Paterson and Hall, 1986). The Kinnesswood and Ballagan formations also equate to their namesakes in the Midland Valley of Scotland, but in the Berwick area and Solway Basin they are separated by the Kelso and Birrenswark Volcanic formations respectively (see Greig, 1988 and Lumsden et al., 1967). There is no equivalent to the Clyde Sandstone Formation of the Midland Valley of Scotland in the Northern England Province.

The base of the group is taken where Silurian strata (greywackes with interbedded mudstones) of the Riccarton Group are succeeded unconformably by red sandstones, siltstones and conglomerates of the Kinnesswood Formation. The base of the Border Group (*heterolithic clastic and nonmarine carbonate facies* and *fluviodeltaic ('Millstone Grit') facies*) defines the top of the group (see Section 6.5).

Tournaisian (Courceyan to Chadian) in age, the Inverclyde Group is up to 900 m thick in the Tweed Valley, Northumberland, and up to 640 m thick in the Solway Firth area.

[Inverclyde Group](#)

[Kinnesswood Formation](#)

[Kelso Volcanic Formation](#)

[Birrenswark Volcanic Formation](#)

[Cottonshope Volcanic Formation](#)

[Roddam Dene Conglomerate Formation](#)

[Ballagan Formation](#)

[Kirkbean Cementstone Member](#)

[Wall Hill Member](#)

[Orroland Member](#)

## **Ravenstonedale Group (RVS)**

The Ravenstonedale Group, named after the Ravenstonedale area of Cumbria, is of *continental and peritidal facies*. It comprises a typically thin succession, with geographically isolated outcrops present across parts of Cumbria.

Lithologically, the group includes green to green-grey and/or variably reddened pebble conglomerate (locally calcite cemented), lithic sandstone, sandstone and mudstone. Evaporitic deposits have been recorded in boreholes. Pedogenic carbonates occur within the sandstones, though they are less common than within the Kinnesswood Formation of the Inverclyde Group. Conglomerates have a local provenance, and basaltic lava flows occur locally within the alluvial fan facies. The most diverse lithological development is in the western part of the Stainmore Trough and northern part of the Askrigg Block.

Within the *Stainmore Trough* the group comprises the Pinskey Gill, Marsett, Cockermouth Volcanic, Stone Gill Limestone and Shap Village Limestone formations (the last mentioned also occurring on the Alston Block and in east Cumbria).

On the *Askrigg Block* the group comprises the Raydale Dolostone, Marsett and Penny Farm Gill formations.

In north, south and west Cumbria the group comprises the Marsett Formation. In the Kendal area it is here suggested that what is presently assigned to the lower part of a local equivalent of the Martin Limestone Formation, Great Scar Limestone Group of *open marine, platform and ramp carbonates facies*, is more typical of the Ravenstonedale Group (see Section 6.6.19).

On the *Isle of Man*, the Langness Conglomerate Formation (formerly the 'Basement Conglomerate') is tentatively referred to the Ravenstonedale Group.

The on-lapping succession of the group was deposited within an epicontinental basin as alluvial fan, fluviodeltaic, marginal marine and peritidal deposits (Holliday et al., 1979). Deposition on the Askrigg Block occurred following early Visean sea-level rise, with the succession located marginal to the more open marine conditions present in the Stainmore Trough at the time. Outside of the Stainmore Trough and northern part of the Askrigg Block the group is dominated by alluvial fan subfacies deposited within linked basins.

The group rests unconformably upon rocks ranging from Ordovician to Devonian in age, including the Wensleydale Granite beneath the Askrigg Block at Raydale. Limestone formations at the base of the Great Scar Limestone Group (*open marine, platform and ramp carbonates facies*) define the top of the Ravenstonedale Group - though locally, a nodular dolostone bed with rhizoliths, indicative of emergence, marks the top of the group on the Askrigg Block (Burgess, 1986).

Occurring across Cumbria and north Yorkshire, the Ravenstonedale Group is thickest in the western

part of the Stainmore Trough (about 380 m) and northern part of the Askrigg Block (about 150 m). In south Cumbria, in the Duddon Estuary, it attains a maximum thickness of 240 m thinning appreciably towards the south and east. In north and east Cumbria the group is typically less than 35 m thick. Within the Stainmore Trough it is Tournaisian in age. Whilst on the northern margin of the Askrigg Block it is Chadian to early Holkerian.

[Ravenstonedale Group](#)

[Stainmore Trough](#)

[Pinskey Gill Formation](#)

[Marsett Formation](#)

[Duddon Conglomerate Member](#)

[Cockermouth Volcanic Formation](#)

[Stone Gill Limestone Formation](#)

[Shap Village Limestone Formation](#)

**Askrigg Block**

[Raydale Dolostone Formation](#)

[Marsett Formation](#)

[Penny Farm Gill Formation](#)

**Isle of Man**

[Langness Conglomerate Formation](#)

## **Border Group (BDR)**

The Border Group (Lumsden et al. 1967; Day, 1970) consists of two sedimentary formations corresponding to some extent to the geographically extended, former Lower and Middle Border groups of Day (1970; see also Waters et al., 2007). The lower, the Lyne Formation (which equates with the 'Cementstones' of older terminology in Northumberland) comprises strata of *heterolithic clastic* and *nonmarine carbonate facies*. The Fell Sandstone Formation, of *fluviodeltaic* ('Millstone Grit') *facies*, diachronously overlies the Lyne Formation. Thin olivine basalt lavas occur as the Kershopefoot basalts (Williamson in Stephenson et al., 2003).

The base of the group is conformable where the interbedded sandstones, limestones, anhydrites, rootlet beds and thin coals of the Ballagan Formation (Inverclyde Group) pass upward into the cyclical sequences of sandstone, mudstone and thin limestone of the Lyne Formation. This is the presumption at Bewcastle and Kirkbean, and it has been proved in a borehole at Annandale. The base is also conformable at Brampton where the Ballagan Formation passes upwards into the sandstone-dominated Fell Sandstone Formation. However, in the north-east part of the Northumberland Trough the same boundary is unconformable; and within the central part of the trough, the base of the group has not been proved. The base of the Yoredale Group (*mixed shelf carbonate and deltaic* ('Yoredale') *facies*) defines the top of the Border Group.

The Border Group is restricted in geographical extent to the Northumberland Trough and Solway Basin, and is greater than 1350 m thick in the central part of the former. It is late Tournaisian to Holkerian in age.

[Border Group](#)

[Lyne Formation](#)

[Easton Anhydrite Member](#)

[Southernness Limestone Member](#)

[Lynebank Member](#)

[Bewcastle Member](#)

[Main Algal Member](#)

[Cambeck Member](#)

[Fell Sandstone Formation](#)

[Gillfoot Sandstone Member](#)

[Powillimount Sandstone Member](#)

[Rascarrel Member](#)

## **Great Scar Limestone Group (GSCL)**

The Great Scar Limestone Group (George et al., 1976; see also Waters et al., 2007) (Figure 7) of *open marine, platform and ramp carbonates facies* is widespread across Northern England. It comprises many formations with distinct formation nomenclature for the isolated horst and tilt-block highs.

The *Alston Block* includes the Melmerby Scar Limestone Formation (see Dunham, 1990).

The *Stainmore Trough* has the Coldbeck Limestone, Scandal Beck Limestone, Brownber, Breakyneck Scar Limestone, Ashfell Sandstone, Ashfell Limestone, Potts Beck Limestone and Knipe Scar Limestone formations (see Dunham and Wilson, 1985). The *Askrigg Block* includes the Tom Croft Limestone, Ashfell Sandstone, Fawes Wood Limestone, Garsdale Limestone and Danny Bridge Limestone formations (see Dunham and Wilson, 1985).

The *Askrigg Block-Craven Basin Transition Zone* includes the Kilnsey, Chapel House Limestone, Malham and Cracoe Limestone formations (see Arthurton et al., 1988).

*South Cumbria* has the Martin Limestone, Red Hill Limestone, Dalton, Park Limestone and Urswick Limestone formations (see Rose and Dunham, 1977; Johnson et al., 2001).

*North and west Cumbria* includes the Frizington Limestone and Eskett Limestone formations (see Akhurst et al., 1997). It therefore includes the lower part of the now obsolete Chief Limestone Group.

The south *Isle of Man* includes the Derbyhaven, Knockrushen and Balladoole formations (see

Chadwick et al., 2001).

The north *Isle of Man* includes undifferentiated strata assigned to either the Great Scar Limestone Group or the Yoredale Group (see Chadwick et al., 2001).

The succession comprises limestone, typically well washed, bioclastic, highly bioturbated with crinoid banks, shelly or coral biostromes and algal (*Girvanella*) bands. The group, common to other Viséan platform areas in the British Isles, shows a trend from dark grey Arundian to Holkerian carbonates to pale grey Asbian to Brigantian limestones with eight major palaeokarstic bedding surfaces overlain by thin mudstones (Waltham, 1971). Apron knoll reefs are developed along the southern margin of the Askrigg Block. In the Stainmore Trough the limestone succession locally includes numerous intercalated sandstone beds, presumably derived from upstanding areas of lower Palaeozoic rocks. The lower part of the group, present in the Stainmore Trough (Coldbeck Limestone Formation) and South Cumbria (Martin Limestone Formation), was deposited in a carbonate dominated, nearshore to peritidal, restricted marine environment with common stromatolites and oncolites. Younger strata, dominated by thick bioclastic limestones, were deposited in an open, shallow marine environment. Palaeokarst surfaces indicate periodic emergence. The alluvial Brownber and fluviodeltaic Ashfell Sandstone formations represent brief incursions of siliciclastic deposits into the Stainmore Trough that encroached from the north. They may have been a distal extension of the Fell Sandstone Formation of the Border Group. In the north of the Isle of Man undifferentiated strata assigned to either the Great Scar Limestone Group or the Yoredale Group comprise massive, stylolitic, fractured and sucrosic dolomite (see Chadwick et al. 2001).

In the Stainmore Trough the base of the group is taken at the base of the Coldbeck Limestone Formation where the Algal Nodular Beds of the underlying Ravenstonedale Group are conformably overlain by carbonate-dominated strata.

On the Askrigg Block the base of the group is taken at the base of the Tom Croft Limestone Formation where a nodular dolostone bed with rhizoliths, indicative of emergence (Burgess, 1986), is locally developed at the top of the underlying Penny Farm Gill Formation (Ravenstonedale Group). This boundary is disconformable and marks a low sea-level stand.

On the Alston Block the base of the group is taken at the base of the Melmerby Scar Limestone Formation where the conglomerates of the underlying Marsett Formation (Ravenstonedale Group) are unconformably overlain by the onset of platform carbonate strata.

In north and west Cumbria the base of the group is taken at the base of the Frizington Limestone Formation where the conglomerates of the Marsett Formation (Ravenstonedale Group) are disconformably overlain by bioturbated peritidal limestones with rhizoliths, lime muds and sandstones. This disconformity represents nondeposition during Chadian to Arundian times.

In south Cumbria the base of the group is not exposed, but it is taken to be at the base of the Martin Limestone Formation where limestone becomes dominant over shale in the conglomeratic Marsett Formation (Ravenstonedale Group).

In the south Isle of Man the base of the group is taken at the base of the Derbyhaven Formation where the conglomerates (some of which are apparently reworked) of the Langness Conglomerate Formation (Ravenstonedale Group) are directly overlain by limestones.

In most places, the base of the Yoredale Group (*mixed shelf carbonate and deltaic ('Yoredale') facies*) defines the top of the Great Scar Limestone Group. The exceptions include the north Isle of Man where the Millstone Grit Group (*fluviodeltaic ('Millstone Grit') facies*) defines the top of what

may be either the Great Scar Limestone Group or the Yoredale Group, and the south Isle of Man where the Craven Group defines the top of the Balladoole Formation.

The type area of the Great Scar Limestone Group is the Askrigg Block, where it was first formalised as a group by George et al. (1976). Subsequently the name was expanded to unify all equivalent, locally named, thick carbonate platform successions of the Tournaisian to early Namurian (Pendleian) of Northern England (see Waters et al., 2007, for further details).

The group is about 107 m thick on the Alston Block and Asbian in age. It gains a maximum thickness of about 800 m in the Stainmore Trough where it is Chadian to Asbian in age. On the Askrigg Block it is about 400 m thick and Arundian to Asbian in age. In Cumbria, up to about 740 m of Tournaisian to Pendleian strata are present, and in the south Isle of Man the group is up to about 157 m thick and Arundian to Asbian in age. In the north Isle of Man the approximately 7.3 m of what may be either Great Scar Limestone Group or Yoredale Group strata at the base of the Ballavaarkish (Shellag North) Borehole (see below) are possibly early Namurian or Visean in age, but diagenesis of the sedimentary rocks has completely ruled out obtaining a biostratigraphical age (Chadwick et al., 2001).

### [Great Scar Limestone Group](#)

#### **Alston Block**

##### [Melmerby Scar Limestone Formation](#)

##### [Stainmore Trough and Ravenstonedale](#)

##### [Coldbeck Limestone Formation](#)

##### [Scandal Beck Limestone Formation](#)

##### [Park Hill Limestone Member](#)

##### [Coupland Syke Limestone Member](#)

##### [Brownber Formation](#)

##### [Breakyneck Scar Limestone Formation](#)

##### [Ashfell Sandstone Formation](#)

##### [Ashfell Limestone Formation](#)

##### [Potts Beck Limestone Formation](#)

##### [Knipe Scar Limestone Formation](#)

#### **Askrigg Block**

##### [Tom Croft Limestone Formation](#)

##### [Ashfell Sandstone Formation](#)

##### [Fawes Wood Limestone Formation](#)

[Garsdale Limestone Formation](#)

[Danny Bridge Limestone Formation](#)

### **Askrigg Block-Craven Basin Transition Zone**

[Chapel House Limestone Formation](#)

[Kilnsey Limestone Formation](#)

[Scaleber Force Limestone Member](#)

[Scaleber Quarry Limestone Member](#)

[Malham Formation](#)

[Cove Limestone Member](#)

[Gordale Limestone Member](#)

[Cracoe Limestone Formation](#)

### **South Cumbria**

[Martin Limestone Formation](#)

[Red Hill Limestone Formation](#)

[Dalton Formation](#)

[Park Limestone Formation](#)

[Urswick Limestone Formation](#)

### **North and West Cumbria**

[Frizington Limestone Formation](#)

[Eskett Limestone Formation](#)

### **Isle of Man**

[Derbyhaven Formation](#)

[Turkeyland Member](#)

[Sandwick \(Isle of Man\) Member](#)

[Skillicore Member](#)

[Knockrushen Formation](#)

[Balladoole Formation](#)



## Yoredale Group (YORE)

There is long established usage of the term Yoredale facies, based upon the description of Yoredale cycles as early as Phillips (1836). The name Yoredale Group now replaces the Wensleydale Group of the Askrigg Block; the Alston Group of the Alston Block; and the Upper Border Group, and Lower and Upper Liddesdale groups of the Northumberland Trough (Waters et al., 2007).

The Yoredale Group (*mixed shelf carbonate and deltaic ('Yoredale') facies and fluviodeltaic ('Millstone Grit') facies*) (Figure 7) extends across the entire Northern England province and comprises:

In the *Northumberland Trough and Solway Basin*, the Tyne Limestone, Alston and Stainmore formations;

In the *Alston Block, Stainmore Trough and Askrigg Block*, the Alston and Stainmore formations;

In *north Cumbria*, the Alston Formation;

In *south Cumbria (and north Lancashire)*, the Alston Formation;

In *west Cumbria*, the Stainmore Formation;

In the *north Isle of Man*, a sequence similar to the Alston Formation, and another apparently assigned to either the Great Scar Limestone Group or Yoredale Group. These are known only in boreholes (see Chadwick et al., 2001).

The Yoredale Group comprises repeated, typically upward-coarsening cycles of basal, laterally extensive marine limestone, marine shale (commonly bioturbated), thin sandstone commonly topped with seatearth or ganister and an overlying coal. The limestones are typically mid to dark grey, thin-bedded and biomicritic, with a restricted benthic fauna and rare ammonoids. The sandstones are typically pale grey, fine- to medium-grained and quartzitic to subarkosic. The clastic component was deposited by progradation of high-constructive lobate deltas, though there is evidence to suggest that there has been extensive shallow marine reworking of clastic sediments following delta abandonment (Elliott, 1975). Large fluvial channels were incised into underlying cyclothem on the Alston Block during the Brigantian and Pendleian (Dunham, 1990), and in Northumberland an element of tectonic control on this process can be demonstrated (Young and Lawrence, 2002). The marine limestones were deposited during sea-level rises and when delta lobes were switched or abandoned. The cycles, which range from 5–90 m thick, are named after the limestone present at the base of the cyclothem (Leeder et al., 1989). Limestones have bed status unless there are good reasons for them to have member status. Minor limestones and sandstones remain informal beds. Dunham and Wilson (1985) provided details of limestone nomenclature and correlations, and cyclothem thicknesses for the Askrigg Block and Stainmore Trough, and Dunham (1990) provided similar information for the Alston Block. On the north Isle of Man undifferentiated strata assigned to either the Great Scar Limestone Group or the Yoredale Group occurs in the Ballavaarkish (Shellag North) Borehole (NX 4625 0070) between 172.34 and 179.60 m depth. They comprise massive, stylolitized, fractured and sucrosic dolostone, which may be of early Namurian or Visean age, but diagenesis has destroyed any biostratigraphical evidence (see Chadwick et al. 2001).

The conformable but diachronous base of the Yoredale Group is typically taken at the base of marine limestone marker bands. In the Solway Basin, Northumberland Trough, Cheviot Block and north-east Northumberland, the sandstones of the Fell Sandstone Formation, Border Group pass upward, locally unconformably and diachronously, into the Tyne Limestone Formation, Yoredale Group; the

lower boundary of which is variably represented as the base of the Clattering Band or its correlative the Kingsbridge Limestone, or in the Langholm area, the Glencartholm Volcanic Beds.

In the Brough-under-Stainmore and Penrith districts the Robinson Limestone of the Melmerby Scar Limestone Formation, Great Scar Limestone Group, is overlain by siltstone or sandstone of the Tyne Limestone Formation, Yoredale Group. There is evidence of penecontemporaneous erosion and potholing on the top surface of the Robinson Limestone.

In east Cumbria and the Stainmore Trough, the lower boundary of the Yoredale Group occurs where the top of the mostly thick-bedded, pale to mid grey limestone of the Knipe Scar Limestone Formation, Great Scar Limestone Group, is disconformably overlain by the variable sandstone and mudstone Wintertarn Sandstone Member of the Tyne Limestone Formation.

On the northern Askrigg Block, the pale to mid grey limestones (with palaeokarst surfaces) and subordinate mudstones of the Danny Bridge Limestone Formation, Great Scar Limestone Group pass upward into the cross-bedded, regressive sandstones of the Wintertarn Sandstone Member, Tyne Limestone Formation.

In the Settle area, the lower boundary of the Yoredale Group is generally taken where the paler grey, thick- to very thick-bedded limestone with palaeokarst surfaces of the Malham Formation, Great Scar Limestone Group pass upward into the darker grey Lower Hawes Limestone (Alston Formation) at the base of the Yoredale facies sequence.

In west Cumbria, in the Egremont-Whitehaven-Maryport-Cockermouth area, the lower boundary of the Yoredale Group occurs where the shelf carbonate sequence of the First Limestone, Eskett Limestone Formation is terminated and conformably overlain by the mostly clastic marine and deltaic facies of the Stainmore Formation. However, at outcrop the basal part of the Stainmore Formation generally comprises the coarse-grained, fluvial, Hensingham Grit, with a basal mudstone.

In north Cumbria, east of the Bothel Fault, the lower boundary of the Yoredale Group occurs above the pale to dark grey limestones of the Eskett Limestone Formation, Great Scar Limestone Group, at the top of the White Limestone unit, which forms the base of the Fourth Limestone. Immediately west of the Bothel Fault, however, the same boundary occurs at the top of the Fourth Limestone, which is distinguished by the inclusion of palaeokarst surfaces and distinctive fossils. It should be stressed that division east and west of the Bothel Fault is purely for ease of description. The Bothel Fault is not implied to have exerted any penecontemporaneous effects on deposition.

In south Cumbria, the lower boundary of the Yoredale Group is at the point where the predominantly pale grey, thickly bedded limestones of the Urswick Formation, Great Scar Limestone Group, pass up into the predominantly dark grey, thinner bedded limestones and mudstones of the Alston Formation.

On the northern part of the Isle of Man, platform carbonates of the Balladoole Formation, Great Scar Limestone Group are thought to be overlain by a cyclothem mixed carbonate clastic sequence, similar to the Alston Formation, Yoredale Group of south Cumbria.

The top of the Yoredale Group is defined in north, west and east Cumbria, the Solway Basin, the Stainmore and Northumberland troughs, on the Alston Block and in north-east Northumberland by the base of the Pennine Coal Measures Group (*fluviodeltaic* ('Coal Measures') facies). To the north of Wensleydale on the Askrigg Block and in the Settle area, it is defined by the base of the Millstone Grit Group (*fluviodeltaic* ('Millstone Grit') facies). On the northern part of the Isle of Man the top of what may be either the Great Scar Limestone Group or the Yoredale Group is also defined by the

base of the Millstone Grit Group. In south Cumbria the base of the Craven Group (*hemipelagic facies*) defines the top of the Yoredale Group.

The type area of the Yoredale Group is the valley of the River Ure, Wensleydale on the Askrigg Block (see Phillips, 1836; George et al., 1976; Dunham and Wilson, 1985), and it extends across the entire Northern England Province. Thickness varies greatly since the group, formations and individual sandstones tend to thicken into troughs and half-grabens, and conversely all the elements of any rhythm may be reduced or absent. The range in thickness is from 50 m in the Lamplugh area of west Cumbria (Young and Bolland, 1992) to a proved maximum of 1219 m in the Seal Sands Borehole (BGS Registration Number NZ52SW/457) (NZ 538 238) in the eastern part of the Stainmore Trough (Dunham and Wilson, 1985). In south Cumbria the group is 80–180 m thick, and over 500 m of strata are present in the Solway Basin in boreholes north of Maryport. On the Askrigg Block, generalised vertical sections on BGS maps suggest a range of thickness in the order of about 200–900 m, and there are marked thickness variations across the Stublick–Ninety Fathom Fault, separating the Northumberland Trough from the Alston Block, to the south.

The age of the Yoredale Group is Holkerian or Asbian to Yeadonian. The base is diachronous, and ranges from Holkerian in the Kirkbean Outlier and early Asbian in the Northumberland Trough and Solway Basin, to early Brigantian on the Alston and Askrigg blocks, in the Stainmore Trough and in south Cumbria, to Pendleian in north and west Cumbria where there is also a large non-sequence within the group in which strata of Chokierian to Marsdenian age are absent (Akhurst et al., 1997). In south Cumbria, only the Visean part of the succession is present.

The top of the group is latest Yeadonian nearly everywhere, the exceptions being on the Askrigg Block where it is late Pendleian and south Cumbria where it is late Brigantian. In the north Isle of Man the top of the sequence, which is similar to the Alston Formation, is at least early Namurian, but the age of the top of what may be either Great Scar Limestone Group or Yoredale Group strata at the base of the Ballavaarkish (Shellag North) Borehole (see above) remains uncertain (see Chadwick et al., 2001). The base of the Namurian Series is defined as the base of the *Cravenoceras leion* Marine Band. The position of this marine band is taken to be near the base of the Great Limestone Member (see Johnson et al. 1962).

[Yoredale Group](#)

[Tyne Limestone Formation](#)

[Arbigland Limestone Member](#)

[Dun Limestone Member](#)

[Alston Formation](#)

[Askham Limestone Member](#)

[Jew Limestone Member](#)

[Oxford Limestone Member](#)

[Tynebottom Limestone Member](#)

[Eelwell limestone Member](#)

[Scar Limestone Member](#)

[Five Yard Limestone Member](#)

[Three Yard Limestone Member](#)

[Four Fathom Limestone Member](#)

[Great Limestone Member](#)

[Stainmore Formation](#)

## **Craven Group (CRAV)**

The Craven Group, of mainly *hemipelagic facies*, is dominated by deposits of calcareous mudstone interbedded with limestone and subordinate limestone breccia, conglomerate and sandstone. The limestones are typically pale coloured and coarsely bioclastic towards the base of the group and more argillaceous towards the top. The group largely occurs in southern Great Britain (see Waters et al., 2007, for a full description), but it also encroaches upon the onshore Northern England Province where:

In *south Cumbria and in the Askrigg Block-Craven Basin 'Transition Zone'* it comprises the Bowland Shale Formation;

On the *Isle of Man* it comprises the Hodderense Limestone and Bowland Shale formations.

Knoll-reef and slope carbonate turbidite facies also occur on the southern margin of the Askrigg Block. In south Cumbria the upper boundary of the Yoredale Group occurs at the base of the *Cravenoceras leion* Marine Band, where the thinly interbedded limestones, mudstones and subordinate sandstones of the Alston Formation pass upward into the thick mudstones and fine-grained siltstones of the Bowland Shale Formation, Craven Group. On the south Isle of Man, the upper boundary of the Great Scar Limestone Group occurs at a change from the wackestones and packstones of the Knockrushen Formation to massive lime mudstones with micrite nodules of the Hodderense Limestone Formation (see Dickson et al., 1987) and at a change from the limestones with subordinate claystones and siltstones of the Balladoole Formation to the overstepping claystone with detrital carbonates of the Bowland Shale Formation. The diachronous base of the Millstone Grit Group (*fluvio-deltaic ('Millstone Grit') facies*) defines the top of the Craven Group.

[Craven Group](#)

[Hodderense Limestone Formation](#)

[Bowland Shale Formation](#)

[Scarlett Point Member](#)

[Scarlett Volcanic Member](#)

## **Millstone Grit Group (MG)**

The name 'Millstone Grit' is derived from the familiar 'gritstones' (coarse-grained sandstones) that were used historically in flourmills. Whitehurst (1778) first proposed the lithostratigraphical name 'Millstone Grit', since when it has become chronostratigraphical in concept. Synonymous with the Namurian, it was divided, in the Central Pennine Basin, into stages bound by key widespread marine

bands (see George and Wagner, 1972; Ramsbottom et al., 1978). The historical precedence was established in the Bradford district (Stephens et al., 1953) where six 'groups' were defined using ammonoid biozones, which broadly correspond to the modern stages of the Namurian. The Stratigraphical Framework Committee concluded that this approach should be maintained, and each of the seven Namurian Stage successions was assigned a distinct formation name, with the exception of the thin, commonly mudstone-dominated successions of the Chokierian and Alportian, which were joined to form a single formation (see Waters et al., 2007). Where marine bands cannot be recognised, or other biostratigraphical data are absent, the group is left undivided.

In central England, the component formations of the group, in ascending order, are the (Pendleian) Pendleton, (Arnsbergian) Silsden, (Chokierian and Alportian) Samlesbury, (Kinderscoutian) Hebden, (Marsdenian) Marsden, and (Yeadonian) Rossendale formations. They are also present in northern England, but limited to the Askrigg Block, south Cumbria (the Pendleton Formation only) and north Isle of Man (the Rossendale Formation only). In northern England (Figure 7), the heterolithic succession of grey sandstone, siltstone and mudstone with subordinate coal and seatearth is characterised by the commonly coarse-grained nature of the sandstone (formerly referred to as grit), typically an arkosic or subarkosic arenite. Marine bands, representing transgressive events, are present in the succession, although fewer in number than the comparable succession in the Central Pennine Basin. The marine bands consist typically of dark grey to black, calcareous, shaly mudstone about 0.5 m thick. Distinct ammonoid faunas and the extensive correlation of the marine bands make them of primary stratigraphical importance.

In Britain, the Millstone Grit Group was deposited by repeated progradation of deltas, predominantly from the north and east. Delta-top subfacies are characterised by condensed, predominantly upward-fining cycles of sandstone to structureless clayrock. Thick, high-alumina seatclay, fireclay and bauxitic clay are common, with sporadic beds of limestone, ironstone, cannel and coal. This subfacies is more typical of the succession developed in northern England, north of the Craven Fault System. It is probable that many of the sandbodies are linear in geometry and occupy incised valleys, with well-developed palaeosols developed on the interfluvies. Sheet-like and laterally extensive deltaic sandbodies, upward-coarsening with a lower part dominated by mouth-bar deposits overlain by distributary sands, more typical of the late Namurian succession of the Central Pennine Basin may extend onto the southern margin of the Askrigg Block. Deep-water deltaic sequences deposited in a delta-front apron of coalescing turbidite lobes, a feature of the lower part of the group in the Central Pennine Basin, are absent north of the Craven Fault System.

The base of the Millstone Grit Group on the Askrigg Block is taken at the base of the 'Bearing' or Howgate Edge grits, Pendleton Formation. Here, the mixed shelf carbonate and deltaic succession of the underlying Stainmore Formation, Yoredale Group is succeeded, at an unconformity of E1c age, by sandstone-dominated strata (see Brandon et al., 1995). The base of the group in south Cumbria is taken at the diachronous base of the Pendleton Formation, where the mudstone-dominated succession of the underlying Bowland Shale Formation, Craven Group, gives way to a predominantly feldspathic sandstone succession. The base of the group on the north Isle of Man in the Ballavaarkish (Shellag North) Borehole (NX 4625 0070) appears to be within the Rossendale Formation at 164.55 m depth. This is at the base of listricated claystone that may lie in the upper part of the *Cancelloceras cumbriense* Marine Band (see Chadwick et al., 2001). This position lies immediately above faulted strata that comprise thin-bedded, listricated and shattered black claystone and siltstone, and pale fine-grained sandstone to a depth of 172.34 m. Below this level occurs a sequence of massive dolostones apparently assigned to either the Great Scar Limestone Group or the Yoredale Group by Chadwick et al. (2001). The base of the Pennine Coal Measures Group (*fluviodeltaic* ('Coal Measures') facies) defines the top of the Millstone Grit Group.

The thickest development of the Millstone Grit Group is in the northern part of the Central Pennine

sub-basin, where 1225.m is recorded in Wharfedale (Ramsbottom, 1978). As the Namurian succession passes northwards over the Askrigg Block it becomes significantly reduced in thickness to about 400 m in the Colsterdale–Upper Nidderdale area (Dunham and Wilson, 1985), and the presence of a mid Carboniferous unconformity is indicated here by the absence of Alportian strata (Ramsbottom, 1977a). The Millstone Grit Group is represented on the north Isle of Man in the Ballavaarkish (Shellag North) Borehole (see above) solely by the Rossendale Formation. It is at least 26 m thick and Yeadonian in age (see Chadwick et al. 2001).

Since the Millstone Grit Group extends into southern Britain the definitions that follow for the constituent formations have been unified with those of Waters et al. (2009). Information relevant solely to northern Britain is, however, provided under the subhead ‘*Local notes*’.

[Millstone Grit Group](#)

[Pendleton Formation](#)

[Silsden Formation](#)

[Samblesbury Formation](#)

[Hebden Formation](#)

[Marsden Formation](#)

[Rossendale Formation](#)

## **Pennine Coal Measures Group (PCM)**

The ‘Coal Measures’ have historically had a chrono-stratigraphical name synonymous with Westphalian plus Stephanian strata. However, the name has recently been redefined lithostratigraphically, to describe the main body of coal-bearing strata in the Westphalian succession (Powell et al., 2000).

The Pennine Coal Measures Group (*fluviodeltaic* (‘*Coal Measures*’) *facies*) (Figure 7) extends from the Wales–Brabant Massif northwards to the Southern Uplands and Cumbria (see Waters et al., 2007; Waters et al., 2009). It also occurs in the north Isle of Man. The group has been given the epithet ‘Pennine’ to distinguish these coal measures from those present in central Scotland, and from those south of the Wales–Brabant Massif. The group is subdivided stratigraphically into three formations, the Lower, Middle and Upper Coal Measures, as defined by Stubblefield and Trotter (1957), and it comprises 10 m-scale cyclothems (more numerous than in the Millstone Grit) of alternating sandstone, grey siltstone and grey mudstone, with many coal seams, ironstone nodules or beds and seatearth (palaeosol) horizons. The base of the cycle is marked by grey mudstones, commonly recognised as nonmarine bands, or less commonly as marine bands. Both are important for correlation. Sandstones are typically very fine- to fine-grained, commonly overlain by leached ganisters or unleached gley seatearths. The Coal Measures accumulated in a delta-top environment with large distributary channels, freshwater lakes and lagoons with small deltas and crevasse splays, and swamps and bogs colonised by plants. Laterally widespread marine bands (generally lacking diagnostic ammonoids, but dominated by foraminifers, *Lingula* sp., fish remains and a shallow marine benthic productid fauna) probably resulted from eustatic sea level rises. Originally deposited in a broad basin, subsequent tectonism has isolated the Coal Measures into smaller coalfields.

As defined by Stubblefield and Trotter (1957), the base of the group is taken at the base of the

Subcrenatum Marine Band (SBMB) or at the base of the coal-bearing sequence if this marker band cannot be identified. The Subcrenatum Marine Band is absent over much of north Cumbria and has a restricted occurrence in west Cumbria. There is also an equivalent in north-east England known as the Quarterburn Marine Band that contains a shallow-marine, benthic, productoid fauna (Calver, 1969).

In north, west and east Cumbria, the Solway Basin (except the Canonbie area), the Stainmore and Northumberland troughs, on the Alston Block and in north-east Northumberland, the typically repetitive mudstones, siltstones, sandstones, thin limestones and thin coals of the Yoredale Group, lie generally conformably below the base of the grey mudstone, siltstone and interbedded pale grey sandstone of the Pennine Lower Coal Measures Formation, Pennine Coal Measures Group. In the Canonbie Coalfield, the boundary between the Stainmore Formation, Yoredale Group and the Pennine Lower Coal Measures Formation is uncertain as to its position and nature (see Jones and Holliday, 2006). On the Askrigg Block, and north Isle of Man in the Ballavaarkish (Shellag North) Borehole (NX 4625 0070) the base of the group is also taken at the generally conformable base of the Pennine Lower Coal Measures Formation. Here, however, dominantly feldspathic sandstones of the underlying Rossendale Formation, Millstone Grit Group are succeeded by the claystone Subcrenatum Marine Band at the base of the Coal Measures cyclothem sequence. The base of the Warwickshire Group or the Permo-Triassic unconformity defines the top of the Pennine Coal Measures Group.

The type area of the Pennine Coal Measures Group is the Pennine coalfields, where they are up to 1900 m thick near Manchester (see Waters et al., 2007; Waters et al., 2009). Within the Northern England Province they are about 1000 m thick in the Canonbie Coalfield where they thin westward as they overstep a structural high. They are up to 900 m thick in the main area of the Northumberland-Durham Coalfield, and between 300 and 400 m thick in west Cumbria where they thicken offshore to the north-west into the Solway Basin. On the north Isle of Man in the Ballavaarkish (Shellag North) Borehole (see above), about 16 m of the group was proved. The Pennine Coal Measures Group is Westphalian in age, typically Langsettian to Bolsovian.

Since the Pennine Coal Measures Group extends into onshore southern Great Britain the definitions that follow for the constituent formations have been unified with those of Waters et al. (2009). Information relevant solely to northern Britain is, however, provided under the subhead 'Local notes'.

[Pennine Coal Measures Group](#)

[Pennine Lower Coal Measures Formation](#)

[Pennine Middle Coal Measures Formation](#)

[Pennine Upper Coal Measures Formation](#)

## **Warwickshire Group (WAWK)**

The name 'Warwickshire Group' (Figure 7), derived from the Warwickshire Coalfield, was introduced to replace such collective terms as 'Barren (Coal) Measures' and 'Red Measures' that were previously used for predominantly red-bed strata of alluvial facies (Powell et al., 2000; Waters et al., 2007). In the Central England Province the Warwickshire Group (*alluvial* ('*Barren Measures*') *facies*) consists of mainly red, brown or purple-grey mudstone, siltstone and sandstone, with locally developed pebbly sandstone, conglomerate and breccia. The red-beds underwent oxidation at or close to the time of deposition. Minor components comprise grey mudstone, thin coals, lacustrine

limestone (*'Spirorbis'* limestone) and pedogenic limestone (caliche or calcrete). However, the Warwickshire Group is also considered to extend to the Northern England Province (Figure 7) where it comprises the Eskbank Wood, Canonbie Bridge Sandstone and Becklees Sandstone formations at Canonbie (Jones and Holliday, 2006; Jones et al., in press), and the stand-alone fluvial and fluviolacustrine Whitehaven Sandstone Formation in north and west Cumbria (Akhurst et al., 1997).

The base of the group in the Canonbie Coalfield is taken at the conformable and gradational base of the Eskbank Wood Formation where the first major red-bed strata overlie the grey mudstone-dominated Pennine Upper Coal Measures Formation. The sharp, unconformable base of the Permian (Variscan) unconformity, overlying the Becklees Sandstone Formation, defines its top. The base of the group in north and west Cumbria is taken at the base of the Whitehaven Sandstone Formation where the non-reddened, cyclical, mudstone-dominated succession with thin coals of the underlying uppermost Pennine Coal Measures Group are succeeded unconformably by red sandstones. Over much of the west Cumbria Coalfield, strata from the upper Similis-Pulchra Chronozone appear to be cut out below the base of the Whitehaven Sandstone Formation. The base of the Permian unconformity defines the top of the group (see Akhurst et al., 1997).

The Type area of the Warwickshire Group is the Warwickshire Coalfield in central England, where the Duckmantian to early Permian (Autunian) succession attains its fullest thickness of 1225 m (see Powell et al., 2000; Waters et al., 2007; Waters et al., 2009). In the Canonbie Coalfield the group may be up to perhaps 500 m thick, whilst in north and west Cumbria it is at least 300 m thick. In both areas the group is late Bolsovian to Asturian (Westphalian D) in age.

[Warwickshire Group](#)

[Eskbank Wood Formation](#)

[Canonbie Bridge Sandstone Formation](#)

[Becklees Sandstone Formation](#)

[Whitehaven Sandstone Formation](#)

[Bransty Cliff Sandstone Member](#)

[Millyeat Member](#)

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