

Warwickshire Group, Carboniferous, Northern England

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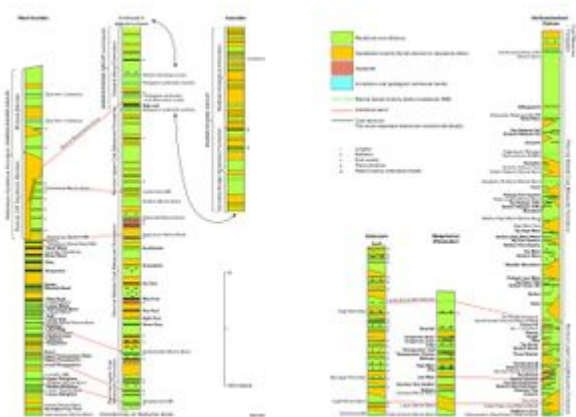
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Introduction



Representative sections and correlations for the Pennine Coal Measures and Warwickshire groups. P916077.

The Pennine Coal Measures Group in the Cumbrian and Canonbie coalfields is overlain by red-bed successions that, together with other, similar late Carboniferous sequences elsewhere in Britain, make up the Warwickshire Group (P916077). Primary reddening, occurring soon after sediment deposition, is a key characteristic but is not uniformly developed throughout, so that in general red beds alternate with unreddened intervals. This phenomenon introduces local uncertainty as to the exact age of the Warwickshire Group strata and their stratigraphical relationship to apparently coeval, but unreddened rocks in the Pennine Coal Measures Group.

Cumbria

In Cumbria, a red-bed succession at least 300 m thick forms the Whitehaven Sandstone Formation. The lithology and sedimentological character distinguish it from the underlying Pennine Coal Measures Group, and its base changes stratigraphical level with respect to coal seam and marine band marker horizons therein.

The most prominent part of the succession is the 100 m or more of pink to red sandstone that forms coastal cliffs at Whitehaven and can be seen in small quarries and natural exposures over much of the central Cumbrian Coalfield. Also included in the formation are 200 m of more lithologically varied, finer-grained red-beds that have been described from two boreholes, at Frizington Hall (NY 019 171) and Millyeat (NY 023 178), and also form small exposures in the valley of the Dub Beck (NY 022 175). This succession, the Millyeat Member, contains thin interbeds of *Spirorbis* limestone, coals, mudstone and sandstone. With the exception of these thin limestone beds, the Whitehaven Sandstone Formation in west Cumbria is all but barren of fossil material. Nonspecific plant remains have been reported, along with the occurrence of the zonal bivalves, *Anthraconauta phillipsi* and *A. tenuis*. This assemblage suggests, but does not prove, a Bolsovian or Westphalian D age for the upper part of the formation. In the northern sector of the Cumbrian Coalfield, a Westphalian D, *Tenuis* Zone bivalve fauna, is found in similar, but more fossiliferous, strata in the Cockermouth area.

The lower part of the Whitehaven Sandstone Formation was laid down in a major braided river system that flowed across the area from the north-east. It carried a voluminous and coarse-grained sediment load of different character to that found in Pennine Coal Measures sandstones. Between the fluvial channels were limited areas of coal swamp, showing that the environment was not, at that stage an arid one. Later, the major river system either switched to another location or the sediment supply became restricted; minor river channels continued to deposit laterally impersistent sandstone beds but deposition of fine-grained sediment in interdistributary or lacustrine environments became dominant. Coal-forming conditions occasionally developed, but a change to a drier climate is indicated by the presence of the *Spirorbis* limestone beds, which formed in shallow and well-oxygenated lakes, possibly brackish due to high evaporation rates.

The Whitehaven Sandstone Formation is faulted against unreddened strata of the Pennine Coal Measures Group, suggesting that reddening was a relatively early process. It seems most likely to have occurred during permeability-controlled, late Carboniferous diagenesis. Whether the process began during a syndepositional change to an arid, oxygenating environment or was accomplished during postdepositional Variscan uplift, remains an open question.

Canonbie

At outcrop, about 290 m of the Warwickshire Group red beds are almost continuously exposed along the banks of the River Esk, but the maximum proved thickness is up to about 530 m, which occurs in the Becklees Borehole close to the central axis of the Solway Syncline. Seismic reflection data indicate that elsewhere in the centre of the syncline the group could be up to about 700 m thick.

Three formations have been recognised within the group, each with distinctive geophysical log signatures that allow them to be readily correlated in the subsurface. The lowermost, Eskbank Wood Formation ranges in thickness between 145 and 175 m. The base of the formation is diachronous, marked by the repeated alternations of grey and primary red-bed strata. Where no core or core descriptions exist, it is difficult to determine the position of this change and it is suggested that the base is taken at the top of the High Coal, which forms a prominent marker horizon. The formation

comprises red mudstone, with some fine-to medium-grained sandstone, calcrete palaeosols, thin beds of *Spirorbis* limestone and *Estheria*-bearing mudstone. The overlying Canonbie Bridge Sandstone Formation ranges in thickness from 131 to 154 m. The base of the formation is sharp, marked by the incoming of thick units of medium- and coarse-grained cross-bedded channel sandstone. A noticeable feature of these sandstones is their greenish grey colouration, which can be related to the presence of abundant lithic grains. The Becklees Sandstone Formation is the highest unit recognised from the Warwickshire Group of Canonbie and is overlain unconformably by Permian strata. Its full thickness is not known, but up to 200 m are proved in the Becklees Borehole. This fine-grained sandstone has a distinct orange-brown colouration.

Warwickshire Group sedimentation in the Canonbie area largely took place on a well-drained alluvial plain, and was characterised by an early, primary oxidation of the strata. Large braided river systems were common features of the alluvial plain, with palaeocurrent data from the Canonbie Bridge Sandstone showing that the rivers flowed towards the north. Overbank and floodplain mud was deposited between the river channels, where soils were able to form during intervals with low rates of aggradation. The youngest Warwickshire Group strata seen in the Canonbie Coalfield are probably typical of what covered most of northern England prior to late Carboniferous folding and uplift.

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