Carboniferous rocks — introduction

Carboniferous rocks formed during the Carboniferous Period, generally regarded as having extended from approximately 354 to 290 million years ago. The term 'Carboniferous', which derives from the abundance of carbon-bearing coal seams within the rocks, was first used in Britain.

Carboniferous rocks in Great Britain

Carboniferous rocks occur extensively within Britain. In much of Britain the base of the Carboniferous System is not exposed, or rests unconformably upon older rocks.

Carboniferous rocks make up one of the most extensive and arguably the most economically important geological units in Britain. These rocks were the source of virtually all of Britain's coal. They attracted the interest of naturalists from the earliest days of scientific enquiry. Many of the basic principles of stratigraphic division and geological structure were established in these rocks. The names used for the major Carboniferous divisions came into use early in the history of geology and this country may in effect be regarded as the 'type district' for these rocks.

At the beginning of the Carboniferous Period Britain was part of a continent known as Laurasia, situated almost astride the equator. During the Carboniferous it drifted north across the Equator from 5 to 10 degrees south to about 5 degrees north. Such movement would have taken the region from the southern hemisphere tropical arid zone, where it was situated during the Devonian Period, through the much wetter Carboniferous equatorial zone into the northern hemisphere tropical arid zone in latest Carboniferous and Permian times.

The succession of Carboniferous rocks in Britain records a gradual change from the early limestone-rich sequences through diverse depositional conditions to the more uniform conditions of late Carboniferous times when widespread fluviatile and deltaic sediments accumulated at or near the prevailing sea level.

Global continental movements initiated towards the end of the Devonian Period resulted in a general north-south extension of the earth's crust beneath the area now occupied by Britain. This produced a series of 'basins' separated by highs or 'blocks' and caused the sea to flood much of the area which had been land at the end of the Devonian. In the early Carboniferous the 'block and basin' topography resulted in the deposition of thick marine shale successions in the rift basins and thin shallow-water limestone sedimentation on the blocks with some areas, such as the Southern Uplands, remaining above the transgressing tropical sea. The blocks were separated from adjacent basins by hinge lines and normal faults along which movement occurred intermittently during sedimentation. Continued earth movements throughout the Carboniferous led to differential subsidence and uplift. Within northern England the buoyancy of the Weardale Granite controlled the evolution of the Alston Block and adjoining Stainmore Trough.

As long ago as the 18th century, three main divisions of Carboniferous rocks, based predominantly on rock type, were recognised: Carboniferous (or Mountain) Limestone, Millstone Grit and Coal Measures. This threefold division has remained more-or-less valid and is reflected in the three age-related terms, Dinantian, Namurian and Westphalian used to describe the rocks in this publication (Table 2).

Carboniferous rocks in County Durham

Outcrops of Carboniferous rocks comprise approximately 185,089 hectares, or almost 83%, of the surface area of County Durham. (Table 2) illustrates the terminology employed for this important group of rocks. In consequence of modern research a new classification of British Carboniferous rocks is being developed. Although not yet widely adopted, this new terminology will soon appear on maps and descriptions of the area and is included in (Table 2).

The Weardale Granite exerted a very strong influence on the nature of Carboniferous rocks across the area which eventually became North East England, particularly in early Carboniferous times. Granite is less dense than most rocks in the earth's crust. It is therefore rather buoyant, tending to rise relative to the rocks which surround it. Because of this, as the area gradually subsided at the beginning of the Carboniferous Period, the 'block' of Ordovician rocks, together with the Weardale Granite, tended to subside rather less rapidly than the surrounding areas. As a result a much thinner succession of Carboniferous limestones, mudstones and sandstones accumulated on this 'block' than in the adjoining areas. Geologists term this area the 'Alston Block'. A similar 'block' here too partly underpinned by an old granite, comprises the area known as the 'Askrigg Block' of the Yorkshire Pennines. County Durham encompasses much of the Alston Block and the extreme northern most parts of the Askrigg Block. Separating these, in the Stainmore area, is the belt of much more rapid Carboniferous subsidence, and thus of much thicker Carboniferous sediments, known as the Stainmore Trough.

A conspicuous feature of much of the Carboniferous succession of rocks in Northern England is a cyclicity or regular repetition of rock types (Figure 9). Periodic change between marine and fluviatile conditions allowed the deposition of well developed and laterally extensive cycles of sedimentation (cyclothems) for which the region is famous. The term Yoredale facies has been used for the repeated upward sequence of limestone, shale, sandstone, seatearth and coal in the Carboniferous of the north of England generally. The cyclicity can be observed at a variety of scales and in varying degrees of complexity. The largest 'cyclothems' occur at the scale of tens to hundreds of metres in thickness. The relative abundance of the different rock types within cycles changes throughout the Carboniferous: Limestone is dominant and coal insignificant in the Lower Carboniferous; sandstone becomes dominant and coal more important in the Upper Carboniferous.

It is not appropriate to describe each individual rock unit of the Carboniferous succession. However, it is important to appreciate some of key characteristics of the main rock types present. These are summarised as follows:

Limestones

Limestones comprise a significant proportion of the lower part of the Carboniferous succession of County Durham, though they become fewer and are separated by increasing thicknesses of other sediments as the sequence is traced upwards. The lowermost limestones are typically pale grey rocks with comparatively few impurities. Higher limestones generally contain significant amounts of clay and bituminous impurities, giving them a rather darker grey colour. Most of the area's limestones contain an abundance of, mainly fragmentary, fossils, though certain limestones, particularly within the Namurian part of the succession, are characterised by rich faunas of corals, sponges etc.

Coals

A feature of the coals of North-East England is their 'rank'. The 'rank' of a coal is its degree of maturity. The effects of temperature and pressure over long periods of geological time tend to expel water and volatile constituents from coal. Thus, a coal which has been subject to elevated temperatures typically exhibits a comparatively low votalile content, high carbon content and high calorific value. In County Durham coal rank increases westwards, with particularly high rank coals present over parts of the concealed Weardale Granite. The little Limestone Coal over much of the North Pennines is of a sufficiently high rank to be described as semi-anthracite. The increase in rank is a result of the heating effects of the concealed Weardale Granite.

The rank of a coal largely determines its use: lower rank coals are well-suited to domestic or power station use, medium rank coals are appropriate for gas and domestic coke production, whilst high rank coals produce good metallurgical coke and anthracites provide smokeless fuels.

Sandstones

The county's sandstones exhibit a considerable variation, details can be found in the relevant BGS memoirs and other publications. The great majority of the sandstones vary from fine to medium grained rocks, composed mainly of quartz grains, though generally with a small but significant content of feldspar grains, most of which are more or less altered to kaolin. Much coarser, locally pebbly, sandstones are present in places. The sandstones vary from hard, resistant rocks with a well-developed cement, to comparatively weak, in some instances almost friable, rocks where only a weak cement is present. Cross-bedding is extremely common and ripple marks are conspicuous locally. Many sandstones provide clear evidence of erosive bases, clearly betraying their origins as the fillings of channels. Erosion surfaces within individual sandstone units are common. Well-preserved fossils are generally uncommon, though casts of marine brachiopods, bivalves and crinoids locally reveal a marine origin. A few persistent thin beds of sandstone with concentrations of marine shells have been shown to have value as correlative horizons. These include the Knucton and Rookhope Shell Beds. More commonly, certain sandstones exhibit recognisable rootlet traces, or other plant remains, clearly indicative of their origins in a well-vegetated fresh-water or swamp environment. The very large cast of a tree stump and root system, recovered from one of these sandstone beds, and preserved today in Stanhope church yard, is a particularly spectacular example of such a plant fossil. Such sandstones comprise fossil soils or 'seat earths', and may be overlain by a thin coal seam or a very bituminous parting representing the remains of the vegetation. It is common for such sandstones to be significantly richer in silica than many of the other sandstones, and for silica to be the major cementing mineral in the rock. These extremely hard silica-rich rocks are commonly known as 'ganisters'. The high silica content makes some of these beds suitable for the making of silica refractory products for furnace linings.

Cherts

Very fine-grained siliceous rocks called cherts occur locally within the lower part of the Namurian succession in the southern part of the county.

Mudstones and siltstones

These rock types commonly make up large proportions of the Carboniferous succession, particularly in the Namurian and Westphalian. They are seldom well exposed and, except in one instance, the 'Tynebotton Plate', have not acquired widely used local names.

Ironstones

These occur at several horizons, mostly within the Namurian and Westphalian successions. Most common are concentrations of clay ironstone nodules or thin beds of clay ironstone composed mainly of impure siderite. More rarely, oolitic ironstones occur locally within parts of the Namurian succession.

Shell Beds

Shell Beds are beds in which fossilised shells are especially common: such beds may be sandstones, shales or limestones.

Naming the rocks

It was the practice of miners and quarrymen to give local names to the rock units, with which they became extremely familiar, particularly the limestones and many of the sandstones. Most of these names were applied at an early date and were adopted by the emerging science of geology as a means of describing the varied stratigraphy of the Carboniferous rocks. These names reflect a variety of intrinsic characteristics. For example:

The Four Fathom and Five Yard limestones reflect typical thicknesses of those units, 24 feet (7.3 m) and 30 feet (9.1 m) respectively.

The Scar Limestone reflects its role in giving rise to landscape features.

The Great Limestone reflects both its thickness and economic importance as a source lime or as a host for mineral deposits.

The Melmerby Scar and Tyne Bottom limestones derived their names from the localities where these units are best developed.

In addition to these stratigraphical names, miners and quarrymen employed local names for rock types. These have not generally been adopted by geological science, though references to them abound on old mine plans and contemporary mine reports.

Hazle (pronounced hezzle) is a sandstone

Sill usually refers to sandstone, or in some instances (e.g. the Coal Sills) a comparatively discreet group of beds consisting predominantly of sandstone.

Flagstones are typically hard sandstones which tend to split readily along, or parallel with, the bedding planes. They may contain thin shale partings which facilitate this splitting.

Grit usually refers to a hard, coarse-grained sandstone, commonly one with a proportion of comparatively softer grains which ensures that the rock maintains a rough surface when exposed to wear in millstones.

Plate was generally used for shales and silty shales.

Selected references

Burgess and Holliday, 1979; Cleal and Thomas, 1996; Dunham, 1990; Dunham and Wilson, 1985; Johnson and Dunham, 1963; Johnson, 1970, 1995; Mills and Holliday, 1998; Mills and Hull, 1976; Taylor et al. 1971.

Figures, photographs and tables

(Figure 9) Idealised 'Yoredale' cyclothem.

(Photo 2) Heights Quarry, Eastgate, Weardale. Great Limestone and overlying shales and sandstones. B Young, BGS, ©NERC, 2004.

(Photo 3) Barnard Castle. The river cliff exposes the Top and Bottom Crag Limestones and intervening beds. BGS, ©NERC, 2004.

(Photo 4) Namurian shales exposed in North Grain, Rookhopehead, Rookhope. An iron-rich spring flows from a fault cutting the shales. B Young, BGS, ©NERC, 2004.

(Table 2) Classification of Carboniferous rocks in County Durham.

Full references

<table>
<tr><th>Traditional name</th><th colspan="2">Modern Chronostratigraphical divisions</th><th>Divisions used on existing 50k geological maps and this document</th><th colspan="2">Divisions likely to be used on maps and descriptions of the area in the future</th></tr>
<tr><td>Coal Measures</td><td rowspan="3">Upper Carboniferous</td><td>Westphalian</td><td>Coal Measures</td><td>Coal Measures</td><td></td></tr>
<tr><td>Millstone Grit</td><td rowspan="2">Namurian</td><td>Stainmore Group</td><td>Stainmore Formation</td><td rowspan="3">Yoredale Group</td></tr>
<tr><td rowspan="5">Carboniferous (or Mountain) Limestone</td><td>Great Limestone</td><td rowspan="2">Alston Formation</td></tr>
<tr><td rowspan="4">Lower Carboniferous</td><td rowspan="4">Dinantian</td><td>Alston Group</td></tr>
<tr><td>Melmerby Scar Limestone</td><td>Robinson Limestone</td><td rowspan="3">Great Scar Limestone Group</td></tr>
<tr><td>Orton Group</td><td rowspan="2">Melmerby Scar Limestone Formation</td></tr>
<tr><td>Basement Group</td></tr>
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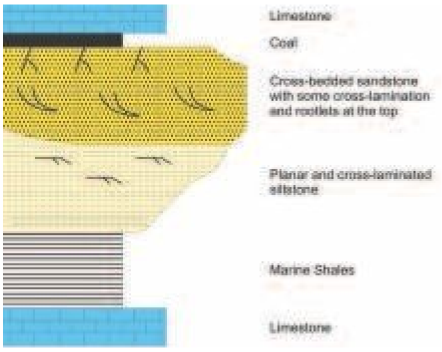

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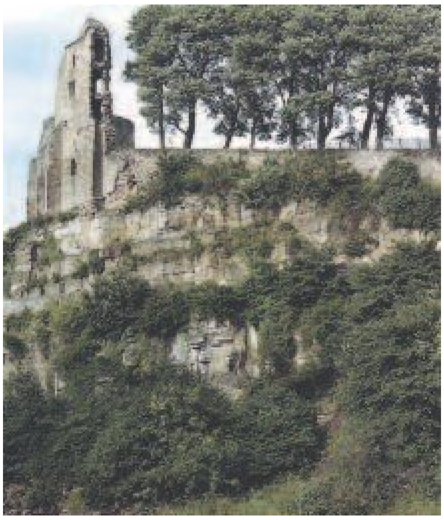

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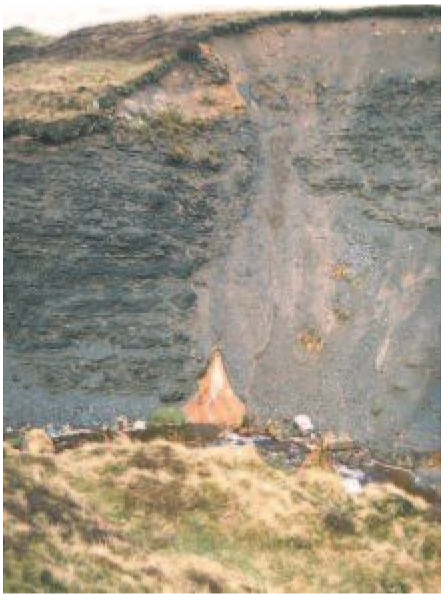

(Photo 4) Namurian shales exposed in North Grain, Rookhopehead, Rookhope. An iron-rich spring flows from a fault cutting the shales. B Young, BGS, ©NERC, 2004.