Stratigraphical principles, Carboniferous, Southern Uplands

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Stratigraphical principles

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The Carboniferous rocks in the south of Scotland have a long history of geological study and a variety of stratigraphical schemes, based on a range of characteristics, has been applied to them. This has led to a confusing plethora of local stratigraphical names and uncertainty over the correlation of the sequences from one area to another. Historically, three divisions of the Carboniferous rocks of Britain were recognised based on the character of the rock sequence, the Carboniferous Limestone, the Millstone Grit and the Coal Measures. These lithostratigraphical (rock) divisions later became broadly equated with the chronostratigraphical (time) divisions of the Dinantian (divided into the Tournaisian and Visean), Namurian and Westphalian; the last two of these divisions, together with younger Carboniferous divisions poorly represented in Britain, made up the Silesian (P912386). International convention has now replaced the Dinantian and Silesian with, respectively, the Mississippian and Pennsylvanian subsystems, though the boundaries do not coincide precisely (P912386). The more detailed subdivision into chronostratigraphical stages and substages (P912386) is largely based on biostratigraphy, which relies on the identification of key fossils and fossil assemblages, and the recognition of how these features change through successions of strata. The Westphalian Stage has traditionally been divided into four stages, originally lettered A to D but now formalised as substages: respectively Langsettian, Duckmantian, Bolsovian and Asturian.

**Biostratigraphy**

Biozones are stratigraphical intervals characterised by the fossil biotas that they contain, and are defined by criteria such as the successive first appearances of distinctive fossil species, the total stratigraphical range of a species, the overlapping ranges of two or more species, or by particularly abundant occurrences of a distinctive species. Biozonation based on the occurrence of corals and brachiopods has been of historical importance in the classification of platform carbonates, mostly of
Visean age, though the faunas are now considered to have been strongly facies controlled. In other Tournaisian and Visean lithofacies, and through the Namurian, the relatively diverse molluscan fauna was utilised. It is now also common to utilise microfauna such as conodonts and foraminifera, which facilitate correlation at international level. Particularly useful for the lower Carboniferous are the corals, foraminifera and conodonts, whilst for the upper Visean, Namurian and Westphalian the best resolution is provided by ammonoids. Nonmarine bivalves, which are important to the zonation of late Namurian and Westphalian sequences, tend to occur in association with fish material and ostracods; at a number of stratigraphical levels bivalve shells have built up to form distinctive ‘mussel bands’. Accumulations of estheriids (small crustaceans that occupied brackish waters) can also be stratigraphically useful. A selection of Carboniferous macrofossils is illustrated in Plate 34.

The ammonoids (goniatites) occur within thin marine bands that developed during discrete marine incursions at periods of high global sea level. The marine bands are present over wide areas and contain characteristic fossil assemblages so that, together with palynology (see below), they have become the primary means of correlation within and between coalfields in both the Pennine and Midland Valley basins, and thence as far as eastern Europe. They have also allowed preliminary correlation of Westphalian sedimentary rocks onshore with those in the southern North Sea. Marine bands represent geographically widespread, short-lived, marine flooding events and are fundamental to a proper understanding of the succession since they reflect the most significant changes in base level (relative sea level). Three widespread marine bands — Subcrenatum, Vanderbeckei and Aegiranum — are used to define the substages of the Westphalian forming, respectively, the bases of the Langsettian, Duckmantian and Bolsovian (P912386). However, a plethora of local names has been applied and different marine bands have been taken as the boundaries of the Coal Measures lithostratigraphical formations in the Pennine and Scottish sequences. Correlation is provided in P912387 with local examples taken from the Sanquhar and Canonbie coalfields in the south of Scotland. Only the Vanderbeckei marine band, separating the Lower and Middle Coal Measures formations, has the same stratigraphical significance in both the Pennine and Scottish successions.

The remains of coal-swamp vegetation (which included relatives of present-day tree ferns, horsetails and club mosses) are common fossils in the Coal Measures strata and following significant studies in the first half of the 20th Century, a set of plant biozones was established for the Westphalian. More recently palynology, which in Carboniferous rocks is focused on plant spores and pollen (miospores), has become a standard biostratigraphical technique. Its great advantage is that only a small rock sample is needed to provide many microfossils (miospores). As a result, it has proved invaluable in the correlation of borehole sequences offshore and enables comparison between them and the onshore basins. It has been much applied to interpretations of Westphalian strata from beneath the North Sea. Miospores are present in both marine and terrestrial environments and so are particularly useful for correlations of marine successions with nonmarine rocks lacking stratigraphically useful macrofossils, and for correlation between separate nonmarine successions.

### Sequence stratigraphy

Seismic profiling has become the primary technique for analysing basin evolution, and from it has developed the discipline of sequence stratigraphy, which affords an alternative approach to the description, interpretation and correlation of the Carboniferous successions. Sequences are defined as stratigraphical units bounded by regional unconformities or disconformities related to cyclical changes of sea level. Sequence stratigraphical models then distinguish between sedimentary units (or systems tracts) produced during different parts of the cycle of variation in relative sea level. So, for example, transgressive systems tracts formed when sea level was rising, high-stand systems tracts formed when sea level was high, and low-stand systems tracts formed when sea level was low. Sequences are on different scales, and are arranged in a hierarchy from 1st order (of longest...
duration) to 5th order. Sequence stratigraphy emphasises the allocyclic controls on sedimentary successions (tectonism, climate and eustacy) and can provide an improved understanding of depositional history and sedimentary system development. In places, especially in concealed sequences with limited borehole control, it can enable a higher resolution correlation than can be obtained by existing lithological and palaeontological methods. However, and despite the advantages, the recognition and correlation of surfaces bounding systems tracts in borehole core or at outcrop can be difficult, and biostratigraphy commonly provides important controls and constraints when integrated with sequence stratigraphy interpretations. Given the fossiliferous nature of most Carboniferous rocks, biozonation is likely to remain an independent tool for stratigraphical subdivision and the establishment of a chronological framework for the succession. A useful equivalence between the two schemes is provided by the marine bands — long established and well tested in stratigraphical correlation — which equate to maximum flooding surfaces in sequence stratigraphy terminology.

**Lithostratigraphy**

In common with Carboniferous successions elsewhere in Britain, those of southern Scotland contain a range of economic mineral products that have long attracted attention. Coal, limestone and sandstone have been worked locally, particularly so in the Canonbie and Sanquhar coalfields, and to help identify the beds they were commonly given local names. For example, in the Langholm and Canonbie districts, the Carboniferous stratigraphical nomenclature applied in the 19th and early 20th century divided the rocks into the Whita Sandstone, the Cementstone Group, the Fell Sandstones, a Marine Limestone Group, the Millstone Grit, two coal groups and the Red Sandstones of Canonbie. Volcanic rocks of Birrenswork were also recognised at the base of the succession and evidence of other short-lived volcanic episodes was noted above the Fell Sandstones. Subsequent work in the 1950s and 1960s divided the Dinantian sequences into a tripartite (Lower, Middle and Upper) Border Group and a bipartite (Lower and Upper) Liddesdale Group. These units were primarily distinguished on biostratigraphical grounds with unit tops and bases defined by marker horizons such as marine bands.

In an attempt to unify the various localised stratigraphical schemes the British Geological Survey has recently rationalised the nomenclature of British Carboniferous lithostratigraphy, grouping together eight broad types of sedimentary lithofacies associations ([P912388](#)). The regional group names used in this account derive from that rationalisation; their lithofacies associations and principal formational components are summarised in [P912347](#) and [P912348](#). The lithostratigraphy defined for the Midland Valley of Scotland can be extended southwards to accommodate the Carboniferous outliers within the Southern Uplands massif: in upward succession this comprises the Inverclyde, Strathclyde, Clackmannan and Scottish Coal Measures groups. The Inverclyde Group can be usefully extended southwards as the lowermost unit of the Carboniferous sequence in the Northumberland and Solway basins. There however, above the Inverclyde Group, the northern England stratigraphy applies with, in upward succession, the Border, Yoredale, Pennine Coal Measures and Warwickshire groups ([P912386](#), [P912347](#) and [P912348](#)).

**Bibliography**


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