Carboniferous rocks of Scotland north of the Southern Upland Fault – lithostratigraphical province

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Contents

Introduction

File:P912768.jpg
Figure 5 Lithostratigraphical nomenclature for the Midland Valley of Scotland. See Section 3 for description of lithofacies, and Figures 6 and 10 for other localities discussed in text. This figure is not intended to name all the formations in the region. Fm formation; Gp group; LCM Lower Coal Measures.
File:P912769.jpg
Figure 6 Generalised vertical sections and correlation for Carboniferous strata in Scotland. Based on Lumsden et al. (1967), BGS (1987a), Browne et

al. (1999), McMillan (2002) and BGS (2008). The profiled location of the numbered and lettered sections is given in the inset map. See Appendices 1 and 2 for the names of the lithostratigraphical units shown by BGS Lexicon of Named Rock Units computer codes. M marine band; L Lingula band. v indicates named volcanic rock units; blue colour indicates named limestone beds; dashed lines indicate conjecture; wavy lines indicate unconformity surfaces.

The group and formation nomenclature for the Midland Valley of Scotland proposed by Browne et al. (1999) has been retained. There are four main groups, in ascending order, the Inverclyde (partly Devonian in age), Strathclyde, Clackmannan and Scottish Coal Measures groups (Figure.5, P912768; see also Figure.6, P912769). The boundaries between the youngest three groups are defined by marker horizons that are widespread within the Midland Valley. Volcanic rocks are common, ranging from thin local beds to widespread thick accumulations. The major occurrences of Carboniferous lavas are in the Strathclyde and Bathgate groups. Those of the Inverclyde and Strathclyde groups exhibit a full range of compositions from basaltic to rhyolitic, whereas later magmatism was entirely basaltic or basanitic.

Inverclyde Group (INV)

The Inverclyde Group (Paterson and Hall, 1986) (Figure.5, P912768; see also Browne et al., 1999, fig..1), of *continental and peritidal facies* comprises, in ascending order, the Kinnesswood, Ballagan and Clyde Sandstone formations. It is characterised by sandstones with pedogenic carbonate (the *continental and peritidal facies* 'cornstone' subfacies) and by silty mudstones containing thin beds of dolostone and limestone (the *continental and peritidal facies* 'cementstone' subfacies). There may be some lateral passage of the two subfacies.

The base of the group is taken at the base of the Kinnesswood Formation where the dominantly sandstone lithologies of the underlying Stratheden Group (Late Devonian: defined by Paterson and Hall, 1986) are succeeded by pedogenic carbonate-bearing strata. Typically transitional, the base is locally defined by an unconformity in the west of the Midland Valley. The base of the Strathclyde Group (*heterolithic clastic and nonmarine carbonate facies*) defines the top of the Inverclyde Group, and the youngest formation, the Clyde Sandstone Formation, that itself represents a return to fluviatile pedogenic facies similar to the basal Kinnesswood Formation.

The type area of the Inverclyde Group is Greenock, Inverclyde District (see Paterson and Hall, 1986). The group extends across the Midland Valley and occurs at Machrihanish and on Arran, the Cumbrae isles and Bute and Cowal. It also extends across and along the southern margin of the 'Southern Uplands Terrane' from Eyemouth to Dalbeattie. Tournaisian (Famennian? to Chadian) in

age, it is about 1500 m thick.

Midland Valley of Scotland

Inverclyde Group

Kinnesswood Formation

Doughend Sandstone Member

Foulport Mudstone Member

West Bay Cornstone Member

Ballagan Formation

Drumwhirn Member

Lindsayston Burn Member

Clyde Sandstone Formation

Isle of Arran

Laggantuin Cornstone Member

Millstone Point Sandstone Member

Isle of Bute

Ascog Member

Cumbrae isles

Millport Cornstones Member

Eileans Sandstone Member

South of the River Clyde

Knocknairshill Member

Gourock Sandstone Member

Broadlee Glen Sandstone Member

North of the River Clyde

Overtoun Sandstone Member

Strathclyde Group (SYG)

The ascending sequence of the Strathclyde Group (Paterson and Hall, 1986) (Figures 5, 6); see also Browne et al., 1999, fig. 2) includes:

In the *western Midland Valley of Scotland*, the Birgidale, Laggan Cottage Mudstone, Clyde Plateau Volcanic, Kirkwood, and Lawmuir formations;

In *Fife*, the Fife Ness, Anstruther, Pittenweem, Sandy Craig, and Pathhead formations

In *West Lothian*, the Arthur's Seat Volcanic, Gullane, and West Lothian Oil-Shale formations.

In *East Lothian*, the Garleton Hills Volcanic, Gullane, and Aberlady formations.

The group comprises mainly *heterolithic clastic and nonmarine carbonate facies* strata deposited in fluviatile, deltaic and lacustrine or lagoonal environments. Lithologies are laterally variable. The sedimentary rocks consist of interbedded sandstone, siltstone and mudstone (including oil shales) with common seatearth, coal and sideritic ironstone. The volcanic successions comprise typically transitional to mildly alkaline lavas, pyroclastic rocks and volcaniclastic sedimentary rocks. Thin bioclastic limestone occurs within the uppermost part of the group that is characterised by the incoming of 'Yoredale'-type cyclothems representing increasing marine conditions (Francis, 1991).

The base of the group is taken, in Fife, at the conformable base of the Fife Ness Formation; in the Lothians, at the mainly conformable base of the Gullane Formation or Arthur's Seat Volcanic Formation; and in Central and Western parts of the Midland Valley, at the sharp, irregular, unconformable base of the Clyde Plateau Volcanic Formation. The group represents a lithological change from the 'cornstone'- and 'cementstone'-bearing strata of the Inverclyde Group to a seatrock and/or coal-bearing sequence in which volcanic rocks may be common. The base of the Clackmannan Group (*mixed shelf carbonate and deltaic ('Yoredale') facies* of a variable succession) defines the top of the Strathclyde Group.

The type area of the Strathclyde Group is the Glasgow area of the Strathclyde Region (see Paterson and Hall, 1986). Reference sections include coastal sections in east Fife, and the group extends across the Midland Valley of Scotland to include Machrihanish, the Isle of Arran, the Cumbrae isles and Bute and Cowal. It also includes Whitecleuch (Leadhills, Southern Uplands).

Visean (Chadian to Brigantian) in age, the Strathclyde Group exceeds 1250 m in thickness. Paterson and Hall (1986) suggested it is about 1500 m thick in the type area. It may locally exceed 2000 m.

Strathclyde Group

West central Scotland

Birgidale Formation

Laggan Cottage Mudstone Formation

Clyde Plateau Volcanic Formation

Renfrewshire Hills

Noddsdale Volcaniclastic Member

Largs Lava Member

Greeto Lava Member

Misty Law Trachytic Member

Strathgryfe Lava Member

Marshall Moor Lava Member

Kilbarchan Lava Member

Beith – Barrhead Hills

Glenburn Volcaniclastic Member

Gleniffer Lava Member

Sergeantlaw Lava Member

Fereneze Lava Member

Beith Lava Member

Dunlop – Eaglesham Block

Lower Flow Moss Lava Member

Moyne Moor Lava Member

Neilston Lava Member

Darvel Lava Member

Dumdruff Hill Lava Member

Harelaw Lava Member

Eaglesham Lava Member

Gowk Stane Volcaniclastic Member

Upper Flow Moss Lava Member

Kilpatrick Hills

Burncrooks Volcaniclastic Member

Saughen Braes Lava Member

Auchineden Lava Member

Carbeth Lava Member

Greenside Volcaniclastic Member

Cochno Lava Member

Mugdock Lava Member

Tambowie Lava Member

Campsie Block (Campsie Fells, Kilsyth Hills, Denny Muir) Note that there are local variations in the general stratigraphy as presented. This is related to the occurrence of interdigitation, the presence of unconformities, and the restricted distribution and multiple sources of some of the members.

North Campsie Pyroclastic Member

Drumnessie Lava Member

Burnhouse Lava Member

Laird's Loup Lava Member

Carron Bridge Lava Member

Faughlin Lava Member

Tappetknowe Lava Member

Campsie Lava Member

Craigentimpin Lava Member

Loup of Fintry Lava Member

Laird's Hill Lava Member

Overton Lava Member

Langhill Lava Member

Lower Lecket Hill Lava Member

Boyd's Burn Lava Member

Fin Glen Lava Member

Upper Lecket Hill Lava Member

Holehead Lava Member

Kilsyth Hills Lava Member

Denny Muir Lava Member

Knowehead Lava Member

Craigdouffie Lava Member

Corrie Lava Member

Garvald Lava Member

Fintry.–.Touch Block (Fintry Hills, Gargunnock Hills, Touch Hills) Note that there are local variations in the general stratigraphy as presented. This is related to interdigitation and unconformities, and the restricted distribution and multiple sources of some of the members.

Slackdown Lava Member

Skiddaw Lava Member

Baston Burn Lava Member

Slackgun Volcaniclastic Member

Spout of Ballochleam Lava Member

Stronend Volcaniclastic Member

Lees Hill Lava Member

Shelloch Burn Lava Member

Fintry Hills Lava Member

Cringate Volcaniclastic Member

Gargunnock Hills Lava Member

Black Mount Lava Member

Touch House Lava Member

Ayr

Greenan Castle Pyroclastic Member

Kirkwood Formation

Lawmuir Formation

Douglas Muir Quartz-Conglomerate Member

Craigmaddie Muir Sandstone Member

Fife

Fife Ness Formation

Anstruther Formation

Charles Hill Volcanic Member

Pittenweem Formation

Sandy Craig Formation

Pathhead Formation

West Lothian and Edinburgh

Arthur's Seat Volcanic Formation

Gullane Formation

West Lothian Oil-Shale Formation

Calders Member

Hopetoun Member

East Lothian

Garleton Hills Volcanic Formation

North Berwick Pyroclastic Member

East Linton Lava Member

Hailes Lava Member

Bangley Trachytic Member

Gullane Formation

Aberlady Formation

Bathgate Group (BATH)

The name was first applied by Browne et al. (1999) and derives from the town of Bathgate. The sequence comprises:

At *Salsburgh, Lanarkshire*, the Salsburgh Volcanic Formation;

In *Fife*, the Kinghorn Volcanic Formation;

In *West Lothian*, the Bathgate Hills Volcanic Formation.

These formations are generally characterised by olivine-microphyric basalts and basanites of 'Dalmeny' and 'Hillhouse' types with some olivine-macrophyric basalts of 'Craiglockhart' and 'Dunsapie' types. Bedded tuffites and tuffaceous sedimentary rocks also occur. However, unlike the petrologically wide ranging volcanic rocks of the Clyde Plateau Volcanic Formation (Strathclyde Group) of the western Midland Valley of Scotland, these formations are not readily subdivided into members.

The base of the group is taken at an upward transition from sedimentary rocks in most areas, but is drawn at the top of the Clyde Plateau Volcanic Formation in the Rashiehill Borehole (BGS Registration Number NS87SW/22) (NS 8386 7301), west of Slammanan, and at a supposed

unconformity in the Salsburgh 1A oil well (BGS Registration Number NS86SW/89) (NS 8166 6487). The top is taken at the top of the highest known pyroclastic rock interdigitated in the Passage Formation (Clackmannan Group) (*fluviodeltaic* (*'Millstone Grit'*) *facies*) in the Central Coalfield area (see Cameron et al. 1998, p. 50).

The type area of the Bathgate Group (not shown on Figure 5) is limited in geographical extent to Falkirk, Fife, Lanarkshire and West Lothian, but it interdigitates with a large thickness of sedimentary formations, including the upper part of the Strathclyde Group and the larger part of the Clackmannan Group. Asbian to Arnsbergian in age, it is very variable in thickness, locally occurring in excess of 450 m.

Bathgate Group

Salsburgh Volcanic Formation

Bathgate Hills Volcanic Formation

Kinghorn Volcanic Formation

Clackmannan Group (CKN)

The term 'Clackmannan Group' (Figure.5, P912768) was first used in the Airdrie district by I H S Hall (BGS, 1992) and Forsyth et al. (1996). The succession comprises the Lower Limestone, Limestone Coal, Upper Limestone and Passage formations, which represent a variable section of *mixed shelf carbonate and deltaic ('Yoredale') facies, fluviodeltaic ('Millstone Grit') facies* and *fluviodeltaic ('Coal Measures') facies*. The formations are characterised by strongly cyclical, upward-coarsening units of limestone, mudstone, siltstone and sandstone capped by coal and seatearth, the proportions differing in each of the formations. Thus, beds of laterally extensive limestone, with diverse marine faunas, are more conspicuous in the Lower and Upper Limestone formations than elsewhere; coals are most common in the Limestone Coal Formation; and sandstones and seatearths (including some economically important high-alumina seatclay, fireclay and bauxitic clay) are the most prominent constituents of the Passage Formation. Depositional environments, likewise, show an underlying similarity, being related to the repeated advance and retreat of fluviodeltaic systems into embayments of varying salinity. The Lower and Upper Limestone formations contain the highest proportion of marine deposits *(mixed shelf carbonate and deltaic ('Yoredale') facies)*, whilst the Passage Formation is dominated by alluvial deposits *(fluviodeltaic ('Millstone Grit') facies)*. The Limestone Coal Formation occupies an intermediate position *(fluviodeltaic ('Coal Measures') facies)*.

The base of the group is taken at the base of the Lower Limestone Formation, where a cyclical sequence of marine limestone-bearing strata normally rests conformably on various formations of the Strathclyde Group. The base of the Scottish Coal Measures Group *(fluvio-deltaic ('Coal Measures') facies)* defines the top of the group.

The type area of the Clackmannan Group is the Clackmannan Syncline. It extends across the Midland Valley of Scotland and includes Machrihanish and Arran. Up to 1800 m thick in the Clackmannan area, the group is mostly Namurian in age, but ranges from Brigantian to early Langsettian.

The Clackmannan Group also occurs in the Southern Uplands of Scotland at Sanquhar and Thornhill. In the eastern part of the Sanquhar Basin the Clackmannan Group (undivided) comprises an older, highly variable sequence of mainly arenaceous and argillaceous strata, which were probably

deposited in semi-isolated sub-basins during the period of maximum marine transgression. In the west of the basin, younger sandstones, siltstones and carbonaceous mudstones with marine bands probably represent marginal deltaic conditions. The base of the group is unconformable on the mainly greywacke sandstones of the Ordovician Tappins and Barrhill groups, and the top is taken at the base of Tait's Marine Band, of possible Westphalian age (Wilson in Davies, 1970, p..52), at the base of the cyclical sandstones, siltstones, mudstones, seatrocks and coals of the Scottish Lower Coal Measures Formation. In the Sanquhar Basin the Clackmannan Group is about 40 m thick in total and falls within the age range of late Visean to Langsettian.

In the Thornhill Basin the Clackmannan Group (see Section.5.3) comprises the marine–intertidal Enterkin Mudstone Formation of '*mixed shelf carbonate and deltaic ('Yoredale') facies*', and the Passage Formation of '*fluviodeltaic ('Millstone Grit') facies*'. The base of the group is unconformable on the mainly sandstone-dominated turbidites of the Ordovician Glenlee Formation, Leadhills Supergroup, and the top is taken at the conformable base of the Scottish Lower Coal Measures Formation of *fluviodeltaic ('Coal Measures') facies*. In the Thornhill Basin the Clackmannan Group is up to 55 m thick in total and falls within the age range of late Visean to pre-Westphalian.

Clackmannan Group

Lower Limestone Formation

Limestone Coal Formation

Kilbirnie Mudstone Member

Black Metals Member

Upper Limestone Formation

Passage Formation

Troon Volcanic Member

Ayrshire Bauxitic Clay Member

Scottish Coal Measures Group (CMSC)

The 'Coal Measures' were regarded as a lithostratigraphical group by Forsyth et al. (1996). The epithet 'Scottish' was proposed by Waters et al. (2007) to distinguish the 'Coal Measures' of Scotland from those of England and Wales to account for the different definitions of the base of the Upper Coal Measures and the base of the groups.

The Scottish Coal Measures Group (Figure 5, P912768; Browne et al., 1999, fig. 7) *(fluviodeltaic ('Coal Measures') facies)* is divided, in ascending sequence, into Scottish Lower, Middle and Upper Coal Measures formations. Lithologically the group comprises repeated cycles of sandstone and mudstone with coal and seatearth, arranged in both upward-fining and upward-coarsening units. The strata are generally grey in colour but are extensively reddened towards the top. A wide range of alluvial and lacustrine environments of deposition is represented. These include wetland forest and soils (coal and seatrock), floodplain (planty or rooted siltstone and mudstone), river and delta distributary channel (thick sandstones), prograding deltas (upward-coarsening sequences) and

shallow lakes (mudstones with nonmarine faunas). Marine bands are rare but provide important stratigraphical markers. Economically important coal seams are common in the Lower and Middle Coal Measures, some of which can be correlated between coalfields.

The base of the group in the Midland Valley of Scotland is now taken at the base of the Lowstone Marine Band, its local correlative, or at a plane of disconformity. This is at a slightly higher stratigraphical level than in England and Wales, where the lower boundary lies at the base of the Subcrenatum Marine Band at the base of the Langsettian (Westphalian A) Stage. This horizon has not been recognised in Scotland though it may correlate with one of the higher marine bands of the Passage Formation (No. 6) and with the Porteous Marine Band of the Douglas Coalfield. An unconformity of regional extent beneath Permian strata marks the top of the Scottish Coal Measures Group in the Midland Valley of Scotland.

The Scottish Coal Measures Group occurs in the Midland Valley of Scotland and adjacent areas including Sanquhar, Thornhill, Machrihanish, Arran, Stranraer and Morvern. Probably exceeding 1790 m in the Midland Valley of Scotland, it is Langsettian to Asturian (Westphalian D) in age. It is considered that no Stephanian rocks have been identified in the Midland Valley of Scotland. However, see Wagner (1983), details provided below.

Scottish Coal Measures Group

Scottish Lower Coal Measures Formation

Scottish Middle Coal Measures Formation

Scottish Upper Coal Measures Formation

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