Chapter 14
Midland Valley of Scotland

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Carboniferous rocks occupy much of the Midland Valley of Scotland, but are commonly obscured at surface by Quaternary deposits. The succession occupies an ENE-trending graben bounded by the complexes of the Highland Boundary Fault to the northwest and the Southern Upland Fault to the southeast. Onshore, the graben is about 90 km wide and extends some 150 km from the Ayrshire coast and Glasgow in the west to the east Fife and East Lothian coasts in the east (Fig. 14.1). The basins within the graben are associated with Carboniferous rocks more than 6 km thick. The Highland Boundary and Southern Upland faults were active and helped control sedimentation, initially during the Tournaisian as sinistral strike/oblique slip faults and subsequently in the Visean to Westphalian a regime of dextral strike/oblique-slip deformation (Browne & Monro 1989; Ritchie *et al*. 2003; Underhill *et al*. 2008). Isolated exposures also occur on the Island of Arran and at Machrihanish in Kintyre. The Midland Valley of Scotland was separated from basins to the south (Tweed and Solway Firth basins and the Northumberland Trough- see Chapter 13) by the Lower Palaeozoic rocks of the Southern Uplands block, which formed a positive, mainly emergent area throughout the Carboniferous. However, this was breached during the Carboniferous by narrow NW–SE trending basins, for example Stranraer and Sanquhar to Thornhill. The Scottish Highlands to the north, of Lower Palaeozoic and Precambrian rocks, were similarly a positive, mainly emergent area with outcrops of Carboniferous (Johnstone 1966) limited to the west coast around Inninmore (Sound of Mull), Bridge of Awe (Pass of Brander) and Glas Eilean (Sound of Islay).

All of the stages of the Carboniferous are present (Fig. 14.2). Tournaisian strata occur at outcrop extensively and have their thickest developments (Paterson & Hall 1986) in the areas of the West Lothian and Edinburgh (1500 m), Glasgow and Stirling (700 m) and south Ayrshire (700 m). The succession is represented by alluvial and peritidal deposits (Inverclyde Group) with a dominant axial flow from the southwest. These strata extend offshore beneath the North Sea (see Chapter 15).

Visean strata crop out extensively in the Midland Valley of Scotland, with the thickest developments in the areas of Fife (2400 m), West Lothian and Edinburgh (2200 m) and Glasgow (950 m). The Visean heterolithic clastic and non-marine carbonate and fluvio-deltaic succession (Strathclyde Group) developed in association with a major reversal of the axial palaeoslope, when flow from the northeast became established. Lavas occur extensively in the Strathclyde Group and the mainly volcanic Bathgate Group. Major eruptive centres locally acted as barriers to the transport of sediment and to marine incursions.

Namurian strata occur at outcrop within the central part of the Midland Valley of Scotland, extending from Glasgow (700 m), via Clackmannan (1400 m) to Fife (1100 m), with structurally isolated outcrops in the vicinity of Edinburgh (800 m), in Ayrshire (450 m) and to the north of the Southern Upland Fault in east Ayrshire (Muirkirk) and Douglas (650 m) in south Lanarkshire. Marine influence reached its peak during the deposition of the mixed shelf carbonate and deltaic succession

(Clackmannan Group), with a strong component of sediment input from the north. Syn-sedimentary tectonic movements were prevalent from the late Visean and especially during Namurian times and are associated with N-S and NNE-SSW striking major growth folds such as in the Clackmannan-Stane and Midlothian-Leven synclines. Aberrant mudstone and coal-rich Passage Formation strata occur in a spectacular growth syncline at Westfield, north Fife (Underhill *et al*. 2008). In Ayrshire, Namurian rocks are also associated with ENE-trending faults controlling marked changes in thicknesses of the deposits across the fault line. Disconformities within the Passage Formation at the top of the Namurian have also been identified.

prominent disconformities.

The main outcrop of Westphalian strata (maximum preserved thickness in brackets) extends across the central part of the Midland Valley of Scotland in structurally separate coalfields. These are in Ayrshire (700 m), Glasgow to Clackmannan (Central Coalfield) and Fife to Midlothian (1100 m), with outliers in the areas of the Firth of Forth, Kintyre and along the Southern Upland Fault complex (Douglas Coalfield). They also occur as basins within the Southern Uplands including Stranraer and Sanquhar–Thornhill–Dumfries. During deposition of these fluvio-lacustrine strata (Scottish Coal Measures Group), sediment input returned to a flow from the northeast. Stephanian strata have been recognised in the Mauchline Basin in Ayrshire.

The lithostratigraphical nomenclature is that of Browne *et al*. (1999), and as amended in Waters *et al.* (2007) and Dean *et al*. (2011).

Tournaisian

The Inverclyde Group extends across much of the Midland Valley of Scotland (Fig. 14.2, cols. 2, 3, 4, 5, 6 & 7), but is absent on the Salsburgh ‘high’ (Read *et al*. 2002, fig. 9.9). The group comprises the Kinnesswood and Clyde Sandstone formations, laid down in fluviatile environments ranging from braided stream to floodplain with well-developed overbank deposits including the distinctive pedogenic carbonate nodules and calcrete horizons, known as “cornstones” (Paterson & Hall 1986). The intervening Ballagan Formation formed in a peritidal lacustrine/lagoonal environment associated with intermittent emergence and formation of evaporites (gypsum). Intercalation of thicker beds of fluvial sandstone is restricted to the south side of the Midland Valley. The base of the group is transitional, from underlying Upper Devonian sandstone formations of the Stratheden Group (Browne *et al*. 2002), typically recognised by the incoming of calcretes, though it is locally marked by an unconformity in the west of the Midland Valley of Scotland (Fig. 14.2, Col. 3). The discovery of miospores of Tournaisian age ^[1](VI – PC biozones) from near the base of the Kinnesswood Formation (Smith 1996) in Ayrshire (Fig. 14.2, Col. 3) confirms that this formation may straddle the Devonian-Carboniferous boundary, but that most of it is of Tournaisian age. Strata similar to the Kinnesswood Formation have also been recorded by Stephenson & Gould (1995) up to 170 m thick in the Helensburgh–Loch Lomond area (Fig. 14.1). The Ballagan Formation has a restricted fauna characterised by the bivalve *Modiolus latus*, with ostracodes of an *Acanthotriletes* cf. *macrogaleatus–Sulcella affiliata* Assemblage typical of the Tournaisian (Stephenson *et al*. 2004) and miospores indicative of the CM biozone (Neves *et al*. 1973; Stephenson *et al*. 2004) in Ayrshire (Fig. 14.2, Col. 3 ^[2]) and in the Spilmersford

Borehole [NT 4569 6901] (Fig. 14.2, Col. 7 ^[1]). However, Stephenson *et al*. (2004) also recorded samples from the PC Biozone in the lower part of the formation in central Fife (Glenrothes Borehole [NO 2561 0314]). In the Spilmersford Borehole (Fig. 14.2, Col. 7) the upper part of the formation contains some 100 m of Pu Biozone strata ^[2] (Neves *et al*. 1973; Stephenson *et al*. 2004).

Visean

The Strathclyde Group was deposited across the Midland Valley of Scotland (Fig. 14.2, Cols 2, 3, 4, 5, 6 & 7) from Chadian to Brigantian times, but most of the floral evidence from the strata available relates to the Asbian and Brigantian and there are disconformities representing the period from mid Chadian to late Holkerian. The group comprises interbedded sandstone, siltstone and mudstone, with common seatearth, generally thin coal seams and sideritic ironstone, deposited in fluviatile, deltaic and lacustrine environments. Typically mildly alkaline lavas, tuffs and volcaniclastic sedimentary rocks are locally interbedded within the succession. A similar range of lithologies is present in each formation, but the emphasis varies between one formation and the next. Thin dolostone and bioclastic limestone units, some of which are of stromatolitic type, are of marine origin in the upper part of the group.

The Strathclyde Group in the west of the Midland Valley of Scotland (Fig. 14.2, Col. 4) comprises the ascending succession of the Clyde Plateau Volcanic, Kirkwood and Lawmuir formations (Paterson & Hall 1986). The base of the Clyde Plateau Volcanic Formation is dated to 335-329 Ma by Monaghan & Pringle (2004) and Monaghan & Parrish (2006). The Kirkwood Formation shows extensive subaerial weathering and lateritisation of tuff and volcaniclastic sediments, during a period of intense tropical weathering. In the Heads of Ayr section, Ayrshire (Fig. 14.2, Col. 3) Chadian to early Asbian strata are absent, with a prominent unconformity overlain by strata of the Lawmuir Formation containing NM Biozone rocks ^[3] (Stephenson *et al*. 2004).

In east Fife (Fig. 14.2, Col. 6) the Strathclyde Group comprises the Fife Ness, Anstruther, Pittenweem, Sandy Craig and Pathhead formations (Forsyth & Chisholm 1977), the overall pattern of sedimentation is of upward-coarsening delta cycles, with thinner upward-fining fluvial units erosively capping them. The status and stratigraphical position of the Fife Ness Formation has recently been challenged by new palynological work (Owens *et al*. 2005), which considers it to be younger (between the uppermost part of the TC and lower part of the NM miospore biozones) than previously supposed. The abundant but restricted non-marine faunas of the lower part of the Anstruther Formation are dominated by *Naiadites obesus*, with *Paracarbonicola* sp., with miospore assemblages consistent with the TC Biozone ^[1] (Owens *et al*. 2005). The diverse and sometimes abundant marine faunas of the Pittenween Formation occur in the Macgregor Marine Bands, which lay near the boundary between the TC and NM miospore biozones ^[2] (George *et al*. 1976). Absent in the west, they represent the first fully marine incursions to affect east and central Scotland in Carboniferous times. The brachiopod *Punctospirifer scabricosta* and the bivalves *Pteronites angustatus* and *Streblopteria redesdalensis* are thought to be diagnostic (Wilson 1974). Asbian ammonoids are recorded from the level of the Macgregor Marine Bands in the West Lothian Oil Shale Formation of West Lothian (Currie 1954; Fig. 14.2, Col. 5 ^[+1]) and *Beyrichoceratoides redesdalensis* in the

Aberlady Formation from Dunbar (Wilson 1952; Fig. 14.2, Col. 7 [+3]). Owens *et al*. (2005) reported miospore assemblages typical of the ME Sub-biozone of the NM Biozone from the upper part of the Pittenween Formation (Fig. 14.2, Col. 6 [^3]). The abundant, but restricted, non-marine faunas of the Sandy Craig and Pathhead formations are dominated by the bivalve *Curvirimula scotica*. R. S. W. Neville in Neves *et al*. (1973) reported a miospore assemblage for the Sandy Craig Formation typical of the ME Sub-biozone of the NM Biozone (Fig. 14.2, Col. 6 [^3]). Owens *et al*. (2005) suggested that the top of the formation occurs within the VF miospore Biozone, close to the NM–VF biozonal boundary (Fig. 14.2, Col. 6 [^4]) and that the overlying Pathhead Formation has miospore assemblages typical of the VF Biozone.

In the Lothians, the group includes both volcanic and sedimentary formations (Fig. 14.2, Cols. 5 & 7), established by Chisholm *et al*. (1989). Two volcanic formations are present at the base of the group; the Arthur's Seat Volcanic Formation and the Garleton Hills Volcanic Formation, the latter radiometrically dated to 343 Ma by Monaghan & Pringle (2004) and Monaghan & Parrish (2006) and hence of earliest Visean age. The Gullane Formation is overlain either by the West Lothian Oil Shale Formation or the laterally equivalent Aberlady Formation. The Gullane Formation was predominantly fluviodeltaic, with deposition into lakes that only occasionally became marine. The absence of palynomorphs of the TS Biozone in the Spilmersford Borehole (Fig. 14.2, Col. 7) may suggest a hiatus in which Holkerian strata are absent (Stephenson *et al*. 2004). This formation passes laterally into volcanic formations, which accumulated in a terrestrial, probably coastal plain environment. Oil-shale formed in large freshwater lakes with outlets, rich in algae and other organic matter. Some of the lacustrine limestone beds (e.g. Burdiehouse Limestone) also rich in algae, formed when the outlets were closed. The uppermost part of the group is characterised by the incoming of Yoredale-type cyclothems representing increasing marine conditions (Francis 1991a).

The Bathgate Group is of limited geographical extent (Falkirk, Fife, Lanarkshire, West Lothian; Fig. 14.2, Col. 5) but interdigitates with a large thickness of the upper part of the Strathclyde Group and the larger part of the Clackmannan Group. The group ranges from Asbian to Arnsbergian in age. The Bathgate Group comprises the Salsburgh Volcanic, Kinghorn Volcanic and Bathgate Hills Volcanic formations. Sedimentary rocks separate the volcanic formations from one another, but their petrographical similarity and restricted geographical extent justify their treatment as a single group.

Marine faunas within the mixed shelf carbonate and deltaic *(*Yoredale) facies of the Sanquhar and Thornhill basins include brachiopods and bivalves of late Visean age (Davies 1970; McMillan & Brand 1995).

Namurian

The Clackmannan Group was deposited across the Midland Valley of Scotland (Fig. 14.2, Cols. 1, 3, 4, 6, 9 & 10) and within basins within the Southern Uplands near to Stranraer, Sanquhar (Col. 8) and Thornhill. The Clackmannan Group is mostly Namurian in age, but ranges from late Visean to early Langsettian. The group comprises a variable succession of Yoredale and fluviodeltaic facies. Coal seams are

common and thick in for example the Limestone Coal Formation. The lower and mid parts of the group (Lower and Upper Limestone formations) are characterised by upward-coarsening Yoredale-type cycles of marine limestone, mudstone, siltstone and sandstone capped by thin beds of seatearth and coal, the proportions differing in each of the formations. Depositional environments are related to the repeated advance and retreat of fluvio-deltaic systems into an embayment of varying salinity.

The name Clackmannan Group was first used in the Airdrie district (Fig. 14.2, Col. 9) by Forsyth *et al*. (1996) to include the Lower Limestone, Limestone Coal, Upper Limestone and Passage formations. The base of each formation is taken at either the base or top of a prominent and laterally extensive limestone; namely in ascending order: Hurlet, Top Hosie (top), Index and Castlecary (top) limestones. The base of the Namurian is taken at the lowest recorded occurrence of the ammonoid *Cravenoceras*, which occurs 1 m below the Top Hosie Limestone in the Kincardine Basin (Currie 1954; Fig. 14.2, Col. 9 $^{+1}$). Recent foraminiferal data (Cozar *et al*. 2008) from the Lower Limestone Formation in the Lothians have suggested that the Brigantian/Serpukhovian (Namurian) boundary should be placed at a slightly lower horizon, at the base of the Second Hosie Limestone. The presence of *Tumulites* (*Eumorphoceras) pseudobilinguis* from the Index Limestone (Ramsbottom 1978b) shows the base of the Upper Limestone Formation to be Pendleian (E_{1b}) in age (Fig. 14.2, Col. 3 $^{+4}$, 4 $^{+1}$ & 9 $^{+2}$). The base of the Arnsbergian is taken at the base of the Orchard Limestone (or equivalents), based upon the presence of *Eumorphoceras grassingtonense* (Ramsbottom 1978b; Fig. 14.2, Col. 9 $^{+3}$). In the lower part of the Passage Formation the presence of *Anthracoceras glabrum, A. paucilobum* and *Tylonautilus nodiferus* from the No. 0 Marine Band (Wilson in Francis *et al.* 1970) and miospores from No. 2 Marine Band indicate an Arnsbergian age (Neves *et al*. 1965; Fig. 14.2, Col. 9 $^{+\wedge 4}$). Thick-shelled ammonoids are largely absent from the Midland Valley of Scotland above the Arnsbergian, and as a result, other Namurian substage boundaries are poorly defined. Miospore evidence in conjunction with the presence of *Homoceratoides*, suggests an R_{1a} age for the No. 3 Marine Band of the Passage Formation (Neves *et al*. 1965; Fig. 14.2, Col. 9 $^{+\wedge 5}$). It seems likely that the Mississippian-Pennsylvanian boundary lies within the fireclay-rich fluvial sequence lying below these marine bands with no evidence for the existence of the Chokierian and Alportian stages (Read *et al*. 2002).

A major disconformity is present in the Passage Formation, just above the Castlecary Limestone of the Kincardine Basin (Read 1981), within the *Cravenoceratoides nitidus* Biozone (Fig. 14.2, Col. 9). This limestone is missing locally in the Kincardine Basin, but totally absent in the west and southwest of the Midland Valley of Scotland. Late Arnsbergian strata (E_{2c} biosubzone) were considered by Ramsbottom (1978b) to be absent in Scotland. In the Sanquhar and Thornhill basins the late Visean succession is overlain unconformably by strata of the Clackmannan Group. At Sanquhar (Fig. 14.2, Col. 8), miospores suggest a Langsettian age for the Passage Formation $^{\wedge 1}$ and that most of the Namurian succession is absent, whilst at Thornhill the Clackmannan Group succession is of early Namurian age (McMillan & Brand 1995).

Although beds of tuff and lapilli-tuff occur throughout the Namurian (and some of the Westphalian) interbedded with the clastic succession, thick piles of basaltic lava are

restricted to the Bathgate Hills Volcanic Formation (Bathgate Group) in the central Midland Valley and the Troon Volcanic Member (Passage Formation) in Ayrshire.

Westphalian

During the Langsettian to Bolsovian, the grey, mudstone-dominated fluvio-lacustrine deposits (Scottish Coal Measures Group) were deposited across the Midland Valley of Scotland and also occupy NW-trending grabens at Sanquhar and Thornhill. Environments of deposition include wetland forest and soils, floodplain, river and delta distributary channel, prograding deltas and shallow lakes. The group comprises repeated cycles of typically grey sandstone, siltstone and mudstone with coal and seatearth, arranged in both upward-fining and upward-coarsening units. Fluvio-deltaic complexes typically prograded westwards down the Midland Valley with fluvial influences of thick, erosively based coarse-grained sandstone units and thick coals occurring in Fife and Midlothian (Reid *et al*. 2002; Fig. 14.3).

The base of the Scottish Coal Measures Group is taken at the base of the Lowstone Marine Band (or local equivalent), at a slightly higher stratigraphical level than at the base of the Subcrenatum Marine Band of the Pennine Coal Measures Group of England and Wales. This marine band is not recognised in Scotland, but may be represented by the three elements of the No 6 Marine Bands near the top of the Passage Formation. Langsettian miospores are recorded in the uppermost beds of the Passage Formation in the Kincardine Basin (Neves *et al*. 1965; Fig. 14.2, Col. 9 $^{\wedge 6}$) indicating a SS miospore Biozone. The Lenisulcata Chronozone is poorly represented in Scotland, though the upper part of the chronozone is present in Ayrshire (Mykura 1967; Fig. 14.2, Col. 3 $^{\sim 5}$), and inferred in association with several *Lingula* bands in the Douglas Coalfield and Kincardine Basin (Ramsbottom *et al*. 1978).

Non-marine bivalves of the Communis, Modiolaris and Lower Similis-Pulchra chronozones are well developed in the Scottish coalfields (e.g. in Ayrshire described by Brand 1983), with the exception of east Fife and Midlothian (Weir & Leitch 1936), where volcanic activity may have restricted their development. It is within this succession, which spans strata of late Langsettian and Duckmantian age, that the main development of coals occurs.

The base of the Scottish Middle Coal Measures Formation is taken at the base of the Vanderbeckei Marine Band (MacGregor 1960). The marine band is found extensively across Scotland, occurring within the Modiolaris Chronozone, though the diagnostic ammonoid *Anthracoceratites vanderbeckei* is rarely found, limited to between Glasgow and Airdrie (Calver in Manson 1957; Brand 1977; Fig. 14.2, Col. 4 $^{+2}$). The upper part of the Scottish Middle Coal Measures includes up to four marine bands (Fig. 14.3), assumed to correlate with the Maltby, Clown, Haughton and Sutton, recognised in the Pennines (Forsyth & Brand 1986).

The base of the Scottish Upper Coal Measures Formation is taken at the base of the Aegiranum, at a lower stratigraphical level than the equivalent Pennines Upper Coal Measures Formation. The marine band lacks the diagnostic thick-shelled ammonoid *Donetzoceras aegiranum*, though an ammonoid–brachiopod facies is observed to the

south-east of Glasgow (Forsyth & Bland 1986). Within the Scottish Upper Coal Measures Formation of Ayrshire (Fig. 14.2, Col. 3) and Fife coast, faunas representative of the Phillipsii and Tenuis chronozones have been recognised ~^6 (Mykura 1967) and floras indicative of Bolsovian and Asturian (Westphalian D) substages (Scott 1976). The Shafton Marine Band is the highest recorded, with the Cambriense Marine Band nowhere found in Scotland. The top of the group is eroded, at an unconformity of regional extent beneath Permian strata. The alkaline Ardrossan Sill intruded into Westphalian strata in Ayrshire constrains their age to older than 298 Ma (Monaghan & Pringle 2004). A thick succession of tuff and lapilli-tuff is interbedded into the Scottish Lower Coal Measures and lower part of the Scottish Middle Coal Measures under the Firth of Forth, off the Fife coast. In the Machrihanish Coalfield (Fig. 14.2, Col. 1) red sandstone present in the northern margin of the coalfield is attributed to reddened Scottish Upper Coal Measures of Bolsovian age (Stephenson & Gould 1995).

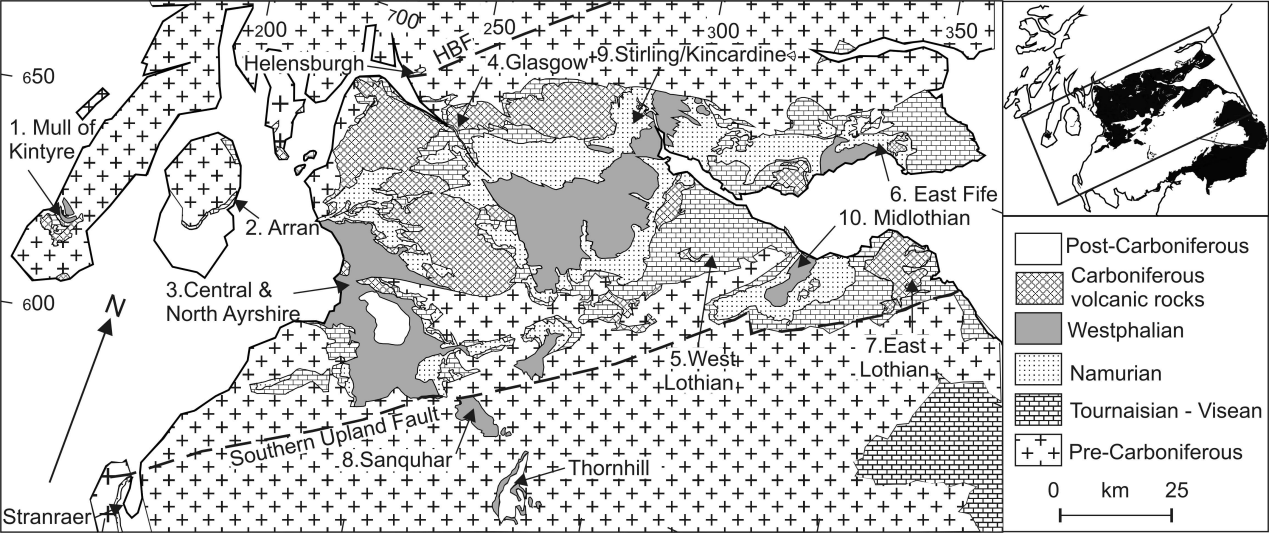
Stephanian

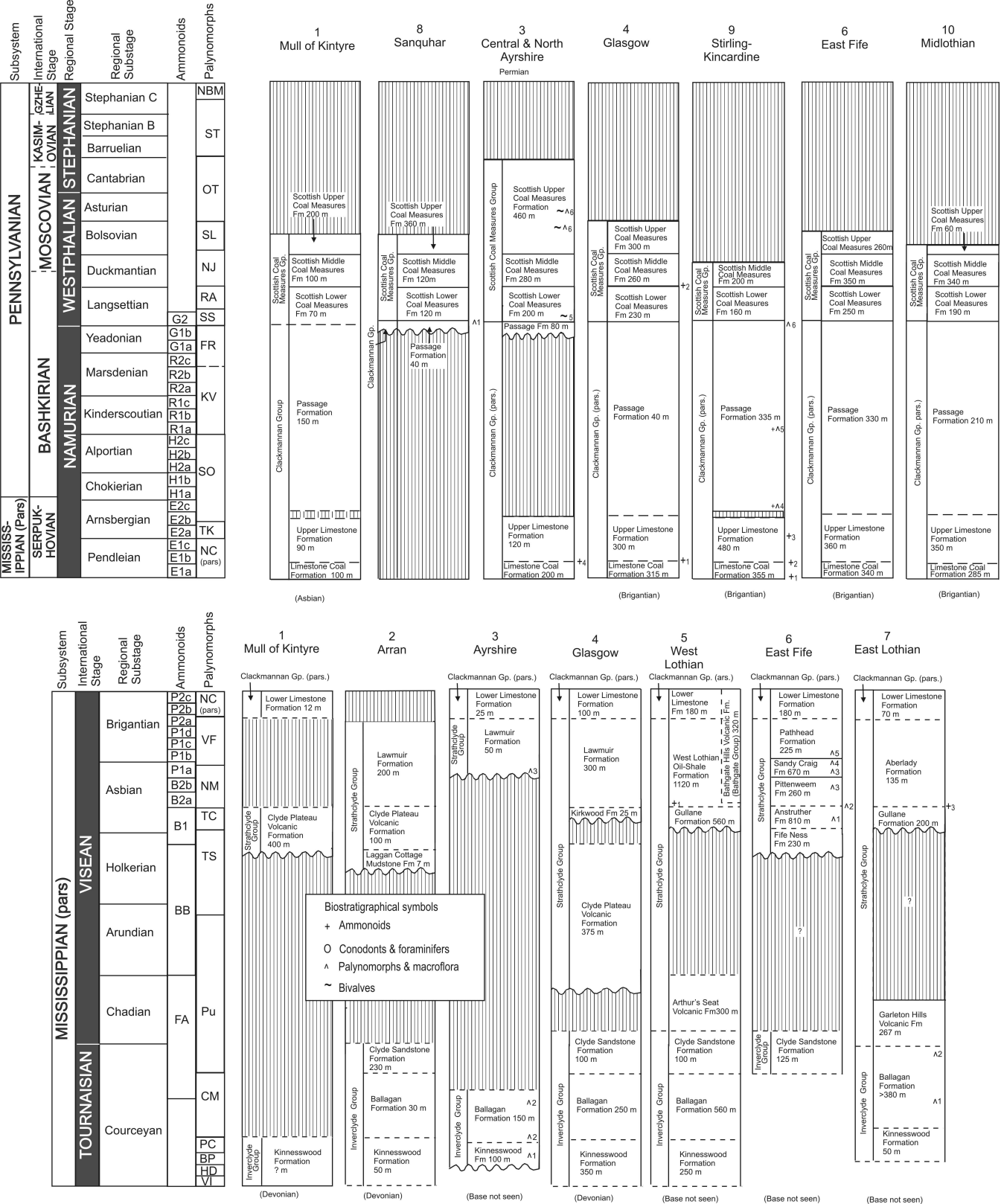
Macroflora from mudstone within the Mauchline Volcanic Formation in Ayrshire have been attributed to an Asturian age (W. C. Chaloner *in* Mykura 1965), but an early Autunian age was preferred by Wagner (1983), accepting that a Stephanian C age was possible.

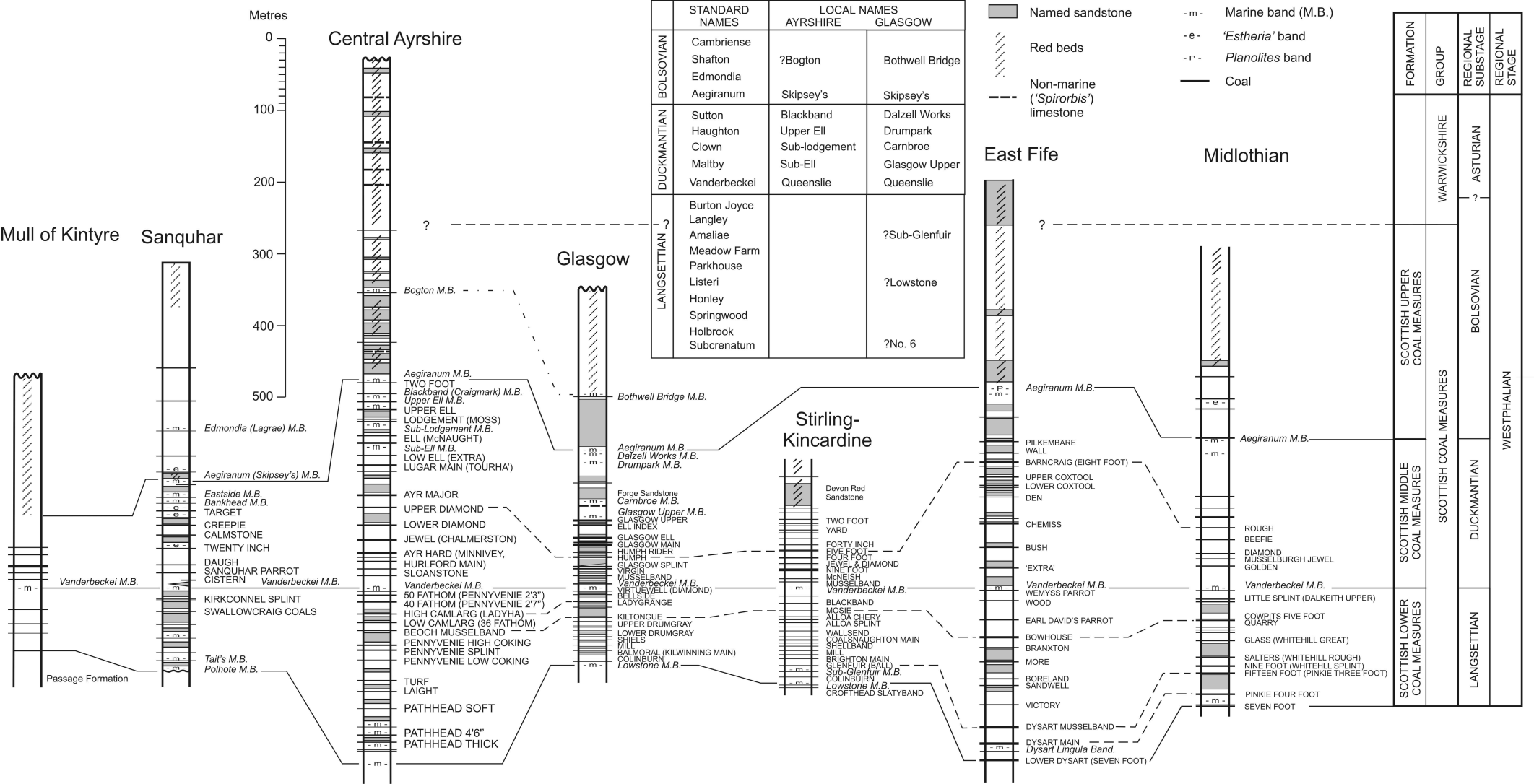
Fig. 14.1. Geological map showing the distribution of Carboniferous strata from the Midland Valley of Scotland and adjacent areas of the Southern Uplands, adapted from IGS (1979). HBF- Highland Boundary Fault;

Fig. 14.2. Correlation of Carboniferous successions in the Midland Valley of Scotland. The nomenclature is that of Waters *et al*. (2007) and Dean *et al*. (2011), with details from the following publications: Col. 1 from Stephenson & Gould (1995); Cols. 2-7 and 9-10 from Browne *et al.* (1999); Col. 8 from Davies (1970).

Fig. 14.3 Correlation of Westphalian strata, showing named coals, sandstones and marine bands, based upon the following: Mull of Kintyre (Stephenson & Gould 1995); Sanquhar (Davies 1970; Smith 2000); Central Ayrshire (Mykura 1967; Brand 1983); Glasgow (Forsyth & Brand 1986; Hall *et al*. 1998); Stirling–Kincardine (Francis 1956; Forsyth & Brand 1986); East Fife (Knox 1954) and Midlothian (Tulloch & Walton 1958).


650
600
200
700
250
300
350
HBF
Helensburgh
4.Glasgow
9.Stirling/Kincardine
1. Mull of Kintyre
2. Arran
3.Central & North Ayrshire
6. East Fife
10. Midlothian
5.West Lothian
7.East Lothian
Southern Upland Fault
8.Sanquhar
Thornhill
Stranraer
N
Post-Carboniferous
Carboniferous volcanic rocks
Westphalian
Namurian
Tournaisian - Visean
Pre-Carboniferous
0 km 25


Subsystem
International Stage
Regional Stage
Regional Substage
Ammonoids
Palynomorphs
PENNSYLVANIAN
MISSISSIPPIAN (Pars)
BASHKIRIAN
MOSCOVIAN
KASIMOVIAN
GZHELIAN
SERPUKHOVIAN
NAMURIAN
WESTPHALIAN
STEPHANIAN
Stephanian C
Stephanian B
Barruelian
Cantabrian
Asturian
Bolsovian
Duckmantian
Langsettian
Yeadonian
Marsdenian
Kinderscoutian
Alportian
Chokierian
Arnsbergian
Pendleian
G2
G1b
G1a
R2c
R2b
R2a
R1c
R1b
R1a
H2c
H2b
H2a
H1b
H1a
E2c
E2b
E2a
E1c
E1b
E1a
NBM
ST
OT
SL
NJ
RA
SS
FR
KV
SO
TK
NC (pars)
1 Mull of Kintyre
8 Sanquhar
3 Central & North Ayrshire
4 Glasgow
9 Stirling-Kincardine
6 East Fife
10 Midlothian
Permian
Scottish Upper Coal Measures Fm 200 m
Scottish Middle Coal Measures Fm 100 m
Scottish Lower Coal Measures Fm 70 m
Scottish Coal Measures Gp.
Clackmannan Group
Passage Formation 150 m
Upper Limestone Formation 90 m
Limestone Coal Formation 100 m
Scottish Upper Coal Measures Fm 360 m
Scottish Middle Coal Measures Fm 120m
Scottish Lower Coal Measures Fm 120 m
Clackmannan Gp.
Passage Formation 40 m
Scottish Coal Measures Group
Scottish Upper Coal Measures Formation 460 m
Scottish Middle Coal Measures Fm 280 m
Scottish Lower Coal Measures Fm 200 m
Clackmannan Gp. (pars.)
Passage Fm 80 m
Upper Limestone Formation 120 m
Limestone Coal Formation 200 m
Scottish Upper Coal Measures Fm 300 m
Scottish Middle Coal Measures Fm 260 m
Scottish Lower Coal Measures Fm 230 m
Passage Formation 40 m
Upper Limestone Formation 300 m
Limestone Coal Formation 315 m
Scottish Middle Coal Measures Fm 200 m
Scottish Lower Coal Measures Fm 160 m
Passage Formation 335 m
Upper Limestone Formation 480 m
Limestone Coal Formation 355 m
Scottish Upper Coal Measures 260m
Scottish Middle Coal Measures Fm 350 m
Scottish Lower Coal Measures Fm 250 m
Passage Formation 330 m
Upper Limestone Formation 360 m
Limestone Coal Formation 340 m
Scottish Upper Coal Measures Fm 60 m
Scottish Middle Coal Measures Fm 340 m
Scottish Lower Coal Measures Fm 190 m
Passage Formation 210 m
Upper Limestone Formation 350 m
Limestone Coal Formation 285 m
(Asbian)
(Brigantian)
(Brigantian)
(Brigantian)
(Brigantian)
Subsystem
International Stage
Regional Substage
Ammonoids
Palynomorphs
MISSISSIPPIAN (pars)
VISEAN
TOURNAISIAN
Brigantian
Asbian
Holkerian
Arundian
Chadian
Courceyan
P2c
P2b
P2a
P1d
P1c
P1b
P1a
B2b
B2a
B1
BB
FA
NC (pars)
VF
NM
TC
TS
Pu
CM
PC
BP
HD
VI
1 Mull of Kintyre
2 Arran
3 Ayrshire
4 Glasgow
5 West Lothian
6 East Fife
7 East Lothian
Clackmannan Gp. (pars.)
Lower Limestone Formation 12 m
Strathclyde Group
Clyde Plateau Volcanic Formation 400 m
Inverclyde Group
Kinnesswood Formation ? m
Lawmuir Formation 200 m
Clyde Plateau Volcanic Formation 100 m
Laggan Cottage Mudstone Fm 7 m
Clyde Sandstone Formation 230 m
Ballagan Formation 30 m
Kinnesswood Formation 50 m
Lower Limestone Formation 25 m
Lawmuir Formation 50 m
Ballagan Formation 150 m
Kinnesswood Fm 100 m
Lower Limestone Formation 100 m
Lawmuir Formation 300 m
Kirkwood Fm 25 m
Clyde Plateau Volcanic Formation 375 m
Clyde Sandstone Formation 100 m
Ballagan Formation 250 m
Kinnesswood Formation 350 m
Lower Limestone Fm 180 m
West Lothian Oil-Shale Formation 1120 m
Bathgate Hills Volcanic Fm. (Bathgate Group) 320 m
Gullane Formation 560 m
Arthur's Seat Volcanic Fm300 m
Clyde Sandstone Formation 100 m
Ballagan Formation 560 m
Kinnesswood Formation 250 m
Lower Limestone Formation 180 m
Pathhead Formation 225 m
Sandy Craig Fm 670 m
Pittenweem Fm 260 m
Anstruther Fm 810 m
Fife Ness Fm 230 m
Clyde Sandstone Formation 125 m
Lower Limestone Formation 70 m
Aberlady Formation 135 m
Gullane Formation 200 m
Garleton Hills Volcanic Fm 267 m
Ballagan Formation >380 m
Kinnesswood Formation 50 m
Biostratigraphical symbols
+ Ammonoids
O Conodonts & foraminifers
^ Palynomorphs & macroflora
~ Bivalves
(Devonian)
(Devonian)
(Base not seen)
(Devonian)
(Base not seen)
(Base not seen)
(Base not seen)


Metres
0
100
200
300
400
500
Central Ayrshire
Mull of Kintyre
Sanquhar
Glasgow
Stirling-Kincardine
East Fife
Midlothian
STANDARD NAMES
LOCAL NAMES
AYRSHIRE
GLASGOW
BOLSOVIAN
DUCKMANTIAN
LANGSETTIAN
Cambriense
Shafton
Edmondia
Aegiranum
Sutton
Haughton
Clown
Maltby
Vanderbeckei
Burton Joyce
Langley
Amaliae
Meadow Farm
Parkhouse
Listeri
Honley
Springwood
Holbrook
Subcrenatum
?Bogton
Skipsey's
Blackband
Upper Ell
Sub-lodgement
Sub-Ell
Queenslie
Bothwell Bridge
Dalzell Works
Drumpark
Carnbroe
Glasgow Upper
Glasgow Lower
?Sub-Glenfuir
?Lowstone
?No. 6
Named sandstone
Red beds
Non-marine ('Spirorbis') limestone
Marine band (M.B.)
'Estheria' band
Planolites band
Coal
FORMATION
GROUP
REGIONAL SUBSTAGE
REGIONAL STAGE
WARWICKSHIRE
ASTURIAN
BOLSOVIAN
DUCKMANTIAN
LANGSETTIAN
WESTPHALIAN
SCOTTISH UPPER COAL MEASURES
SCOTTISH MIDDLE COAL MEASURES
SCOTTISH LOWER COAL MEASURES
SCOTTISH COAL MEASURES
Bogton M.B.
Aegiranum M.B.
TWO FOOT
Blackband (Craigmark) M.B.
Upper Ell M.B.
UPPER ELL
LODGEMENT (MOSS)
Sub-Lodgement M.B.
ELL (McNAUGHT)
Sub-Ell M.B.
LOW ELL (EXTRA)
LUGAR MAIN (TOURHA')
Edmondia (Lagrae) M.B.
Aegiranum (Skipsey's) M.B.
Eastside M.B.
Bankhead M.B.
TARGET
CREEPIE
CALMSTONE
TWENTY INCH
DAUGH
SANQUHAR PARROT
CISTERN
Vanderbeckei M.B.
KIRKCONNEL SPLINT
SWALLOWCRAIG COALS
Tait's M.B.
Polhote M.B.
Passage Formation
AYR MAJOR
UPPER DIAMOND
LOWER DIAMOND
JEWEL (CHALMERSTON)
AYR HARD (MINNIVEY, HURLFORD MAIN)
SLOANSTONE
Vanderbeckei M.B.
50 FATHOM (PENNYVENIE 2'3")
40 FATHOM (PENNYVENIE 2'7")
HIGH CAMLARG (LADYHA)
LOW CAMLARG (36 FATHOM)
BEOCH MUSSELBAND
PENNYVENIE HIGH COKING
PENNYVENIE SPLINT
PENNYVENIE LOW COKING
TURF
LAIGHT
PATHHEAD SOFT
PATHHEAD 4'6"
PATHHEAD THICK
Bothwell Bridge M.B.
Aegiranum M.B.
Dalzell Works M.B.
Drumpark M.B.
Forge Sandstone
Carnbroe M.B.
Glasgow Upper M.B.
GLASGOW UPPER ELL INDEX
GLASGOW ELL
GLASGOW MAIN
HUMPH RIDER
HUMPH
GLASGOW SPLINT
VIRGIN
MUSSELBAND
Vanderbeckei M.B.
VIRT/JEWELL (DIAMOND)
BELLSIDE
LADYGRANGE
KILTONGUE
UPPER DRUMGRAY
LOWER DRUMGRAY
SHIELS
MILL
BALMORAL (KILWINNING MAIN)
COLINBURN
Lowstone M.B.
Devon Red Sandstone
TWO FOOT
YARD
FORTY INCH
FIVE FOOT
FOUR FOOT
JEWEL & DIAMOND
NINE FOOT
McNEISH
MUSSELBAND
Vanderbeckei M.B.
BLACKBAND
MOSIE
ALLOA CHERY
ALLOA SPLINT
WALLSEND
COALSNAUGHTON MAIN
SHELLBAND
MILL
BRIGHTON MAIN
GLENFUIR (BALL)
Sub-Glenfuir M.B.
COLINBURN
Lowstone M.B.
CROFTHEAD SLATYBAND
Aegiranum M.B.
PILKEMBARE
WALL
BARNCRAIG (EIGHT FOOT)
UPPER COXTOOL
LOWER COXTOOL
DEN
CHEMISS
BUSH
'EXTRA'
Vanderbeckei M.B.
WEMYSS PARROT
WOOD
EARL DAVID'S PARROT
BOWHOUSE
BRANXTON
MORE
BORELAND
SANDWELL
VICTORY
DYSART MUSSELBAND
DYSART MAIN
Dysart Lingula Band.
LOWER DYSART (SEVEN FOOT)
Aegiranum M.B.
ROUGH
BEEFIE
DIAMOND
MUSSELBURGH JEWEL
GOLDEN
Vanderbeckei M.B.
LITTLE SPLINT (DALKEITH UPPER)
COWPITS FIVE FOOT
QUARRY
GLASS (WHITEHILL GREAT)
SALTERS (WHITEHILL ROUGH)
NINE FOOT (WHITEHILL SPLINT)
FIFTEEN FOOT (PINKIE THREE FOOT)
PINKIE FOUR FOOT
SEVEN FOOT