

Ordovician and Silurian, Midland Valley of Scotland

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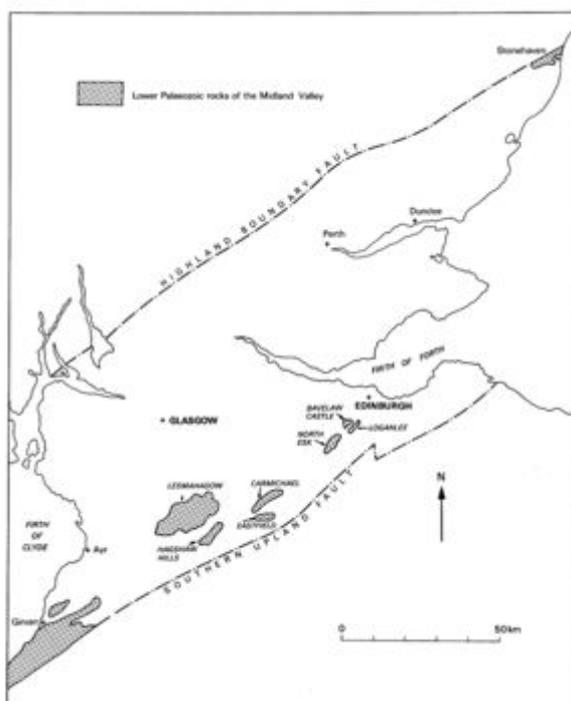
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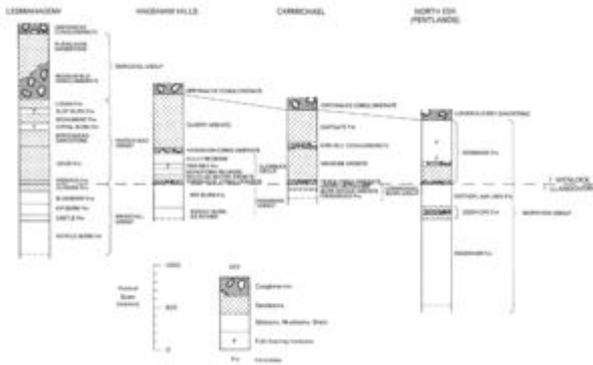
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Ordovician



Location map of Lower Palaeozoic inliers of the Midland Valley. P915515.



Silurian successions in the inliers of the Midland Valley. P915516.

Rocks of Ordovician age cover a considerable area in the south-west part of the Midland Valley in the Girvan-Ballantrae district and appear also in the Craighead Inlier on the north side of the Girvan valley. An account of these appears in the volume on the South of Scotland in this series of handbooks. Reference must be made here, however, to three small lenticular inliers of Benan Conglomerate at Big Hill of the Baing, Knockinculloch (north-east of the Pilot) and Linfern Loch, which occur in the disturbed belt of sediments and volcanic rocks of Lower Devonian age that adjoins the Southern Upland Fault between Barr and Straiton. The Big Hill of the Baing outcrop, south-east of Straiton, is the largest, being five kilometres long. The conglomerate, well exposed in the Water of Girvan near Tairlaw, contains a varied assemblage of igneous pebbles derived from Arenig rocks. At Knockinculloch the conglomerate is associated with the Stinchar Limestone and Caradoc shales.

Silurian

The sediments of Llandoverly and Wenlock age which occur in the Girvan-Ballantrae district and in the Craighead Inlier are described in the volume on the South of Scotland in this series of handbooks. Farther to the north-east, however, strata ranging in age from Llandoverly to Ludlow or even Downtonian (Rolfe, 1973) occur in a series of inliers along the southern margin of the Midland Valley (P915515). These are known as the Lesmahagow, Hagshaw Hills, Carmichael, Eastfield, North Esk, Bavelaw Castle and Loganlee inliers, the last three being in the Pentland Hills. Downtonian strata also occur near Stonehaven.

As research has continued over the years, there has been a trend to recognise successively older horizons in these outcrops. The general succession in the inliers is of great importance as it records the transition from the generally marine conditions of the Llandoverly, through the fish-bearing, red-bed facies of the Wenlock and Ludlow, into the true continental deposits of the Lower Devonian. Unfortunately, as the sediments become increasingly continental, so the fauna becomes more facies dependent and of less value for stratigraphical correlation with full marine successions elsewhere. Evidence of Wenlock age is present in the middle parts of the inlier successions, and a Ludlow age has been assigned to some beds at Lesmahagow (Selden and White, 1983) and Downtonian strata may also be present. P915516 illustrates the Silurian successions in the inliers.

Lesmahagow Inlier

The most important of the inliers of Silurian rocks in the region occurs between Lesmahagow and Muirkirk. In the inlier, the Silurian strata occur in a broad anticline covering a roughly oval area measuring about 23 km by 10 km. The succession, approximately 2500 m thick, is shown in

Silurian succession in the Lesmahagow Inlier		
Groups	Formations, etc.	Thickness (m)
Dungavel Group	Plewlands Sandstone	420
Dungavel Group	Middlefield Conglomerate	450
Waterhead Group	Logan Formation	2-105
Waterhead Group	Slot Burn Formation	60
Waterhead Group	Monument Formation	50-100
Waterhead Group	Dippal Burn Formation	55-90
Waterhead Group	Birkenhead Sandstone	150-190
Waterhead Group	Leaze Formation	200-390
Waterhead Group	Passage Formation	35-45
Priesthill Group	Dunside Formation	40-65
Priesthill Group	Blaeberry Formation	75-150
Priesthill Group	Kip Burn Formation	20-135
Priesthill Group	Castle Formation	60
Priesthill Group	Patrick Burn Formation	400 +

The Priesthill Group, thought to be, at least in part, of Llandovery age, consists of grey and greenish greywackes, sandstones, siltstones and mudstones. The oldest beds are of undoubted marine origin but as the succession is traced upwards, the sediments gradually take on a more non-marine aspect. The Patrick Burn Formation at the base is a typical marine turbidite sequence of alternating thin greywackes and mudstones with subsidiary bands of laminated siltstones. The greywackes contain a redeposited shelly assemblage of brachiopods, bivalves, trilobites, including *Encrinurus* and *Podowrinella*, ostracods and crinoid columnals. Laminated siltstones on the other hand yield an indigenous fauna comprising arthropods such as *Ceratiocaris* and *Slimonia* and the fish *Jamoytius* and *Thelodus*. The overlying unfossiliferous Castle Formation consists of massive siltstones with shale partings. Mudstones with dark laminated silty bands characterise the Kip Burn Formation, the lower part of which, the 'Ceratiocaris beds', is highly fossiliferous yielding the arthropods *Ceratiocaris*, *Dictyocaris*, *Pterygotus*, *Slimonia* and the fish *Birkenia* and *Thelodus*. The upper part of the formation, the 'Pterygotus beds', contains an abundant eurypterid fauna together with the brachiopod *Lingula* and *Ceratiocaris*. The faunas in the Kip Burn Formation reflect the start of the transition from marine to quasi- or non-marine conditions in the inlier. Mudstones again predominate in the succeeding Blaeberry Formation, including some highly fossiliferous bands containing *Lingula*, the gastropod '*Platyschisma*', *Slimonia* and ostracods. The Dunside Formation, at the top of the Priesthill Group, consists of flaggy micaceous sandstones with some cross-bedding. These strata, the '*Trochus* beds', contain abundant specimens of '*Platyschisma helicites*

The Waterhead Group, of Wenlock/Ludlow age, comprises red, green and variegated beds including sandstones, siltstones, mudstones and shales and is unfossiliferous except for two fish-bearing horizons. The group as a whole is thought to represent deposition in shallow marine, deltaic and lagoonal conditions. The Passage, Leaze, Monument and Logan formations are composed of fine- to coarse-grained sandstones and mudstones which may be greenish grey or red-brown. Mudcracks, indicative of subaerial conditions, are common in the red beds but are not found in the green beds whereas occasional *Lingula* are found only in the latter in the lower two formations. The Birkenhead Sandstone, of deltaic origin, is distinguished by its massive, orange, cross-bedded sandstones containing pebbles of acid igneous rocks. The fish-bearing horizons occur in the Dippal Burn and Slot Burn formations which consist of greenish grey mudstones, siltstones and thick sandstones. The

fossils are found in dark grey laminated siltstones which alternate with grey mudstones. Fossils obtained include unidentifiable plants, arthropods and fish including *Birkenia*, *Lasanius* and *Thelodus*.

The Dungavel Group is unfossiliferous but is thought to be of Ludlow or even Downtonian age. The oldest beds are the conglomeratic basal members of the Middlefield Conglomerate which contain pebbles and boulders up to 45 cm in diameter consisting dominantly of quartzite, vein-quartz, jasper and some acid igneous rocks. Lenses of coarse-grained, greyish brown, feldspathic sandstones alternate with the conglomeratic units. As the succession is ascended, the sandstone becomes the dominant member, enclosing isolated conglomeratic lenses. The greyish brown, micaceous, cross-bedded fluvial sandstones of the Plewlands Sandstone are the youngest rocks in the inlier. The succeeding 'Greywacke Conglomerate' has been taken as the local base of the Devonian in the area.

Hagshaw Hills Inlier

The steeply inclined strata of this inlier form an overturned asymmetrical anticline which can be traced from the vicinity of Little Cairn Table north-eastwards to Rob's Hill, just west of Douglas ([P915515](#)). The inlier is about 34 km² in area and the succession present, about 1500 m thick, has been subdivided as shown on

Silurian succession in the Hagshaw Hills Inlier		
Groups	Formations, etc.	Thickness (m)
	Quarry Arenite	600
	Hareshaw Conglomerate	75
Glenbuck Group	Gully Redbeds	120
Glenbuck Group	Fish Bed Formation	60
Glenbuck Group	Dovestone Redbeds	75
Glenbuck Group	Douglas Water Arenite	75
Glenbuck Group	Parishholm Conglomerate	40
Hagshaw Group	Ree Burn Formation	280
Hagshaw Group	Smithy Burn Siltstone	120

The Hagshaw Group consists of dark to medium-grey greywackes, siltstones, mudstones and shales of marine origin with, in the Ree Burn Formation, a poorly preserved shelly fauna including the brachiopods *Protochonetes* aff. *edmundsi*, *Howellella*, various bivalves, ostracods and species of *Encrinurus* and *Podowrinella*. An earlier record of the graptolite *Monoclimacis vomerina* has not been confirmed but the above fauna is thought to indicate an Upper Llandovery or Lower Wenlock age for the Hagshaw Group.

The Parishholm Conglomerate is a pebble and cobble conglomerate with a varied suite of igneous and sedimentary clasts including felsite, porphyrite, spilite, keratophyre, quartzite, vein-quartz, greywacke, mudstone, chert and ?tuff. From its composition it may be tentatively correlated with the Fence Conglomerate of the Carmichael Inlier which has a similar pebble suite.

The succeeding formations of the Glenbuck Group consist of grey and greyish red sandstones, calcareous mudstones, siltstones and shales with a fish fauna, including species of *Birkenia*, *Lasanius* and *Lanarkia*, from the Fish Bed Formation.

They are succeeded by the Hareshaw Conglomerate, a pebble and cobble conglomerate containing

an abundance of vein-quartz and quartzite clasts as well as pebbles of porphyrite, granite, rhyolite, gneiss, schist, mudstone, chert and pyroclastics.

The highest formation seen in the inlier is the Quarry Arenite, a greenish grey and pale red, medium- and coarse-grained sandstone often containing intraclast fragments of red shale. Sedimentary features such as current bedding and scour-and-fill structures are common throughout the formation.

Carmichael Inlier

This inlier occupies a strip of ground about 11 km long by 2 km wide on the north-west side of Tinto ([P915515](#)). The sequence comprises a lower succession of mainly greenish grey mudstones and siltstones (Carmichael Burn Group) succeeded by a coarser-grained sequence divided into the Fence Conglomerate, with igneous-rock pebbles, the Newside Arenite, the Kirk Hill Conglomerate, with quartzite pebbles and the Eastgate Formation. Many of the lithologies can be matched quite closely with rocks from parts of the Pentland Hills and Hagshaw Hills inliers as well as from the Blair-Knockgardner-Straiton inlier at Girvan.

In the lower part of the Carmichael Burn Group a relatively large fauna was obtained from thin siltstone seams within a mudstone sequence. The fauna includes annelids, brachiopods, cephalopods, ostracods, phyllocarids (*Ceratiocaris*), crinoid columnals and graptolites (mainly monograptids of the *vomerina* type) suggesting a late Llandovery age for the lowermost beds of the inlier (Rolfe, 1960).

Eastfield

A small inlier, about 5 km long and 1 km wide, is present on the south side of Tinto near Eastfield Farm. The sediments are poorly exposed and consist of greenish sandstones with conglomerate bands containing pebbles of quartzite, chert, jasper, vein-quartz, granite, porphyry, etc. No fossils have so far been found in these beds and the age of the rocks is based on lithological criteria.

Pentland Hills

Silurian strata crop out in three small areas in the Pentland Hills, where they form the North Esk, Bavelaw Castle and Loganlee inliers. They are everywhere highly inclined and are overlain with marked unconformity by beds of Lower or Upper Devonian age.

North Esk Inlier

This inlier, occupying about 6 km² of country at the head of the Lyne Water and North Esk River, is the largest area of Silurian rocks in the Pentland Hills.

The succession begins in the river below the North Esk Reservoir with the alternating purple and grey mudstones and siltstones of the Reservoir Formation. The beds are sparsely fossiliferous, with brachiopods such as *Craniops* and *Glassia* found scattered throughout the sequence. In the upper part of the formation a benthonic fauna is found including the brachiopods *Atrypa*, *Coolinia*, *Leptaena*, *Resserella*, the trilobites *Acernaspis* and *Harpidella*, ostracods and crinoid columnals. In the same part of the succession certain flaggy sandstones in the Gutterford Burn contain the well known eurypterid and starfish beds. Rare graptolites obtained from the Reservoir Formation include *Koremagraptus* and *Monoclimacis* cf. *vomerina*.

The Reservoir Formation is succeeded by the more arenaceous sediments of the Deerhope Formation consisting of flaggy greywacke interbedded with purplish grey and green siltstones and mudstones. These grade upwards into the coarse greenish grits and pebbly sandstones referred to as the Haggis Grit and Conglomerate. Silty beds in various parts of the formation have yielded a coral and shelly fauna including the coral *Pleurodictyum*, the brachiopods *Chonetes* and '*Strophomena*' and the bivalves *Modiolopsis* and *Orthonota*?. Trilobites and ostracods also occur.

The Haggis Grit and Conglomerate is overlain by highly fossiliferous greenish brown mudstones and siltstones of the Wether Law Linn Formation. These beds have provided many species of brachiopods, bivalves and gastropods as well as a few cephalopods and trilobites. Prominent species include brachiopods such as *Skenidioides lewisii* and *Eoplectodonta penkillensis*, species of *Acernaspis*, *Encrinurus*, *Podowrinella*, and the ostracod *Craspedobolbina (Mitrobeyrichia) impendens*. A 250-mm bed of white clay, thought to be a volcanic ash, has been recorded between 3 and 10 m above the base of the formation.

The Reservoir, Deerhope and Wether Law Linn formations were formerly considered to be of Wenlock-Ludlow age, but further research suggests a late Llandovery age.

Both in the Lyne Water and in the North Esk, the Wether Law Linn Formation is succeeded by a red igneous-pebble conglomerate followed by red mudstones, siltstones, sandstones and intercalated chert-pebble conglomerates. These red beds form the Henshaw Formation and contain a restricted fauna including bryozoa, eurypterid fragments, *Ateleaspis*, *Birkenia* and *Lasanius*. The fauna was formerly placed in the Downtonian but recent work suggests that the Henshaw Formation is, at least in part, of Wenlock age.

Bavelaw Castle

This inlier occupies a triangular area extending eastwards from Bavelaw Castle to the western slope of Black Hill and south to the northern slope of Hare Hill. The beds consist of grey to purplish grey mudstones or silty mudstones with interlaminated siltstones and occasional thin flaggy sandstones. In lithology they resemble the lowermost beds of the North Esk Inlier, but the fauna is slightly more varied and includes *Glassia*, species of *Dictyocaris* and *Orthoceras* as well as a monograptid and *Retiolites geinitzianus*. These beds were considered by Peach and Home (1899) to be of Wenlock age but a detailed re-examination of the fauna led Lamont (1947) to claim that they are older and of Llandovery age.

Loganlee

This inlier forms a narrow belt of country extending from near Loganlee along the eastern side of Black Hill to the west slope of Bell's Hill. The sediments are best exposed on the south-east slope of Black Hill close to the footpath leading from Loganlee to Bavelaw. They consist of greenish grey and purple shales with layers of siltstone and occasional thin beds of flaggy sandstone as well as a number of thicker sandstone beds. The shales have yielded several species of graptolites which were once considered to represent a Wenlock assemblage. More recent work, however, has failed to confirm these findings and, by analogy with the latest work on the nearby North Esk Inlier, the beds could well be of Llandovery age.

Downtonian of Stonehaven

The Downtonian of this area consists of shales, mudstones and sandstones of the Stonehaven Group which rest unconformably on the Cambro-Ordovician rocks of the Highland Border Series. They are

succeeded, apparently without significant unconformity, by massive conglomerates of the Dunnottar Group. The steeply dipping beds, exposed in nearly continuous section on the shore near Stonehaven, are divisible into two formations.

The lower division, the Cowie Formation, has a total thickness of about 730 m and consists of a thin basal breccia followed by dull red, grey and yellow sandstones with numerous intercalations of red or grey mudstone. The sandstones are fine- to medium-grained, cross-bedded and contain abundant metamorphic rock fragments. In the upper part of the Cowie Formation, conglomerates containing rounded pebbles of acid volcanic rocks are succeeded by grey sandstones and shales containing *Dictyocaris slimoni* at intervals throughout their thickness as well as in the important Cowie Harbour Fish-bed near their base. The latter has also yielded the arthropods *Archidesmus*, *Ceratiocaris*, *Hughmilleria norvegica*, *Kampecaris?* and *Pterygotus* and the fish *Hemiteleaspis heintzi*, *Pterolepis* and *Traquairaspis campbelli*. The Carron Formation forms the upper division of the Stonehaven Group and consists of about 820 m of medium- to coarse-grained, cross-bedded reddish brown sandstones with a high proportion of acid volcanic debris. Locally the beds are conglomeratic, containing pebbles of a variety of igneous rocks and metasediments while continuing sporadic volcanic activity is demonstrated by an agglomerate, containing angular fragments of biotite and hypersthene-andesite, which is intercalated with sandstones on the south side of Stonehaven harbour.

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