

Devensian, Quaternary, Midland Valley of Scotland

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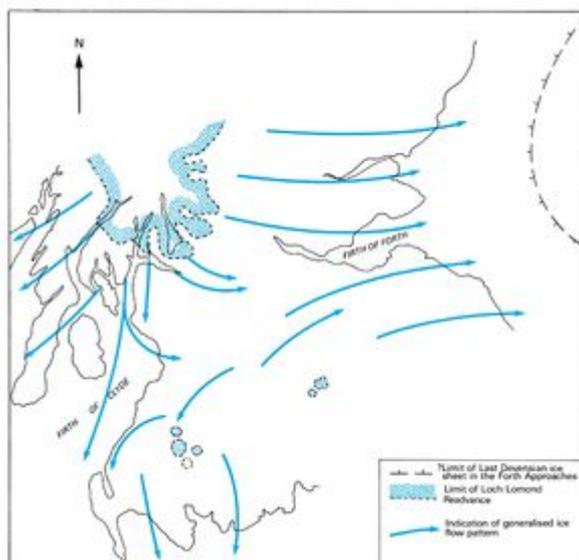
Cameron, I B, and Stephenson, D. 1985. British regional geology: The Midland Valley of Scotland. Third edition. Reprint 2014. Keyworth, Nottingham: British Geological Survey.

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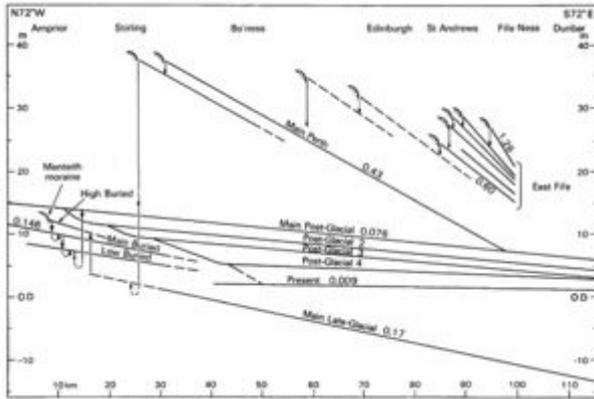
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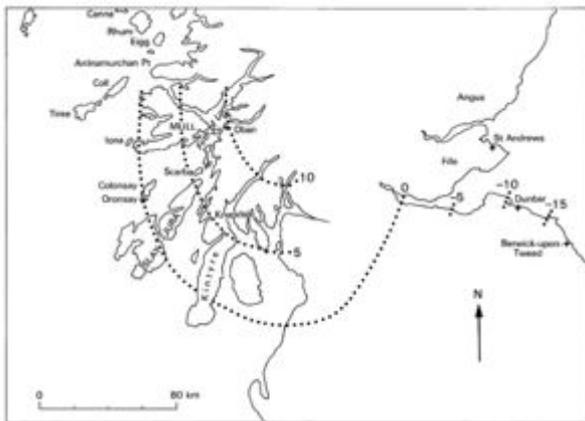
Devensian, introduction



Generalised pattern of ice-flow and ice limits. P915549.



Sequence of shorelines in SE Scotland with gradients in m/km (from Sissons, 1974). P915550.



Isobases (in metres) of the Main Late Glacial Shoreline (after Dawson, 1980). P915551.

Very little evidence exists of Devensian events prior to the retreat of the last glaciation, but biological remains at three sites give an inkling of conditions earlier in the Devensian. Bones and a tooth of the woolly rhinoceros, *Coelodonta antiquitatis* have been found in sands and gravels beneath till in the Kelvin Valley near Bishopbriggs. One of the bones gave a radiocarbon date of 27500 (+ 1370, -1680) years B.P.

In the early part of the 19th century animal remains including mammoth tusks, reindeer antlers and arctic shells were found in a pit near Kilmaurs. The fossils were obtained from beds of sand and clay beneath till. A mammoth tusk gave a radiocarbon date of 13700 (+ 1300, -1700) years B.P., but a reindeer antler believed to come from the same deposits was found to have a radiocarbon date of >40000 years B.P.

Since it is possible that one or more of the dated fossils from Kilmaurs and Bishopbriggs have been derived from pre-existing sediments the stratigraphic significance of the material is limited. In addition doubt has been cast on the validity of the radiocarbon dates (Sissons, 1981) and until either of the finite dates can be confirmed conclusions drawn about the limits of the ice-sheet at those dates must be tentative.

At Burn of Benholm, near Johnshaven in Kincardineshire lenses of peat intercalated in the basal part of the till have been dated by radiocarbon measurements at >42000 years B.P. The pollen analyses of the samples indicate a tundra environment and the peat is interpreted as being of Early or Middle Devensian age incorporated in a Late Devensian till. At some time during the Devensian glaciation Scandinavian erratics were transported across the North Sea, perhaps indirectly, and were deposited in NE Scotland.

Glaciation

The last glaciation to affect the Midland Valley occurred in the latter part of the Devensian Stage. The ice-sheet spread into the Midland Valley from centres in the western part of the Grampian Highlands and to a lesser extent from the Southern Uplands. The direction of ice movement is shown in Figure

39. The ice-sheet is thought to have reached its maximum development about 18 000 years B.P. when the entire region was buried beneath a thick cover of ice. Estimates of the maximum height of the ice-sheet surface are of the order of 1500 to 1800 m.

Towards the end of the Devensian a period of climatic amelioration caused the ice-sheet to retreat and vegetation colonised the exposed surface. Radiocarbon dates indicate that the Midland Valley was free of ice shortly after 13000 years B.P., but a deterioration in the climate allowed glaciers to form again in the Grampians and locally in the western part of the Southern Uplands. Glacial encroachment into the Midland Valley occurred in the upper parts of the Teith and Forth valleys and south-east of Loch Lomond ([P915549](#)). This episode is known as the Loch Lomond Readvance and it occurred between about 11000 and 10300 years B.P.

The climatic conditions between the glacial retreat and the Loch Lomond Readvance, according to the evidence of the Coleoptera, are thought to have been comparable to the present day between 13 000 and 12 000 years B.P., but deteriorated thereafter. The interval is known as the Windermere or Late Glacial Interstadial and the episode which includes the Loch Lomond Readvance is referred to as the Loch Lomond Stadial.

Other readvances of the ice have been postulated by various authors but the Loch Lomond Readvance is at present the only generally accepted major glacial readvance known to have affected the Midland Valley.

A rapid improvement in the climate at the end of the Devensian brought glaciation to an end.

Glacial erosion

The movement of ice across the landscape caused considerable modification to the topography and the most intense erosion occurred in the valleys in the vicinity of the ice dispersion centres in the Highlands. Glacial erosion features in the Midland Valley are numerous but usually less dramatic. However, where there were constrictions or obstructions to ice movement the amount of erosion was considerable. The glaciated landforms may relate to more than one glaciation.

Ice moved over the entire area causing a greater or lesser amount of streamlining or gouging according to the resistance of the underlying rock and the power of the ice at any particular point. Ice flowed into the valleys in the lowlands, modifying their outline, overdeepening them and spilling through breaches in the watershed into adjacent valleys. Glacial breaches occur in the Ochil Hills and in other areas of high ground. Crag-and-tail features are numerous and glacially eroded depressions around the upstream end of these features indicate the scale of erosion. It is estimated that at least 105 and 150m of rock have been removed from around Edinburgh's Castle Rock and Salisbury Craigs respectively. Crag-and-tail features and other elongate ice-moulded landforms help to indicate directions of ice movement. Less obvious but very considerable erosional effects are revealed by boreholes which indicate the presence of rock basins and glacially overdeepened valleys concealed by superficial deposits. Closed channels in the rock surface beneath the Devon valley are more than 100 m below OD. Similarly a buried trench in solid rock in the valley of the Forth west of

Queensferry is known to be up to 200 m deep. In the area west of Stirling it has been estimated that over 100 m of Devonian sediments have been removed over a large area by glacial erosion.

During deglaciation meltwater rivers within, below or at the margins of the ice, eroded channels in the ice and in the underlying till or rock. The channels commonly run obliquely downhill and are often discontinuous. They also occur cutting valley spurs. The channels range in size from 1 to 2m to over 20 m deep and may be occupied by misfit streams whereas others are dry. Such channels are common in many parts of the region and have been described from several areas.

Glacial deposits

Till

The detritus of glacial erosion was deposited as till either below the ice-sheet as lodgement till or laid down from melting ice as ablation till. The former is of wide distribution and the latter is generally thin. The composition and colour of the till depends to a large extent on the lithology of the underlying bedrock but it also contains rock fragments carried from a distance. Till derived from Devonian sediments has a reddish brown colour and contains a higher proportion of sand than till which consists predominantly of the detritus from Carboniferous sediments. The latter is usually dark brownish grey and contains a higher proportion of clay and silt. Undisturbed lodgement till is commonly a very firm, tough deposit.

The till forms a mantle of irregular thickness being generally thickest in low ground and patchy or absent on the hill tops. The more resistant rock types which have suffered less erosion tend to project through the mantle of till to form crags or rock knobs. Drumlins, elongate hills formed of till, some with a rock core, are common in the low ground in the Clyde and Forth valleys and in Ayrshire.

In the North Sea deposits of till and marine sediments, known as the Wee Bankie Beds, are believed to be the terminal moraine of the last ice-sheet and the eastern limit of these beds indicates the approximate maximum extent of the late Devensian glaciation.

In several areas there is more than one till. Three can be distinguished in Midlothian with fluvioglacial sand and gravel deposits between them. The content of the tills indicates that the basal one was deposited by ice moving eastwards. The overlying red-brown till was deposited by ice from the Southern Uplands and the top one, the Roslin Till, which has a limited distribution, is a very local deposit. There are no organic remains in the beds between the tills which could be used for dating.

In the Glasgow area a red till overlies a grey till, but this is thought to be related to different bedrock sources and that the two tills were deposited virtually contemporaneously.

Trails of erratic blocks carried by the ice downstream from readily identifiable sources are well-known in the Midland Valley. The most familiar is the trail of boulders of Essexite extending eastwards from the small Essexite plug near Lennoxton. The trail is at least 64 km long. Other examples include the transport of granite fragments into the Midland Valley from the western part of the Grampians and from the granites of the western Southern Uplands.

There are several very large masses of rock which are thought to have been transported by ice. The largest is a mass of limestone near Kidlaw in East Lothian which is about 530 m long by 400 m wide and was formerly quarried. The mass is thought to have been moved a few kilometres to the east.

In several areas the till contains marine fossils, including bivalves and foraminifera. Shelly till covers much of the low ground in Ayrshire extending up to a height of at least 300m OD in eastern

Ayrshire, and till containing foraminifera occurs in the Glasgow area. Ice moving from the Highlands picked up marine organisms, either from the sea bed or from an area formerly covered by the sea, and spread into the Glasgow area and central Ayrshire. Shells dating from the Late Glacial Interstadial, transported by ice during the Loch Lomond Readvance have been found in moraine and fluvio-glacial deposits near the Lake of Menteith and near Drymen.

Fluvio-glacial deposits

When the climate improved, towards the end of the Devensian, the ice melted and water flowed on, through and under the ice carrying glacially eroded debris. The sediment was deposited either within, or in contact with, the ice as kames and eskers or was carried beyond the ice-front and laid down in broad outwash fans. The finer fraction consisting of clay and silt was carried farther and was deposited in lakes or in the sea. In the last stages of melting, areas of inactive ice, surrounded and partially covered by sand and gravel, tended to block the drainage. Temporary ponding of water allowed the deposition of silt and clay.

There are extensive fluvio-glacial deposits in Strathmore, in parts of Fife and Kinross and also in a belt along the south side of the Midland Valley between Dunbar and Lanark. Smaller areas of sand and gravel also occur around Darvel, Drymen and in the valley of the River Kelvin.

Large areas of glacial outwash sand and gravel occur in Strathmore where meltwater issued from the Highland valleys. Examples of these are found near Blairgowrie and Edzell. The deposits are coarser near the Highland border, where they consist of coarse, cobble gravel, and they pass into sands and finer gravels farther away.

The area of mounds and ridges of sand and gravel around Carstairs is an example of a system of eskers. They were formerly believed to be moraine marking the limit of the Highland ice or the Southern Uplands ice. The landforms consist of a series of branching ridges up to 30m high enclosing numerous kettleholes.

Marine sediments

Marine sediments of late Devensian age occur commonly in the Tay and Forth estuaries and at various sites around the Firth of Clyde. They are late Glacial in age and have given radiocarbon dates up to about $13\,780 \pm 120$ years B.P. The sediments consist of laminated silt and clay, shelly clays, silts and silty sands, overlain by sands and gravels. They contain a fauna of molluscs, foraminifera and ostracods. The coarser sediments are, in part at least, reworked fluvio-glacial deposits. Their occurrence on land is due to a subsequent relative drop in sea level.

In the Firth of Clyde area the 'Clyde Beds' have radiocarbon dates between $13\,780 \pm 120$ years B.P. and about 10 200 years B.P. In the Tay-Earn area, the late Glacial marine clays are subdivided into the Errol Beds which were deposited prior to 13500 years B.P. and the younger Powgavie Clay which contains a fauna similar to that of the Clyde Beds in the west. The Errol Beds were deposited during deglaciation and the Powgavie Clay after deglaciation.

The upper part of the clay sequence is replaced west of Errol by the marine sands of the Culfargie Beds.

In the North Sea the Marr Bank Beds are shallow water sands with a cold water fauna. They are thought to be contemporaneous with the Wee Bankie Beds and were deposited in the sea to the east of the ice limit ([P915549](#)).

Late Devensian and Flandrian fossil shorelines

Raised beaches are a prominent feature of the coastal landscape in Scotland and are a consequence of changes in the relative position of sea level during the Quaternary. The position of sea level varied in relation to the interaction of two main causes. Eustatic lowering or raising of sea level occurred in response to the formation or wasting of vast ice-sheets, and isostatic uplift occurred when the glaciated area was relieved by melting of the mass of ice. The isostatic uplift was centred in the western Grampian Highlands and the amount of uplift diminished radially from the centre. The differential isostatic recovery after glaciation had the effect that the oldest beach now has the greatest gradient outwards from the centre of isostatic uplift and the gradient diminishes in successively younger shoreline features.

During deglaciation the sea level fell from a level relatively higher than at the present time and a number of shoreline features in east Fife, and in Angus and Kincardineshire have been interpreted as late Devensian shorelines formed in association with a westerly retreating ice margin (Cullingford and Smith, 1966, 1980). The younger, lower, shoreline features have lower gradients than their predecessors and extend farther to the west ([P915550](#)). However the correlation of individual shoreline fragments in east Fife and their relationship to actual shorelines of the period has been questioned (Forsyth and Chisholm, 1977). The most obvious late Glacial shoreline is the Main Perth Shoreline which has its western limits in outwash deposits between Falkirk and Stirling.

Continued emergence led to a period of relatively low sea level during which the Main Late Glacial Shoreline was formed. In the east around Grangemouth the shoreline is represented by a layer of gravel buried by later deposits resting on a bevelled surface of rock, till and late Glacial marine deposits. This shoreline slopes gently eastwards and passes below Ordnance Datum near Grangemouth ([P915551](#)). In the Firth of Clyde a prominent rock platform and cliff is correlated with the Main Late Glacial Shoreline. The feature has a gradient to the south and south-west and it passes below Ordnance Datum in south Kintyre. The age of the raised beach in the west of Scotland was originally believed to be Post-Glacial but subsequently an interglacial age became accepted. More recently it has been suggested that it was formed more or less contemporaneously with the Loch Lomond Readvance. The relatively short period available for the formation of a very prominent rock platform and cliff is explained by assuming particularly intense frost shattering in the intertidal and splash zones.

A relative rise in sea level following the formation of the Main Late Glacial Shoreline and a subsequent intermittent fall caused the formation of the High, Main and Low Buried Beaches. These features are known from borehole information in the Carse of Stirling. Stepped features overlain by thin peat layers are interpreted as beaches that have been buried under the Carse Clay during the Post-Glacial transgression. The age of the High Buried Beach is taken as 10 300 to 10 100 years B.P. and is believed to be contemporaneous with the Loch Lomond Readvance ice limit at Menteith. Radiocarbon dates and pollen analyses indicate ages of about 9600 and 8800 years B.P. for the Main and Low Buried Beaches respectively.

A transgression of the sea occurred in early Flandrian times and it formed the Main Post-Glacial Shoreline prior to 6500 years B.P. at or near the maximum extent of the transgression. The deposition of extensive marine and estuarine deposits, called Carse Clays, took place in the estuaries of the Forth and the Tay contemporaneously with the local accumulation of beds of peat. In the Firth of Clyde sand and gravel beaches formed at many places and are especially prominent in Ayrshire between Ayr and Ardrossan, and at Girvan. The sea also connected with the Loch Lomond basin at the maximum of the Flandrian transgression.

Isostatic tilting resulted in the beach sloping gently eastwards in the Forth and Tay areas and to the south and south-west in the Firth of Clyde.

Since the formation of the Main Post-Glacial Shoreline, sea level has fallen and younger, lower shoreline features have formed.

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