# Late Devensian, Quaternary, Grampian Highlands

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Stephenson, D, and Gould, D. 1995. British regional geology: the Grampian Highlands. Fourth edition. Reprint 2007. Keyworth, Nottingham: British Geological Survey.
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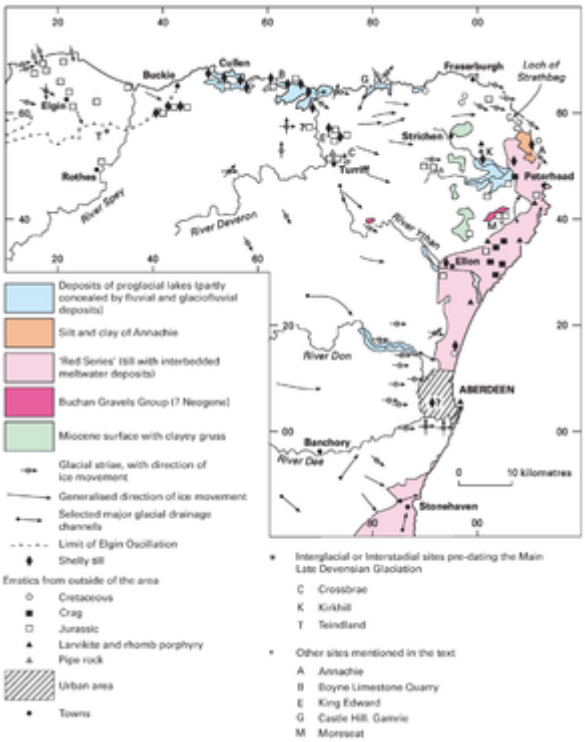
## Contents



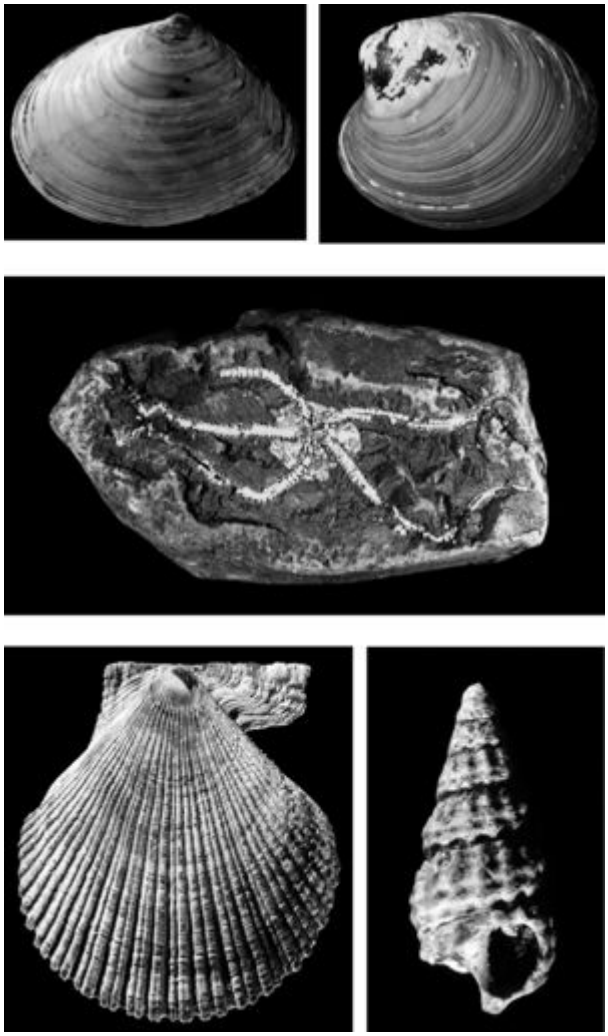
## Late Devensian - introduction

Events during the Late Devensian can be considered under three headings (P915455). During the Dimlington Stadial, the *Main Late Devensian Glaciation* reached its maximum at about 22 000 BP when an ice sheet covered most, if not all, of the Grampians region. During the following period of ice wastage, sheets of gravel, sand and silt were laid down and the movement of any active ice was controlled by the local topography. This was followed by the almost complete disappearance of the ice sheet during the *Windermere (Late-glacial) Interstadial*. Glaciers of the *Loch Lomond Readvance* returned to the mountains during the cold period of the Loch Lomond Stadial between 11 000 and 10 000 BP, and possibly earlier. The Loch Lomond Stadial was followed by a rapid amelioration of climate at the beginning of the Flandrian, about 10 000 BP. The period of time between the end of the deglaciation of the Main Late Devensian ice sheet and the beginning of the Flandrian (Holocene) is known informally as Late-glacial, whereas the Flandrian is equivalent to Post-glacial (Gray and Lowe, 1977).

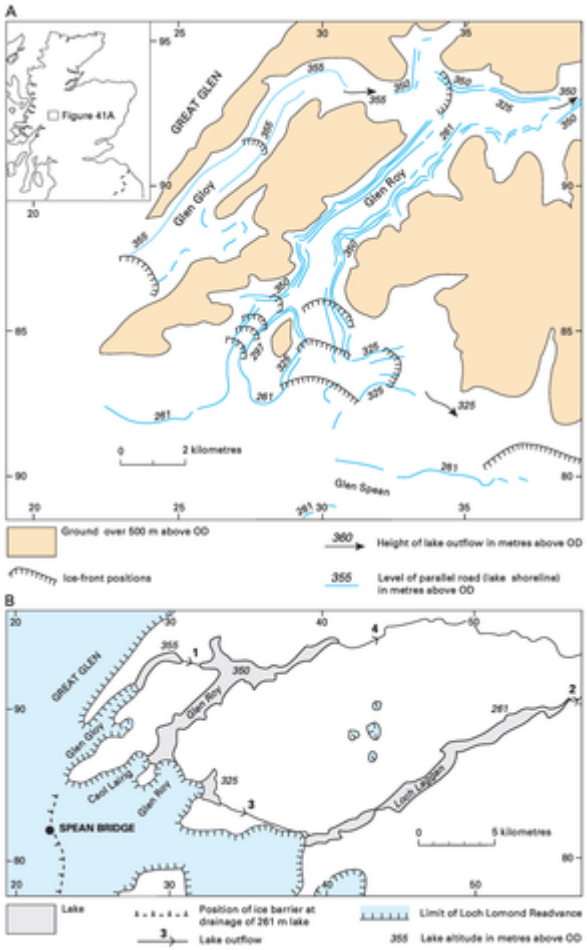



Selected aspects of the Neogene and Quaternary geology of the North-east Highlands. P915447.

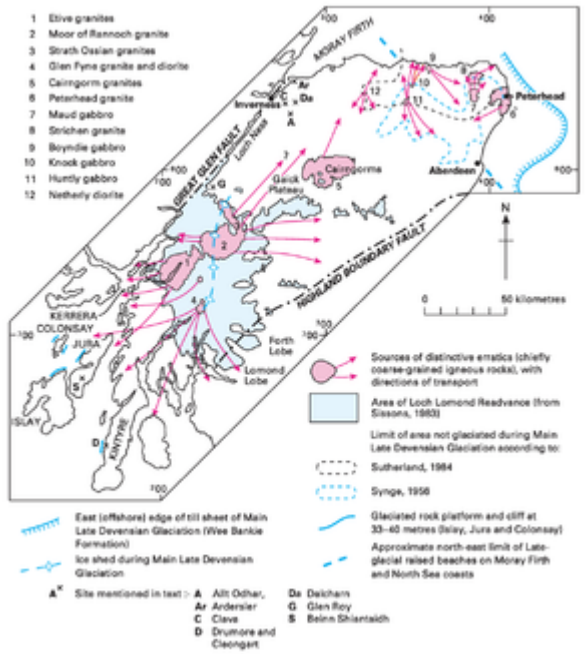
Glaciofluvial deposits, Findhorn valley at Quilichan, Nairnshire. In the foreground are floodplain alluvium and low-lying fluvial and glaciofluvial outwash terraces. P008519.



Quaternary fossils from Ardyne and Elgin.
P915457.




Parallel Roads of Glen Roy. A Ice front positions and lake shorelines during the Loch Lomond Stadial. B Lake outflows at the maximum of the Loch Lomond Readvance. P915449.




Selected aspects of the Quaternary geology of the Grampian Highlands. P915448.

# Main Late Devensian Glaciation

From the distribution of erratics, the ice-shed during this glaciation seems to have been over, or just west of, the Moor of Rannoch (P915448), with ice moving westwards across Islay and Jura and southwards and eastwards into the Midland Valley (Sutherland, 1991). A large ice stream from the Western and Northern Highlands flowed eastwards into the Moray Firth and another from the South-west Highlands extended north-eastwards along the southern flank of the Grampians. Between Fort Augustus and Glen Spean the distribution of erratics suggests that the major centres of glaciation migrated southwards from the Northern Highlands to the Moor of Rannoch. The highest summits are free of erratics and it is likely that they stood above the ice sheet for much of the Dimlington Stadial.

In north-east Scotland three separate ice streams appear to have coalesced during the Dimlington Stadial (Clapperton and Sugden, 1977). One powerful stream moved out of the Moray Firth into the North Sea; another originating in the South-west Highlands moved eastwards along Strathmore and then northwards along the North Sea coast towards Peterhead; and a third, more sluggish, possibly thinner ice body flowed eastwards towards the coast from the mountains and foothills of the eastern Grampian Highlands. Along the coast itself, tills formed by the ice flowing from the interior commonly underlie tills formed by the Strathmore and Moray Firth ice streams, indicating that 'inland' ice expanded initially to the coast before flow weakened sufficiently to allow incursion of ice from the north and south. Further retreat of the inland ice early in the deglaciation, if not before, allowed ice-dammed lakes to form on the Moray and Banffshire coasts against the Moray Firth ice lobe and on the coast north of Aberdeen against the Strathmore lobe. Similar proglacial lakes occupied the lower reaches of the valleys of the Deveron, North and South Ugie, Ythan, Don and Dee (Brown, 1993) and spreads of interbedded silt and clay were deposited on the interfluves, where extensive tracts may have been inundated up to 80 m above OD (P915447).

In eastern Aberdeenshire, the deposits associated with the Strathmore ice stream, which are informally known as the 'Red Series', are the onshore equivalent of the offshore Wee Bankie Formation (Andrews et al., 1990; Gatliff et al., 1994). 'Red Series' tills are typically a vivid red-brown and contain rocks derived from Devonian strata in Strathmore and Permo-Triassic, Devonian and Cretaceous strata offshore. North of Aberdeen, the 'Red Series' comprises a complex sequence in which basal tills are overlain by interstratified flow tills, muds, silts, sands and gravels.

Tills deposited by the Moray Firth ice stream occur as far east as Peterhead. They are typically calcareous, fine-grained, dark grey and contain abundant fossils derived from Late Jurassic and Early Cretaceous strata as well as rafts of these rock types ripped up from the floor of the Moray Firth. The tills formed by the 'inland' ice are typically sandy and their composition strongly reflects the character of the local bedrock, which is commonly deeply weathered.

The glacial landforms in the ground covered by the Strathmore and Moray Firth ice streams are sharp, whereas in much of the area overrun by 'inland' ice to the north and north-west of Ellon they are indistinct. It has, therefore, been suggested that parts of Buchan were ice-free during the Dimlington Stadial and that the last ice to cross the area was either Early Devensian or pre-dated the Ipswichian Interglacial. The difficulties of defining the boundaries of the 'unglaciated' area (if any) are illustrated by the two limits shown on P915448; other workers have placed the limit even farther west.

Although Buchan displays relatively little discernable evidence of glacial erosion, as shown by the survival of deeply weathered bedrock and patches of Neogene gravel, it does exhibit a network of glacial meltwater channels. It is known from Scandinavia and elsewhere that cold-based parts of ice

sheets, such as those that may have covered Buchan, can cause minimal subglacial erosion and can leave delicate morphological features such as eskers and meltwater channels virtually unscathed (Hall and Sugden, 1987).

During retreat, the Main Late Devensian ice sheet probably remained active locally, taking the form of valley glaciers. The southern edge of such a glacier can be traced on the south side of Rothiemurchus, near the Cairngorm ski slopes, where it is defined by marginal channels and lateral deposits. Ice-marginal channels, terraces and benches are also displayed spectacularly in the gorge of the River Findhorn downstream of Tomatin (P008519), and in the valley of the River Nairn downstream of Daviot (Auton et al., 1990). The terraces of the River Nairn merge into Late-glacial beach deposits towards the coast. Local readvances such as the Elgin Oscillation in the east (Peacock et al., 1968), and a (probably later) stillstand or minor readvance (the 'Otter Ferry stage') in the west (Sutherland, 1984), interrupted the general retreat. Other readvances such as the Perth and Dinnet readvances have been reported in the literature, but the evidence is disputed and largely rejected. Another disputed readvance east of Inverness has recently been confirmed on the Ardersier Peninsula, although the timing of the event is unclear.

During deglaciation meltwaters laid down extensive spreads of sand and gravel, particularly on the low ground on the south side of the Moray Firth from the north end of the Great Glen to near Elgin, and also in Strathspey. The deposits include eskers, kames, kame-plateaux and kame-terraces, many having formed in ephemeral ice-marginal lakes as deltas or subaqueous fans (Fletcher et al., 1994). The Flemington Eskers, which extend over a distance of about 10 km to the south-west of Nairn, are probably the best example in Britain of a braided esker system that remains essentially unmodified by sand and gravel extraction (Auton, 1992). They are 5 to 10 m high, with intervening kettleholes. The Torvean Esker in Inverness, now largely quarried away, reached a height of some 60 m, making it one of the largest features of its kind in the country.

In Scotland, the eustatic lowering of sea level caused by the abstraction of water to form the continental and local ice sheets, was more than offset by the isostatic depression of the land. Sea level initially rose quickly during the deglaciation following the Main Late Devensian Glaciation and consequently the lobes of the ice sheet occupying the firths of eastern Scotland retreated rapidly by the process of iceberg calving. Some of the associated glaciomarine sediments are now raised above sea level. The oldest of these deposits occur in the extreme north-east Grampians, where the glaciomarine St Fergus Silts at Annachie (P915447) are radiocarbon dated at 15 320 BP (Hall and Jarvis, 1989). Glaciomarine clays near Elgin, which have yielded well-preserved remains of the brittle star *Ophiolepis gracilis* Allman, can be compared with the *Errol Beds* of the Firth of Tay which were laid down in the arctic conditions preceding the Windermere Interstadial (Armstrong et al., 1985).

## Windermere Interstadial and Loch Lomond Stadial

Deglaciation of the Firth of Clyde area was followed by the deposition of the *Clyde Beds*, which began to form about 13 000 to 12 800 BP, when glaciers finally retreated to within the mouths of the sea lochs in response to the sharp climatic amelioration marking the beginning of the Windermere Interstadial (Sutherland, 1984).

Pollen analysis of lake sediments and peat bogs shows that the climate warmed rapidly about 13 000 BP. The freshly deglaciated areas of the mainland were colonised by a pioneer vegetation of open habitat taxa which was followed by the immigration of crowberry heath, juniper and tree birch. There was a short-lived reversion to open habitat species in some areas at about 12 000 BP and during the succeeding Loch Lomond Stadial there was a more general return to open habitat vegetation and tundra. On the west coast, the raised marine shelly clays of the Clyde Beds include

both cool-water interstadial faunas similar to those found today on the north-west Norwegian coast and an arctic fauna which can be referred to the Loch Lomond Stadial (Plate 20; Peacock, 1993).

The extent of deglaciation during the Windermere Interstadial is unknown because the evidence has largely been destroyed by glaciers during the subsequent *Loch Lomond Readvance*, but it is likely that some ice would have survived at high levels in the western mountains.

There is abundant evidence in the form of terminal moraines and the presence of hummocky gravel, till and fluted drift for renewed glaciation in the Loch Lomond Stadial, during which glaciers once more became extensive in the Central and South-west Highlands (P915448; P002838) (Gray and Coxon, 1991; Thorp, 1991). Glaciers in the upper Forth valley and the basins of Loch Lomond and Loch Creran ploughed through marine deposits of the Windermere Interstadial. An ice cap centred west of Rannoch Moor extended to 700 m above OD and ice at this time was some 600 m thick in the Great Glen. A smaller ice cap was present on the Gaick Plateau.

Ice crossing the Great Glen from the west and south dammed up lakes which gave rise to the shorelines known as the Parallel Roads of Glen Roy, Glen Gloy and Glen Spean (P915449A; Peacock and Cornish, 1989). Successive lakes in Glen Roy were controlled by outlets at present levels of 261 m, 325 m and 350 m above OD as the ice advanced and at 325 m and 261 m as the ice retreated (2 to 4 on P915449B). The maximum position of the readvance ice associated with the highest lakes is clear in Glen Roy and Glen Spean, where it is marked by terminal moraines and/or thick lake sediments, but less so in Glen Gloy. Here two positions have been suggested, one being east of the col (355 m) leading to upper Glen Roy. The latter position, however, may predate the Loch Lomond Stadial. The retreat of the ice from the maximum in these glens is thought to have been accompanied by catastrophic lake drainage, possibly accompanied by earthquakes.

During the Loch Lomond Stadial and during the earlier part of the retreat phase from the Late Devensian maximum, the arctic climate led to intense frost action which gave rise to blockfields and stone lobes on high ground and to patterned ground and solifluction sheets at all levels. Ice-wedge pseudomorphs are said to occur outside the limit of the Loch Lomond Readvance glaciers; in present-day arctic climate environments such pseudomorphs indicate permafrost conditions and average annual temperatures several degrees below 0° C (Ballantyne and Harris, 1994). Fossil rock glaciers and protalus ramparts (ridges of debris formed at the base of snow slopes) were formed at several localities, mainly in the Cairngorms. A particularly striking example of a rock glacier can be seen on Beinn Shiantaidh in Jura (P915448). Landslips are common in the western Grampians, particularly within the limits of the Loch Lomond Readvance. They were probably triggered by a combination of factors such as unloading of rock faces as the ice melted, changes in water table and the presence of suitably oriented joints and bedding surfaces. It is likely that severe frost action at the shoreline played a part in the formation of the Parallel Roads of Glen Roy, which are partly incised in bedrock.

## Full list of references

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