

Late-glacial raised beaches and the Flandrian transgression, 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.

Late-glacial raised beaches and associated marine deposits and clifflines

Isostatic depression of the lithosphere by the Main Late Devensian ice sheet was sufficiently great to ensure that, although global eustatic sea levels were low during deglaciation, local sea levels around the Scottish ice sheet were high. In Late-glacial and Flandrian (Post-glacial) times, isostatic recovery sometimes failed to keep pace with the eustatic rise in sea level as the water was returned to the oceans. Consequently, raised beaches and associated marine deposits are now found well above OD on all coasts except part of Buchan (Smith and Dawson, 1983). Isostatic uplift was greatest where the ice load had been maximal, as a result of which the beaches tend to be tilted away from a centre of uplift in the South-west Highlands. Beaches of the same height in different places are therefore not necessarily of the same age. The raised beaches are divisible into a Late-glacial series (formed sometimes adjacent to retreating ice) and a Flandrian series (sometimes termed Post-glacial) which are separated in time, for the most part, by a period of relatively low sea level.



Rock platforms, near Port a'Chotain, north Islay. The 30 m rock platform produced by marine erosion is overlain by Late-glacial beach gravels. P001978.



Recessional moraine ridges composed mostly of sand and gravel that formed during the 'active retreat' (right to left) of a Loch Lomond Readvance glacier. Strath Fillan, Perthshire. P002838.

The widespread Late-glacial beaches formed partly during the retreat of the Main Late Devensian ice sheet and partly during the Windermere Inter-stadial and the Loch Lomond Stadial ([P001978](#)). They are usually in the form of accumulations of gravel which rest on platforms cut in drift. Heights of a little above 40 m above OD have been recorded both on the mainland adjacent to the Firth of Clyde and on Jura where a 'staircase' of 50 shingle ridges has been mapped. The regression of the sea from these high levels may have been briefly checked in the inner Firth of Clyde during the 'Otter Ferry stage'. In the east, raised beaches have been recorded up to 35 m above OD at Inverness and Stonehaven and at about 30 m above OD near Elgin.

To the east of Inverness and as far as Forres, some 40 km to the north-east, there are large tracts of mounded, ice-contact topography that lie below the elevation of the highest Late-glacial marine shoreline (the 'marine limit'), yet provide no positive evidence of any marine incursion. These low-lying areas are considered, therefore, to have remained covered either by ice or by sediment containing buried ice masses, until relative sea level had fallen. The absence of marine or littoral deposits in several large kettleholes occurring within these tracts, indicates that ice remained inland of those coasts until relative sea level had fallen to less than 13 m above OD (Firth, 1989).

A well-marked platform and cliff occurs along much of the west coast, the base of the cliff sloping gently south and west from more than 10 m above OD in the inner sea lochs and firths to below high-tide level in Islay and southern Kintyre ([P002838](#)). This feature, which has been termed the Main Late-glacial Shoreline, has also been recorded near Inverness, where it is at about 2 m above OD. It is believed to have been formed by marine erosion accelerated by severe frost action during the Loch Lomond Stadial and part of the preceding interstadial.

Flandrian

The abrupt increase of temperature following the Loch Lomond Stadial led to the rapid establishment of crowberry and juniper scrub with subsequent expansion of mixed deciduous woodland of birch and hazel, followed by oak and elm, or pine, and alder (Walker, 1984). The forests so formed declined after about 5000 BP, partly as the result of the cooler, wetter climate which

favoured the growth of blanket peat and partly as a result of human activities.

Relative sea level fell following the final disappearance of the glaciers, to be followed by a marine transgression which culminated between about 6000 and 6800 BP (Smith and Dawson, 1983). This transgression formed the Flandrian raised beaches (the '25 ft' and '40 ft' beaches of older Geological Survey publications), which usually take the form of gravel storm beaches, but in sheltered situations estuarine silt and clay predominate. Lower beaches occur in places. The beaches tilt away from the centre of isostatic uplift, the Moor of Rannoch. The highest beaches occur 12-14 m above OD near Stirling and 10 m above OD at Inverness, but are at sea level on the Buchan coast at Fraserburgh; the average tilt is about 0.06-0.07 m/km. A gradient of 0.05 m/km has been calculated for the equivalent beach in the Firth of Lorn. Along the east coast a prominent fine-grained sand horizon, present in both estuarine and nearshore terrestrial sediments, was deposited at around 7000 BP in response to either a major storm surge in the North Sea basin or a tsunami resulting from a major submarine slide on the Norwegian continental slope (Long, Smith and Dawson, 1989).

Sandy beaches and blown sand are extensively developed on parts of the Moray Firth and North Sea coasts, but are less important in the west. Inland, the blanket peat referred to above is widespread in parts of the Grampians, but the extensive tracts formerly present on low ground have been greatly reduced to create agricultural land. The glacial deposits have been partly eroded and redistributed by streams to form the alluvial haughs and terraces seen in many Highland glens (Ballantyne, 1991).

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