Main Late Devensian glaciation, Quaternary, Northern England

Speculative reconstructions of the last ice sheet. a At about the Last Glacial Maximum (LGM): 28–22 ka BP, but when Scottish ice had ceased flowing across Stainmore, and Scandinavian ice had advanced into the central North Sea Basin, forcing ice from the Pennines and Tweed Basin to flow into the Vale of York. b Following a major glacial reorganisation involving ‘drawdown’ and
‘headward scavenging’ of the Irish Sea ice stream into the Solway lowlands and Vale of Eden. Exact timing and correlation of events is unknown, but North Sea ice pushed farther into the Teesside lowlands once ice from the Lake District ceased flowing across Stainmore. Subglacial glaciofluvial deposition probably occurred within tunnel valleys in the Durham lowlands prior to the creation of Glacial Lake Wear. c Scottish ice advances into the Solway lowlands following retreat of ice sourced in the Lake District. Multiple readvances affect the Isle of Man and the west Cumbrian coast. P916098.

NEXTMap Digital Surface Model (1.2 m vertical resolution) (NEXTMap Britain elevation data from Intermap Technologies).

ALB Alston Block; ASB Askrigg Block; B Brampton Kame Belt; CF Carter Fell; CH Cheviot Hills; CR Criffel; DG Dalston Gap; FG Ferryhill Gap; HF Howgill Fells; LH Langholm Hills; MH Moffat Hills; MO Maidens Hall opencast site; MP Millfield Plain; R Rogen moraine; S Shap Fell; SG Stainmoor Gap; SR Scottish Readvance limit at Carlisle; SB Scandal Beck interstadial site; StB St Bees Moraine; T Troutbeck interglacial sites; TG Tyne Gap; TV Team Valley. (P916120).

Most of the glacigenic deposits now preserved in northern England were laid down during the MLD glaciation, between at least 28 and 14.7 ka BP, when the district was overwhelmed entirely by ice
apart from, perhaps, some of the highest peaks in the south-west Lake District. The deposits are assigned to the Caledonia Glacigenic Group.

There is growing evidence from the global sea-level record that the Last Glacial Maximum (LGM) occurred relatively early in the Late Devensian, from about 27 ka BP and lasting for about five thousand years. A period of rapidly rising global sea level starting at about 22 ka BP possibly triggered a large-scale glacial reorganisation of the last British ice sheet, which achieved its maximum position at Dimlington, in Holderness, shortly after 21.6 ka BP. Local readvances occurred during overall glacial retreat, mainly involving mobile coastal ice streams. A subsequent, more controversial event, the Scottish Readvance, has been correlated tentatively with Heinrich Event 1. It is thought to have affected the northern tip of the Isle of Man and north-western Cumbria, and may have been contemporaneous with a readvance in north-east Ireland at about 16.7 ka BP. The whole of the northern England district was probably ice-free by 14 ka BP.

Directions of ice flow have been obtained mainly from the orientation of drumlins and other ice-moulded landforms, together with the distribution of striae and glacial erratics (P916098). However, the ice-flow indicators clearly relate to more than one glacial event and generalised directions of ice flow often conflict with those inferred from detailed mapping, lithostratigraphy, till fabric analysis, satellite imagery or digital terrain models. It is clear that local centres of ice accumulation formed important elements of the MLD ice sheet, separated by relatively fast-flowing, topographically constrained, ice streams (P916120). Accumulation centres were positioned over the Langholm Hills in the Southern Uplands of Scotland, Carter Fell and the Cheviot Hills on the Scottish border, and the high ground of the Alston and Askrigg blocks. There the ice remained relatively sluggish and cold-based, depositing little till and causing relatively little glacial erosion. A major, linear ice divide linked the Lake District and the western Pennines across Shap Fell; it was independent of topography and its position shifted northwards during the glaciation. Palaeonunataks identified in the Lake District demonstrate that the surface of the ice sheet stood at between 800 and 870 m OD. These mountains are capped by frost-shattered rock, blockfields and tors that are apparently separated from glacially moulded bedrock at lower elevations by sharp periglacial trimlines. The surface of the ice sheet has been estimated to be about 700 m OD over the Irish Sea basin during the LGM, when even Snaefell (621 m) on the Isle of Man was buried.

The sequence of events that occurred during the MLD glaciation is not fully understood since there is insufficient geochronological control, some phenomena result from more than one phase of glaciation, and the stratigraphical record is beset with difficulties of regional correlation. The MLD ice sheet was dynamic with migrating ice divides, corridors of fast-flowing ice (ice streams) and fluctuating margins that locally surged into proglacial lakes and across the adjacent sea bed. This resulted in multiple local readvances leading to the juxtaposition of tills of markedly different provenance. There are numerous references in the older literature to ‘tripartite sequences’ comprising ‘lower’ tills, ‘middle’ sands, silts and clays, and enigmatic ‘upper’ tills; modern work has shown that the stratigraphy cannot be so simply rationalised.

The Vale of Eden was an extremely ‘congested’ sector of the former ice sheet, for which some widely published glacial reconstructions are glaciologically implausible. For example, Scottish ice is envisaged to have flowed eastwards across the Solway lowlands and through the Tyne Gap contemporaneously with ice flowing westwards from the Vale of Eden, either adjacent, or at different levels in the ice sheet. It is more likely that ice ceased to flow through the Tyne Gap as a consequence of the westward flow becoming established (P916098). This major glacial readjustment probably resulted from changing mass balances of accumulation areas and shifting ice divides that allowed ice to flow into the Irish Sea basin. The drawdown of ice into the basin may have been triggered by rapid global sea level rise at about 22 ka BP causing accelerated iceberg calving.
The pattern of ice flow across the Pennine uplands can be deciphered from swathes of drumlins and other glacially streamlined landforms, which mainly relate to an earlier phase in the glaciation, prior to the major readjustment (P916098). The picture is more complicated on lower ground towards the North Sea coast, where there are thick and complex glacigenic sequences, but relatively weak drumlinisation. Here a powerful, coastal ice stream abutted, diverted and interacted with more locally sourced ice (P916098).

A controversial factor is the role of Scandinavian ice, which is widely believed not to have crossed the North Sea during the Late Devensian, because lodgement tills of this age are largely absent offshore. However, it is now known that low gradient ice sheets flowing over wet, deformable beds, especially in marine areas, are unlikely to form thick units of stony lodgement till. Instead, thin units of fine-grained diamicton with well-dispersed pebbles and shell fragments are produced that can be mistaken for in situ glaciomarine deposits. It seems increasingly likely that the Scottish and Scandinavian ice sheets did indeed coalesce during at least an early phase of the MLD glaciation, and possibly on two previous occasions during the Devensian. This helps to explain why ice from Scotland and the Tweed Basin evidently encroached back onto the coast between Northumberland and north Norfolk rather than simply flowing offshore.

**Bibliography**


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