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Early Pleistocene glaciations of the North Sea basin revealed by geomorphic evidence from 3D seismic datasets

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The record of the last major glaciation across northwest Europe is increasingly well understood, but the extent, timing, and palaeoenvironmental significance of earlier Pleistocene glaciations is still poorly known. Here, two sets of iceberg ploughmarks and a buried tunnel valley, all well-imaged within 3D seismic data, provide direct geomorphic evidence for glacial conditions in the central North Sea during periods of the Early to Middle Pleistocene. Each set of geomorphic features is mapped within separate stratigraphic intervals and constrained using seismic-borehole ties to the Bruhnes-Matuyama [B-M] palaeomagnetic reversal, dated in NW Europe at approximately 0.79 Ma B.P (Funnell, 1995).

The first set of iceberg ploughmarks mapped within the Witch Ground Basin at approximately 0°30'W, 58°10N comprises 423 scours within a package of relatively disturbed seismic reflectors approximately 130-170m below seabed. Scours are sub-parallel, cross-cutting, and occasionally sinuous, with widths of 40-60m and lengths between 1km and 10km+. The ploughmarked surface is extensively incised by multiple generations of younger tunnel valleys imaged within the same 3D seismic data, and lies above the older B-M horizon.

A second set of ploughmarks are buried approximately 250-430m beneath seabed at 2 °40'E 56 °30'N approximately180km SE of the Witch Ground Basin scours. More than 1800 individual scours are observed with widths between 50m and 100m, and lengths from 1km to 17km. The buried scours are observed within three horizons, and their stratigraphic position indicates they pre-date the B-M reversal, lying within a unit traditionally associated with times of non-glacial deposition.

A single buried tunnel valley, c.60km in length, is observed towards the NW of the study area at approximately 0°30'W and 58°30'N. The main channel of the tunnel valley is curvilinear and trends approximately NE-SW with two significant tributary channels trending NW-SE. The tunnel valley displays an undulating base, with internal depths varying from 30m to 60m, and is between 990m and 1500m in width. It incises from just below the stratigraphic level tied to the B-M reversal and thus lies stratigraphically below well-documented younger tunnel valleys that are widespread in the central and southern North Sea.

The two sets of ploughmarks indicate iceberg activity at two separate intervals within the stratigraphic record, requiring the presence of marine-terminating ice-sheets which extended over adjacent landmasses to generate such ice floes. The undulating basal profile of the buried tunnel valley proves a subglacial origin, indicating the presence of a grounded ice sheet at this location well before the formation of the more well-known younger tunnel valleys.

Combined, the ploughmarks and tunnel valley observed in 3D seismic data and stratigraphically related to the B-M reversal provide new and compelling geomorphic evidence for the presence of Early Pleistocene glaciations that affected the North Sea region. These new observations corroborate sparse terrestrial evidence for Early to Middle Pleistocene glaciations in northern Europe and are consistent with marine and ice core records which reflect the overall transition towards a cold climate from the beginning of the Pleistocene.