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Seismic geomorphological mapping of buried glacial landforms at Dogger Bank, North Sea: implications for ice-sheet retreat

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Dogger Bank, in the southern North Sea, is a large shallow bank surrounded by deeper waters, which makes it an ideal site for offshore wind turbine development. Site investigations as part of the Forewind wind farm project have provided a wealth of data that permit geological investigation of the recent glacial and postglacial history of the North Sea. The integrated dataset consists of a dense grid of high-resolution 2D shallow seismic survey, boreholes, cone penetration tests and vibrocores. Calibration between sedimentary facies observed in vibrocores and boreholes to the seismic facies allows a robust geomorphological interpretation to be built. This provides vital inputs into ground models for placement of offshore wind turbines.

At the Last Glacial Maximum, Dogger Bank was covered by the British-Irish Ice Sheet. During ice-sheet advance, streamlined subglacial bedforms formed and were subsequently preserved. This implies both fast ice streaming during ice advance, and limited reworking of the bedforms during retreat. During ice sheet retreat, a large terminal thrust moraine ridge formed. The NE-SW trending moraine ridge dammed a large (approximately 750 km2) proglacial lake. Subsequent sedimentation infilled the lake with up to 30 m of glacial outwash sediments. The lake-fill seismic stratigraphy comprises discrete units of low amplitude, chaotic, or moderate to high amplitude, rhythmic seismic facies. A unit of chaotic facies with a lobate geometry thinning towards the southeast is interpreted to be an ice-contact subaqueous fan. This has minor thrust faulting and folding at the toe of the wedge, which suggest gravity-driven mass movement, or deformation due to minor ice margin oscillation. Iceberg scour marks and a layer of ice-rafted debris at the base of the lake suggest that the ice sheet front was calving icebergs into the lake. Onlapping the subaqueous fan, rhythmic seismic facies represent lake sediments calibrated to vibrocores as alternating clay and silt laminae, which are interpreted to be varves reflecting annual variation of sediment input. The varves also indicate quiet water sedimentation, which suggests ice sheet retreat and ice-distal sedimentation with a strong density stratification of the water column and a range of overflow and underflows that dispersed sediment in the lake.

This dataset suggests a record of punctuated ice-sheet retreat. After the initial formation of the terminal moraine, an ice-contact lake formed. The ice front then retreated to allow-distal lake sedimentation, before sediment and water supply switched off as the ice retreated further northwards. This stepped retreat occurred after the LGM at around 27 ka and before a ribbon lake, formed to the north of Dogger Bank, approximately 60 metres lower in elevation, which has been dated previously to 23 ka. An initial phase of rapid, passive retreat was followed by a slow phase of retreat that allowed approximately 2000 years of lake varves to form. Subsequently, retreat was rapid towards the 23 ka ribbon lake. A negative subglacial slope as the ice sheet retreated northwards may have influenced this rapid phase of retreat.