



Submarine glacial geomorphology of the Irish-UK Celtic Sea: results from the GLAMAR and GATEWAYS campaigns

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The submarine geomorphology of the Celtic Sea is dominated by a vast system of shelf-crossing ridges, which fan seaward across up to 300 km of the mid- to outer shelf of the Irish, UK and French sectors. The ridges have long been interpreted as moribund tidal sand ridges formed during the post-glacial marine transgression, which may have reworked glacial outwash from the last British-Irish Ice Sheet (BIIS). No geomorphological evidence of the BIIS has been recognised, but a mid-shelf grounding line has been proposed based on a seaward transition from subglacial till to glaciomarine sediments at the base of several BGS vibrocores from the Irish-UK sectors. However, one of these vibrocores proved till on a ridge flank, implying ice advance across it; this has led to a model in which the ridges were formed by palaeo-tidal processes prior to or during a rapid late-glacial advance of the Irish Sea Ice Stream (ISIS) to the mid-shelf. An alternative explanation is that the ridges are glaciofluvial features, formed by subglacial meltwater drainage beneath a more extensive ice sheet. This hypothesis formed the basis of an International Polar Year project (IPY EoI 529) that has been supported by campaigns of the r/v OGS Explora in 2009 (GLAMAR) and of the r/v Celtic Voyager in 2012 (GATEWAYS). The GLAMAR campaign targeted the mid-shelf grounding line, acquiring multibeam imagery and high-resolution seismic profiles (Chirp, sparker) correlated to BGS vibrocores. The multibeam imagery revealed remarkable bedforms at various scales: en echelon ridge segments up to 7 km wide and 55 m high, giving way laterally and axially to transverse 'ribs' up to 10 m high; superimposed on both are 'crenellations' <1 m in relief, of varying backscatter. No change in these morphologies is observed within a 25 x 100 km area extending 65 km seaward of the proposed grounding line. Stratigraphic correlation of seismic profiles to BGS vibrocores confirms the ridges to be mantled by glacial till and/or glaciomarine sediments, and shows the ribs to be developed in part within this glacial layer. The GATEWAYS campaign confirmed the presence of small E-W ridges in the northern Irish sector which, together with a remapping of the ridges from Olex bathymetric data, emphasises the fan shape of the ridge system as a whole, with an apex pointing at the Irish Sea. We infer the Celtic Sea ridges and ribs to be subglacial rather than tidal bedforms; a working model is of broad eskerine ridges and transverse de Geer moraines, formed by subglacial outwash beneath an ISIS margin retreating from the shelf edge following a rapid late-glacial advance. Additional data is required to determine if the crenellations are of glacial or post-glacial origin.