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Submarine geomorphology of the Celtic Sea continental shelf and the southern extent of glaciation on the Atlantic margin of Europe



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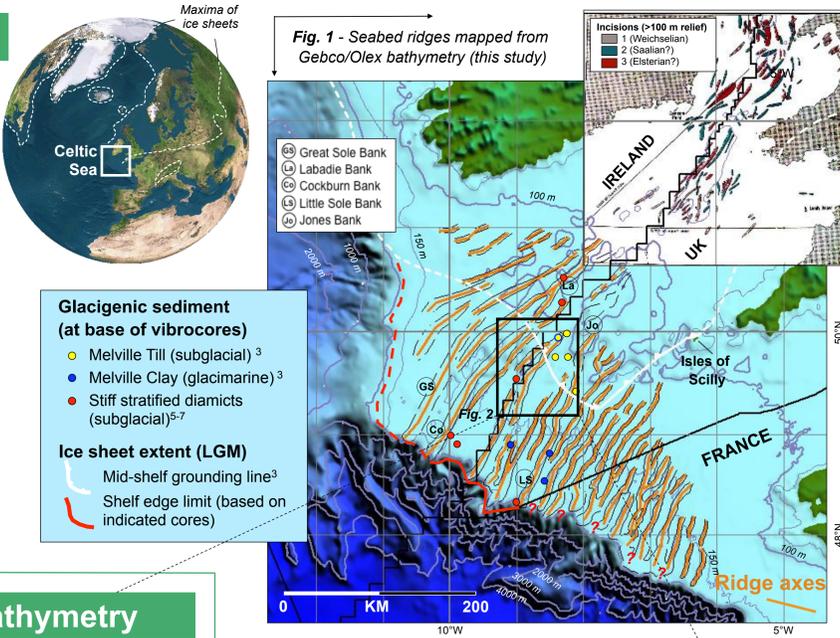
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Celtic Sea glaciation : open questions

- How far have ice sheets advanced SW into the Celtic Sea? Surprisingly, we are still not sure.
- Subglacial and glacial marine sediments cored in the 1970s on and between a system of shelf-crossing seafloor ridges^{1,2} indicated ice extent to at least the mid-shelf of the Irish and UK sectors^{3,4} (Fig. 1).
- Recent coring of subglacial sediments on and adjacent to ridges indicates ice extent >100 km farther seaward to the Irish & UK shelf edge⁵⁻⁷ (Fig. 1, red line).
- Ice extent in the French sector remains unconstrained.
- What are the ridges? Integration of cores with seismic data suggests they could be a) post-glacial tidal sand banks, or b) relict glaciofluvial landforms^{5,6}.



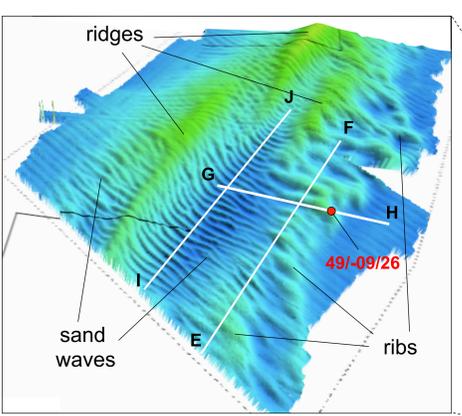
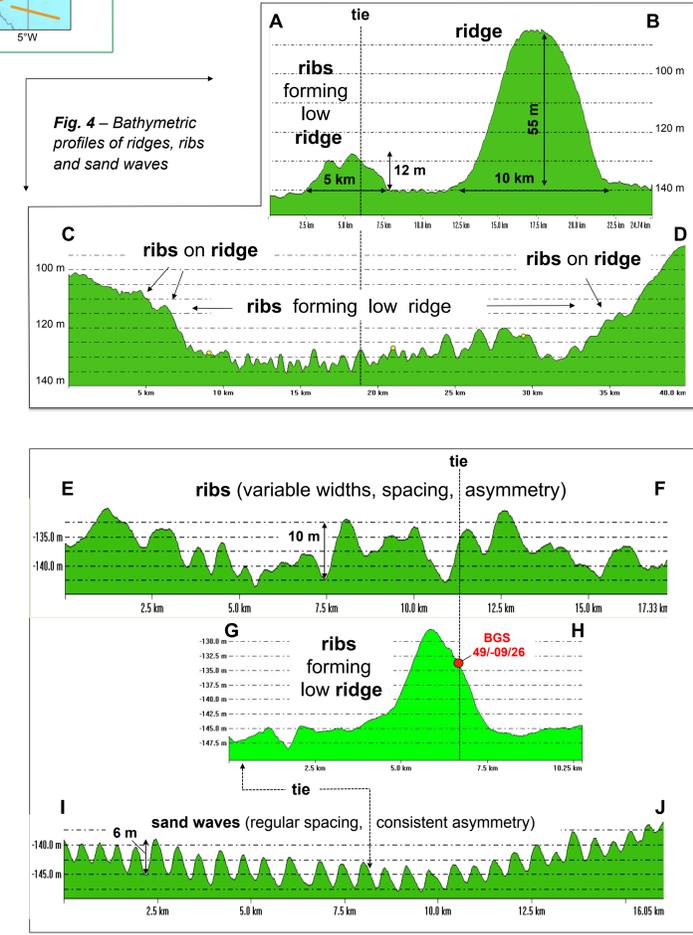
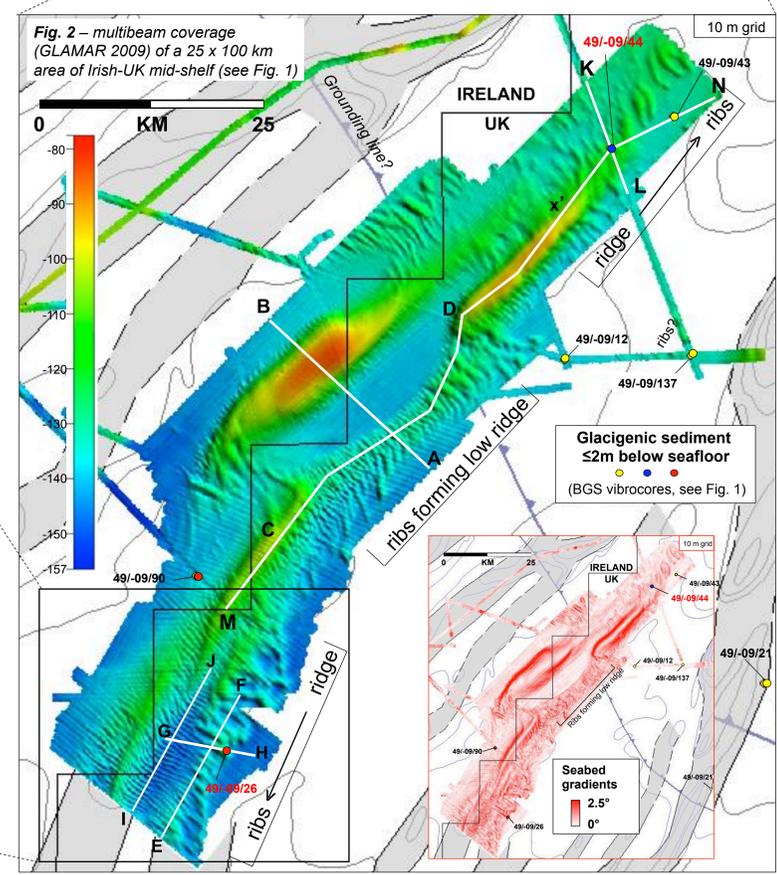
Regional submarine landforms

- ### North Celtic Sea : incisions⁸ (tunnel-valleys)
- up to 250 m in relief, 5 km wide, 20 km long
 - at least 3 stratigraphic levels (mainly infilled)
 - meltwater drainage during at least 3 glaciations
- ### Celtic Sea shelf : seafloor ridges
- up to 60 m high, 10 km wide, 300 km long
 - fan-shaped, apex points to North Celtic Sea
 - axial rotation of up to 80° (W-E to almost N-S)
 - axial convergences seaward, some landward
 - up & down axial profiles (segments 10s km long)

Mid-shelf landforms from multibeam bathymetry

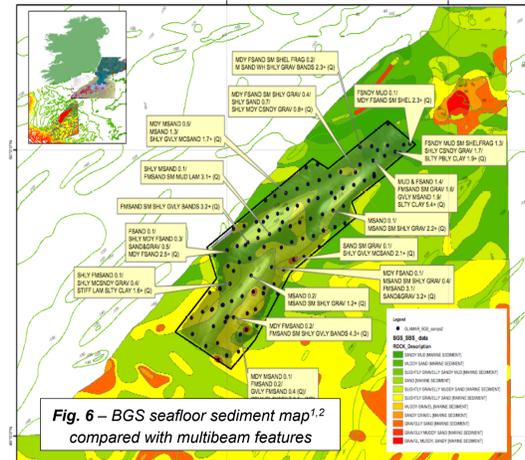
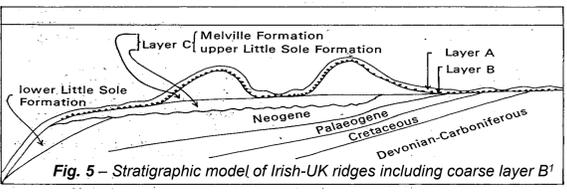
Rectilinear network of seafloor features :

- Ridge segments** : en echelon elements up to 55 m high, 10 km wide and 10s km long
- Transverse ribs** : up to 15 m high, 1 km wide and 10 km long; arcuate to linear, no consistent spacing or asymmetry; occur both lateral to ridges and as axial extensions forming low ridges (see A-B vs C-D)
- Sand waves** : 3-7 m high, up to 0.6 km wide; consistent spacing, asymmetry, widths; occur in south of area, on and between ridges (see I-J)



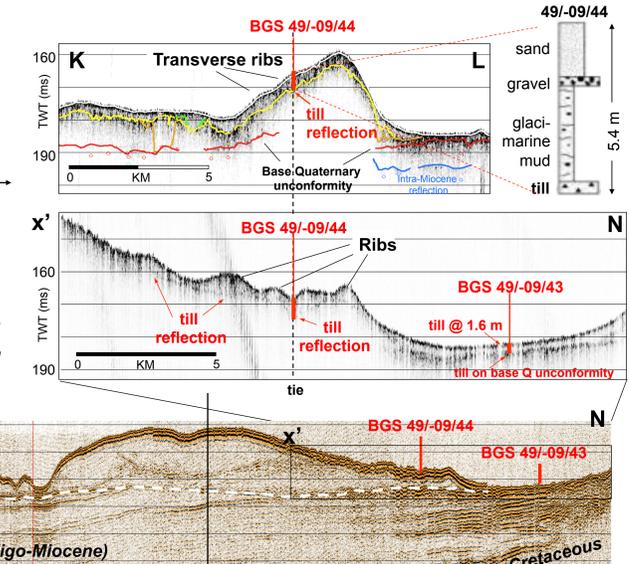
Glacialic drape of ridges and ribs ?

- Ridges shown to be truncated by a regional unconformity overlain by a fining-upward succession⁶ (layers A & B, Fig. 5)
- Sample & sonar data show layer B to include gravel (to >1 m size) of presumed glacial origin (ice-rafted or reworked till)^{1,2}



Glacialic sediments in ribs of study area supported by two vibrocores :

- 49/09/44 : beneath layer B gravel at 2 mbsf, 3 m of glacimarine mud² lies within transverse ribs, above Melville Till at base that correlates to a reflection extending across the ridge (Fig. 7, K-L, M-N)
- 49/09/26 high : beneath layer B gravel at 0.5 mbsf, stiff sandy clay considered Neogene (BGS field log); located on ridge/rib 15 m high (Figs 2-4, G-H)

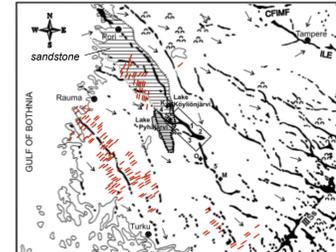


Are we looking at tidal or glaciofluvial landforms ?

- ### Tidal banks and sand waves : too big + wrong morphologies ?
- Up to 50% higher than largest known tidal banks, and at upper limit of sand wave heights → low slopes imply that, if degraded, both were originally far bigger than any known features
 - Lack morphologies consistent with the cyclonic flow systems typical of tidal systems (curvature into parallelism with bank crests, opposite symmetry on opposite sides of banks...)

Giant eskerine ridges and glaciofluvial (De Geer) moraines ?

- Comparable to rectilinear networks of giant eskers (up to 10 km wide, 40 m high) and De Geer moraines in Canada and Finland^{9,10}, formed by subaqueous outwash during ice margin retreat
- Consistent with evidence of subglacial and glacial marine sediments in ridges and ribs in Irish and UK sectors
- Broad implications for ice sheet extent and dynamics – notably in the French sector



➤ These hypotheses invite testing through targeted acquisition of data from ridges and ribs in the Irish, UK and French sectors

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