Geophysical Research Abstracts
Vol. 17, EGU2015-13272, 2015
EGU General Assembly 2015

Submarine geomorphology of the Celtic Sea – new observations and hypotheses for the glaciation of a mid-latitude continental shelf

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The southern limit of glaciation of the European continental margin lies in the Celtic Sea, where the full extent and dynamics of the British-Irish Ice Sheet (BIIS) remain in question. This is in part because the broad continental shelf contains no obvious glacial geomorphological features, but is dominated by a system of shelf-crossing sediment ridges, up to 60 m high, 10 km wide and 300 km long, traditionally interpreted as moribund palaeo-tidal sand banks. Ice sheet extent has been constrained by samples of subglacial and glacimarine sediments recovered (in the 1970s) between the ridges, and in places on their flanks, used to propose a tidewater ice margin that advanced to a grounding line on the mid-shelf, overriding a precursor ridge system. New information on the glaciation of the Celtic Sea is available from geophysical and core data acquired during Italian- and Irish-led campaigns in 2009, 2012, and 2014, both from the mid- and outer shelf. On the mid-shelf, multibeam seabed imagery of a 25 x 100 km area reveal a distinctive rectilinear network of en echelon ridge segments giving way laterally and longitudinally to transverse ribs. Seismic correlation to glacigenic sediments previously cored on a ridge flank (at core site 49/-09/44) indicates the ribs to be composed in part of glacimarine sediments, above a till reflection that can be traced across the ridge crest. No change in seabed morphology is observed across the proposed grounding line. On the outer shelf, new cores of glacigenic sediments were obtained from the flank of a shelf-crossing ridge, and provide evidence of ice sheet advance to the shelf edge, 150 km beyond the proposed grounding line. The cores from outer Cockburn Bank contain facies interpreted to record subglacial deformation and glacimarine deposition from turbid meltwater plumes during withdrawal of a tidewater ice sheet margin from the shelf edge by 24,265 $\pm$ 195 cal BP. These sediments are inferred to form part of a sheet of glacigenic deposits that extends across the shelf, and at least in part overlies the seabed ridges. These observations challenge available models of ridge formation by paleo-tidal deposition and/or erosion during the post-LGM marine transgression, and raise the possibility that they are glacial landforms. We consider two hypotheses: the ridges are paleo-tidal banks formed during the Eemian transgression, overridden by and largely preserved beneath the last BIIS; or they are glaciofluvial landforms (giant eskers and De Geer moraines), the results of meltwater drainage beneath the last ice sheet. We favor the latter hypothesis, which if correct has broad implications for the maximum extent and dynamics of the Irish Sea Ice Stream.