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Preface to MG SI

Geological evolution and processes of the glaciated North Atlantic margins

Hans Petter Sejrup[a], Mike Bentley[b], Berit Oline Hjelstuen[a], Colm Ó Cofaigh[b]

[a] Department of Earth Science, University of Bergen, Allégaten 41, N-5007 Bergen, Norway
[b] Department of Geography, Durham University, Durham DH1 3LE, UK

Understanding the evolution and nature of the glaciated margins of the North Atlantic is of considerable societal and academic importance. The sediments and landforms along these margins provide a record of past ice sheet activity as well as spatial and temporal variations in ice-ocean-climate interaction. Notably, in terms of climate research, they provide a direct link between the deep oceans and the ice sheets sourced in the interiors of the surrounding landmasses. The North Atlantic continental margins also have considerable economic and societal importance in terms of their implications for hydrocarbon exploration (and thus the oil and gas industry) and hazard prediction and mitigation (e.g., large-scale sediment slides along the margin that threaten seabed infrastructure and generate tsunami). Understanding their geomorphological, geophysical and sedimentological nature and, in particular, the underlying physical controls on margin evolution, is therefore of widespread importance.

Over the last 20 years, there has been a large research effort, involving both European academia and industry, which has contributed to our current understanding of the development of the glaciated North Atlantic margins. EU/ESF-funded programs such as PONAM, ENAM I and II, STRATAGEM, COSTA, HOLSMEER and the recently completed GLANAM, have been central to major advances in understanding the modes and evolution of the ice sheet-influenced continental margins and contributed to the current awareness of the significance of this natural system. This has nurtured interactions between academia and offshore industry with respect to the mutual exchange of data and ideas, and has also facilitated rapid technological advances in the methods used by both sectors to collect and analyze geophysical data and sediment cores from offshore areas.

This special issue contributes to our understanding of the spatial and temporal controls on the development of glaciated continental margins with specific reference to the North Atlantic (Fig. 1). It consists of a suite of papers which investigate the evolution of the North Atlantic continental margins, especially with regard to the role and influence of past ice sheet growth and decay. The deglaciation, following the last glacial maximum, of ice sheets from the continental shelves and landmasses surrounding the North Atlantic is an important analogue for the potential retreat of the modern Antarctic and Greenland ice sheets under future climate warming. Deciphering the timing and rate of past ice sheet retreat is thus important for predicting future sealevel changes and also to our understanding of feedbacks between ice sheet decay and the climate system. Furthermore, the special issue also includes papers on large-scale sediment architecture and slope morphology of certain sectors of the North Atlantic margins, thus providing a better understanding of the controls on this pattern and its implications for glacial dynamics and the sensitivity of ice sheets to forcing factors through time.

The special issue comprises papers centered on three regions of the North Atlantic (Fig. 1):

1. Greenland margin

Five of the papers in the special issue focus on Greenland and present a range of geophysical, sedimentological and micro-palaeontological data from the fjords, shelf and continental slope. The Disko Trough Mouth Fan (TMF) and adjoining shelf on the central west Greenland margin is the subject of three of these papers. Jennings et al. (this issue) use a long piston core from the fan itself to test whether an ice shelf covered Baffin Bay during the last glacial maximum (LGM) and at the onset of the subsequent deglaciation. They employ a range of biological, sedimentological and mineralogical data constrained by radiocarbon dates to conclude that Baffin Bay was covered by perennial sea ice rather than an ice shelf and was influenced by nutrient-rich, relatively warm Atlantic water during the LGM.

Ó Cofaigh et al. (this issue) investigate the processes of glacigenic sediment delivery to the Disko TMF during the LGM-Younger Dryas. A strong meltwater influence is documented, both in the fan morphology and sedimentology, reflecting the delivery of dense sediment-laden meltwater to the upper slope from an ice sheet positioned at the shelf edge. Although such meltwater-influenced, TMFs have been described previously from mid-latitude settings they have rarely been described from high-latitudes.

Hofmann et al. (this issue) present 3D seismic data from the continental shelf adjoining the Disko TMF. Based on these data they propose that this sector of the Greenland margin was affected by different glacial regimes during the late Pleistocene. Their lowermost seismic unit is inferred to be of Saalian age and records major glacial advance(s) to the outer margin. The most recent phase of glaciation is recorded by multiple sets of terminal moraines indicating slow retreat of active grounded ice from the outer shelf following the LGM.

Previous research on the offshore record of glaciation on the northwest Greenland margin has tended to focus on the full glacial to deglacial record on the mid-outer shelf. The paper by Batchelor et al. (this issue) presents new swath bathymetric data from the inner shelf and fjords of the region. They image a variety of ice flow parallel and

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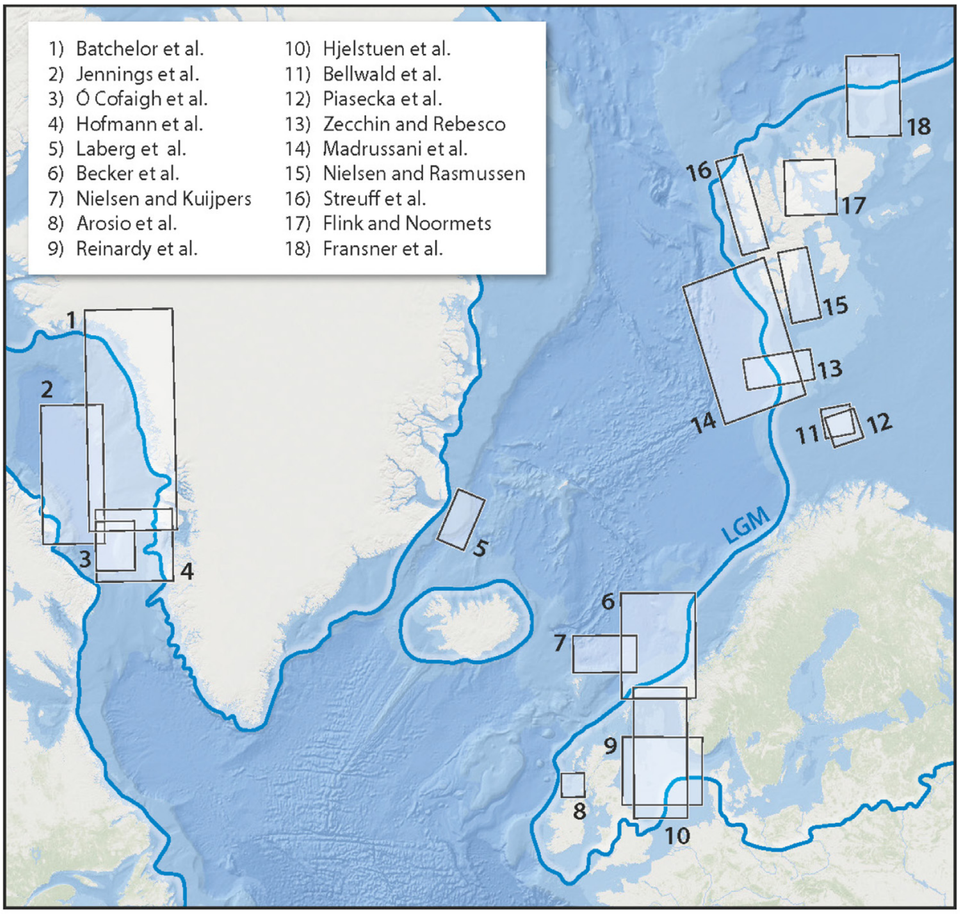

Fig. 1. Locations of study areas for the 18 papers included in this issue. The Last Glacial Maximum (LGM) ice limits are based on reconstructions by Svendsen et al. (2004), Sejrup et al. (2005), Funder et al. (2011), Geirsdottir (2011) and Larsen et al. (2016).

flow transverse landforms, including major moraine ridges and grounding zone wedges (GZWs) which showed that the Greenland Ice Sheet underwent a series of stillstands during deglaciation and subsequent readvances during the Little Ice Age. Water depth in the fjords exerted a strong control on retreat rates and styles during regional deglaciation.

The final Greenland paper in the special issue is by Laberg et al. (this issue) and comprises a sedimentological re-evaluation of the upper part of ODP site 987 from the distal Scoresby Sund TMF, on the East Greenland margin. The authors document a change in sedimentation style on the fan at around 0.99 Ma, the time of the Mid-Pleistocene Transition. This change is reflected in a marked increase in sandy turbidites accompanied by longer run-out debris flows. The paper is a good illustration of the potential of high-latitude trough mouth fans to act as archives of major Pleistocene climatic changes.

2. North Sea - SE Nordic Seas margin

Five of the papers in this issue are from the North Sea - SE Nordic Sea region (Arosio et al., this issue; Becker et al., this issue; Hjelstuen et al., this issue; Nielsen and Kuijpers, this issue; Reinardy et al., this issue). The paper by Reinardy et al. (this issue) is a compilation of lithological and geochronological data from shallow drillings from the central to northern North Sea. Based on new and existing amino acid data from benthonic foraminifera, five informal amino zones are defined. The absolute ages of these zones are estimated based on chronological information from Sr-isotopes, paleomagnetic studies, radiometric dating and biostratigraphy. From this compilation they conclude that the earliest lithological evidence of glaciation of the central parts of the North Sea Basin, was during the Mid Pleistocene Transition.

Becker et al. (this issue) and Hjelstuen et al. (this issue) present acoustic data and sediment cores from the North Sea and the adjacent continental slope covering the period since 35 ka. Based on compilation of lithologic and biostratigraphic data, Becker et al. (this issue) suggest that the Norwegian Channel Ice Stream reached the shelf edge at least three times between 25 and 19 ka BP. They also conclude that rapidly deposited plume sediments on the upper continental slope dated to 18.6 ka BP most likely represents the separating of the Fennoscandian and British-Irish Ice Sheets in the North Sea through the drainage of a glacial lake in the southern North Sea. The paper by Hjelstuen et al. (this issue) is focusing on this drainage event and present seismic and morphological data which describe features in the central North Sea and the Norwegian Channels related to this event.

Based on acoustic data and provenance studies of sediment cores, Arosio et al. (this issue) are investigating the changing flow patterns during the last deglaciation of the western seaboard of Scotland with a special focus on the Hebrides Ice Stream. The study demonstrate how geochemical investigation of continental shelf sediments can be used to constrain the activity and flow sources of palaeo-ice streams, and the utility of combining detrital and FeMn oxyhydroxides to determine the combined influence of the continental sources of material and their dispersal in the marine environment.

Based on acoustic data and information from sediment cores, Nielsen and Kuijpers (this issue) have investigated various glacially influenced features on the northern Faroese continental margin. On the shelf and upper slope extensive evidence of iceberg turbation, estimated to have been formed during extreme glaciation within the period MIS12-6, are found. The origin of the turbate is suggested to be