ARTICLE IN PRESS

Marine Geology xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Marine Geology

journal homepage: www.elsevier.com/locate/margo

Depositional processes on the distal Scoresby Trough Mouth Fan (ODP Site 987): Implications for the Pleistocene evolution of the Scoresby Sund Sector of the Greenland Ice Sheet

Jan Sverre Laberg[a,*], Tom Arne Rydningen[a], Matthias Forwick[a], Katrine Husum[b]

[a] Department of Geosciences, UiT - The Arctic University of Norway in Tromsø, NO-9037 Tromsø, Norway
[b] Norwegian Polar Institute, Fram Centre, NO-9296 Tromsø, Norway

ARTICLE INFO

Keywords:
Trough mouth fans
Paleoclimatic archives
High-latitude continental margins
East Greenland
Greenland Ice Sheet

ABSTRACT

The investigation of trough mouth fans (TMFs), important paleoclimatic archives on mid- and high-latitude continental margins, has so far mainly been based on the integration of various types of acoustic data supplemented with short sediments cores. In consequence, sedimentological and chronological data about parts of TMFs deposited prior to the Last Glacial Maximum remains sparse. Here, we re-evaluate the upper part of ODP Site 987 drilled on the distal part of the Scoresby Sund TMF on the east Greenland continental margin, which records the former dynamics of the Scoresby Sund sector of the Greenland Ice Sheet. Based on a more detailed sedimentological description than previously available we find that lithological unit I, deposited over the last ~2.14 Ma, can be divided into two parts, a lower part dominated by glacimarine and marine deposits including some scattered, sandy turbidites and an upper part of debris flow deposits interbedded with sandy turbidites. The transition between these parts occurred at about 0.99 Ma, i.e. at the same time when the mode of ice-sheet variation changed globally, the average ice sheet size increased significantly and the periodicity of ice-volume variation increased from around 41 ka to approximately 100 ka (the "Mid-Pleistocene Transition"). On the distal Scoresby Sund TMF, this change appears to be reflected through a marked increase in the abundance of sandy turbidity flows accompanied by a longer run-out of some of the debris flows due to the delivery of larger sediment volumes during longer-lasting glacial maxima. This suggests that long sediment cores from TMFs have the potential to record the major climatic trends occurring during the Pleistocene.

1. Introduction

During the Pleistocene several major cooling phases occurred, and the global climate changed into glacial-interglacial cycles. The glacial cycles initially showed a periodicity of ~41 kyr, but after the Mid Pleistocene Transition (MPT), between 1.2 and 0.7 Ma, the periodicity changed to ~100 kyr cycles without any significant changes of the orbital forcing (e.g. Tziperman and Gildor, 2003; Lisiecki and Raymo, 2005; Clark et al., 2006). Ice sheets have left behind sedimentary evidence, which hold important information on the evolution of the atmosphere-ocean-ice sheet climate system throughout the Pleistocene, including the MPT. Hence, in order to understand the evolution of the ice sheets and evaluate the climate forcing and responses it is important to locate and decode marine, continuous paleo-climatic archives. Marine palaeo-climatic archives from mid- and high-latitude continental margins that have not been affected by post-depositional mass wasting provide valuable archives to reconstruct the response of ice sheets to climate forcing in the past.

A characteristic feature of glaciated continental margins are trough mouth fans (TMFs) which are composed of thick, continuous successions of glacigenic erosional products from ice sheets. This particular group of submarine fans are located at high-latitude and glaciated continental margins beyond the terminations of cross shelf troughs (Vorren et al., 1989; Aksu and Hiscott, 1992; O'Brien et al., 2007). The largest TMFs, such as the northern high-latitude Bear Island TMF and the mid-latitude North Sea TMF, are several orders of magnitude larger than the smallest (Vorren and Laberg, 1997) that prograded into the northern and southern part of the Norwegian Sea, respectively (Fig. 1). They have low axial gradients (~1°, Vorren and Laberg, 1997) and are in their proximal part dominated by large glacigenic debris flow deposits occurring in units (or sets; Vorren et al., 1989) separated by glacimarine and/or hemipelagic sediments (Laberg and Vorren, 1996). The same characteristics apply also for southern high-latitude trough mouth fans (Passchier et al., 2003; O'Brien et al., 2007). A unit of

* Corresponding author.
E-mail address: jan.laberg@uit.no (J.S. Laberg).

https://doi.org/10.1016/j.margeo.2017.11.018
Received 30 March 2017; Received in revised form 11 July 2017; Accepted 27 November 2017

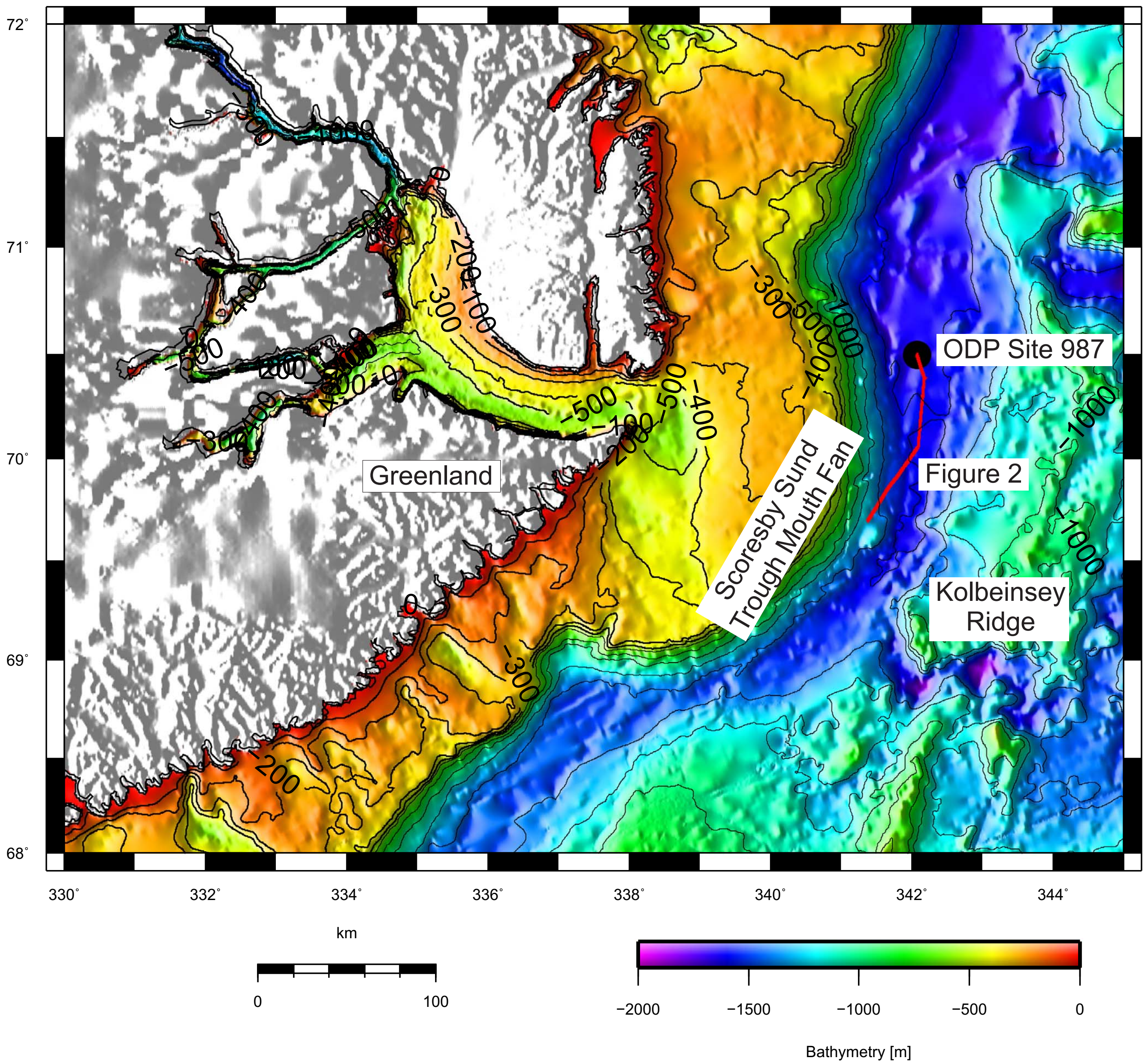

Fig. 1. Bathymetric map of the study area offshore the Scoresby Sund fjord system, East Greenland. The location of the seismic profile shown in Fig. 2 and ODP Site 987 are shown. The bathymetry is from IBCAO 3.0 (Jakobsson et al., 2012).

glacigenic debris flow deposits has been interpreted to be deposited when an ice sheet extended to the shelf break. During full glacial conditions, the LGM ice sheets included sectors of fast flow that developed within and led to deepening of cross-shelf troughs. TMFs developed beyond the terminations of the troughs because of more pronounced erosion and sediment transport beneath the ice streams (Laberg and Vorren, 1995, 1996; King et al., 1996, 1998; Nygård et al., 2007; Tripsanas and Piper, 2008). The large fans received their sediments from a large drainage basin, whereas smaller fans corresponds to minor drainage basins (Batchelor and Dowdeswell, 2014; Rydningen et al., 2016).

There is still a need to more fully understand the East Greenland continental margin as compared to the conjugate Barents Sea margin where more details are known. For instance, studies of the long-term evolution of the continental slope beyond the Bear Island cross-shelf trough revealed that the succession deposited over the last ~2.7 Ma, corresponding to the trough-mouth-fan part of the continental margin strata, can be separated into three main seismic units: GI (oldest) – GIII (Laberg et al., 2010). The paleo–slope morphology of unit GI (~1.5–2.7 Ma) shows a gentle, low-relief surface with channels. Unit GII (~0.7–1.5 Ma) has a more complex seismic facies where irregular to chaotic intervals dominate, but where also acoustically laminated intervals and mounded facies occur. The irregular to chaotic intervals were interpreted as paleo slide scars and slide deposits, whereas the mounded signature is interpreted to reflect cross sections through glacigenic debris flow deposits. Glacigenic debris flows appeared for the first time in unit GII. Channels have also been identified within this unit. Unit GIII, deposited over during the last ~0.7 Ma, is dominated by large glacigenic debris flow deposits (Laberg et al., 2010). This development has been assigned to an overall climate deterioration; from a temperate Barents Sea Ice Sheet with channelized meltwater flow to a more polar ice sheet which included large ice streams but with little or no channelized meltwater flow (Laberg et al., 2010).

More recent work, e.g. by Rydningen et al. (2016) revealed that smaller fans have higher axial gradients and that some are dominated by turbidity currents resulting from transformation of glacigenic debris