Quaternary Science Reviews 169 (2017) 131–147

Contents lists available at ScienceDirect

Quaternary Science Reviews

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

Retreat patterns and dynamics of the Sentralbankrenna glacial system, central Barents Sea

Mariana Esteves [a, *], Lilja R. Bjarnadóttir [b], Monica C.M. Winsborrow [a], Calvin S. Shackleton [a], Karin Andreassen [a]

[a] CAGE - Centre for Arctic Gas Hydrate, Environment and Climate, Department of Geosciences, UiT the Arctic University of Norway, 9037 Tromsø, Norway
[b] Geological Survey of Norway (NGU), Postboks 6315 Sluppen, 7491, Trondheim, Norway

ARTICLE INFO

Article history:
Received 17 January 2017
Received in revised form
30 May 2017
Accepted 1 June 2017

Keywords:
Late quaternary
Deglaciation
Barents Sea Ice Sheet
Glacial geomorphology
Sentralbankrenna palaeo-ice stream
GZW
MSGL
Marine-based ice sheet
Ice stream reconstruction
Glacial dynamics

ABSTRACT

The Barents Sea Ice Sheet (BSIS) is a good palaeo-analogue for the present day West Antarctic Ice Sheet. Both were marine-based ice sheets, particularly vulnerable to ocean warming and sea-level rise. Understanding the BSIS ice dynamics and patterns of retreat since the Last Glacial Maximum (LGM) is useful in developing our knowledge of spatial and temporal variations during marine-based ice sheet retreat. While the western margins of the Barents Sea have been extensively studied, few studies have focused on the central regions, which hosted key ice stream tributaries and major ice domes and divides. Presenting a new high-resolution (5 m) bathymetric dataset, this glacial geomorphological study focuses on the Sentralbankrenna palaeo-glacial system in the central Barents Sea. A large number of grounding zone wedges, mega-scale glacial lineations and areas with tunnel valleys and palaeo-subglacial basins were identified. These form the basis for a six-stage reconstruction of ice stream retreat through deglaciation since the LGM. In reconstructing the retreat of the Sentralbankrenna Ice Stream, we document the rapid but highly spatially variable pattern of retreat of a marine-based ice sheet margin. The presence of several tunnel valleys and interconnected palaeo-subglacial basin systems indicates an abundance of meltwater, likely to have been stored and released through several discharge events, significantly influencing the ice stream margin dynamics. This study provides insight into the behaviour and dynamics of ice during the late stages of the BSIS deglaciation within the central Barents Sea, increasing our understanding of grounding line processes.

1. Introduction

Ice streams are important and highly dynamic components of contemporary- and palaeo-ice sheets, transporting large amounts of ice and sediment from the ice sheet interior to the margins (Bamber et al., 2000); thereby significantly influencing the stability of the ice sheet (Bennett, 2003). Insight into the processes that occur at ice margins is of vital importance for understanding ice-ocean interactions and the consequences of ocean warming (Alley et al., 2005; Bindschadler, 2006; Pritchard et al., 2009). In particular, processes occurring at the grounding zones (where grounded ice loses contact with the bed), where a large amount of mass is lost by calving and melting (Jenkins and Doake, 1991; Rignot and Jacobs, 2002). This, in conjunction with other climatic changes, can lead to acceleration of ice streams, promoting destabilisation in the interior of the ice sheet (Oppenheimer, 1998; Rignot et al., 2004; Shepherd et al., 2004; Bindschadler, 2006). Present day Antarctic and Greenland Ice Sheets are vulnerable to oceanographic and climatic changes, such as increasing surface water temperatures and atmospheric warming, particularly at their ocean margins, thus it is essential to develop our understanding of the processes and mechanisms that influence the spatial and temporal retreat of ice streams.

During the Last Glacial Maximum (LGM; 18–21 cal ka BP) a large marine-based ice sheet covered the Barents Sea, extending to the western continental shelf break (Fig. 1; Svendsen et al., 2004). The Barents Sea Ice Sheet (BSIS) is considered a good palaeo-analogue for marine-based ice sheets (Siegert et al., 2002) such as the present-day West Antarctic Ice Sheet (WAIS). They have many similarities, both are marine-based with their beds mostly below sea-level, both are overlying sedimentary bedrock, and had similar

* Corresponding author.
E-mail address: mariana.esteves@uit.no (M. Esteves).

http://dx.doi.org/10.1016/j.quascirev.2017.06.004
0277-3791/

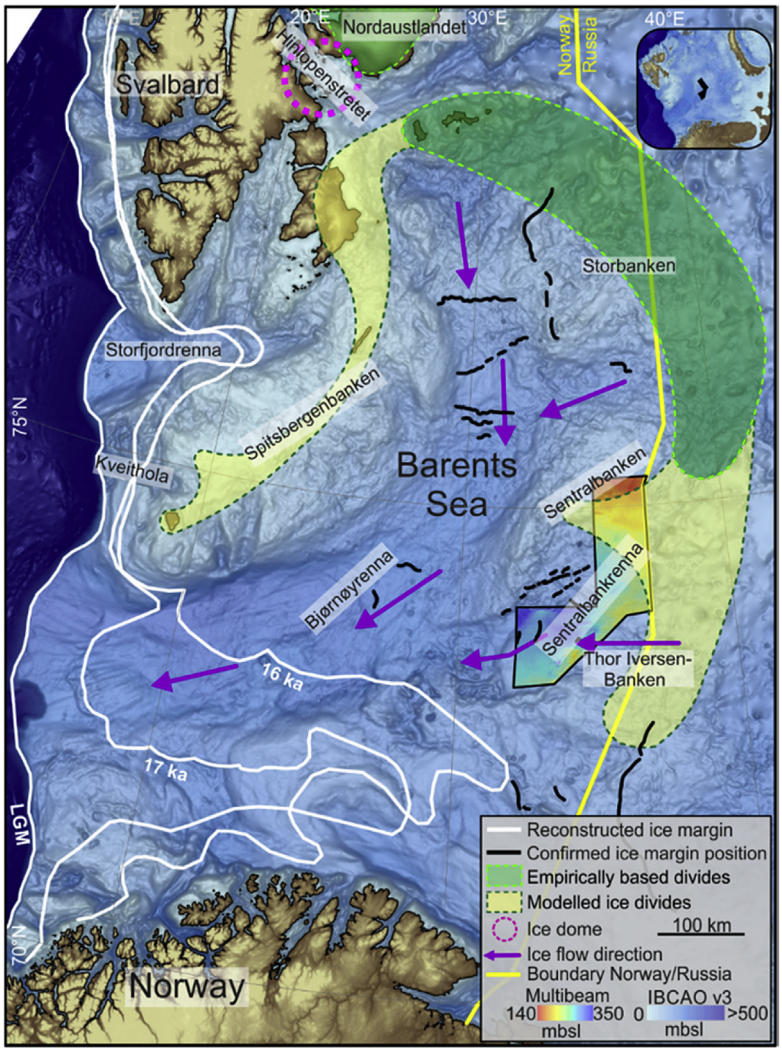

Fig. 1. Map of the Barents Sea, showing the location of the study area (multibeam bathymetry: © Kartverket), the marine border between Norway and Russia, the Last Glacial Maximum (LGM; Svendsen et al., 2004) and 17- and 16-cal ka BP ice margin extents (Winsborrow et al., 2010; extents north of Kveithola from Hughes et al., 2015), as well as the confirmed ice margin positions based on geophysical investigations (Rüther et al., 2012; Andreassen et al., 2014; Bjarnadóttir et al., 2014). The general ice flow directions are indicated by the purple arrows. The locations for the Storbanken ice divide (Bondevik et al., 1995; Ottesen et al., 2005), its speculated extent over Sentralbanken/Thor Iversenbanken/Spitsbergenbanken (Patton et al., 2015) and the Hinlopenstretet ice dome (Dowdeswell et al., 2010) are also presented. Background bathymetry is from the International Bathymetric Chart of the Arctic Ocean (IBCAO) version 3.0 (Jakobsson et al., 2012a). Inset map shows the location of the study area in relation to the whole Barents Sea. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

sizes and extents during the LGM (Andreassen and Winsborrow, 2009). However, unlike the WAIS, the BSIS completely deglaciated following the LGM.

Details of its deglaciation history are preserved in the glacial sediments and landforms imprinted onto the seafloor of the Barents Sea and have been extensively studied in southwest Barents Sea and parts of the Svalbard margin (Fig. 1; i.e. Vorren and Kristoffersen, 1986; Elverhøi et al., 1993; Solheim et al., 1996; Landvik et al., 1998; Dowdeswell et al., 2010; Winsborrow et al., 2010; Rüther et al., 2012; Ingólfsson and Landvik, 2013; Andreassen et al., 2014; Bjarnadóttir et al., 2014; Piasecka et al., 2016). In contrast, the central Barents Sea remains poorly studied, despite it being the site of a major ice dome and ice divides for the BSIS, as well as hosting several ice streams and their tributaries.

Ice streams leave a series of characteristic geomorphic imprints on the seafloor, which document the spatial and temporal patterns of retreat. By studying these we can gain valuable insights into the processes and mechanisms controlling ice stream behaviour (Stokes and Clark, 2001; Livingstone et al., 2012a).

Until recently, there has been a particular scarcity of bathymetric data available from the central Barents Sea due to a political Norwegian-Russian border dispute. This is in contrast to that available from the southwestern Barents Sea where several surveys have been undertaken. We present a high-resolution dataset from the central Barents Sea, immediately west of the border between Norway and Russia (Fig. 1). Focusing on the Sentralbankrenna Ice Stream and its glacial system, which encompasses the adjacent bank areas Sentralbanken and Thor Iversenbanken. The Sentralbankrenna Ice Stream was a tributary to Bjørnøyrenna during the LGM and an important area during the final stages of the central BSIS deglaciation. In this paper, we present glacial geomorphological mapping from the bed of the Sentralbankrenna palaeo-Ice Stream, which is then interpreted to determine ice flow patterns and ice dynamics during deglaciation. We document rapid, episodic ice stream retreat associated with periods of increased ice margin break up punctuated by margin stillstands or short readvances. Subglacial meltwater was abundant in this area and is suggested to have significantly influenced the overlying ice by facilitating fast