Quaternary Science Reviews 154 (2016) 182–198

Contents lists available at ScienceDirect

Quaternary Science Reviews

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

Greenland ice sheet retreat history in the northeast Baffin Bay based on high-resolution bathymetry

Patricia Slabon [a, *], Boris Dorschel [a], Wilfried Jokat [a, b], Reidun Myklebust [c], Dierk Hebbeln [d], Catalina Gebhardt [a]

[a] Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Am Alten Hafen 26, 27568 Bremerhaven, Germany
[b] University of Bremen, Department of Geosciences, Klagenfurter Straße, 28359 Bremen, Germany
[c] TGS, Lensmannslia 4, P.O. Box 154, N-1371, Asker, Norway
[d] MARUM, Center for Marine Environmental Sciences, University of Bremen, Leobener Strasse, 28359 Bremen, Germany

ARTICLE INFO

Article history:
Received 20 May 2016
Received in revised form
28 October 2016
Accepted 31 October 2016
Available online 18 November 2016

Keywords:
Ice-stream retreat
Grounding-zone wedge
Ice dome
Glacial landform
Greenland
Baffin Bay
Melville Bay

ABSTRACT

New swath-bathymetric data acquired in 2010 and 2015 indicate a variety of glacial landforms in cross-shelf troughs of the Melville Bay (northeast Baffin Bay). These landforms reveal that, at their maximum extent, ice streams in the troughs crossed the shelf all the way to the shelf edge. Moraines, grounding-zone wedges (GZWs) and subglacial till lobes on the continental shelf define a pattern of variable ice stream retreat in the individual troughs. On the outer shelf, in the northern cross-shelf trough, ice-stream retreat was slow compared to more episodic retreat in the central (at least one stabilization on the outer shelf) and southern cross-shelf trough (re-advances at the shelf edge and fast retreat thereafter). Large GZWs on the mid-to inner shelf of the troughs indicate periods of grounding-zone stabilization. According to glacial landforms, the final retreat across the inner shelf (before 8.41 ka BP) was episodic to slow. Furthermore, evidence has been found for localized ice domes with minor ice-streams on inter-trough banks. The glacial landforms in Melville Bay, thus, indicate the varying and discontinuous ice sheet retreat history across the Northwest Greenland continental shelf.

1. Introduction

The Greenland Ice Sheet (GIS) is fast declining, contributing approximately 0.57 mm (Rignot and Kanagaratnam, 2006) to the annual global sea-level rise of ~3.3 mm (Cazenave and Remy, 2011). Accordingly, the ice-sheet dynamics of the GIS has received considerable attention in recent decades (IPCC, 2013). In this context, the extent of the GIS during the Last Glacial Maximum (LGM) is of interest to constrain predictions and models of sea-level rise. Melville Bay, in the northeast Baffin Bay area of the broad Northwest Greenland shelf (Fig. 1), hosts records of past ice sheets dynamics. Presently, about 13.5% by volume of annual GIS drainage is directed along glaciers that feed into Melville Bay (Rignot and Kanagaratnam, 2006). The catchment area feeding these glaciers covers approximately 11.5% of the GIS ice sheet. In this regard, the fast-flowing ice of the Northwest Greenland Ice Sheet (nwGIS) accounts for ~25.5 Gt, or ~7%, of the total annual mass loss of the GIS (Joughin et al., 2010; Kjær et al., 2012; Rignot and Kanagaratnam, 2006; Shfaqat et al., 2015).

Thus, understanding the dynamics of the nwGIS is a prerequisite to assessment of the fate of the ice sheet in a time of accelerated global change. Evidence for ice sheet dynamics beyond the period of satellite observations (Box et al., 2012; Morlighem et al., 2014; Nghiem et al., 2012) can be obtained from reconstructions of the nwGIS under past global warming events, namely during the last deglaciation, interpreted from glacial landforms.

In earlier studies, mass balance estimates and remote-sensing data supported the idea of acceleration of ice streams in Northwest Greenland (Joughin et al., 2010, 2004; Kjær et al., 2012; Rignot et al., 2011; Shfaqat et al., 2015). However, so far the role and extent of grounded ice, including fast-flowing ice streams, in Melville Bay draining the nwGIS during the last glacial Maximum (LGM) (~26.5 to ~19 ka BP) remains uncertain (Clark et al., 2009; Funder et al., 2011). The remote Melville Bay is only sparsely covered by high-resolution bathymetric surveys (ArcticNet, 2016; Jakobsson et al., 2012; NOAA, 2016) and, as such, little is known about the distribution and shape of its glacial landforms. These landforms can,

* Corresponding author.
E-mail address: Patricia.Slabon@awi.de (P. Slabon).

http://dx.doi.org/10.1016/j.quascirev.2016.10.022

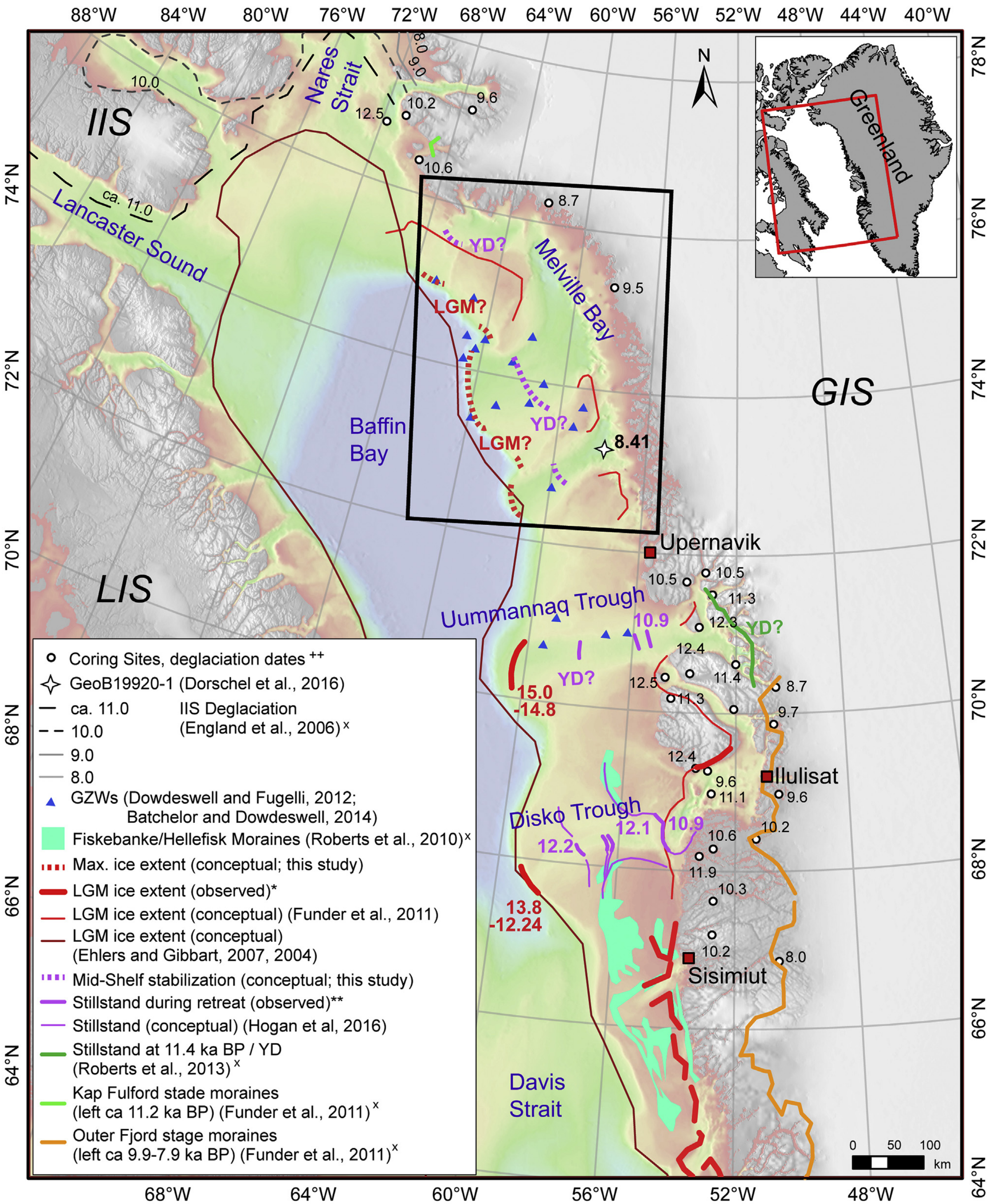

Fig. 1. Overview of existing datasets from the north and eastern Baffin Bay concerning the last deglaciation. See legend for further details. Dashed red and violet lines (in Melville Bay) show conceptual maximum ice extent and mid-shelf stabilization based on thin multibeam surveys (this study). Thick red lines indicate the observed (partially minimum) LGM ice extent and thick violet lines show the retreat phases thereafter. Thin red and dark red lines indicate conceptual LGM ice extent proposed by Funder et al. (2011, 2004) and Ehlers and Gibbard (2007). White dots indicate dated sites (either radiocarbon dating or cosmogenic surface exposure ages). Thick colored numbers show important ages related to LGM and YD. The white asterisk (in Melville Bay) shows the location of Core GeoB 19920-1 (Dorschel et al., 2016) with its dated age (cal kyr BP). Inset shows the general location of the research area. Black box indicates location of Fig. 2. As background, regional bathymetry and topography is taken from IBCAO (Jakobsson et al., 2012). ++ (Bennike and Björck, 2002; Kelley et al., 2013; Rinterknecht et al., 2014; Roberts et al., 2013);x and references therein; * (Dowdeswell et al., 2014; Funder et al., 2011; references therein; Hogan et al., 2016; Ó Cofaigh et al., 2013a, 2013b; Sheldon et al., 2016); ** (Dowdeswell et al., 2014; Hogan et al., 2016; Ó Cofaigh et al., 2013b); GIS = Greenland Ice Sheet; LIS = Laurentide Ice Sheet, IIS = Innuitian Ice Sheet.