Quaternary Science Reviews 147 (2016) 69–90

Contents lists available at ScienceDirect

Quaternary Science Reviews

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

Seismic architecture and evolution of the Disko Bay trough-mouth fan, central West Greenland margin

Julia C. Hofmann [a, b, *], Paul C. Knutz [a], Tove Nielsen [a], Antoon Kuijpers [a]

[a] Geological Survey of Denmark and Greenland, Øster Voldgade 10, 1350 Copenhagen K, Denmark
[b] Natural History Museum of Denmark, Øster Voldgade 5-7, 1350 Copenhagen K, Denmark

ARTICLE INFO

Article history:
Received 2 November 2015
Received in revised form
23 April 2016
Accepted 9 May 2016
Available online 27 May 2016

Keywords:
Greenland Ice Sheet
Trough-mouth fan
Ice-stream dynamics
Seismic stratigraphy
Neotectonics
Disko Bay
West Greenland
2D and 3D seismic
Glaciated continental margin
Grounding-zone wedge

ABSTRACT

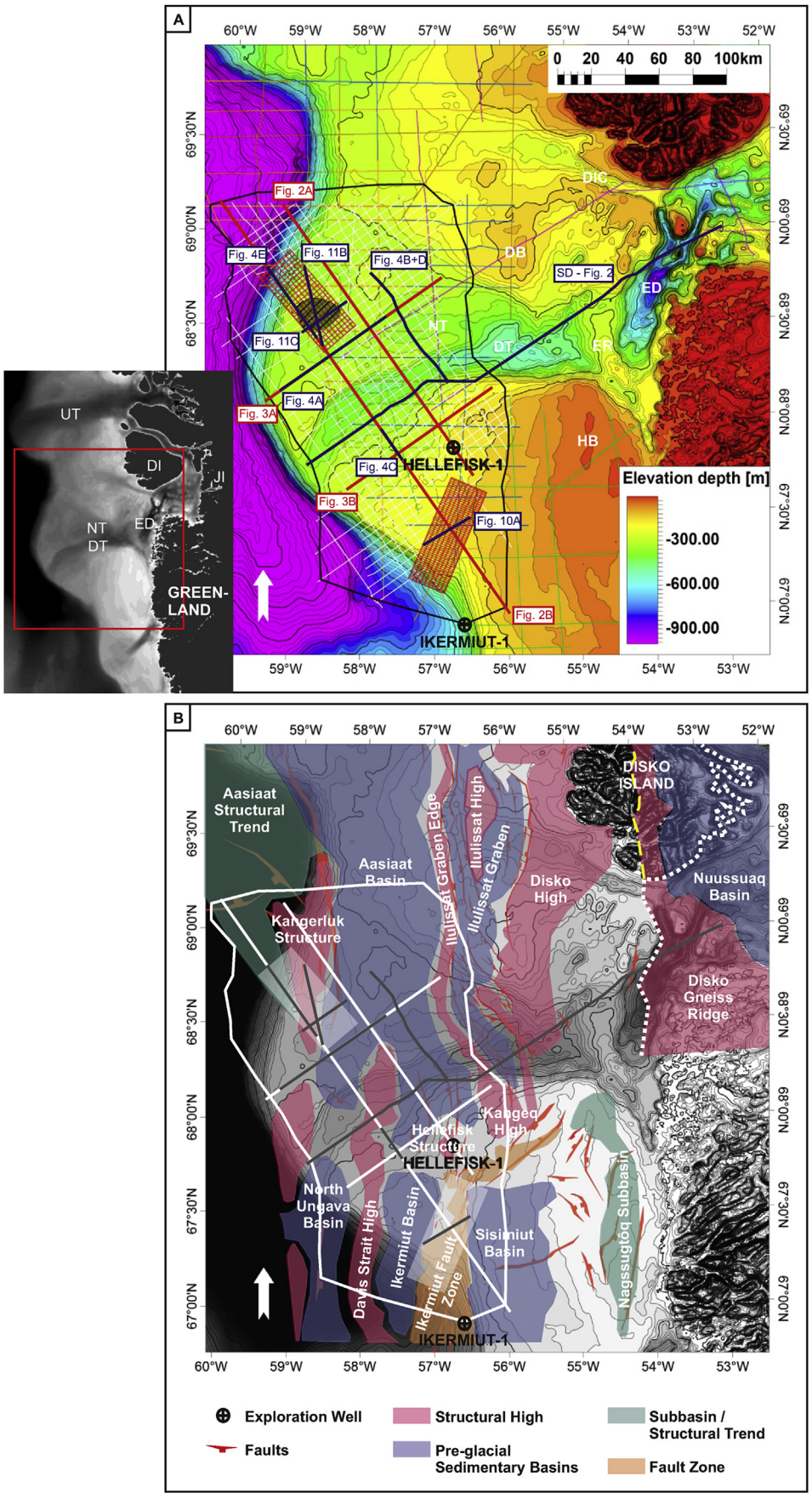
The present study is the first to document the large-scale glacigenic evolution of a West Greenland trough-mouth fan (TMF) system, i.e. the Disko Bay TMF, from onset of shelf-based glaciation to present. We have constrained the paleo-ice sheet configuration in the Disko Bay region and determine the controlling factors of ice-stream development using 2D- and 3D-seismic reflection data, seabed bathymetry and stratigraphic information from two exploration wells. This has revealed three stages of the Disko Bay TMF development. The early stage, probably of Pliocene-early Pleistocene age, marks the onset of a central depocentre located below the modern mid-shelf and constructed by sediment progradation delivered through at least two erosive pathways related to fast-flowing, grounded ice. At that time, ice-stream routing in the Disko Bay shelf region was strongly controlled by the pre-glacial topography and structural boundaries associated with fracture zones and deep-seated faults. During the middle evolutionary stage, the focus of deposition shifted from the mid-shelf to two elongate areas fringing the outer margin. The marginal depocentres were not only related to glacial processes but also alongslope deposition by contour currents, which may have developed as a consequence of basin subsidence surrounding the Davis Strait High and the Kangerluk Structure. The late stage of TMF development, presumably representing the late Pleistocene to Holocene, is characterized by the marginal depocentres becoming less significant and sediment aggradation occurring over wide parts of the mid-outer shelf, while features of subglacial erosion are generally absent. In contrast to the inferred fast-flowing ice streams of the early-middle evolutionary stages, this points to the existence of a rather thin and "lightly" grounded ice sheet, i.e. at the threshold of floatation. The "lightly" grounded ice sheet scenario, applying to the late Pleistocene interval of the Disko Bay TMF, was possibly associated with floating ice shelves during periods of maximum cooling, while intermittent and short-lived advances of grounded ice streams may have occurred during interstadial-stadial climate transitions. A controlling factor for the development of the aggradational stage may relate to the prominent basement ridge that separates the Disko Trough from the Egedesminde Dyb depression. We suggest that a neotectonic emergence of the ridge gradually restricted the flow of ice through the central Disko Trough forcing glaciers to diverge along the entire length of the ridge and find complementary drainage routes.

1. Introduction

Spatial and temporal changes of the Greenland Ice Sheet during past glaciations on the continental shelf bordering Baffin Bay remain poorly constrained. It is assumed that fast-flowing ice streams and outlet glaciers have played a key role in the mass balance and stability of polar ice sheets. In 2012 and 2013, record summer speeds (>17 km a^{-1}), more than four times greater than in the mid-1990s, were observed for Jakobshavn Isbræ (Fig. 1A), Greenland's largest outlet glacier, currently draining c. 6.5% of the ice sheet (Joughin et al., 2004, 2014). These flow rates are the fastest ever recorded for any glacier or ice stream in Greenland or Antarctica, emphasizing the high sensitivity of marine-based ice-streams to climate change and implications for future developments (Joughin et al., 2014). Despite the significance for the present dynamic state of the Greenland Ice Sheet and potential changes in global sea level, our understanding of the evolution and long-term behavior of ice streams in the Disko region, particularly during glaciations older than the LGM, is still limited (Dowdeswell

* Corresponding author. Geological Survey of Denmark and Greenland, Øster Voldgade 10, 1350 Copenhagen K, Denmark.
E-mail address: juh@geus.dk (J.C. Hofmann).

http://dx.doi.org/10.1016/j.quascirev.2016.05.019
0277-3791/


A
60°W 59°W 58°W 57°W 56°W 55°W 54°W 53°W 52°W
0 20 40 60 80 100km
69°30'N
69°00'N
68°30'N
67°30'N
67°00'N
Fig. 2A
Fig. 4E
Fig. 11B
Fig. 4B+D
Fig. 11C
Fig. 4A
Fig. 3A
Fig. 4C
Fig. 3B
Fig. 10A
Fig. 2B
SD - Fig. 2
HELLEFISK-1
IKERMIUT-1
DIC
DB
ED
NT
DT
ER
HB
Elevation depth [m]
-300.00
-600.00
-900.00
UT
DI
JI
NT
DT
ED
GREEN-
LAND
B
Aasiaat
Structural
Trend
Aasiaat
Basin
Ilulissat Graben Edge
Ilulissat High
Ilulissat Graben
DISKO
ISLAND
Disko
High
Nuussuaq
Basin
Kangerluk
Structure
Disko
Gneiss
Ridge
Kangeq
High
Hellefisk
Structure
HELLEFISK-1
North
Ungava
Basin
Davis Strait High
Ikermiut Basin
Ikermiut Fault
Zone
Sisimiut
Basin
Nagssugtóq Subbasin
IKERMIUT-1
Exploration Well
Faults
Structural High
Pre-glacial
Sedimentary Basins
Subbasin /
Structural Trend
Fault Zone