Indications of Gas-Hydrate Dissociation Caused by Sea Level Rise off Ilulissat Icefjord, Greenland

K. Schumann[1], W. Weinrebe[1,2], D. Völker[3], A. Kuijpers[3]

(1) Leibniz-Institute of Marine Sciences IFM-GEOMAR, Kiel, Germany, (2) Cluster of Excellence "The Future Ocean", University of Kiel, Germany, (3) GEUS - Geological Survey of Denmark and Greenland, Copenhagen, Denmark

C23B-0603

1. Introduction

Fig. 1. The survey area (circle) in West-Greenland

The Ilulissat Icefjord is one of the few places in West-Greenland where the ice cap reaches the sea. Furthermore, it is the fastest and most productive iceberg calving area outside Antarctica. The line at which the icebergs are broken off the ice cap has encountered a steady recession since about 150 years and seems to have reached now the same position as during the climatic optimum 4,000 – 5,000 years ago (Weidick et al., 2004). Consequently, the changes in climate exert a first order control on the recession of the ice-front and the calving of icebergs, which are transported through the Icefjord into Disko Bay with a speed of about 1 m per hour. Large icebergs accumulate over a sill off the fjord mouth where they reside several months until they are finally released through the combined effect of tides and streams, melting, and melt-water lubrication. All these processes shape the morphology of the seafloor in front of the mouth and create characteristic submarine landforms. Revealing the morphology by high-resolution bathymetric mapping helps to understand these processes.

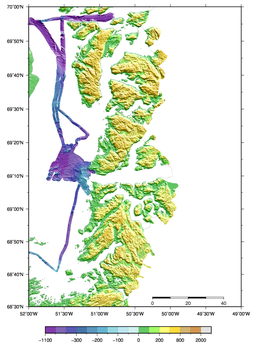

Fig. 3 Bathymetric survey at Disko Bay during cruise MSM 05/03

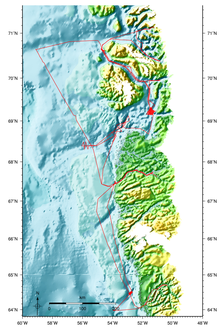

Fig. 2 Trackplot of cruise MSM 05/03

2. Field Work

During a cruise with RV Maria S. Merian (figs. 2, 4) in summer 2007 large parts of the area were mapped with Kongsberg EM120 and EM1002 multibeam systems (figs. 3, 6). This data was complemented by a survey using a portable Seabeam 1180 multibeam system temporarily mounted on the small local vessel Smilla (fig. 5) which could navigate through areas inside the icefjord inaccessible to large research vessels. A comprehensive image of the morphology of the area was achieved by compiling and merging both datasets (fig. 6).

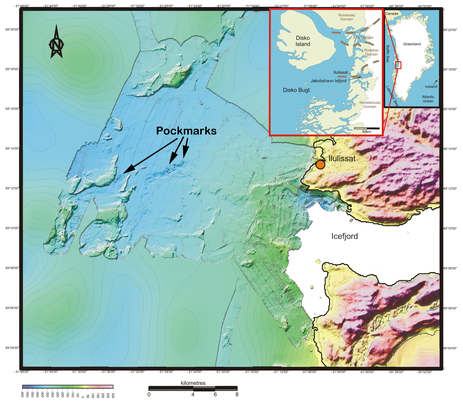

Fig. 6 Compiled bathymetric map of the area off the mouth of Ilulissat Icefjord.

Fig. 4 RV Maria S. Merian in Greenland

Fig. 5 M/V Smilla

3. Disko Bay Bathymetry

A high-resolution bathymetric map was produced based on the multibeam data of the Merian and the Smilla surveys (fig. 6). The map displays a morphology shaped by glacial geological processes. The southern part of the mouth of Ilulissat Icefjord is formed by a large sill with water depths as shallow as up to 50 m, whereas close to the northern bank depths up to 420 m are found. This explains the prevailing drift direction of calved icebergs to the north.

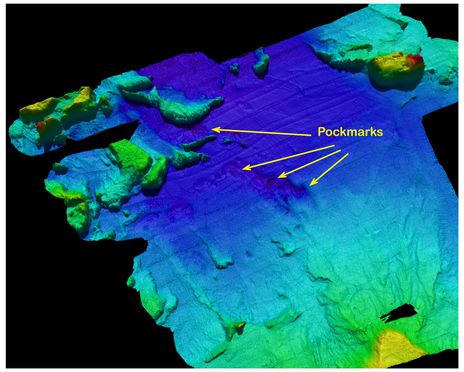

Fig. 7 Perspective view of the bathymetry off the mouth of Ilulissat Icefjord

Different morphological features such as ridges, shaped like drumlins and valleys which could be connected to channel systems, directing debris flows to a deposition centre characterize the central part of the survey area (figs. 6, 7). Here, a series of prominent circular features 80 m to 150 m in diameter and up to 30 m deep have been found and are interpreted as pockmarks (figs. 7-9).

4. Dissociation of Gas Hydrates

A parasound echosounder profile across one of the pockmarks documents the absence of the upper sedimentary unit inside the pockmark (fig. 10). This interpretation is supported by a blank zone in the central part of the pockmark, indicating uprising fluids or gas. The northeast – southwest alignment of the pockmarks points to a formation related to slides, faults, and iceberg furrows. The depth of their occurrence of around 400 m indicates a formation by dissociating gas hydrates. The most recent active pockmarks are located in the centre and the northeastern end of the depression in a depth of 395 m. The gas hydrate stability zone in arctic regions tapers out at around 400 m at 3° bottom water temperature which coincides with the values measured with a CTD during the Merian MSM05/03 cruise quite close to this position. The decreasing age from southwest to northeast could be explained by changing water temperature coupled to sea level rises. The gas hydrate stability zone would migrate upward with rising sea level. Coupled to climate warning, the upward migration of the gas hydrate stability zone would be retarded (fig. 11).

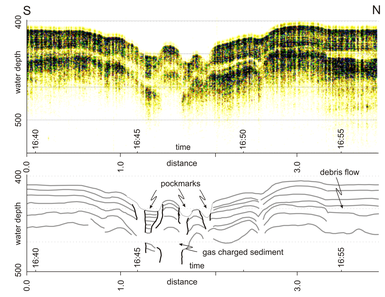

Fig. 10 Parasound profile crossing a pockmark in the central part of the survey area. The upper sedimentary unit is clearly missing in the pockmark. An acoustical blanked zone is visible in the central part beneath the pockmark. This might be the pathway for fluids.

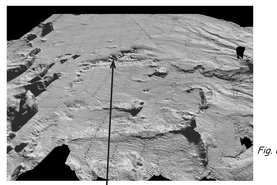

Fig. 8 Perspective view of the survey area at Disko Bay, view from south

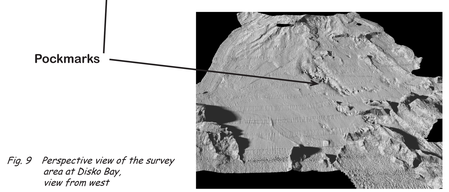

Fig. 9 Perspective view of the survey area at Disko Bay, view from west

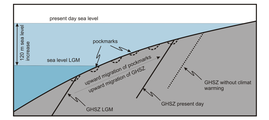

Fig. 11 Upward migration of the gas hydrate stability zone (GHSZ) due to sea level rise after the last glacial maximum (LGM), retarded by climate change. Pockmarks do also migrate upward, coupled to the migration of the GHSZ.

Acknowledgements

The cruise MSM05/3 with R/V Maria S. Merian was funded by the German Research Foundation (DFG). Thanks are given to the ship's master, Captain Friedhelm von Staa and his crew, who provided an excellent working environment. Shiptime on M/V Smilla was provided by Greenland Tours Elke Meissner, Ilulissat, which is gratefully acknowledged. Particular thanks are given to Captain Dieter Zillmann and his crew for a highly professional survey in this extremely difficult waterway.

The work at Ilulissat Icefjord is part of the project "Iceflow activity revealed from submarine morphology" which is funded by the German Research Foundation (DFG) through the Cluster of Excellence "The Future Ocean" at Kiel University.

References:

Weidick, A., Mikkelsen, N., Meyer, C., and Podlech, S., Jacobshavn Isbræ, West Greenland: the 2002-2003 collapse and nomination for the UNESCO World Heritage List, Geol. Survey of Denmark and Greenland Bull. 4, 85-88, 2004

more Information:

wweinrebe@ifm-geomar.de

http://www.ifm-geomar.de/index.php?id=iceflowactivity