AGU FALL MEETING

C31E-0563

High-Resolution Bathymetry of Disko Bay and Ilulissat Icefjord, West-Greenland

W. Weinrebe(1,2), A. Kuijpers(3), I. Klaucke(1), M. Fink(1), J. B. Jensen(3), N. Mikkelsen(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

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Introduction

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

Sermeq Kujalleq is one of the few glaciers through which the Greenland ice cap (fig. 1) reaches the sea. With a speed of nearly 1 m per hour it is one of the fastest and most prolific ice-calving tide-water glacier in Greenland and one of the most active glaciers in the world. The annual calving of over 35 km^3, which is more than any other glacier outside Antarctica, equals to 10% of the production of Greenland calf ice. A continuous procession of calved icebergs floats into Disko Bay through Ilulissat Icefjord, a 60 km long and 3-6 km wide tide-water ice-stream (fig. 2, 3).

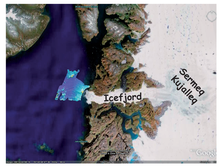

Fig. 2 Inner part of Disko Bay with Sermeq Kujalleq, Ilulissat Icefjord and the survey area

The unique and impressive area is a UNESCO World Heritage Site since 2004. The large calving production and the high velocity imply a rapid response to climate changes. Thus this site is a key area for the understanding of West Greenland Holocene climate history.

Fig. 3 Aerial view of Ilulissat Icefjord

Background

The geology and glaciology of the area was extensively studied for over 250 years. Numerous observations document an advance of the ice-front up to 1851. Since then a constant recession of the glacier front was observed with accelerated speed in recent years (fig. 4). Now the glacier front seems to have reached the same position as during the climatic optimum 4,000 – 5,000 years ago. Consequently, the recession of the glacier front exerts a first-order control on the floating of the icebergs off the front of the ice-stream at the mouth of Ilulissat Icefjord. 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 (fig. 14). Revealing the morphology helps to understand these processes. However, in contrast to the well studied surface geology of the area, the bathymetry is incomplete.

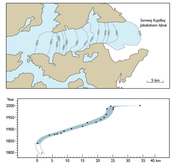

Fig. 4 Recession of Sermeq Kujalleq from 1850 till now (Weidick et al., 2004)

Field Work

Fig. 5 R/V Maria S. Merian in Greenland

Fig. 6 R/V Maria S. Merian in Greenland

Fig. 7 R/V Maria S. Merian in Greenland

Marine surveys in arctic environments are expensive and difficult to perform. This explains the lack of detailed bathymetric data for the Disko Bay area. A first survey was done during the cruise MSM05/3 with R/V Maria S. Merian in June 2007. A large area adjacent to the mouth of Ilulissat Icefjord was mapped (fig. 15). Two multibeam systems were used during this survey, a shallow water Kongsberg EM1002 and a deep water EM120. Water depths in Disko Bay are less than about 500 m, so the EM1002 performed better, however the transducer of the EM120 are flush mounted in the hull and protected by an "ice window", therefore the EM120 had to be used on all profiles close to the icefront. The results (fig. 15) display the extensive shaping of the submarine morphology by glacial processes. Unfortunately, areas close to the icefront and inside the fjord were unaccessible to this large vessel.

Fig. 9 M/V Smilla in the port of Ilulissat, Greenland

Fig. 10 Surveying Ilulissat Icefjord with M/V Smilla

Fig. 11 Surveying Ilulissat Icefjord with M/V Smilla

Fig. 12 Surveying Ilulissat Icefjord with M/V Smilla

Fig. 13 Surveying Ilulissat Icefjord with M/V Smilla

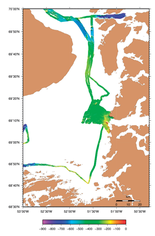

Fig. 8 Bathymetric survey in the Disko Bay area

In order to extend the survey as far as possible inside the fjord, a second field survey was done in August 2008 using a small vessel and a portable multibeam system. In a successful cooperation with the tour operator Greenland Tours Elke Meissner in Ilulissat we mounted a portable Seabeam 1180 multibeam system onboard the 12-m-long M/V Smilla. With this vessel it was possible to detour floating icebergs and reach areas deep inside the fjord.

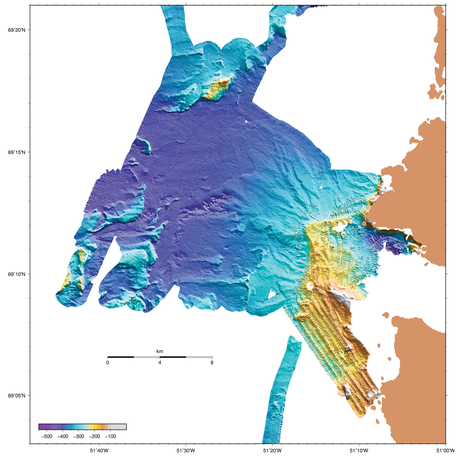

Fig. 14 Digital terrain model based on multibeam bathymetry data from R/V Maria S. Merian and M/V Smilla. The processing of the Smilla data is still preliminary and shows some artefacts

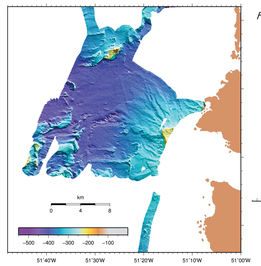

Fig. 15 Digital terrain model based on multibeam bathymetry data from R/V Maria S. Merian survey 2007

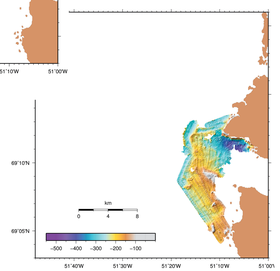

Fig. 16 Digital terrain model based on multibeam bathymetry data from M/V Smilla survey 2008

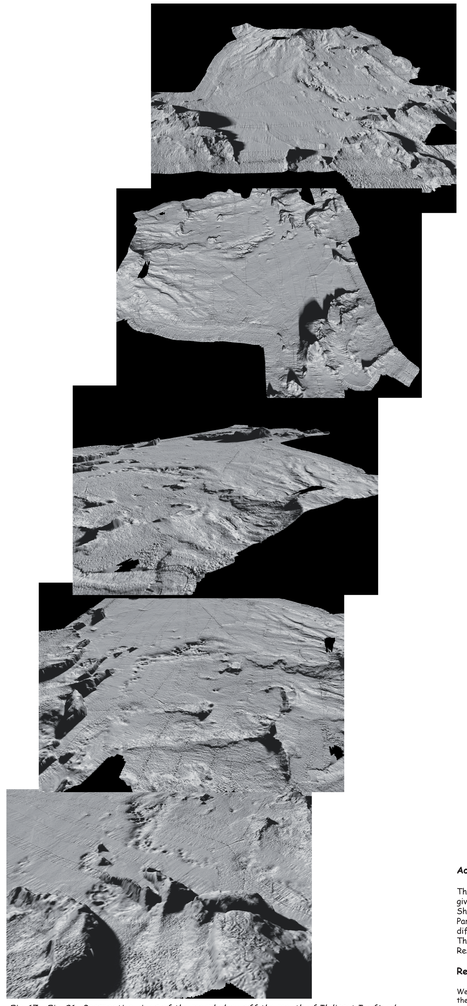

Fig. 17 - Fig. 21 Perspective views of the morphology off the mouth of Ilulissat Icefjord, view from West, North, Southeast, South, Southwest (top to bottom)

Morphology of the Ilulissat Icefjord Area

The area off the mouth of Ilulissat Icefjord is dominated by a large basin with a diameter of at least 15 km. The rims of the basin to the South, West, and North have only partly been mapped. Generally the basin shows a smooth surface gently dipping westward from a water depth of about 100 m in the vicinity of the ice front to about 450 m at the western rim of the surveyed area. The western rim of the basin is marked by a series of elongated ridges or highs, partly crescent-shaped. These ridges have lengths of 2 km to 5 km, widths of about 1 km and heights of 50 m and more. The sides facing the ice front are generally very steep whereas the far sides are dipping gently. The ridges probably act as a kind of a backstop for larger, deep-reaching icebergs. This is documented by abundant iceberg plow marks on top of some of the ridges, particularly on the hill at 69°10.8'N, 51°35.8'W in a water depth of 260 m which is intensively scoured by drifting icebergs. The plow marks do not show a distinct pattern indicating probable changes of the prevailing drift directions in history. More plow marks are found close to the ice front. Generally the surveyed area is divided into two parts. The southern part is characterized by fluvioglacial denudation and deposition processes displayed in some elongated depressions and steep holes about 20 m deep and 120 m in diameter (kettle holes?). The northern part shows slightly less water depths and is shaped by the drift of icebergs which have been detached from the ice front of Ilulissat Icefjord. Elongated ridges and grooves stretching in northwest direction clearly document the prevailing drift direction. This is also demonstrated in the satellite image shown in fig. 2. Large ice blocks and icebergs which can be identified at the surface of the ice stream close to its mouth seem to follow this direction.

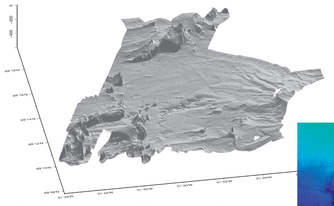

Fig. 22 Perspective view of the morphology off Ilulissat Icefjord, view from South

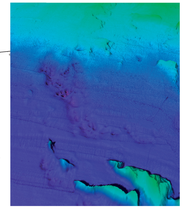

Fig. 23 Perspective view of elongated depressions and small holes in the center of the survey area

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.
This work 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.

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Weidick, A., Mikkelsen, N., Mayer, 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