Multibeam Bathymetry Surveys in Fjords and Coastal Areas of West-Greenland

OS21A-1152

W. Weinrebe[1,2], A. Kuijpers[3], I. Klaucke[1], M. Fink[1]

IFM-GEOMAR

(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

1. Multibeam Bathymetry Surveys in West-Greenland

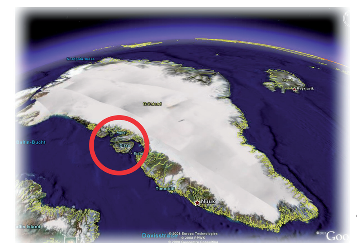

Fig. 1.1 The survey area (circle) in West-Greenland

High-resolution bathymetric maps are not available for many of the sparsely populated fjords in Greenland as those areas are remote and difficult to navigate. During a recent cruise (MSM 05/03, 2007) of RV Maria S. Merian large coastal areas of West-Greenland including some of these fjords were mapped in detail with multibeam bathymetry, among them many parts which never had been investigated before. The data acquired by a Kongsberg EM120 deep water and a EM1002 shallow water multibeam system were of very good quality. Four of the newly mapped areas showing interesting features are presented in this poster (c.f. 2 – 4).

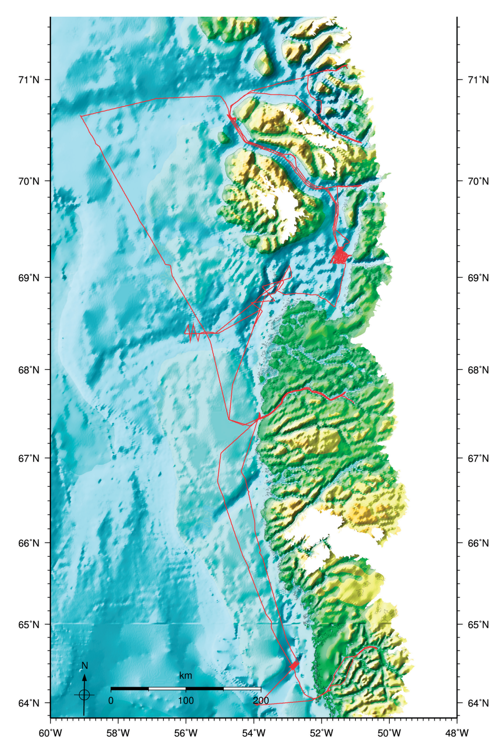

Fig. 1.2 Trackplot of cruise MSM 05/03

In order to extend the survey as far as possible inside the Ilulissat Icefjord, 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 MV Smilla (fig. 14). With this vessel it was possible to detour floating icebergs and reach areas deep inside the fjord (figs. 12 - 17). The seafloor in these areas is intensively shaped by glacial processes which create characteristic submarine landforms. Revealing the morphology helps to understand these processes, high-resolution bathymetry displays the relief and morphology of the seafloor.

2. Davis Strait: Abundant Iceberg Plow Marks

The multibeam system was operated continuously throughout the entire survey. Whereas the mapping along the transits off the coast in the Davis Strait do not really contribute to a comprehensive bathymetric map, they nicely document differences in iceberg drifting history along a transect as large parts of the seafloor are sculptured by iceberg plow marks (figs. 2.1 - 2.10). Several distinct patterns of directions can be identified which probably represent different phases of drift. Relative age determinations can be derived from the images based on interruptions and mutual distortions of these furrows. Furthermore, newer plow marks are characterized by steeper rims and a sharper morphology. Generally, these newer features are found in water depths of about 200 m, whereas broader and deeper plow marks can be traced even in water depths of 500 m, indicating the existence of giant icebergs in the past. Some of the newest most undisturbed tracks are quite straight which might indicate that they originate from bottom trawling and not from icebergs.

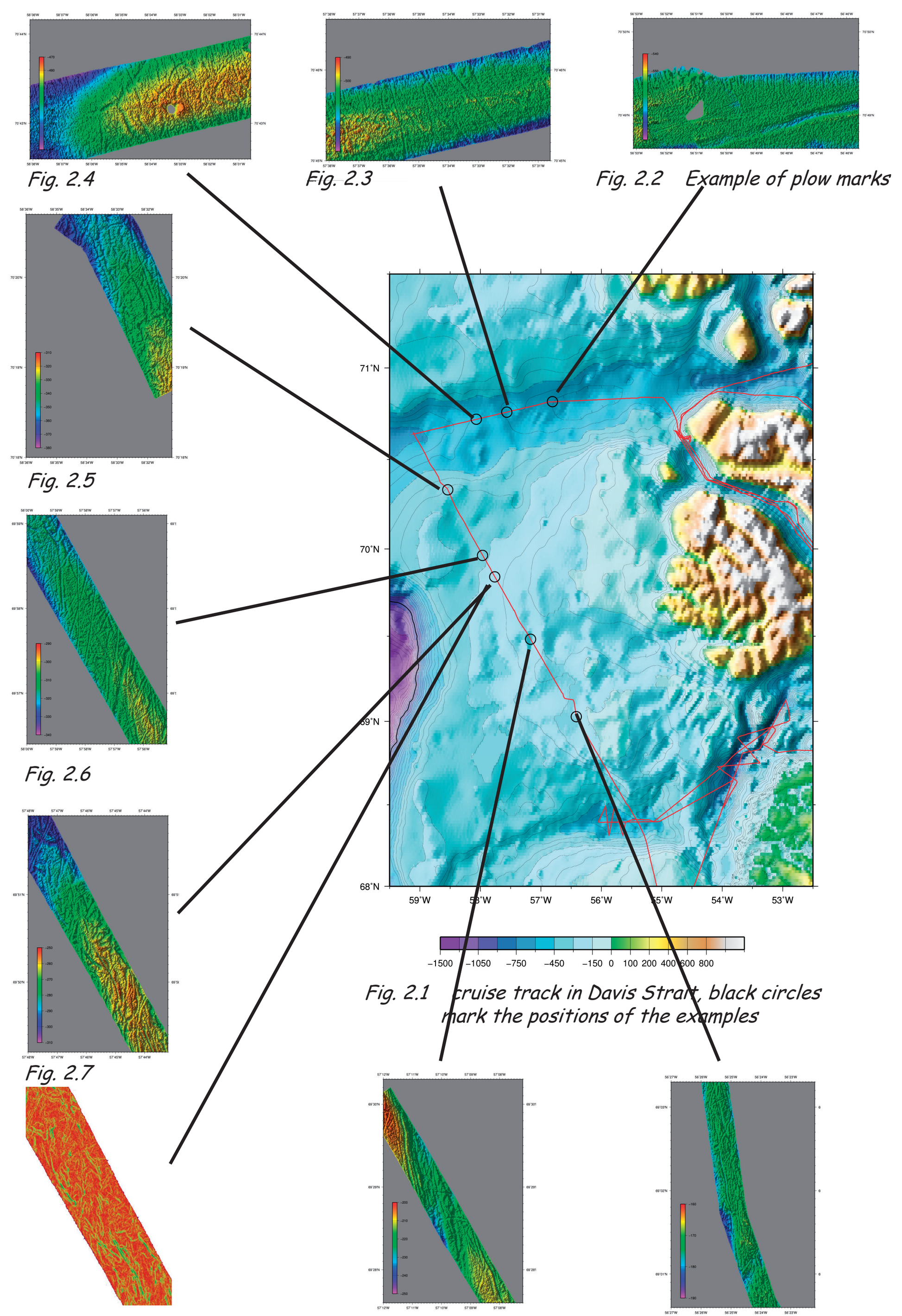

Fig. 2.4 Fig. 2.3 Fig. 2.2 Example of plow marks

Fig. 2.5

Fig. 2.6

Fig. 2.7

Fig. 2.1 Cruise track in Davis Strait, black circles mark the positions of the examples

Fig. 2.8 Slope map of fig. 2.7 Fig. 2.9 Fig. 2.10

3. Vaigat: Landslides and Tsunamis

The narrow passage between Disko Island and Nuussuaq Peninsula is named Vaigat. During the cruise MSM-05/03 RV Maria S. Merian passed this waterway three times, thus the central part of the passage could be mapped by the multibeam system. Vaigat acts as the northern outflow of Disko Bay, most of the icebergs spawned through Ilulissat Icefjord pass Vaigat on their way to Davis Strait.

The mountains on both sides are quite steep and high (up to 2,000 m) and are built up of dense basaltic rocks overlying poorly consolidated sedimentary rocks, hence landslides in this area are common. On November 21, 2000 a landslide comprising 90 million m^3 (about 260 million tons) occurred at the northern coast of Vaigat (red star in fig. 3.1, Dahl-Jensen et al., 2004). About one third of the slide mass entered the sea and generated a tsunami with a run-up height of 50 m in the vicinity of the slide and about 28 m on the opposite coast. In the village of Saqqaq about 40 km east several boats were destroyed. Unfortunately the seafloor in this area was only partially surveyed, however the debris fan is well displayed in the bathymetry (figs. 3.3 and 3.4). In addition, more debris fans can be traced in the new high-resolution bathymetry (figs. 3.2, 3.5 - 3.7), documenting that more tsunamis had occurred in this area in the past.

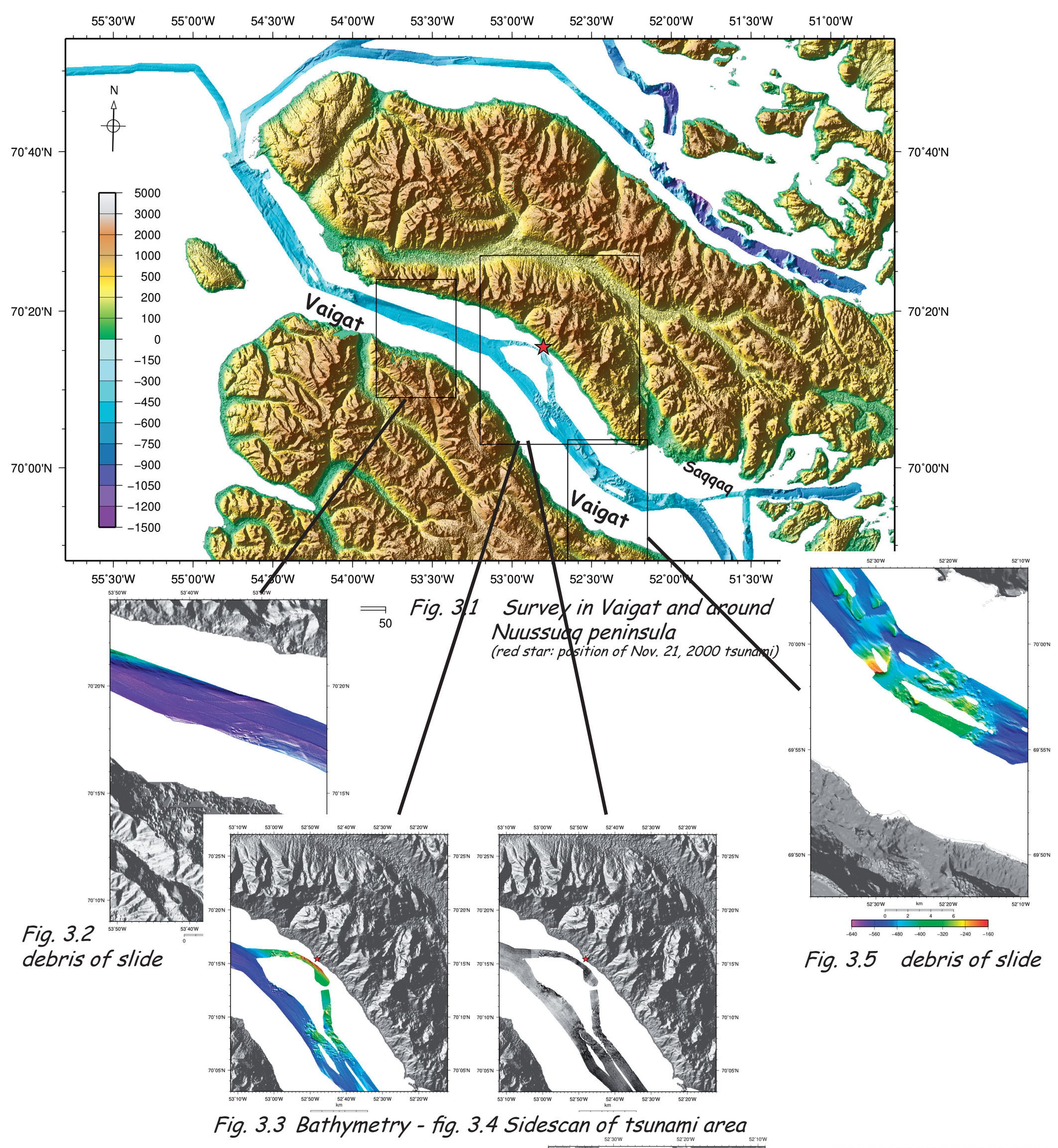

Fig. 3.1 Survey in Vaigat and around Nuussuaq peninsula (red star: position of Nov. 21, 2000 tsunami)

Fig. 3.2 debris of slide

Fig. 3.5 debris of slide

Fig. 3.3 Bathymetry - fig. 3.4 Sidescan of tsunami area

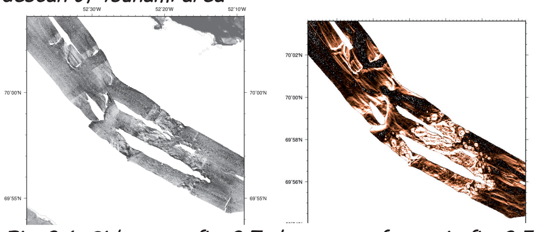

Fig. 3.6 Sidescan - fig. 3.7 slope map of area in fig. 3.5

4. Ilulissat Icefjord: Survey between Icebergs

Sermeq Kujalleq is one of the few glaciers through which the Greenland ice cap reaches the sea (fig. 4.1). With a speed of nearly 1 m per hour it is one of the fastest tide-water glacier in Greenland and one of the most active glaciers in the world, producing more icebergs than any other glacier outside Antarctica. Continuously calved icebergs float into Disko Bay through Ilulissat Icefjord, a 50 km long and 3-6 km wide tide-water ice-stream (fig. 4.1). The unique and impressive area is a UNESCO World Heritage Site since 2004 (Weidick et al., 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.

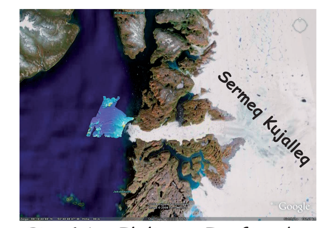

Fig. 4.1 Ilulissat Icefjord

The area off the mouth of Ilulissat Icefjord is dominated by a large basin with a diameter of at least 15 km (figs. 4.2 - 4.4). Generally the basin shows a smooth surface gently dipping westward from a water depth of about 250 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. 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.

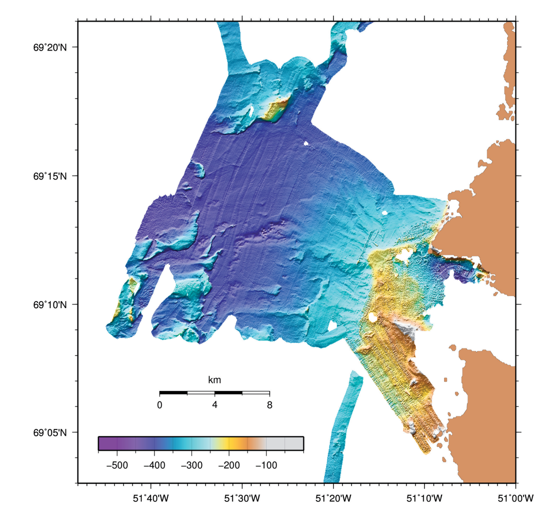

Fig. 4.2 Bathymetric survey in Disko Bay area

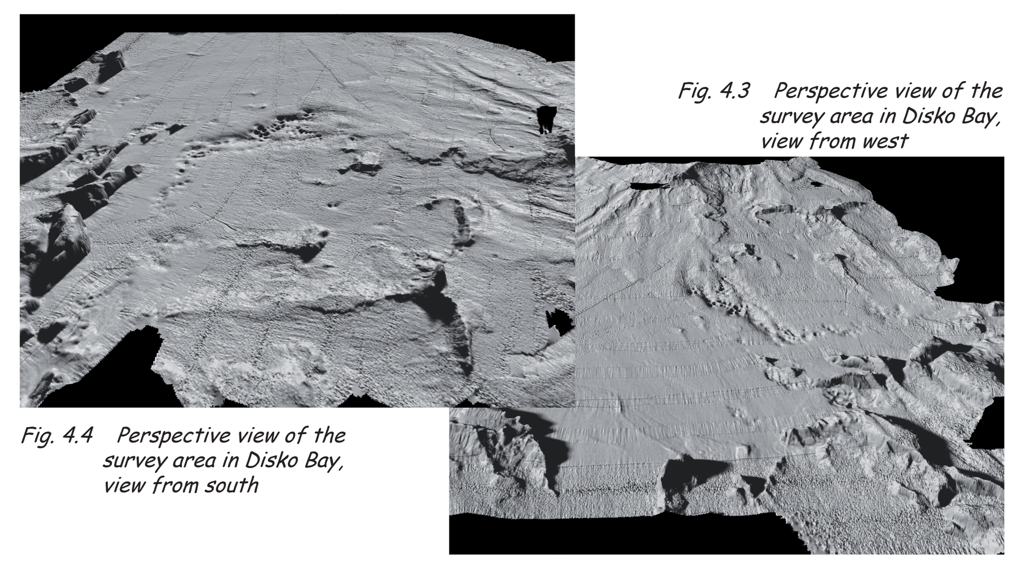

Fig. 4.3 Perspective view of the survey area in Disko Bay, view from west

Fig. 4.4 Perspective view of the survey area in Disko Bay, view from south

5. Marmorilik: Mine Spoils at the Seafloor

Qaamarurujuk Fjord about 500 km north of the arctic circle was the northernmost area surveyed during the cruise MSM05/03. Maarmorilik on the southern shore of this fjord was a place of strong mining activity in the years 1973 to 1990. The Black Angel Mine, named after a picturesque pelite outcrop in the form of a dark angel (fig. 20), was operated by the Canadian company Greenex A/S. In total about 11 million tons of lead-zinc ore were mined and processed at Maarmorilik. The mined ore was grinded by rod- and ball-mills and then recovered by conventional selective flotation. During the years of mining activity a total amount of about 8 million tons of tailings were discharged into the Affarlikassaa fjord, a 4 km long branch of Qaamarujuk fjord south of Maarmorilik.

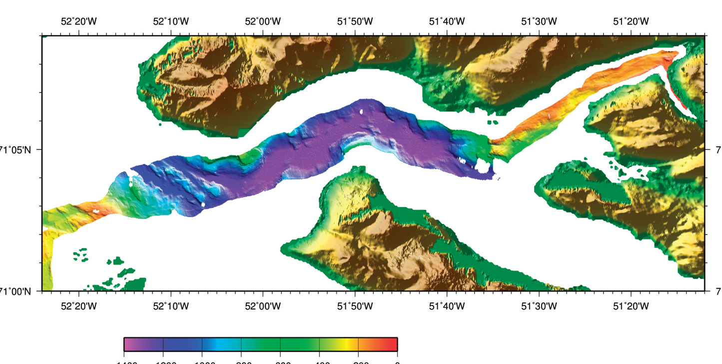

Fig. 5.1 Bathymetric survey in the Maarmorilik area

Both fjords were nearly completely mapped during the cruise, using the shallow water multibeam EM1002 in the Affarlikassaa fjord and the deep-water multibeam in the Qaamarujuk fjord (figs. 5.1 - 5.4). The entrance to Affarlikassaa is formed by a sill with a minimum water depth of just 23m whereas the maximum depth in the fjord is about 75 m. Due to favourable weather conditions and the slow speed of the vessel during the survey the data quality was extremely good and allowed to calculate a digital terrain model of the data with a grid spacing of just 2 m by 2 m (fig. 5.3). Clearly a debris fan just opposite the processing area of the mine (fig. 18) can be seen in the terrain model documenting the deposition of mine tailings into the fjord. A slope map (maximum gradient) of the digital terrain model is shown in fig. 5.4 displaying the anthropogenic impact on the fjord environment even more clearly.

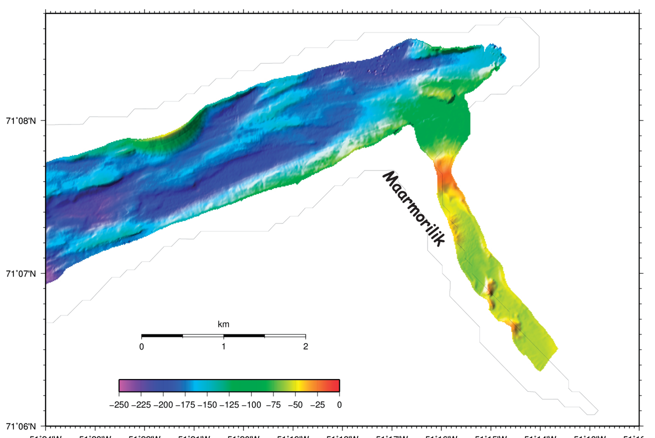

Fig. 5.2 Bathymetry of Qaamarujuk and Affarlikassaa fjord

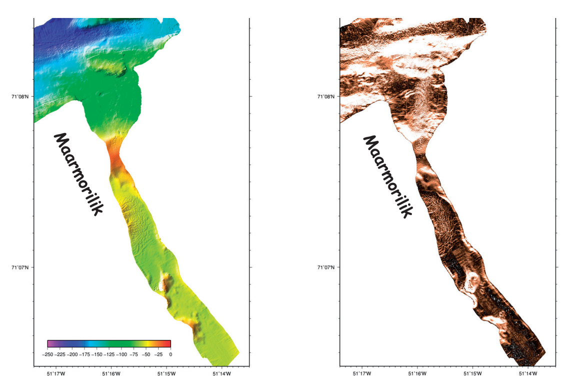

Fig. 5.3 Bathymetry - fig. 5.4 slope map of Affarlikassaa fjord

Fig. 6 Maria S. Merian in Greenland

Fig. 7 Nuussaq (northside)

Fig. 8 Vaigat



Fig. 9 - 11 Maria S. Merian in Greenland


Fig. 12, fig. 13 Survey inside the Icefjord

Fig. 14 M/V Smilla



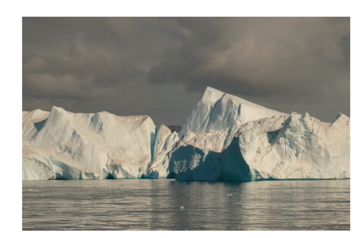

Fig. 15 - 17 Survey inside the Icefjord

Fig. 18 Maarmorilik

Fig. 19 inside Affarlikassaa

Fig. 20 "Black Angel Mine"

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.

Topography data in figs. 3.1 - 3.5 and 5.1 from ASTER-GDEM (www.gdem.aster.ersdac.or.jp)

References:

Weidick, A., Mikkelsen, N., Mayer, C., and Podlech, S., Jacobshavn Isbrae, 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

Trine Dahl-Jensen, Lotte Melchior Larsen, Stig A. Schack Pedersen, Jerrik Pedersen, Hans F. Jepsen, Gunver Pedersen, Tove Nielsen, Asger Ken Pedersen, Frants von Platen-Hallermund and Willy Weng, Landslide and Tsunami 21 November 2000 in Paatuut, West Greenland, Natural Hazards, 31, 277-287, 2004

more Information:

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