"Poseidon" Cruise No. 243
Reykjavik - Greenland - Reykjavik
24 August - 11 September 1998

Climate change and the Viking-age fjord environment of the Eastern Settlement, sw Greenland

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Gerd Hoffmann, Antoon Kuijpers, Jörn Thiede, and the Shipboard Scientific Party

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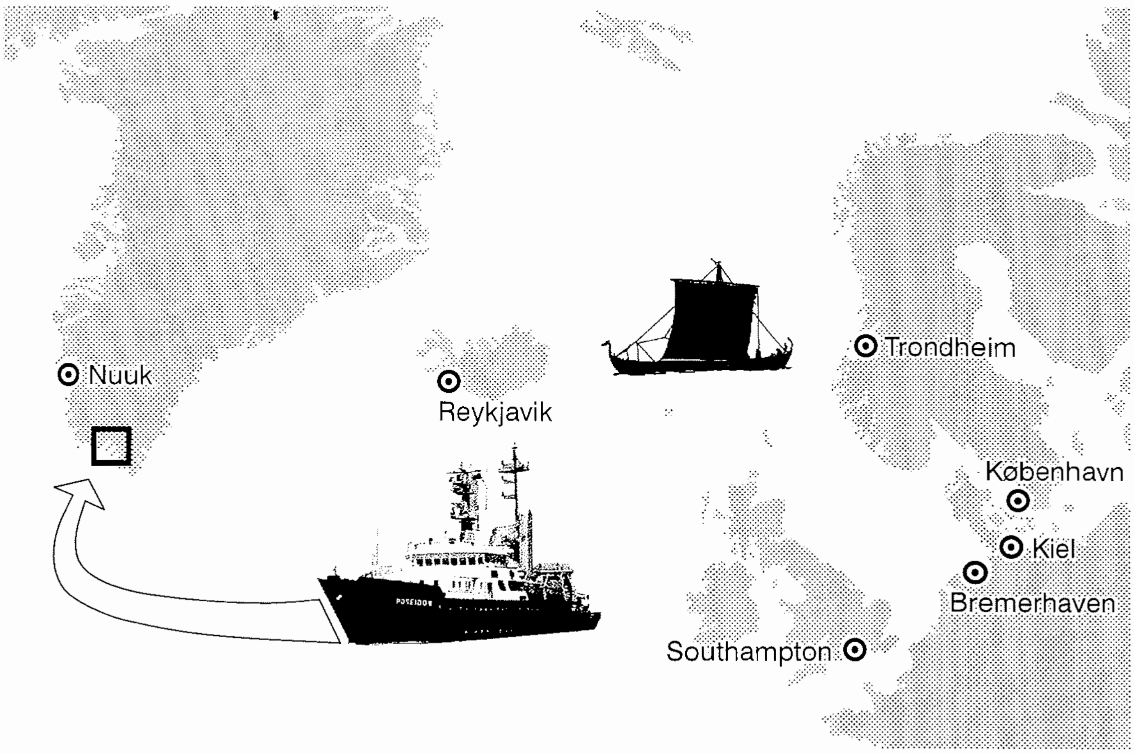

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Poseidon cruise
No. 243

POSEIDON CRUISE 243 - CRUISE REPORT

G. Hoffmann, A. Kuijpers, J. Thiede, and the Shipboard Scientific Party

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Summary

During RV Poseidon cruise 243 an international team of marine geologists and archeologists has investigated southwest Greenland inshore waters of the former Viking-age "Eastern Settlement". Main target areas were Tunugdliarfik and Igaliku fjord. These fjords were investigated using Poseidon´s 18 kHz hull-mounted sediment echosounder, a CHIRP high-resolution (2-10 kHz) towed subbottom profiler system, a deep-tow EG&G 59 kHz side scan sonar, a 100 kHz Klein side scan sonar, and a Remote Operated Vehicle (ROV) underwater video system. Furthermore, a hull-mounted ELAC multibeam system specially installed for this cruise was used. For sediment sampling, a Reineck box corer and a 6-m gravity corer were deployed. Immediately prior to the cruise, the Royal Danish Administration for Navigation and Hydrography had made bathymetric charts for the study areas. Subbottom profiler data, side scan sonar information and the sedimentary sequences retrieved by coring correspondingly indicate that downslope sediment transport processes are a characteristic feature in both fjords investigated. A well-defined multi-lobe debris flow complex was found in Tunugdliarfik fjord. Ice berg plow marks are widespread in this fjord at water depths of less than approx. 100 m. The seabed of Igaliku Fjord is generally much less disturbed by iceberg reworking. The CHIRP records indicate that undisturbed, acoustically laminated, sediments found in some of the deeper parts of the fjords have a thickness of at least 30 m.

The sonographs obtained revealed a variety of seabed features, of which only a few could be tentatively interpreted as to possibly represent human artifacts. As far as possible, some of the latter targets were investigated by ROV.The man-made origin of these targets could, however, not be further verified. Additional ROV seabed records from various bathymetric settings of Igaliku Fjord showed major elements of the benthic flora and fauna of this fjord. The 100 kHz side scan sonar records from shallow coastal waters (close to Brattahlid and Gardar) indicate the presence of a former coast line at water depths of 2-4 m below present mean sea level.

Zusammenfassung

Während der Forschungsreise Nr. 243 mit FS "Poseidon" untersuchte ein Team mariner Geowissenschaftler und Archäologen das wasserseitige Umfeld der wikingerzeitlichen "Ostsiedlung". Die zentralen Untersuchungsgebiete befinden sich im Tunugdliarfik Fjord und Igaliku Fjord. Zur geophysikalischen Untersuchung der beiden Fjorde wurde ein schiffsseitig montiertes 18 kHz-Sedimentecholot, ein geschlepptes hochauflösendes 2-10 kHz Chirp-Profiler-System , ein tiefgeschlepptes 59 kHz- und ein flachgeschlepptes 100 kHz-Seitensichtsonar sowie ein unbemanntes Tauchgerät (ROV) eingesetzt. Die geologische Probennahme erfolgte mit einem Reineck Kastengreifer und einem 6m-Schwerelot. Direkt vor der Ausfahrt hatte die "Royal Danish Administration for Navigation and Hydrography" das Untersuchungsgebiet vermessen. Diese Daten wurden ab der 10-m-Isobathe durch weitere von FS "Poseidon" mit einem Fächerlot aufgenommene Vermessungsdaten ergänzt. Aufnahmen vom Seitensichtsonar, von den profilierenden geophysikalischen Systemen und aus den Bohrkernen zeigen zahlreiche Schuttströme in beiden Fjorden. Ein charakteristisch ausgebildeter mehrlobiger Schuttstrom wurde im Tunugdliarfik Fjord entdeckt. Eisberg-pflugmarken sind häufig zu beobachten im Tiefenbereich bis 100 m. Der Meeresboden im Igaliku-Fjord ist generell deutlich weniger gestört durch Eisbergaktivität. Die CHIRP-Untersuchungen belegen, daß ungestörte, geschichtete Sedimente in tieferen Fjordbereichen Mächtigkeiten von mindestens 30 m aufweisen. Die Sonaraufnahmen zeigen unterschiedliche Muster am Meeresboden, von denen einige als Artefakte interpretiert werden können. Auch die Untersuchung mit dem unbemannten Tauchgerät (ROV) konnte diese als Artefakte nicht eindeutig zu identifizieren. Die ROV-Aufnahmen zeigen zudem die benthische Flora und Fauna, vorwiegend aus dem Igaliku-Fjord.

Resumé
På R V "POSEIDON"s sejlads 243 har en international gruppe af maringeologer og -arkäologer undersögt sydvestgrönlands fjorde i det tidligere nordboområde, "Österbygden". Hovedmålsområdet var Tunugdliarfik og Igaliku fjordene. Disse fjorde blev undersögt ved hjälp af POSEIDON's 18 kHz skrogmonterede sediment ekkolod, et CHIRP towed sub-bottom profiler system med höj oplösning (1-10 kHz), en deep-towed EG&G 59 kHz side-scan sonar, en 100 kHz Klein side-scan sonar og et Remote Operated Vehicle (ROV) undervandsvideo system. Yderligere blev der benyttet et skrogmonteret ELAC multibeam system (50 kHz), der var installeret specielt for denne sejlads. Til sediment prövetagning bleb benyttet en Reineck box corer og en 6 m gravity corer. Lige inden sejladsen havde Farvandsväsenet lavet bathymetriske kort for undersögelsesområderne.
Ved at sammenholde sub-bottom profiler data, side-scan sonar information og sedimentsekvenser opnået med corings indikeres, at downslope sediment transport processer er karakteriske fänomener i begge de undersögte fjorde. Et godt defineret multi-lobe debris flow kompleks blev fundet i Tunugdliarfik fjorden. Plov furer fra isbjerge er spredt vidt omkring i denne fjord på vanddybder mindre en ca. 100 m. Igaliku fjordens havbund er generelt meget mindre forstyret af isbjerge.CHIRP udskrifter indikerer at uforstyrede,akustisk laminerede sedimenter, der fandtes i nogle af de dybere dele af fjordene, har en tykkelse på mindst 30 m. De optagede sonografiske billeder afdäkkede en forskelligartethed af fänomener på havbunden, hvoraf kun få kunne göres til genstand for en tänkt tolkning, der pegede på en repräsentation af menneskelig fremstilling. Så langt det var muligt, blev nogle af disse sidste mål undersögt med ROV. Disse mål kunne dog ikke blive verificeret som kommende fra menneskelig fremstilling. Hertil viste ROV havbundsoptagelser fra forskellige dybder i Igaliku fjorden vigtige elementer af undervandsflora og –fauna i denne fjord. 100 kHz side-scan sonar optagelser fra kystnäre områder på grundt vand indikerer tilstedevärelse af en tidligere kystlinie på 2-4 m dybde under den nuvärende gennemsnitlige vandstand.

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SAMMENDRAG

På tokt 243 med forskningsfartøyet Poseidon undersøkte et internasjonalt team av marin geologer og arkeologer fjordområder i sørvest Grønland. Disse områdene er kjent som "østerbygd" i perioden for norrøn bosetning på Grønland. Hovedområdene var Eiriksfjord og Einarsfjord. Havbunnen i disse fjordområdene ble undersøkt med Poseidons 18kHz skrog-monterte sediment ekkolodd, et CHIRP høyoppløselig (2-10kHz) tauet, bunnpenetrerende system, en EG&G 59kHz sidesøkende sonar (på dypt vann), et Klein (100kHz) sidesøkende sonar system (på grunt vann) og en fjernstyrt undervannsfarkost (ROV). I tillegg ble et skrog-montert ELAC multistråle system for batymetri installert særskilt for dette toktet. En Reineck bokscorer og en 6 m gravitasjons corer ble benyttet for sediment innsamling. Rett før toktet hadde det danske Farvandsvæsenet laget batymetriske kart for fjordområdene. Data samlet inn med bunnpenetrerende utstyr, sidesøkende sonar og kjerneprøvene indikerer at sterk sedimentering er en viktig karakteristikk i begge fjorder. Et veldefinert sediment basseng ble funnet i Eiriksfjord. Skrapemerker fra isfjell er vanlig i denne fjorden ned til ca 100 m dybde. Sjøbunnen i Einarsfjorden er vanligvis mye mindre påvirket av isfjell. CHIRP undersøkelsene påviste at sedimentlagene i de dype delene av fjordene kan ha en tykkelse på minst 30 m. Sonogrammene viste flere karakteristiske trekk ved sjøbunnen, men bare noen få anomalier som kunne være kulturminner ble påvist. Disse ble undersøkt med ROV, men alle anomaliene viste seg å ha en naturlig forklaring. I tillegg ble sjøbunnen i Einarsfjord undersøkt med ROV for å dokumentere hovedelementene av flora og fauna i fjorden. Undersøkelsen med 100kHz Klein sidesøkende sonar på grunt vann tyder på at det finnes en tidligere vannlinje på et nivå som ligger 2-4 m under dagens nivå.

Samantekt

Í leiðangri RV Poseidon 243 rannsakaði alþjóðlegur hópur hafsbotnsjarðfræðinga og fornleifafræðinga hafsbotn fjarðanna utan við hina fornu víkingabyggð, Eystribyggð, á SV Grænlandi. Aðalrannsóknarsvæðið var í Tunugdliarfik og Igaliku firði. Við rannsóknina var notaður dýptarmælir (18kHz) rannsóknarskipsins Poseidon, CHIRP endurvarpsútbúnaður (2-10 kHz) sem dreginn var við hlið skipsins og rannsakaði þykkt og gerð setsins á hafsbotninum með hárri upplausn, EG&G 59 kHz botnsjá (dregin við hafsbotn), Klein 100 kHz botnsjá og fjarstýrð neðansjávarmyndavél (ROV). Einnig var notast við ELAC fjölgeislamæli sem var komið fyrir neðan á skipinu í leiðangrinum. Setkjörnum úr fjörðunum var loks safnað með Reineck yfirborðskjarnataka og 6 m löngum fallborskjarna.

Í leiðangrinum var stuðst við ítarleg dýptarkort sem Royal Danish Administration for Navigation and Hydrography hafði búið til skömmu fyrir leiðangurinn.

Gögn frá CHIRP og botnsjám, auk setásýnda sem sáust í setkjörnum sem safnað var, sýna að neðansjávar eðjuflóð eru ráðandi ferli í báðum fjörðum. M.a. voru kortlögð vel afmörkuð aurflóð í Tunugdliarfik firði. För eftir borgarísjaka eru mjög algeng á hafsbotninum ofan við 100 m dýpi í þessum firði, en svipuð för eru mun færri í Igaliku firði. CHIRP gögnin sýna að þar sem firðirnir eru dýpstir má finna ótruflað, lagskipt set sem er allt að 30 m þykkt.

Með gögnum frá botnsjám var hægt að kortleggja kennileiti á hafsbotni. Þar sem því var við komið var fjarstýrð neðansjávarmyndavél (ROV) send til að rannsaka slík ummerki, en engin ummerkjanna sem voru skoðuð með ROV reyndust vera hugsanlegar mannvistarleifar. Aðrar ROV myndir frá fjölmörgum dýptum í Igaliku firði sýna aðalásýndir hafsbotnsfánu og -flóru fjarðarins. Niðurstöður 100 kHz botnsjárgagnanna frá strandsvæðinu og grunnsævi sýna eldri strandlínu á um 2-4 m dýpi.

OBJECTIVES

Using a multidisciplinary approach, the project aims to investigate SW Greenland fjords (Fig. 1) off the Eastern Settlement and adjacent coastal waters in order 1) to reconstruct Late Holocene marine environmental changes with a focus on the transition from the „Medieval Warm Period" (ca AD 900-1350) to the „Little Ice Age" (ca AD 1350-1850), and 2) to trace possible underwater archeological remains from the Norse settlement period.

Long before the Industrial Revolution human beings have had a profound impact on the face of the earth. Early human activities modified vegetation, soils, waters and wildlife of large parts of the earth. Changed terrestrial vegetation, which in turn alters the soil structure and water regime, is one of the factors to be considered when studying climate change. On the other hand, evidence has been found for a possible role of climate in the termination of major cultural evolution

The old Icelandic and Norwegian saga´s and medieval historical annals indicate that the first colonisation of SW Greenland by Eric the Red and his people (ca AD 985) coincides with the Medieval Warm Period. At middle latitudes over Northamerica this period was characterized by a greater drought intensity and frequency. Such extreme large-scale droughts did occur also in more recent times such as in the 1930´s, a period during which northern polar ice had retreated, and the intertropical atmospheric pressure trough over the Atlantic was, on average, 2-40 latitude farther north. Such favorable icefree conditions for transatlantic shipping between Iceland and Greenland must have prevailed at the time of the Norse colonisation of Greenland. Iceland historical annals suggest the occurence on Iceland of larger areas with forest vegetation until a time between AD 1200 and 1300. The disappearance of these forests may have been caused by climate change, but may of course also (partly) have been due to overexplotation by the Islandic people. It is, however, evident from the Islandic annals that the climate on Iceland markedly deteriorated in the period 1291-1392 AD.

With the results from the investigations proposed we hope to be able to reconstruct the local marine environmental conditions during the final phase of the Eastern Settlement. The bearing idea is to study sediment cores from SW Greenland inshore and coastal waters for the immediate impact of large-scale climate range („Little Ice Age") on the hydrographic conditions of Eastern Settlement waters. It is evident that such an impact - as, for example, a more persistant ice cover - could have had large effects on the availability of living ressources as well as on navigation, both crucial factors for the survival of the local population. Using primarely acoustic techniques such as side scan sonar and high resolution high frequency acoustic (e.g. Chirp) technology principally required for selection of suitable coring sites, our further objective is to trace possible underwater cultural heritage as, for example, shipwrecks, lost cargo, constructions or other items from the settlement period. Once traced, such targets will further be investigated and documented by Remote Operated Vehicles (ROV) and, later, by divers.

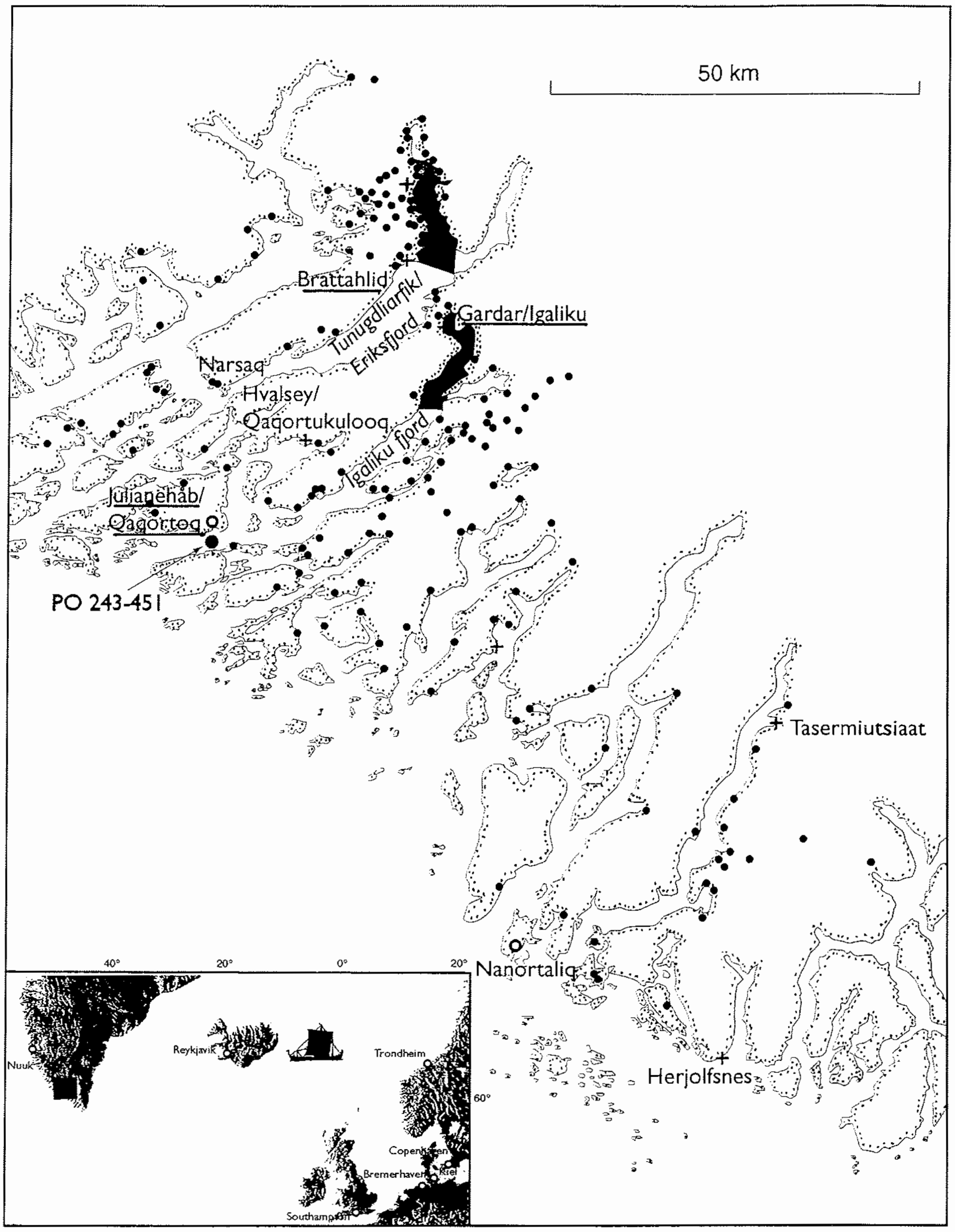

Fig. 1. Regional setting of the study areas in Igaliku and Tunugdliarfik Fjord. The location of core PO243-451 near Julianehab is shown as well. Black dots mark locations of remains from the Norse Eastern settlement.

THE CRUISE

On August 23, 24 and 25 the scientific crew and the scientific equipment arrived in the Reykjavik harbour. After the installation and testing of the scientific equipment R.V. „Poseidon" left Reykjavik on August 25 at 17:30 h and arrived at Julianehaab / SW-Greenland on August 29, 1998, 14:20 h. In contrast to the stormy weather, with some seasick experienced scientists during the passage from Iceland to Greenland, we had wonderful sunny weather during the whole time in the greenland fjords. After arrival at Julianehaab the greenland televison came onboard to do a recording. Escorted into the inner part of Igaliku fjord by SKA 11 and SKA 12, survey ships of the Royal Danish Administration for Navigation and Hydrography which shortly prior to the cruise finished the bathymetric mapping of the investigation areas, R.V. „Poseidon" began profiling with the ELAC bottomchart-system in the working area at 20:00 h, 29.08.. Due to dangerous squalls and icebergs the greenland authorities onboard advised us against working during nighttime, what we did. On August, 30th the anchor was raised at 05:12 h and profiling was continued. At the same time 6 members of the scientific crew made an excursion with a rented speedboat to the norsemen settlements. The mayor of Igaliku visited R.V. „Poseidon" on 30.08, while the first tracks with CHIRP sonar were run parallel to the ELAC-bottom mapping. During the evening Reineck-boxcorer and gravity corer were used at two sites, located by the results of the chirp sonar. On 31st the profiling with Chirp sonar and Deeptow sonar was continued between 05:34 and 09:54, followed by coring activities with the two corers until12:08 h. During the 75 sm long inshore transit in the admirable landscape of the Igaliku fjord and the Tunugdliarfik fjord the commander of SKA 11 and 12 (Jesper Hojdal) was on the bridge of R.V. „Poseidon" to give nautical advice. Close to Narssaq and in the SW-part of Tunugdliarfik fjord several icebergs and growlers had to be passed. At 22:47 h, after nearly 11 hours, R.V. „Poseidon" reached the northern part of Tunugdliarfik fjord, where a wonderful display of the northern lights could be observed. On 1st of september the bathymetric survey with the ELAC bottom chart system of Tunugdliarfik fjord began, often interrupted by moving growlers and large icebergs. At the same time some excursions with the rubberboat gave the opportunity to observe some icebergs closer. The norwegian scientists made an excursion to Brattalhid, the historic settlement of Eric the Red under the guidance of the director of the National Museum of Greenland Emil Rosing, also a member of the scientific crew. In the afternoon two profiles with the deeptow sidescan sonar and Chirp sonar were run, followed by the taking of cores with the box corer and gravity corer.

In the early morning of 02.09. profiling with the deeptow sidescan sonar and Chirp sonar were continued, parallel to the bathymetric mapping. In the afternoon W. Weinrebe was transported with the rubberboat to the airport Narsarsuaq for his return flight. During the following three nights Marek Jasinski stayed at the Hotel Narsarsuaq, as two new members of the cruise arrived at 18:00 h by plane at Narsarsuaq. Jörn Thiede, director of the Alfred-Wegener-Institute for Polar and Marine Research (Bremerhaven, Germany) and Thor-Olav Sperre (Trondheim, Norway), Engeneer, owner and pilot of his Remote Operated Vehicle (ROV), which arrived on the same plane. The new crew members and the ROV came onboard at the jetty of Narsarsuaq harbour, where R.V. „Poseidon" spent the night 02./03.September until 06:00 h. Until 22:12 h further profiles with deeptow sidescan sonar and Chirp sonar were run, samples were taken with box corer and gravity corer and at three sites the ROV was employed. Simultaneous to the ROV operations five scientist and two members of R.V. „Poseidons" crew ran profiles with the KLEIN sidescan sonar in the shallow water area close to Brattahlid.

On september, 4th, at 06:00 h R.V. „Poseidon“ started the Transit back to Igaliku Fjord, where the scientific work could be continued with sampling by box corer and gravity corer at13:19 h, followed by ROV operations at three sites. The „rubberboat-party“ documented with the KLEIN sidescan sonar, simultaneously to the ROV operations, the shallow water area close to the former seat of the bishop of the norsemen at Igaliku/Gardar. From 06:19 h until 08:28 h on 5th september two profiles with deeptow sidescan sonar and Chirp sonar were run. At 08:30 h J. Thiede and E. Rosing left R.V. „Poseidon“ for Narsarsuaq airport, another gravity core was taken and during the afternoon the ROV investigated features shown in the sidescan sonar records. During the ROV activities the „rubberboat party“ continued the sidescan sonar survey in the shallow water area close to Igaliku/Gardar. At 19:36 h R.V. „Poseidon“ left the inner part of Igaliku fjord with direction Julianehaab, where we arrived at 21:51 h. Thanks to the permission by the Greenland Command of september, 5th two short Chirp sonar profiles could be run and samples could be taken by the box and gravity corers during the morning 06.09. close to Julinehaab. The scientific work on this cruise finished at 11:00 h. Invited by the chief scientist and captain the commander and crew of the two survey vessels SKA 11 and SKA 12 were invited to a „Thank You“-brunch onboard R.V. „Poseidon“. The extensive support from the commander and crew of the Royal Danish Administration for Navigation and Hydrography´s vessels and the good atmosphere during this cooperation was an essential factor in the success of this cruise. After brunch the Norwegian scientists left R.V. „Poseidon“ for Narsarsuaq airport. R.V. „Poseidon“ left Julianehaab at 15:06 for another stormy transit with seasickness-problems, to Iceland, where due to bad weather conditions we arrived at 08:00 h, 11th of september.

EQUIPMENT AND METHODS

Positioning

All investigations done by R.V. „Poseidon“ were positioned by a DGPS-positioning system. Positioning during the shallow water side scan sonar surveys by rubberboat was based on terrestrial (compas) navigation.

Bathymetric mapping

A prerequisite for all kinds of marine geological and geophysical investigations is a good knowledge of the bathymetry of the area of interest. The fjords in southwest Greenland have been surveyed recently by the Royal Danish Administration for Navigation and Hydrography (Farvandsvaesnet), but primarily for navigational purposes. These surveys were carried out with single beam echosounders.

During cruise PO243 of R/V POSEIDON a multibeam survey was planned to achieve a complete coverage of the area of investigation in the inner parts in Tunugdliarfik and Igaliko Fjord. As R/V POSEIDON is not equipped with a multibeam system, a temporal installation was necessary. The Kiel based company L3 Communications ELAC Nautic placed a Bottomchart Mk II multibeam echosounder to the disposal of the cruise PO243.

Bottomchart MK II – technical specifications

The ELAC Bottomchart MK II is available in two different versions for shallow and medium depth waters. As the expected depths in the inner parts of Tunugdliarfik and Igaliko fjord were 300 m to 400 m on average, the Bottomchart system for medium depths was used on POSEIDON.

Frequency	50 kHz
Max swath width	150°
Max no of beams	126
Max depth range	2,800 m

Bottomchart Mk II – installation on R/V POSEIDON

The Bottomchart system comprises two transducers, connection cables, an «SEE30» electronics cabinet, and a HP workstation with online and postprocessing software. The electronics cabinet as well as the workstation were set up in the central lab.The two transducers were mounted in a V-shaped orientation with an angle of approximately 38° to a steel plate and placed in the moonpool.

A reliable operation of a multibeam system requires additional data:

Navigation information	An Ashtec differential GPS (D-GPS) system is available onboard R/V POSEIDON. The data stream is standard NMEA format. The Ashtec D-GPS system was interfaced to the SEE30 using a serial line.
Compass information	R/V POSEIDON is equipped with an analog Ansch tz LR40 gyro compass and a «daughter» compass with digital output. This output line was interfaced with the SEE30 using a serial line.
Attitude information	Continuous information on ship's attitude (roll, pitch, heave, yaw) is required for high precision multibeam surveys. However, there is no motion sensor available on R/V POSEIDON, as there is no multibeam system permanently installed onboard. The survey during PO243 was made deep inside the fjords at optimal weather conditions with reduced ships speed at 4 knots, so roll, pitch, heave, and yaw movements of the ship were minimized. However, due to the missing motion sensor, the achievable resolution was slightly reduced.

Bottomchart MK II – calibration of the system

A new installation of a multibeam system onboard a ship requires a complete calibration of the system. This applies to the temporal installation of the ELAC Bottomchart MK II onboard R/V POSEIDON as well. Generally, the exact positions of the transducers relative to the GPS antenna, a time delay in the navigation system, and the precise angles of the transducers to the horizontal plane across («roll offset») and along («pitch offset») the ship have to be determined. The theoretical background of the calibration process is outlined in detail in Steenstrup (1996).

Due to strong constraints in the tight time schedule only a reduced calibration scheme could be accomplished. On september 2, a profile 3 km in length across Tunugdliarfik from Qagssiarssuk to Narssassuak was measured twice by R/V POSEIDON in opposite directions. So a bias in the roll angle («roll offset») and in the pitch angle («pitch offset») which have the greatest influence on the data could be determined.

Water sound velocity profiles

Crucial for the depth determinations of bathymetric surveys is the exact knowledge of the sound velocities in the waterlayers. During their surveys in the area the Danish Hydrographic Office (Farvandsvaesnet) recorded the water sound velocity profiles at many different locations. In these shallow fjord areas the water sound velocity is primarily dependent on the water temperature and the influx of fresh water from rivers and glaciers. As the velocity measurements of the Danish Hydrographic Office were made just days before PO243 cruise, these results were a good approximation to the actual velocity distribution and were used to process the recorded Bottomchart data during PO243.

Igaliko Fjord survey

The inner part of Igaliko fjord between about 60° 52' and 60° 59' northern latitude was mapped with Bottomchart Mk II on august 29 and 30. With 6 parallel profiles in the southern part and 4 parallel profiles in the northern part with a spacing of around 500 m on average a complete coverage of the fjord area could be achieved (Fig. 2). Due to drop outs in navigation and gyro information one profile had to be recorded twice.

The data were processed with ELAC Postprocessing software. Sound velocity profiles and calibration offsets were taken into account. Preliminary results are shown in Fig.3 as an isocontour map with contour intervals of 10 m. Generally Igaliko fjord shows an U-shaped cross profile with increasing depths from 60 m off the village of Igaliko in the north to 360 m at 60° 53' latitude in the south. The gradual increase in water depth is interrupted by a slight step just north of the entrance to Kujatdleq fjord. The side walls of the fjord are generally very steep and reflect the steep mountain slopes onshore.

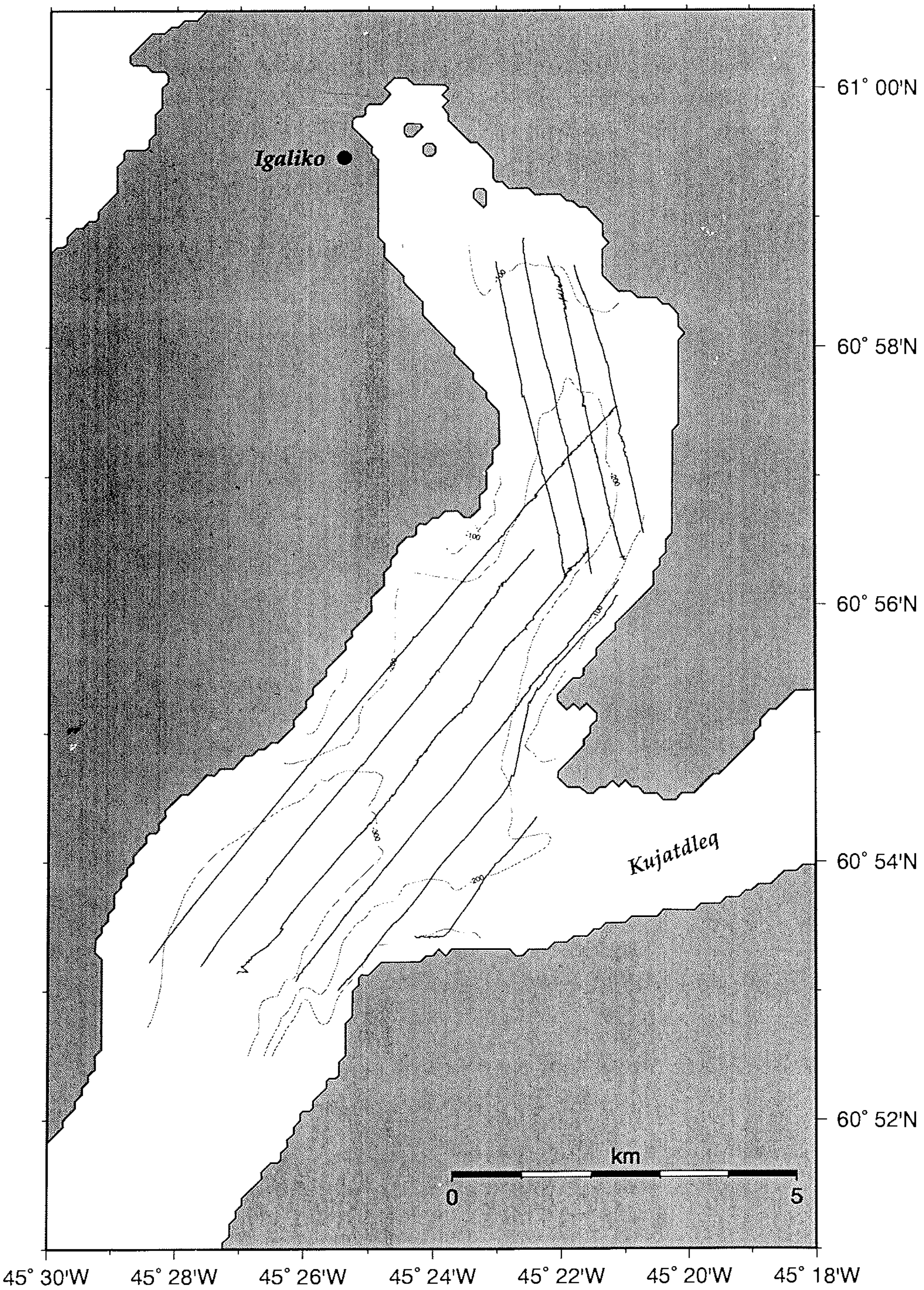

Fig. 2: Track chart with multibeam profiles (Igaliko Fjord)

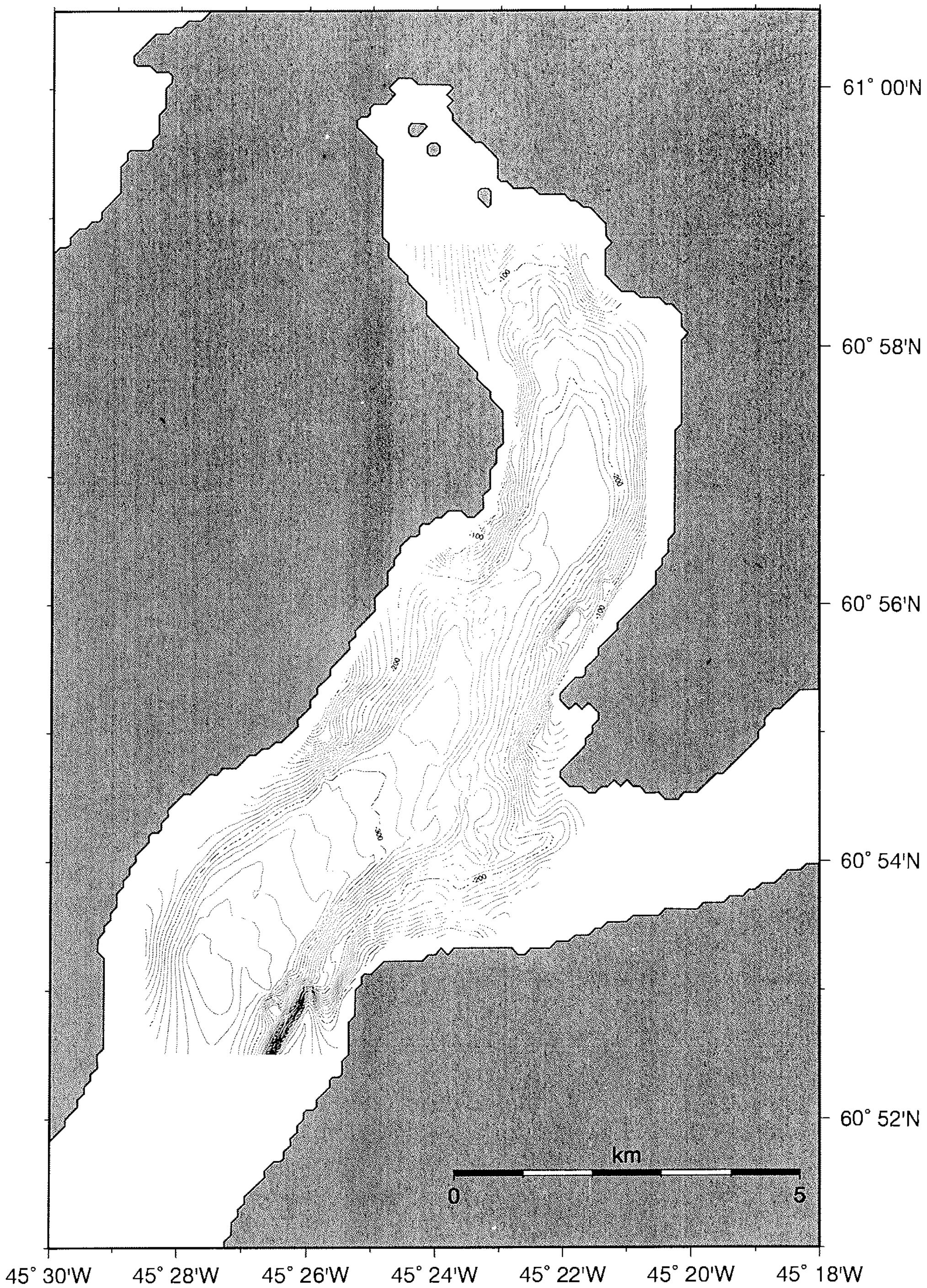

Fig. 3: Bathymetry of Igaliko Fjord

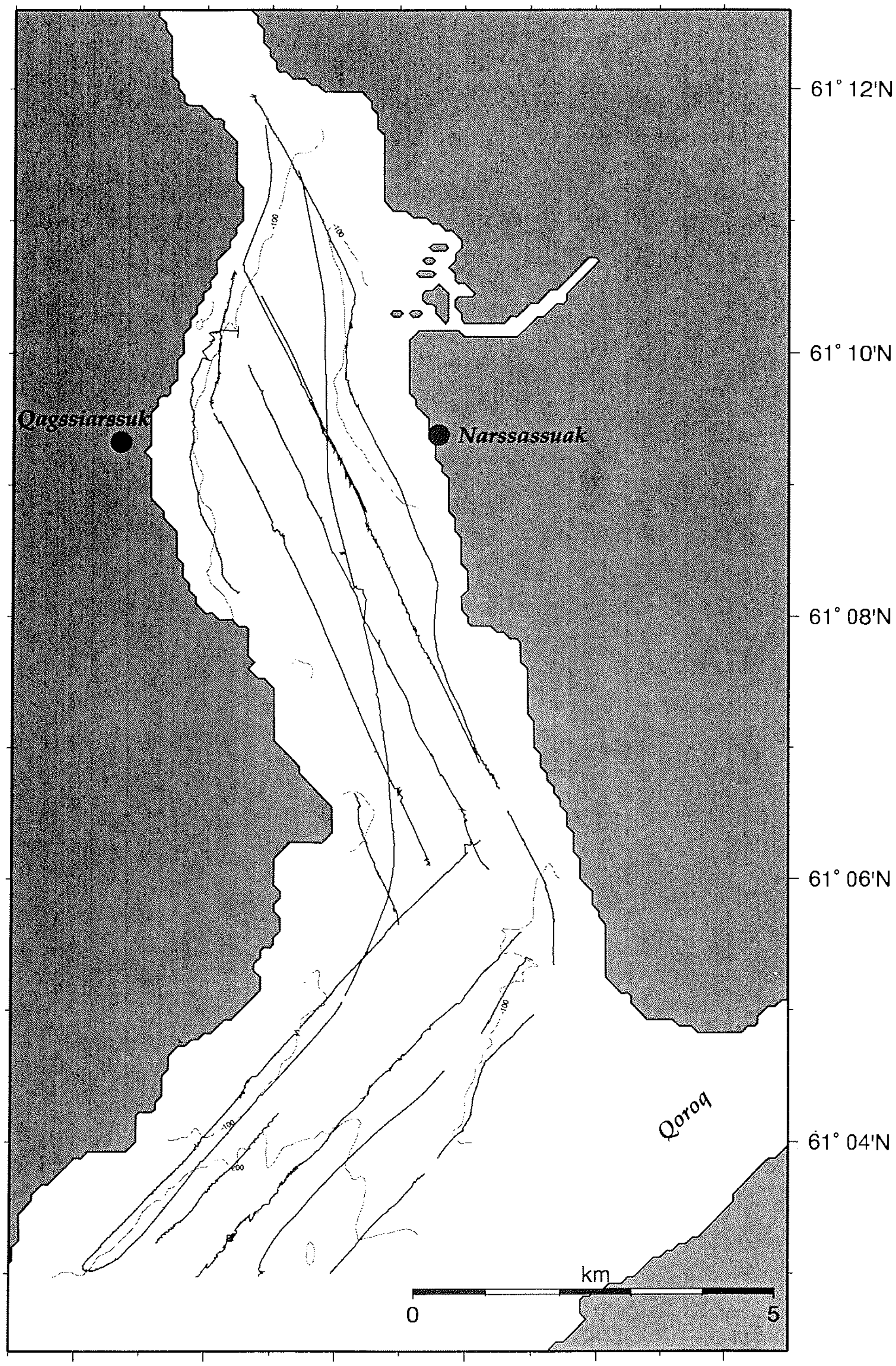

Fig. 4: Track charts with multibeam profiles (Tunugdliarfik Fjord)

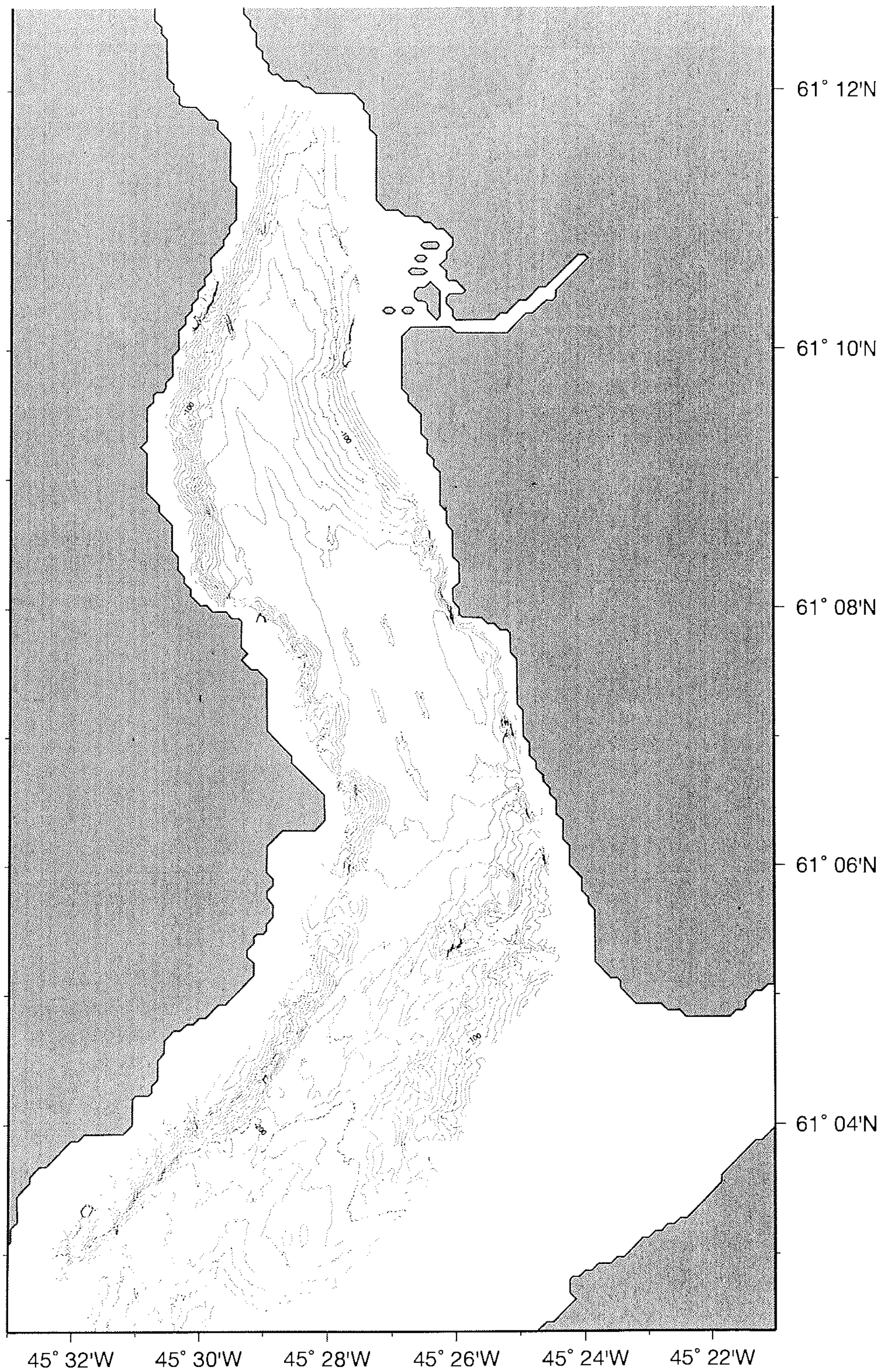

Fig. 5: Bathymetry of Tunugdliarfik Fjord

Tunugdliarfik Fjord survey

The inner part of Tunugdliarfik between about 61° 02.5' and 61° 12' northern latitude was mapped with Bottomchart Mk II on august 31 and september 1 and 2. In the inner parts of the fjord a nearly total coverage was achieved (Fig.4), wheras in the south only the west side of Tunugdliarfik could be mapped due to many growlers and icebergs off the entrance to Qoroq fjord.

An isocontour map of Tunugdliarfik is shown in Fig.5. Generally Tunugdliarfik has an U-shaped cross profile with increasing depths from 40 m in the north to 260 m in the south, interupted north of Qoroq fjord entrance with a swell in a waterdepth of around 170 m. Massive sedimentary fans are found in front of the river north of Narssassuak airport. Also in front of Qoroq fjord fans are evident, but not in such a regular pattern as in the north. The area between 61° 06' and 61° 08' north is essentially flat with a depth of 170 m.

Subbottom profiling

During the entire survey the hull-mounted 18 kHz sediment echosounder was used. Maximum subbottom penetration depth in the area was 25 – 30 m. Analogue data were displayed on a graphic recorder.
During acoustic profiling, the 18 kHz echosounder was run concurrently with one of the side scan sonar systems (59 or 100 kHz), whereas simultaneously a high-resolution (2 – 10 kHz) CHIRP subbottom profiler system was towed (port side) at approx. 4 m depth below the sea surface. Data were analogue displayed on a graphic recorder, while a Sony datrecorder was used for digital recording.

Side scan sonar seabed imaging

Deep-tow EG&G 59 kHz

The sidescan used for this survey was a 59 kHz high-resolution deeptowed sidescan sonar (Mod. 996, EG&G Comp.). The range of the swath was 400m to each side with a beam widths 0f 1.3 degrees and a maximum resolution approx. 2m. The sonar data were displayed online to a graphic recorder (Mod. 260, EG&G Comp.) and stored on analog tape for backup. Sensor data (temperature, speed, heading and depths) were collected on PC. Due to the perfect weather conditions the sonar fish could be towed without depressor and buoyancy fish, with a towing speed of 2-3 knots over ground, at a depths of 40-60 m above the seafloor (which corresponds to 10-15 % of range used). The side scan device was connected to a 11 mm double steel armoured coax cable on a HATLAPA deep sea winch with a total cable lengths of 4620 m.

During the transit from Reykjavik to Greenland a test of the deep-tow system with a short test cable showed no apparent failures in the signal transmission. A further test after the deep-tow fish had been coupled to the HATLAPA deep sea conductor cable indicated, however, severe problems with the signal transmission from the fish to the recorder modem. After a long series of tests it was found that the problem presumably was due to poor condition (corrosion) of the conductor cable giving way to an increased resistance. In order to compensate for this, the signal detection level of the recorder modem was tuned more sensitive in order to better detect the returned signals.

Klein 100 kHz

A 100 kHz Klein side scan sonar system with a fixed depressor was used on selected tracks in Tunugdliarfik fjord. The fish was towed behind the ship (port side) with an extra tow wire and a 100 m conductor cable. Data were displayed on a Klein graphic recorder, and simultaneously recorded on a Sony 8-channel digital recorder. Ship's speed was ca. 3 knts.

In addition, the 100 kHz side scan sonar was deployed in shallow water from one of Poseidon's rubberboats. During these shallow water surveys, that were carried out both in Tunugdliarfik and Igaliku fjord, the transducer fish was towed without depressor at 1.5 to 1.8 m depth below the sea surface, with a recording range of 75 m. The data were analogue recorded on the Klein graphic recorder. Power supply was through a 24 V battery provided by the Royal Danish Administration for Navigation and Hydrography (SKA survey vessel). Tow speed was ca 2 knts most of the time.

Sediment sampling

Box coring

In order to sample undisturbed surface sediments, a REINECK box corer was used with an additional ballast weight of 300 kg (6 weights of 50 kg each). The size of the boxes used is 0.2x0.3x0.4 m. The mechanical setting of the corer for obtaining a good core quality with a sufficient sediment penetration was made based on previous experiments. The corer was lowered with the ship´s winch at a speed of 0.5 m/s down to a height of 20 m above the seafloor. After a short stop here, the box corer was finally lowered to the seabed for sample collection.

Gravity coring

For obtaining longer sediment cores, a gravity corer made by HYDROWERKSTÄTTEN KIEL (Germany) was deployed with a barrel lengths of 5.75 m. The inside barrel diameter was 130 mm. For collecting the sediment cores a PVC liner with an outside diameter of 125 mm was used. At one occasion, thin trasparent plastic was used for enabling an immediate onboard description of the entire sedimentary sequence cored in the fjord. The total weight of the corer also including the core barrel is 1650 kg. This is the maximum weight in case all 27 ballast weights (50 kg each) are used. In our case, the mainly fine-grained sediments were relatively soft, which made it necessary to remove in total 500 kg ballast weight in order to prevent sediment disturbance of the top section of the core. Depending on the sediment type, the corer was lowered at a speed of between 0.4 and 0.9 m/s. Similarely as with the box corer, immediately prior to sample collection the lowering of the corer was shortly stopped at 20 m above the seabed.

The ROV investigation

This part of the investigation was carried out by the Norwegian University of Science and Technology (NTNU) under the direction of Marek E. Jasinski (Institute of Archaeology) and Fredrik Søreide (Department of Marine Systems Design).

The side-scan sonar results obtained with the EG&G 59 kHz side-scan sonar in deep water (>30 m) were analysed and interpreted with respect to locating cultural remains on the sea-floor. This revealed a variety of seabed features but only four which could be tentatively interpreted as human artifacts. Of these anomalies, three were situated in the Tunugdliarfik and one situated in the Igaliko fjord. All of the anomalies were found on the relatively flat seafloor in deep water. Closer to the shore the terrain is steep with rocks and others features, making it difficult to separate cultural remains from the natural features of the seafloor using a low frequency sonar.

The 3 anomalies in the Tunugdliarfik can best be described as thin, long spikes on the side scan sonar image. This shape does not correspond to natural seabed features and a Remotely Operated Vehicle (ROV) was therefore used to investigate these sites. The ROV system was built, owned and operated by the Norwegian company Sperre AS which cooperates closely with NTNU. This ROV could be operated down to 500 m depth in the present configuration and was equipped with thrusters that enable it to move in all directions, controlled by an operator on board the Poseidon. Control signals and power are supplied via a tether. The system was further equipped with 3 video cameras, a scanning sonar to relocate the anomalies and a one function manipulator arm to take samples. The 3 targets in Tunugdliarfik had the following positions (all positions reflect the position of the Poseidon as no underwater positioning system was used):

Target 1: N 61.10.1543, W 45.29.1555, 40 m water depth.
Target 2: N 61.08.3736, W 45.30.0992, 60 m water depth.
Target 3: N 61.08.0933, W 45.29.7282, 140 m water depth.

These 3 targets were investigated on September 3. One natural feature was discovered on the seabed close to anomaly number 1 using the scanning sonar. The top of a 30 m long hill had the same characteristic as the side-scan sonar anomaly and may explain the anomaly. In the areas surrounding targets 2 and 3 nothing could be found which could account for the side-scan anomaly. It is therefore likely that these two targets were the result of noise distortions.

Target 4: N 60.58.5535, W 45.22.2001.

Target 4 was the most interesting of the anomalies discovered. Several objects were situated on a flat seafloor in approximately 80 m depth, see Figure 2. This site in the Igaliko fjord was investigated by the ROV on September 4. While Poseidon was positioned on the site the ROV was sent down to inspect the area. The scanning sonar discovered two features with similar characteristics as the anomalies. These targets were a pair of mounds, one 20-30 m long and 1 m high and one 4-5 m long and 2 m high. There were, however, no signs of man-made objects visible on the seafloor in this area, and even a small excavation in the largest mound using the manipulator arm could not reveal if man-made artifacts were hidden inside the mound, or give another explanation why these mounds had been created.

Additional seabed records made by the ROV cameras on September 5 over a cross section of bathymetric settings in the Igaliko fjord showed major elements of the benthic flora and fauna of this fjord. These unique video recordings will be analysed by biologists at the participating universities. The documentation was made from approximately 250 m depth in the centre of the Igaliko fjord to the shoreline from starting position: N 60.54.829, W 45.23.216 to position: N 60.54.796, W 45.22.163. An additional area in shallow water (0-30 m) was also examined to locate possible ancient shorelines. No evidence could, however, be found to support this theory in this area located around position: N 60.53.247, W 45.29.058.

PRELIMINARY RESULTS

Acoustic profiling and seabed imagery

During POSEDON cruise 243 profiles with deep-tow (59 kHz) sidescan sonar recording were run both in Igaliko (Fig. 6) and Tunugdliarfik Fjord (Fig.7). On the first profile in Igaliku Fjord the recordings were delayed because of renewed signal problems caused by the winch cable. This time the problem was solved immideately by the technical staff, and the delay of the data collection was negligable. The direction of the profiles in the latter fjord were NNW-SSE, in the northern and the NE-SW in the more southern part of the fjord.

The central, deeper part of the fjord is charakterized by a featureless smooth seafloor with very low backscatter. This can be ascribed to the soft, fine-grained type of sediment found in the sediment cores from this area. The shallow (< 100 m water depths) areas show a generally higher backscatter value, with some rock outcrop and blocks of rock material. In contrast to these lines, the profiles run close to the coast of the fjord show many rock outcrops, small iceberg plow marks, and sediment waves. Sometimes the sonar data were disturbed by the beam interference due to the thermocline present in the fjords.

In the northern part of the surveyed area in Igaliko Fjord, some seabed features with a maximum lengths of approx. 25 m were detected, which could not be excluded to have an anthropic origin. Water depths at this site is around 80 m. These targets were surveyed also with 200m and 100m range in order to gain a higher resolution of the features, and they were finally invetigated with the Norwegian ROV.

The deeptow survey in Tunugdliarfik Fjord (see Fig. 7) includes 9 profiles. The main direction of the tracks were NNW-SSE and N-S. In the shallow area (water depths about 50m) iceberg plow marks are widerspread, but sometimes also anthropogenic trawl marks could be found. The backscatter values range from very high (rock outcrop) and intermediate to high (debris flow material with blocks) to very low (smooth seafloor with muddy material). At a water depths below 100m the iceberg plough marks disappear, and the seabed becomes smooth an featureless down to about 400m in the central part of the fjord.

Like in Igaliko Fjord some targets of possible anthropogenic origin were found. Their size ranges from 10-30m in length and 5-20m in width. These features were also investigated by ROV (see above).

The acoustic profiles run with the CHIRP subbottom profiler system are presented in Fig. 8 (Igaliku Fjord) and Fig.9 (Tunugdliarfik Fjord). The location of the sediment coring sites and ROV deployments is shown in Fig. 10 (Igaliko Fjord) und 11 (Tunugdliarfik). For further details, i.e. the precise geographical coordinates of the survey lines and cores, is referred to the Annex. Figure 12 and 13 indicate the areas where 100 kHz side scan sonar profiles were run with R.V. Poseidon and Poseidon's rubberboat. It should be noted (see Annex, Table 3) that an additional box core and gravity core were taken off Julianahaab (Fig 1).

The deep-tow side scan sonar records and – to some extent – the multibeam echosounder data from both fjords clearly demonstrate the common occurence of seabed relief associated with the presence of debris flow deposits (Fig. 14).

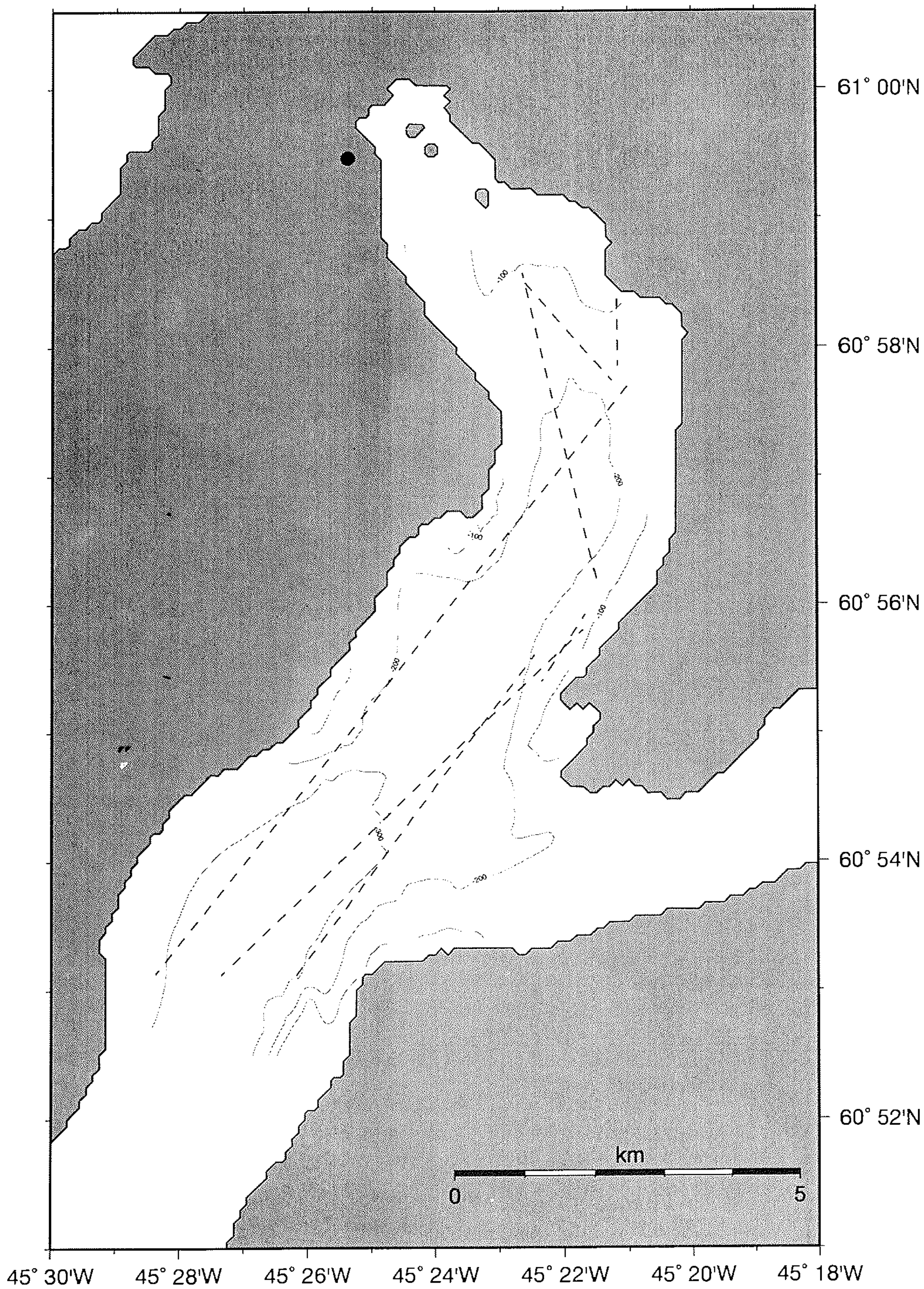

Fig. 6: Deeptow sidescan sonar tracks (Igaliko Fjord)

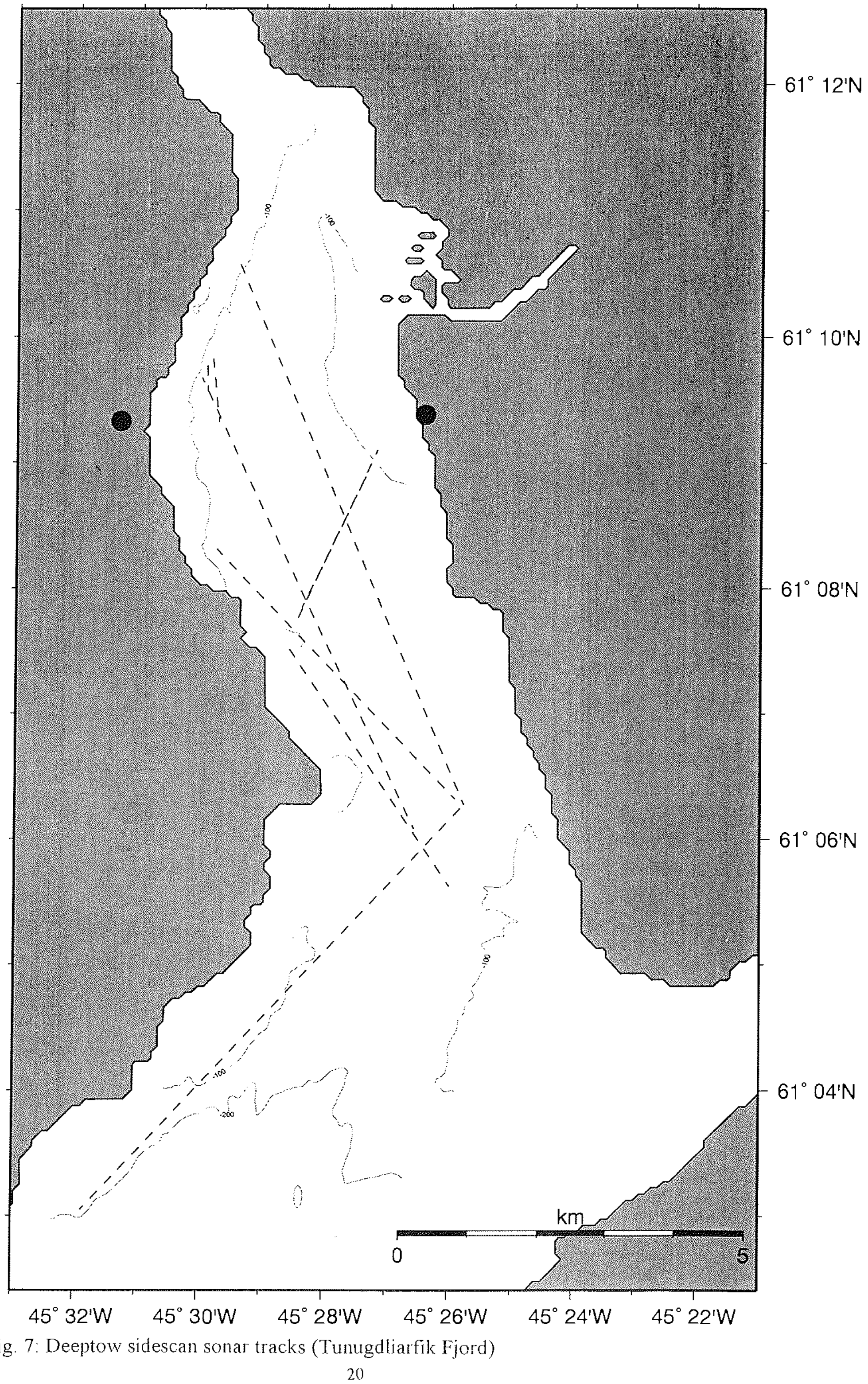

Fig. 7: Deeptow sidescan sonar tracks (Tunugdliarfik Fjord)

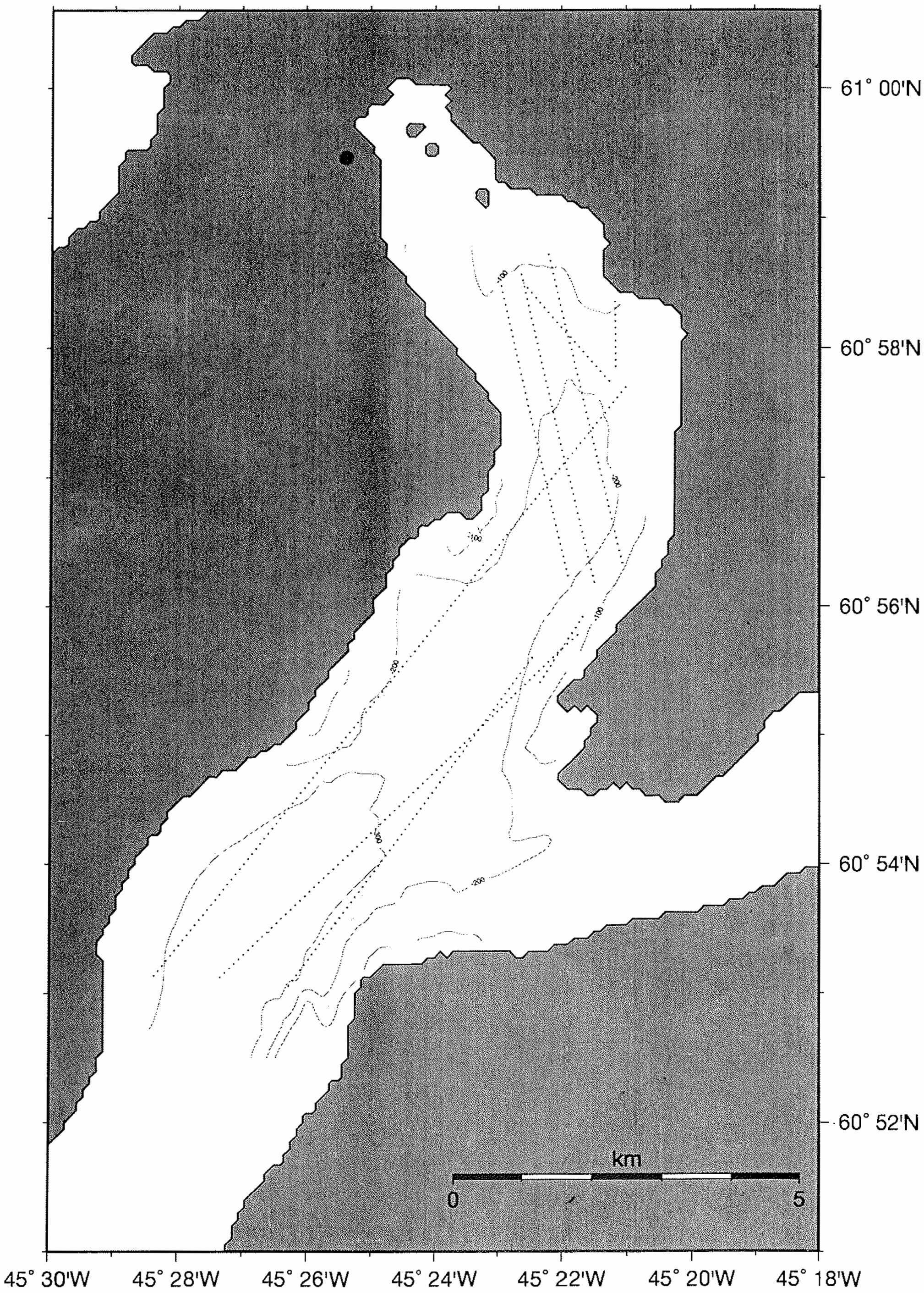

Fig. 8: CHIRP subbottom profiler tracks (Igaliko Fjord)

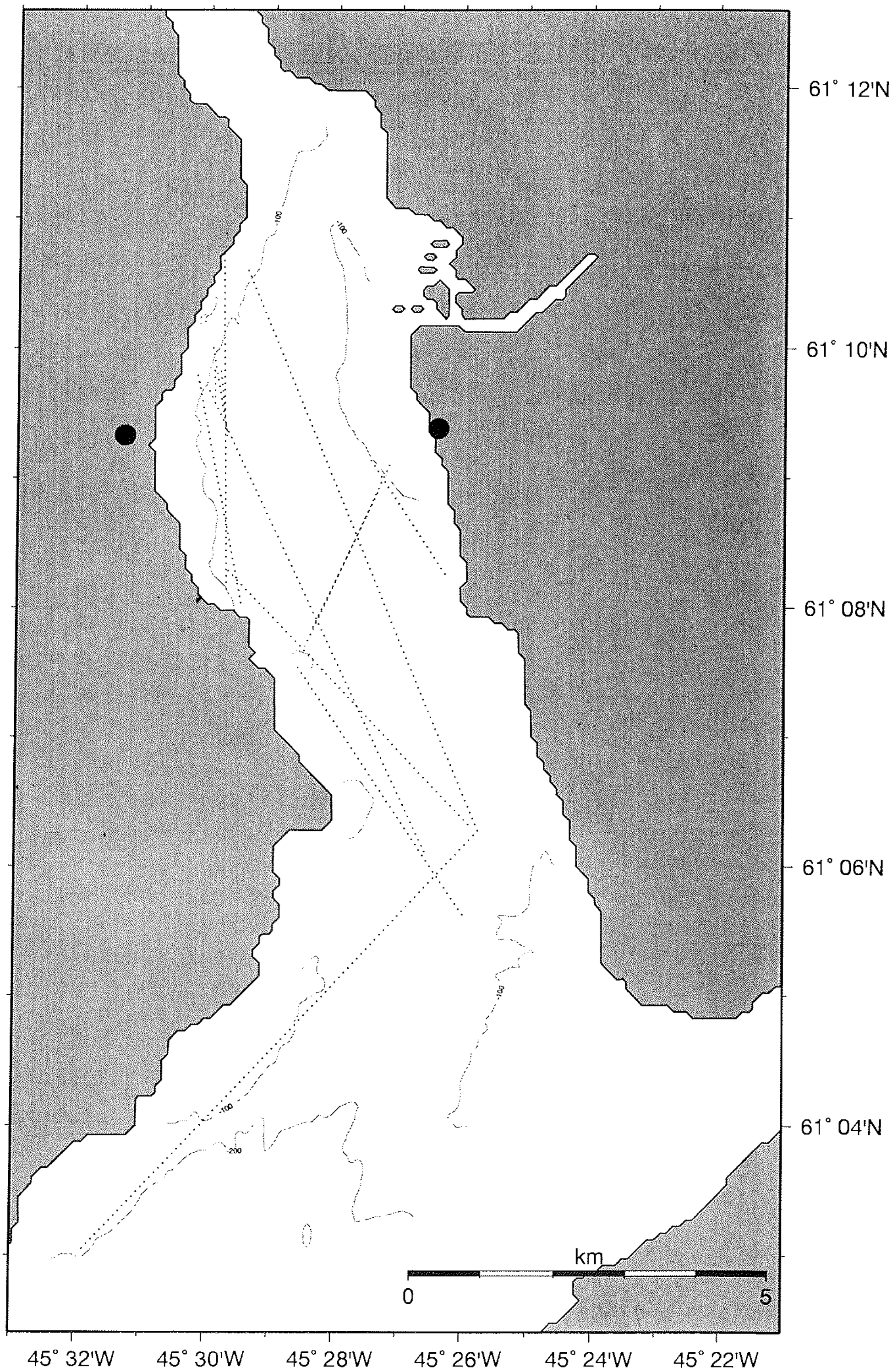

Fig. 9. CHIRP subbottom profiler tracks (Tunugdliarfik Fjord)

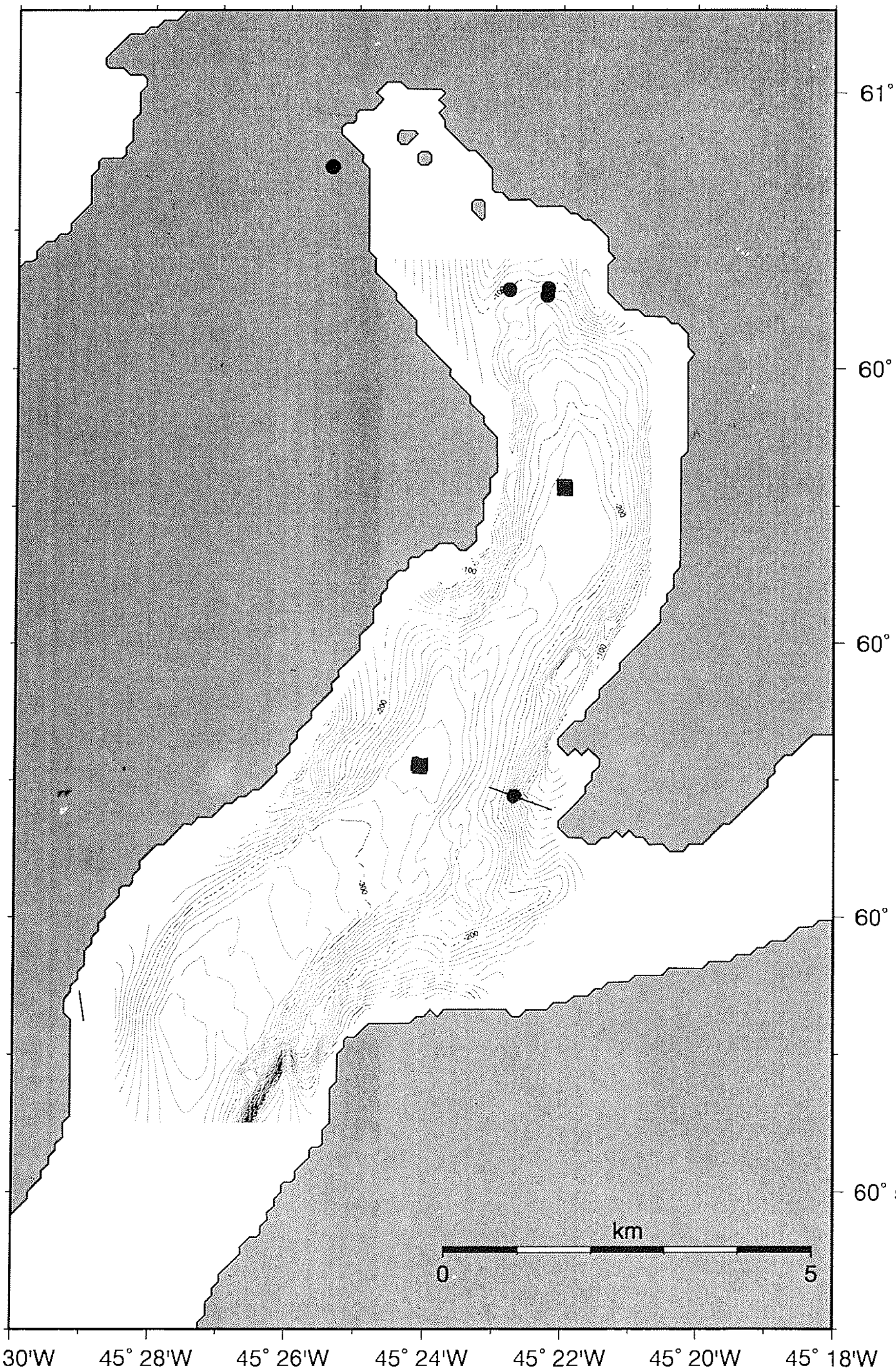

Fig. 10: Location of sediment coring sites ■ and ROV stations ● (Igaliko Fjord)

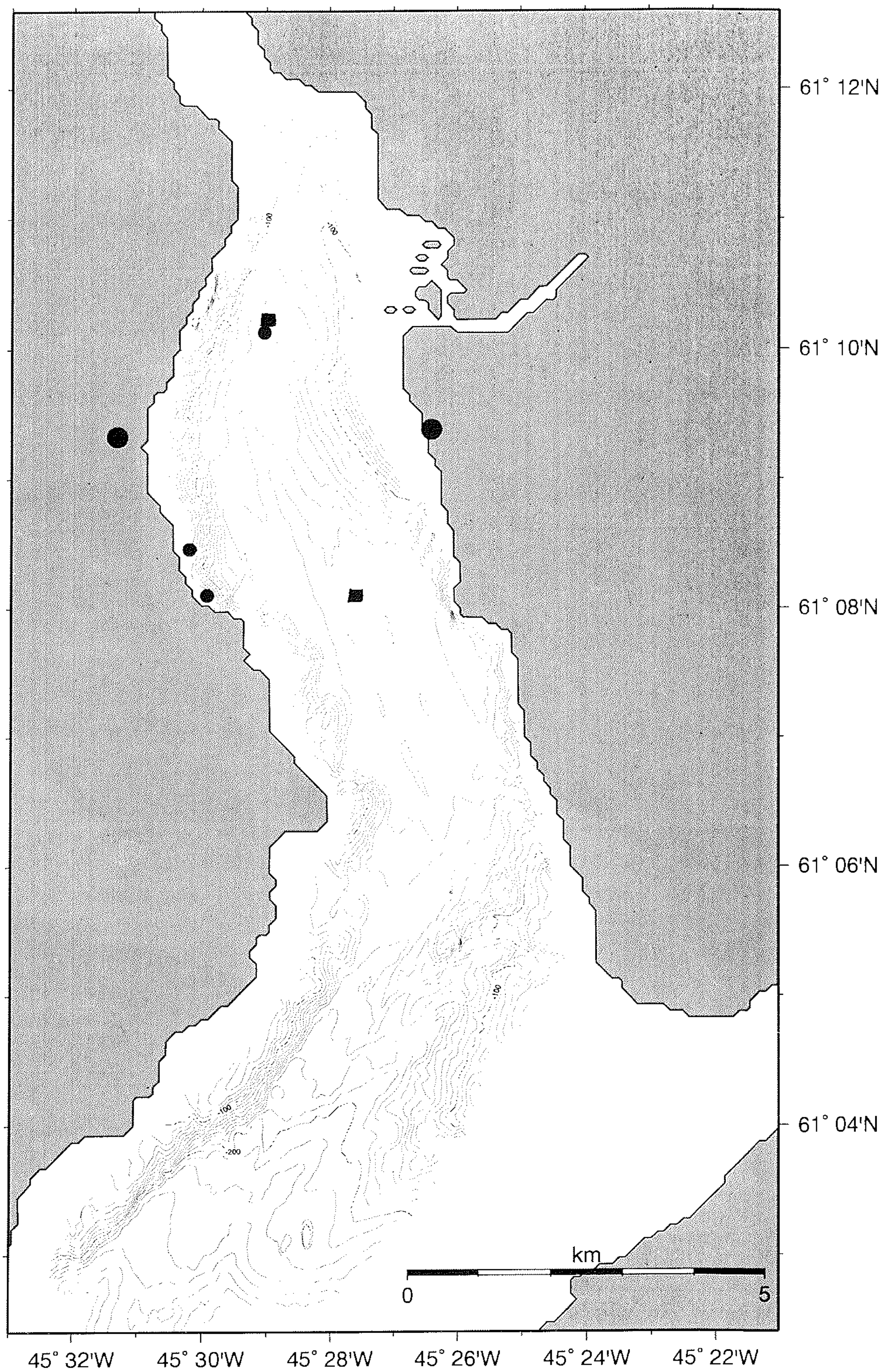

Fig. 11: Location of sediment coring sites ■ and ROV stations ● (Tunugdliarfik Fjord)

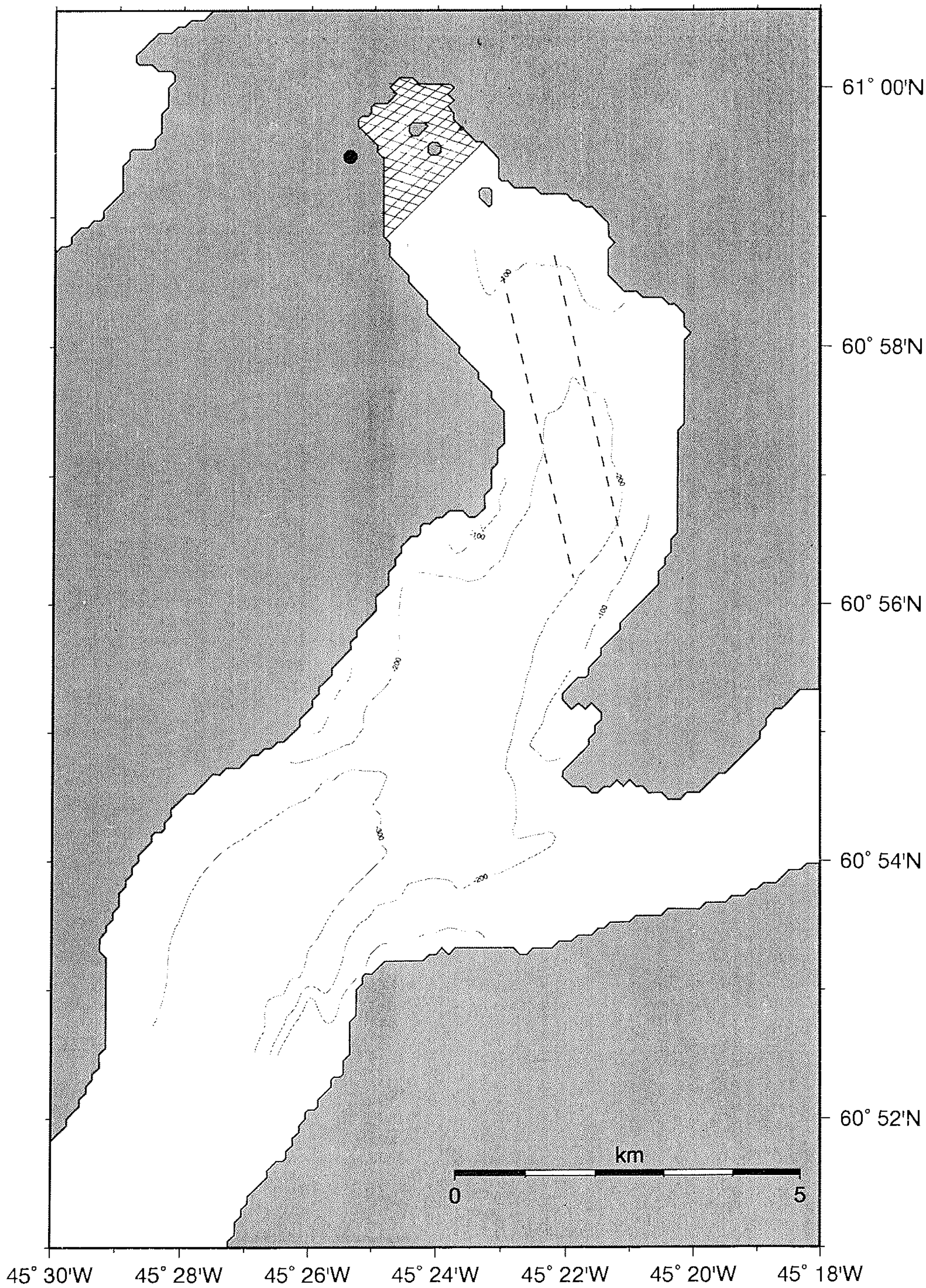

Fig. 12: KLEIN sidescan sonar tracks (Igaliko Fjord). Cross-hatched shallow water areas were surveyed by rubberboat.

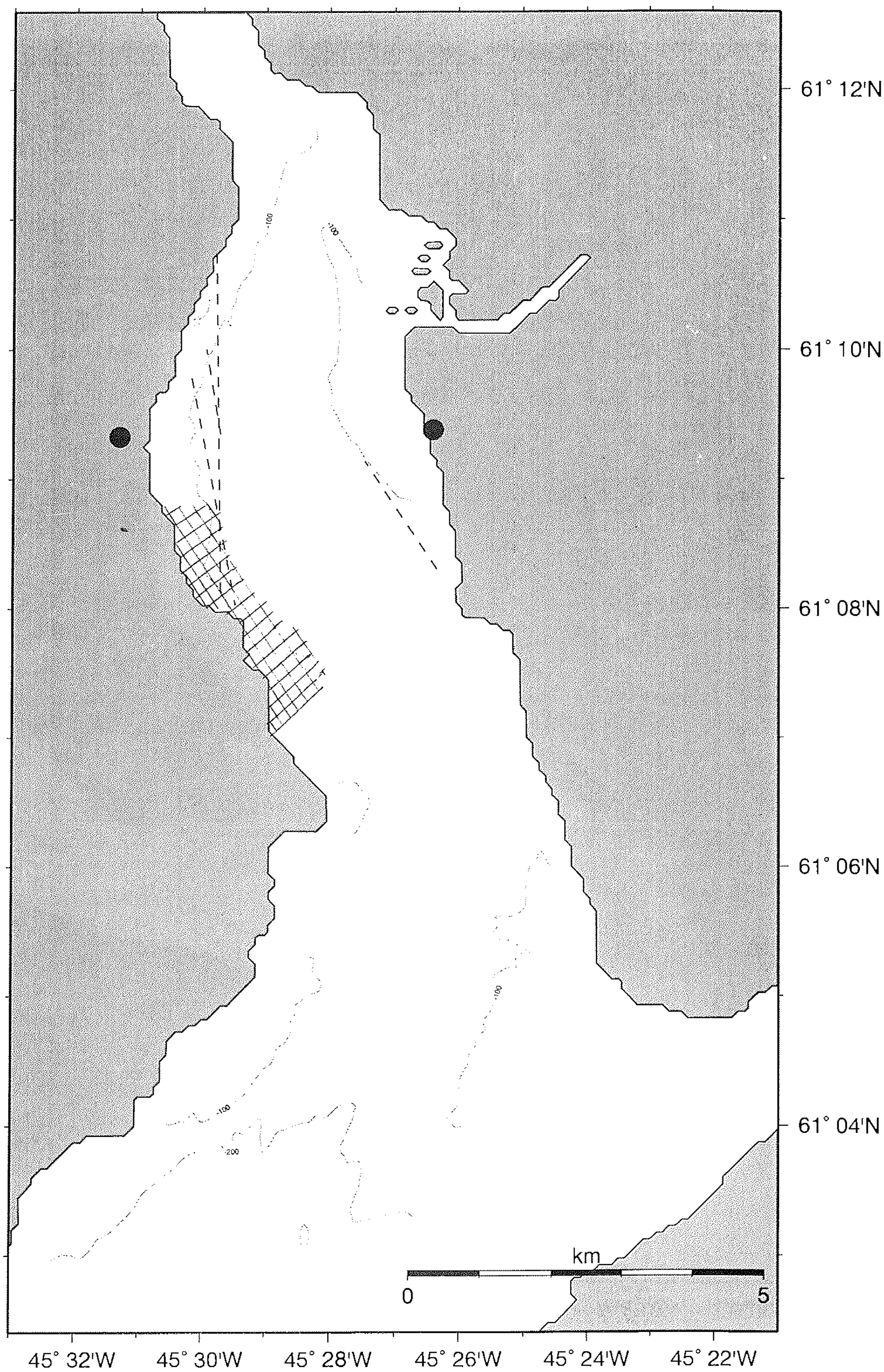

Fig. 13: KLEIN sidescan sonar tracks (Tunugdliarfik Fjord). Cross-hatched shallow water areas were surveyed by rubberboat.

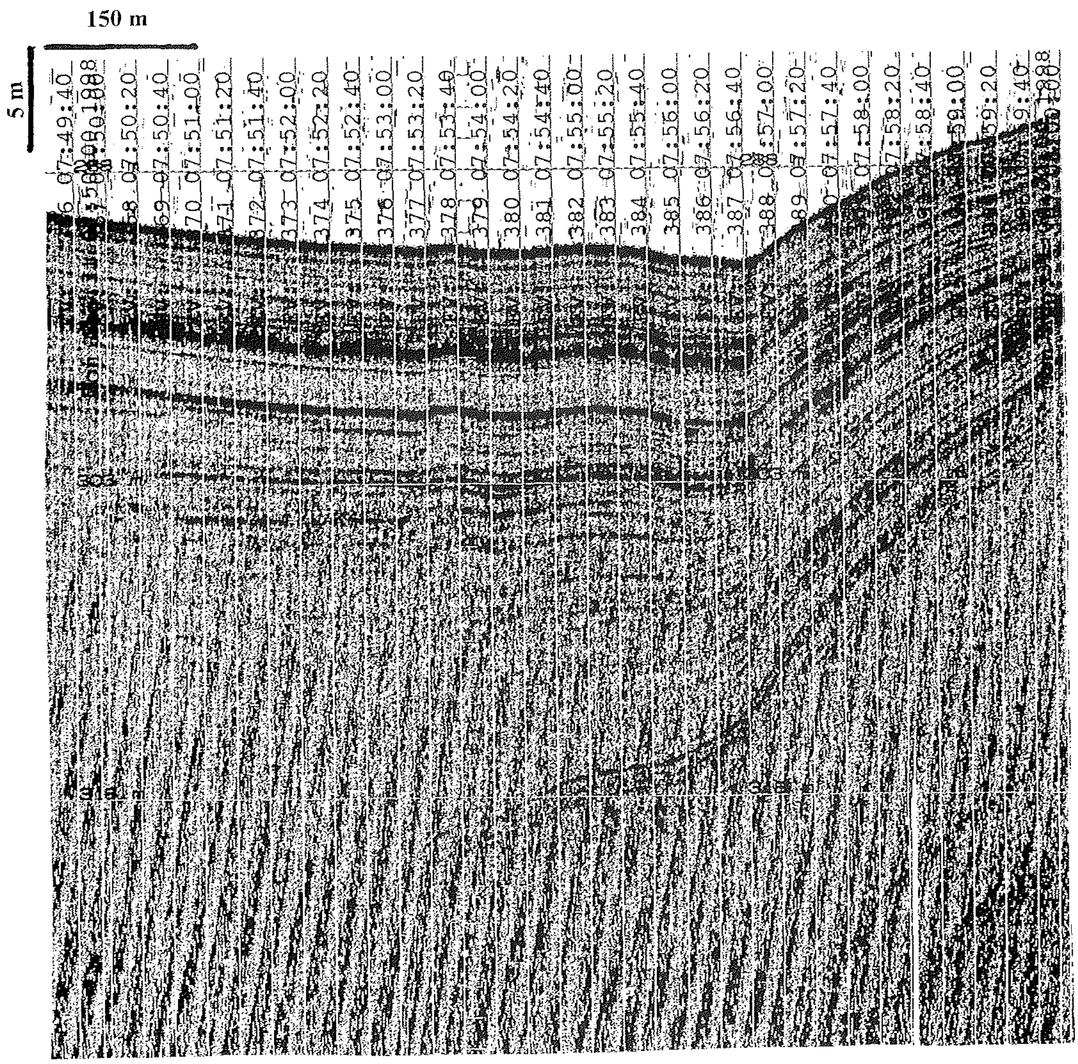

Fig. 14: Example of a CHIRP subbottom profiler record from the central part of the Igaliko Fjord study area. The record shows acoustically finely laminated sediments mainly in the upper part of the sedimentary sequence, presumably indicative of turbidite deposits alternating with intervals of authigenic fjord sediments. The underlying, more transparent units may indicate the presence of thick sandy debris flow deposits. The water depths is around 290 m.

Also the sediment cores yield ample evidence for the relatively frequent occurrence of debris and turbidity flows. The CHIRP records from areas where downslope processes dominate display a relatively rough topography, whereas acoustic lamination is absent or rare, with thicker, acoustically more transparent (muddy silt-sand) units dominating. However, some areas display regular and continuous acoustic lamination , suggesting a sedimentary environment less disturbed by debris flow activity. CHIRP records from these sites show that the sedimentary infill of the fjords deposited since the last glaciation has a maximum thickness of at least 35 m. These areas were preferably selected for sediment sampling.

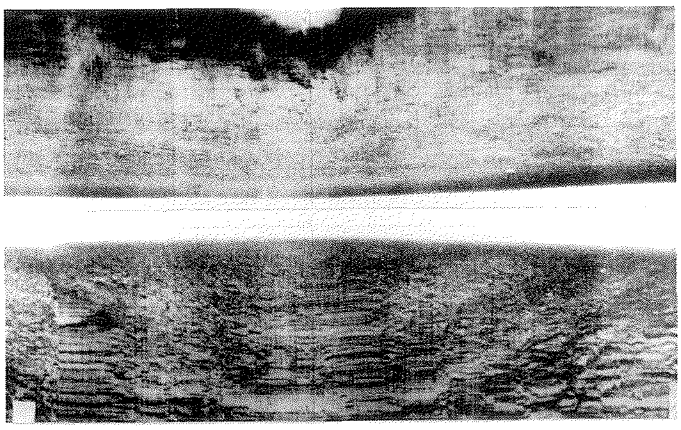

Fig. 15: Sonograph from coastal waters off Brattahlid showing a drowned coastline at 3-4 m water depths.

The profiles run with the Klein 100 kHz side scan sonar in shallow (< 10 m) and deep water are shown in Fig. 12 (Igaliko Fjord) and 13 (Tunugdliarfik Fjord). The 100 kHz sonographs from the shallow water survey (cross-hatched ares, Fig. 12, 13) demonstrate the local presence of a drowned coastline (Fig. 15) at water depths of 3 – 4 m below present mean sea level (Tunugdliarfik Fjord).
At water depths of less than 100 m both the deep-tow 59 kHz and 100 kHz shallow water sonographs demonstrate, however, a marked difference of the small-scale seabed relief, when comparing both study areas.
While the seabed of Tunugdliarfik fjord has been intensively reworked by grounded ice bergs, sonographs from the seabed of the Igaliku Fjord only rarely show the presence of iceberg plow marks.

Some seabed features observed on the sonoraphs suggested the possible presence of human-made artifacts on the bottom of the fjords. A ROV deployment on one of these targets could, however, not further verify the character of the target dealt with. It must be assumed that generally the sediment accumulation rate in the deeper part of the fjords is probanly that high, that after several centuries objects will be covered by meter(s) of mud. A major difference between the two study areas with an immediate impact on ROV work is the underwater visibility. While in Tunugdliarfik turbidity of the surface water layer caused a reduction of the visibility in this layer to less than 1-2 m, visibility conditions in the Igaliku fjord were much more favourable. ROV recordings made in the latter fjord at different water depths clearly showed major benthic flora and fauna elements present in the fjord.

Sediments

The sediment water interface was well preserved in all the box cores that were taken during the cruise. This was demonstrated by intact surface wormtubes and an oxidized top layer (ca 2 cm thick). The sediment in the box cores was soft mud to sandy mud; varying in colour from olive gray to brownish gray. Faint layering was observed in some of the cores when they were subsampled.

One gravity core was split during the cruise to get an impression of the deeper sediments already during the cruise. Core 243-431, which was sampled in a soft plastic tube, included an upper section with olive gray, mottled mud/sandy mud with occasional pebbles (ca. 0.5 cm in diameter) and layers of well sorted sand. Mollusc shells were found within this unit. The middle part of the core included approximately 1,5 m of matrix supported gravel and pebbles (up to 2 cm), although some layering and upward grading could be observed within this unit. The third unit resembled the uppermost part of the core and contained mainly mottled mud with occasional pebbles (<1.5 cm in diameter). Finally, the lowermost meter of the core included coarser material with matrix supported coarse sand/gravel and occasional layers of well sorted sand. Evidence for downslope sediment processes (turbidity currents and debris flows) are ample in the core which correlates well with preliminary results from acoustic data. Examination of core catchers and surface sediment from the other gravity cores showed that the dominating sediment type is olive gray mud.

ACKNOWLEDGEMENTS

First of all we would like to thank the Royal Danish Administration for Navigation and Hydrography for excellent cooperation in the planning stage as well as during the cruise, and for the bathymetric mapping immediately prior to the cruise. This particularly applies to the commanding officers and crew of the survey vessels SKA 11 and 12. Without this work, the project would not have been possible. In addition, the master and crew of RV Poseidon are sincerely acknowledged for their engagement and help during all stages of the cruise. Here we would like to mention also the crew members who assisted with the many hours of work done by Poseidon's rubberboat. The Geological Survey of Denmark and Greenland (GEUS), the Danish Natural Science Research Council (SNF), the GEOMAR Institute for Marine Geosciences (Kiel), the German Alfred-Wegener-Institute for Polar Research (Bremerhaven), and the Norwegian University for Technology and Natural Sciences (NTU), Trondheim, are thanked for their share of the financial support of the cruise. In addition, Greenlandic funding was obtained for post-cruise analysis of the sediment cores through a grant to Naja Mikkelsen (GEUS) and Joel Berglund, National Museum of Greenland (Nuuk). Special thanks are due to Peter T. Jörgensen (GEUS) and Thorsten Schott (Kiel) for skillful work with the acoustic and coring equipment, which functioned without failure throughout the survey. The "L3 Communications ELAC Nautik" company (Kiel) contributed to the project by having provided their multi-beam echosounding system. The Icelandic Meteorological Office is thanked for providing useful information on weather and ice conditions prior to departure for Greenland.

Annex

1. Geographic coordinates of acoustic profiles (start/end position)
2. Geographic coordinates of sediment cores
3. Geographic coordinates of ROV sites
4. List of participants and affiliation
5. Crew List R.V. „Poseidon“

1. Geographic coordinates of acoustic profiles (start/end position)

Deep towed side scan sonar: D
Chirp sonar: C,
18 kHz: A
ELAC Bottom chart system: E
Klein side scan sonar: S

Igaliko Fjord

TrackNo.	Start	End	Date	Time Equipment
PO98-01	60 53,12 N/045 27,34 W	60 56,24 N/045 22,23 W	29.08.98	/22:00-22:38: A,E
PO98-02	60 56,46 N/045 21,54 W	60 53,25 N/045 26,71 W		/22:40-23:22: A,E
PO98-03	60 53,10 N/045 26,08 W	60 56,20 N/045 21,05 W	30.08.98	/08:24-09:00: A,E
PO98-04	60 56,08 N/045 21,11 W	60 53,01 N/045 25,48 W		/09:07-09:41: A,E
PO98-05	60 53,45 N/045 23,84 W	keine Pos., Gerätedefekt		/10:36-10:45: A,E
PO98-06	60 56,14 N/045 21,89 W	60 58,62 N/045 22,96 W		/11:06-11:32: A,E
PO98-07	60 58,81 N/045 22,57 W	60 56,24 N/045 21,51 W		/11:36-12:00: A,E
PO98-08	60 56,32 N/045 20,99 W	60 58,70 N/045 22,18 W		/12:12-12:34: A,E
PO98-09	60 58,64 N/045 21,76 W	60 56,60 N/045 20,68 W		/12:58-13:18: A,E
PO98-06A	60 56,20 N/045 21,90 W	60 58,66 N/045 22,98 W		/13:32-13:55: A,E
(Wiederholungsprofil PO98-06)				
PO98-10	60 57,50 N/045 21,16 W	60 53,13 N/045 28,47 W		/14:47-15:39: A,E
PO98-11	60 53,13 N/045 28,37 W	60 57,70 N/045 21,00 W		/17:11-18:54: E,C,D
PO98-12	60 57,85 N/045 21,16 W	60 58,39 N/045 21,81 W		/18:57-19:10: E,C,D
PO98-13	60,58,57 N/045 22,64 W	60 56,15 N/045 21,48 W		/19:25-20:14: E,C,D
PO98-14	60 55,92 N/045 21,67 W	60 55,40 N/045 22,34 W		/20:19-20:30: E,C,D
PO98-14A	60 55,60 N/045 22,45 W	60 53,05 N/045 26,28 W	31.08.98	/07:27-08:27: E,C,D
PO98-15	60 53,12 N/045 27,35 W	60 55,80 N/045 21,70 W		/09:03-10:30: E,C,D
PO98-16	60 57,74 N/045 21,26 W	60 58,50 N/045 22,60 W		/10:53-11:51: E,C,D
PO98-16	60 58,53 N/045 22,98 W	60 56,20 N/045 21,88 W	05.09.98	/08:22-09:07: D
PO98-17	60 56,33 N/045 21,06 W	60 58,73 N/046 22,20 W		/09:21-10:05: D
PO98-18	60 42,44 N/046 01,90 W	60 41,99 N/046 01,96 W	06.09.98	/11:03-11:15: C
PO98-19	60 41,82 N/046 01,91 W	60 42,42 N/046 01,90 W		/11:23-11:29: C

Tunugdliarfik Fjord

TrackNo.	Start	End	Date	Time Equipment
PO98-01T	61 12,00 N/045 29,20 W	61 05,36 N/045 24,65 W	01.09.98	/07:15-09:00: A,E
PO98-02T	61 05,36 N/045 24,65 W	61 02,95 N/045 28,17 W		/09:00-10:00: A,E
PO98-03T	61 03,00 N/045 29,13 W	61 05,10 N/045 25,10 W		/10:10-11:07: A,E
PO98-04T	61 05,60 N/045 25,10 W	61 02,99 N/045 30,12 W		/13:31-14:30: A,E
PO98-05T	61 03,00 N/045 31,12 W	61 06,10 N/045 25,17 W		/14:44-15:52: A,E
PO98-06T	61 06,32 N/045 25,90 W	61 06,32 N/045 25,90 W		/16:51-18:05:E,C,D
PO98-07T	61 06,32 N/045 25,90 W	61 08,31 N/045 29,75 W		/18:05-19:12:E,C,D
PO98-08T	61 03,05 N/045 31,88 W	61 06,27 N/045 25,76 W	02.09.98	/09:46-11:21:E,C,D
PO98-09T	61 06,27 N/045 25,76 W	61 10,62 N/045 29,44 W		/11:21-13:01: E,C,D
PO98-10T	61 09,67 N/045 30,01 W	61 06,08 N/045 26,56 W		/13:27-14:38: E,C,D
PO98-11T	61 05,62 N/045 25,99 W	61 07,55 N/045 28,62 W		/15:00-15:39: E,C,D
PO98-12T	61 07,84 N/045 28,37 W	61 08,90 N/045 27,35 W		/15:44-16:12: E,C,D
PO98-13T	61 09,10 N/045 27,17 W	61 07,70 N/045 28,49 W		/16:37-17:03: E,C,D
PO98-14aT	61 09,57 N/045 29,91 W	61 09,83 N/045 29,93 W		/18:39-18:44: E,C,D
PO98-14bT	61 29,65 N/045 29,66 W	61 29,32 N/045 29,58 W		/18:54-19:09: E,C,D
PO98-14cT	61 09,32 N/045 29,73 W	61 09,82 N/045 29,83 W		/19:16-19:28: E,C,D
PO98-15T	61 10,00 N/045 29,95 W	61 09,35 N/045 29,73 W	03.09.98	/08:50-10:51: C,S
PO98-16T	61 11,02 N/045 29,80 W	61 08,10 N/045 29,72 W		/11:40-13:04: C,S
PO98-17T	61 08,03 N/045 29,49 W	61 09,83 N/045 30,21 W		/13:35-14:26: C,S
PO98-18T	61 09,14 N/045 27,47 W	61 08,25 N/045 26,28 W		/14:54-15:18: C,S

2. Geographic coordinates of sediment cores (with water depth and core length)

Reineck Box Cores

No.	water depths	position	lengths	area	date
PO 98 - 430	222 m	60 57,13 N / 045 21,99 W	45 cm	Igaliku Fjord	30.08.1998
PO 98 - 434	296 m	60 55 10 N / 045 24,10 W	60 cm		31.08.1998
PO 98 - 435	178 m	61 08,10 N / 045 27,60 W	50 cm	Tunugdliarfik Fjord	01.09.1998
PO 98 - 437	136 m	61 10,22 N / 045 28,99 W	30 cm		01.09.1998
PO 98 - 450	304 m	60 41,89 N / 046 02,16 W	40 cm	Julianehaab	06.09.1998

Gravity Cores

No.	water depths	position	lengths	area	date
PO 243/431, 1-6	222m	60 57,12 N / 045 57,12 W	700 cm	Igaliku Fjord	30.08.1998
PO 243/432, 1-5	238m	60 57,11 N / 045 22,04 W	500 cm		31.08.1998
PO 243/433, 1-6	288m	60 55,10 N / 045 21,10 W	580 cm		31.08.1998
PO 243/436, 1-6	172m	61 08,10 N / 045 27,60 W	580 cm	Tunugdliarfik	01.09.1998
PO 243/438, 1-2	137 m	61 10,22 N / 045 28,99 W	180 cm	Fjord	01.09.1998
PO 243/439, 1-2	135 m	61 10,22 N / 045 28,99 W	180 cm		01.09.1998
PO 243/440, 1-6	230 m	60 57,12 N / 045 22 00 W	600 cm	Igaliku-Fjord	04.09.1998
PO 243/ 441, 1-6	242 m	60 57 12 N / 045 22,00 W	550 cm		04.09.1998
PO243/ 442, 1-6	231 m	60 57,14 N/ 045 22,00 W	560 cm		04.09.1998
PO 243/443, 1-5	229 m	60 57,12 N/ 045 21,95 W	500 cm		05.09.1998
PO 243/451, 1-4	304 m	60 41,96 N / 046 02,00 W	350 cm	Julianehaab	06.09.1998

3. Geographic coordinates of ROV sites

No.	water depths	position	Area	Date/Time
1 (440)	38 m	61 08,46 N / 045 30,20 W	Tunnugdliarfik Fjord	01.09.1998 / 18:55-20:42
2 (441)	48m	61 08,10 N / 045 29,93 W		01.09.1998 / 20:59-22:25
3 (442)	135m	61 10,13 N / 045 29,04 W		01.09.1998 / 23:09-00:02
4 (444)	92m	60 58,56 N / 045 22,22 W	Igaliku Fjord	04.09.1998 / 17:28-19:23
5 (445)	103m	60 58,57 N / 045 22,78 W		04.09.1998 / 20:18-20:48
6 (447)	84m	60 58,53 N / 045 22,23 W		05.09.1998 / 13:19-13:40
7 (448)	234m- -39m	60 54,95 N / 045 23,06 W - 60 54,78 N / 045 22,14 W		05.09.1998 / 14:54- -17:58
8 (449)	86m	60 53,24 N / 045 28,96 W - 60 53,46 N / 045 29,03 W		05.09.1998 / 18:59- -21:36

4. List of participants and affiliation

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5. Crew List of R.V. „Poseidon“, 24.08.-11.09.1998

Kull, Master

Szymanski, Ch.Mate

Becker, Ch.Mate

Oberdalhoff, Ch.Eng.

Trübe, 2nd. Eng

Konrath, Elektr.

Rosemeyer, Deckspl.

Kühe, Motorman

Zeitz, Motorman

Wieden, Cook

Scheller, 1. Stew.

Boldt, Boatswain

Spörck, A.B.

Rosin, A.B.

Engel, A.B.

Klävemann, A.B.

Böhnke, A.B.

Hänel, A.B.

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  zusammengestellt von Dieter Adelung
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