The Expedition ARKTIS-XIII/3 of RV "Polarstern" in 1997

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with contributions of the participants

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ARK XIII/3

TROMSØ - BREMERHAVEN

13.08.1997 - 29.09.1997

Chief Scientist: Gunther Krause

Cruise leg ARK XIII/3 Tromsø - Bremerhaven
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1. Introduction

1.1 Scientific Background

The ice conditions encountered during this expedition did not allow to carry out an important block of projects planned for the area of the Morris Jessup Rise in the North of Greenland. As a situation like this is not unlikely to occur, alternative or restricted programs had been planned in advance to be carried out in Fram Strait.

From a geological point of view this deep-water connection between the Arctic Ocean and the North Atlantic with an age of only 10 million years is a rather young feature. The opening is asumed to have started some 40 million years ago during the separation of Svalbard from Northern Greenland. Associated movements of the earth´s crust are still active. In order to investigate the underlying geodynamical and glacial processes seismic and gravimetric methods were employed. Although the top priority region could not be reached, a considerable number of seismic lines could be carried out between Northern Greenland and Svalbard and on the East Greenland Shelf while a seismic refraction experiment was performed in the Van Mijen Fjord as planned.

The geological investigations were part of a larger programme to reconstruct the history of sedimentation and paleo climate of the Arctic Basin. In coordination with the preceeding expedition ARK XIII/2 sampling concentrated on profiles along the Northeast Greenland continental margin.

The bathymetry of Fram Strait is still poorly known. In addition to the continuous measurements with the Hydrosweep system, larger areas could be charted to extend the coverage of existing bathymetric data.

The distribution of the numerous water masses of Arctic origin was studied employing CTD measurements and nutrient analyses. Finally, the hydrographical and chemical observations on a section at 75°N between Greenland and Bear Island were performed as in previous years to reveal the processes associated with the deep-water renewal in the central Greenland Sea. Marine chemical investigations also dealt with dissolved organic compounds (DOM) throughout the cruise.

1.2 Narrative of the cruise

"Polarstern" left the port of Tromsø on August 13, 1997 at 8h in the morning. On the way to the North only a couple of hours were spent for mooring work at 75°N in the Central Greenland Sea.

The intention was to head North as fast as possible. Due to a loose ice coverage progress was rapid until Ob Bank. Further North a huge triangular old ice floe (former fast ice) with a dimension in the order of some 50 nautical miles stopped the cruise towards the Morris Jessup Rise. The first part of our alternative programme came into effect, and a seismic line was performed across Fram Strait until 1°E. The way back to Ob Bank for the next try to proceed North was used for a CTD section, geological sampling and Hydrosweep surveying of the Eastern part of Lena Trough.

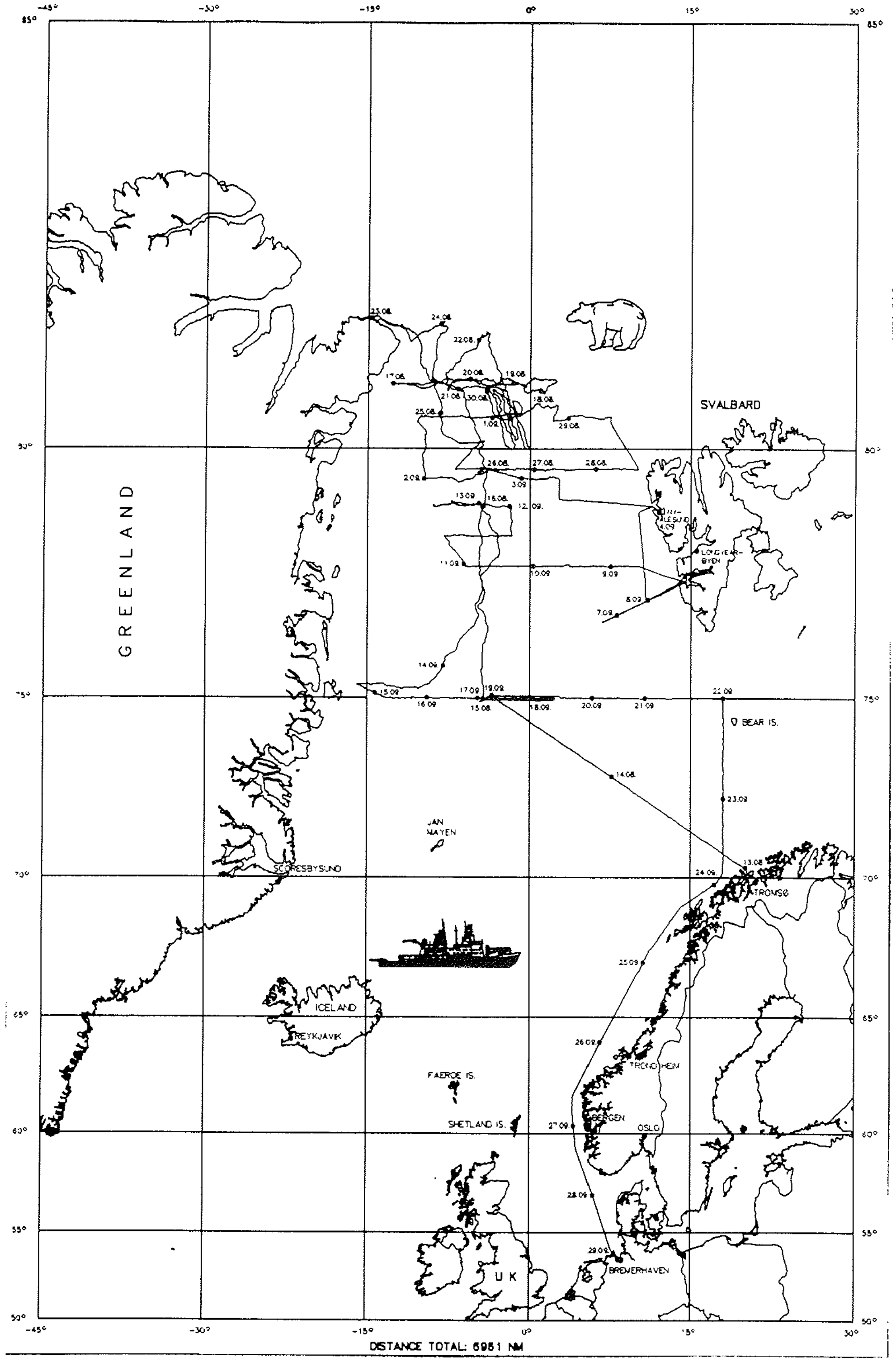


Fig. 1.1 Cruise track of the expedition

Back to Ob Bank, the mentioned ice floe was still in the North, but a small channel of about 5 nautical miles of water between Greenland and the floe was open. Towing the seismic streamer we entered the gap carefully because of missing depth entries in the sea chart. In fact, due to GPS positions we were cruising on land! After 60 miles an ice barrier limited our way towards the West, and we were forced to return to Nordostrundingen (81°N) from where the only CTD section planned perpendicular to the Greenland Shelf was performed in this area.

Following the long-term plans of Geophysics and Geology we worked on sections across Fram Strait, using the return tracks for CTD-work and bathymetric surveying - always evaluating satellite pictures for a chance to make our way towards the Morris Jessup Rise.

On the 2nd of September the large ice floe hit the Greenland coast, and we were happy to find ourselves on the safe side. Two days later we visited Ny-Alesund at the end of another section across Fram Strait. In the early morning of September 5, the extensive seismic refraction experiment in and around the Van Mijen Fjord started and was successfully completed after only 4 days.

The time saved for not reaching the Morris Jessup Rise was used for hydrographic and geological work on 79°40'N across Fram Strait and on the East Greenland Shelf. After reaching 75°N near the Island of Shannon, the rest of the expedition consisted of CTD work. Only the very last station on the Barents Sea section could not be performed because a storm of Bft. 8-9 had increased to Bft. 11. On the 29th of September "Polarstern" arrived in her homeport.

On this cruise we enjoyed the company of a non-scientific party: a photographer and a sculptor. Their cruise report follows below.

KUNST TRIFFT WISSENSCHAFT - WISSENSCHAFT TRIFFT KUNST

ARK XIII-3
mit der Wissenschaft in einem Boot
setzt die Kunst die Dinge neu ins Bild
vermittelt die Fotografie Wahrnehmungen in ästhetischer Form
erfaßt der Film die Bewegung im Eis
skizziert der Zeichenstift
setzt die Skulptur den Maßstab im maßstablosen Raum
reduziert auf das Wesentliche
macht Kunst Wesentliches sichtbar und erlebbar
zeigt scheinbar Bekanntes
oft Übersehenes
längst Vergessenes.

Kunst trifft Wissenschaft
Wissenschaft trifft Kunst

Lutz Fritsch
Britta Lauer
1997

1.3 Weather conditions
(T. Bruns)

When RV "Polarstern" departed from Tromsø at 6.30 UTC on August 13th, moderate northwesterly winds and some isolated showers indicated the retreat of a low over Finland. After a calm day under high pressure influence a new low developed off the Greenland coast on August 15th. During the recovery of a mooring at position 75°N 3°W the windforce was 5 to 6 Beaufort, but in the afternoon, the wind weakened. The first relatively large iceberg was observed at 75°N 3.4°W.

In the following days, "Polarstern" escaped from the current track of cyclones. Sea ice occurred with increasing frequency and density. North of 80°N, the first shallow fog banks, characteristic for arctic summer, were encountered. Fog cleared up at 81°N on August 17th getting close to the northeastern Greenland coast, allowing for undisturbed helicopter operation. Calm weather with rapid changes between fog banks and very good visbility in dry arctic air dominated the first part of a traverse along 81°N across Fram Strait. On August 19th and 20th, a low approached from the south with periods of snowfall und freezing fog.

Subsequently, a low over northern Canada and a strong arctic high were accompanied by moderate southerly winds over northeastern Greenland, increasing the chance for a polynya along the northern coast. "Polarstern" returned to Greenland in order to enter the northeastern fjord system. On a sunny August 22nd, several helicopter flights were undertaken to investigate the ice conditions in the Wandel Sea and the adjacent coastal waters. However, cirrus clouds over Greenland announced an approaching change. In the late afternoon, the vessel was already hidden under a low stratus ceiling.

Due to the uncertainties of arctic weather and in view of the unfavourable ice situation, the original plan to reach Morris Jessup Rise had to be given up. A substitute plan was to investigate Fram Strait in detail on traverses along 79°40'N and 80°40'N. The weather during the next week was characterized by a large zone of high pressure between Alaska and the European Arctic. At the same time, frequent cyclonic activity took place over northern Canada, only sometimes penetrating eastward and interrupting the foggy days with light snowfall.

This period ended, when the occluded front of a low near Jan Mayen brought rain and dense fog for two days. After the low had moved to Fram Strait very slowly, "Polarstern" experienced heavy snowfall and northwesterly winds in it's rear on September 1st. Good conditions returned together with southwesterly winds when another north canadian low took control. All Helicopter operation in the Northeast-Water-Polynia region were carried out successfully.

Between September 2nd and 4th "Polarstern" crossed Fram Strait again, heading for Spitsbergen. Conditions varied between sun, fog and snow. After a one day visit of Ny Ålesund, where sun rarely showed up, the scientific program was continued in Van Mijen Fjord. Many flights were necessary to take geophysical equipment to land stations. Due to a high over Spitsbergen, the plan was almost fulfilled in the evening. However, in the meantime, a frontal system of a Jan Mayen low had reached the southern tip of Spitsbergen, while easterly winds increased to force 7 inside the fjord. Mountains were cloud covered in the morning of September 6th, but the remaining flight missions could be completed before noon.

The low moved to Fram Strait and deepened further, while "Polarstern" headed southwestward running the geophysical experiment under strong southerly winds. The land equipment had to be picked up on September 8th under poor conditons. Low clouds persisted until late afternoon before the last helicopter returned. A new storm low had moved from Iceland to the Norwegian

Sea and weakened slowly in the following. Therefore, northerly winds with force 5 to 7 were dominant for 2 days, when "Polarstern" left Spitsbergen for another westward traverse.

The next disturbance approached from northeast with heavy snowfall in the early morning of September 12th. The meeting of arctic and moderate air masses now caused cyclonic activity to concentrate over the Greenland Sea for 2 days. Another strong low, however, developed again over the Norwegian Sea on September 15th, accompanied with increasingly stormy northwest winds over the Greenland Sea. "Polarstern" now slowly traversed along 75 N in eastward direction.

Due to waves up to an average of 4 meters two new Jo-Jo-Moorings could not be put out, when the intended positions were reached. Thus, "Polarstern" continued on her eastward course and returned in the morning of September 19th, when waves had diminished under intermediate high pressure influence. Later, the meridional circulation was established again by a low over Barents Sea and a Greenland high. On September 22nd, Bear Island weather station was visited by helicopter under marginal conditions: northerly winds 6 to 7 and frequent snow or rain showers.

The transition to a westerly air stream began on September 23th with a new low moving from Greenland to the area north of Norway, while a high strengthened over Scotland. Rain and wind force between 6 and 8 from west to southwest complicated a helicopter flight to Tromsø-Airport. During the next days, a whole family of cyclones followed on the same track with increasing intensity. Therefore, "Polarstern" had to steam against westerly winds 8 or 9, shortly even 10, until early September 26th. Finally, the cruise through the North Sea under high pressure influence was very calm and "Polarstern" entered Bremerhaven on September 29th on time.

2. Physical Oceanography

(G. Budéus, W. Schneider, R. Plugge, K. Bittner, S. Ronski, M. Hoock, AWI)

General

The work of the Physical Oceanography group concentrated on two main items, one being the long term changes in the Greenland Sea, the second being the water mass analysis in Fram Strait. The Fram Strait work was implemented as an alternative programme since the Morris Jessup Plateau could not be approached due to actual ice conditions.

The Fram Strait work consisted of a number of east-west transects, which are located on 81°N, 79°40'N,and 77°55'N. They have been sampled with a station distance of about 10 nautical miles, with a somewhat higher resolution on the slopes. Care has been taken to include the deep troughs in the stationwork. An additional short transect could be performed to the northeast of Nordostrundingen. This dataset will in particular allow a distinction of deep water masses north and south of the Fram Strait sill and contribute to concepts of deep water exchange.

The sampling in the Greenland Sea continued field work of previous years. It is focussed on the understanding of changes in water properties with and without winter convection and is presently incorporated in the EC project ESOP-2. A longer time series is necessitated to identify the conditions under which deep convection occurs and to resolve processes acting under its absence. During the last few years (1990 to 1996) a clear increase in bottom water temperature was observed, amounting to roughly 10 mK/a. The temperature increase affected not only the bottom waters but rather the entire water column below 2000 m. At the same time, no deep convection could be identified during this time interval.

During ARK XIII/3 the time series was continued by an east west transect across the Greenland Sea at 75°N. One of two moored deep sea profilers was recovered and two were deployed. The mentioned stationwork was complemented by a north south transect between Bear Island and Norway in order to construct a closed box for transport calculations.
The complete station grid is depicted in Fig. 2.1.

Equipment and methods

For the station work a ‚SBE 911 plus' CTD with duplicate T and C sensors was used. The duplication allows for immediate checks of sensor drifts on board. Water was sampled by means of a SBE32 rosette, equipped with 16 bottles of 12 L content and 8 bottles of 5 L content. The equipment worked faultlessly.

For temperature calibration our SBE35 Ultra Precision Deep Sea Thermometer underwent its first sea application. The thermometer is triggered by the SBE32 rosette each time a bottle is fired and stores measured temperatures internally.

Comparisons between SBE35 and CTD measurements have been restricted to depth levels below 2000 dbar to ensure a thermally quiet environment. Checks of vertical temperature gradients showed, however, that even in the closed basins of the Arctic Mediterranean a constriction to these depths does not guarentee temperature fluctuations small enough to allow for in situ calibrations on the level of 1 mK. At each sampling point it has been individually verified that temperature calibration is allowed (see Fig. 2.2). The valid data points are identified by the larger size of the respective dots in Fig. 2.3.

All CTD measurements at valid calibration points are well within a deviation of 1 mK from the SBE35 values, the primary temperature sensor of the CTD showing maximum deviations of about 0.5 mK.

Water for salinity checks has been sampled at chosen locations and will be analysed in the lab. An RDI ADCP (150 kHz) has been running continuously.

Moorings

only one of the two moorings deployed in 1996 with RV "Petr Kottsov" could be recovered (74°59'N, 04°20'W). The second mooring (74°58'N, 03°04'W) did not come up although the releaser could be ranged and did answer to release attempts. Since it could not be deployed at the planned location in 1996 but had to be dropped at a more shallow spot, we suspect that the top buoyancy was at the surface instead in a depth of 75 m. Most probably the top bouy did not survive the winter ice. Thus the mooring is likely to be lost. The recovered mooring was principally intact, however with the control unit dispatching the weights to the moving JoJo-vehicle being flooded after only a few days. Consequently, the mooring sampled only surface values (70 m depth, 90 minutes per day) then. The downward speed of the vehicle exceeded pre-launch estimations and amounted to about 1 m/s.

Two new JoJo-moorings have been deployed successfully during ARK XIII/3. The positions are 75°04.8'N, 03°26.9'W and 74°54.8'N, 04°36.8'W. The vehicle design is unaltered but the control unit had been modified including the part that was responsible for the leakage.

SF6 sampling

Within ESOP-2, SF6 has been released into the Greenland Sea as a tracer. Due to heavy ice conditions the western part of the Greenland Gyre could not be sampled up to now. Therefore the Polarstern cruise has been used to fill this gap. Samples have been taken between 12°W and 1°E on 75°N. One additional sampling station was placed at 77°55'N, 01°11'E to investigate the spreading of the tracer towards the north. The samples will be analysed by M.-J. Messias, University of Northeast Anglia.

CTD station work

The transect on 75°N extends from the East Greenland to the Norwegian shelf. For decisive conclusions the final calibration has to be awaited, but owing to the high quality of the primary data some ad hoc statements can be made nevertheless.

A modification of the upper water column down to about 1000 m is obvious at all stations in the central gyre. The salinity is clearly lower than in the preceeding year and amplitudes of temperature fluctuations have increased, both serving as indicators for winter convection. At a number of stations isolated volumes of water cooler than their surroundigs are detected.

The local vertical temperature maximum at roughly 1500 m depth, observed since 1994, still persists. From 1996 to 1997, modifications of the deepest parts of the water column are only marginal, with no conclusive temperature increase being observed. The continuous warming of the deep waters, as observed the last few years, did clearly cease. A preliminary version of the temperature transect is presented in Fig. 2.4.

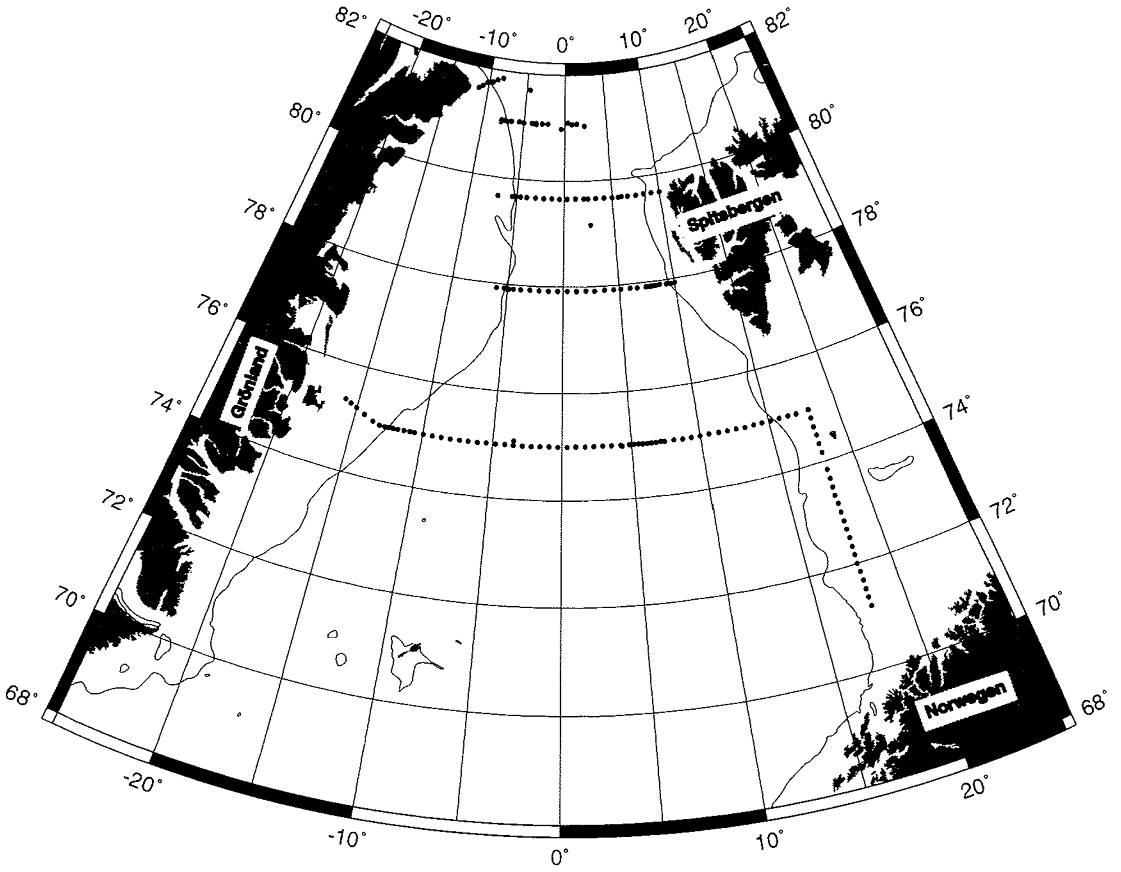


Fig. 2.1 CTD stations performed during ARK XIII / 3

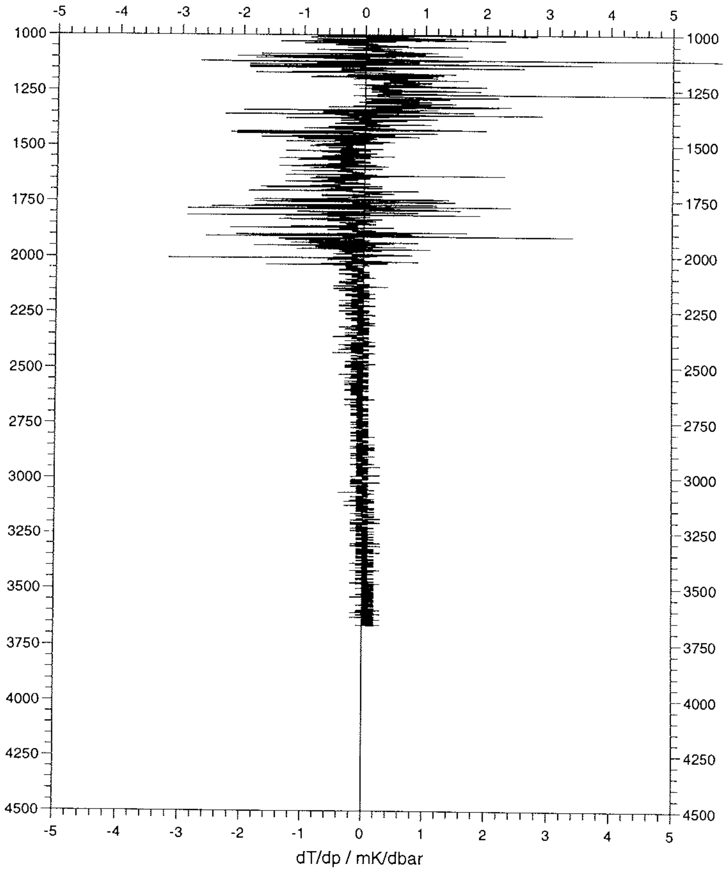
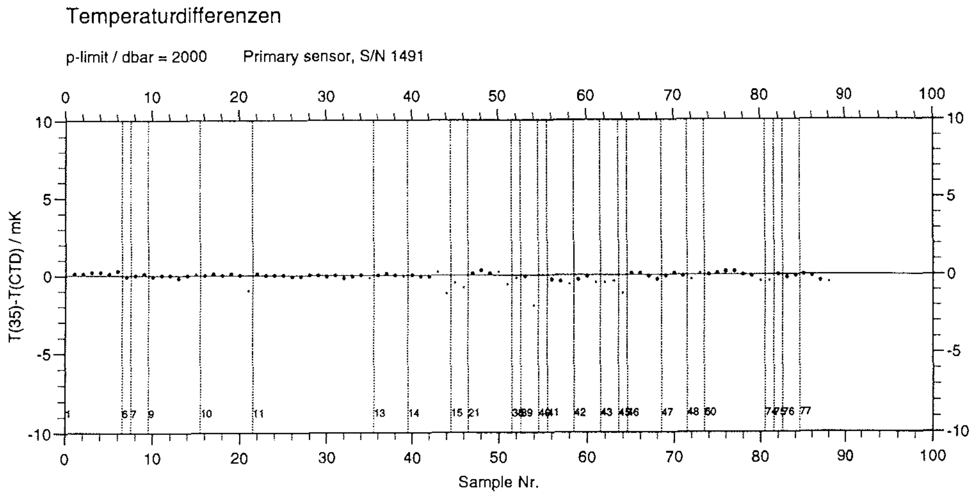


Fig. 2.2 Profile of temperature gradients (ΔT/Δp) between 1000 dbar and bottom, plotted for a decision at what locations in situ temperature calibrations are allowed. In this case calibration attempts above 2100 dbar are invalid. The station is at 75°N and 3°W.



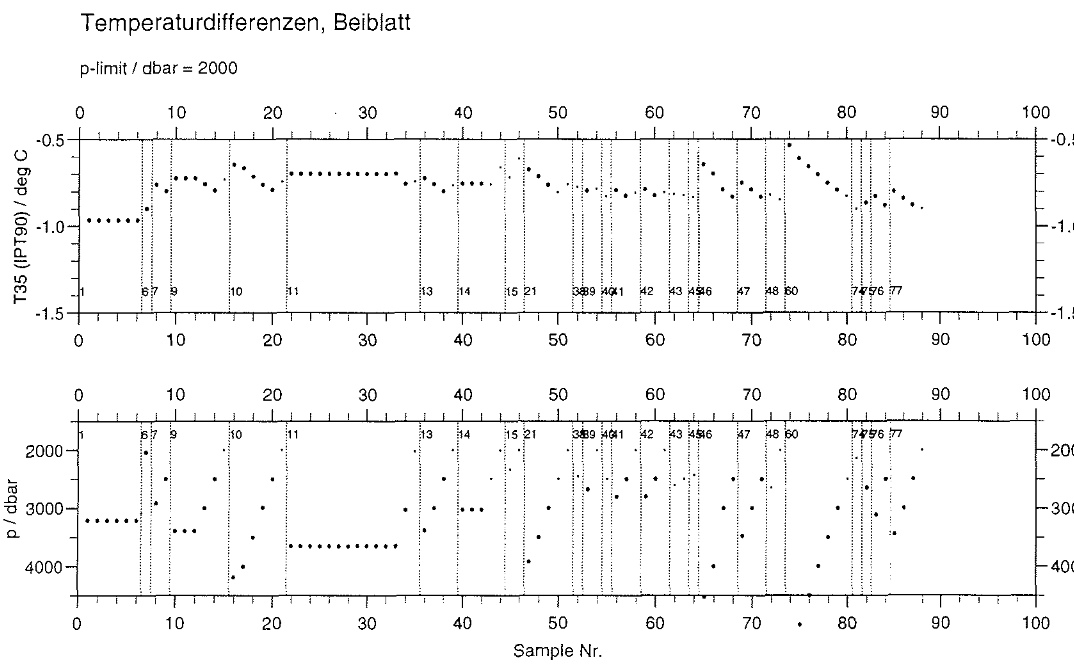


Fig. 2.3a+b Example of field calibrations by means of the SBE35. Fig 2.3a) shows differences between the reference and the CTD-thermometer. Stations are annotated and separated by vertical lines. Calibration locations have been restricted to pressure levels greater than 2000 dbar. Valid calibration points are indicated by bigger dots. At small dots the ocean has not been quiet enough thermally. Fig. 2.3b) shows temperature and pressure values of the calibration points.

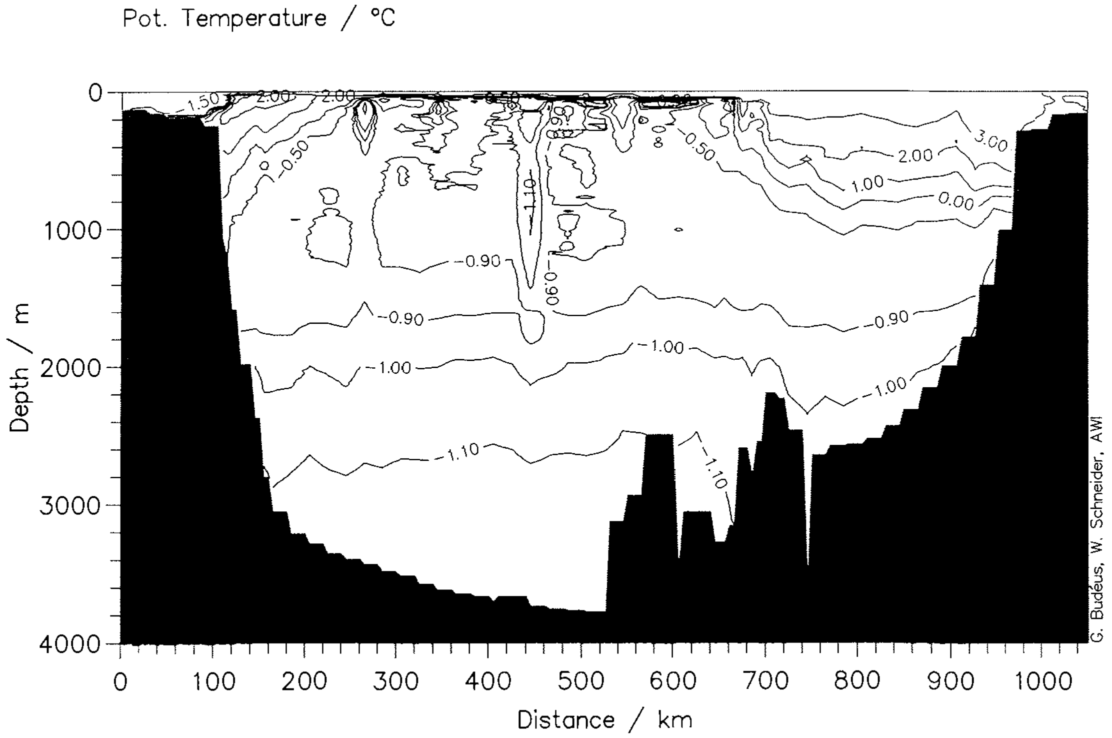


Fig. 2.4 Preliminary plot of the temperature distribution on the 75°N-transect.

3. Marine Chemistry

(Ingeborg Bussmann, Rainer Amon, Ralph Engbrodt, Carmen Hartmann, Andreas Ratje, Marthi Stürcken-Rodewald, Anja Terbrüggen, AWI)

Dissolved Organic Matter

Dissolved organic matter (DOM) in the ocean is one of the major pools of organic carbon in the biosphere and as such has the potential to influence the global carbon cycle on a time scale of 1000 to 10000 years. The Arctic Ocean is characterized by a great input of freshwater, partly due to large river discharge from Siberian rivers. In previous cruises near the Siberian shelf natural DOM was characterized on an elemental level, while humic substances, extracted by resin chromatography, were analyzed on a molecular level. Modifications of DOM, mainly by bacteria will alter the chemical structure of this material. One goal of this cruise was to gather samples to compare their chemical structure with the ones found on the Siberian shelf and other regions of the worlds ocean. Bacterial activity will reduce part of the Arctic DOM, but a large and recalcitrant portion of DOM will remain in the out flowing Arctic Water. Therefore the heterotrophic activity of microbes growing on natural DOM and humic substances was also investigated.

Two methods were used to isolate DOM from the sea water matrix. Tangential-flow-ultrafiltration through 1000 Dalton filters was used to concentrate DOM up to 200 fold. Humic substances were extracted by passing sea water through macroporous hydrophilic resins (XAD 2 and 4).

Ultrafiltrations and XAD extraction of HS were carried out in all characteristic water masses of the region, Polar Surface Water, inflowing Atlantic water, Return Atlantic Water, deep water derived from the Eurasian Basin, intermediate water derived from the Canada Basin, and at several depths in the Greenland Gyre. Additionally, one ice flow and probably very old water at 5600 m from the Moloy Deep were sampled. Ultrafiltered DOM will partly be analyzed at the AWI and at the University of Texas Marine Science Institute as part of a starting cooperation between UTMSI and the AWI. Chemical characterization of the isolated DOM will include stable isotopes (C,N), carbohydrate composition, amino acid and lignin phenol analysis.

Additional samples for analysis of DOC (dissolved organic carbon), simple carbohydrates and DON (dissolved organic nitrogen) were taken along 5 transects at 74 stations (see map). All samples were filtered through precombusted glass fiber filters, filled in precombusted glass ampoules and stored frozen. Some DON samples could be analyzed on board. For DOC measurements the Total Organic Carbon Analyzer onboard proved to be incompatible with the ships movement and vibrations due to ice breaking, waves and seismic measurements.

Bacteria are mineralizing and modifying DOM. To determine the bacterial activity following parameters were measured: Leucine incorporation rate, oxygen consumption and DOC removal. Bacterial activity was measured under different conditions:

a) *in situ* activity

With high spatial resolution (42 stations) bacterial leucine incorporation was measured in the upper 100 m along the 5 transects. Along with leucine incorporation we measured community respiration at selected stations.

b) bioavailability of natural DOM

At three stations we set up a long term (200h) decomposition experiment to evaluate the biolability of natural DOM. Additions of nitrate, phosphate or glucose can give information on the growth limiting factors in this environment.

c) bioavailability of humic substances

Humic substances were isolated at different depths (i.e. age and origin of the HS) and their bioavailability was compared. Also, the bioavailability of the different fractions of the HS-extraction (neutral, acid and hydrophilic fraction) were determined. The influence of

temperature and substrate concentration was also investigated. Experiments with the recalcitrant HS lasted up to 400 h at 0°C.
Unfortunately it was not possible to measure the parameters onboard, therefore we have to wait for the analysis in Bremerhaven.

Nutrients

In the Arctic Ocean nutrient concentrations provide a valuable tool to trace water masses and to detect transport and mixing mechanisms. By this means a water mass with high silicate concentrations can be traced to the Greenland Sea. This water mass is propably Pacific water entering the Arctic through Bering Strait.
The concentrations of dissolved inorganic nutrients, nitrate, nitrite, phosphate and silicate were determined in high spatial dissolution. Water samples taken with CTD casts were analyzed immediately on board with a Technicon Autoanalyzer system according to standard methods. Nutrients were determined at all stations from usually 24 depths distributed between surface and bottom. The sampling schedule followed standard oceanographic depths.
On five transects, across the northern Greenland continental slope, across Fram Strait at 81°, 79°, 78° and across the Greenland Sea at 75°N the nutrient distribution was measured and compared with oceanographic parameters.
High concentrations of silicate, indicative for presumably Pacific water could be followed from the north to the south, reaching maximal values of 20 µM at the Greenland slope. Phosphate concentrations were also elevated and showed the same distribution pattern as silicate. At the Greenland slope the concentrations of silicate and phosphate in the Arctic Surface water (30 - 50 m) were two to three fold higher than in the central Greenland Sea. At the 75°N transect east of 12°E a steep decrease of silicate and phosphate concentrations was detected, with maximal differences of 6 and 0.3 µM respectively.

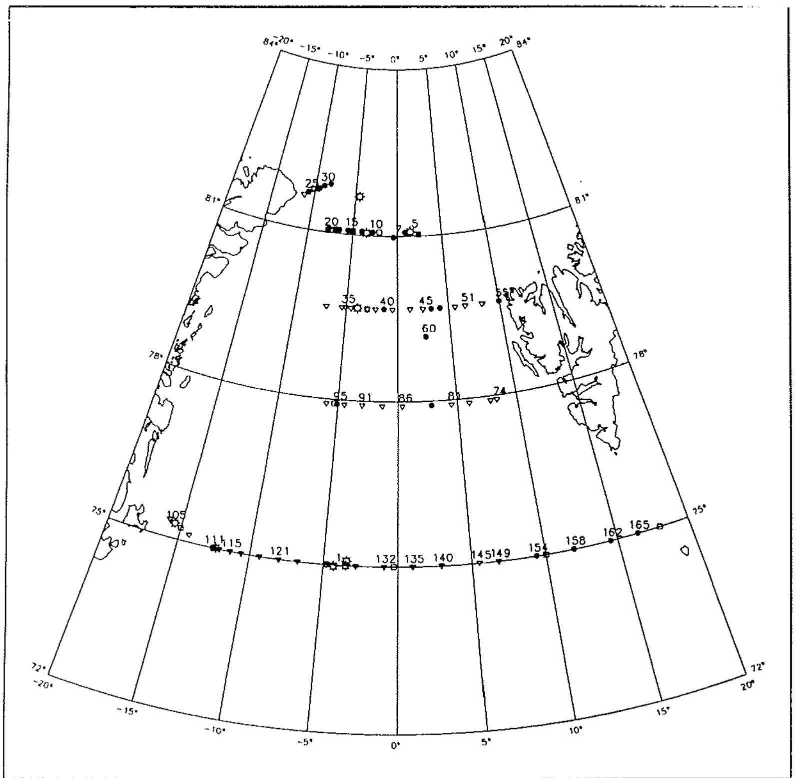


Fig. 3.1 Location of sampling for DOM, v bacterial production, x ultrafiltration and extraction of humic substances

4. Bathymetry

4.1 Extension of the Seafloor Mapping of the Fram Strait with HYDROSWEEP

(K. Heidland, O. Böhne, B. Dallmeier-Tießen)

The last week of the leg ARK XIII/2 was used for a bathymetric boxed survey with the multibeam echosounding system HYDROSWEEP. This survey was planned for the leg ARK XIII/3. The bathymetric group came already on board of RV "Polarstern" on August 4th in the vicinity of Longyearbyen and started the HYDROSWEEP operation.

The first planned HYDROSWEEP survey north of 80° N had to be canceled because of heavy ice conditions and compact ice coverage which caused HYDROSWEEP failures. Satellite images with the actual ice coverage for the profile planning in that area were not available.

Therefore the box survey was carried out east of the precisely mapped area between 77°55'N - 78°50'N and 5°E - 8°E. In order to achieve the best coverage of the area 22 parallel profiles were planned with a distance of 2 nautical miles in the northern and 2.5 nm in the southern part.

The processing on board included the editing and cleaning of the navigation and depth measurements with the graphic editor HDCS of the Caris system, the computation of isolines for the profiles along the ships track, the gridding of measurements and the determination of a digital terrain model (DTM).

The 3d-view (Fig. 4.1) gives an impression of the seabottom topography. The trench west of the Knipovich Ridge ends in the SE of the surveyed area, the NE shows the Spitzbergen shelf.

4.2 First Seafloor Mapping of the Lena Trough with HYDROSWEEP

(K. Heidland, O. Böhne, B. Dallmeier-Tießen)

The bathymetry of the Fram Strait is poorly known except for the boxed surveys carried out with the well-established multibean systems by RV "Polarstern". Precise mapping of the seafloor along the Lena Through and from the northernmost part of the Knipovich Ridge extended the existing boxed surveys.

HYDROSWEEP was operated continously from August 13th until September 23rd parallel to all seismic profiles and between the oceanographic and geological station work. Special multibeam profiles were planned parallel to existing multibeam profiles wherever it was possible.

The HYDROSWEEP system provides also sidescan sonar data. These data consist of the amplitude of the backscattered energy for each ping. The waveforms from the 59 beamformers are combined and resampled to yield 1000 amplitude values across the swath. These data were plotted continously in map form on a display to provide a view of relative scattering strengh of the seafloor. Sidescan data were stored every second day on DAT for further processing.

Navigation and Data Processing

Navigation data and the data from all sensors which are relevant for the scientific work were collected, distributed and stored on the VAX computer. All sensors which are necessary for the bathymetric data processing were extracted in a 15 second interval by the POLDAT system. All positions were checked against errors with the graphic editor HDCS, offsets larger then 100 m were corrected or eliminated.

Differential GPS on board of RV "Polarstern" is supplied by the SkyFix system using the Inmarsat satellites as the differential data broadcast link. Differential corrections used for this cruise were generated at reference stations located in Norway or Scotland.
The working area between Greenland and Spitsbergen is only partly covered by the Inmarsat satellite AOR(E) (position: 20°W over the equator) for the eastern part of the Atlantic ocean region. Therefore differential GPS was only partly available especially north of 80°N.

Data Processing
All HYDROSWEEP measurements were stored on magnetic tape and on the vax computer AWI30 which is connected with the HYDROSWEEP system. Online output of contourplots used raw data on the AWI30 display or on the plotter oce 1835 for special tracks. The daily processing on board included the editing and cleaning of the depth measurements with the graphic editor HDCS of the Caris system and the computation of contourplots for all profiles along the ship's track.

Boxed Survey of the Lena Trough
The Lena Through is part of the Mid Ocean Ridge and the northern continuation of the Spitsbergen Fracture Zone.The seismic profile from the Greenland shelf to the Yermak Plateau and the oceanographic CTD profile back crossed the Lena Trough at 81°N. Poor ice coverage in that area enabled a first HYDROSWEEP survey on August 21st along the eastern slope of the Lena Trough from 81°N until 81°40'N where compact ice coverage stopped the ship. The depth of the trough is 4300 m.

A box survey was carried out from August 31st until September 2nd. Seven parallel profiles in a distance of 3 nm and a course of 160°/340° followed the axis of the trough. Compact sea ice fields often forced the ship to change the course and to leave the planned profile. However, the HYDROSWEEP measurements covered the whole box and only a few small gaps remained. It was the first possibility to map the Lena Through. Before, this northern regions was almost covered with compact sea ice.

The 3d-view of the Lena Trough (Fig. 4.2) illustrates the bathymetry. The trough ist 4300 m deep, in the southern part between 80°20'N and 80°40'N 8 km wide, spreads up to 15 km and becomes again smaller to a width of 8 km. An offset of 5 km at 81°N and a change of the axis direction characterize the trough and indicate tectonic activity.

Plotting Sheets 1 : 200000
Bathymetric charts provide essential information for the marine scientific work. It is necessary to have bathymetric charts for the planning before and during a scientic cruise.

Multibeam measurements from 1984 until 1987 with SEABEAM and from 1990 until 1997 with HYDROSWEEP DS were used for the preparation of plotting sheets with a scale of 1:200000.

The index of the bathymetric plotting sheets corresponds with the catalogue of the General Bathymetric Charts of the Ocean (GEBCO) published by the International Hydrographic Organistion (IHO). The GEBCO sheets no. 581, 589 and 590 were divided in subsheets with 1° N-S and 5° W-E extension. Two series with 70 plotting sheets were plotted during the leg ARK XIII/3. The plotting sheets are available on board of "Polarstern" and in the AWI.

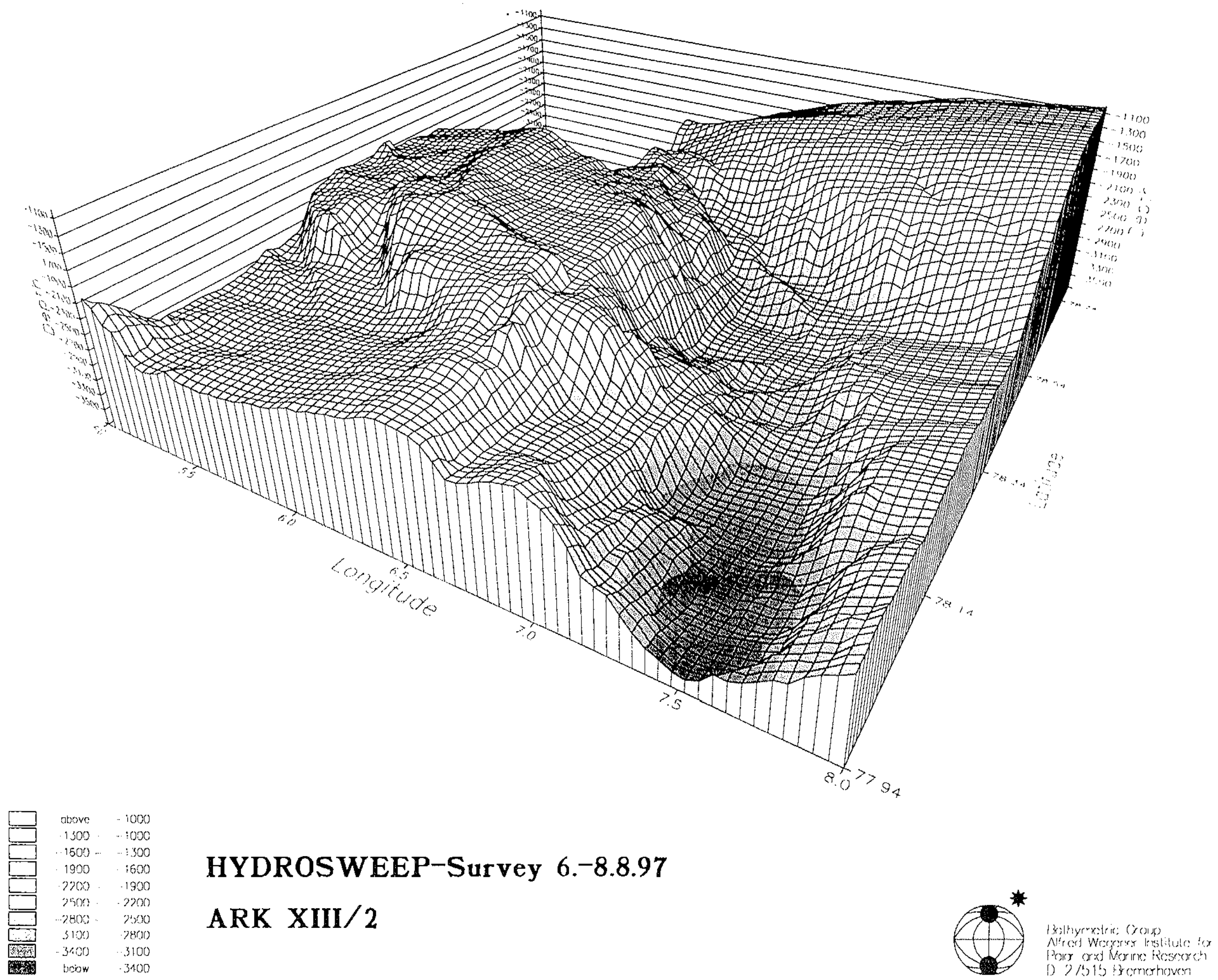


Fig. 4.1: 3d-view of the northern part of the Knipovich Ridge

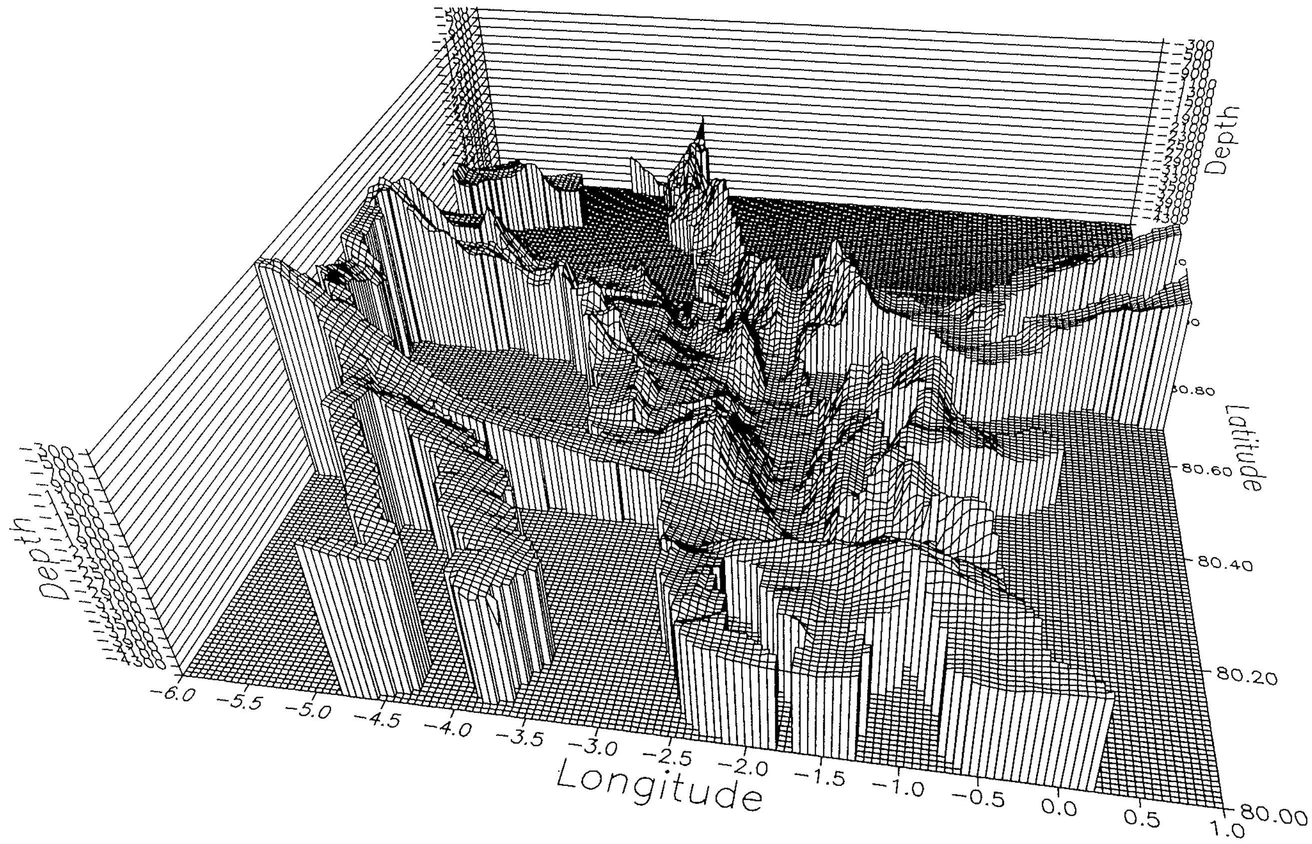


Fig. 4.2: 3d-view of the Lena Trough

5. Marine Geology

(H.-P. Kleiber, N. Lensch, G. Nehrke, N. Nørgaard-Pedersen, F. Schulze, O. Swientek, D. Weiel)

5.1 Marine geological investigations of the northern Fram Strait during ARK XIII/3

(N. Nørgaard-Pedersen)

The geological investigations in the Arctic Ocean and the adjacent ocean and shelf regions concentrate on detailed stratigraphical, sedimentological, mineralogical, and geochemical analyses of sediments. These studies aim at reconstructing the short and long-term changes in paleoclimate, paleocenographical circulation, paleoproductivity and ice cover of land and sea areas. The connections to the adjacent oceans are of particular importance to understand the paleoceanographical development, of which the Fram Strait is most important for surface and deep water exchange between the Arctic Ocean and the global ocean.

For ARK XIII/3 it was planned to sample the unknown North Greenland continental margin. As ice conditions allowed navigation only up to about 82° N, emphasis was placed on profiles along the northeast Greenland continental margin. This was done also in coordination with ARK XIII/2 core sites, having the Yermak Plateau as a key investigation area.

5.1.1 Geological sampling

During expedition ARK XIII/3, a total of 22 geological coring stations were carried out. All coring positions were carefully selected based on PARASOUND profiling (see Chapter 5.3). The main study areas were the continental slope of Northeast Greenland and the Fram Strait between 79°N and 82°N (Fig. 5.1, 5.2).

In order to get undisturbed surface and near-surface sediments, a large box corer (GKG: 50x50x60 cm) was used. Sampling with the box corer was carried out routinely on all geological stations, except one. In all cases sediment sequences were succesfully recovered. At 17 sites, long gravity cores were taken parallel to the box cores. The 'Schwerelot' (SL) gravity core used has a penetration weight of 1.5 t and a core barrel segment lenght of 5 or 3 m with a diameter of 12 cm. The core barrels used had lengths of 5, 8, and 10 m. The longest SL-core taken was 6.78 m long. At 3 sites the 'Kastenlot' (KAL) gravity core were used. The KAL-core has a penetration weigth of 3.5 t and core barrel segments of 5.75 m with a square cross section of 30x30cm. The core barrels used had lenghts of 5.75 and 11.50 m plus 35 cm for the core catcher. The maximum length penetrated with the KAL-core was 5.47 m (exclusive the core catcher (30 cm)). In one case the core catcher of the Kastenlot did not close (site PS2880) and the KAL was therefore run again.

5.1.2 Sedimentological methods applied onboard "Polarstern"

All cores taken were logged with the multi-sensor core logging system (see Chapter 5.2.1). Based on that selected cores were opened, described and sampled onboard. Sampling was performed for detailed shorebased stratigraphic, paleoceanographic, geochemical, and micropaleontological studies (AMS ^{14}C dating, stable isotopes, x-ray diffraction, grain size, coarse fraction, carbonate, organic carbon, microfossil assemblages, etc.).

The sediment cores opened, were routinely photographed and described, and are graphically displayed within the Annex. Sediment colours were identified according to the "Munsell Soil Color Chart". Radiograph slabs of 0.5 cm in thickness were taken continously from all cores to elucidate sedimentary and biogenic structures and to determine the content of coarse-grained detritus. Moreover, selected sub-samples were washed through a 63 mm sieve and dried. The coarse fraction was analysed using a binocular microscope to estimate the lithogenic/biogenic composition (Fig. 5.4). Shipboard analyses of density properties on discrete samples were conducted on the long Kastenlot cores and have been compared to the logging results (see Chapter 5.2.2).

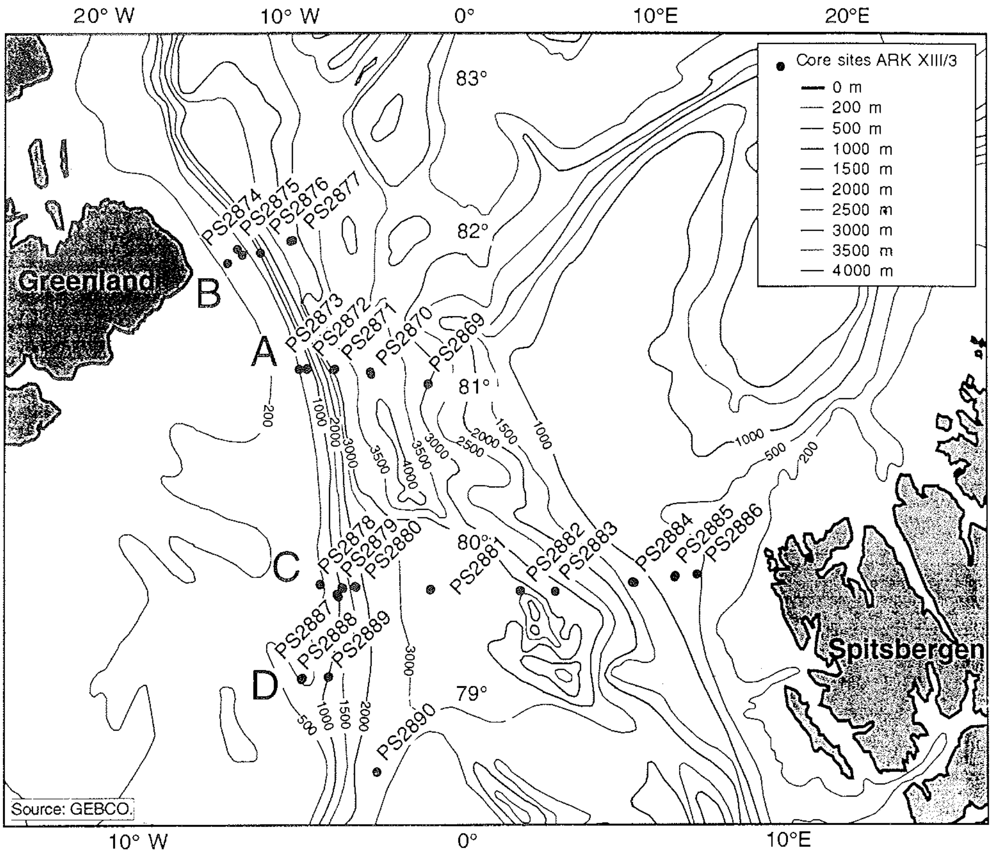


Fig. 5.1: ARK XIII/3 Core site locations. Profiles A-D are referred to in the text.

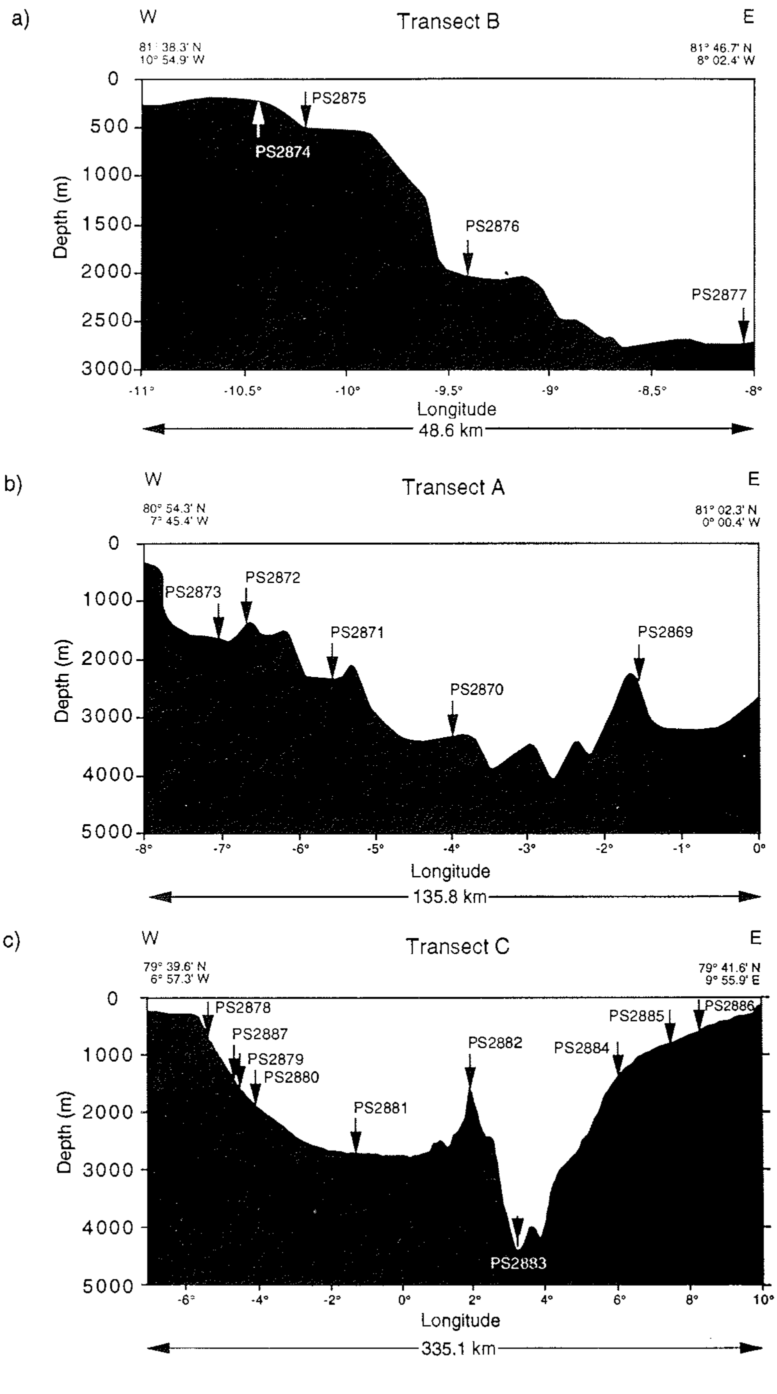


Fig. 5.2: Bathymetric Profiles A-C and core sites. a) Profile B, b) Profile A, c) Profile C

5.1.3 Sediment description and lithostratigraphy

The near surface sediments of box cores taken from the Fram Strait and the continental slope of NE Greenland in general are composed of brownish silty sandy clay or silty clay with a common occurrence of dropstones, and planktic and benthic foraminifera. More sandy sediments, or even gravel pavements, with abundant dropstones and biogenic remains were found at northeast Greenland outer shelf sites (e.g PS2874, PS2875) and on sea mounts (e.g. PS2871, PS2882).

The sedimentary sequences of the longer gravity cores show a variety of colours and textures. In general silty, sandy clays with a variable content of pebble-size dropstones and planktic and benthic calcareous foraminifera dominate. Intercalated well-sorted sandy sediments or heterolithic grayish sediment units showing alternations of silty clays and sand-silt lamina or lenses are commonly also found. Noticeably differences are found between the cores taken from the NE Greenland slope at the northernmost profile (B) and the cores taken from profile C at about 79° 40' N. In the following the sediment sequences from profile B and C are described separately.

Profile B.
4 box cores and two SL- cores were taken along profile B from the outer shelf (208 m) to the lower part of the slope (2699 m). Box cores 2874-1 and PS2875-1 from water depths of 208 m and 488 m respectively, both show very similar sequences. The surface is covered by dark Fe-Mn-stained gravel. Below a brown silty clay with scattered pebbles and cobbles are found. The box cores retrieved from the deeper part of the slope (PS2876-1, PS2877-1) show silty clayey sediments, remarkably poor in dropstones. Below a 5 cm brown top layer, characteristic reddish brown colours dominate.

The 6.78 m long SL-core PS2876-2 (water depth 1991 m), opened on board, reveal that reddish brown and reddish grey colours also characterise the longer sediment sections at profile B. Thin layers of greyish or olive colours are also found. Sandy silty clays with only scattered dropstones dominate. About 1 m below surface, a 20 cm thick pebble-rich layer is found. Below 450 cm, thin beds (2-10 cm) of well-sorted sand or fine gravel (turbidites?) are found intercalated with silty clays or silty sandy clays.

Profile C.
5 long cores from the western part of profile C were opened on board and described in detail. Lithostratigraphic correlation of the sediment cores were done convincingly by aligning archive boxes of several cores along each other. Hereby delicate changes in colours, texture and internal structure could be compared and distinct units correlated. The cores have been taken from water depths of 717 m (PS2878) to 2669 m (PS2881) and include also three kastenlot cores taken at sites PS2879, PS2880, PS2887, from water depths of 1411 m to 1853 m (Fig. 5.3). Silty, sandy clays with units rich in pebble-size dropstones and mud clasts dominate. Colours range from dark grey, to olive green, reddish grey and yellowish brown. Bioturbation mottling obscuring a weak internal stratification are frequently observed. These units commonly have a high percentage of planktic and benthic foraminifers in the coarse fraction investigated (>63mm). Intercalated between the mottled units are well-stratified heterolithic greyish sediment units (20-100 cm) showing alternations of silty clays and sand-silt laminae or lenses. In general bioturbation mottling of these greyish units are absent and most of them are barren of microfossils. The lower boundary of the grey units are sharp, weak erosive and often superimposed by a cm-thin strata of coarse to pebbly sand.

The characteristic coloured sedimentary units in all 5 cores allow a detailed lithostratigraphic correlation (Fig. 5.3), which is supported also by core logging results (Fig. 5.6). From the

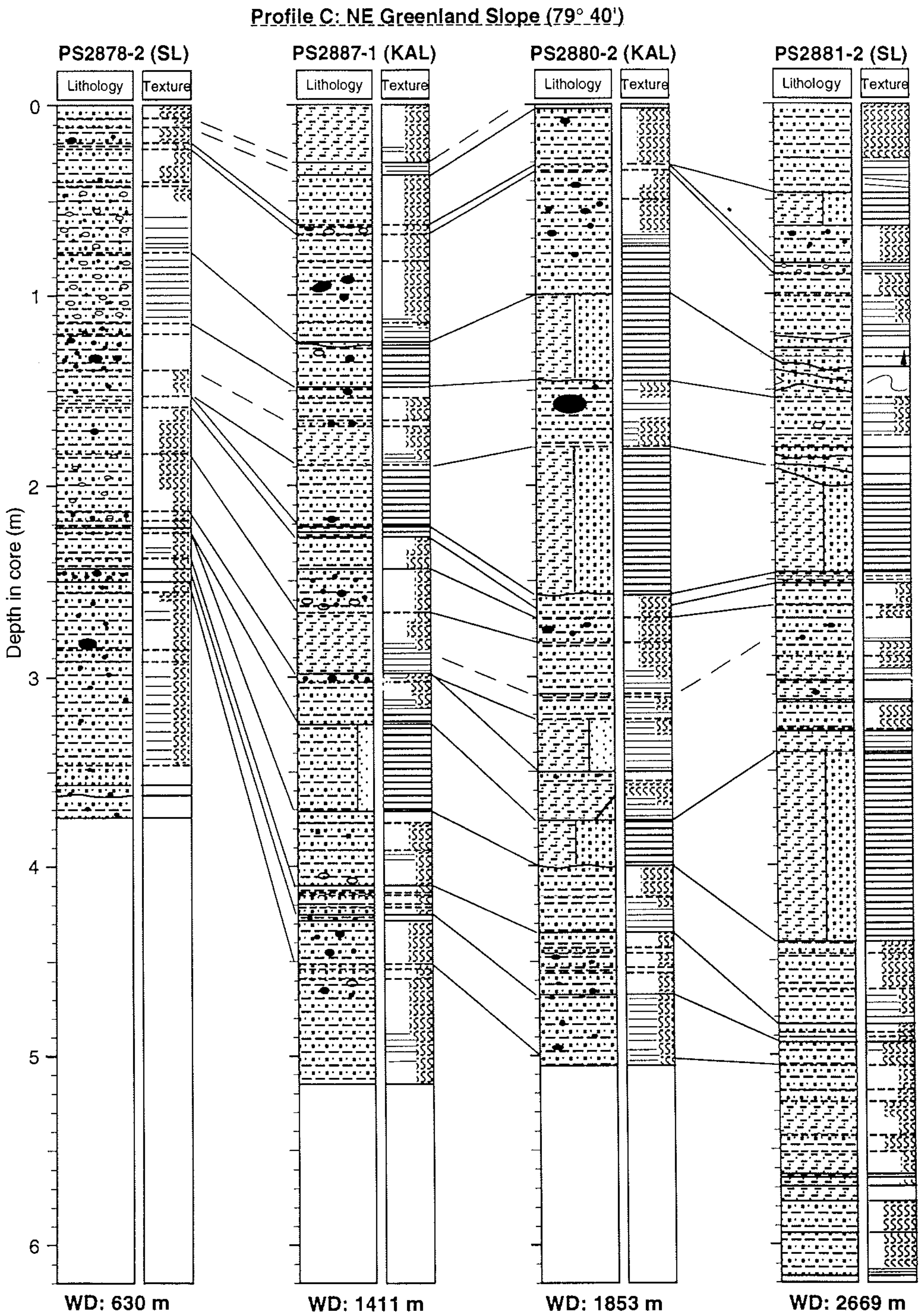


Fig. 5.3 Suggested lithostratigraphic correlation of cores PS2878-2, PS2880-2, PS2887-1, and PS2881-1 from the northeast Greenland slope (profile C).

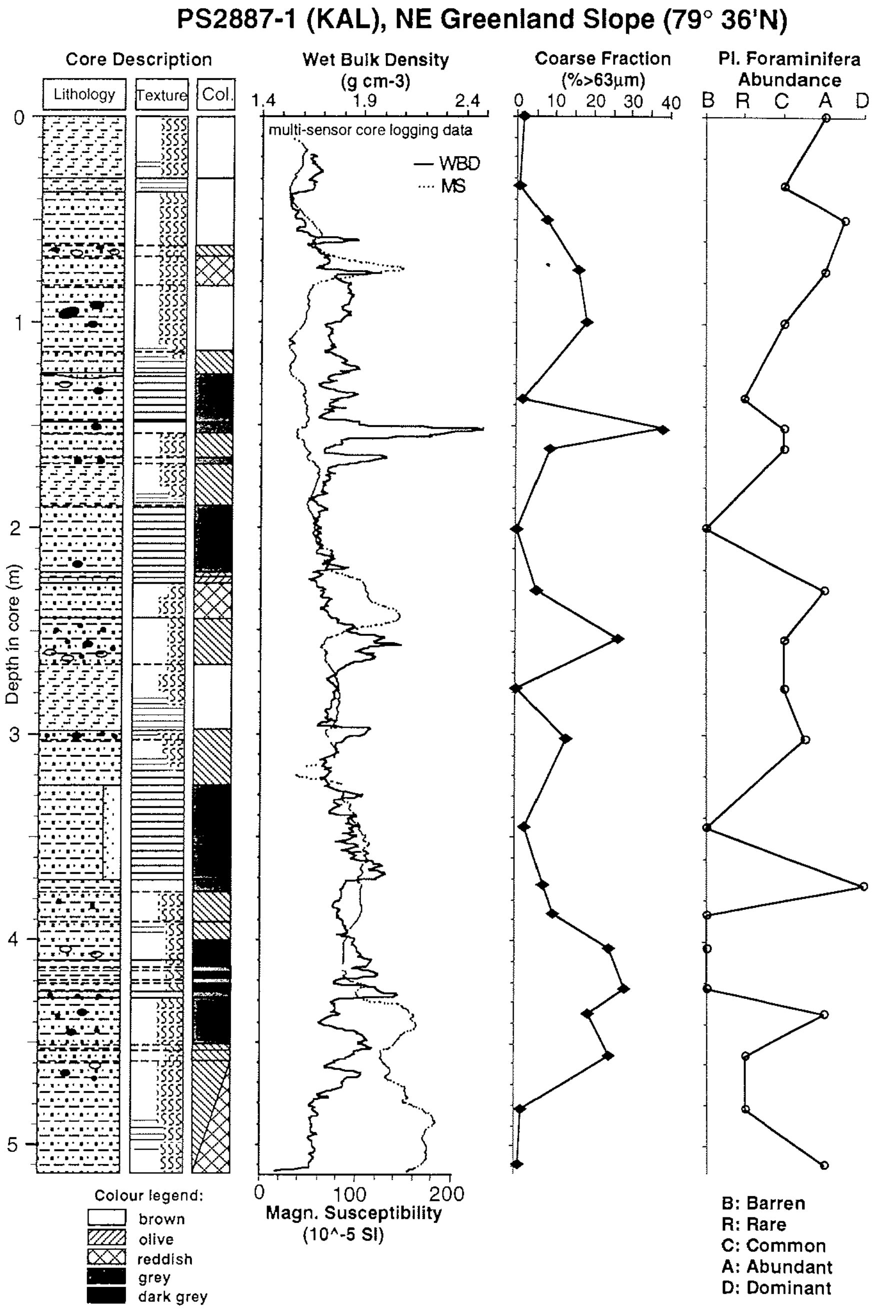


Fig. 5.4 Compilation of preliminary data on core PS2887-1. The colour signatures shown are generalized from the more detailed record shown within the Annex.

correlation profile a distinct increase of dropstone content toward the NE Greenland continental margin apppears. A compilation of preliminary data of KAL-core PS2887-1 is presented in Fig. 5.4. It is demonstrated that the density log pattern reflects the coarse fraction content quite well, with distinct peaks related to dropstone-rich sandy layers. With respect to the magnetic susceptibility log it is evident, by comparison to the lithostratigraphic description, that peak values ubiquitously correlate with characteristic reddish grey, silty sandy clay layers. Preliminary investigations of the coarse fraction and dropstone composition in the the reddish gray layers, reveal that abundant dark basaltic rocks can explain the high magnetic susceptibility values.

5.1.4 Sedimentary environment and preliminary chronostratigraphy

The sediment records reported here from the northern Fram Strait area show characteristics related to changes in climate (glacial-interglacial cycles), oceanographic circulation, sediment source areas, transport modes and local bathymetry. In general hemipelagic sediments, mass flow deposits (e.g. turbidites, debris flows) and bottom current influenced sediments (e.g. lag deposits, contourites) can be recognised.
The steep slopes and regions characterised by typical disorganised mass flow structures have been avoided by the selection of coring sites. However, in most cores from slope sites and abyssal plains thinner turbidite-like units have been found.

The dropstones as well as the mud clasts commonly found in the cores investigated probably indicate transport by icebergs. The increasing dropstone abundance observed in direction towards Greenland suggests a source from that area. The composition of the dropstones, mainly sandstones, metamorhites, and dark grey carbonates, suggest the palaeozoic rocks on Greenland to be the main source area.

The greyish stratified heterolithic silty clay/silty sand layers in the cores from the northeast Greenland slope show characteristics which may be attributed to fine-grained turbidites and/or fine-grained contourites. Their lack of bioturbation, lack of foraminifera, and a common lowermost more coarse-grained part, however, may speak for the turbidite interpretation as the most likely. Sediments from the Northeast greenland slope at about 75°N, in many aspects similar to the above, were in Thiede and Hempel (1991) interpreted as contourites.

With respect to the stratigraphic age of the sediment cores retrieved during ARK XIII/3 more detailed investigations are necessary. By comparison of magnetic susceptibility records of cores from ARK XIII/3 with cores from the Fram Strait showing well-documented age models (e.g. PS1535: Nowaczyk, 1991; Köhler and Spielhagen, 1990), preliminary interpretations, however, can be done. It is suggested that the well-correlatable cores from Profile C, reach down at least into marine oxygen isotope stage 6 (> 130,000 years B.P.). The occurrence of dark grayish layers with abundant coal fragments in the lower part of several cores, also support a stage 6 age of these deposits (cf. Bischoff et al., 1990).

More detailed sedimentological and geochemical investigations as well as a much better stratigraphic framework are absolutely necessary for a more detailed reconstruction of the origin of the different sediment types, their changes through time, and their paleoenvironmental significance.

5.2 Physical properties of sediment cores
(H.P. Kleiber, O. Swientek)

During the cruise ARK XIII/3 physical properties (magnetic susceptibility, p-wave velocity, wet bulk density) of all gravity cores (KAL, SL) were measured on whole cores by logging.

Physical properties of marine sediments are important parameters for the interpretation of the sedimentary record.

Magnetic susceptibility is defined as the dimension-less proportional factor of an applied magnetic field in relation to the magnetization in the sample (expressed in SI units). Changes in susceptibility are mainly caused by variations in the content of the mineral magnetite. Magnetite has a significantly higher susceptibility ($k = +10^{-2}$) than most common minerals (-10^{-6} to $+10^{-6}$). Thus the magnetic susceptibility is commonly used as an indicator of lithological changes (e.g. Nowaczyk, 1991). In marine environments of high latitude, magnetite is mostly derived from terrigenous input and/or volcanic ashes. The share of magnetite depends on its dilution by marine components such as carbonates and opal. Hence, the magnetic susceptibility may be used as an indicator for marine versus terrestrial origin of the sediments. Magnetic susceptibility records are ideal for lateral core correlation.

P-wave and wet bulk density can be used for the calculation of synthetic seismograms in order to compare the cored sedimentary record with the high resolution seismic profiles obtained by the PARASOUND system. The aim is a better understanding of the sound reflection behaviour of marine sediments. This is controlled by the contrasts of acoustic impedances in the sedimentary sequence. Acoustic impedance is the product of density and p-wave velocity.

Wet bulk density (WBD) is defined as the density of the total sample including the pore fluid (M_t) divided by the total volume of the sample (V_t):

$$WBD = M_t / V_t \qquad [\, Mg / m^{-3} \, ; \, g/cm^3 \,]$$

Porosity and dry bulk density are two variables required for calculation of sediment accumulation rates [g/cm^{-2} ky^{-1}].

Logs of wet bulk density are useful to test and confirm lateral core correlation based on magnetic susceptibility. In addition, wet bulk density of marine sediments can be used to interpret their degree of consolidation (Rachor et al., 1997).

5.2.1 Continuous whole-core logging of magnetic susceptibility, wet bulk density and p-wave velocity

During the cruise, magnetic susceptibility, p-wave velocity and wet bulk density were determined in 1 cm intervals on all gravity cores. All measurements were carried out on the "Multi Sensor Core Logger (MSCL)" of Geotek (UK), which allows the determination of sediment temperature, core diameter, p-wave travel time, Gamma-ray attenuation and magnetic susceptibility. The system is automated (PC based) and designed for non-destructive logging of up to 1.3 m long whole-core sections.

SL gravity cores were cut into 1 m sections and logged in their PVC-liners. Shortly after KAL gravity cores were opened, polysterine boxes (size inside 82.5 x 72 x 1000 mm) were filled with sediments by pushing them into the cores. The samples were stored at least 24-hours at room temperature before they were logged.
Because the loop sensor used has a different response to varying core diameter, all magnetic susceptibility values determined for Kastenlot boxes are multiplied by 2.324 (Table 5.1) according to the manufactor's correction instructions.

The MSCL system is described in detail by Kuhn (1994), its calibration by Niessen (1996) and Weber et al. (1997). All technical specifications used during the cruise ARK XIII/3 are listed in Table 5.1. At the beginning of the cruise the Gamma-ray attenuation was calibrated to density using aluminum, nylon and water. A computer programme is used to link the different sensor data according to their actual depth in the core. It also provides the susceptibility correction for the ends of the individual liner sections.

Magnetic susceptibility	
Loop sensor type	MS-2B (Bartington Ltd.)
Loop sensor diameter	14 cm
Alternating field frequency	0.565 kHz
Loop sensor correction coefficient SL	1 (113 cm^2 core cross section)
KAL	2.324 (59.4 cm^2 core cross section)
P-wave Velocity and Core Diameter	
Transducer diameter	5 cm
Transmitter pulse frequency	500 kHz
Transmitter pulse repetition rate	1 kHz
Receiver pulse resolution	50 ns
P-wave travel-time offset	8.47 ms (KAL, 2 x 3 mm box wall thickness)
	7.79 ms (SL, 2 x 2.5 mm liner wall thickness)
Density	
Gamma-ray source	Cs-137
Source activity	356 MBq
Source energy	0.662 MeV
Collimator diameter	5 mm
Gamma-ray detector	Scintillator Counter (John Count Scientific Ltd.)

Table 5.1: Multi Sensor Core Logger (MSCL) specifications used during cruise ARK XIII/3.

General observations

All cores show a good correlation of MSCL wet bulk density and P-wave velocity (see Appex). Wet bulk density and P-wave velocity generally range from 1.4 g cm^{-3} and 1350 ms^{-1} to 2.1 g cm^{-3} and 1825 ms^{-1}. On opened gravity cores, distinct peaks and thin layers with densities above 2.1g cm^{-3} show a positive correlation with IRD-rich sections and sandy turbidites. A few cores show distinct sections with P-wave velocities below 1300 ms^{-1}, which are most likely caused by insufficient P-wave transmission.

The magnetic susceptibility varies considerably throughout the area of investigation. Cores taken from the continental slope of Svalbard show values between 5 and 30 (10^{-5} SI-units), with single peaks up to 90 (10^{-5} SI-units). In the Fram Strait the magnetic susceptibility ranges from 20 up to 130 (10^{-5} SI-units). Cores from the Greenland continental slope show values between 5 and 140 (10^{-5} SI-units) with distinct peaks reaching up to 240 (10^{-5} SI-units).

Greenland Continental slope - Fram Strait (transect A, B, C)

The two presented transects A and C (Fig. 5.5, 5.6), show an increase in thickness and thus higher sedimentation rates from the shelf towards the Fram Strait. The increase of thickness is mainly due to a higher amount of "scatter noise" towards the deeper areas (transect C). "Scatter noise" can be caused by thin turbidites which are often characterized by large density variations on small scale due to grain-size grading (Niessen, 1996). This corresponds with the lithological descriptions and the variations of the seismic units as observed in the PARASOUND profiles (Chapter 5.3). Due to the high amount of ice-rafted debris and the strongly varying thicknesses of turbidites, the lateral core correlation across the Greenland Continental slope is difficult.

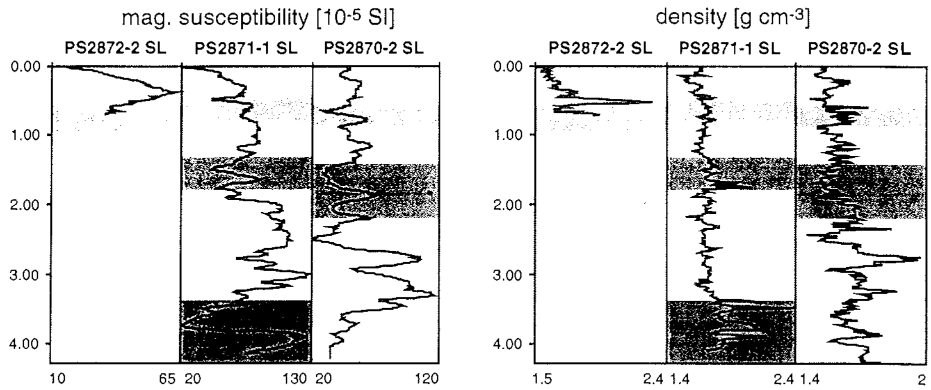


Fig. 5.5 Suggested lateral correlation based only on whole-core logging results from transect A, Greenland Continental slope (approx. 81°04'N).

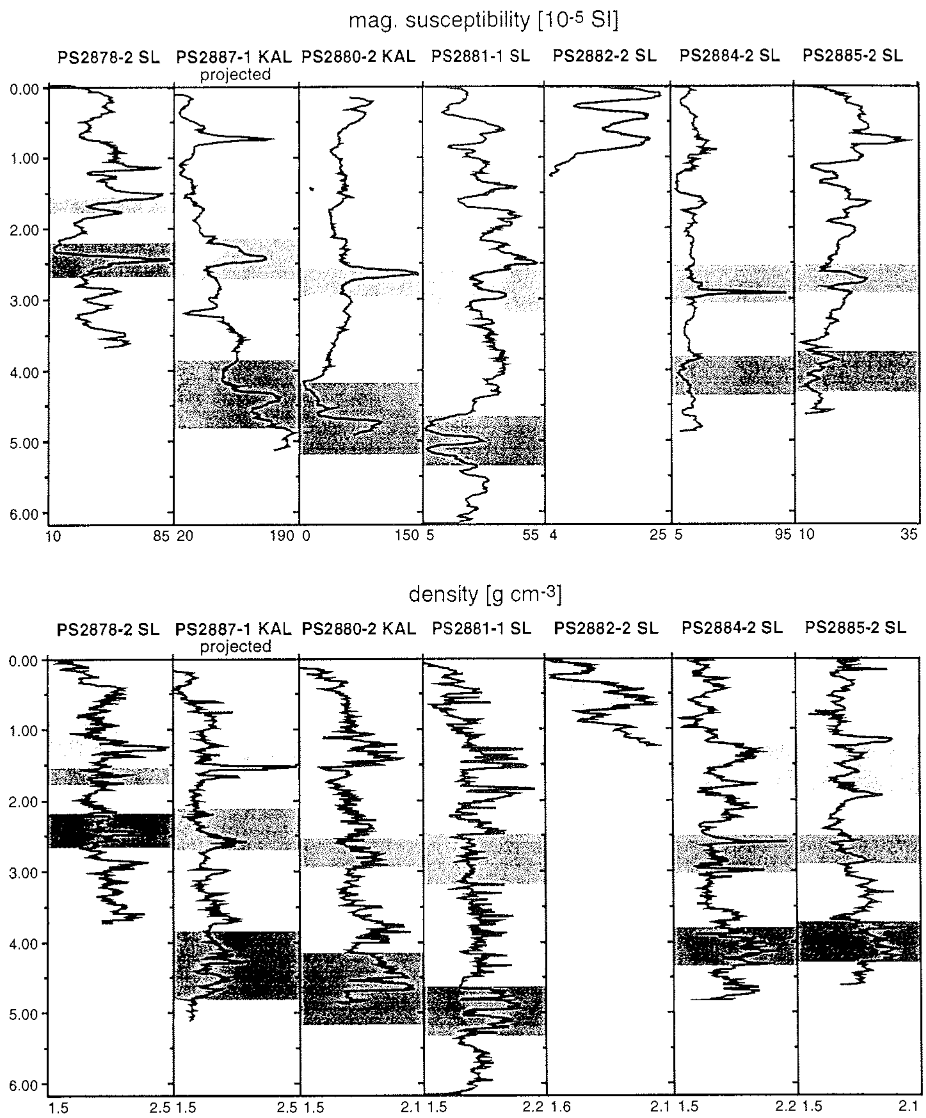


Fig. 5.6 Lateral correlation based on magnetic susceptibility and density whole-core logging results and lithological descriptions. Transect C (PS2887-2 KAL projected), Greenland Continental slope - Svalbard Continental slope (approx. 79° 40'N).

All other core logging results from cores taken as well from the Greenland Continental slope can be seen in the Annex, Core Logging Graphs.

Central Fram Strait (transect C)
The core PS2882-2 SL is taken from a sea mount in the central Fram Strait (Fig. 5.6). There is no obvious lateral correlation of down core physical properties pattern between this core and the adjacent cores of the transect C. The slightly higher density values compared to all other cores, could be related to winnowing of fine grained sediments by currents. Because the magnetic susceptibility as well permits no unequivocal assignment, the suggested correlation in Figure 5.6 is preliminary and must be confirmed by further investigations.

Svalbard Continental slope (transect C)
Only two gravity cores were taken from the Svalbard Continental slope during cruise ARK XIII/3. Lateral correlation based only on magnetic susceptibility and wet bulk density (Fig. 5.6) suggest only minor differences in unit thickness. Both observations are in general agreement with the seismic PARASOUND profiles (Chapter 5.3).

5.2.2 Physical Properties of discrete sediment samples
(G. Nehrke, F. Schulze)

Discrete samples from "Kastenlot"-cores PS2880-2 and PS2887-1 were used to calculate down core values of wet bulk density (WBD), grain density (GD), water content (WC) and porosity (n). Discrete samples were taken by using a constant volume sampling tube (10 cm³). The tube was carefully pushed into the sediment, cut out, trimmed and weighed (using a ship motion compensating balance). The sample interval of PS2880-1 was 10 cm and of PS2887-1 5 cm. The following formulas were used for calculation.

WC water content (%)
m_d dry weight (g)
m_w wet weight (g)
GD grain density (g/cm^3)
WBD wet bulk density (g/cm^3)
V_w wet sample volume (cm^3)
V_d dry sample volume (cm^3)
V_{h+s} pore volume
m_h evaporated water weight (g)
m_{h+s} pore fluidum weight (g)
m_s salt weight (g)
n porosity (%)

water content:

$$WC = \frac{(m_w - m_d)}{m_w} * 100$$

pore fluid volume:

$$V_{h+s} = \frac{(m_s + m_h)}{1.024}$$

wet bulk density:

grain density:

$$WBD = \frac{m_w}{V_w}$$

$$GD = \frac{(m_d - m_s)}{(V_w - V_{h+s})}$$

evaporated water weight:

$$m_h = m_w - m_d$$

dry sample volume:

$$V_d = \frac{m_d}{GD}$$

salt weight (35‰ salt content):

$$m_s = \frac{m_h}{0.965} - m_h$$

porosity:

$$n = \frac{V_{h+s}}{(V_d - V_s + V_{h+s})} * 100$$

salt volume (d=2.1g/cm^3):

$$V_s = \frac{m_s}{2.1}$$

The results are shown in Fig. 5.7 (PS2880-2) and Fig. 5.8 (PS2887-1).

A comparison of the WBD data using the discrete sample method and multi sensor core logging (MSCL) is shown in Fig. 5.9. It can be shown that the values determined by the two methods are quite similar.The MSCL-data, however, seem systematically to be about 0.1-0.2 g/cm^3 higher. One explanation therefore could be that the discrete samples were taken several hours after the core was opened, whereas the boxes used for core logging were taken immediately after opening the core. It is possible that a loss of water took place in the meantime. Some greater differences obtained for core PS2887-1 are due to the high amount of dropstones in this core.

5.3. High resolution sub-bottom profiling using PARASOUND
(H. P. Kleiber and D. Weiel)

The hull-mounted PARASOUND system designed by Atlas Electronics (Bremen, Germany) generates two primary frequencies between 18 and 23.5 kHz, transmitting in a narrow beam of 4°. As a result of the interaction of the primary frequencies in the water column a secondary frequency is created, based on the parametric effect. This parametric frequency is the difference frequency of the two primary waves transmitted. During the cruise ARK XIII/3, the parametric frequency was set to 4 kHz. The latter is suitable for continuous sub-bottom profiling of the uppermost unconsolidated sediment layers (Spiess, 1992). The sub-bottom penetration is up to 100 m with a vertical resolution of ca. 30 cm. The parametric pulse length was set to 2 under normal operation conditions. Under extreme conditions, such as a steeply dipping seafloor or operation in heavy ice, the pulse length was increased up to 8. The recorded seismograms were independently digitized by two different systems: (i) by the PARASOUND system for simultaneous printing on a chart recorder (Atlas DESO 25) and (ii) by the PARADIGMA system (Spiess, 1992) for tape storage and post-processing. The settings of the PARADIGMA system were as follows: sampling rate 25 ms, trace length 133 or 266 ms, block size 10640 byte, format "SEG-Y packed" (Spiess, 1992).

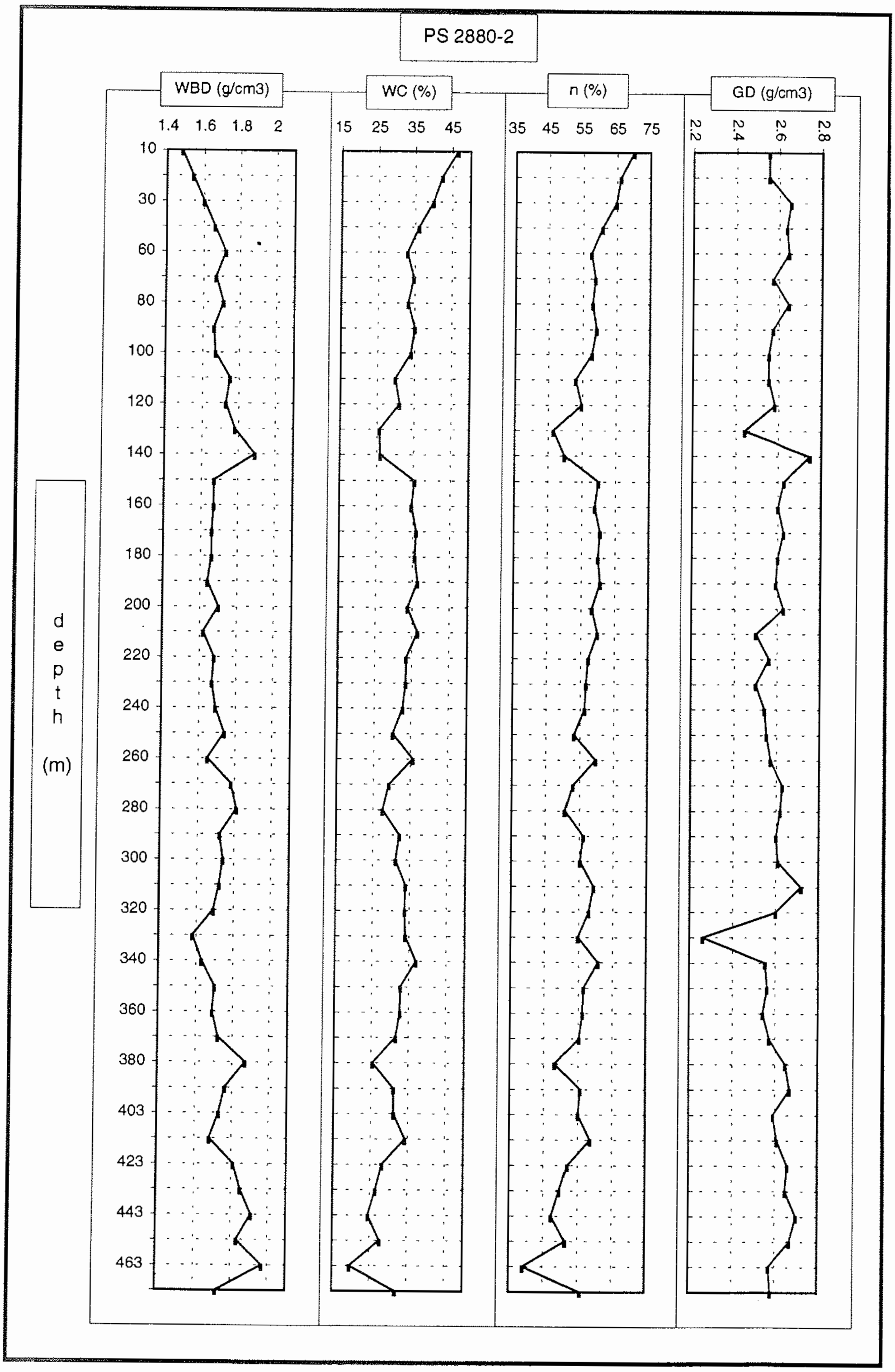


Fig. 5.7 Physical properties of core PS2880-2 (KAL) measured on discrete sediment samples. WBD: wet bulk density; WC: water content, n: porosity; GD: grain density.

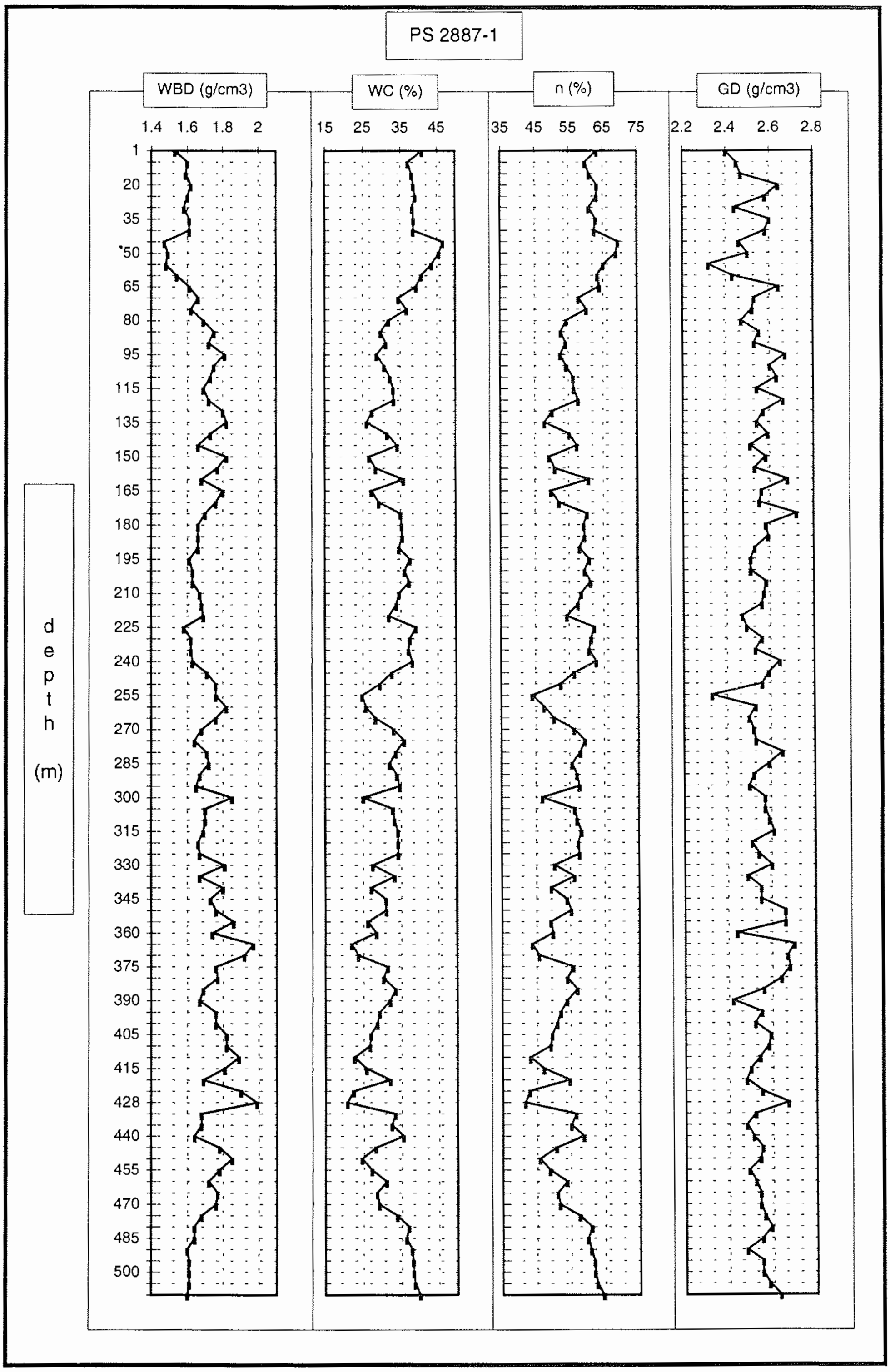


Fig. 5.8 Physical properties of core PS2887-1 (KAL) measured on discrete sediment samples. WBD: wet bulk density; WC: water content; n: porosity; GD: grain density.

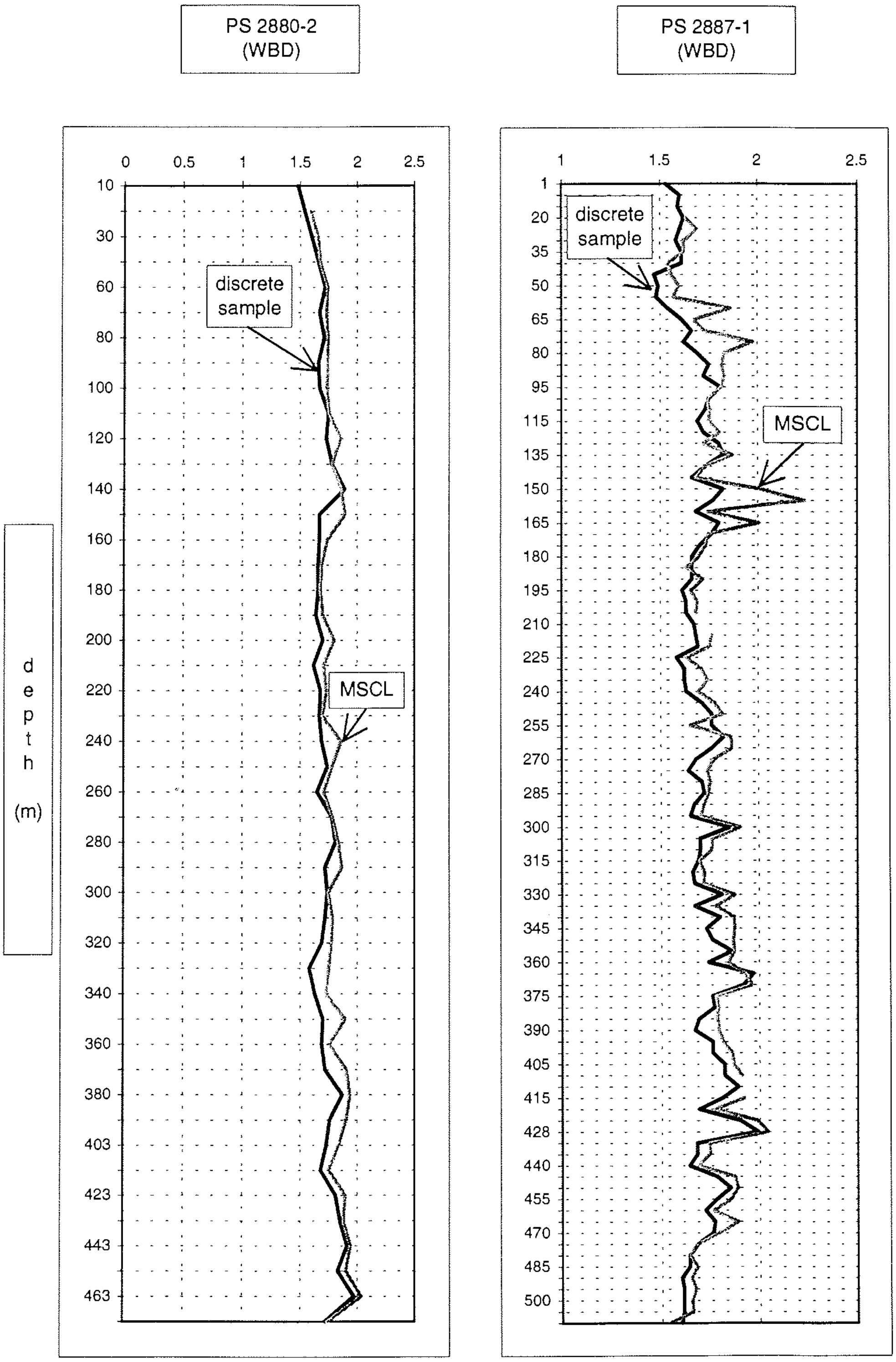


Fig. 5.9 Comparison of wet bulk values of cores PS2880-2 and PS2887-1 measured by core logging and measured on discrete sediment samples.

The recorded bottom and sub-bottom reflection pattern characterizes the uppermost sediments in terms of their acoustic behaviour. This can be used to interpret the sedimentary environments and their changes in space and time.

During ARK XIII/3 the aims of PARASOUND profiling were (i) to select coring locations for gravity and box cores, (ii) to identify lateral differences of sedimentary facies, (iii) to characterize and correlate seismic units in order to assess the variability of sediment thicknesses in the major working areas. The PARASOUND sediment echosounder was in 24-hour operation, starting the 14. August 1997 (72°49´ N, 8°19´ E) until the 22. September 1997 (73°39.8´ N, 18°00.1´ E).

Conditions during the investigation

During the entire cruise ARK XIII/3 echosounding conditions were hardly restricted by the sea ice cover. Only in the southern Lena Trough and Yermak Plateau area the quality of the seismic profiles is poor due to heavy ice conditions (strong noise level and ice ramming of the vessel). Major recording interruptions occurred, when the recording of the echoes within the narrow beam failed due to the steepness of the surveyed slopes. This problem could often be observed while crossing the Mohns and Knipovich Ridge, Fram Strait Fracture Zone including Molloy Deep and Lena Trough. On shallow shelves and gently dipping slope sections good recording conditions in general prevailed.

Seismic facies and units

The Fram Strait and the adjacent slopes of Greenland, Svalbard and Yermak Plateau are dominated by three reflection patterns:

- stratified sediments with different acoustic characteristics (deep sea areas, slopes of Greenland, Svalbard and Yermak Plateau)
- a surface reflector of very high backscatter and no or limited penetration (shelves of Greenland and Svalbard)
- diffuse, indistinct echoes from steep submarine slopes (Fram Strait Fracture Zone including Molloy Deep and Lena Trough, parts of Greenland and Svalbard slopes)

The shelf areas of Greenland and Svalbard are characterized by a relatively flat to smooth relief at several places interrupted by steep valley-like features. The latter are up to several tens of meters deep and could be the result of glacial and/or glaciofluvial truncation (Fig. 5.10). Small scale surface morphology interpreted as iceberg ploughing can locally be observed at the Greenland and Svalbard shelves down to approximately 200 mbsl. (Fig. 5.11). Due to the limited penetration (1 - 3 m, locally up to 10 m), and the lack of internal reflectors this dominant facies is interpreted as a diamict. Some few profile sections show clearly folded sub-bottom reflection patterns indicating truncated and exposed bedrock at the seafloor. A transparent surface layer (Holocene?) appears occasionally up to 3 m in thickness (Fig. 5.10). If the morphological ridges found at two locations of the Greenland shelf are of glacial origin (moraines?) remains unclear. At the entrance of Van Mijenfjord, 20 m of well stratified sediments cover a very distinct reflector which can be correlated with the surface of the diamict. Up to 25 m of well stratified sediments are penetrated within Van Mijenfjord. At some places, the well stratified sediments are superimposed by a transparent layer forming a steep ridge of up to 50 m in height. This ridge is the only elevation in the otherwise flat fjord topography and is interpreted as a moraine.

In seismic profiles across the Greenland (between 79° N and 81° N), Svalbard and Yermak Plateau slope, the subdivision of the stratified sediments into two stratigraphic units, as described by Stein et al. (in prep.), can be recognized. A lower unit of weak reflectors is conformably or unconformably overlain by a unit of well stratified beds characterized by higher

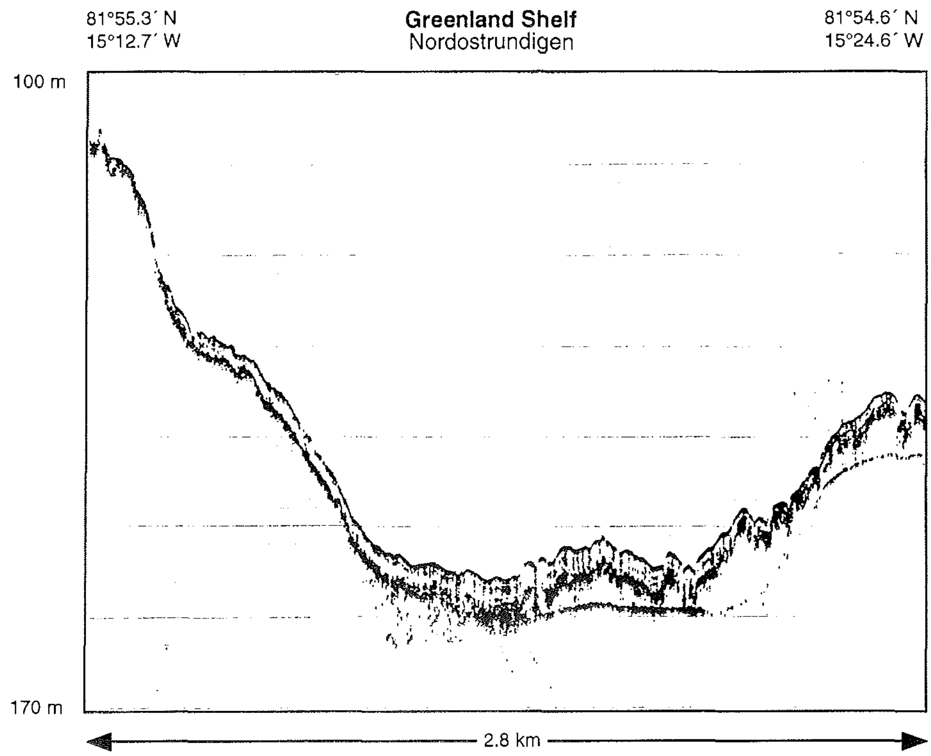


Fig. 5.10 PARASOUND profile showing a cross-section of a valley-like feature near the Nordostrundigen, Greenland Shelf. The rounded shape of the lowermost reflector suggests glacial truncation. The overlying acoustically transparent layer is interpreted as diamict. The uppermost, stratified unit is related to glaciomarine sedimentation.

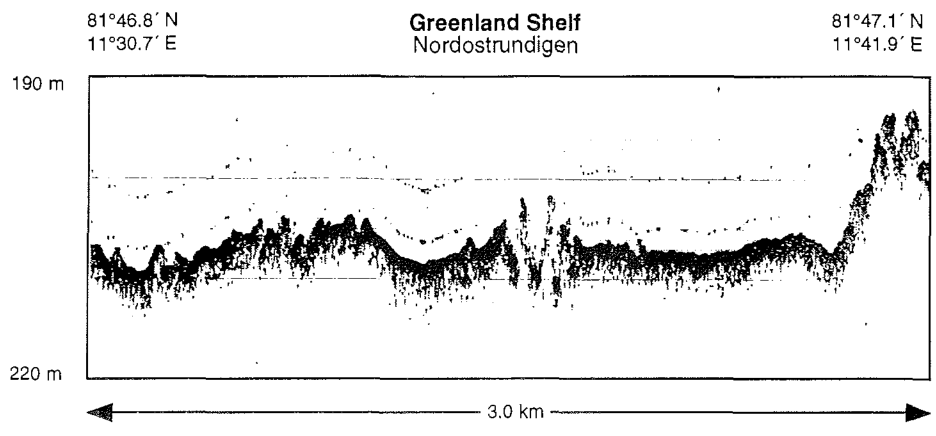


Fig. 5.11 PARASOUND profile near Nordostrundigen, Greenland Shelf showing a 7 m deep furrow interpreted as iceberg plough mark.

backscatter from distinct reflectors (Fig. 5.12). Both units can be laterally followed over the distance of several kilometers. The recorded thickness of the lower unit is up to 30 m. Generally, this thickness is limited to a few meters or the lower unit can even not be identified due to insufficient penetration of the 4 kHz pulse. The upper unit varies in thickness between 7 and 40 m. The lateral thickness variability over relatively short distances, especially of the upper unit, allows the detection of high accumulation areas. The mainly conformable boundary is in one section of the uppermost part of the Svalbard slope very irregular. The small scale relief is formed by acoustically transparent units. The latter are interpreted due to their shape as slump deposits. The superimposed upper unit flattens the irregular relief and therefore pinches out at several places. An unconformable boundary between the two units can be observed at the eastern slope of the Yermak Plateau. Here, the reflectors of the lower unit are truncated by the base of the undisturbed sediments of the upper unit.
In the Fram Strait, penetration of the well stratified sediments reaches up to 50 m. The two seismic units can only be observed close to the Greenland slope.

On the lowermost sections of all slopes and in the adjacent Fram Strait, the well stratified sediments of the upper unit are intercalated and/or overlain by lenticular-shaped and acoustically transparent layers. The latter are interpreted as debris flows indicating redeposition from the adjacent slopes and thus a high sedimentation rate. At two locations on the lower part of the Greenland slope (77°12.3´ N, 4°23.8´ W and 77°05.4´ N, 5°02.9´ W) the entire recorded sequences with thicknesses up to 20 m consist of debris flows. Distinct layers also pinch out against lower parts of the slopes, suggesting that turbidites are common in the sedimentary sequence.
Extreme thinning of the stratified sediments near the crest of the Yermak Plateau is shown In figure 5.13. The entire sedimentary package of 14 m in thickness pinches out over a distance of only 2.8 km. The obvious lateral thinning as well as v-shaped features truncating into the well stratified sediments might be related to bottom currents (contourites?). Both features can be observed on all slopes and at several places throughout the entire Fram Strait.

Diffuse or indistinct echoes are typical for the steepest sections of all continental slopes and especially for the steep morphological features of the Fram Strait Fracture Zone, including Molloy Deep and Lena Trough. In these areas the slope angle is often around or above 2° so that no sub-bottom information can be obtained, if an echo can be recorded at all.

The sediments of the Molloy Deep, Lena Trough and smaller basins within the Fram Strait Fracture Zone are well stratified. The seismic penetration reaches in the Lena Trough up to 40 m, in the Molloy Deep even up to 50 m. The sediments are frequently intercalated with distinct acoustically transparent layers of lenticular shape. The latter are interpreted as debris flows. In the Lena Trough packages of debris flows, several tens of meters in thickness, indicate a high redeposition rate from the adjacent slopes. Many beds pinch out against the slopes implying that turbidites are very common in the sedimentary sequence of these deep-sea areas. In the Lena Trough hyperbolic reflection patterns are observed at the base of the slopes. They most likely indicate small scale topography within the PARASOUND footprint caused by mass flow deposits.

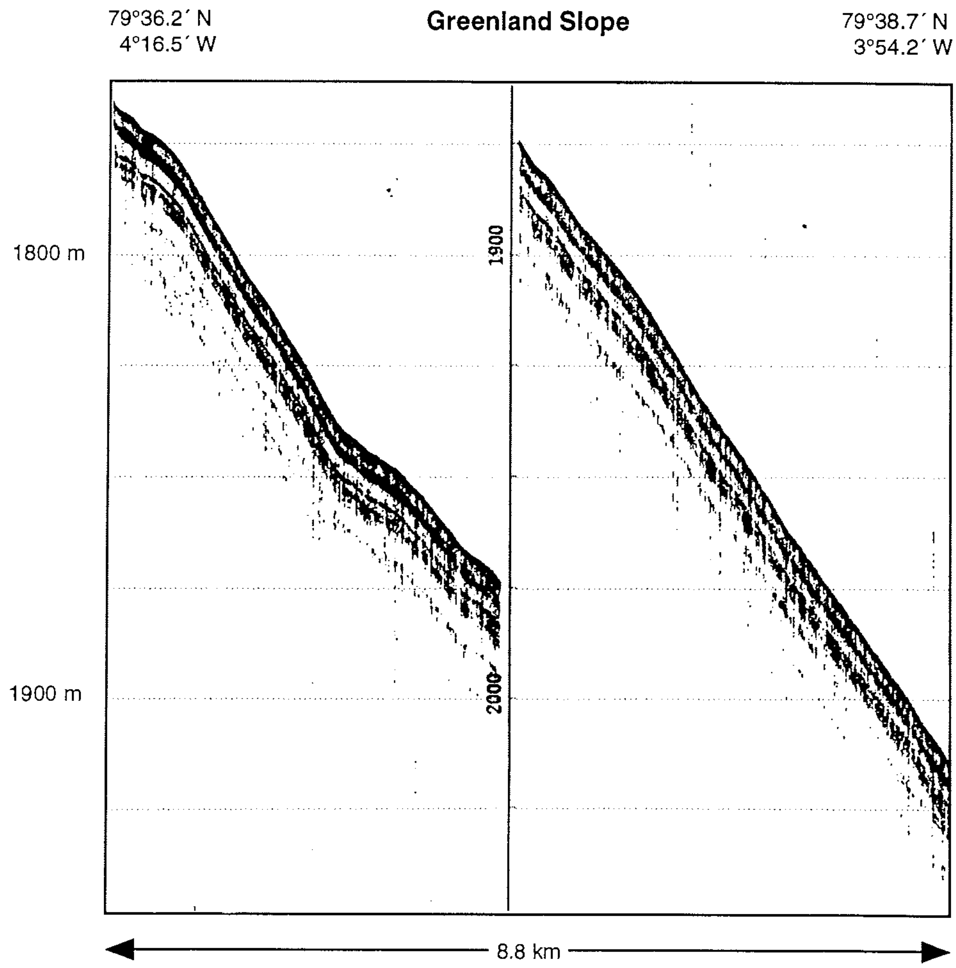


Fig. 5.12 PARASOUND profile across the Greenland Slope, showing the upper seismic unit with high backscatters from distinct reflectors overlaying conformably the lower seismic unit with only weak, diffuse reflectors.

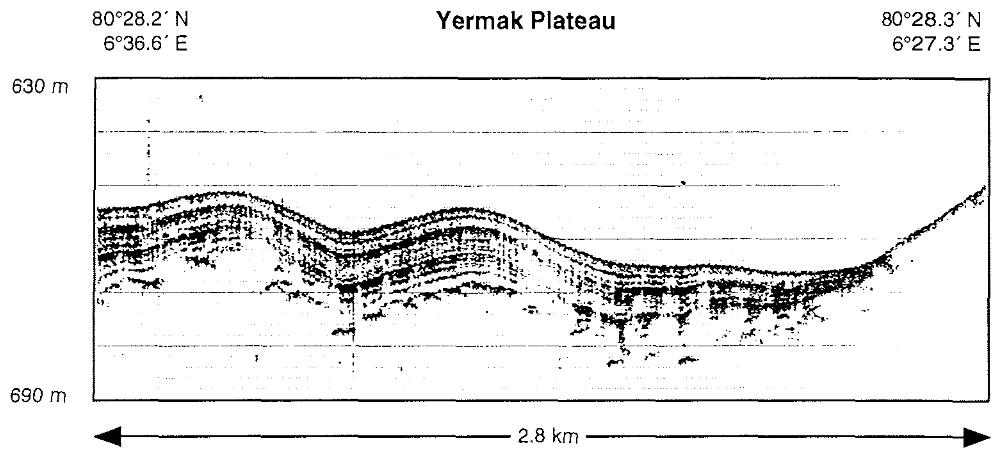


Fig. 5.13 PARASOUND profile near the crest of the Yermak Plateau which shows the extreme thinning of the well stratified sediments, most likely related to (contourity?) currents

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5.4 Annex:

- Station List, Geology

- Core Description with legend

- Core Logging Graphs
  Magnetic susceptibility, wet bulk density, p-wave velocity (Vp) and p-wave amplitude versus core length (depth)

STATION LIST

Station list ARK-XIII/3								
Station	AWI-No.	Date	Time (GMT)	Latitude	Longitude	corr.Depth	Activity	Recovery
45/8	PS2869-1	19.08	9:53	81°00.84 N	1°35.32 W	2262 m	GKG	45 cm
	PS2869-2		11:10	81°00.94 N	1°33.55 W	2391 m	10 m SL	0 cm
45/12	PS2870-1	20.08	0:57	81°04.37 N	4°02.28 W	3292 m	GKG	49 cm
	PS2870-2		2:44	81°03.67 N	3°59.55 W	3277 m	5 m SL	426 cm
45/14	PS2871-1	20.08	12:16	81°04.38 N	5°31.89 W	2277 m	5 m SL	408 cm
	PS2871-2		13:40	81°04.25 N	5°34.01 W	2282 m	GKG	46 cm
45/16	PS2872-1	20.08	19:38	81°03.2 N	6°41.53 W	1109 m	GKG	40 cm
	PS2872-2		20:42	81°03.47 N	6°41.53 W	1124 m	5 m SL	72 cm
45/17	PS2873-1	20.08	23:42	81°02.95 N	7°01.73 W	1588 m	GKG	37 cm
45/25	PS2874-1	23.08	21:33	81°39.38 N	10°45.84 W	208 m	GKG	25 cm
45/26	PS2875-1	23.08	23:10	81°43.69 N	10°12.30 W	488 m	GKG	21 cm
45/29	PS2876-1	24.08	5:54	81°45.54 N	9°26.13 W	1976 m	GKG	44 cm
	PS2876-2		7:03	81°45.68 N	9°24.03 W	1991 m	10 m SL	678 cm
45/31	PS2877-1	24.08	14:50	81°51.89 N	8°08.39 W	2674 m	GKG	41 cm
	PS2877-2		16:25	81°52.26 N	8°02.62 W	2699 m	10 m SL	487 cm
45/34	PS2878-1	26.08	7:23	79°40.24 N	5°18.90 W	717 m	GKG	48 cm
	PS2878-2		8:04	79°40.15 N	5°18.12 W	730 m	8 m SL	377 cm
45/36	PS2879-1	26.08	11:53	79°39.76 N	4°30.90 W	1514 m	GKG	45 cm
	PS2879-2		13:04	79°39.51 N	4°28.86 W	1542 m	12 m KAL	233 cm
45/37	PS2880-1	26.08	16:29	79°40.32 N	4°00.29 W		6m KAL	0 cm
	PS2880-2		17:46	79°40.50 N	4°02.42 W	1853 m	6 m KAL	547 cm
45/40	PS2881-1	27.08	4:29	79°40.67 N	1°18.04 W	2669 m	GKG	31 cm
	PS2881-2		6:04	79°40.91 N	1°16.71 W	2669 m	10 m SL	623 cm
45/44	PS2882-1	27.08	18:13	79°39.92 N	2°00.57 E	1671 m	GKG	27 cm
	PS2882-2		19:20	79°40.03 N	2°01.31 E	1666 m	5 m SL	128 cm
45/46	PS2883-1	28.08	3:08	79°39.08 N	3°16.5 E	4508 m	GKG	40 cm
45/50	PS2884-1	28.08	13:02	79°40.3 N	6°01.6 E	1330 m	GKG	40 cm
	PS2884-2		14:07	79°40.17 N	6°04.74 E	1298 m	5 m SL	489 cm
45/52	PS2885-1	28.08	17:58	79°40.45 N	7°31.86 E	770 m	GKG	39 cm
	PS2885-2		18.44	79°40.78 N	7°33.79 E	766 m	8 m SL	472 cm
45/53	PS2886-1	28.08	20:33	79°40.26 N	8°20.98 E	537 m	GKG	27 cm
45/58	PS2887-1	3.09	0:54	79°36.00 N	4°36.46 W	1411 m	6 m KAL	538 cm
	PS2887-2		2:22	79°37.03 N	4°40.58 W	1352 m	GKG	40 cm
45/101	PS2888-1	13.9	8:48	79°03.32 N	5°37.17 W	912 m	GKG	38 cm
	PS2888-2		9:49	79°03.01 N	5°38.89 W	888 m	8 m SL	559 cm
045/102	PS2889-1	13.9	11:53	79°04.98 N	4°44.24 W	1519 m	8 m SL	552 cm
	PS2889-2		13:19	79°04.79 N	4°44.87 W	1509 m	GKG	40 cm
045/103	PS2890-1	13.9	19:01	78°29.22 N	2°54.14 W	2470 m	GKG	37 cm

CORE DESCRIPTIONS

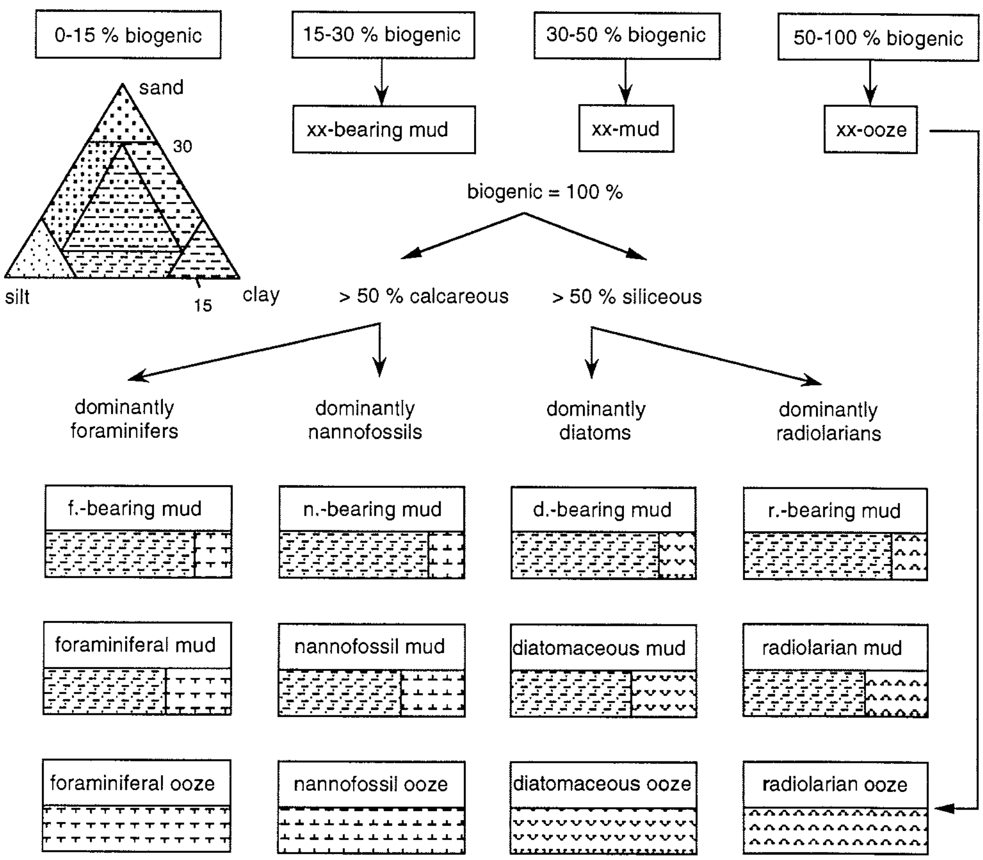
Lithology

- sand
- sandy silt
- sandy clay
- sandy mud
- silt
- mud
- clay
- diamicton
- foraminiferal ooze
- nannofossil ooze
- diatomaceous ooze
- radiolarian ooze
- volcanic ash
- chert / porcellanite
- pebbles, dropstones
- sediment clasts

Structure

- bioturbation
- stratification
- lamination
- coarsening upward sequence
- fining upwards sequence
- sharp boundary
- gradational boundary
- transition zone

Nomenclature



PS2869-1 (GKG) Fram Strait **ARK-XIII/3**

Recovery: 0.46 m 81°00.84 N 01°35.32 W Water depth: 2262 m

Surface : dark brown, sandy silty clay with benthic foraminifera (pyrgo), bivalve and small sponges (surface inclined).

Color	Description	Age
10YR4/3	0-9 cm: brown to dark brown, sandy silty clay with foraminifera (pyrgo).	
10YR4/2	9-16 cm: dark grayish brown, sandy silty clay, mottled with specks of very dark grayish brown at 14 cm black dropstone (ø 1 cm).	
10YR5/4	16-23 cm: yellowish brown, silty clay with specks of sandy silty clay (very dark grayish brown).	
10YR4/2	23-27 cm: dark yellowish brown, sandy silty clay rich in foraminifera.	
10YR4/2	27-37 cm: dark grayish brown, silty clay, mottled with specks of strong brown and gray.	
10YR5/4	37-46 cm: yellowish brown, silty clay.	

Depth in core (m): 0 – 0.5

PS2870-1 (GKG) Fram Strait **ARK-XIII/3**

Recovery: 0.49 m 81°04.37 N 04°02.28 W Water depth: 3292 m

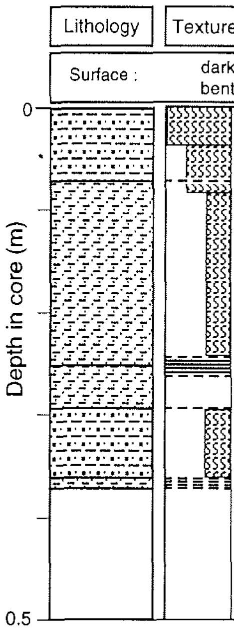
Surface : dark brown, silty clay with few large mushels

Color	Description	Age
10YR3/3	0-8 cm: dark brown, silty clay.	
10YR4/2	8-9 cm: dark grayish brown, silty sand.	
10YR3/3	9-40 cm: dark brown, silty clay, interbedded with reddish brown (10YR3/3) layers (mud turbidites ?).	
5YR4/3		
10YR3/3		
5YR4/3		
10YR3/3		
5YR4/3		
10YR3/3		
10YR5/4		
5YR4/3	40-43 cm: silt, fining upwards sequence to silty clay	
10YR4/2	43-49 cm: dark grayish brown, silty clay.	

Depth in core (m): 0 – 0.5

PS2871-2 (GKG) Fram Strait **ARK-XIII/3**

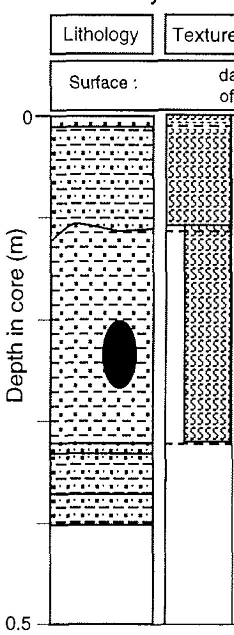
Recovery: 0.37 m 81°04.25 N 05°34.01 W Water depth: 2282 m



Color	Description	Age
Surface :	dark brown, sandy silty clay, with dropstones (few mm - 3 cm), many pyrgo and agglutinated benthic foraminifera.	
10YR4/3	0-7 cm: dark brown, sandy silty clay, with benthic foraminifera (pyrgo).	
5YR4/3	7-25 cm: reddish brown, silty clay with dark brown specks.	
10YR4/4	25-29 cm: dark yellowish brown, silty clay .	
5YR4/3	29-36 cm: reddish brown, sandy silty clay, bioturbated.	
10YR4/4	36-37 cm: dark yellowish brown, silty clay with weak lamination.	

PS2872-1 (GKG) Fram Strait **ARK-XIII/3**

Recovery: 0.40 m 81°03.20 N 06°41.3253 W Water depth: 1109 m

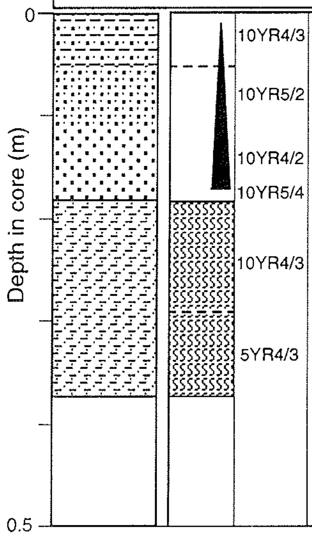


Color	Description	Age
Surface :	dark grayish brownsand (most fine) slightly claye with pebbles and many long tubes and branches of sepulicha, mushels shals and benthic foraminifera	
	0-1 cm: as surface	
10YR4/2	1-11 cm: brown, sandy silty clay, homogeneous with serpulida tubes (more sandy in loower part).	
5YR4/3	11-32 cm: reddish brown, sandy silty clay, with large specks of brown and dark grayish brown and small dark gray specks of sandy silty clay. few serpulida tubes and dropstone (ø 7cm).	
10YR5/4	32-33 cm: yellowish brown, silty sand.	
5Y3/2	33-37 cm: dark olive gray, sandy silty clay.ilty clay.	
5Y3/1	37-40 cm: very dark gray, sandy silty clay.	

PS2873-1 (GKG) | Fram Strait | **ARK-XIII/3**

Recovery: 0.37 m | 81°02.895 N 07°01.73 W | Water depth: 1588 m

Lithology	Texture Color	Description	Age
Surface :		brown, sandy silty clay, rich in planktic foraminifera	



0-28 cm: turbidite (from bottom to top): dark grayish brown, grayish brown and brown, coarse sand, fine sand and sandy silty clay with foraminifera.

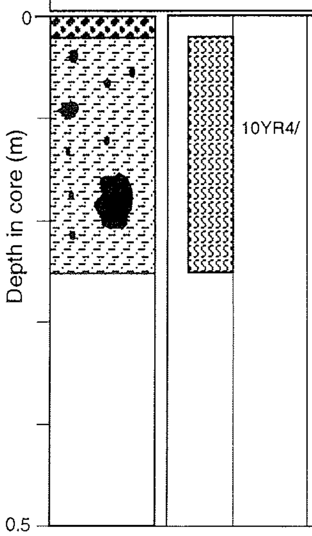
18-29 cm: brown, silty clay, mottled - homogeneous.

29-37 cm: reddish brown with specks of brown silty clayd.

PS2874-1 (GKG) | Fram Strait | **ARK-XIII/3**

Recovery: 0.25 m | 81°39.38 N 10°45.84 W | Water depth: 208 m

Lithology	Texture Color	Description	Age
Surface :		pebbles, black (Mn - Fe), with few mushels (lag deposit ?)	

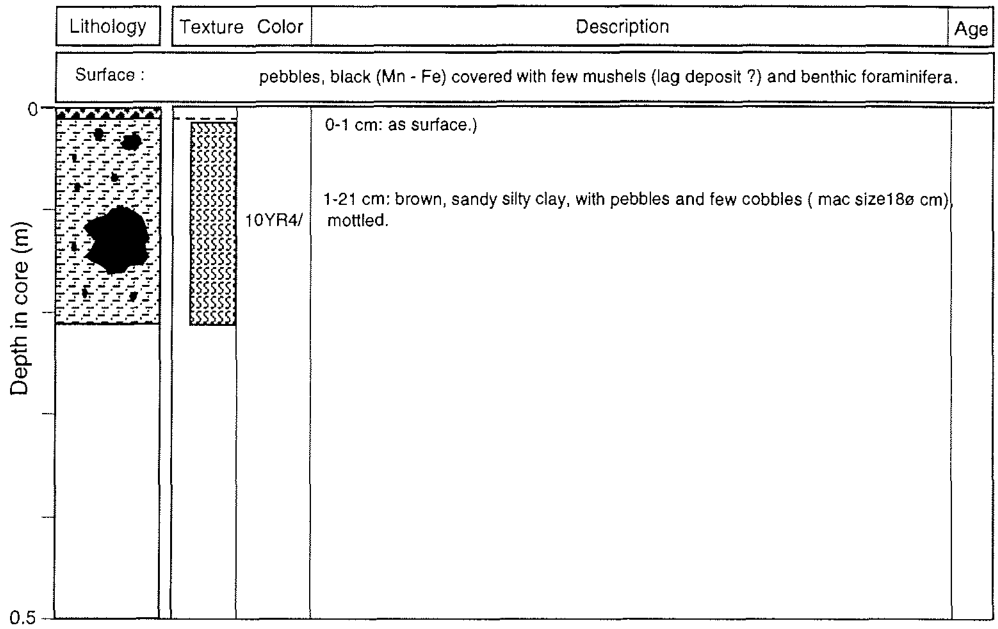


0-2 cm: as surface.

2-25 cm: brown, silty clay, with pebbles and few cobbles (10ø cm), mottled.

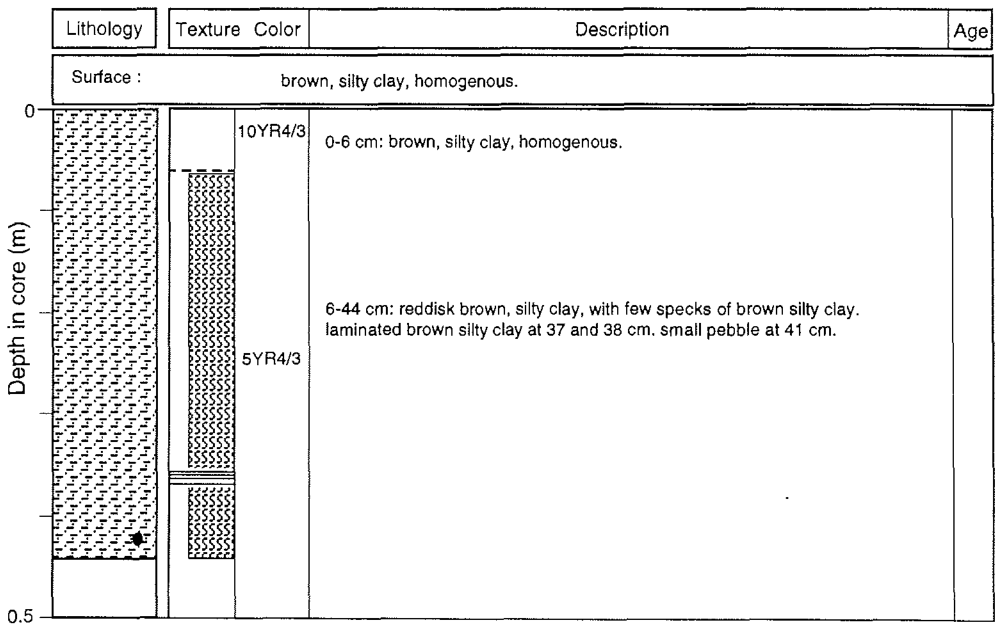
PS2875-1 (GKG) Fram Strait **ARK-XIII/3**

Recovery: 0.21 m 81°43.69 N 10°12.30 W Water depth: 488 m



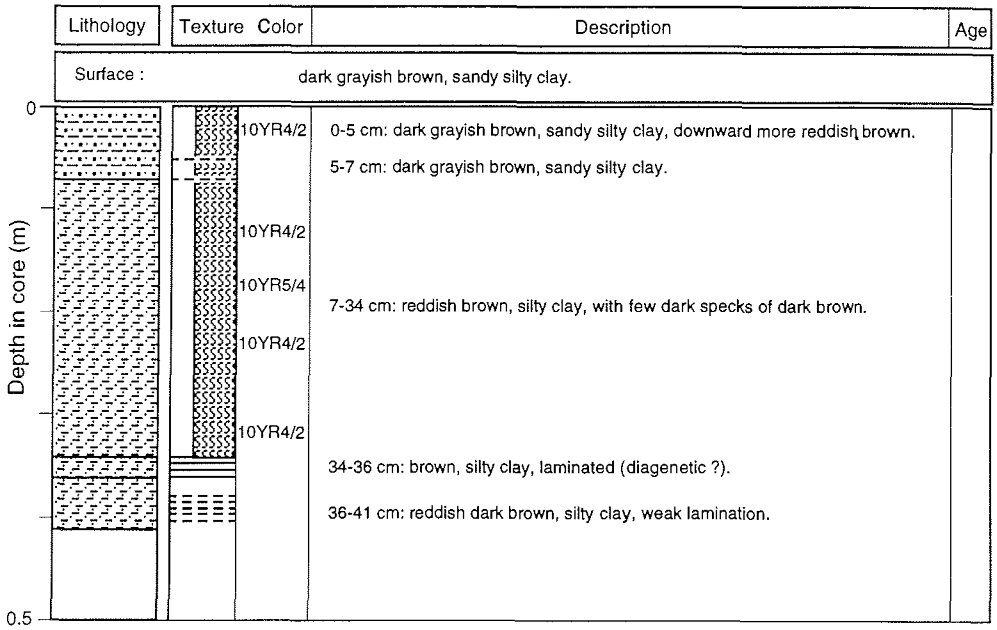
PS2876-1 (GKG) Fram Strait **ARK-XIII/3**

Recovery: 0.44 m 81°45.54 N 09°26.13 W Water depth: 1976 m



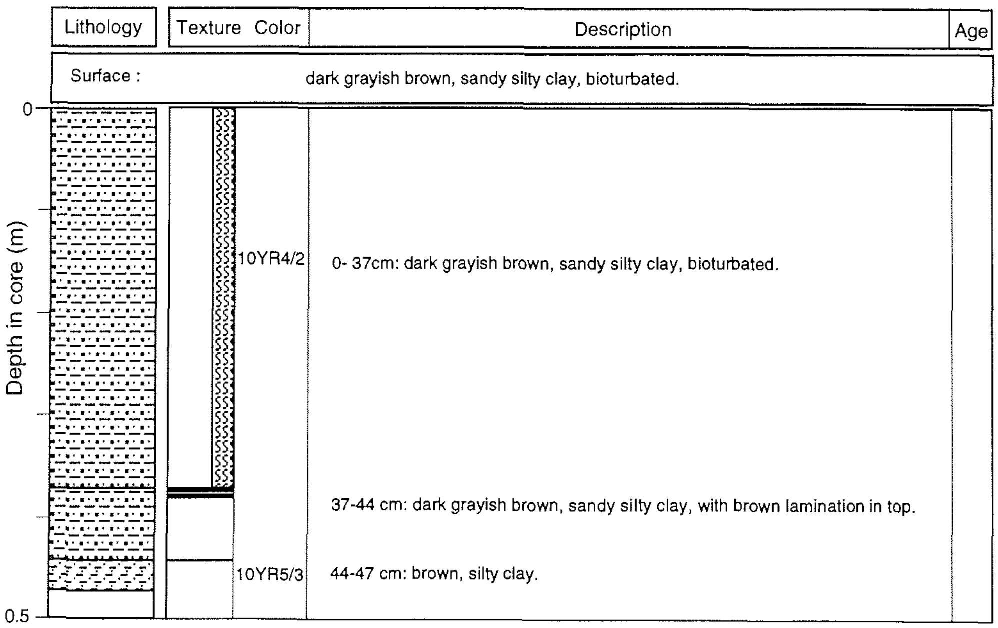
PS2877-1 (GKG) Fram Strait **ARK-XIII/3**

Recovery: 0.41 m 81°51.89 N 08°08.39 W Water depth: 2674 m

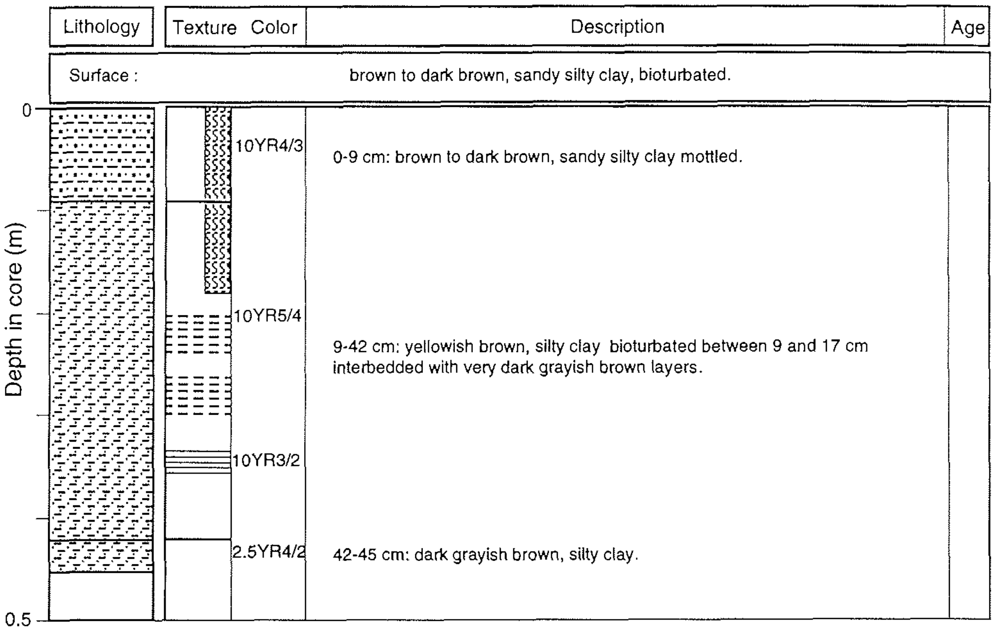


PS2878-1 (GKG) Fram Strait **ARK-XIII/3**

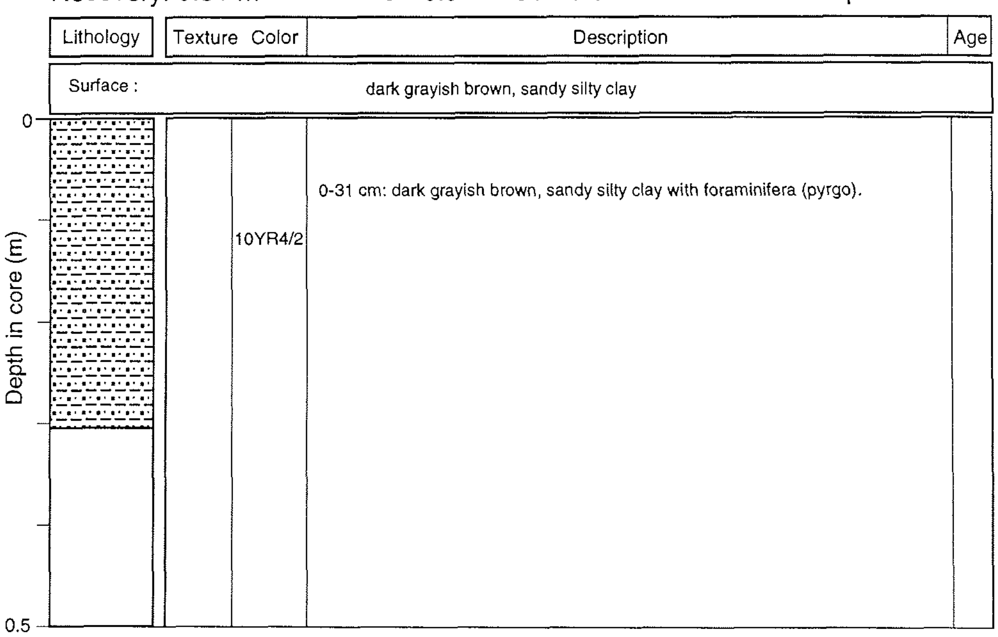
Recovery: 0.47 m 79°40.24 N 05°18.90 W Water depth: 717 m



PS2879-1 (GKG) Fram Strait **ARK-XIII/3**
Recovery: 0.45 m 79°39.76 N 04°30.90 W Water depth: 1514 m

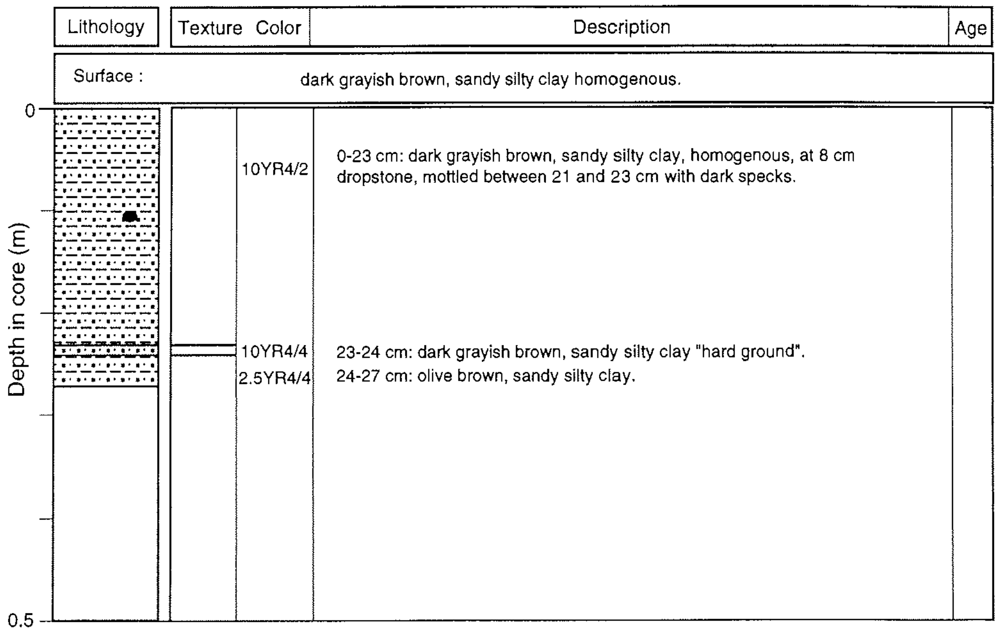


PS2881-1 (GKG) Fram Strait **ARK-XIII/3**
Recovery: 0.31 m 79°40.67 N 01°18.04 W Water depth: 2669 m



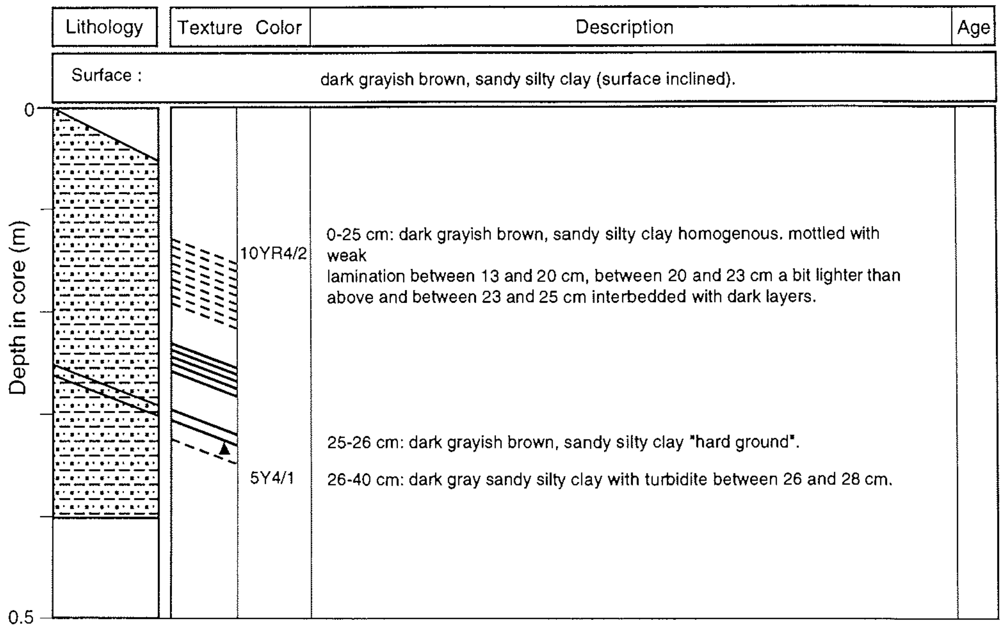
PS2882-1 (GKG) Fram Strait **ARK-XIII/3**

Recovery: 0.27 m 79°39.92 N 02°00.357 E Water depth: 1671 m



PS2883-1 (GKG) Lena Trough **ARK-XIII/3**

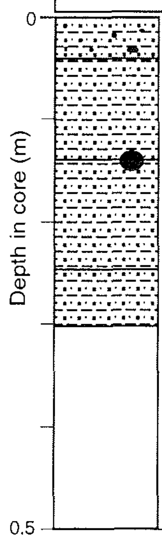
Recovery: 0.46 m 79°39.08 N 03°16.50 E Water depth: 4508 m



PS2884-1 (GKG) Fram Strait **ARK-XIII/3**

Recovery: 0.44 m 79°40.30 N 06°01.60 E Water depth: 1330 m

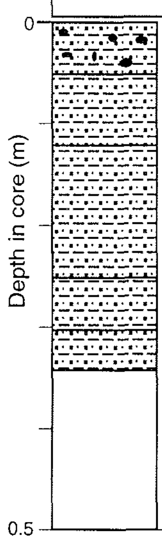
Lithology	Texture	Color	Description	Age
Surface :			olive brown, sandy silty clay with dropstones.	
		2.5Y4/4	0-4 cm: olive brown, sandy silty clay with dropstones.	
		5Y4/3	4-14 cm: olive sandy silty clay.	
		5Y4/2	14-32 cm: dark olive gray, sandy silty clay with dropstone (ø 2 cm) at 14 cm.	
		5Y4/2	32-40 olive, sandy silty clay.	



PS2885-1 (GKG) Fram Strait **ARK-XIII/3**

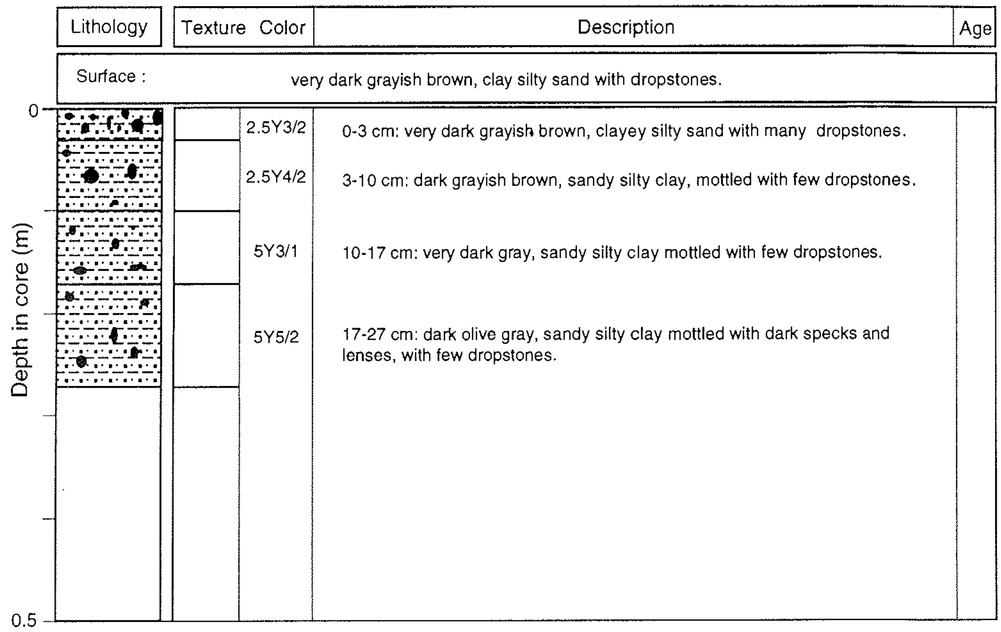
Recovery: 0.34 m 79°40.45 N 07°31.86 E Water depth: 770 m

Lithology	Texture	Color	Description	Age
Surface :			olive brown, clay sandy silt with dropstones.	
		2.5Y3/2	0-5 cm: olive brown, clayey sandy silt with dropstones.	
		2.5Y4/2	5-12 cm: olive brown, sandy silty clay.	
		5Y4/2	12-25 cm: olive, sandy silty clay strong mottled with darker specks.	
		2.5Y4/4	25-30 cm: olive brown, sandy silty clay.	
		2.5Y4/2	30-34 cm: dark grayish brown, sandy silty clay.	



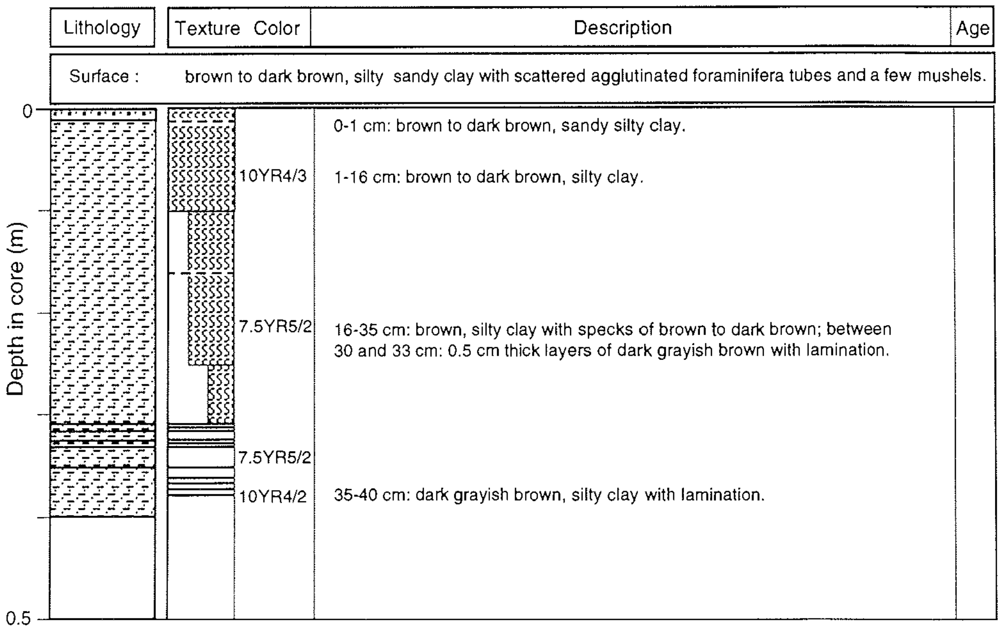
PS2886-1 (GKG) Fram Strait **ARK-XIII/3**

Recovery: 0.34 m 79°40.26 N 08°20.98 E Water depth: 537 m



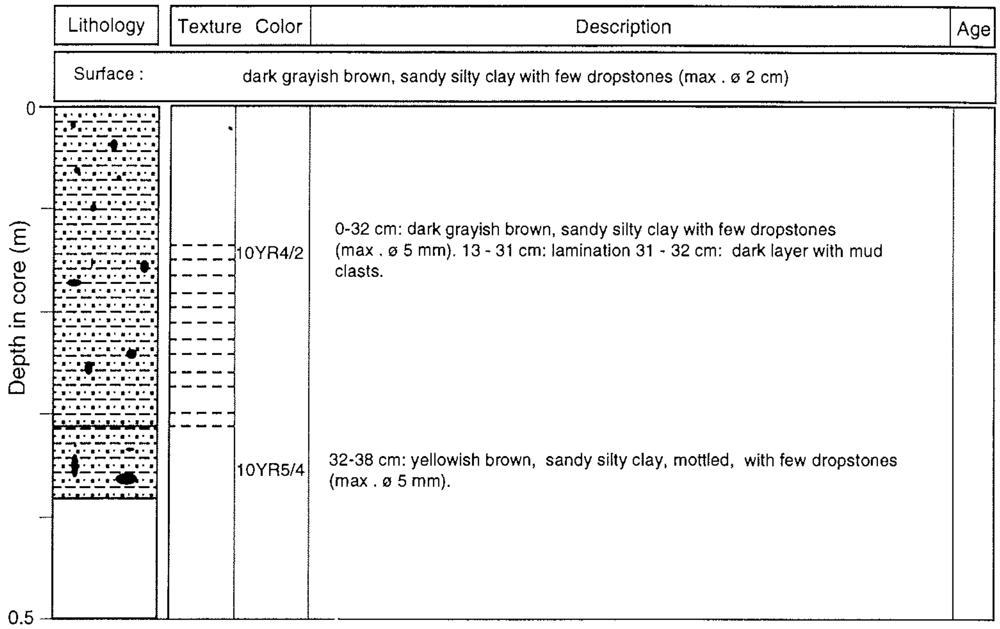
PS2887-2 (GKG) Fram Strait **ARK-XIII/3**

Recovery: 0.40 m 79°37.03 N 04°40.58 W Water depth: 1352 m



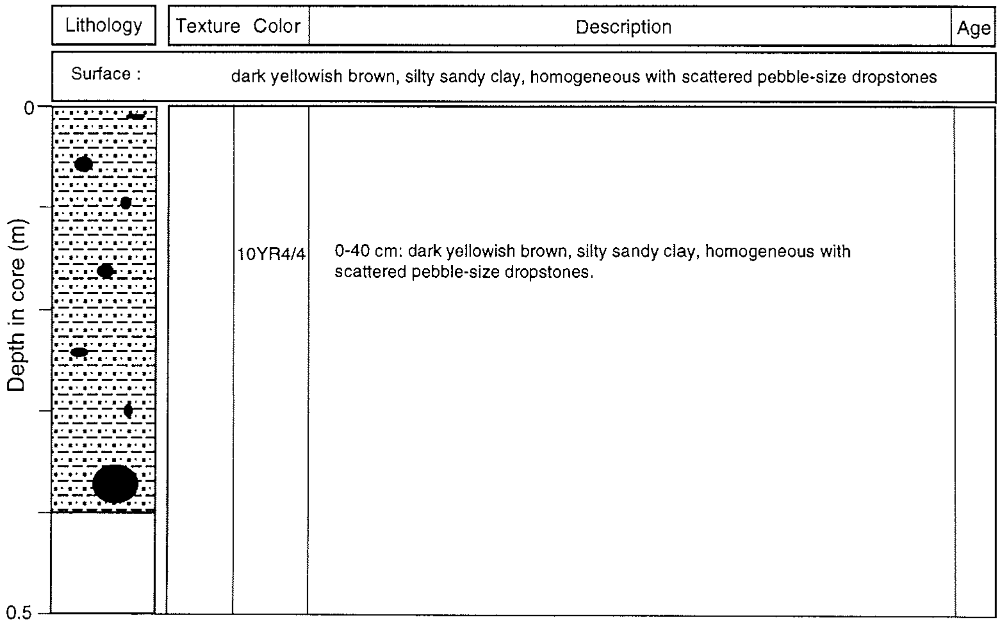
PS2888-1 (GKG) Fram Strait **ARK-XIII/3**

Recovery: 0.48 m 79°03.32 N 05°37.17 W Water depth: 912 m



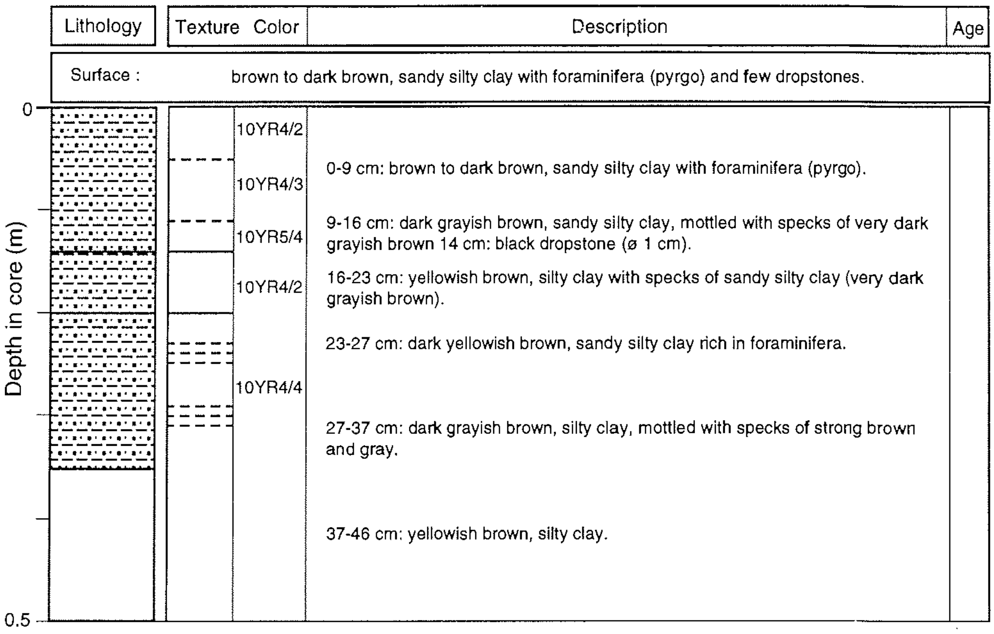
PS2889-2 (GKG) Fram Strait **ARK-XIII/3**

Recovery: 0.40 m 79°03.32 N 05°37.17 W Water depth: 1509 m



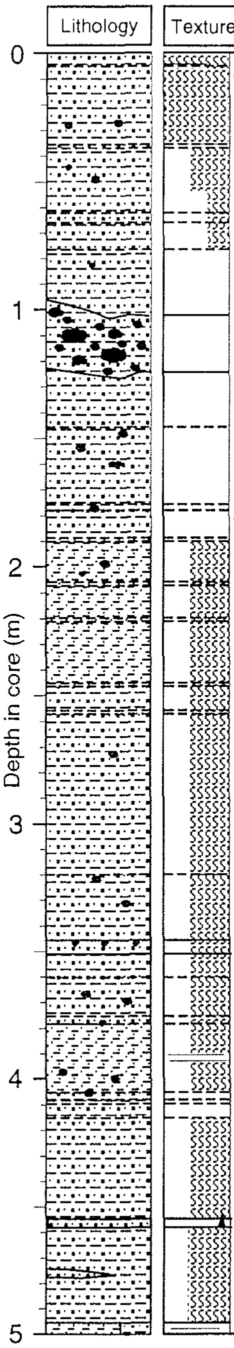
PS2890-1 (GKG) | Fram Strait | **ARK-XIII/3**

Recovery: 0.36 m | 79°04.79 N 04°44.87 W | Water depth: 2470 m



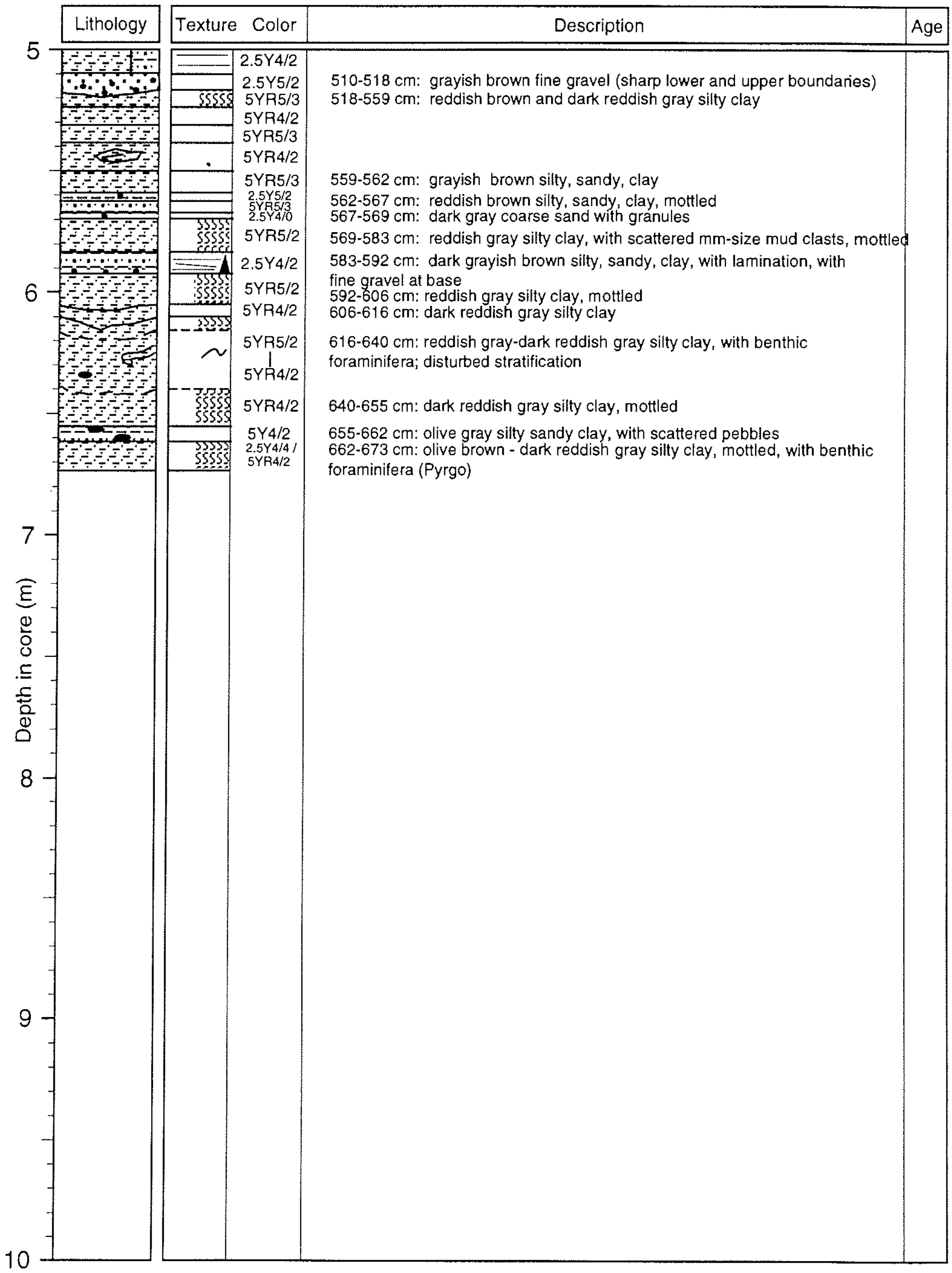
PS2876-2 (SL) | Fram Strait | **ARK XIII/3**

Recovery: 6.73 m | 81° 45.68′ N, 9° 24.03′ W | Water depth: 1991 m



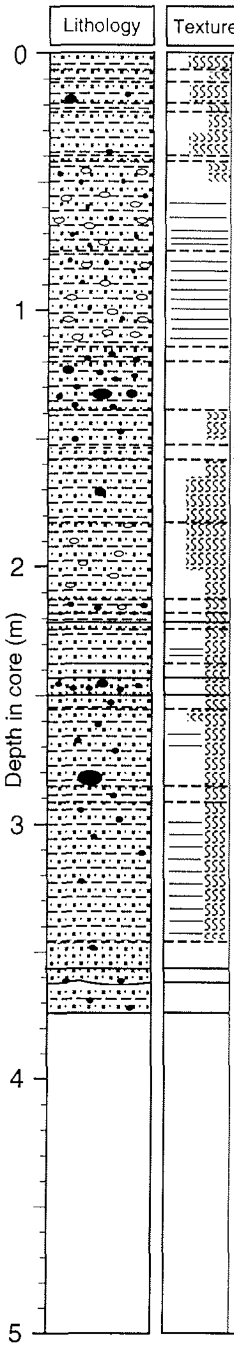
Color	Description	Age
10YR4/3	0-5 cm: brown to dark brown silty, sandy, clay, homogeneous	
7.5YR4/4	5-36 cm: brown to dark brown silty, sandy, clay, with few scattered pebbles	
10YR4/4	36-37 cm: dark yellowish brown silty, sandy, clay (diagenetic horizon)	
10YR4/3	37-62 cm: brown to dark brown silty, sandy, clay, with few scattered pebbles mottled	
10YR4/3	62-66 cm: grayish brown silty, sandy, clay, mottled	
10YR4/3	66-77 cm: brown to dark brown silty, sandy, clay, mottled	
10YR5/2 | 5YR4/3	77-100 cm: brown to dark brown silty, sandy, clay, with few scattered pebbles	
5YR4/3	100-123 cm: pebbly, silty sandy, clay, (pebbles max. 5 cm Ø)	
5YR4/3	123-146 cm: reddish brown to dark brown silty, sandy, clay, homogeneous	
5YR4/2	146-176 cm: dark reddish gray silty, sandy, clay	
5YR4/1	176-178 cm: gray silty, sandy, clay	
7.5YR4/2	178-189 cm: brown to dark brown silty, sandy, clay	
5Y5/3	189-190 cm: olive silty clay, mottled	
5YR4/3, 10YR4/1, 5YR4/3, 10YR4/1, 5YR4/3, 10YR4/1	190-246 cm: reddish brown silty clay, mottled with dark gray bands	
5YR4/3, 10YR4/1	246-256 cm: reddish brown silty, sandy, clay, mottled	
5YR4/3	256-320 cm: reddish brown silty, sandy, clay, mottled, with sand streaks and a few scattered pebbles	
5YR4/2	320-347 cm: dark reddish gray silty, sandy, clay, mottled, with a few scattered pebbles	
2.5Y5/0	347-351 cm: gray silty, sandy, clay, mottled, with benthic foraminifera	
2.5Y5/2	351-360 cm: grayish brown silty, sandy, clay, mottled, with benthic foraminifera	
5YR5/3	360-375 cm: reddish brown silty, sandy, clay, mottled, with a few scattered pebbles	
5YR4/2	375-378 cm: dark reddish gray silty, sandy, clay, mottled	
5YR5/3, 2.5Y5/0	378-405 cm: reddish brown silty clay, mottled, with few scattered pebbles, with olive gray lamina at 390 cm	
5YR5/2, 2.5Y5/0, 5YR5/2	405-415 cm: olive gray silty, sandy, clay, with small pebble and benthic foraminifera; gray layer at 408-409 cm	
5YR5/3	415-456 cm: reddish brown silty, sandy, clay, mottled	
5YR5/3	456-458 cm: olive silty sand, fining upwards (turbidite)	
5YR4/2 | 5YR5/3	458-496 cm: dark reddish gray - reddish brown brown silty, sandy, clay, mottled	
2.5Y4/2	496-510 cm: dark grayish brown silty clay, with 1cm thick very dark gray layers	

ARK XIII/3


Lithology
Texture Color
Description
Age
Depth in core (m)
5
6
7
8
9
10
2.5Y4/2
2.5Y5/2
5YR5/3
5YR4/2
5YR5/3
5YR4/2
5YR5/3
2.5Y5/2
5YR5/3
2.5Y4/0
5YR5/2
2.5Y4/2
5YR5/2
5YR4/2
5YR5/2
5YR4/2
5YR4/2
5Y4/2
2.5Y4/4 /
5YR4/2
510-518 cm: grayish brown fine gravel (sharp lower and upper boundaries)
518-559 cm: reddish brown and dark reddish gray silty clay
559-562 cm: grayish brown silty, sandy, clay
562-567 cm: reddish brown silty, sandy, clay, mottled
567-569 cm: dark gray coarse sand with granules
569-583 cm: reddish gray silty clay, with scattered mm-size mud clasts, mottled
583-592 cm: dark grayish brown silty, sandy, clay, with lamination, with fine gravel at base
592-606 cm: reddish gray silty clay, mottled
606-616 cm: dark reddish gray silty clay
616-640 cm: reddish gray-dark reddish gray silty clay, with benthic foraminifera; disturbed stratification
640-655 cm: dark reddish gray silty clay, mottled
655-662 cm: olive gray silty sandy clay, with scattered pebbles
662-673 cm: olive brown - dark reddish gray silty clay, mottled, with benthic foraminifera (Pyrgo)

PS2878-2 (SL) Fram Strait **ARK XIII/3**

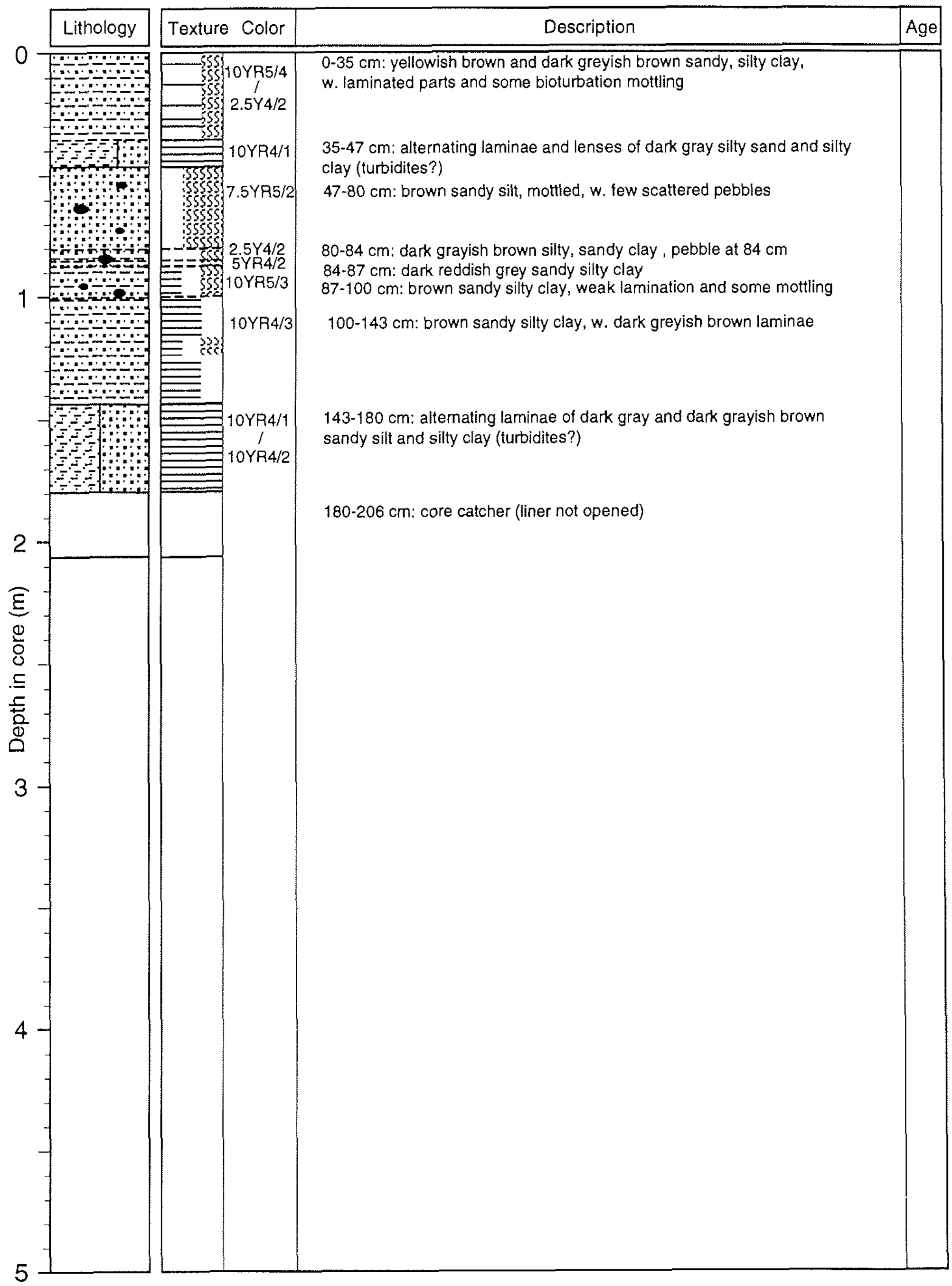
Recovery: 3.74 m 79° 40.15´ N, 5° 18.12´ W Water depth: 730 m



Color	Description	Age
10YR5/3	0-7 cm: brown silty sandy clay, homogeneous, weak mottling	
10YR5/2	7-11 cm:grayish brown silty sandy clay, weak mottling	
10YR5/3	11-20 cm: brown silty sandy clay, mottled, with few scattered pebbles	
10YR3/2	20-23 cm: very dark grayish brown silty sandy clay	
10YR5/3	23-40cm: brown silty sandy clay, mottled, with few scattered pebbles	
5YR5/4	40-42 cm: reddish brown silty sandy clay	
7.5YR5/4 – 10YR5/2	42-77 cm: brown to grayish brown silty sandy clay with abundant dark grayish brown mud clasts and granule-size clasts; stratified in lower part	
10YR4/1	77-114 cm: gray silty sandy clay, with abundant mud clasts and small pebbles; stratified (at 108 cm: one poorly preserved bivalvia shell)	
10YR3/1	114-116 cm: very dark gray silty sandy clay	
5YR4/2	116-120 cm: dark reddish gray silty sandy clay	
5Y5/1	120-139 cm: gray silty sandy clay, with abundant pebbles (e.g. black shale, basalt, glauconitic sandstone)	
5Y4/2	139-153 cm: olive gray silty sandy clay, with few small pebbles, weak mottling	
5Y4/1, 5YR5/2, 5Y4/3	153-158 cm: dark gray, reddish gray and olive silty clay to sandy silty clay	
2.5Y5/2	158-183 cm: grayish brown silty sandy clay, mottled	
10YR5/3	183-213 cm: brown silty sandy clay, with scattered small mud clasts, mottled	
2.5Y4/4	213-218 cm: olive brown silty sandy clay, stiff, with many small pebbles and mud clasts (?hardground)	
10YR4/2	218-222 cm: dark grayish brown silty sandy clay	
2.5Y5/0	222-224 cm: gray silty sandy clay with abundant planktic foraminifera	
5Y5/4 / 5Y4/4	224-238 cm: olive silty sandy clay, mottled	
10YR3/1	238-243 cm: very dark gray alternating with gray silty sandy clay	
10YR5/1	243-249 cm: gray silty sandy clay, with abundant pebbles	
2.5Y5/4	249-256 cm: ligth olive brown silty sandy clay	
10YR5/4	256-287 cm: yellowish brown silty sandy clay, mottled, weak lamination (cobble at 284 cm: reddish grey fossiliferous limestone)	
5Y5/3	287-292 cm: olive silty sandy clay, with few small pebbles	
10YR5/4 / 10YR5/2	292-347 cm: yellowish brown/grayish brown silty sandy clay, mottled, with scattered small pebbles	
5Y4/3 – 2.5Y5/4	347-357 cm: olive - ligth olive brown clayey silty sand	
2.5Y5/0	357-362 cm: gray clayey silty sand, with scattered pebbles	
5Y4/2	362-374 cm: olive gray silty sandy clay with scattered pebbles	

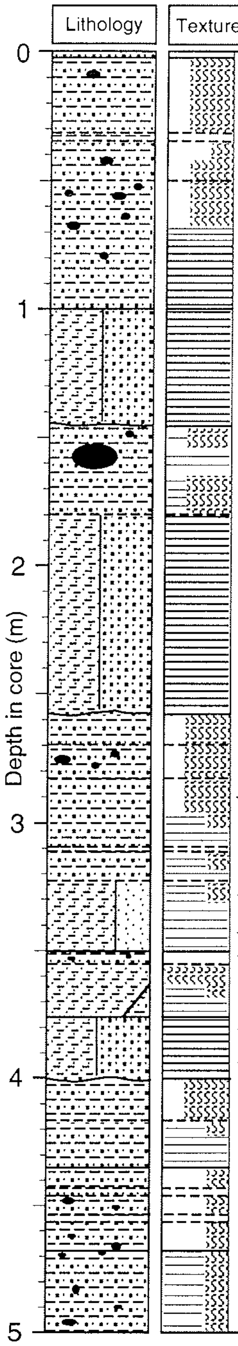
PS2879-2 (KAL) Fram Strait **ARK XIII/3**

Recovery: 2.07 m 79° 39.76´ N, 4° 28.86´ W Water depth: 1542 m



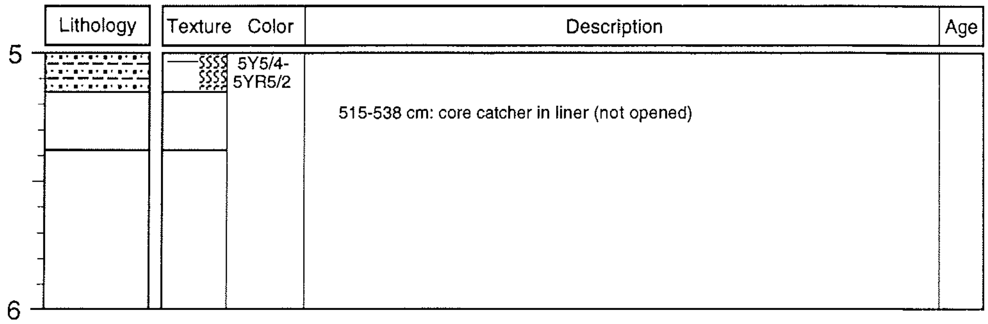
PS2880-2 (KAL) | Fram Strait | **ARK XIII/3**

Recovery: 5.47 m | 79° 40.50′ N, 4° 02.42′ W | Water depth: 1853 m



Color	Description	Age
5YR4/1	0-3 cm: dark gray silty sandy clay, soft	
5YR4/2	3-32 cm: dark reddish gray silty sandy clay, homogeneous w. weak mottling	
2.5Y4/2	32-35 cm: dark grayish brown silty sandy clay, with dark spots (sulphide min.?)	
5YR5/2	35-50 cm: reddish gray silty sandy clay, homogeneous w. weak mottling	
10YR5/4 / 10YR4/2	50-99 cm: yellowish brown silty sandy clay, with lamina of dark grayish brown silty sandy clay increasing downwards	
10YR5/1 / 10YR4/1	99-146 cm: interlayered gray silty clay and dark gray sandy silt, ondulating lamination, lower boundary of unit erosive with granule clasts (turbidites?)	
2.5Y4/4	146-180 cm: olive brown silty sandy clay, mottled with weak lamination, at 160 cm: dropstone (glauconitic sandstone) with glacial striation	
10YR5/1 / 10YR4/1	180-258 cm: interlayered gray silty clay and dark gray sandy silt, ondulating lamination, fine to medium sand above erosive boundary (turbidites?)	
5YR5/2	258-270 cm: reddish gray silty sandy clay	
5Y5/2	270-283 cm: olive gray silty sandy clay, lowermost part with olive brown specks	
10YR5/3	283-323 cm: brown silty sandy clay, with dark greyish brown specks, increasing lamination downwards	
10YR3/1 10YR5/3	at 310-311 cm: very dark gray layer (diagenetic?)	
10YR5/1 / 10YR4/1	323-351 cm: dark grey to gray silty clay with silt streaks and lenses	
10YR5/1	351-354 cm: gray silty sandy clay with few small pebbles	
2.5Y4/4	354-375 cm: olive brown silty clay, more sandy and increasing stratification in lower part of unit	
10YR5/1 / 10YR4/1	375-400 cm: interlayered gray silty clay and dark gray sandy silt, ondulating lamination, fine to medium sand above erosive boundary (turbidites?)	
5Y5/3	400-417 cm: olive silty sandy clay, slightly mottled	
5Y5/3 / 2.5Y4/4	417-435 cm: alternating bands of olive and olive brown silty sandy clay	
2.5Y3/0 2.5Y4/0 2.5Y3/0 2.5Y4/0 2.5Y3/0	435-468 cm: very dark gray silty sandy clay with two grey bands, scattered small pebbles, slightly mottled	
5YR5/2	468-500 cm: reddish gray to gray silty sandy clay with scattered small pebbles, weak lamination, slightly mottled	

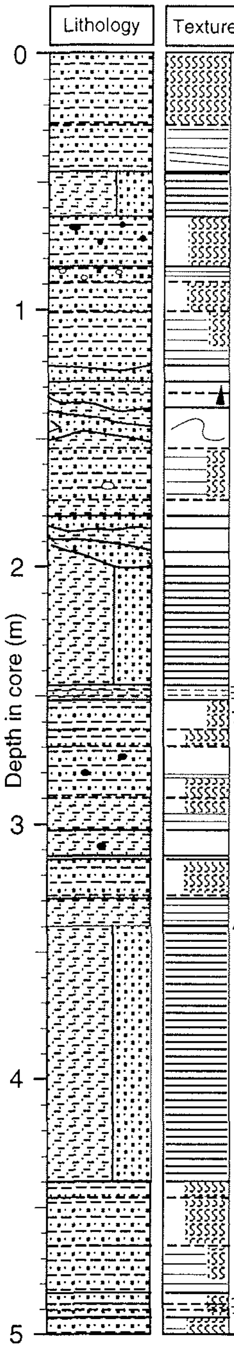
ARK XIII/3



Lithology
Texture
Color
Description
Age
5
6
5Y5/4-
5YR5/2
515-538 cm: core catcher in liner (not opened)

PS2881-2 (SL) | Fram Strait | **ARK XIII/3**

Recovery: 6.16 m | 79° 40.91´ N, 1° 16.71´ W | Water depth: 2669 m



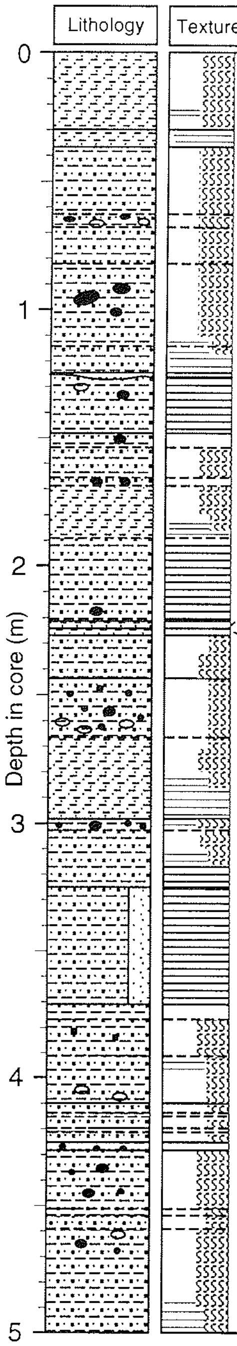
Color	Description	Age
10YR4/3	0-28 cm: brown silty sandy clay, homogeneous with scattered benthic foraminifera	
10YR3/3 / 10YR4/2	28-46 cm: brown silty sandy clay, with dark brown inclined laminae	
10YR5/1 / 10YR4/1	46-64 cm: gray silty clay with intercalated streaks and lenses of dark gray silty sand	
2.5Y4/2	64-83 cm: grayish brown silty sandy clay, mottled, with scattered granule and pebble-size clasts	
5Y4/2, 2.5Y3/0, 2.5Y6/0	83-89 cm: olive gray to very dark gray silty sandy clay, with small mud clasts and coal fragments	
10YR5/4	89-101 cm: yellowish brown silty sandy clay, with few scattered pebbles	
10YR5/6 / 2.5Y4/2	101-125 cm: yellowish brown silty clay, mottled, with dark grayish brown laminae and specks	
10YR5/4	125-128 cm: yellowish brown silty sand, sharp lower and upper boundary	
10YR5/4	128-132 cm: yellowish brown silty clay	
10YR5/4	132-137 cm: yellowish brown silty sandy (?turbidite 137-128 cm)	
2.5Y3/0	137-155 cm: gray silty sand alternating with silty clay, irregular boundaries; deformed, (?slump unit)	
5Y5/2	155-174 cm: olive gray silty sandy clay, weak mottling and faint lamination	
10YR5/1	174-190 cm: gray silty clay, weak mottling and faint lamination	
10YR5/1 / 10YR4/1	190-246 cm: gray and dark gray silty sand laminae and lenses alternating with silty clay (?erosive boundaries or deformed stratification); ?turbidites	
5YR5/2, 5Y4/2, 5Y5/2	246-252 cm: reddish gray, dark reddish gray and olive gray silty clay, with benthic foraminifera	
7.5YR5/2	252-263 cm: brown silty sandy clay, weak mottlling	
5Y5/3	263-270 cm: olive silty sandy clay, mottled	
2.5Y5/4, 10YR5/1	270-290 cm: ligth olive brown silty sandy clay, with scattered small pebbles and lense with abundant planktic foraminifera	
10YR5/4	290-303 cm: yellowish brown silty clay	
10YR5/2	303-315 cm: grayish brown to gray silty sandy clay, mottled	
10YR5/1	315-316 cm: gray silty sand	
10YR5/4	316-329 cm: yellowish brown silty clay, mottled	
10YR5/6	329-329.5 cm: yellowish brown silt	
10YR5/3 / 10YR4/2	329.5-340 cm: alternating brown and dark grayish brown silty clay, lamination	
10YR4/1 / 10YR5/1	340-440 cm: gray and dark gray silty clay with intercalated laminae and lenses of silty sand (?turbidites)	
5Y5/1	440-446 cm: gray silty sandy clay, with lenses of silty sand, mottled	
10YR5/1	446-465 cm: greenish gray and olive silty sandy clay, weak mottling	
5Y5/2 / 5Y5/4	465-484 cm: olive gray to olive silty sandy clay, weak mottling	
10YR3/1, 10YR5/1	484-493 cm: very dark gray silty sandy clay, with intercalated gray layer	
10YR3/1, 10YR6/1	493-505 cm: light gray to pinkish gray silty sandy clay, mottled	

ARK XIII/3

	Color	Description	Age
5	5Y4/3	505-519 cm: olive silty sandy clay, laminated, weak mottling	
	5Y4/2	519-525 cm: olive gray silty sandy clay, weak mottling	
	5Y5/3 - 5Y4/4	525-543 cm: olive silty clay, mottled	
	5Y5/1-5G4/1	543-551 cm: gray to dark greenish gray silty sandy clay, mottled	
	10YR5/4	551-563 cm: yellowish brown silty clay with a 0.5 cm thick silt laminae	
	10YR4/1	563-565 cm: olive gray silty sandy clay, weak mottling and faint lamination	
	2.5Y4/2	565-569 cm: dark grayish brown silty clay, weak mottling	
	2.5Y4/0	569-577 cm: dark gray silty clay with lenses of silty sand	
	5GY4/1	577-593 cm: dark greenish gray silty sandy clay, mottled	
6	5Y5/2 10YR4/1	593-616 cm: olive gray silty sandy clay; mottled; at 613 cm: 0.3 cm lamina of gray silty sand	

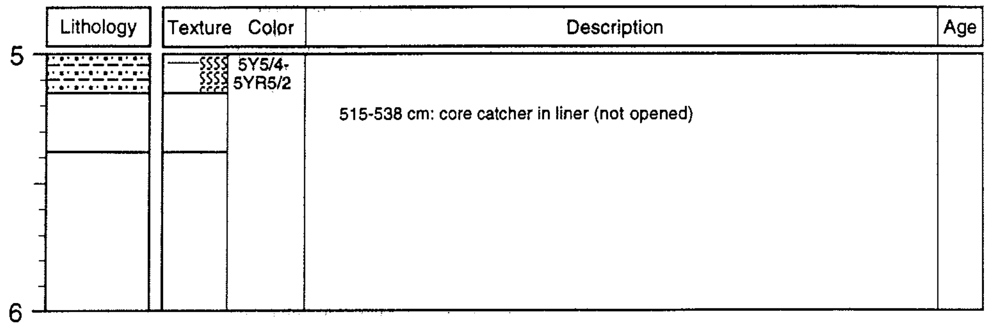
PS2887-1 (KAL) | Fram Strait | **ARK XIII/3**

Recovery: 5.38 m | 79° 36.00′ N, 4° 36.46′ W | Water depth: 1411 m



Color	Description
10YR5/4	0-30 cm: yellowish brown silty clay, homogeneous with weak bioturbation mottling
10YR3/2	30-37 cm: very dark grayish brown silty clay
7.5YR5/2	37-63 cm: brown silty clay, homogeneous
5Y4/2	63-68 cm: olive gray silty sandy clay w. scattered mudclasts and small pebbles
5YR5/2	68-82 cm: reddish gray silty sandy clay, homogeneous w. weak mottling
10YR5/4	82-114 cm: yellowish brown silty sandy clay, mottled, with several cobble-size dropstones (Ø 5-20 cm)
2.5Y4/4	114-124 cm: olive brown silty sandy clay, with a few mudclasts, laminated 124-126 cm: dark gray silty sand
10YR4/1	126-148 cm: dark gray silty sandy clay with scattered pebbles and mud clasts
10YR5/1	148-154 cm: gray silty sandy clay, with one pebble at 150 cm
2.5Y5/4	154-166 cm: light olive brown silty sandy clay
2.5Y5/0	166-169 cm: gray silty sandy clay, with one coal clast (1 cm Ø)
2.5Y5/4	169-189 cm: light olive brown silty clay, mottled
10YR4/1	189-222 cm: dark gray silty sandy clay, with scattered small mud clasts (2-3 mm), laminated one pebble at 215 cm
5YR5/2	222-225 cm: reddish gray silty clay
5Y5/2	225-227 cm: olive gray silty clay
5YR5/2	227-247 cm: reddish gray silty sandy clay
5Y5/2	247-267 cm: olive gray silty sandy clay with many pebble-size dropstones, at 263-2677 with many dark gray mud clasts
10YR5/4	267-297 cm: yellowish brown silty clay, with increasing lamination downwards
	297-303 cm: silty sandy clay with a few small pebbles
5Y4/3 - 5Y5/2	303-325 cm: olive silty sandy clay with increasing lamination downwards
10YR4/1	325-371 cm: dark gray silty sandy clay with silt streaks and fine lamination
2.5Y5/0	371-377 cm: gray silty sandy clay with small mudclasts (1-3 mm)
5Y5/2	377-392 cm: olive gray silty sandy clay, mottled with several coal clasts (up to 1 cm Ø)
5Y3/2 5Y3/1	392-410 cm: dark olive gray silty sandy clay, mottled with dark gray mud clasts and light yellowish brown specks
2.5Y4/0 / 2.5Y3/0	410-426 cm: very dark gray silty sandy clay, with two intercalated layers of gray silty clay
5YR5/1	426-429 cm: silty sandy clay, with pebbles and small coal clasts 429-452 cm: gray (weak reddish) silty sandy clay, with pebbles and cobbles
5Y4/2	452-454 cm: olive gray silty sandy clay
5Y5/2	454-459 cm: olive gray silty sandy, rich in foraminifera
5Y5/4 / 5YR5/2	459-515 cm: olive gray silty sandy clay with few pebbles and mud clasts grading downwards into olive and reddish gray mottled silty clay

ARK XIII/3

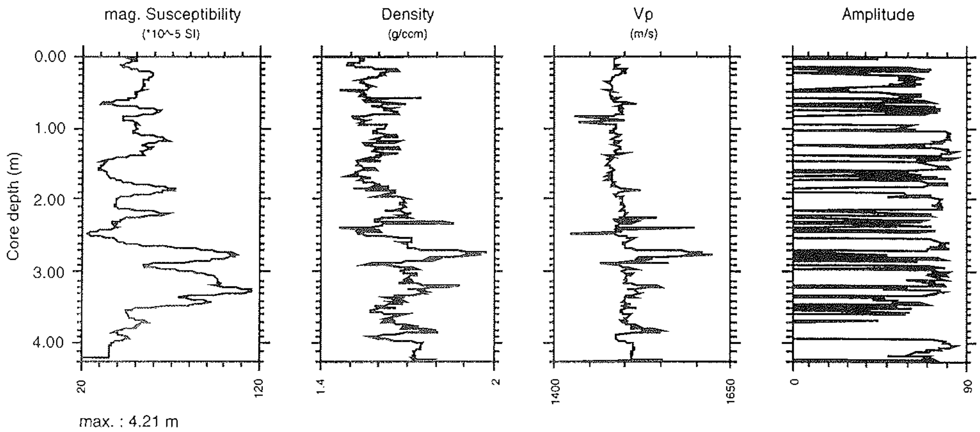

Lithology
Texture Color
Description
Age
5
5Y5/4-
5YR5/2
515-538 cm: core catcher in liner (not opened)
6

Core Logging Graphs

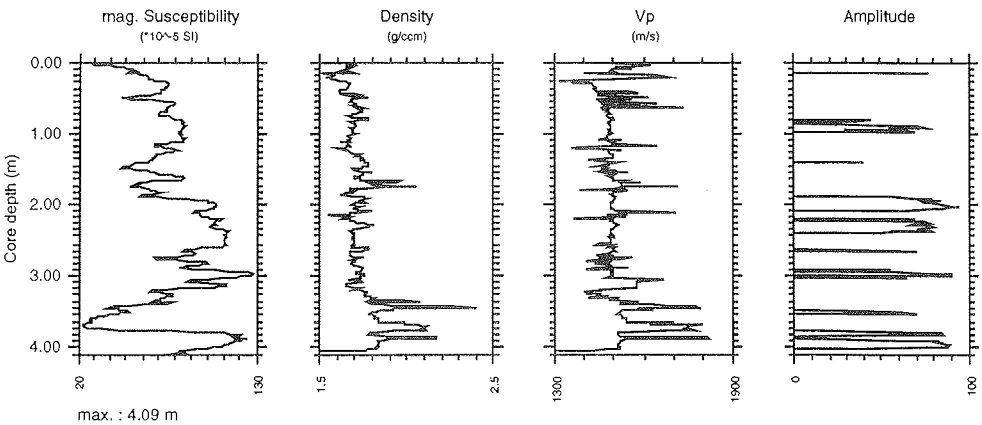
Magnetic susceptibility, wet bulk density,
p-wave velocity (Vp) and p-wave amplitude

versus core length (depth)

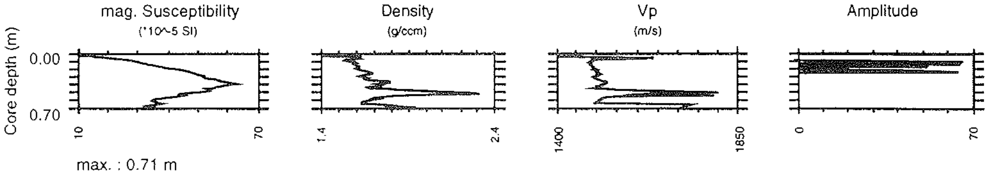
PS2870-2 SL



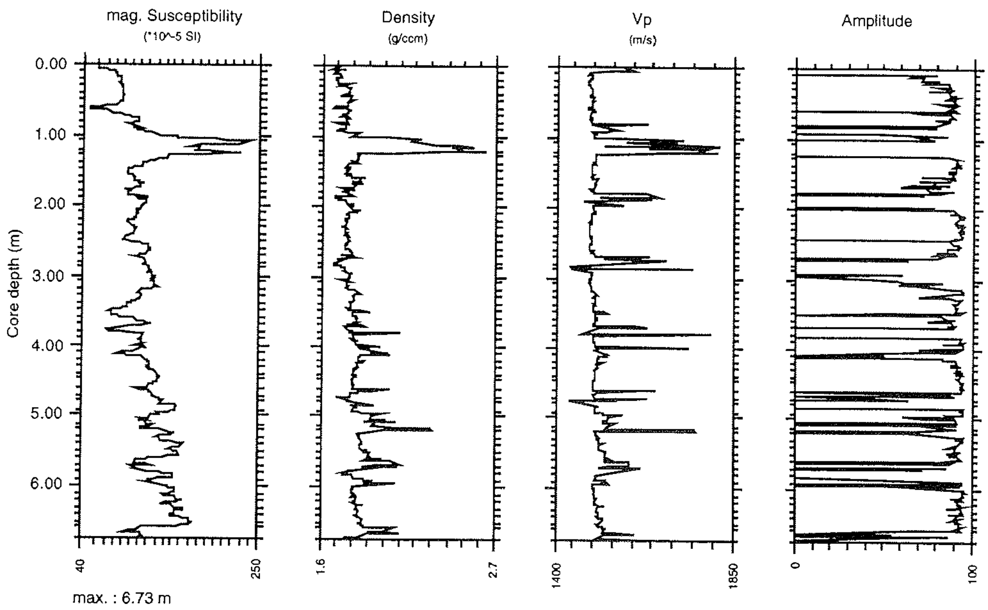
PS2871-1 SL



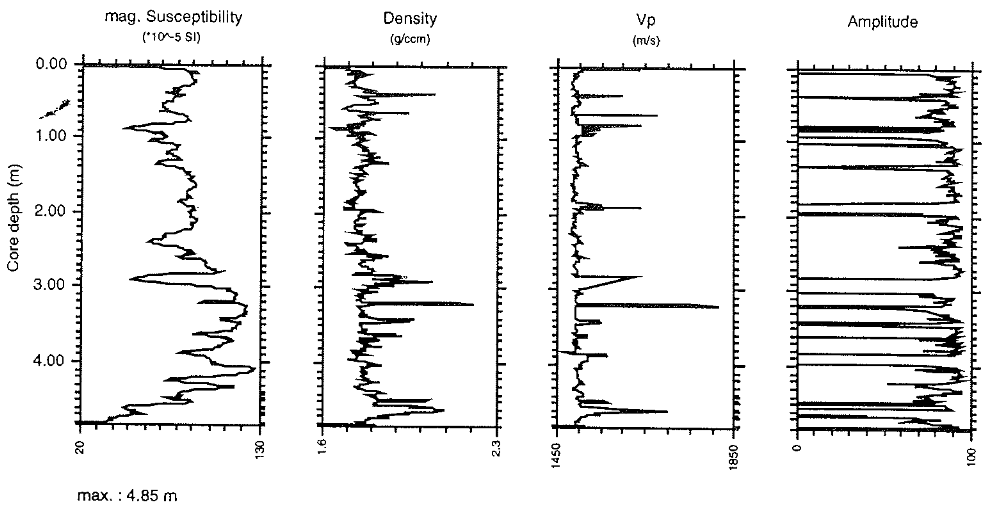
PS2872-2 SL



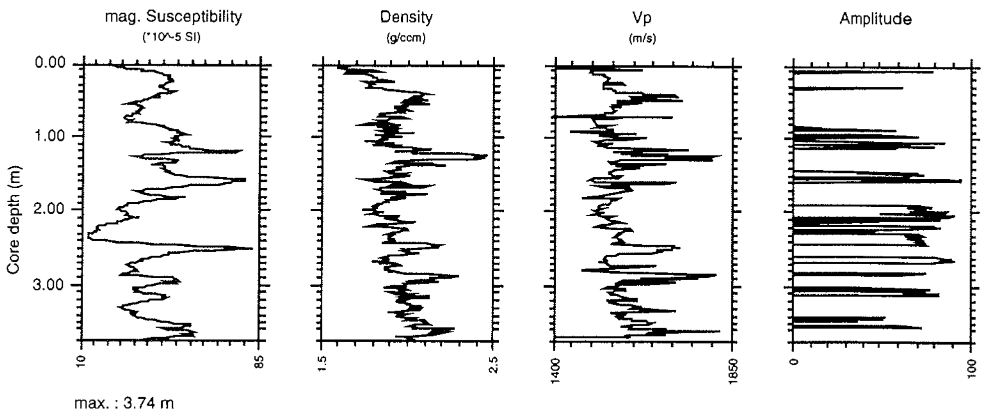
PS2876-2 SL



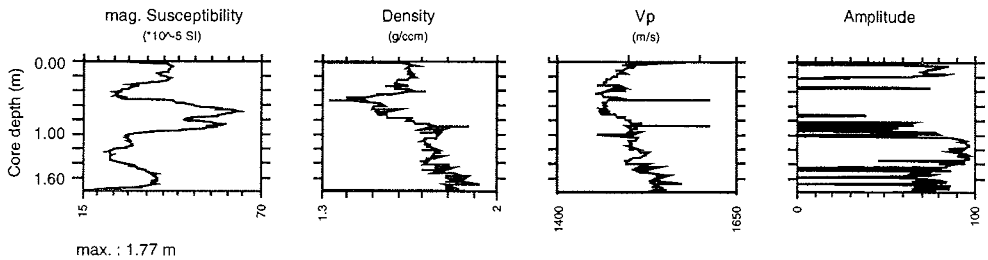
PS2877-2 SL



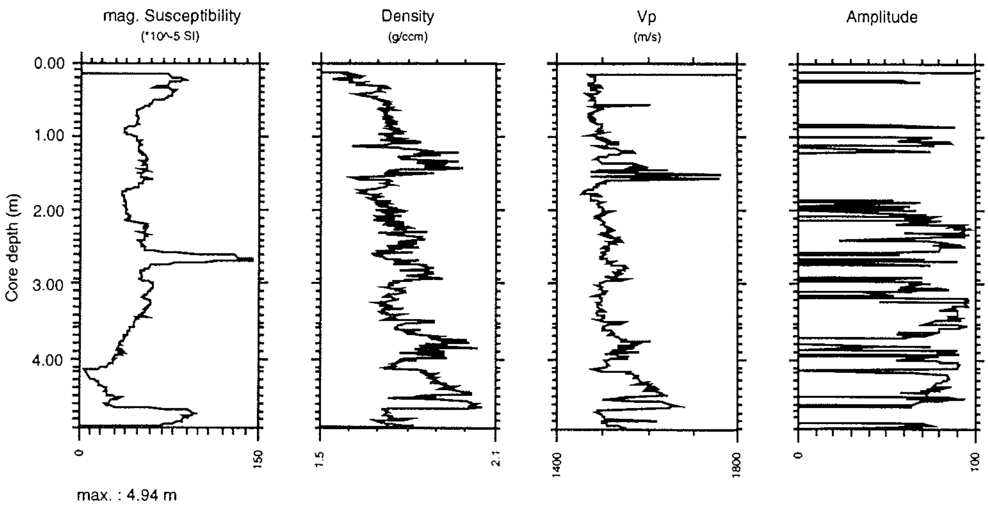
PS2878-2 SL



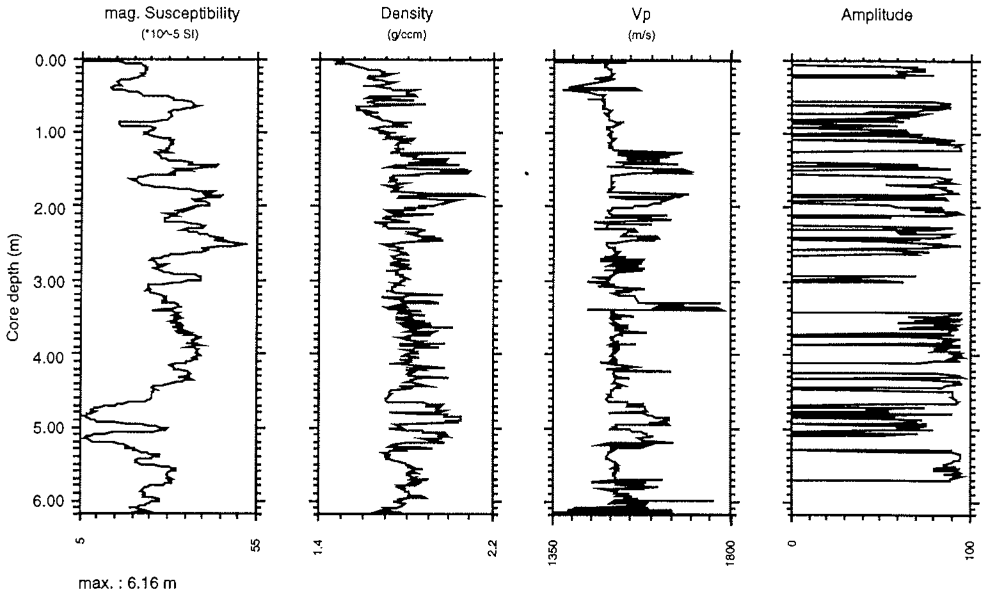
PS2879-2 KAL



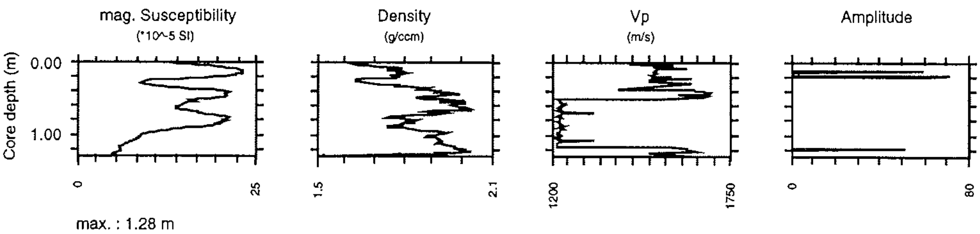
PS2880-2 KAL



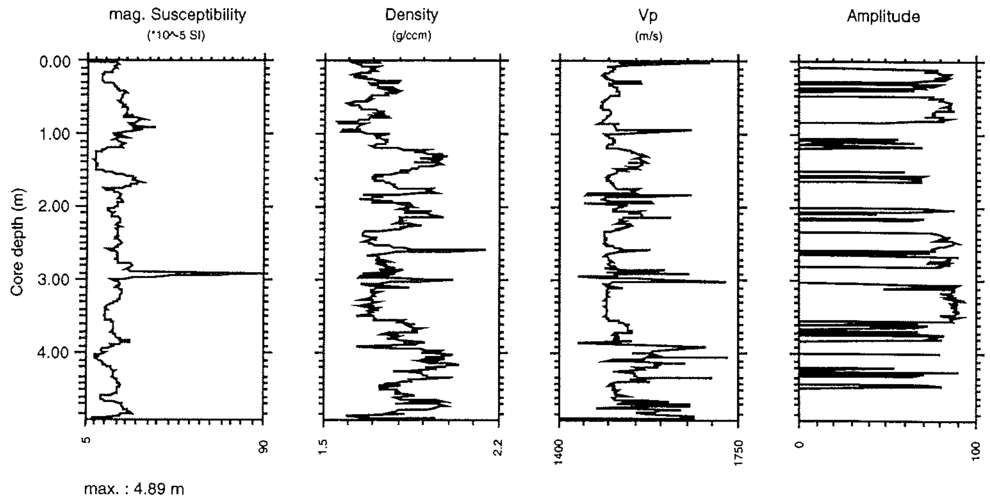
PS2881-2 SL



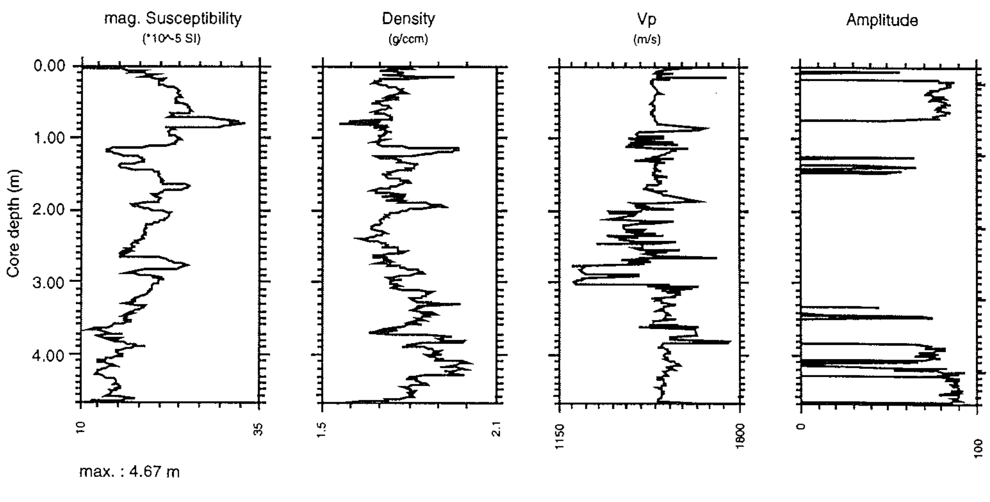
PS2882-2 SL



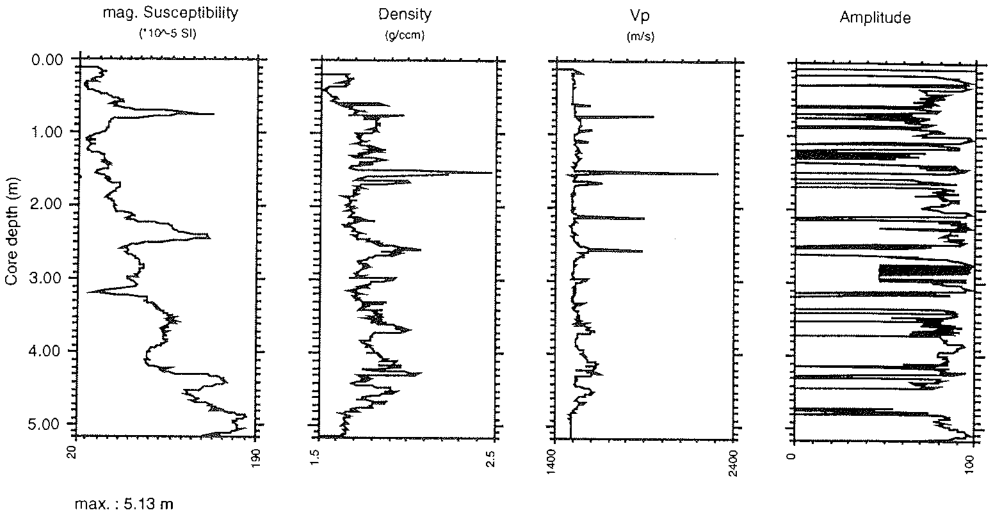
PS2884-2 SL



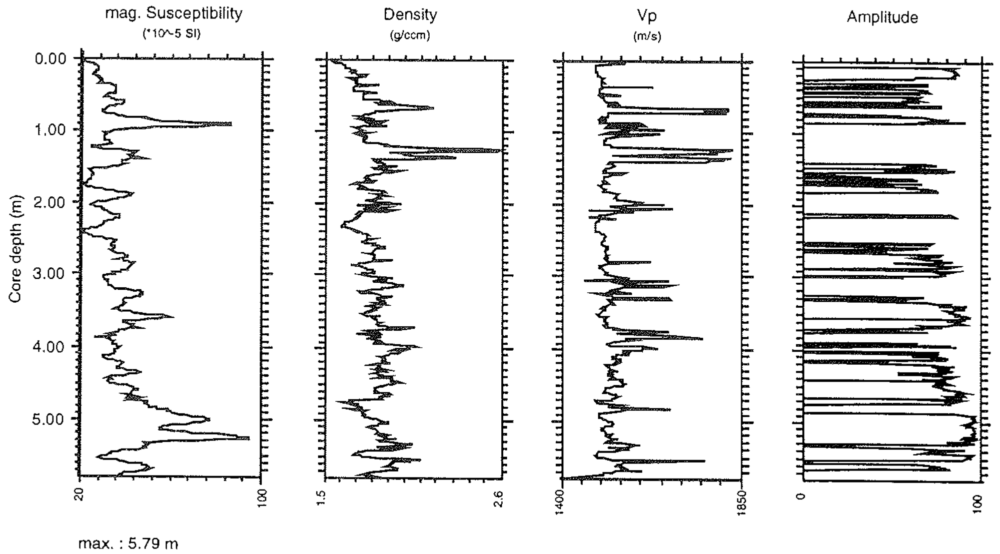
PS2885-2 SL



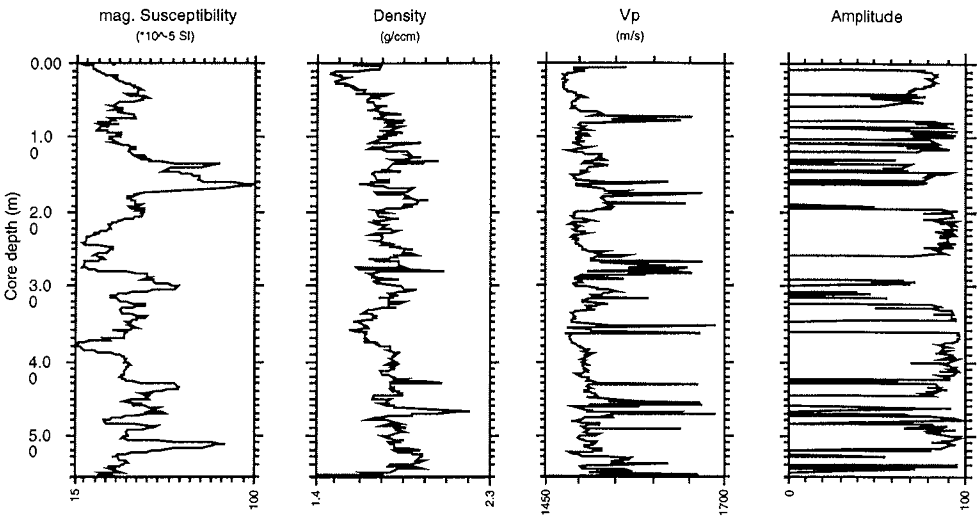
PS2887-1 KAL



PS2888-2 SL



PS2889-1 SL



max. : 5.53 m

6. Geophysics

6.1 Marine Geophysics

(Wilfried Jokat, Olaf Eisen, Birgit Konn, Norbert Lensch, Hartmut Martens, Oliver Ritzmann, Johannes Rogenhagen, Kerstin Thalmann, Estella Weigelt)

The Fram Strait, a young geological feature, is an important area in the northern Atlantic for studying recent geodynamic processes. Furthermore it is the only deep water connection of the central Arctic Ocean with the world ocean, which is believed to influence significantly the temperature budget of the Arctic Ocean and consequently the world's climate. From a geological point of view the deep water connection of the central Arctic is rather young, only 10 Myr old. According to a widely accepted geodynamic model the Fram Strait was formed during the separation of Svalbard from northern Greenland along a pronounced shear zone, the Spitzbergen Fracture Zone and the Lena Trough. The movement between Greenland and Svalbard started about 40 Myr ago and is still active. Parallel with the break-up of the continent, extensive volcanism occurred.

This is documented on two plateaus in the Central Arctic Ocean, the Morris Jessup Rise and the Yermak Plateau, which most likely have been formed during the initial opening of the Eurasian Basin. Both plateaus are interpreted to consist mostly out of oceanic basalts. This interpretation explains the large magnetic anomalies found on the plateaus. However, also the latest rift event in this area, the opening of the Fram Strait tectonically affected the continental margins of Greenland and Svalbard and most likely also the Yermak Plateau.

Systematic bathymetric mapping south of 80°N shows a complex sea floor topography which is created by an active mid-ocean ridge system. Similiar information north of 80°N are sparse. Therefore, only few information exist on the bathymetry and geological structure of the mid-ocean ridge in this area.

In addition to the geodynamic objectives, any information on the glacial history of the Greenland ice shield is of great interest. Seismic data can map sediment structures, which are created by advances and retreats of glaciers during glacial/interglacial periods.

On the eastern margin of the Fram Strait, off Van Mijenfjord (West-Svalbard), a deep seismic sounding experiment was conducted to map the continent-ocean transition zone (COT). The transition zone here is a rather young feature and the mid-ocean ridge is quite close (approx. 100 km) to the fjord allowing us to study a quite young, passive continental margin. Based on potential field data it has been suggested that the COT is located quite close to the fjords and therefore can also be investigated with the help of closely spaced land stations along the fjords. At mature margins in the North Atlantic the COT is at least 50 to 100 km off the present coast line.

In summary, the scientific objective of this expedition was to gather new geophysical information in the Fram Strait area, to investigate the geodynamic and glacial processes of the region. For this, mainly seismic and gravimetric methods were used. The top priority region for the geophysical programme was the Morris Jessup Rise, which is not well mapped by geophysical data at all due to the heavy ice conditions most of the year. As mentioned earlier due to the ice conditions the rise could not be reached during this expedition. Therefore, no geophysical data could be collected on the rise itself and the North-Greenland fjords. Consequently, the geophysical programme was performed in the area between the North-Greenland and Svalbard continental margins. In addition, seismic lines were acquired across the East Greenland Shelf between 80°30'N and 78°30'N to investigate glacial sediment deposits.

In the following the preliminary geophysical results will briefly be described. The location of the seismic profiles are shown in Fig. 6.1.

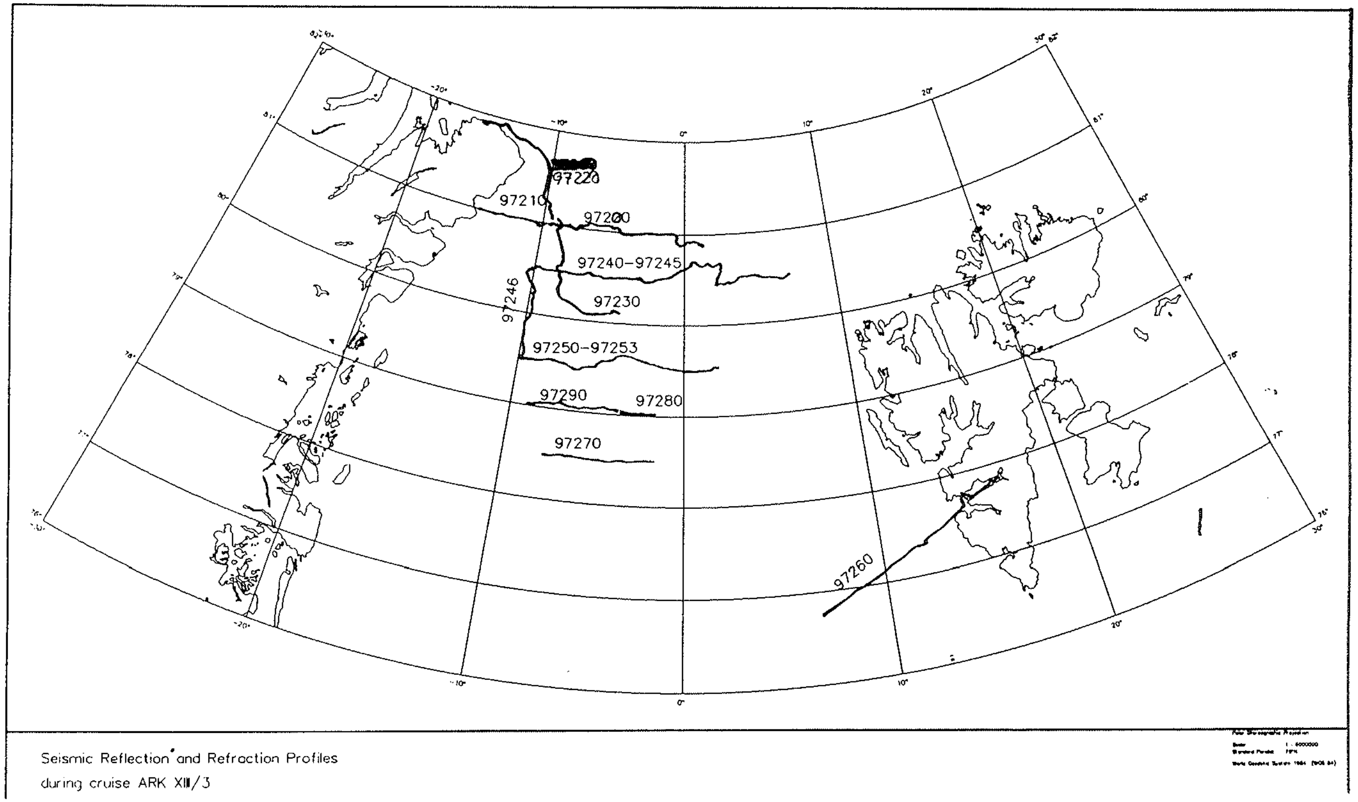


Fig. 6.1 Location of all seismic profiles.

Profile 97260 - VanMijen Fjord

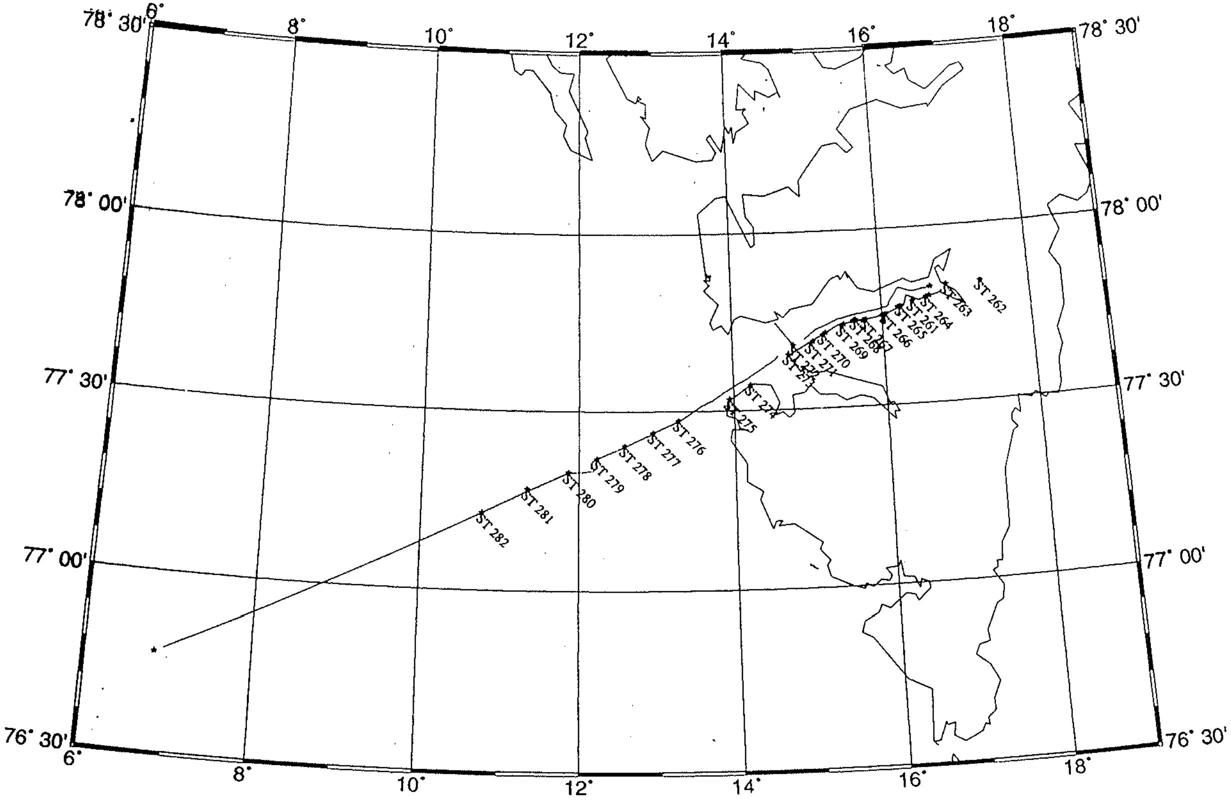


Fig. 6.2 Location plan for all recording stations of the deep seismic sounding profile in the Van Mijenfjord

Data acquisition and problems
All of the seismic reflection data were acquired with a 96-channel streamer (group spacing 6.25 m) and an airgun cluster with a total volume of 24 l (8 VLF airguns) was used as seismic source. The shooting interval varied between 10 and 15 s, which resulted in a coverage of 50 to 80 fold. As the airgun frame broke into two parts after finishing the first two profiles, so all other lines were collected with a four airgun cluster (12 l total volume). The seismic energy, however, still was strong enough to image the basement reflection in the deep parts of the Fram Strait. Strong disturbances in the seismic data occurred in heavy ice when the ship's speed and heading varied quite often. In total 1762 km of multichannel seismic data were collected during the cruise (Tab. 6.1). REFTEK recording stations onshore and on ice floes were deployed in parallel to the seismic reflection data acquisition onshore and on ice floes for determining the seismic velocities of the Ob Bank and the East Greenland Shelf more precisely. Signals were recorded up to 40 km. As the ice floes moved with a speed up to 1 km/h, a small radio transmitter was left on the floes for easier location of the recording equipment. No disturbances or noise from the transmitter can be seen in the seismic data. As the REFTEK units are logging their own position every hour, it was easy to reconstruct the drift path of the floe. This way the location error could be minimised for the velocity analysis.

Within the Van Mijenfjord and along its seaward prolongation a detailed deep seismic experiment was conducted to map the COT of the western Svalbard margin. In total 15 REFTEK recording instruments were deployed along the southern coast of the fjord (Fig. 6.2). The distance between the stations varied between 3 and 10 km. Off Van Mijenjord seven oceanbottom hydrophones (OBH) were deployed up to a distance of 68 km. Here the distances between the instruments varied between 9 and 15 km. The recording parameter of all seismic stations are summarised in table 6.2. One REFTEK station and one OBH failed to record any data.
In general, the subsurface was built out of chaotic sorted glacial deposits (moraine material), which degraded the coupling of the geophones. On a few stations the geophones were placed into clay deposits of river deltas. Basement outcrops were only found at one station (273). Other basement or sediment outcrops were located in steep dipping slopes and therefore not accessible. In addition, the strong wind during the shooting produced a significant higher noise level on the seismic records.
In total three large volume airguns (2x60 l; 1x32 l) were used to produce the seismic signal. The airguns were fired every 60 s and were operated with a pressure of 100 bar. They worked without any problems along the whole profile. Small damages at the air hoses occurred but without disturbing the shooting. The profile was interrupted close to Akseløya. Here, the water is too shallow to allow a safe passage for "Polarstern". The fjord was left, therefore, at its northern end. Then the ship sailed south and the profile was started again close to Akseløya. The gap has a width of almost 10 km.

Seismic data processing
For the seismic data processing a CONVEX 3410EX vector computer, a SUN SPARC 20 and a SPARC 2 were available. On both computers commercial seismic processing software (DISCO) was installed. While the main frame computer processed seismic jobs with heavy input/output operations, first analyses of the seismic data were done on the workstation for velocity analyses and filter tests. Both engines were networked and shared their discs. The first steps of the processing sequence could be finished for most of the profiles (Tab. 6.3). This included demultiplexing, velocity analyses, filter tests and CDP sorting.

Seismic reflection data -First Results-
For acquiring the seismic reflection data a 800 m long streamer (96 channels) together with a 24/12 l airgun cluster has been used. REFTEK recording stations were deployed on ice floes at

four different locations to gain more detailed information on the seismic velocity of the subsurface.

North Greenland Shelf

As already mentioned, it was not possible to perform geophysical measurements north of 81°45'N as no favourable ice conditions were found. However, seismic data could be acquired up to 81°45'N 16°01'W during the ship's passage in the outer part of the polynya. Here, the water depths along line 97210 vary around 100 m. Therefore, strong water bottom multiples are present and the seismic data in the present unprocessed form are difficult to interpret. This will change after finishing the processing sequence. North of the Denmark Fjord a REFTEK station was deployed on stable, not moving sea ice. The station recorded signals up to 15 km. The signals have an almost constant velocity of 4.0 km/s (Fig. 6.3).

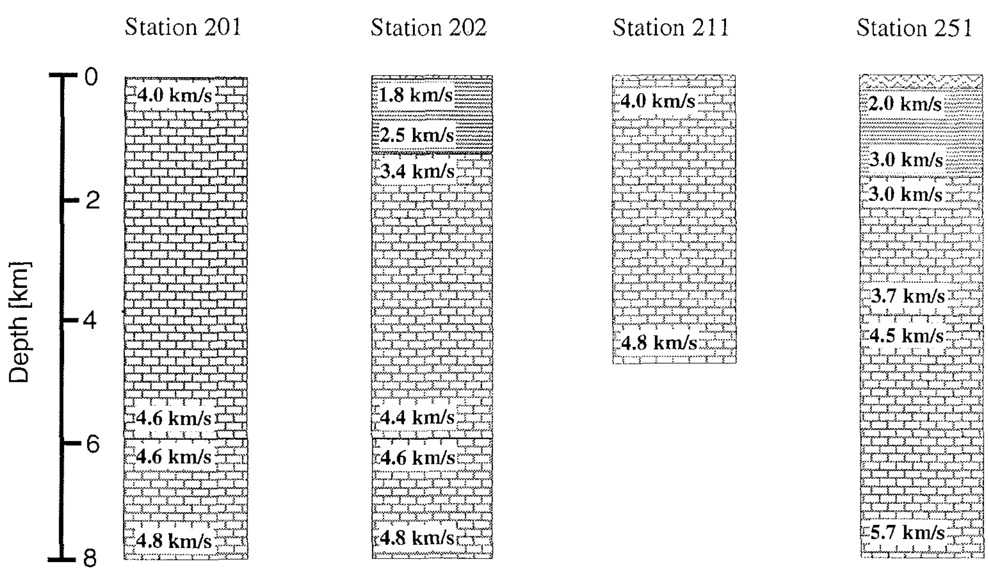


Fig. 6.3 Velocity-depth functions of all seismic recording stations, which were deployed parallel to the seismic reflection profiles.

Ob-Bank
The northern part of the East Greenland Shelf is named Ob-Bank. Here, the water depths vary between 30 and 200 m. The seismic reflection data show only a thin sediment layer of 100 m thickness at maximum. We suggest that this layer represents Quarternary sediment, deposited since the last glaciation of the shelf. Below this layer no clear signals could be identified on the constant offset plots as strong sea floor multiples mask the primary signals. The reflection pattern allows the interpretation that this layer consists out of compacted sediments. This is confirmed by the seismic velocities derived from two REFTEK stations (Tab. 6.2), one deployed onshore (station 201, Fig. 6.4) and one on an ice floe (station 202). In addition, refracted signals on the streamer recordings were analysed to gain information on the velocity of the thin cover layer. The velocities of the Quarternary sediments range from 2.0 to 2.7 km/s. For the layer below seismic velocities ranging from 3.4 to 4.0 km/s were calculated (Fig. 6.3).

Fram Strait
Seismic profiles between the North-Greenland and Svalbard shelves were collected along 81°N, 80°30'N and 79°30'N latitude (Fig. 6.1). The transect along 79°30'N terminated at the Molloy Deep. Profile 97200 (81°N) shows strong basement variations between the central valley of the Lena Trough and the North Greenland Shelf. Here, the sediments are very thin. The data close to the Greenland shelf show downfaulted and rotated sediment units. In the central valley of the Lena Trough thin sediment layer are deposited. The sea floor topography between the Lena Trough and the Yermak Plateau is less rough. The seismic data indicate that here basement highs are covered by 1-2 s TWT of sediments. The profile had to be terminated at the slope of the Yermak Plateau as ice conditions became more severe. The profiles 97240 to 97245 along 80°30'N show different structural units than line 97200, 50 km more to the north. From the Greenland Shelf to the Lena Trough the oceanic basement is covered by several kilometres of sediments. The sediments are downfaulted towards the ridge. A detailed interpretation will be available after the final processing of the seismic data, as the basement is not always visible on the constant offset plots. Towards the Yermak Plateau the basement is covered by at least 2000 m of sediments. The deposition along the western margin of the plateau is clearly influenced by strong currents. This is not visible on the Greenland side.

East Greenland Shelf and the continental margin between 81°N and 78°30'N
The North-East Greenland margin was crossed with in total six seismic profiles. The first one is located at 81°N, the last one at 78°30'N. Between them three more profiles (80°30'N, 80°N, 79°30'N, 79°N) were acquired with a N-S spacing of 50 km. The scientific objective of this regional network was to search for prograding sequences created by glacier advances and retreats during glacial/interglacial cycles. While we found only weak evidence for the presence of such layers at 81°N (Ob-Bank), they are much more developed on the southern profiles. Here, we can follow them up to 20 km westward of the present shelf edge.
Due to time constraints the profiles were terminated at 10°W. The profile length was long enough for the glacial objectives. Most of the profiles show only few structural elements for the first 500 ms. First a thin cover layer (Quarternary ??) can be seen underlain by a sequence without significant seismic structures. The velocity of this layer is based on a REFTEK ice floe recording (Tab. 6.2). The high velocities of 2-3 km/s may indicate that they represent glacially compacted sediments. In some areas clear evidence is found that the inner shelf has been eroded by glaciers in the past.
The only exception is line 97220 which runs in a N-S direction from the Ob Bank to 80°N. South of the Ob-Bank the data show strongly faulted sediments. At the southern end of the profile an erosional unconformity gently dipping towards the south can be identified. This may indicate that the Ob-Bank was quite stable against tectonic stress during the break-up of the North Atlantic.

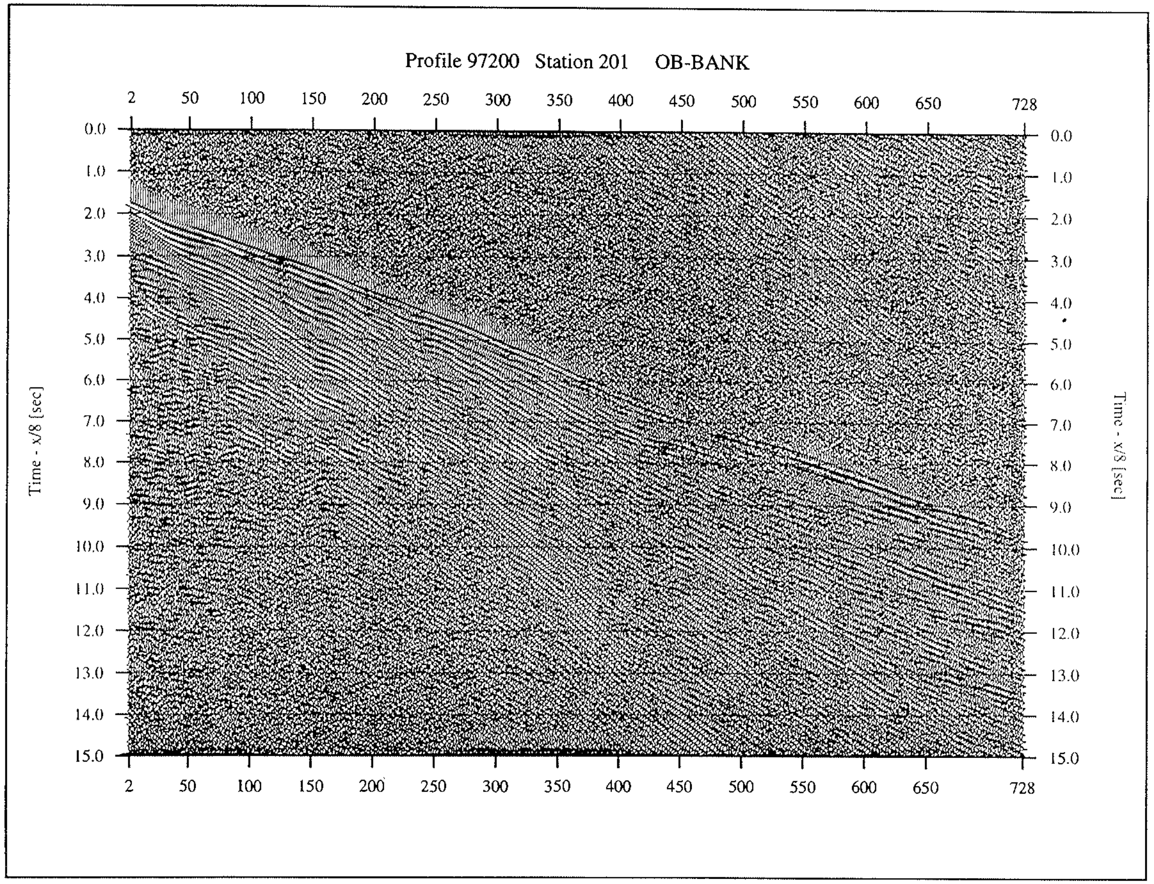


Fig. 6.4 Seismic record section of station 201. It was deployed onshore Nordostrundingen in the prolongation of profile 97200.

Tab. 6.1 Recording parameters for all seismic profiles

Profile	Time Range	Leadin (m)	Streamer (m)	Chan	dx Chan	Airguns	Shots	x [km]	Start Lat	Start Lon	End Lat	End Lon
97200	17.08.1997 11:45:15 - 18.08.1997 13:49:45	182	800	96	6,25	8 x 3 (VLF)	6254	300	81,0105	-12,8663	80,8791	1,3087
97210	22.08.1997 20:45:40 - 23.08.1997 14:12:00	170	800	96	6,25	8 x 3 (VLF)	6243	181	81,0501	-9,3721	81,9034	-16,0203
97220	25.08.1997 06:42:40 - 25.08.1997 19:58:00	170	800	96	6,25	2 x 3 (GI)	4734	144	81,0594	-8,9586	80,0916	-6,6591
97230	25.08.1997 20:02:30 - 25.08.1997 23:59:00	170	800	96	6,25	2 x 3 (GI)	1409	47	80,0889	-6,6123	80,1192	-4,2544
97240	29.08.1997 04:55:00 - 29.08.1997 11:45:30	165	800	96	6,25	4 x 3 (VLF)	1632	68	80,5036	7,0443	80,5029	3,6226
97241	29.08.1997 11:49:00 - 29.08.1997 15:22:45	170	800	96	6,25	4 x 3 (VLF)	850	34	80,4995	3,5957	80,4491	2,0587
97242	29.08.1997 15:23:00 - 29.08.1997 18:03:30	170	800	96	6,25	4 x 3 (VLF)	638	28	80,4494	2,0603	80,6768	2,5229
97243	29.08.1997 18:04:00 - 29.08.1997 22:59:45	170	800	96	6,25	4 x 3 (VLF)	1175	49	80,6772	2,5227	80,7018	0,5017
97244	29.08.1997 23:00:00 - 30.08.1997 06:59:15	170	800	96	6,25	4 x 3 (VLF)	1905	80	80,7017	0,4994	80,4998	-3,1982
97245	01.09.1997 11:02:00 - 02.09.1997 00:10:00	170	800	96	6,25	4 x 3 (VLF)	3131	139	80,5038	-3,0238	80,5090	-10,1359
97246	02.09.1997 00:20:15 - 02.09.1997 11:43:00	170	800	96	6,25	4 x 3 (VLF)	2712	129	80,4986	-10,2059	79,5036	-9,9875
97250	02.09.1997 11:52:00 - 02.09.1997 21:04:00	170	800	96	6,25	4 x 3 (VLF)	2192	99	79,5028	-9,9514	79,5040	-5,3531
97251	02.09.1997 21:07:00 - 02.09.1997 22:17:30	170	800	96	6,25	4 x 3 (VLF)	280	11	79,5066	-5,3358	79,5776	-4,9969
97252	02.09.1997 22:20:30 - 02.09.1997 23:21:30	170	800	96	6,25	4 x 3 (VLF)	242	9	79,5786	-4,9739	79,5900	-4,5262
97253	03.09.1997 04:24:30 - 03.09.1997 18:05:45	170	800	96	6,25	4 x 3 (VLF)	3263	143	79,5894	-4,5336	79,5342	1,9752
97270	11.09.1997 18:03:00 - 12.09.1997 08:04:00	170	800	96	6,25	4 x 3 (VLF)	5018	139	78,4938	-7,7859	78,5002	-1,7164
97280	12.09.1997 11:38:20 - 12.09.1997 15:57:00	170	800	96	6,25	4 x 3 (VLF)	1543	44	79,0315	-1,7191	79,0485	-3,6665
97290	12.09.1997 16:24:50 - 13.09.1997 03:36:50	170	800	96	6,25	4 x 3 (VLF)	4012	118	79,0534	-3,7649	79,0302	-9,0094
							Σ 47233	Σ 1762				

Profil	Time Range	OBH	Refteks	Source	Shots	x [km]	Start Lat	Start Lon	End Lat	End Lon
97260	06.09.1997 11:11:00 - 07.09.1997 15:50:00	1 - 7	17,16,15,12,11,10,09,08,07, 06,05,04,03,02,01	2 x 60 1 x 32	1597	291	77,8290	16,6681	76,7643	6,7126

Tab. 6.2 Recording parameter for all seismic stations on- and offshore during the Van Mijenfjord Experiment.

Station	Gerät	Kanal	Komp.	geograph. Länge	geograph. Breite	Höhe (m)	Absolutentf. in Profilkm.	d x (km)	Signalreich-weite (km) E	Signalreich-weite (km) W
282	OBH 1	1	Hydro	10,7720	77,2140	-1281	110,6	110,6	0 - 21	0 - 45
282	OBH 1	2	Hydro	10,7720	77,2140	-1281	110,6	110,6		
282	OBH 1	3	Hydro	10,7720	77,2140	-1281	110,6	110,6		
282	OBH 1	4	Hydro	10,7720	77,2140	-1281	110,6	110,6		
281	OBH 2	1	Hydro	11,3377	77,2793	-591	126,4	15,8	0 - 33	6 - 10
281	OBH 2	2	Hydro	11,3377	77,2793	-591	126,4	15,8		
281	OBH 2	3	Hydro	11,3377	77,2793	-591	126,4	15,8		
281	OBH 2	4	Hydro	11,3377	77,2793	-591	126,4	15,8		
280	OBH 3	1	Hydro	11,8644	77,3263	-148	140,4	14,0	3 - 10	3 - 10
280	OBH 3	2	Hydro	11,8644	77,3263	-148	140,4	14,0		
280	OBH 3	3	Hydro	11,8644	77,3263	-148	140,4	14,0		
280	OBH 3	4	Hydro	11,8644	77,3263	-148	140,4	14,0		
279	OBH 4	1	Hydro	12,2260	77,3653	-182	150,3	9,9	0 - 118	0 - 30
279	OBH 4	2	Hydro	12,2260	77,3653	-182	150,3	9,9		
279	OBH 4	3	Hydro	12,2260	77,3653	-182	150,3	9,9		
279	OBH 4	4	Hydro	12,2260	77,3653	-182	150,3	9,9		
278	OBH 5	1	Hydro	12,5807	77,4014	-228	159,9	9,6	4 - 95	4 - 38
278	OBH 5	2	Hydro	12,5807	77,4014	-228	159,9	9,6		
278	OBH 5	3	Hydro	12,5807	77,4014	-228	159,9	9,6		
278	OBH 5	4	Hydro	12,5807	77,4014	-228	159,9	9,6		
277	OBH 6	1	Hydro	12,9457	77,4387	-240	169,7	9,8	0 - 100	0 - 55
277	OBH 6	2	Hydro	12,9457	77,4387	-240	169,7	9,8		
277	OBH 6	3	Hydro	12,9457	77,4387	-240	169,7	9,8		
277	OBH 6	4	Hydro	12,9457	77,4387	-240	169,7	9,8		
276	OBH 7	1	Hydro	13,2781	77,4726	-191	178,6	8,9	0	0
276	OBH 7	2	Hydro	13,2781	77,4726	-191	178,6	8,9		
276	OBH 7	3	Hydro	13,2781	77,4726	-191	178,6	8,9		
276	OBH 7	4	Hydro	13,2781	77,4726	-191	178,6	8,9		
275	AWI 17	1	Z	13,9417	77,5317	3	196,0	17,4	3 - 73	3 - 82
275	AWI 17	2	Z	13,9417	77,5317	3	196,0	17,4		
275	AWI 17	3	Z	13,9417	77,5317	3	196,0	17,4		
274	AWI 16	1	Z	14,2207	77,5712	27	204,1	8,1	2 - 74	2 - 70
274	AWI 16	2	Z	14,2207	77,5712	27	204,1	8,1		
274	AWI 16	3	Z	14,2207	77,5712	27	204,1	8,1		
273	AWI 15	1	Z	14,7317	77,6550	15	219,6	15,5	7 - 45	4 - 145
273	AWI 15	2	Z	14,7317	77,6550	15	219,6	15,5		
273	AWI 15	3	Z	14,7317	77,6550	15	219,6	15,5		
272	AWI 12	1	Z	14,7995	77,6805	1	222,9	3,3	4 - 45	5 - 56
272	AWI 12	2	Z	14,7995	77,6805	1	222,9	3,3		
272	AWI 12	3	Z	14,7995	77,6805	1	222,9	3,3		
271	AWI 11	2	Z	15,0387	77,6838	84	227,7	4,8		
271	AWI 11	3	Z	15,0387	77,6838	84	227,7	4,8		
271	AWI 11	1	Z	15,0687	77,6902	60	228,5	0,8	2 - 39	12 - 100
270	AWI 10	1	Z	15,2107	77,7080	30	232,2	3,7	0	0
270	AWI 10	2	Z	15,2107	77,7080	30	232,2	3,7		
270	AWI 10	3	Z	15,2395	77,7125	30	233,1	0,9		
269	AWI 09	1	Z	15,4558	77,7293	60	238,7	5,6	3 - 31	3 - 105
269	AWI 09	2	Z	15,4558	77,7293	60	238,7	5,6		
269	AWI 09	3	Z	15,4848	77,7352	60	239,7	1,0		
268	AWI 08	3	Z	15,6125	77,7422	20	242,8	3,1		
268	AWI 08	1	Z	15,6437	77,7460	20	243,6	0,8	2 - 25	2 - 95
268	AWI 08	2	Z	15,6437	77,7460	20	243,6	0,8		
267	AWI 07	1	Z	15,7402	77,7427	27	245,9	2,3	3 - 24	3 - 105
267	AWI 07	2	Z	15,7792	77,7440	27	246,8	0,9		
267	AWI 07	3	Z	15,7792	77,7440	27	246,8	0,9		
266	AWI 06	3	Z	16,0067	77,7550	60	252,4	5,6		
266	AWI 06	1	Z	16,0483	77,7567	72	253,4	1,0	3 - 16	3 - 130
266	AWI 06	2	Z	16,0483	77,7567	72	253,4	1,0		
265	AWI 05	1	Z	16,2183	77,7762	45	258,0	4,6	3 - 12	3 - 145
265	AWI 05	2	Z	16,2537	77,7777	60	258,9	0,9		
265	AWI 05	3	Z	16,2537	77,7777	60	258,9	0,9		
261	AWI 03	1	Z	16,4200	77,7913	30	263,1	4,2	3 - 7	3 - 115
261	AWI 03	2	Z	16,4200	77,7913	30	263,1	4,2		
261	AWI 03	3	Z	16,4200	77,7913	30	263,1	4,2		
264	AWI 04	1	Z	16,6092	77,8008	36	267,7	4,6	0	3 - 266
264	AWI 04	2	Z	16,6092	77,8008	36	267,7	4,6		
264	AWI 04	3	Z	16,6483	77,8038	30	268,7	1,0		
263	AWI 01	1	Z	16,8807	77,8332	24	275,0	6,4	0	5 - 125
263	AWI 01	2	Z	16,8807	77,8332	24	275,0	6,4		
263	AWI 01	3	Z	16,8807	77,8332	24	275,0	6,4		
263	AWI 01	4	H1	16,8807	77,8332	24	275,0	6,4		
263	AWI 01	5	H2	16,8807	77,8332	24	275,0	6,4		
263	AWI 01	6	V3	16,8807	77,8332	24	275,0	6,4		
262	AWI 02	1	Z	17,3440	77,8363	690	286,0	10,9	0	16 - 195
262	AWI 02	2	Z	17,3440	77,8363	690	286,0	10,9		
262	AWI 02	3	Z	17,3440	77,8363	690	286,0	10,9		
262	AWI 02	4	H1	17,3440	77,8363	690	286,0	10,9		
262	AWI 02	5	H2	17,3440	77,8363	690	286,0	10,9		
262	AWI 02	6	V3	17,3440	77,8363	690	286,0	10,9		
251	AWI 15	1	Hydro	-6,9630	79,4978	1				
251	AWI 15	2	Z	-6,9630	79,4978	1				
251	AWI 15	3	Z	-6,9630	79,4978	1				
211	AWI 12	1	Hydro	-14,8270	81,9057	1				
211	AWI 12	2	Z	-14,8270	81,9057	1				
211	AWI 12	3	Z	-14,8270	81,9057	1				
202	AWI 15	1	Hydro	-10,2557	80,9783	1				
202	AWI 15	2	Z	-10,2557	80,9783	1				
201	AWI 02	1	Z	-13,2343	80,0217	5				
201	AWI 02	2	Z	-13,2343	80,0217	5				
201	AWI 02	3	Z	-13,2343	80,0217	5				

Tab. 6.3 Seismic data processing onboard "Polarstern".

Profil	Exp. Type	Field Tape	Demultiplxed	DEMUX Tape	Geometry	Sorted	SORT Tape	CVA
97200	marine	F01400-F01444	19.08.1997	C10650-C10709	01.09.1997	20.08.1997	C10710-C10767	24.08.1997
97210	marine	F01445-F01475	24.08.1997	C10813-C10856	24.08.1997	25.08.1997	C10857-C10899	26.08.1997
97220	marine	F01476-F01515	26.08.1997	C10900-C10953	26.08.1997	27.08.1997	C10954-C11005	30.08.1997
97230	marine	F01516-F01519	28.08.1997	C11006-C11021	28.08.1997	28.08.1997	C11022-C11037	30.08.1997
		F01550-F01557						
97240	marine	F01558-F01569	29.08.1997	C11038-C11053	01.09.1997	01.09.1997	C11091-C11099	07.09.1997
97241	marine	F01570-F01602	31.08.1997	C11054-C11062	01.09.1997	01.09.1997	C11863-C11870	07.09.1997
97242	marine	"	"	C11062-C11068	07.09.1997	07.09.1997	C11871-C11876	07.09.1997
97243	marine	"	"	C11068-C11079	02.09.1997	07.09.1997	C11877-C11887	09.09.1997
97244	marine	"	"	C11079-C11856	07.09.1997	09.09.1997	C11888-C11905	09.09.1997
97245	marine	F01603-F01625	"	C11907-C11937	22.09.1997			
97246	marine	F01626-F01645	"	C11938-C11964	22.09.1997			
97250	marine	F01645-F01661	15.09.1997	C11906,C11965-C11969	15.09.1997			
				C11971-C11986				
97251	marine	F01661-F01663	16.09.1997	C11987-C11990	22.09.1997			
97252	marine	F01663-F01665	16.09.1997	C11991-C11993	22.09.1997			
97253	marine	F01666-F01690		/				
97260	Reftek/OBH	F01691	16.09.1997	C11994				
97270	marine	F01692-F01717						
97280	marine	F01718-F01725						
97290	marine	F01726-F01745						

Seismic refraction -First Results- (Van Mijenfjord)

The recording parameters of all REFTEK recording stations as well as the signal quality is summarised in table 6.2 and in the appendix (App. 6.1). The data of all stations have been controlled for channel 1. Seismic data processing of the refraction data was restricted on the application of a frequency filter. In general the seismic data show the following features:

1. Most of the recordings show signals up to 130 km. Inbetween the quality is changing obviously due to lateral variations in the subsurface. However, the phases through the upper and lower crust (Pg) can be identified as well as the phase from the upper mantle (Pn) on most of the recordings. The Pn can be followed in some cases up to 200 km.
2. Strong lateral variations in the sediment thickness, especially west of Akseløya make the velocity determination difficult. The sediment basin offshore delays the signal with more than 1 s.
3. Sediment velocities of more than 4.0 km/s can be found in the fjord, while they have lower values at the westernmost OBH stations. Some OBH recording show signals only up to 20 km. They are located on the Hornsund Fault system. It is assumed that the complex geology of the fault system scatters the seismic energy extremely strong. This is obvious on recordings of OBH-6, where seismic signals towards the Van Mijenfjord can be followed up to 100 km, while westward the signals are disappearing within several tenth of kilometers.
4. Clear reflection from the Moho (PmP) on all seismic stations and its lateral variation in the apparent mean velocity indicate that the transition zone between pure continental crust and mixed rifted crust could be mapped by the experimental layout. The strong variation in the PmP hyperbola‘s shape indicate a rough Moho topography and a thinning of crustal thickness towards the west.
5. S-wave travel time branches are visible in some of the record section onshore. However, they are difficult to pick.

Gravity measurements

A fixed installed gravity meter KSS31 (Bodenseewerke) on board operated during the whole cruise without problems. The data were collected with a sampling interval of 10 s and stored every hour on the central VAX computer. Control points were taken with a Lacoste&Romberg Landgravity Meter in Tromsoe (old Police Station) and at the absolute point in Bremerhaven (AWI). In total almost 13000 km of gravity data were acquired.

Appendix 6.1

Stationen 97261 - 97282, VAN MIJENFJORD-Profil

Station Nr.	Reftek Nr.		Speicher	Ketten	Kabel	Batterien
97261	AWI 03	(6)	1 Gb	9 Z	1 x 200m	2 Batterien
97262	AWI 02	(6)	1 Gb	9 Z; 2 x 3K	2 x 50m	2 Batterien
97263	AWI 01	(6)	1 Gb	9 Z; 2 x 3K	1 x 200m	2 Batterien
97264	AWI 04	(6)	0.425 Gb	9 Z	2 x 500m	1 Batterie
97265	AWI 05	(6)	0.425 Gb	9 Z	2 x 500m; 2 x 50m	1 Batterie
97266	AWI 06	(6)	0.425 Gb	9 Z	2 x 500m	1 Batterie
97267	AWI 07	DAT	1 Gb	9 Z	2 x 500m	1 Batterie
97268	AWI 08	DAT	1 Gb	8 Z	2 x 500m	1 Batterie
97269	AWI 09	DAT	1 Gb	8 Z	2 x 500m; 1 x 50m	1 Batterie
97270	AWI 10	DAT	1 Gb	8 Z	5 x 200m	1 Batterie
97271	AWI 11	(3)	1 Gb	8 Z	5 x 200m	1 Batterie
97272	AWI 12	(3)	1 Gb	8 Z		2 Batterien
97273	AWI 15	(3)	1 Gb	8 Z	1 x 200m	2 Batterien
97274	AWI 16	(3)	1 Gb	8 Z		2 Batterien
97275	AWI 17	(3)	1 Gb	7 Z		2 Batterien
97276	OBH-7					
97277	OBH-6					
97278	OBH-5					
97279	OBH-4					
97280	OBH-3					
97281	OBH-2					
97282	OBH-1					

VORHANDEN:

Ketten:	127 x Z	Kabel:	13 x 500m
	12 x 3K		15 x 200m
			25 x 50m

VERBRAUCH:

Ketten:	126 x Z	Kabel:	12 x 500m
	4 x 3K		13 x 200m
			3 x 50m

7. Station list

Date	Station	Time	Latidude	Longitude	Equipment employed
15.08.	001	06.16	74° 58,2' N	03° 04,4' W	JoJo-Verankerung
		09.29			
	002	11.14	74° 49,4' N	04° 20,5' W	JoJo-Verankerung
		14.57	74° 58,9' N	04° 20,0' W	CTD
17.08	003	10.15	81° 00,3' N	12° 54,7' W	Seismik
18.08		14.36	80° 53,9' N	01° 16,0' E	
	004	17.01	81° 01,7' N	02° 22,7' E	CTD
		17.54			
	005	20.03	81° 01,5' N	01° 26,9' E	CTD
		21.07			
	006	22.35	81° 03,8' N	00° 45,8' E	CTD
		23.45	81° 04,0' N	00° 51,3' E	
19.08	006b	01.05	81° 05,8' N	00° 21,2' E	CTD
		02.27			
	007	06.04	80° 58,6' N	00° 26,1' W	CTD
		07.43	80° 58,1' N	00° 22,7' W	
	008	09.25	81° 00,8' N	01° 36,1' W	CTD; SL
		11.41	81° 01,0' N	01° 33,0' W	
	009	13.08	81° 04,2' N	02° 02,7, W	CTD
		15.14			
	010	17.07	81° 03,7' N	02° 46,4, W	CTD
		19.15			
	011	20.26	81° 03,9' N	03° 29,6, W	CTD
		23.12			
20.08	012	00:08	81° 04,0' N	04° 02,2' W	CTD; GKG; SL
		05:47			
	013	07:52	81° 03,9' N	04° 59,4' W	CTD
		09:24			
	014	10:30	81° 04,1' N	05° 34,5' W	CTD; GKG; SL
		14:16			
	015	16:14	81° 03,8' N	06° 31,8' W	CTD
		17:26			
	016	19:23	81° 03,4' N	06° 41,5' W	GKG; SL
		21:07			
	017	22:08	81° 03,7' N	07° 00,4' W	CTD; GKG
21.08		00:04			
	018	00:52	81° 04,2' N	07° 19,3' W	CTD
		01:46			
	019	04:18	81° 04,5' N	07° 43,0' W	CTD
		05:15			
	020	06:32	81° 02,1' N	07° 47,0' W	CTD
		06:57			
	021	08:15	80° 55,6' N	07° 35,4' W	EBS
		09:44	80° 54,3' N	07° 43,5' W	
		10:15	80° 56,6' N	07° 40,1' W	HS-Profil
22.08		02:50	81° 44,3' N	04° 05,6' W	
	022	06:05	81° 40,7' N	04° 35,6' W	CTD
		08:46	81° 41,2' N	04° 33,2' W	
	023	20:08	81° 02,3' N	09° 08,5' W	Seismik
23.08		14:44	81° 55,6' N	16° 08,3' W	

	024	19:58	81° 36,1' N	11° 14,0' W	CTD
		20:12			
	025	20:59	81° 39,5' N	10° 46,5' W	CTD; GKG
		21:38			
	026	22:32	81° 43,8' N	10° 12,7' W	CTD; GKG
		23:18			
24.08	027	00:10	81° 44,7' N	09° 42,9' W	CTD
		01:02			
24.08	028	02:15	81° 44,7' N	09° 33,4' W	CTD
		03:16			
	029	04:00	81° 45,3' N	09° 29,0' W	CTD; GKG; SL
		07:30			
	030	08:43	81° 48,8' N	08° 56,8' W	CTD
		10:05			
	031	12:24	81° 51,5' N	08° 13,8' W	CTD; GKG; SL
		17:02			
25.08	032	06:14	81° 05,2' N	09° 01,1' W	Seismik
26.08		00:14	80° 07,1' N	04° 18,5' W	
	033	04:22	79° 39,7' N	06° 57,5' W	CTD
		04:37			
	034	06:26	79° 40,1' N	05° 28,2' W	CTD; GKG; SL
		08:14			
	035	08:40	79° 40,3' N	05° 05,5' W	CTD
		09:18			
	036	10:14	79° 40,1' N	04° 34,6' W	CTD; GKG; KL
		13:28			
	037	14:52	79° 40,2' N	03° 56,4' W	CTD; KAL
		16:02	79° 40,5' N	04° 03,0' W	
	038	19:48	79° 40,0' N	03° 00,1' W	CTD
		21:11			
	039	22:46	79° 39,9' N	02° 11,0' W	CTD
27.08		00:19			
	040	02:10	79° 40,1' N	01° 19,3' W	CTD; GKG; SL
		03:34	79° 41,0' N	01° 16,6' W	
	041	08:05	79° 39,9' N	00° 29,7' W	CTD
		09:32			
	042	10:53	79° 40,0' N	00° 19,9' E	CTD
		12:23			
	043	13:48	79° 39,9' N	01° 11,2' E	CTD
		15:17			
	044	16:33	79° 39,9' N	02° 02,4' E	CTD; GKG; SL
		19:57			
	045	20:53	79° 40,0' N	02° 29,9' E	CTD
		22:08			
	046	23:15	79° 40,0' N	03° 19,3' E	CTD; GKG
28.08		04:06	79° 38,7' N	03° 13,9' E	
	047	05:26	79° 40,0' N	04° 10,1' E	CTD
		07:04			
	048	08:03	79° 40,0' N	05° 00,0' E	CTD
		09:22			
	049	10:12	79° 40,0' N	05° 39,8' E	CTD
		11:09			
	050	11:42	79° 40,2' N	05° 59,4' E	CTD; GKG; SL
		14:30	79° 40,1' N	06° 05,9' E	

	051	15:18	79° 40,0' N	06° 40,6' E	CTD
		16:04			
	052	16:58	79° 40,1' N	07° 30,0' E	CTD; GKG; SL
		18:59	79° 40,8' N	07° 34,7' E	
	053	19:55	79° 40,0' N	08° 19,9' E	CTD; GKG
		20:43			
	054	21:56	79° 40,2' N	09° 09,4' E	CTD
		22:14			
	055	23:18	79° 40,1' N	09° 59,2' E	CTD
		23:30			
29.08	056	04:07	80° 30,4' N	07° 17,2' E	Seismik
01.09		09:15	80° 30,5' N	03° 15,0' W	
	057	09:53	80° 29,5' N	02° 56,0' W	Seismik
02.09		23:50	79° 35,4' N	04° 40,5' W	
03.09	058	00:15	79° 35,7' N	04° 34,8' W	KL; GKG
		02:48			
	059	03:05	79° 37,3' N	04° 40,9' W	Seismik
		18:34	79° 32,7' N	02° 09,3' E	
	060	20:47	79° 10,0' N	02° 39,6' E	CTD
		23:40	79° 09,5' N	02° 45,1' E	
05.09.	061	02:00	77° 12,8' N	10° 46,3' E	CTD; Seismik
		07:54	77° 28,4' N	13° 16,7' E	
	062	10:45	77° 49,6' N	16° 42,0' E	Seismik
07.09		16:08	76° 45,4' N	06° 38,6' E	
08.09	063	04:11	77° 22,4' N	12° 13,7' E	Seismik
		04:55			
	064	05:35	77° 24,2' N	12° 33,9' E	Seismik
		05:59			
	065	06:39	77° 26,5' N	12° 56,0' E	Seismik
		07:00			
	066	07:32	77° 28,6' N	13° 16,1' E	Seismik
		07:53			
	067	11:15	77° 12,9' N	10° 47,2' E	Seismik
		11:43			
	068	12:30	77° 16,9' N	11° 19,0' E	Seismik
		12:49			
	069	13:31	77° 19,5' N	11° 51,1' E	Seismik
		13:44			
09.09.	070	00:13	77° 55,2' N	10° 01,0' E	CTD
		00:30			
	071	01:13	77° 55,0' N	09° 38,4' E	CTD
		01:40			
	072	02:12	77° 55,1' N	09° 17,6' E	CTD
		02:53			
	073	03:46	77° 55,5' N	08° 42,0' E	CTD
		04:34			
	074	05:16	77° 55,3' N	08° 17,9' E	CTD
		06:23			
	075	06:52	77° 55,2' N	08° 00,0' E	CTD
		08:15			
	076	08:54	77° 55,2' N	07° 44,7' E	CTD
		10:24			
	077	10:57	77° 55,0' N	07° 24,8' E	CTD
		12:44			

	078	14:07	77° 55,1‘ N	06° 39,3‘ E	CTD
		15:29			
	079	16:28	77° 55,1‘ N	05° 59,8‘ E	CTD
		17:50			
	080	18:58	77° 55,0‘ N	05° 10,4‘ E	CTD
		20:19			
	081	21:35	77° 55,0‘ N	04° 30,9‘ E	CTD
		22:51			
10.09.	082	00:03	77° 55,2‘ N	03° 40,5‘ E	CTD
		01:52			
	083	03:02	77° 55,1‘ N	02° 49,4‘ E	CTD
		04:37			
	084	05:44	77° 55,1‘ N	02° 00,1‘ E	CTD
		07:20			
	085	08:20	77° 55,1‘ N	02° 00,1‘ E	CTD
		09:58			
	086	10:59	77° 55,0‘ N	00° 22,2‘ E	CTD
		12:38			
	087	13:51	77° 55,2‘ N	00° 30,3‘ W	CTD
		15:28			
	088	16:38	77° 55,0‘ N	01° 20,3‘ W	CTD
		18:12			
	089	19:27	77° 55,0‘ N	02° 10,0‘ W	CTD
		21:00			
	090	22:03	77° 55,0‘ N	02° 59,0‘ W	CTD
		23:36			
11.09	091	00:20	77° 55,1‘ N	03° 00,4‘ W	CTD
		11:48			
	092	03:00	77° 55,1‘ N	03° 50,3‘ W	CTD
		04:24			
	093	05:22	77° 54,9‘ N	04° 29,5‘ W	CTD
		06:38			
	094	07:15	77° 54,9‘ N	04° 53,3‘ W	CTD
		08:04			
	095	08:33	77° 54,8‘ N	05° 04,8‘ W	CTD
		09:08			
	096	09:36	77° 55,1‘ N	05° 18,0‘ W	CTD
		09:58			
	097	11:10	77° 55,1‘ N	05° 58,2‘ W	CTD
		11:31			
	098	13:36	78° 06,8‘ N	06° 34,7‘ W	EBS
		14:30	78° 07,2‘ N	06° 35,8‘ W	
	099	17:29	78° 29,7‘ N	07° 58,5‘ W	Seismik
12.09		08:30	78° 30,7‘ N	01° 41,7‘ W	
	100	11:05	78° 59,9‘ N	01° 45,2‘ W	Seismik
13.09		04:44	79° 03,4‘ N	08° 58,7‘ W	
	101	08:35	79° 03,4‘ N	05° 36,7‘ W	GKG; SL
		10:07			
	102	11:37	79° 05,0‘ N	04° 43,7‘ W	GKG; SL
		13:40			
	103	18:26	78° 29,3‘ N	02° 53,2‘ W	GKG
		19:47			
15.09	104	06:09	75° 19,4‘ N	15° 55,8‘ W	CTD
		06:19			

	105	07:54 08:05	75° 16,0‘ N	15° 30,1‘ W	CTD
	106	09:42 09:56	75° 12,6‘ N	15° 00,2‘ W	CTD
	107	11:50 12:04	75° 07,9‘ N	14° 20,5‘ W	CTD
	108	14:09 14:24	75° 02,9‘ N	13° 39,8‘ W	CTD
	109	16:04 16:22	75° 00,5‘ N	13° 07,0‘ W	CTD
	110	17:20 17:55	75° 00,0‘ N	12° 43,2‘ W	CTD
	111	18:30 19:19	74° 59,4‘ N	12° 30,3‘ W	CTD
	112	19:57 20:45	74° 59,4‘ N	12° 30,3‘ W	CTD
	113	21:30 22:38	74° 59,9‘ N	12° 06,5‘ W	CTD
 16.09	114	23:31 00:52	75° 00,1‘ N	11° 46,7‘ W	CTD
	115	01:50 03:13	75° 00,3‘ N	11° 21,2‘ W	CTD
	116	04:09 05:45	75° 00,1‘ N	10° 54,8‘ W	CTD
	117	06:51 08:27	75° 00,2‘ N	10° 34,3‘ W	CTD
	118	09:43 11:14	75° 00,0‘ N	09° 56,9‘ W	CTD
	119	12:30 14:18	75° 00,0‘ N	09° 18,4‘ W	CTD
	120	15:35 17:16	74° 59,8‘ N	08° 39,4‘ W	CTD
	121	18:34 20:28	75° 00,2‘ N	08° 01,2‘ W	CTD
	122	21:50 23:38	75° 00,0‘ N	07° 22,0‘ W	CTD
17.09	123	00:53 02:37	75° 00,4‘ N	06° 44,6‘ W	CTD
	124	04:09 05:54	75° 00,1‘ N	06° 05,1‘ W	CTD
	125	07:12 09:05	75° 00,1‘ N	05° 26,3‘ W	CTD
	126	10:48 12:40	75° 00,1‘ N	04° 48,1‘ W	CTD
	127	13:58 15:51	75° 00,3‘ N	04° 07,7‘ W	CTD
	128	17:05 19:00	74° 59,9‘ N	03° 30,9‘ W	CTD
	129	20:16 22:15	74° 59,8‘ N	02° 50,9‘ W	CTD
 18.09	130	23:27 01:22	75° 00,0‘ N	02° 13,4‘ W	CTD
	131	02:35 04:40	75° 00,0‘ N	01° 35,6‘ W	CTD

	132	06:02 07:59	75° 00,0' N	00° 56,0' W	CTD
	133	09:21 11:09	75° 00,0' N	00° 17,4' W	CTD
	134	12:19 14:16	75° 00,0' N	00° 22,5' E	CTD
	135	15:30 17:31	75° 00,0' N	00° 59,4' E	CTD
	136	18:38 19:25	74° 59,9' N	01° 38,5 E	CTD
	137	21:28 23:12	75° 00,1' N	02° 16,9' E	CTD
19.09	138	08:09 10:00	74° 54,9' N	04° 36,3' W	JoJo-Verankerung
	139	12:00 14:03	75° 04,8' N	03° 29,1' W	JoJo-Verankerung
	140	21:18 22:37	75° 00,1' N	02° 56,2' E	CTD
 20.09	141	23:47 01:29	75° 00,1' N	03° 34,2' E	CTD
	142	02:40 04:10	75° 00,2' N	04° 13,9' E	CTD
	143	05:21 07:01	75° 00,0' N	04° 51,6' E	CTD
	144	07:42 09:25	75° 00,0' N	05° 10,8' E	CTD
	145	10:05 11:33	75° 00,4' N	05° 31,1' E	CTD
	146	12:14 13:40	75° 00,0' N	05° 49,3' E	CTD
	147	14:26 15:50	75° 00,1' N	06° 09,1' E	CTD
	148	16:34 17:57	75° 00,2' N	06° 27,8' E	CTD
	149	18:47 19:58	75° 00,1' N	06° 48,3' E	CTD
	150	20:35 21:49	75° 00,2' N	07° 08,2' E	CTD
	151	22:30 23:48	74° 59,8' N	07° 25,2 E	CTD
21.09	152	01:08 02:56	75° 00,3' N	08° 05,5E	CTD
	153	04:13 05:33	75° 00,1' N	08° 44,0' E	CTD
	154	06:43 08:03	75° 00,1' N	09° 22,2' E	CTD
	155	09:14 10:32	74° 59,8' N	10° 00,6 E	CTD
	156	11:42 13:03	75° 00,2' N	10° 38,5' E	CTD
	157	14:30 15:49	75° 00,1' N	11° 19,6' E	CTD
	158	17:00 18:10	75° 00,2' N	11° 56,6' E	CTD

	159	19:22 20:45	75° 00,1' N	12° 35,0E	CTD
	160	21:53 22:55	75° 00,1' N	13° 13,7 E	CTD
22.09	161	00:11 01:24	75° 00,1' N	13° 52,6' E	CTD
	162	02:44 03:41	75° 00,1' N	14° 31,3' E	CTD
	163	05:08 05:50	75° 00,0' N	15° 10,1' E	CTD
	164	07:03 07:20	75° 00,1' N	15° 48,7' E	CTD
	165	08:35 08:46	75° 00,0' N	16° 26,4' E	CTD
	166	10:04 10:18	74° 59,8' N	17° 05,0' E	CTD
	167	11:55 12:10	75° 00,0' N	17° 59,4' E	CTD
	168	13:22 13:39	74° 49,9' N	17° 59,5' E	CTD
	169	14:46 14:54	74° 40,0' N	17° 58,9' E	CTD
	170	16:06 16:18	74° 30,2' N	17° 59,6' E	CTD
	171	17:50 18:00	74° 20,0' N	17° 59,9' E	CTD
	172	19:10 19:19	74° 09,9' N	18° 00,0' E	CTD
	173	20:32 20:38	74° 59,6' N	17° 59,5' E	CTD
	174	21:53 21:58	73° 49,8' N	18° 00,1' E	CTD
	175	23:11 23:24	73° 49,6' N	18° 00,0' E	CTD
23.09	176	00:41 01:01	73° 29,8' N	17° 58,9' E	CTD
	177	02:15 02:37	73° 19,9' N	17° 57,6' E	CTD
	178	03:44 04:12	73° 10,0' N	17° 59,6' E	CTD
	179	05:51 06:14	72° 59,7' N	17° 59,4' E	CTD
	180	07:26 07:54	72° 50,0' N	17° 59,5' E	CTD
	181	09:08 09:31	72° 40,2' N	18° 00,2' E	CTD
	182	10:48 11:07	72° 30,1' N	18° 00,2' E	CTD
	183	12:25 12:49	72° 20,0' N	17° 58,6' E	CTD
	184	14.00 14:30	72° 10,0' N	17° 59,7' E	CTD
	185	15:40 16:02	71° 59,9' N	17° 59,9' E	CTD

186	17:11 17:29	71° 50,0' N	18° 00,2' E	CTD
187	18:39 18:56	71° 39,8' N	18° 00,6' E	CTD
188	20:05 20:21	71° 30,0' N	18° 00,1' E	CTD
189	21:28 21:44	71° 20,0' N	18° 00,0' E	CTD
190	22:59 23:12	71° 10,1' N	18° 00,3' E	CTD

8. Participants

Name	Institutions
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1. Offc.	Rodewald, Martin
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2. Offc.	Block, Michael
2. Offc.	-
Doctor	Fleischer-P., Brigitte
R. Offc.	Koch, Georg
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2. Eng.	Ziemann, Olaf
2. Engl.	Fleischer, Martin
Electron.	Lembke, Udo
Electron.	Muhle, Helmut
Electron.	Greitemann-Hackl., A.
Electron.	Roschinsky, Jörg
Electr.	Muhle, Heiko
Boatsw.	Clasen, Burkhard
Carpenter	Reise, Lutz
A.B.	Bohne, Jens
A.B.	Hartwig, Andreas
A.B.	Gil Iglesias, Luis
A.B.	Pousada Martinez, S.
A.B.	Kreis, Reinhard
A.B.	Schultz, Ottomar
A.B.	Burzan, G.-Ekkehard
A.B.	Pulss, Horst
Storek.	Müller, Klaus
Mot-man	Ipsen, Michael
Mot-man	Husung, Udo
Mot-man	Grafe, Jens
Mot-man	Hartmann, Ernst-Uwe
Mot-man	Preußner, Jörg
Cook	Haubold, Wolfgang
Cooksmate	Völske, Thomas
Cooksmate	Yavuz, Mustafa
1. Stwdess	Jürgens, Monika
Stwdss/KS	Dähn, Ulrike
2. Stwdess	Czyborra, Bärbel
2. Stwdess	Deuß, Stefanie
2. Stwdess	Neves, Alexandra
2. Steward	Huang, Wu Mei
2. Steward	Mui, Kee Fung
Laundrym.	Yu, Kwok Yuen

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