

REPORT

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QUATERNARY SAMPLES COLLECTED AS A PART
OF THE PROJECT SHALLOW DRILLING ELF AQUITAINE/
NORSK HYDRO/STATOIL
BARENTS SEA 1987

REPORT NO.: 21.3441.00/03/89

AUTHORS:

J. Sættem, H.M. Weiss and D.A. Westgaard



IKU

SINTEF GROUP



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REPORT

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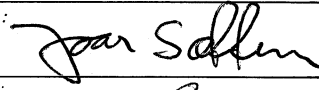
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Elf Aquitaine Norge A/S, Norsk Hydro a.s, Statoil,

SUMMARY:

During July to September 1987 18 shallow boreholes were drilled in Quaternary and pre Quaternary sediments in the Barents Sea as part of three different IKU projects. The present report gives the result of soil mechanical analyses, sediment description and datings done on samples from holes drilled as part of IKU project 21.3435.00. Two of the holes are located close to the Dia-Structure and two holes are located in the Nordkapp Basin area. Fourteen samples with a total length of 3.82 m were recovered.

Most of the Quaternary samples are collected by hammer - or push - sampling, but a number of samples of stony soil are also collected by rotary diamond coring.

KEY WORDS: Barents Sea	Shallow drilling
Quaternary	Glacigenic sediments
Soil conditions	Project 21.3435.00

PREFACE

The present report gives the results of analyses carried out on Quaternary samples collected as part of the project 21.3435 Shallow Drilling Elf Aquitaine/ Norsk Hydro/ Statoil Barents Sea 1987 during a combined shallow drilling cruise in the southern Barents Sea in 1987.

The participants of the project are:

Elf Aquitaine Norge A/S

Norsk Hydro a.s

Den norske stats oljeselskap a.s (Statoil)

The field work was coordinated by Tom Bugge and Joar Sættem and the laboratory work by Joar Sættem. The report is based on contributions from the following IKU personnel:

Field work: T. Berg, T. Bugge, G. Elvebakk, E. Haugane, G. Haugen,
L. Husvik, A. Mørk, H. Rendall, L. Rise, J. Sættem,
D.A Westgaard.

Sample description: D.A. Westgaard and J. Sættem.

Laboratory analyses: H. Rendall, H.M. Weiss and D.A. Westgaard.

Foraminifer picking: R. Wilhelmsen.

Drawing: R. Angell-Petersen, B. Fossum, J. Johansen.

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A study of magnetic properties is carried out by R. Løvlie and K.L. Ellingsen at the University of Bergen, geotechnical laboratory investigations are carried out by the SINTEF Division of Geotechnical Engineering.

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1. INTRODUCTION

During a shallow drilling cruise in the Barents Sea in 1987 (Appendix 1) samples were obtained from the Quaternary sediments covering the pre Quaternary rocks in the area. The purpose of this sampling was in the case of the heat flow boreholes to determine the thermal conductivity of the sediments and in the other boreholes to document the conditions of the drilled formation and to provide some regional data on general geotechnical conditions and glacial geology of the area. The sampling was carried out by a hammersampler, a hydraulic pushsampler or by rotary diamond coring. The latter method was used when the soil conditions hampered penetration by standard soil boring bits and the piggyback equipment was used to advance to bedrock. Brief descriptions of the methods are given in Appendix 1.

The purpose of the present report is to provide a documentation of the Quaternary samples and results of various analyses. The report focuses on data documentation. Discussion and interpretation of the results are limited to a few brief comments outlining typical conditions and to some comments related to crossplots of index parameters. The present report includes samples from boreholes drilled as part of IKU project 21.3435.00. Results from analyses of other Quaternary samples collected on the cruise are given in IKU reports 21.3441.00/01/89 and 21.3441.00/02/89.

2. SUMMARY OF MAIN FINDINGS, AND BRIEF COMMENTS ON THE RESULTS

2.1 Physical properties

The sites are located in areas with Quaternary thickness varying from 36.3 m to 75.4 m. The sea bed has typically a rough relief caused by relict iceberg ploughmarks, and in the Nordkapp Basin area numerous small pockmarks occur on the sea bed.

A general sediment description for most of the material would be: "silty, sandy, clay, with scattered fragments of gravel(f)". Towards the rockhead the content of gravel tends to increase, and close to the Norwegian coast the samples reflect the provenance from a shield area by a reduced clay content and increase in size and amount of crystalline rock fragments. Nearly all the samples are homogeneous and nonstratified, but a slight fissility is found in a number of the samples. This fissility is often enhanced and deformed by strain related to the sampling.

A number of routine soil mechanical analyses and various other tests have been carried out on these samples. Details of the results are given in Chapter 5.

In Figure 2.1 all measured undrained shear strength (with few exceptions from falling cone tests) from all sites are plotted along a common depth axis. Two straight lines in the plot represent $0.2 - 0.3 \times p_o'$. They are based on an average bulk density of 2.03 g/cm^3 . Undrained shear strength is as a rule of thumb generally expected to plot in the vicinity of these lines, and the figure indicates that many of the soil samples represent a sediment that has been overconsolidated - probably by the direct effect from an ice sheet or by previous sediment load which has been eroded away.

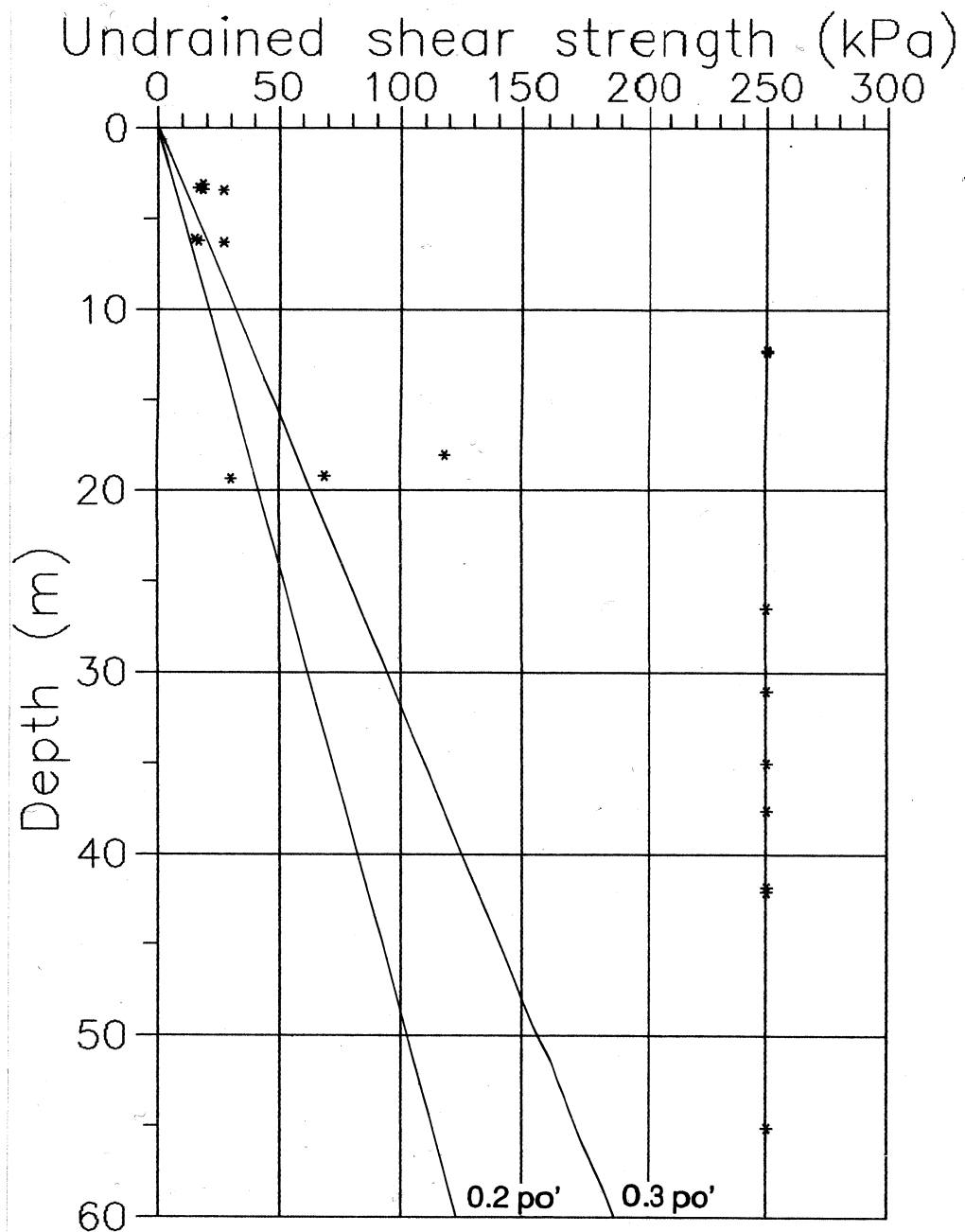


Figure 2.1 Undrained shear strength from all sites plotted along a common depth axis. Straight lines represent 0.2 and $0.3 \times p_0'$. All datapoints along $s_u = 250$ kPa are minimum values.

In Figure 2.2 undrained shear strength is plotted versus remoulded shear strength. The data on remoulded shear strength is very limited due to the stiffness of the sediment with a low sensitivity of the clays. The low sensitivity compares well with what is found for till and glaciomarine clays elsewhere on the Norwegian continental shelf (e.g. Rokoengen et al 1980; Fig.18). Nearly all samples plot within the "glacial clay" - area in the summarizing diagram of Terzaghi and Peck (1967) and close to the T-line of Boulton and Paul (1976) in the plasticity chart (Figure 2.3). This T-line is, however, not regarded as unique for tills (Sladen and Wrigley 1983).

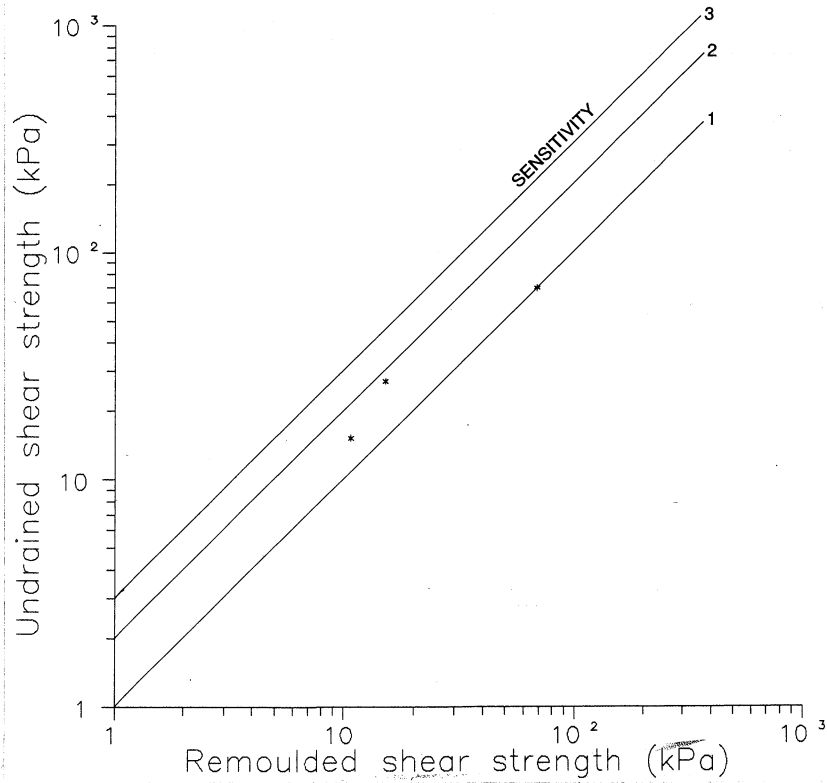


Figure 2.2 Undrained versus remoulded shear strength. Straight lines represent sensitivity values (s_u/s_r) of 1, 2 and 3.

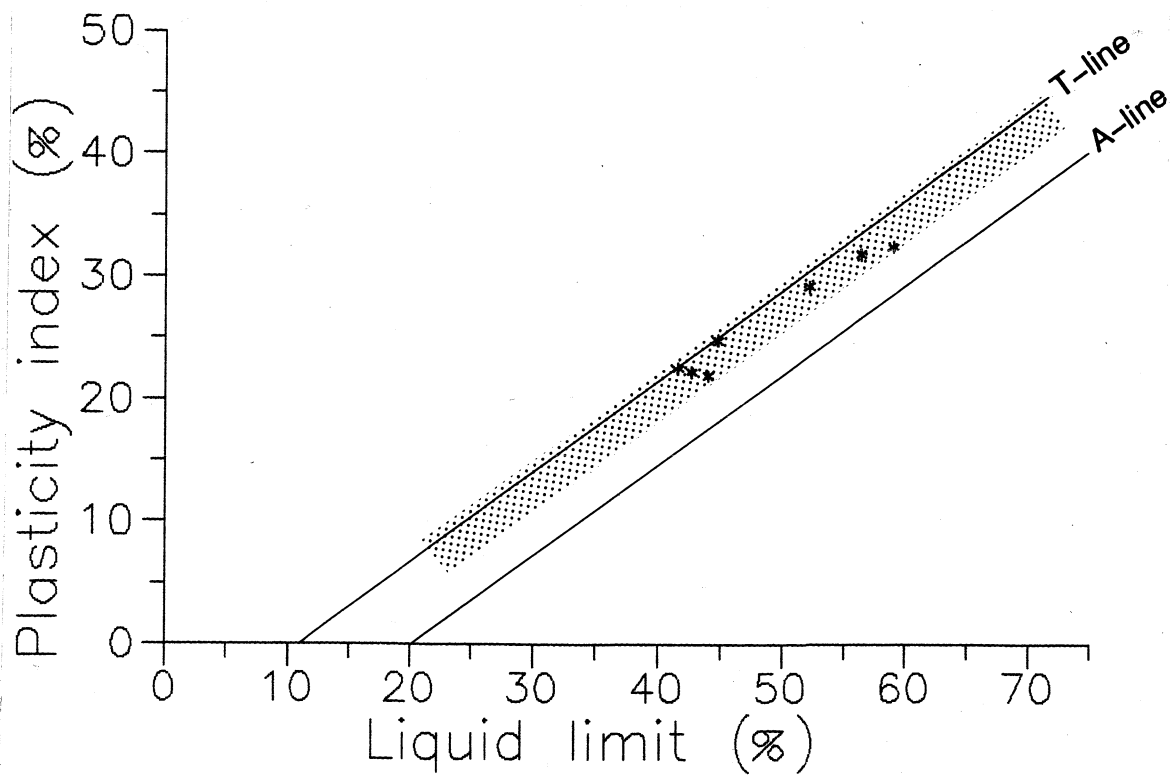


Figure 2.3 Plasticity chart. The A-line is the boundary between sediments of inorganic (above) and organic (below) nature (Casagrande 1948). The T-line is the "till line" of Boulton and Paul (1976).

2.2 Age

^{14}C accellerator mass spectrometry measurements on small reworked shell fragment at site 7324/07-U-01 gave an infinite radiocarbon age.

The dating was done on a small shell fragment which clearly has been mechanically fragmented, most likely by glacial action. The infinite age does therefore not give any clue as to the age of the sediments.

No successful aminoacid analysis on the foraminifera has yet been completed. Foraminifera have, however, recently been picked from the Dia-Structure sites and will hopefully yield results indicative of age. Data from neighbouring previously drilled sites at the Dia-Structure suggests a late Middle to early Late Weichselian age for most of the Quaternary sediments in this area (Hald et al. in prep.).

3. DRILL SITE KEY DATA

3.1 Location of sites

Bentech A/S in Tromsø was operator of the navigation chains in the Barents Sea, and they provided equipment and personnel for positioning of the drilling vessel.

Hyperfix was used as the main system, with Navstar GPS as a backup system during the about 8 hours a day this system provided navigation coverage. The Hyperfix was calibrated using a Syledis navigation chain. This chain has a range of about 100 km, and calibration was done every time the vessel approached the coastal area. The general survey activity in the area was moderate this year, and the Hyperfix chain was therefore available in range-range mode all the time. We also had access to the same station combination as during the seismic survey. The best possible navigation accuracy was therefore achieved during the whole survey.

The final positions are listed in Table 3.1 and the location of the sites is also shown in Figure 3.1.

Table 3.1. Final positions (ED 50) for sites drilled as part of project 21.3435.00. Note the two different central meridians for the UTM coordinates.

LOCATION	Latitude 72° 45' 12.45" N Longitude 31° 07' 30.21" E
7231/01-U-01	Northing 8 077 891.7 m Easting 636 418.1 m UTM 27°
LOCATION	Latitude 72° 44' 16.31" N Longitude 31° 07' 28.94" E
7231/04-U-01	Northing 8 076 155.2 m Easting 636 526.0 m UTM 27°
LOCATION	Latitude 72° 37' 22.44" N Longitude 30° 22' 31.41" E
7230/05-U-09	Northing 8 061 797.7 m Easting 612 471.4 m UTM 27°
LOCATION	Latitude 73° 18' 56.92" N Longitude 24° 08' 21.22" E
7324/07-U-01	Northing 8 138 574.7 m Easting 600 560.4 m UTM 21°
LOCATION	Latitude 73° 14' 17.81" N Longitude 23° 57' 00.65" E
7323/12-U-01	Northing 8 129 626.3 m Easting 594 935.6 m UTM 21°

3.2 Data recovery

Table 3.2 summarizes key data for the boreholes. The recovery of Quaternary samples for each site is given in detail in Table 3.3.

The samples are collected by use of hammersampler. This method is together with other coring methods used on the cruise further described in Appendix 1.

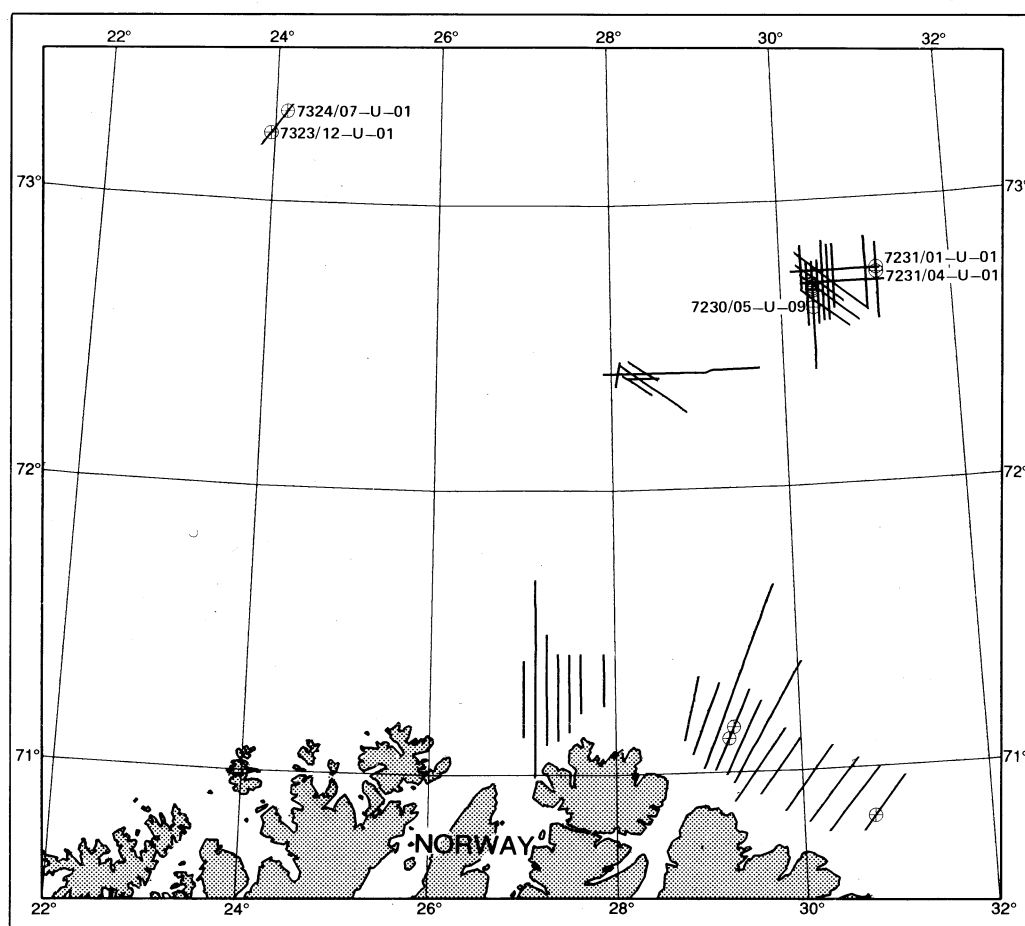


Figure 3.3 Location of the 21.3435.00 - project sites

Table 3.2 Key data for the Shallow drilling sites.

Site	Seismic Line	SP	Water depth (m)	Quaternary thickness (m)	Bedrock coring length (m)	Bedrock Core Recovery		Quaternary samples		TD below seabed (m)
						(m)	% of cored length	no of samp.	Acc.samp. length	
7230/05-U-09	IKU-302230-87	1186.1	294	20.0	55.1	42.7	77.5	0	-	75.1
7231/01-U-01	IKU-310730-87	2130.7	278	36.3	56.5	55.7	98.6	4	0.69	92.8
7231/04-U-01	IKU-310730-87	2246.3	280	37.7	59.7	58.0	97.8	5	4.87	97.4
7323/12-U-01	IKU-21-87	411.1	402	69.2	60.6	60.6	100.0	2	0.57	129.8
7324/07-U-01	IKU-21-87	1106.8	402	75.4	49.4	48.4	98.8	3	0.97	124.4
					895.4	849.45			23.62	

Table 3.3 Sample recovery.

Project	Location	Depth	Equipment	Comment
21.3435.00	7231/01-U-01	3.00- 3.36	Hammer	
		18.00-18.20	Hammer	
		26.50-26.58	Hammer	
		33.00-33.05	Hammer	
	7231/04-U-01	6.00- 6.40	Hammer	
		19.00-19.48	Hammer	
		31.00-31.21	Hammer	
		35.00-35.29	Hammer	
		37.50-37.71	Hammer	
	7323/12-U-01	12.15-12.46	Hammer	
		42.00-42.26	Hammer	
	7324/07-U-01	41.70-42.07	Hammer	
		55.00-55.30	Hammer	
		64.00-64.30	Hammer	

4. LABORATORY ANALYSES

4.1 On board procedures

As soon as each sample was retrieved during drilling, it was extruded from the sampling tube and the total length of the sample was measured. The sample was then cut in shorter length and when possible sound velocity was measured both vertically and horizontally (V_{vert} and V_{hor} respectively in Table 5.1) using a portable ultrasonic (100 kHz) non destructive tester, make Pundit. The samples collected at the heat flow sites were also subjected to measurement of thermal conductivity.

The samples were then packed and stored. A number of samples chosen for oedometer or triaxial testing were waxed in order to prevent water loss and disturbance. A few samples were also canned and stored in a -80°C freezer for later gas analyses.

4.2 On shore work

4.2.1 Physical properties

In the IKU laboratory the samples have been visually described, photographed and radiographed. Then a suite of standard soil mechanical tests have been performed.

The following routine soil mechanical analyses were carried out in the IKU laboratories.

- Water content (w , % of dry sample weight)
- Unit weight of soil (γ , kN/m^3)
- Undrained shear strength (s_u , kN/m^2)
- remoulded shear strength (s_r , kN/m^2)

In addition to this some further routine analyses in addition to a number of oedometer and triaxial tests were done at the SINTEF, Division of Geotechnical Engineering. These tests include:

- unit weight of soil (γ , kN/m^3)

- water content (w , % of dry sample weight)
- liquid limit (w_L , %)
- plastic limit (w_p , %)
- plasticity index ($I_p = w_L - w_p$)
- undrained shear strength (s_u)
- grain size distribution

4.2.2 Organic geochemistry (by Hermann Weiss)

Experimental procedures

Headspace gas:

The can was thawed over night and shaken vigorously. Then a septum was attached to the can and a sample of the headspace gas was taken for analysis of C_1 , C_2 , C_3 , $i-C_4$ and C_{5+} hydrocarbons.

This analysis was performed on a Carlo Erba Fractovap 2350 gas chromatograph equipped with a 2 m x 1/8" stainless steel column filled with Porapak Q on Chromosorb using nitrogen as carrier gas. An oven temperature of 150°C was used. After elution of n-butane, the column was back-flushed and C_{5+} compounds were recorded as one peak. A standard gas sample containing methane, ethane, propane, n-butane, n-pentane and n-hexane (100 ppm each) was used for quantification.

The can was then opened and headspace volume, water volume, and sample weight were measured.

Total Organic Carbon:

Bulk samples were crushed in a mortar. Aliquots of the samples were then weighed into Leco crucibles, then treated three times with hot 10% HCl in order to remove carbonate, and finally washed four times with distilled water in order to remove any traces of HCl. The crucibles were then placed on a hot plate (60°C) and dried for 24 hours. The total organic carbon (TOC) content of the dried samples was determined using a Leco CS 244 carbon/sulphur analyser.

The instrument was calibrated using a sediment standard with 2.72% carbon. Calibration and blank runs were carried out every 15th measurement.

The total carbon (TC) content was determined on untreated crushed sediment.

4.2.3 Dating and amino acid measurements

The sediment samples contain very few and small shell fragments. A few fragments of sufficient size for ^{14}C dating by the accelerator method were, however, found. A tentative identification of the fragments are made by E. Thomsen and ^{14}C measurements have been done by the Swedberg Laboratory, Uppsala University.

Identification and picking of foraminifera (*Elphidium Excavatum*) for amino acid measurements are done on selected 13 samples by stud. R. Wilhelmsen, University of Oslo. It was found that the foraminifera content was extremely low and sufficient material (about 100 *Elphidium Excavatum*) was only found in one of the investigated samples (after sieving 230 - 375 g of sample). This sample yielded no amino acid results. More samples will be studied.

4.2.4 Magnetic properties

Magnetic properties were measured at the University of Bergen on 83 samples from 13 locations of the 1987 cruise. The purpose of this was to measure magnetic fabric and paleomagnetic properties for genetic interpretation or chronostratigraphy. The details of this work is given by the report from University of Bergen. The conclusion so far is that the stress and deformation induced by the sampling seems to disturb the magnetic properties and that the results therefore are difficult to use. These problems will, however, be studied thoroughly as the magnetic property studies has a potential both in chronostratigraphy and in genetic classification.

5. DATA PRESENTATION

5.1 General comments to data presentation

Chapter 5 gives the results of laboratory analyses of the Quaternary samples. The data presentation is organized as follows:

In chapter 5.2 all test results are given in tables for each type of analysis.

In chapter 5.3 the information is grouped in drill sites. Each subchapter commences with a brief site description. A seismic section across the site is then shown and seismic reflections are shown. Deep towed boomer and sidescan sonar data are included where they exist). This is followed by a soil boring summary sheet. On this sheet physical properties and age information are plotted. Reflections detected on the seismic profiles are also drawn.

5.2 Test result tables

5.2.1 Soil mechanical data and sound velocities

Table 5.1 shows results from routine soil mechanical analyses and on board measurement of sound velocity of the samples.

Table 5.1 Routine soil mechanical data and sound velocity measured on Quaternary samples (Abbreviations are explained in Section 4.2.1).

WELL: 7231/01-U-01

DEPTH (m)	w (%)	γ (kN/m ³)	w_L (%)	w_p (%)	I_p (%)	s_u (kN/m ²)	s_r (kN/m ²)		Vhor (m/s)	Vvert (m/s)
3.10									1613	
3.20									1631	
3.30	57.3	17.0	56.4	24.6	31.8	16.7			1554	
18.04	41.6	19.1	41.6	19.1	22.5					
18.06	16.8					118.8				
18.11										
26.52	9.7									
26.55						>250.0				

WELL: 7231/04-U-01

DEPTH (m)	w (%)	γ (kN/m ³)	w_L (%)	w_p (%)	I_p (%)	s_u (kN/m ²)	s_r (kN/m ²)	S_t	Vhor (m/s)	Vvert (m/s)
6.12	47.7	17.2				15.2	10.8	1.41		
6.20	46.6	17.6	59.0	26.6	32.4	16.7				
6.30	41.5	18.3								
6.37						27.0	15.2	1.78		
19.10	22.9	20.9								
19.22						69.2	69.2	1.0		
19.30									1726	1686
19.36	28.9	19.1	44.0	22.1	22.1	30.4				
31.05						>250.0				
31.20	17.3									
35.02	16.2	23.0				>250.0				
35.07						>250.0				
35.15	16.7	21.5	42.7	20.5	22.2					
35.19									1966	
37.59			44.2	29.4	14.8					
37.62	16.2					>250.0			1397	
37.64										

WELL: 7323/12-U-01

DEPTH (m)	w (%)	γ (kN/m ³)	w_L (%)	w_p (%)	I_p (%)	s_u (kN/m ²)	s_r (kN/m ²)		Vhor (m/s)	Vvert (m/s)
12.23						>250.0				
12.28	19.2	21.6								
12.35	21.4		52.2	23.0	29.2	>250.0				
42.08	16.9	22.0				>250.0				
42.17	17.8	21.3	44.8	20.0	24.8					

Table 5.1 Continued

WELL: 7324/07-U-01

DEPTH (m)	w (%)	γ (kN/m ³)	w _L (%)	w _p (%)	I _p (%)	s _u (kN/m ²)	s _r (kN/m ²)		V _{hor} (m/s)	V _{vert} (m/s)
41.83	15.4	22.5				>250.0				
55.07	13.9	23.3				>250.0				
64.08	14.1									
64.22	32.9	20.9		23.7		>250.0				

Additional routine analyses and advanced soil mechanical tests are carried out by the SINTEF Division of Geotechnical Engineering. A summary of the results is given in Table 6.2. Symbols and abbreviations used are as follows:

a	=	Coulombian attraction (kN/m ²)
c _v , c _h	=	vertical, horizontal coefficient of consolidation (m ² /year)
m	=	deformation modulus number
p _o '	=	effective overburden pressure (kN/m ²)
p _c '	=	preconsolidation pressure (kN/m ²)
s _u	=	undrained shear strength (kN/m ²)
tan ϕ	=	mobilized friction
w	=	water content (%)
w _L	=	liquid limit (%)
w _p	=	plastic limit (%)
ϵ_f	=	failure strain (%)
γ	=	unit weight of soil (kN/m ³)

Table 5.2 Extract of results from analyses performed at the SINTEF Division of Geotechnical Engineering.

Boring No.	Sample depth m	w %	Index Properties					Soil Description	- p _o ' kN/m ²	Oedometer Tests				Triaxial Tests				Remarks/Sample Quality
			w _L %	v _D %	γ kN/m ³	s _{u, cone} kN/m ²	Clay <2μ %			-p _o ' kN/m ²	m -	c m ² /year	Hor./ Vert.	s _u kN/m ²	a kN/m ²	tanφ -	e _f %	
7231/01-U-01	3.24-3.34	57.3	56.4	24.6	17.0	16.7	57.6	Clay. Soft.	23.0	50	10.8	0.4	V	-	-	-	-	Good.
7231/04-U-01	6.17-6.25	46.6	59.0	26.6	17.6	16.7	52.2	Clay. Soft. Sand layers, thin.	47.2	p _o '	15.7	0.4	V	-	-	-	-	Good.
	19.30-19.43	28.9	44.0	22.1	19.1	30.4	34.6	Clay. Sand and gravel grains.	-	30	15.4	0.3	H	-	-	-	-	Good.
	35.09-35.27	16.7	42.7	20.5	21.5	>250	36.2	Clay. Sand grains and sandstone.	176.7	p _o '	13.1	1.0	V	-	-	-	-	Good.
7323/12-U-01	12.31-12.42	21.4	52.2	23.0	-	>250	46.8	Clay. Sand and gravel grains.	404.6	100	15.9	1.0	H	300	50	0.50	6	Stone in triax. sample.
	42.11-42.26	17.8	44.8	20	21.3	>250	44.0	Clay. Sand and gravel grains.	124.0	500	18.3	0.6	H	-	-	-	-	Good.
									476.1	p _o '	15.4	2.0	V	320	50	0.46	6	Good.
7324/07-U-01	64.14-64.30	32.90	-	23.7	20.9	>250	19.5	Silty. Sandy Clay. Sandstone.	700.0	p _o '	15.4	1.0	V	280	50	0.44	6	Good.

Grain size distribution analysis has been carried out selected samples by use of the falling drop method.

The percentage of equivalent particle sizes above 0.06 mm, 0.02 mm, 0.006 mm and 0.002 mm have been recorded. The results are given in Figure 5.1, and in the soil boring summary sheets.

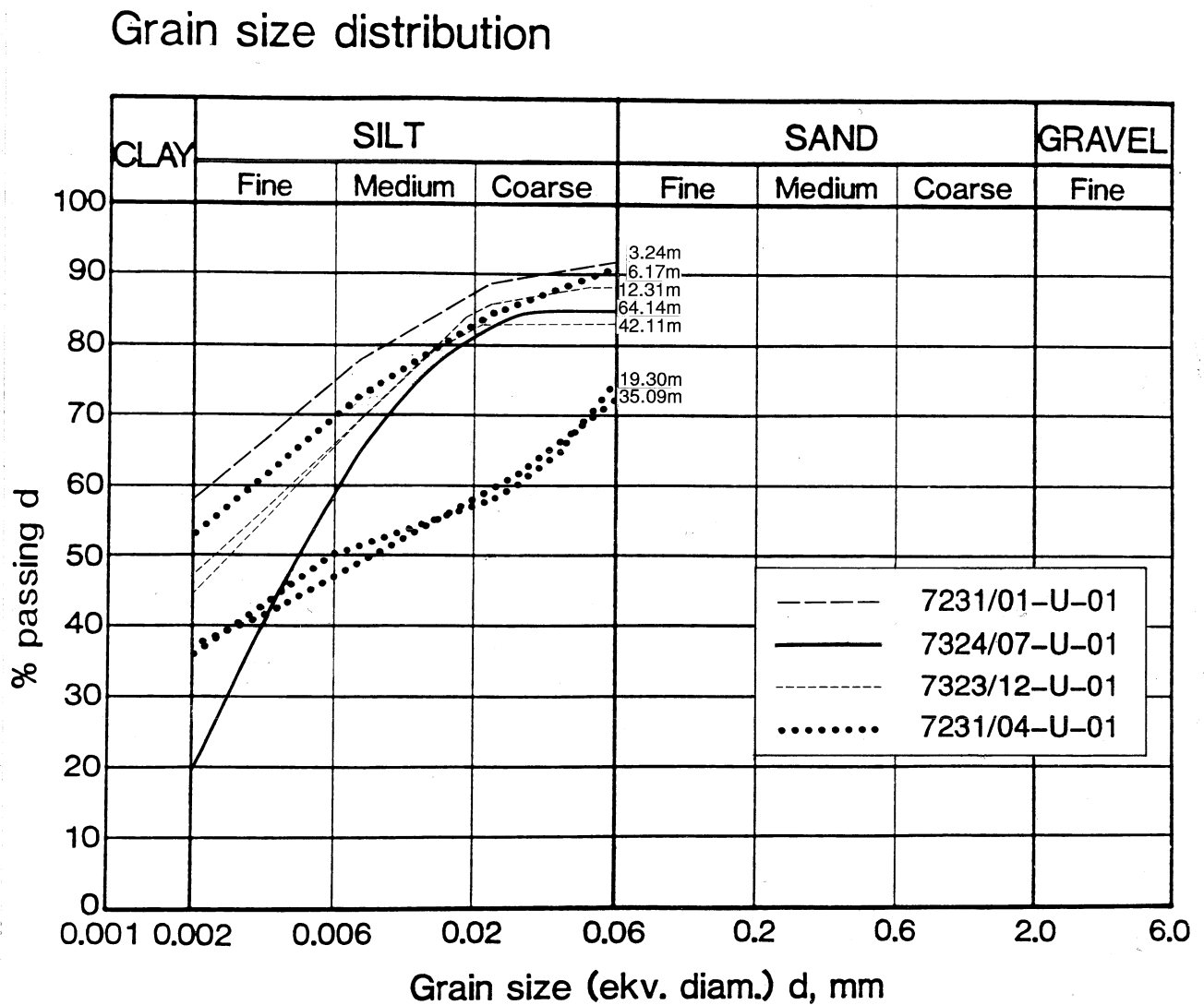


Figure 5.1 Grain size distribution curves. The grain size distribution as a function of depth is shown in the soil boring summary sheets.

5.2.2 Datings

Our shell sample has been attempted ^{14}C dated by the accellerator method at the Swedberg Laboratory, Uppsala University, Sweden. The sample consists of small shell fragments.

Table 5.3 ^{14}C -datings and tentative identification of shell fragments.

Site	Depth	Age (yr)	Lab.no.	Fragment identification
7324/7-U-01	64.1m	>45000	Ua-989	Bivalve

5.2.3 Micropaleontology and amino acid measurements

No results have been obtained from the 21.3435 project sites.

5.2.4 Organic geochemistry

The total carbon (TC) and total organic carbon (TOC) content of the Quaternary sediments were determined on 6 selected samples. The results are given in Table 5.4. The TC contents range from 1.07 to 1.39 wt% and the TOC contents vary between 0.68 and 0.99 wt% of the dry sediment. Both parameters usually show a fair correlation with each other and increase slightly with depth. The inorganic carbon (TC-TOC) is thought to be present in the form of carbonates. Assuming that all calcium carbonate is the only carbonate present in these sediments, the difference between the TC and TOC was expressed in wt% CaCO_3 . These values range from 0 to 10.3% and vary independently from the TC and TOC contents.

Table 5.4 Analysis of total carbon (TC), total organic carbon (TOC) and content of CaCO_3 .

Site	IKU ref. no.	Depth (m)	TC (wt% of dry sediment)	TOC	CaCO_3
7231/01-U-01	C-7103	3.34- 3.36	1.12	0.80	2.67
	C-7198	18.10	1.25	0.68	4.75
7231/04-U-01	C-7194	6.00- 6.05	1.39	0.99	3.34
	C-7206	6.11	1.16	0.95	1.75
	C-7207	9.15	1.07	0.80	2.25
	C-7195	19.43-19.45	1.21	0.81	3.34

5.3 Description of individual sites

5.3.1 Site 7231/01-U-01

Seismic interpretation

Top bedrock was penetrated at 36.3 m. The seismic interpretation of top bedrock is uncertain because of a diffuse zone between 40 ms and 48 ms. Choosing the top of this zone as top bedrock corresponds to a sound velocity of 1800 m/s. The seismic signature is chaotic, but more transparent in the upper part. Some faint reflections occur, and a high amplitude reflection at 29 ms marks the top of a less transparent unit.

Lithology and mechanical properties

Four samples of Quaternary sediments plus one sample comprising a rock fragment was obtained at this site. All samples comprise silty sandy clay with some gravel (f). The subangular - subrounded fragments comprise both metamorphic rocks as well as sandstone, siltstone and claystone. The upper sample is laminated.

All samples are overconsolidated and there is a marked increase in stiffness both from 3m (16.7kPa) to 18 m (119 kPa) and between 18 m and 26 m (>250 kPa). The water content is also for the shallowest sample close to the plasticity limit.

LOC. 7231/01-U-01-01A

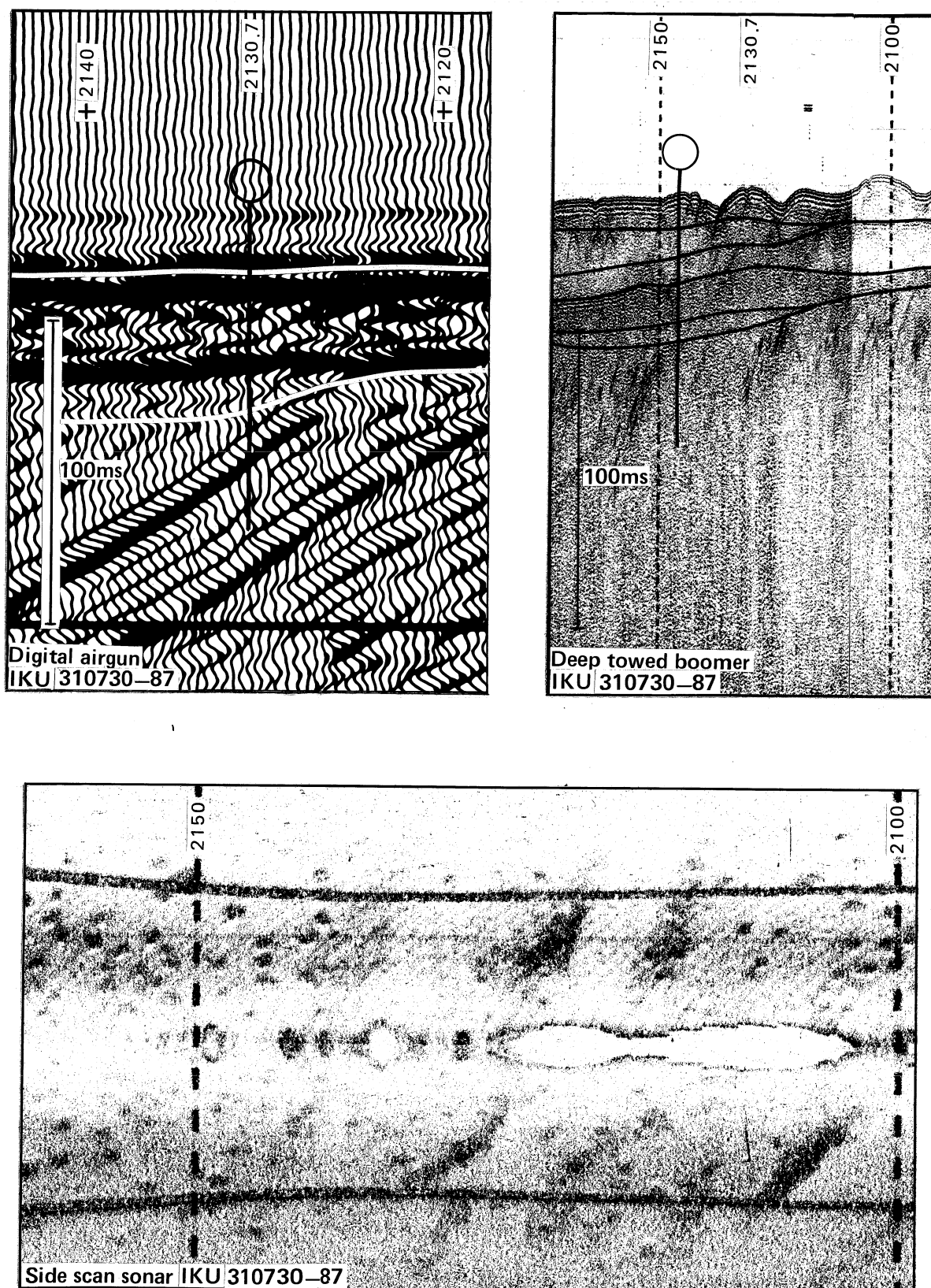
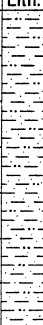
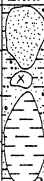


Figure 5.2 Seismic section across site 7231/01-U-01. The figure is continued on the following pages by a soil boring summary sheet, a description sheet and drawings of radiographs for each sample.

IKU SINTEF GROUP		POS.: N E		SEISMIC LINE: IKU 310730-87		WATER DEPTH: 278 m		SITE: 7231/01-U-01								
UTM ZONE : N E		REFERENCES:		SP:		IKU REPORT: 21.3441.00/01/89		ACCESS-ABILITY: RESTRICTED								
NO OF SAMPLES:		Σ SAMPLE LENGTH: 0.69 m		ROCKHEAD: 36.3 m												
DEPTH(m)	LITHO-LOGICAL COLUMN	WATER CONTENT (%)	UNIT WEIGHT (kN/m ³)	S _u ▽-F.CONE (▽=S _p) ○-1 ax ○ ₃ -3 ax kN/m ²	SOUND VELOCITY m/s H _o =HORIZONTAL V=VERTICAL	COLOUMBIAIAN ATTRACTION, a (kN/m ²)	tan φ	PRECONSOLIDATION PRESSURE, p _c (kN/m ²)	GRAIN SIZE DISTRIBUTION % < d	DATING	MAGN.	MISC. ANALYSES	SEISMIC REFLECTIONS		COMMENTS	
													(m)	INTERVAL VELOCITY (m/s)		
10																
20																
30																
40																BQ
50																
60																

	Project 21.3441.00: Quaternary samples Barents Sea 1987			Location 7231/01 - U - 01		
	Equipment Hammer sampler	Water depth 278.0 m	Latitude 72°45'12.45"N	Longitude 31°07'30.21"E	Depth below seabed 3.00 - 3.36 m	
Analytical results	Subsample	m	Lith.	Core description	s _v	s _r
V _{SH} = 1613 m/s V _{SH} = 1631 m/s w = 57.3% γ = 17.0 kN/m ³ w _L = 56.4% w _p = 24.6% V _{SH} = 1554 m/s	Oe TOC/TC	3.00		CLAY, silty, some sand, scattered gravel (f)	5Y - 3/1	16.7
				Laminated	Very dark grey	
		.10				
		.20				
		.30				
		3.36				

		Project 21.3441.00: Quaternary samples Barents Sea 1987		Location 7231/01 - U - 01	
Equipment Hammer sampler		Water depth 278.0 m	Latitude 72°45'12.45"N	Longitude 31°07'30.21"N	Depth below seabed 18.00 - 18.20 m
Analytical results	Subsample	m	Lith.	Core description	s _u s _r
w _L = 41.6% w _p = 19.1% w = 16.8%	TOC/TC	18.00		CLAY, very silty, sandy, gravelly (f-m) Subrounded sandstone fragment, 5 cm Subrounded quartzite fragment, 2 cm Rounded quartzite fragment, 7 cm (striated)	5Y - 3/1 Very dark grey 118.8
		18.20			
Comments:			Symbols: K _f = grain size distribution K _t = thermal conductivity XRD = mineralogy w = water content (% water of dry sample) w _L -w _p = liquid and plasticity limits γ = unit weight of soil (kN/m ³) V _{SH} = horizontal sound velocity (m/s) V _{SV} = vertical sound velocity (m/s) Oe = oedometer test T = triaxial test TOC = total organic carbon TC = total carbon s _u = undrained shear strength from falling cone test (kN/m ²) s _r = remoulded shear strength (kN/m ²) Magn. = magnetic fabric OG = organic geochemistry MPal = micropaleontology		

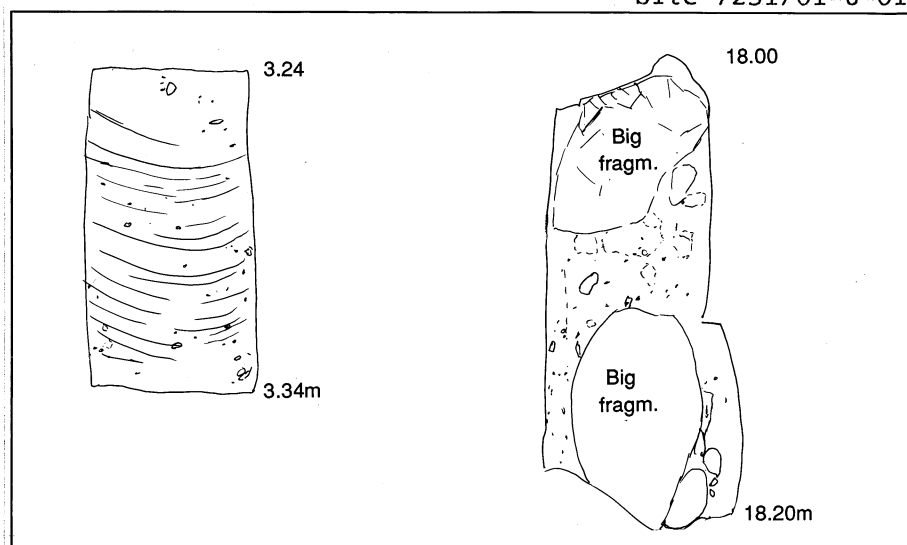
Site 7231/01-U-01

		Project 21.3441.00: Quaternary samples Barents Sea 1987			Location 7231/01 - U -01	
Equipment Hammer sampler	Water depth 278.0 m	Latitude 72°45'12.45"N	Longitude 31°07'30.21"E	Depth below seabed 26.50 - 26.58 m		
Analytical results	Subsample	m	Lith.	Core description	s _v	s _r
w = 9.7%		26.50		SAND (vf), silty, clayey, gravelly (f) subangular silt -and claystone fragments Olive grey	5Y - 4/2	
		26.58		Subrounded metasandstone fragment, 5 cm	>250.0	

		Project 21.3441.00: Quaternary samples Barents Sea 1987			Location 7231/01 - U -01	
Equipment Hammer sampler	Water depth 278.0 m	Latitude 72°45'12.45"N	Longitude 31°07'30.21"E	Depth below seabed 33.00 - 33.05 m		
Analytical results	Subsample	m	Lith.	Core description	s _u	s _r
		33.00		Grey, subangular sandstone fragmented from larger block by drillbit		
		33.05				

Site 7231/01-U-01

Site 7231/01-U-01



5.3.2 Site 7231/04-U-01

Seismic interpretation

Top bedrock is penetrated at 37.7 m and interpreted on the seismic record at 42 ms. The corresponding average sound velocity is 1795 m/s. The Quaternary interval is divided in an upper transparent part and a lower acoustically "chaotic" part by an irregular reflection at about 34 ms. The reflection is best described as a zone of incoherent irregular reflections partly resembling an ploughed seabed, but other processes like subglacial deformation could have contributed to this pattern. There is also a faint reflection at about 14 ms. This reflection is probably less significant.

Lithology and mechanical properties

The two samples above the 34 ms - reflection are both normally consolidated silty clays with some sand and gravel(f). Rock fragments are dominated by subangular - rounded claystone/ siltstone, but more angular crystalline rock fragments occur. The undrained shear strength vary from 15 - 30 kPa at 6 m to 30 - 70 kPa at 19 m.

The sample at 31 m comprise a gravelly diamicton, and the indicated shear strength of > 250 kPa is probably rather uncertain. An undrained shear strength of 300 kPa (triax.) of the silty sandy clay with some gravel (f) at 35 m does, however, confirm that the lower interval consists of stiff sediments. Oedometer test at 35 m indicates an effective preconsolidation pressure of 1000 kPa. The sandy silt at 37.5 m probably represents a transition to the underlying bedrock.

LOC. 7231/04-U-01

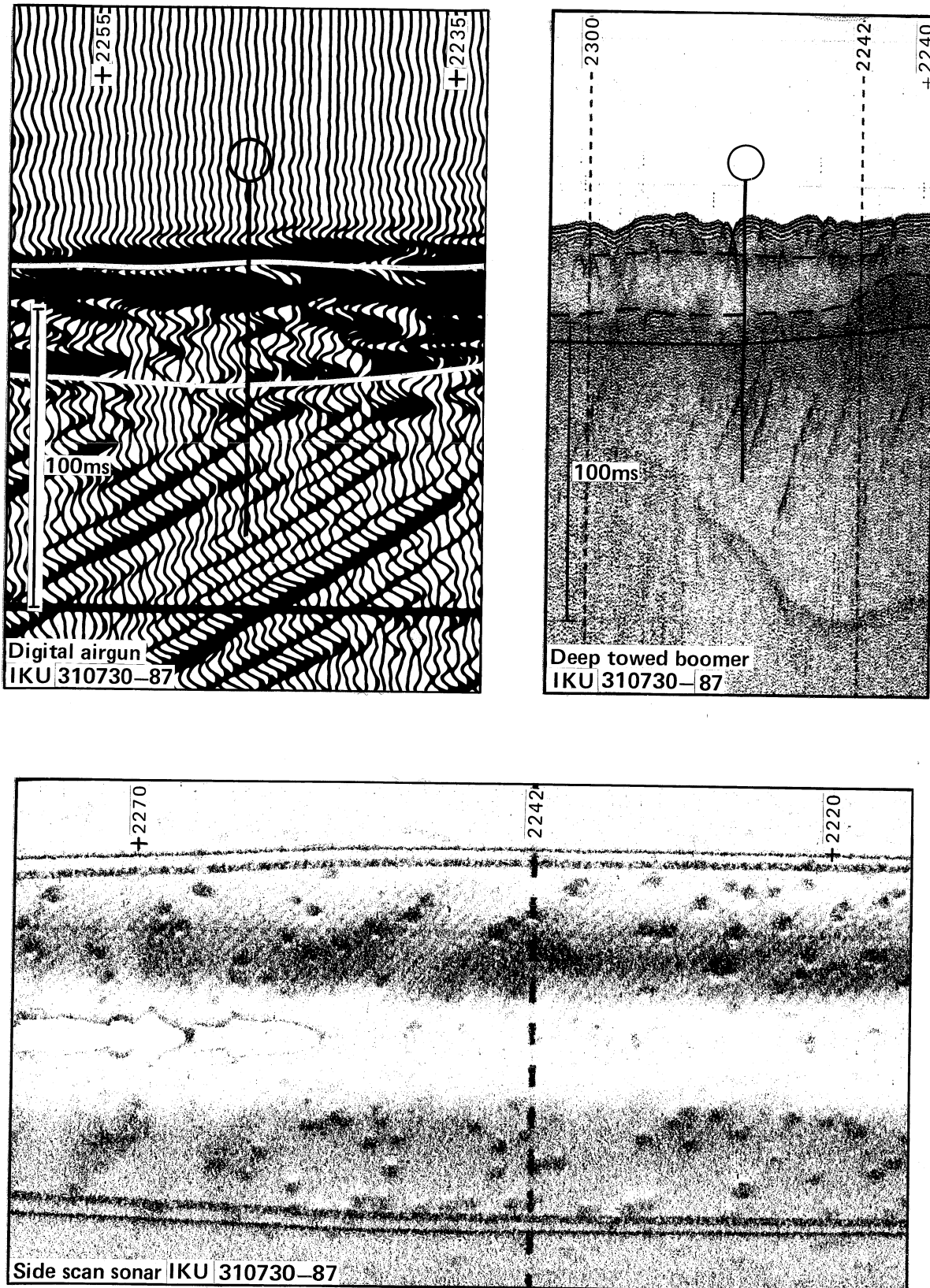
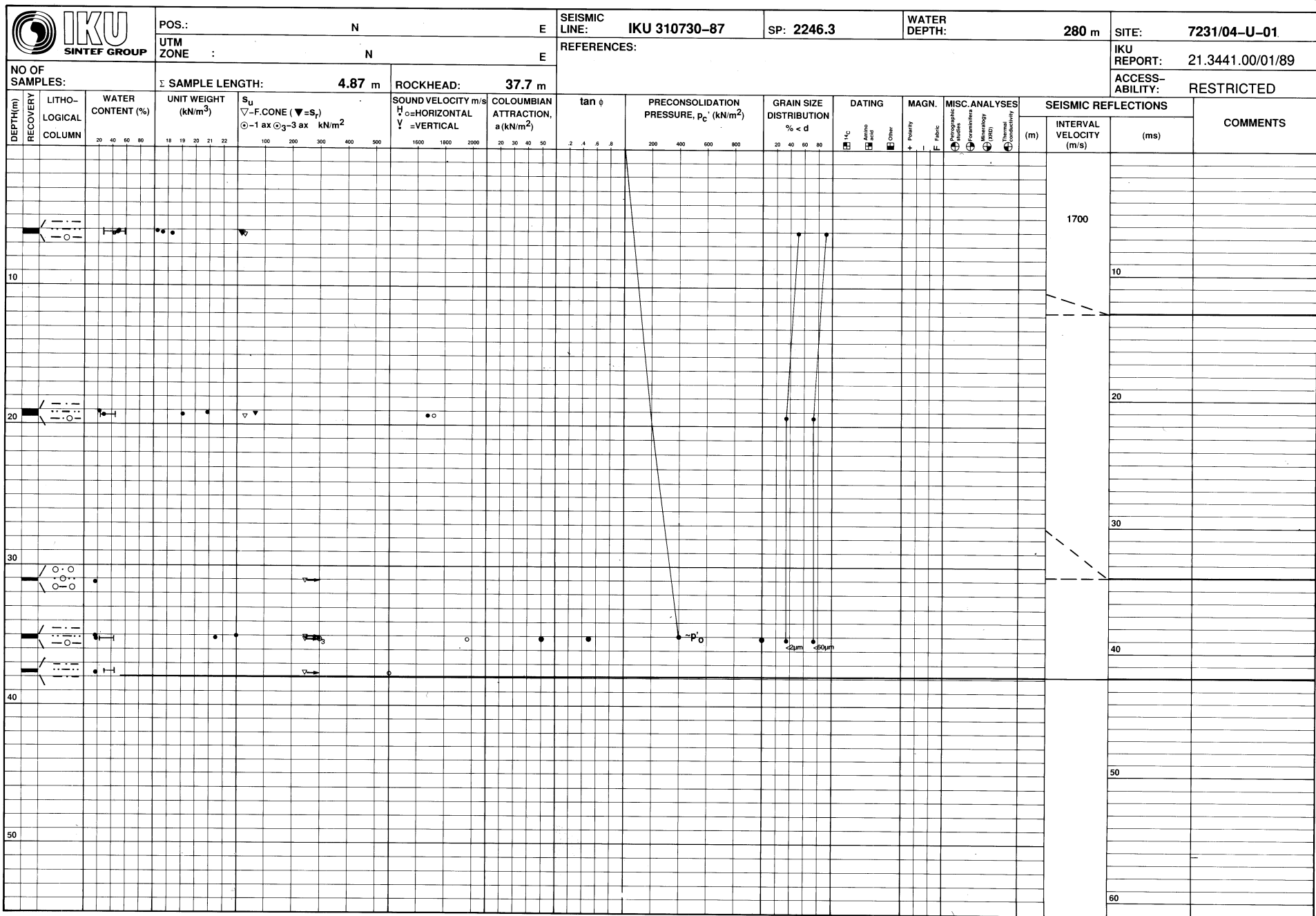


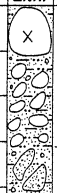
Figure 5.3 Seismic section across site 7231/04-U-01. The figure is continued on the following pages by a soil boring summary sheet, a description sheet and drawings of radiographs for each sample.



		Project 21.3441.00: Quaternary samples Barents Sea 1987			Location 7231/04 - U -01		
Equipment Hammer sampler		Water depth 280.0 m	Latitude 72°44'16.31"N	Longitude 31°07'28.94"E	Depth below seabed 6.00 - 6.40 m		
Analytical results	Subsample	m	Lith.	Core description		s _u	s _r
w = 47.7% γ = 17.2kN/m ³ w = 46.6% γ = 17.6kN/m ³ w _L = 59.0% w _p = 26.6% w = 41.5% γ = 18.3kN/m ³	TOC/TC	6.00		CLAY, silty, some sand and gravel (f)			
				Subrounded claystone and some few subangular - angular crystalline rock fragments		5Y - 4/1 Dark grey	
	Magn. TOC/TC	.10				15.2	10.8
	K _f O _e	.20				16.7	
		.30		CLAY, silty		27.0	15.2
		6.40					

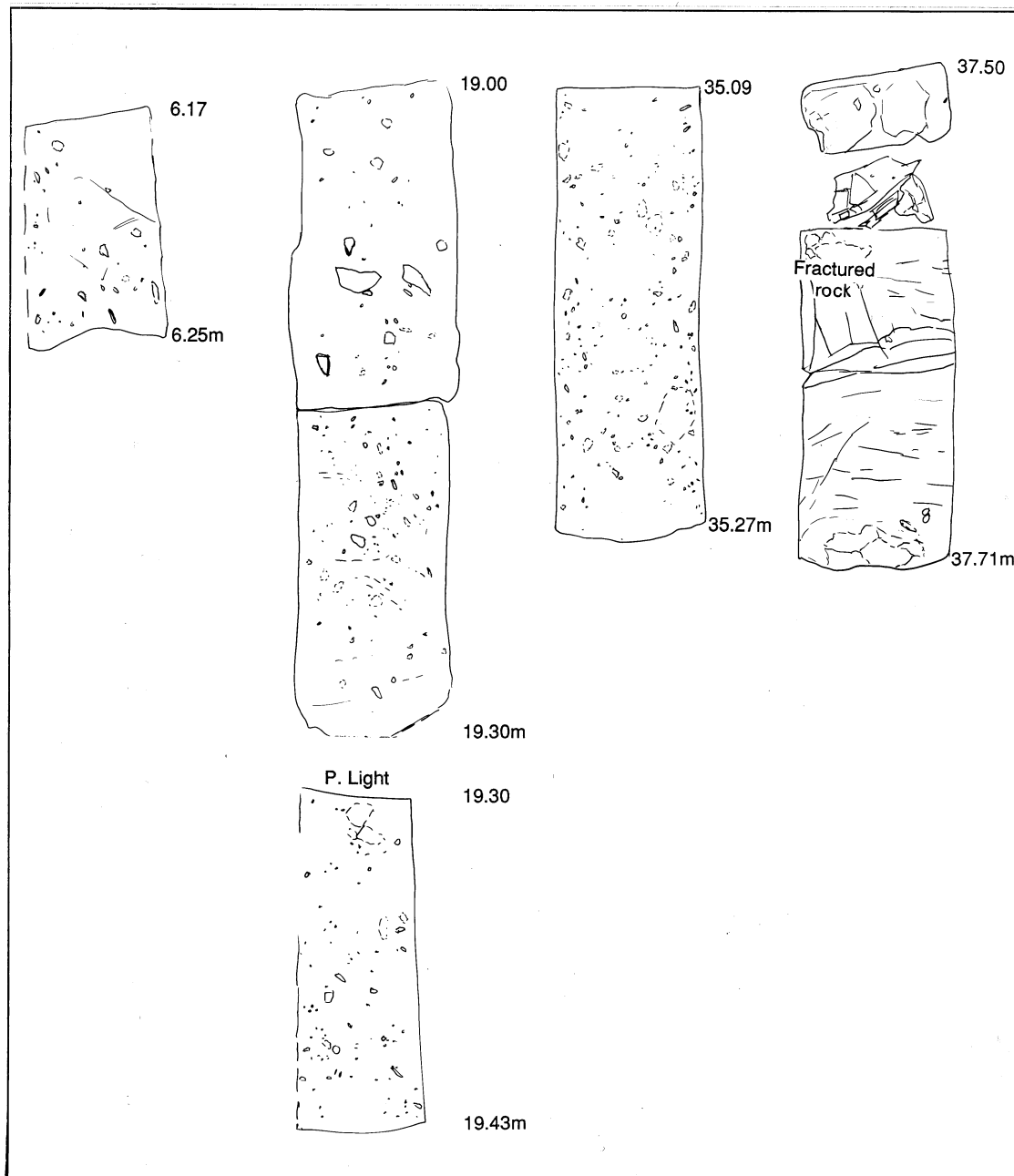
		Project 21.3441.00: Quaternary samples Barents Sea 1987		Location 7231/04 - U -01		
Equipment Hammer sampler		Water depth 280.0 m	Latitude 72°44'16.31"N	Longitude 31°07'28.94"E	Depth below seabed 19.00 - 19.48 m	
Analytical results	Subsample	m	Lith.	Core description	s_u	s_r
$w = 22.9\% \quad \gamma = 20.9 \text{ kN/m}^3$ $V_{SH} = 1726 \text{ m/s} \quad V_{SV} = 1686 \text{ m/s}$ $w = 28.9\% \quad \gamma = 19.1 \text{ kN/m}^3$ $w_L = 44.0\% \quad w_p = 22.1\%$	Magn.	19.00		CLAY, silty, sandy, some gravel (f) Subangular rounded silt- and claystone fragments Angular claystone rocks		
	TOC/TC	.10		Very dark grey Rounded sandstone fragment, 2.5cm		
		.20			69.2	69.2
		.30				
	Oe	.40			30.4	
	TOC/TC	19.48				

Site 7231/04-U-01

		Project 21.3441.00: Quaternary samples Barents Sea 1987			Location 7231/04 - U - 01	
Equipment Hammer sampler		Water depth 280.0 m	Latitude 72°44'16.31"N	Longitude 31°07'28.94"E	Depth below seabed 31.00 - 31.21 m	
Analytical results	Subsample	m	Lith.	Core description	s _u	s _r
		31.00		GRAVEL (c-f), sandy, silty, clayey Subangular/subrounded claystone and crystalline pebbles GRAVEL (c-f), clayey, silty, sandy Subangular sandstone fragments, 3.5 and 5 cm	5YR - 3/2 Dark reddish brown 5Y - 3/1 Very dark grey	>250.0
w = 17.3%		XRD				
		31.21				

		Project 21.3441.00: Quaternary samples Barents Sea 1987			Location 7231/04 - U - 01	
Equipment Hammer sampler		Water depth 280.0 m	Latitude 72°44'16.31"N	Longitude 31°07'28.94"E	Depth below seabed 35.00 - 35.29 m	
Analytical results	Subsample	m	Lith.	Core description	s _u	s _r
w = 16.2% γ = 23.0kN/m³	Oe/T	35.00		CLAY, silty, sandy some gravel (f) Subangular silt -and claystone fragments	5Y - 3/1 Very dark grey	>250.0
w = 16.7% γ = 21.5kN/m³		.10		Subangular crystalline pebble, 2.5cm		
w _L = 42.7% w _p = 20.5%		.20				>250.0
V _{BH} = 1966 m/s						
	XRD	35.29				
Comments:			Symbols: K _t = grain size distribution K _c = thermal conductivity XRD = mineralogy w = water content (% water of dry sample) w _L -w _p = liquid and plasticity limits γ = unit weight of soil (kN/m³) V _{BH} = horizontal sound velocity (m/s) V _{SV} = vertical sound velocity (m/s) Oe = oedometer test T = triaxial test TOC = total organic carbon TC = total carbon s _u = undrained shear strength from falling cone test (kN/m²) s _r = remoulded shear strength (kN/m²) Magn. = magnetic fabric OG = organic geochemistry MPal = micropaleontology			

Site 7231/04-U-01



		Project		Location	
21.3441.00: Quaternary samples Barents Sea 1987		7231/04 - U - 01			
Equipment	Water depth	Latitude	Longitude	Depth below seabed	
Hammer sampler	280.0 m	72°44'16.31"N	31°07'28.94"E	37.50 - 37.71 m	
Analytical results	Subsample	m	Lith.	Core description	s _u , s _r
w _L = 44.2% w _p = 29.4% w = 16.2% V _{SH} = (1397 m/s)		37.50		SILT, sandy (I-vf)	5Y - 3/1 Very dark grey
		.60			>250.0
		.70			
		37.71			
Comments:		Symbols: K _r = grain size distribution K _t = thermal conductivity XRD = mineralogy w = water content (% water of dry sample) w _L -w _p = liquid and plasticity limits γ = unit weight of soil (kN/m ³) V _{SH} = horizontal sound velocity (m/s) V _{sv} = vertical sound velocity (m/s) C _e = oedometer test T = triaxial test TOC = total organic carbon TC = total carbon s _u = undrained shear strength from falling cone test (kN/m ²) s _r = remoulded shear strength Magn. = magnetic fabric OG = organic geochemistry MPal = micropaleontology			

5.3.3 Site 7323/12-U-01

Seismic interpretation

Only digital seismic of rather poor quality cross this site, and intra Quaternary reflections are poorly defined. The top bedrock reflection is interpreted at about 73 ms. During drilling top bedrock was reported at 69 m implying an average sound velocity of 1890 m/s. This is possibly too high and some soft rock in the top of the borehole may have been assumed unconsolidated by the driller. Faint reflections are found at 20 ms and 30 ms, separating three intervals.

Lithology and mechanical properties

The two samples from this site both comprise very dark grey, silty, sandy clay with some gravel(f). Subangular silt- and claystone fragments are present, but no crystalline rocks are found. Both the sample from the upper interval and the sample from the lower interval (the mid interval is not sampled) have undrained shear strength in excess of 250 kPa and a water content below the plasticity limit. Oedometer tests are run on both samples. Only the upper sample is overconsolidated. The interpreted effective preconsolidation pressure is slightly in excess of the present effective lithostatic pressure at the level of the lower sample, and a preconsolidation to this level would probably not be recognized in the latter sample.

LOC. 7323/12-U-01

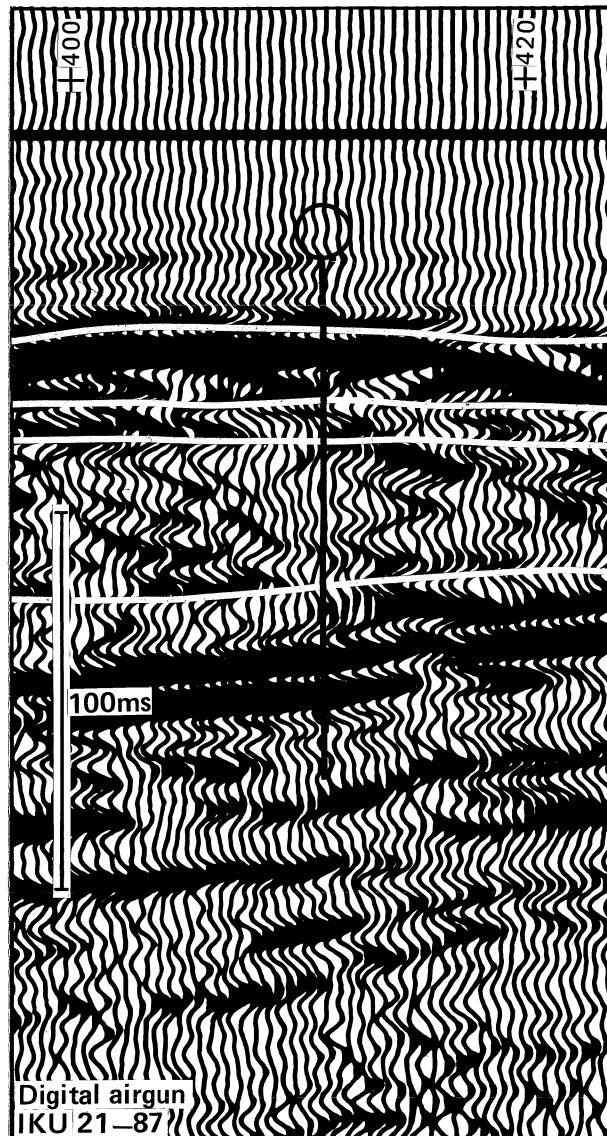
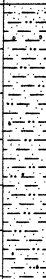


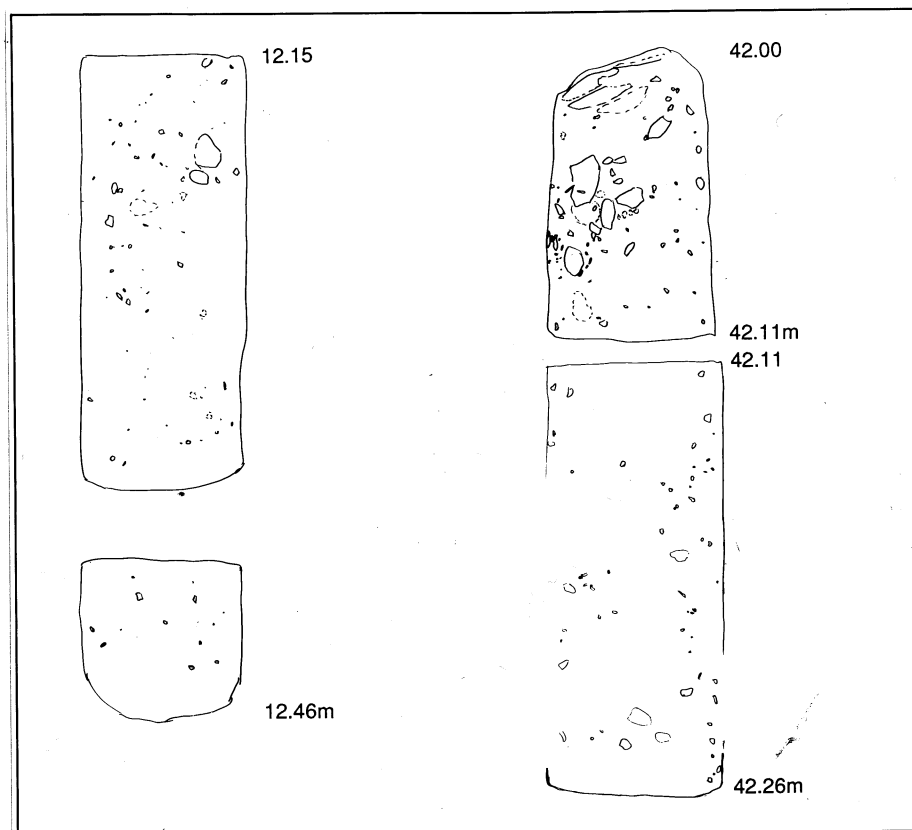
Figure 5.4 Seismic section across site 7323/12-U-01. The figure is continued on the following pages by a soil boring summary sheet, a description sheet and drawings of radiographs for each sample.

IKU SINTEF GROUP		POS.: N E		SEISMIC LINE: IKU 21-87		SP: 411.1		WATER DEPTH: 402 m		SITE: 7323/12-U-01					
UTM ZONE : N E		REFERENCES:		IKU REPORT: 21.3441.00/01/89		ACCESS- ABILITY: RESTRICTED									
NO OF SAMPLES:		SAMPLE LENGTH: 0.57 m		ROCKHEAD: 69.0 m											
DEPTH(m)	LITHO- LOGICAL COLUMN	WATER CONTENT (%)	UNIT WEIGHT (kN/m³)	S _u ∇-F.CONE (▼=S _r) ○-1 ax ○ ₃ -3 ax kN/m²	SOUND VELOCITY m/s H = HORIZONTAL V = VERTICAL	COLOUMBIAIAN ATTRACTION, a (kN/m²)	tan φ	PRECONSOLIDATION PRESSURE, p _c (kN/m²)	GRAIN SIZE DISTRIBUTION % < d	DATING	MAGN.	MISC. ANALYSES	SEISMIC REFLECTIONS		COMMENTS
													(m)	INTERVAL VELOCITY (m/s)	
10															
20															
30															
40															
50															

		Project 21.3441.00: Quaternary samples Barents Sea 1987			Location 7323/12 - U -01		
Equipment Hammer sampler		Water depth 402.0 m	Latitude 73°14'17.81"N	Longitude 23°57'00.65"E	Depth below seabed 12.15 - 12.46 m		
Analytical results	Subsample	m	Lith.	Core description	s _u	s _r	
w = 19.2% γ = 21.6kN/m ³ w = 21.4% w _L = 52.2% w _p = 23.0%	Oe	12.15		CLAY, silty, some sand and gravel (f)	5Y - 3/1		
				Subangular silt -and claystone fragments	Very dark grey		
		.25					>250.0
		.35					>250.0
	Magn.	.45					
		12.46					
Comments:				Symbols: K _f = grain size distribution k _r = thermal conductivity XRD = mineralogy w = water content (% water of dry sample) w _L -w _p = liquid and plasticity limits γ = unit weight of soil (kN/m ³) V _{SH} = horizontal sound velocity (m/s) V _{SV} = vertical sound velocity (m/s) Oe = oedometer test T = triaxial test TOC = total organic carbon TC = total carbon s _u = undrained shear strength from falling cone test (kN/m ²) s _r = remoulded shear strength (kN/m ²) Magn. = magnetic fabric OG = organic geochemistry MPal = micropaleontology			

		Project 21.3441.00: Quaternary samples Barents Sea 1987			Location 7323/12 - U -01	
Equipment Hammer sampler		Water depth 402.0 m	Latitude 73°14'17.81"N	Longitude 23°57'00.65"E	Depth below seabed 42.00 - 42.26 m	
Analytical results	Subsample	m	Lith.	Core description	s_u	s_r
$w = 16.9\% \quad \gamma = 22.0 \text{ kN/m}^3$ $w = 17.8\% \quad \gamma = 21.3 \text{ kN/m}^3$ $w_L = 44.8\% \quad w_p = 20.0\%$	Magn.	42.00		CLAY, silty, sandy, some gravel (f) subangular silt -and claystone fragments	5Y - 3/2 Very dark grey	>250.0
		.10				
	Oe/T	.20				>250.0
		42.26				
Comments:			Symbols: K_f = grain size distribution k_r = thermal conductivity XRD = mineralogy w = water content (% water of dry sample) w_L - w_p = liquid and plasticity limits γ = unit weight of soil (kN/m ³) V_{SH} = horizontal sound velocity (m/s) V_{SV} = vertical sound velocity (m/s) Oe = oedometer test T = triaxial test TOC = total organic carbon TC = total carbon s_u = undrained shear strength from falling cone test (kN/m ²) s_r = remoulded shear strength (kN/m ²) Magn. = magnetic fabric OG = organic geochemistry MPal = micropaleontology			

Site 7323/12-U-01



5.3.4 Site 7324/07-U-01

Seismic interpretation

This site is located along the same line as 7323/12-U-01, and Quaternary reflections are also here poorly defined. Two faint reflections are, however, found at 22 and 30 ms. A fairly clear reflection of probable regional significance occur at 40 ms (although it does not appear on the shown section) and it may correspond to one of the reflections at 20 or 30 ms at site 7323/12-U-01. A fourth reflection is located at 72 ms, 9 ms above bedrock. The depth to bedrock of 75.4 m implies an average sound velocity in the Quaternary sediments of about 1860 m/s.

Lithology and mechanical properties

Only the interval between 40 and 72 ms is sampled and a very dark grey silty clay with some sand and gravel is found. Rock fragments comprise only claystone/siltstone and sandstone. All samples are stiffer than 250 kPa and have a low water content. An oedometer test at 64 m indicate that the sample has not experienced any preconsolidation pressure in excess of the present vertical effective pressure of 700 kPa.

Age

A small shell fragment at 64.1 m has been AMS - dated and gave an infinite radiocarbon age.

LOC. 7324/07-U-01

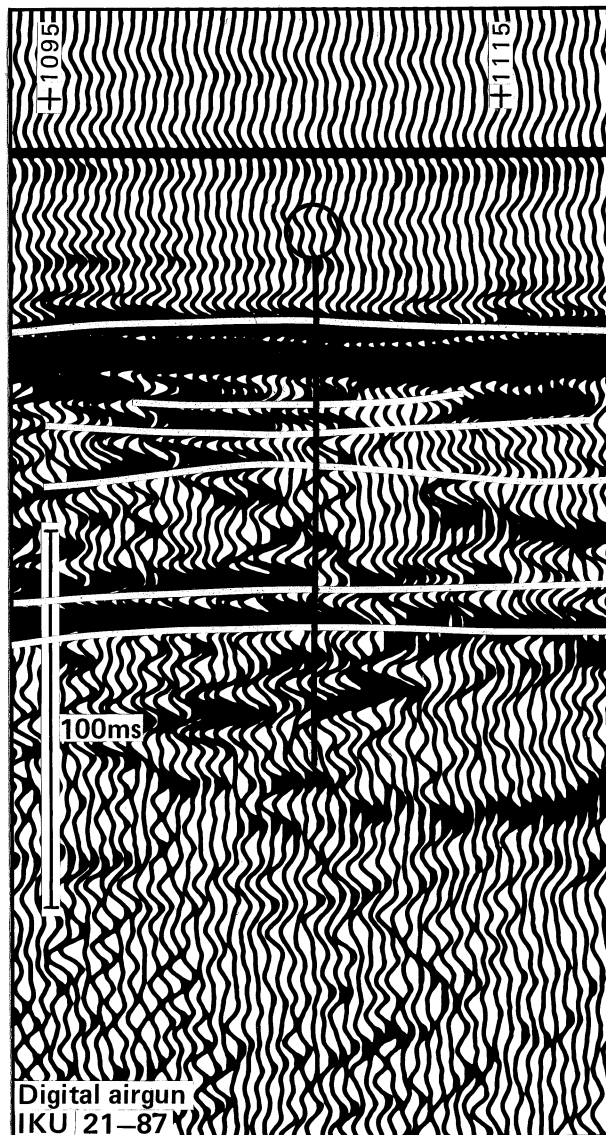


Figure 5.5

Seismic section across site 7324/07-U-01. The figure is continued on the following pages by a soil boring summary sheet, a description sheet and drawings of radiographs for each sample.

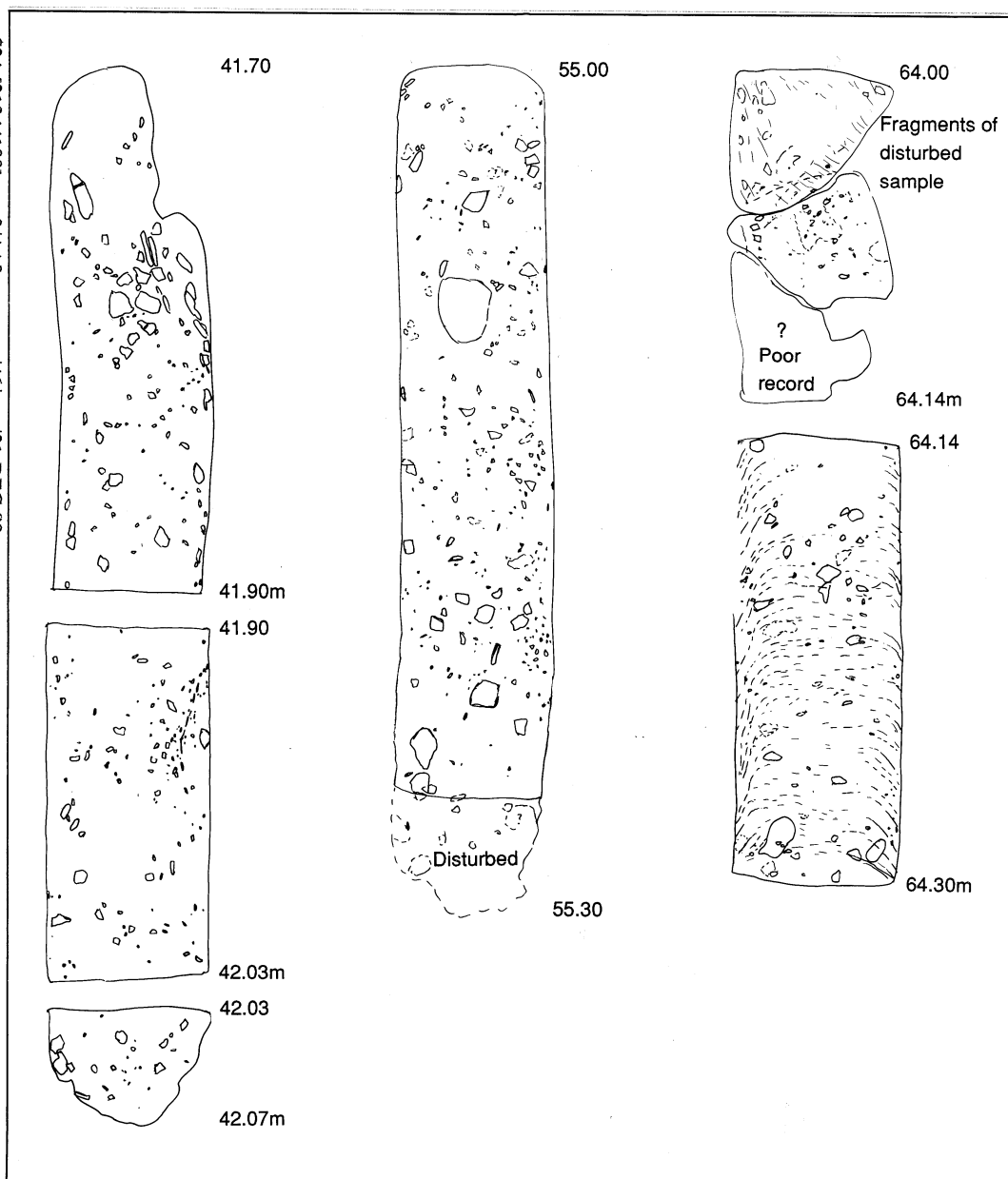
[illegible]

[illegible]

		Project 21.3441.00: Quaternary samples Barents Sea 1987			Location 7324/07 - U - 01	
Equipment Hammer sampler		Water depth 401.7 m	Latitude 73°18'56.92"N	Longitude 24°08'21.22"E	Depth below seabed 41.70 - 42.07 m	
Analytical results	Subsample	m	Lith.	Core description	s_u	s_r
w = 15.4% $\gamma = 22.5 \text{ kN/m}^3$	Magn.	41.70		CLAY, silty, some sand and gravel (f-m) 5Y - 3/1 Very dark grey		
				Subangular claystone -and subrounded sandstone fragments	>250.0	
		.80				
		.90				
		42.00				
		42.07				
Comments:		Symbols: K_f = grain size distribution T = triaxial test k_t = thermal conductivity TOC = total organic carbon XRD = mineralogy TC = total carbon w = water content (% water of dry sample) s_u = undrained shear strength from falling cone test (kN/m ²) w_L - w_P = liquid and plasticity limits s_r = remoulded shear strength γ = unit weight of soil (kN/m ³) Magn. = magnetic fabric V_{SH} = horizontal sound velocity (m/s) OG = organic geochemistry V_{SV} = vertical sound velocity (m/s) MPal = micropaleontology O_e = oedometer test				

		Project 21.3441.00: Quaternary samples Barents Sea 1987			Location 7324/07 - U - 01	
Equipment Hammer sampler		Water depth 401.7 m	Latitude 73°18'56.92"N	Longitude 24°08'21.22"E	Depth below seabed 55.00 - 55.30 m	
Analytical results	Subsample	m	Lith.	Core description	s_u	s_r
w = 13.9% γ = 23.3kN/m ³		55.00		CLAY, very silty, gravelly (f-m)	5Y - 3/1	
					Very dark grey	
				Subangular claystone -and subrounded sandstone fragments		>250.0
		.10				
		.20				
				55.30		
Comments:		Symbols:				
		K_f = grain size distribution k_t = thermal conductivity XRD = mineralogy w = water content (% water of dry sample) w_L - w_P = liquid and plasticity limits γ = unit weight of soil (kN/m ³) V_{SH} = horizontal sound velocity (m/s) V_{SV} = vertical sound velocity (m/s) O_e = oedometer test	T = triaxial test TOC = total organic carbon TC = total carbon s_u = undrained shear strength from falling cone test (kN/m ²) s_r = remoulded shear strength Magn. = magnetic fabric OG = organic geochemistry MPal = micropaleontology			

Site 7324/07-U-01



IKU SINTEF-GRUPPEN		Project 21.3441.00: Quaternary samples Barents Sea 1987			Location 7324/07 - U - 01	
Equipment Hammer sampler		Water depth 401.7 m	Latitude 73°18'56.92"N	Longitude 24°08'21.22"E	Depth below seabed 64.00 - 64.30 m	
Analytical results		Subsample	m	Lith.	Core description	s_u
w = 14.1%		14 _C	64.00	CLAY, silty, some sand and gravel (f)	5Y - 3/1	
w = (32.9%) γ = 20.9 kN/m ³			10	Subangular silt - and claystone fragments	Very dark grey	
w _p = 23.7%		Oe/T	20	Subrounded sandstone fragment, 2.0 cm		
			64.30			>250.0
Comments: 14 _C (Va - 988): >45000 BP		Symbols:				
		- K_s = grain size distribution - K_t = thermal conductivity - XRD = mineralogy - w = water content (% water of dry sample) - w_L-w_p = liquid and plasticity limits - γ = unit weight of soil (kN/m³) - V_{SH} = horizontal sound velocity (m/s) - V_{SV} = vertical sound velocity (m/s) - Oe = oedometer test - T = triaxial test - TOC = total organic carbon - TC = total carbon - s_u = undrained shear strength from falling cone test (kN/m²) - s_r = remoulded shear strength - Magn. = magnetic fabric - OG = organic geochemistry - MPal = micropaleontology				

6. REFERENCES

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APPENDIX 1

FIELD WORK

A.1 General

The field work commenced 22.07.87 and lasted until 09.09.87.

The contractor for the drilling operations was Offshore Support Services A/S in Oslo, using the drill ship M/S "Bucentaur" (Figure A.1.1). As bed-rock coring machine the DB 1500S from Diamant Boart, Belgium/Norway was used, and Dia-Team, Norway provided diamond drilling staff.



Figure A.1.1 The drill ship M/S "Bucentaur".

A.2 Technical Data

Drill ship M/S "Bucentaur".

Length over all	78.07 m
Breadth moulded	16.00 m
Draft fully loaded	5.55 m
Displacement	4.470 tonnes
Gross register tonnage, international	2.768 tonnes

Main engine: Four Wärtsilä diesels, type Vasa 8R22HE, each driving a van Kaick generator of 1200 kW at 1200 RPM, 600V/60 periods AC.

Propulsion units: Two azimuthing thrusters with CP propeller in nozzle, make Liaaen.

Bow thrusters: Two tunnel thrusters with CP propeller, make KaMeWa.

Dynamic positioning system: One GEC simplex system with GEC-Elliott 2050 computer, video display and joystick. Positioning reference by deep water tautwire system and by Simrad HPR T209 hydro-acoustic system.

Hard-tie winch: One Ingersoll Rand, max pull 10,000 lbs, with auto. Failsafe brake.

Elevator: Wirth, type special pipe pick-up chuck, suitable for 51/2" F.H. joints.

Slips: Wirth power slips type B12, with inserts for 5" pipe.

Heavy lift winch: One winch make Pusnes, capacity on single drum 2 lengths each 1200 m wire 36 mm dia. Braking force 90 tonn.

Mud system: Complete dry mud system with mud mixing equipment mud storage, and mud pumps (three X: WIRTH TPK 51/2" x 51/2", 84 HP hydraulic motor, capacity 1600 l/min at 20 bar).

Main drill string

Drill pipe: 2000 m of API-5" Grade E, range II, 19.51 lbs/ft with 51/2" tool joints, 4" I.D.

Drill collars: Sixteen, each 5 m long, 7" O.D. and 4" I.D. with 51/2" tool joints.

Diamond core drill system Drilling machine: DBH 1500S electro/hydraulic drill.

Spindle opening: 127 mm

Rotating speed: Max 900 rpm.

Drill string: Wireline HP Heavy duty rods O.D. 88.9 mm, mI.D. 70 mm, length 10 ft, weight 38 kg. Back-up NR Heavy duty wire line drill rods, O.D. 69.9 mm, I.D. 60.3 mm.

Core barrels: Triple tube, 10 ft with split tube.

Core diameters: HR triple tube 54.2 mm, NR triple tube 38.1 mm.

Drilling capacities: HR-1000 m, NT 1500 m.

Seabed template: Fugro SEACLAM with hydraulic pipe clamping system, inclinometers and underwater Tv camera.

A.3 Standard drilling operation (Figure A.1.2)

- (a) M/S "Bucentaur" moves onto position and sets the dynamic positioning system (D.P.) in operation.
- (b) Seabed re-entry template is lowered to the seabed, and constant tension is applied to the template cables via the template heave compensation system.
- (c) The 5" drill pipe with open centre bit is lowered on a guided template cable rider to the seabed.
- (d) The Quaternary overburden is penetrated until the drillbit is drilled into rockhead. Samples of Quaternary sediments are recovered during drilling.
- (e) The powerswivel heave compensator is then set to give the chosen bit weight on the API string (often slightly in excess of the maximum weight that may be required by the diamond core bit used for the coring), and the 5" drill string is clamped to the seabed template.
- (f) The piggyback coring wireline core barrel is then run into the hole.
- (g) Core drilling commences, with length of each run being determined by the length of the inner tube (3.05 m), or by the drilling conditions. Coring continues for 1-2 days. Typical production rates are 1.5-3.0 m/h.
- (h) The coring pipe and subsequently the 5" drill pipe are pulled and stored on the deck. The seabed template is hoisted into the moonpool, D.P. is disengaged and the vessel proceeds to the next location.

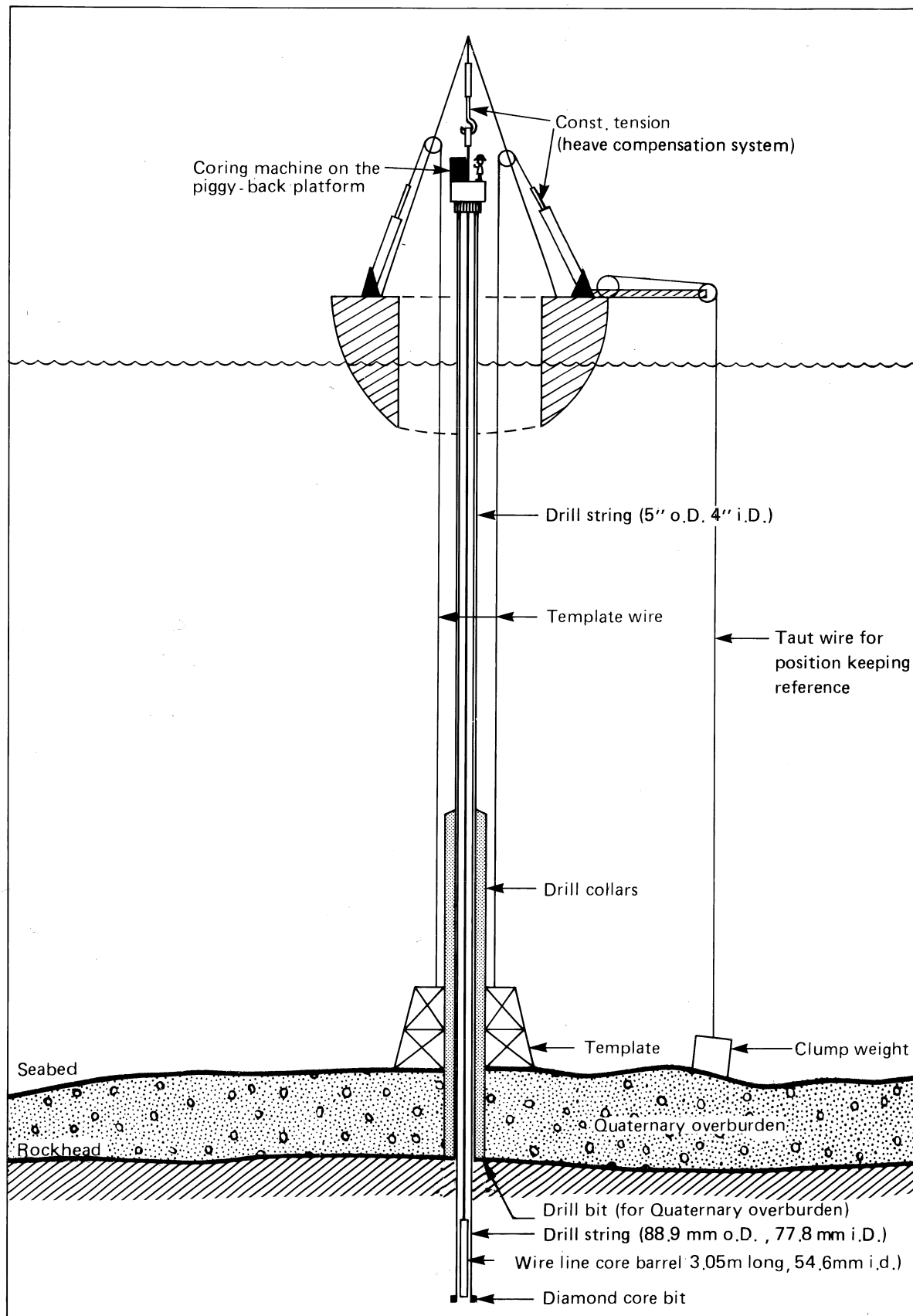


Figure A.1.2 Sketch showing the drilling operation for M/S "Bucentaur".

Two types of standard soil sampling equipment were used in addition to the piggyback coring. These were: The Fugro Wip sampler and a hammersampler. These two systems were combined with 3 inch and 2 inch steel sampling tubes, respectively.

The Wip system comprises a hydraulically operated jack that is lowered down inside the drill string and latched with the sampling tube cutter at drill bit level. The sampling tube is then pushed down into undisturbed sediments and cuts a cylindrical sample.

The hammersampler is mechanically operated from a winch on the main deck and comprises a load that can move freely a certain distance up and down along a shaft which on the lower end is connected to the tube. During sampling the load is pulled up and allowed to drop freely down about 10-30 times and by this the sampling tube is hammered into the sediment.

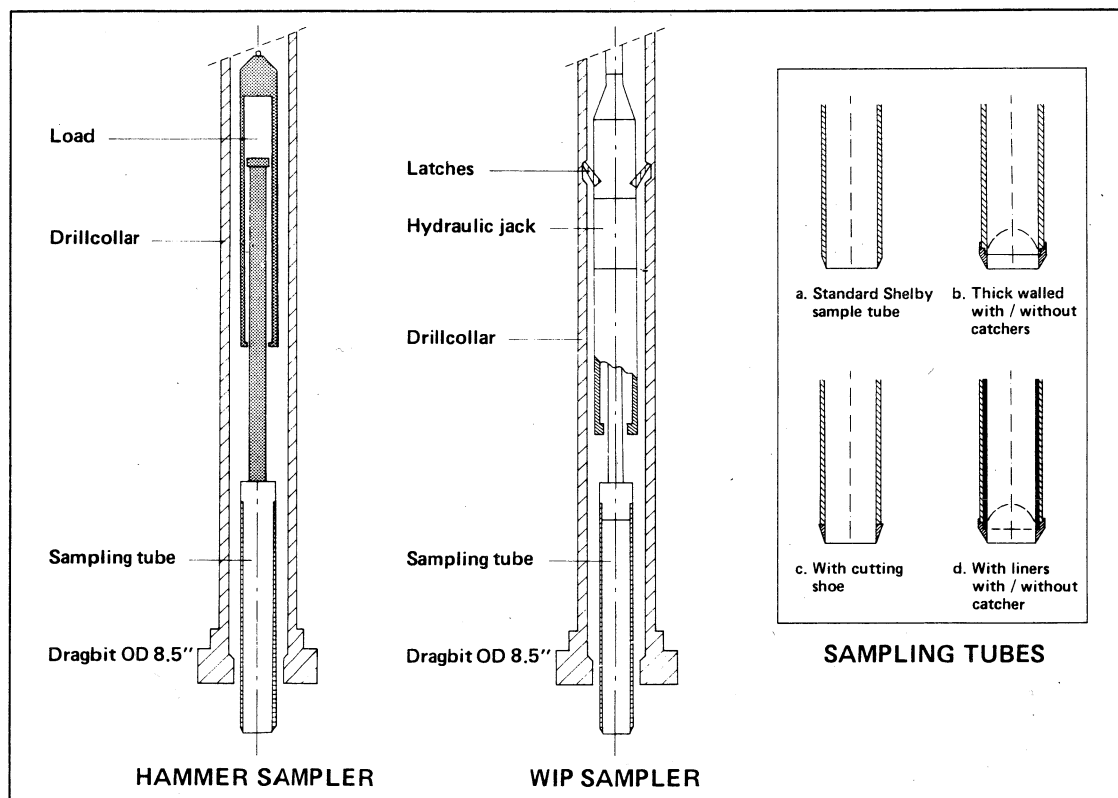


Figure A.1.3 Hammer sampler and wip sampler.