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BP Petroleum Development (Norway) Ltd.

Well 2/1-7
Petroleum Engineering
Completion Report

by

K. Vasseljen

Report No.: PED/8/00
JULY 1985

Approved by: Alan Harding

BP PETROLEUM DEVELOPMENT OF NORWAY A.S.
LOCATION PLAT WELL: 2/1-7

COUNTRY NORWAY
AREA - NORTH SEA

LICENCE NO. 019 B
BLOCK NO. 2/1

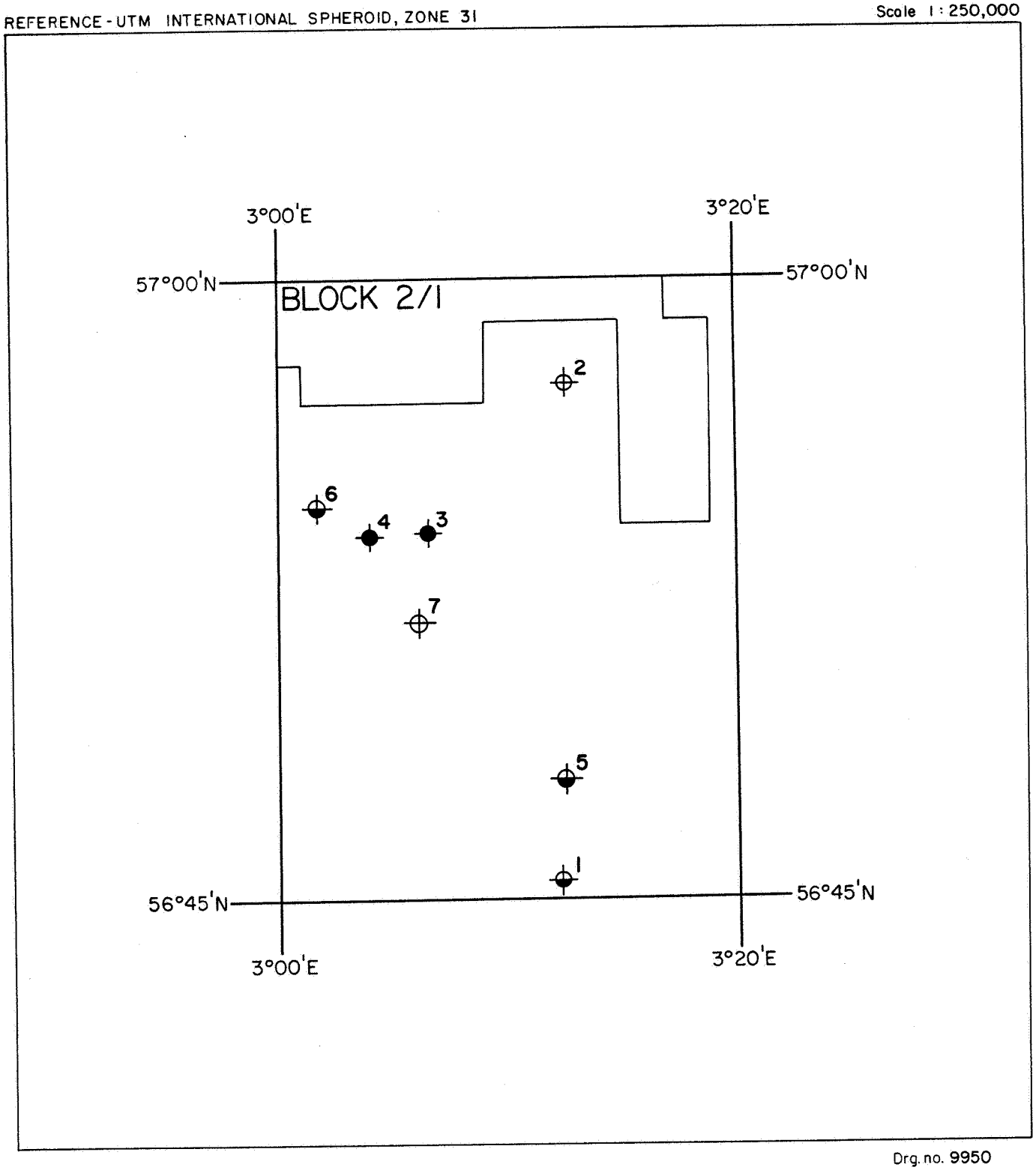
CO-ORDINATES: LAT. 56°51'51.32"N
LONG. 03°05'40.36"E

GRID REFERENCE N 6 302 420.00
E 505 763.53

ELEVATION OF ROTARY TABLE 38.9 metres AMSL

REFERENCE - UTM INTERNATIONAL SPHEROID, ZONE 31

Scale 1 : 250,000



Drg. no. 9950

SUMMARY

The exploration well 2/1-7 was spudded by the jack-up drilling rig Glomar Moray Firth I on the 6th of September 1984. A total depth of 5465 mBRT was reached in Permian rock with 6" hole, before the well was abandoned on the 6th of March 1985.

This well was drilled for the 019B license. The licensees are:

BP (Operator)	26.625%
Conoco	19.375%
Pelican	4.000%
Statoil	50.000%

The primary objective of the well was to test a Permian prospect in block 2/1. A secondary objective was to evaluate the Upper Jurassic 2/1-3 sand. This target was to establish a data point in the ongoing evaluation of the 2/1-North Reservoir.

The secondary target, the Upper Jurassic sand was not encountered in the well as expected.

Top Rotliegendes sand was expected at 4835 mss (4874 mBRT) with an uncertainty of ± 300 m, and was encountered at 5083 mBRT. No gas was seen. 6" hole was drilled to 5113 mBRT where RFT pressure readings were attempted. The RFT tool became stuck (top fish 5096 mBRT), and a sidetrack was drilled. Kick off point was at 5080 mBRT.

Coring was initiated at 5115 mBRT. 4 cores were cut in two intervals. Core 1,2 and 3 from 5115 mBRT to 5127 mBRT and core 4 from 5147 mBRT to 5165 mBRT. The hole was then drilled through continuous Rotliegendes sand where, at a depth of 5465 mBRT, the drill string became stuck. A backoff was achieved at 5198 mBRT and TD logs were run.

The 6" open hole logging was performed in the period 22nd to 24th of February 1985. An average of 14.6% porosity over the sand interval was seen. The average water saturation at around 90% indicated that the formation was waterbearing. From cores, the average (arithmetic) permeability was 2.28 mD.

2/1-7 was plugged and abandoned without any flow tests being carried out.

GENERAL WELL DATA

WELL:	2/1-7 NOCS		
LATITUDE:	56°51'51,32"N	RTE:	38,9 m.a.m.s.l
LONGITUDE:	03°05'40,36"E	WATER DEPTH:	67 m
TYPE OF RIG:	JACK-UP	NAME:	GLOMAR MORAY FIRTH I

OBJECTIVES: The primary target was Rotliegendes sandstone in a fault bonded structure mapped at base Zechstein Group level. This was expected to be a dry gas play. The secondary target was Upper Jurassic sandstone, to establish the SE extent of the 2/1-North oil accumulation.

DATE SPUDDED: 6th September, 1984 DATE COMPLETED: 6th March, 1985

WELL STATUS: Plugged and abandoned

GEOLOGICAL DATA

	Tops		Thickness	
	LD (mBRT)	LD (mss)	(m)	
Nordland Group	106	67	1724	
Hordaland Group	1830	1791	1087	
Rogaland Group	2917	2878	31	
Balder Fm	2917	2878		22
Sele Fm	2939	2900		9
Montrose Group	2948	2909	239	
Forties Fm	2948	2909		70
Lista Fm	3018	2979		75
Maureen Fm equ.	3093	3054		94
Chalk Group	3187	3148	615	
Ekofisk Fm	3187	3148		88
Tor Fm	3275	3236		373
Hod Fm	3648	3609		123
Plenus Marl Fm	3771	3732		15
Hidra Fm	3786	3747		16
Cromer Knoll Group	3802	3763	172	
Rødby Fm	3802	3763		84
Valhall Fm	3886	3847		88
Boknfjord Group	3974	3935	50	
Mandal Fm	3974	3935		22
Haugesund Fm	3996	3957		28
Vestland Group	4024	3985	81	
Ula Fm	4024	3985		38
Bryne Fm	4062	4023		43
"Triassic Group"	4105	4066	227	
Zechstein Group	4332	4293		
Z5	4332	4293		116
Z4	4448	4409		110
Z3	4558	4519		251
Z2	4809	4770		218
Z1	5037	4998		46
Rotliegendes Group	5083	5044	382	
TD	5465			

Chronostratigraphy (BP Sunbury)

	Tops L.D. (mbrt)	L.D. (mss)	Tickness (m)
Tertiary	106	67	3169
Pleistocene-Eocene	106*	67	2842
Palaeocene	2948*	2909	327
Danian	3187*	3148	88
Cretaceous	3275*	3236	699
Maastrichtian-Turonian	3275*	3236	498
Turonian	3773	3734	20
Cenomanian	3793	3754	70
Late Albian	3863	3824	10
Early Aptian-? Barremian	3873	3834	30
Early Valanginian	3903	3864	20
Earliest Valanginian-Latest Ryazanian	3923*	3884	51
Earliest Cretaceous-Latest Jurassic	3974*	3935	9
Late Ryazanian-Late Volgian	3973*	3935	9
Jurassic	3983	3944	122
Middle Volgian	3983*	3944	13
Kimmeridgian	3996*	3957	65
Middle Jurassic	4061*	4022	44
Triassic	4105*	4066	227
Permian	4332	4293	+1133

*Log picks based on lithostratigraphy

CONVENTIONAL CORES

No.	LD (mBRT)	DD (mBRT)	Recovery (m)
1	5121.05-2130.25	5115.05-2124.25	9.20 m 100%
2	5130.25-5131.52	5124.25-5125.52	1.27 m 100%
3	5131.52-5133.00	5125.52-5127.00	1.48 m 100%
4	5153.00-5171.00	5147.00-5165.00	18.0 m 100%

SIDEWALL CORES:

RUN NO.	SHOT NO.	LD (mBRT)
Run 5A	1	5066.0
	2	5062.5
Run 5B	11	4124.0
	19	4083.0
	33	4039.0
Run 5C	7	4102.5
	9	4093.6
	12	4065.5
	14	4055.5
	19	4024.0
	20	4020.0
	22	4010.0
	25	3995.0
	26	3990.0
	27	3985.0
	28	3980.0
	30	3965.0
Run 5D	5	4144.1
	10	4089.0
	11	4085.0
	12	4080.0
	20	4043.0
	23	4028.5
	24	4025.9
	25	4022.5
	28	3999.9
	29	3996.4
	30	3974.8

SHOWS:

No oil or gas shows.

CASING:

Size	Depth (mBRT)	Cemented
36"	171.0	to seabed
20"	745.0	to seabed
13 3/8"	2473.0	to seabed
9 5/8"	3873.0	1450 mBRT (T.O.C)
7"	5076.0	3663 mBRT (T.O.L)

LOGGING: LOGS RUN IN WELL 2/1-7

RUN NO	LOG	DATE	HOLE SIZE (inch)	LOGGED INTERVAL (mBRT)	MAX. TEMPERATURE (^{o}F)
1A	ISF/SLS/GR/SP	15/9/84	26	100-754	98
2B	ISF/SLS/GR/SP	2/10/84	17 1/2	744.2-2462	170
3C	ISF/SLS/MSFL/ GR/SP/CAL	11/11/84	12 1/4	2473-3881	228
3A	CBL/VDL/GR/CCL	12/11/84	13 3/8 CSG	450-1000	-
4D	ISF/SLS/MSFL/ GR/SP/CAL	24/11/84	8 3/8	3876-4293	283
4A	SHDT/GR	25/11/84	8 3/8	3876-5081	294
5A	BHC/MSFL/GR/ SP/CAL	23/12/84	8 3/8	3876-4930	319
5A	LDL/CNL/NGT/DLL CAL/SP	24/12/85	8 3/8	3876-4930	-
5A	RERUN LDL/CNL/ NGT/DLL/CAL/SP	25/12/84	8 3/8	4850-5081	314
5A,B,C,D	CST/GR	25/12/84	6	3974-5066	-
6A	RFT/GR	13/1/85	6	5103-5076.5	331
7B	RFT/GR	11/2/85	6	5115-5145	332
8E	ISF/SLS/MSFL/ GR/SP/CAL	22/2/85	6	5083-5193	322
8B	LDL/CNL/GR	22/2/85	6	5083-5194.5	330
8B	DLL/GR/SP	23/2/85	6	5083-5189	332
8A	VSP/GR	24/2/85		150-5185	332
8B	CBL/VDL/GR/CCL	24/2/85	7 liner + 9 5/8 CSG		-
8C	RFT/GR	24/2/85	6	5110.5-5178.5	322

TESTS:

RFT: No valid RFT points were obtained. See Chapter 6.
DST: No DST's were run.

Comments:

2/1-7 penetrated 356 m of water bearing Lower Permian Rotliegendes sandstone. The "2/1-3 Sand" was not present in the well, but 38 m of water bearing sandstone of the Ula Formation was penetrated. The well has severely downgraded the prospectivity of the Rotliegendes sandstone, and is thought to be dry due to the absence of Carboniferous source rocks.
Report Reference: 2/1-7 W. 28: D. Aga/E. Kvadsheim

CONTENTS

1. HYDROCARBON INDICATIONS

In well 2/1-7 there were no reported indications of hydrocarbon presence. The Jurassic section (3974-4105 mBRT loggers depth) of the 8 3/8" hole showed gas levels whilst drilling varying from 0.03% to 0.1% of background gas. No major peaks were reported from that part of the hole. In 6" hole, the gas readings down to 5100 mBRT (drillers depth) were generally below 0.1%. After Core 4 was cut to a depth of 5165 mBRT an RFT tool was run to measure formation pressure. As a result of this the mudweight was reduced from 1.92 SG to 1.72 SG to minimize the overbalance. Subsequent drilling showed a slight increase in gas levels to 0.15% from 5165-5180 mBRT (drillers depth). After this increase, the background gas readings went down to below 0.1%. Two trip gas peaks were seen; one at 5377 mBRT and one at 5460 mBRT (drillers depth). They were 0.72% and 4.46% respectively.

No hydrocarbon indications were seen from the 4 cores that were cut. They showed no visible fluorescence.

2. CORE ANALYSIS

A) Wireline Samples

Sidewall cores were required for dating, lithological and geochemical purposes. Two intervals were selected for sidewall coring attempts. Above the Zechstein salt the interval was 3974-4313 mBRT. Below the salt, the interval was 5041-5066 mBRT.

132 shots were attempted of which 28 were successful and cores recovered. Out of 132 shots, 38 misfired. A list of the recovered cores is shown in Table 2.1. The low recovery was attributed to hard formation.

B) Conventional Cores

In 2/1-7, 4 conventional cores were cut in the Rotliegendes sandstone. Cores 1 to 3 were cut from 5115.05 mBRT to 5127 mBRT. From 5127 mBRT, the coring slowed down due to problems with the drill string torquing up. Therefore drilling was resumed. The drilling was carried out down to 5147 mBRT. Core 4 was cut from 5147 mBRT to 5165 mBRT. Core recoveries are shown in Table 2.2.

Approximately 5% of the core was preserved using the Seal Peal Technique. A listing of seal peals is shown in Table 2.3.

Conventional core analysis was performed on plugs, cut at 30 cm intervals. The following parameters were determined:

i) Helium and saturation porosity.
ii) Horizontal and vertical air permeability.
iii) Residual fluid saturations.
iv) Grain density.

Results are available in Reference (2). A plot of helium porosity and Klinkenberg corrected air permeability versus depths is shown on the 2/1-7 Reservoir Composite Log. (See Enclosure).

The measured core permeability-porosity relationship for 2/1-7 is shown in Fig. 1, and the core data is summarized in Table 2.4. Core

porosities ranged from 11% to 25% and the Klinkenberg corrected horizontal permeabilities ranged from 0.08 mD to 73.5 mD. The average porosity for the total cored section was found to be 14.9% and the arithmetic average horizontal permeability was 2.28 mD. Core porosities and permeabilities have not been corrected for overburden pressure.

Since the core was split in two sections (Core 1-3 and Core 4), it was hard to see a distinct poro/perm relationship over a larger section of the sand. However, one significant feature was recognized from core 4 data. The porosities did not vary with increasing depth, whereas the permeability varied without having a distinct trend (see 2/1-7 Res. Comp. Log). This could be an effect of the clay minerals in the sand.

Two of the cores were chipped and studies utilizing the Scanning Electron Microscope (Ref. 3) was carried out. A core chip from 5125.35 mBRT was found to contain quartz and feldspar with fibrous illite as the major cement. The intergranular porosities were good in this sample (15-20% estimated visible porosity), but the permeability was highly restricted.

The core chip from 5160.35 mBRT contains a cement which was an irregular platy clay mineral believed to be smectite or mixed layer smectite-illite clays. Permeability was very strongly reduced and considerable microporosity was present but to a lesser extent than in the core from 5125.35 mBRT.

3. LOG EVALUATION

A summary of the wireline logs run in well 2/1-7 is shown in Table 3.1.

The sand included in this evaluation was the Permian Rotliegendes Sandstone from 5110-5185 mBRT which was a red-brown, quartz sandstone cemented extensively by clay minerals. No shows were reported in this Permian Sand (6" hole).

For evaluation of the Rotliegendes sand, a conventional FDC/CNL crossplot was used for porosity determination. The Indonesia equation was used for fluid saturation calculations. Unfortunately, no regional knowledge of the formation water resistivity existed. Since no formation water samples were taken, determination of the formation water resistivity had to be carried out by using logs applying the resistivity-ratio method. At 324°F, the R_w was 0.011 ohm-m which corresponds to 230 000 ppm equivalent NaCl concentration. Resistivities from the Induction and MSFL were used. The core analysis showed no hydrocarbon in the zone where Rw was picked. Other parameters used are shown in Table 3.2.

It was concluded that the induction derived resistivities were more appropriate for determination of R_t. The very fresh mud system (R_{mf} = 0.071 ohm-m at 324°F) favours the Induction log and this was indicated by using Ref. 4.

The Dual Laterolog showed an apparent hydrocarbon saturation with a transition zone at 5160 mBRT. This inconsistency with the Induction/SFL/MSFL combination was attributed to a phenomenon known as the Groningen effect. This "Groningen phantom" was caused by a 751 m thick bed of highly resistive Zechstein salt overlying the conductive Rotliegendes sand. As a result of this, the Dual Laterolog was ignored.

Porosities were calculated from the LDL/CNL/GR RUN 8E. The most significant environmental correction was for temperature on the CNL readings as hole conditions were generally good. In the absence of better data, the cementation factor and intercept were taken as 2 and 1 respectively and the saturation exponent assumed to be 2. Log

derived porosities showed good agreement with core porosities. A shale point was picked at 4304 mBRT (which is above salt) and the porosities from the ρb/ØN were corrected for shale using the parameters from that point (see Table 3.2). The selection of the clay parameters may not be correct, but ρ b/ØN values show reasonable agreement with the properties for illite. Both ρ b/ØN crossplot and GR were used to determine the shale content in the Rotliegendes sand. The minimum calculated shale volume was selected (from GR) and the clay resistivity was 3.65 ohm-m (from MSFL).

For the saturation calculation, the resistivities from the Deep Induction/SFL/MSFL combination were used. They were corrected for mudcake and invasion. The results from the log analysis are listed in Table 3.3. From core data a porosity cut off was chosen as 11% equivalent to 0.1 mD within the Rotliegendes sand. This gave:

Net sand ..... 65 m
Total logged sand interval ..... 75 m
Av. porosity in net sand 14.6%
Av. Sw within net sand (5110-5172 mBRT). 90%
Av. V_{clay} in net sand 12%
Net sand porosity cut off 11.0%

It should be emphasized that these numbers are for the logged interval which represented 75 m of the total Rotliegendes sand.

Because of the extensive clay cementation seen in core chips, it is believed that clay volumes may have been underestimated. This would not change the conclusion however that the formation is water bearing.

4. FORMATION TESTING

4.1 Wireline Testing

A Repeat Formation Tester (RFT) equipped with a 20 K psig strain gauge was used for formation pressure measurements. The stated gauge accuracy was 0.13% of full scale which represents a maximum error of ± 26 psi. However, in practice this is rather optimistic, and an accuracy of ± 35 psi is more realistic.

Within the Permian Rotliegendes Sandstone, three RFT runs were made. Drilling problems seen whilst drilling with 1.92 SG mud indicated a too high overbalance. Run 6A and run 7B were therefore made in order to determine the magnitude of the hydrostatic overbalance applied to the formation and to measure the actual formation pressure. During run 6A four pressure tests were attempted. No valid pressure points were obtained because of seal failures. In addition a failure in the tool logic prevented the RFT from setting properly. Finally the RFT became stuck at 5089 mBRT.

After sidetracking in 6" hole, run 7B was made to fulfill the objective of the previous run. A total of six pressure measurements were recorded in the interval from 5115 mBRT to 5145 mBRT. (See Table 4.1). Two dry tests were obtained in the tight sand. Supercharging was seen in two of the points. No valid formation pressure gradient could be established, but the measurements indicated an 1800-1900 psi overbalance. In order to reduce this the mud weight was reduced from 1.92 SG to 1.72 SG.

The objective of run 8C was to establish a formation fluid gradient in the 2/1-7 Permian reservoir. A total of 13 pressure measurements were recorded. (See Table 4.2). The first 9 points were recorded going in the hole, the remaining points were recorded going up. All the points except possibly one (at 5132.5 mBRT) were supercharged or tight. Seal failures were seen at 5110.5 mBRT and 5168 mBRT and both measurements had to be repeated. No reliable formation fluid gradient could be established.

The mud hydrostatic readings were also inconclusive (see Fig. 2). Whilst running in hole, three control readings were made in cased hole, and they shared a mud gradient of 2.39 psi/m (1.68 SG

mudweight). Further down the hole, the hydrostatic readings departed drastically from this expected mud gradient. One should note the mud engineer stated mud weight of 1.70 SG (2.415 psi/m gradient).

After the RFT-tool had returned to the base, the gauge master calibration was repeated. The temperature correction at 330°F had shifted about 20 psi, but the calibration curve shape was identical with the pre-run master calibration. This indicated that the gauge worked correctly. However, because of supercharging, departures of the hydrostatic pressures from the mud gradient and a calibration shift, there remains considerable doubt about the accuracy of the measurements.

4.2 Drill Stem Tests

No Drill Stem Tests were carried out in 2/1-7.

5. RESERVOIR FLUID PROPERTIES

5.1 Water Analysis

An attempt was made to see if the core was flushed completely with mud filtrate. A plug was cut from the centre of a piece of full core without using cooling water. The contained fluid was extracted from the plug and an analysis carried out. The results are listed in Table 5.1, showed that the salinity of the extracted fluid was higher than for the mud filtrate. This could indicate that some formation water was still left in the core. Since only one sample was extracted, the results were inconclusive.

6. RESERVOIR PRESSURE AND TEMPERATURE

6.1 Reservoir Pressure

As mentioned within the RFT section, reliable pressure data from the 2/1-7 Permian sand is limited. Only one reading from RFT run 8c may have given a formation pressure. At 5132.5 mBRT the pressure was 11771 psig and the build up time was 15 seconds. This corresponds to a pore pressure of 1.61 SG. However, since the RFT measurements were considered unreliable, and it is possible that this point was also significantly affected by supercharging, the pressure should be treated with caution.

6.2 Reservoir Temperature

The reservoir temperature has been estimated from temperatures recorded during wireline logging runs. The maximum reading thermometers were checked in boiling water prior to logging, and the recorded temperatures are shown in Table 6.1.

Figure 3 shows the temperatures plotted versus depth. To estimate the built-up temperature from log temperatures, a Horner type plot was used for temperatures recorded during runs 4, 6 and 8. Two slopes were calculated from the plot. Above the Zechstein salt, the temperature gradient was 6.5°F/100 m which compares to gradients in well 2/1-4 and 2/1-6. The slope in the Rotliegendes sand was based on extrapolated Horner temperatures which gave a gradient of 8.4°F/100 m. Reservoir temperature at 5183 mBRT was estimated at 341°F.

TABLES

TABLE 2.1: CORE RECOVERIES

Sidewall cores

RUN NO.	SHOT NO.	Depth* (mBRT)
Run 5A	1	5066.0
	2	5062.5
Run 5B	11	4124.0
	19	4083.0
	33	4039.0
Run 5C	7	4102.5
	9	4093.6
	12	4065.5
	14	4055.5
	19	4024.0
	20	4020.0
	22	4010.0
	25	3995.0
	26	3990.0
	27	3985.0
	28	3980.0
	30	3965.0
Run 5D	5	4144.1
	10	4089.0
	11	4085.0
	12	4080.0
	20	4043.0
	23	4028.5
	24	4025.9
	25	4022.5
	28	3999.9
	29	3996.4
	30	3974.8

* Log depth

TABLE 2.2: CORE RECOVERIES

Conventional Cores

Core no.	Interval Cored mBRT Drillers Depth	Recovery (m)	Recovery (%)
1	5115.05-5124.25	9.20	100
2	5124.25-5125.52	1.27	100
3	5125.52-5127.00	1.48	100
4	5147.00-5165.00	18.00	100

Note: Loggers Depth = Drillers Depth + 6 m.

TABLE 2.3: PRESERVED SECTIONS OF CORE

Core number	Piece Number	Cored depth (mBRT)*
1	1	5115.22-5115.40
	2	5117.14-5117.31
	3	5117.99-5118.13
	4	5119.11-5119.20
	5	5120.36-5120.45
	6	5122.10-5122.21
	7	5123.54-5123.70
2	8	5124.52-5124.69
3	9	5126.36-5126.41
4	10	5149.02-5149.24
	11	5151.25-5151.49
	12	5152.78-5153.10
	13	5156.58-5156.75
	14	5159.57-5159.79
	15	5162.24-5162.46
	16	5163.45-5163.54

* Drillers depth

TABLE 2.4: SUMMARY OF WELL 2/1-7 CORE DATA

Av. Core Porosity (%)	Av. Horizontal Permeabilities (mD)			Av. Vertical Permeabilities (mD)		
	K_{arith}	K_{geom}	K_{harm}	K_{arith}	K_{geom}	K_{harm}
14.9	2.28	0.64	0.37	0.80	0.20	0.13

Notes: i) All permeabilities are Klinkenberg corrected.
ii) No overburden correction has been applied.
iii) Core 1, 2, 3 and 4 all included.

TABLE 3.1: LOGS RUN IN WELL 2/1-7

RUN NO	DATE	LOG	LOGGED INTERVAL (mBRT)	HOLE SIZE (inch)	BOTTOM HOLE temp °F	TIME TAKEN (hours)	LOST TIME (hours)	REMARKS
1A	15/9/84	ISF/SLS/GR/SP	100-754	26	98	3 1/2	0	
2B	2/10/84	ISF/SLS/GR/SP	744.2-2462	17 1/2	170	6 1/4	0	MSFL/CALI was not run because of bad hole conditions.
3C	11/11/84	ISF/SLS/MSFL/ GR/SP/CAL	2473-3881	12 1/4	228	26.15	19.65	
3A	12/11/84	CBL/VDL/GR/CCL	450-1000	13 3/8 CSG		2 3/4	0	
4D	24/11/84	ISF/SLS/MSFL/ GR/SP/CAL	3876-4293	8 3/8	283	5	0	
4A	25/11/84	SHDT/GR	3876-5081	8 3/8	294	4.5	0	
5A	23/12/84	BHC/MSFL/GR/ SP/CAL	3876-4930	8 3/8	319	8.0	1	The SLS failed, had to run BHC. Lost two thermometers.
5A	24/12/84	LDL/CNL/NGT/DLL/ CAL/SP	3876-4930	8 3/8	314	8.5	0	Hung up at tight spot 4930 mBRT, could not reach TD. Did a wiper trip.
5A	25/12/84	RERUN	4850-5081	8 3/8		5.0	0	Had to rerun log to get to TD.
5A,B,C,D	25/12/84	CST/GR	3974-5066	6		22 1/2	0	CST gun failed during RUN 5A. Had to run CST Run 5B, C, D because hard formation made recovery difficult.
6A	13/1/85	RFT/GR	5103-5076.5	6	331	23 1/2	0	3 RFT failures before RFT got stuck during the third run.
7B	11/2/85	RFT/GR	5115-5145	6	332	4.25	0	
8E	22/2/85	ISF/SLS/MSFL/ GR/SP/CAL	5083-5193	6	324	4	0	
8B	22/2/85	LDL/CNL/GR	5083-5194.5	6	330	4.5	0	
8B	23/2/85	DLL/GR/SP	5083-5189	6	332	4.5	0	
8A	24/2/85	VSP/GR	150-5185		332	11.5	0	In 6" hole, 7" liner and 9 5/8 casing.
8B	24/2/85	CBL/VDL/GR/CCL	2350-5077			6.5	0	
8C	24/2/85	RFT/GR	5110.5-5178.5	6	322	8.5	0	

TABLE 3.2: LOG PARAMETERS

Well Properties

Bottom hole temperature (at 5183 mBRT)	341°F
Mud weight	1.7 SG
Mud type	Fresh water based high temp. bentonite mud.
R_m	0.602 ohm-m at 57°F
R_{mf}	0.381 ohm-m at 55°F
R_{mc}	1.280 ohm-m at 55°F

Formation Properties

Matrix:	Type	..... Sandstone
	ρ_{ma}	..... 2.67 g/cc (from Core data)
	GR_{min}	..... 38 API
Shale:	GR_{max}	..... 95 API
	ρ_{cl}	..... 2.65 g/cc
	ϕ_{Ncl}	..... 15 p.u.
	R_{cl}	..... 3.65 ohm-m
	Δt_{cl}	..... 67 sec/ft
Lithology coefficient, a		..... 1.0
Cementation factor, m		..... 2.0
Saturation exponent, n		..... 2.0
Temperature gradient		..... 6.5°F/100 m above salt
		..... 8.4°F/100 m below salt

Formation Fluids

Formation water resistivity, R_w	..... 0.011 ohm-m at 324°F

TABLE 3.3: 2/1-7 LOG RESULTS

Depth mBRT	Porosity %	Sw %	Vcl %
5110 - 5125	17	87	18
5125 - 5133	14	91	23
5133 - 5147	13	91	18
5147 - 5154	16	92	4
5154 - 5172	12	89	15
5172 - 5185	13	-	6

TABLE 4.1: FORMATION PRESSURE MEASUREMENTS

RFT RUN NO. 7B

POINT NO.	DEPTH (mBRT)	HYDROSTATIC INITIAL PRESSURE (PSIG)	HYDROSTATIC FINAL PRESSURE (PSIG)	TEMP. CORR FORMATION PRESSURE (PSIG)	COMMENTS/APPROX. BUILD-UP TIME (SEC)
1	5115	13710	13715	11857	TIGHT
2	5125	13715	13717	12080	SUPER CHARGED
3	5135	13742	13738	11847	TIGHT
4	5145	13745	13765	120	DRY TEST
5	5144	13765	13770	124	DRY TEST
6	5124	13697	13683	12040	SUPER CHARGED

TABLE 4.2: FORMATION PRESSURE MEASUREMENTS

RFT RUN NO. 8C

POINT NO.	DEPTH (mBRT)	HYDROSTATIC INITIAL PRESSURE (PSIG)	HYDROSTATIC FINAL PRESSURE (PSIG)	TEMP. CORR FORMATION PRESSURE (PSIG)	COMMENTS/APPROX. BUILD-UP TIME (SEC)
1	5110.5	12191	-	-	SEAL FAILURE
RPT	5110.5	12184	12156	11837	SUPERCHARGED
2	5112.5	12157	12156	11841	SUPERCHARGED
3	5132.5	12208	12197	11771	15
4	5139.5	12212	12210	11841	SUPERCHARGED
5	5148.5	12216	12220	11869	SUPERCHARGED
6	5153.5	12217	12218	11970	SUPERCHARGED
7	5168.0	12256	-	-	SEAL FAILURE
RPT	5168.0	12258	12261	12138	SUPERCHARGED
8	5173.0	12255	12256	9160	TOOL RETRACTED EARLY
9	5178.5	12284	12260	11985	SUPERCHARGED
10	5171.6	12230	12230	12010	SUPERCHARGED
11	5121.7	12132	12144	11797	SUPERCHARGED
12	5117.8	12125	12120	-	TIGHT
13	5118.3	12130	12132	-	TIGHT

Table 5.1

LABORATORY

FORMATION WATER ANALYSIS

Company BP, Norge Date 11.02.85. SAmple no. .....

Well ..... Field ..... State .....

Sampled from .....

Date sampled ..... Date analyzed 19.02.85. Analyst B.B.

Total Dissolved Solids 3.020 mg/L ..... Specific Gravity 1.003 (a 68 °F

Resistivity 1.905 ohm-meters (a 68 °F ph 5.04 (a ..... °F

*Constituens	mg/L	meq/L	Constituents	mg/L	meq/L
Sodium	886	39	Chloride	1.822	51
Calcium	171	9	Bicarbonate	-	
Magnesium	38	3	Sulfate	2.0	-
Strontium	9	-	Carbonate	-	
Barium	1.4	-	Hydroxide	-	
Iron	0		Phosfate	-	
Potassium	102	3			

REMARKS:

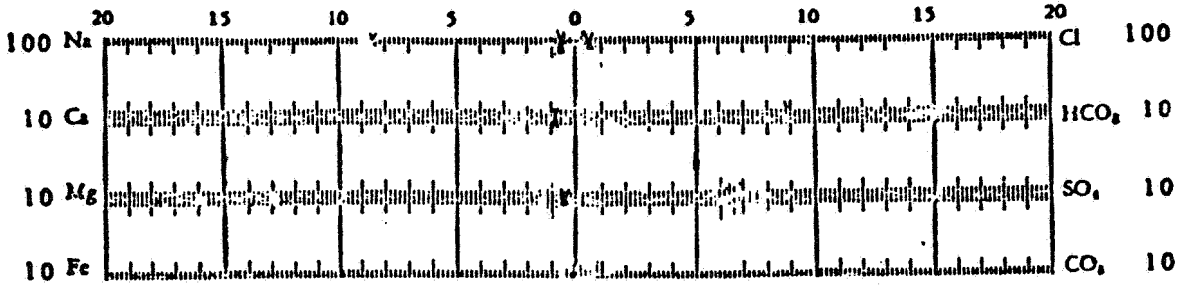


TABLE 6.1: LOG TEMPERATURE DATA

Run No	Log	Time since circulation stopped (hrs)	Max. temp °F	Depth (mBRT)
1A	ISF/SLS/GR	5 3/4	98	736
2B	ISL/SLS/GR	10 1/3	170	2445
3C	ISF/SLS/MSFL/GR	8	228	3858
4D	ISF/SLS/MSFL/GR	9 1/4	283	4270
4A	SHDT/GR	11 1/2	294	4284
5A	BHC/MSFL	11 1/6	319	5067
5A	DLL/LDL/CNL/NGT	8	314	5059
6A	CERT/GR/CCL	8	328	5094
6A	RFT/GR	16 2/3	331	5094
7B	RFT/GR	11 3/4	332	5145
8A	VSP/GR	15 3/4	332	5183
8B	DLL/GR/SP	17 1/4	332	5181
8B	LDL/CNL/GR	11 2/3	330	5183
8C	RFT/GR	10 3/4	322	5171
8E	ISF/SLS/MSFL/GR	8	324	5169

NB. 1) Horner build-up temperature at 4283.5 mBRT ..... 312°F

2) Horner build-up temperature at 5094.0 mBRT ..... 334°F

3) Horner buil-up temperature at 5183 mBRT ..... 341°F

References

1) BP Petroleum Development Ltd., Norway
Well 2/1-7 Geological Completion Report.
D. Aga/E. Kvadsheim, March 1985.

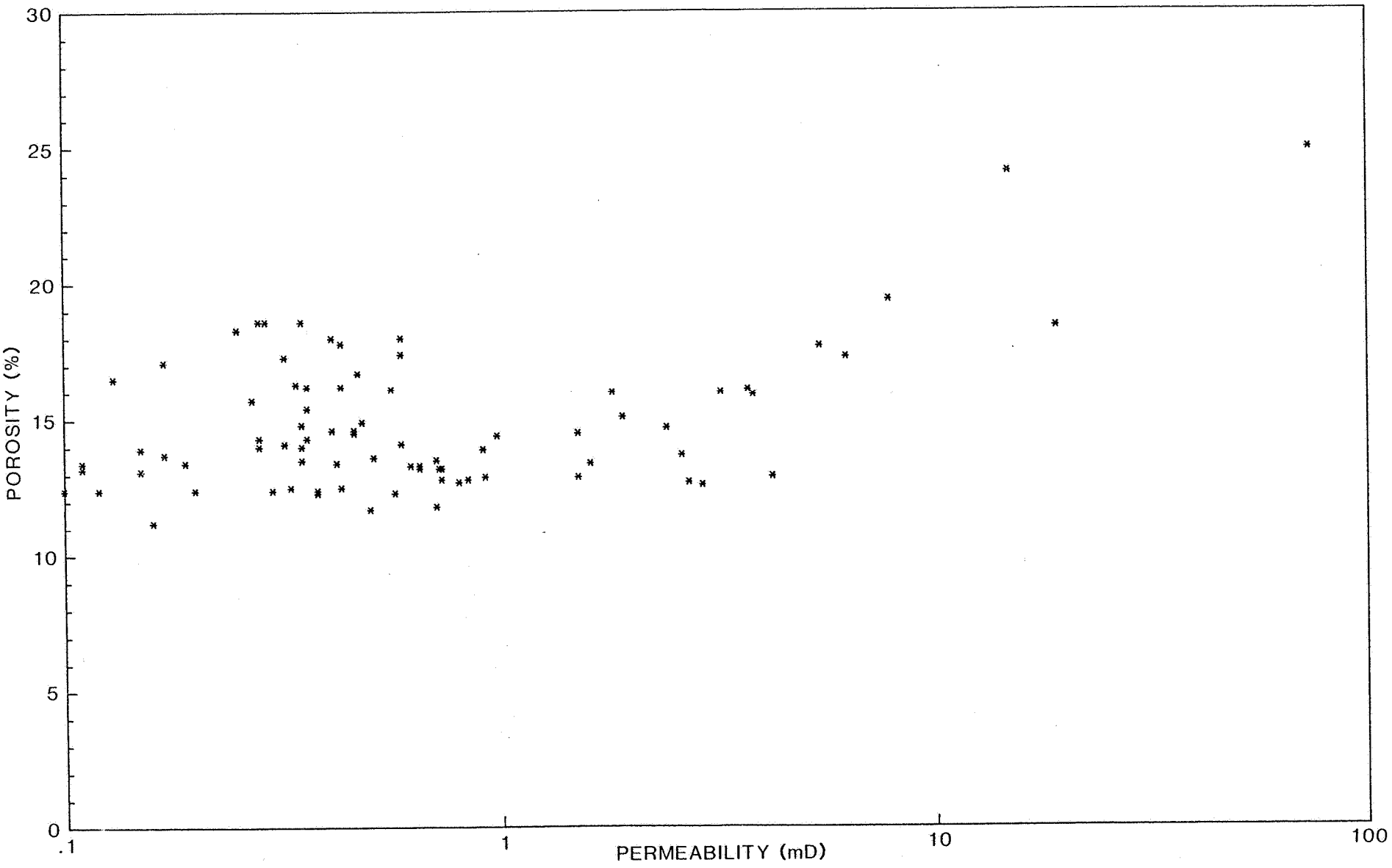
2) Geophysical Laboratories Norway Ltd.
Well 2/1-7 Conventional Core Analysis
March 1985.

3) SEM Examination of Core Chips from Rotliegendes Sandstone, Well 2/1-7
NOCS, Norway. File note of 19th March 1985 by M.J. Mayall.

4) Schlumberger Log Interpretation Volume 1 -Principles. 1972 Edition
Fig. 14-1 page 83.

FIGURES

Fig.1 WELL 2/1-7 COREDATA



Drg.no. 9946

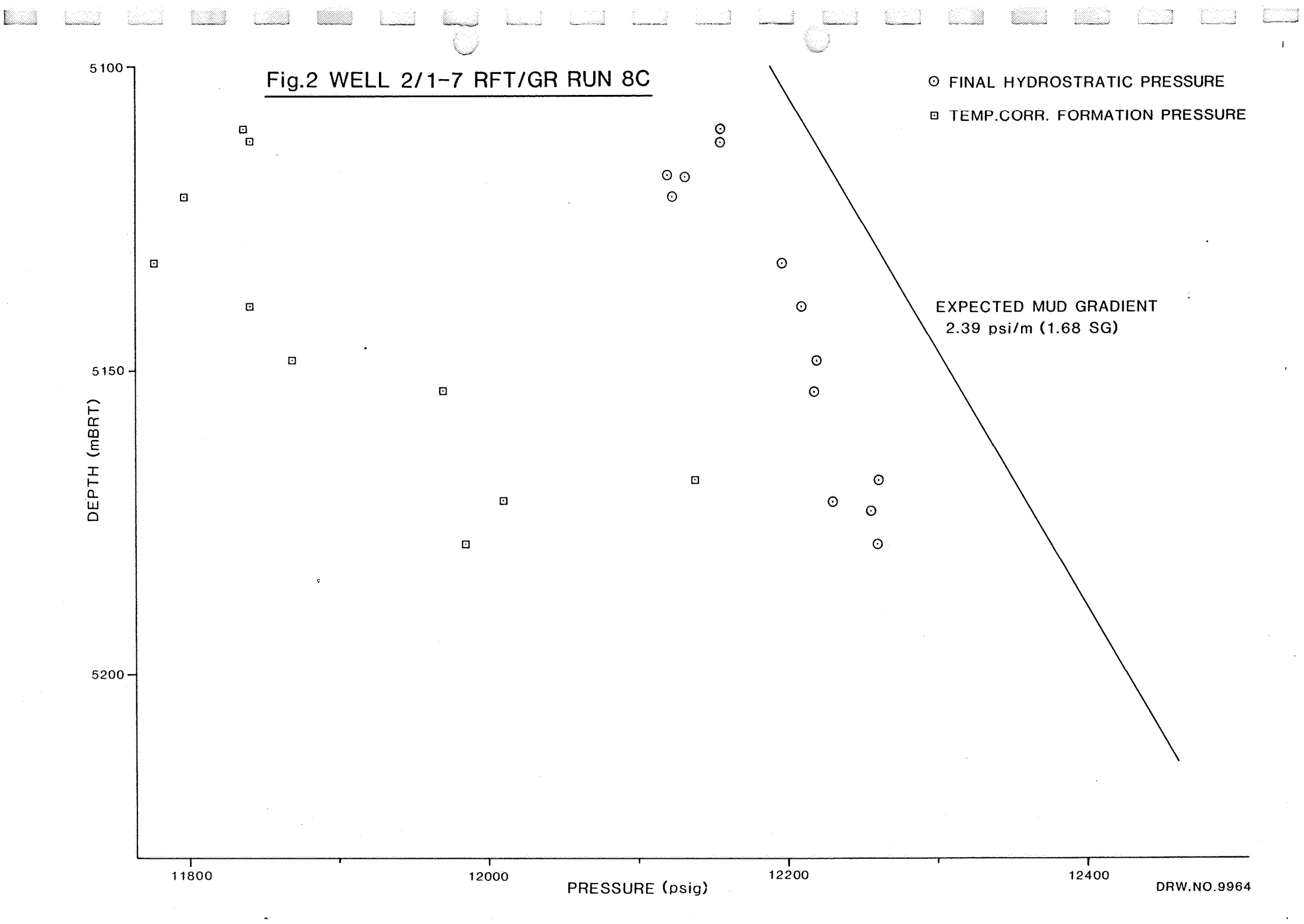
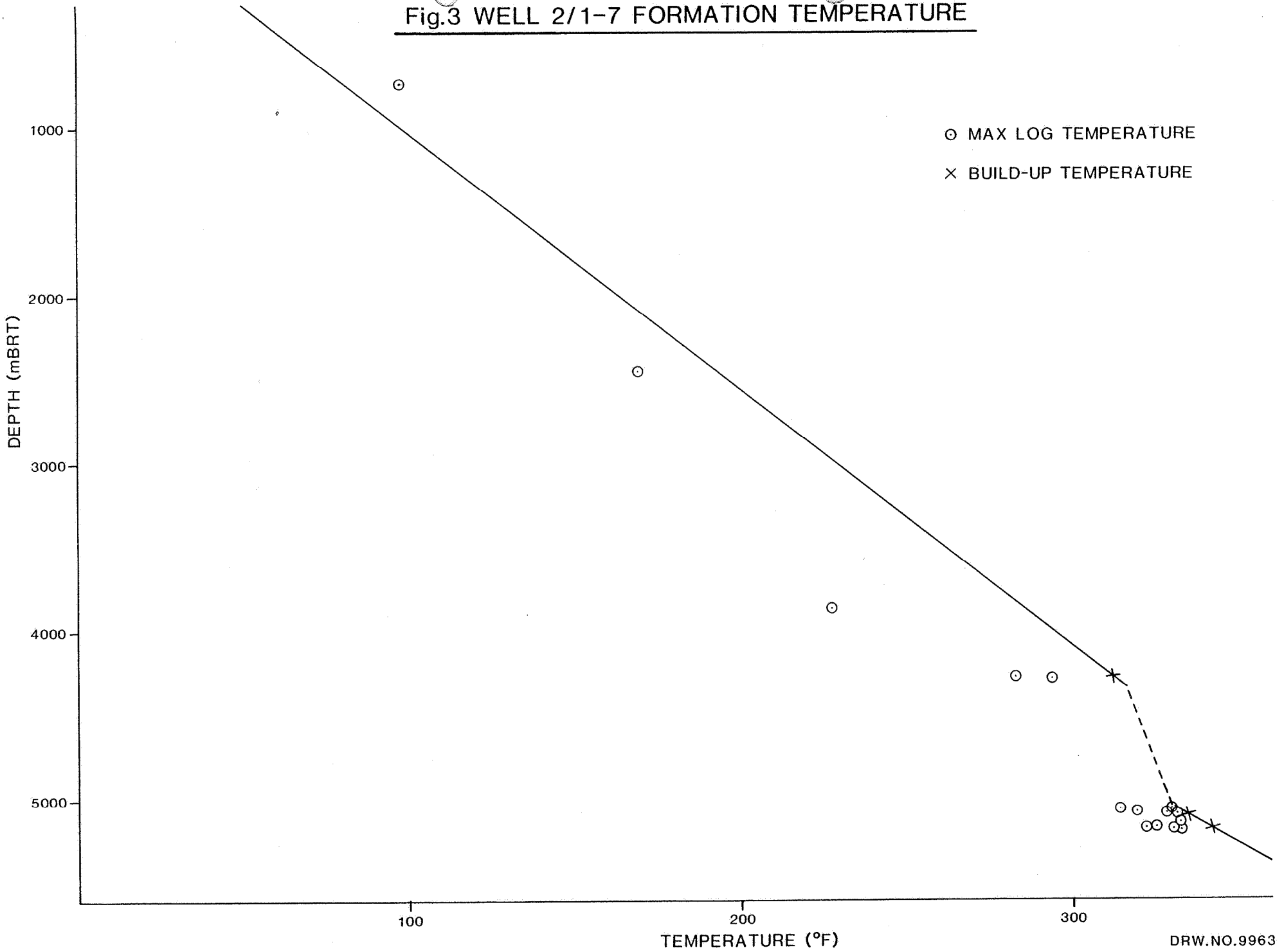


Fig.2 WELL 2/1-7 RFT/GR RUN 8C
FINAL HYDROSTRATIC PRESSURE
TEMP.CORR. FORMATION PRESSURE
EXPECTED MUD GRADIENT
2.39 psi/m (1.68 SG)
DEPTH (mBRT)
5100
5150
5200
11800
12000
12200
12400
PRESSURE (psig)
DRW.NO.9964

Fig.3 WELL 2/1-7 FORMATION TEMPERATURE



3

BP PETROLEUM DEVELOPMENT (NORWAY) LTD.

GEOLOGICAL COMPLETION REPORT
NOCS WELL 2/1-7

Authors: E. Kvadsheim/D. Aga

Approved by:

May 1985

2/1-7 W. 28

1833/EK

BP Petroleum Development (Norway) Limited
Utenlandsk aksjeselskap

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0202 OSLO 2

Attn.: V. Wiik

Our reference	Your reference	Telephone (04) 58 95 80 Telex 33339 BPEXPN	Date
PCH/ajS/700/019B			2.7.1985

Dear Sirs,

GEOLOGICAL COMPLETION REPORT, NOCS WELL 2/1-7

I have pleasure in enclosing copies of the above report for your records.

Yours sincerely,
for BP Petroleum Development (Norway) Ltd.

P.C. Home
Exploration Group Leader S. Norway

c.t. A. Allen
P.F. Owen
A. Harding
A. Johansen, NPD Stavanger (+ 1 copy report)
B.G. Williams, EXT BP London (+ 1 copy report)

1924/PCH5

CONTENTS

FIGURES

ENCLOSURES

1. SUMMARY

NOCS well 2/1-7 (Fig. 1) was drilled to evaluate an Early Permian prospect with significant dry gas potential (M.L. reserves 11 Tcf). The target was Rotliegendes sandstone in a large fault bounded structure mapped at base Zechstein Group level. A secondary objective was Upper Jurassic sandstone in a possible extention of the 2/1-North oil accumulation.

The well was spudded on the 6th September 1984. Rotliegendes sandstone was penetrated at 5109 mbrt, but was water bearing. The sandstone has a continental aeolian origin, and consists of medium grained, well sorted quartzose sands, with rounded and occasionally frosted grains. Average core porosity is 15% (range 12-24%). The well was terminated 365 m into the sandstone reservoir, before the base was penetrated.

Four cores were cut in the Rotliegendes sandstone, three of which cover the interval 5115.05-5127.0 mbrt (D.D.), and one between 5147.0-5165.0 mbrt (D.D.).

The secondary target was absent in the well. This confirmed the seismic mapping which picked the subcrop of the "2/1-3 Sand" beneath the base Mandal Formation to the north of the 2/1-7 well location.

38 meters of water bearing sandstone of the Ula Formation were penetrated below 4024 mbrt.

The well was eventually terminated at 5465 mbrt on the 18th February 1985 in the Early Permian after sidetracking twice from below the 7" casing shoe. There were no significant hydrocarbon shows in any section of the well.

2. DATA SHEET

WELL:	2/1-7 NOCS	OPERATOR:	BP Petroleum Development (Norway) Ltd.
LATITUDE:	56°51'51.32"N	RTE:	38.9 m.a.m.s.l.
LONGITUDE:	03°05'40.36"E	WATER DEPTH:	67 m
TYPE OF RIG:	Jack-up	NAME:	Glomar Moray Firth 1
OBJECTIVES:	The primary target was Rotliegendes sandstone in a fault bonded structure mapped at base Zechstein Group level. This was expected to be a dry gas play. The secondary target was Upper Jurassic sandstone, to establish the SE extent of the 2/1-North oil accumulation.		
DATE SPUDDED:	6th September, 1984	DATE COMPLETED:	6th March, 1985
WELL STATUS:	Plugged and abandoned dry.		

GEOLOGICAL DATA

Lithostratigraphy	Tops LD (mbrt)	LD (mss)	Thickness (m)
Nordland Group	106	67	1724
Hordaland Group	1830	1791	1087
Rogaland Group	2917	2878	31
Balder Fm	2917	2878	22
Sele Fm	2939	2900	9
Montrose Group	2948	2909	239
Forties Fm equivalent	2948	2909	70
Lista Fm	3018	2979	75
Maureen Fm equivalent	3093	3054	94
Chalk Group	3187	3148	615
Ekofisk Fm	3187	3148	88
Tor Fm	3275	3236	373
Hod Fm	3648	3609	123
Plenus Marl Fm	3771	3732	15
Hidra Fm	3786	3747	16
Cromer Knoll Group	3802	3763	172
Rødby Fm	3802	3763	84
Valhall Fm	3886	3847	88
Tyne Group	3974	3935	50
Mandal Fm	3974	3935	22
Haugesund Fm	3996	3957	28
Vestland Group	4024	3985	81
Ula Fm	4024	3985	37
Bryne Fm	4061	4022	44
"Triassic Group"	4105	4066	227
Zechstein Group	4332	4293	752
Undifferentiated Basinal Sequence	4332	4293	751
Kupferschiefer Fm	5083	5044	1
Rotliegendes Group	5084	5045	381
Unnamed interval	5084	5045	25
Auk Fm equivalent	5109	5070	356
TD =	5465	5426	

Chronostratigraphy (BP Sunbury)

	Tops L.D. (mbrt)	L.D. (mss)	Tickness (m)
Tertiary	106	67	3169
Pleistocene-Eocene	106	67	2842
Palaeocene	2948*	2909	327
Danian	3187*	3148	88
Cretaceous	3275*	3236	699
Maastrichtian-Turonian	3275*	3236	498
Turonian	3773	3734	20
Cenomanian	3793	3754	70
Late Albian	3863	3824	10
Early Aptian-? Barremian	3873	3834	30
Early Valanginian	3903	3864	20
Earliest Valanginian-Latest Ryazanian	3923	3884	51
Earliest Cretaceous-Latest Jurassic	3974*	3935	9
Late Ryazanian-Late Volgian	3973*	3935	9
Jurassic	3983	3944	122
Middle Volgian	3983	3944	13
Kimmeridgian	3996*	3957	65
Middle Jurassic	4061*	4022	44
Triassic	4105*	4066	227
Permian	4332*	4293	+1133

* Log picks based on lithostratigraphy

CORES

No.	DD (mbrt)	LD (mbrt)	Recovery
1	5115.05 - 2124.25	5121.05 - 5130.25	9.20 m 100%
2	5124.25 - 5125.52	5130.25 - 5131.52	1.27 m 100%
3	5125.52 - 5127.0	5131.52 - 5133.0	1.48 m 100%
4	5147.0 - 5165.0	5152.0 - 5171.0	18.0 m 100%

132 sidewall cores were attempted between 3965 mbrt and 5066 mbrt of which 28 were recovered.

SHOWS

No oil or gas shows.

TESTS

Type and no.	Depth (mbrt)	Pressure (psig)
RFT 7b - 17	5115	11857
7b - 20	5125	12080
7b - 23	5135	11847
7b - 32	5124	12040
8c - 16	5110.5	11837
8c - 19	5112.5	11841
8c - 20	5132.5	11771
8c - 21	5139.5	11841
8c - 24	5148.5	11869
8c - 25	5153.5	11970
8c - 29	5168	12138
8c - 34	5178.5	11985
8c - 35	5171.6	12010
8c - 38	5121.7	11797

COMMENTS

2/1-7 penetrated 356 m of water bearing Lower Permian Rotliegendes sandstone. The "2/1-3 Sand" was not present in the well, but 38 m of water bearing sandstone of the Ula Formation was penetrated. The well has severely downgraded the prospectivity of the Rotliegendes sandstone, and is thought to be dry due to the absence of Carboniferous source rocks.

REPORT REFERENCE: Completion Report 2/1-7 W. 28

AUTHORS: D. Aga/E. Kvadsheim

DATE: May 1985

3. SAMPLES AND SAMPLING INTERVALS

A. CUTTING SAMPLES

i) 3 sets of washed and dried cutting samples were collected at the following intervals:

Seabed - 210 mbrt	No returns
210 - 2500 mbrt	10 m interval
2500 - 3875 mbrt	5 m interval
3875 - TD	3 m interval

ii) 3 sets of unwashed bulk samples with sampling frequency as i).

iii) 1 set of unwashed bulk samples for palaeontological studies were collected at 10 m intervals.

iv) 2 sets of unwashed canned bulk samples for geochemical studies were collected at 30 m intervals from 2250 m - TD, with 1/3 of sample taken every 10 m.

v) 1 set of mud samples were collected at the following intervals:

210 - 3876 mbrt	500 m interval
3876 - TD	25 m interval
When coring	10 m interval

B. CONVENTIONAL CORES

4 cores were cut in the upper part of the Rotliegendes Sandstone.

Core No.	Depth Drilled (mbrt)	Recovery (m)
1	5115.05 - 5124.25	9.20 (100%)
2	5124.25 - 5125.52	1.27 (100%)
3	5125.52 - 5127.0	1.48 (100%)
4	5147.0 - 5165.0	18.0 (100%)

C. SIDEWALL CORES

Run No.	No. Cores Attempted	Depth Range	No. Cores Recovered
1	21	4117 - 5066 m	2
2	51	3965 - 4313 m	3
3	30	3965 - 4204 m	12
4	30	3975 - 4204 m	11

LIST OF ELECTRIC LOGS RUN IN 2/1-7

Run No	Depth (mbrt)	Type	BHT (°C)	Dist. Thermom to TD (m)	Time Since Circ.	Hole Diameter	Date
1A	170 - 754	ISF/SLS/GR/SP	36	18.8	5 hr 47 min	26"	15. 9.84
2B	744.2 - 2462.1	ISF/SLS/GR/SP	76.5	19.3	10 hr 19 min	17 ½"	2.10.84
3C	2473 - 3879	ISF/SLS/MSFL/GR/SP/CAL	109	23.4	8 hr	12 1/4"	10.11.84
3A	450 - 1000	CBL/VDL/GR/CCL	64.5	10.6	12 hr 25 min	13 3/8"CSG	11.11.84
4A	3876 - 4293	SHDT/GR	145.5	10.0	14 hr 20 min	8 3/8"	24.11.84
4A	3876 - 4293	CYBERDIP	145.5	10.0	14 hr 20 min	8 3/8"	24.11.84
4D	3876 - 4291.5	ISF/SLS/MSFL/GR/SP/CAL	139.5	23.4	9 hr 15 min	8 3/8"	24.11.84
5A	3876 - 4930	BHC/MSFL/GR/SP/CAL	156.5	15.9	11 hr 10 min	8 3/8"	25.12.84
5A	3876 - 5078.5	DLL/MSFL/NGT/SP	156.5	24.1	8 hr	8 3/8"	25.12.84
5A	3876 - 5071.5	LDL/CNL/NGT	156.5	24.1	8 hr	8 3/8"	25.12.84
6A	5076.5 - 5103	RFT/GR	166		16 hr 35 min	6"	13. 1.85
7B	5115 - 5145	RFT/GR	166.5		11 hr 43 min	6"	11. 2.85
8E	5083 - 5193	ISF/SLS/MSFL/GR/CAL/SP	162	25.5	7 hr 55 min	6"	22. 2.85
8B	5083 - 5194.5	LDL/CNL/GR	165.5	12.5	11 hr 50 min	6"	22. 2.85
8B	5083 - 5189	DLL/GR/SP	166.5	13.5	17 hr 15 min	6"	23. 2.85
8	5083 - 5187	CYBERLOOK	166.5		17 hr 15 min	6"	23. 2.85
8A	150 - 5185	VSP/GR					24. 2.85
8C	5110.5 - 5187.5	RFT/GR	160.5		10 hr 45 min	6"	24. 2.85

5. LITHOSTRATIGRAPHIC SUMMARY

The lithostratigraphic nomenclature used in this report is based on that proposed by Deegan and Scull (1977) and Vollset and Doré (1984).

All depths are in mbrt.

NORDLAND GROUP (106 - 1830 m)

The interval between seabed and 210 m was drilled without returns.

From 210 to 400 m the sequence consists of interbedded sands and mudstones with minor streaks of lignite. The sands are clear to milky white and fine to medium grained, becoming coarse grained towards the base. The quartz grains are subrounded to rounded and well to poorly sorted. Scattered shell fragments are commonly observed within the sand beds. The mudstones are grey and very soft. They are occasionally calcareous above 300 m, and mainly sandy below this depth.

The section from 400 to 805 m includes a number of stacked coarsening upward sequences of mudstones, sandy mudstones and thin sandstones. The mudstones are grey to dark grey, soft, non- to moderately calcareous and become silty below 760 m. The sandstones are milky white to grey, fine to medium grained, subrounded and moderately sorted.

Below 805 m the group consists predominantly of mudstone with stringers of limestone. The mudstone is light to medium grey, soft to firm and non to moderately calcareous. It is also occasionally silty and grades to siltstone near the top of the interval. The limestone stringers are white to light brown, firm and cryptocrystalline, becoming reddish brown, very hard, occasionally coralline and dolomitic downwards.

The base of the group is defined by a pronounced downwards decrease in the gamma ray response and a slight increase in sonic velocity.

HORDALAND GROUP (1830 - 2917 m)

The interval from 1830 to 2352 m consists of mudstone with interbeds of limestone and dolomite. The mudstone is light to dark grey, occasionally

greyish green, soft to firm and moderately calcareous. The limestone is white to cream, soft to firm, microcrystalline and argillaceous. The dolomite is light brown to brown, very hard and microcrystalline.

From 2352 to 2708 m the group consists of alternating mudstone, siltstone and argillaceous sandstone. The mudstones are light to medium grey, becoming brownish grey downwards, soft to firm, non to very silty, and non- to slightly calcareous. Below 2525 m the mudstones are frequently interbedded with thin stringers of limestone which are light brown, white or buff, soft to hard and dolomitic in parts. The siltstones are buff to yellow in colour, firm and slightly calcite cemented. The interbedded sandstones are generally less than 5 meters in thickness. They comprise fine grained, subrounded, moderately sorted, argillaceous and slightly micaceous sandstone.

The interval from 2708 to 2917 m consists of mudstone with interbedded limestone and dolomite. The mudstones are light to medium grey, soft to firm and generally non-calcareous. The interbedded limestones are white to buff, soft to firm and grade to dolomite. The dolomite is brown, very hard and cryptocrystalline. Towards the base the mudstones become reddish brown with traces of volcanic tuff. The tuffaceous material is light brown with white speckles and is very hard.

The base of the Hordaland Group is picked at a marked log break reflecting the top of the considerably more tuffaceous mudstones of the Balder Formation.

ROGALAND GROUP (2917 - 2948 m)

Balder Formation (2917 - 2939 m)

This formation consists of tuffaceous mudstones. These are grey, light grey, reddish and brown, soft to firm and non calcareous. The formation displays a downwards gradual increase in interval sonic velocity with a sharp decrease at the bottom.

Sele Formation (2939 - 2948 m)

This formation consists of grey to greyish green, occasionally reddish brown mudstone, which is soft and non-calcareous.

The base corresponds to an abrupt downward lithological change into sandstone. The mudstone/sandstone interface is well defined on the gamma ray log.

MONTROSE GROUP (2948 - 3187 m)

Forties Formation Equivalent (2948 - 3018 m)

This formation consists of homogeneous sandstone. This is predominantly white, speckled with green and black grains, fine grained, subangular to angular, calcite cemented, glauconitic, and becomes slightly pyritic downwards. It is noted that the sandstones of the Forties Formation are considereably cleaner and thicker in 2/1-7 than in the previously drilled wells in the block.

Beneath 3015 m the sandstone grades into the mudstones of the Lista Formation. This is reflected by a downwards increase in gamma ray response and a gradual decrease in sonic velocity.

Lista Formation (3018 - 3093 m)

The interval from 3018 to 3066 m consists of slightly sandy mudstones with minor interfingering sandstones. The mudstones are predominantly grey to greyish green, soft to firm and non calcareous. The interbeds of sandstone are white, buff and brown, very fine to fine grained, subrounded, hard, well sorted, calcite cemented, and contain traces of pyrite.

From 3066 to 3093 m sandstone predominates. This is light brown, very fine to fine grained, well rounded, generally well sorted and well cemented with calcite, traces of haematite cement and become very argillaceous towards the bottom.

The base of this unit is well defined on the electric logs reflecting the sharp boundary to the underlying limestones.

Maureen Formation Equivalent (3093 - 3187 m)

The Maureen Formation consists of limestone with traces of chert between 3093 and 3157 m. The limestone is white to off-white, occasionally buff, firm to hard, microcrystalline, becoming cryptocrystalline and slightly oolitic in the lower part. The chert is opaque, translucent, very hard and has a concoidal fracture.

From 3157 to 3187 m the formation consists predominantly of mudstone with numerous stringers of limestone. The mudstone is varicoloured, but mainly grey to dark grey. It is firm to hard, occasionally soft, slightly silty and slightly calcareous. It is interbedded with a white, hard, cryptocrystalline and occasionally oolitic limestone.

The lower part of this unit displays an overall gradual increase in sonic velocity downwards, reflecting the gradual increase in calcite content and the corresponding decrease in mud fraction. The base is picked at the last occurence of mudstone.

CHALK GROUP (3187 - 3082 m)

Ekofisk Formation (3187 - 3275 m)

This unit consists of limestone with minor chert nodules. The limestone is white and hard, cryptocrystalline and occasionally oolitic. Towards the base it becomes light greyish green and very argillaceous.

The base is picked at the downwards drop in gamma ray response reflecting the interface between the argillaceous limestone of the Ekofisk Formation, and the pure limestones of the Tor Formation.

Tor Formation (3275 - 3648 m)

This is a thick, homogeneous limestone unit. Traces of chert are observed near the top. The limestone is generally white, but becomes slightly pink to light brown towards the base. It is hard, occasionally firm and occasionally slightly oolitic. Towards the base the limestone becomes softer and increasingly argillaceous. This causes an increased reading on the SP-log which is the basis of the pick of the lower boundary of the unit.

Hod Formation (3648 - 3771 m)

This formation consists of dull white, occasionally pink limestone. It is soft to firm, and slightly argillaceous, with traces of very fine quartz grains and mica. It grades into very calcareous mudstone (marl) at the base.

The base is picked at an increase on the gamma ray log, coupled with a decrease in resistivity and sonic velocity.

Plenus Marl Formation (3771 - 3786 m)

This is a thin unit of argillaceous limestone. The limestone is white to light pink, firm to brittle, micritic to microcrystalline and grades into calcareous mudstone.

The base is easily picked on the electric logs due to the re-occurrence of clean limestone.

Hidra Formation (3786 - 3802 m)

The Hidra Formation also consists of limestones. They are white to grey, firm to brittle, microcrystalline to micritic and argillaceous in the middle part.

The base marks the lower boundary of the Chalk Group and is recognisable on the electric logs by an increase in gamma ray response and a decrease in sonic velocity.

CROMER KNOLL GROUP (3802 - 3974 m)

Rødby Formation (3802 - 3886 m)

This formation consists of very calcareous mudstones, interbedded with minor sandstones. The mudstones are pale grey, occasionally reddish, soft to firm, calcareous and silty. Below 3863 m they are darker, and slightly carbonaceous. The sandstones are grey, friable, quartzose and calcite cemented. They are very fine grained and argillaceous.

The base coincides with the top of a thick sandstone unit, and is associated with a decrease in resistivity and sonic velocity.

Valhall Formation (3886 - 3974 m)

This unit is an overall coarsening upwards sequence. The upper part (3886 - 3900 m) contains an unconsolidated sandstone with generally rounded grains and is moderately sorted. This is underlain by white to grey and red siltstones which grade to mudstones below 3950 m. The mudstones are medium to dark grey, soft to hard and non calcareous.

The base is picked at the sharp increase in gamma ray and resistivity readings associated with the top of the carbonaceous mudstones of the Mandal Formation.

TYNE GROUP (3974 - 4024 m)

Mandal Formation (3974 - 3996 m)

This thin unit consists of dark brown to black, slightly calcareous, carbonaceous mudstone. This grades to grey to green, firm, slightly calcareous siltstone downwards.

The base is an unconformity detectable on the dipmeter, gamma ray and sonic log. The Farsund Formation, including the Unnamed Sandstone Member ("2/1-3 Sand") is absent in this well.

Haugesund Formation (3996 - 4024)

The Haugesund Formation consists of siltstone and mudstone with minor stringers of sandstone. The siltstone is white to pale grey, soft, and grades to white to pale grey mudstone. This is interlaminated with dark grey to black mudstone. The sandstone is colourless to white, quartzose, fine grained, moderately to poorly sorted and calcite cemented.

The base of the unit is marked by a downwards lithological change from a mudstone to a sandstone dominated sequence.

VESTLAND GROUP (4024 - 4105 m)

Ula Formation (4024 - 4061 m)

This unit consists predominantly of quartzose, colourless to white sandstones. They are fine to medium grained, subangular to subrounded, moderately to poorly sorted and calcite cemented. Minor interbeds of grey to greenish grey siltstone are observed below 4033 m.

The base is picked at an increase in mudstone content associated with an increase in gamma ray response. This is correlatable to all the nearby wells and coincided with a major hiatus (the Kimmeridgian rests on the Middle Jurassic).

Bryne Formation (4061 - 4105 m)

This unit consists predominantly of interbedded sandstones and siltstones with minor mudstone interbeds. The sandstones are quartzose, colourless to white, fine to medium grained, subangular to subrounded, moderately to poorly sorted and calcite cemented. The siltstones are light to medium grey, occasionally dark grey or purple becoming reddish brown towards the base, firm to hard and slightly carbonaceous.

The base is picked at a downward increase in the sonic velocity and is interpreted to coincide with the top of the Triassic. The dipmeter results indicate a possible unconformity at this level.

"TRIASSIC GROUP" (4105 - 4332 m)

Unnamed interval (4105 - 4153 m)

This is a sequence of interbedded sandstones and siltstones with minor mudstone beds between 4110 - 4135 m. The sandstones are white to light grey, friable, quartzose, fine grained, subangular to subrounded, moderately to well sorted, calcite cemented and have no visible porosity. The siltstone is light to medium grey, firm to hard, argillaceous and contains calcite laminae.

The lower boundary of this interval is defined by the downward appearance of reddish brown sandstone.

Unnamed interval (4153 - 4332 m)

This interval consists of Triassic "redbeds". It consists of red to reddish brown, fine grained, and quartzose sandstones. They are moderately well sorted, subangular, often calcite cemented and have low visible porosity. Numerous interbedded siltstones and mudstones occur throughout, and scattered traces of anhydrite are observed below 4190 m. The siltstones are reddish brown or occasionally grey, mostly firm, argillaceous and slightly calcareous. The mudstones are orange, pink, grey and greyish green, soft to firm and calcareous.

The base of the Triassic sequence is defined by the abrupt downwards change from clastic sediments into the evaporites of the Zechstein Group.

ZECHSTEIN GROUP (4332 - 5084 m)

Undifferentiated Basinal Sequence (Deegan and Scull, 1977) (4332-5083 m)

This thick evaporite sequence consists predominantly of halite. Potash salt (sylvite) is common in small amounts dispersed within the halite, but below 4775 m also occur as individual beds. Anhydrite is also present in minor quantities, generally associated with interbeds of mudstone which locally grade into siltstone (4540- 4550 m and 4065 - 5083 m). The entire interval seems to be significantly distorted by halokinesis. Thus stratigraphic interpretation referring to the cyclic nature of deposition has not been attempted.

The halite is colourless to milky white, transparent to translucent, brittle, homogeneous and occasionally crystalline. The anhydrite is white to off white and soft. The potash salt is pink, red or brownish red, translucent, soft to firm and occasionally crystalline. The mudstone is medium to dark grey.

The base of the basinal evaporite sequence is defined by the incoming of black, carbonaceous mudstones which causes a downwards sudden increase in gamma ray readings.

Kupferschiefer Formation (5083 - 5084 m)

This thin horizon consists of dark grey to black mudstone which is firm, occasionally calcareous, micaceous and carbonaceous. It is characterized by a high gamma ray peak, and also a marked decrease in sonic velocity.

The Kupferschiefer marks the base of the Zechstein Group.

ROTLIEGENDES GROUP (5084 m - TD)

Unnamed interval (5084 - 5109 m)

The upper part of the Rotliegendes Group consists of mudstones, siltstones and very fine sandstones. The mudstones are grey to greenish grey, soft to firm, slightly fissile and non calcareous. The siltstone is orange to reddish brown, soft to firm with occasionally very fine angular quartz grains. It grades into a very fine to fine grained sandstone, which is friable and generally colourless. However, the quartz grains are occasionally stained red and are subangular to subrounded with moderate to low sphericity. The sandstone also contains traces of pyrite.

The base of this unit is defined by the first occurrence of well rounded, well sorted aeolian sandstones, coinciding with to a downwards decrease in gamma ray readings and sonic velocity.

Auk Formation Equivalent (5109 - TD)

This unit consists of thick aeolian sandstones and is equivalent to the Auk Formation in the UK sector of the North Sea. The sandstone is medium grained, quartzose, well sorted with well rounded, occasionally frosted grains, and has a grainstone texture. It is moderately well cemented with a siliceous and haematitic cement. The colour is reddish brown in the upper part, but turns pale red to milky white and colourless downwards. The sandstone has moderate to good visible porosity and an average core porosity in the upper part of 15%. A few minor interbeds of dark grey mudstone occur.

The base of this unit was not penetrated in well 2/1-7 due to severe drilling problems. For the same reason no electric logs are available beneath 5193 m.

6. HYDROCARBON INDICATIONS

No significant hydrocarbon shows were encountered in any section of the well. However, trip gas was encountered within the Rotliegendes sandstone sequence. 0.72% total gas was recorded at 5379 mbrt and 4.46% at 5460 mbrt (bottoms-up sample). Both consisted mostly of methane.

7. SIDEWALL CORE DESCRIPTIONS

This excludes misfires.

SWC No.	Depth (mbrt)	Recovery	Description
1	5066	1 cm	MDST: very silty, dark grey, firm to mod. hard, very calcareous,
2	5062.5	1 cm	MDST: slightly silty, dark grey to black, firm, angular fractures, slightly subfissile, mod. to very calcareous.
3	5050.5	Empty	
4	4313	Lost	
5	4279	Lost	
6	4250	Lost	
7	4226.5	Lost	
8	4204	Lost	
9	4182.5	Lost	
10	4164	Lost	
11	4154	Lost	
12	4144	Lost	
13	4134	Lost	
14	4124	2 cm	SST: quartzose, light grey to pale green, occ. black quartz grains, soft, fine to very fine grained, well sorted, subrounded to subangular, very poorly cemented, calcite cement, no visible porosity, glauconitic.
15	4117	Lost	
16	4111.5	Lost	
17	4102	Lost	
18	4100	Lost	
19	4096.5	Lost	
20	4089	Lost	
21	4085	Lost	
22	4083	2 cm	SST: quartzose,med. grey to pale green, occ. black quartz grains, soft to mod. hard, very fine grained, poor sorting, subangular to subrounded, mod. cemented, argillaceous cement, very slightly calcareus, no visible porosity, glauconitic, micaceous.
23	4080	Lost	
24	4076	Lost	
25	4072	Lost	
26	4067.5	Lost	
27	4064	Lost	
28	4062	Lost	
29	4058	Lost	
30	4055	Lost	
31	4052	Lost	
32	4050	Lost	
33	4048	Lost	
34	4039	2 cm	SST: quartzose, light grey to pale green, occ. black quartz grains, mod. hard, very fine grained, poorly sorted, subangular to subrounded, mod. to well cemented, calcite cement, no visible porosity.
35	4204	Empty	
36	4151	Lost	
37	4143.5	Empty	
38	4134	Empty	
39	4117.5	Empty	
40	4111	Empty	
41	4102.5	1.2 cm	SST: quartzose, light grey to pale green, soft, very fine grained, well sorted, subangular, very well cemented, argillaceous cement, slightly calcareous, no visible porosity, glauconitic.

42	4096.5	Lost	
43	4093.5	1.5 cm	SST: quartzose, light grey to pale green, soft, very fine grained, well sorted, subangular to subrounded, very well cemented, argillaceous cement, very glauconitic.
44	4089	Empty	
45	4076	Empty	
46	4065.5	1 cm	SST: quartzose, greyish green, speckled, soft to mod. firm, very fine grained, well sorted, subangular, poorly cemented, calcite cement, no visible porosity, very micaceous.
47	4062	Lost	
48	4055.5	1.5 cm	SST: quartzose, light grey, speckled, mod. hard, very fine grained, well sorted, subangular, poorly cemented, silica cement, slightly calcareous, no visible porosity, occ. red quartz grains, mica.
49	4048	Empty	
50	4045.5	Empty	
51	4040.5	Lost	
52	4033	Empty	
53	4024	2.3 cm	MDST laminated with SST. MDST: greenish grey, soft, very glauconitic. SST: quartzose, white to green, soft, very fine grained, grading to sltst, well sorted, subangular, poorly cemented, no visible porosity.
54	4020	1 cm	SST: quartzose, green, white quarte grains, soft, very fine grained, well sorted, subangular, well cemented with argillaceous cement, no visible porosity.
55	4018	Empty	
56	4010	2 cm	SST: quartzose, off white to light grey, soft to med. hard, very fine grained, poorly sorted, subangular, poorly cemented, silica cement, no visible porosity.
57	4006	Lost	
58	4001.5	Empty	
59	3995	1.5 cm	MDST: dark brown, firm to mod. firm, slightly calcareous, partly silty, occ. quartz grains. very fine grained, mod. sorted.
60	3990	1.1 cm	SLTST: dark brown, mod. hard to firm, angular fracture, mod. calcareous.
61	3985	1.2 cm	MDST: very dark brown, mod. firm, blocky to subfissile, occ. silty, mod. calcareous, mica.
62	3980	1.5 cm	MDST: dark brown, mod. firm, occ. silty, very calcareous, tr. biotite.
63	3975	Lost	
64	3965	3.5 cm	MDST: grey, firm to soft, very calcareous.
65	4204	Lost	
66	4182.5	Lost	
67	4164	Lost	
68	4154	Lost	
69	4144	1.5 cm	SLTST: reddish brown, soft, dolomitic, very micaceous, grading to SST: very fine grained, well cemented with argillaceous cement.
70	4134	Broken	
71	4117	Lost	
72	4112	Broken	
73	4096.5	Lost	
74	4089	1.4 cm	SST: quartzose, greyish green, soft, very fine grained, very poorly sorted, subangular to subrounded, poorly cemented, argillaceous cement, sl. micaceous, no visible porosity, occ. red quartz grains, glauconitc.
75	4085	1.3 cm	SST: as at 4089 m.
76	4080	1.7 cm	SST: quartzose, off white to light grey, soft, very fine grained, poorly sorted, subangular to subrounded, mod. cemented, calcite cement, hard, occ. red quartz grains, no visible porosity, sl. mineral fluorescence due to calcite cement.
77	4076	Broken	
78	4072	Empty	

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79	4064	Empty	
80	4062	Broken	
81	4058	Lost	
82	4052	Lost	
83	4048	Lost	
84	4043	1.4 cm	SST: quartzose, off white to light grey, soft, very fine grained, poorly sorted, subangul to subrounded, poorly cemented, calcite cement, occ. red quartz grains, no visible porosity.
85	4040.5	Lost	
86	4036.5	Broken	
87	4028.5	1.2 cm	SST: quartzose, off white to light grey, soft, very fine grained, poorly sorted, subangul to subrounded, mod. cemented, calcite cement, occ. red quartz grains, no visible porosity.
88	4026	1.2 cm	SST: quartzose, light greyish green, soft, very fine grained, poorly sorted, subangular t subrounded, poorly to mod. cemented with calcite cement, occ. red quartz grains, micaceous, no visible porosity.
89	4022.5	1.3 cm	SST: quartzose, ligth brown, soft, very fine grained, poorly sorted, subrounded, poorly cemented, calcite cement, micaceous, no visible porosity.
90	4006	Broken	
91	4001.5	Lost	
92	4000	1.2 cm	MDST:laminated with SST: MDST: greyish green, soft, grading to siltstone. SST: quartzose, dark greyish green, soft to mod. hard, very fine grained, poorly sorted, subrounded, mod. cemented, calcite cement, also argill. cement, micaceous, green quartz grains.
93	3996.5	0.5 cm	SST: grading to SLTST. grey, soft to firm, sl. calcareous.
94	3975	1.6 cm	MDST:black, soft, very calcareous.