GEUS

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LILY-1X

Conventional core analysis for Mærsk Olie og Gas A/S
Well: Lily-1X

Springer, N., Høier, C. & Stentoft, N.

GEUS
Copenhagen
07-07-2000

G E U S

RKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2000/46

Conventional Core Analysis for Mærsk Olie og Gas A/S

Well: Lily-1X

Core Laboratory
Niels Springer, Christian Høier and
Niels Stentoft

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GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF ENVIRONMENT AND ENERGY

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Confidential report

Copy No.

To be released 30.06.2005

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF ENVIRONMENT AND ENERGY

G E U S

Contents

Enclosure: - Core log M 1:200
- Data on diskette

Req. no.: 09250-454
File: Lily1xrep.doc
Lily1x.dat

1 Introduction

By request of Mærsk Olie og Gas A/S, GEUS Core Laboratory has performed conventional core analysis on the Lily-1X well, Danish North Sea.

The experimental programme was specified in a facsimile message from Mr. David Steer, dated December 3, 1999. The following analytical programme has been carried out:

- Hot-shot plug analysis
- Cutting of aluminium liner sections containing unconsolidated core material
- Sampling of unconsolidated core
- Fluid saturation determination by Dean Stark extraction
- Soxhlet cleaning and drying
- Unconfined Helium porosity and grain density
- Gas permeability and Klinkenberg corrected gas permeability @ 800 psi confining pressure
- Lithological description of plugs following guidelines given by the Joint Chalk Research Program

This study is carried out under contract GSC 1418, CWO 176. Preliminary data have been reported to Mærsk during the period January to May, 2000.

2 Sampling and analytical procedures

2.1 Sampling

Three cores were cut from the well covering the Danian and the Maastrichtian chalk formations respectively. 12 "hot-shot" plugs and 3 core sections for closer inspection were received in GEUS Core Laboratory on January 25, 2000. Hot-shot core analysis data and a short statement on the condition of the unconsolidated core sections were transmitted to Mærsk within 5 days. 14 additional core sections and 55 plugs cut by Mærsk Laboratory were forwarded to GEUS on February 2, 2000. As requested by Mærsk GEUS Core Laboratory cut open all 17 aluminium liner tubes for inspection, and later prepared 21 samples from the unconsolidated core sections in core # 3. After sampling the unconsolidated core sections were re-preserved in the aluminium liner tubes.

2.2 Analytical

The 1" diameter plugs were trimmed to a length of approx. 1½". The horizontal plugs and the hot-shot plugs were Dean Starked to determine the fluid saturation, and later Soxhlet cleaned with the vertical plugs following standard procedures as given in section 4. Samples were then dried at 110 °C and analyzed for porosity and gas permeability using a confining sleeve pressure of 800 psi. "Hot-shot" plugs were recleaned and remeasured. Samples from the unconsolidated part of core#3 could not be taken as cylindrical plugs but only as small irregular samples. These samples were dried and analyzed for porosity and grain density. As all samples survived this treatment it was decided to clean the samples in methanol and re-measure for porosity and grain density. No cleaning in toluene was necessary because there is no oil in the unconsolidated core. A few samples were taken for insoluble residue analysis from the unconsolidated part of core #3. Finally all plugs and samples were lithologically described following the guidelines established by Joint Chalk Research. Results are presented in section 5.

3 Flow diagram of the analytical procedures

- **Unconsolidated core sections in aluminium liner tubes**
- **Cutting open for inspection and sampling**
- **Sample drying at 110 °C**
- **He-porosity**
- **Grain density**
- **Hot soxhlet cleaning**
- **Sample drying at 110 °C**
- **He-porosity**
- **Grain density**
- **Insoluble residue analysis**
- **Re-preservation of core sections in aluminium liner tubes**

- **Horizontal and "hot-shot" plugs**
- **Fluid saturation by Dean Stark extraction**
- **Vertical plugs**
- **Hot soxhlet cleaning**
- **Drying at 110 °C**
- **He-porosity**
- **Grain density**
- **Gas permeability @ 800 psi**
- **Klinkenberg corrected gas permeability @ 800 psi**
- **Lithological description**

4 Analytical Methods

The following is a short description of the methods used by the Core Analysis Laboratory. For a more detailed description of methods, instrumentation and principles of calculation the reader is referred to API recommended practice for core-analysis procedure (API RP 40, 2nd ed. 1998).

4.1 Conventional cleaning and drying

The plugs are drilled and trimmed to a size of 1" diameter and approx. 1½" in length (in this study). The samples are then placed in a Soxhlet extractor, which continuously soaks and washes the samples with methanol. This process removes water and dissolves salt precipitated in the pore space of the rock. Extraction is terminated when no chloride ions are present in the methanol. Samples containing hydrocarbons are then cleaned in toluene until a clear solution is obtained. Samples are vacuum dried at 90 °C or 110 °C, or they are humidity dried at 60 °C and 40% relative humidity until constant weight occurs, depending on the requirements of the client.

4.2 Gas permeability

The plug is mounted in a Hassler core holder, and a confining pressure of 800 psi applied to the sleeve. The specific permeability to gas is measured by flowing nitrogen gas through a plug of known dimensions at differential pressures between 0 and 1 bar. No back pressure is applied. The readings of the digital gas permeameter are checked regularly by measurement of permeable steel reference plugs (Core Laboratories™ gas permeability reference plug set).

4.3 Klinkenberg permeability

The Klinkenberg corrected gas permeability, sometimes termed the equivalent liquid permeability, is calculated from gas permeability measurements performed at 3 different mean pressures in the plug sample.

The plug is mounted in a Hassler core holder, and a confining pressure of 800 psi is applied to the sleeve. Nitrogen gas pressures of 3, 5 and 8 atm. (abs.) are applied at the upstream end of the plug, and the downstream pressure is regulated until a suitable flow is obtained. The differential pressure is kept approx. constant in order to maintain a similar flow regime during the 3 measurements. When a steady state is reached, the upstream pressure, the differential pressure across the plug and the flow reading is recorded. A linear regression of permeability on inverse mean pressure is performed for the 3 measurements, and the intercept on the permeability axis is the Klinkenberg corrected gas permeability. To ensure compatibility with plug data which do not include Klinkenberg corrected gas permeability, a permeability value pertaining to a mean pressure of 1.5 atm. (abs) is calculated from the Klinkenberg regression coefficients. This value is reported as "1.5 P-M permeability" in the core analysis tabulation, and should be comparable to the conventional gas permeability which is measured at the same mean pressure.

Klinkenberg corrected gas permeabilities are only reported down to approx. 0.1 mD on normal routine terms. However, on request measurements can be carried out to a lower limit of 0.01 mD. The performance of the digital gaspermeameter is checked regularly by measurements of permeable steel reference plugs (Core Laboratories™ gas permeability reference plug set).

4.4 He-porosity and grain density

The porosity is measured on cleaned and dried samples. The porosity is determined by subtraction of the measured grain volume and the measured bulk volume. The Helium technique, employing Boyle's Law, is used for grain volume determination, applying a double chambered Helium porosimeter with digital readout, whereas bulk volume is measured by submersion of the plug in a mercury bath using Archimedes principle. Grain density is calculated from the grain volume measurement and the weight of the cleaned and dried sample.

4.5 Fluid saturation

The water content of a plug is extracted by Dean Stark distillation with toluene. The water is retained by a condenser, and the amount is directly measured in a calibrated trap. The oil content of the plug is dissolved in the toluene. The quantity of oil is calculated as the difference between the original sample weight and the weight after extraction, corrected for the amount of water recovered. The plug is finally Soxhlet cleaned to remove salt precipitated in the pore space. The porosity is then measured as described above.

The calculation of fluid saturation presumes that the water and oil density is known. If it is unknown, a value is assumed in the final calculation, usually 1.0 g/ml for the brine and 0.85 g/ml for the oil. The percentage of the plug pore volume which is not occupied by either water or oil is the gas saturation.

4.6 Insoluble residue

Calcite is removed using a buffered acetic acid at pH 4.5. This mild dissolution of the calcite is carried out in order to avoid dissolution of non – calcite minerals.

X – ray diffraction (XRD) is carried out on randomly oriented specimens using a Philips 1050 goniometer with Co - Kα radiation (pulse – high selection and Fe – filter). The amount of quartz in the residues is determined using quartz 4.5 - 45 μm in size as a standard.

4.7 Precision of analytical data

The table below gives the precision (= reproducibility) at the 68% level of confidence (+/- 1 standard deviation) for routine core analysis measurements performed at GEUS Core Laboratory.

Measurement	Range, mD	Precision
Grain density		0.003 g/cc
Porosity		0.1 porosity-%
Permeability:	0.01-0.1	15%
Permeability:	0.001-0.01	25%

The precision of the fluid saturation determination depends on the pore volume of the plug. The greater the plug and the greater the porosity of the plug, the better precision is obtained. The following table gives the precision in absolute percent-point:

Porosity	1" x 1.5" plugs	1.5" x 3" plugs
> 20%	5%	1%
10-20%	10%	2%
5-10%	20%	5%
< 5%	> 20%	> 5%

Certain factors might alter the stated precision of the fluid saturation determination. Loss of material during handling of the plug will result in an increase in the calculated oil saturation, and a similar decrease in the calculated gas saturation. This may occur for fragile for loosely consolidated rocks or if the rock contains dissolvable matters like halite. As the lost material usually has a greater density than oil, it may happen that the estimated volume of oil and the measured volume of water all together take up more space than the actual pore volume after cleaning.

5. Results

5.1 Conventional core analysis data

- Listing of conventional core analysis data
- Relevant frequency and scatter diagrams
- Corelog M 1:200 (attached)
- Data on diskette (attached)

For the unconsolidated part of core #3 only porosity and grain density data were measured. After cleaning and drying of the unconsolidated chalk samples it was observed that the Helium porosimeter determination of the grain density yielded higher than normal values. A second set of measurements gave more normal values, and it is therefore assumed that surface adsorption of Helium occurred. This effect and the small and irregular sample size for the unconsolidated samples affect the precision of the measurements with at least a factor of 3 ref. to the values given in section 4.7

Table 5.1. Lily-1X, tops. The depth conversion data in the table below has been made available by Mærsk Olie og Gas:

Tops, Contacts	**Depth** (ft)			**Stratigraphic Marker Type**
	Model	**Actual**		
	TVDSS[1]	TVDSS	MDRT	
Top Balder Formation	-	6,804	6,921	Log
C-marker	6,801	6,809	6,926	Cuttings
Top Sele Formation	-	6,817	6,934	Log
Top Lista Formation	-	6,849	6,966	Log
Top Chalk/Ekofisk	6,879	6,860	6,977	Log
Top Maastrichtian/Tor	7,044	6,938	7,055	Log
Top Hod	7,220	7,313	7,430	Biostratigraphy/Log
Top Campanian	-	7,343	7,460	Biostratigraphy
TD	-	7,513	7,630	

[1]Depth according to prognosis

For the measured plug set this means that the following plugs belong to the Danian/Ekofisk Fm.:

Plug no. 1–32 + 1X–10X + 1V–7V

The following plugs belong to the Maastrichtian/Tor Fm.:

Plug no. 33–62 + 11X–12X + 8V–11V

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND

GEUS CORE LABORATORY

CORE ANALYSIS TABULATION

FINAL REPORT

Compiled by Niels Springer

WELL : Lily-1X

CORE : 1,2,3

Printed : 6-JUL-00

GENERAL INFORMATION ON THE ANALYSIS

COMPANY	: Maersk Olie og Gas	LOCATION	: Danish North Sea
DEPTH INTERVAL	: 6984.00 - 7185.84	CORE NO.'S	: 1,2,3
DEPTHS ARE MEASURED FROM KB		ANALYSTS	: MJ, GG, HJL
DEPTHS ARE IN FEET		DATE	: 0607 0
PROGRAM POPE V.5.*		FILE	: LILY1X

REMARKS :

Plugs have been soxhlet cleaned in methanol and toluene and dried at 110 C. He-porosity was measured unconfined; gas permeability was measured at 800 psi confining sleeve pressure.

Suffix "X" indicates "hot-shot" plugs (re-cleaned and re-measured)

NB.: Samples below 7138' are taken from unconsolidated chalk and are only measured for porosity and grain density.

SAMPLE NO.	DEPTH FEET	PLUG TYPE	GAS 1.5 P-M PERM mD	PERM mD	KLINK PERM mD	KLINK CORR. COEF.	POROSITY %	GRAIN DENS. G/CCM	WATER SATUR. %	OIL SATUR. %	GAS SATUR. %	COMMENT
1X	6984.25	HOR	2.80	2.66	1.46	0.999	40.74	2.702	61	25	15	
1	6984.33	HOR	2.26	2.17	1.11	1.000	40.13	2.700	53	27	20	
2X	6984.92	HOR	0.976	0.942	0.421	1.000	32.15	2.708	78	4	18	
2	6985.50	HOR	3.06	3.03	1.43	0.999	43.00	2.704	68	14	18	
3X	6986.58	HOR	3.79	3.66	1.86	0.999	43.08	2.696	72	12	15	
3	6987.00	HOR	3.35	3.30	1.67	0.998	42.62	2.702	58	25	17	
4X	6989.08	HOR	1.74	1.71	0.828	0.999	35.67	2.700	74	12	15	
4	6989.42	HOR	1.48	1.46	0.637	1.000	38.96	2.700	74	11	15	
1V	6989.58	VERT	2.40	2.31	1.14	0.999	42.74	2.703				
5	6990.33	HOR	2.63	2.59	1.20	0.999	42.48	2.698	85	8	7	
5X	6992.33	HOR	2.01	1.92	0.998	1.000	36.54	2.686	65	16	19	
6	6992.58	HOR	2.11	2.08	1.06	0.999	36.56	2.694	62	24	15	
7	7020.33	HOR	7.16	6.97	4.81	0.999	38.10	2.682	38	28	34	
6X	7020.67	HOR	3.81	3.67	2.47	0.998	34.20	2.674	41	31	28	
8	7021.42	HOR	1.55	1.51	0.836	0.999	32.82	2.675	66	12	22	
2V	7021.67	VERT	0.306	0.302	0.099	1.000	31.72	2.676				
9	7022.50	HOR	0.663	0.662	0.304	1.000	30.04	2.676	36	31	33	
10	7023.08	HOR	0.538	0.533	0.232	1.000	26.95	2.678	39	30	31	
11	7024.08	HOR	0.369	0.376	0.157	1.000	23.90	2.684	37	31	32	
12	7025.08	HOR	0.520	0.512	0.244	1.000	25.71	2.669	77	6	17	
13	7026.00	HOR	1.08	1.08	0.591	0.995	29.90	2.673	35	33	32	
7X	7027.00	HOR	0.802	0.808	0.371	0.999	30.61	2.675	47	26	27	

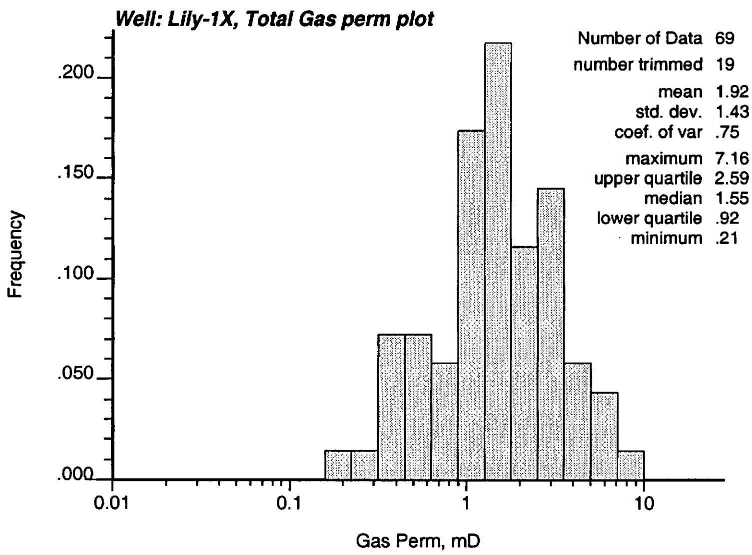
SAMPLE NO.	DEPTH FEET	PLUG TYPE	GAS PERM mD	1.5 P-M PERM mD	KLINK PERM mD	KLINK CORR. COEF.	POROSITY %	GRAIN DENS. G/CCM	WATER SATUR. %	OIL SATUR. %	GAS SATUR. %	COMMENT
14	7027.00	HOR	0.923	0.893	0.468	1.000	31.47	2.682	41	31	28	
3V	7027.42	VERT	0.589	0.609	0.226	0.997	32.72	2.671				
15	7028.00	HOR	3.19	3.16	1.87	0.999	36.87	2.681	45	34	22	
16	7028.92	HOR	4.67	4.55	3.00	0.993	40.34	2.678	46	34	20	
17	7030.00	HOR	2.25	2.31	1.07	0.998	37.46	2.677	49	30	22	
18	7032.00	HOR	1.66	1.61	0.928	0.998	34.69	2.685	49	22	28	
4V	7032.25	VERT	0.320	0.324	0.094	1.000	32.28	2.671				
8X	7033.00	HOR	1.25	1.24	0.662	0.999	31.60	2.664	86	1	13	
19	7033.08	HOR	0.731	0.725	0.371	0.999	29.32	2.673	78	4	18	
20	7034.00	HOR	1.45	1.42	0.739	1.000	35.10	2.692	77	9	15	
21	7035.00	HOR	1.45	1.39	0.666	1.000	35.65	2.690	73	4	23	
22	7036.00	HOR	2.21	2.17	1.20	1.000	36.84	2.694	54	27	19	
23	7036.75	HOR	2.60	2.53	1.44	0.999	37.41	2.689	57	19	23	
5V	7036.83	VERT	1.63	1.54	0.826	0.996	37.69	2.685				
24	7038.00	HOR	1.12	1.09	0.563	1.000	33.46	2.692	69	12	20	
25	7038.92	HOR	1.16	1.16	0.564	0.994	32.12	2.687	64	14	22	
9X	7039.00	HOR	0.921	0.957	0.429	1.000	31.83	2.691	81	8	12	
26	7040.00	HOR	0.806	0.777	0.418	0.992	29.02	2.676	80	2	18	
27	7041.00	HOR	0.471	0.470	0.187	0.998	30.03	2.700	81	5	14	
6V	7041.25	VERT	0.207				31.93	2.696				
28	7043.00	HOR	1.65	1.60	0.896	1.000	35.23	2.690	57	23	20	
29	7044.00	HOR	0.436	0.426	0.174	0.998	28.34	2.704	69	17	14	

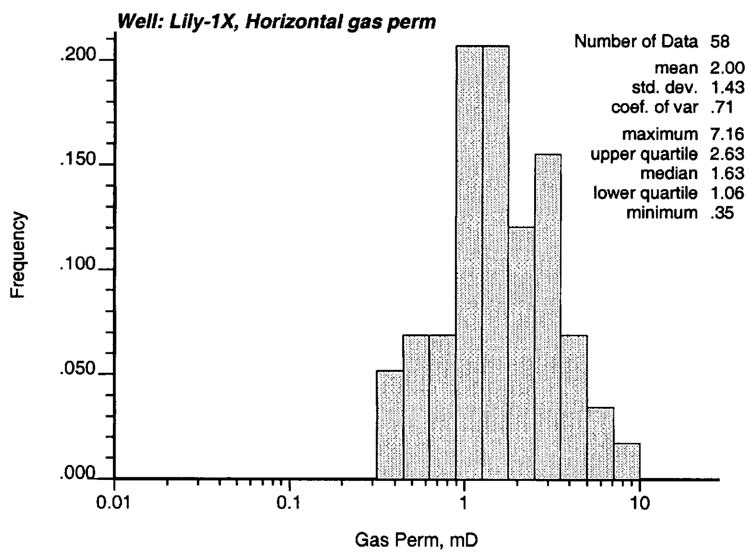
SAMPLE NO.	DEPTH FEET	PLUG TYPE	GAS PERM mD	1.5 P-M PERM mD	KLINK PERM mD	KLINK CORR. COEF.	POROSITY %	GRAIN DENS. G/CCM	WATER SATUR. %	OIL SATUR. %	GAS SATUR. %	COMMENT
30	7045.08	HOR	0.353	0.340	0.133	0.999	28.36	2.703	80	4	15	
10X	7045.25	HOR	0.612	0.617	0.257	0.999	30.81	2.692	86	2	12	
31	7045.83	HOR	1.12	1.10	0.536	0.999	35.18	2.700	83	4	13	
7V	7045.92	VERT	0.430	0.438	0.148	0.999	34.86	2.695				
32	7046.83	HOR	1.17	1.12	0.566	1.000	32.88	2.698	85	3	12	
33	7120.08	HOR	1.06	1.01	0.519	1.000	25.49	2.701	80	18	2	
34	7121.00	HOR	1.74	1.71	0.923	1.000	27.45	2.704	66	25	9	
8V	7121.33	VERT	1.43	1.39	0.762	1.000	27.29	2.708				
11X	7122.33	HOR	1.61	1.59	0.861	1.000	26.94	2.703	74	5	21	
35	7122.33	HOR	1.72	1.66	0.890	1.000	26.63	2.706				
36	7122.92	HOR	1.53	1.48	0.794	1.000	26.47	2.706	74	6	19	
37	7124.00	HOR	1.13	1.09	0.544	0.999	25.89	2.704	74	-1	27	
38	7125.42	HOR	1.22	1.20	0.626	0.996	26.70	2.701	76	0	24	
39	7125.92	HOR	1.72	1.67	0.912	0.999	28.90	2.704	64	3	32	
9V	7125.92	VERT	1.41	1.36	0.684	1.000	29.62	2.707				
40	7126.92	HOR	1.78	1.73	0.938	1.000	29.13	2.699	77	-1	24	
41	7128.08	HOR	4.36	4.23	2.49	0.997	33.32	2.697	73	-2	29	
42	7129.00	HOR	5.62	5.56	3.37	0.991	35.29	2.694	77	1	22	
10V	7129.17	VERT	5.04	5.05	2.98	0.999	36.50	2.708				
43	7136.08	HOR	2.29	2.23	1.18	0.999	31.26	2.692	83	2	15	
11V	7136.08	VERT	2.59	2.54	1.33	1.000	32.23	2.706				
12X	7137.00	HOR	2.95	2.91	1.66	1.000	32.21	2.708	91	6	3	

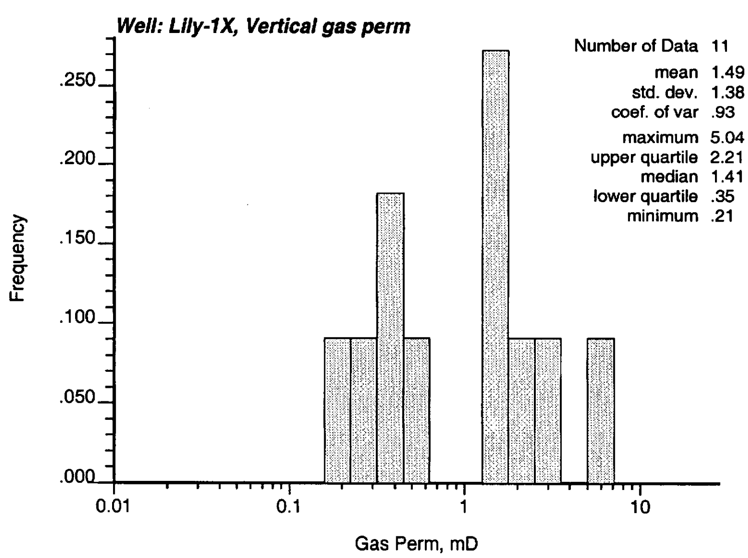
SAMPLE NO.	DEPTH FEET	PLUG TYPE	GAS PERM mD	1.5 P-M PERM mD	KLINK PERM mD	KLINK CORR. COEF.	POROSITY %	GRAIN DENS. G/CCM	WATER SATUR. %	OIL SATUR. %	GAS SATUR. %	COMMENT
44	7137.08	HOR	3.50	3.35	1.99	1.000	32.55	2.690	80	-1	21	
45	7138.16	HOR	5.76	5.57	4.05	0.996	33.25	2.704				
46	7139.16	HOR	3.23	3.16	1.86	0.998	31.98	2.714				
H1	7142.00	MISC					34.47	2.733				
H2	7142.00	MISC					34.75	2.724				
47	7143.25	MISC					34.65	2.721				
48	7146.16	MISC					32.41	2.696				
49	7149.50	MISC					32.15	2.728				
50	7152.50	MISC					34.72	2.728				
51	7155.33	MISC					38.07	2.662				
M1	7157.00	MISC					37.43	2.731				
52	7158.00	MISC					40.05	2.720				
53	7161.50	MISC					29.79	2.677				
54	7164.50	MISC					31.38	2.707				
55	7167.50	MISC					33.32	2.728				
56	7170.50	MISC					31.63	2.679				
57	7173.50	MISC					32.00	2.735				
58	7176.50	MISC					33.95	2.715				
59	7179.50	MISC					30.77	2.691				
60	7182.50	MISC					27.79	2.727				
61	7185.84	MISC					32.99	2.726				
62	7185.84	MISC					26.61	2.698				

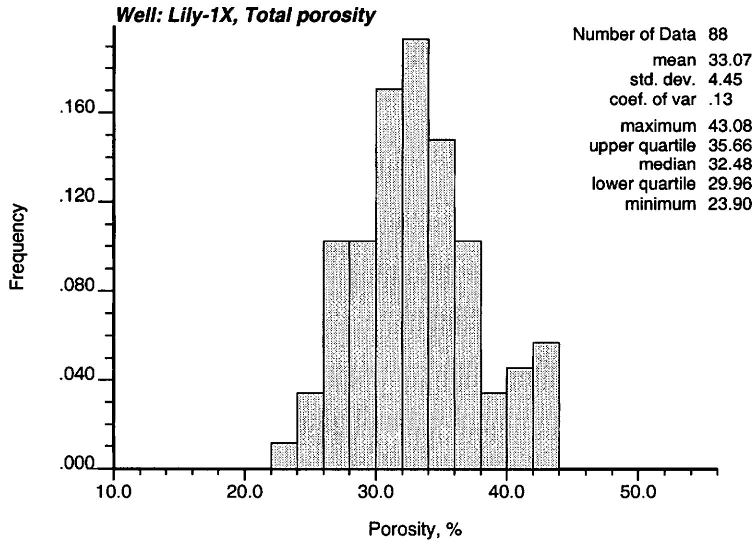
DISTRIBUTION OF GAS PERMEABILITY

WELL : Lily-1X
CORE : 1 - 3








Well: Lily-1X, Total porosity
Frequency
Porosity, %
Number of Data 88
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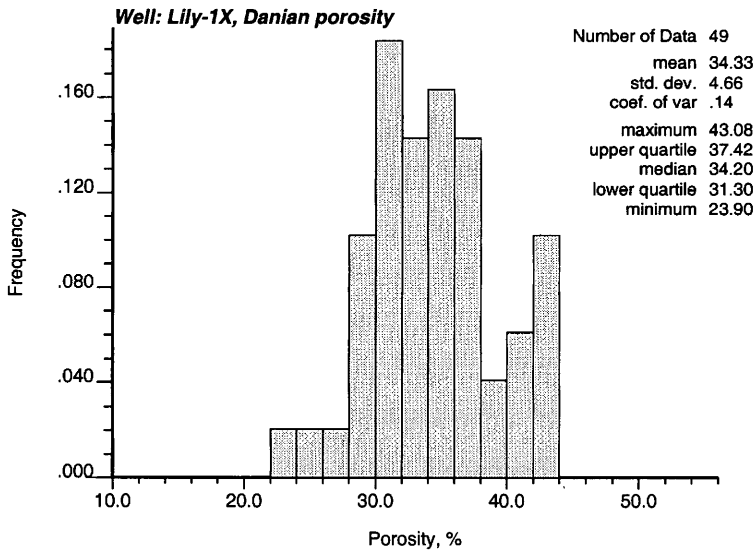
std. dev. 4.45
coef. of var .13
maximum 43.08
upper quartile 35.66
median 32.48
lower quartile 29.96
minimum 23.90


Well: Lily-1X, Danian porosity
Frequency
Porosity, %
Number of Data 49
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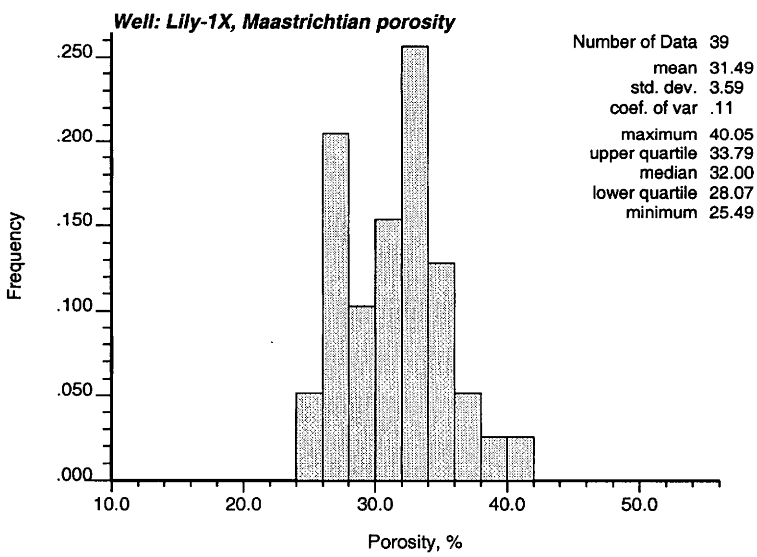
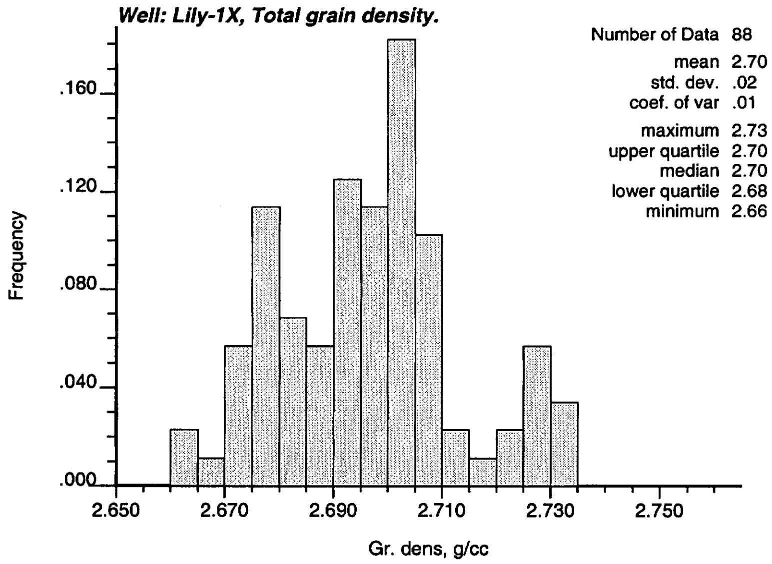
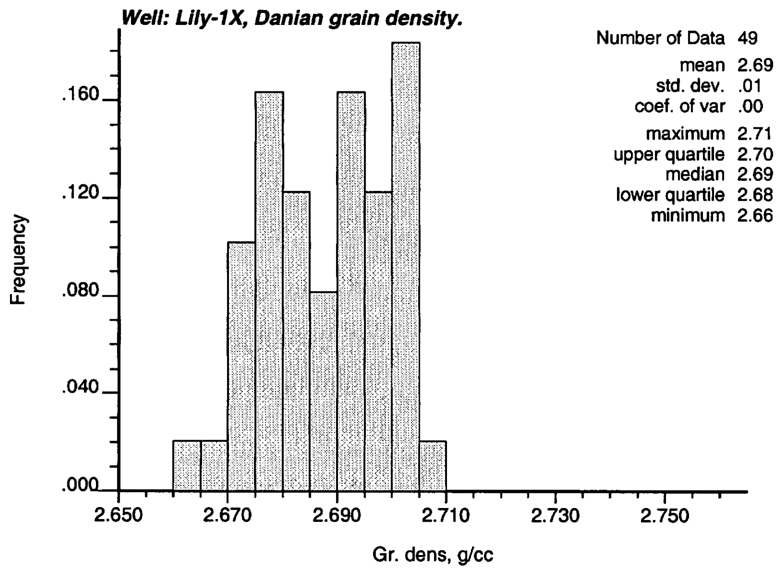
std. dev. 4.66
coef. of var .14
maximum 43.08
upper quartile 37.42
median 34.20
lower quartile 31.30
minimum 23.90

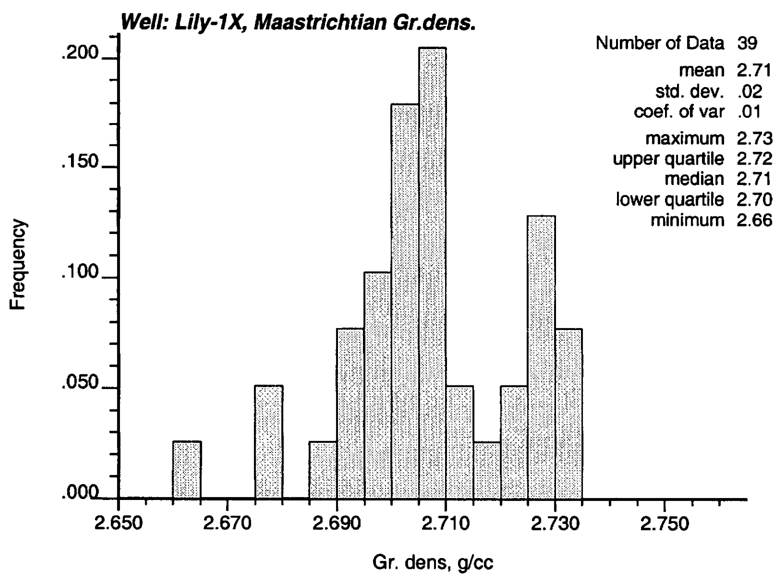

Well: Lily-1X, Maastrichtian porosity
Frequency
Porosity, %
Number of Data 39
mean 31.49
std. dev. 3.59
coef. of var .11
maximum 40.05
upper quartile 33.79
median 32.00
lower quartile 28.07
minimum 25.49

DISTRIBUTION OF GRAIN DENSITY

WELL : Lily-1X
CORE : 1 – 3

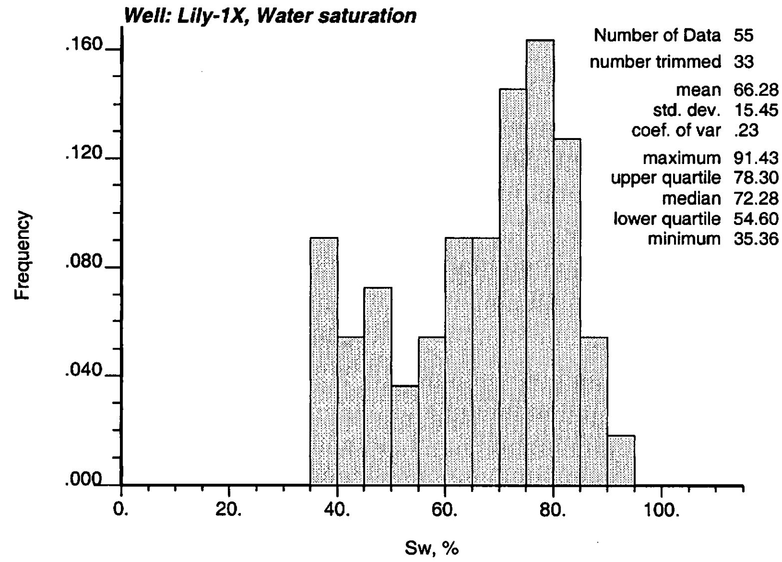


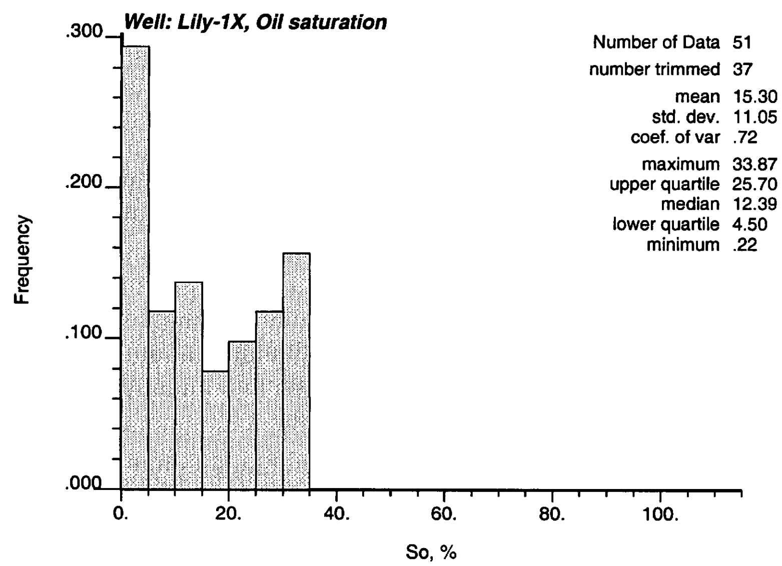


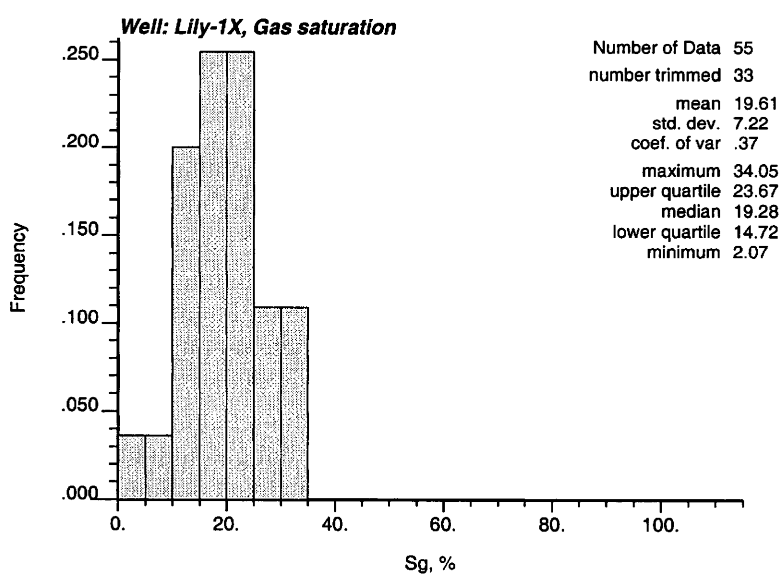


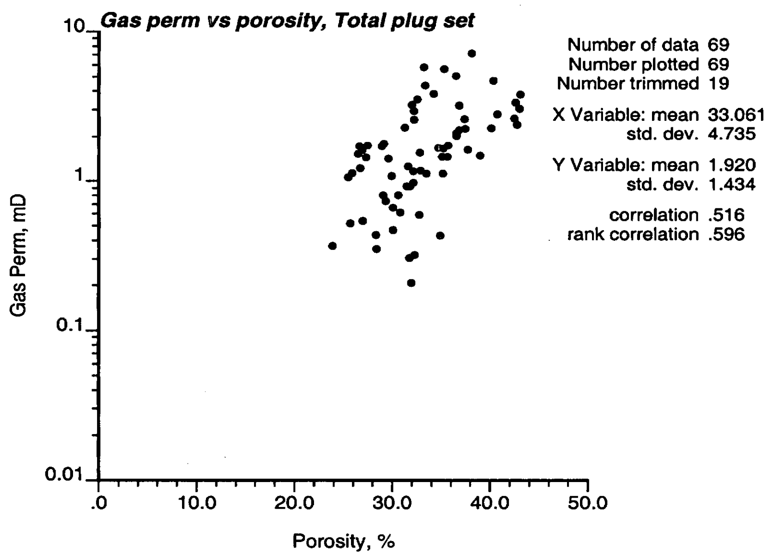
DISTRIBUTION OF FLUID SATURATIONS

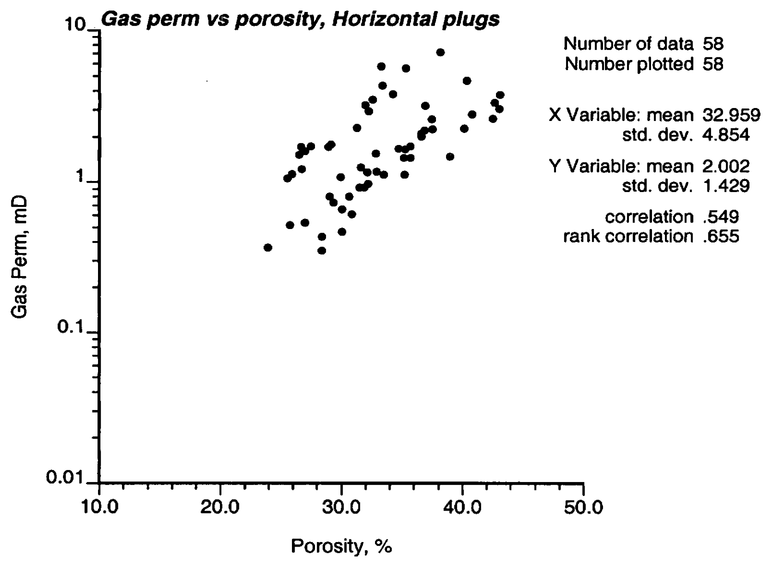
WELL : Lily-1X
CORE : 1 - 3

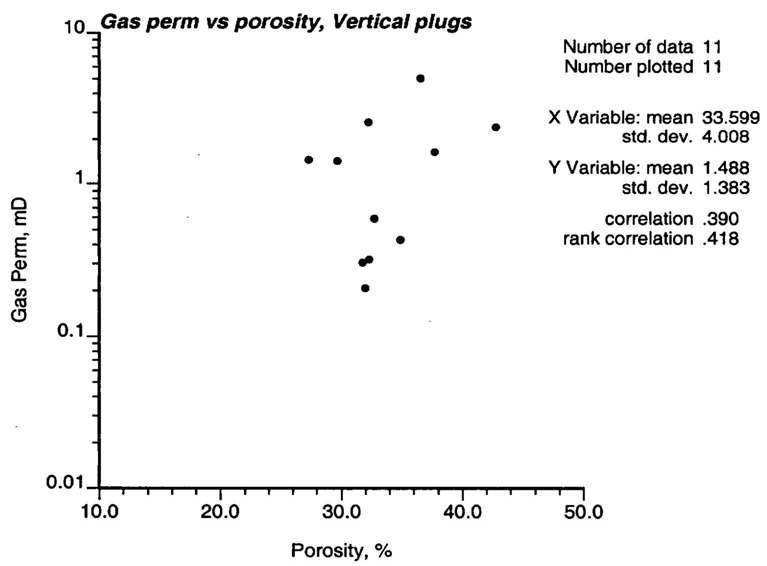


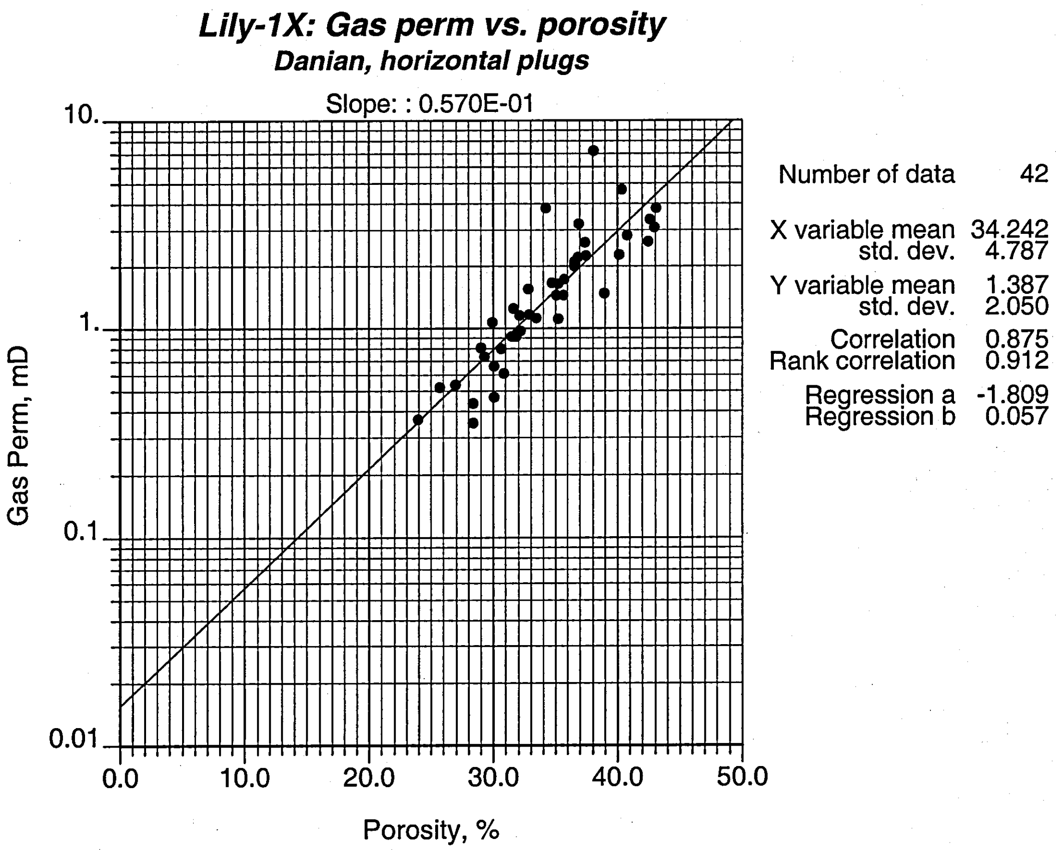


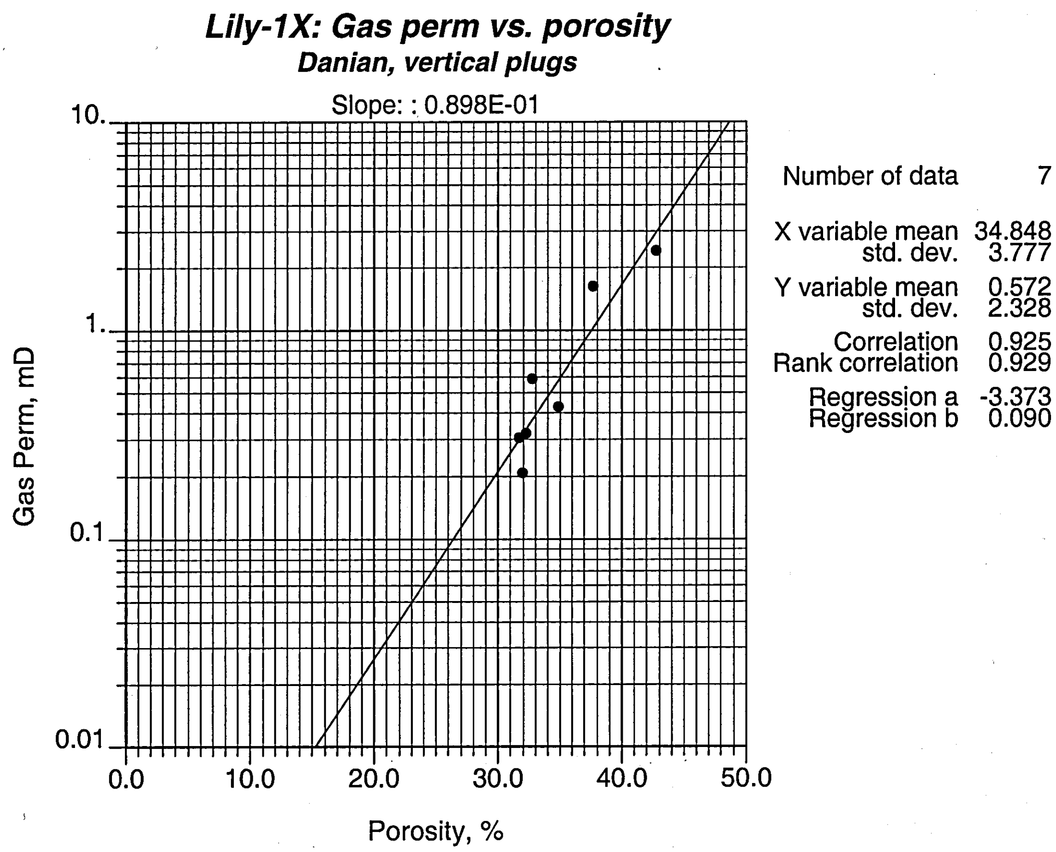



Gas perm vs porosity, Total plug set
Number of data 69
Number plotted 69
Number trimmed 19
X Variable: mean 33.061
std. dev. 4.735
Y Variable: mean 1.920
std. dev. 1.434
correlation .516
rank correlation .596
Gas Perm, mD
10
1
0.1
0.01
.0
10.0
20.0
30.0
40.0
50.0
Porosity, %


Gas perm vs porosity, Horizontal plugs
Number of data 58
Number plotted 58
X Variable: mean 32.959
std. dev. 4.854
Y Variable: mean 2.002
std. dev. 1.429
correlation .549
rank correlation .655
Gas Perm, mD
10
1
0.1
0.01
10.0
20.0
30.0
40.0
50.0
Porosity, %

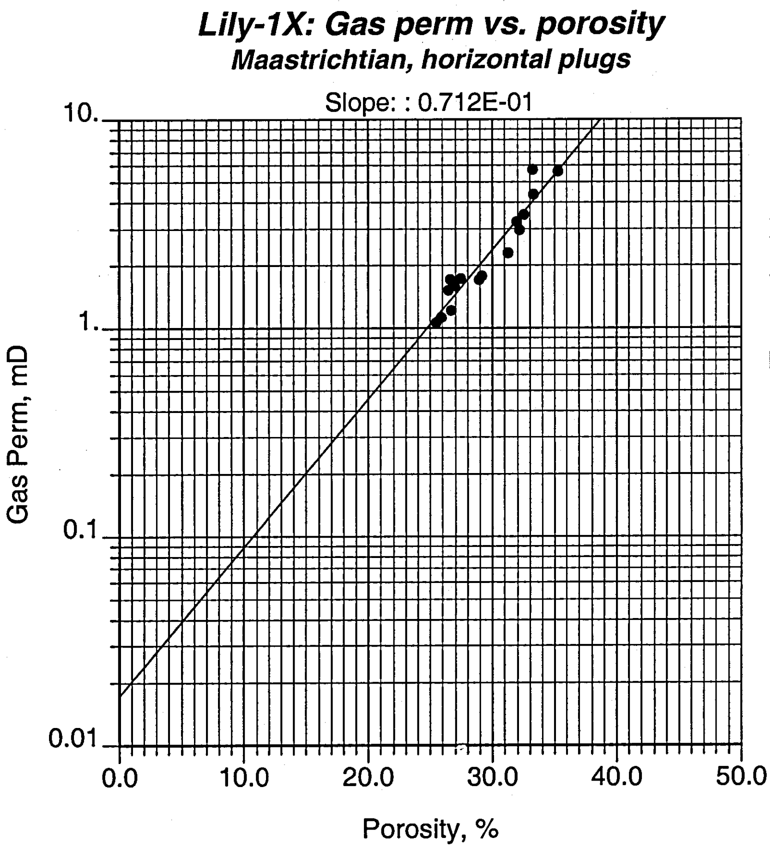

Gas perm vs porosity, Vertical plugs
Number of data 11
Number plotted 11
X Variable: mean 33.599
std. dev. 4.008
Y Variable: mean 1.488
std. dev. 1.383
correlation .390
rank correlation .418
Gas Perm, mD
10
1
0.1
0.01
10.0
20.0
30.0
40.0
50.0
Porosity, %


Lily-1X: Gas perm vs. porosity
Danian, horizontal plugs
Slope: : 0.570E-01
10.
1.
0.1
0.01
Gas Perm, mD
0.0
10.0
20.0
30.0
40.0
50.0
Porosity, %
Number of data 42
X variable mean 34.242
std. dev. 4.787
Y variable mean 1.387
std. dev. 2.050
Correlation 0.875
Rank correlation 0.912
Regression a -1.809
Regression b 0.057

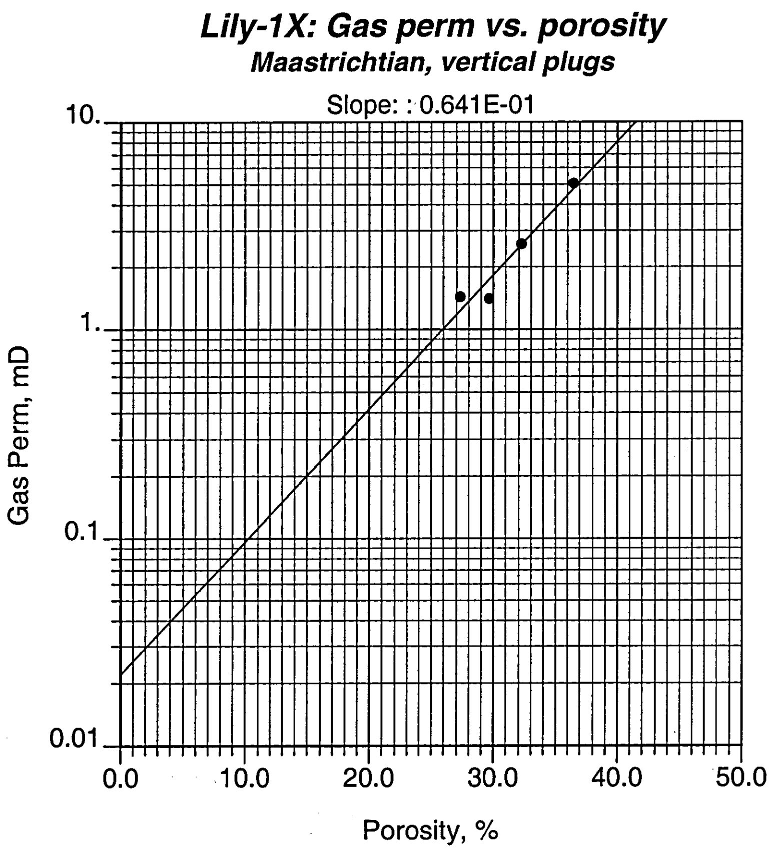

Lily-1X: Gas perm vs. porosity
Danian, vertical plugs
Slope: : 0.898E-01
10.
1.
0.1
0.01
Gas Perm, mD
0.0
10.0
20.0
30.0
40.0
50.0
Porosity, %
Number of data 7
X variable mean 34.848
std. dev. 3.777
Y variable mean 0.572
std. dev. 2.328
Correlation 0.925
Rank correlation 0.929
Regression a -3.373
Regression b 0.090

CROSSPOLT OF POROSITY VS. GAS PERMEABILITY

WELL : LILY-1X
CORE : 1 - 3



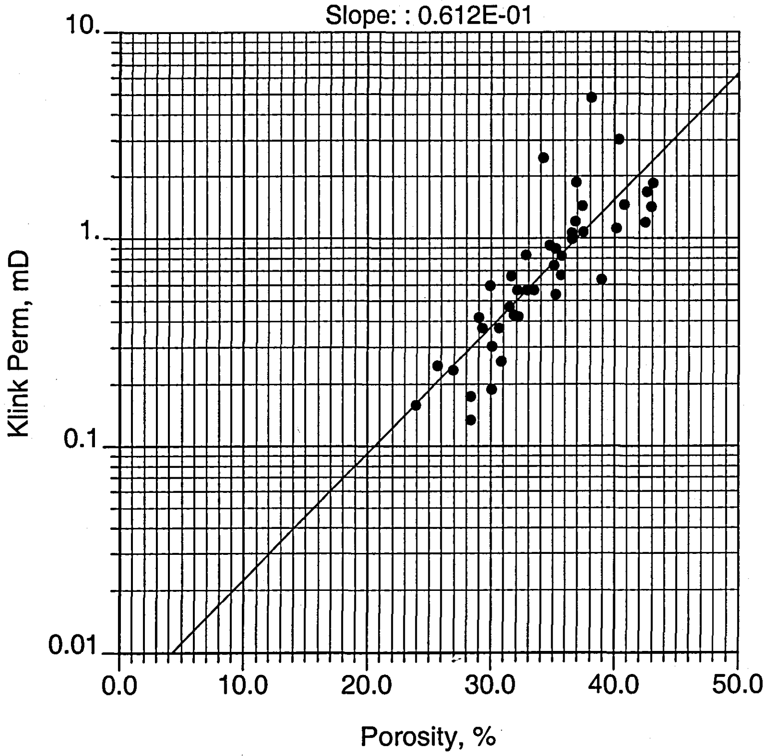
Number of data	16
X variable mean	29.591
std. dev.	3.098
Y variable mean	2.222
std. dev.	1.700
Correlation	0.958
Rank correlation	0.971
Regression a	-1.761
Regression b	0.071



Number of data	4
X variable mean	31.412
std. dev.	3.420
Y variable mean	2.268
std. dev.	1.685
Correlation	0.968
Rank correlation	0.800
Regression a	-1.659
Regression b	0.064

Lily-1X: Klinkenberg perm vs. porosity

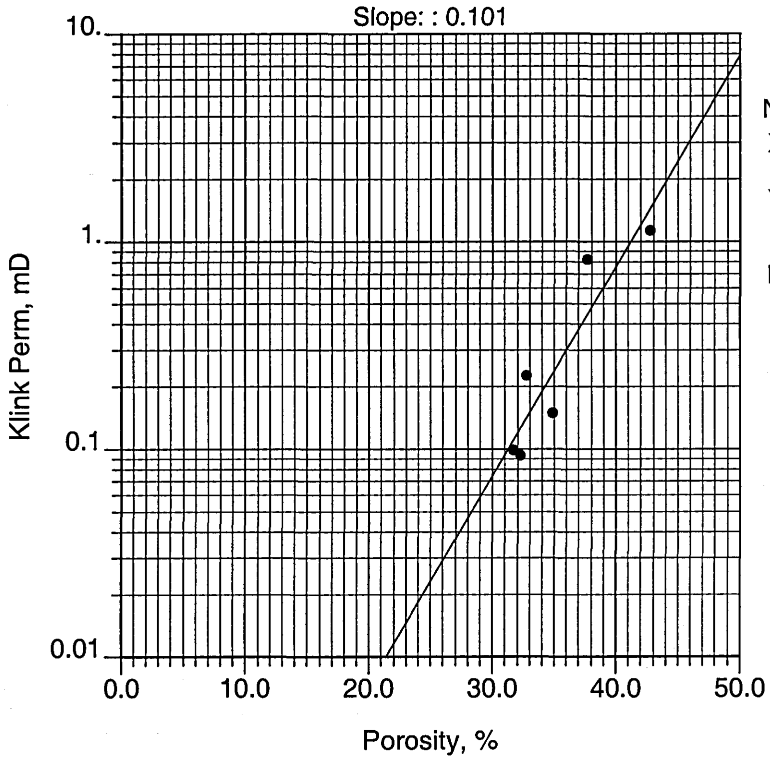
Danian, horizontal plugs



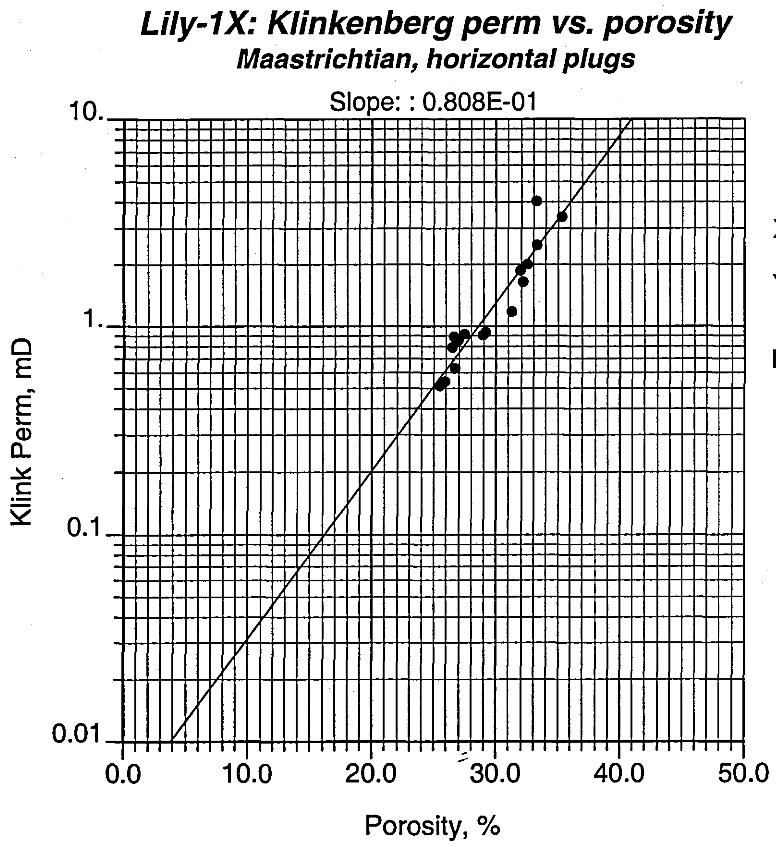
Number of data	42
X variable mean	34.242
std. dev.	4.787
Y variable mean	0.683
std. dev.	2.256
Correlation	0.829
Rank correlation	0.884
Regression a	-2.261
Regression b	0.061

Lily-1X: Klinkenberg perm vs. porosity

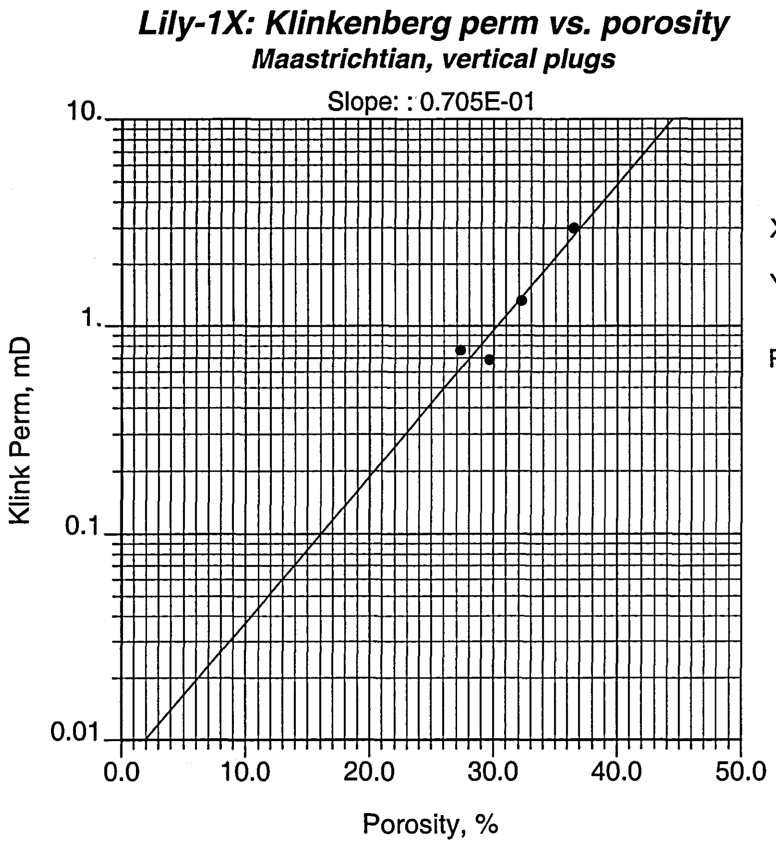
Danian, vertical plugs



Number of data	6
Number trimmed	1
X variable mean	35.335
std. dev.	3.871
Y variable mean	0.258
std. dev.	2.679
Correlation	0.914
Rank correlation	0.886
Regression a	-4.157
Regression b	0.101



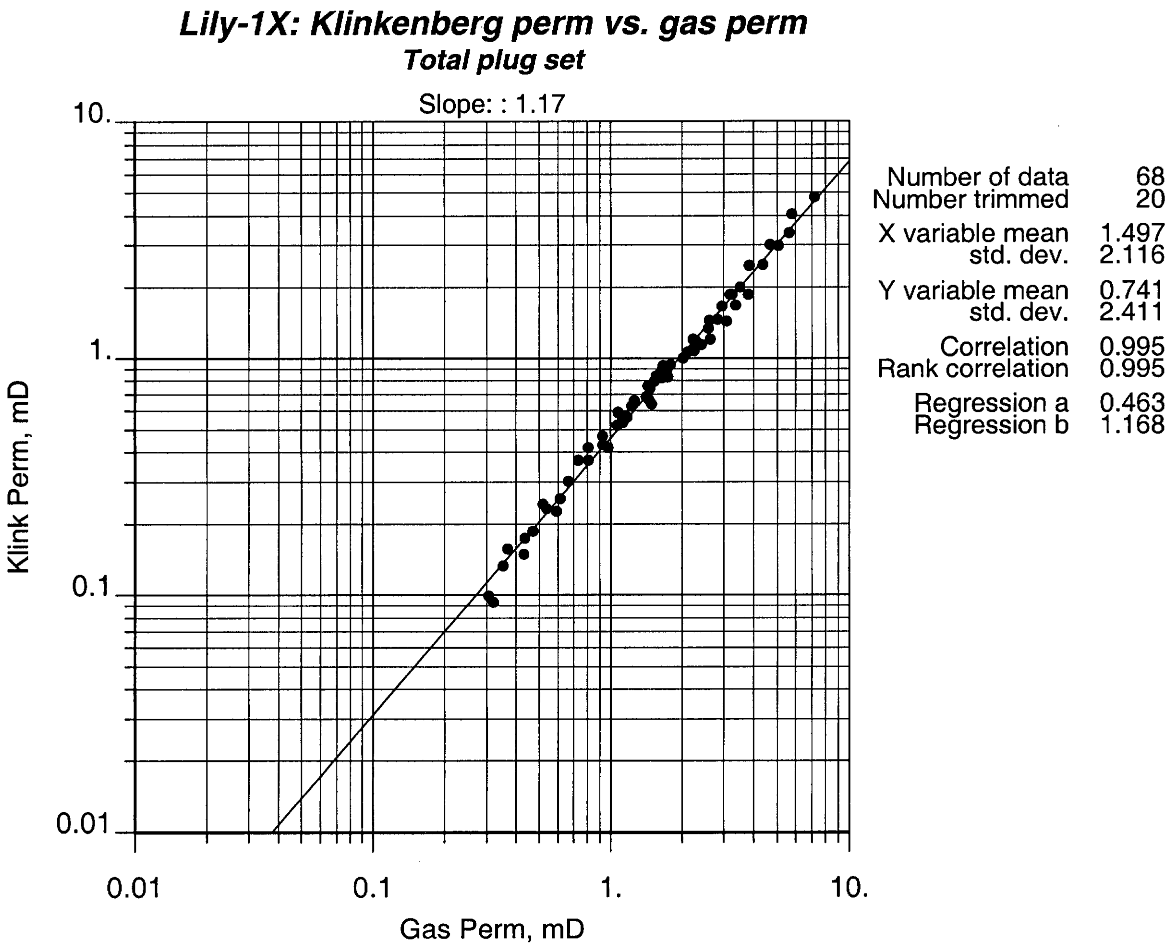
Number of data	16
X variable mean	29.591
std. dev.	3.098
Y variable mean	1.209
std. dev.	1.841
Correlation	0.945
Rank correlation	0.971
Regression a	-2.310
Regression b	0.081



Number of data	4
X variable mean	31.412
std. dev.	3.420
Y variable mean	1.200
std. dev.	1.792
Correlation	0.952
Rank correlation	0.800
Regression a	-2.135
Regression b	0.070

CROSSPOLT OF KLINKENBERG PERMEABILITY VS. GAS PERMEABILITY

WELL : LILY-1X
CORE : 1 - 3



5.2 Insoluble residue data

Due to the nature of the unconsolidated chalk in core #3 and the scatter in grain densities it was decided to run a few insoluble residue determinations. Three samples were taken and analyzed by GEUS Clay Minerals Laboratory.

Table 5.2. Lily-1X, weight percent insoluble residue (ISR) and quartz content (Qz) in core #3.

Depth in feet	% ISR	% Qz in ISR
7138.16	3	10
7164.50	3	13
7179.50	3	13

5.3 Plug description

The plug description sheet is made in accordance with the description system given in:
Crabtree, B., Fritsen, A., Mandzuich, K., Moe, Aa., Rasmussen, F.O., Siemers, T. Søiland, G. & Tirsgaard, H., 1996: Description and Classification of Chalks – North Sea Central Graben. Joint Chalk Research Phase IV, July 1996. Norwegian Petroleum Directorate (NPD), Stavanger.

The following additional abbreviations are intended to be used in the comment column of the plug description sheet:

- Rock colour

blk = black
br = brown
gn = green
gy = grey
ol = olive
rd = red
wh = white
owh = off-white
vl- = very light
l- = light, e.g. lgy = light grey
ml- = medium light
m- = medium
md- = medium dark
d- = dark
-sh = -ish, e.g. brsh = brownish
var = varicoloured

- Miscellaneous

amp = amplitude of stylolite
art = artificial(-ly)
art F = artificially induced fracture
bio tex = bioturbate texture
Btn = thin-bedded
Cl = low consolidation

Cm = medium consolidation
Chi = high degree of consolidation
Ggl = glauconite grains
GIn = *Inoceramus* fragments
Gph = phosphorite grains
ids = indistinct(-ly)
ira = insoluble residue accumulation
leo = leopard structure
mic = micro
mic S = microstylolite, almost invisible with the naked eye
mou = mould(-s) from Gsk
mot = mottled
rep = replaced by
S = stylolite
slg = slight(-ly)
Ss = solution seam
Ssh = high density of solution seams
Ssl = low density of solution seams
TCh = *Chondrites* trace fossil
TPl = *Planolites* trace fossil
TTe = *Teichichnus* trace fossil
TTh = *Thalassinoides* trace fossil
TTr = *Trichichnus* trace fossil
TZo = *Zoophycos* trace fossil

The description of samples from the unconsolidated C#3 is less precise due to the small sample size and very fragile nature of the core material.

JCR plug description scheme

Well: 1X | Field: Lily | Sheet no.: 1 | Geologist: NIS

Plug size Ø = 1"

			Depositional fabric									Composition									Stratification									Deformation structures						Bioturbation				Hardness					Stylolites				Secondary minerals						Fractures							Comments
			Rock type									Matrix			Grains						Bedding				Lamination											Trace fossils																										
Plug	Core depth	Lithotype	M	Mf	Mc	Wf	Wc	Pf	Pc	Gf	Gc	Ch	Arl	Arh	Gn	Gsh	Gch	Gsk	Gct	Go	Bn	Btn	Bm	Btk	Ln	Lpl	Lun	Lx	Lg	Dn	Dfl	Dfh	Dcl	Dch	Ds	Tn	Tl	Tm	Th	Hvs	Hs	Hm	Hh	Hvh	Sn	Sl	Sm	Sh	Mn	Mca	Mpy	Mdo	Msi	Mo	Fn	Fo	Fm	Fhl	Fhh	Fs	Plug	
no.	m/ft.		1	2	3	4	5	6	7	8	9	1	2	3	1	2	3	4	5	6	1	2	3	4	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	5	6	1	2	3	4	5	6	no.	
1X	6984.25	MaMu	1									1						4			1				1					1						1					2				1				1										5		1X	owh
1	6984.33	MaMu	1									1			1						1				1					1						1					2				1				1										5		1	owh
2X	6984.92	MaMu	1									1			1						1				1					1						1					2							4	1						1						2X	owh, 3 mic S
2	6985.50	MaMu	1									1			1						1				1					1						1				1					1				1									4			2	owh
3X	6986.58	MaMu	1									1						4			1				1					1						1					2				1				1						1						3X	owh
3	6987.00	MaMu	1									1			1						1				1					1						1					2				1				1									4			3	owh
4X	6989.08	MaMu	1									1			1						1				1					1						1					2				1				1										5		4X	owh
4	6989.42	MaMu	1									1			1						1				1					1						1					2				1				1										5		4	owh
1V	6989.58	MaMu	1									1			1						1				1					1						1					2				1				1						1						1V	owh, ids mot
5	6990.33	MaMu	1									1						4			1				1					1						1					2				1				1						1						5	owh
5X	6992.33	MaMu	1									1						4			1				1					1						1					2				1				1						1						5X	owh
6	6992.58	MaMu	1									1			1						1				1					1						1					2					2			1						1						6	owh, 1 mic S
7	7020.33	MaMu	1									1			1						1				1					1						1						3			1				1						1						7	owh
6X	7020.67	MaMu	1									1						4			1				1					1						1						3			1				1						1						6X	owh-lgy, Ssl
8	7021.42	MaMu	1									1			1						1				1					1						1							4		1					2							3				8	owh, Ssl
2V	7021.67	MaMu	1									1						4			1				1					1						1							4		1				1						1						2V	owh, ids Ssl
9	7022.50	MaMu	1									1			1						1				1					1						1							4		1				1						1						9	owh, ids Ssl
10	7023.08	MaMu	1									1			1						1				1					1						1							4		1				1						1						10	owh
11	7024.08	MaMu	1									1						4			1				1					1						1								5	1				1						1						11	owh, ids mot
12	7025.08	LaMu	1									1			1						1						3			1						1								5	1				1									4			12	owh-lgy, Ssh
13	7026.00	MaMu	1									1						4			1				1		3			1						1								5	1				1						1						13	owh, Ssl
7X	7027.00	MaMu	1									1			1						1				1					1						1							4		1						3							4			7X	owh
14	7027.00	MaMu	1									1			1						1				1					1							2						4		1						3				1						14	owh, TCh
3V	7027.42	MaMu	1									1						4			1				1					1						1								5	1				1						1						3V	owh
15	7028.00	MaMu	1									1						4			1				1					1						1							4		1				1						1						15	owh, Ssl
16	7028.92	MaMu	1									1			1						1				1					1						1						3			1				1						1						16	owh-lgy, ids mot
17	7030.00	MaMu	1									1			1						1				1					1							2					3			1				1						1						17	owh, TCh
18	7032.00	MaMu	1									1						4			1				1					1						1						3			1				1						1						18	owh, Ssl
4V	7032.25	MaMu	1									1			1						1				1					1						1							4		1				1						1						4V	owh
8X	7033.00	MaMu	1									1						4			1				1					1						1							4		1				1						1						8X	owh
19	7033.08	LaMu	1									1						4			1						3			1						1							4		1				1						1						19	owh, ids Ssh
20	7034.00	MaMu	1									1						4			1				1					1						1						3			1				1						1						20	owh
21	7035.00	MaMu	1									1						4			1				1					1						1						3			1				1										5		21	owh
22	7036.00	MaMu	1									1			1						1				1					1						1						3			1				1									4			22	owh
5V	7036.83	MaMu	1									1			1						1				1					1						1						3			1				1						1						5V	owh
23	7036.75	MaMu	1									1			1						1				1					1						1						3			1				1						1						23	owh

JCR plug description scheme

Sheet no.: 2

Well:1X Field: Lily

Geologist: NIS

Plug size Ø = 1"

Plug	Core depth	Lithotype	Depositional fabric									Composition									Stratification								
			Rock type									Matrix			Grains						Bedding				Lamination				
			M	Mf	Mc	Wf	Wc	Pf	Pc	Gf	Gc	Ch	Arl	Arh	Gn	Gsh	Gch	Gsk	Gct	Go	Bn	Btn	Bm	Btk	Ln	Lpl	Lun	Lx	Lg
no.	m/ft.		1	2	3	4	5	6	7	8	9	1	2	3	1	2	3	4	5	6	1	2	3	4	1	2	3	4	5
24	7038.00	MaMu	1									1			1						1				1				
25	7038.11	MaMu	1									1						4			1				1				
9X	7039.00	MaMu	1									1			1						1				1				
26	7040.00	LaMu	1									1			1						1						3		
27	7041.00	MaMu	1									1			1						1				1				
6V	7041.25	MaMu	1									1			1						1				1				
28	7043.00	MaMu	1									1						4			1				1				
29	7044.00	LaMu	1									1			1						1						3		
30	7045.08	LaMu	1									1			1						1						3		
10X	7045.25	MaMu	1									1			1						1				1				
7V	7045.92	MaMu	1									1						4			1				1				
31	7045.83	MaMu	1									1			1						1				1				
32	7046.83	MaMu	1									1			1						1				1				
33	7120.08	BuMaMu	1									1						4			1				1				
34	7121.00	MaMu	1									1						4			1				1				
8V	7121.33	MaMu	1									1			1						1				1				
11X	7122.33	BuMaMu	1									1			1						1				1				
35	7122.33	BuMaMu	1									1						4			1				1				
36	7122.92	MaMu			3							1						4			1				1				
37	7124.00	MaMu	1									1						4			1				1				
38	7125.42	BuMaMu	1									1						4			1				1				
39	7125.92	MaMu	1									1						4			1				1				
9V	7125.92	MaMu	1									1						4			1				1				
40	7126.92	MaMu	1									1			1						1				1				
41	7128.08	MaMu	1									1						4			1				1				
42	7129.00	MaMu	1									1						4			1				1				
10V	7129.17	MaMu	1									1			1						1				1				
43	7136.08	MaMu	1									1			1						1				1				
11V	7136.08	BuMaMu	1									1			1						1				1				
12X	7137.00	MaMu	1									1						4			1				1				
44	7137.08	MaMu	1									1						4			1				1				
45	7138.16	MaMu	1									1						4			1				1				
46	7139.16	MaMu		2	3							1						4			1				1				
47*	7143.25	MaMu	1									1						4			?				1				
48*	7146.16	MaMu	1									1						4			?				1				
49*	7149.50	MaMu	1									1						4			?				1				

Plug	Deformation structures						Bioturbation				Hardness					Stylolites				Secondary minerals						Fractures						Plug	Comments
							Trace fossils																										
	Dn	Dfl	Dfh	Dcl	Dch	Ds	Tn	Tl	Tm	Th	Hvs	Hs	Hm	Hh	Hvh	Sn	Sl	Sm	Sh	Mn	Mca	Mpy	Mdo	Msi	Mo	Fn	Fo	Fm	Fhl	Fhh	Fs	Plug	
no.	1	2	3	4	5	6	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	5	6	1	2	3	4	5	6	no.	
24	1						1						3			1				1						1						24	owh, ids Ssl
25	1						1							4		1				1						1						25	owh
9X	1						1							4		1				1						1						9X	owh, ids mot
26	1						1							4		1				1						1						26	owh-lgy, ids Ssh
27	1							2						4		1				1						1						27	owh, TCh?, ids Ssl
6V	1						1							4		1				1						1						6V	owh, ids Ssl
28	1							2						4		1				1						1						28	owh,TZo
29	1						1							4		1				1						1						29	owh, ids Ssh
30	1						1							4		1						3				1						30	owh-lgy, Ssh
10X	1						1							4		1						3				1						10X	owh, ids Ssl
7V	1						1							4		1						3				1						7V	owh
31	1						1							4		1				1						1						31	owh
32	1						1							4			2			1						1						32	owh, 1 mic S
33	1								3					4		1						3							4			33	owh-lgy, TCh?
34	1							2						4				3				3								5		34	owh, TCh, 2 S
8V	1							2						4		1						3								5		8V	owh-lgy TCh? biotex
11X	1								3					4		1				1										5		11X	owh-lgy, TCh
35	1								3					4		1						3								5		35	owh-lgy,TCh,biotex
36	1							2						4				3				3							4			36	owh-lgy, TCh, 2 S
37	1							2						4		1						3								5		37	owh-lgy, TCh
38	1									4				4		1						3								5		38	owh-lgy, TCh
39	1							2						4		1						3							4			39	owh-lgy, TCh, mot
9V	1						1							4		1						3							4			9V	owh-lgy, biotex
40	1						1							4		1						3								5		40	owh-lgy, biotex
41	1						1						3			1						3				1						41	owh-lgy, biotex
42	1						1						3			1						3				1						42	owh, ids mot
10V	1						1						3			1				1										5		10V	owh
43	1						1							4		1				1									4			43	owh-lgy, biotex
11V	1								3				3			1						3							4			11V	owh-lgy, biotex
12X	1						1						3				2			1										5		12X	lgy, biotex, 1 S
44	1						1							4		1						3								5		44	owh-lgy, biotex
45	1						1						3			1						3								5		45	var owh-lgy, art F
46	1						1						3					3		1									4			46	owh-lgy, Gln,biotex
47*	1						1						3				2					3				?						47*	owh, 1 S, biotex
48*	1						1						3				2					3				?						48*	owh-lgy, 1 S, biotex
49*	1						1							4			2			1									?			49*	owh, 1 S

* Disintegrated core sample (no true plug could be drilled)

JCR plug description scheme

Sheet no.: 3

Well:1X | Field: Lily | Geologist: NIS

Plug size Ø = 1"

Plug no.	Core depth m/ft.	Lithotype	M 1	Mf 2	Mc 3	Wf 4	Wc 5	Pf 6	Pc 7	Gf 8	Gc 9	Ch 1	Arl 2	Arh 3	Gn 1	Gsh 2	Gch 3	Gsk 4	Gct 5	Go 6	Bn 1	Btn 2	Bm 3	Btk 4	Ln 1	Lpl 2	Lun 3	Lx 4	Lg 5
			Depositional fabric: Rock type									Composition: Matrix			Composition: Grains						Stratification: Bedding				Stratification: Lamination				
50*	7152.50	MaMu	1									1						4			?				1				
51*	7155.33	MaMu ?	1									1			?						?				?				
52*	7158.00	MaMu ?	?									1			?						?				1				
53*	7161.50	MaMu	1									1						4			1				1				
54*	7164.50	MaMu	1									1						4			1				1				
55*	7167.50	MaMu	1									1						4			1				1				
56*	7170.50	MaMu	1									1						?			1				1				
57*	7173.50	MaMu	1									1						4			?				1				
58*	7176.50	MaMu	1									1						?			1				1				
59*	7179.50	MaMu		2	3							1					3	4			1				1				
60*	7182.50	MaMu	1									1						4			1				1				
61*	7185.77	MaMu	1									1						4			?				1				
62*	7185.84	MaMu	1									1			1						1				1				

Plug no.	Dn 1	Dfl 2	Dfh 3	Dcl 4	Dch 5	Ds 6	Tn 1	Tl 2	Tm 3	Th 4	Hvs 1	Hs 2	Hm 3	Hh 4	Hvh 5	Sn 1	Sl 2	Sm 3	Sh 4	Mn 1	Mca 2	Mpy 3	Mdo 4	Msi 5	Mo 6	Fn 1	Fo 2	Fm 3	Fhl 4	Fhh 5	Fs 6	Plug no.	Comments
	Deformation structures						Bioturbation: Trace fossils				Hardness					Stylolites				Secondary minerals						Fractures							
50*	1						1							4			2					3				?						50*	owh, 1S
51*	1						?						3				2					3				?						51*	owh, 1S
52*	1						?						3			1						3				?						52*	owh
53*	1						1						3			1						3				1						53*	owh
54*	1							?					3				2					3							?			54*	owh-lgy, 1 S
55*	1						?						3			1						3							?			55*	owh-lgy, biotex
56*	1						?						3			1						3							4			56*	owh, ids mot
57*	1						1						3				2					3				?						57*	owh, 1 S
58*	1						1						3			1						3				1						58*	owh
59*	1						1						3				2			1										5		59*	owh, 1 S
60*	1						1							4			2					3				?						60*	owh, 1 S
61*	1						1						3					3				3				?						61*	owh, 2 S
62*	1						1							4		1						3							?			62*	owh

* Disintegrated core sample (no true plug could be drilled)

GEUS
Report file no.
Enclosure
17728 (1/1)

Well: Lily-1X
Core: 1,2 & 3

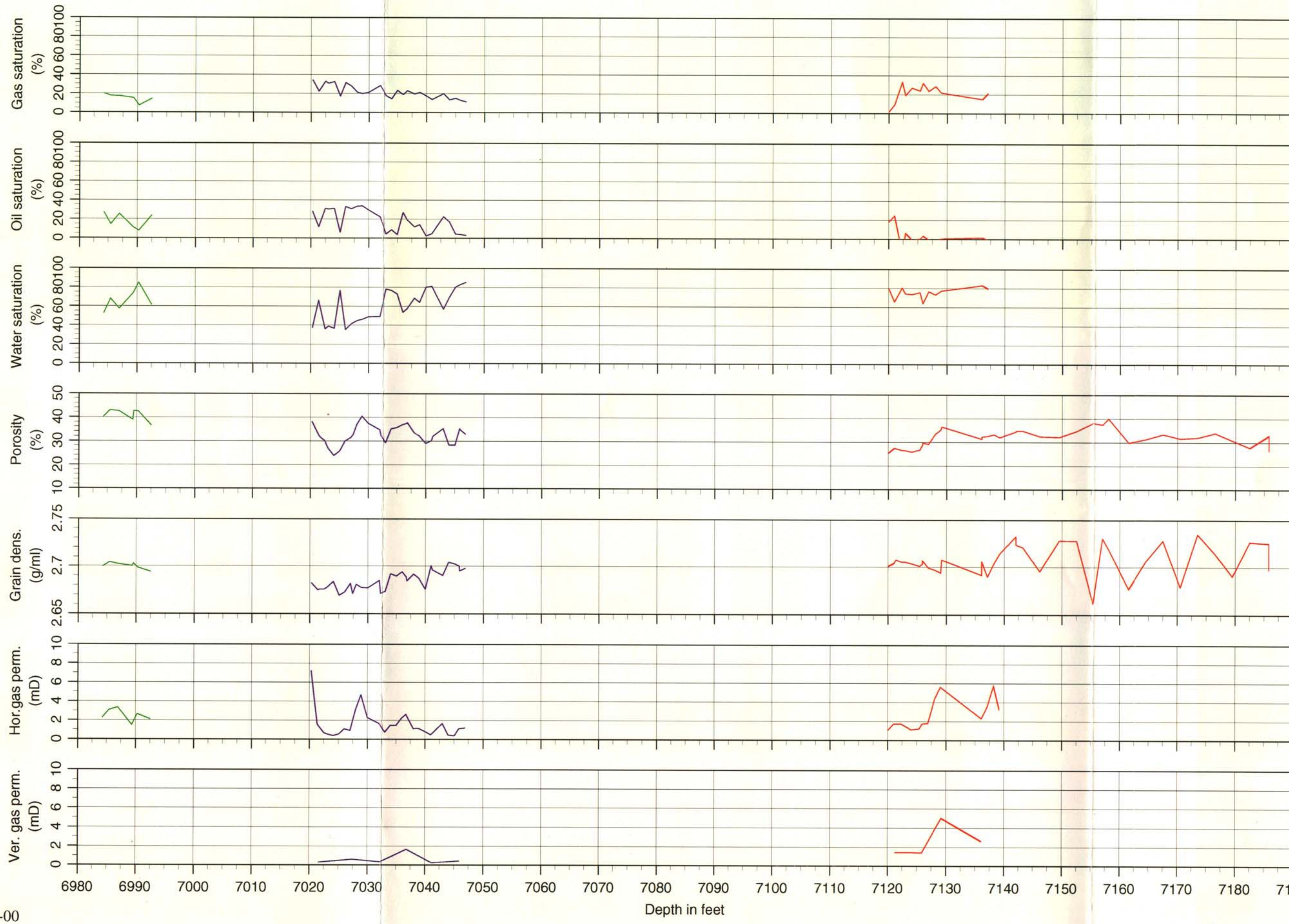
Core log

Depth vs.
Gas saturation
Oil saturation
Water saturation
Porosity
Grain density
Hor. gas perm.
Ver. gas perm.

Scale 1:200

Legend

Core 1
Core 2
Core 3



GEUS Core Analysis Laboratory, 30-JUN-00