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NW ADDA-1XA

Conventional and special core analysis for Mærsk Olie og Gas A/S Well: NW Adda-1XA

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Conventional and Special Core Analysis for Mærsk Olie og Gas A/S

Well:NW Adda - 1XA

Core Laboratory

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GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF ENVIRONMENT AND ENERGY

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1. Introduction

By request of Mærsk Olie & Gas A/S, GEUS Core Laboratory has carried out conventional and special core analysis on the well: North West ADDA-1XA

The analytical programme was specified by Mr. David Steer and included the following services:

- Spectral core gamma log
- Core bulk density and porosity log
- Conventional plug analysis
- Fluid saturation measurements
- Liquid permeability
- Lithological description of plugs

GEUS Core Laboratory received 53 plugs from NW ADDA-1XA on July 15 1998. Later 9 plugs were received for fluid saturation measurements. A preliminary spectral core gamma log and several preliminary reports have been forwarded to Mærsk Olie & Gas A/S during October, November and December 1998.

2. Sampling and analytical procedure

The laboratory received 62 plugs from NW ADDA-1XA taken in the interval 9349'4" – 9478'2" feet measured depth.

2.1 Spectral gamma and bulk density core log

The spectral gamma and bulk density core log was recorded using a scanning speed of 1 cm per minute. The integrated gamma activity was recorded at every 3" of core and the bulk density was recorded at every centimetre.

The bulk density log is very sensitive to change in the diameter along the core axis as a result of the small window for measuring (8 mm diameter bundle of gamma-ray). Any irregularities of the core like rubble, plug holes, gaps etc. can be seen on the bulk density log as spikes.

2.2 Porosity log

The porosity log was calculated from the bulk density core log using only the recorded values above 2.0 g/cc and the following data for the material balance equation:
10 cm core diameter, an average grain density of 2.65 g/cc and a presumed pore fluid density of 0.25 g/cc.(The presence of gas leads to a low average pore "fluid" density)

2.3 Cold Soxhlet cleaning

The plugs were cleaned at ambient temperature in methanol and toluene and then dried at 60 ^{0}C and 40% humidity

2.4 Conventional core analysis

Conventional core analysis including He-porosity, grain density, gas permeability and Klinkenberg permeability was performed. The permeability was measured using a sleeve pressure of 800 psi.

2.5 Fluid saturation

The plugs used for fluid saturation measurement were received later and may have suffered partly drying before they were analysed. The following densities were used for the calculation of fluid saturation: 1.039 g/cc for the brine and 0.85 g/ml for the oil.

2.6 Re-cleaning and plug measurement

The plugs were cleaned again in hot Soxhlet and then dried at 95^{0}C. He-porosity and grain density was remeasured.

2.7 Cold flushing

The plugs for liquid permeability measurements were cleaned in a coreholder by flushing with methanol and toluene. Toluene was used until the effluent was colourless and then the plugs were flush with 10 – 30 pore volume of methanol. A sleeve pressure of 800 psi was applied. After cleaning the plugs were fully submerged in methanol, until they were placed in the permeability rig.

2.8 Liquid permeability

The permeability to methanol, brine and then again methanol was determined by logging the differential pressure over the plug at every 5-55 seconds and keeping the flow at a constant rate. A sleeve pressure of 800 psi was applied.

2.9 Lithological description

The plugs were lithologically described by a geologist, and the descriptions are included with the result in section 5.

2.10 Tables for NW ADDA-1XA

Table 2.1 Chemical composition of the brines.

Brine 1: 41,000 ppm NaCl equivalent

Component	Concentration g/l
NaCl	33.600
$CaCl_2$	8.400

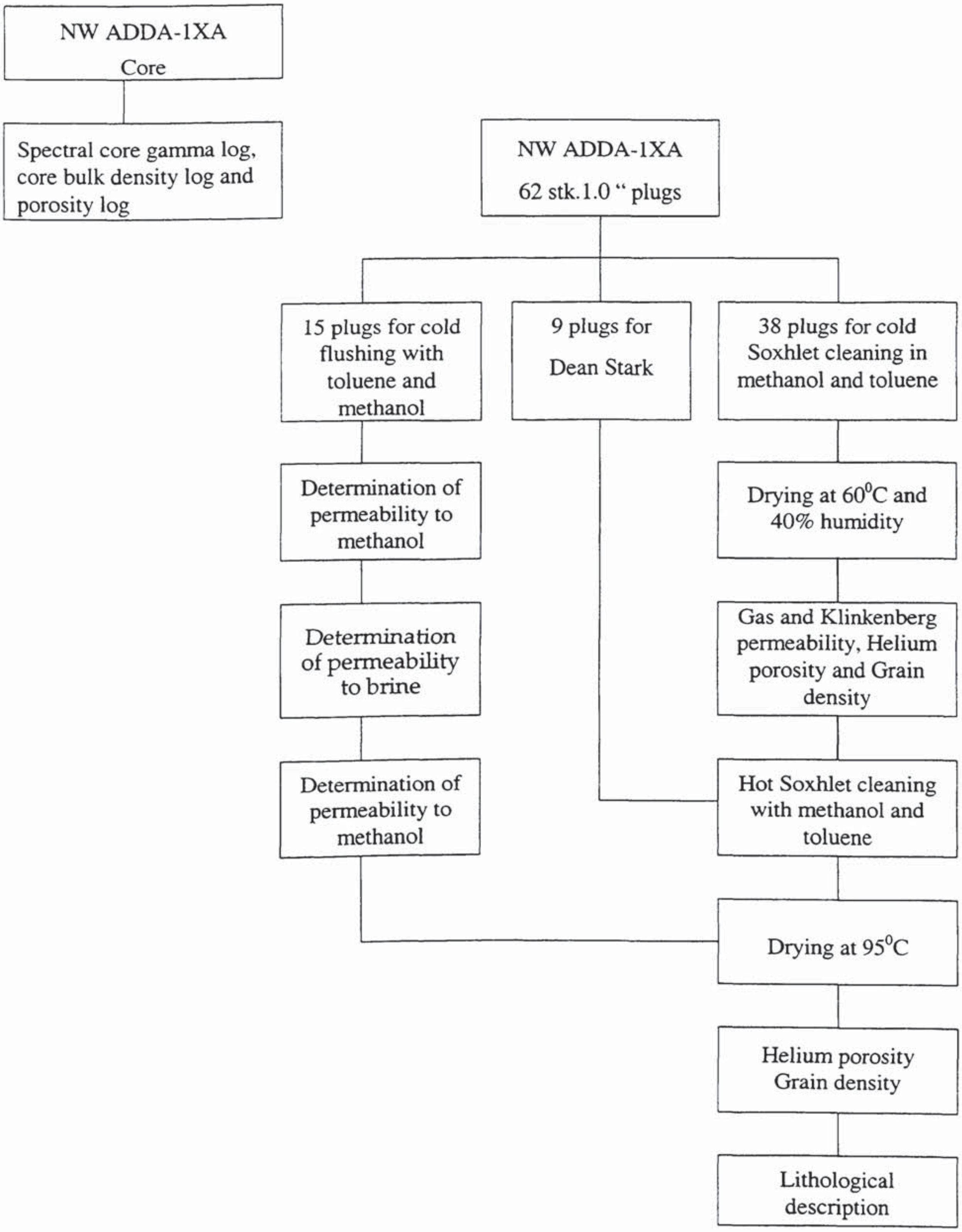
Brine 2: 80,000 ppm NaCl equivalent

Component	Concentration g/l
NaCl	65.561
$CaCl_2$	16.390

Table 2.2 Physical data on the brines.

Brine	Temperature °C	Density g/l	Viscosity cP
Brine1 (41,000 ppm)	21	1.0258	1.068
	22	1.0258	1.041
	23	1.0252	1.022
Brine2 (80,000 ppm)	21	1.0516	1.151
	22	1.0514	1.127
	23	1.0512	1.095

3. Flow chart of the analytical procedure



4. Analytical methods

The following is a short description of the methods used by the GEUS Core 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, 1960).

4.1 Spectral core gamma log

The natural gamma radiation of a core is recorded within an energy window of 0.5 - 3.0 MeV, using Tl activated NaI scintillation detectors, connected to a multichannel analyzer. The core is passed through a lead shielded tunnel at constant speed while the gamma activity is continuously recorded. Refer to Chapter 2 for the scanning speed used. The integrated gamma activity is recorded at regular intervals, either every 10 cm or every 3". The gamma activity represents the mean activity over a 10 cm or 3" interval, the assigned depth being the middle of the interval. The measured gamma activity is corrected for background activity, and in the case of sleeved core, also for activity of the sleeve.

Scanning results are assigned to core depths during the dataprocessing. Top and bottom depths of the boxes were compared to the physical length of the sleeves, and data are linear stretched or compressed if any differences.

Gamma activity is normally reported in counts per minute (cpm) at the actual core diameter. The following empirical relationship between "GAPI" from wireline logs and the actual cpm from GEUS core gamma logs (GEUS-cpm) has been established. The relationship should be used as a guideline only:

$$GAPI = GEUS\text{-}cpm * (10cm/d)^2 / 18,2 \qquad ;\ d \text{ is the core diameter in cm.}$$

Radiation from the decay of potassium and the uranium and thorium decay series are recorded in separate energy windows. Concentrations are calculated using synthetic standards of concrete doped with radioactive minerals in decay equilibrium. Concentrations of K, U and Th are reported as % K, ppm U and ppm Th, respectively. Relevant ratios are given.

4.2 Bulk core density log

Measurement of the core bulk density is based on the attenuation of gamma rays passing through the core and liner sleeve. A collimated beam (ø 8 mm) of gamma rays from a 30mCi ^{137}Cs source is passing through the core and recorded in an opposing NaI scintillation detector. The total number of counts are collected in time intervals of 60 seconds. Using a core scanning speed of 1 cm/min the bulk density is recorded at each cm of core.

Calibration is done on a short core sample with known bulk density (2.34g/cc) having the same diameter as the unknown core and being placed in the same type of liner sleeve. A mass attenuation coefficient is predetermined using several sheets of limestone, and a check of the resulting calibration is made on an empty sleeve.

4.3 Conventional cleaning and drying

The samples are 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.

4.4 Cold flush cleaning

Samples selected for special core analysis may be cleaned using the cold flush miscible liquids cleaning technique. Depending on the final saturation the cleaning sequence is the following:

methanol → toluene → lab. oil
methanol → toluene → methanol → formation water

The plug sample is mounted in a Hassler core holder and a confining pressure of 800 psi applied. The liquids are flushed through the sample. Each step in a cleaning cycle may require a liquid throughput of 5-20 PV's, or until the effluent is free of salt and colourless. As an alternative the cleaning cycle may be repeated several times.

4.5 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 routine measurement of permeable steel reference plugs.

4.6 Klinkenberg permeability (steady state instrument)

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 routine measurements of permeable steel reference plugs.

4.7 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.

4.8 Fluid saturation determination

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.

4.9 Liquid permeability

The liquid permeability is measured by flowing a liquid through the sample at a differential pressure between 0 and 20 bar. The measurement is performed at room temperature with no back pressure applied. The confining pressure is applied according to the requirements of the client, see section 2.9. The measurement continues until the permeability is approximately constant with time. The reported liquid permeability is the mean value of several determinations performed over a period of minutes to a few hours, depending on the permeability of the sample.

4.10 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 the GEUS Core Laboratory.

Measurement	Range, mD	Precision
Grain density		0.003 g/cc
Porosity		0.1 porosity-%
Gas Permeability	0.001-0.01 0.01-0.1 > 0.1	25% 15% 4%

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.

The precision (reproducibility) of the total gamma activity analysis is calculated from counting statistics. The table below list shows the precision as a function of count rate at the 2 standard deviation level.

Record interval : Live time : Log speed :	10 cm 595 sec 1 cm/min	3" 452 sec 1 cm/min
Count rate (cpm)	Reproducibility (cpm)	Reproducibility (cpm)
125	7.1	8.1
250	10.0	11.5
500	14.2	16.3
1000	20.1	23.0
2000	28.4	32.6
4000	40.2	46.1

Precision (reproducibility) of the amount af uranium, thorium and potassium from gamma radiation is dependent on concentration. Two values for reproducibility are given, one for normal to high concentration range, and one for low concentration range. The latter also defines the detection limit (LLD). The reproducibility values are applicable to total gamma activity above and below 800 cpm, respectively.

	K(%)	U(ppm)	Th(ppm)
Reproducibility			
Normal to high range	0.05	0.56	1.05
Low range (LLD)	0.02	0.18	0.30
Accuracy	0.04	0.21	0.26

Accuracy is calculated as mean deviation from the accepted concentration of an internal standard. This value is only applicable to low concentrations. For high concentrations the high range reproducibility may serve as an approximation to accuracy. Accuracy is reported as an arithmetic mean.

5. Results

The following results are presented:

- Liquid permeability data and recorded differential pressure as a function of time for each plug.
- Conventional core analysis data.
- Crossplot of porosity vs. Gas perm., Klinkenberg perm. and 1.5 P-M perm.
- Lithological description.
- Attached logs:
  - A spectral gamma log plotting Depth vs.
  Total gamma count, Potassium, Uranium, Thorium , Th/K, Th/U, U/K, Bulk core density.

  - A bulk core density log plotting Depth vs.
  Total gamma count, Potassium, Uranium, Thorium , Core bulk density , Core bulk density (plotting only values above 2.0 g/cc), Calculated porosity log combined with porosity measured on plugs, Grain density measured on plugs.
- All presented data are also included on a diskette.

5.1 Special core analysis data from NW ADDA-1XA

The sandstone from NW ADDA-1XA contains clay, which affects the permeability measurements. As the clay does not react with the methanol, stable permeabilities for methanol are obtained. The permeability measured on brine declines for many of the plugs. Changing the brine from 41,000 ppm to 80,000 ppm has not prevented swelling of the clay. Reflooding with methanol does not restore the permeabilities. No fines have been observed in the effluent.

The measured liquid permeabilities can be seen in the table below. If it was not possible to obtain a stable permeability then the lowest value measured is listed.

Table 5.1: Measured liquid permeabilities for NW ADDA-1XA

Plug	Orientation	Depth	Brine conc.	$K_{methanol}$	K_{brine}	$K_{methanol}$
No.		feet	ppm	mD	mD	mD
1V	Vertical	9350'1"	41,000	0.023	0.017	0.014
2	Horizontal	9350'4"	41,000	0.39	0.34	0.30
5	Horizontal	9360'1"	41,000	20.00	19.42	19.42
15	Horizontal	9382'8"	-	Fatal fracture – not replaced		
5V	Vertical	9389'7"	41,000	0.04	<0.04	0.03
22	Horizontal	9390'8"	41,000	0.06	0.04	0.02
23	Horizontal	9391'8"	41,000	92.11	85.35	55.69
26	Horizontal	9396'5"	41,000	0.08	0.08	0.05
29	Horizontal	9424'0"	80,000	0.19	<0.02	<0.004
31	Horizontal	9428'5"	41,000	0.22	0.06	0.006
33	Horizontal	9449'0"	41,000	0.31	0.21	0.17
36	Horizontal	9452'4"	80,000	0.96	<0.06	0.07
7V	Vertical	9453'6"	-	<0.003	-	-
38	Horizontal	9454'7"	41,000	0.22	0.13	0.04
40	Horizontal	9456'8"	41,000	0.02	<0.006	0.006
44	Horizontal	9477'1"	80,000	0.012	<0.007	-
45	Horizontal	9478'2"	-	Fatal fracture – replaced with plug no. 44		

For better evaluation of the results, the logged differential pressures over each plug are listed in the diagrams on the following pages.

Each diagram contains the logged pressures from the methanol, brine and methanol experiments plotted in continuation of each other. The flow rate is indicated in the diagrams and may vary from fluid to fluid.

Company	: Mærsk Olie & Gas AS	**Liquid permeability**	
Well no.	: NW ADDA-1XA	Temperature:	21-23 ^{0}C
Plugs no.	: 2, 5 and 22	Sleeve pressure:	800 psi
Depth	: 9350'4", 9360'1" and 9390'8"	Brine (NaCl eq.):	41,000 ppm

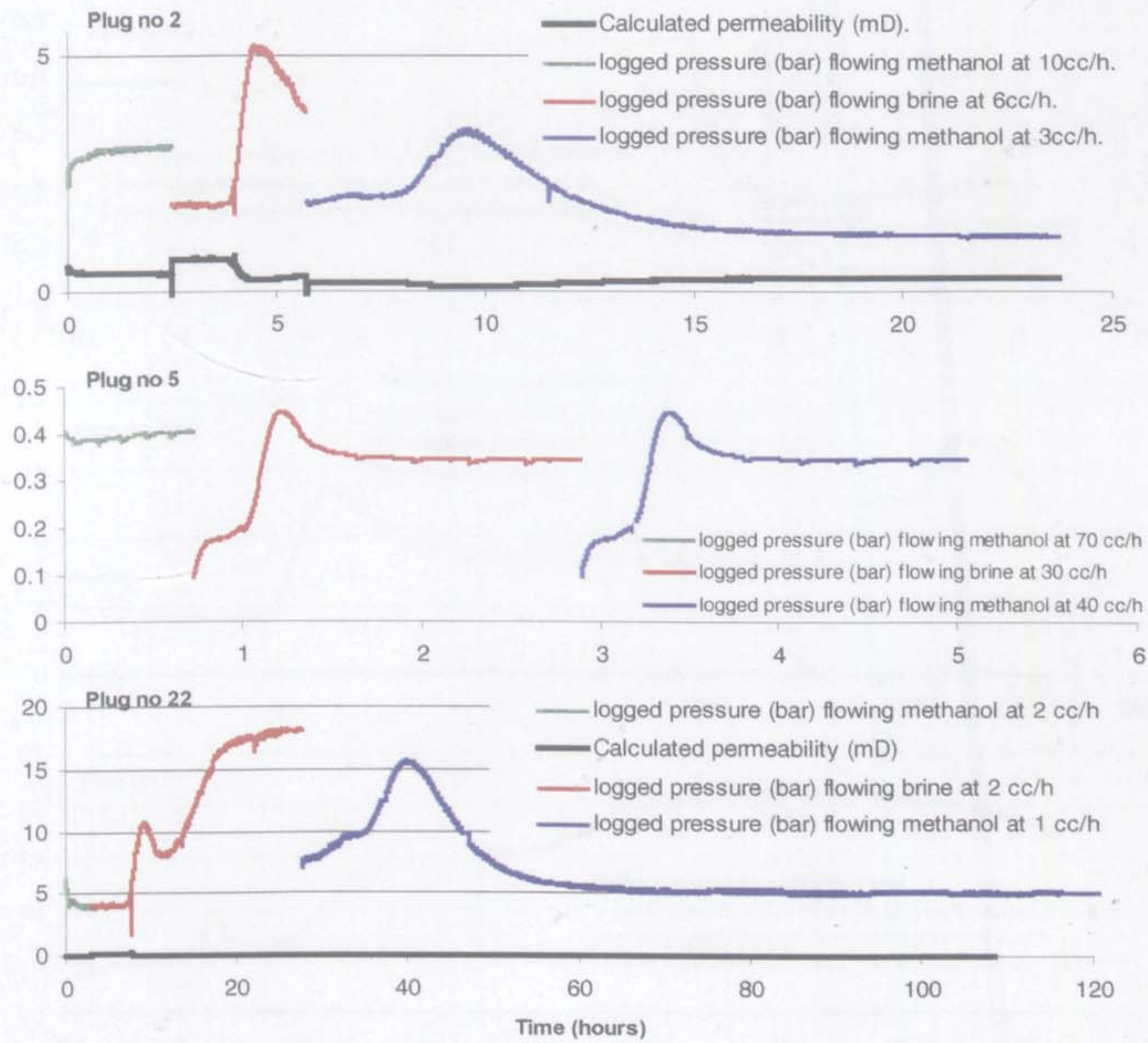


Figure 5.2: Recorded pressure as a function of time. Flooding order: methanol, brine, methanol.

For plug 2 the permeability for methanol is stabilised and the brine permeability approaches stable conditions, though the experiment has been terminated to soon. For plug 5 the permeability is stabilised for both methanol and brine. For plug 22 the permeability to brine decreases after displacing the methanol and then slowly approaches steady state.

Company	: Mærsk Olie & Gas AS	**Liquid permeability**	
Well no.	: NW ADDA-1XA	Temperature:	21-23 ^{0}C
Plugs no.	: 23, 26 and 31	Sleeve pressure:	800 psi
Depth	: 9391'8", 9396'5" and 9428'5"	Brine (NaCl eq.):	41,000 ppm

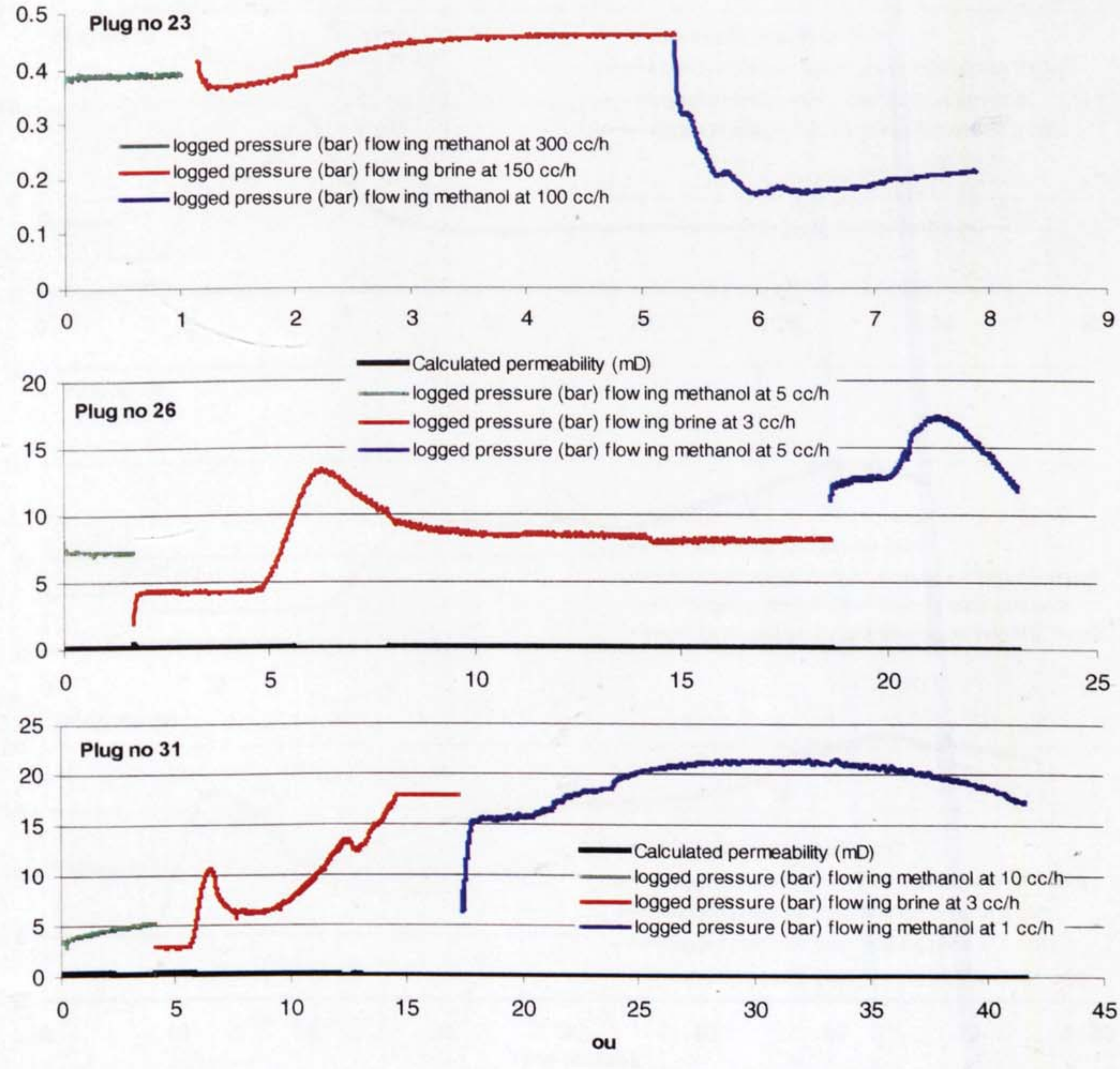


Figure 5.3: Recorded pressure as a function of time. Flooding order: methanol, brine, methanol.

For plug 23 and 26 the permeability for methanol and brine stabilises. For plug 31 the permeability to brine decreases after methanol displacement but finally stabilises.

Company	: Mærsk Olie & Gas AS	**Liquid permeability**	
Well no.	: NW ADDA-1XA	Temperature:	21-23 ^{0}C
Plugs no.	: 33, 38 and 40	Sleeve pressure:	800 psi
Depth	: 9449'0", 9454'7" and 9456'8"	Brine (NaCl eq.):	41,000 ppm

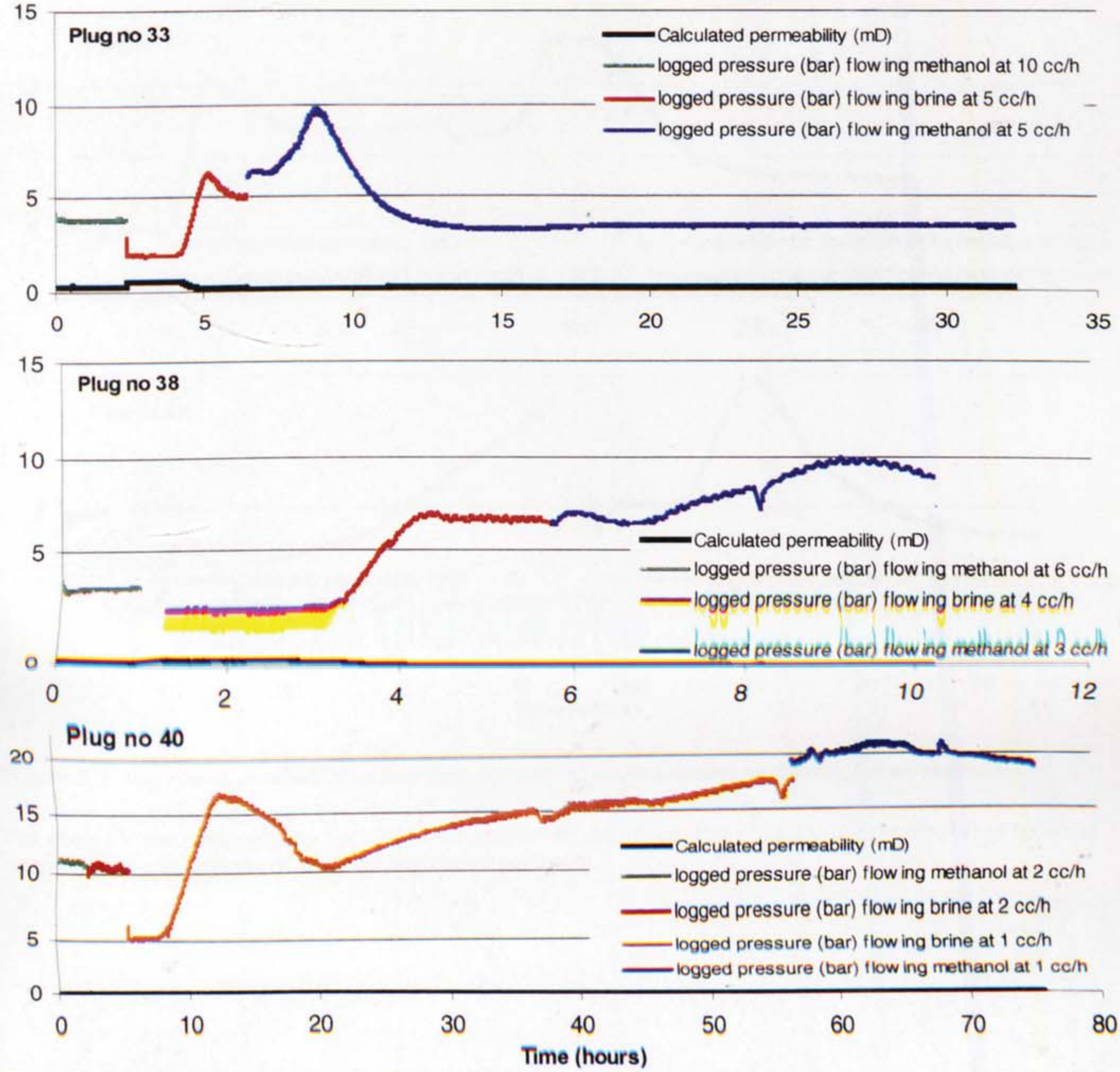


Figure 5.4: Recorded pressure as a function of time. Flooding order: methanol, brine, methanol.

For plug 33 and 38 the permeability for methanol and brine stabilises. For plug 40 the permeability to brine decreases after displacing the methanol.

Company	: Mærsk Olie & Gas AS	**Liquid permeability**	
Well no.	: NW ADDA-1XA	Temperature:	21-23 ^{0}C
Plugs no.	: 1V and 5V	Sleeve pressure:	800 psi
Depth	: 9350'1" and 9389'7"	Brine (NaCl eq.):	41,000 ppm

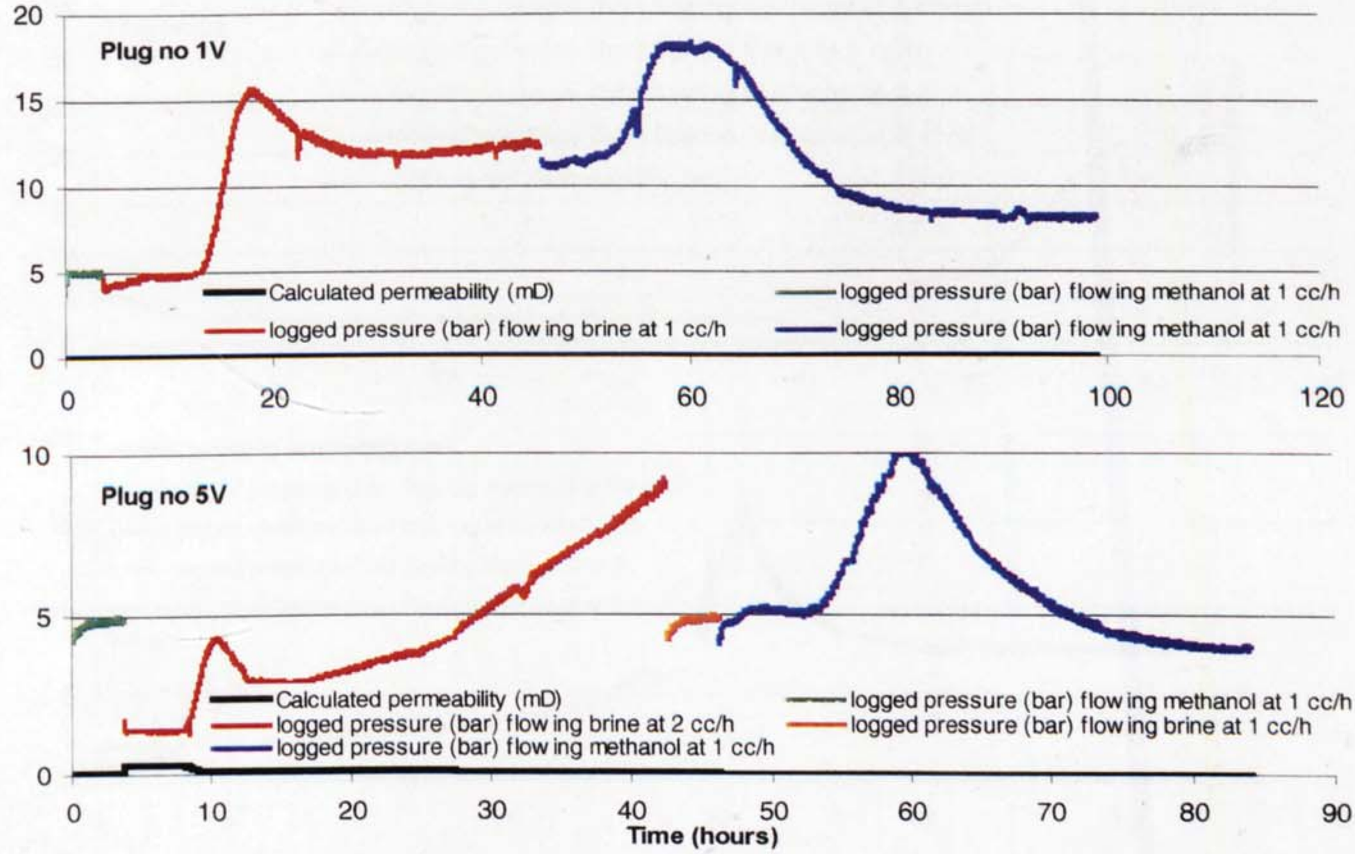


Figure 5.5: Recorded pressure as a function of time. Flooding order: methanol, brine, methanol.

For plug 1V the permeability for methanol and brine stabilises. For plug 5V the permeability to brine decreases as a functions of time during the experiment.

Company : Mærsk Olie & Gas AS
Well no. : NW ADDA-1XA
Plugs no. : 29, 36 and 44
Depth : 9424'0", 9452'4" and 9477'1"

Liquid permeability
Temperature: 21-23 °C
Sleeve pressure: 800 psi
Brine (NaCl eq.): **80,000 ppm**

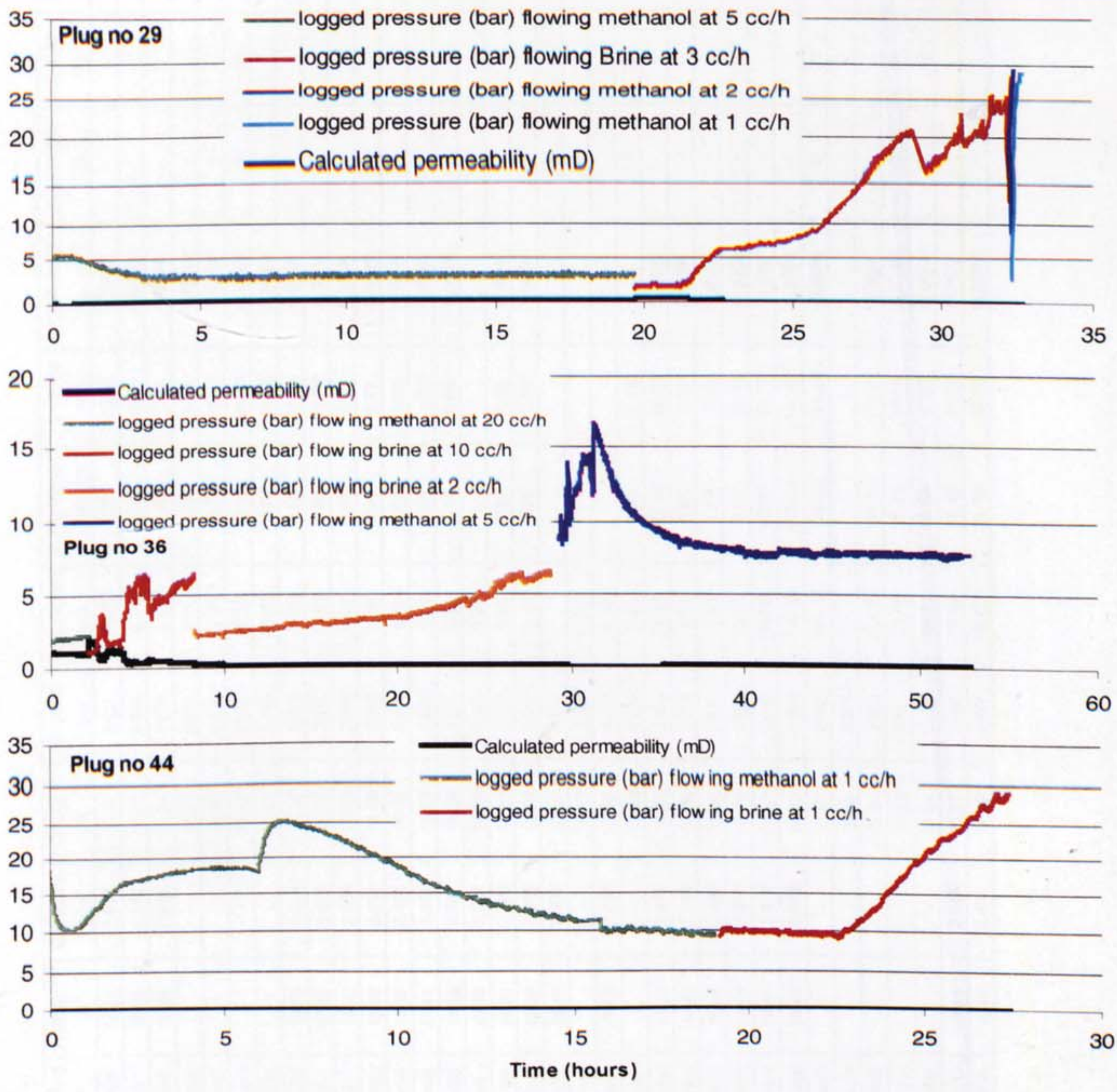


Figure 5.6: Recorded pressure as a function of time. Flooding order: methanol, brine, methanol.

For all the plugs the permeability to brine decreases as a functions of time through out the experiment. Using the 80,000 ppm brine has not improved permeability results.

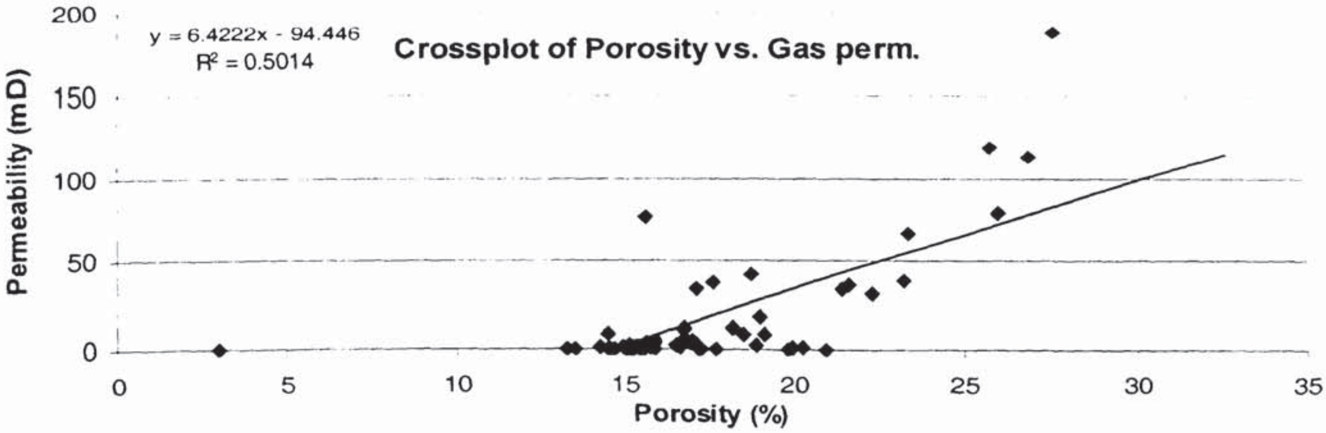
5.2 Core Analysis Tabulation from NW ADDA-1XA

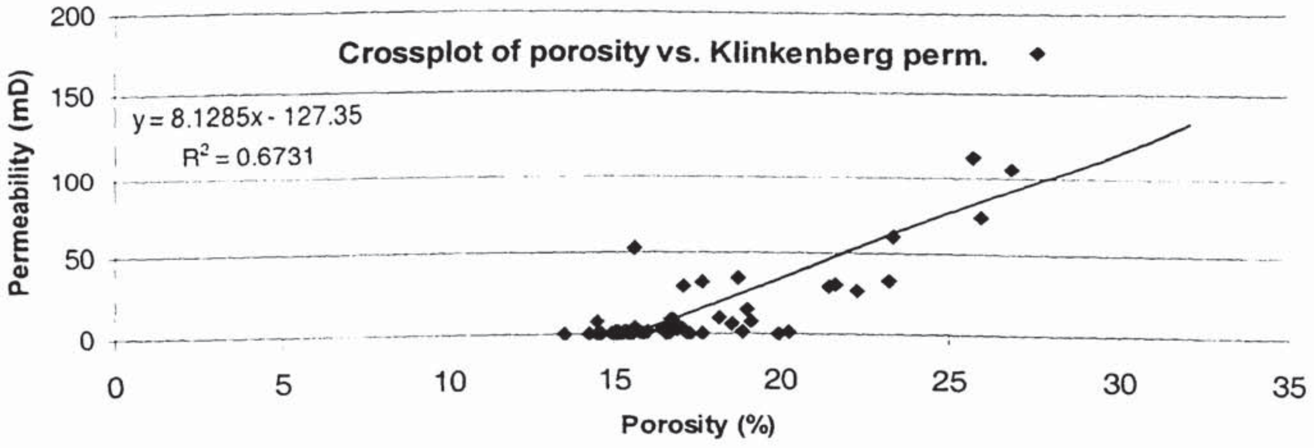
Plug NUMBER	DEPTH Feet	PLUGTYPE	***POROSITY %***	***GR.DENS. g/cc***	POROSITY %	GR.DENS. g/cc	GAS PERM mD	KLINK PERM mD	1.5 PERM mD	KORR.KOEF.	WATER SAT. %	OIL SAT. %	GAS SAT. %
1	9349.33	Horizontal	*14.80*	*2.623*	15.39	2.631	1.57	1.00	1.61	0.9957	-	-	-
1V	9350.08	Vertical	*16.28*	*2.616*	15.23	2.634	0.11	0.05	0.07	0.6175	-	-	-
2	9350.33	Horizontal	*18.56*	*2.633*	15.14	2.630	1.81	1.26	1.86	0.9998	-	-	-
3	9351.50	Horizontal	-	-	17.01	2.626	4.91	3.22	4.86	0.9994	-	-	-
4	9358.83	Horizontal	-	-	18.99	2.639	17.39	14.88	17.17	0.9948	-	-	-
100	9359.00	Horizontal	-	-	18.74	2.636	42.33	34.95	34.89	-0.0324	3	21	76
5	9360.67	Horizontal	-	-	17.11	2.489	33.72	30.22	33.58	0.9102	-	-	-
6	9362.66	Horizontal	*16.15*	*2.636*	16.74	2.643	11.28	8.58	13.54	0.9808	-	-	-
7	9364.41	Horizontal	*17.55*	*2.635*	18.19	2.645	11.95	9.48	12.22	0.9634	-	-	-
2V	9368.00	Vertical	*12.36*	*2.560*	13.49	2.573	0.16	0.13	0.14	0.7691	-	-	-
8	9368.66	Horizontal	*13.43*	*2.511*	16.48	2.556	2.78	2.41	2.77	0.9269	-	-	-
9	9369.66	Horizontal	*13.90*	*2.498*	16.92	2.540	3.25	2.63	3.06	0.9874	-	-	-
10	9370.66	Horizontal	*17.11*	*2.574*	16.73	2.547	6.18	4.05	4.71	0.9946	-	-	-
11	9371.66	Horizontal	*12.89*	*2.557*	15.28	2.591	0.68	0.47	0.68	0.9996	-	-	-
3V	9372.00	Vertical	*13.46*	*2.528*	14.70	2.544	0.09	-	-	-	-	-	-
12	9373.33	Horizontal	*12.89*	*2.499*	14.49	2.520	8.85	7.82	8.96	0.9749	-	-	-
13	9374.33	Horizontal	*11.94*	*2.472*	15.60	2.518	3.50	3.26	3.38	0.9194	-	-	-
14	9375.58	Horizontal	*20.45*	*2.560*	20.65	2.556	-	-	-	-	-	-	-
15	9382.66	Horizontal	-	-	18.07	2.635	-	-	-	-	-	-	-
4V	9383.58	Vertical	*19.93*	*2.665*	19.81	2.657	0.10	-	-	-	-	-	-
5V	9383.58	Vertical	-	-	17.68	2.627	0.21	0.09	0.19	1	-	-	-
16	9384.16	Horizontal	*14.36*	*2.601*	15.61	2.618	76.58	52.75	94.05	0.9822	-	-	-
17	9385.33	Horizontal	*14.61*	*2.618*	15.32	2.628	1.08	0.65	1.09	0.9961	-	-	-
18	9386.25	Horizontal	*15.60*	*2.631*	16.02	2.636	2.36	1.67	2.30	0.9948	-	-	-
19	9387.58	Horizontal	*14.96*	*2.560*	16.75	2.585	12.16	9.22	12.45	0.9909	-	-	-
20	9388.66	Horizontal	*20.87*	*2.629*	21.43	2.636	33.98	29.63	33.77	0.988	-	-	-
21	9389.66	Horizontal	*25.48*	*2.645*	25.72	2.649	119.64	113.84	116.87	0.9062	-	-	-
101	9390.00	Horizontal	-	-	27.57	2.653	186.13	176.03	144.96	-0.9399	0	21	79
22	9390.66	Horizontal	-	-	7.35	2.671	-	-	-	-	-	-	-
23	9391.66	Horizontal	-	-	26.84	2.652	114.20	105.72	113.13	0.887	-	-	-
102	9391.83	Horizontal	-	-	25.95	2.651	79.18	72.47	78.54	0.9197	0	21	79
103	9392.33	Horizontal	-	-	23.34	2.645	66.51	60.69	68.86	0.9646	0	27	73
24	9393.00	Horizontal	*22.96*	*2.646*	23.21	2.650	38.82	34.43	38.80	0.9876	-	-	-
25	9394.00	Horizontal	*21.40*	*2.644*	21.63	2.647	35.63	31.03	36.10	0.9868	-	-	-

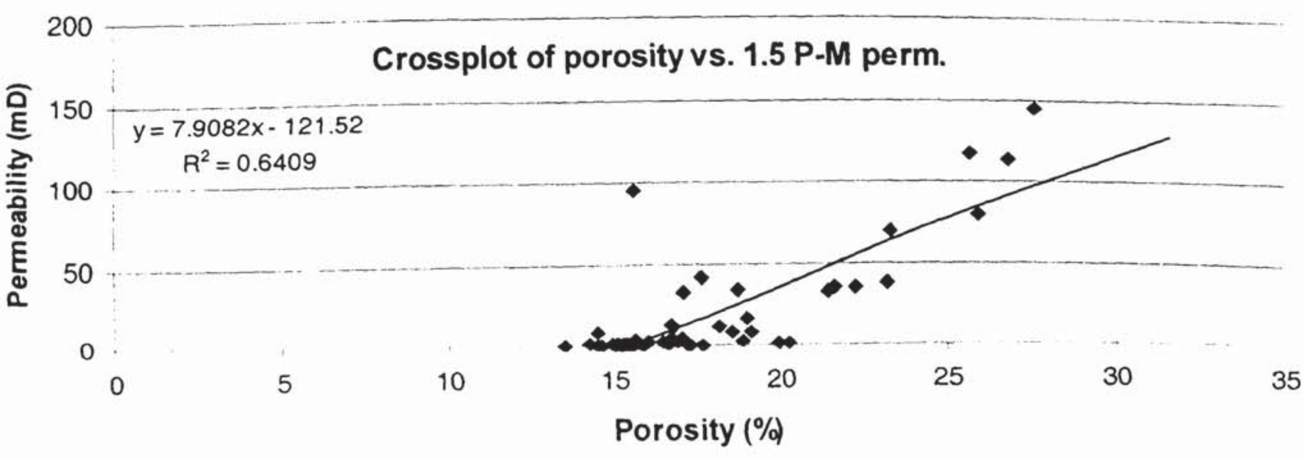
Plug NUMBER	DEPTH Feet	PLUGTYPE	***POROSITY %***	***GR.DENS. g/cc***	POROSITY %	GR.DENS. g/cc	GAS PERM mD	KLINK PERM mD	1.5 PERM mD	KORR.KOEF.	WATER SAT. %	OIL SAT. %	GAS SAT. %
104	9396.42	Horizontal	-	-	17.27	2.647	0.38	0.18	0.37	0.9981	0	21	79
26	9396.42	Horizontal	-	-	15.88	2.642	0.25	0.12	0.24	0.9996	-	-	-
105	9396.75	Horizontal	-	-	15.47	2.642	0.30	0.14	0.27	0.9834	0	25	75
27	9397.42	Horizontal	***21.30***	***2.596***	22.27	2.608	31.58	27.72	36.08	0.963	-	-	-
28	9423.00	Horizontal	***13.23***	***2.589***	15.08	2.616	1.19	0.86	1.07	1	-	-	-
29	9424.00	Horizontal	-	-	15.74	2.635	1.74	1.41	1.85	0.9943	-	-	-
6V	9424.17	Vertical	***15.48***	***2.625***	16.62	2.626	-	-	-	-	-	-	-
7V	9424.17	Vertical	-	-	20.91	2.643	0.09	-	-	-	-	-	-
30	9425.00	Horizontal	***15.50***	***2.574***	17.64	2.606	36.63	32.49	42.67	0.9793	-	-	-
31	9428.41	Horizontal	-	-	15.18	2.624	0.42	0.23	0.42	0.9991	-	-	-
32	9430.16	Horizontal	***13.41***	***2.573***	14.93	2.593	0.75	0.48	0.78	0.9932	-	-	-
33	9449.00	Horizontal	-	-	17.21	2.707	0.60	0.34	0.57	0.9854	-	-	-
34	9450.00	Horizontal	***17.45***	***2.662***	18.51	2.677	7.94	5.73	8.45	0.9958	-	-	-
108	9450.08	Horizontal	-	-	19.11	2.691	8.86	7.12	8.87	0.9709	2	13	85
35	9451.33	Horizontal	***15.12***	***2.618***	16.64	2.642	0.67	0.26	0.67	0.9994	-	-	-
36	9452.33	Horizontal	-	-	18.84	2.629	1.91	1.53	1.95	0.9942	-	-	-
106	9452.75	Horizontal	-	-	20.26	2.665	1.16	0.72	1.13	0.9974	17	8	75
37	9453.50	Horizontal	***19.26***	***2.632***	19.96	2.639	0.79	0.53	0.81	1	-	-	-
38	9454.58	Horizontal	-	-	16.60	2.660	0.82	0.53	0.80	0.9864	-	-	-
39	9455.58	Horizontal	***15.28***	***2.686***	15.53	2.684	0.47	0.24	0.46	1	-	-	-
40	9456.66	Horizontal	-	-	14.60	2.661	0.11	0.03	0.10	0.9983	-	-	-
107	9467.58	Horizontal	-	-	2.99	2.785	0.02	-	-	-	14	9	78
41	9473.83	Horizontal	***12.35***	***2.512***	15.06	2.544	0.12	0.07	0.09	0.965	-	-	-
42	9475.08	Horizontal	***15.59***	***2.571***	15.55	2.546	0.32	0.06	0.11	0.9838	-	-	-
8V	9475.58	Vertical	***13.00***	***2.698***	13.25	2.698	0.01	-	-	-	-	-	-
43	9476.00	Horizontal	***12.21***	***2.507***	14.51	2.533	0.45	0.35	0.45	0.9871	-	-	-
44	9477.08	Horizontal	-	-	14.26	2.538	0.73	0.53	0.71	0.9945	-	-	-
45	9478.16	Horizontal	-	-	13.98	2.574	-	-	-	-	-	-	-

Please observe that the **bold mark porosity and grain density** is the data obtained before the hot soxlet cleaning. The data is obtained on insufficiently cleaned samples.

5.3 Crossplot of porosity vs. Gas perm., Klinkenberg perm. and 1.5 P-M perm







5.4 Lithological description

PLUG Number	DEPTH Feet	PLUG TYPE	POROSITY %	GR.DENS. g/cc	GAS PERM mD	LITHOLOGICAL DESCRIPTIONS
1	9349.33	H	15.39	2.631	1.57	vfsst, mgy, fin lam, calc
1V	9350.08	V	15.23	2.634	0.11	vfsst, mgy, fin lam, calc
2	9350.33	H	15.14	2.630	1.81	vfsst, mgy, fin lam, calc
3	9351.50	H	17.01	2.626	4.91	vfsst, mgy, fin lam, calc
4	9358.83	H	18.99	2.639	17.39	vfsst, mgy, w cly strp, bio, calc
100	9359.00	H	18.74	2.636	42.33	vfsst, mgy, w cly strp, calc
5	9360.67	H	17.11	2.489	33.72	htrl, vfsst/slt/cly, mgy/dgy, calc
6	9362.66	H	16.74	2.643	11.28	vfsst, mgy, w fin slt/cly lam, calc
7	9364.41	H	18.19	2.645	11.95	vfsst, mgy, w fin slt/cly lam, calc
2V	9368.00	V	13.49	2.573	0.16	cly, dgy/blk, fin lam, slg calc, F
8	9368.66	H	16.48	2.556	2.78	cly, dgy/blk, fin lam, F
9	9369.66	H	16.92	2.540	3.25	cly, dgy/blk, fin lam, F
10	9370.66	H	16.73	2.547	6.18	cly, dgy/blk, fin lam, w fsst strp, F
11	9371.66	H	15.28	2.591	0.68	cly, dgy/blk, fin lam, slg calc, F
3V	9372.00	V	14.70	2.544	0.09	cly, dgy/blk, fin lam, slg calc, F
12	9373.33	H	14.49	2.520	8.85	cly, dgy/blk, fin lam, w fsst lam, F
13	9374.33	H	15.60	2.518	3.50	cly, dgy/blk, fin lam, F
14	9375.58	H	20.65	2.556	-	cly, dgy/blk, fin lam, slg calc, F, FT FRA
15	9382.66	H	18.07	2.635	-	htrl, vfsst/slt/cly, mgydg, calc, F, FT FRA
4V	9383.58	V	19.81	2.657	0.10	fsst, lgy, fin lam, calc
5V	9383.58	V	17.68	2.627	0.21	fsst, lgy, fin lam, calc, F
16	9384.16	H	15.61	2.618	76.58	vfsst, dgy, fin lam, calc, F
17	9385.33	H	15.32	2.628	1.08	vfsst, lgy/dk, fin lam, calc
18	9386.25	H	16.02	2.636	2.36	fsst, lgy, fin lam, calc
19	9387.58	H	16.75	2.585	12.16	htrl, vfsst/cly, lgy/dk, calc, F
20	9388.66	H	21.43	2.636	33.98	vfsst, lgy, w cly/slt lam,calc
21	9389.66	H	25.72	2.649	119.64	fsst, lgy, fin lam, calc
101	9390.00	H	27.57	2.653	186.13	fsst, lgy, fin lam, calc
22	9390.66	H	7.35	2.671	-	fsst, lgy, ids lam, tot ccem
23	9391.66	H	26.84	2.652	114.20	fsst, lgy, ids lam, calc
102	9391.83	H	25.95	2.651	79.18	fsst, lgy, ids lam, calc
103	9392.33	H	23.34	2.645	66.51	fsst, lgy, lam, calc
24	9393.00	H	23.21	2.650	38.82	vfsst, lgy, ids lam, calc
25	9394.00	H	21.63	2.647	35.63	vfsst, lgy, lam,calc
104	9396.42	H	17.27	2.647	0.38	vfsst, lgy, ids lam, calc
26	9396.42	H	15.88	2.642	0.25	vfsst, lgy, ids lam, calc
105	9396.75	H	15.47	2.642	0.30	vfsst, lgy, ids lam, calc
27	9397.42	H	22.27	2.608	31.58	htrl, vfsst/cly, lgy/blk, bio, calc
28	9423.00	H	15.08	2.616	1.19	htrl, cly/slt, mgy/blk, fin lam, calc
29	9424.00	H	15.74	2.635	1.74	htrl, cly/slt, mgy/blk, fin lam, calc, F
6V	9424.17	V	16.62	2.626	-	htrl, cly/slt, mgy/blk, fin lam, calc, F

PLUG Number	DEPTH Feet	PLUG TYPE	POROSITY %	GR.DENS. g/cc	GAS PERM mD	LITHOLOGICAL DESCRIPTIONS
7V	9424.17	V	20.91	2.643	0.09	fsst, lgy, w cly lam, calc
30	9425.00	H	17.64	2.606	36.63	htrl, cly/slt, mgy/blk, fin lam, calc, F
31	9428.41	H	15.18	2.624	0.42	vfsst/slt/cly, mgy/dgy, fin lam, calc
32	9430.16	H	14.93	2.593	0.75	vfsst/slt/cly, mgy/dgy, fin lam, bur, calc
33	9449.00	H	17.21	2.707	0.60	fsst, lgy, ids lam, calc
34	9450.00	H	18.51	2.677	7.94	fsst, lgy, w cly lam, calc, w thn cvn
108	9450.08	H	19.11	2.691	8.86	fsst, lgy, w cly lam, some ccem
35	9451.33	H	16.64	2.642	0.67	vfsst/slt/cly, mgy/dg, fin lam, calc, F
36	9452.33	H	18.84	2.629	1.91	vfsst/slt/cly, mgy/dg, fin lam, calc, F
106	9452.75	H	20.26	2.665	1.16	vfsst/slt/cly, mgy/dg, bed
37	9453.50	H	19.96	2.639	0.79	fsst, lgy, w slt/cly lam, calc
38	9454.58	H	16.60	2.660	0.82	htrl, fsst/slt/cly, lgy/dgy, fin lam, calc
39	9455.58	H	15.53	2.684	0.47	fsst, lgy, w slt/cly lam, calc
40	9456.66	H	14.60	2.661	0.11	sst, lgy, w slt/cly lam, calc
107	9467.58	H	2.99	2.785	0.02	slt, dgy, w vffst lam, ccem
41	9473.83	H	15.06	2.544	0.12	cly, blk, fin lam, F
42	9475.08	H	15.55	2.546	0.32	cly, blk, fin lam, F
8V	9475.58	V	13.25	2.698	0.01	vfsst, mgy, slt, w fin lam, calc
43	9476.00	H	14.51	2.533	0.45	cly, blk, fin lam
44	9477.08	H	14.26	2.538	0.73	cly, blk, fin lam
45	9478.16	H	13.98	2.574	-	cly, blk, fin lam

ABBREVIATIONS FOR LITHOLOGICAL DESCRIPTIONS.

Rock type	carb	Carbonate
	chk	Chalk
	cly	Claystone
	cl	Clay
	fl	Flint/chert
	slt	Siltstone
	sst	Sandstone
	sd	Sand
	cngl	Conglomerate
	htrl	Heterolith
Grain size	vf-	Very fine grained
	f-	Fine grained
		ex. fsst = fine grained sst
	m-	Medium grained
	c-	Coarse grained
	vc-	Very coarse grained
	unsrt	Unsorted
Colour	blk	Black
	br	Brown
	gn	Green
	gy	Grey
	ol	Olive
	rd	Red
	wh	White
	vl-	Very light
	l-	Light, ex. lgy = light grey
	ml-	Medium light
	m-	Medium
	md-	Medium dark
	d-	Dark
	-sh	-ish, ex. brsh = brownish
	var	Varioloured
Structures	bed	Bedding
	bio	Bioturbation
	brc	Brecciated
	bur	Burrow(-s)
	cho	Chodrites
	cla	Clast(-s)
	crs	Crossbedding
	cvn	Calcite vein(-s)
	concr	Concretion
	domn	Domains
	fos	Fossil (-s)
	frg	Fragment(-s)
	lam	Lamina/lamination
	pynd	Pyrite nodule(-s)
	shl	Shell fragment(-s)
	slmp	Slumped
	sly clv	Slaty cleavage
	sol sm	Solution seam(-s)
	spng	Sponge(-s)
	strp	Stripe
	sty	Stylolite seam(-s)
	trc fos	Trace fossil(-s)
	vn	Vein
	zoo	Zoophycos
Miscellaneous	ab	Abundant
	arg	Argillaceous
	art	Artificial
	bit	Bitumineous
	calc	Calcareous
	ccem	Calcite cemented
	cem	Cemented
	ds	Distinct
	dom	Dominantly
	fnt	Faint
	fw	Few
	hrd	Hard
	hom	Homogeneous
	ids	Indistinct
	int	Intraformational
	mny	Many
	mot	Mottled
	prt	Partly
	sil	Silicified
	slg	Slightly
	sme	Some
	sort	Sorting
	str	Strongly
	sp	Sparse
	thn	Thin
	thk	Thick
	tot	Total
	v	Very
	w	With
Fractures	FRC	Fracture
	FT FRC	Fatal fracture
	SG FRC	Significant fracture
	F FRC	Fine fracture
	H FRC	Hairline
	ST FRC	Stylolite ass. fracture
Minerals	fsp	Feldspar
	mica	Mica flakes
	qtz	Quartz/silica
	py	Pyrite

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