DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2003/35

Special Core Analysis for Mærsk Olie og Gas A/S

Well: Sif-1X

Amott wettability, mercury injection, capillary pressure and electrical measurements

Niels Springer and Gert Andersen

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
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1. Introduction

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

The experimental programme was specified in a facsimile message from Ms. Pia M. Hansen, dated September 1, 1999. The following analytical programme has been carried out:

- CT-screening of plugs for SCAL
- Formation resistivity factor measurement at overburden conditions
- Resistivity index measurement at overburden conditions
- Mercury injection capillary pressure at overburden conditions
- Amott wettability test at ambient conditions

This study is carried out under contract GSC 1418, CWO 174. Preliminary SCAL data have been reported to Mærsk during the period October 2000 to November 2001.

2. Sampling and analytical procedures

In collaboration with Mærsk Olie og Gas and based on the conventional core analysis data [1] in total 29 plugs from the Danian and Maastrichtian section of the core were selected for the special core analysis (SCAL) study, ref. table 2.1.

2.1 Plug quality screening

The total SCAL plug set were X-ray CT-screened using the scanning facility at the Department of Chemical Engineering, Technical University of Denmark. Two longitudinal cuts perpendicular to each other are recorded for each plug. Scanning images are included with section 5.3.

2.2 Amott wettability

Based on the scanning images, 7 preserved samples were selected for Amott's test, table 2.1 and section 5.1.

2.2.1 Initial plug characterization and preparation

Data from plug off-trims were used to obtain an estimate of the porosity and fluid saturation of the preserved plug samples. Mærsk supplied data for the target S_{wi}. All samples contained excess water due to downhole water imbibition (water base drilling mud). Therefore plugs for Amott's test were subjected to oil flooding down with Isopar-L™ laboratory oil. The experimental set-up was heated to about 40^{o}C during the preparation step for the purpose of dissolving/displacing most of the dead oil in the plug samples as well during the lab. oil flooding. Permeability was monitored during the experiment. The target S_{wi} as specified by Mærsk could not be reached for the samples.

Original brine produced from the plugs during oil flooding down was collected and analyzed for density to improve the material balance calculations. Significant scatter in water density was observed.

2.2.2 Spontaneous imbibition

The spontaneous imbibition cycles lasted for approx. two months. Intensive recording of the water imbibition was done in the beginning of the cycle as required by Mærsk in their specification to the experimental programme. Plug no. 18, 118 and 134 were selected in cooperation with Mærsk Olie og Gas A/S to undergo also the oil imbibition part of Amott's test. No oil imbibition was observed to take place. Further details of the wettability test are described in the analytical section 4.

2.2.3Instrumental

Spontaneous imbibition of brine and laboratory oil took place in traditional glass imbibition cells. Plugs were fixed with at spring to prevent grain loss during shaking of the imbibiometer.

Flushing of samples was done in a coreholder with 35 bar confining sleeve pressure, and 30bar differential pressure. Differential pressure was maintained at 30 bar by continous adjustment of the flowrate. Flowrates were controlled by a computer, and the permeabilities were measured and written to files in the same operation.

2.3 Electrical measurements

From inspection of the scanning images the most homogeneous plugs were selected for the electrical measurements, table 2.1. A few of the plugs were trimmed to remove excessive pyrite sitting close to the end

surfaces. Plugs were next vacuum and pressure saturated in simulated formation brine, table 2.2, and then left to equilibrate in an anaerobic jar for several weeks.

The pore volume compressibility was recorded during a period of 24 hours while the confining sleeve pressure was increased from 150 psi to 800 psi. During the following 2-3 days regular measurements of the plug resistivity R_0 at $S_w = 1$ was carried out until stable readings were obtained. The resistivity index was measured during a period of 4-5 weeks using the RICI technique. The samples were mounted in single cells at a net confining pressure of 800 psi without a porous plate. Archie parameters are contained in section 5.2.

2.4 Mercury injection capillary pressure

A set of 10 plugs of diameter 38 mm was used for mercury injection capillary pressure measurement. Plugs were installed in core holders at 800 psi net confining pressure and both the injection and withdrawal curve was measured from vacuum to 2000 psi. A stepwise constant pressure measurement regime was applied and total analytical time was 2-4 days per plug sample. Reservoir Laboratories A/S carried out this study, and results are given in a separate report (no. 2071/45-00).

SCAL test	Danian D1+D2A and Maastrichtian M1 chalk unit
FRF+RI :	6, 29, 55, 97, 111, 120, 129, 132, 142, 175
Wettability :	4, 18, 38, 117, 118, 134, 153
Hg-injection :	7, 22, 48, 60, 85, 114, 125, 171, 186, 15X
Reserve :	121, 180

Table 2.1. Sif-1X, 29 plugs were X-ray CT-screened and a number of plugs were later taken for the specified special core analysis tests. Two plugs were being kept in reserve.

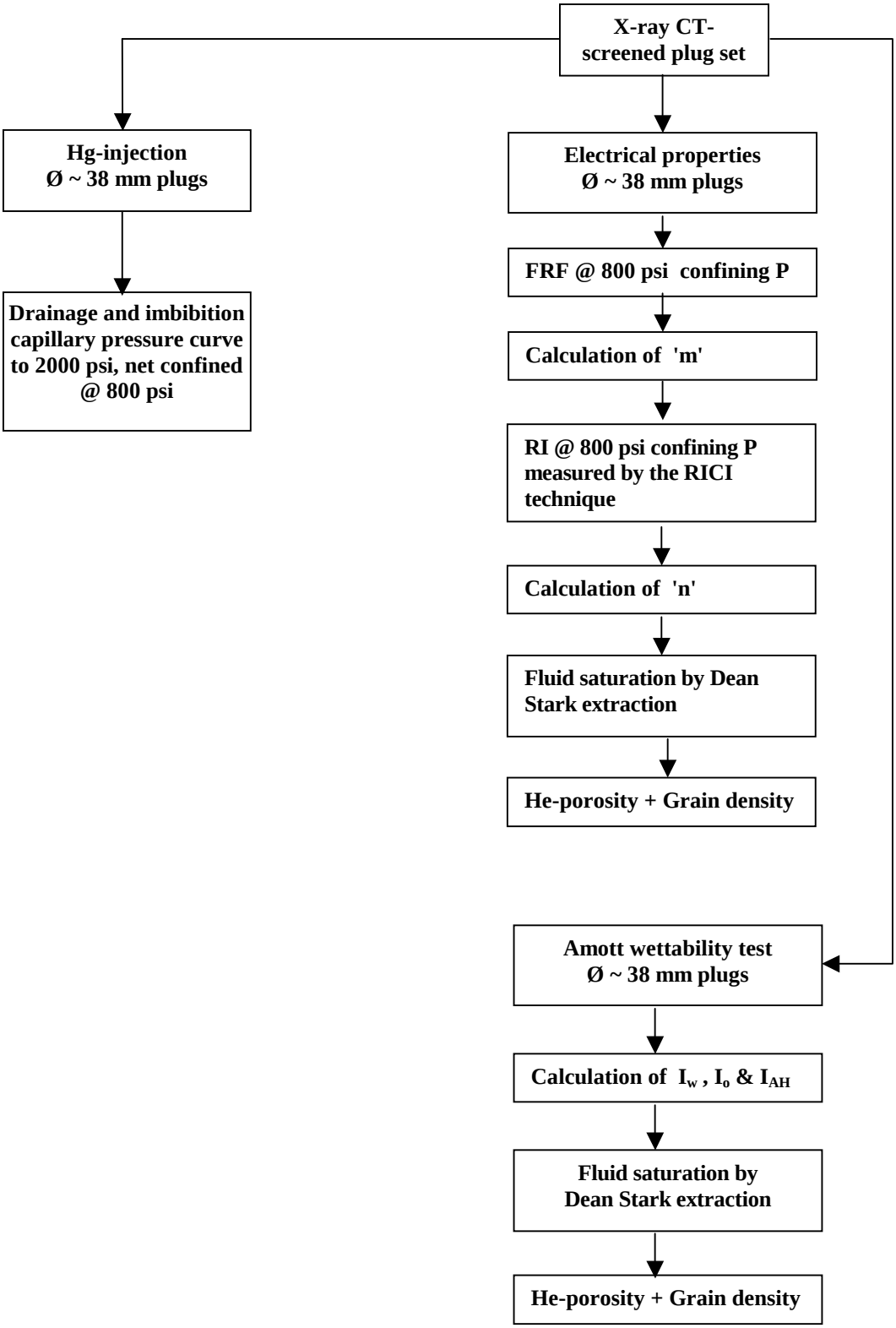
Element	Concentration
	mg/l
Na total	16200
Na+	16200
Na+	0
K+	145
Mg2+	290
Ca2+	1020
Ca2+	
Ca2+	
Sr2+	80
Ba2+	
Cl-	27829
HCO3-	0
TDS:	45564

Table 2.2. Sif-1X, chemical and physical data for the simulated formation brine. The chemical composition is formulated by GEUS Core Laboratory based mainly on Tyra field formation water composition and information from Mærsk Olie og Gas.

$NaHCO_3$ is excl. from the reciepe, but the brine equilibrated with crushed chalk.

Physical data:		
pH: 7.8 @ 23 °C	Measured R_w	0.145 ohmm @ 25 C
	Calculated R_w	0.141 ohmm @ 25 C
	Measured d_w	1.028 g/ml @ 25 C
	Calculated d_w	n.d. g/ml @ 25 C

3. Flow diagram of the analytical procedures

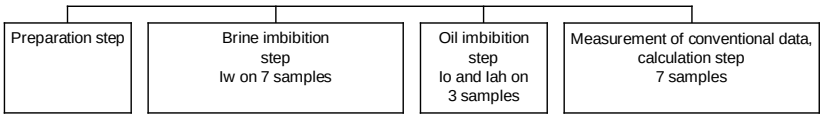


Amott wettability procedure:

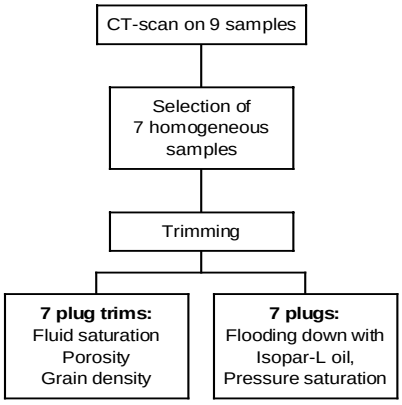
Room temperature ~ 25 °C
Minimum flooding volumes: 7 PV's

Confining sleeve pressure during forced imb.: 35 bar
Differential pressure: 30 bar

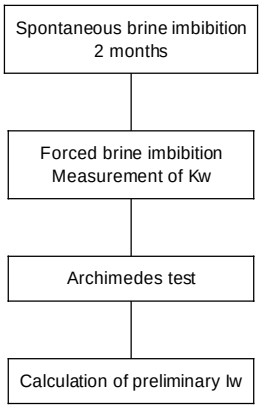
Analytical steps



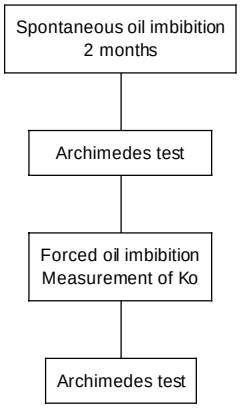
Preparation



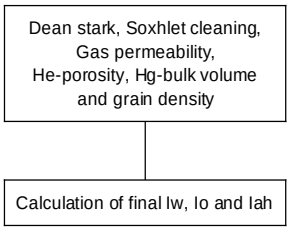
Brine imbibition



Oil imbibition



Routine data and calculation



4. Analytical methods

For an explanation of the routine core analysis methods, please refer to the conventional core analysis report [1].

Electrical measurements are performed at 25 ± 1 ºC, and to the guidelines established by the Society of Core Analysts [2].

4.1 Formation resistivity factor

In a "clean" formation (non-shaly) the formation factor F is described by Archie's equation:

$$F = \frac{R_0}{R_w} = \frac{a}{Ø^m}$$

Where
R_0 = resistivity of sample @ S_w = 100%
R_w = resistivity of formation brine
Ø = porosity
a = constant
m = cementation exponent

For a plug sample F is calculated from the following formula:

$$F = \frac{1}{R_w} \cdot \frac{z \cdot A}{L}$$

Where
R_w = resistivity of brine in ohm-m
z = impedance of plug sample in ohm @ S_w = 100%
A = area of the plug in m^2
L = length of plug in m

Rearranging Archie's equation for the formation factor:

$$\log F = -m \log Ø + \log a$$

produces a straight-line relationship in a double logarithmic diagram where F is plotted as a function of Ø. The constant a is then determined as the intercept and the cementation exponent m as the slope of the best fit straight line. Values for m are usually preferred for a = 1, which is expected from theoretical grounds. Therefore a set of regression constants are given for a regression line which has been biased through (1,1).

The measurement of F is performed with the plug mounted in a 2-electrode resistivity core holder at an overburden pressure >300 psi. The plug is allowed to settle for more that 3 hours. The porosity reduction/pore volume compressibility is recorded consecutively. The plug resistance is measured as the impedance to an AC signal of 5-20 kHz frequency depending of the resistivity cell design (minimum phase angle). Data logging is performed using the HP 4276A LCZ-meter controlled by a PC. The resistivity of the brine is measured in a specially designed standard cell. The standard cell is calibrated using a suitable conductivity standard solution delivered by a recognised chemical company. The measured formation brine resistivity is checked against a model calculated resistivity.

4.2 Resistivity index

In a "clean" formation (non-shaly) Archie determined experimentally that the water saturation could be expressed by the following equation:

$$S_w^{\,n} = \frac{FR_w}{R_t} = \frac{R_o}{R_t} = \frac{1}{RI}, \qquad RI = \frac{R_t}{R_o}$$

where
S_w = water saturation
n = saturation exponent
F = formation resistivity factor
RI = resistivity index
R_0 = resistivity of sample @ S_w = 100% in ohm-m
R_t = resistivity of sample @ S_w < 100% in ohm-m
R_w = resistivity of brine in ohm-m

Rearranging Archie's equation for the water saturation :

$$RI = S_w^{\,-n}$$

and

$$\log(RI) = -n \ \log(S_w)$$

In a double logarithmic diagram consecutive values of S_w and RI should produce a straight line from which the saturation exponent n can be determined as the slope.

Measurement of RI is conducted by the constant injection (RICI) technique or the constant pressure technique with or without a porous plate fitted to the downstream end of the plug sample. The measurement of RI is performed with the plug mounted in a resistivity core holder at an overburden pressure >300 psi. The plug is allowed to settle for more that 3 hours. The porosity reduction/pore volume compressibility is recorded consecutively. The two-electrode method is normally applied and the resistance measured as the impedance to an AC signal of 5-20 kHz frequency depending of the resistivity cell design and the type of rock (minimum phase angle). Data logging is performed using the HP 4276A LCZ-meter controlled by a PC.

4.3 Amott wettability test

Wettability measurements are carried out on fresh or preserved core as soon as possible after the core has been cut. The test is carried out using degassed stocktank oil at reservoir temperature or laboratory oil at ambient temperature. Dry core material should be extensively cleaned before it is aged in stocktank oil at reservoir temperature for an extended period of time (4-6 weeks).

During four measurement steps Amott's test records the spontaneous and forced imbibition of brine and oil into a core sample initially at S_{wi}. The symbols used in the following refer to figs. 4.1 and 4.2:

The sample is placed in a brine filled imbibiometer, and the spontaneous imbibed brine $\mathbf{V_{ws1}}$ is equal to the volume of displaced oil.

The sample is removed from the imbibiometer and placed in a core holder. The forced brine imbibition is carried out by flowing brine through the sample at increasing rates until a differential pressure of 200 psi (in this study 450 psi) has been attained across the sample. The volume of brine taken up by forced imbibition $\mathbf{V_{wf2}}$ is equal to the volume of displaced oil.

The sample, which is now at S_{or}, is placed in an oil filled imbibiometer, and the spontaneous imbibed oil $\mathbf{V_{os3}}$ is equal to the volume of displaced brine.

The sample is removed from the imbibiometer and placed in a core holder. The forced oil imbibition is carried out by flowing oil through the sample at increasing rates until a differential pressure of 200 psi (in this study 450 psi) has been attained across the sample. The volume of oil taken up by the forced imbibition $\mathbf{V_{of4}}$ is equal to the volume of displaced brine.

Material balance calculations are performed after each step in the Amott test based on the weight of the plug and, if possible, the collected volume of displaced phase. The wettability index to water $\mathbf{I_w}$ and oil $\mathbf{I_o}$ is calculated from the following:

$$\mathbf{I_w = V'_{ws1}/(V'_{ws1}+V'_{wf2})}$$
$$\mathbf{I_o = V'_{os3}/(V'_{os3}+V'_{of4})}$$

where $\mathbf{V'_{xx}}$ indicates mass balance corrected volumes.
Amott index = 1 indicates a very strongly wetting fluid
Amott index = 0 indicates a very weakly wetting fluid
If $\mathbf{I_w = I_o}$ ~ 0 the sample is said to have neutral wettability to the fluids.

The Amott-Harvey index $\mathbf{I_{AH}}$ is calculated from the difference between the two indices:

$$\mathbf{I_{AH} = I_w - I_o}$$

Amott-Harvey index = [+1, +0.3] indicates a water wet system
Amott-Harvey index = [+0.3, -0.3] indicates an intermediate wet system
Amott-Harvey index = [-0.3, -1] indicates an oil wet system

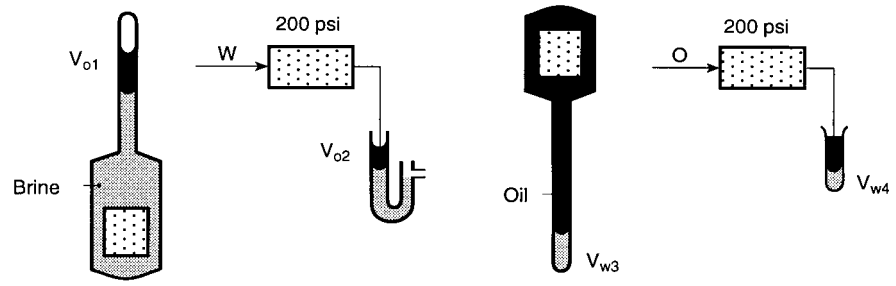


Fig. 4.1. Sketch showing the four steps of Amott's wettability test.

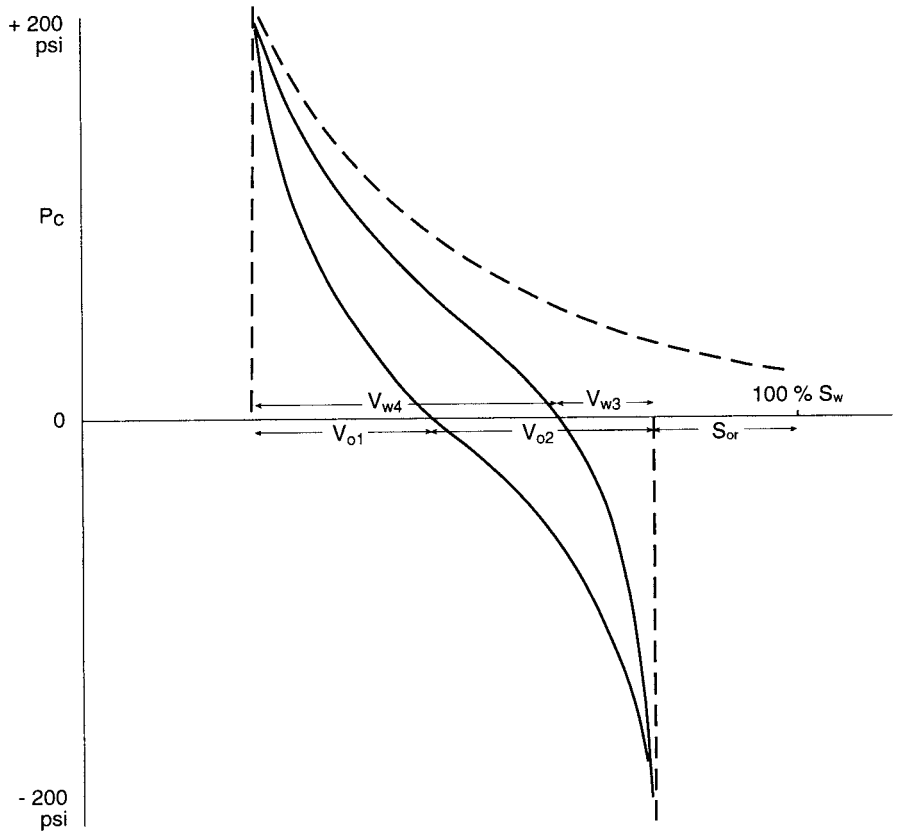


Fig. 4.2. Hysteresis loop showing the relationship between Amott's wettability and capillary pressure curves for a mixed-wet system.

5. Results

5.1 Wettability data

5.1.1 Plug trim data and connate water saturation

To check the condition of the preserved plugs selected for wettability test, a plug trim was cut. The measured conventional data, including fluid saturations by Dean Stark extraction, are listed in table 5.1.

Plug no.	Depth in feet	Porosity %	GD g/cc	S_w %	S_o %	S_g %	Target S_{wi} *
4	6725.08	37.30	2.726	51.1	7.5	41.5	5
18	6740.25	35.05	2.711	58.3	9.9	31.8	6
38	6762.17	30.78	2.726	63.8	11.6	24.7	8
117	6850.67	24.36	2.715	74.9	4.7	20.5	13
118	6871.17	36.78	2.717	36.0	27.0	37.1	5
134	6890.08	24.70	2.719	58.1	16.8	25.0	12
153	6910.67	19.34	2.721	71.6	4.0	24.4	21

Table 5.1. Plug offtrim data measured on preserved plugs from Sif-1X.

5.1.2 In-situ brine density

During initial flooding down, in-situ brine was displaced from the preserved plugs. This brine was collected and the density measured as an aid in the initial material balance calculations, table 5.2.

Plug no.:	Measured in-situ brine density	Remarks %
	g/ml	
4	1,052	
18	1,065	
38	1,061	
117	1,051	
118	1,095	
134	1,059	
153	1,080	Suspended material of red colour.

Table 5.2. Density of the displaced brine from the Sif-1X preserved samples.

5.1.3 Sif-1X, Amott wettability data at ambient conditions.

Basis data:					Initial step		Brine imbibition				Oil imbibition				Brine volumes		Oil volumes		Amott calculations		
Plug	**Depth in feet**	**Ø**	**BV**	**GD**	**S_{wi}**	**K_o @ S_{wi}**	**S_{w1}**	**S_{w2}**	**S_{or}**	**K_w @ S_{or}**	**S_{w3}**	**S_{w4}**	**S_{wf}**	**K_o @ S_{wf}**	**V_{ws1}**	**V_{wf2}**	**V_{os3}**	**V_{of4}**	**I_w**	**I_o**	**I_{AH}**
no.		pct	ml	g/ml	pct	mD	pct	pct	pct	mD	pct	pct	pct	mD	ml	ml	ml	ml			
4	6725.08	37,05	38,74	2,708	19	0,5	64	68	32	0,09			68		6,55	*0,51**			**0,93**		
18	6740.25	32,46	39,22	2,714	18	0,36	61	62	38	0,07	62	24	24	0,30	5,45	0,1	0,00	4,75	**0,98**	**0,00**	**0,98**
38	6762.17	30,65	37,15	2,709	27	0,09	56	56	44	0,01			56		3,30	0,1			**0,97**		
117	6850.67	24,52	41,13	2,712	35	0,03	60	60	40	<0,00			60		2,50	0,0			**1,00**		
118	6871.17	35,71	44,68	2,711	5	1,62	41	72	28	0,42	72	17	17	1,20	5,80	5,0	0,00	8,85	**0,54**	**0,00**	**0,54**
134	6890.08	24,57	39,73	2,713	21	0,18	54	54	46	0,02	54	18	18	0,14	3,20	0,0	0,00	3,50	**1,00**	**0,00**	**1,00**
153	6910.67	18,22	41,88	2,712	44	0,73[+]	62	62	38	0,05[+]			62		1,40	0,0			**1,00**		

[+] Open fracture observed in plug

***** calculated from weight difference

List of abbreviations and symbols used in the table. Units are given in square brackets.

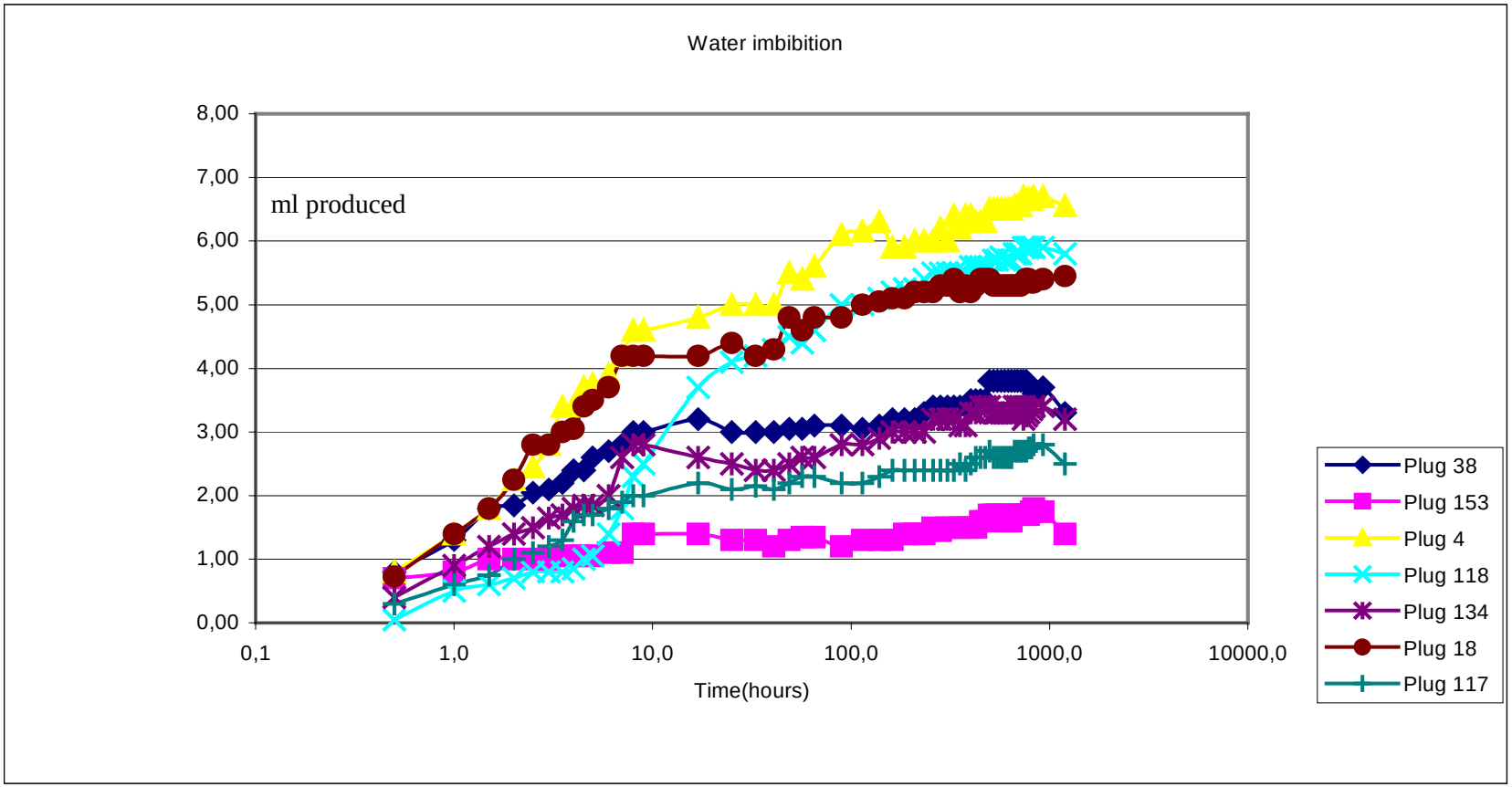
Ø : Porosity [percent]
BV : Bulk Volume [ml]
GD : Grain Density [g/ml]
S_w : Water saturation [percent of pore volume]
S_o : Oil saturation [percent of pore volume]
S_{or} : Residual (or immobile) oil saturation [percent of pore volume]
S_g : Gas saturation [percent of pore volume]

S_{wi} : Initial water saturation before Amott's test [percent of pore volume]
S_{w1} : Water saturation after spontaneous water imbibition, Amott step 1 [pct]
S_{w2} : Water saturation after forced water imbibition, Amott step 2 [pct]
S_{w3} : Water saturation after spontaneous oil imbibition, Amott step 3 [pct]
S_{w4} : Water saturation after forced oil imbibition, Amott step 4 [pct]
S_{wf} : Final water saturation by Dean Stark after Amott's test [percent of pore volume]

V_{ws1} : Volume of spontaneous imbibed water, Amott step 1 [ml]
V_{wf2} : Volume of forcefully imbibed water, Amott step 2 [ml]
V_{os3} : Volume of spontaneous imbibed oil, Amott step 3 [ml]
V_{of4} : Volume of forcefully imbibed oil, Amott step 4 [ml]

I_w : Amott water wetting index
I_o : Amott oil wetting index
I_{AH} : Amott-Harvey wettability index

Fig. 5.1. Sif-1X, volumes (incl. a small amount of gas) recorded during spontaneous brine imbibition.



5.1.4 Volumes recorded during spontaneous brine imbibition

Dec. hour	Plug 38	Plug 153	Plug 4	Plug 118	Plug 134	Plug 18	Plug 117
0,5	0,80	0,70	0,80	0,05	0,40	0,73	0,30
1,0	1,30	0,80	1,40	0,50	0,90	1,40	0,60
1,5	1,80	1,00	1,80	0,60	1,20	1,80	0,75
2,0	1,85	1,00	2,25	0,70	1,40	2,25	1,00
2,5	2,05	1,00	2,45	0,80	1,50	2,80	1,10
3,0	2,10	1,00	2,80	0,80	1,65	2,80	1,20
3,5	2,20	1,05	3,40	0,80	1,70	3,00	1,30
4,0	2,40	1,05	3,40	0,85	1,80	3,05	1,60
4,5	2,40	1,05	3,70	1,00	1,85	3,40	1,70
5,0	2,60	1,05	3,75	1,05	1,85	3,50	1,70
6,0	2,70	1,10	3,90	1,40	2,00	3,70	1,80
7,0	2,80	1,10	4,20	1,80	2,60	4,20	1,90
8,0	3,00	1,40	4,60	2,30	2,80	4,20	2,00
9,0	3,00	1,40	4,60	2,50	2,80	4,20	2,00
17,0	3,20	1,40	4,80	3,70	2,60	4,20	2,20
25,0	3,00	1,30	5,00	4,10	2,50	4,40	2,10
33,0	3,00	1,30	5,00	4,20	2,40	4,20	2,15
40,8	3,00	1,20	5,00	4,30	2,40	4,30	2,10
48,8	3,05	1,30	5,50	4,50	2,50	4,80	2,20
56,8	3,05	1,35	5,40	4,40	2,60	4,60	2,30
65,3	3,10	1,35	5,60	4,60	2,60	4,80	2,30
89,3	3,10	1,20	6,10	5,00	2,80	4,80	2,20
114,3	3,05	1,30	6,15	5,00	2,80	5,00	2,20
138,8	3,10	1,30	6,30	5,10	2,90	5,05	2,30
161,8	3,20	1,30	5,90	5,20	3,00	5,10	2,40
185,8	3,20	1,40	5,90	5,25	3,00	5,10	2,40
209,8	3,20	1,40	6,00	5,25	3,00	5,20	2,40
233,8	3,30	1,40	6,00	5,40	3,00	5,20	2,40
257,8	3,40	1,50	6,00	5,50	3,20	5,20	2,40
281,8	3,40	1,45	6,20	5,50	3,20	5,30	2,40
305,8	3,40	1,50	6,00	5,50	3,20	5,30	2,40
329,8	3,40	1,50	6,40	5,50	3,20	5,40	2,40
353,8	3,40	1,50	6,20	5,50	3,10	5,20	2,50
377,8	3,40	1,50	6,40	5,50	3,10	5,30	2,40
401,8	3,50	1,50	6,40	5,60	3,30	5,20	2,50
425,8	3,50	1,50	6,30	5,60	3,30	5,30	2,60
449,8	3,50	1,60	6,30	5,60	3,40	5,40	2,60
473,8	3,50	1,60	6,30	5,60	3,40	5,40	2,60
497,8	3,80	1,70	6,50	5,60	3,40	5,40	2,70
521,8	3,80	1,70	6,50	5,70	3,30	5,30	2,60
545,8	3,80	1,70	6,50	5,70	3,30	5,30	2,60
569,8	3,80	1,70	6,50	5,75	3,30	5,30	2,60
593,8	3,80	1,60	6,50	5,70	3,30	5,30	2,60
617,8	3,80	1,60	6,50	5,70	3,30	5,30	2,60
641,8	3,80	1,60	6,50	5,70	3,30	5,30	2,60
665,8	3,80	1,70	6,55	5,80	3,40	5,30	2,70
689,8	3,80	1,70	6,55	5,80	3,40	5,30	2,70
713,8	3,80	1,70	6,55	5,80	3,40	5,30	2,70
737,8	3,80	1,70	6,70	5,90	3,20	5,35	2,70
761,8	3,80	1,70	6,65	5,90	3,25	5,40	2,70
785,8	3,75	1,70	6,65	5,90	3,30	5,40	2,75
809,8	3,70	1,75	6,65	5,90	3,35	5,35	2,75
833,8	3,60	1,80	6,70	5,90	3,40	5,35	2,80
929,8	3,70	1,75	6,70	5,90	3,40	5,40	2,80
1193,8	3,30	1,40	6,55	5,80	3,20	5,45	2,50

- imbibition volumes are given in ml.
- The last measurement (1193,8 hours) has been corrected for a small amount of gas.

5.2 Electrical measurements

5.2.1 Formation resistivity factor data

Formation / Chalk unit	Plug no.	Porosity Ø @ 800 psi	Formation factor FRF	Cementation exponent m
Ekofisk/Danian D1+D2A	6 29 55 97 111	39,74 35,10 30,26 24,14 17,24	6,1 8,7 13,2 24,4 35,5	2.10
Tor / Maastrichtian M1	120 129 132 142 175	40,49 35,84 28,84 17,50 24,17	6,0 7,1 10,5 28,3 14,5	1.90

Table 5.3. Sif-1X, analytical data corrected for pore volume compressibility. Basic data are shown in the tables below.

Nomenclature

L	– sample length [cm]
D	– sample diameter [cm]
BV	– bulk volume [cc]
PV	– pore volume [cc]
GV	– grain volume [cc]
GD	– grain density [g/cc]
DW	– dry weight [g]
WW	– wet weight [g]
Ø	– porosity [pct. or fraction]
S_w	- water saturation [pct. or fraction]
S_{wf}	- final water saturation [pct. or fraction]
S_{wir}	- irreducible water saturation [pct. or fraction]
F or FRF	– formation resistivity factor
RI	– resistivity index
RICI	– resistivity index by continuous injection
m	– cementation exponent
n	– saturation exponent
a	– Archie constant, normally a=1
R_0	- resistivity of water saturated sample [ohm meter]
R_w	- resistivity of formation water [ohm meter]
Z_0	- impedance of formation water saturated sample [ohm]
Z_t	- impedance of sample at $S_w < 1$[ohm]
τ	- tortuosity

Table 5.4. Sif-1X, conventional and material balance data for the selected plug set to be measured for electrical parameters. Formation factor data appears from the table below.

Subject: Electrical properties **Well: Sif-1X**
Company: Mærsk Olie og Gas A/S **GEUS Core Lab, 28.02.2001**

Brine density, g/ml: 1,028

Plug no.	Depth	CCAL data				Data after careful plug trim								Mass balance data		
	feet	BV, cc	Dry wt., g	Porosity, %	GD, g/cc	L, mm	D, mm	Dry wt., g	Wet wt., g	BV', cc	PV1, cc	PV2, cc	Delta PV, cc	M_{grain}, g	M_{fluid}, g	ΣM_{plug}, g
6	6727,00	64,67	104,63	40,29	2,708	55,40	37,70	99,78	125,31	61,78	24,89	24,83	0,06	99,88	25,59	125,46
29	6752,67	58,74	102,45	35,57	2,708	50,39	37,87	98,98	119,25	56,72	20,17	19,72	0,45	98,95	20,74	119,69
55	6779,08	57,60	108,21	30,60	2,708	49,22	37,85	104,14	121,33	55,41	16,96	16,72	0,23	104,12	17,43	121,55
97	6824,92	55,33	113,03	24,48	2,705	47,56	38,04	110,73	124,27	54,2	13,27	13,17	0,10	110,72	13,64	124,36
111	6843,33	51,03	114,16	17,52	2,711	43,83	38,08	111,43	120,60	49,85	8,73	8,92	-0,19	111,47	8,98	120,44
120	6874,67	59,01	93,60	41,40	2,707	50,77	37,76	90,42	114,82	56,99	23,59	23,74	-0,14	90,41	24,25	114,66
129	6884,00	54,75	94,51	36,28	2,711	47,01	37,84	91,78	111,51	53,09	19,26	19,19	0,07	91,72	19,80	111,52
132	6888,17	48,29	92,64	29,30	2,714	39,97	37,94	87,19	100,85	45,45	13,31	13,29	0,03	87,20	13,69	100,89
142	6898,00	48,59	107,88	18,13	2,712	40,86	38,09	104,20	112,88	46,94	8,51	8,44	0,07	104,20	8,75	112,95
175	6934,08	54,64	111,94	24,42	2,712	46,14	38,01	108,13	121,24	52,73	12,87	12,75	0,12	108,09	13,23	121,32

PV1: pore volume calculated from He-porosity measurement
PV2: pore volume calculated from wet-dry plug wt.

Subject: Electrical properties by RICI
Company: Mærsk Olie og Gas A/S

Well: Sif-1X
GEUS Core Lab, 07.03.2001

Formation Resistivity Factor data

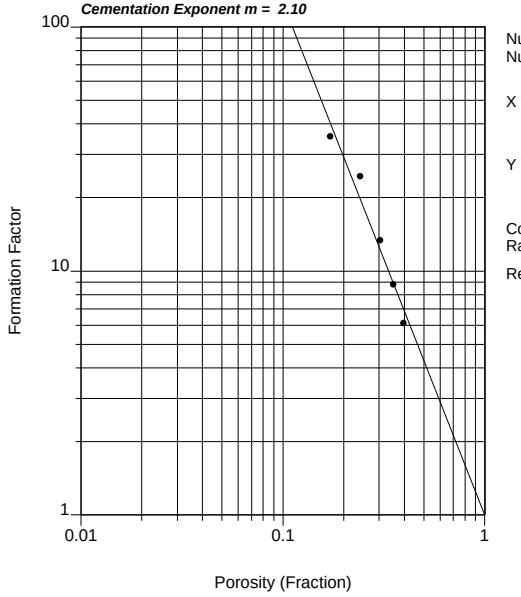
Brine density, g/ml: 1,028 Brine resistivity, ohmm: 0,145 @ 25 C Plug impedance measured @ 10 kHz

Plug no	SCAL data			Overburden data @ 800 pi				Plug resistivity data @ 800 psi				
	BV', cc	PV1, cc	Ø , %	Δ PV800 psi, cc	PV800 psi, cc	Ø 800psi, %	τ	L800 psi, cm	A800 psi, cm2	|Z0|, ohm	Phase, deg.	FRF
6	61,78	24,89	40,29	0,56	24,33	39,74	2,4	5,523	11,08	43,8	-0,29	6,1
29	56,72	20,17	35,57	0,41	19,76	35,10	3,1	5,027	11,20	56,9	-0,20	8,7
55	55,41	16,96	30,60	0,27	16,69	30,26	4,0	4,914	11,22	83,9	-0,96	13,2
97	54,20	13,27	24,48	0,24	13,03	24,14	5,9	4,749	11,36	148,0	-0,87	24,4
111	49,85	8,73	17,52	0,17	8,56	17,24	6,1	4,378	11,35	198,4	-0,90	35,5
120	56,99	23,59	41,40	0,87	22,72	40,49	2,4	5,051	11,11	39,4	-0,54	6,0
129	53,09	19,26	36,37	0,36	18,90	35,84	2,5	4,690	11,24	42,7	-0,62	7,1
132	45,45	13,31	29,35	0,29	13,02	28,84	3,0	3,988	11,32	53,5	-1,57	10,5
142	46,94	8,51	18,11	0,36	8,15	17,50	4,9	4,076	11,43	146,1	-0,71	28,3
175	52,73	12,87	24,44	0,17	12,70	24,17	3,5	4,609	11,40	85,0	-0,42	14,5

Raw data					
Imp1, ohm	Imp2, ohm	Imp3, ohm	Phase1, deg.	Phase2, deg.	Phase3, deg.
43,91	43,84	43,79	-0,30	-0,25	-0,31
56,96	56,86	56,79	-0,19	-0,18	-0,23
84,93	84,76	82,13	-1,09	-1,08	-0,71
148,20	148,00	147,90	-0,86	-0,87	-0,89
198,50	198,40	198,40	-0,90	-0,90	-0,90
40,20	39,80	38,11	-0,59	-0,56	-0,48
43,00	42,61	42,48	-0,67	-0,64	-0,55
54,01	53,51	53,10	-1,65	-1,64	-1,42
146,90	146,35	145,10	-0,76	-0,78	-0,60
85,78	84,92	84,16	-0,46	-0,44	-0,37

PV1: pore volume calculated from He-porosity measurement
BV' : bulk volume from mercury submersion

Sif-1X, Danian samples
Cementation Exponent m = 2.10



Number of data 5
Number plotted 5

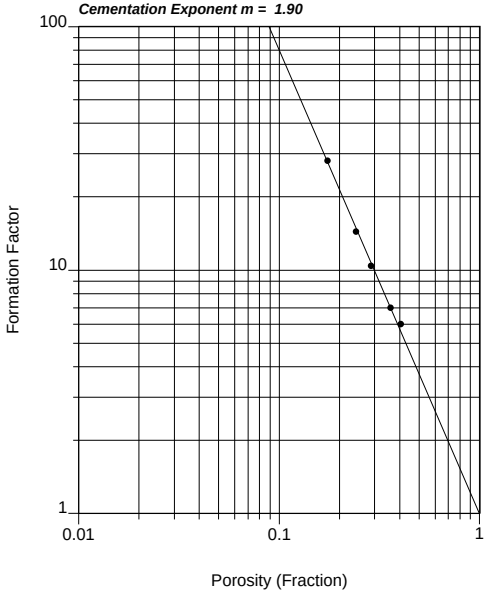
X Variable:
geom. mean 0.281
std. dev. 1.346

Y Variable:
geom. mean 14.426
std. dev. 1.907

Correlation -0.979
Rank correlation -1.000

Regression:
intercept 1.00
slope -2.10

Sif-1X, Maastrichtian samples
Cementation Exponent m = 1.90



Number of data 5
Number plotted 5

X Variable:
geom. mean 0.282
std. dev. 1.347

Y Variable:
geom. mean 11.207
std. dev. 1.737

Correlation -0.998
Rank correlation -1.000

Regression:
intercept 1.00
slope -1.90

Archie parameters: a = 1.0

Danian m = 2.10
Maastrichtian m = 1.90

Mean tortuosity:

Danian τ = 4.30
Maastrichtian τ = 3.26

5.2.2 Resistivity index data

Background: In the original CWO from Mærsk, GEUS Core Laboratory was asked to perform resistivity index measurements by the RICI technique on a set of 10 plugs for a period of 3 weeks. A low injection rate of 0.1 ml/h was decided for and the experiment initiated without a porous plate in the downstream end of the plug. From other studies it is known that the addition of a porous plate will extend the experiment for more than 6 months if equilibrium data be obtained. However, with the low injection rate water saturations below 70% were not reached, meaning a poor determination of the saturation exponent. It was therefore decided to increase the injection rate stepwise to obtain lower water saturations, and the measurements were then completed in 4-5 weeks. After the final S_{wir} measurement the flow was reversed and approx. one pore volume of oil injected to even out any end-effects present in the plug.

Observations: The RICI procedure described above may have generated end-effects in the samples, and therefore it cannot be excluded that some saturation exponents be slightly overestimated. It should be observed however, that curved lines were not observed for most samples in the RI diagrams, section 5.2.3. From another SCAL study[3] performed for Mærsk Olie og Gas it is known that the RICI procedure applied here gave results in very good agreement with traditional constant pressure porous plate experiments running for 6 months i.e. close to equilibrium. Reversing the flow rate gave only minor deviations from RI @ S_{wir} . The Danian plugs generally fell slightly below the final RI value while the Maastrichtian plugs showed no specific trend. The reverse flow RI data are listed in the tables printed in italic but not shown in the diagrams because this would mean inclusion in the regression analysis.

The peculiar results measured for plug 111 may be explained by this plug probably containing more pyrite than original suspected, cf. the X-ray CT-image. This plug was excluded from the Danian mean saturation exponent value calculation in Table 5.5.

Table 5.5. Sif-1X, measured resistivity index data.

Subject: Electrical properties by RICI
Company: Mærsk Olie og Gas

Well: Sif-1X
GEUS Core Lab, 15.03.2001

Saturation exponent data

Brine density, g/ml: 1,028
Oil density, g/ml: 0,763
Brine resistivity, ohmm: 0,145 @ 25 C
Plug impedance measured @ 10 kHz
Dead volume: 2,87 ml

Plug no.	Depth	SCAL data				Data after RICI test ref. @ 800 psi								
	feet	BV', cc	Ø , %	PV1, cc	Wet wt., g	M_{final}, g	Grav.Prod., ml	Swf 1	Vol.Prod., ml	Vol.Prod-Dead V., ml	Swf 2	DS, ml H2O	Dean Stark Swf 3	Applied Swf
6	6727,00	61,78	40,29	24,89	125,31	120,76	17,17	0,31	20,40	17,53	0,28	7,20	0,296	0,30
29	6752,67	56,72	35,57	20,17	119,25	116,04	12,11	0,40	15,90	13,03	0,34	6,20	0,314	0,32
55	6779,08	55,41	30,60	16,96	121,33	118,46	10,83	0,36	13,80	10,93	0,34	4,60	0,276	0,30
97	6824,92	54,20	24,48	13,27	124,27	122,15	8,00	0,40	10,70	7,83	0,40	4,50	0,345	0,37
111	6843,33	49,85	17,52	8,73	120,60	119,15	5,47	0,37	9,85	6,98	0,18	3,80	0,444	0,44
120	6874,67	56,99	41,40	23,59	114,82	109,25	21,02	0,11	24,25	21,38	0,06	4,70	0,207	0,21
129	6884,00	53,09	36,28	19,26	111,51	107,51	15,09	0,22	20,00	17,13	0,09	4,60	0,243	0,24
132	6888,17	45,45	29,30	13,31	100,85	98,10	10,38	0,22	12,90	10,03	0,23	3,00	0,230	0,23
142	6898,00	46,94	18,13	8,51	112,88	111,21	6,30	0,26	9,35	6,48	0,20	2,20	0,270	0,27
175	6934,08	52,73	24,42	12,87	121,24	118,61	9,92	0,23	12,30	9,43	0,26	3,20	0,252	0,25

Plug no.	RI data @ 800 psi	
	Porosity	RICI
	$Ø_{800psi}$, %	n
6	39,74	2,04
29	35,10	1,80
55	30,26	1,47
97	24,14	1,41
111	17,24	1,34
120	40,49	2,12
129	35,84	2,01
132	28,84	1,80
142	17,50	1,81
175	24,17	1,53

Danian plugs, mean n = 1.68 *

Maastrichtian plugs, mean n = 1.85

* excluding plug 111

The applied final water saturation Swf is calculated from the Dean Stark Swf 3 and the volumentric production Swf 2 with the weight being on the Dean Stark value. The gravimetric Swf 1 value may be affected by small grain loss problems, and is not related to overburden conditions.

The discrepancy between Sw2 and Sw3 data for samples 111, 120 and 129 is due to a systematic error on the dead volume determination for these 3 samples. This does not in any way affect the quality of the final data.

5.2.3 RICI sample data

Plug no.: 6
Depth: 6727,00

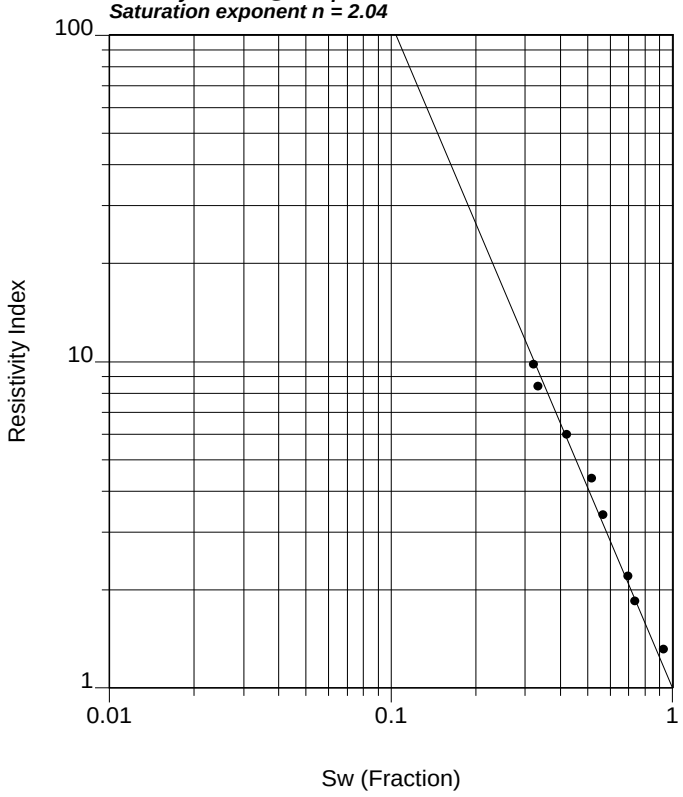
Company: Mærsk Olie og Gas A/S
Plug resistivity data @ 800 psi

S_w, %	$\|Z_t\|$, ohm	Phase, deg.	RI
92,7	58,0	-0,48	1,32
73,4	80,9	-0,42	1,85
69,4	97,8	-0,47	2,23
56,5	149,5	-0,40	3,41
51,7	191,2	-0,42	4,36
42,1	261,5	-0,42	5,96
33,2	369,0	-0,50	8,42
32,0	430,0	-0,60	9,81
30	*400,0*	*-0,50*	*9,12*

Formation: Danian

$|Z_0|$, ohm : 43,85

Well: Sif-1X, plug no. 6
Porosity: 39.7% @ 800 psi
Saturation exponent n = 2.04



Number of data 8
Number plotted 8

X Variable:
geom. mean 0.529
std. dev. 1.430

Y Variable:
geom. mean 3.757
std. dev. 1.975

Correlation -0.996
Rank correlation -1.000

Regression:
intercept 1.00
slope -2.04

Plug no.: **29**
Depth: **6752,67**

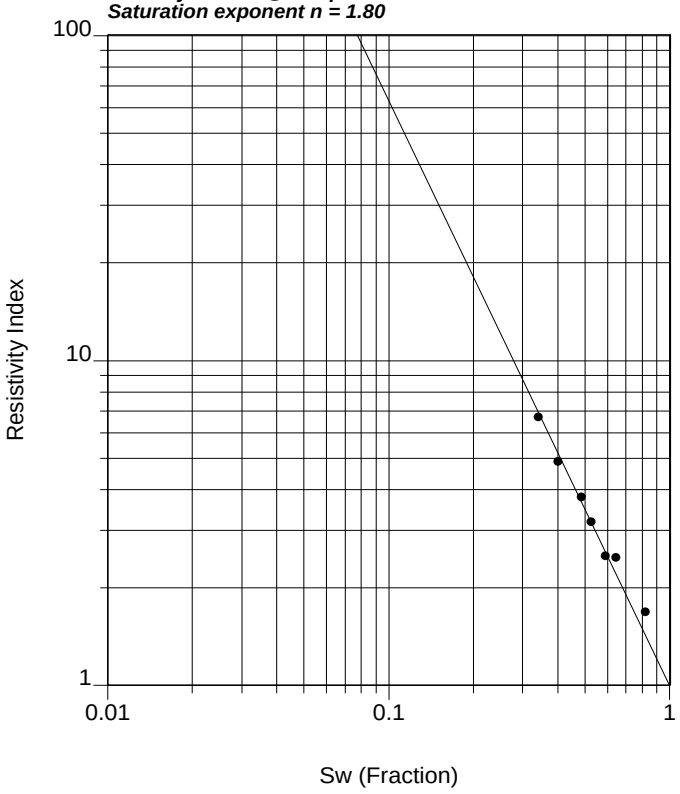
Company: Mærsk Olie og Gas A/S
Plug resistivity data @ 800 psi

S_w, %	$\|Z_t\|$, ohm	Phase, deg.	RI
82,2	95,8	-0,55	1,69
64,3	140,9	-0,48	2,48
59,1	142,9	-0,54	2,51
52,4	181,7	-0,58	3,20
48,5	217,0	-0,58	3,82
40,0	276,7	-0,63	4,87
34,1	379,0	-0,80	6,66
32	*371,0*	*-0,90*	*6,52*

Formation: Danian

$|Z_0|$, ohm : 56,87

Well: Sif-1X, plug no. 29
Porosity: 35.1% @ 800 psi
Saturation exponent n = 1.80



Number of data 7
Number plotted 7

X Variable:
geom. mean 0.524
std. dev. 1.314

Y Variable:
geom. mean 3.293
std. dev. 1.534

Correlation -0.995
Rank correlation -1.000

Regression:
intercept 1.00
slope -1.80

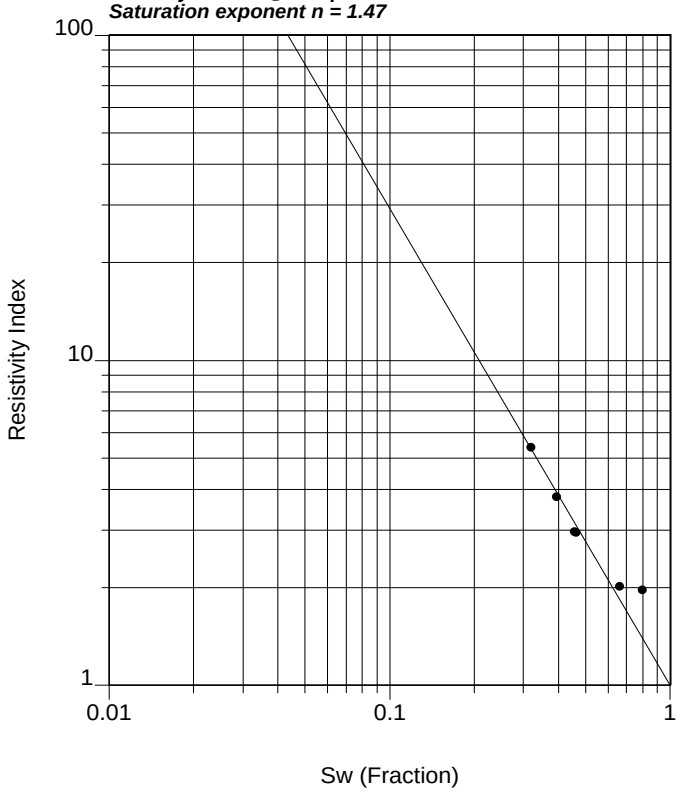
Plug no.: 55 **Company:** Mærsk Olie og Gas A/S
Depth: 6779,08 **Plug resistivity data @ 800 psi**

S_w, %	$\|Z_t\|$, ohm	Phase, deg.	RI
79,7	165,1	-1,07	1,97
66,2	169,9	-1,32	2,02
46,2	247,8	-1,66	2,95
45,6	249,2	-1,62	2,97
39,3	317,8	-1,32	3,79
31,8	454,0	-1,30	5,41
30	*410,0*	*-1,60*	*4,88*

Formation: **Danian**

$|Z_0|$, ohm : 83,94

Well: Sif-1X, plug no. 55
Porosity: 30.3% @ 800 psi
Saturation exponent n = 1.47



Number of data 6
Number plotted 6

X Variable:
geom. mean 0.490
std. dev. 1.362

Y Variable:
geom. mean 2.991
std. dev. 1.419

Correlation -0.969
Rank correlation -1.000

Regression:
intercept 1.00
slope -1.47

Plug no.: 97
Depth: 6824,92

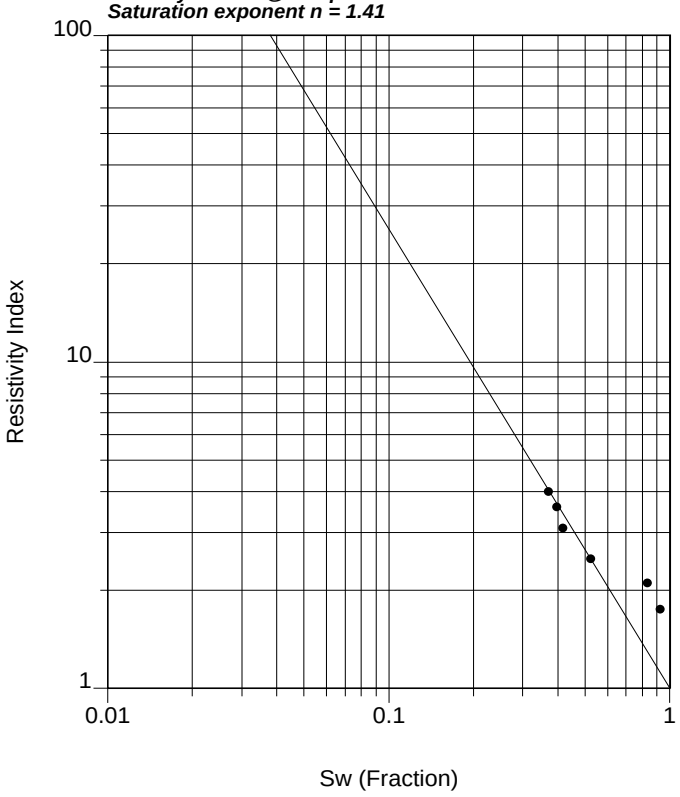
Company: Mærsk Olie og Gas A/S
Plug resistivity data @ 800 psi

S_w, %	$\|Z_t\|$, ohm	Phase, deg.	RI
92,0	258,7	-1,33	1,75
83,0	305,5	-1,72	2,06
52,1	370,0	-1,80	2,50
41,5	464,0	-1,40	3,13
39,6	525,0	-1,60	3,55
37,0	598,0	-1,80	4,04
37	*513,0*	*-1,60*	*3,47*

Formation: Danian

$|Z_0|$, ohm : 148,03

Well: Sif-1X, plug no. 97
Porosity: 24.1% @ 800 psi
Saturation exponent n = 1.41



Number of data 6
Number plotted 6

X Variable:
geom. mean 0.538
std. dev. 1.434

Y Variable:
geom. mean 2.726
std. dev. 1.340

Correlation -0.966
Rank correlation -1.000

Regression:
intercept 1.00
slope -1.41

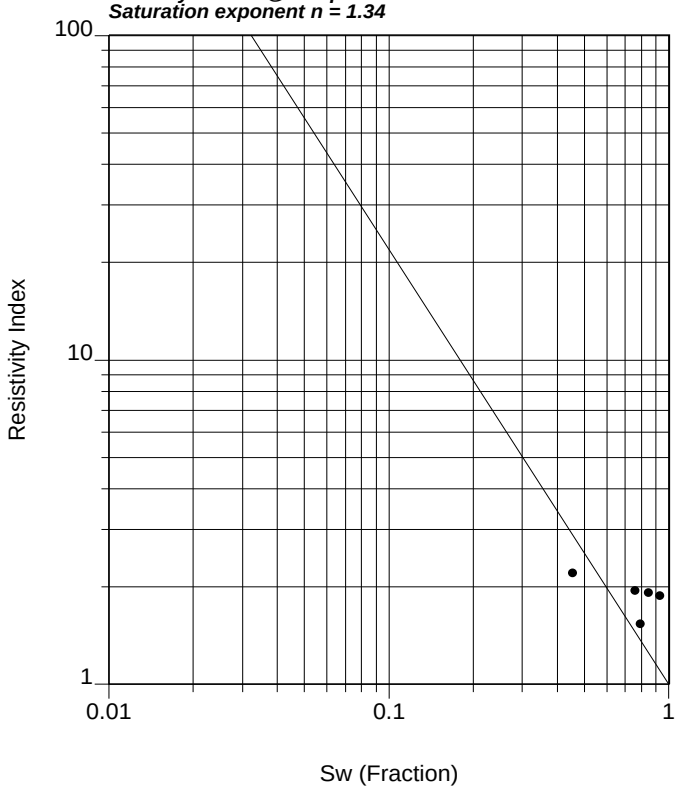
Plug no.: 111 **Company:** Mærsk Olie og Gas A/S
Depth: 6843,33 **Plug resistivity data @ 800 psi**

S_w, %	$\|Z_t\|$, ohm	Phase, deg.	RI
92,7	373,0	-1,30	1,88
84,7	381,0	-1,40	1,92
78,9	304,7	-0,66	1,54
75,5	387,0	-1,10	1,95
45,2	438,0	-1,30	2,21
44	*414,0*	*-1,30*	*2,09*

Formation: **Danian**

$|Z_0|$, ohm : 198,43

Well: Sif-1X, plug no. 111
Porosity: 17.2% @ 800 psi
Saturation exponent n = 1.34



Number of data 5
Number plotted 5

X Variable:
geom. mean 0.733
std. dev. 1.286

Y Variable:
geom. mean 1.886
std. dev. 1.122

Correlation -0.598
Rank correlation -0.700

Regression:
intercept 1.00
slope -1.34

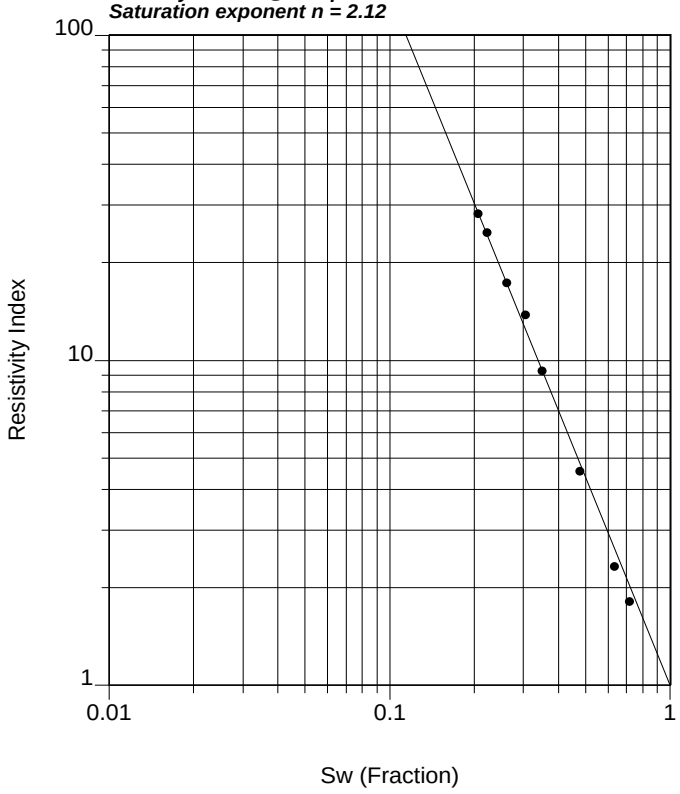
Plug no.: 120 **Company:** Mærsk Olie og Gas A/S
Depth: 6874,67 **Plug resistivity data @ 800 psi**

S_w, %	$\|Z_t\|$, ohm	Phase, deg.	RI
71,5	71,3	-0,40	1,81
63,2	91,2	-0,46	2,32
47,6	179,4	-0,43	4,56
35,0	366,0	-0,60	9,30
30,4	544,0	-0,90	13,82
26,2	683,0	-1,20	17,35
22,2	972,0	-1,20	24,69
20,7	1115,0	-1,30	28,32
20	*1185,0*	*-1,60*	*30,10*

Formation: Maastrichtian

$|Z_0|$, ohm : 39,37

Well: Sif-1X, plug no. 120
Porosity: 40.5% @ 800 psi
Saturation exponent n = 2.12



Number of data 8
Number plotted 8

X Variable:
geom. mean 0.359
std. dev. 1.550

Y Variable:
geom. mean 8.596
std. dev. 2.685

Correlation -0.999
Rank correlation -1.000

Regression:
intercept 1.00
slope -2.12

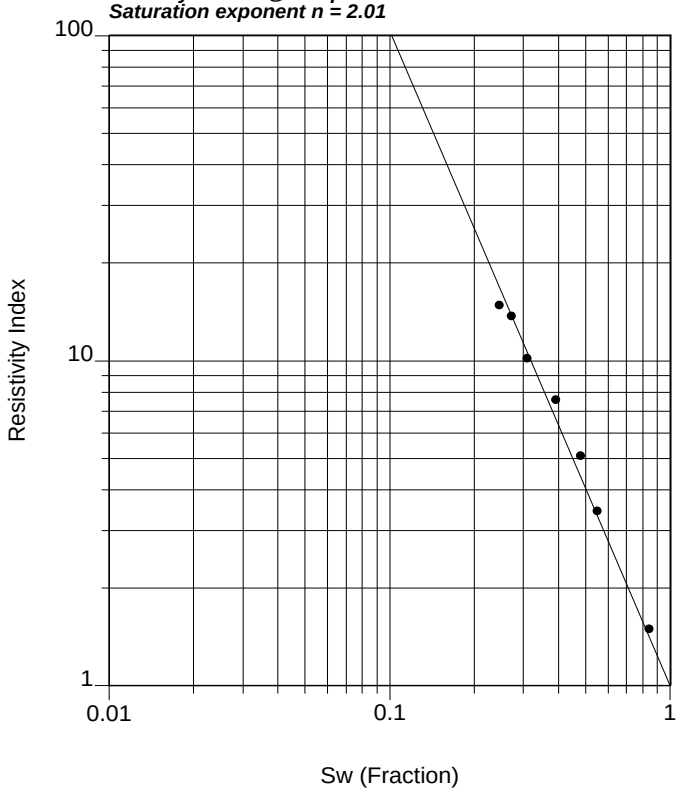
Plug no.: 129 **Company:** Mærsk Olie og Gas A/S
Depth: 6884,00 **Plug resistivity data @ 800 psi**

S_w, %	$\|Z_t\|$, ohm	Phase, deg.	RI
84,0	63,9	-0,72	1,50
54,9	146,9	-0,60	3,44
48,0	218,5	-0,66	5,12
39,1	325,8	-0,71	7,63
30,8	434,0	-0,80	10,16
27,1	587,0	-0,90	13,75
24,5	632,0	-0,90	14,80
24	*635,0*	*-1,00*	*14,87*

Formation: Maastrichtian

$|Z_0|$, ohm : 42,70

Well: Sif-1X, plug no. 129
Porosity: 35.8% @ 800 psi
Saturation exponent n = 2.01



Number of data 7
Number plotted 7

X Variable:
geom. mean 0.404
std. dev. 1.498

Y Variable:
geom. mean 6.350
std. dev. 2.144

Correlation -0.995
Rank correlation -1.000

Regression:
intercept 1.00
slope -2.01

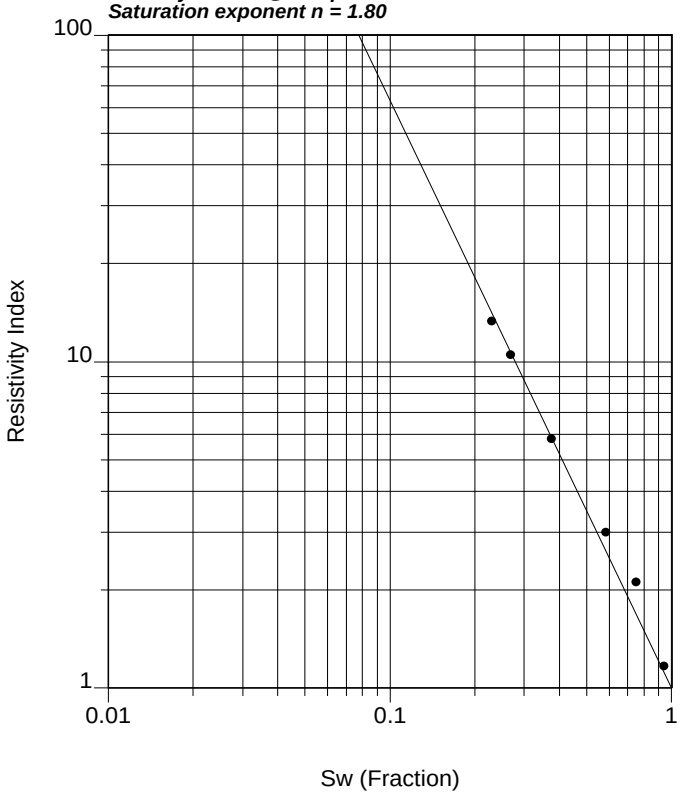
Plug no.: 132 **Company:** Mærsk Olie og Gas A/S
Depth: 6888,17 **Plug resistivity data @ 800 psi**

S_w, %	$\|Z_t\|$, ohm	Phase, deg.	RI
93,6	62,4	-4,30	1,17
74,8	113,4	-3,38	2,12
58,3	159,1	-2,79	2,97
37,3	309,5	-2,08	5,78
26,8	564,0	-1,80	10,53
23,0	710,0	-1,80	13,26
23	*684,0*	*-2,60*	*12,78*

Formation: Maastrichtian

$|Z_0|$, ohm : 53,54

Well: Sif-1X, plug no. 132
Porosity: 28.8% @ 800 psi
Saturation exponent n = 1.80



Number of data 6
Number plotted 6

X Variable:
geom. mean 0.459
std. dev. 1.680

Y Variable:
geom. mean 4.266
std. dev. 2.374

Correlation -0.997
Rank correlation -1.000

Regression:
intercept 1.00
slope -1.80

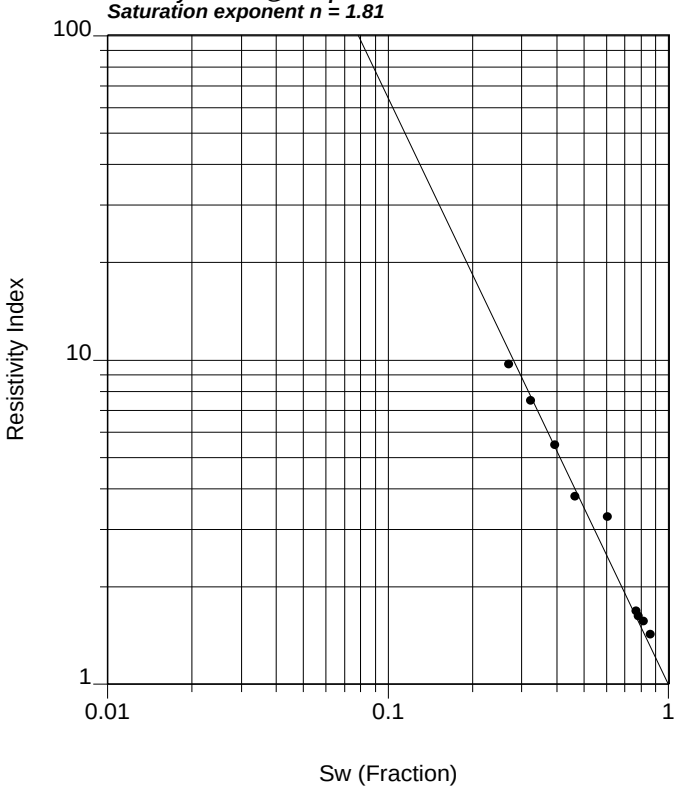
Plug no.: 142 **Company:** Mærsk Olie og Gas A/S
Depth: 6898,00 **Plug resistivity data @ 800 psi**

S_w, %	$\|Z_t\|$, ohm	Phase, deg.	RI
86,3	209,0	-1,65	1,43
81,6	229,4	-1,60	1,57
78,1	237,5	-1,88	1,63
76,4	246,6	-1,75	1,69
60,5	481,0	-1,50	3,29
46,4	551,0	-1,60	3,77
39,3	803,0	-2,30	5,50
32,3	1094,0	-3,00	7,49
27	1421,0	-3,00	9,73
27	*1490,0*	*-2,30*	*10,20*

Formation: Maastrichtian

$|Z_0|$, ohm : 146,12

Well: Sif-1X, plug no. 142
Porosity: 17.5% @ 800 psi
Saturation exponent n = 1.81



Number of data 9
Number plotted 9

X Variable:
geom. mean 0.542
std. dev. 1.510

Y Variable:
geom. mean 3.157
std. dev. 1.997

Correlation -0.992
Rank correlation -1.000

Regression:
intercept 1.00
slope -1.81

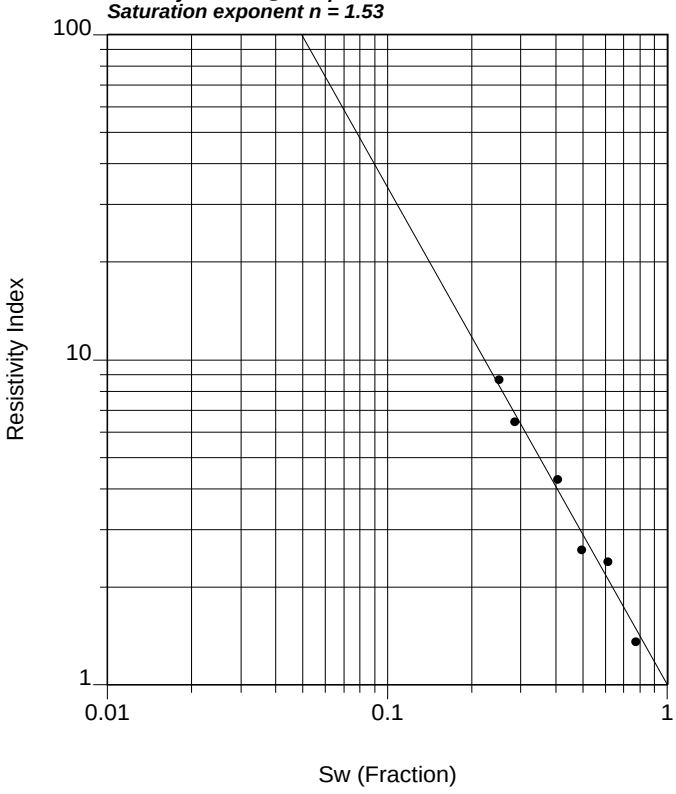
Plug no.: 175 **Company:** Mærsk Olie og Gas A/S
Depth: 6934,08 **Plug resistivity data @ 800 psi**

S_w, %	$\|Z_t\|$, ohm	Phase, deg.	RI
77,0	115,3	-0,75	1,36
61,2	203,9	-0,75	2,40
49,4	221,3	-0,86	2,60
40,4	365,0	-1,00	4,30
28,5	548,1	-1,20	6,45
25,0	738,0	-1,20	8,69
25	*792,0*	*-1,20*	*9,32*

Formation: Maastrichtian

$|Z_0|$, ohm : 84,95

Well: Sif-1X, plug no. 175
Porosity: 24.2% @ 800 psi
Saturation exponent n = 1.53



Number of data 6
Number plotted 6

X Variable:
geom. mean 0.434
std. dev. 1.489

Y Variable:
geom. mean 3.561
std. dev. 1.873

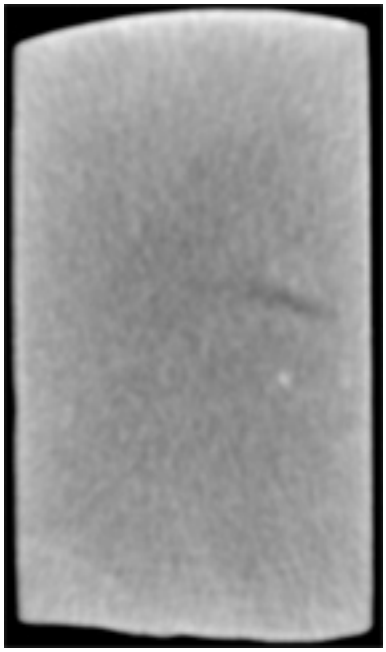
Correlation -0.990
Rank correlation -1.000

Regression:
intercept 1.00
slope -1.53

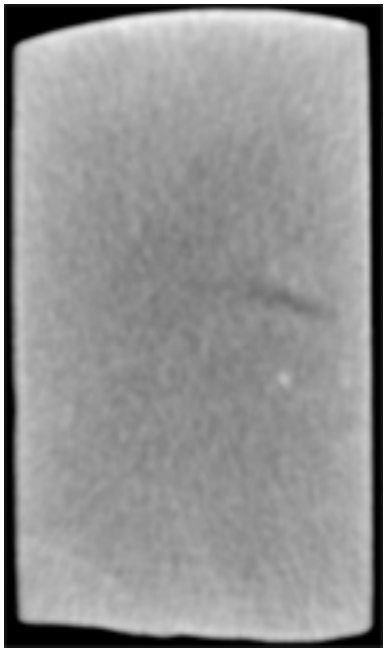
5.3 Plug quality screening

CT-parameters Algorithm: standard
Voltage: 120 kV
mAs: 85
Scan mode: 1s
Time: 1
Slice: 2 mm

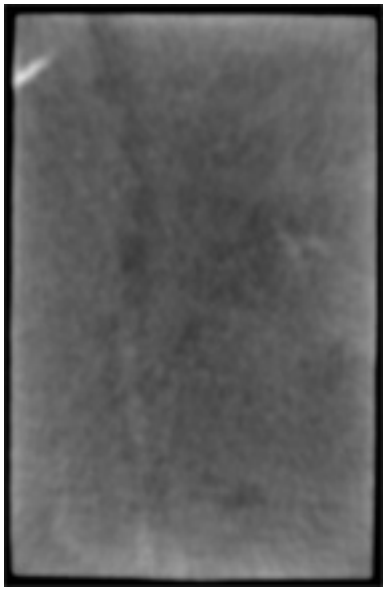
All plugs are 38 mm in diameter and horizontal in orientation



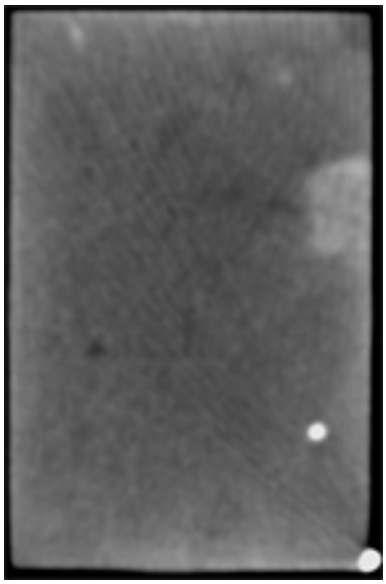
Plug 4 Rotated 0 deg.
Depth: 6725.08 feet
Selected for: Wettabillity



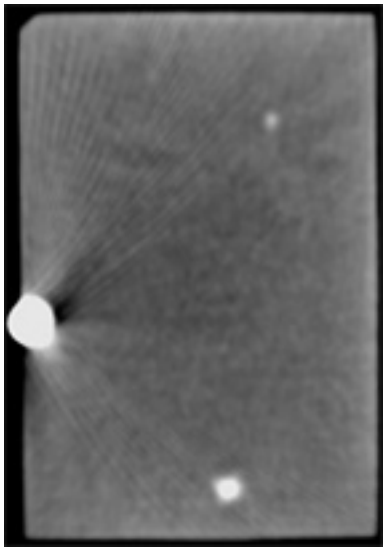
Plug 4 Rotated 90 deg.
Depth: 6725.08 feet
Selected for: Wettabillity



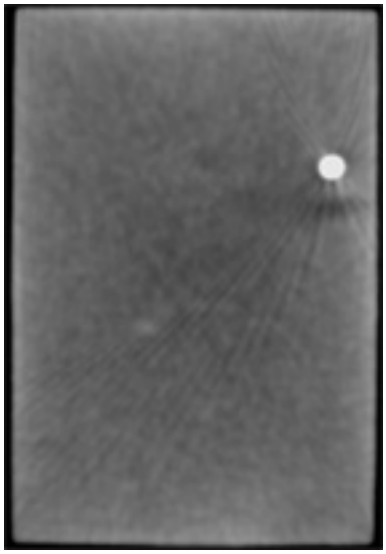
Plug 6 Rotated 0 deg.
Depth: 6727.00 feet
Selected for: Resistivity index



Plug 6 Rotated 90 deg.
Depth: 6727.00 feet
Selected for: Resistivity index



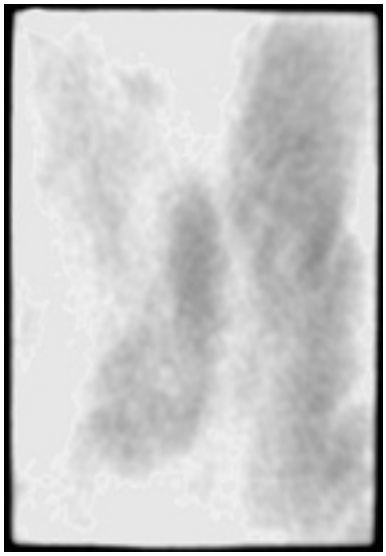
Plug 7 Rotated 0 deg.
Depth: 6728.00 feet
Selected for: Mercury injection



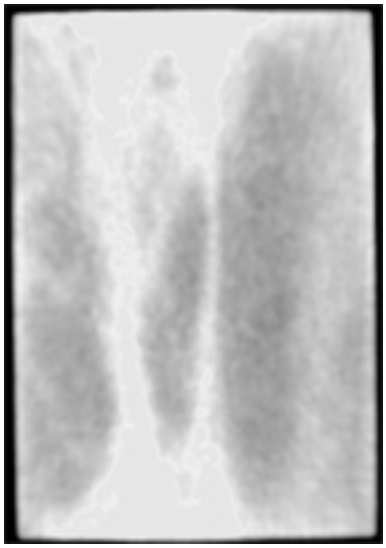
Plug 7 Rotated 90 deg.
Depth: 6728.00 feet
Selected for: Mercury injection

Plug 18 Rotated 0 deg.
Depth: 6740.25 feet
Selected for: Wettabillity

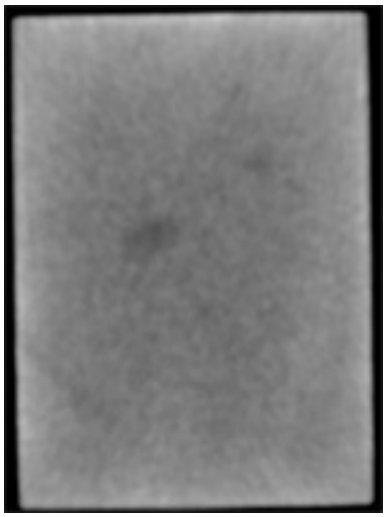
Plug 18 Rotated 90 deg.
Depth: 6740.25 feet
Selected for: Wettabillity



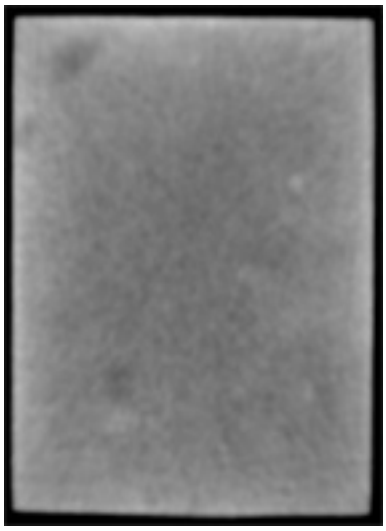
Plug 22 Rotated 0 deg.
Depth: 6745.08 feet
Selected for: Mercury injection



Plug 22 Rotated 90 deg.
Depth: 6745.08 feet
Selected for: Mercury injection



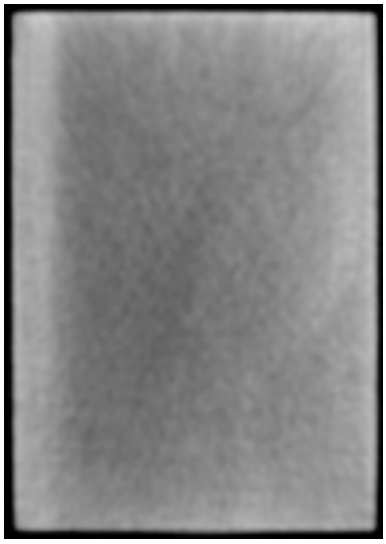
Plug 29 Rotated 0 deg.
Depth: 6727.00 feet
Selected for: Resistivity index



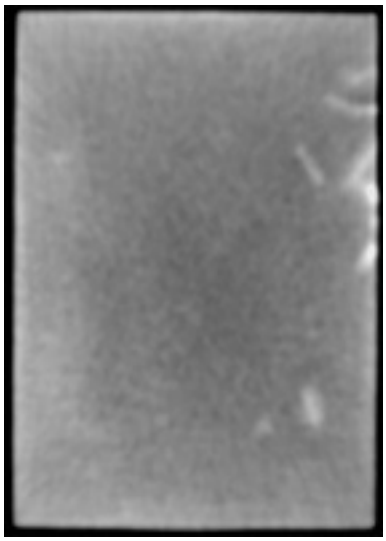
Plug 29 Rotated 90 deg.
Depth: 6727.00 feet
Selected for: Resistivity index

Plug 38 Rotated 0 deg.
Depth: 6762.17 feet
Selected for: Wettabillity

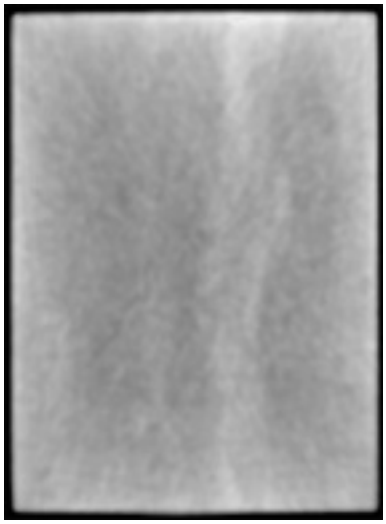
Plug 38 Rotated 90 deg.
Depth: 6762.17 feet
Selected for: Wettabillity



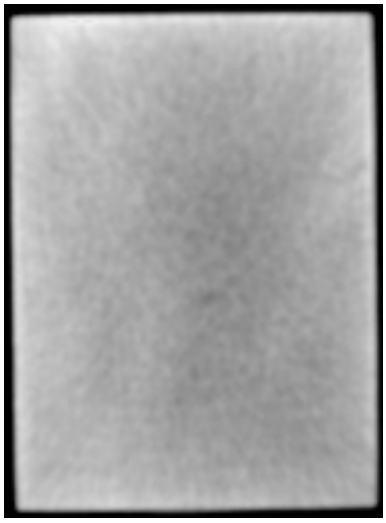
Plug 48 Rotated 0 deg.
Depth: 6772.17 feet
Selected for: Mercury injection



Plug 48 Rotated 90 deg.
Depth: 6772.17 feet
Selected for: Mercury injection



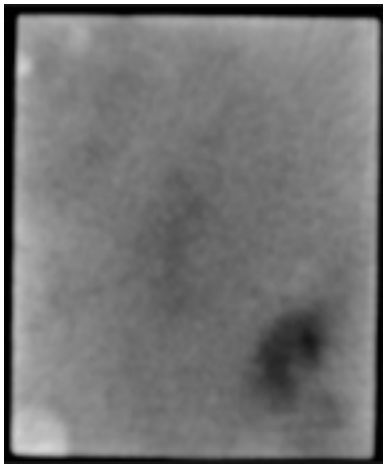
Plug 55 Rotated 0 deg.
Depth: 6779.08 feet
Selected for: Resistivity index



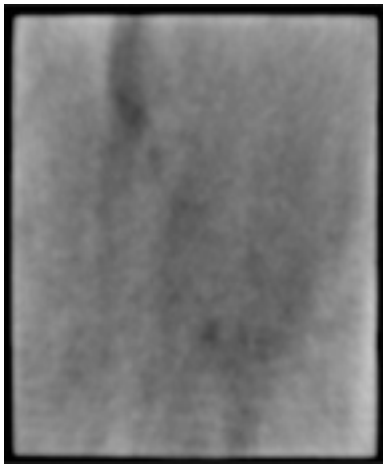
Plug 55 Rotated 90 deg.
Depth: 6779.08 feet
Selected for: Resistivity index

Plug 60 Rotated 0 deg.
Depth: 6785.25 feet
Selected for: Mercury injection

Plug 60 Rotated 90 deg.
Depth: 6785.25 feet
Selected for: Mercury injection



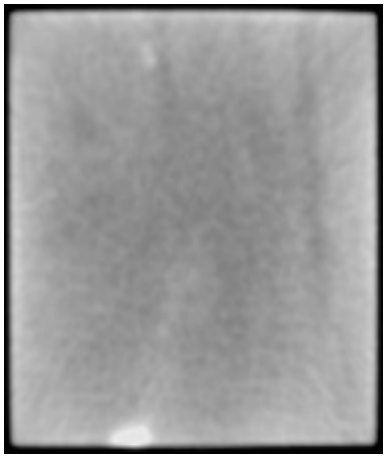
Plug 85 Rotated 0 deg.
Depth: 6811.92 feet
Selected for: Mercury injection



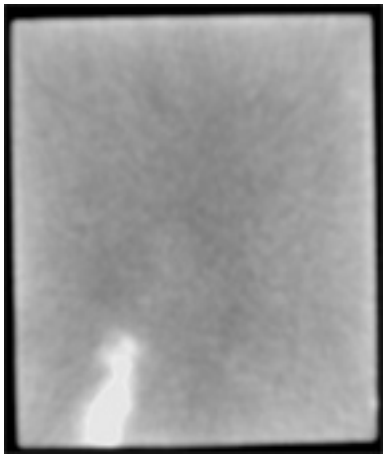
Plug 85 Rotated 90 deg.
Depth: 6811.92 feet
Selected for: Mercury injection

Plug 97 Rotated 0 deg.
Depth: 6824.92 feet
Selected for: Resistivity index

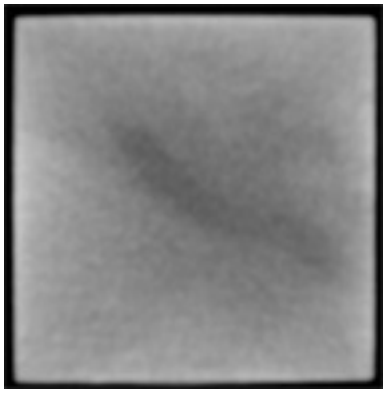
Plug 97 Rotated 0 deg.
Depth: 6824.92 feet
Selected for: Resistivity index



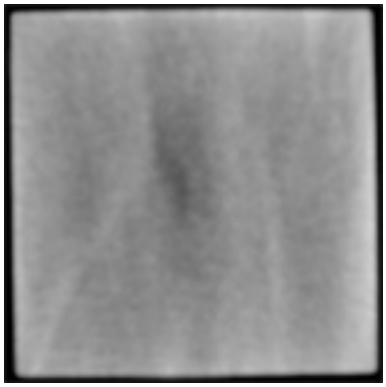
Plug 111 Rotated 0 deg.
Depth: 6843.33 feet
Selected for: Resistivity index



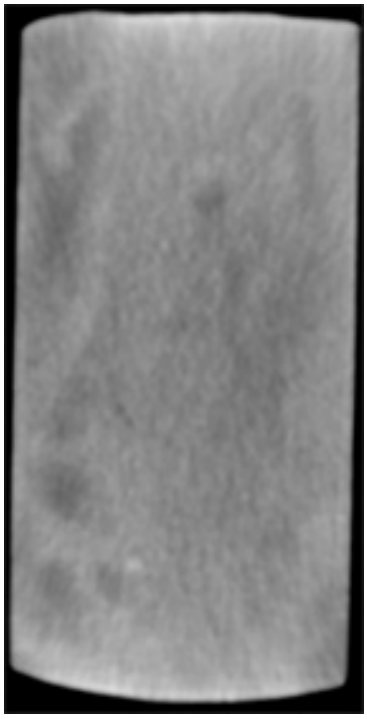
Plug 111 Rotated 90 deg.
Depth: 6843.33 feet
Selected for: Resistivity index



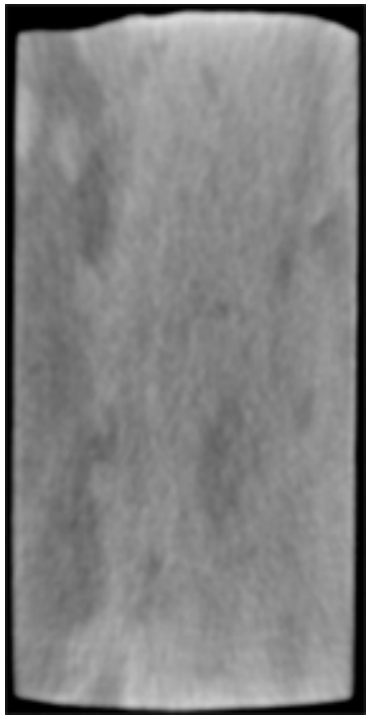
Plug 114 Rotated 0 deg.
Depth: 6846.25 feet
Selected for: Mercury injection



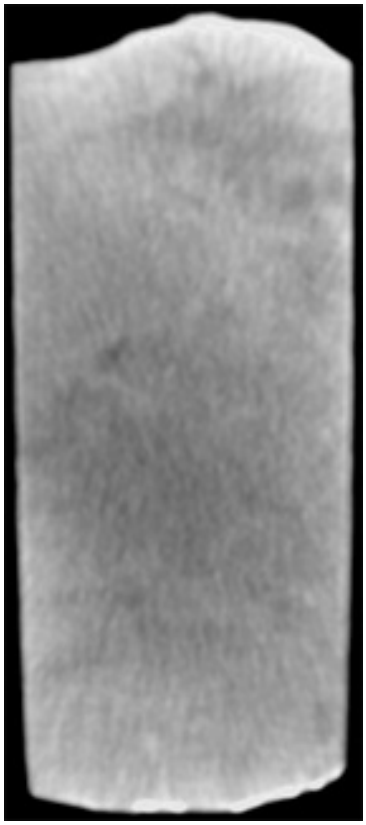
Plug 114 Rotated 90 deg.
Depth: 6846.25 feet
Selected for: Mercury injection



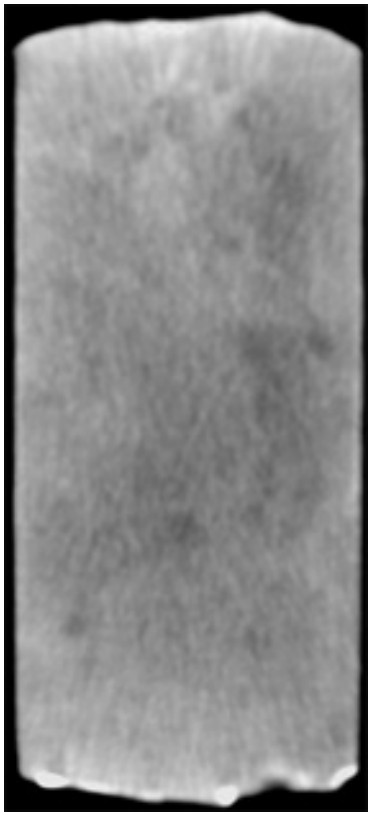
Plug 117 Rotated 0 deg.
Depth: 6850.67 feet Wettabillity



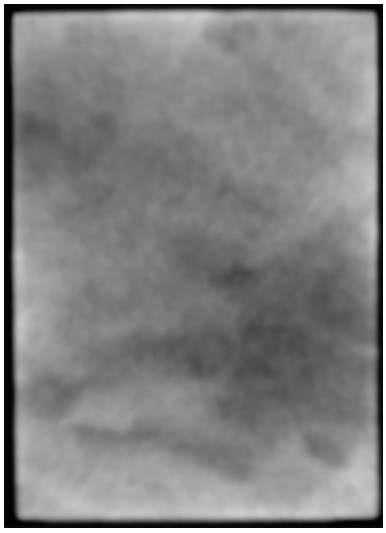
Plug 117 Rotated 90 deg.
Depth: 6850.67 feet Wettabillity



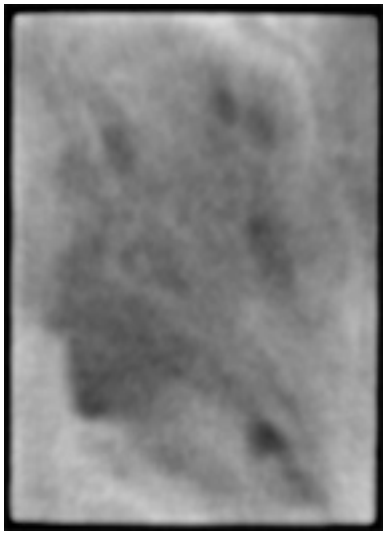
Plug 118 Rotated 0 deg.
Depth: 6871.17 feet Wettabillity



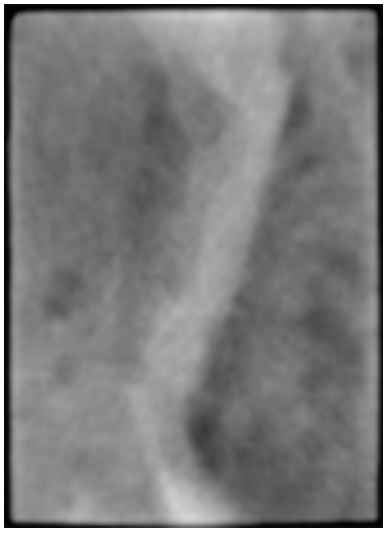
Plug 118 Rotated 90 deg.
Depth: 6871.17 feet Wettabillity



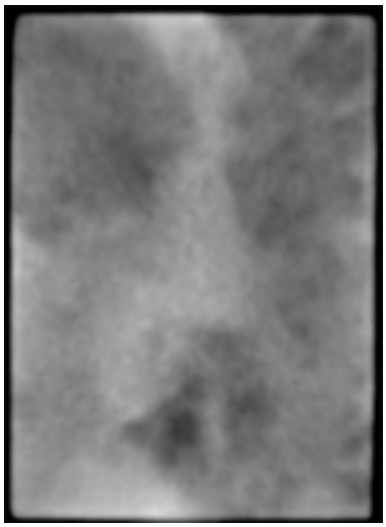
Plug 15X Rotated 0 deg.
Depth: 6873.58 feet
Selected for: Mercury injection



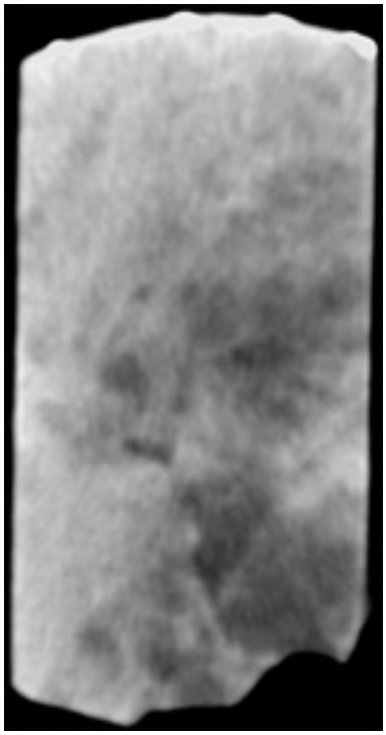
Plug 15X Rotated 90 deg.
Depth: 6873.58 feet
Selected for: Mercury injection



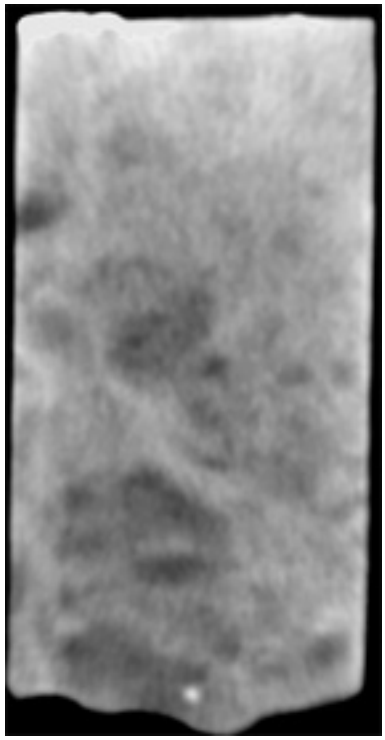
Plug 120 Rotated 0 deg.
Depth: 6874.67 feet
Selected for: Resistivity index



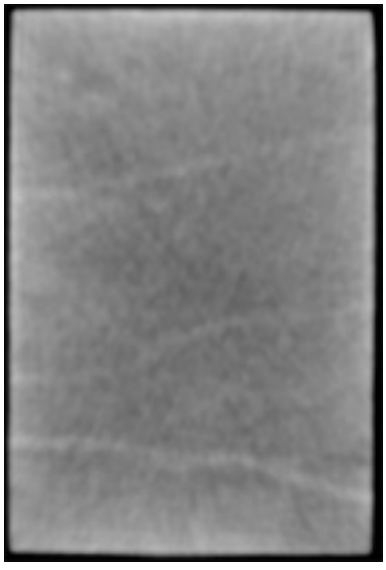
Plug 120 Rotated 90 deg.
Depth: 6874.67 feet
Selected for: Resistivity index



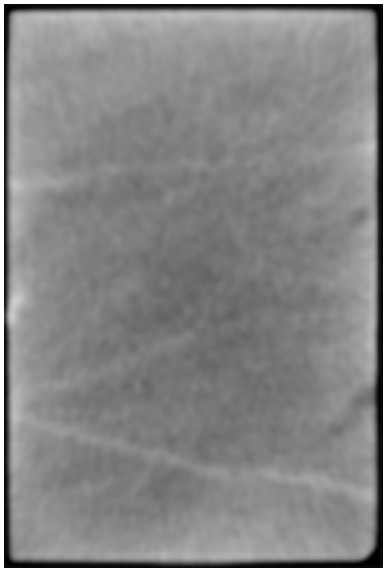
Plug 121 Rotated 0 deg.
Depth: 6875.67 feet
Selected for: Wettabillity



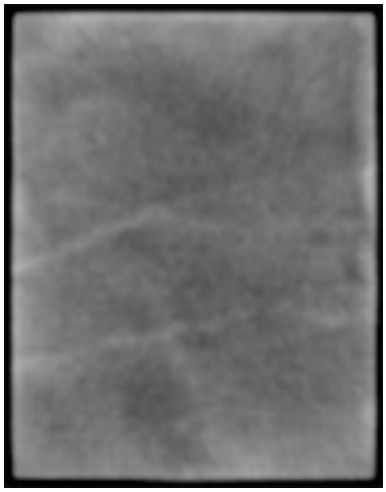
Plug 121 Rotated 90 deg.
Depth: 6875.67 feet
Selected for: Wettabillity



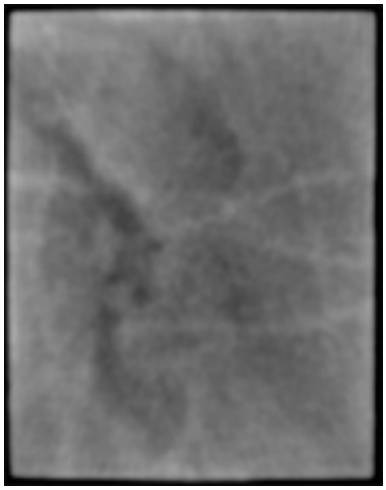
Plug 125 Rotated 0 deg.
Depth: 6880.17 feet
Selected for: Mercury injection



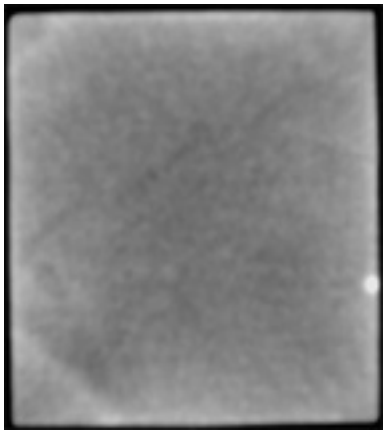
Plug 125 Rotated 90 deg.
Depth: 6880.17 feet
Selected for: Mercury injection



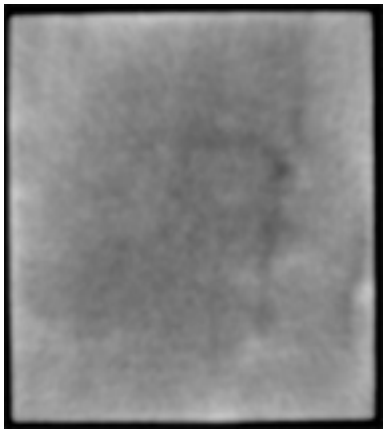
Plug 129 Rotated 0 deg.
Depth: 6884.00 feet
Selected for: Resistivity index



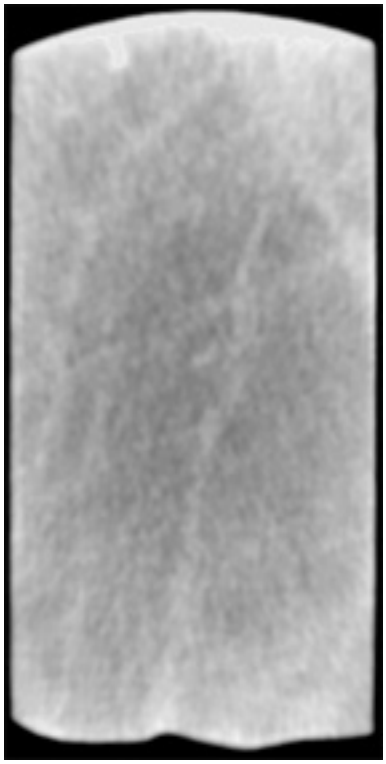
Plug 129 Rotated 90 deg.
Depth: 6884.00 feet
Selected for: Resistivity index



Plug 132 Rotated 0 deg.
Depth: 6888.17 feet
Selected for: Resistivity index

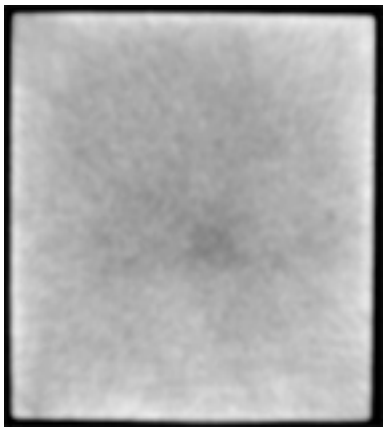


Plug 132 Rotated 90 deg.
Depth: 6888.17 feet
Selected for: Resistivity index

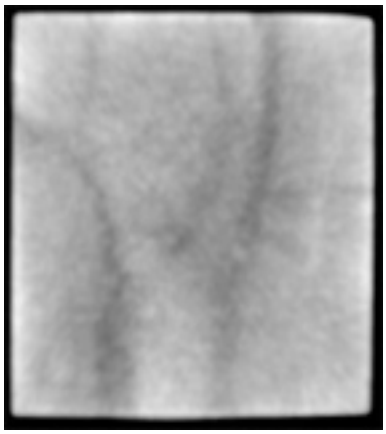


Plug 134 Rotated 0 deg.
Depth: 6890.08 feet
Selected for: Wettabillity

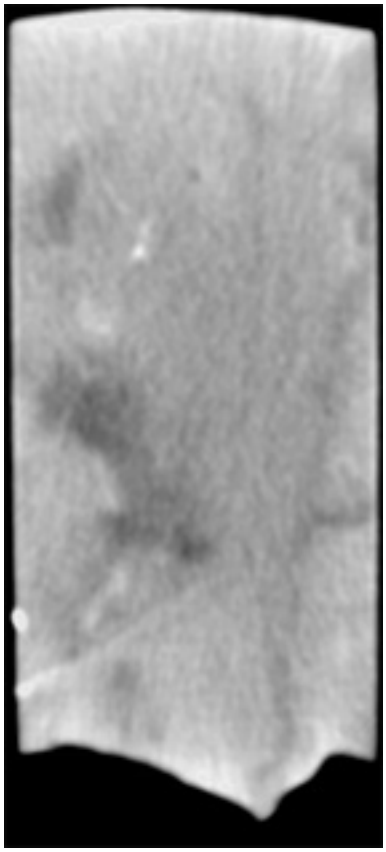
Plug 134 Rotated 90 deg.
Depth: 6890.08 feet
Selected for: Wettabillity



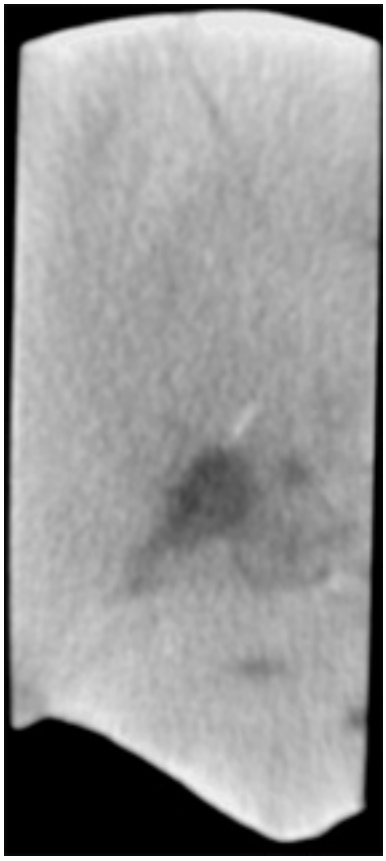
Plug 142 Rotated 0 deg.
Depth: 6898.00 feet
Selected for: Resistivity index



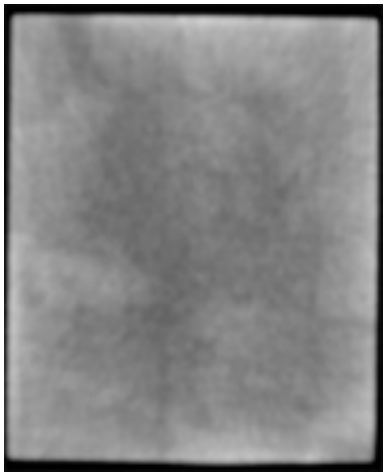
Plug 142 Rotated 90 deg.
Depth: 6898.00 feet
Selected for: Resistivity index



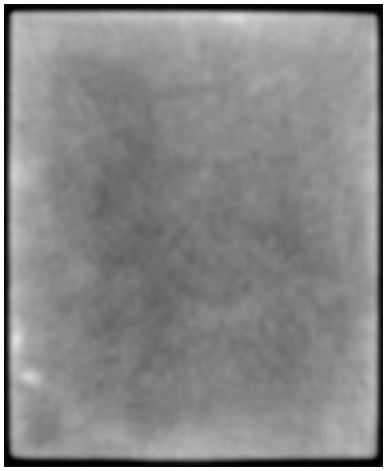
Plug 153 Rotated 0 deg.
Depth: 6910.67 feet
Selected for: Wettabillity



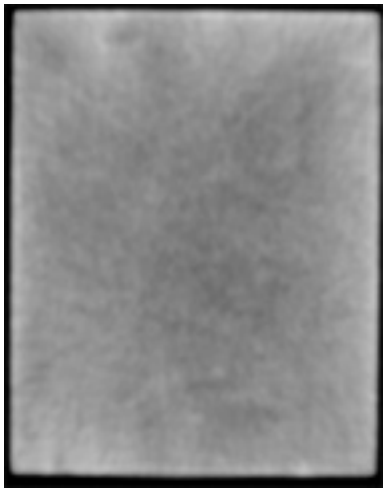
Plug 153 Rotated 90 deg.
Depth: 6910.67 feet
Selected for: Wettabillity



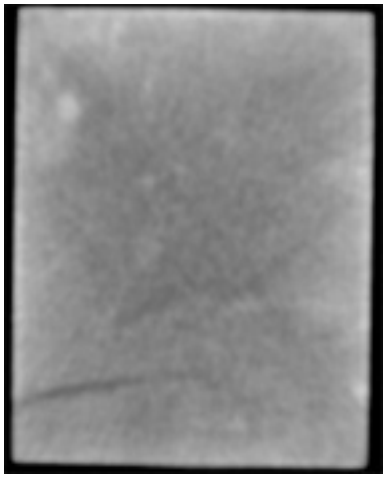
Plug 171 Rotated 0 deg.
Depth: 6930.17 feet
Selected for: Mercury injection



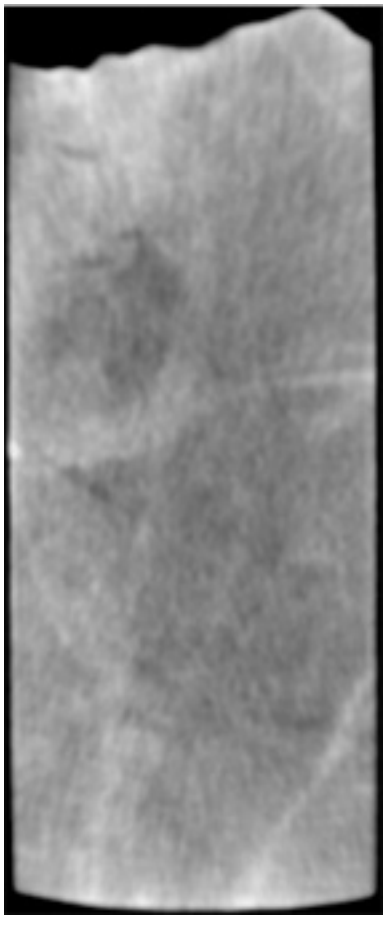
Plug 171 Rotated 90 deg.
Depth: 6930.17 feet
Selected for: Mercury injection



Plug 175 Rotated 0 deg.
Depth: 6934.08 feet
Selected for: Resistivity index



Plug 175 Rotated 90 deg.
Depth: 6934.08 feet
Selected for: Resistivity index



Plug 180 Rotated 0 deg.
Depth: 6939.00 feet
Selected for: Wettabillity

Plug 180 Rotated 90 deg.
Depth: 6939.00 feet
Selected for: Wettabillity

Plug 186 Rotated 0 deg.
Depth: 6945.17 feet
Selected for: Mercury injection

Plug 186 Rotated 90 deg.
Depth: 6945.17 feet
Selected for: Mercury injection

6. References

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2. SCA Guidelines for sample preparation and porosity measurement of electrical resistivity samples, part I-IV. The Log Analyst, **31**, 1 & 2, 1990.

3. Springer, Niels: Special Core Analysis for Mærsk Olie og Gas A/S. Well: Igor G-2X.
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