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Denne rapport
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LTEK DOK.SENTER

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Returneres etter bruk

Co-work

Mathilde-Sørenssen

Title

WATER ANALYSIS

1/9-6

DST 1

STATOIL
EXPLORATION & PRODUCTION
LABORATORY

A.L. Berge

FEB

LAB 82.39

Prepared

28/10-82 *And Nyfling Berge*
And Nyfling Berge

Approved

28/10-82 Per Thomassen



Classification

Requested by

Steinar Lyngroth. FLT

Subtitle

Co-workers

D. Malthe-Sørenssen

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1. INTRODUCTION

Statoil production laboratory (PROLAB) received thirteen, 1 l plastic bottles with water from well 1/9-6 DST 1 sampled at depth 3771.6 m - 3776.7 m RKB. The water samples were 3 from bottom hole sampler and 8 from water in the test string. PROLAB was asked to see if the water was representative for the formation, and to see to what extent they were diluted with mud filtrate or sea water. The test string was balanced with seawater before test.

2. SAMPLE DESCRIPTION

The water samples contained particles and had a brown colour and smelled oil except for the samples from the bottom hole sampler. The brown colour increased from upper sample in the bottom hole sampler to sample no. 2. Sample marked no. 1 and lower, were clear but contained dark particles. (Table 1).

3. METHODS OF ANALYSIS USED BY PROLAB

The samples were filtrated through 0.45µm millipore filters. The samples were stabilized by adding concentrated nitric acid (1:1000) prior to the ionic analysis. Most of the analysis were carried out according to ASTM methods using atomic absorption. The following ions were determined by wet chemistry.

Ions	Methods
Cl (including Br and I)	ASTM D512
SO ₄ ²⁻	ASTM D516
Lignosulphonate (LS)	Light absorption at 280 mm (1)

Total dissolved solids are determined by drying the residue at 120°C over night. Density was measured by PAAR 401 densito-meter. Conductivity was determined by using a Philips Conduc- tivity Meter PW 9501/01. These measurements were done at carefully controlled temperatures.

Relativ standard deviation, RSD, is determined (experimentally and/or theoretically) on every measured value.

$$\text{RSD} = s/\bar{x} \cdot 100\% \quad \text{where} \quad \bar{x} = \frac{\sum_{i=1}^n x_i}{n}, \quad x_i \quad (i=1 \dots n)$$

is measured values in n independent measurements

$$\text{and, } s = \left[\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1} \right]^{1/2}$$

Table 1. Formation water 1/9-6 DST 1 sample description

Sample no.	Colour	Depths (ft)
Upper	brown	12249
Middle	brown	12361
Lower	Clear	12374
10	brown	12000
9	brown	11600
8	dark brown	11300
7	dark brown	11000
6	dark brown	10600
5	dark brown	10300
4	dark brown	10000
3	dark brown	9600
2	dark brown	9300
1	clear	9000

Table 2. Results of ionanalysis of water samples from well 1/9-6

Sample No.	UPPER	MIDDLE	LOWER	No.10	No.9	No.8	No.7	No.6	No.1	RSD%
Density 20°C, g/cm ³	1.0841	1.0776	1.0245	1.0775	1.0775	1.0750	1.0672	1.0517	1.0242	0.01
pH at 20°C	6.29	6.31	8.11	6.37	6.42	6.99	7.68		7.84	1
Total dissolved solid, %	12.08	11.09	3.80	11.15	11.14	10.87	9.77	6.55	3.84	1
Conductivity at 20°C,	130.6	124.7	46.9	124.3	123.5	120.3	108.7	89.09	45.1	1
Lignosulphonate, ppm	635	844	37	821	868	1033	1513	2453	30	
Ion	Concentration ppm									
Na ⁺	43907	42688		41392	35452				11912	1
Ca ²⁺	9625	8556		8556	9087				523	2
Mg ²⁺	812	715		715	798				1230	2
K ⁺	641	781		612	645				327	7
Fe ⁿ⁺	65.5	112.8		8	18.7				32	3
Ba ²⁺	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	
Cl ⁻	67108	62126	19655	61965	62078	60090	53629	40218	19558	1
SO ₄ ²⁻	535	807	2665	836	835	1014	1555	2472	2714	1
HCO ₃ ^{-*}		282								
Sum ion. %	12.27	11.58		11.41	11.61				3.63	3.7

* The value given for HCO₃⁻ ppm is probably a minimum value due to difficulties in establishing the level in stored water.

5. DISCUSSION

5.1. Ionanalysis

As can be seen from table 2 both Cl^- and Na^+ concentration decreased from the upper bottom hole sample throughout the samples from the test string, indicating an increasing infiltration of seawater (and mudfiltrate) in the samples. Simultaneously there is an increasing amount of sulfate in the samples, also suggesting an increasing amount of seawater in the samples. Both seawater and mudfiltrate have a lower concentration of Cl^- and Na^+ than the formation water but a higher sulfate concentration. In accordance with an increasing mudfiltrate infiltration in the samples from bottom hole sampler and the test string (sample no. 6) an increased concentration of lignosulphonate could be observed (table 2).

They are all mixed with seawater or mudfiltrate but to a different degree. The samples from the bottom hole sampler represents probably the best samples.

Assuming that there is no sulfate in the formation water it would be possible to estimate the original salt concentration in the formation water using the dilution-factor found from the dilution of sulfate in the sample compared to the concentration of sulfate in seawater.

Accordingly the concentration of the different ions in the formation water have been estimated. (See appendix 1 for calculation). A good correlation between the salt concentration in the upper, middel bottom hole samples and sample no. 10 and 9 from the test string was found (table 3) suggesting that the concentrations given in table 3 for Na^+ , Cl^- , K^+ , Ca^{++} should be a good approximation of representative formation water values.

Similarly the conductivity and hence resistivity can be estimated from the new calculated salt concentrations. The corrected conductivity at 20°C is given in table 3.

Table 3. Estimated ion concentration in formation water and % dilution with seawater. Calculation see appendix 1.

SAMPLE	UPPER	MIDDEL	no. 10	no. 9
% diluted	19.71	29.7	30.80	30.77
	Concentration (ppm.)			
Cl ⁻	78262	80110	80840	80976
Mg ²⁺	709	497	486	606
Ca ²⁺	11859	11949.7	12131.4	12893.4
K ⁺	718	972.8	738.8	786.3
Na ⁺	51761	55690.1	54513.2	45914.6
	143309	149219.5	148709.6	141176.3
Conductivity at 20°C correlated from "Equivalent NaCl" concentration appendix 3				
mho/cm	167.6	172.3	172.0	162.10

5.2 Comparison between total dissolved solids measured and calculated.

The consistency on the analysis can also be checked by comparing measured and calculated numbers for total dissolved (TDS). The results in table 4 shows that it is good agreement between TDS from residue after evaporation, and TDS correlated form density.

Table 4. Comparison of calculated and 5 measured total dissolved solid data (%)

Sample no.	UPPER	MIDDLE	LOWER	No.10	NO.9	No.8	No.7	No.6	No.1	RSD%
Residue after evaporation	12.08	11.09	3.80	11.15	11.14	10.87	9.77	6.55	3.84	1
Calculated from Cl ⁻ (Cl ⁻ 1.65)	11.07	10.25	3.24	10.22	10.24	9.91	8.85	6.64	3.23	1
Correlated from density	11.79	10.93	3.69	10.92	10.92	10.58	9.53	7.43	3.64	0.1
Correlated from conductivity	10.46	9.87	3.22	9.83	9.75	9.43	8.37	6.57	3.08	3
Equivalent NaCl	12.07	11.38		11.22	10.69				3.51	-
Calculated from table 1	12.27	11.58		11.41	11.61				3.63	3.7

5.3 Formation water analysis which are recommended.

Sample named upper bottom hole sample seems to be the most representative sample for the formation water of the four samples given in table 4.

However, since the water is to some degree diluted with mudfiltrate we cannot give a fully correct composition of the formation water. The low Ba concentration < 0.05 ppm can be due to precipitation with SO_4^{2-} forming BaSO_4 .

Since mud filtrate had not been sampled during drilling as a control of the dilution of the formation water samples, the corrected values given in table 3 may deviate from the real values by ≤ 5 %.

6. CONCLUSION

The brown colour and the presence of lignosulphonate demonstrate that all samples are contaminated with mud. The most representative sample is the sample marked upper from the bottom hole sampler.

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- 1) CRC Handbook of Chemistry and Physics 60th edition page D-261.
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APPENDIX 1

Calculation of Cl^- concentration in formation water, when assumed no SO_4^{2-} concentration in formation water.

% seawater in the sample = X

S_s = sulfate concentration in sample

S_{sw} = sulfate concentration in seawater.

$$X = \frac{S_s}{S_{sw}} \times 100$$

Estimated Cl^- concentration in formation water.

X = % of seawater in the sample.

Y = % of formationwater in the sample.

C_s = Cl^- concentration in sample.

C_{sw} = Cl^- concentration in seawater.

C_f = Cl^- concentration in formation water.

$$Y \times C_f + X \times C_{sw} = C_s$$

Appendix 2.

A transformation of ionic concentrations from table 1 into "equivalent NaCl" concentration.

Sample Ion.	Factor*	Upper	Eq. NaCl concentration. ppm.	Middel	no 10.	no 9.	no 1.
Na ⁺	1	43907	42688	41392	35452	11912	
Cl ⁻	1	67108	62126	61965	62078	19558	
Ca ²⁺	0,81	7796	6930	6930	7360	424	
Mg ²⁺	1,26	1023	901	901	1005	1550	
K ⁺	0,9	557	703	551	581	294	
SO ₄ ²⁻	0,5	268	404	418	418	1357	

Sum "equ NaCl" concentration% 12.07 11.38 11.22 10.69 3.51

* See reference 3.

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Cl ⁻	1	78262	80110	80840	80976
Mg ²⁺	1.22	864	606.3	592.9	739.3
Ca ²⁺	1.2	14230.8	14339.6	14557.7	15472.1
K ⁺	0.9	646.2	875.5	664.9	707.7
Na ⁺	1	51761	55690.1	54513.2	141176.3
Sum "eq NaCl" %		14.58	15.16	15.12	13.91

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statoil
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Correlated from density	11.79	10.93	3.69	10.92	10.92	10.58	9.53	7.43	3.64	0.1
Correlated from conductivity	10.46	9.87	3.22	9.83	9.75	9.43	8.37	6.57	3.08	3
Equivalent NaCl	12.07	11.38		11.22	10.69				3.51	-
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$$Y \times C_f + X \times C_{sw} = C_s$$

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