



Classification

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Title
GEOCHEMICAL ANALYSIS OF SHOWS, WELL 6406/3-1
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GEOCHEMICAL ANALYSIS OF SHOWS, WELL 6406/3-1

1. Summary

The hydrocarbons of this well are of gas or gas/condensate nature. This is supported by analyses performed on the solvent extractable material "C₁₅+" fractions of the EOM and also by chromatograms of thermally extracted matter of the sediments. DST sample analyses show water samples lean in "C₁₅+" hydrocarbons of "oil" nature. The findings are related to PVT analyses and $\delta^{13}\text{C}$ analyses of gas samples.

2. Introduction

The aim of this study was to establish the amounts and the quality of hydrocarbons in the samples taken from the Middle Jurassic, Brent Eq. reservoir sandstone from 3782.5 to 3844.97 m.

Table I shows the samples used in this work and which kinds of analyses have been performed on each of the samples.

The samples were all of reasonable quality and the seal peal cores were further cleaned of wax contamination before extraction.

10 copies of this report were prepared and copies distributed to Mobil and Saga Petroleum.

3. Results

The analytical procedures used in this work are thoroughly described in the Appendix A.

The results are listed in Tables 2 to 5. Chromatograms are presented in Figures 1 to 14.

The DST samples from this well consisted of water with some dissolved hydrocarbons. Extraction of the water samples showed that hydrocarbons with carbon number up to approximately C₃₀ were present (Figs. 1 and 2), but the extracts were very lean with respect to amounts of "oil" components in the "C₁₅+" range.

The chromatograms from the solvent extracted saturate fractions (Figs. 3-10) show a relatively smooth distribution of n-paraffins with a maximum at n-C₁₃ to n-C₁₅, falling off relatively quickly. This is indicative of a light crude oil or condensate. A relatively medium high maturity level is shown by the ratios of pristane and phytane to the normal paraffins C17 and C18, respectively, Table 3. The thermal extraction chromatograms (Figs. 11-14) also support the idea of relatively light hydrocarbons with a distributional maximum at n-C₁₃ to n-C₁₄, indicating the presence of a condensate or condensate/gas in the light grey, homogeneous, well sorted sandstone of the Middle Jurassic sandstone sequence of this well.

Apart from a slight tendency of an increase of extractable organic matter towards the top of this reservoir sequence, the samples are, as expected, very similar with respect to content and types of hydrocarbons. A value of - 28 to - 29 ‰ for $\delta^{13}\text{C}$ is likely to be found in a mature oil reservoir.

The pore saturation shows a very small amount (0.7 - 1.3%) of "C₁₅+" hydrocarbons in the reservoir sequence relative to pore water. This supports a production of water rather than oil hydrocarbons, as shown by the DST samples.

The PVT report points out methane as the major hydrocarbon component of the DST from this well, and the gas isotopic analyses indicate a gas related to a condensate of relatively high maturity. (See report on isotopic analyses on test gas samples from IFE).

The maturity findings in this work is, however, not in keeping with the gas isotopic results, even though the isotopic analyses of the saturate and aromatic fractions from three of the core extracts were indicated to be of relatively high maturity (See Appendix B).

4. Tables and figures

Table 1 shows the samples and the analytical program for this study.

Table 2 shows the quality of the EOM from all the seal peals, among which there are no apparent differences whether they were stored frozen until analysis or not.

Table 3 shows important relationships between the paraffinic members of the saturate fractions of all the extracted core samples. The ratios are based on chromatographic peak areas of identified components.

Table 4 shows paraffinic relationships between the thermal extracted samples.

Table 5 shows relations between porosity, pore saturation (S_o) with respect to hydrocarbons and grain density, all related to sample depth.

Figure 1 and 2 respectively, show the chromatographic profiles of the extracts from the two DST 1 water samples.

Figures 3-10 show the respective profiles of the " $C_{15}+$ " saturate part of the extracts from the seal peal samples in the range from 3783.91 to 3844.97 m RKB.

Figures 11-14 show the chromatographic profiles of the thermal extracted (S_1) components from four of the analysed seal peals.

Table 1

SAMPLES USED FOR RESERVOIR ANALYSIS

Statoil sample number	Sample type	Sample depth	Analytical program
S - 329	DST-1;02.08.84 1140 hr.;	3782.5 - 3787.5 m	1)
S - 330	DST-1;02.08.84 1145 hr.;	3782.5 - 3787.5 m	1)
S - 340	Core sample; Homogeneous light grey sst. (seal peal)	3813.56 - 3813.93 m	3)
S - 341	(———"——)	3822.69 - 3822.89 m)	3)
S - 342	(———"——)	3837.78 - 3838.17 m)	3).
S - 343	(———"——)	3806.16 - 3806.58 m)	2) 3) 4)
S - 344	(———"——)	3843.50 - 3843.85 m)	3)
S - 345	(———"——)	3783.91 - 3784.21 m)	2) 3) 4)
S - 346	Frozen seal peal	3844.97 m	2) 3) 4)
S - 347	(———"——)	3795.35 m	2) 3)

Key to Table 1 Analytical Program

- 1) Extraction of approx 1.1 kg of water samples and gas chromatography.
- 2) Thermal extraction of hydrocarbons and gas chromatography (S)
- 3) Extraction of organic matter with 99 % methylene chloride + 1% methanol (v/v) and precipitation of asphaltenes with n-pentane (95%). Separation of saturates, aromatics and NSO's by means of MPLC (Radke et al.; Anal. Chem. 1980 (52), 406).
Gas chromatography of saturate fraction ("C₁₅+").
- 4) Isotopic analysis of saturate and aromatic fractions with respect to ¹³C.

For further details concerning analytical methods, see Appendix.

Table 2 THE QUALITY OF THE EXTRACTS FROM THE SEDIMENT SAMPLES WITH INCREASING DEPTH

Sample no.	Depth in m RKB	EOM (ppm)	Saturates in % ($\delta^{13}\text{C}$)	Aromatics in % ($\delta^{13}\text{C}$)	Non HC incl. asph. in %	Precip. asph. in %	Sats./ arom.
S-345	3783.91-	937	68.40	22.31	9.28	1.85	3.07
	3784.21		(-29.7)	(-28.0)			
S-347	3795.35	846	66.00	19.40	14.61	4.61	3.40
S-343	3806.16-	766	68.62	20.04	11.33	2.26	3.42
	3806.58		(-29.8)	(-28.1)			
S-340	3813.56-	715	67.28	14.15	18.57	2.60	4.75
	3813.93						
S-341	3822.69-	606	67.69	16.57	15.74	2.04	4.09
	3822.89						
S-342	3837.78-	628	65.06	18.47	16.46	1.49	3.52
	3838.17						
S-344	3843.50-	431	65.20	18.07	16.73	2.12	3.61
	3843.85						
S-346	3844.97	459	65.54	16.17	18.30	3.65	4.05
			(-29.6)	(-28.1)			

Table 3. IMPORTANT PARAFFINIC RELATIONSHIPS WITH INCREASING DEPTH.
(SATURATE FRACTIONS OF SOLVENT EXTRACTED SAMPLES).

Sample	Pristane/ Phytane	(A) $\frac{\text{Pristane}}{\text{n-C}_{17}}$	(B) $\frac{\text{Phytane}}{\text{n-C}_{18}}$	A/B	$\frac{\text{n-C}_{17}}{\text{n-C}_{27}}$
S-345	1.32	0.85	0.73	1.16	6.43
S-347	1.36	0.81	0.69	1.17	7.14
S-343	1.47	0.81	0.69	1.17	6.85
S-340	1.32	0.80	0.70	1.14	7.29
S-341	1.42	0.78	0.65	1.20	11.44
S-342	1.40	0.80	0.72	1.11	14.16
S-344	1.40	0.80	0.68	1.18	7.94
S-346	1.43	0.82	0.68	1.20	12.87

Table 4. PARAFFINIC RELATIONSHIPS FROM THERMALLY EXTRACTED SAMPLES (S1).

Sample	Pristane/ Phytane	(A) $\frac{\text{Pristane}}{\text{n-C}_{17}}$	(B) $\frac{\text{Phytane}}{\text{n-C}_{18}}$	A/B	$\frac{\text{n-C}_{17}}{\text{n-C}_{27}}$
S-345	1.90	1.24	1.15	1.08	—
S-347	2.09	1.14	0.98	1.16	—
S-343	1.17	0.97	0.74	1.31	6.59
S-346	1.78	0.96	0.68	1.41	12 ¹⁾

1) This value is visually estimated from the chromatogram.

Table 5 POROSITY AND PORE SATURATION

Depth in m RKB	Sample equivalent	Porosity % He	Pore saturation So	Grain density in g/cm ³
3784.30	S-345	23.7	1.2	2.66
3795.30	S-347	21.9	1.2	2.64
3806.00	S-343	18.5	1.3	2.65
3806.65		20.0	1.2	2.65
3813.30	S-340	18.8	1.2	2.65
3814.00		19.4		2.65
3822.65	S-341	19.6	0.9	2.66
3823.00		20.0		2.65
3837.65	S-342	18.6	1.0	2.65
3838.30		18.7		2.66
3843.30	S-344	18.6	0.7	2.64
3844.00		20.4		2.64
3845.00	S-346	19.0	0.7	2.65

APPENDIX A
ANALYTICAL PROCEDURES

EXTRACTABLE ORGANIC MATTER (EOM)

About 100 g of finely crushed rock was extracted by 500 ml dichloromethane - methanol (99:1 % v/v) and a few mg copper in a stainless steel flask using a high speed mixer at 9000 rpm for 10 min. The sample was then centrifuged, filtered, through a 0.5 μ Millipore filter, rotavaporated and dried under N_2 -stream. The sample was then weighed.

EXTRACTION OF WATER SAMPLE

About 1 l of water sample was extracted by shaking with 1 x 50 ml + 3 x 40 ml dichloromethane in a separating funnel. The combined extracts were dried with sodium sulphate before filtered, rotavaporated and dried under N_2 -stream to approximately 0.5 ml. The sample was then ready for gas chromatographic analysis.

CLASS SEPARATION

Asphaltene

Precipitation of asphaltenes was done by adding 40 times as much pentane as material, vibrated in an ultrasound bath for three min. and left to stand in the dark at room-temperature for at least 8 hours. The solution was then filtered through a preweighed 0.5 μ Millipore filter and washed several times. After air-drying, the filter was weighed and the differences in weight taken to be the amount of asphaltene.

Precipitated material retained in the bottle was also weighed and added to the amount of filtered asphaltene.

Saturates, aromatics and NSO-compounds

The extract was separated into saturates, aromatics and NSO-compounds by dilution with hexane to 1 ml and injection into a medium pressure liquid chromatograph (Radke, M. et al., Anal. Chem., 52, 406-411, 1980). The fractions were rotavaporated and dried under vacuum before weighing.

Gas chromatography

The saturated fractions were analysed on a Perkin Elmer Sigma 2000 gas chromatograph under following conditions:

Column : 25 m x 0.22 mm. vitreous silica bonded phase
BP 1 (0.25 μ) from SGE.
Flow approx. 1.3 ml. H₂/min.
Temp. program: 50°C isothermal in 4 min., 4°C/min. to 300°C
and isothermal in 20 min.
Injector : Splittless injection, temp. 320°C.
Detector : Flame ionisation, temp. 320°C.

THERMAL EXTRACTION

Volatile hydrocarbons (S1) were evolved from 30-40 mg crushed sediment introduced into a pyrolysis-GC unit using a probe. The probe was carefully taken into a stream of He at 300°C, and the evolved hydrocarbons were trapped at the first half meter of the gas chromatographic column by using liquid nitrogen as cooling agent. The trapped hydrocarbons were then analysed chromatographically using the condition described under Gas chromatography with the exception that He was used as carrier gas.

APPENDIX B