

ADDRESS		KJELLER N-2007 Kjeller, Norway	HALDEN N-1751 Halden, Norway	AVAILABILITY
TELEPHONE		(02)712560 - 713560	(031)83100	Private
TELEX		76361 energ n	76335 energ n	Confidential
REPORT TYPE	REPORT NO.	IFE/KR/F-84/029		DATE 1984-03-08
	REPORT TITLE	MUD AND HEAD SPACE GAS GEOCHEMISTRY ON SAMPLES FROM WELL 31/5-1, 31/5-2		DATE OF LAST REV.
	CLIENT	STATOIL, NORSK HYDRO AND SAGA		NUMBER OF PAGES
	CLIENT REF.			NUMBER OF ISSUES 20
SUMMARY				DISTRIBUTION
<p>Migrated thermogenic methane is mixed with biogenic methane at least to about the 1000 m level.</p> <p>Rather heavy $\delta^{13}\text{C}$ propane value (as heavy as -17.9), can in our view only be explained by effects from bacterial degradation in the reservoir.</p> <p>This biodegradation was followed by a period of renewed supply of pre- dominantly dry gas. High maturity gases, which are not biodegradaded, found below the present reservoir may represent the gases os gas which super imposed the biodegraded situation of the reservoir.</p>				<p>Contractors, 10 Andresen, B. Berg, J.O. Brevik, E. Garder, K. Gaudernack, B. Råheim, A. Thronsen, T.O.</p>
<p>1 6 MARS 1984</p> <p>REGISTRERT</p> <p>OLJESENTERNAET</p>				
KEYWORDS GAS GEOCHEMISTRY, MIGRATION, BACTERIAL DEGRADATION, MATURITY				
NAME		DATE		SIGNATURE
PREPARED BY	Björg Andresen Einar Brevik Arne Råheim	1984-03-08		Arne Råheim
REVIEWED BY				
APPROVED BY	Karen Garder	1984-03-08		Karen Garder

1. INTRODUCTION

The samples were received in December 1983. The main part of the work has been done in January 1984. 21 gas samples taken at 100 m intervals from the mud line at depths from 470 to 2403 m have been analysed. Only one sample had a concentrations of hydrocarbons above 1%. Due to low hydrocarbon concentrations, it has only been possible to determine the $\delta^{13}\text{C}$ -methane value of two vaqtainer samples. The $\delta^{13}\text{C}$ - measurements on methane and, when possible, on ethane and propane, have therefore been made on headspace gas from cans, taken at about the same depth intervals as the vaqtainers.

2. ANALYTICAL PROCEDURE

The natural gas has been separated into the different gas components by a Carlo-Erba 4200 instrument. The hydrocarbon gas components were oxydized in separate CuO-ovens, which enables us to collect several times when the concentration of a gas component is low. The combustion products CO_2 and H_2O were frozen into collection vessels and separated. The isotopic measurements were performed on a Finnigan Mat 251 mass spectrometer. Our $\delta^{13}\text{C}$ -value on NBS-22 is -29.77 ± 0.06 ‰.

3. RESULTS

The stable isotope results are given in Table 1. The composition of the gases from the vacutainers are given in table 2., and the composition of the headspace gases are given in table 3.

4. INTERPRETATION

As seen from table 1, thermogenic methane migrated and was mixed with biogenic methane at least to about the 1000 m level. The sealing efficiency of the cap rock may therefore not be complete with respect to methane.

The differences between the $\delta^{13}\text{C}$ propane values from about the 1500 m level to the 1800 m level are unrealistically high. The rather heavy propane values are in accordance with the data reported from the reservoir gases of well 31/3-1. These heavy $\delta^{13}\text{C}$ propane values (as heavy as - 17.9) can in our view only be explained by effects from bacterial degradation. Similar heavy $\delta^{13}\text{C}$ propane values have been found by James and Burns (1984)* from bacterially altered subsurface reservoir hydrocarbon accumulations.

The methane and most of the ethane have, however, not been effected by the bacterial degradation. If this was the case, we should according to our previous experience, have seen much heavier $\delta^{13}\text{C}$ -methane and -ethane values.

In accordance with our conclusion given in the report on well 31/3-1, new methane and ethane (possibly also water components) must therefore have migrated into the reservoir after the bacterial degradation had stopped and could, particularly if the geological situation of the reservoir is complex, have been mixed with varying amount of the already biodegraded hydrocarbon gas components in the reservoir.

It is in this connection interesting to note the $\delta^{13}\text{C}$ values of the samples from the (1989-1998)m level and the (2205-2214)m level. In these cases the distribution of the $\delta^{13}\text{C}$ values of methane, ethane and propane have a normal trend. Both samples indicate when plotted on the maturity diagram by James (1983)** a high maturity situation, eq. to the condensate field of the oil window (Fig. 1).

These gases may represent; a) The generation of gas (or gases) which did occur in the reservoir prior to the bacterial degradation, or b) they may represent the gases which migrated into the reservoir after the bacterial degradation had taken place and may thus represent the gases which are presently migrating into the reservoir.

The relatively light $\delta^{13}\text{C}$ ethane value (- 28.2) from the (1290-1300)m sample should also be noted. This gas may have been migrated from the

reservoir and mixed with early diagenetic ethane.

5. CONCLUSION

The interpretation given for the reservoired gas of well 31/3-1 would fit the present data from well 31/5-1, 31/5-2 on gases from the 1500 m level to the 1800 m level.

Biodegradation of hydrocarbons in the reservoir was followed by a period of renewed supply of predominantly dry gas.

The gas samples taken underneath the reservoir {(1989-1998)m level and (2205-2214)m level)} have been formed at a high maturity situation, eq. to the condensate field of the oil window. These gases are not affected by bacterial degradation, and may therefore represent the gases (or gas) which are presently migrating into the reservoir.

Remark

The difference which sometime occurs between the $\delta^{13}\text{C}$ methane values obtained from vacutainers and the head space concentration from the same or similar depth indicate that bacterial oxydation may have occurred in the vacutainer. A comparison between the $\delta^{13}\text{C}$ methane values from the present well and the $\delta^{13}\text{C}$ methane values from well 31/3-1 indicate that the vacutainers may be more subjected to bacterial oxydation than the head space cans (if bacterizides have been used). Most of the $\delta^{13}\text{C}$ methane values on vacutainer samples reported from well 31/3-1 are therefore very likely too heavy.

- * James, A.T. and Burnes, B.J.(1984): Microbiological Alteration of Subsurface Natural Gas Accumulations. A.A.P.G. (In press).

- ** James, A.T. (1983): Correlation of Natural Gas by Use of Carbon Isotopic Distribution between Hydrocarbon Components. A.A.P.G. Vol. 67, No. 7, July 1983.

TABLE : 1 Isotopic composition of headspace gas and mud gas from
well 31/5-1,

ISOTOPIC COMPOSITION OF HEADSPACE GAS, $\delta^{13}\text{C}$ (‰)

Sample depth m	C ₁	C ₂	C ₃
470*	- 51.8 *		
490- 500	- 72.6		
610- 620	- 75.1		
710- 720	- 78.5		
810- 820	- 78.3		
870- 880	- 70.5		
1010-1020	- 63.9		
1090-1100	- 56.7		
1190-1200	- 55.3		
1290-1300	- 53.6	- 28.2	
1390-1400	- 48.0		
1503-1512	- 42.5	- 24.9	- 17.9
1521-1530	- 46.7	- 26.6	- 20.6
1557-1566*	- 43.5 *		
1575-1584	- 40.9	- 24.5	- 20.3
1593-1602	- 37.5	- 26.5	- 19.6
1701-1710	- 43.7	- 25.6	- 21.0
1791-1800	- 44.5	- 26.2	- 22.6
1881-1890	- 42.9		
1989-1998	- 46.1	- 27.3	- 27.2
2115-2124	- 41.5		
2205-2214	- 44.6	- 29.5	- 28.4
2313-2322	- 42.2		
2385-2394	- 45.6		
2493-2508	- 46.5		

* vacutainer sample.

TABLE : 2. Mudgas from vacutainers

Sample depth m	C ₁	C ₂	C ₃	iC ₄	nC ₄	Co ₂
% of C ₁ -C ₄ , Co ₂						
470	0.5	0.003	0.0007	≈0.0010	≈0.0010	0.08
570	0.1	0.0005	-	-	-	0.06
670	0.2	-	-	-	-	0.10
770	0.13	-	-	-	-	0.05
860	0.12	-	-	-	-	0.06
960- 970	0.05	-	-	-	-	0.05
1060-1070	0.06	0.001	-	-	-	0.08
1160-1170	0.10	0.001	-	-	-	0.07
1260-1270	0.08	0.001	-	-	-	0.07
1360-1370	0.06	-	-	-	-	0.06
1458-1467	0.04	-	-	-	-	0.04
1557-1568	1.1	0.04	0.003	-	-	0.05
1719-1728	0.03	0.001	-	-	-	0.05
1800-1809	0.02	0.0001	-	-	-	0.06
1899-1908	0.02	0.0003	-	-	-	0.07
1986-1995	0.07	0.004	-	-	-	0.06
1995-2004	0.03	0.001	-	-	-	0.06
2097-2106	0.01	0.0003	-	-	-	0.06
2196-2205	0.03	-	-	-	-	0.06
2292-2301	0.03	0.0006	-	-	-	0.08
2394-2403	0.02	0.0005	-	-	-	0.07

TABLE : 3 Headspace gas

Sample depth m	C ₁	C ₂	C ₃	iC ₄	nC ₄	Co ₂	$\frac{C_2 - C_4}{C_1 - C_4}$	$\frac{iC_4}{nC_4}$
							% of C ₁ -C ₄	
490- 500	2.5					0.06		
610- 620	1.2	0.003					0.002	
710- 720	3.7	0.02	0.002			0.16	0.006	
810- 820	5.3	0.03	0.006	0.006	0.004	0.29	0.009	
870- 880	0.53	0.007	0.001	0.003	0.001	0.001	0.024	
1010-1020	0.39	0.004				0.19	0.010	
1090-1100	0.84	0.05	0.002				0.058	
1190-1200	0.20	0.015				0.22	0.070	
1290-1300	1.2	0.01	0.02	0.010	0.001	0.01	0.033	
1390-1400	0.68	0.05	0.02	0.010	0.012	0.13	0.288	0.83
1503-1512	1.8	0.58	0.37	0.12	0.10	0.004	0.394	1.20
1521-1530	2.1	0.55	0.26	0.17	0.09	0.04	0.360	1.89
1575-1584	2.2	0.93	0.54	0.39	0.15	5.8	0.477	2.60
1693-1602	1.8	0.98	0.65	0.19	0.11	0.03	0.517	1.73
1701-1710	1.6	0.44	0.17	0.10	0.05	0.06	0.322	2.00
1791-1800	3.3	0.75	0.31	0.14	0.12	0.02	0.286	1.17
1881-1890	0.33	0.16	0.11	0.05	0.05	0.006	0.529	1.00
1989-1998	50.0	3.8	1.0	0.08	0.06	0.006	0.090	1.33
2115-2124	0.17	0.06	0.04	0.013	0.005	0.02	0.410	2.60
2205-2214	0.74	0.23	0.19	0.07	0.04	0.003	0.417	1.75
2313-2322	1.4	0.28	0.16	0.03	0.03	0.06	0.263	1.00
2385-2394	0.89	0.11	0.04	0.006	0.002	0.17	0.151	3.00
2493-2508	2.1	0.16	0.03	0.004	0.003	0.003	0.086	1.33

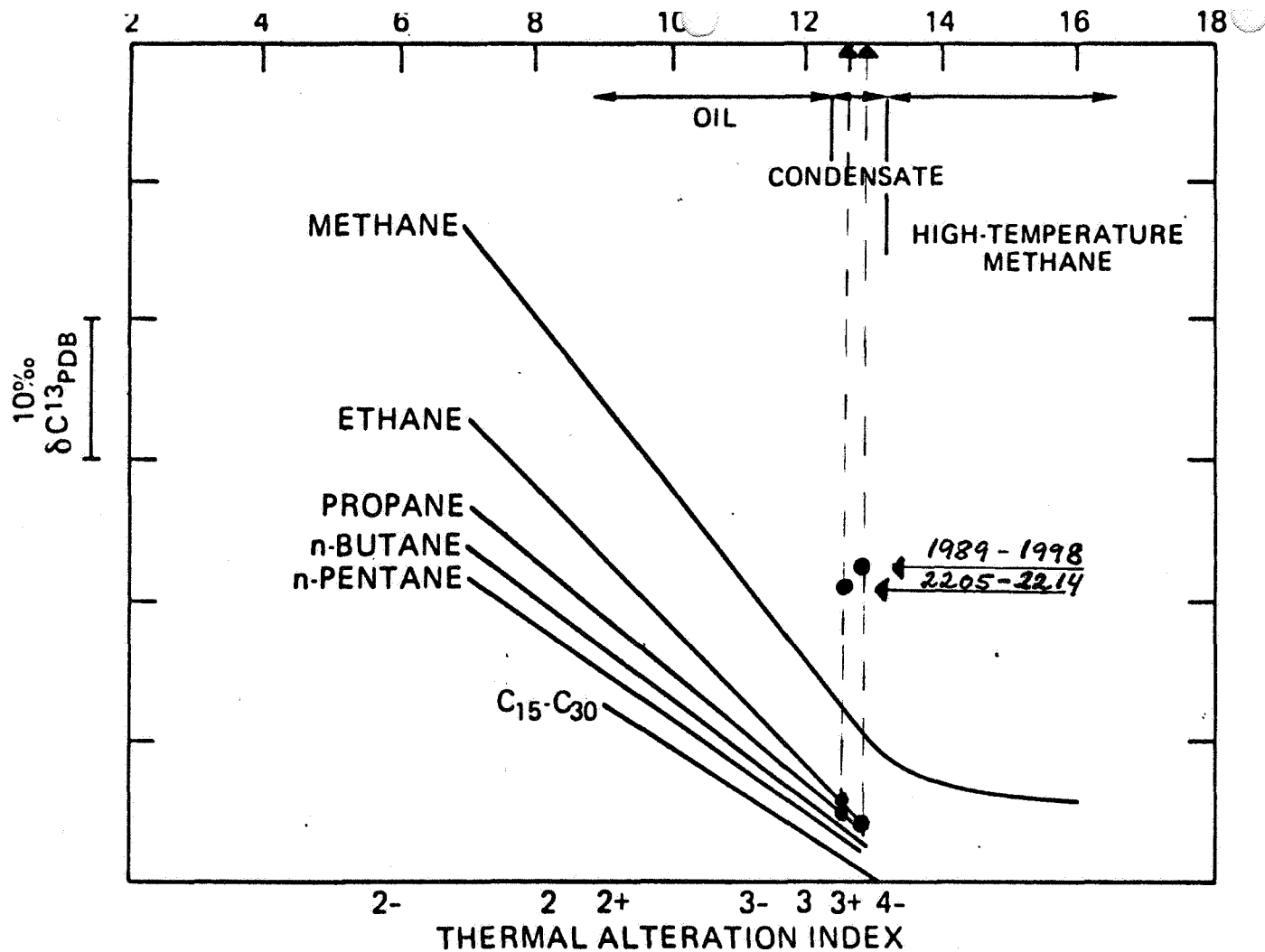


Figure 1. Carbon isotopic separations of the head space gases from the (1989-1998) m level and the (2205-2214) m level of well 31/5-1, 31/5-2 is plotted on the maturity diagram (after James, 1983). A source LOM of about 13 is indicated for the gases.

The calculated carbon isotopic separations between gas component are plotted on the vertical axis using a sliding scale that is simply the algebraic difference, in parts per mil, between the isotopic compositions of the natural gas components. The scale does not possess a fixed origin, but is oriented with the more depleted $\delta^{13}\text{C}$ values at the upper end. Use of this sliding scale allows the maturity of a gas to be assessed without prior knowledge of the isotopic composition of the gas' source.