


ADDRESS KJELLER HALDEN N-2007 Kjeller, Norway N-1751 Halden, Norway TELEPHONE +47 6 812560 - 813560 +47 31 83100 TELEX 74 573 energ n 76 335 energ n TELEFAX +47 2 815553		AVAILABILITY Private Confidential	
REPORT TYPE	REPORT NO. IFE/KR/F-87/102	DATE 1987-09-10	
	REPORT TITLE REPORT ON STABLE ISOTOPES (C, H, O) ON NATURAL GASES FROM WELL 30/9-6	DATE OF LAST REV.	
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SUMMARY The gas components C ₁ -C ₄ and CO ₂ have been separated from natural gases of well 30/9-6, and the $\delta^{13}\text{C}$ values of these components have been measured. The isotopic composition of hydrogen from CH ₄ has also been measured. The isotope study of natural gas samples from well 30/9-6 indicates a high maturity situation. The gas may possibly be derived at different maturity levels from the same source.		DISTRIBUTION Hydro (13) Andresen, B. Brevik, E.M. Råheim, A. Throndsen, T.	
			
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	NAME	DATE	SIGNATURE
PREPARED BY	Bjørg Andresen Einar M. Brevik	1987-09-10 1987-09-10	Bjørg Andresen Einar M. Brevik
REVIEWED BY	Thorbjørn Throndsen	1987-09-10	Thorbjørn Throndsen
APPROVED BY			

1. INTRODUCTION

Four gas samples from well 30/9-6; geochem #1 test no. 1 and test no. 2, and geochem #2 test no. 1 and test no. 2, were received and analyzed August 1987.

The geochem #1 test no. 2 sample was empty at the arrival on the laboratory.

On the three other samples C_1 - C_4 and CO_2 are quantified, and the $\delta^{13}C$ value is measured on methane, ethane, propane, the butanes and CO_2 and the δD value is also measured on methane.

2. ANALYTICAL PROCEDURE

The natural gases have been quantified and separated into the different gas components by a Carlo-Erba 4200 instrument. This gas chromatograph is equipped with a special injection loop in order to concentrate the samples, in the case of low concentration of the gas components. The hydrocarbon gas components were oxidized in separate CuO -ovens in order to prevent cross contamination. The combustion products CO_2 and H_2O were frozen into collection vessels and separated.

The water was reduced with zinc metal in a sealed tube to prepare hydrogen for isotopic analysis. The isotopic measurements were performed on a Finnigan Mat 251 and a Finnigan Mat delta mass spectrometer. Our $\delta^{13}C$ value on NBS 22 is $-29.77 \pm .06$ o/oo PDB.

3. RESULTS

The composition of the samples is given in Table 1. The results have been normalized to 100%. The stable isotope results are given in Table 2.

Our uncertainty on the $\delta^{13}C$ value is estimated to be ± 0.3 o/oo and includes all the different analysis step. The uncertainty on the δD value is likewise estimated to be ± 5 o/oo.

Table 1 Volume composition of gas samples from well 30/9-6

Sample	IFE no.	C ₁ %	C ₂ %	C ₃ %	i-C ₄ %	n-C ₄ %	CO ₂ %	ΣC _{1-C₄}	$\frac{\Sigma C_2-C_4}{\Sigma C_1-C_4}$	$\frac{i-C_4}{n-C_4}$
Geochem #1 Test no. 1	6725	82.6	9.2	4.6	0.61	1.2	1.9	98.1	0.16	0.53
Geochem #2 Test no. 1	6727	83.1	9.1	4.3	0.59	1.1	1.8	98.2	0.15	0.54
Geochem #2 Test no. 2	6728	83.9	8.9	4.0	0.54	1.0	1.6	98.4	0.15	0.51

Table 2 Isotopic composition of gas samples from well 30/9-6

Sample	IFE no.	C ₁		C ₂	C ₃	i-C ₄	n-C ₄	CO ₂	
		δ ¹³ C PDB	δD SMOW	δ ¹³ C PDB	δ ¹³ C PDB	δ ¹³ C PDB	δ ¹³ C PDB	δ ¹³ C PDB	δ ¹⁸ O PDB
Geochem #1, test no. 1	6725	-43.0	-180	-28.5	-28.0	-27.8	-27.3	-10.3	-13.1
Geochem #2, test no. 1	6727	-43.1	-180	-28.9	-27.1	-27.0	-27.6	-11.0	-12.4
Geochem #2, test no. 2	6728	-42.8	-179	-28.9	-26.5	-27.4	-27.4	-10.1	-14.2

4. INTERPRETATION

A general isotopic trend for unaltered gases is found to be a smooth progression from methane to n-butane, excluding i-butane (James 1983).

In the present case this is the situation for the geochem #1 test no. 1 sample. The carbon isotopes of methane, ethane, propane and n-butane can then be used to indicate the maturity level of the gas by using James' maturity diagram (James 1983), Figure 1.

A source LOM between 12 and 13 is then indicated, e.g. that the gas was formed at high maturity in the condensate field of the oil window. This is also in accordance with the combined use of the carbon and hydrogen isotopes of methane (Schoell 1983), Figure 2.

The geochem #2 test no. 1 and 2 samples have a slight opposite isotopic trend, with $\delta^{13}\text{C}$ n-butane values lighter than or at the same level as the $\delta^{13}\text{C}$ propane values. This opposite trend is very slight and may be insignificant.

It may, however, indicate a mixed gas at least derived from two different sources with one source dominating from the $\text{C}_1\text{-C}_3$ range and the other dominating from C_4 and higher.

Gases derived from the same source but at different maturity levels is also a possibility.

The present relationship between the $\delta^{13}\text{C}$ values of propane and n-butane may also indicate a high maturity situation.

This is also in accordance with the combined use of the $\delta^{13}\text{C}$ and δD values of methane (Schoell 1983), Figure 2, and the geochem #1 test no. 1 sample.

If it is assumed that $\text{C}_1\text{-C}_3$ are dominantly derived from one source the $\delta^{13}\text{C}$ values of methane, ethane and propane can be used to indicate the maturity level of the gas, by using James' maturity diagram (James 1983), Figure 1.

A source LOM of about 11 may thus be indicated, e.g. that the gas was formed at a relatively high maturity level in the oil window, with the geochem #2 test no. 1 sample slightly more mature than the geochem #2 test no. 2 sample.

As seen from Table 2 and Figure 2 all three gas samples have very similar isotopic composition of methane, ethane and n-butane. This indicates that the gases are derived from the same source but at different maturity levels. This seems to be the most likely explanation in the present case, and that the geochem #1 test no. 1 sample represents the most mature gas in the mixture.

5. CONCLUSION

The isotope study of natural gas samples from well 30/9-6 indicates a high maturity situation in the oil window. The gas may possibly be derived at different maturity levels from the same source.

- * James, Alan T. (1983): Correlation of Natural Gas by Use of Carbon Isotopic Distribution between Hydrocarbon Components, AAPG, Vol. 67, No. 7, July 1983.
- ** Schoell, M. (1983): Genetic Characterization of Natural Gases, AAPG, Vol. 67, no. 12, December 1983.

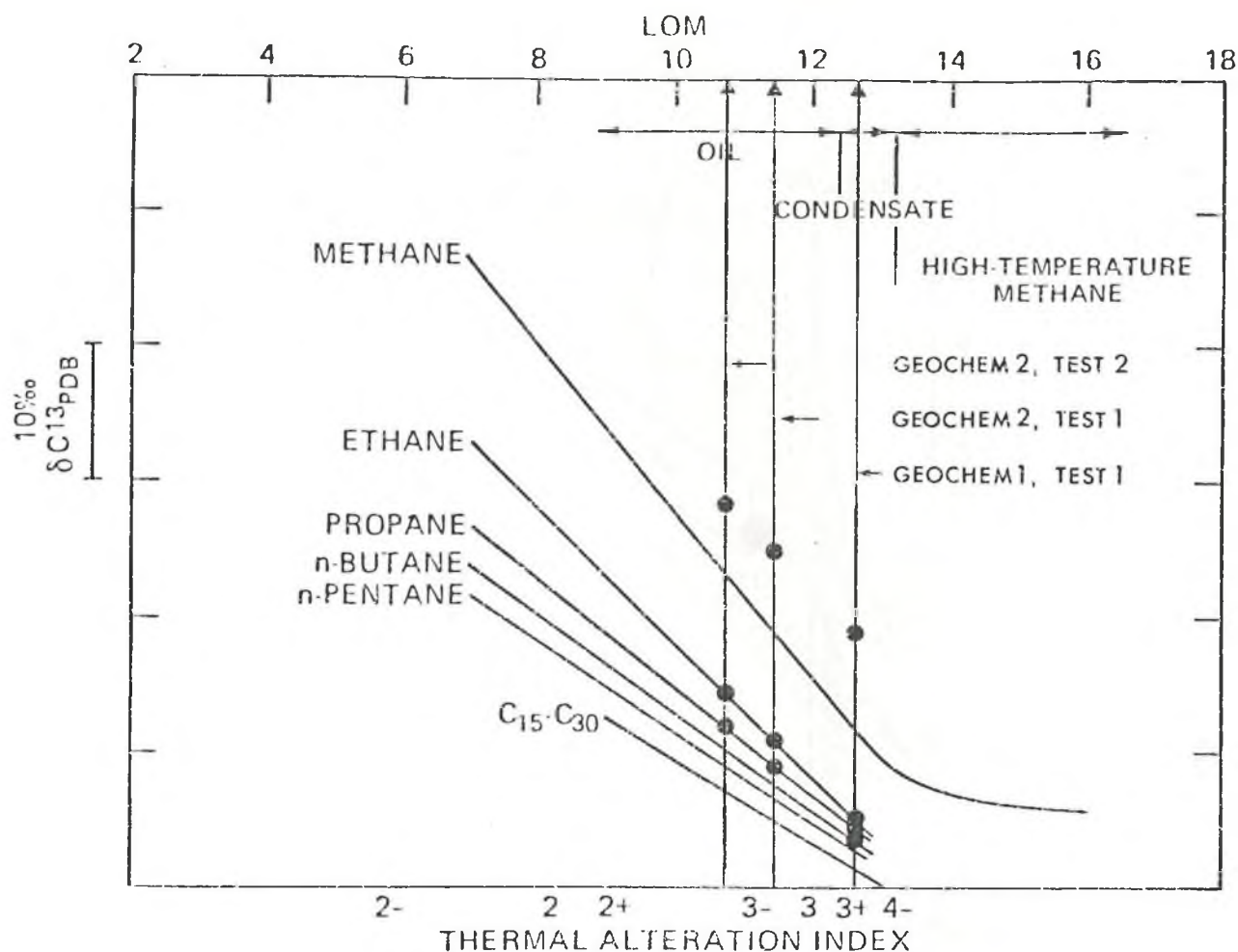


Figure 1. Carbon isotopic separations of gas samples from well 30/9-6 are plotted on the maturity diagram (after James, 1983). A source LOM between 10 and 13 is indicated for the gas.

The calculated carbon isotopic separations between gas components 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.

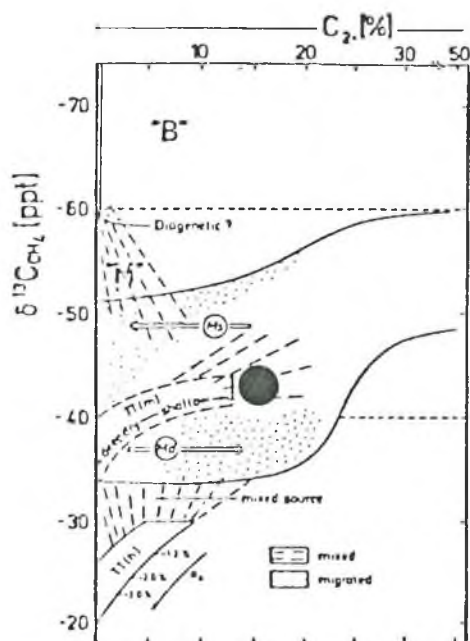


Figure 2a

Variations of molecular composition in natural gases related to the isotope variations of methane.

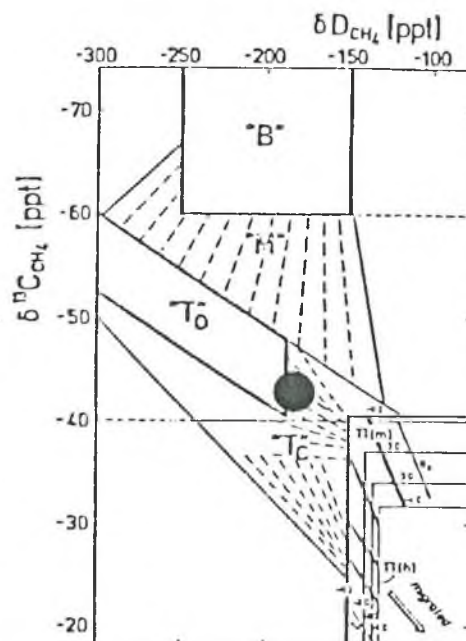


Figure 2b

Carbon and hydrogen isotope variations in methanes.

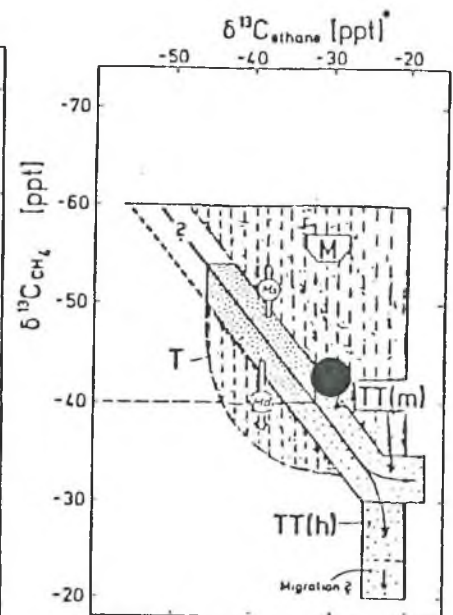


Figure 2c

Carbon isotope variations in ethane related to carbon isotope variations in methane.

The principle for the genetic characterization of natural gases is that the primary gases (B-biogenic gas, T-associated gas, TT-non-associated gas) are defined by fields of compositional variations. These primary gases may become mixed and form various mixtures "M" of intermediate composition. "TT(m)" and "TT(h)" are non-associated gases from marine source rocks and coal gases from N.W. Germany, respectively, compositional shifts due to migration are indicated by arrows Md (deep migration) and Ms (shallow migration), respectively. "T" are gases associated with petroleum in an initial phase of formation. "T_c" are gases associated with condensates. (Schoell 1983).