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Håkon Magnussons gt. 1B — N-7000 Trondheim — Telephone (075) 15 660 — Telex 55548

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REPORT TITLE/ TITTEL			
Headspace Isotope Analyses of well 6407/2-1.			
CLIENT/ OPPDRAGSGIVER			
Saga Petroleum A/S			
RESPONSIBLE SCIENTIST/ PROSJEKTANSVARLIG			
N. Mills			
AUTHORS/ FORFATTERE			
M. Schoell			
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SUMMARY/ SAMMENDRAG

On the basis of isotope compositions ($\delta^{13}C$ values), gas from mature sources is found in well 6407/2-1.

Other maturity parameters reveal that the well does not reach maturities high enough for such gas to be produced in situ and a migration of gases produced from a mature zone elsewhere is most likely.

KEY WORDS/ STIKKORD

Mature Gas	Migration
Secondary Effects	6407/2-1

These isotope analyses are part of Source Rock Analysis on well 6407/2-1 (IKU report 0-493). The work was subcontracted to

Priv. Doz. Dr. M. Schoell
Memeler Strasse 33
3000 Hannover 51
Deutschland

The report is authored by Dr. Schoell with minor technical changes and brief summary by IKU (see title page).

1. INTRODUCTION

Isotope analyses on head space methane allows one to estimate the maturity regime of a drilled section (Schoell 1981). This report compiles $^{13}C/^{12}C$ isotope analyses on methane from well 6407/2-1 in the Haltenbanken area.

2. SAMPLES

Sixteen canned cuttings were submitted for analysis. The cans were partly very corroded (rusty) and had little or no head space gas remaining. Some of the cans contained too much water. The status of the cans is noted in the tables.

3. ANALYTICAL TECHNIQUE

The cans are homogenized by rolling them for one hour. Head space gas was extracted by expanding the gas to a vacuum which is the inlet volume of the GC. Methane was separated from air by gas-chromatography and was oxidized to CO_2 at the outlet of the GC by passing it over CuO at 850°C. ^{13}C was determined by mass-spectrometry; δ-values are reported against PDB standard.

$$\delta = \left(\frac{R_{sample}}{R_{standard}} - 1\right) \times 1000 \ (\text{‰})$$

4. RESULTS

The results are listed in Table 1 and are graphically displayed in Fig. 2. Unreliable results due to quality of cans have been omitted.

5. INTERPRETATION OF RESULTS

5.1 General background

The genetic interpretation of the results follows the general genetic characterization of natural gases (1) which is reproduced in Fig. 1 for easier reference. The various genetic types of natural gases are often distributed in the sedimentary sequences in a characteristic zoning, which results from increasing maturity of organic matter. The following zones can be distinguished in an undisturbed sequence of increasingly mature sediments (see Figure 1 and 2).

Biogenic Zone ("B"): Immature, often unconsolidated sediments, dry gases of bacteriogenic origin, $\delta^{13}C$ values of methane range from -80 to -60 ‰. Maturity of OM $R_o \sim 0.5\%$.

Mixing Zone ("M"): Transition zone between biogenic and mature zone. Here, often, mixing of biogenic and thermogenic gases is observed. Typical $\delta^{13}C$ values of methane range from -60 to -50. Maturity of OM $R_o \sim$ 0.5 to 0.6%.

Thermogenic Zone ("T"): Principal zone of oil formation. Maturity of organic matter $R_o \sim 0.7$ to 1.2%. Formation of oil and associated gas.

Overmature Zone ("TT(m)"): Principal zone of dry gas formation. Organic matter is overmature ($R_o > 1.2$). Source rocks contain organic matter of Type II.

Coal Gas Zone ("TT(h)"): Mature to overmature zone. Typical isotope values of gases formed from coal of the mature to overmature stage are more positive than -30 ‰. Also high rank organic matter ($R_o \sim 2.5\%$) of any type may form gases of this isotopic composition.

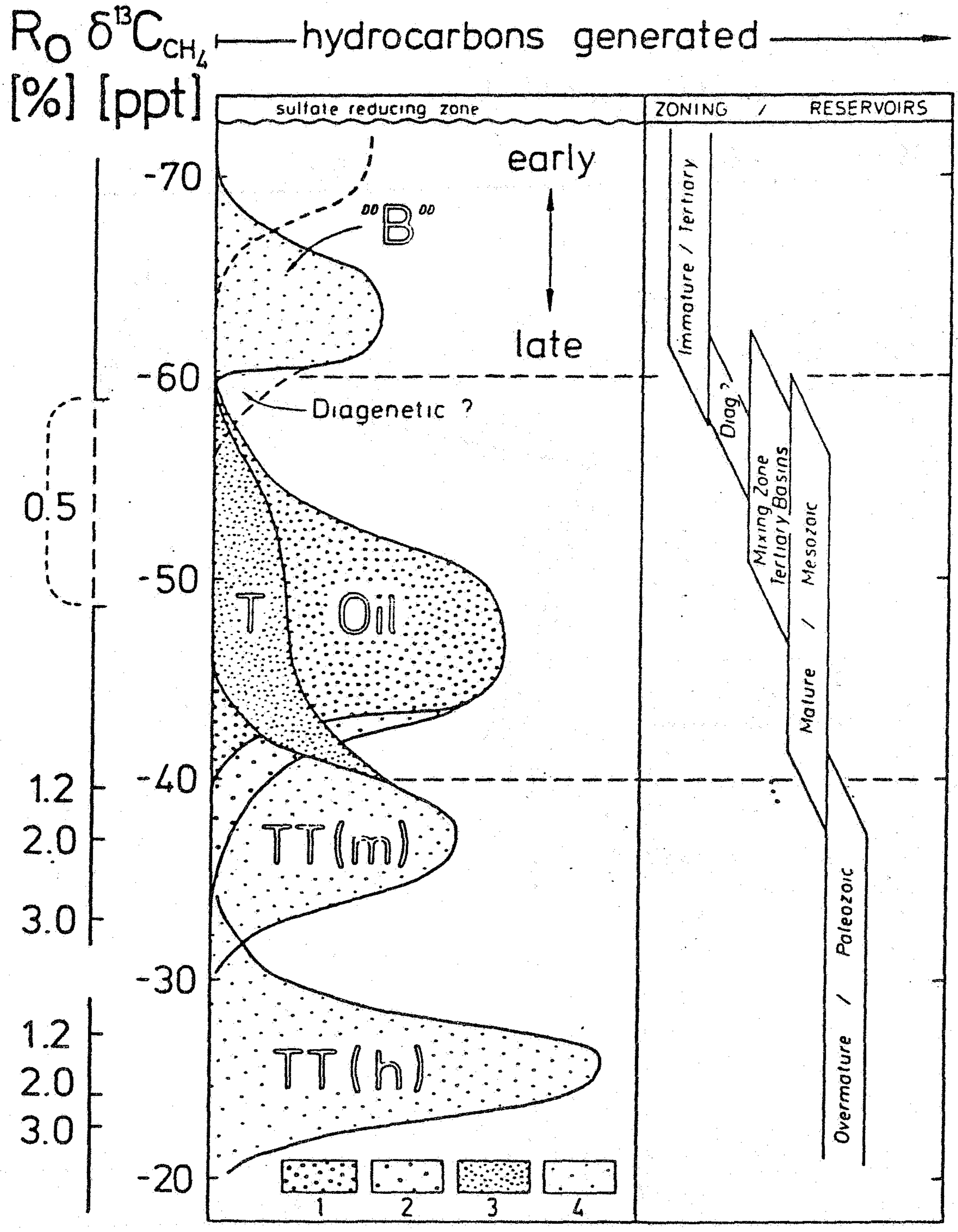
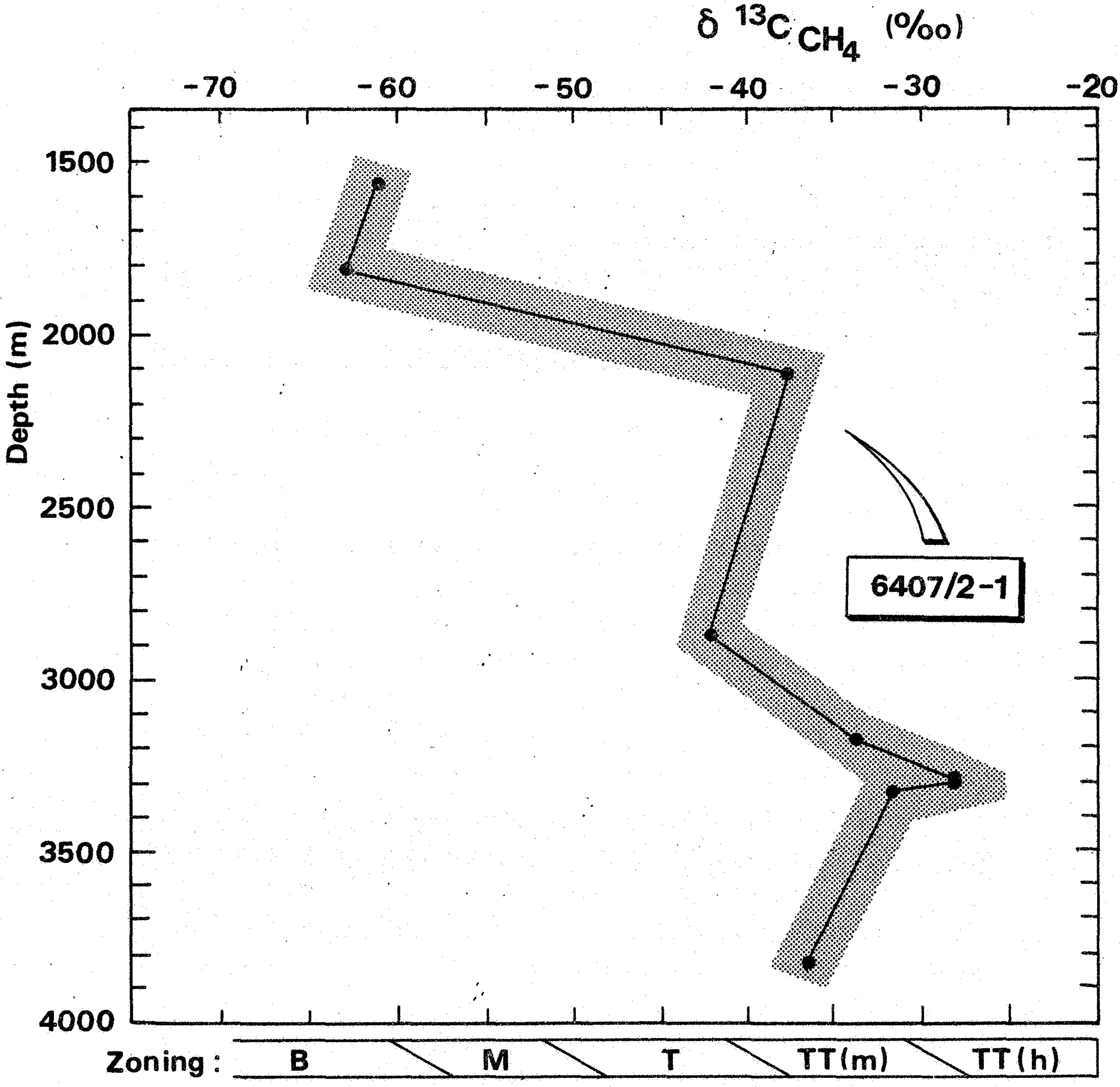


Fig. 1 : Genetic characterization of natural gases

Fig.2


δ 13C CH4 (‰)
-70
-60
-50
-40
-30
-20
Depth (m)
1500
2000
2500
3000
3500
4000
6407/2-1
Zoning :
B
M
T
TT(m)
TT(h)

5.2 Secondary isotope effects in head space gases

Head space gases generally resemble reservoir gases in their isotopic composition (2,3). However, systematic isotope fractionations in different lithologies have been observed (3). Usually, pure sandy cuttings reveal a shift to positive $\delta^{13}C$ values. Drilling additives may also influence the results. If cans are stored for lengthy periods after sampling, any methane present may become oxidized, or conversely methane may be bacterially formed. Because information on lithology and sampling is not available the following interpretation may have to be reviewed to account for these effects. Moreover all cans were more or less corroded. This could lead to gas loss and would cause unpredictable changes in the isotope values.

5.3 Evaluation of isotope measurements

There is a pronounced trend of the methane isotope values with increasing depth.

The values from the two shallowest samples suggest biogenic formation of the methane down to a depth of 1900m. Between 1900 and 2100m there is a drastic change in the $\delta^{13}C$ value of the methane to a value of more positive than -40 ‰. This is quite unusual for undisturbed sedimentary sequences. A pronounced change in lithology and/or maturity could account for the observed change. Below a depth of 2100m isotopic compositions which are typical for the mature to overmature stage are encountered. At depths below 3000m even overmature gases are in the head space of the cuttings.

A maturity of the organic matter above 1.2% vitrinite reflectance would be required to account for the isotopic values found in the head space methane. If such high maturities are found at these depths an indigenous formation of the gases must be assumed. If organic matter is less mature than 1.2% vitrinite reflectance migration of the gases from a more mature source is likely.

6. CONCLUSIONS

The analyses reveal a pronounced increase of $\delta^{13}C$ values in the head space methane. This indicates that gases from mature sources are either formed in situ or are migrated to the area. The results indicate mature to overmature gases over most of the drilled section.

7. SUGGESTION

The canned cutting head space technique has some disadvantages regarding sample preservation. Corrosion of the cans may cause severe changes in the isotopic composition. This cannot be ruled out for the cans in this study. Further sampling should be performed with vacutainers which allow easy sampling and shipping and storage of samples without secondary changes.

Table 1: Results of isotope analyses on head space methane well 6407/2-1

	IKU No.	Depth m	$\delta^{13}C$ (‰)	Remarks[1] on can
1	M-7299	1540 - 1550	-61.0	1
2	M-7311	1660 - 1670	(-21.0)	2
3	M-7325	1800 - 1810	-62.9	3
4	M-7339	1940 - 1950	-	4
5	M-7353	2080 - 2090	-37.2	1
6	M-7369	2240 - 2250		
7	M-7381	2360 - 2370	-	4
8	M-7395	2500 - 2509	(-22.0)	2
9	M-7435	2860 - 2869	-	4
10	M-7437	2870 - 2887	-41.9	1
11	M-7672	3184 - 3193	-35.4	1
12	M-7684	3292 - 3301	-27.9	5
13	M-7686	3310 - 3319	-27.7	5
14	M-7688	3328 - 3337	-31.6	
15	M-7725	3659 - 3668	-	6
16	M-7745	3838 - 3847	-36.2	

1) Quality of can:
1 good can, 2 leakage, 3 filled with water, 4 no head space gas,
5 small head space gas, 6 open can, 7 corroded can.

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