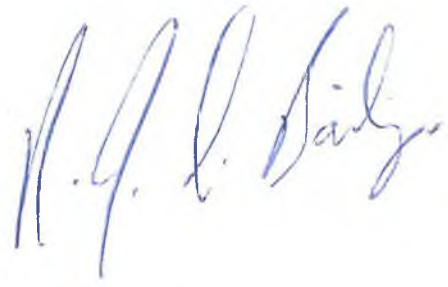
CORRELATION OF THREE OILS FROM THE NORWEGIAN NORTH SEA

SUMMARY

Three crude oil samples from two Mobil wells in the Norwegian sector of the North Sea - 33/9-3 (FIT 2) and 33/12-2 (DST 2 and DST 5) have been examined using high resolution analytical techniques.

Compositional differences between the oils are minimal and suggest that they were derived from a common source rock in which the kerogen was largely non-marine algal material. The environment of deposition of the source sediment was probably lacustrine but possibly lagoonal.



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INTRODUCTION

This report presents the results of a geochemical study of three Norwegian North Sea crude oils from Mobil's 33/9-3 and 33/12-2 (DSTs 2 and 5) wells.

The study was designed to determine whether all three oils were produced from the same source rock horizon. Such studies are primarily a correlation between crude oils and organic matter, and relate to source rock intervals through the assumption, commonly justified, that the kerogens within the possible source rock intervals are distinctively different.

This study was authorised by Mr H P Raveling of Mobil Exploration Norway Inc.

A. ANALYTICAL

Oil correlation studies require high resolution analytical techniques as meaningful results have to be derived from fine differences, gross differences between oils being generally (but not always) a function of other processes and not of the source.

For the purpose of this study, gas chromatography of the gasoline range (C_4-C_7) hydrocarbons and the C_{15+} paraffin-naphthenes and carbon isotope mass spectroscopy of the paraffin-naphthene and aromatic hydrocarbons were selected.

The three oil samples were assigned the job number 17 and sequential sample numbers from -001 to -003.

The analytical data are presented in tables 1 through 3 and graphically in figure 1.

B. GENERAL INFORMATION

Ten copies of this report have been forwarded to Mr H P Raveling, Mobil Exploration Norway Inc. A copy of the data has been retained by Geochem for future consultation with authorised Mobil personnel.

All of the data and interpretations related to this study are regarded as highly confidential and are proprietary to Mobil Exploration Norway Inc.

RESULTS AND INTERPRETATION

The results derived from the individual analyses will be discussed in turn, following which, conclusions will be drawn.

A. GASOLINE RANGE HYDROCARBONS (C_4-C_7)

The data presented in table 1 show that the detailed (by compound) and group (e.g. naphthenes) composition of these three crude oils is very similar.

Some relatively minor differences are indicated by the ratios of the individual hydrocarbons. The DST 2 sample from 33/12-2 has higher values for the ratios of cyclohexane to methylcyclopentane, methylcyclopentane to methylcyclohexane and 2-methylhexane to 3-methylhexane than the other two crudes which resemble each other very closely. Variations involving individual naphthenes (cycloparaffins) are less likely to reflect differences in either the maturation state of the oil or its migrational history and more likely to indicate source variations. In this case, the differences are relatively small.

B. HEAVY (C_{15+}) FRACTION

Hydrocarbons constitute a similar proportion of all these crudes, but the paraffin-naphthene to aromatic ratio (table 2A) is quite variable between these three oils. The most striking contrast is between the DST 5 sample from 33/12-2 and the other two crudes as the former is significantly more aromatic and contains less of the paraffin-naphthenes.

Within the paraffin-naphthene fraction (table 2B) the same oil has a somewhat lower proportion of naphthenes and rather more normal paraffins. The carbon preference indices for all three samples are essentially unity.

The high proportion of naphthenes within the total paraffin-naphthene fraction suggests that all three crudes were derived from source rocks rich in algal organic matter. At the same time, the gravity of the crudes and the relative absence of steranes on the gas chromatogram (figure 1) suggests a mature source rock.

The chromatograms also show relatively low normal paraffin peaks beyond nC_{28}-nC_{29} for the FIT 2 sample from 33/9-3. In the other two samples, these peaks are significantly higher.

C. CARBON ISOTOPES

The carbon isotope composition (relative to PDB) of the paraffin-naphthene and aromatic fraction are plotted as the two axes of the graph in figure 1. As the values become more negative, so the proportion of the lighter isotope (C^{12}) increases.

Carbon isotopes are an extremely effective method of correlating crude oils to each other or to parent source rocks and also provide a comment upon the character of the organic matter in the source sediment.

These three oils are very similar and such differences as exist fall within the limits which are commonly encountered for oils from a single source. Hence there is no evidence to suggest that any of the oils come from different source horizons.

Furthermore, the abundance of the light isotope in these crudes is reminiscent of the Green River oil shale and suggests the probability of a non-marine environment of deposition.

D. CONCLUSIONS

The compositional differences between these three oils which were detected using a selected suite of analyses are minimal in terms of source. Gasoline range and carbon isotopic data are very similar and such variations as exist fall within the range that would be expected for a single family of oils. This is also true of the breakdown of the paraffin-naphthene fraction into is component groups whilst the differences between the gas chromatograms of this fraction are probably not a function of source.

The variations in aromaticity are real and probably reflect changes in the proportions of the different kerogen types which constitute the total organic matter in the source rock. Nevertheless, the significant feature is the high naphthene content of all the oils, which emphasises their overall similarity and the fact that they were derived from a similar type of organic matter.

The combined data strongly suggest that these three crude oils were derived from essentially the same type of organic matter.

Although the crudes are naphtheneic, sterane peaks are not significant in the gas chromatograms. This indicates that the source organic matter was dominantly algal and thermally mature. Furthermore, the relative abundance of the light carbon isotope (C^{12}) suggests that the algae and the environment of deposition was non-marine and probably lacustrine (but possibly lagoonal).

The compositional similarity of the three crude oils stongly suggests a common parent source rock and this is confirmed by the requirement of a non-marine algal-rich source bed.

C_4-C_7 DATA - NORMALISED COMPOSITIONS

	33/9-3 FIT 2	33/12-2 DST 2	33/12-2 DST 5
Isobutane	3.1	3.3	3.8
n-butane	11.4	13.9	15.1
Isopentane	8.3	8.8	8.8
n-pentane	14.0	14.5	13.6
2, 2-Dimethylbutane	0.3	0.3	0.2
Cyclopentane	1.6	1.7	1.6
2, 3-Dimethylbutane	0.6	0.6	0.6
2-Methylpentane	5.5	5.4	5.1
3-Methylpentane	3.4	3.3	3.1
n-Hexane	9.2	9.4	8.9
Methylcyclopentane	4.7	4.7	4.6
2, 2-Dimethylpentane	0.2	0.2	0.2
Benzene	4.4	3.9	3.6
2, 4-Dimethylpentane	-	-	-
2, 2, 3-Trimethylbutane	-	0.0	-
Cyclohexane	5.3	5.3	5.2
3, 3-Dimethylpentane	0.3	0.2	0.2
1, 1-Dimethylcyclopentane	0.6	0.5	0.5
2-Methylhexane	3.3	2.9	2.9
2, 3-Dimethylpentane	-	-	-
1, c-3-Dimethylcyclopentane	0.7	0.6	-
3-Methylhexane	3.6	2.5	3.2
1 t-3-Dimethylcyclopentane	-	0.7	0.7
1 t-2-Dimethylcyclopentane	1.8	1.6	1.6
3-Ethylpentane	0.4	0.3	0.3
n-Heptane	6.2	5.5	5.6
1, c-2-Dimethylcyclopentane	0.4	0.3	0.3
Methylcyclohexane	6.3	5.6	6.0
Toluene	4.5	4.0	4.3
Total n-paraffins	40.8	43.3	43.2
Total iso-paraffins	29.0	27.8	28.4
Total napththenes	21.4	21.0	20.5
Total aromatics	8.9	7.9	7.9

RATIOS

2-Methylpentane/3-methylpentane	1.62	1.64	1.65
isopentane/n-pentane	0.59	0.61	0.65
cylohexane/methylcyclopentane	0.84	0.95	0.87
methylcyclopentane/methyl-cyclohex	0.75	0.84	0.77
2-methylhexane/3-methylhexane	0.92	1.16	0.91

TABLE 2A

Composition (Normalised %) of C_{15+} Material

GEOCHEM SAMPLE NUMBER	CRUDE	PARAFFIN-NAPHTHENES	AROMATICS	P-N AROM	ELUTED NSO	NON ELUTED NSO	PRECIPITATED ASPHALTENES	TOTAL HYDROCARBONS
17-001	33/9-3 FIT 2	50.8	28.8	1.76	12.8	1.8	5.8	79.6
17-002	33/12-2 DST 2	53.1	26.1	2.03	12.5	5.4	2.9	79.2
17-003	33/12-2 DST 5	46.1	36.7	1.26	13.4	0.3	3.5	82.8

TABLE 2B

Group Composition (Normalised %) of C_{15+} Paraffin-Naphthenes

GEOCHEM SAMPLE NUMBER	CRUDE	C.P.I.$_A$	C.P.I.$_B$	N-PARAFFINS	ISO-PARAFFINS	NAPHTHENES
17-001	33/9-3 FIT 2	1.02	1.06	15.1	0.4	84.5
17-002	33/12-2 DST 2	1.02	1.03	16.4	0.2	83.4
17-003	33/12-2 DST 5	1.02	1.05	19.5	0.2	80.3

TABLE 3

Carbon Isotope Compositions ($d C^{13}$, $^{o}/_{oo}$)

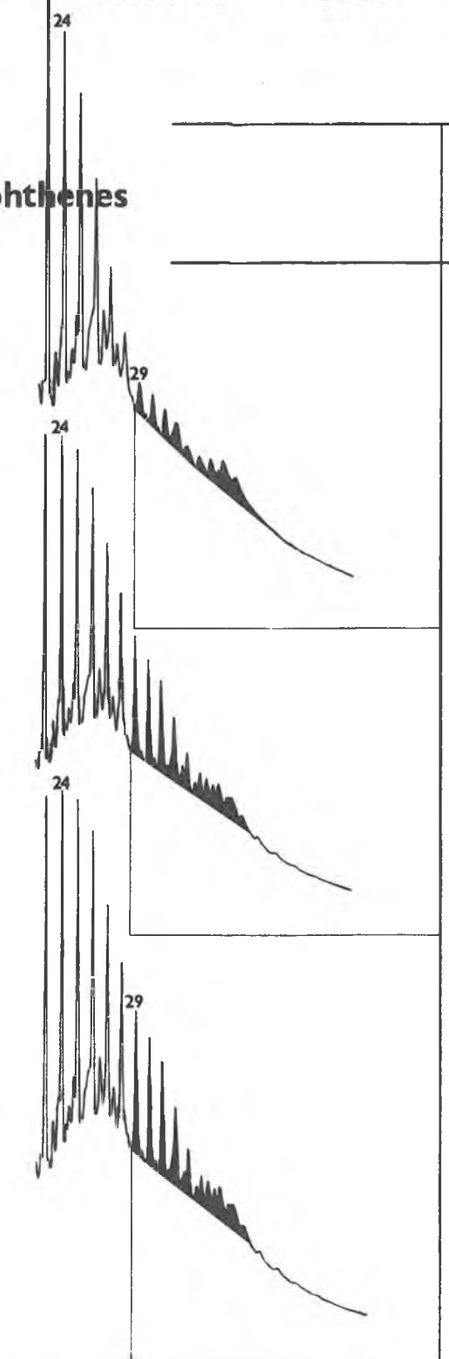
GEOCHEM SAMPLE NUMBER	CRUDE	PARAFFIN-NAPHTHENES	AROMATICS
17-001	33/9-3 FIT 2	-30.5	-29.9
17-002	33/12-2 DST 2	-30.9	-29.6
17-003	33/12-2 DST 5	-30.6	-30.3

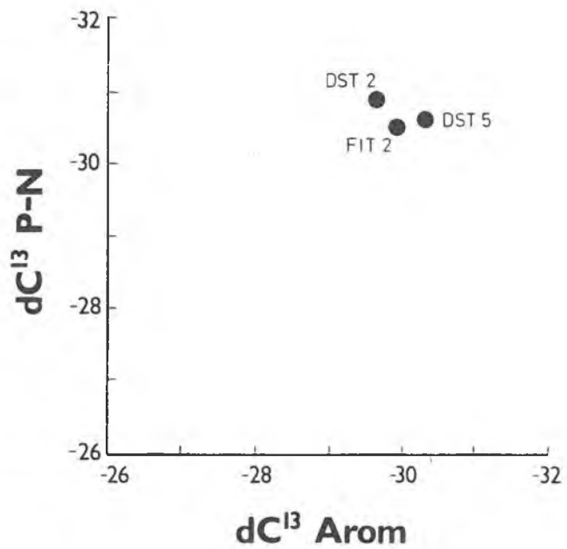
NORWEGIAN NORTH SEA CRUDE OILS

	C_4-C_7 0·7 0·9 1·1	C_{15+} Paraffin – Naphthenes P-N/AROM	CPI	% n-Pa	% i-Pa	% Nap
33/9-3 FIT 2	★ ● ▲	1·76	1·06	15·1	0·4	84·5
33/12-2 DST 2	★ ● ▲	2·03	1·03	16·4	0·2	83·4
33/12-2 DST 5	★ ●▲	1·26	1·05	19·5	0·2	80·3

★ MCP/MCH ● CH/MCP ▲ 2MH/3MH

Cyclo Methyl — Hexane Pentane





	very alike DST 2 sl. diff.	all naphthenic DST 5 > aromatic & diffs. in P-N FIT 2 dies at nC_{29}	very alike

⊙ ALL FROM MATURE ALGAL SOURCE. NO SIGNIFICANT DIFFERENCES ∴ PROBABLY FROM SAME SOURCE INTERVAL. ⊙