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EXPLORATION AND PRODUCTION DIVISION

TECHNICAL NOTE

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PROPERTIES OF CRUDE OIL SAMPLES FROM NOCS WELL 7/12-2

by

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Summary

Crude oil from DST 3A in NOCS Well 7/12-2 was shown to be a very light oil with an SG of 0.827 and low sulphur (0.10% wt) and asphaltenes contents (0.25 % wt). The oil gave high distillate yields and 85% wt boiled < 538°C.

Geochemical parameters indicated that the oil originated in a marginally marine environment with a marked terrestrial input. Stable isotope values suggested a similar origin to other crudes in the area, but with the latter samples having somewhat less terrestrially influenced sources. The 7/12-2 oil was fairly mature and did not appear to have undergone biodegradation.

Extracts from 2 reservoir cores were generally similar to the produced oil, but displayed some differences in medium/high molecular weight components which warranted further investigation. A range of geochemical parameters was obtained on the 7/12-2 sample which were suitable for additional UKCS and NOCS oil-oil and oil-source rock correlation studies.

A. INTRODUCTION

During the drilling and testing of Well 7/12-2 in the BP/Conoco concession area of the Norwegian Continental Shelf, a large number of core samples were taken over the interval 3316.12m - 3651.44m for petrographic examination. In addition, a number of crude oil samples were collected from Drillstem Tests 1A, 2, 3A and 4 for laboratory studies.

The separator oil collected during DST 3A was considered representative of the reservoir crude and was employed for the determination of a number of basic geochemical parameters for use in correlation studies. In addition, oil was extracted from cores taken at 3398.75m and 3416m to see if any significant reservoir variations existed in oil properties.

The properties of the oil from the 7/12 Field were of interest in relation to other Norwegian discoveries such as those in the Ekofisk area to the south, as well as to other oil occurrences to the east on the UK Continental Shelf.

B. SAMPLES AND TECHNIQUES

The separator oil sample from DST 3A was obtained from Technical Services Branch, EPD, Sunbury. The crude was atmospherically stabilised and required no additional processing prior to analysis.

The 2 core samples were selected as they exhibited marked evidence of oil staining. After washing the surface of the cores, the samples were ground and exhaustively extracted with methylene chloride. The extract was centrifuged and the excess solvent removed in a rotary film evaporator. The final concentrate was warmed to constant weight at 30°C, a procedure which removed the last traces of solvent but resulted in considerable loss of lower boiling components. In both cases, the extracted oil amounted to $\sim$ 1% wt of the core.

C. RESULTS AND DISCUSSION

Inspection data obtained on the oil and the 2 reservoir core extracts is given in Table 1. The crude oil was very light, with an API gravity of 39.5 and a high light hydrocarbon content (Table 3). The specific gravity of 0.827 was lower than that of other North Sea crudes such as Ekofisk (0.850), Forties (0.842) and Auk (0.837). The large light hydrocarbon content and extreme lightness of the 7/12-2 oil was reflected in its distillation characteristics (Table 2 and Figure 1) which showed that 85% wt boiled < 538°C.

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As would be anticipated from the method of extraction and recovery, the 2 core extracts displayed much higher specific gravities than the produced crude. However, after allowing for light end losses, both core extracts showed similarities to the produced oil. Sulphur, nitrogen and trace metal contents of all of the samples were quite low and in agreement with values expected for this region of the North Sea. The wax contents of the extracts were, however, somewhat higher than expected after allowing for light end losses although, it should be noted, enhanced concentrations of higher molecular weight crude oil components are sometimes observed in reservoir core extracts when the latter are compared with the produced crude oil. The wax content of the separator crude was very similar to the average value for most North Sea Jurassic oils.

Both reservoir core extracts displayed generally similar properties, but some variations in sulphur, asphaltenes and nitrogen contents were evident. These differences may well have been due to the phenomenon noted previously in which variations are sometimes observed between core extracts and produced crudes or, they may be due to genuine differences which existed in the reservoir and which were accurately reflected in the core extracts. The latter may be the result of imperfect mixing resulting from permeability 'barriers' within the reservoir system, the variations being due to slight differences in hydrocarbon sources.

The n-alkane distributions of the crude oil and the 2 extracts are given in Table 5 and illustrated in Figure 2. Both core samples displayed very smooth distributions with maxima at $\sim C_{15}$ and, as would be anticipated, complete lack of components $< C_{10}$. The n-alkane distribution of the crude was fairly typical of a mature, marginally marine oil with a significant terrestrial contribution to its source environment. The distribution maximum was at nC_5 with a general decrease with increasing carbon number although a slight indication of bi-modality, with another maximum at nC_{15}, was probably present. This latter observation suggested that the oil may be only moderately mature, which was in agreement with the overall n-alkane distribution, although all of the samples have CPI values of 0.99. No evidence of oil biodegradation appeared to be present.

The stable carbon isotope value of the separator crude $\delta^{13}C_{PDB-1}$ was - 28.8‰, with the extract results also in very close agreement i.e. within experimental error. This $\delta^{13}C$ value confirmed the marginally marine origin of the oil as suggested by the n-alkane distribution. The extract $\delta^{13}C$ values also suggested that, if any variations existed within the reservoir, they were probably only minor in nature. The $\delta^{13}C$ value of the oil can be compared with the values of - 28.4‰ for Ekofisk crude and, again, - 28.4‰ for a shallow oil from another nearby well. These $\delta^{13}C$ values suggested a very similar type of source environment for all of these crudes, with the 7/12-2 oil having a slightly more terrestrially influenced source environment.

A number of other geochemical parameters were also determined for use in oil-oil and oil-source rock correlations. Acyclic isoprenoid alkane variations (Table 6 and Figure 3) were quite similar for the crude oil and the extract from 3416.3m, but the extract from 3398.75m displayed some differences which probably warranted further investigation. Pentacyclane distributions (Table 6 and Figure 4) were generally similar, but difficulties

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were experienced in detecting the higher molecular weight components. Sterane distributions showed similarities in the higher molecular weight components, but some marked differences in the lower molecular weight region. In particular, the components designated S_1 -S_4 in the core extracts appeared to be absent in the oil sample.

D. CONCLUSIONS

1) The oil sample from DST 3A in NOCS Well 7/12-2, which was considered representative of the reservoir crude, was shown to be a very light oil with an SG of 0.827 (39.5° API) and low sulphur (0.10% wt) and asphaltenes contents (0.25% wt). The oil gave high yields of light and middle distillates and 85% wt boiled < 538°C.

2) Although extracts from 2 reservoir cores were generally similar to the separator oil, after allowing for weathering and sample handling losses, some differences remained which suggested either slight reservoir variations in crude properties or enhanced retention of high molecular weight components in the reservoir rock compared to the produced oil.

3) Stable carbon isotope values and n-alkane distributions indicated an origin of the 7/12-2 oil in a marginally marine environment with a marked terrestrial input. Comparison with oils from adjacent areas suggested a marked similarity of origin with the 7/12-2 oil having the slightly higher terrestrial influence.

4) The 7/12-2 oil was mature, but probably not highly mature, although both maturation indications and reservoir property variations warranted further investigation.

5) Stable carbon isotope values and n-alkane, acyclic isoprenoid alkane, sterane and pentacyclane distributions obtained from this investigation can be used in NOCS and UKCS oil-oil and oil-source rock correlation studies.

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FIGURE 4: PENTACYCLANE DISTRIBUTIONS

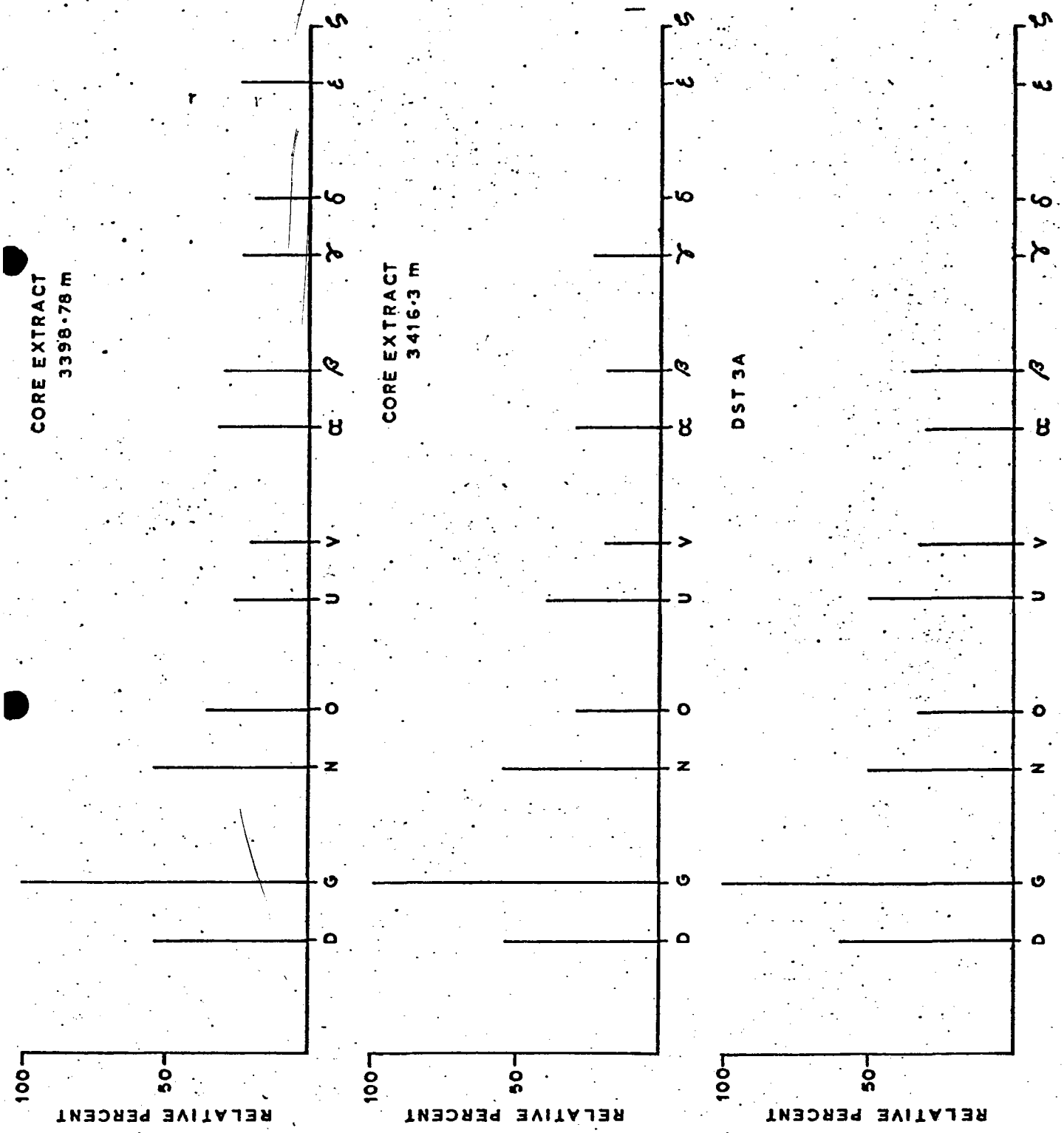

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FIGURE 5: STERANE DISTRIBUTIONS

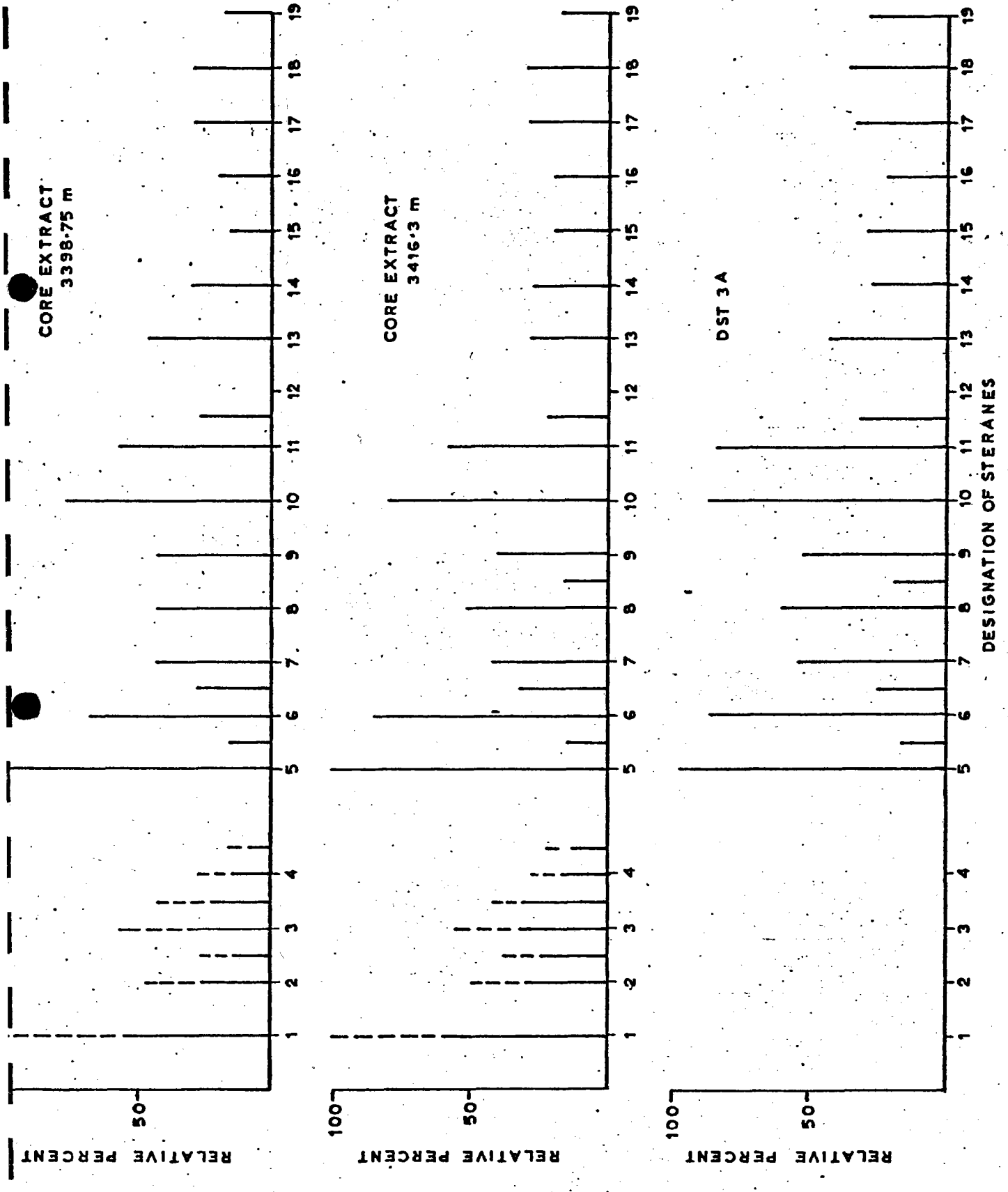

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TABLE 1 : INSPECTION AND STABLE ISOTOPE DATA

NORWEGIAN C.S. 7/12-2	CORE EXTRACT 3398.75m		CORE EXTRACT 3416.3m		DST 3A	
INSPECTION DATA						
Specific Gravity (60/60°F)	0.8833		0.8876		0.8274	
API Gravity	28.7		27.9		39.5	
Sulphur (% wt)	0.92		0.39		0.10	
Wax (BP method 237/74, using dichloromethane (% wt)	13.5		14.0		7.0	
Wax mpt (°C)	59.5		62.0		58.0	
Pour Point (°C)	-		-		3	
Asphaltenes (% wt)	0.22		0.99		0.25	
Nickel (ppm)	< 2		3		1	
Vanadium (ppm)	< 2		< 2		< 1	
Ni/V ratio	-		-		-	
Nitrogen (ppm)	690		815		510	
Total Acidity (BP method 408) (mg. KOH/g)	< 0.2		< 0.2		-	
Kinematic viscosity (cSt at 70°F)	-		-		10.1	
(cSt at 100°F)	-		-		-	
STABLE ISOTOPE DATA						
Stable Carbon Isotope Ratio ($\delta^{13}C$, ‰)	-28.9		-28.7		-28.8	

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TABLE 2 : SIMULATED TRUE BOILING POINT DATA BY GAS-LIQUID CHROMATOGRAPHY (n.b.)

Weight percent distilled off	Distillation temperature, °C					
		NOCS	7/12-2 DST 3A			
0.5 (IBP)			- 2			
1			14			
2			24			
5			67			
10			95			
15			123			
20			145			
25			175			
30			198			
35			226			
40			252			
45			276			
50			303			
55			329			
60			358			
65			386			
70			420			
75			451			
80			491			
85			538			
90			-			
95			-			
100			-			
FP			-			
% wt distilled by 538°C/1000°F			85.0			

n.b.: Comparable to TBP data obtained from ASTM Method, Distillation of Crude Petroleum (15 Theoretical Plate Column) (D 2892-73).

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TABLE 3 : INDIVIDUAL LOW BOILING POINT HYDROCARBON (C_1-C_7) ANALYSES

Hydrocarbon	Weight Percent on Crude Oil					
		NOCS	7/12-2 DST 3A			
Methane			< 0.005			
Ethane			0.02			
Propane			0.44			
Isobutane			0.34			
n-Butane			1.47			
Isopentane			1.10			
n-Pentane			1.69			
2,2-Dimethylbutane			0.03			
Cyclopentane			} 0.27			
2,3-Dimethylbutane						
2-Methylpentane			0.82			
3-Methylpentane			0.47			
n-Hexane			1.56			
2,2-Dimethylpentane			} 0.82			
Methylcyclopentane						
2,4-Dimethylpentane			0.08			
Benzene			0.36			
3,3-Dimethylpentane						
Cyclohexane			0.99			
2-Methylhexane			0.48			
2,3-Dimethylpentane			} 0.27			
1,1-Dimethylcyclopentane						
3-Methylhexane			0.54			
1,cis-3-Dimethylcyclopentane			0.18			
1,trans-3-Dimethylcyclopentane			0.18			
3-Ethylpentane			} 0.32			
1,trans-2-Dimethylcyclopentane						
n-Heptane			1.60			
1,cis-2-Dimethylcyclopentane						
Methylcyclohexane						
2,2,3,3-Tetramethylbutane						
1,1,3-Trimethylcyclopentane						
3,3-Dimethylhexane			} 0.81			
Toluene						
Total weight percent on crude:			14.84			

TABLE 4 A : VACUUM MICRO DISTILLATION TO 200°C, 760 TORR CUT : PRODUCT DISTRIBUTION
B : PARAFFIN-NAPHTHENE-AROMATIC (PNA) ANALYSIS ON < 200°C DISTILLATE;
C : SILICIC ACID ADSORPTION CHROMATOGRAPHY ON > 200°C Residue

A : Vacuum Micro Distillation Fraction	Weight Percent Yield on Total Sample		
NORWEGIAN C.S. 7/12-2	CORE EXTRACT 3398.75 m	CORE EXTRACT 3416.3 m	DST 3A
< 200°C distillate	-	-	28.5
> 200°C residue	-	-	71.5
B : PNA Analysis on < 200°C distillate Hydrocarbon Type	**Weight Percent on < 200°C Distillate**		
C 3			-
C 4			1.01
C 5P (paraffin)			4.38
5N (naphthene)			0.41
C 6P			6.17
6N			3.82
C 7P			7.50
7N			6.62
C 8P			8.21
8N			5.91
C 9P			8.60
9N			5.75
C10P			7.51
10N			5.30
C11P			5.45
11N			3.71
C12 + 13 (paraffin + naphthene)			4.90
Total P			48.83
N			31.52
A (aromatic)			14.75
Total n-alkanes			26.65
P/N ratio			1.55
(P + N)/A ratio			5.45
C : Silicic Acid Analysis on > 200°C Residue Hydrocarbon Type	**Weight Percent on > 200°C Residue on Deasphaltened Oil**		
Saturate Alkanes	67.9	65.4	66.0
Aromatic + Heteroaromatic + Heteroalkanes (fraction 1)	5.9	11.8	13.3
Aromatic + Heteroaromatic + Heteroalkanes (fraction 2)	23.7	18.0	17.7
Resins	2.5	4.8	3.0
Asphaltenes	-	-	-

TABLE 5 : n-ALKANE DISTRIBUTIONS

Carbon Number of n-Alkane	Weight Percent on Crude Oil		
NORWEGIAN C.S. 7/12-2	CORE EXTRACT 3398.75m	CORE EXTRACT 3416.3m	DST 3A
1			< 0.005
2			0.02
3			0.44
4			1.47
5			1.69
6			1.56
7			1.60
8			1.18
9			1.22
10			1.06
11	0.09	0.05	0.80
12	0.37	0.27	0.68
13	0.71	0.59	0.64
14	0.90	0.81	0.77
15	1.02	0.94	0.84
16	1.01	0.95	0.75
17	1.01	0.95	0.72
18	0.89	0.84	0.62
19	0.84	0.80	0.59
20	0.81	0.78	0.56
21	0.73	0.69	0.51
22	0.68	0.66	0.49
23	0.63	0.61	0.46
24	0.60	0.56	0.44
25	0.48	0.47	0.37
26	0.41	0.40	0.34
27	0.33	0.33	0.30
28	0.26	0.27	0.25
29	0.24	0.25	0.23
30	0.21	0.22	0.19
31	0.18	0.19	0.16
32	0.16	0.17	0.14
33	0.14	0.14	0.11
34	0.10	0.12	0.09
35	0.08	0.09	0.08
36	0.06	0.08	0.08
37	0.05	0.07	0.07
38	0.04	0.07	0.06
39	0.03	0.06	0.06
40	0.02	0.05	0.06
41	0.01	0.03	0.05
42	0.01	0.03	0.05
43	-	-	-
44	-	-	-
45	-	-	-
Total n-alkane content	13.10	12.54	21.80
n-Alkane Carbon Preference Index (CPI) *	0.992	0.993	0.997

* $CPI = \frac{\Sigma \text{odd n-C19} \rightarrow \text{n-C31}}{2\Sigma \text{even n-C18} \rightarrow \text{n-C30}} + \frac{\Sigma \text{odd n-C19} \rightarrow \text{n-C31}}{2\Sigma \text{even n-C20} \rightarrow \text{n-C32}}$

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TABLE 6 : RELATIVE DISTRIBUTIONS OF: A: ACYCLIC ISOPRENOID ALKANES; B: PENTACYCLANES

A Carbon Number of Acyclic Isoprenoid Alkane	Relative Distribution		
NORWEGIAN C.S. 7/12-2	CORE EXTRACT 3398.75m	CORE EXTRACT 3416.3m	DST 3A
15 ('farnesane')	51.5	36.4	46.7
16	100.0	81.5	95.1
17	–	–	–
18	69.7	72.2	86.9
19 ('pristane')	84.8	100.0	100.0
20 ('phytane')	50.0	71.0	72.1
pristane/phytane ratio	1.70	1.41	1.39
B Alphabetical Designation of Pentacyclane	Relative Distribution		
	CORE EXTRACT 3398.75m	CORE EXTRACT 3416.3m	DST 3A
H2			
B1			
B2			
D	55	54	60
G	100	100	100
N	56	55	51
O	35	30	34
U	27	40	52
V	20	19	34
α	31	30	31
β	29	22	36
γ	22	23	–
δ	20	–	–
ε	26	–	–
ζ			

Comments:

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WELL NOCS 7/12-2

TABLE 7 : STERANE DISTRIBUTIONS

	CORE EXTRACT 3398.75m		CORE EXTRACT 3416.3m		DST 3A
S_1	53.8	100^+	62.0	100^+	
S_2	25.6	47.7	31.6	51	
S_{2b}	13.8	25.6	24.1	38.7	
S_3	30.6	57.0	34.2	55	
S_{3b}	21.9	40.3	25.4	42	
S_4	15.0	27.9	17.1	27.6	
S_{4b}	8.1	15.1	13.9	22.4	
S_5	100		100		100
S_{5b}	16.3		15.8		16.7
S_6	65.6		87.3		87.0
S_{6b}	28.8		32.3		26.8
S_7	43.1		42.4		54.3
S_8	43.1		51.3		61.5
S_{8b}			16.5		19.6
S_9	40.6		39.9		54.3
S_{9b}	30		32.3		33.3
S_{10}	75.6		79.1		87.7
S_{11}	58.1		59.5		84.8
S_{11c}	25		21.5		34.8
S_{13}	46.3		27.2		42.8
S_{14}	28.8		27.2		28.3
S_{15}	17.5		20.3		30.4
S_{16}	21.3		22.2		23.2
S_{17}	30		30.4		35.5
S_{18}	30		30.4		37.7
S_{19}	19.4		17.7		29.0

Results normalised over range $S_1 - S_{4b}$

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FIGURE 3: ACYCLIC ISOPRENOID ALKANE DISTRIBUTIONS

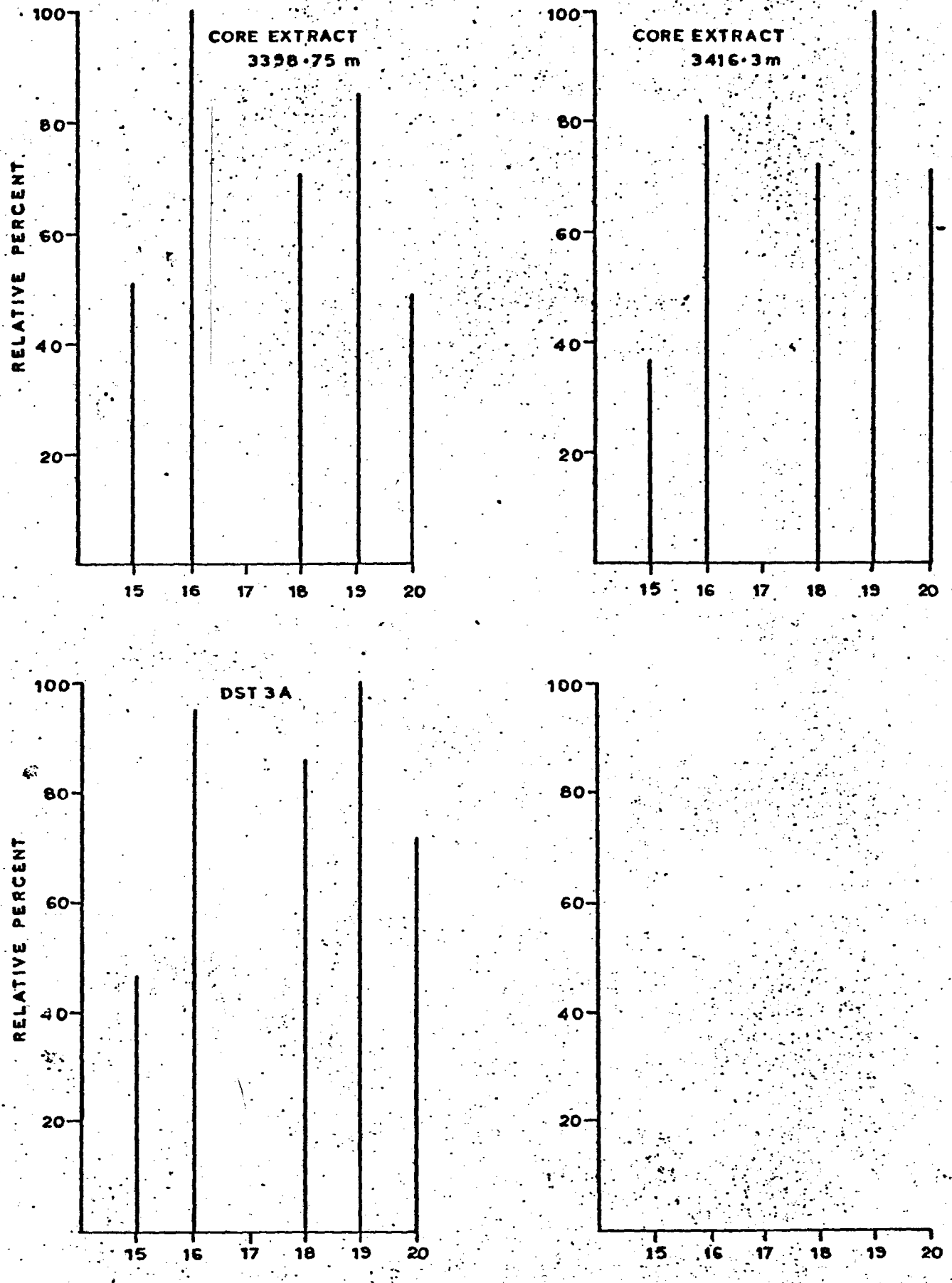

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FIGURE 2: n-ALKANE DISTRIBUTIONS

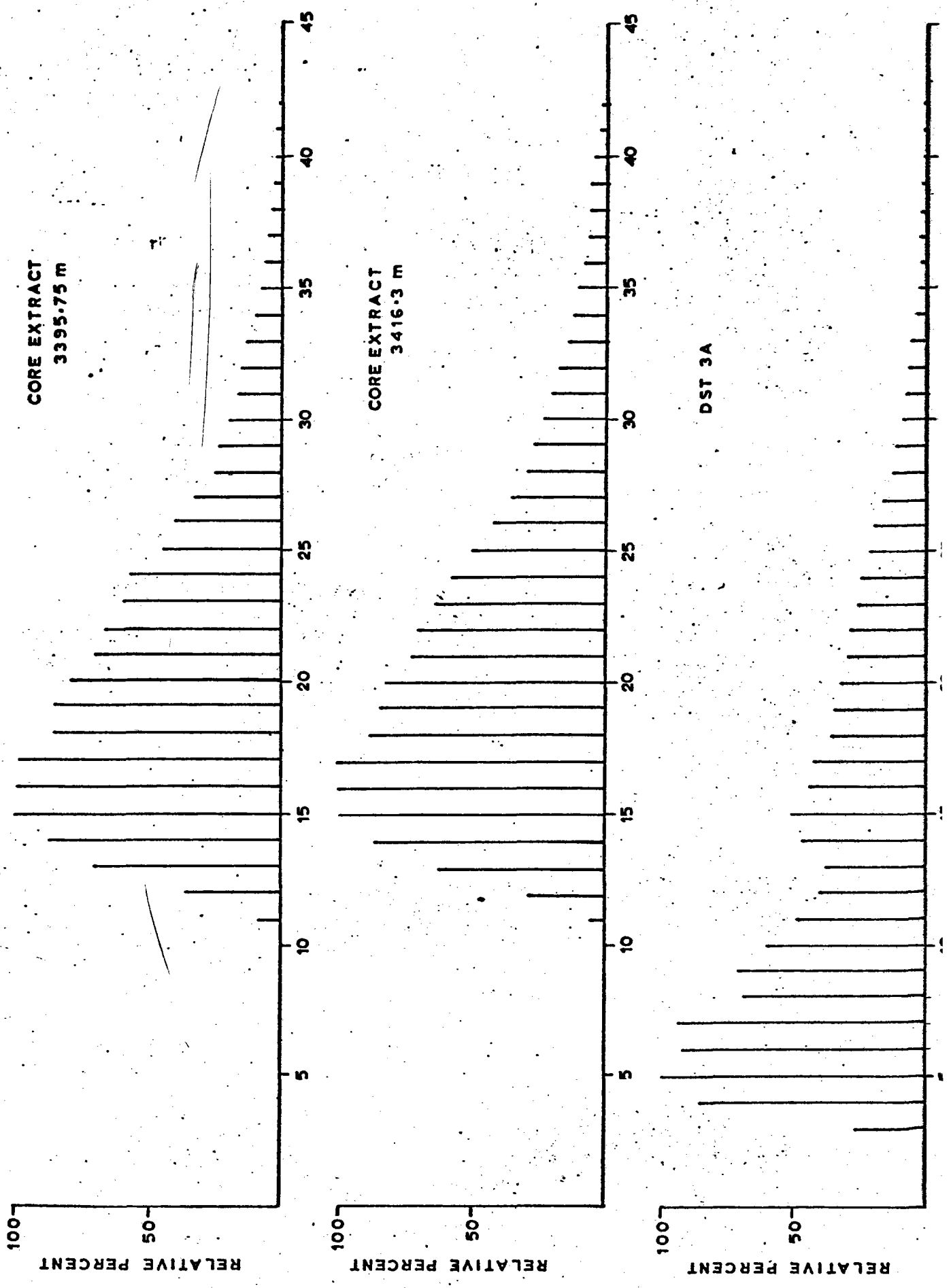

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FIGURE 1: SIMULATED TBP DATA BY GAS-LIQUID CHROMATOGRAPHY