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A MATURATION AND SOURCE ROCK STUDY OF THE SECTION 480-1,842 METRES OF THE CONOCO NORWAY 10/5-1 WELL, NORWEGIAN NORTH SEA

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I

INTRODUCTION

A maturation and source rock study has been carried out on samples received from the section 480 to 1,842 metres of the Conoco Norway 10/5-1 well, drilled in the Norwegian North Sea. Canned wet ditch cuttings samples and selected sidewall core samples were received over the entire section.

Maturation evaluation has been performed using light hydrocarbon, spore colouration, vitrinite reflectivity and maximum palaeotemperature analyses. Source rock potential analysis was carried out on selected cuttings samples and sidewall cores below 1,110 metres depth.

The canned samples were analysed for headspace gas, (C_1 to C_4 gases), before preparation for the other analyses. All the samples, apart from the sidewall cores, were washed in cold water to remove drilling mud etc., and, after drying and description, were found to be of fair to good quality for geochemical analysis. The age of the samples ranges from Tertiary to Permian.

II

RESULTS AND INTERPRETATION

A. MATURITY EVALUATION

Four principal maturation parameters have been used in this study and the results are discussed below:

1. Light Hydrocarbon Analysis (Tables 1 and 2, and Figure 1)

The canned samples were initially analysed for headspace gases C_1 to C_4. After completion of this analysis the cuttings were washed and samples selected for C_1 to C_7 analysis.

Headspace Gas (Table 1 and Figure 1)

Wide variations can be seen in both C_1 to C_4 gas concentrations and in individual gas abundances throughout the analysed section. Samples from 210 and 360 metres depth are seen to have very high concentrations of gas with methane generally accounting for 99% and believed to be of biogenic origin. Even if this is true the amounts are very high and concentration by migration must have taken place; the possibility that this is dry gas of deep origin cannot be ruled out and it is likely to be associated with a fault.

Within the interval 390 to 990 metres the proportion of methane is lower and the relative abundance of each of the C_2 to C_4 hydrocarbons is abruptly increased which appears to be out of place for the general trend for the well; again the possibility of migrant light gases must be examined.

Over the short interval from 1,020 to 1,380 metres the total concentration of the gases increases only slightly but these shale samples show a steadily increasing enrichment in each of the C_2 to C_4 gases indicating the advancement in maturation of these sediments. From 1410 to 1530 metres depth the total concentration of the headspace gases increases, except at 1,500 metres, in response to both increasing organic carbon content of the Jurassic sediments and the further development of organic maturity. However the proportion of methane is high and usually greater than 80% of the total gas. Below 1530 metres the total C_1 to C_4 gas concentration decreases except in occasionally rich samples and the proportion of methane decreases quite sharply from 75% to around 40% at the base of the section.

Gaseous and Gasoline Range Hydrocarbons (Table 2)

The results of this analysis show very low gas and gasoline contents at the limits of precision of the method. It is suspected that indigenous organic matter is immature but that inertinites present in substantial proportions make up the bulk of the organic matter with some admixture of reworked matter. The data are not found to be of great help in interpreting the maturity of the section, but are consistent with the generally low head space gas concentrations.

2. Spore Colouration Analysis (Table 3 and Figure 4)

An effect of maturation processes on sporopollenin is to increase the visible colour density from pale yellow, through orange and brown to black. The determinative procedures of Staplin (1969) have been largely followed in this analysis, except that a ten-point scale of colour indices has been utilised rather than the five-point scale adopted by Staplin.

Within the interval 1260 to 1347 metres spore colour indices of 2 to 2.5, suggestive of organically immature sediments, were found. The actual range in spore colours for the assemblages was very small, spores being moderately abundant to abundant in all the analysed samples. In the interval 1470 to 1503 metres, spore colours average 2.5 to 3, indicative of transitional immature - mature sediments.

The sample from 1520 metres with an assemblage of Bathonian age gave rather darker spore colours than would be expected, a spore colour index of 4 being recorded. It is possible that these darker colours may be due to staining. Within the section from 1530 to 1808 metres, a wide range in spore colour index from 2 to 6.5 was noted, though the higher values are due to the presence of thick exined spores. The low index values are attributed to predepositional oxidation so that the true spore colour index of the indigenous sporomorphs is thought to be 4 to 5, indicative of sediments in an early state of maturity. Within the interval 1260 to 1565 metres the kerogen was found to consist mainly of inertinite with subordinate amounts of vitrinite and exinite; inertinite is less dominant in the samples at 1470, 1475, 1520 and 1530 metres. In the samples between 1659 and 1808 metres, although inertinite is common, exinite, vitrinite and, more rarely amorphous sapropel, can also be commonly encountered.

3. Vitrinite Reflectivity Analysis (Tables 3, Figure 2)

Measurement of vitrinite reflectivity was carried out on a total of eleven samples. The quantities of vitrinite seen were very low in the majority of samples, though only one sample contained insufficient organic particles for any measurements to be made. However the results obtained show a trend of increasing vitrinite reflectivity with depth. Vitrinite reflectivity is seen to increase from an interpreted value of 0.28% at 1300 metres to 0.36% at 1680 metres depth. A particularly good reflectivity distribution was obtained on a sample from 1410 metres an average vitrinite reflectivity of 0.32% being obtained. From this good quality data it appears that at least the entire Cretaceous section is immature for hydrocarbon generation. Occasional low reflectivity values particularly those around 0.28% are associated with liptinitic organic material rather than caved vitrinite. Small quantities of reworked vitrinite have been noted over parts of section and inertinite with reflectivities of 0.7% and greater has been observed throughout the section.

In ultraviolent light, yellow fluorescing spores were observed throughout the section usually in small amounts, though moderate quantities of spores were noted in samples from 1350 and 1770 metres depth.

The reflectivity results suggest that humic, gas-prone types of organic material will be immature for the generation of gas throughout the analysed section. Oil-generating organic material is likely to be mature below 1,500 metres at which depth vitrinite reflectivities of 0.35% have been reached and are associated with yellow fluorescing exinitic material.

4. Maximum Palaeotemperature Analysis (Table 3 and Figure 3)

Maximum Palaeotemperature analysis was carried out on sixteen samples, fifteen of which gave consistent values for the measured parameters. On plotting the results against depth a fairly uniform increase in values can be seen, the palaeotemperatures being interpreted as increasing from approximately 208°F at 1140 metres to about 255°F at 1770 metres depth. These values are however considered to be rather higher than would be expected for the present depth of burial and in view of the results of the other maturation parametres.

5. Comparison of Maturation Indices (Table 3 and Figure 4)

Apart from the rather advanced state of maturity predicted by the maximum palaeotemperature method, spore colouration and vitrinite reflectivity and to some extent, headspace gas analysis, are in good agreement. Each method of analysis has suggested that the Tertiary and Cretaceous parts of the section are quite immature for the generation of hydrocarbons. Within the Jurassic part of the section oil-prone organic matter is only at a marginal state of maturity for hydrocarbon generation. Below 1520 metres depth ie., Triassic and Permian, any contained oil-prone organic matter is likely to be mature for heavy grading to medium gravity oil with increasing depth. It is doubtful if humic, gas-prone organic matter has reached maturity anywhere within the analysed section for gas generation.

B. SOURCE ROCK EVALUATION (Table 4 and Figures 5, 6 and 7)

Prior to full source rock analysis a total of forty-one samples was analysed for their organic carbon content. Of these samples twenty-six were fully analysed and organic carbon determinations were conducted on a further five samples of picked lithology.

The source rock evaluation results are discussed in five parts in order to relate hydrocarbon source potential with stratigraphy and maturation state.

1. Interval 480-900 metres, Samples 1 and 2, Upper Cretaceous

Green-grey shale, (480 metres) and a chalky limestone, (900 metres) were found to have organic carbon contents of 0.19% and 0.05% respectively. In view of their organic cleanness and immaturity, sediments from similar depths are unlikely to have hydrocarbon source potential.

2. <u>Interval 1,110-1,350 metres, Samples 3 to 14, Lower Cretaceous</u>

The grey and black mudstones and shales have a variable organic carbon content for their lithologic type, ranging from 0.68% to 3.8%, though most samples have at least 1% organic carbon. The extractability of this organic matter in solvent is variable from 0.7% to 6.8%. Hydrocarbon abundance ranges from less than 20ppm to 105ppm.

The organic matter in these immature sediments appears to be of a gas-prone nature at present, but, if encountered in a mature situation horizons with organic carbon contents exceeding 2% might have an appreciable hydrocarbon potential.

3. <u>Interval 1,380-1,520 metres, Samples 15 to 23, Upper and Middle Jurassic</u>

Within the Jurassic interval the quantity of organic carbon contained by the dominantly grey shales is average to above average, all the shales having organic carbon contents of greater than 1% and reaching 4.2%. The proportion of organic material extractable in organic solvents is, however, low ranging from 0.3% to 1.9%. Hydrocarbon contents are very low ranging from 5ppm to 28ppm.

The most likely present hydrocarbon product from these sediments in view of their above average general organic richness but low hydrocarbon concentrations is gas. However in view of the particularly low quantities of hydrocarbons so far generated and the very low extractability of the mainly mixed humic, (gas-prone) and sapropelic, (oil-prone) material present it must be concluded that these Jurassic sediments are at a very early stage of maturity for hydrocarbon generation.

4. <u>Interval 1,530-1,565 metres, Samples 24 to 28, Triassic.</u>

This interval comprises green sand and green shales with red mudstones.

Samples 24 and 25 which consist of grey shale are considered to represent shales caved from the overlying Jurassic. The recognised Triassic lithologies show very low quantities of organic carbon to be present; 0.05% to 0.08% and hydrocarbon concentrations are very low and do not exceed 25 ppm. Extractabilities are high and contamination by an organic substance of low hydrocarbon content. is suspected. The caved Jurassic shales are of average organic richness with organic carbon contents of 1.80% and 2.85%. Extractability is again low at 1.9% and 3.8% and hydrocarbon content in one sample, 1,533 metres, reaches 130ppm.

The Triassic sediments themselves are insufficiently rich in organic matter to be considered as hydrocarbon source rocks although the interval is mature for oil-generation. The caved Jurassic shale at 1,533 metres indicates the existence of a shale horizon with very restricted ability to source a likely product of gas-with-some-oil. This restriction appears to be due to the early stage of maturity predicted for the Jurassic interval.

5. Interval 1,590-1,842 metres, Samples 29 to 41, Permian

The Permian interval consists mainly of limestones with occasional grey shales. For some samples organic carbon contents are rather higher than would be expected and this is attributed to the occurrence of anhydrite from which sulphur is a contaminant. Organic carbon contents themselves are highly variable, from 0.15% to 5.0%, with shales having contents of between 1% and 2%. Extractabilities vary from 0.4% to 5.5%. Hydrocarbon contents are mainly very low ranging from 12ppm to 120ppm in sample 36, a grey shale from 1757 metres.

The most likely product in general is gas from the Permian interval especially in view of the dominance of humic, (gas-prone) types of organic material. At the present stage of maturity however, it is doubtful whether significant quantities of gas have been generated. Sample 36 from 1757 metres depth indicates a shale horizon with a fair potential for sourcing medium gravity oil, however it is doubtful if this horizon could be a significant hydrocarbon source in view of its probably limited vertical extent.

III

CONCLUSIONS

On integration of the maturation and source rock evaluation data the following conclusions have been reached concerning the section 480 to 1842 metres of the 10/5-1 well.

a) Interval 480-900 metres, Upper Cretaceous

Organic richness was found to be low in samples analysed from this interval and the associated chalk sediments are indicated to be immature. For these reasons the interval appears to be non-prospective for sources of hydrocarbons.

b) Interval 1,110-1,350 metres. Lower Cretaceous

Samples analysed from this interval were of widely varying organic richness but often contained abundant organic material. However, only small quantities of hydrocarbons were found to be present which, taken with the maturation data, suggests that the sediments are as yet immature for hydrocarbon generation.

c) Interval 1,380-1,520 metres. Jurassic

All the samples analysed from this interval were found to be organically rich but very low in quantity of extractable organic matter and hydrocarbon abundance. In the Triassic part of the section, shale with a fair hydrocarbon content was found which is believed caved and of Jurassic origin. Maturation studies have shown that the interval is at a transitional stage of maturity for oil generation partially explaining why only low quantities of hydrocarbons are present. A further reason for this lack of hydrocarbon generation is that the dominant organic matter in these sediments is humic and gas-prone in nature with only subordinate amounts of exinitic, oil-prone material being observed. None of the Jurassic sediments analysed appear prospective as source rocks.

d) Interval 1,530-1,565 metres. Triassic

The Triassic sediments analysed have shown very small quantities of organic matter to be present and, though mature for liquid hydrocarbon generation, are non-prospective as hydrocarbon source rocks.

e) Interval 1590-1842 metres Permian

Occasional shale horizons of average to above average organic richness have been identified within the main limestone of this section. A single sample has shown the presence of fair quantities of hydrocarbons though in general hydrocarbon concentrations are low. Though the dominant type of organic matter is gas-prone it is doubtful whether a sufficiently advanced state of maturity has been attained for significant gas generation.

TABLE 1

HEADSPACE GAS DATA ANALYSIS

WELL: 10/5-1 CLIENT: CONOCO NORWAY LOCATION: NORWEGIAN NORTH SEA

DEPTH METRES	TOTAL C_1-C_4 GAS PPM	PERCENT C_1	PERCENT C_2	PERCENT C_3	PERCENT ISO C_4	PERCENT nC_4
210	9800	99.9	0.1	0.03	0.01	0.04
240	12780	99.8	0.1	0.02	0.01	0.02
270	2560	99.9	0.04	0.04	0.004	0.03
300	900	99.5	0.2	0.12	0.004	0.12
330	1390	99.7	0.14	0.06	0.02	0.06
360	1290	99.7	0.15	0.06	tr	0.05
390	50	87.7	5.84	3.89	0.58	1.95
420	50	90.5	6.04	2.01	0.40	1.00
450	50	84.4	9.38	3.75	0.56	1.88
480	690	99.1	0.43	0.29	0.03	0.12
510	490	98.9	0.61	0.41	0.02	0.10
540	95	57.9	11.58	16.84	2.10	11.58
570	40	67.6	12.07	12.07	0.97	7.25
600	20	59.7	14.93	14.93	0.43	9.95
630	<5	71.4	11.90	9.52	tr	7.14
660	<3	96.7	3.23	tr	-	-
690	5	76.9	11.54	9.62	-	1.92
720	8	72.3	12.05	10.84	-	4.82
750	5	76.9	11.54	9.62	-	1.92
780	30	80.9	6.23	9.35	0.31	3.12
810	40	80.1	8.71	6.97	0.69	3.48
840	40	83.3	8.33	5.55	0.28	2.50
870	30	89.1	6.60	3.30	-	0.99
900	- - - - - -	- - - - NO GAS	- - - -	- - - -	- - - -	- - - -
930	20	94.5	3.98	1.49	-	-
960	20	83.7	13.22	2.64	-	0.44
990	70	82.6	15.29	1.53	-	0.61
1020	450	82.0	12.44	3.77	0.22	1.55
1050	100	73.8	17.25	5.75	0.28	2.87
1080	40	91.1	5.21	2.60	tr	1.04
1110	30	93.2	2.87	2.87	0.72	0.36
1140	80	94.5	2.39	2.39	0.12	0.59
1170	120	95.2	1.68	1.68	0.67	0.76
1200	510	94.5	1.56	1.95	0.97	0.97
1230	240	91.4	2.47	3.29	1.23	1.64
1260	340	91.1	2.98	3.27	0.89	1.79
1290	850	90.9	3.16	3.52	0.94	1.52
1320	70	83.8	4.05	6.76	1.35	4.05
1350	180	86.9	4.57	4.57	1.14	2.86
1380	200	91.9	2.51	2.51	1.01	2.10
1410	1080	90.4	3.99	3.06	0.84	1.67
1440	940	86.2	5.42	4.46	1.49	2.44
1470	6450	88.5	5.50	4.80	0.57	0.64
1500	3290	82.1	7.44	8.38	1.15	0.94
1530	620	60.2	9.15	20.55	5.30	4.81
1560	110	75.0	7.40	11.11	2.77	3.70

TABLE 1 (Cont'd.)

HEADSPACE GAS DATA ANALYSIS

WELL: 10/5-1 CLIENT: CONOCO NORWAY LOCATION: NORWEGIAN NORTH SEA

DEPTH METRES	TOTAL C_1-C_4 GAS PPM	PERCENT C_1	PERCENT C_2	PERCENT C_3	PERCENT ISO C_4	PERCENT nC_4
1590	70	72.5	5.79	14.49	2.89	4.34
1620	784	72.8	9.56	13.39	2.16	2.04
1650	180	66.2	8.57	16.59	4.00	4.57
1680	200	60.0	11.79	20.00	3.56	4.62
1710	240	45.3	13.99	26.75	6.17	7.81
1740	130	39.2	12.00	26.40	10.40	12.00
1770	200	59.6	9.36	18.72	4.93	7.39
1800	1410	38.7	25.07	26.41	2.69	7.08
1830	880	40.6	24.43	23.52	3.98	7.50
1842	210	22.1	17.37	34.27	8.92	17.37

TABLE 2

GASEOUS AND GASOLINE HYDROCARBON DATA

CLIENT CONOCO NORWAY WELL 10/5-1 LOCATION NORWEGIAN N. SEA

GAS ($C_1 - C_4$)

SAMPLE NO.	1							
DEPTH METRES	480		540		600		1020	
	P. P. B.	$\%C_1 - C_4$	P. P. B.	$\%C_1 - C_4$	P. P. B.	$\%C_1 - C_4$	P. P. B.	$\%C_1 - C_4$
C_1	–	–	–	–	–	–	–	–
C_2	–	–	–	–	–	–	–	–
C_3	–	–	–	–	–	–	–	–
iC4	–	–	–	–	–	–	–	–
nC4	–	–	–	–	–	–	–	–
TOTAL	–	–	–	–	–	–	–	–

GASOLINE RANGE ($C_5 - C_7$)

SAMPLE NO.	1							
DEPTH METRES	480		540		600		1020	
	P. P. B.	$\%C_5 - C_7$	P. P. B.	$\%C_5 - C_7$	P. P. B	$\%C_5 - C_7$	P. P. B.	$\%C_5 - C_7$
ISO-PENTANE	2	6	1	5	tr	*	2	6
N-PENTANE	3	8	1	5	tr	*	2	6
CYCLOPENTANE	2	6	1	5	tr	*	2	6
2-ME. PENTANE	2	6	1	5	tr	*	2	6
3-ME. PENTANE	2	6	1	5	tr	*	2	6
N-HEXANE	3	8	1	5	*	*	2	6
ME. CYCLOPENTANE	3	8	1	5	1	14	3	8
CYCLOHEXANE	3	8	2	10	1	14	3	8
2-ME. HEXANE	3	8	2	10	1	14	3	8
3-ME. HEXANE	3	8	2	10	1	14	3	8
3-ETHYLPENTANE	3	8	2	10	1	14	3	8
N-HEPTANE	4	11	2	10	1	14	3	8
BENZENE	*	*	*	*	*	*	tr	*
DIME. PENTANE	*	*	*	*	*	*	*	*
ME. CYCLOHEXANE	3	8	2	10	1	14	3	8
TOTAL	36	(100)	19	(100)	7	(100)	33	(100)

GASEOUS AND GASOLINE HYDROCARBON DATA

CLIENT CONOCO NORWAY WELL 10/5-1 LOCATION NORWEGIAN N. SEA

GAS ($C_1 - C_4$)

SAMPLE NO.			6		9		12	
DEPTH METRES	1080		1200		1260		1320	
	P. P. B.	$\%C_1 - C_4$	P. P. B.	$\%C_1 - C_4$	P. P. B.	$\%C_1 - C_4$	P. P. B.	$\%C_1 - C_4$
C_1	2	89	3	88	2	100	2	95
C_2	0.3	11	0.4	8	tr	*	0.1	5
C_3	tr	*	0.2	4	tr	*	tr	*
iC_4	tr	*	tr	*	*	*	tr	*
nC_4	*	*	*	*	*	*	tr	*
TOTAL	2.3	(100)	3.6	(100)	2	(100)	2.1	(100)

GASOLINE RANGE ($C_5 - C_7$)

SAMPLE NO.			6		9		12	
DEPTH METRES	1080		1200		1260		1320	
	P. P. B.	$\%C_5 - C_7$	P. P. B.	$\%C_5 - C_7$	P. P. B	$\%C_5 - C_7$	P. P. B.	$\%C_5 - C_7$
ISO-PENTANE	*	*	*	*	tr	*	14	16
N-PENTANE	*	*	*	*	1	12	57	63
CYCLOPENTANE	tr	*	tr	*	tr	*	14	16
2-ME. PENTANE	tr	*	tr	*	*	*	2	2
3-ME. PENTANE	tr	*	1	14	*	*	1	1
N-HEXANE	5	44	tr	*	3	38	14	16
ME. CYCLOPENTANE	1	8	*	*	tr	*	11	12
CYCLOHEXANE	1	8	1	14	1	12	1	1
2-ME. HEXANE	1	8	1	14	1	12	4	4
3-ME. HEXANE	1	8	1	14	*	*	1	1
3-ETHYLPENTANE	1	8	1	14	*	*	tr	*
N-HEPTANE	1	8	1	14	1	12	10	11
BENZENE	*	*	*	*	*	*	*	*
DIME. PENTANE	*	*	*	*	*	*	*	*
ME. CYCLOHEXANE	1	8	1	14	1	12	9	10
TOTAL	12	(100)	7	(100)	8	(100)	90	(100)

TABLE 2 (Cont'd)

GASEOUS AND GASOLINE HYDROCARBON DATA

CLIENT CONOCO NORWAY WELL 10/5-1 LOCATION NORWEGIAN N. SEA

GAS ($C_1 - C_4$)

SAMPLE NO.	15		17		21		27	
DEPTH METRES	1380		1440		1550		1560	
	P.P.B.	$\%C_1-C_4$	P.P.B.	$\%C_1-C_4$	P.P.B.	$\%C_1-C_4$	P.P.B.	$\%C_1-C_4$
C_1	2	57	6	90	4	97	6	98
C_2	0.1	3	0.2	10	0.1	3	0.1	2
C_3	0.4	12	*	*	tr	*	*	*
iC_4	0.4	12	*	*	*	*	*	*
nC_4	0.6	18	*	*	tr	*	*	*
TOTAL	3.5	(100)	6.2	(100)	4.1	(100)	6.1	(100)

GASOLINE RANGE ($C_5 - C_7$)

SAMPLE NO.	15		17		21		27	
DEPTH METRES	1380		1440		1550		1560	
	P.P.B.	$\%C_5-C_7$	P.P.B.	$\%C_5-C_7$	P.P.B	$\%C_5-C_7$	P.P.B.	$\%C_5-C_7$
ISO-PENTANE	3	15	*	*	3	9	*	*
N-PENTANE	3	15	*	*	5	15	*	*
CYCLOPENTANE	tr	*	*	*	tr	*	*	*
2-ME. PENTANE	1	5	*	*	tr	*	*	*
3-ME. PENTANE	1	5	*	*	1	3	*	*
N-HEXANE	5	25	1	33	12	36	*	*
ME. CYCLOPENTANE	3	15	*	*	3	9	*	*
CYCLOHEXANE	tr	*	*	*	tr	*	*	*
2-ME. HEXANE	1	5	*	*	1	3	*	*
3-ME. HEXANE	1	5	*	*	tr	*	*	*
3-ETHYLPENTANE	tr	*	*	*	tr	*	*	*
N-HEPTANE	tr	*	1	33	3	9	*	*
BENZENE	tr	*	*	*	tr	*	*	*
DIME. PENTANE	*	*	*	*	*	*	*	*
ME. CYCLOHEXANE	2	10	1	33	5	15	*	*
TOTAL	20	(100)	3	(100)	33	(100)	*	*

GASEOUS AND GASOLINE HYDROCARBON DATA

CLIENT CONOCO NORWAY WELL 10/5-1 LOCATION NORWEGIAN N. SEA

GAS ($C_1 - C_4$)

SAMPLE NO.	30		32		34		39	
DEPTH METRES	1620		1680		1740		1800	
	P.P.B.	$\%C_1-C_4$	P.P.B.	$\%C_1-C_4$	P.P.B.	$\%C_1-C_4$	P.P.B.	$\%C_1-C_4$
C_1	3	90	2	100	3	93	3	97
C_2	0.1	3	tr	*	0.2	7	0.1	3
C_3	*	*	*	*	tr	*	tr	*
iC_4	0.2	6	*	*	*	*	*	*
nC_4	tr	*	*	*	*	*	*	*
TOTAL	3.3	(100)	2	(100)	3.2	(100)	3.1	(100)

GASOLINE RANGE ($C_5 - C_7$)

SAMPLE NO.	30		32		34		39	
DEPTH METRES	1620		1680		1740		1800	
	P.P.B.	$\%C_5-C_7$	P.P.B.	$\%C_5-C_7$	P.P.B.	$\%C_5-C_7$	P.P.B.	$\%C_5-C_7$
ISO-PENTANE	tr	*	*	*	2	8	7	6
N-PENTANE	3	33	*	*	4	16	7	6
CYCLOPENTANE	*	*	*	*	tr	tr	3	3
2-ME. PENTANE	1	11	*	*	3	12	14	12
3-ME. PENTANE	tr	*	*	*	1	4	7	6
N-HEXANE	2	23	tr	*	2	8	16	14
ME. CYCLOPENTANE	1	11	tr	*	3	12	5	5
CYCLOHEXANE	tr	*	*	*	1	4	2	2
2-ME. HEXANE	tr	*	*	*	1	4	14	12
3-ME. HEXANE	tr	*	*	*	1	4	11	10
3-ETHYLPENTANE	tr	*	*	*	1	4	1	1
N-HEPTANE	1	11	*	*	1	4	14	12
BENZENE	*	*	*	*	*	*	*	*
DIME. PENTANE	*	*	*	*	*	*	*	*
ME. CYCLOHEXANE	1	11	tr	*	3	12	10	9
TOTAL	9	(100)	*	*	23	(100)	111	(100)

TABLE 2 (Cont'd)

GASEOUS AND GASOLINE HYDROCARBON DATA

CLIENT CONOCO NORWAY WELL 10/5-1 LOCATION NORWEGIAN N. SEA

GAS ($C_1 - C_4$)

SAMPLE NO.	41							
DEPTH METRES	1842							
	P.P.B.	$\% C_1 - C_4$	P.P.B.	$\% C_1 - C_4$	P.P.B.	$\% C_1 - C_4$	P.P.B.	$\% C_1 - C_4$
C_1	25	31						
C_2	16	20						
C_3	23	29						
iC_4	5	6						
nC_4	11	14						
TOTAL	80	(100)						

GASOLINE RANGE ($C_5 - C_7$)

SAMPLE NO.	41							
DEPTH METRES	1842							
	P.P.B.	$\% C_5 - C_7$	P.P.B.	$\% C_5 - C_7$	P.P.B	$\% C_5 - C_7$	P.P.B.	$\% C_5 - C_7$
ISO-PENTANE	6	13						
N-PENTANE	6	13						
CYCLOPENTANE	*	*						
2-ME. PENTANE	8	18						
3-ME. PENTANE	1	2						
N-HEXANE	7	16						
ME. CYCLOPENTANE	3	7						
CYCLOHEXANE	1	2						
2-ME. HEXANE	3	7						
3-ME. HEXANE	3	7						
3-ETHYLPENTANE	tr	*						
N-HEPTANE	5	11						
BENZENE	*	*						
DIME. PENTANE	*	*						
ME. CYCLOHEXANE	2	4						
TOTAL	45	(100)						

TABLE 3

MATURATION EVALUATION DATA

COMPANY: CONOCO NORWAY WELL: 10/5-1 LOCATION: NORWEGIAN N. SEA

SAMPLE DEPTH METRES OR NOTATION	SAMPLE TYPE	GENERALISED LITHOLOGY	MAXIMUM PALAEOTEMPERATURE °F	VITRINITE REFLECTIVITY %	SPORE COLOURATION (1-10)	LIGHT HYDROCARBONS
480	Ctgs	Gn-gy sh+chk		True Reflectivities Underlined		Not Possible to Evaluate
540	"	Chk+mdst				
600	"	Chk				
1020	"	Chk+mnr sh				
1080	"	Blk slty sh				
1140	"	Ditto	208			
1170	"	Gy sh		0.39		
1200	"	Ditto				
1230	"	Ditto	216			
1250	S.W.C.	Blk mdst	263			
1260	Ctgs	Gy slty sh		0.76	2-2.5	
1285	S.W.C.	Blk mdst	236		2-2.5	
1320	Ctgs	Gy slty sh	259			
1347	S.W.C.	Blk mdst	245		2.5	
1350	Ctgs	Dk gy sh		0.26		
1380	"	Ditto+sst				
1410	"	Gy slty sh	234	0.32		
1440	"	Ditto+mnr lstn				
1470	"	Ditto+mnr ditto			2.5-3	
1475	S.W.C.	Dk gy sh			2.5-3	
1479	"	Ditto			2.5-3	
1491	"	Ditto			3	
1500	Ctgs	Gy slty sh	237	0.32		
1503	"	Dk gy sh+mnr sst		0.35	3	
1520	S.W.C.	Gy mdst	245		4	
1530	Ctgs	Gy slty sh				
1533	"	Dk gy sh		0.35		
1539	S.W.C.	Gy slty sh			4	
1542	"	Gn snd	243			
1560	Ctgs	Gn-gy sh				
1565	S.W.C.	Gn sh	250			
1590	Ctgs	Gn-gy slty sh	235	0.87		
1620	"	Dk gy sh				
1659	S.W.C.	-			4.5	
1680	Ctgs	Wht lstn+mnr sh	251	0.36	4.5	

MATURATION EVALUATION DATA

COMPANY: CONOCO NORWAY WELL: 10/5-1 LOCATION NORWEGIAN N. SEA

SAMPLE DEPTH METRES OR NOTATION	SAMPLE TYPE	GENERALISED LITHOLOGY	MAXIMUM PALAEOTEMP-ERATURE °F	VITRINITE REFLECTIVITY %	SPORE COLOURATION (1-10)	LIGHT HYDROCARBONS
1683	S.W.C.	Yel-gy lstn			4.5	
1705	"	Ditto			4.5	
1715	"	Ditto			4.5 - 5	
1740	Ctgs	Gy sh				
1757	S.W.C.	Ditto	229			
1767	Ctgs	Ditto+sltst			5	
1770	"	Wht sltst+sh *	255	0.74		
1775	S.W.C.	Dk gy sh			5	
1800	Ctgs	Dk gy sh+sltst				
1808	S.W.C.	Ditto			5	
1842	Ctgs	Dk gy sh		*		

TABLE 4

SOURCE ROCK EVALUATION DATA

COMPANY: CONOCO NORWAY WELL: 10/5-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH METRES OR NOTATION	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT P.P.M.	EXTRACT % OF ORGANIC CARBON	HYDRO-CARBONS P.P.M. OF ROCK	HYDRO-CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO-CARBONS
1. 480	Ctgs	Gn-gy calc sh+50% wht chk+10% flint	0.19					
2. 900	"	Lt gy chky lstn	0.05					
3. 1110	"	Med-dk gy calc sh+mnr red calc mdst	0.92	630	6.8	90	14	53
4. 1140	"	Ditto+tr ditto+tr blk lstn	1.26					
5. 1170	"	Gy calc sh	3.8	250	0.7	90	35	70
6. 1200	"	Ditto+tr red calc mdst	3.2					
7. 1230	"	Ditto+tr ditto	3.3					
8. 1250	S.W.C.	Blk mdst	1.25	145	1.2	30	21	*
9. 1260	Ctgs	Gy slty calc sh	2.23	390	1.7	105	27	69
10. 1285	S.W.C.	Blk mdst	0.68	325	4.8	40	12	62
11. 1290	Ctgs	Gy slty calc sh+tr snd	1.08					
12. 1320	"	Ditto	1.70	435	2.6	45	11	55
13. 1347	S.W.C.	Blk mdst	0.88	240	2.7	<20	*	*
14. 1350	Ctgs	Dk gy sh	1.13	410	3.6	25	6	76
15. 1380	"	Ditto+40% sst	0.79					
16. 1410	"	Med gy slty calc sh	1.02	195	1.9	<20	*	*
17. 1440	"	Ditto+mnr gy lstn	4.2					
18. 1470	"	Ditto+tr ditto+tr pyrite	2.82	85	0.3	<20	*	*
19. 1473	"	Dk gy sh	2.62	480	1.8	28	6	65
20. 1488	"	Ditto+20% gy sst	1.94	360	1.9	5	1	*
21. 1500	"	Gy slty calc sh	1.64	225	1.4	20	9	*
22. 1503	"	Med-dk gy sh+mnr sst	2.59	300	1.2	17	6	85
23. 1520	SWC	Gy calc mdst	1.55	270	1.7	20	7	54
24. 1530	Ctgs	Gy slty calc sh	1.80	350	1.9	25	7	70
25. 1533	"	Dk gy sh	2.85	1081	3.8	130	12	84
26. 1542	S.W.C.	Gn snd	0.05	365	73.0	25	7	63
27. 1560	Ctgs	Gn-gy sh+snd+red mdst	0.08					
28. 1565	S.W.C.	Gn sh	0.05	110	22.0	<20	*	*
29. 1590	Ctgs	Gn-gy slty sh+lt brn lstn+snd+red mdst	0.75					
30. 1620	"	Dk gy sh+red slty mdst+anhydrite	0.54					

SOURCE ROCK EVALUATION DATA

COMPANY: CONOCO NORWAY WELL: 10/5-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH METRES OR NOTATION	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT P.P.M.	EXTRACT % OF ORGANIC CARBON	HYDRO-CARBONS P.P.M. OF ROCK	HYDRO-CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO-CARBONS
31. 1650	Ctgs	Wht chky lstn+tr gy sh	0.15	80	5.3	< 20	*	*
32. 1680	"	Ditto+tr ditto	0.70					
33. 1710	"	Ditto+tr gy sltst	0.78					
34. 1740	"	Med gy sh+20% gy sltst+20% lt gy lstn+10% red sltst	1.33	265	2.0	13	5	75
35. 1755	"	Lt gy sl slty sh+dk gy sh+anhydrite	5.0	200	0.4	15	8	83
36. 1757	S.W.C.	Gy sh	1.04	570	5.5	120	21	66
37. 1767	Ctgs	Med gy sh+30% wht calc sltst	1.31	235	1.8	12	5	*
38. 1770	"	Wht calc sltst+30% gy sh+20% anhydrite	3.4					
39. 1800	"	Ditto+60% dk gy sh+mnr lstn+mnr red mdst	1.51	255	1.7	50	20	71
40. 1830	"	Granitic frags+mnr dk gy sh	0.25					
41. 1842	"	Ditto+10% dk gy sh	0.20	25	1.2	<20	*	*
		ORGANIC CARBON DETERMINATIONS						
15. 1380		Gy sh	2.06					
30. 1620		Ditto	1.83					
34. 1740		Med gy sh	1.34					
39. 1800		Dk gy sh	1.35					
40. 1830		Ditto	0.93					

FIGURE I

HEADSPACE ($C_1 - C_4$) HYDROCARBONS

COMPANY : CONOCO NORWAY WELL : 10/5-1 LOCATION : NORWEGIAN NORTH SEA

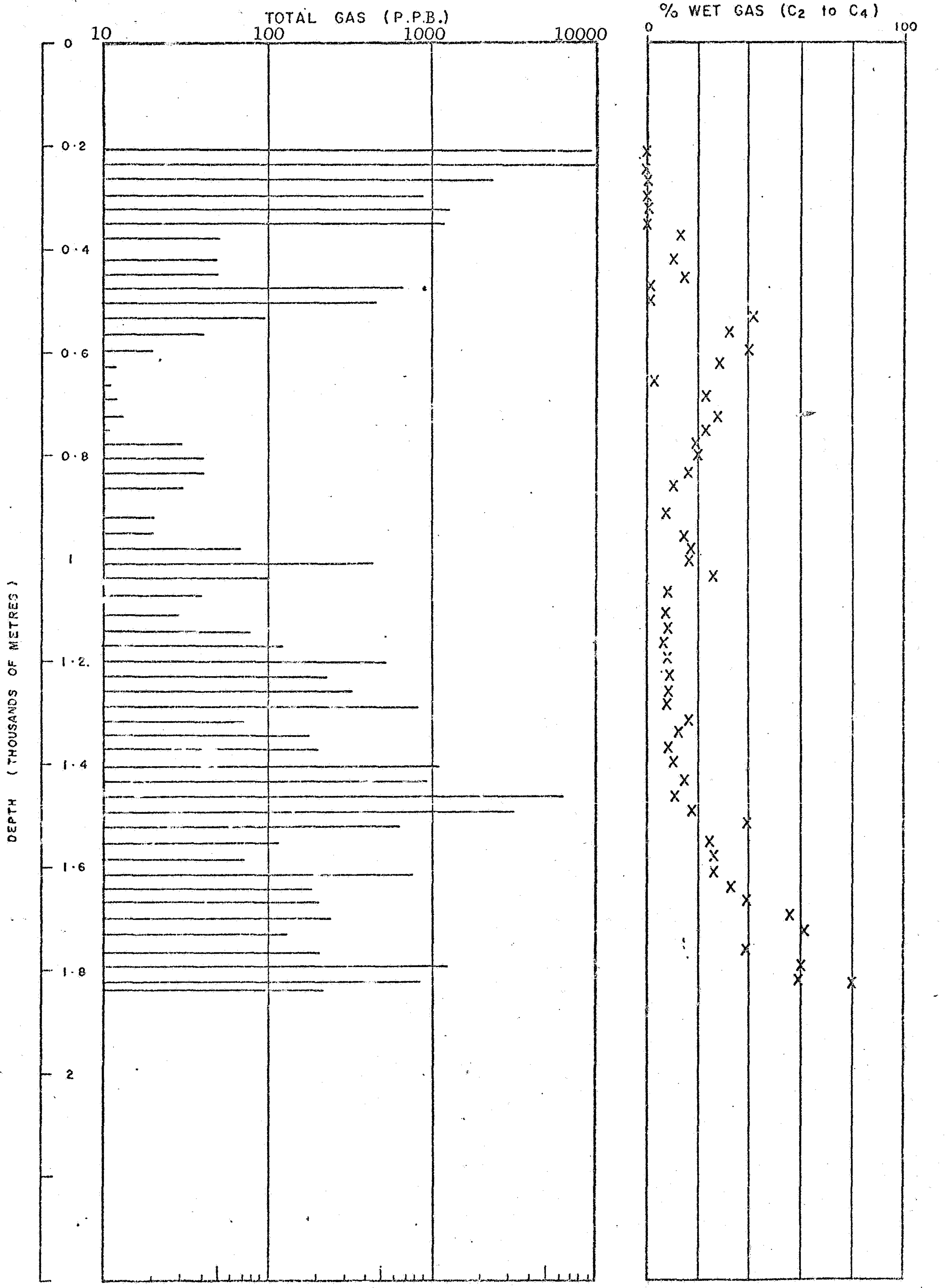

FIGURE 2

VITRINITE REFLECTIVITY AGAINST DEPTH

COMPANY : CONOCO NORWAY   WELL : 10/5-1   LOCATION : NORWEGIAN NORTH SEA

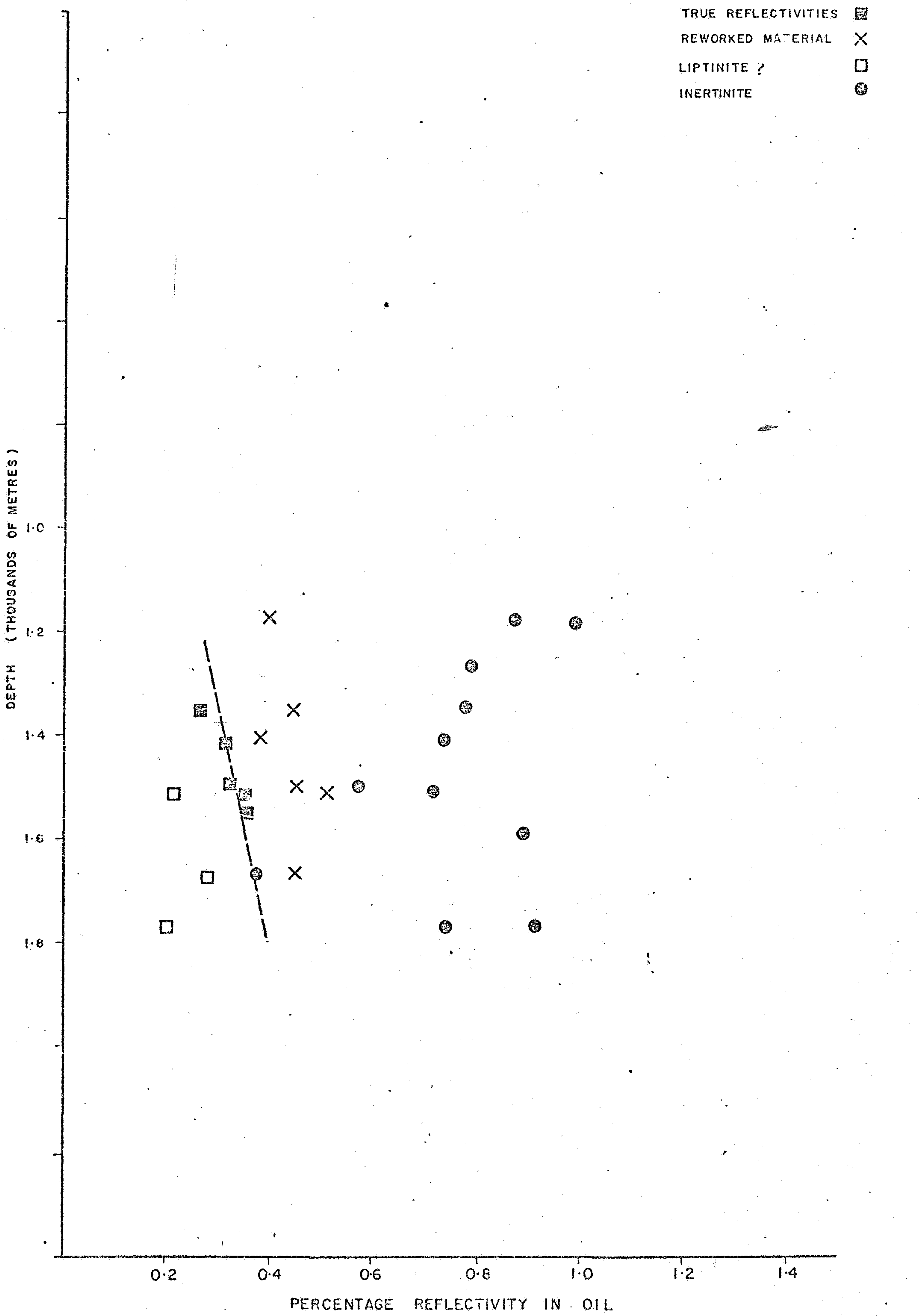

FIGURE 3

MAXIMUM PALAEOTEMPERATURE AGAINST DEPTH

COMPANY : CONOCO NORWAY   WELL : 10/5-1   LOCATION : NORWEGIAN NORTH SEA

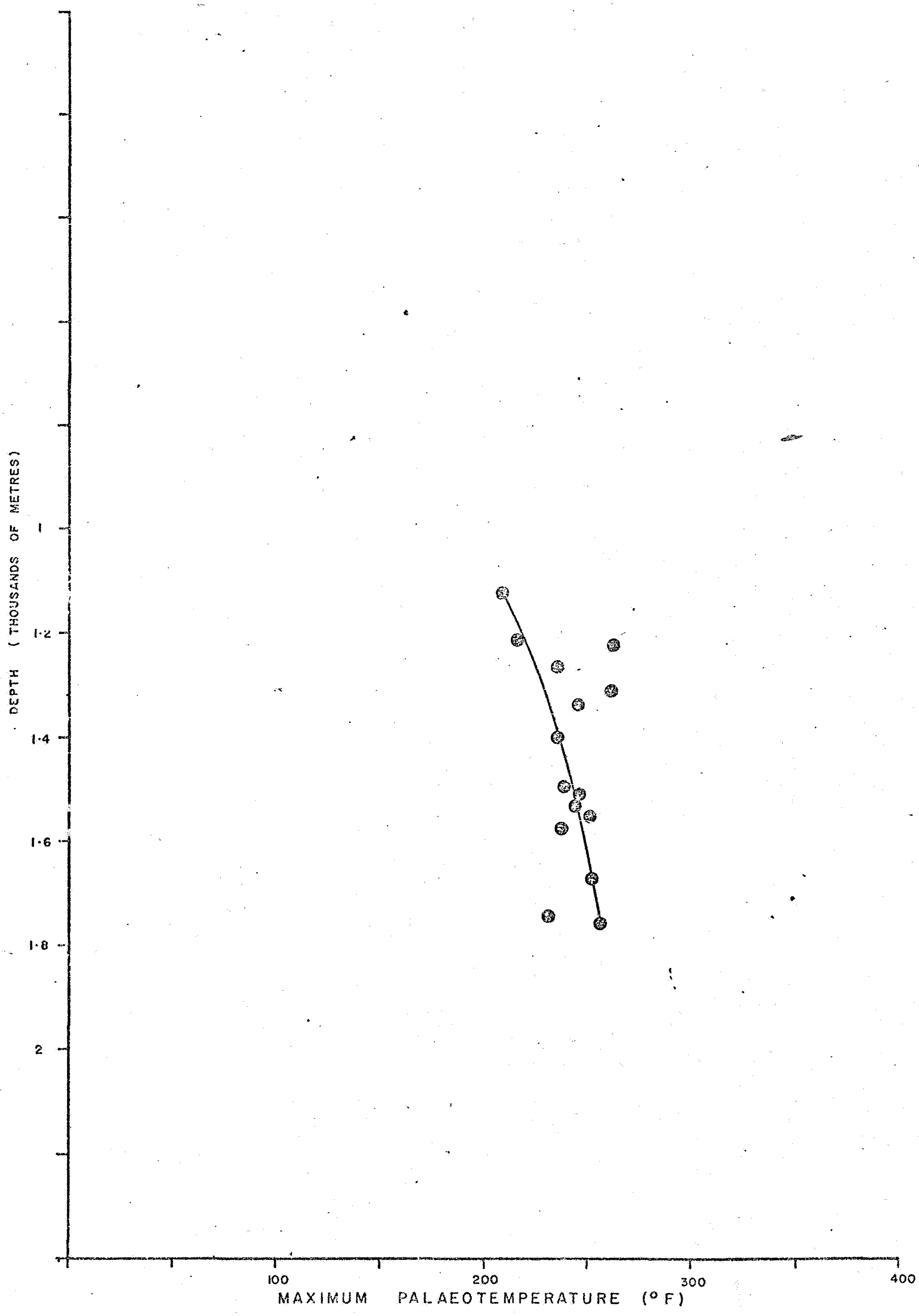

FIGURE 4

MATURATION INDICES AGAINST DEPTH

COMPANY : CONOCO NORWAY WELL : 10/5-1 LOCATION : NORWEGIAN NORTH SEA

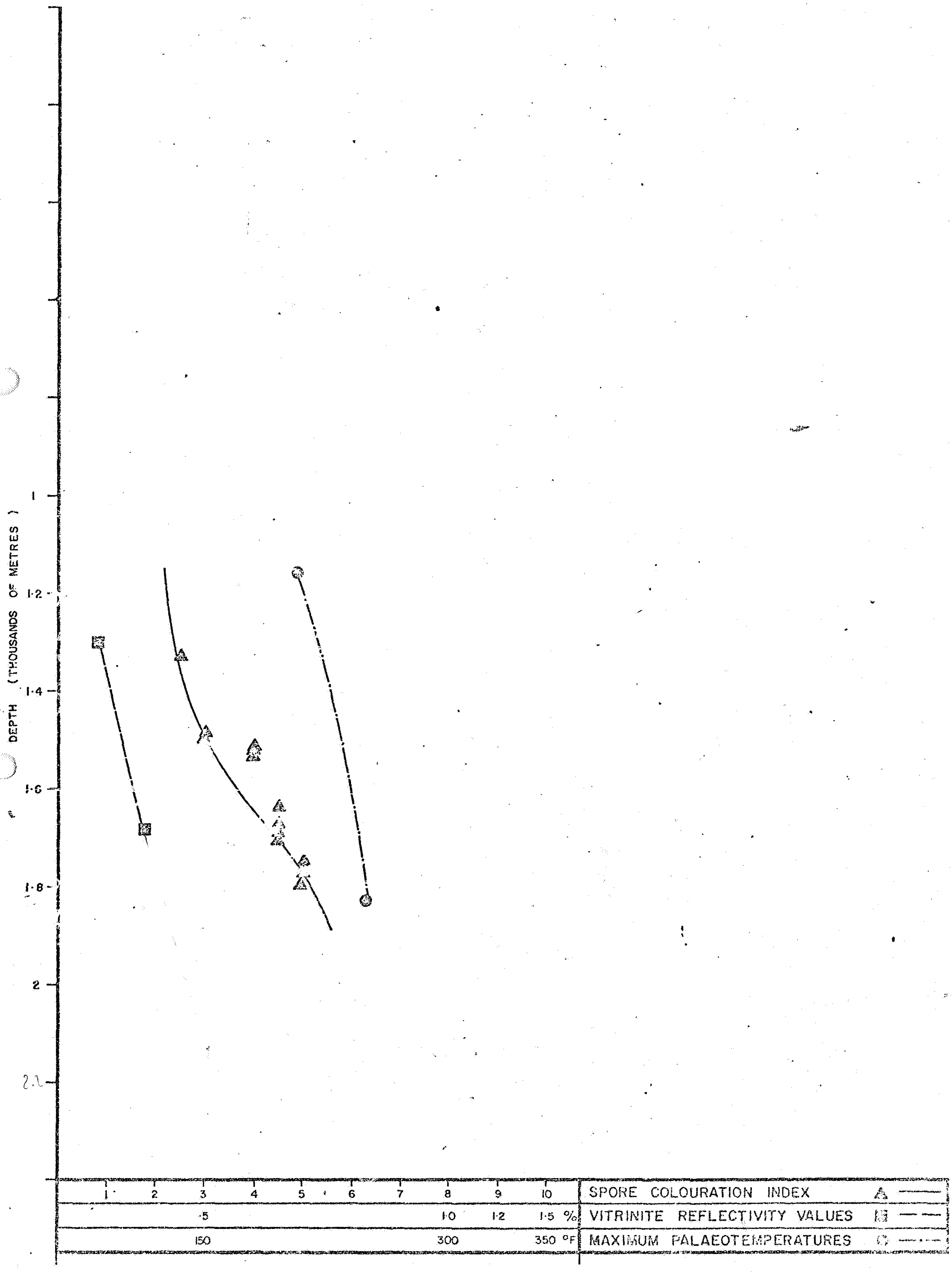

FIGURE 5

TYPE OF HYDROCARBON PRODUCT FROM SOURCE ROCKS

COMPANY : CONOCO NORWAY WELL : 10/5-1 LOCATION : NORWEGIAN NORTH SEA

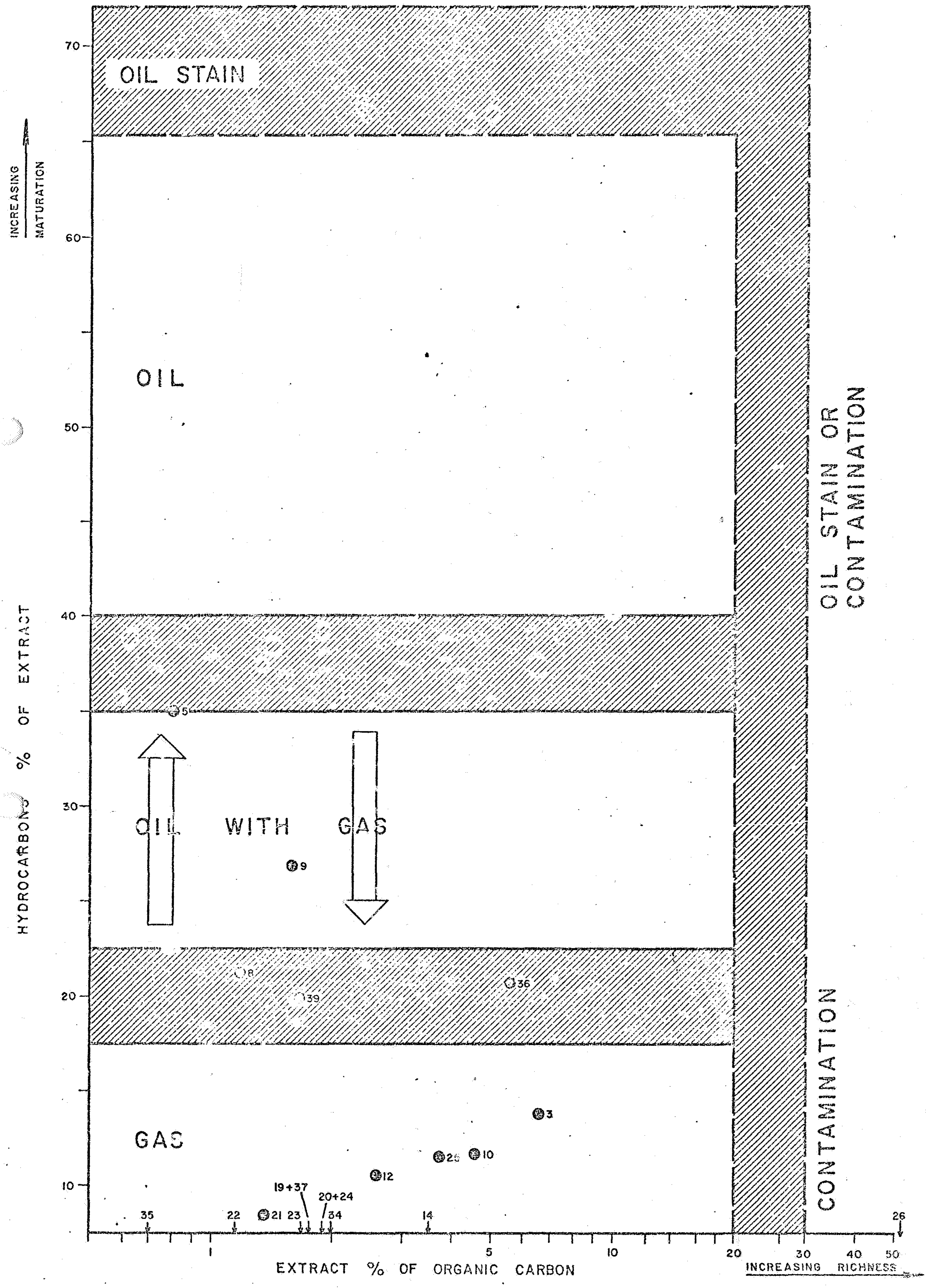

FIGURE 6

MATURE SOURCE ROCK RICHNESS

COMPANY : CONOCO NORWAY WELL : 10/5-1 LOCATION : NORWEGIAN NORTH SEA