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A HYDROCARBON SOURCE POTENTIAL AND MATURATION STUDY OF THE 16/8-1 WELL, NORWEGIAN NORTH SEA

by

B.S. COOPER

W.B. SIMPSON

P.C. BARNARD

K. LEWIS

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Prepared by:
Robertson Research International Limited,
Ty'n-y-Coed, Llanrhos,
Llandudno, Gwynedd,
North Wales, LL30 1SA.

Prepared for:
Conoco Norway Inc.,
P.O. Box 488,
4001 Stavanger,
Norway.

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SUMMARY

A maturation and source rock potential study has been carried out on samples from 1000 to 2300 metres in the Conoco Norway 16/8-1 well.

Maturation level has been determined using headspace gas, spore colouration and vitrinite reflectivity data and indicates that the analysed section is immature down to about 2000 metres. Below this depth the contained organic matter becomes transitionally mature.

Source rock evaluation analyses have confirmed the generally low level of maturity in the section in that extractability values and hydrocarbon contents of the samples analysed are rather low.

The organic carbon content of the interval 1000 to 1650 metres is about average and may become a significant hydrocarbon source off-structure.

The interval 1650 to 2041.3 metres is organically lean.

Dark grey shales in the interval 2050 to 2090 metres have high organic carbon contents and may have oil generating potential if found at a significantly higher level of maturity off-structure.

Sands and red-grey shales below 2090 metres are organically lean and do not have significant hydrocarbon potential.

I

INTRODUCTION

A maturation and source rock study has been carried out using sidewall cores and canned wet ditch cuttings from the section 1000 to 2300 metres of the Conoco Norway 16/8-1 well, drilled in the Norwegian North Sea.

The sidewall cores, received on 2nd November 1976 by post, packed in glass bottles some of which were broken, were also mainly of good quality for geochemical analysis.

The cuttings samples received on 17th November 1976 were seen to be of fair to good quality for geochemical analysis, although in the Tertiary section caving may be a problem.

All of the canned samples were analysed to determine the content and composition of the headspace gases (C_1 to C_4 gases). Subsequently, the samples were washed in cold water to remove drilling mud and, after drying and lithological description, were found to be of good quality for geochemical analysis. Sidewall cores were prepared for analysis by careful removal of drilling mud and other contaminants and were of generally good quality, though small in quantity for geochemical analysis.

Evaluation of maturity has been based on analyses of headspace gases of the canned samples, spore colouration and vitrinite reflectivity, the latter two analyses mostly being performed on kerogen prepared from the sidewall cores. Analysis for total organic carbon was carried out on all the samples received and on picked lithologies from the cuttings samples where necessary. The results were used in the selection of samples for source rock analysis.

Gas chromatographic analysis has been carried out on source rock samples containing greater than 100 ppm of C_{15+} hydrocarbons.

The lithologies observed suggest that the ages of the samples range from Tertiary to Triassic.

II

RESULTS AND INTERPRETATION

A. MATURITY EVALUATION

Three maturation parameters have been used in this study and the results of these analyses are discussed below:-

1. Headspace Gas (Table 1 and Figure 1)

From Figure 1 it may be seen that, with one or two exceptions, the gas contents between 1000 and 2000 metres are about 10000 ppm. The constitution of the gas samples is 97% or greater, of methane and is indicative of the presence of immature organic matter.

Between 2060 and 2300 metres the gas contents are more variable, ranging from 34000 ppm at 2060-090 metres decreasing to 1600 ppm at 2270-300 metres. The composition of the gas also changes and the percentage of wet gas rises to between 10% and 25%, indicating that the contained organic matter within this interval is transitionally mature.

2. Spore Colouration (Table 2 and Figure 3)

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. Detailed kerogen descriptions have not been made,but comments on the dominant kerogen components are included.

Interval 1369.5 to 2055 metres

Spore colour indices range from 1.5 to 2.5 and indicate that immature oil-prone organic matter if present in the sediments is immature. In the section 1369.5 to 1647.3 metres vitrinite is the dominant kerogen type with some sapropel and generally minor inertinite. Below 1647.3 metres, however,

inertinite is the dominant kerogen type, although there is a rich exinite fraction at 1970 and 2024.6 metres and lesser exinite at 2050 and 2055 metres.

Interval 2060 to 2120 metres

Spore colour indices range from 2.5 to 3 in samples from 2060 to 2120 metres, indicating that any oil-prone organic matter in the sediments may be transitionally mature. At 2060, 2065 and 2074.5 metres sapropelic debris and degraded vitrinite are the dominant kerogen components while at 2120 metres humic components are dominant.

3. Vitrinite Reflectivity (Table 2, Figure 2 and enclosure)

Vitrinite reflectivity analysis has indicated that the analysed section is immature for generation of significant quantities of gas from humic materials.

Many of the samples contained little detectable vitrinite and on some, no measurements have been possible. However, in other cases, reliable readings on well-polished, positively identified vitrinite particles have been possible.

The results are discussed in groups based on lithology.

Interval 1000 to 1647.3 metres

The section, which is possibly of Tertiary age, is relatively rich in vitrinite and Table 2 shows the results obtained. The reflectivities range from 0.25 to 0.31% for vitrinite, usually collinite, though telinite is also recognised. Small particles of low-reflecting vitrinite and semifusinite are often seen, but the numbers of particles available for measurement, even in kerogen concentrates, are frequently low.

Fluorescence colours of exinite particles in blue light are mainly yellow. Yellow and yellow-orange spores are recognised in amounts which range from relatively small to relatively large. At some horizons algal fragments, resin and possible sapropelic matter have been seen.

Interval 1647.3 to 2024.6 metres

The samples in this interval (believed to be of Cretaceous age) are

low in vitrinite,but contain appreciable amounts of inertinitic material. Such vitrinite as has been seen has a reflectivity of about 0.3%.

Fluorescence colours in blue light are usually yellow,though the abundance in most cases is extremely low.

Interval 2050 to 2120 metres

The samples from this interval, whilst they are lean in vitrinitic matter, contain abundant fluorescent organic matter when viewed in blue light. The few readings which have been possible on vitrinite range from 0.28% to 0.31% with equivalent amounts of semifusinite also being noted, the material with reflectivity of 0.46% at 2074.5 metres is probably reworked.

The fluorescent organic material was of yellow or yellow-orange colour with occasional yellow-green spores. The material consisted of resins, spores and algae and these were present in relatively large quantities. These sediments, if sufficiently rich in total organic matter could be anticipated to be good oil source rocks when more mature.

Interval 2120 to 2300 metres

No vitrinite was found in this interval, represented by one sidewall core and one cuttings sample and no fluorescence was observed under blue light.

On the basis of lithology and the barren nature of the sediments this interval is believed to be of Triassic age.

4. Comparison of Maturation Indices (Tables 1 and 2, Figure 3)

Three maturation parameters have been employed in this study. They are headspace gas analysis, spore colouration indices and vitrinite reflectivity analysis.

Headspace gas analysis indicates that the organic matter in the samples is immature down to a depth of about 2000 metres after which it becomes transitionally mature and remains so until the deepest sample at 2300 metres.

Spore colouration analysis indicates that oil-prone material in samples from the interval 1369.5 to 2060 metres is immature whilst in

samples from the interval 2065 to 2250 metres oil-prone material becomes transitionally mature.

Vitrinite reflectivity analysis indicates that humic material in the samples from the whole of the analysed section is immature whilst fluorescence colours suggest that oil-prone material becomes marginally mature at about 2000 metres.

In summary oil-prone material is immature until a depth of about 2000 metres is reached and transitionally mature from this depth to the bottom of the analysed section. Gas-prone matter is immature throughout the analysed section.

B. SOURCE ROCK EVALUATION

The source rock evaluation results for this well are discussed in five parts based on lithology. (Table 3, Figures 4, 5 and 6).

i Interval 1000 to 1647.3 metres (Samples 1 to 11)

This interval comprises brown-grey and green-grey shales in the upper part, the colour becoming lighter and the lithology more calcareous below 1545 metres. The samples received consist of both ditch cuttings and sidewall cores.

Three brown-grey shale sidewall cores were analysed from this interval and their organic carbon contents have values from 1.54% to 1.94%. These values are somewhat higher than those of the green-grey ditch cuttings received from this interval and, taking both sidewall cores and ditch cuttings samples into consideration, the average value is about 1.2%.

The amount of solvent extractable organic matter in these samples is more variable having quantities which range from 210 ppm in sample 11 to 1145 ppm in sample 5. The average value is 550 ppm. As a percentage of total organic carbon the extract values range from 1.9% in sample 11 to 5.9% in sample 5 and indicate that the organic matter is presently immature. The concentration of hydrocarbons in the samples is generally low with values of 20 to 120ppm as would be expected in samples which are presently immature.

The likely hydrocarbon product from the source rocks is gas in all cases apart from sample 2; sample 2 has a higher proportion of hydrocarbons in the extract and may be stained.

The present potential of these source rocks for liquid hydrocarbons is low and only gas with minor oils is expected at the present low level of maturation.

ii Interval 1700 to 1800 metres (Samples 12 to 14)

The samples from this interval comprising two sidewall cores and one ditch cuttings samples consist of light olive-grey mudstones or shales

in part calcareous. The organic carbon contents measured are low, only one sidewall core having a value above the screening limit with a value of 0.34. A subsample 12A, of medium grey calcareous shale has an organic carbon content of 0.82%.

The total extractable matter content is low with only 240 ppm. The hydrocarbon content is low at 35 ppm as is the value of hydrocarbons as a percentage of extract at 15%. Source rock analysis of the medium grey calcareous shale subsample from 1700-800 metres, has given similar results with an extractability indicative of immaturity of 3.8% and hydrocarbon content of 20 ppm.

The samples are presently immature,but appear to contain mostly gas-prone organic matter and have little present potential to yield oil.

iii Interval 1800 to 2055 metres (Samples 15 to 28)

This interval is represented by medium or olive grey often calcareous mudstones or shales. There are also occasional horizons of red-brown calcareous mudstone.

The organic carbon contents range from 0.09% in sample 19 at 1929 metres to 0.64% in sample 25 at 2030-060 metres and are below average. Sample 15A, medium-grey calcareous shale, has an organic carbon content of 0.64% and this is diluted by the presence of light grey calcareous siltstone in the ditch cuttings sample.

Source rock analysis has been carried out on samples with organic carbon contents of more than 0.3% which are in the main variously coloured grey shales or mudstones and the quantities of extract obtained are low to average ranging from 110 ppm in sample 22 to 540 ppm in sample 23. When related to the organic carbon content the extract values are mainly low with values ranging from 2.5% in sample 22 to 5.2% in sample 21; sample 23 has a higher value of 13.5%. The likely hydrocarbon product from these samples is gas (samples 20, 21 and 23), gas-with-oil

(samples 18, 22 and 25) and oil-with-gas (sample 15).

The samples in this interval are in a state of low maturity and this is reflected in the low yield of hydrocarbons. The extractable matter when related to organic carbon shows an apparent increase with depth and may possibly indicate increasing maturation of contained organic matter within this interval. However, the richness of the organic matter in these source rocks is poor in all cases.

iv Interval 2060 to 2074.5 metres (Samples 29 to 32)

The samples from this interval consist of medium to dark grey shales and mudstones with 40% glauconitic sandstone in the cuttings sample.

The organic carbon contents of the samples are high and range from 3.3% to 7.2%. Total extractable matter amounts are high at 2725 to 5310 ppm, but when related to organic carbon contents all lie within the range 6.1% to 8.4%. Similarly, the hydrocarbon contents are high at 525 to 775 ppm,but related to extractable matter fall in the range 11% to 19%.

The organic material in these samples has been shown by visual examination to be largely sapropelic which in its present transitional state of maturity will be expected to yield only gas - samples 28, 29 and 31 or gas-with-oil - samples 27 and 30. When mature, perhaps off-structure at greater depths, similar organic matter is expected to be a fair or good potential oil source.

v Interval 2090 to 2120 metres (Samples 33 and 34)

The two samples in this interval, one sidewall core at 2120 metres and one ditch cutting sample at 2090-2120 metres are light grey in colour and consist of siltstone or sandstone with in the ditch cuttings 20% dark grey shale which is presumed caved.

The very light grey siltstone from the sidewall core sample has an organic carbon content of only 0.06% and so has not been analysed further. The ditch cuttings sample has an organic carbon content of 1.29%, a slightly higher than average value and the total extractable material at 1135 ppm is

relatively high,but when related to total organic carbon content represents 8.8%. The hydrocarbon concentration is low at 175 ppm which as a percentage of the total extract is 15%.

The sandstone/siltstone in this interval cannot be considered of interest as source rocks for hydrocarbons. The dark grey shale appears to be potentially a fair to good oil source when mature,but is suspected to be caved.

vi Interval 2120 to 2300 metres (Samples 35 to 43)

This interval consists principally of red-brown silty mudstones with minor light olive-grey silty shales and occasional dark grey shales, these latter grey lithologies being considered to be caved.

Organic carbon content of the red-brown mudstone is typified by samples at 2195 and 2250 metres with 0.11% and less than 0.05% respectively. The red-brown mudstone at 2150 metres was apparently contaminated by drilling mud and has a carbon content of 0.85%. The cuttings samples in this interval, although consisting dominantly of red-brown mudstone contain other caved grey shales/siltstones and the carbon content of these samples have,therefore, been distorted so that values of 0.58% upto 1.11% have been recorded. The organic carbon contents of hand selected red-brown mudstone/siltstone from 2210-240 and 2270-300 metres are 0.09% and 0.06% while the light olive-grey siltstone/silty shale lithologies from 2210-240 and 2270-300 metres both have 0.35% carbon. The dark grey silty shale from 2120-150 metres has a carbon content of 5.4% indicating that it is caved probably from the interval approximately 2060 to 2075 metres.

Samples containing greater than 0.30% carbon have been analysed for source rock potential and extractability values of 4.6% to 7.1% and one value for a hand selected lithology, of 17.1%, have been recorded. The hydrocarbon content of all these samples, however, is low at 100 ppm or less.

It is clear that the red-brown mudstones/silty shales in this interval can have no hydrocarbon source potential. It is also clear that dark grey shale probably from the interval 2060 to 2075 metres has caved into the

cuttings samples and is distorting the results to some extent. The light olive-grey silty shale/siltstone lithology observed in a number of cuttings samples is a poor potential oil-prone source rock. With the information available it is difficult to determine whether this shale is caved or in situ.

C. GAS CHROMATOGRAPHY

A total of nine samples when hydrocarbon content was greater than 100 ppm, was selected for gas chromatographic analysis of the saturate hydrocarbon fraction. In the majority of samples the amount of rock available for extraction and of extract remaining after fractionation analysis, was too low to obtain reliable gas chromatographic traces.

The only reliable trace is that from 2060-090 metres which shows an n-alkane distribution from $n\text{-}C_{15}$ to $_{25}$ peaking at $n\text{-}C_{18}$, and $n\text{-}C_{18}$ to phytane, $n\text{-}C_{17}$ to pristane and pristane to phytane ratios of 0.41, 0.44 and 0.89 respectively.

III

CONCLUSIONS

As a result of the present study of the Conoco Norway 16/8-1 well, the following conclusions are drawn.

1. Green-grey/olive-grey/brown-grey shales in the interval 1000 to 1700 metres are presently immature and unable to source significant quantities of oil or gas. The organic content is about average and is dominantly humic in origin so that gas is the likely product from this interval if located at a more advanced level of maturity off-structure.

2. Medium grey calcareous shales in the interval 1700 to 1800 metres are organically lean and are presently immature. They can have no significant hydrocarbon source potential.

3. Medium or olive-grey shales or sandstone in the interval 1800 to 2055 metres are organically lean. The organic constituents are dominantly humic, though there are occasional exinite-rich intervals. The likely product is only minor quantities of gas with occasional oil from these immature samples.

4. The medium-dark grey mudstones or shales in the interval 2060 to 2074.5 metres are immature for generation of hydrocarbons from gas-prone and oil-prone organic material. The organic carbon contents are high as are the extractable matter contents. The likely product is presently gas or gas-with-oil, but it is considered that considerable quantities of oil could be generated at a more advanced level of maturity off-structure.

5. The light grey sandstone/siltstone in the interval 2090 to 120 metres has about average organic carbon content and the contained organic matter is presently immature. No significant hydrocarbon generation is anticipated from this interval.

6. The red-brown silty mudstone and if in situ the light blue-grey silty shales below 2120 metres are organically lean and are considered to have no significant hydrocarbon generating potential.

TABLE 1

HEADSPACE GAS ANALYSIS DATA

CLIENT: CONOCO NORWAY WELL: 16/18-1 LOCATION: NORWEGIAN N. SEA

Sample Depth (Metres)	Total C_1-C_4 Gas ppm	Percent C_1	Percent C_2	Percent C_3	Percent iso C_4	Percent n-C_4
1000- 100	7800	99.5	0.4	0.06	0.008	0.01
1100- 200	8700	97.0	0.9	1.6	0.3	0.13
1200- 300	9400	98.4	0.4	0.6	0.3	0.1
1300- 400	9600	97.4	0.7	1.1	0.4	0.2
1400- 500	10600	97.4	1.1	0.9	0.2	0.1
1500- 600	11300	98.2	1.3	0.2	0.1	0.06
1600- 700	23500	98.0	1.2	0.5	0.1	0.08
1700- 800	11400	98.3	0.9	0.5	0.1	0.05
1800- 900	4700	98.1	1.0	0.6	0.1	0.1
1900-2000	7600	97.8	1.0	0.8	0.2	0.1
2060- 090	34000	89.4	4.0	4.3	0.9	1.4
2090- 120	5500	88.4	4.2	4.9	0.8	1.6
2120- 150	6300	82.5	5.1	7.7	1.6	3.1
2150- 180	4200	75.3	5.7	11.9	2.4	4.7
2180- 210	5300	87.0	4.0	6.0	1.0	2.0
2210- 240	7400	86.1	4.5	6.2	1.1	2.1
2240- 270	3200	80.1	5.1	9.2	1.7	3.5
2270- 300	1600	82.0	4.8	8.5	1.6	3.1

TABLE 2

MATURATION EVALUATION DATA

COMPANY: CONOCO NORWAY WELL: 16/8-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (METRES) OR NOTATION	SAMPLE TYPE	GENERALISED LITHOLOGY	MAXIMUM PALAEOTEMP-ERATURE °F	VITRINITE REFLECTIVITY %	SPORE COLOURATION (1-10)	LIGHT HYDROCARBONS
1000- 100	Ctgs	Dk ol-gy sh (glauc?)+mnr gn-gy sh		0.25 (12)	-	
1100- 200	"	Ditto+60% gn-gy sh		0.30 (12)	-	
1200- 300	"	Gn-gy sh/mdst		0.29 (22)	-	
1300- 400	"	Ditto		0.28 (3)	-	
1369.5	SWC	Brn-gy sh		0.25 (14)	1.5 - 2	
1400- 500	Ctgs	Gn-gy sh/mdst		0.28 (16)	-	
1408	SWC	Brn-gy sh		0.31 (1)	1.5 - 2	
1500- 600	Ctgs	Gn-gy sh/mdst		*	-	
1545	SWC	Lt ol-gy sl slty mdst		0.27 (24)	1.5 - 2	
1600- 700	Ctgs	Gn-gy sh/mdst		*	-	
1647.3	SWC	Med-lt gy calc sh		0.25 (15)	2	
1725	"	Lt ol-gy mdst		*	2	
1800- 900	"	Med gy calc sh+ 30% lt gy sltst		*	-	
1847.3	"	Med gy v calc sltst		0.31 (3)	2	
1900-2000	Ctgs	Lt ol-gy sl calc sh+mnr red-brn sh		*	-	
1950	SWC	Ol-gy v calc mdst		0.32 (1)	2 - 2.5	
1970	"	Med gy v calc mdst		0.31 (1)	2 - 2.5	
2005	"	Ol-gy v calc mdst		*	2.5	
2000- 030	Ctgs	Med gy calc sh+ tr red mdst+lt ol-gy calc sh		*	-	
2024.6	SWC	Med gy v calc sltst		0.37 (1)	2.5	
2050	"	Lt bl-gy v calc mdst		0.29 (1)	2.5	
2055	"	Lt brn-gy v calc mdst		-	2.5	
2060	"	Dk gy sh		*	2.5 - 3	
2065	SWC	Dk gy sh		0.31 (4)	2.5 - 3	
2060- 090	Ctgs	Dk gy sl slty sh+ 40% lt gy glauc. sst		0.28 (29)	-	

TABLE 2 (Cont'd)

MATURATION EVALUATION DATA

COMPANY: CONOCO NORWAY WELL: 16/8-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (METRES OR NOTATION	SAMPLE TYPE	GENERALISED LITHOLOGY	MAXIMUM PALAEOTEMP-ERATURE °F	VITRINITE REFLECTIVITY %	SPORE COLOURATION (1-10)	LIGHT HYDROCARBONS
2074.5	SWC	Med gy mdst		0.46 (5)	2.5 - 3	
2090-120	Ctgs	Lt gy calc glauc sst+20% lt gy dk gy calc sh		*	-	
2120	SWC	V lt gy sltst+ tr mica		*	3?	
2150-180	Ctgs	Red-brn slty mdst +mnr lt ol-gy sltst		*	-	
2150	SWC	Red-brn mdst		-	-	
2195	SWC	Ditto		-	-	
2250	SWC	Ditto		-	-	

TABLE 3

SOURCE ROCK EVALUATION DATA

COMPANY : CONOCO NORWAY WELL : 16/8-1 LOCATION : NORWEGIAN N. 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 % OF C15+ CARBONS
1. 1000-100	Ctgs	Dk ol-gy sh (glauc?) +mnr gn-gy sh	1.10	555	5.0	85	15	84
2. 1100-200	"	Ditto+60% gn-gy sh	0.81	395	4.9	45	42	100
3. 1200-300	"	Gn-gy sh/mdst	1.11	490	4.4	65	13	69
4. 1300-400	"	Ditto	1.24	545	4.4	35	6	68
5. 1369.5	SWC	Brn-gy sh	1.94	1145	5.9	55	5	66
6. 1400-500	Ctgs	Gn-gy sh/mdst	0.84	240	2.9	35	15	65
7. 1408	SWC	Brn-gy sh	1.54	770	5.0	55	7	74
8. 1500-600	Ctgs	Gn-gy sh/mdst	0.87	355	4.1	20	6	66
9. 1545	SWC	Lt ol-gy sl slty mdst	1.83	1000	5.5	120	12	77
10. 1600-700	Ctgs	Gn-gy sh/mdst	0.73	235	3.2	45	19	65
11. 1647.3	SWC	Med-lt gy calc sh	1.12	210	1.9	20	12	100
12. 1700-800	Ctgs	Med gy calc sh+30% chk	0.29	-	-	-	-	-
13. 1725	SWC	Lt ol-gy mdst	0.34	240	7.1	35	15	100
14. 1759	"	V lt ol-gy v calc mdst	0.15	-	-	-	-	-
15. 1800-900	Ctgs	Med gy sl calc sh+ 30% lt gy sl calc sltst	0.42	115	2.7	35	30	51
16. 1847.3	SWC	Med gy v calc sltst	0.49	195	4.0	<20	*	*
17. 1868	"	Lt bl-gy mdst	0.27	-	-	-	-	-
18. 1900-2000	Ctgs	Lt ol-gy sl calc sh+ mnr red-brn sh	0.53	180	3.4	40	22	65
19. 1929	SWC	Red-brn calc mdst	0.09	-	-	-	-	-
20. 1950	"	Ol-gy v calc mdst	0.40	155	3.9	20	13	100
21. 1970	"	Med gy v calc mdst	0.59	305	5.2	35	11	100
22. 2000-030	Ctgs	Med gy calc sh+tr red mdst+lt ol-gy calc sh	0.44	110	2.5	25	23	72
23. 2005	SWC	Ol-gy v calc mdst	0.40	540	13.5	35	6	56
24. 2024.6	"	Med gy v calc mdst	0.45	165	3.7	<20	*	*

TABLE 3 (Cont'd)

SOURCE ROCK EVALUATION DATA

COMPANY: CONOCO NORWAY WELL: 16/8-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH METRES OR NOTATION	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT PPM.	EXTRACT % OF ORGANIC CARBON	HYDRO-CARBONS PPM. OF ROCK	HYDRO-CARBONS % OF EXTRACT	TOTAL ALKANES %+TO C25+
25. 2030-060	Ctgs	Med gy calc sh+lt ol-gy calc sh+tr red mdst +10% red-brn sh	0.64	295	4.6	55	19	47
26. 2041.3	SWC	Lt gy sltst/mud cont	0.15	-	-	-	-	-
27. 2050	SWC	Lt bl-gy v calc mdst	0.14	-	-	-	-	-
28. 2055	"	Lt brn-gy v calc mdst	0.16	-	-	-	-	-
29. 2060	"	Dk gy sh	6.00	5025	8.4	655	13	45
30. 2060-090	Ctgs	Dk gy sl slty sh+40% lt gy glauc sst	3.30	2725	8.3	525	19	23
31. 2065	SWC	Dk gy sh	7.20	5310	7.4	590	11	41
32. 2074.5	"	Med gy mdst	6.60	4030	6.1	775	19	48
33. 2090-120	Ctgs	Lt gy calc glauc sst+ 20% lt dk gy calc sh	1.29	1135	8.8	175	15	33
34. 2120	SWC	V lt gy sltst+tr mic	0.06	-	-	-	-	-
35. 2120-150	Ctgs	Red-brn slty mdst+ 20% dk gy sh+40% lt gy/ol-gy/slty sh/sltst	1.11	730	6.6	100	14	52
36. 2150	SWC	Red-brn mdst	0.85	605	7.1	100	17	58
37. 2150-180	Ctgs	Red-brn slty mdst+mnr lt ol-gy sltst	0.51	300	5.9	55	18	54
38. 2180-210	"	Ditto+10% lt ol-gy sltst/slty sh	0.69	320	4.6	55	7	44
39. 2195	SWC	Red-brn mdst	0.11	-	-	-	-	-
40. 2210-240	Ctgs	Red-brn slty mdst+10% lt ol-gy sltst/slty sh+mnr dk gy sh	0.85	485	5.7	70	14	49
41. 2240-270	"	Ditto+10% ditto	0.58	350	6.0	55	16	50
42. 2250	SWC	Red-brn mdst	<0.05	-	-	-	-	-
43. 2270 300	Ctgs	Red-brn slty mdst+10% lt ol-gy sltst/slty sh+mnr dk gy sh	0.93	515	5.5	95	18	49
		PICKED LITHOLOGIES						
12A.1700-800	Ctgs	Med gy calc sh	0.82	305	3.8	20	7	100
15A.1800-900	"	Ditto	0.64	-	-	-	-	-
35A.2120-150	"	Dk gy sl slty sh	5.4	-	-	-	-	-

SOURCE ROCK EVALUATION DATA

COMPANY: CONOCO NORWAY WELL: 16/8-1 LOCATION: NORWEGIAN N. SEA

SAMPLE DEPTH (Metres OR NOTATION	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT PPM	EXTRACT % OF ORGANIC CARBON	HYDRO-CARBONS P.P.M. OF ROCK	HYDRO-CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO-CARBONS
40A. 2210-240	Ctgs	Lt ol-gy sltst/slty sh	0.35	250	7.1	*	*	*
40B. 2210-240	"	Red-brn mdst/sltst	0.09	-	-	-	-	-
43A. 2270-300	"	Lt ol-gy sltst/slty sh	0.35	600	17.1	95	16	100
43B. 2270-300	"	Red-brn mdst/sltst	0.06	-	-	-	-	-

FIGURE 1

HEADSPACE GAS ($C_1 - C_4$) HYDROCARBONS

COMPANY : CONOCO NORWAY WELL : 16/8-1 LOCATION : NORWEGIAN NORTH SEA

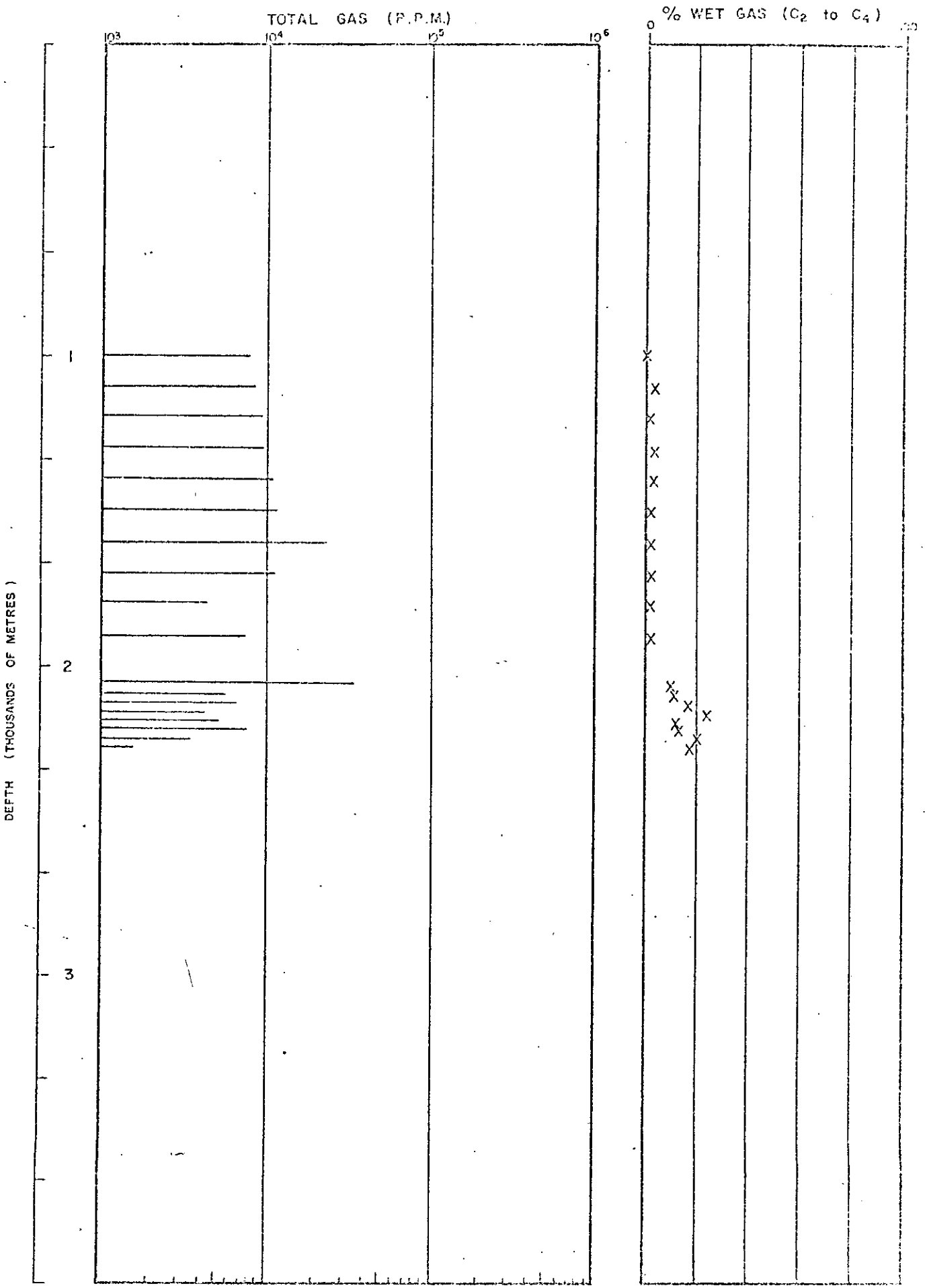


FIGURE 2

VITRINITE REFLECTIVITY AGAINST DEPTH

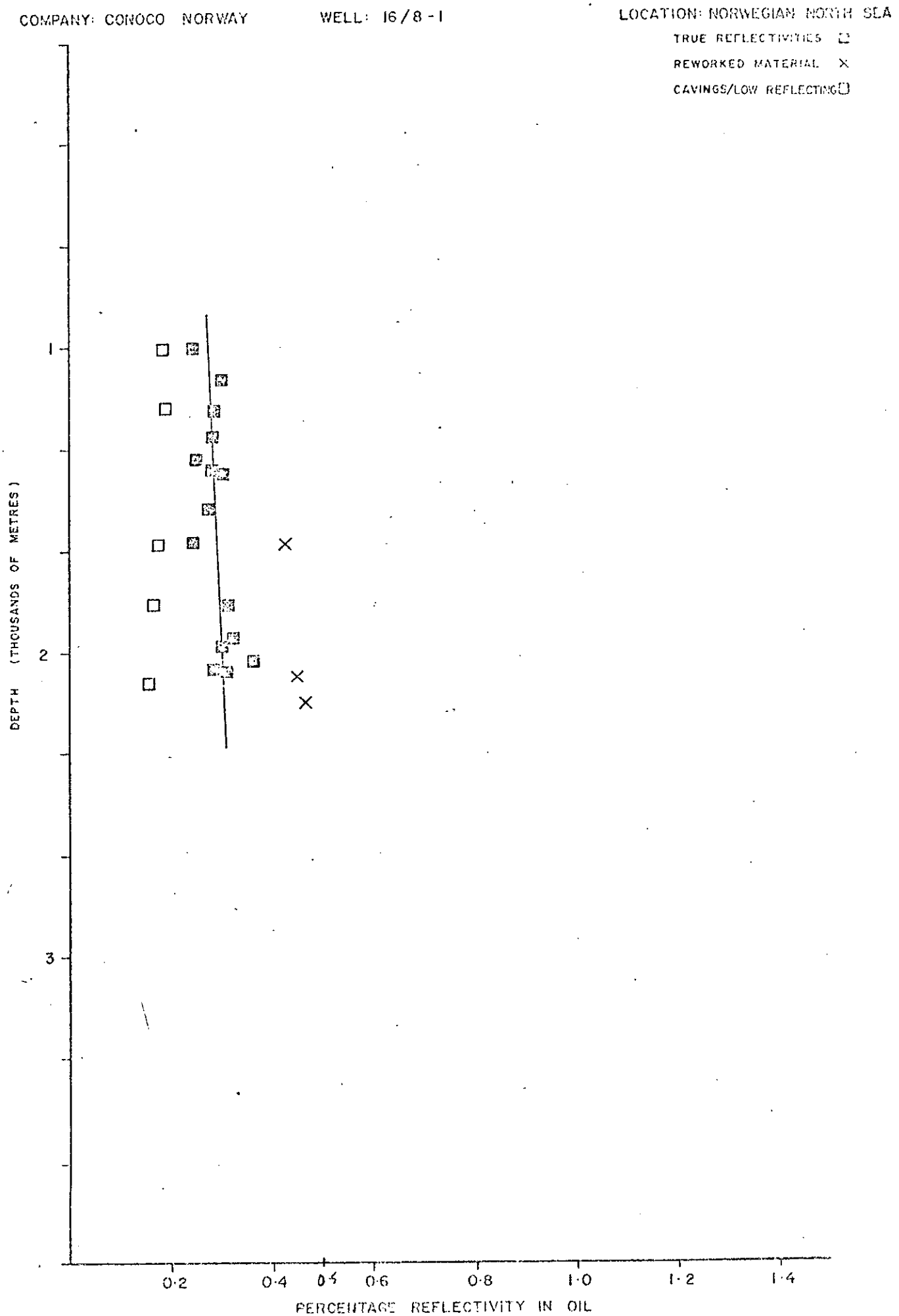


FIGURE 3

MATURATION INDICES AGAINST DEPTH

COMPANY : CONOCO NORWAY WELL : 16/8-1 LOCATION : NORWEGIAN NORTH SEA

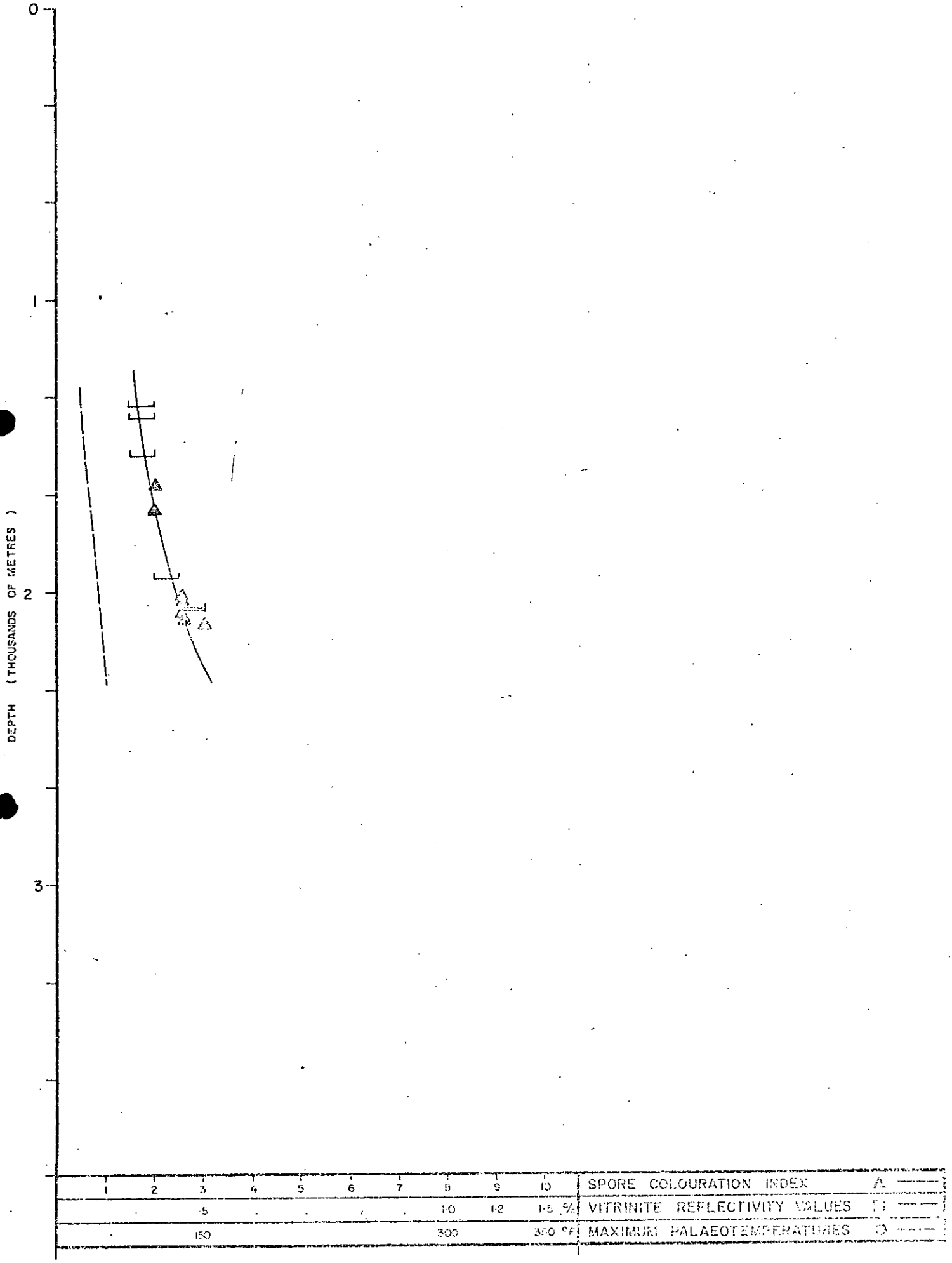


FIGURE 4

TYPE OF HYDROCARBON PRODUCT FROM SOURCE ROCKS

COMPANY : CONOCO NORWAY WELL : 16/8-1 LOCATION : NORWEGIAN NORTH SEA

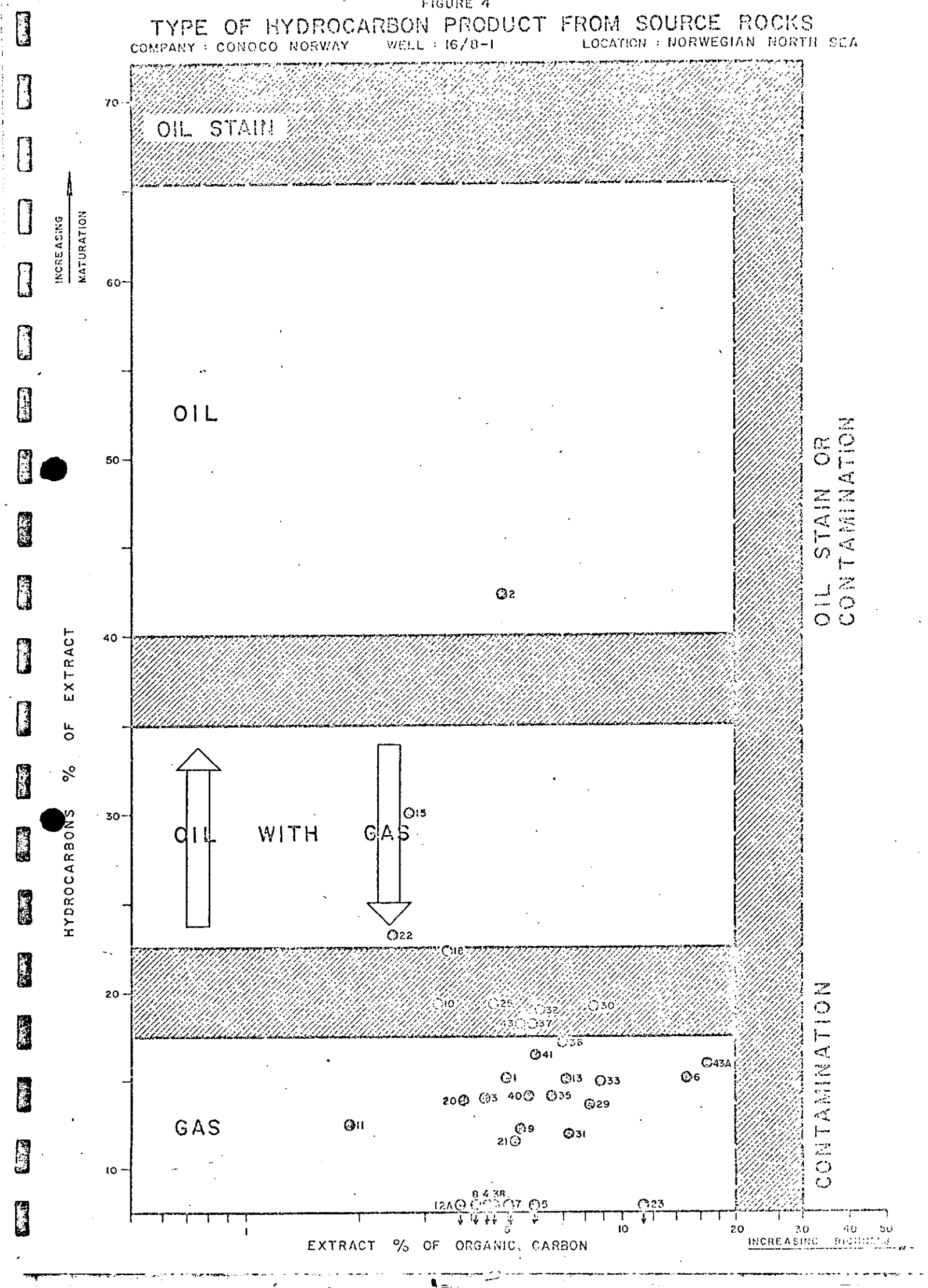
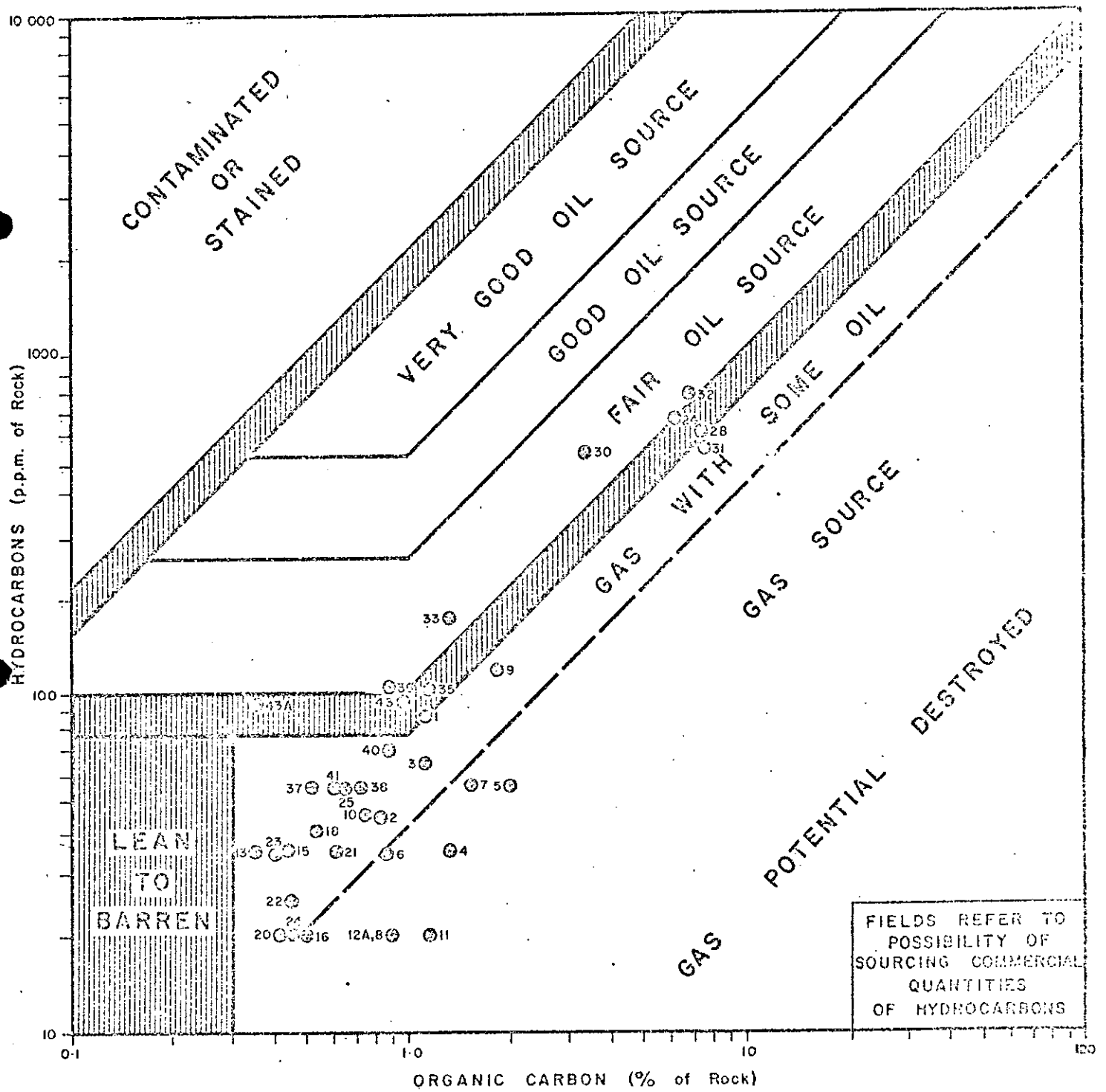


FIGURE 5

MATURE SOURCE ROCK RICHNESS

COMPANY : CONOCO NORWAY WELL : 16/8-1 LOCATION : NORWEGIAN NORTH SEA



SOURCE ROCK SUMMARY CHART

COMPANY : CONOCO NORWAY WELL : 16/8-1 LOCATION : NORWEGIAN NORTH SEA

DEPTH (Thousands of metres)

LITHOLOGY

Green-grey and brown shales and mudstones

Lt-med gy calc sh/mdst

Dk gy sh

Red-brn and gy calc sh/sltst

ORGANIC CARBON % OF ROCK

0·1 0·3 0·5 0·75 1·0 2·5 5·0 10·0

HYDROCARBONS PPM OF ROCK

50 100 250 500 1000 2500

EXTRACT % OF ORGANIC CARBON

1 2·5 5 10 20 30 50

OIL RICHNESS

Poor Fair Good Very good Oil stain

SAMPLE NUMBER

1 2 3 4 5 6 7 8 9 10 11 13 15 16 18 20 21 22 23 25 30 29 31 32 33 35 36 37 38 40 41 43 43A

LIKELY PRODUCT

Gas | Gas & oil | Oil & gas | Oil

PROSPECTIVE SECTIONS

EXINITE FLUORESCENCE

y Y y y Y

I M M A T U R E

TRANSITIONALLY MATURE

	Lean	Fair	Aver.	Above average	Lean	Average	Above average	Gas-prone ⟷ Oil-prone	Contamin.	Good gas source ✳	Lithology symbols	IMMATURE	MATURE	OIL PHASE-OUT	ORGANIC METAMORPHISM

EXINITE FLUORESCENCE — Abundant exinite content R; Moderate exinite content b — Orange-brown O, o — Orange — Y, y — Yellow — G, g — Yellow-green — No observed fluorescence X

Drawing No. 068P/2424/3716

FIGURE 6

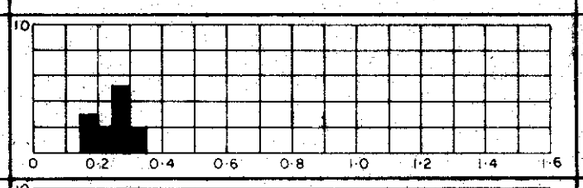
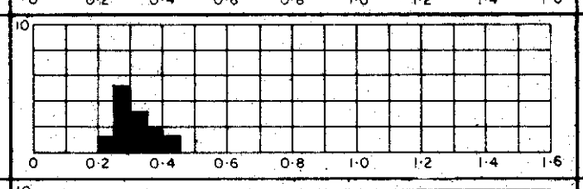
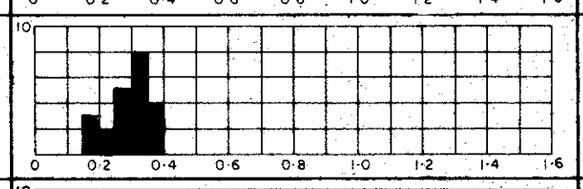
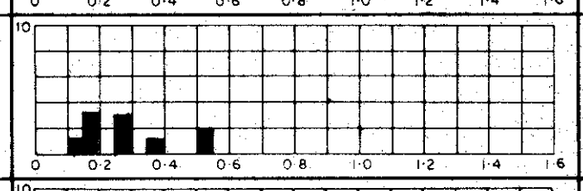
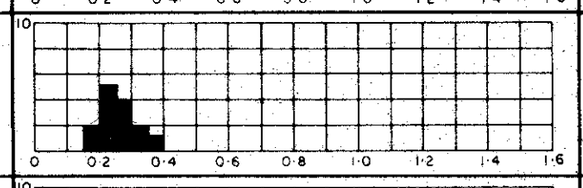
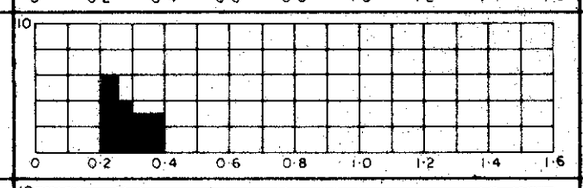
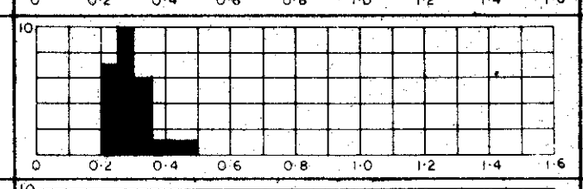
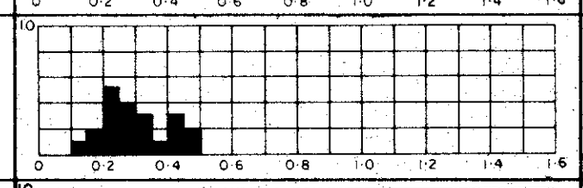
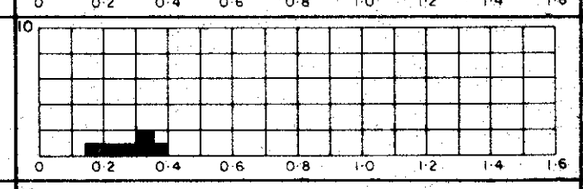
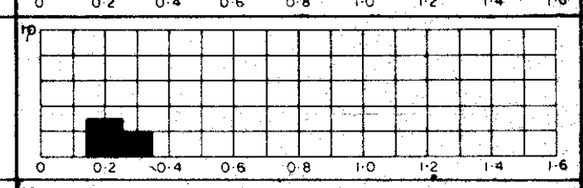
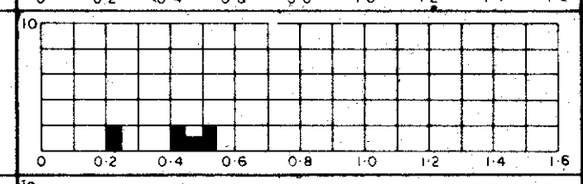
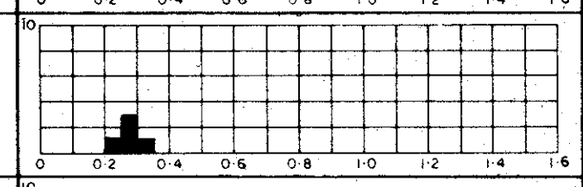
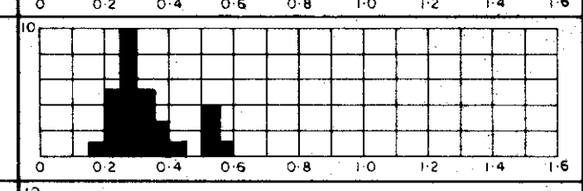
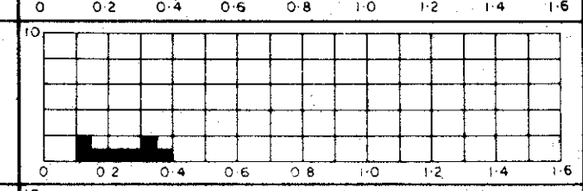
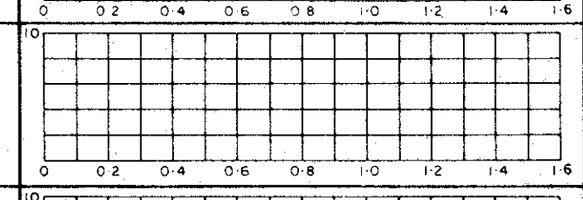
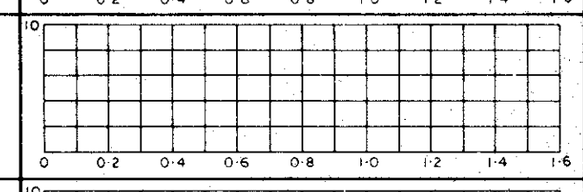
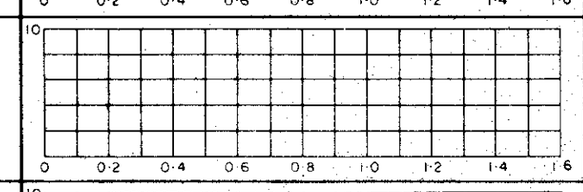
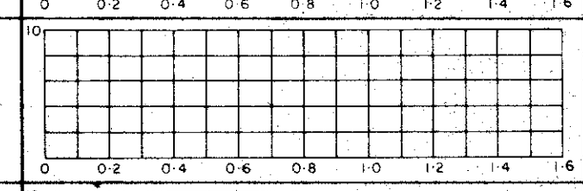
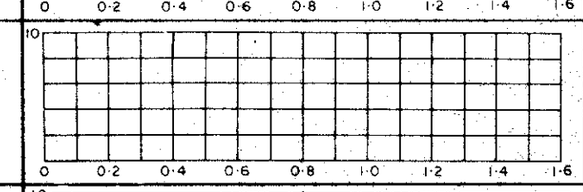
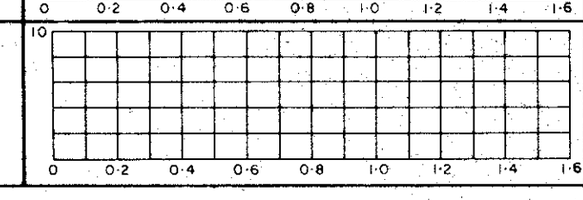
APPENDIX I

ABBREVIATIONS USED IN ANALYTICAL DATA SHEETS

Alg	–	Algae	Mtl	–	Mottled
Aren	–	Arenaceous	Musc	–	Muscovite
Arg	–	Argillaceous	NS	–	No sample
Bit	–	Bitumen/bituminous	Occ	–	Occasional
Bl	–	Blue	Ol	–	Olive
Blk	–	Black	Ool	–	Oolite/oolitic
Brn	–	Brown	Orng	–	Orange
Calc	–	Calcareous	Pnk	–	Pink
Carb	–	Carbonaceous	Pop	–	Population
Chk	–	Chalk	Pp	–	Purple
Cht	–	Chert	Pyr	–	Pyrite/pyritic
Cgl	–	Conglomerate	Qtz	–	Quartz
Cly	–	Clay	Ref	–	Reflectivity
CMT	–	Cement	Sap	–	Sapropel
Crs	–	Coarse	Sft	–	Soft
Ctgs	–	Ditch cuttings	Sh	–	Shale
Dk	–	Dark	Shly	–	Shaly
Dol	–	Dolomite	Sil	–	Siliceous
F	–	Fine	Slt	–	Silt
Fer	–	Ferruginous	Sltst	–	Siltstone
Flu	–	Fluorescence	Slty	–	Silty
Fm	–	Formation	Snd	–	Sand
Foram	–	Foraminifera	Sndy	–	Sandy
Fr	–	Friable	Sst	–	Sandstone
Frags	–	Fragments	SWC	–	Sidewall core
Glc	–	Glauconite	Tr	–	Trace
Gn	–	Green	V	–	Very
Gy	–	Grey	Vgt	–	Variegated
Gyp	–	Gypsum	Vit	–	Vitrinite
Hd	–	Hard	Wht	–	White
Inert	–	Inertinite	Yel	–	Yellow
Lam	–	Laminae/laminated	–	–	Sample not analysed
LCM	–	Lost circulation material	*	–	No results obtained
Lig	–	Lignite/lignitic	Gy-gn	–	Greyish green
Lst	–	Limestone	Gn/gy	–	Green to/and grey
Lt	–	Light	Gn-gy	–	Greenish grey
Mdst	–	Mudstone			
Med	–	Medium			
Mic	–	Micaceous			
Mnl	–	Mineral			
Mnr	–	Minor			

VITRINITE REFLECTIVITY DATA SUMMARY CHART

MULTI CLIENT REPORT CONOCO NORWAY WELL 16/8-1 LOCATION: NORWEGIAN NORTH SEA

DEPTH (FEET)	LITHOLOGY & MINERALOGY	TYPE OF ORGANIC MATTER	HISTOGRAM SHOWING REFLECTIVITY VALUES/NO. OF MEASUREMENTS	R (av) (%)	NO OF PARTIC-LES	FLUORESCENCE IN BLUE LIGHT
1000-100 Ctgs	Microcrystalline limestone with pyrite. White shale (barren) Orange and black shaly siltstone.	Occasional vitrinite and inertinite		0.18 0.29	5 7	Pale yellow spores and dinoflagellates Some yellow mineral fluorescence
1100-200 Ctgs	White siltstone with rare vitrinite and occasional semifusinite White shale with occasional vitrinite.	Vitrinite and semifusinite Telinite at 0.36% Ro.		0.30	12	Moderate quantities of yellow and yellow-orange spores.
1200-300 Ctgs	Light grey and yellow shale with occasional vitrinite and rarer semifusinite. Framboidal pyrite.	Some low reflecting vitrinite at ca. 0.2% Ro Good vitrinite at ca 0.35 Ro.		0.19 0.30	5 17	Fairly abundant yellow and yellow-orange spores.
1300-400 Ctgs	Cream and cream-pink shale Occasional barren fine-grained limestone. Some barren calcareous shale	Vitrinite in cream-pink shale at ca 0.3% Ro Semifusinite at ca 0.5% Ro. Low-reflecting vitrinite at ca 0.15% Ro.		0.16 0.28	4 3	No definite organic fluorescence Occasional yellow algal fragments.
1369.5 SWC	Kerogen	Small corroded vitrinite particles with Ro. ca 0.3% Ro.		0.25	14	Fairly abundant bright yellow spores
1400-500 Ctgs	Cream and orange shale with good vitrinite. Occasional siltstone and sandstone. Good sample.	Abundant telinite and collinite		0.28	16	No organic fluorescence
1545 SWC	Kerogen	Rate vitrinite - Ro ca 0.3% Semifusinite at Ro ca 0.45%		0.27	24	Yellow spores and algae General dull brown background fluorescen ce - possibly sapropel.
1647.3 SWC	Kerogen	Low-reflecting vitrinite at ca 0.15% Ro Good vitrinite at ca 0.25% tp 0.3% Ro		0.17 0.27 0.42	4 11 6	Fair to moderate content of yellow and yellow-orange spores
1847.3 SWC	Kerogen	Abundant organic matter almost wholly semifusinite at ca 0.9% Ro.		0.16 0.31	1 3	Rare yellow spores and resins
2065 SWC	Kerogen	Rare organic matter Good vitrinite at ca 0.3%		0.19 0.31	6 4	Abundant yellow-green, yellow and yellow-orange spores. Possible yellow algae.
2074.5 SWC	Kerogen	Low reflecting vitrinite at ca 0.15% Ro. Exinitic material predominant.		0.46	5	Abundant yellow spores and algae.
2060-090 Ctgs	Brown pyrite shale with strong brown stains and spore outlines	Occasional resin and semifusinite Some low-reflecting vitrinite		0.28	5	Abundant pale yellow resin and spores.
2060-090 Ctgs	Kerogen	Good telinite at 0.27% - 0.32% Ro Semifusinite at ca 0.5% Ro		0.28	24	Abundant yellow and yellow-orange spores and algae
2090-120 Ctgs	Varicoloured shales - pyritic with large carbonaceous streaks Ro. ca 0.15% Poor sample.	Occasional inertinite. rare vitrinite		0.15 0.19	3 5	Abundant yellow resin, yellow algae and yellow to yellow-green spores
						
						
						
						
						
						

REF: RRI, 767, 2424, IID DRAWING NO: 068P, 2424, 3741 DATE: March, 1977