C. Casing: 30" at 145.4m (-119.2 m.)
20" at 273.8m (-244.6m.)
13⅜" at 1063 m. (-1037 m.)
9 5/8" at 2963 m. (-2937m.)

D. Mud Programme: Initial drilling from the sea floor to 277 m. was with sea water and gel without casing. Returns were to the sea floor. Below 277 m. to approximately 2290 m., a sea water slurry with Spersene, XP-20 and 0-12% diesel oil was used. At 2284 m. the major salt section was topped and the drilling fluid converted to a salt saturated mud.

While pulling out of the hole to pick up a core barrel at a depth of 2961 m. the pipe struck at 1660 m. and was pumped free with sea water. The hole began caving immediately. Stable hole conditions were eventually attained by raising the mud weight to 12 ppg., viscosity to 150, dropping the pH and FL, adding diesel oil to 12% and increasing the pump rate. Casing was set at 2963 m. and no further hole trouble occurred. From 2290 m to 3015 m. the drilling mud was essentially a salt saturated mud with Spersene, XP-20, and 6-12% diesel oil.

ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO. 9(9A to 9H)

Project No. RRPS/789/B/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL AND BIOSTRATIGRAPHIC STUDIES OF EIGHT WELLS

NOVEMBER, 1978

Prepared by:

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Petroleum Geochemical Preliminary Reports

Biostratigraphic Preliminary Report

ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO. 9A

Project no. RRPS/789/B/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES OF THE AMOCO NORWAY 7/1-1 WELL

NOVEMBER, 1978

I

INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Amoco Norway 7/1-1 well. The samples were received at varying intervals and were selected for analysis by compositing at 60 feet intervals dependent on sample availability and lithological data. After compositing, samples were washed with cold water as necessary to remove drilling mud, and air dried at 50°C.

No drilling information or logs have been available for assistance in analysing this well, although we have had a preliminary biostratigraphic breakdown of the well (Report No. 8L) for interpretational purposes. The samples were of good quality for geochemical analysis and no significant drilling contamination seems to have occurred. Compositing was started at 2790

feet so that representative material below the mid-Miocene unconformity has been analysed down to 9100 feet in the Triassic(?).

The analytical procedures used include organic carbon analysis on all the bulk cuttings samples at 60 feet intervals and also on individual lithologies where bulk samples consisted of more than one lithotype. Extractive source rock analysis has been carried out on samples containing more than 0.5% organic carbon at approximately 250 feet intervals. Gas chromatographic analysis has been carried out on alkane fractions from samples containing greater than 100 ppm of hydrocarbons. Pyrolysis source rock evaluation using the IFP/Fina ROCK-EVAL apparatus has been carried out on the same samples as used for extractive analysis, on samples where insufficient material was available for extractive analysis and also on samples of picked lithologies where composite samples contained more than one significant lithotype. Kerogen composition has been assessed on a semiquantitative basis by visual estimation of the kerogen components in unsieved, unoxidised, palynological preparations.

Maturity levels have been assessed in this study using principally spore colouration analysis on sieved unoxidised palynological preparations and vitrinite reflectivity on kerogen concentrates. In assessing maturity level, reference may also be made to the temperatures of maximum pyrolysis rate which give useful indications of maturity level when used in conjunction with the kerogen type.

II

RESULTS AND INTERPRETATION

The results of the various analyses carried out on the 7/1-1 well are

presented in Tables 1 to 3 and are represented graphically in Figures 1 to 4. Table 1 lists data on maturity level in the section along with the kerogen composition data for the same samples. The spore colouration and vitrinite reflectivity trends with depth are shown in Figures 1 and 2 respectively. Table 2 lists the organic carbon and extractive source rock evaluation data. Pyrolysis data are presented in Table 3 and represented graphically against depth in Figures 3 and 4. A detailed graphic compilation of all the data will be presented later in the compilation report.

MATURITY DATA

Our assessment of the spore colouration data is that the Lower Tertiary sediments in the analysed interval are immature and no significant hydrocarbon generation is anticipated. No spore colour data have been obtained in the Lower Cretaceous interval, but it is anticipated that the Lower Cretaceous sediments will be at an early stage of maturity.

Vitrinite reflectivity data give a trend rising from about 0.30% at 4000 feet to about 0.40% at the base of the Tertiary. On this basis the Tertiary section is probably immature for liquid hydrocarbon generation. The reflectivity level in the Lower Cretaceous has not been determined.

HYDROCARBON SOURCE POTENTIAL DATA

On the basis of the geochemical data obtained, the following breakdown of the analysed interval of the 7/1-1 well is made;

Interval 2790 to 6500 feet - Interval is represented by variously coloured medium-dark grey, dark grey and olive-grey shales and mudstones with fairly well above average organic carbon contents (typically 3% to 4% although some samples contain up to 6% carbon).

Kerogen composition is humic and is predominantly vitrinitic below 4000 feet. Pyrolysis source rock evaluation confirms the strongly vitrinitic composition for the interval and at optimum maturity these source rocks would be prolific gas sources. Production indices suggest a significant amount of migrant hydrocarbon is present in this interval,as has been confirmed by extractive source rock analysis and gas chromatography of the alkanes from samples at around 4000 feet.

This interval is presently immature and will source only gas at optimum maturity.

Interval 6520 to 7460 feet - This interval represented mostly by green-grey shales, has average organic carbon content. Kerogen composition is again predominantly vitrinitic and the sediments will be fair gas sources at optimum maturity. There is some evidence of migrant hydrocarbon in this interval.

This interval presently has no source potential and will source gas at optimum maturity.

Interval 7460 to 8530 feet - Predominantly white chalk.

No hydrocarbon generating potential.

Interval 8530 to 8660 feet	-	This interval is believed to be of Upper/Lower Cretaceous age and to be represented by medium-dark grey shale. The carbon content is below average and the organic matter is inertinitic on the basis of the pyrolysis data. No hydrocarbon generating potential.
Interval below 8660 feet	-	This interval consists of grey-red chalk/ marl with lesser amounts of grey-red and green-grey shales, siltstones and sandstones which is believed to represent a condensed sequence of Barremian - Neocomian possibly overlying a thin ?late Jurassic shale overlying Triassic Red Beds. In the samples analysed, various lithologies have been picked, but none has proved to be of significance as potential hydrocarbon source rocks. The presence of Jurassic "Hot" shale has not been proved.

TABLE 1 MATURITY EVALUATION DATA

WELL: 7/1-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET)	SAMPLE TYPE	GENERALISED LITHOLOGY	SPORE COLOUR INDEX (1 - 10)	VITRINITE REFLECTIVITY IN OIL, R av%	KEROGEN COMPOSITION (%)		
					INERTINITE	VITRINITE	SAPROPEL
2790-850	Ctgs	Med-dk gy sh	1.5-2	-	90	10	*
3150-210	"	Ol-gy sh	1.5-2	-	80	20	*
3960-4020	"	Dk gy sh	2	0.29(22)	5	95	*
4320-380	"	Ditto	-	0.32(22)	-	-	-
4770-830	"	Med-dk gy sh	2	0.30 (8)	10	90	*
5480-540	"	Ol-gy mic sh	2.5	0.33(13)	10	90	*
5800-860	"	Ditto	-	0.40(24)	-	-	-
6120-180	"	Ditto	2.5-3	0.37 (9)	5	95	*
6440-500	"	Med-dk gy sh	-	0.43(27)	-	-	-
6760-820	"	Gn-gy sh	3	-	10	90	*
7000-060	"	Ditto	3	0.40 (5)	15	80	5
7300-360	"	Med gy/gn-gy sh +chk	3	0.40(14)	35	65	*

TABLE 2A

SOURCE ROCK EVALUATION DATA

WELL 7/1-1 LOCATION NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) 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 % HYDRO-CARBONS
2790-850	Ctgs	Med-dk gy sh+mnr ol-gy sl slty sh	1.73					
2970-3030	"	Ol-gy sl slty sh+mnr snd/slt	2.68					
3150-210	"	Ditto+ditto	2.49					
3330-390	"	Ditto+ditto	3.13					
3420-480	"	Ditto+ditto+mnr med gy sh	2.00					
3600-660	"	Ditto+ditto+mnr dk gy sh	3.55					
3690-750	"	Ol-gy/med-dk gy sl slty sh+occ glauc	3.84					
3780-840	"	Med-dk gy sl slty sh+ mnr ol-gy slty sh+ mnr brn-gy sh	3.34					
3870-930	"	Ditto+ditto	3.99	3650	9.1	125	4	92
3960-4020	"	Dk gy sl slty sh	5.00					
4050-110	"	Ditto	5.48					
4140-200	"	Ditto	6.04	6280	10.4	120	2	>95
4230-290	"	Ditto	5.57					
4320-380	"	Ditto	5.42					
4410-470	"	Ditto	4.30					
4500-560	"	Ditto	4.40					
4590-650	"	Ditto	4.82					
4680-740	"	Ditto	5.30					
4770-830	"	Med-dk gy slty sh+ mnr slt	3.87					
4860-920	"	Ditto	3.63					
4950-5010	"	Ditto	3.11					
5040-130	"	Ditto	2.83					
5160-220	"	Ditto	2.61					
5250-300	"	Ditto	2.78					
5320-380	"	Ditto	2.95					
5400-460	"	Ol-gy mic sl slty sh+ mnr dk gy sh	3.04					
5480-540	"	Ditto+ditto	2.56					
5560-620	"	Ditto+ditto	3.54					
5640-700	"	Ditto+ditto	3.53					

TABLE 2B

SOURCE ROCK EVALUATION DATA

WELL: 7/1-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) 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
5720-780	Ctgs	Ol-gy mic sl slty sh+ 20% dk gy mic sh	5.67					
5800-860	"	Ditto+ditto	4.79					
5880-940	"	Ditto+ditto	4.84					
5960-6020	"	Ditto+ditto	4.55					
6040-100	"	Ditto+ditto	4.61					
6120-180	"	Ditto+mnr med-dk gy sl slty sh	3.38					
6200-260	"	Med-dk gy sl slty sh+ mnr lt ol-gy sh	3.23					
6280-340	"	Ditto+40% ditto	4.73					
6360-420	"	Ditto+50% ditto	4.80					
6440-500	"	Ditto+40% ditto	3.28					
6520-580	"	Gn-gy sh+mnr lt ol-gy /med gy/ dk gy sh	1.85					
6600-660	"	Ditto	1.52					
6680-740	"	Ditto	1.56					
6760-820	"	Ditto	1.29					
6840-900	"	Ditto	1.77					
6920-980	"	Ditto	1.92					
7000-060	"	Ditto	2.21					
7080-140	"	Ditto	1.27					
7160-220	"	Gn-gy sl+mnr ol-gy/ med-dk gy/gy-red sh	0.96					
7240-280	"	Ditto+ditto	1.24					
7300-360	"	Med gy/gn-gy sh+30% wht chk	0.98					
7400-460	"	Ditto+40% ditto	1.25					
		CHALK						
8530-590	"	Med-dk gy sh+60% wht chk	0.83					
8640-660	"	Gy-red chk/marl+mnr med-dk gy sh	0.74					
		PICKED LITHOLOGIES						
3420-480	"	Ol-gy slty sh	2.41					
3420-480	"	Med gy sh	5.82					
3600-660	"	Ol-gy slty sh	4.18					

TABLE 3A

ROCK - EVAL. PYROLYSIS DATA

WELL: 7/1-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
2790-850	Med-dk gy sh	1.73	*	*	72	*	*
3150-210	Ol-gy sh	2.49	426	161	22	0.04	4000
3330-390	Ditto	3.13	415	11	48	*	300
3600-660	Ditto	3.55	420	45	43	0.3	1600
3870-930	Med-dk gy sh	3.99	417	50	61	0.1	2000
4140-200	Dk gy sh	6.04	419	20	58	0.03	1200
4410-470	Ditto	4.30	425	67	53	0.3	2900
4680-740	Ditto	5.30	418	54	61	0.06	2900
4950-5010	Med-dk gy slty sh	3.11	423	69	63	0.1	2200
5250-300	Ditto	2.78	424	49	53	0.1	1400
5480-540	Ol-gy mic sh	2.56	421	51	93	0.3	1300
5720-780	Ditto	5.67	427	92	27	0.06	5200
5960-6020	Ditto	4.55	420	64	71	0.5	2900
6200-260	Med-dk gy sh	3.23	424	60	64	0.4	1900
6440-500	Ditto	3.28	425	59	38	0.3	2000
6520-580	Gn-gy sh	1.85	429	23	64	0.5	400
6760-820	Ditto	1.29	424	14	73	0.8	200
6840-900	Ditto	1.77	423	9	103	0.6	200
7000-060	Ditto	2.21	426	29	87	*	700
7080-140	Ditto	1.27	410	41	110	*	500
7240-280	Ditto	1.24	*	*	107	*	*
8530-590	Med-dk gy sh+60% chk	0.83	*	*	248	*	*
8640-660	Gy-red marl+mnr dk gy sh	0.74	*	*	161	*	*
	PICKED LITHOLOGIES						
3420-480	Lt ol-gy sh	2.41	*	*	81	*	*
3420-480	Med gy sh	5.82	428	3	22	0.8	200
3600-660	Dk gy sh	4.59	426	46	65	*	2100
3690-750	Ditto	4.58	432	10	48	*	500
3780-840	Brn-gy sh	3.85	435	99	23	*	3800
4050-110	Dk gy sh	5.82	433	66	209	0.08	3800
6200-260	Med-dk gy sh	4.65	435	153	65	0.2	7100
6200-260	Lt ol-gy sh	2.05	430	107	189	*	2200
6760-820	Med-dk gy sh	4.88	430	182	113	0.6	8900
6760-820	Lt ol-gy sh	0.75	*	*	505	*	*

TEMPERATURE (°C) = TEMPERATURE AT MAXIMUM RATE OF PYROLYSIS
PRODUCTION INDEX = AN ESTIMATE OF PRESENT HYDROCARBON GENERATING POTENTIAL COMPARED TO THAT AT OPTIMUM MATURITY
POTENTIAL YIELD = AN ESTIMATE OF HYDROCARBON PRODUCTION AT OPTIMUM MATURITY

TABLE 3B

ROCK - EVAL. PYROLYSIS DATA

WELL: 7/1-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
7400-460	Med gy sh	3.09	436	116	46	0.2	3600
8680-740	Med-dk gy sh	3.10	433	72	28	0.3	2200
8750-820	Gy-red sh	0.41	*	*	204	*	*
8830-890	Gy-red calc sh/ sltst	1.90	*	*	54	*	*
8830-890	Med-dk gy sh	0.88	435	266	173	0.2	2300
9040-100	Ditto	1.72	434	134	52	0.2	2300

TEMPERATURE (°C) = TEMPERATURE AT MAXIMUM RATE OF PYROLYSIS
PRODUCTION INDEX = AN ESTIMATE OF PRESENT HYDROCARBON GENERATING POTENTIAL COMPARED TO THAT AT OPTIMUM MATURITY
POTENTIAL YIELD = AN ESTIMATE OF HYDROCARBON PRODUCTION AT OPTIMUM MATURITY

FIGURE 1 SPORE COLOURATION INDICES AGAINST DEPTH

WELL: 7/1-1 LOCATION: NORWEGIAN NORTH SEA

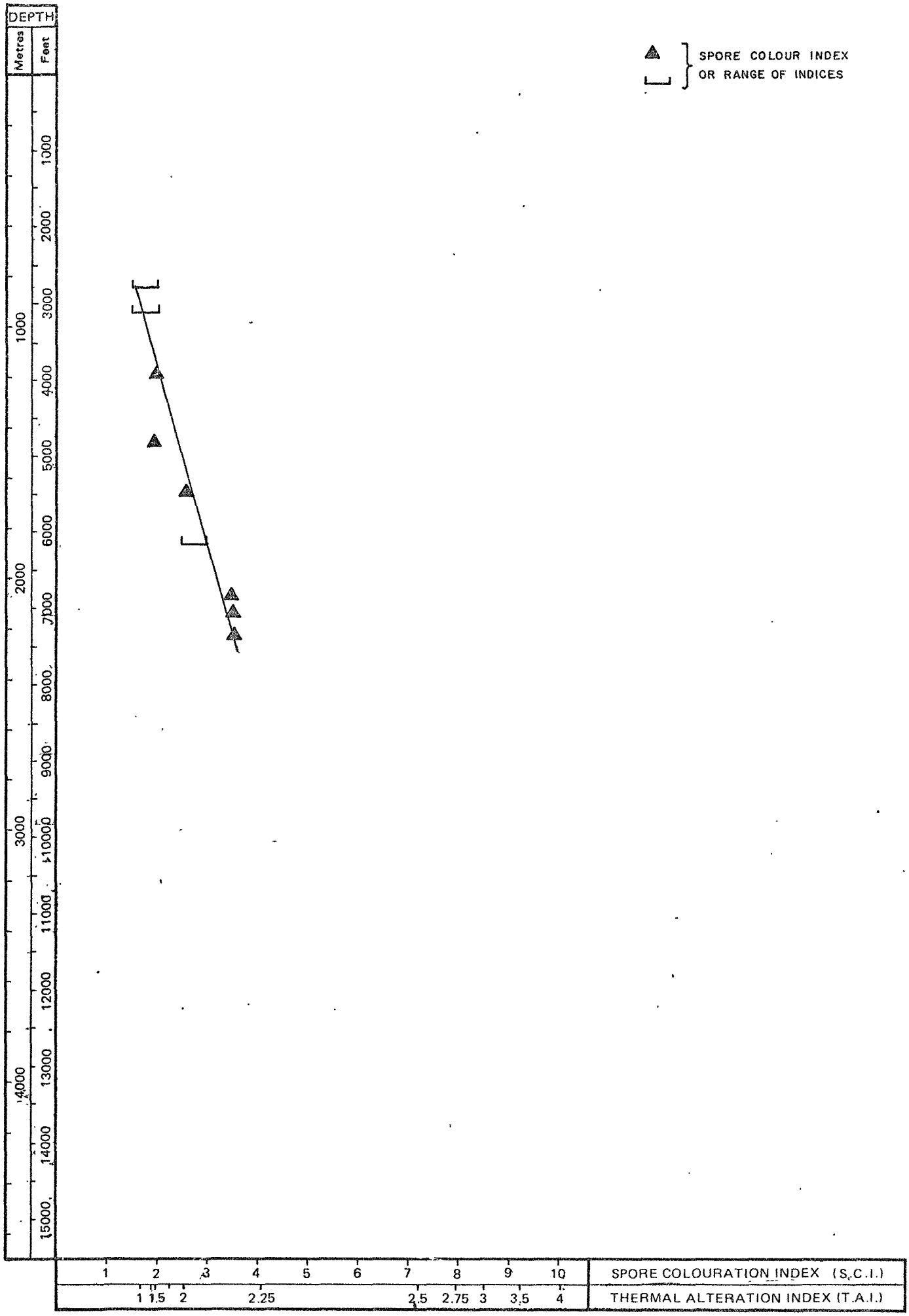


FIGURE 2 VITRINITE REFLECTIVITY AGAINST DEPTH

WELL: 7/1-1

LOCATION: NORWEGIAN NORTH SEA

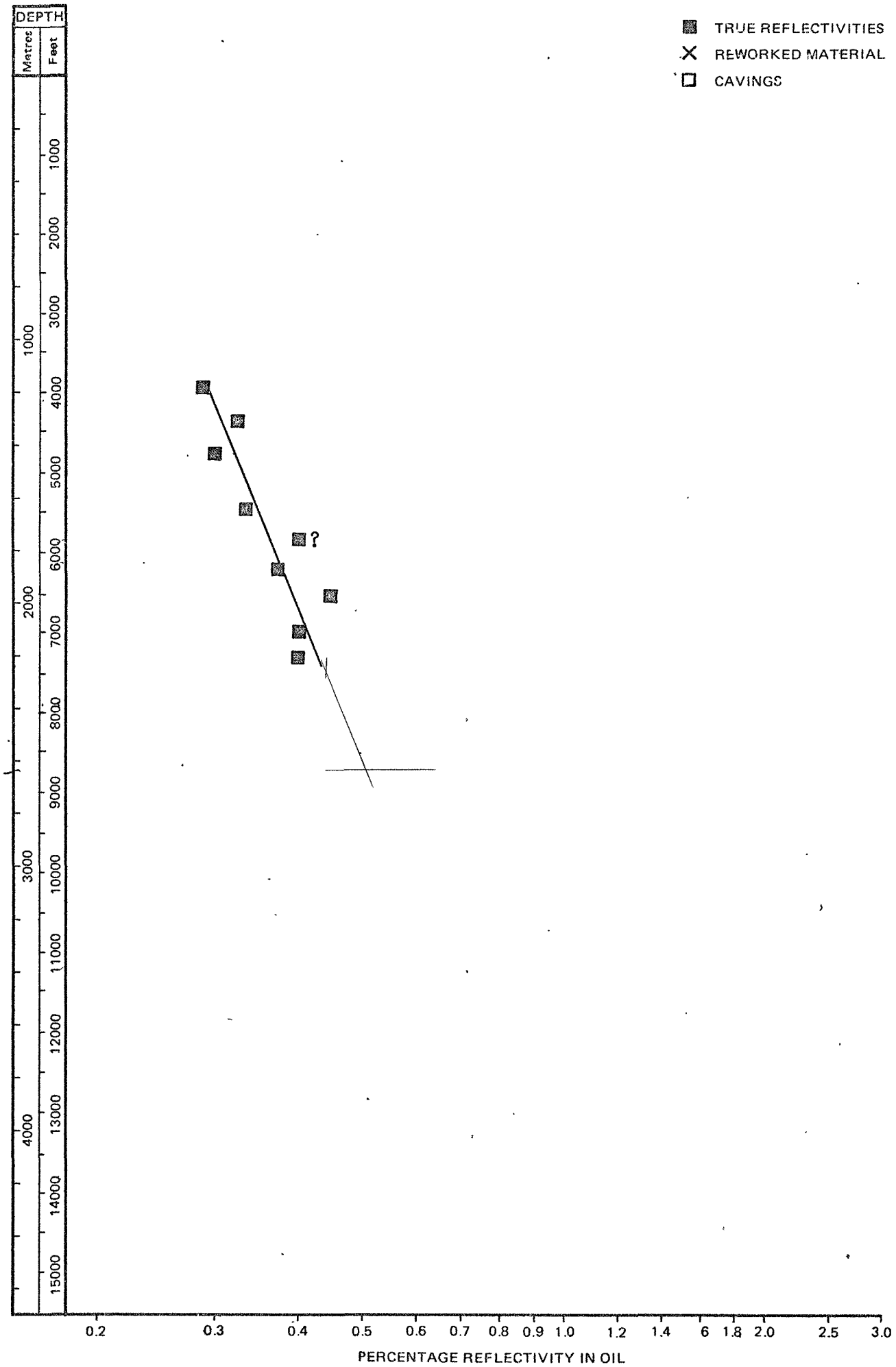


FIGURE 3 PYROLYSIS DATA SUMMARY CHART

WELL: 7/1-1 LOCATION: NORWEGIAN NORTH SEA

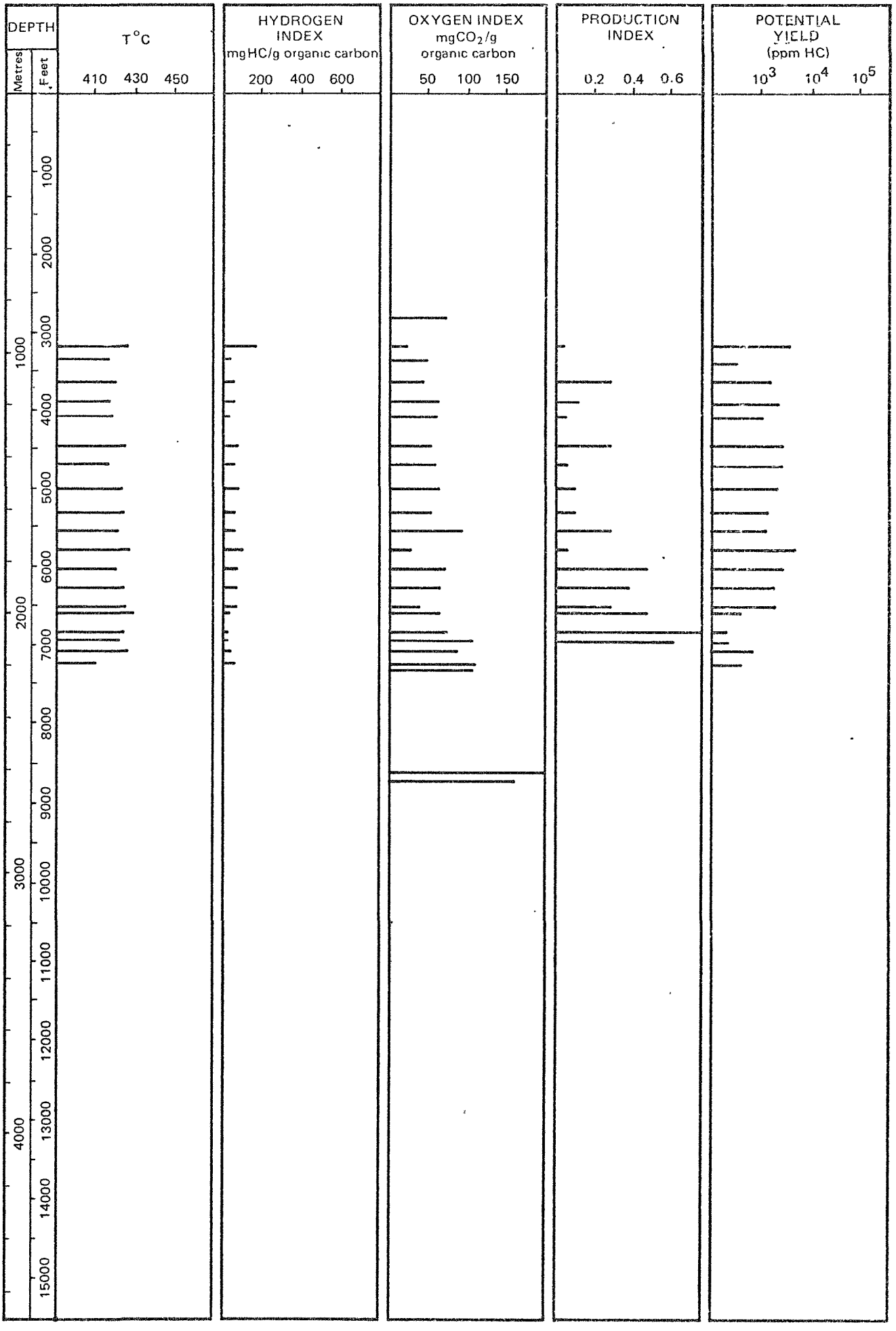
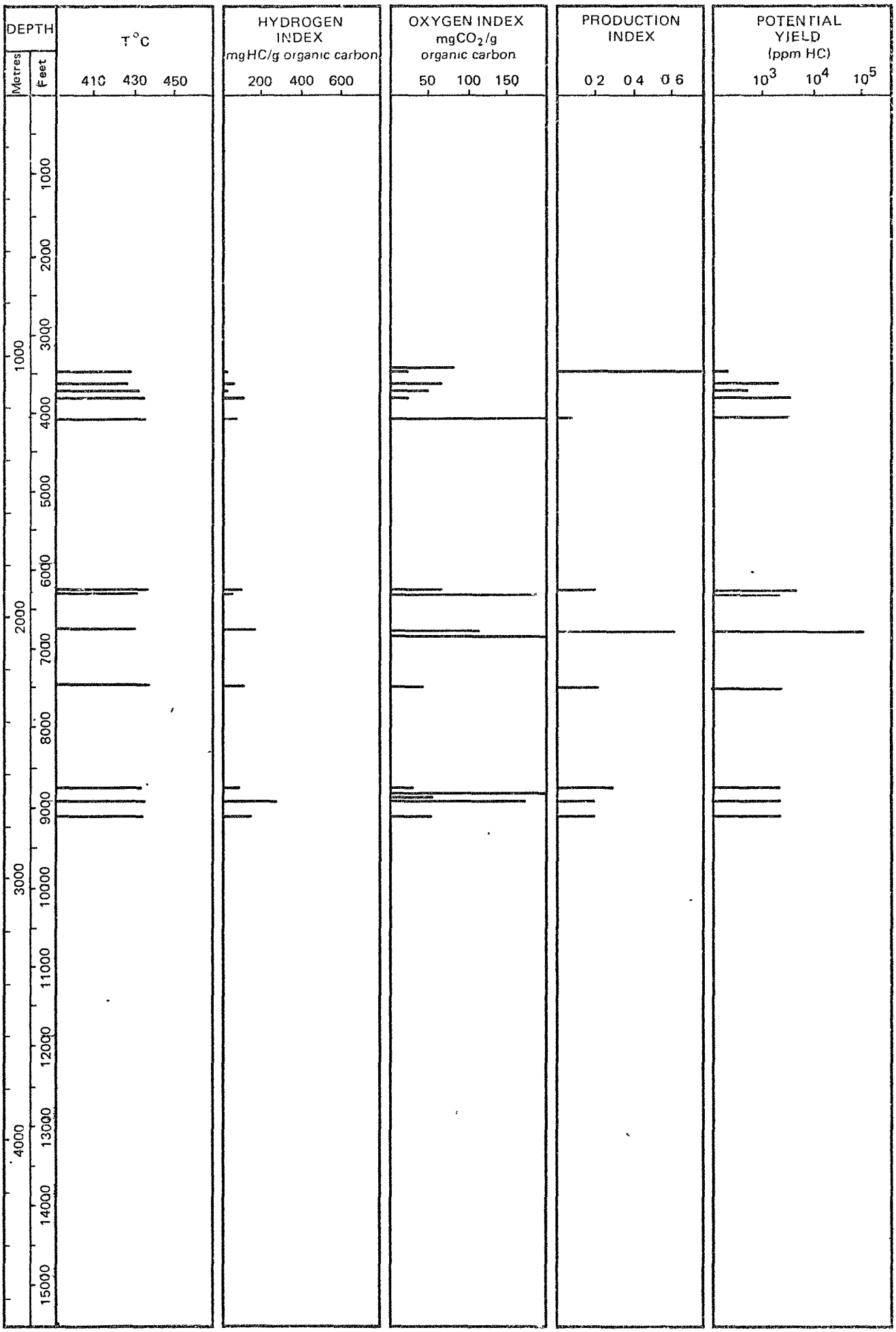


FIGURE 4 PYROLYSIS DATA SUMMARY CHART
PICKED LITHOLOGIES

WELL: 7/1-1 LOCATION: NORWEGIAN NORTH SEA



ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO.9B

Project No. RRPS/789/B/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES OF THE ESSO NORWAY 8/3-1 WELL

NOVEMBER, 1978

I

INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Esso Exploration Norway Inc. 8/3-1 well. Samples were received at variously 3 to 8 metre intervals and were composited at 20 metre intervals from 650 to 2252 metres, dependent on sample availability, lithological and log data. The composite samples were washed with cold water as necessary to remove drilling mud and air dried at 50°C.

Relevant information on drilling conditions and mud properties are included in N.P.D. Paper 1 and this information has been utilised in interpretation of the geochemical data obtained from the study.

The analytical procedures used include organic carbon analysis on most of

the bulk cuttings samples at 20 metre intervals and also on individual lithologies where bulk samples consisted of more than one lithotype. Extractive source rock analysis has been carried out on selected samples at varying intervals. Gas chromatographic analysis has not been carried out on alkane fractions in this section since no samples contained greater than 100 ppm of hydrocarbon. Pyrolysis source rock evaluation using the IFP/Fina ROCK-EVAL apparatus has been carried out on the same samples as used for extractive analysis, on samples where insufficient material was available for extractive analysis and on samples of picked lithologies where composite samples contained more than one significant lithotype. Kerogen composition has been assessed on a semiquantitative basis, by visual estimation of the kerogen components in unsieved, unoxidised, palynological preparations.

Maturity levels have been assessed in this study using principally spore colouration analysis on sieved, unoxidised, palynological preparations and vitrinite reflectivity on kerogen concentrates and on picked coal fragments. In assessing maturity level, reference may also be made to the temperatures of maximum pyrolysis rate which give useful indications of maturity level when used in conjunction with the kerogen type.

II

RESULTS AND INTERPRETATION

The results of the various analyses carried out on the 8/3-1 well are presented in Tables 1 to 3 and are represented graphically in Figures 1 to 3. Table 1 lists data on maturity level in the section along with the kerogen composition data for the same samples. The spore colouration and vitrinite

reflectivity trends with depth are shown in Figures 1 and 2 respectively. Table 2 lists the organic carbon and extractive source rock evaluation data. Pyrolysis data are presented in Table 3 and are represented graphically against depth in Figure 3. A detailed graphic presentation of all the data will be made later in the compilation report.

MATURITY DATA

Our assessment of the spore colouration data is that the analysed Tertiary interval of the well is presently immature. The Lower Cretaceous and Jurassic intervals of the well are at an early stage of maturity for generation of oil from oil-prone organic matter (see source rock evaluation). Oil-prone organic matter in the Jurassic interval would be anticipated to be capable of heavy (low ^{o}API gravity) oil generation.

Vitrinite reflectivity analysis has given data which rise from about 0.28% at 700 metres to about 0.42% at 2100 metres. These results indicate that the Tertiary interval is presently immature while the Lower Cretaceous and Jurassic interval is at an early stage of maturity.

HYDROCARBON SOURCE POTENTIAL DATA

On the basis of the geochemical data obtained, the following breakdown of the analysed interval of the 8/3-1 well is made:

Interval 650 to 1035 metres - Mostly olive-grey mudstones, variously silty and micaceous at the top of this interval and being mostly medium grey below 950 metres.

Organic carbon contents are mostly about average, although the Oligocene interval tends to be organically richer at 2% to 3%. Kerogen composition is humic, mostly vitrinite, in this interval. Pyrolysis data

confirm this composition.

No present hydrocarbon generating ability.

Poor to fair gas source at optimum maturity.

Interval 1035 to 1330 metres - Chalk.

No hydrocarbon generating potential.

No trace of migrated hydrocarbons at the top of the chalk.

Interval 1330 to 1450 metres - Olive-grey mudstone with below average content of inertinitic organic matter.

No present or future hydrocarbon generating potential.

Interval 1450 to 1800 metres - No samples available.

Interval 1800 to 2040 metres - This interval of supposedly Upper Jurassic age is represented by a rather uniform sequence of indurated medium-dark grey slightly micaceous shales. A marked change in gamma log response between 1855 and 1980 metres corresponds to the "Hot" shale, but this change is not so well illustrated in the geochemical data.

Organic carbon content in this interval is a little above average at around 2.5% down to 1860 metres and around 3% to 5% below this depth. The kerogen composition is predominantly sapropel in this interval

with subordinate inertinite. Pyrolysis parameters suggest appreciable oil generating potential, but it appears that sapropel is subordinate to inertinite. The organically richest sample at 1960-980 metres, which gave the highest hydrocarbon yield and hydrogen index (and gamma ray log response), is rated a fair to good oil source at optimum maturity.

No significant amounts of solvent extractable hydrocarbons were observed in the samples analysed.

This interval contains potentially fair to good oil prone source rocks. They presently have little or no hydrocarbon generating potential on-structure.

Interval 2040 to 2252 metres - Lithologically this interval comprises variegated and mottled, coarse through fine sandstones and siltstones with dark grey and medium-dark grey silty shales, light grey limestones and coals. Cuttings samples in this interval were of rather poor quality and few detailed analyses were carried out. Pyrolysis analyses suggest that organic matter in the Middle Jurassic(?) section is humic (vitrinite) with no liquid hydrocarbon generating potential. Kerogen

composition data, however, indicate a more sapropelic composition which may be a result of Upper Jurassic caving.

On balance it is considered that the argillaceous and coaly horizons in this interval have no present potential and will probably source minor quantities of gas at optimum maturity.

TABLE 1 MATURITY EVALUATION DATA

WELL: 8/3-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (METRES)	SAMPLE TYPE	GENERALISED LITHOLOGY	SPORE COLOUR INDEX (1 - 10)	VITRINITE REFLECTIVITY IN OIL, R av%	KEROGEN COMPOSITION (%)		
					INERTINITE	VITRINITE	SAPROPEL
668-690	Ctgs	Ol-gy slty mic mdst	2.5-3	0.22 (8)	30	70	*
790-810	"	Ol-gy mdst+30% med-dk gy mdst+ 30% gn-gy mdst	3	0.21 (5); 0.29 (4)	30	70	-
1015-035	"	Med gy mdst+40% gn-gy mdst	3-3.5	0.31 (7)	30	70	*
1310-330	"	Chk+40% gn-gy/ med gy mdst	3.5	-	60	40	*
1410-430	"	Ol-gy mdst	4	0.38 (5)	100	*	*
1800-820	"	Med-dk gy mic sh	4	0.35 (8)	20	10	70
1860-880	"	Ditto	-	0.35 (3)	-	-	-
1920-940	"	Ditto	4-4.5	0.38 (3)	20	10	70
1980-2000	"	Ditto	4.5	0.43 (2)	30	*	70
2020-040	"	Ditto	4-4.5	-	20	10	70
2040-060	"	Snd/sst+10% med-dk gy sh+tr coal	-	0.39(10)	-	-	-
2090-110	"	Dk gy mic sh+tr coal	4-4.5	0.45(20)	20	10	70
2160-180	"	Med-dk gy sh	4.5	0.38 (5)	20	10	70
2240-252	"	Lt gy lst+mnr gy sh	4.5-5	-	5	5	90?

TABLE 2A

SOURCE ROCK EVALUATION DATA

WELL 8/3-1 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 % HYDRO CARBONS
668-690	Ctgs	Ol-gy slty mic mdst+ mnr med-dk gy mdst+ mnr gn-gy mdst	1.61					
790-810	"	Ol-gy mdst+30% ditto+ 30% ditto	2.94					
810-825	"	Ditto+30% ditto+30% ditto	2.62	975	3.7	25	3	>95
835-855	"	Ditto+30% ditto+30% ditto	2.01					
895-915	"	Ol-gy/gn-gy sl slty calc mdst+mnr med-dk gy mdst	1.59					
955-975	"	Med gy mdst+40% gn-gy mdst+mnr lstn/slt	1.33	435	3.2	<20	1	86
995-1015	"	Ditto+ditto	1.41					
1015-035	"	Ditto+ditto	0.84					
1035-055	"	Wht/lt gy chk+40% gn-gy/med gy mic slty mdst	0.73	330	4.5	<20	3	>90
1310-330	"	Wht chk+20% med-dk gy mdst	1.15					
1350-370	"	Ditto+20% ditto	1.25					
1390-1410	"	Ol-gy sl slty mdst+ mnr wht chk	0.88					
1410-430	"	Ditto	-					
1430-450	"	Ditto+50% med gy mic sh	0.99					
1800-820	"	Med-dk gy mic sh	2.60					
1820-840	"	Ditto	2.43					
1840-860	"	Ditto	2.65	930	3.5	<20	1	77
1860-880	"	Ditto	3.02					
1880-900	"	Ditto	3.06	7830	25.6	<20	*	*
1900-920	"	Ditto	4.23					
1920-940	"	Ditto	3.39					
1940-960	"	Ditto	3.37	1275	3.8	<20	1	70
1960-980	"	Ditto	4.88					
1980-2000	"	Ditto	4.39					
2000-020	"	Ditto	3.62	1045	2.9	<20	1	81
2020-040	"	Ditto+mnr lt brn lst	3.83					

TABLE 2B

SOURCE ROCK EVALUATION DATA

WELL: 8/3-1 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 % HYDRO-CARBONS
2040-060	Ctgs	Vgt crs snd/sst+10% med-dk gy sh+tr coal	16.17					
2060-075	"	Med-dk gy mic sl slty sh+mnr crs snd/sst+ tr coal	7.78					
2090-2110	"	Dk gy sl slty mic sh+ mnr med-dk gy sh+mnr crs snd+tr coal	1.96					
2160-180	"	Med-dk gy sh+wht/gy-red sltst+crs snd+tr coal	3.88					
2240-252	"	Lt gy lst+mnr med-dk gy sh+mnr snd/sst/ sltst	-					
		PICKED LITHOLOGIES						
790-810	"	Med-dk gy mdst	4.02					
935-955	"	Med gy mdst	1.17					
935-955	"	Gn-gy mdst	0.97					
955-975	"	Med gy mdst	1.47					
955-975	"	Gn-gy mdst	0.90					
975-995	"	Med gy mdst	1.13					
975-995	"	Gn-gy mdst	0.70					
995-1015	"	Med gy mdst	0.63					
995-1015	"	Gn-gy mdst	0.69					
1015-035	"	Med gy mdst	2.46					
1015-035	"	Gn-gy mdst	0.76					
2040-060	"	Med-dk gy mic sh	10.01					
2090-2110	"	Dk gy sl slty mic sh	4.53					

TABLE 3

ROCK - EVAL. PYROLYSIS DATA

WELL: 8/3-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (METRES) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
810-825	Ol-gy mdst+30% med-dk gy mdst+ 30% gn-gy mdst	2.62	420	81	143	*	2100
955-975	Med gy mdst+40% gn-gy mdst	1.33	419	8	163	*	100
1035-055	Chk+40% gy sh/ mdst	0.73	415	12	213	*	100
1800-820	Med-dk gy mic sh	2.60	433	131	83	*	3400
1840-860	Ditto	2.65	430	79	91	*	2100
1860-900	Ditto	3.02	435	164	41	0.06	5000
1880-900	Ditto	3.06	426	120	63	*	3700
1900-920	Ditto	4.23	433	197	34	0.03	8300
1920-940	Ditto	3.39	429	131	52	*	4500
1940-960	Ditto	3.37	428	150	49	*	5100
1960-980	Ditto	4.88	431	259	43	*	12600
2000-020	Ditto	3.62	426	60	69	*	2200
2020-040	Ditto+mnr lst	3.83	425	168	32	*	6500
2060-075	Med-dk gy mic sh	7.78	428	16	43	*	1200
2090-2110	Dk gy mic sh	1.96	424	167	53	*	3300
2160-180	Med-dk gy sh	3.88	420	121	30	*	4700
	PICKED LITHOLOGIES						
790-810	Med-dk gy mdst	4.02	401	32	123	*	1300
2040-060	Med-dk gy mic sh	10.01	424	202	23	*	20200
2090-2110	Dk gy sl slty mic sh	4.53	420	194	36	0.02	8800

TEMPERATURE (°C) = TEMPERATURE AT MAXIMUM RATE OF PYROLYSIS
PRODUCTION INDEX = AN ESTIMATE OF PRESENT HYDROCARBON GENERATING POTENTIAL COMPARED TO THAT AT OPTIMUM MATURITY
POTENTIAL YIELD = AN ESTIMATE OF HYDROCARBON PRODUCTION AT OPTIMUM MATURITY

FIGURE 1 SPORE COLOURATION INDICES AGAINST DEPTH

WELL: 8/3-1 LOCATION: NORWEGIAN NORTH SEA

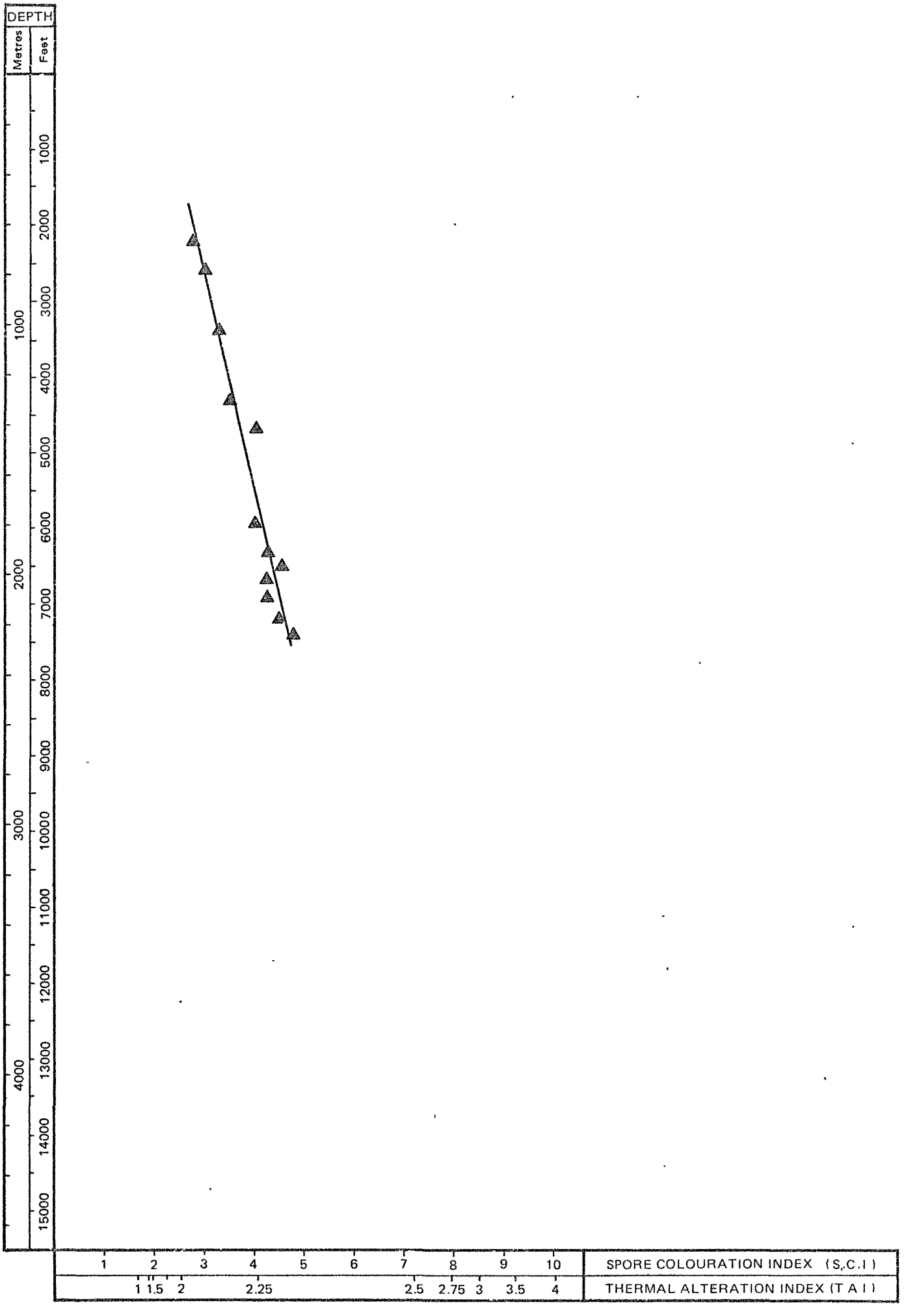


FIGURE 2 VITRINITE REFLECTIVITY AGAINST DEPTH

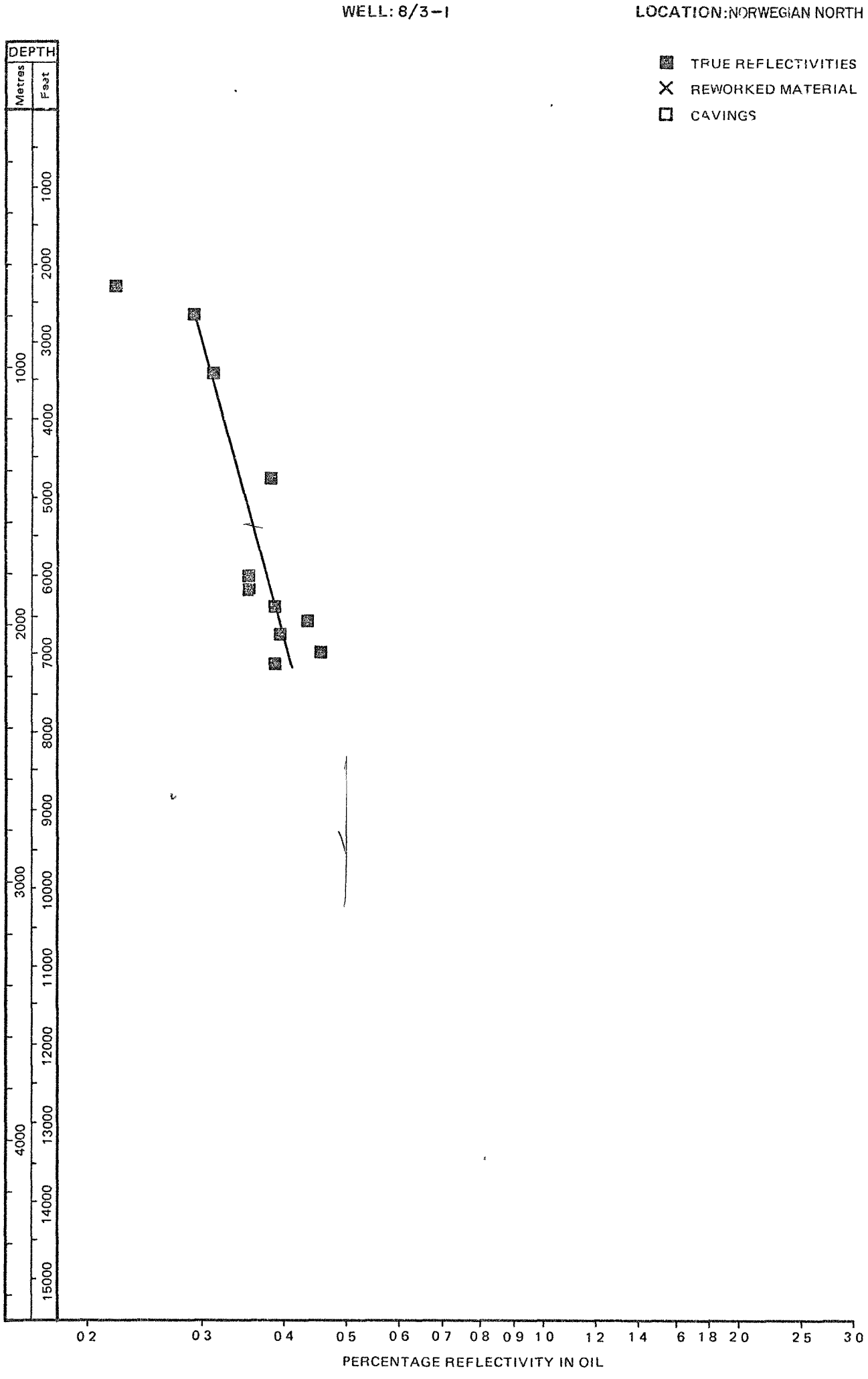
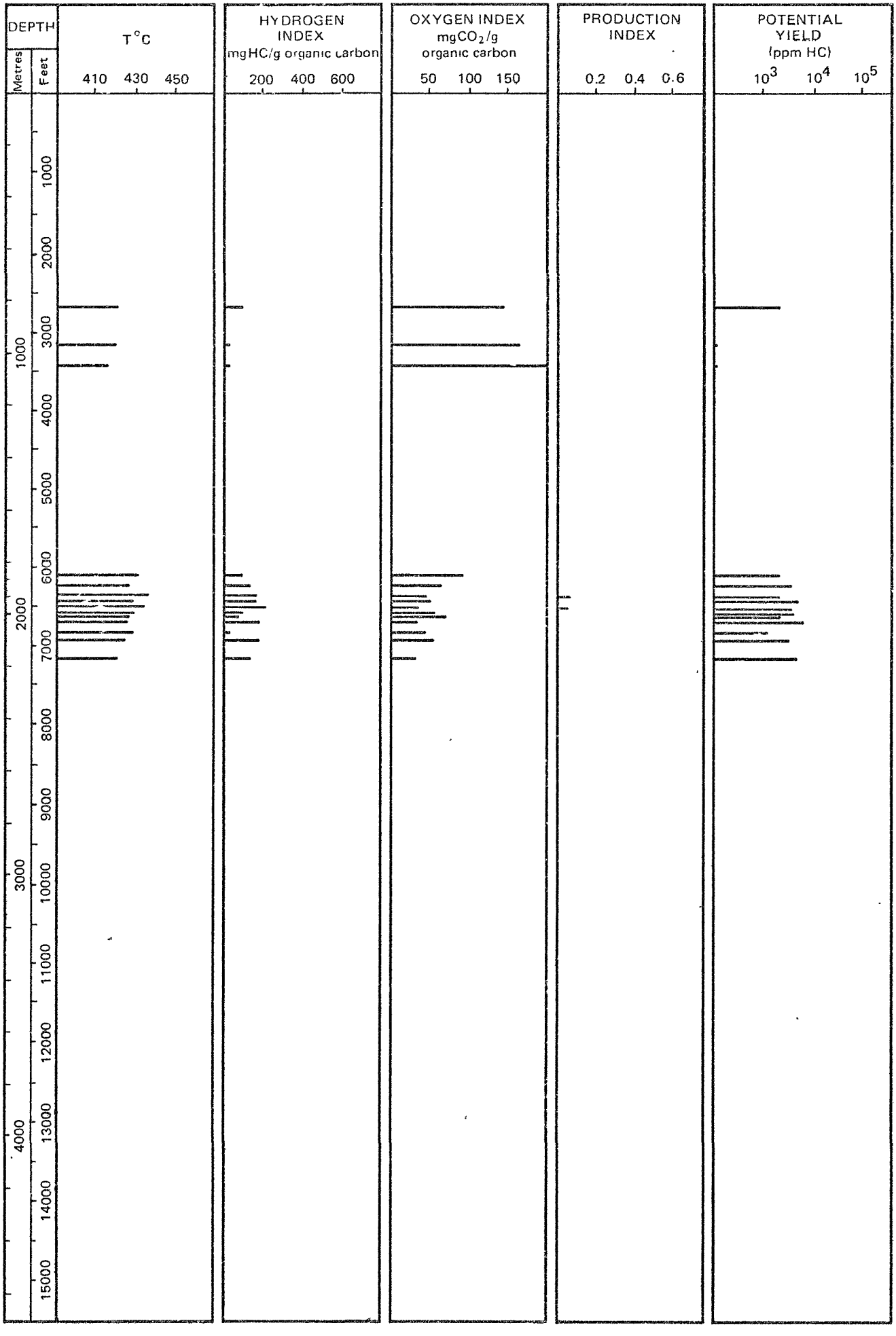


FIGURE 3 PYROLYSIS DATA SUMMARY CHART

WELL: 8/3–1 LOCATION: NORWEGIAN NORTH SEA



ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO. 9C

Project No. RRPS/789/B/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES OF THE PHILLIPS NORWAY 8/10-1 WELL

NOVEMBER, 1978

I

INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Phillips Norway 8/10-1 well. Samples were received mostly at 30 feet intervals from 2500 to 10160 feet and were composited at 60 feet intervals dependent on lithological and log data. The composite samples were washed with cold water as necessary to remove drilling mud and air dried at 50°C. The $13\frac{3}{8}$" casing was set at 6972 feet in the Lower Tertiary with no further casing points to T. D. Caving seems to be a significant problem in geochemical evaluation of the lower part of the analysed section.

For interpretational purposes we have had access to gamma/sonic and mudloggers logs and reference to a preliminary micropalaentological stratigraphic breakdown of the Lower Cretaceous and Jurassic intervals. The well is believed to have been drilled with a sea-water based drilling mud throughout. No significant amounts of diesel were used during drilling except when the pipe stuck at 9981 feet depth. The caliper log shows that caving was quite severe

in several intervals and most particularly between 8780 and 9090 feet.

The analytical procedures used include organic carbon analysis on most of the bulk cuttings samples at 60 feet intervals and also on individual lithologies where bulk samples consisted of more than one lithotype. Extractive source rock analysis has been carried out at varying intervals. Gas chromatographic analysis has been carried out on two alkane fractions in this section. Pyrolysis source rock evaluation using the IFP/Fina ROCK-EVAL apparatus has been carried out on the same samples as used for extractive analysis, on samples where insufficient material was available for extractive analysis and on samples of picked lithologies where composite samples contained more than one significant lithotype. Kerogen composition has been assessed on a semiquantitative basis, by visual estimation of the kerogen components in unsieved, unoxidised, palynological preparations.

Maturity levels have been assessed in this study using principally spore colouration analysis on sieved, unoxidised, palynological preparations and vitrinite reflectivity on kerogen concentrates. In assessing maturity level, reference may also be made to the temperatures of maximum pyrolysis rate which give useful indications of maturity level when used in conjunction with the kerogen type.

II

RESULTS AND INTERPRETATION

The results of the various analyses carried out on the 8/10-1 well are presented in Tables 1 to 3 and are represented graphically in Figures 1 to 4. Table 1 lists data on maturity level in the section along with the kerogen composition data for the same samples. The spore colouration and vitrinite

reflectivity trends with depth are shown in Figures 1 and 2 respectively. Table 2 lists the organic carbon and extractive source rock evaluation data. Pyrolysis data are presented in Table 3 and are represented graphically against depth in Figures 3 and 4. A detailed graphic compilation of all the data will be presented later in the compilation report.

MATURITY DATA

Our assessment of the spore colouration data is that the Tertiary interval of the well is immature tending to transitional maturity below about 5000 feet. The Lower Cretaceous and Jurassic intervals of the well below 8500 feet are at an early stage of maturity for generation of oil from oil-prone organic matter (see source rock evaluation). Oil-prone organic matter in the Jurassic interval would be anticipated to be capable of heavy (low ^{o}API gravity) oil generation. There appears to be a break in maturity gradient as judged by spore colouration in the Lower Cretaceous and Upper Jurassic interval.

Vitrinite reflectivity data show a steady increase through the Tertiary interval of the well, but with a change in gradient apparent at the base of the Tertiary. Reflectivity values rise from about 0.28% at 2500 feet to about 0.5% at 9000 feet. These results suggest that the Jurassic through the Lower Tertiary intervals may be at an early stage of maturity for oil generation given the presence of oil-prone organic matter. No significant gas generation is anticipated to have yet occurred.

HYDROCARBON SOURCE POTENTIAL DATA

On the basis of geochemical data obtained, the following breakdown of the analysed interval of the 8/10-1 well is made.

INTERVAL 2500 to 6500 feet - This interval is predominantly soft mudstone variably medium through dark grey and occasionally silty and micaceous. The organic carbon contents are generally above average through most of the interval and are well above average at 4% to 6% between 4300 and 6000 feet. Kerogen composition is humic and almost entirely vitrinitic.

Pyrolysis parameters confirm the immature to early mature status and the vitrinitic composition. Extractive source rock evaluation has shown no significant amounts of hydrocarbon being present.

No present hydrocarbon generating potential. Good gas source, particularly between 4300 and 6000 feet, at optimum maturity.

INTERVAL 6660 to 7860 feet - This interval is represented by predominantly olive-grey and light olive - grey silty mudstones giving way to green-grey shales below 7140 feet. The organic carbon content is about average, but kerogen composition, although humic throughout, changes in this interval from vitrinitic to predominantly inertinitic below about 7000 feet.

Pyrolysis parameters below 7220 feet reflect this kerogen change. Extractive source rock evaluation showed no significant concentration of hydrocarbons in the sample analysed.

No hydrocarbon generating potential at present. Minor gas source at optimum maturity.

INTERVAL 7860 to 8470 feet - Chalk

No hydrocarbon generating potential.

INTERVAL 8470 to 9020 feet - The caliper log between about 8800 and 9100 feet shows a substantial increase in hole diameter which is attributed to caving. The effect of this appears to mask the true lithology drilled below 9100 feet, so that the geochemical results are interpreted below with reference to the gamma/sonic logs.

Green-grey shale with lesser olive-grey and medium grey shales. Organic carbon content is mostly above average at greater than 2%. Kerogen composition data indicate a humic assemblage through this interval with inertinite dominant over, or in about equal proportions to, vitrinite. The pyrolysis data indicate no hydrocarbon generating potential at all as suggested by the kerogen composition. No hydrocarbon source potential.

INTERVAL 9060 to 9200 feet - Medium and medium-dark grey shale with olive-grey shale. The gamma log shows a high response between 9095 and 9155 feet which corresponds to a low sonic velocity and is interpreted as the "Hot" shale. Carbon content for the composite samples is above average at nearly 3%,but pyrolysis data for most of the composite and picked shales below 9060 feet indicate no, or at best poor hydrocarbon source potential. However, picked medium-dark grey shales from 9220 - 280 and 9300-380 feet have recorded high carbon contents, hydrogen indices and potential yield values. These results are considered to represent the "Hot" shale, although they have been selected from samples occurring below the high gamma reading interval.

The high gamma ray response interval from 9095 to 9155 feet, has well above average organic carbon content. It is at an early stage of maturity and has limited source potential. At optimum maturity it will be a prolific oil source. The rest of the interval has poor or no hydrocarbon generating potentia

INTERVAL 9220 to 9660 FEET

This interval, from log interpretation, is believed to be of Triassic age. It is, therefore, of no interest as a hydrocarbon source. The results obtained in this interval, as discussed above, are from caved Lower Cretaceous, Upper Jurassic and possibly Lower Tertiary sediments.

TABLE 1 MATURITY EVALUATION DATA

WELL: 8/10-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH	SAMPLE TYPE	GENERALISED LITHOLOGY	SPORE COLOUR INDEX (1 - 10)	VITRINITE REFLECTIVITY IN OIL, Rav%	KEROGEN COMPOSITION (%)		
					INERTINITE	VITRINITE	SAPROPEL
2620-700	Ctgs	Med/med-dk gy mdst	2.5-3	0.27 (3)	30	70	*
2980-3060	"	Ditto	2.5-3	-	20	80	*
3580-660	"	Ditto	3	0.29 (7)	20	80	*
3940-4020	"	Ditto	-	0.34 (17)	-	-	-
4220-300	"	Ditto	3	0.34 (9)	30	70	*
4580-620	"	Ditto	-	0.35 (16)	-	-	-
4940-5020	"	Ditto	3-3.5	0.38 (17)	10	90	*
5420-500	"	Ditto	-	0.41 (38)	-	-	-
5660-740	"	Med-dk gy mdst	3-3.5	0.42 (41)	10	90	*
6420-500	"	Ol-gy slty mdst/sh	-	0.46 (3)	-	-	-
6780-860	"	Ditto	3-3.5	0.40 (32); 0.53 (9)	20	80	*
7400-460	"	Gn-gy sh	3-3.5	0.40 (7); 0.56 (3)	70	25	5
7720-780	"	Ditto	3-3.5	0.38 (12); 0.50 (9)	70	25	5
8680-760	"	Ditto	4.5?	-	85	10	5
9060-120	"	Ditto	4.5?	0.51 (5)	40	60	*
9220-280	"	Ditto	4.5?	-	20	80	*
9300-380	"	Ditto	4.5?	-	30	70	*

TABLE 2A

SOURCE ROCK EVALUATION DATA

WELL 8/10-1 LOCATION NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) 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 %HYDRO CARBONS
2500-580	Ctgs	Mtl med gy/med-dk gy sl calc mic soft mdst	2.17					
2620-700	"	Ditto	2.49					
2740-820	"	Ditto	2.23	695	3.1	<20	2	71
2860-940	"	Ditto	2.52					
2980-3060	"	Ditto	2.25					
3100-180	"	Ditto	-					
3220-300	"	Ditto	2.36					
3340-420	"	Ditto	2.71	865	3.1	<20	3	88
3460-540	"	Ditto	-					
3580-660	"	Ditto	2.56					
3700-780	"	Ditto	2.42	595	2.5	<20	3	88
3820-900	"	Ditto	-					
3940-4020	"	Ditto	2.68					
4060-120	"	Ditto	-					
4220-300	"	Ditto	2.38					
4340-420	"	Dk gy sl mic sl slty soft mdst	6.43	2500	3.9	45	2	88
4460-540	"	Mtl med gy /med-dk gy sl calc mic soft mdst	-					
4580-620	"	Ditto	3.85					
4700-780	"	Ditto	3.58					
4820-900	"	Ditto	3.89	2610	6.7	80	3	90
4940-5020	"	Ditto	4.03					
5060-180	"	Ditto	4.91					
5300-380	"	Ditto	-					
5420-500	"	Ditto	4.58					
5540-620	"	Ditto	5.18					
5660-740	"	Med-dk gy sl slty mic soft mdst	4.97					
5820-900	"	Ditto	5.31					
5940-6020	"	Ditto	4.18					
6060-140	"	Ol-gy slty mdst/sh	3.57					
6180-260	"	Ditto	3.14					
6300-380	"	Ditto	3.05					
6420-500	"	Ditto	2.00					
6540-620	"	Ditto	-					

TABLE 2B

SOURCE ROCK EVALUATION DATA

WELL: 8/10-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) 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
6660-740	Ctgs	Ol-gy slty mdst/sh	1.59					
6780-860	"	Ditto	2.01					
6900-980	"	Lt ol-gy sltst/slty mdst+mnr gn-gy/gy-red /med gy mdst/sh	-					
7040	"	Lt ol-gy slty mdst/ marl+mnr gn-gy sh	-					
7140-200	"	Gn-gy sh+mnr ol-gy sh /mdst	0.92					
7220-280	"	Gn-gy sh+mnr ol-gy/ med gy/gy-red sh+mnr wht chk	1.56	645	4.1	45	6	90
7320-380	"	Ditto+ditto	2.82					
7400-460	"	Ditto+ditto	1.85					
7500-540	"	Ditto+ditto	2.81					
7600-680	"	Ditto+ditto	1.59					
7720-780	"	Ditto+ditto	1.17					
7820-860	"	Ditto+ditto	0.65					
7940-980	"	Wht chk+mnr med gy/ gn-gy sh	0.25					
8020-080	"	Ditto+30% ditto	-					
8100-160	"	Ditto+40% ditto	-					
8180-240	"	Ditto+30% ditto	-					
8260-320	"	Ditto+10% ditto	-					
8340-420	"	Ditto+10% gn-gy/gy-red sh	-					
8460-540	"	Ditto+ditto	0.80					
8580-650	"	Gn-gy sh+mnr ol-gy/ med gy/med-dk gy sh	2.41					
8680-760	"	Ditto+ditto	1.25					
8820-900	"	Ditto+ditto	1.98					
8940-9020	"	Ditto+ditto	2.37					
9060-120	"	Ditto+ditto	2.72	3750	13.8	400	11	95
9140-200	"	Ditto+ditto	2.93					
9220-280	"	Ditto+ditto	2.26					
9300-380	"	Ditto+ditto	2.43					
9420-500	"	Pnk gy marl+10% med gy/gn-gy sh	3.08					

TABLE 2C

SOURCE ROCK EVALUATION DATA

WELL 8/10-1 LOCATION NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) 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 % HYDRO CARBONS
9540-600	Ctgs	Med gy sh+mnr gn-gy/ red-brn sh	0.77					
9640-700	"	Med gy sh+mnr red-brn sh+mnr pnk-gy marl	0.58					
9720-780	"	Ditto+mnr ditto	0.55					
9800-860	"	Ditto+mnr ditto	0.58					
9880-960	"	Med gy sh+10% gy-red sh+mnr wht chk/gy marl	0.57					
9980-10040	"	Med gy sh+20% gy-red sh+10% wht chk/pnk-gy marl	0.83					
10060-120	"	Ditto+ditto	0.73					
10140-160	"	Ditto+ditto	1.36					
		PICKED LITHOLOGIES						
7040	"	Gn-gy sh	0.56					
9220-280	"	Ol-gy sh	2.03					
9220-280	"	Med - dk gy sh	7.10					
9300-380	"	Ol-gy sh	0.73					
9300-380	"	Med-dk gy sh	5.32					
9420-500	"	Ditto	0.70					
9640-700	"	Ditto	0.53					
9640-700	"	Red-brn sh	0.14					
9720-780	"	Med gy sh	0.40					
9720-780	"	Red-brn sh	0.19					
9800-860	"	Med gy sh	0.44					
9800-860	"	Red-brn sh	0.30					

TABLE 3

ROCK - EVAL. PYROLYSIS DATA

WELL: 8/10-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
2740-820	Med gy/med-dk gy mdst	2.23	425	27	120	*	600
3340-420	Ditto	2.71	425	25	83	*	700
3700-780	Ditto	2.42	427	17	89	*	400
4340-420	Dk gy mdst	6.43	424	60	65	*	3900
4820-900	Med gy/med-dk gy mdst	3.89	434	76	78	*	2900
5940-6020	Med-dk gy mdst	4.18	429	83	59	*	3500
7220-280	Gn-gy sh	1.56	429	6	74	*	100
7500-540	Ditto	2.81	*	*	52	*	*
7720-780	Ditto	1.17	*	*	97	*	*
8580-650	Ditto	2.41	*	*	48	*	*
8820-900	Ditto	1.98	*	*	59	*	*
9060-120	Ditto	2.72	429	28	35	*	800
9300-380	Ditto	2.43	421	8	32	*	200
9640-700	Med gy sh	0.58	*	*	101	*	*
9800-860	Ditto	0.58	*	*	117	*	*
9880-960	Ditto	0.57	*	*	127	*	*
	PICKED LITHOLOGIES						
9220-280	Ol-gy sh	2.03	423	26	37	0.2	500
9220-280	Med gy sh	7.10	424	509	11	0.1	36100
9300-380	Ditto	5.32	424	388	17	0.2	20600
9640-700	Ditto	0.53	433	20	121	*	600
9720-780	Ditto	0.40	*	*	145	*	*
9800-860	Ditto	0.44	*	*	129	*	*

TEMPERATURE (°C) = TEMPERATURE AT MAXIMUM RATE OF PYROLYSIS
PRODUCTION INDEX = AN ESTIMATE OF PRESENT HYDROCARBON GENERATING POTENTIAL COMPARED TO THAT AT OPTIMUM MATURITY
POTENTIAL YIELD = AN ESTIMATE OF HYDROCARBON PRODUCTION AT OPTIMUM MATURITY

FIGURE 1 SPORE COLOURATION INDICES AGAINST DEPTH

WELL: 8/10-1 LOCATION: NORWEGIAN NORTH SEA

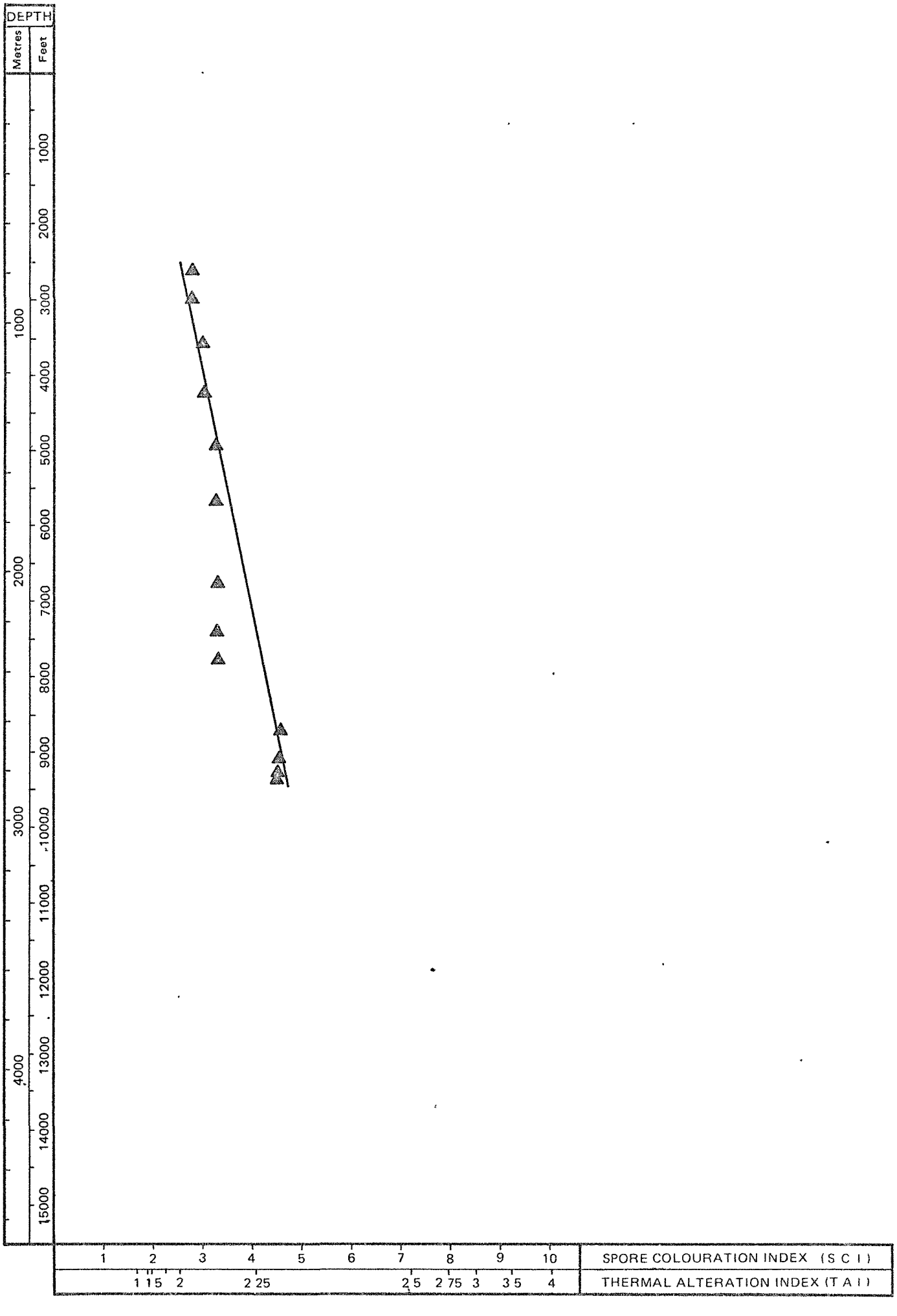


FIGURE 2 VITRINITE REFLECTIVITY AGAINST DEPTH

WELL: 8/10-1

LOCATION: NORWEGIAN NORTH SEA

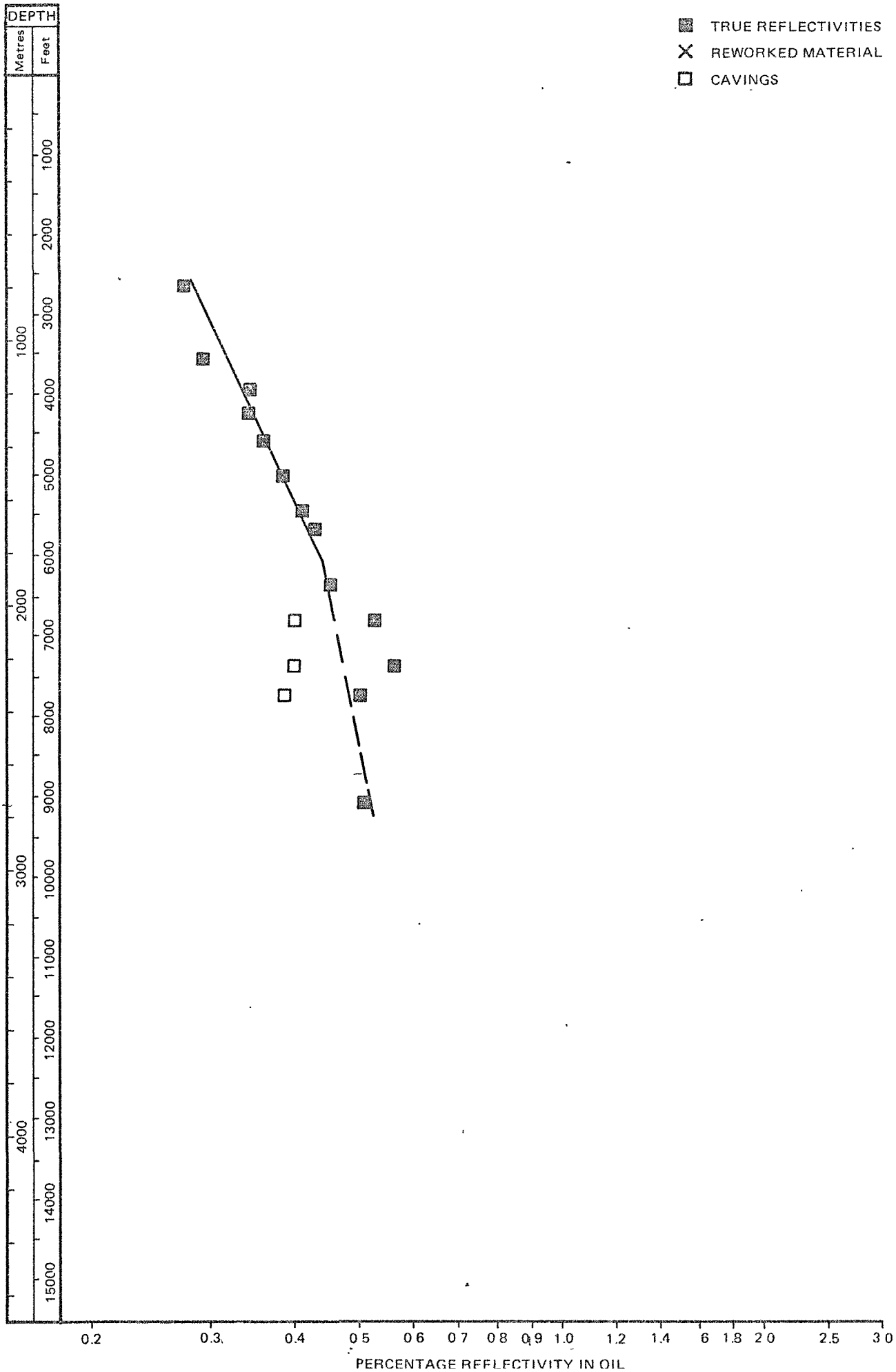


FIGURE 3 PYROLYSIS DATA SUMMARY CHART

WELL: 8/10-1 LOCATION: NORWEGIAN NORTH SEA

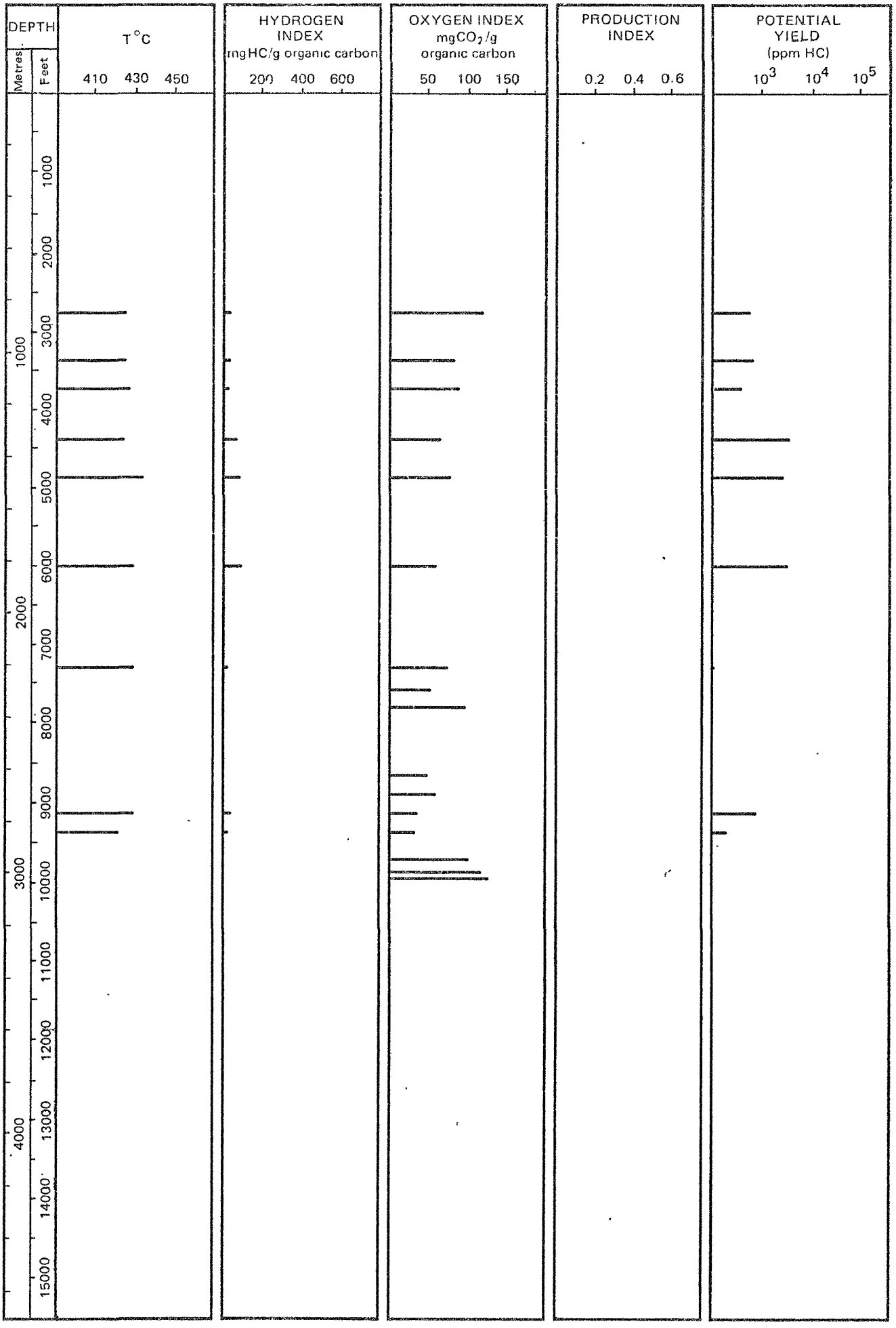
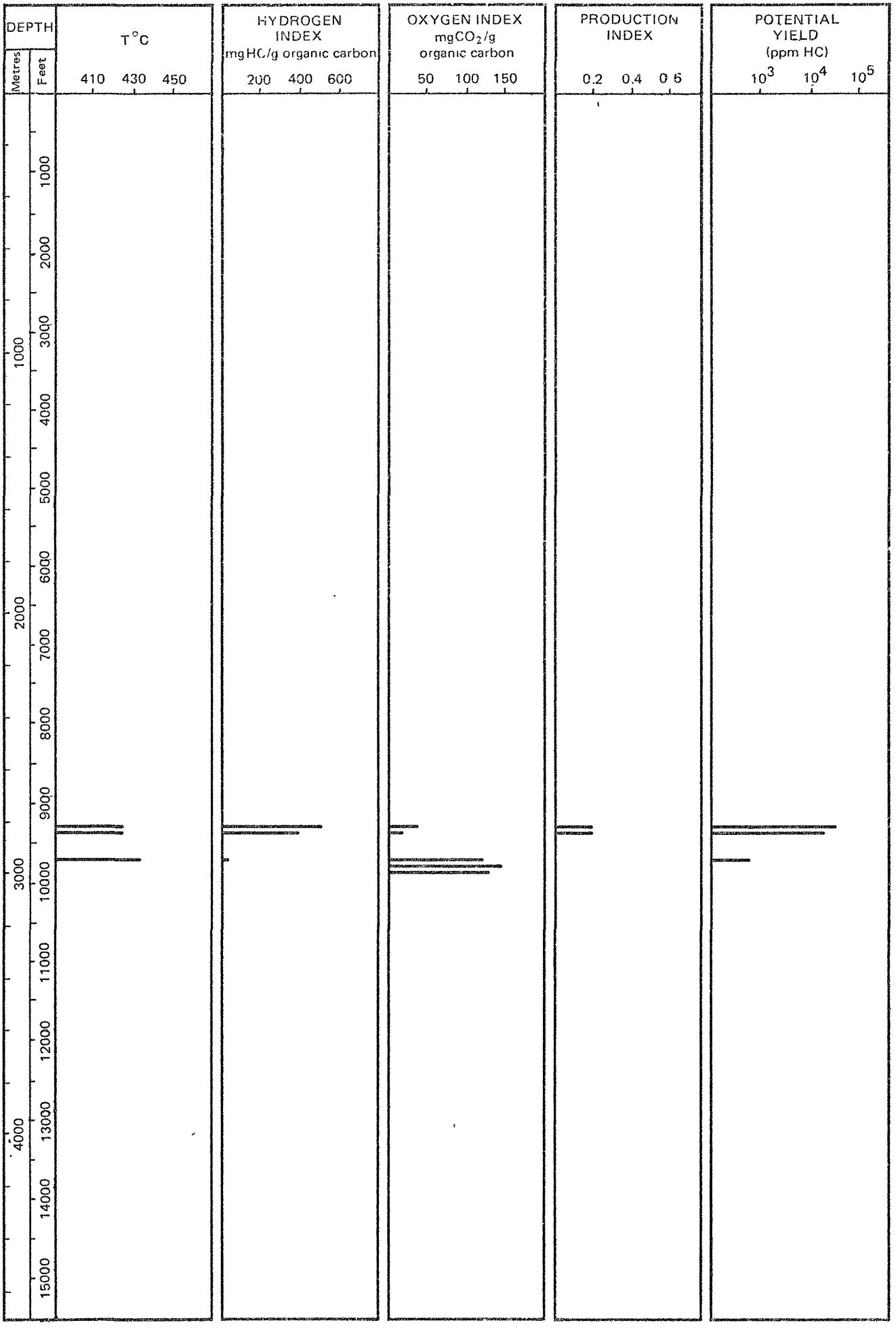


FIGURE 4 PYROLYSIS DATA SUMMARY CHART

(PICKED LITHOLOGIES)

WELL: 8/10-1 LOCATION: NORWEGIAN NORTH SEA



ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO.9D

Project No. RRPS/789/B/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES OF THE ESSO 9/8-1 WELL

NOVEMBER, 1978

I

INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Esso Exploration Norway 9/8-1 well. The samples were received at 2 to 20 feet intervals and were selected for analysis by compositing at mostly 60 feet intervals dependent on lithological and log data from 5000 to 7000 feet. After compositing, samples were washed with cold water as necessary to remove drilling mud, and air dried at 50°C.

In this well we have analysed only the Lower Cretaceous and Jurassic interval and samples have accordingly been composited from 5260 feet. The samples after washing were of fair to good quality for geochemical analysis.

For interpretation, we have had access to NPD Paper 5 which contains relevant information on drilling additives, casing points etc. The well is believed to have been drilled with a sea water based drilling mud throughout.

The analytical procedures used include organic carbon analysis on most of the bulk cuttings samples and on several picked lithologies, where more than one lithology was observed in the samples. No samples were considered suitable for extractive source rock analysis. Pyrolysis source rock evaluation using the IFP/Fina ROCK-EVAL apparatus has been carried out on several samples of both composite cuttings and picked lithologies. Kerogen composition has been assessed on a semiquantitative basis by visual estimation of the kerogen components in unsieved, unoxidised, palynological preparations.

Maturity levels have been assessed in this study using principally spore colouration analysis on sieved, unoxidised, palynological preparations and vitrinite reflectivity on kerogen concentrates and picked coal fragments. In assessing maturity level, reference may also be made to the temperatures of maximum pyrolysis rate which give useful indications of maturity level when used in conjunction with the kerogen type.

II

RESULTS AND INTERPRETATION

The results of the various analyses carried out on the 9/8-1 well are presented in Tables 1 to 3 and are represented graphically in Figure 1. Table 1 lists data on maturity level in the section along with the kerogen composition data for the same samples. The spore colouration trend with depth is shown in Figure 1. Table 2 lists the organic carbon and extractive source rock evaluation data while pyrolysis data are presented in Table 3. A detailed

graphic presentation of all the data will be made later in the compilation report.

MATURITY DATA

Our assessment of the spore colouration data is that the analysed Lower Cretaceous and Jurassic interval of the well is at an early level of maturity and oil-prone organic matter if present is likely to source low ^{o}API gravity oil. Vitrinite reflectivity values are well defined in the Middle Jurassic coaly interval of the well at around 0.4% to 0.45%.

HYDROCARBON SOURCE POTENTIAL DATA

On the basis of the geochemical data obtained, the following breakdown of the analysed interval of the 9/8-1 well is made:

Interval 5000 to 5250 feet	Chalk. No hydrocarbon generating potential.
Interval 5260 to 5860 feet	This interval of Lower Cretaceous age is represented by mostly olive-grey tending to medium-dark grey calcareous mudstone or marl with varying proportions of grey-red/ pink-grey marl/chalk. The organic carbon content is about average, but the organic matter is predominantly inertinitic by both visual observation and pyrolysis data. No hydrocarbon generating potential at present or at optimum maturity.
Interval 5880 to 6315 feet	This interval is of Upper Jurassic (?) age and is represented by medium to medium-dark grey slightly calcareous mudstones becoming

more shaly with depth. Carbon content is slightly above average and is 3.5% to 5.0% in the deepest sample analysed which corresponds to the "Hot" shale.

Kerogen composition is inertinitic for the most part, although pyrolysis parameters show the sample at 6260-315 feet to be a potentially fair to good oil source at optimum maturity.

Minor present hydrocarbon generating potential in the interval 6230-300 feet ("Hot" shale).

Good oil source at optimum maturity.

Interval 5880 to 6230 feet - poor hydrocarbon generating potential.

Pyrolysis data obtained for samples from 5560 to 6040 feet show abnormal production indices which may signify the presence of minor amounts of migrant hydrocarbon in this interval.

Interval 6350 to 6930 feet

Middle Jurassic sandstones, siltstones and occasional shales overlying a similar Triassic (?) sequence. No hydrocarbon generating potential. Coal fragments in this interval have proved of value in vitrinite reflectivity determination.

TABLE 1 MATURITY EVALUATION DATA

WELL: 9/8-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET)	SAMPLE TYPE	GENERALISED LITHOLOGY	SPORE COLOUR INDEX (1 - 10)	VITRINITE REFLECTIVITY IN OIL, R av%	KEROGEN COMPOSITION (%)		
					INERTINITE	VITRINITE	SAPROPEL
5260-320	Ctgs	Ol-gy marl+30% gy-red chk	4	-	70	20	10
5560-620	"	Ditto+mnr ditto	4	-	70	30	*
5720-780	"	Ditto+mnr ditto	4-4.5	-	50	50	*
6040-100	"	Med-dk gy mdst+ mnr lt ol-gy chk	4.5	-	80	20	*
6260-315	"	Ditto+ditto	4	0.42 (3)	30	70	*
6350-410	"	Coal (Picked)	-	0.40(23)	-	-	-
6420-480	"	Med-dk gy mic slty sh+mnr coal	4.5-5	-	30	70	*
6420-480	"	Coal (Picked)	-	0.41(13)	-	-	-
6490-550	"	Ditto	-	0.44(14)	-	-	-
6920-930	"	Red-brn/med-lt gy marl+snd/sst	5-6?	-	*	*	*

TABLE 2

SOURCE ROCK EVALUATION DATA

WELL 9/8-1 LOCATION NOPWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) 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 % HYDRO CARBONS
5260-320	Ctgs	Ol-gy/dk gy marl+30% gy-red/yel-gy marl/chk	1.53					
5400-460	"	Ditto+ditto	1.35					
5560-620	"	Med gy/ol-gy calc mdst/marl+mnr gy-red/ lt ol-gy marl/chk	1.47					
5720-780	"	Ditto+mnr ditto	1.95					
5880-940	"	Ditto+mnr ditto	2.41					
5960-6020	"	Med gy/dk gy calc mdst/marl+mnr lt ol-gy chk	2.60					
6040-100	"	Ditto+mnr ditto	1.80					
6110-170	"	Ditto+ditto	1.35					
6180-240	"	Ditto+ditto	1.90					
6260-315	"	Ditto+ditto	3.65					
6350-410	"	Lt ol-gy qtz snd/sst+ 10% med-dk gy slty sh +mnr coal	-					
6420-480	"	Med-dk gy mic slty sh +mnr coal	-					
6490-550	"	Lt gy qtz snd/sst+20% med-dk gy sh+mnr coal	-					
6560-620	"	Red-brn sh+lt gy-brn snd/sst+mnr dk gy sh	-					
6920-930	"	Ditto+ditto+ditto	-					
		PICKED LITHOLOGIES						
6260-315	"	Med gy mdst	4.99					
6260-315	"	Med-dk gy mdst	4.05					

TABLE 3

ROCK - EVAL. PYROLYSIS DATA

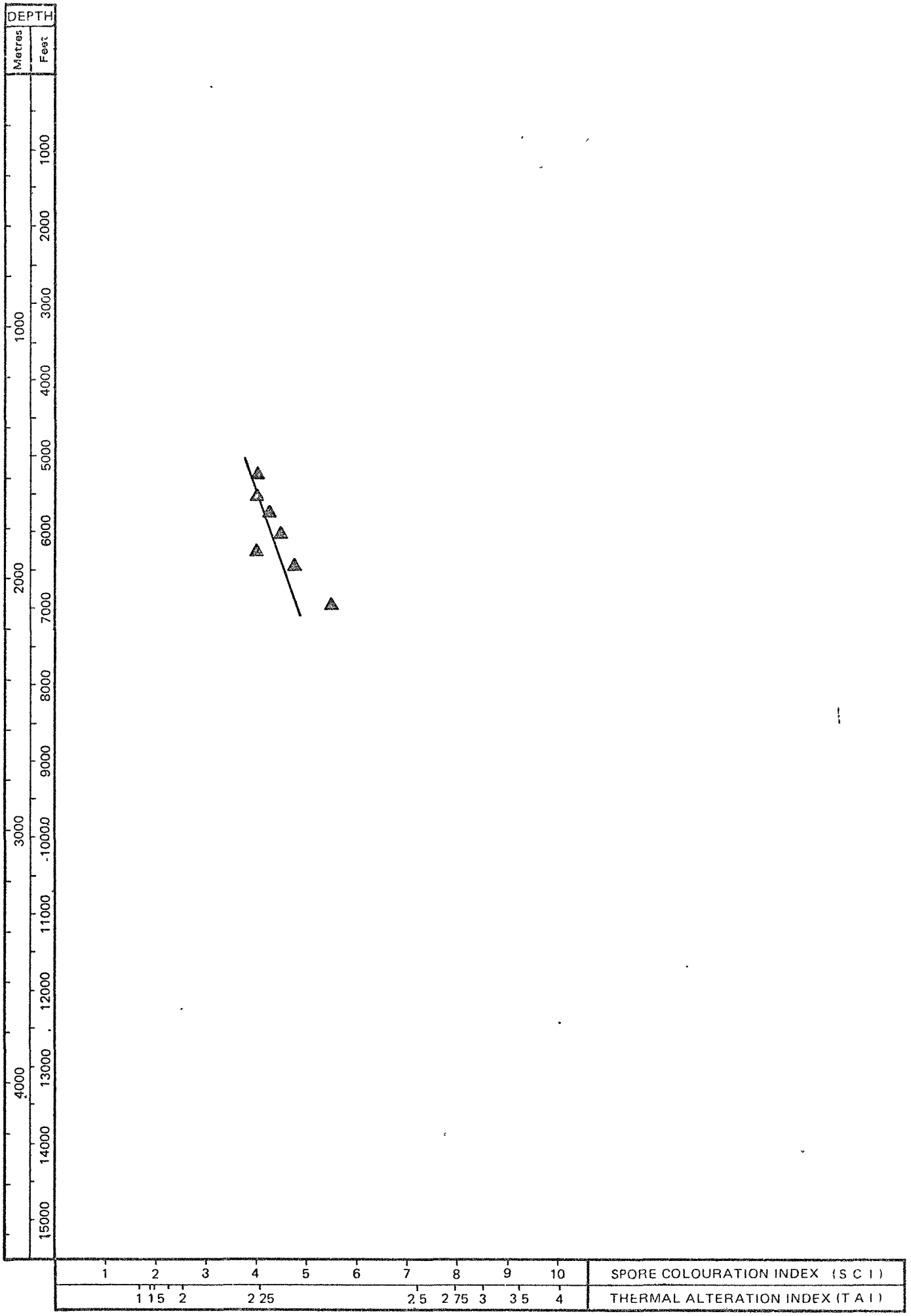
WELL: 9/8-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
5560-620	Med gy/ol-gy marl +mnr gy-red chk	1.47	432	25	149	0.8	400
5960-6020	Med gy/dk gy mdst	2.60	422	37	117	0.6	1000
6040-100	Ditto	1.80	426	81	169	0.6	1600
6260-315	Ditto	3.65	422	301	65	0.2	11000
	PICKED LITHOLOGIES						
6260-315	Med gy mdst	4.99	423	335	64	0.2	16800
6260-315	Med-dk gy mdst	4.05	423	289	101	0.3	11700

TEMPERATURE (°C) = TEMPERATURE AT MAXIMUM RATE OF PYROLYSIS
PRODUCTION INDEX = AN ESTIMATE OF PRESENT HYDROCARBON GENERATING POTENTIAL COMPARED TO THAT AT OPTIMUM MATURITY
POTENTIAL YIELD = AN ESTIMATE OF HYDROCARBON PRODUCTION AT OPTIMUM MATURITY

FIGURE I SPORE COLOURATION INDICES AGAINST DEPTH

WELL: 9/8-I LOCATION: NORWEGIAN NORTH SEA



ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO. 9E

Project No. RRPS/789/B/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES OF THE SYRACUSE OILS NORGE 11/10-1 WELL

NOVEMBER 1978

I

INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Syracuse Oils Norge 11/10-1 well. The samples were received at varying intervals and were selected for analysis by compositing at 200 down to 60 feet intervals dependent on sample availability and lithological data. After compositing, samples were washed with cold water as necessary to remove drilling mud, and air dried at 50°C. No core samples were available from this well section.

For interpretational purposes we have had access to Gamma/Sonic and Mudloggers logs and to a stratigraphic breakdown of the well produced as Preliminary Report No. 6C of this study. The well is believed to have been drilled with a sea water based drilling mud throughout.

The samples were generally of good quality for geochemical analysis although, often of small quantity, particularly between 1000 and 3400 feet. Compositing was started at 1000 feet so that representative material of Oligocene age and older has been analysed. The analytical procedures used include organic carbon analysis on all the bulk cuttings samples, followed by extractive source rock analysis on two samples where sample volume and quality permitted. Gas chromatographic analysis has been carried out on alkane fractions from both samples. Pyrolysis source rock evaluation using the IFP/Fina ROCK-EVAL apparatus has been carried out on the same samples as used for extractive analysis, on samples where insufficient material was available for extractive analysis and on samples of individual lithotypes. Kerogen composition has been assessed on a semiquantitative basis by visual estimation of the kerogen components in unsieved, unoxidised, palynological preparations.

Maturity levels have been assessed in this study using principally spore colouration analysis on sieved unoxidised palynological preparations and vitrinite reflectivity on kerogen concentrates. In assessing maturity level, reference may also be made to the temperatures of maximum pyrolysis rate which give useful indications of maturity level when used in conjunction with the kerogen type.

II

RESULTS AND INTERPRETATION

The results of the various analyses carried out on the 11/10-1 well are presented in Tables 1 to 3 and are represented graphically in Figures 1 to 4. Table 1 lists data on maturity level in the section along with the kerogen composition data for the same samples. The spore colouration and vitrinite reflectivity trends with depth are shown in Figures 1 and 2 respectively.

Table 2 lists the organic carbon and extractive source rock evaluation data. Pyrolysis data are presented in Table 3 and represented graphically against depth in Figures 3 and 4. A detailed graphic presentation of all the data will be made later in the compilation report.

MATURITY DATA

Our assessment of the spore colouration data is that the analysed Tertiary interval of the well below 1000 feet is immature and no significant hydrocarbon generation is anticipated. Spore colour indices of 3.5 rising to 4.5 in the Lower Cretaceous and Jurassic intervals, suggest an early stage of maturity for these sediments. The apparently high surface intercept of the spore colouration gradient suggests that a considerable thickness of post-Oligocene section is missing.

Vitrinite reflectivity values increase in the analysed interval of the well from about 0.2% at 1000 feet to about 0.4% at 6000 feet. The marked increase in reflectivity and change in reflectivity gradient in the Tertiary interval is unusual. We suspect that in this case it is a function of change in subsidence rate. The present low reflectivity at the top (?) of the Oligocene suggests that maximum overburden may have been significant in thickness, but was not present for long in geological terms.

HYDROCARBON SOURCE POTENTIAL DATA

On the basis of the geochemical data obtained, the following breakdown of the analysed interval of the 11/10-1 well is made:

Interval 1000 to 3400 feet	Tertiary brown-grey soft siltstones with minor grey shales below 1800 feet, but light olive-grey silstones and quartz sand with minor mudstones and shell debris above 1800 feet. Organic carbon content is mostly above average but the organic matter is predominantly vitrinite.

The section is immature and presently has no hydrocarbon generating potential. At optimum maturity this interval will source gas. Pyrolysis data have confirmed the vitrinitic nature of the organic matter in this interval. It is also of note, however, that production indices in this interval suggest a degree of contamination in this interval which is attributed to migrant hydrocarbons. In this context it is of note that the Mudloggers log records a significant background level of gas drilled through the Tertiary between 1800 feet and the top of the Chalk at about 3400 feet. No extraction analysis or gas chromatographic analysis data are available to confirm the nature of the hydrocarbons in this interval.

Interval 3450 to 4780 feet — Upper Cretaceous Chalk.
No hydrocarbon generating potential. It is noted that extraction analysis and subsequent gas chromatography of the alkanes, has shown the presence of a considerable amount of hydrocarbons with an oil-like alkane distribution at the base of the Tertiary/top of the Chalk.

Interval 4780 to 5420 feet — Lower Cretaceous light olive-grey mudstone with caved chalk. Organic carbon content is above average and the organic matter is predominantly humic, although it is of interest

that vitrinite is present in somewhat greater proportions than is usual in the Lower Cretaceous. Pyrolysis parameters indicate the possible presence of small amounts of contaminant hydrocarbons, although this has not been confirmed. No hydrocarbon generating potential.

Interval 5460 to 6130 feet

This interval of supposed Upper Jurassic age is represented by medium grey shales becoming medium-dark grey in the sample at 6100-160 feet. Organic carbon content is mostly above average at 2% to 3%. The kerogen composition is humic, predominantly inertinitic, with only minor to 10% sapropel observed. Pyrolysis parameters for bot composite samples and picked lithotypes, confirm the poor hydrocarbon source potential of this interval. Samples of caved (?) dark grey shales seen in the underlying Triassic interval have also been analysed in case these represented caving from a good source horizon, but no significant source beds have been defined. Pyrolysis production indices and extractive source rock evaluation analyses have shown the presence of contaminant hydrocarbons in this interval of the well. Gas chromatographic analysis has shown an oil-like alkane distribution and migrant hydrocarbons may be represented in this interval as in the Tertiary and Upper

	Cretaceous interval.
	No hydrocarbon generating potential.
Interval 6130 feet to T.D.	Triassic coarse grained sands and siltstones.
	No hydrocarbon generating potential.

TABLE 1 MATURITY EVALUATION DATA

WELL: 11/10-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET)	SAMPLE TYPE	GENERALISED LITHOLOGY	SPORE COLOUR INDEX (1 10)	VITRINITE REFLECTIVITY IN OIL, Rav%	KEROGEN COMPOSITION (%)		
					INERTINITE	VITRINITE	SAPROPEL
1000-200	Ctgs	Lt ol-gy sltst	2	-	*	100	*
1300-500	"	Ditto	2.5-3	0.22 (14)	*	100	*
1550-750	"	Sst+mnr gy sh	-	0.23 (19)	-	-	-
2050-200	"	Ditto+mnr gy sh	2.5-3	0.24 (13)	*	100	*
2600-800	"	Brn-gy sltst	3	0.27 (43)	*	100	*
3200-400	"	Ditto	3	0.32 (36)	5	95	*
4840-900	"	Chk+40% ol-gy mdst	3-3.5	-	90	10	*
5000-060	"	Ditto+60% ditto	3.5	0.39 (4)	40	40	20
5180-260	"	Med gy sh	4	0.37 (6)	85	15	*
5360-420	"	Lt ol-gy mdst	4	0.42 (8)	50	40	10
5620-680	"	Med gy sh	4	0.47 (9)	80	10	10
5860-940	"	Ditto	3.5-4	0.42 (7)	85	10	5
6030-090	"	Ditto	4-4.5	0.39 (11)	60	40	*
6170-230	"	Med-dk gy sh	4.5	0.41 (19)	85	10	5

TABLE 2A

SOURCE ROCK EVALUATION DATA

WELL 11/10-1 LOCATION · NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) 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 % HYDRO-CARBONS
1000-200	Ctgs	Lt ol-gy calc sltst+ 40% wht qtz+mnr ol-gy slty mdst	0.68					
1300-500	"	Ditto+mnr ditto+ditto	1.49					
1550-750	"	Vgt sst/snd+mnr med-dk gy sh+shell frags	3.93					
1800-2000	"	Gy-brn mic sltst+mnr med-dk gy sh	2.10					
2050-200	"	Ditto+mnr ditto	2.24					
2300-500	"	Brn-gy soft mic sltst +mnr mod yel-brn qtz snd+mnr med gy sh	3.29					
2600-800	"	Ditto+mnr ditto+mnr ditto	4.70					
2900-3100	"	Ditto+mnr ditto+mnr ditto	3.09					
3200-400	"	Ditto+mnr ditto	1.21					
3450-510	"	V lt gy chk+mnr med gy sh	3.16	5750	18.2	570	10	97
3540-600	"	Ditto+ditto	0.86					
4840-900	"	Wht chk+40% lt ol-gy mdst/sh+tr glauc	1.25					
4920-980	"	Ditto+50% ditto						
5000-060	"	Ditto+60% ditto	2.67					
5100-160	"	Ditto+80% ditto	2.48					
5180-260	"	Med gy sh+mnr wht chk	4.56					
5280-340	"	Lt ol-gy soft mdst/sh +mnr wht chk+mnr med gy sh	3.05					
5360-420	"	Ditto+ditto+ditto	2.79					
5460-520	"	Med gy sh	1.57					
5540-600	"	Ditto	3.36	3310	21.1	275	8	94

TABLE 2B

SOURCE ROCK EVALUATION DATA

WELL 11/10-1 LOCATION NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) 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 % HYDRO CARBONS
5620-680	Ctgs	Med gy sh	2.62					
5700-760	"	Ditto	3.14	3780	12.0	370	10	95
5780-840	"	Ditto	2.57					
5860-940	"	Ditto	2.54					
5960-6020	"	Ditto	3.34	4370	13.1	310	7	94
6030-090	"	Ditto	2.53					
6100-160	"	Med-dk gy sh+mnr med gy sh	2.74	2025	7.5	<20	*	*
6170-230	"	Ditto+mnr ditto	1.36					
6240-300	"	Ditto+mnr ditto	1.04	1190	11.4	100	8	98
6320-360	"	Ditto+mnr ditto+40% vgt crs snd	0.68	1160	17.0	100	9	>95
		PICKED LITHOLOGIES						
1300-500	"	Ol-gy slty mdst	5.05					
1550-750	"	Ditto	2.82					
2050-200	"	Ditto	2.32					
6030-090	"	Med dk gy sh	2.10					
6170-230	"	Med-dk gy sh	2.20					
6240-300	"	Ditto	1.77					
6240-300	"	Mod brn calc sh	0.35					
6320-360	"	Med-dk gy sh	1.62					
6320-360	"	Mod brn calc sh	0.47					
6480-540	"	Med-dk gy sh	1.68					
6480-540	"	Mod brn calc sh	0.54					
6640-700	"	Med-dk gy sh	1.49					
6640-700	"	Mod brn calc sh	0.30					
6880-900	"	Med-dk gy sh	1.33					
6880-900	"	Mod brn calc sh	0.29					

TABLE 3

ROCK - EVAL. PYROLYSIS DATA

WELL: 11/10-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
2300-500	Brn-gy soft sltst	3.29	412	18	80	0.2	600
2600-800	Ditto	4.70	424	15	54	*	700
2900-3100	Ditto	3.09	429	33	78	0.3	1000
3200-400	Ditto	1.21	428	30	188	0.6	400
5460-520	Med gy sh	1.57	432	36	154	0.7	600
5700-760	Ditto	3.14	431	20	45	0.8	600
5960-6020	Ditto	3.34	428	12	33	0.3	400
6100-160	Med-dk gy sh	2.74	428	23	41	0.2	600
6170-230	Ditto	1.36	425	14	34	0.7	200
6240-300	Ditto	1.04	428	6	86	0.05	400
	PICKED LITHOLOGIES						
6030-090	Med-dk gy sh	2.19	428	44	59	0.6	1000
6170-230	Ditto	2.20	431	41	75	0.4	1000
6240-300	Ditto	1.77	420	35	86	0.6	600
6320-360	Ditto	1.62	419	23	70	0.8	400
6480-540	Ditto	1.68	418	20	93	0.7	300
6640-700	Ditto	1.49	420	33	89	0.7	500
6880-900	Ditto	1.33	420	32	70	0.7	400

TEMPERATURE (°C) = TEMPERATURE AT MAXIMUM RATE OF PYROLYSIS
PRODUCTION INDEX = AN ESTIMATE OF PRESENT HYDROCARBON GENERATING POTENTIAL COMPARED TO THAT AT OPTIMUM MATURITY
POTENTIAL YIELD = AN ESTIMATE OF HYDROCARBON PRODUCTION AT OPTIMUM MATURITY

FIGURE 1 SPORE COLOURATION INDICES AGAINST DEPTH

WELL: 11/10-1 LOCATION: NORWEGIAN NORTH SEA

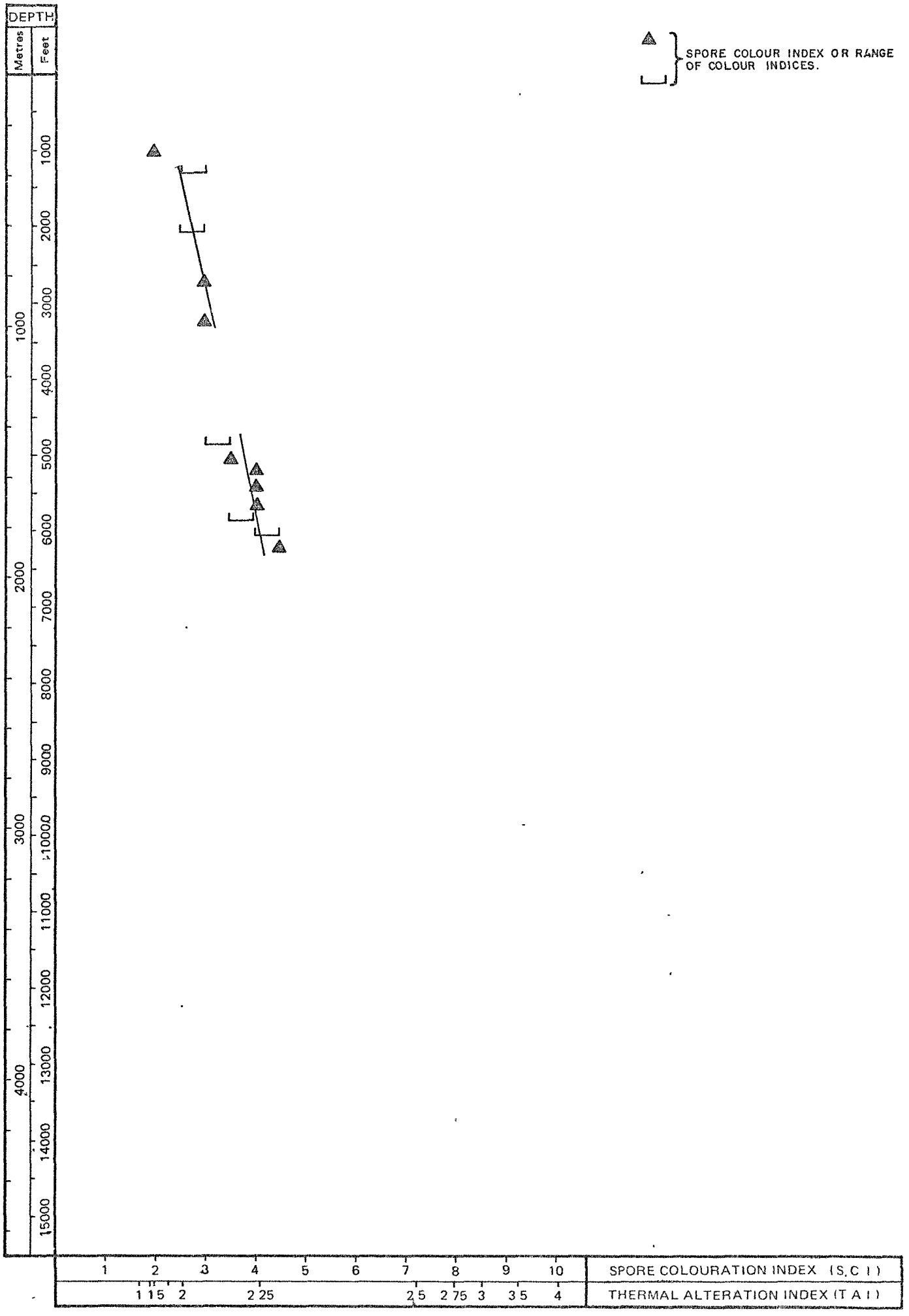


FIGURE 2 VITRINITE REFLECTIVITY AGAINST DEPTH

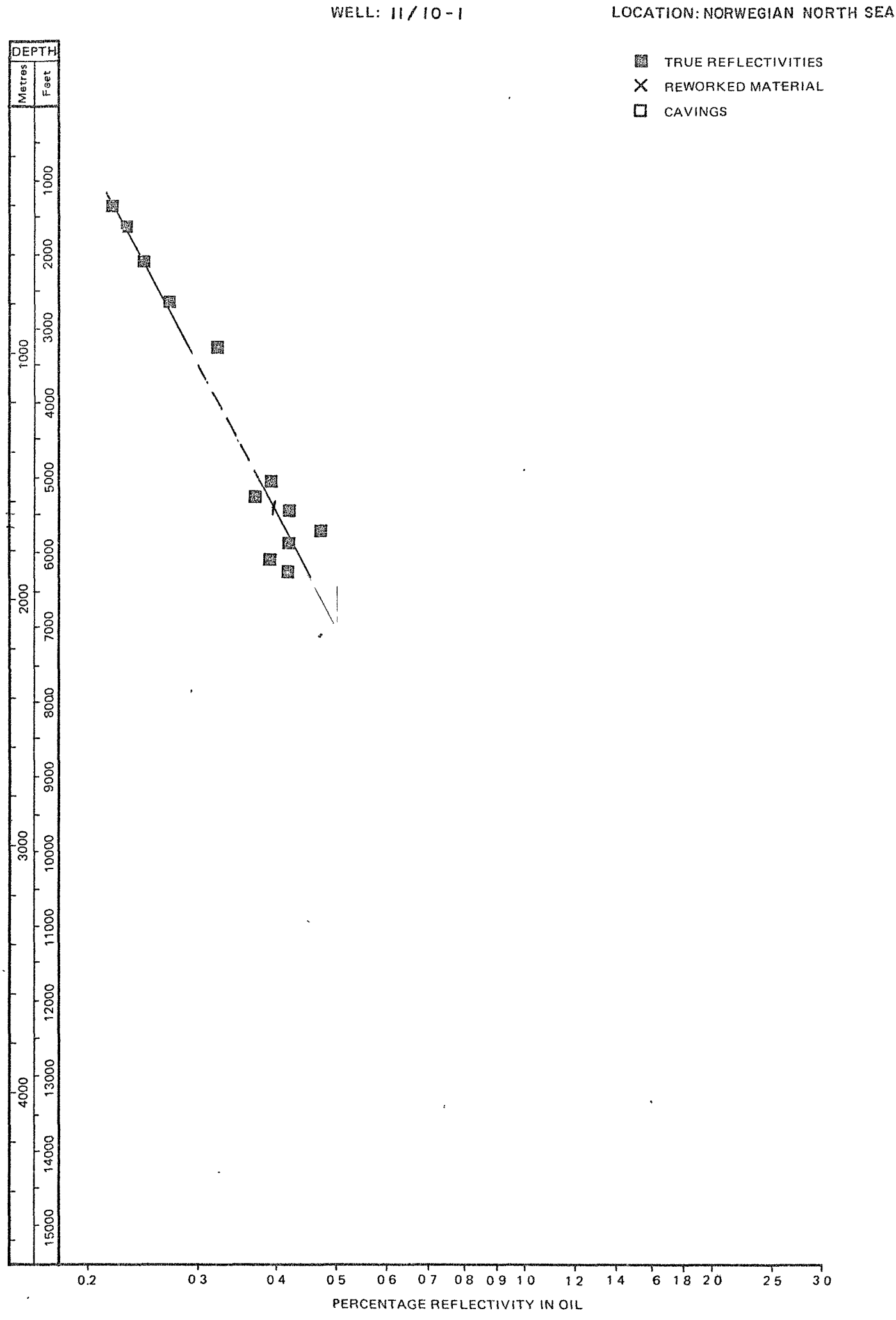
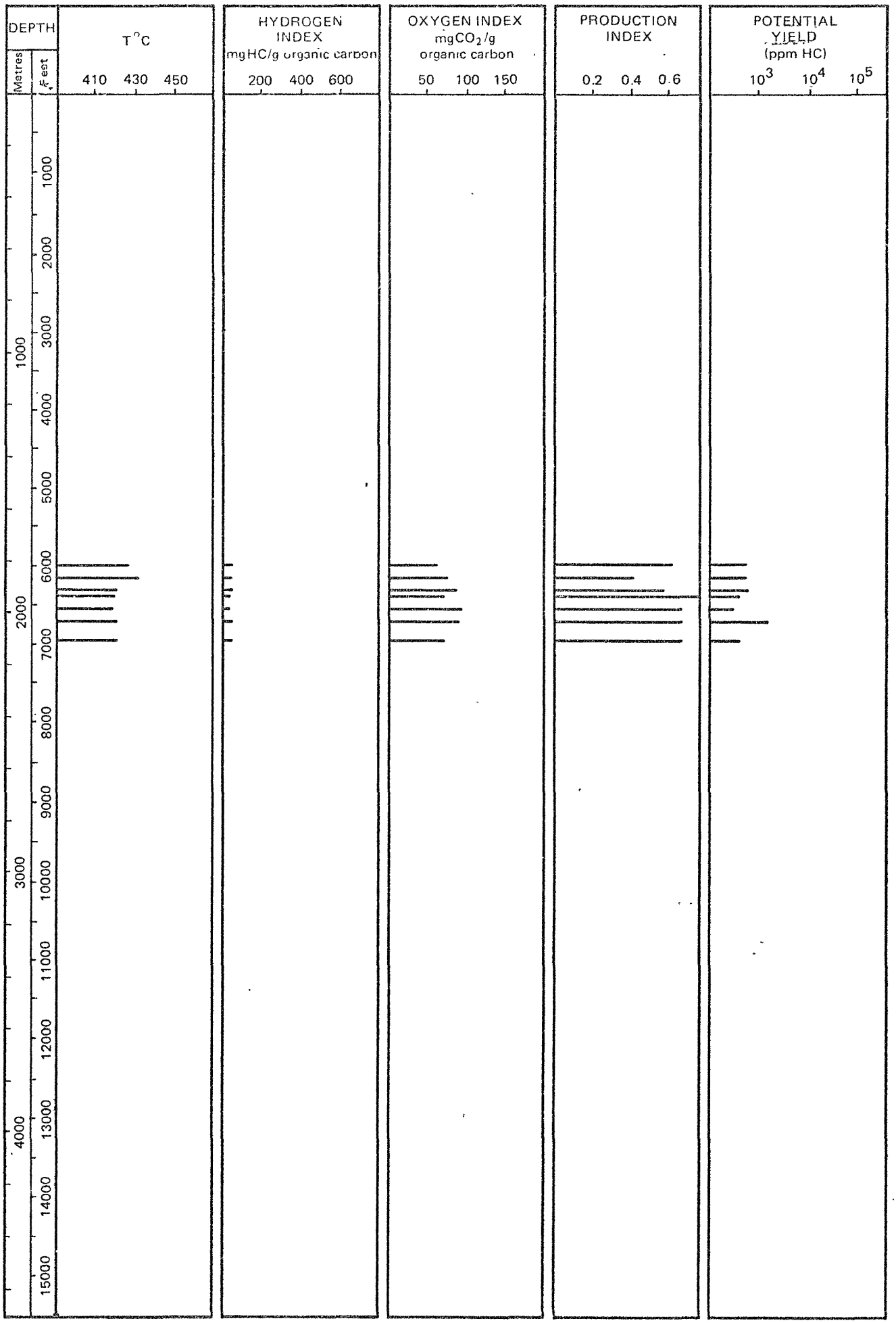


FIGURE 3 PYROLYSIS DATA SUMMARY CHART

WELL: 11 / 10 - 1 LOCATION: NORWEGIAN NORTH SEA

FIGURE 4 PYROLYSIS DATA SUMMARY CHART
PICKED LITHOLOGIES

WELL: 11 / 10-1 LOCATION: NORWEGIAN NORTH SEA



ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO.9F

Project No. RRPS/789/B/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES OF THE ESSO 16/7-1 WELL

NOVEMBER, 1978

I

INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Esso Exploration Norway 16/7-1 well. Samples were received at 30 feet intervals from 2990 to 7010 feet and were composited mostly at 60 feet intervals dependent on sample availability, lithological and log data. The composite samples were washed with cold water as necessary to remove drilling mud and air dried at 50°C.

For interpretational purposes we have had access to Gamma/Sonic and Mudlogger logs as well as to NPD Paper 6 which contains relevant data on drilling conditions etc. The principal purpose of this study is to evaluate

the maturity level of the section,although some analyses of the source potential have also been carried out in the Tertiary and Cretaceous intervals.

The analytical procedures used include organic carbon analysis on the bulk cuttings samples mostly at 60 feet intervals and also on individual lithologies where bulk samples consisted of more than one lithotype. Extractive source rock analysis has been carried out on several samples containing more than 0.5% organic carbon at varying intervals. Gas chromatographic analysis has been carried out on alkane fractions where samples contained greater than 100 ppm of hydrocarbon. Pyrolysis source rock evaluation using the IFP/Fina ROCK-EVAL apparatus has been carried out on the same samples as used for extractive analysis, on samples where insufficient material was available for extractive analysis and on samples of picked lithologies where composite samples contained more than one significant lithotype. Kerogen composition has been assessed on a semiquantitative basis, by visual estimation of the kerogen components in unsieved, unoxidised, palynological preparations.

Maturity levels have been assessed in this study using principally spore colouration analysis on sieved, unoxidised, palynological preparations and vitrinite reflectivity on kerogen concentrates. In assessing maturity level, reference may also be made to the temperatures of maximum pyrolysis rate which give useful indications of maturity level when used in conjunction with the kerogen type.

II

RESULTS AND INTERPRETATION

The results of the various analyses carried out on the 16/7-1 well are

presented in Tables 1 to 3 and are represented graphically in Figures 1 to 3. Table 1 lists data on maturity level in the section along with the kerogen composition data for the same samples. The spore colouration and vitrinite reflectivity trends with depth are shown in Figures 1 and 2 respectively. Table 2 lists the organic carbon and extractive source rock evaluation data. Pyrolysis data are presented in Table 3 and are represented graphically against depth in Figure 3. A detailed graphic presentation of all the data will be made later in the compilation report.

MATURITY DATA

Our assessment of the spore colouration data is that the Lower Cretaceous through basal Tertiary interval of the well is at an early stage of maturity where generation of low ^{o}API gravity oil would be anticipated from oil-prone organic matter (see source rock evaluation). Spore colour indices are poorly defined in the Lower Cretaceous,but there is a suggestion of an increased maturity gradient as the Permian salt is approached.

Reliable vitrinite reflectivity data have only been obtained in the Tertiary interval of the well and values are observed to rise from about 0.26% at 3300 feet to about 0.45% at the base of the Tertiary. By extrapolation, reflectivity values at the base of the Cretaceous would be around 0.5% suggesting an early stage of maturity. A few humic fragments were observed at about this level, but their identification is suspect and the assemblages were dominated by material at around 0.4% which is possibly caved from the lower Tertiary.

HYDROCARBON SOURCE POTENTIAL DATA

On the basis of the geochemical data obtained, the following breakdown of the analysed interval of the 16/7-1 well is made:

Interval 2990 to 5220 feet - This interval is represented predominantly by soft light olive-grey to olive-grey

silty mudstones with occasional darker grey silty mudstones. Organic carbon contents are generally above average throughout most of the interval at 2% to 3%, particularly between about 3500 and 4600 feet (Oligocene). Kerogen composition is predominantly vitrinitic as is confirmed by the few pyrolysis analyses carried out in this interval.

Extractive source rock evaluation has shown the presence of anomalous amounts of hydrocarbons in the two samples examined and these have an oil-like alkane distribution.

No present hydrocarbon generating potential. Good gas source at optimum maturity.

Interval 5220 to 6100 feet – Represented by green-grey and medium grey shales with about average organic carbon content. Kerogen composition is humic and apparently predominantly vitrinitic in the one sample analysed, although pyrolysis parameters indicate this interval is dominated by inertinite. Hydrocarbon potential at optimum maturity is very poor.

Extractive source rock evaluation has revealed no significant amounts of hydrocarbon being present.

This interval has no hydrocarbon generating potential at present or at optimum maturity.

Interval 6100 to 6570 feet	-	Chalk. No hydrocarbon generating potential. No trace of reservoired hydrocarbons.
Interval 6570 to 7010 feet	-	The interval from 6570 to 6840 feet is reported to be of Lower Cretaceous age overlying late Permian anhydrite, shales, silts and sands. The samples examined are contaminated by caved lower Tertiary and Cretaceous Chalk. Organic carbon content is about average, but the kerogen composition is mostly inertinitic. No significant source rocks have been identified by pyrolysis analysis, although some organically richer dark grey shales were picked from 6750 and 6920 feet.

TABLE 1 MATURITY EVALUATION DATA

WELL: 16/7-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET)	SAMPLE TYPE	GENERALISED LITHOLOGY	SPORE COLOUR INDEX (1 10)	VITRINITE REFLECTIVITY IN OIL, R av%	KEROGEN COMPOSITION (%)		
					INERTINITE	VITRINITE	SAPROPEL
2990-3050	Ctgs	Ol-gy slty mdst	2.5	-	5	95	*
3290-410	"	Ditto	2.5	0.26 (10)	5	95	*
3590-650	"	Ditto+med-dk gy mdst	-	0.28 (19)	-	-	-
3890-4010	"	Ditto+ditto	2.5-3	0.28 (17)	5	95	*
4190-310	"	Ditto+ditto	-	0.28 (8)	-	-	-
4490-610	"	Ditto	3-3.5	0.30 (12)	10	90	*
4830-920	"	Ol-gy mdst	-	0.33 (12)	-	-	-
5100-220	"	Ol-gy/med-dk gy mdst	3.5	0.36 (19)	10	90	*
5400-520	"	Gn-gy sh	-	0.40 (18)	-	-	-
5700-820	"	Ditto	3.5	0.41 (10)	10	90	*
6690-750	"	Med gy sh+gn-gy sh	4?	-	60	30	10
6880-920	"	Ditto+ditto	*	0.40 (13)	50	50	*
6980-7010	"	Ditto+ditto	4-6?	0.40 (6)	20	80	*

TABLE 2A

SOURCE ROCK EVALUATION DATA

WELL: 16/7-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) 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
2990-3050	Ctgs	Lt ol-gy/ol-gy slty mdst+mnr med-dk gy sh /mdst	0.97					
3050-110	"	Ditto+ditto	1.45					
3170-230	"	Ditto+ditto	1.93					
3230-290	"	Ditto+ditto	2.19					
3290-410	"	Ditto+ditto	2.48					
3470-530	"	Ol-gy soft slty mdst+ 40% med-dk gy mdst+ 20% gn-gy/brn-gy mdst	2.92					
3590-650	"	Ditto+ditto+mnr ditto	3.44					
3710-770	"	Ditto+ditto+mnr ditto	3.09					
3830-890	"	Ditto+ditto+mnr ditto	3.36					
3890-4010	"	Ditto+ditto+mnr ditto	3.60					
4010-070	"	Ditto+ditto+mnr ditto	3.32					
4070-130	"	Ditto+ditto+mnr ditto	2.75					
4190-310	"	Ditto+ditto+mnr ditto	2.78	3050	11.0	140	5	96
4310-370	"	Ditto+ditto+mnr ditto	2.75					
4430-490	"	Ditto+ditto+mnr ditto	2.59					
4490-610	"	Ditto+mnr med-dk gy mdst	2.81					
4610-670	"	Ol-gy soft mdst/sh+ mnr med-dk gy mdst/sh	2.33					
4770-830	"	Ditto+mnr ditto	1.74					
4830-920	"	Ditto+mnr ditto	2.17					
4980-5040	"	Ditto+mnr ditto	3.33					
5100-220	"	Ol-gy/med-dk gy mdst/ sh	3.24	3260	10.1	170	5	93
5220-280	"	Med-dk gy sh+60% ol-gy/gn-gy sh	1.30					
5340-400	"	Gn-gy sh+30% med gy sh	1.46					
5400-520	"	Ditto+ditto	1.43					
5520-580	"	Ditto+ditto	1.77					
5580-640	"	Ditto+ditto	1.75					
5700-820	"	Ditto+ditto	1.51	830	5.5	<20	*	>95
5935-980	"	Ditto+ditto+20% brn-gy sh	0.55					
5980-6040	"	Ditto+ditto+ditto	0.77					
6040-100	"	Med-dk gy/gn-gy sh+ mnr wht chk	0.80	490	6.2	20	*	>95

TABLE 2B

SOURCE ROCK EVALUATION DATA

WELL: 16/7-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT PPM	EXTRACT % OF ORGANIC CARBON	HYDRO-CARRONS PP.M OF ROCK	HYDRO-CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO-CARBONS
6100-160	Ctgs	Med gy sh+mnr gn-gy sh+20% wht chk	0.35	160	4.5	20	12	92
6520-570	"	Gy-red sh+mnr chk+mnr med gy sh	0.78					
6570-630	"	Ditto+mnr ditto+mnr ditto	1.13					
6630-690	"	Med gy sh+20% gn-gy sh+20% gy-red sh+mnr wht chk	0.77					
6690-750	"	Ditto+ditto+ditto	2.04					
6750-820	"	Ditto+ditto+ditto	1.81					
6820-880	"	Ditto+ditto+ditto	2.29					
6880-920	"	Ditto+ditto+ditto	1.30					
6920-980	"	Ditto+ditto+ditto	1.74					
6980-7010	"	Ditto+ditto+ditto	1.19					
		PICKED LITHOLOGIES						
5580-640	"	Med gy sh	3.03					
5580-640	"	Gn-gy sh	1.41					
5935-980	"	Brn-gy sh	0.85					
5935-980	"	Gn-gy sh	0.70					
5980-6040	"	Brn-gy sh	0.96					
5980-6040	"	Gn-gy sh	0.95					
6690-750	"	Med gy sh	1.40					
6690-750	"	Gy-red sh	0.37					
6690-750	"	Gn-gy sh	1.76					
6750-820	"	Med-dk gy sh	7.21					
6750-820	"	Gy-red sh	0.48					
6920-980	"	Med-dk gy sh	5.58					

TABLE 3

ROCK - EVAL. PYROLYSIS DATA

WELL: 16/7-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
4190-310	Ol-gy slty mdst+ 40% med-dk gy mdst	2.78	426	37	117	*	1000
5100-220	Ol-gy/med-dk gy mdst	3.24	425	52	182	*	1700
5700-820	Gn-gy sh+med gy sh	1.51	417	10	207	*	100
5980-6040	Ditto+ditto	0.77	*	*	150	*	*
6040-100	Med-dk gy/gn-gy sh	0.80	416	12	489	*	100
6100-160	Med gy sh	0.35	421	6	635	*	*
6630-690	Ditto	0.77	*	*	198	*	*
6690-750	Ditto	2.04	426	3	60	*	100
6820-880	Ditto	2.29	429	13	56	*	300
6980-7010	Ditto	1.19	434	14	57	*	200

TEMPERATURE (°C) = TEMPERATURE AT MAXIMUM RATE OF PYROLYSIS
PRODUCTION INDEX = AN ESTIMATE OF PRESENT HYDROCARBON GENERATING POTENTIAL COMPARED TO THAT AT OPTIMUM MATURITY
POTENTIAL YIELD = AN ESTIMATE OF HYDROCARBON PRODUCTION AT OPTIMUM MATURITY

FIGURE 1 SPORE COLOURATION INDICES AGAINST DEPTH

WELL: 16/7-1 LOCATION: NORWEGIAN NORTH SEA

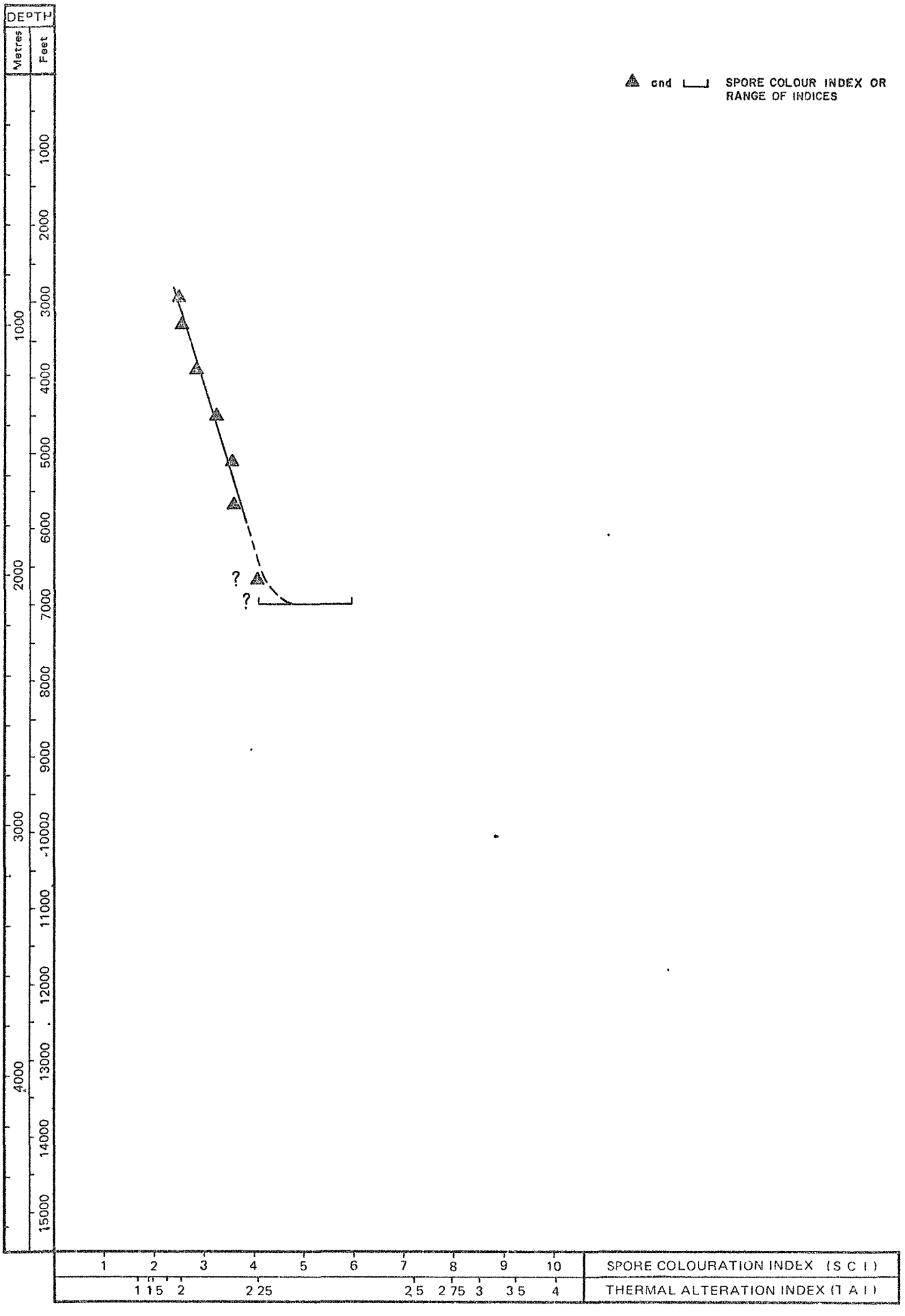


FIGURE 2 VITRINITE REFLECTIVITY AGAINST DEPTH

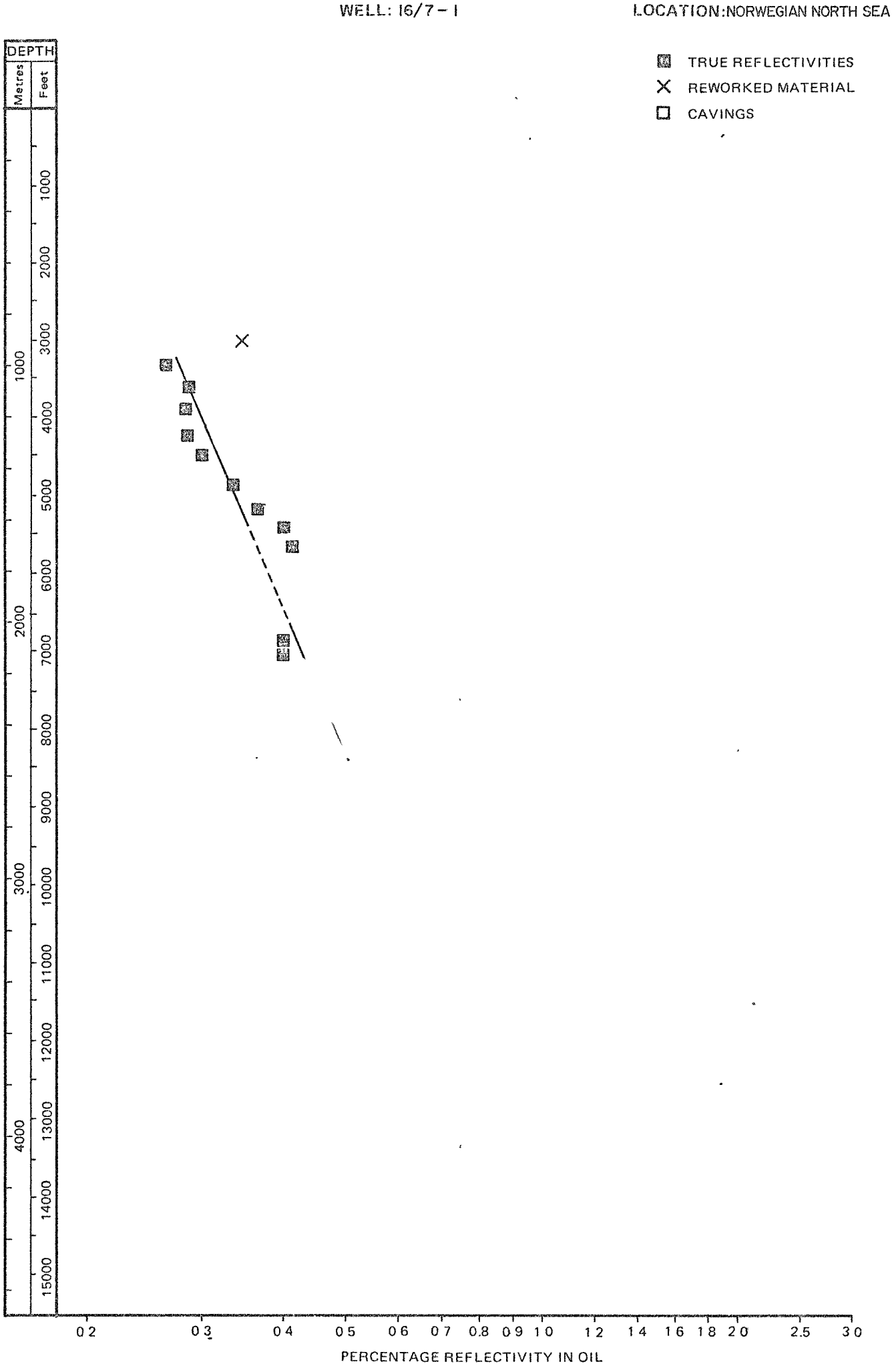
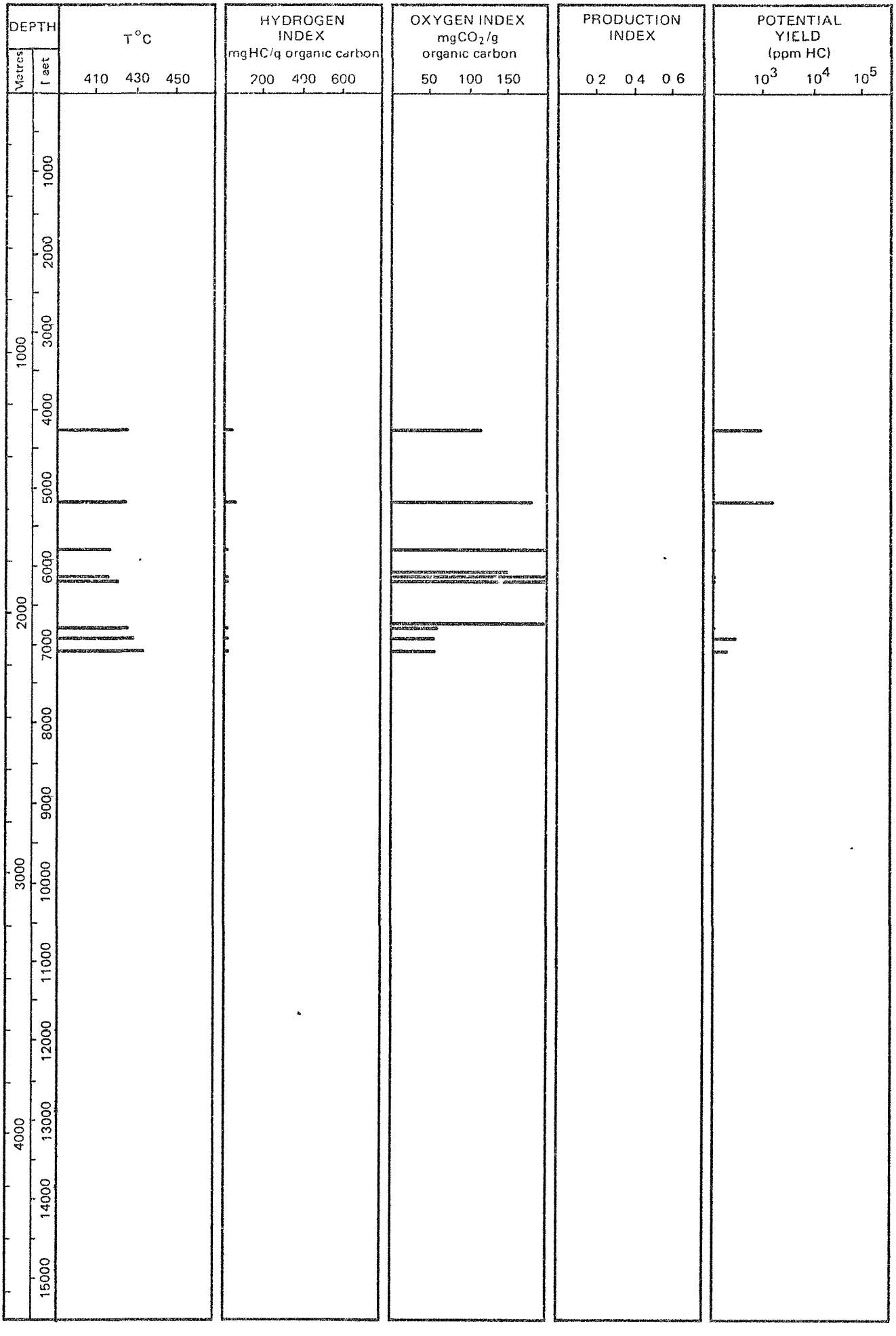


FIGURE 3 PYROLYSIS DATA SUMMARY CHART

WELL: 16/7-1 LOCATION: NORWEGIAN NORTH SEA



ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO. 9G

Project No. RRPS/789/B/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES OF THE NORSKE SHELL 17/11-1 WELL

NOVEMBER, 1978

I

INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Norske Shell 17/11-1 well. Samples were received at 30 feet intervals and compositing was started at 1000 feet in the Pliocene and was continued at 60 feet intervals, dependent on lithological and log data through to the Triassic at 8000 feet. The composite samples were washed with cold water as necessary to remove drilling mud and air dried at 50°C. The $13\frac{3}{8}$" casing was set at 3837 feet in the Upper Cretaceous Chalk with no further casing points to T.D. Caving has not caused any major problems in geochemical evaluation of the section.

Relevant information on drilling conditions and mud properties are included in N.P.D. Paper 12. As an aid to interpretation we have also had access to formation density, temperature and mudloggers logs. A sea water based drilling mud was used throughout the drilling of the well.

The analytical procedures used include organic carbon analysis on most of the bulk cuttings samples at 60 feet intervals and also on individual lithologies where bulk samples consisted of more than one lithotype. Extractive source rocks analysis has been carried out on a number of samples at varying intervals. Gas chromatographic analysis has been carried out on several alkane fractions. Pyrolysis source rock evaluation using the IFP/ Fina ROCK-EVAL apparatus,has been carried out on the same samples as used for extractive analysis and on samples of picked lithologies where composite samples contained more than one significant lithotype. Kerogen composition has been assessed on a semiquantitative basis, by visual estimation of the kerogen components in unsieved, unoxidised, palynological preparations.

Maturity levels have been assessed in this study using principally spore colouration analysis on sieved, unoxidised, palynological preparations and vitrinite reflectivity on kerogen concentrates. In assessing maturity level, reference may also be made to the temperatures of maximum pyrolysis rate which give useful indications of maturity level when used in conjunction with the kerogen type.

II

RESULTS AND INTERPRETATION

The results of the various analyses carried out on the 17/11-1 well are

presented in Tables 1 to 3 and are represented graphically in Figures 1 to 4. Table 1 lists data on maturity level in the section along with the kerogen composition data for the same samples. The spore colouration and vitrinite reflectivity trends with depth are shown in Figures 1 and 2 respectively. Table 2 lists the organic carbon and extractive source rock evaluation data. Pyrolysis data are presented in Table 3 and are represented graphically against depth in Figures 3 and 4. A detailed graphic presentation of all the data will be made later in the compilation report.

MATURITY DATA

Our assessment of the spore colouration data, is that the Lower Cretaceous and Jurassic intervals of the well are at an early stage of maturity, for generation of oil from oil-prone organic matter (see source rock evaluation). Oil-prone organic matter in the Jurassic interval would be anticipated to be capable of heavy (low ^{o}API gravity) oil generation. However, the Lower Tertiary and younger sediments are presently immature.

Vitrinite reflectivity values in the Lower Tertiary rise from about 0.26% at 2000 feet to about 0.31% at the base of the Tertiary. Reflectivity values in the Lower Cretaceous and Jurassic are mostly between 0.4% and 0.45% suggesting an early stage of thermal maturity.

HYDROCARBON SOURCE POTENTIAL DATA

On the basis of the geochemical data obtained, the following breakdown of the analysed interval of the 17/11-1 well is made:

Interval 1000 to 1860 feet - Neogene to Recent silty muds and sand/silt. Variable carbon content, organic matter, humic mostly inertinitic and immature. No source potential.

Interval 1880 to 3180 feet – Mostly medium-dark grey micaceous silty and glauconitic mudstones of Oligocene and Upper Eocene age. The sediments are organically rich at 3% to 6% carbon content, but ranging up to 10%. The organic matter is vitrinitic but immature.

No hydrocarbon generating potential at present, but could be prolific gas source at optimum maturity.

Interval 3200 to 3420 feet – Basal Tertiary green-grey mudstones with minor silt and sand and Danian chalk at the base of the interval. About average carbon content, but humic organic matter.

No hydrocarbon generating potential at present or at optimum maturity.

Interval 3440 to 4750 feet – Chalk.

No hydrocarbon generating potential.

No evidence of migrant hydrocarbons.

Interval 4800 to 6910 feet – This interval of Lower Cretaceous age is represented by mostly medium-dark grey shale with occasional minor grey-red shale and grey siltstone/sandstone. Organic carbon contents are mostly about average at around 1% to 2%, but higher values up to 6% are noted between 5680 and 6100 feet. The organic matter is almost entirely inertinite as is shown by the virtual absence of pyrolysable hydrocarbons

(potential yield).

No hydrocarbon generating potential at present or at optimum maturity.

Interval 6920 to 7260 feet – Upper Jurassic medium-dark grey shales.

Although the quality of samples received in this interval appears good, there is believed to be considerable masking of the geochemical characteristics of the "Hot" shale between 7050 and 7250 feet. The organic carbon content of the composite samples is above to well above average at 3% to 7% while picked lithologies have shown some variation.

Kerogen composition is variable,but the sample at 6920 to 980 feet is reported to contain 65% sapropel. The pyrolysis data for the composite samples show poor source potential,but picked lithologies in this interval have been identified as considerably better oil source rocks.

It is of note that in drilling the well to 8796 feet, the "Hot" shale caved extensively, as recorded by the caliper log, so that in the samples between 7340 and 7720 feet, dark grey shales have been picked and give pyrolysis data considered to indicate the maximal potential of the "Hot" shale in this well.

This interval of the well contains dark

grey shales with above average organic content. The shales are presently at an early stage of maturity and will source limited quantities of low ^{o}API gravity oil. At optimum maturity this interval will be a prolific oil source.

Interval 7270 to 8000 feet – This interval is believed to be of Triassic age and to be represented by sandstones overlying grey-red shale and siltstone. However, the samples are dominated by caved Jurassic shales which have been analysed as described above.

This interval has no hydrocarbon generating potential.

TABLE 1 MATURITY EVALUATION DATA

WELL: 17/11-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET)	SAMPLE TYPE	GENERALISED LITHOLOGY	SPORE COLOUR INDEX (1 - 10)	VITRINITE REFLECTIVITY IN OIL, R av%	KEROGEN COMPOSITION (%)		
					INERTINITE	VITRINITE	SAPROPEL
1160-220	Ctgs	Lt ol-gy mdst	1-1.5	0.23 (27)?	40	60	*
1400-460	"	Lt gy calc mdst	1.5	-	70	30	*
2120-200	"	Ditto	2.5	0.27 (4)	20	80	*
2480-540	"	Ditto	-	0.28 (14)			
2800-860	"	Ditto	2.5-3	0.27 (10)	30	70	*
3040-100	"	Gn-gy mdst+50% med-dk gy mdst	-	0.30 (5)			
3280-340	"	Ditto	2.5	0.33 (11)	30	70	*
4880-940	"	Med gy slty mdst	4	0.38 (3)	100	*	*
5200-260	"	Med-dk gy slty mdst	4.5	-	100	*	*
5520-580	"	Ditto	4	0.46 (4)	80	20	*
5830-890	"	Ditto/sh	4	0.42 (7)	90	10	*
6120-180	"	Ditto	4	0.42 (14)	90	10	*
6350-410	"	Med-dk gy mdst/sh	4	0.37 (20)	85	15	*
6570-630	"	Ditto	5	0.41 (31)	70	20	10
6780-840	"	Ditto	4-4.5	0.40 (5)	60	20	20
6920-980	"	Med-dk gy sh	4.5	0.42 (10)	30	5	65
7130-190	"	Ditto	5?	-	80	10	10
7270-330	"	Ditto	4.5-5	-	40	5	55
7420-480	"	Ditto	5	-	25	5	70
7570-630	"	Ditto	4.5-5	-	30	10	60

TABLE 2A

SOURCE ROCK EVALUATION DATA

WELL: 17/11-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) 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 % HYDRO CARBONS
1080-140	Ctgs	Lt ol-gy sl slty mdst +mnr crs snd	0.73					
1160-220	"	Ditto+ditto	1.03					
1240-300	"	Ditto+ditto	0.94					
1320-380	"	Gn-gy sl slty mdst	2.37					
1400-460	"	Lt gy calc mdst+mnr crs snd	0.78					
1560-620	"	Ditto+ditto	4.68					
1640-700	"	Ditto+ditto	1.20					
1720-780	"	Ditto+ditto	3.94					
1800-860	"	Med-dk gy mic slty glauc mdst+mnr lt gy calc mdst+mnr snd/qtz/slt	2.76					
1880-940	"	Ditto+ditto	2.82					
1960-2020	"	Ditto+ditto	4.97					
2040-100	"	Ditto+ditto	3.76	1675	4.4	65	4	93
2120-200	"	Ditto+ditto	3.07					
2220-280	"	Med-dk gy mic slty glauc mdst+mnr wht lstn+mnr lt gy snd/qtz	2.97					
2300-380	"	Ditto+ditto+ditto	3.71					
2400-460	"	Ditto+ditto+ditto	4.04					
2480-540	"	Ditto+ditto+ditto	5.94					
2560-600	"	Ditto+ditto+ditto	10.16					
2640-700	"	Ditto+ditto+mnr ditto	6.69					
2720-780	"	Ditto+ditto+mnr ditto	5.07	1435	2.8	50	3	79
2800-860	"	Ditto+ditto+mnr ditto	7.62					
2880-920	"	Ditto+ditto+mnr ditto	6.71					
2960-3020	"	Lt gn-gy mdst+50% med-dk gy mdst+mnr slt/snd	5.06					
3040-100	"	Gn-gy mdst+40% med-dk gy mic slty mdst	5.32					
3120-180	"	Ditto+ditto	2.06					
3200-260	"	Ditto+ditto	1.46	890	6.1	90	10	91
3280-340	"	Ditto+ditto	1.42					
3360-420	"	Gn-gy mdst+40% med-dk gy mic mdst+10% wht chk	0.93					

TABLE 2B

SOURCE ROCK EVALUATION DATA

WELL 17/11-1 LOCATION NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) 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 % HYDRO CARBONS
3440-500	Ctgs	Gn-gy mdst+10% wht chk	0.87	325	3.7	20	6	81
4800-4860	"	Med gy slty mic mdst +30% wht chk+med gy sltst/sst	0.77					
4880-940	"	Ditto+20% ditto	0.71					
4960-5020	"	Ditto+10% ditto	0.94					
5040-100	"	Med-dk gy sl calc soft slty mdst	1.56					
5120-180	"	Ditto	1.65					
5200-260	"	Ditto	2.40					
5280-340	"	Ditto	1.58					
5360-420	"	Ditto	2.18					
5440-500	"	Ditto	2.51					
5520-580	"	Ditto	1.96					
5600-660	"	Med-dk gy sl mic slty mdst/sh+mnr gy-red sh +mnr mod yel-brn sst	1.28					
5680-740	"	Ditto+ditto+ditto	3.55					
5760-820	"	Ditto+ditto+ditto	2.45					
5830-890	"	Ditto+ditto+ditto	2.35					
5900-960	"	Ditto+ditto+ditto	3.17	420	1.3	25	6	>90
5970-6030	"	Ditto+ditto+ditto	6.13					
6040-100	"	Ditto+ditto+ditto	6.55					
6120-180	"	Ditto+ditto+ditto	1.83					
6200-260	"	Ditto+ditto+ditto	1.78					
6275-335	"	Med-dk gy mdst/sh	1.40					
6350-410	"	Ditto	1.48					
6425-485	"	Ditto	1.26					
6500-560	"	Ditto	1.53	515	3.4	45	9	80
6570-630	"	Ditto	1.84					
6640-700	"	Ditto	1.15					
6710-770	"	Ditto	1.62					
6780-840	"	Ditto	1.91					
6850-910	"	Med gy sh+20% med-dk/ dk gy sl mic sh	1.95	595	3.1	45	8	89
6920-980	"	Med-dk gy sl mic sh+ mnr med gy mdst	3.00					
6990-7050	"	Ditto+ditto	3.17	1075	3.4	55	5	85

TABLE 2C

SOURCE ROCK EVALUATION DATA

WELL: 17/11-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) 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 % HYDRO-CARBONS
7060-120	Ctgs	Med-dk gy sl mic sh+ mnr med gy mdst	3.14					
7130-190	"	Ditto+ditto	7.17					
7200-260	"	Ditto+ditto	3.81	925	2.4	30	3	>90
7270-330	"	Ditto+ditto	4.10					
7340-400	"	Ditto+ditto	4.83					
7420-480	"	Ditto+ditto	4.06					
7490-550	"	Ditto+ditto	5.15					
7570-630	"	Med-dk gy sl mic sh+ mnr wht chk/gy-red sh/ gn-gy marl	4.22					
7650-720	"	Med-dk gy sl mic sh+ 50% gy-red sl slty sh +mnr slt/snd	2.22					
7810-880	"	Gy-red sl slty sh+40% med-dk gy sh	1.29					
7920-8000	"	Ditto+20% ditto	0.87					
		PICKED LITHOLOGIES						
6710-770	"	Med-dk gy mdst/sh	0.78					
6710-770	"	Mod yel-brn sst	0.62					
6850-910	"	Med gy sh	2.47					
6850-910	"	Dk gy sh	1.61					
6920-980	"	Med gy sh	3.98					
6920-980	"	Dk gy sh	3.98					
6990-7050	"	Med gy sh	1.81					
6990-7050	"	Dk gy sh	4.64					
7060-120	"	Med gy sh	2.84					
7060-120	"	Dk gy sh	4.18					
7130-190	"	Med gy sh	1.88					
7130-190	"	Dk gy sh	1.52					
7200-260	"	Med gy sh	2.71					
7200-260	"	Dk gy sh	2.69					
7270-330	"	Ditto	5.58					
7340-400	"	Ditto	5.24					
7420-480	"	Ditto	5.48					
7490-550	"	Ditto	5.85					
7570-630	"	Ditto	5.77					
7650-720	"	Ditto	5.88					

TABLE 3

ROCK - EVAL. PYROLYSIS DATA

WELL: 17/11-1 **LOCATION:** NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
2040-100	Med-dk gy slty mdst	3.76	411	55	165	*	2100
2720-780	Ditto	5.07	415	19	88	*	1000
3200-260	Gn-gy mdst+40%med-dk gy mdst	1.46	414	12	119	*	200
3440-500	Gn-gy mdst	0.87	416	13	188	*	100
4960-5020	Med gy slty mdst	0.94	*	*	60	*	*
5200-260	Med-dk gy soft mdst	2.40	*	*	38	*	*
5360-420	Ditto	2.18	*	*	101	*	*
5900-960	Med-dk gy slty mdst/sh	3.17	419	4	39	*	100
6040-100	Ditto	6.55	*	*	19	*	*
6500-560	Med-dk gy mdst/sh	1.53	407	7	39	*	100
6850-910	Med gy sh	1.95	427	45	33	*	900
6920-980	Med-dk gy sh	3.00	437	103	37	*	3100
6990-7050	Ditto	3.17	423	134	16	*	4300
7060-120	Ditto	3.14	425	9	75	*	300
7130-190	Ditto	7.17	*	*	20	*	*
7200-260	Ditto	3.81	424	78	58	*	2200
	PICKED LITHOLOGIES						
6850-910	Med gy sh	2.47	434	35	66	*	900
6850-910	Dk gy sh	1.61	435	38	78	*	600
6920-980	Ditto	3.98	434	217	34	*	8600
6990-7050	Med gy sh	1.81	436	114	55	*	2100
6990-7050	Dk gy sh	4.64	432	221	37	*	10200
7060-120	Ditto	4.18	432	159	39	*	6700
7130-190	Med gy sh	1.88	*	*	74	*	*
7130-190	Dk gy sh	1.52	*	*	82	*	*
7200-260	Med gy sh	2.71	*	*	66	*	*
7200-260	Dk gy sh	2.69	425	4	96	*	100
7270-330	Ditto	5.58	426	81	36	*	4600
7340-400	Ditto	5.24	426	269	54	*	14100
7420-480	Ditto	5.48	425	275	52	*	15100
7490-550	Ditto	5.85	426	350	63	*	20500
7570-630	Ditto	5.77	432	336	19	*	19400
7650-720	Ditto	5.88	424	237	55	*	13900

TEMPERATURE (°C) = TEMPERATURE AT MAXIMUM RATE OF PYROLYSIS
PRODUCTION INDEX = AN ESTIMATE OF PRESENT HYDROCARBON GENERATING POTENTIAL COMPARED TO THAT AT OPTIMUM MATURITY
POTENTIAL YIELD = AN ESTIMATE OF HYDROCARBON PRODUCTION AT OPTIMUM MATURITY

FIGURE 1 SPORE COLOURATION INDICES AGAINST DEPTH

WELL: 17/11-1 LOCATION: NORWEGIAN NORTH SEA

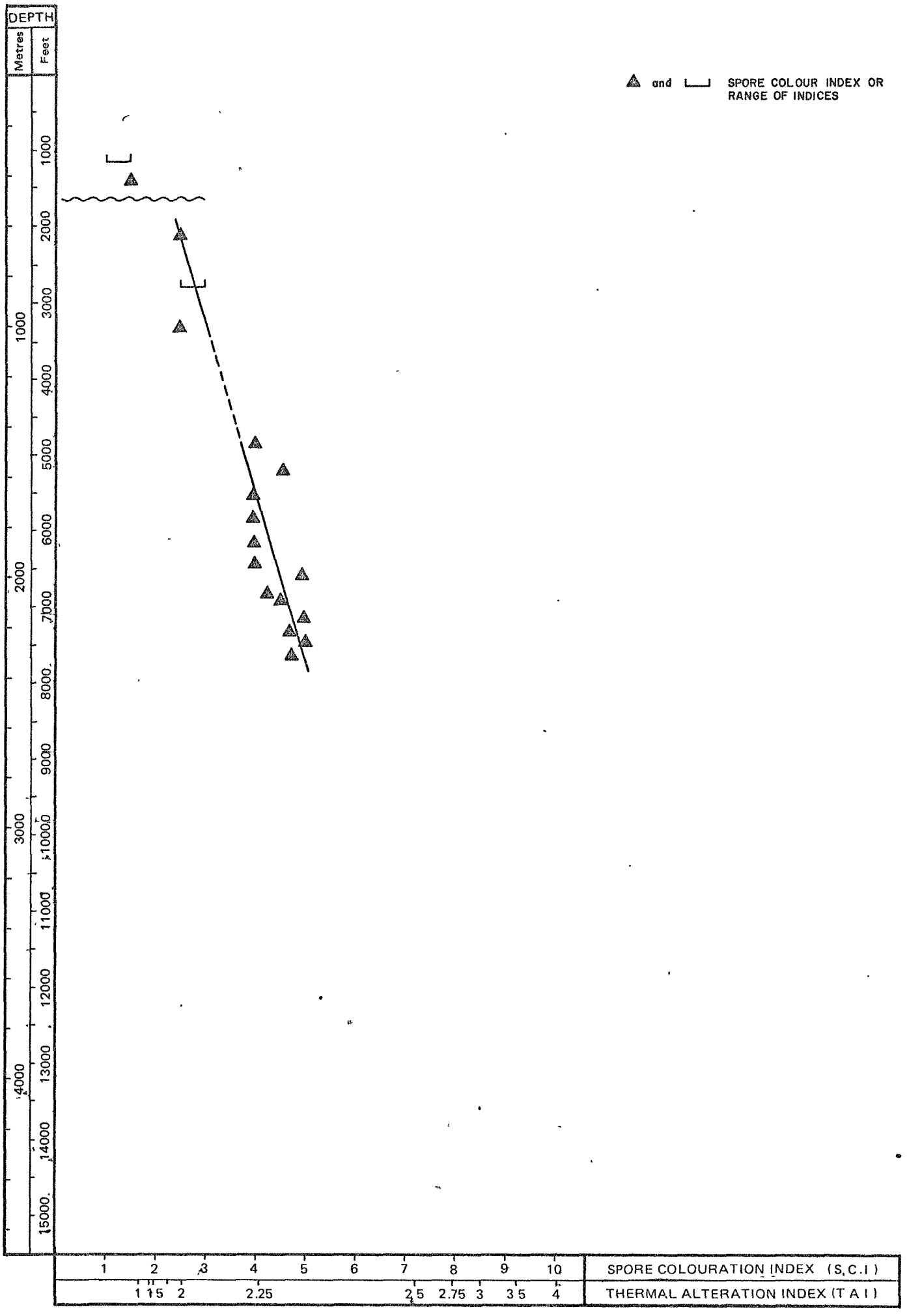


FIGURE 2 VITRINITE REFLECTIVITY AGAINST DEPTH

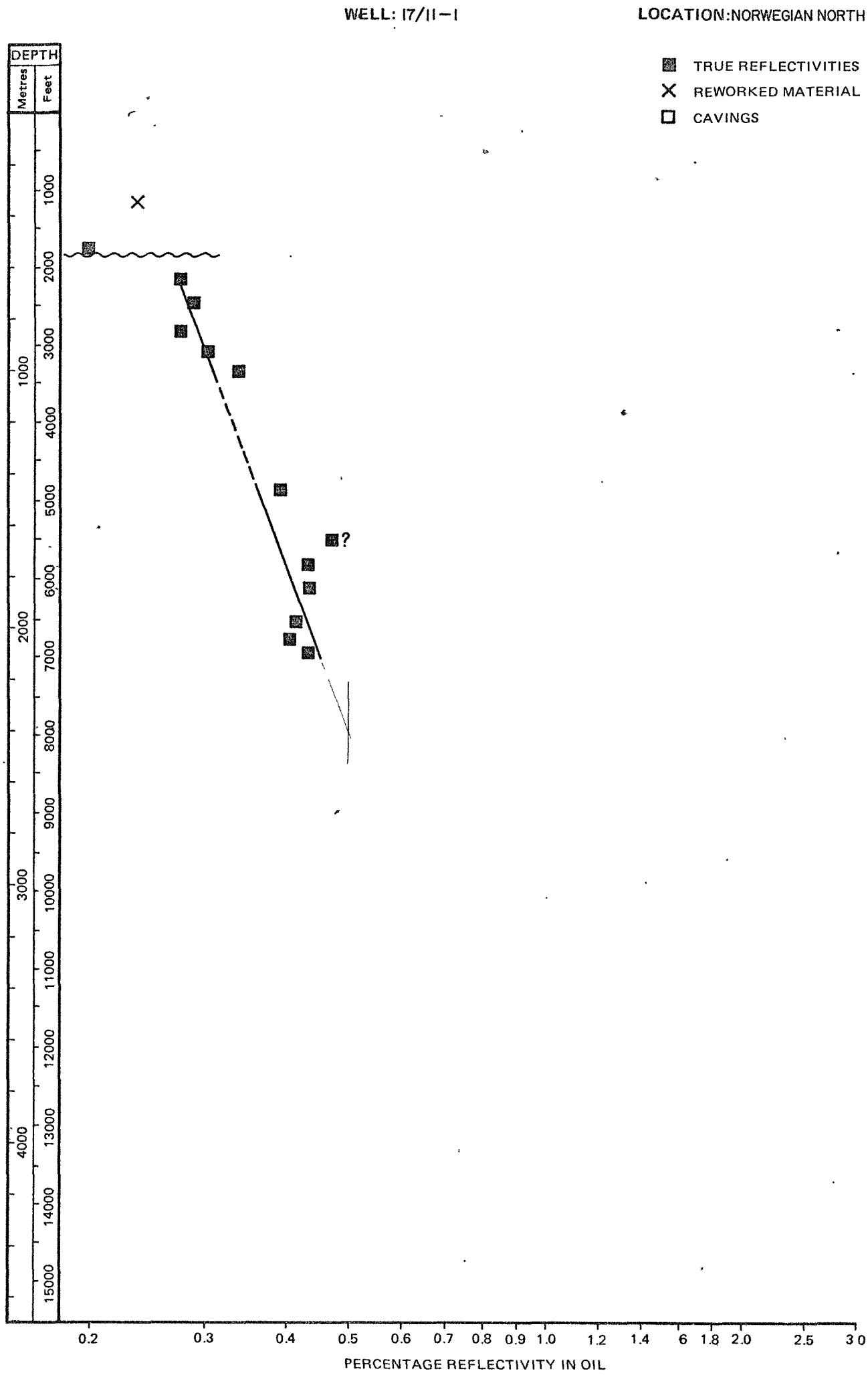


FIGURE 3 PYROLYSIS DATA SUMMARY CHART

WELL: 17 / 11 - 1 LOCATION: NORWEGIAN NORTH SEA

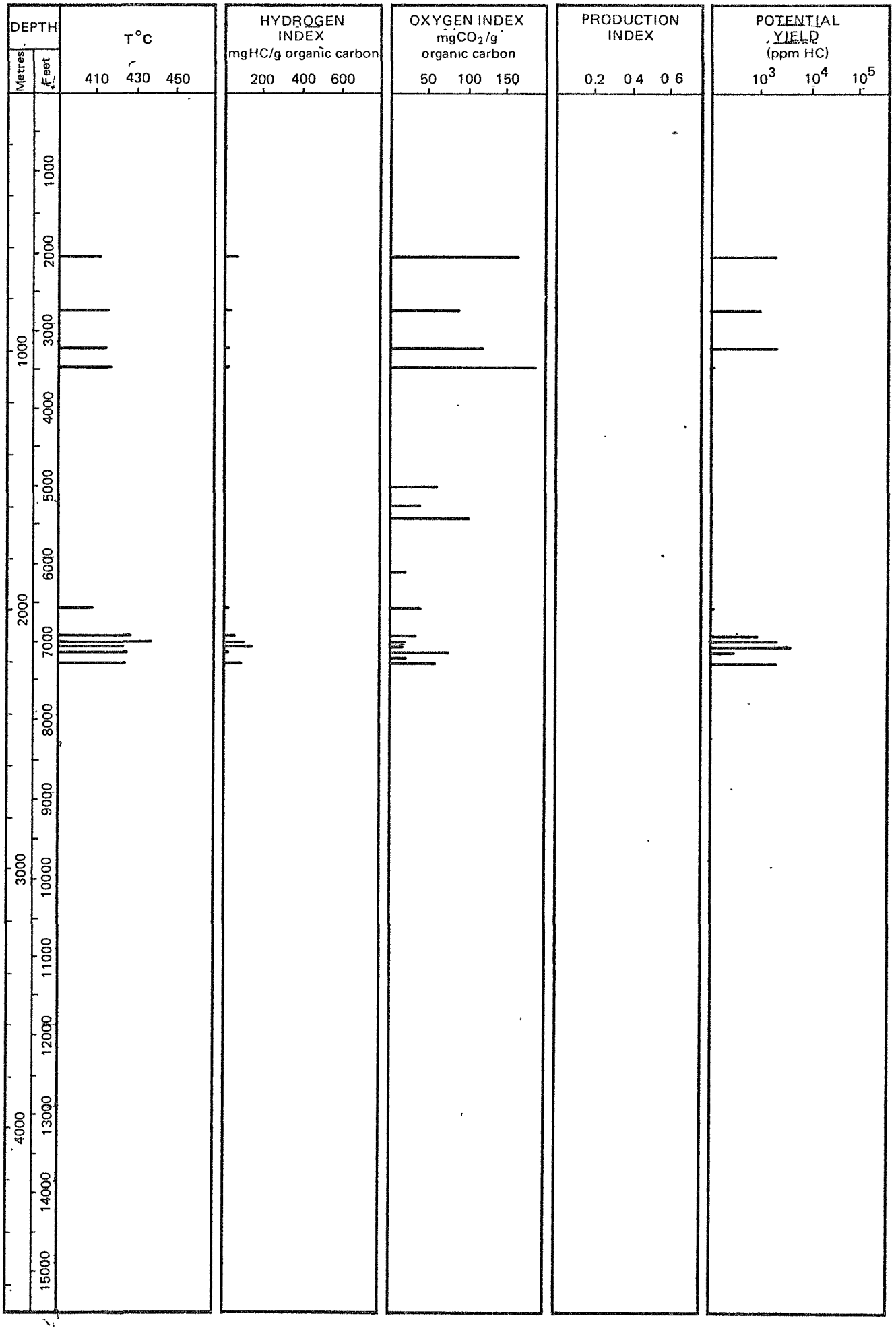
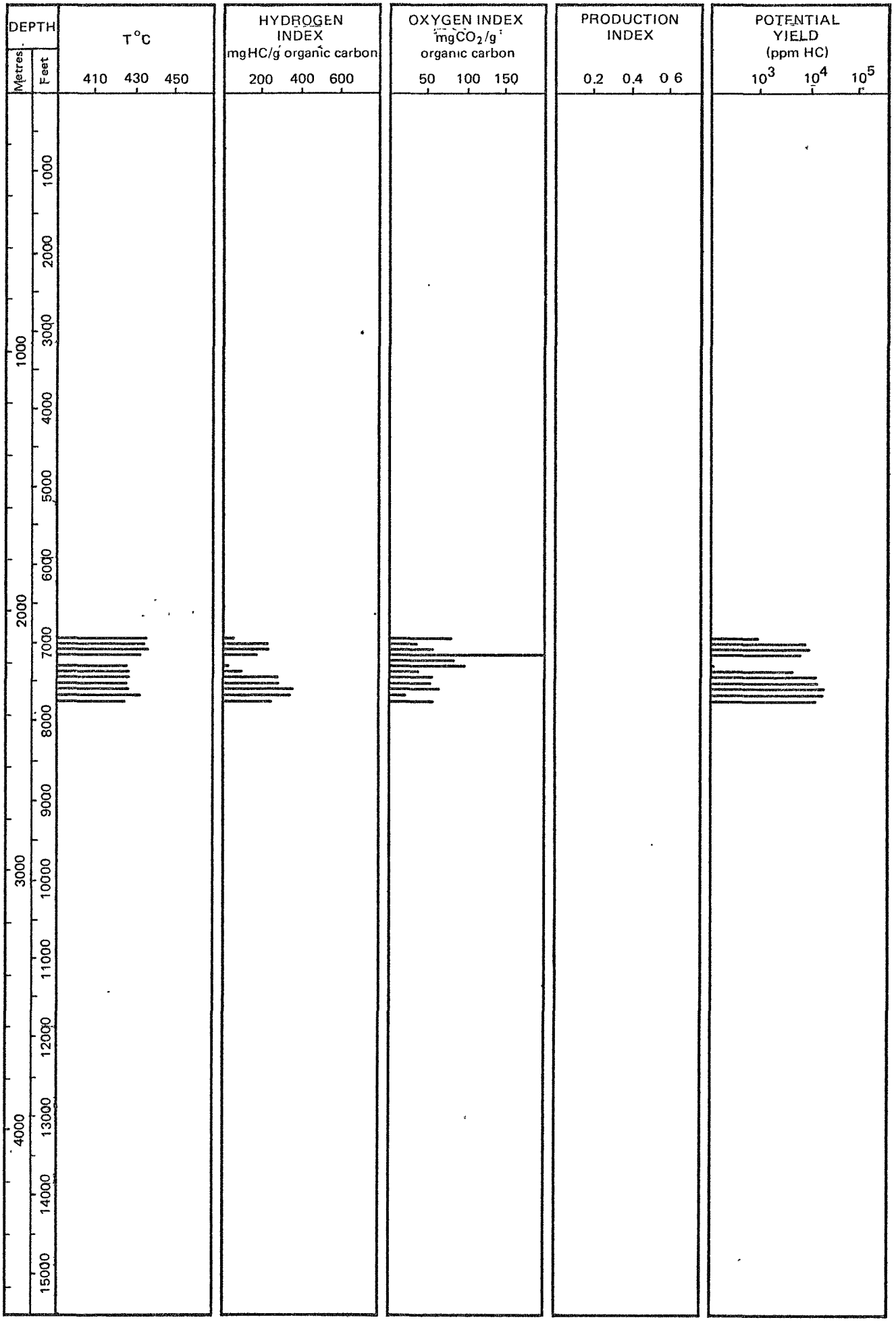


FIGURE 4 PYROLYSIS DATA SUMMARY CHART
PICKED LITHOLOGIES

WELL: 17 / 11 - 1 LOCATION: NORWEGIAN NORTH SEA



ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO. 9H

Project No. RRPS/789/B/2676

PRELIMINARY RESULTS OF BIOSTRATIGRAPHIC STUDIES OF THE ESSO 16/9-1 WELL

November 1978

I

BIOSTRATIGRAPHIC BREAKDOWN

A complete breakdown of the Tertiary, Cretaceous and Jurassic sections of this well has been made, although only the Lower Cretaceous - Jurassic interval has been studied in detail. This breakdown may be subject to modification on completion of the project.

Tops (in feet)	
1350	Pleistocene
1500	Pliocene
2130	Upper Miocene

Tops (in feet)	
2430	Middle - Lower Miocene
3060	Oligocene
3900	Oligocene - ?Eocene
4035	Lower Eocene
4320	Palaeocene
4640	Danian
4680	late Maastrichtian
4700	Maastrichtian
5040	early Maastrichtian
5360	Campanian
5560	Santonian
5640	Coniacian - Turonian
5990	?Cenomanian
6000	?Albian
6020	early Albian - Aptian
6636	Barremian
6760	Hauterivian
7040	Hauterivian - Valanginian
7334	Valanginian
7519	early Valanginian
7540	Ryazanian - late Volgian
7652	middle Volgian
7740	Top Triassic (based on lithology)

II

LITHOLOGICAL COMMENTS

The Cainozoic in this well is dominated by clays and shales. Of particular note is the presence of greenish grey calcareous shales in the Lower Eocene, with Balder Formation tuffs and Sele and Lista Formations shales beneath. The Danian and Upper Cretaceous consists of white chalk except in the basal 50' where grey and pink marly glauconitic limestones occur. This section may be a condensed sequence encompassing the Plenus Marl and Hidra Formations with possibly a thin Rødby Formation below. The Valhall Formation is dominated by grey shales, but red calcareous horizons occur at 6300' and again at 7450'. There is also a silty shale/siltstone section between 6600' and 6700'. A distinct log break at 7520' marks the top of the Bream Formation which consists of 'hot' grey and black shales. Another distinct log break at 7740' marks the incoming of pebbly non-marine sandstones of the Triassic Skagerrak Formation.

III

MICROPALAEONTOLOGICAL COMMENTS

Microfaunas throughout the Cainozoic are poor to moderate in numbers and diversity. As in other wells in this area the Oligocene - Eocene boundary is the most difficult to identify. Preliminary examination would seem to indicate that this boundary has no palaeontological expression in many wells where the palaeoenvironment was deep water with predominantly agglutinating assemblages.

In the Upper Cretaceous moderate microfaunas occur which suggest that the Campanian - Santonian interval is thin and may be a condensed section. The base of the Upper Cretaceous is poorly defined, although the palaeontological evidence suggests that the Upper - Lower Cretaceous boundary area is also a complete but condensed section. The Lower Cretaceous sediments contain well-preserved microfaunas which suggest that a relatively complete section is present.

The top of the Bream Formation is marked by a distinct microfaunal break with the appearance of assemblages dominated by agglutinating foraminifera which continue to the base of the Jurassic section.

IV

PALYNOLOGICAL COMMENTS

The Lower Cretaceous yielded rich and diverse palynologic assemblages which are dominated by marine dinocysts. This interval appears to be complete, although it is impossible to accurately define the Jurassic - Cretaceous boundary and possibly some of the Ryazanian could be absent. The Volgian, as usual, is poorer in palynomorphs and rich in amorphous kerogen. A well-defined middle Volgian interval, however, can be identified above the sands, but older diagnostic Jurassic palynomorphs are absent.