ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PERLIMINARY REPORT NO. 5A

Project No. RRPS/789/B/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES OF THE CONOCO NORWAY 8/12-1 WELL

18th August, 1978

BA 78-0160-1

I

INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Conoco Norway 8/12-1 well. The samples were received at varying intervals and were selected for analysis by compositing at 90 or 60 feet intervals dependent on lithological and log data. After compositing, samples were washed with cold water as necessary to remove drilling mud, and air dried at 50°C. No core samples are yet available from this well section although access is being sought and results may be available at a later date.

The well was drilled using a water based drilling mud throughout. Diamond drilling bits were used intermittently in the Lower Cretaceous and Triassic.

The samples were of good quality for geochemical analysis. Compositing was started at 2780 feet so that representative material of Miocene age and older has been analysed. 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 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 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 8/12-1 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

while pyrolysis data are presented in Table 3. Pyrolysis data are represented graphically against depth in Figures 3 and 4. A detailed graphic presentation of all the data will be available later in the compilation report.

MATURITY DATA

Our assessment of the spore colouration data is that the Lower Tertiary sediments in the interval below about 5000 feet are at an early stage of maturity for oil generation given the presence of oil-prone organic matter (see source rock evaluation). No reliable spore colour data have been obtained in the Lower Cretaceous interval but spore colour values in the Upper Jurassic seem to indicate a maturity gradient which is continuous with that in the Tertiary. The Upper Jurassic Kimmeridgian rocks have spore colours which indicate that sapropelic organic matter would be capable of sourcing low ^{o}API gravity oils. Extrapolation of the spore colouration gradient indicates that a considerable thickness of later Tertiary sediments is missing; this could be in excess of 3000 feet.

Vitrinite reflectivity data give a trend rising from about 0.30% at 3000 feet to about 0.4% at the base of the Tertiary. A value of 0.35%, which we consider can indicate the onset of maturity for oil generation in a Tertiary basin, has therefore already been reached in the analysed interval of the Tertiary. The reflectivity level in the Lower Cretaceous is poorly defined as little clearly identified vitrinite was seen in this interval. However, in the Jurassic interval carbonaceous shales and coals have given values of around 0.5%. In the Triassic interval values of around 0.5% have probably been obtained on caved Jurassic material.

HYDROCARBON SOURCE POTENTIAL DATA

On the basis of the geochemical data obtained, the following breakdown of the analysed interval of the 8/12-1 well is made:

Interval 2780 to 6180 feet - Interval is represented by variously coloured green-grey, medium grey and brown-grey shales and mudstones with well above average organic

carbon content (typically 4% to 5%) although the base of the Tertiary section below about 5300 feet is rather leaner but with carbon contents still mostly above average.

On the basis of visual kerogen examination and pyrolysis data it is clear that the interval contains predominantly vitrinitic organic matter and at present levels of maturity no significant quantities of hydrocarbons can be generated. However many of the samples contain significant amounts of solvent extractable hydrocarbons particularly between 4880 and 6140 feet. Pyrolysis production indices are also high in this interval. Gas chromatographic analysis has shown these hydrocarbons to be oil-like in alkane distribution. The hydrocarbons are clearly not indigenous and represent either contamination by diesel or perhaps more likely represent traces of migrant oil. It is notable that significant amounts of gas were recorded during drilling through a large part of the Tertiary interval of this well.

Interval 6240 to 7530 feet - Chalk - organically lean with no hydrocarbon source potential.

Interval 7540 to 8530 feet - Lower Cretaceous - consists of varicoloured marls with caved chalk in the upper part of the interval down to 7690 feet but consists predominantly of medium and medium-dark grey shales below this depth. The organic carbon

content is variable but generally low in the upper part but is more uniform and about average in the lower part. The organic matter appears to be predominantly inertinite throughout this interval and pyrolysis analysis indicates no significant source potential.

Extractive source rock evaluation has again showed the presence of migrant hydrocarbons and gas chromatography has shown them to have an oil-like composition.

Interval 8540 to 8920 feet - Upper Jurassic (?) - the samples analysed consist of medium-dark grey shale with slightly above average organic carbon content. Significant amounts of sapropel were recorded at 8540-600 feet but other samples analysed were predominantly humic. Pyrolysis data suggest poor source potential. Hydrocarbon content by solvent extraction is fair and the sample at 8540-600 feet may have minor oil generating potential. However gas chromatography indicates that contamination by migrant oil is more likely.

Interval 8940 to 9190 feet - Jurassic (?) - the samples analysed consist of mostly medium-dark grey shale with occasional siltstone, sand and marl. Organic carbon contents are well above average but the organic matter appears mostly humic. It is notable that a dark grey shale picked from a sample at 9080-120 feet seems to have a significant sapropel content on the basis of the pyrolysis data with above average

carbon content (3.56%) but whether these shales cuttings are in situ is not clear. Gas chromatography of the alkanes from this interval has shown that the hydrocarbons may be indigenous to the formation which is at an early stage of maturity.

Interval 9200 to 9420 feet - This interval is reported to be of Triassic age but the samples analysed appear to be dominated by grey shales and occasional coal which are believed to be caved. These samples have been analysed but the results are not considered representative of the section. The true source potential of the interval is expected to be very limited.

PCB/Eml.
18th August, 1978

TABLE 1 MATURITY EVALUATION DATA

WELL: 8/12-1 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
2780- 840	Ctgs	Ol-gy mdst	.2.5-3	0.29(10)	10	90	*
2900- 980	"	Ditto	2.5-3	0.30(3)	20	80	*
3290- 350	"	Ol-gy/dk gy sh	3	0.28(18)	10	90	*
3560- 620	"	Ditto	3	0.31(17)	10	90	*
3880- 940	"	Ditto	3	0.32(3)	20	80	*
4200- 260	"	Lt ol-gy mdst	3	0.34(23)	5	95	*
4520- 580	"	Ditto	3-3.5	0.33(7)	5	95	*
4840- 900	"	Ditto	3.5	0.35(22)	10	90	*
5150- 210	"	Ditto	3-3.5	0.38(15)	20	80	*
5370- 430	"	Ditto	3-3.5	0.35(20)	20	80	*
5580- 640	"	Ditto	3-3.5	0.38(15)	10	90	*
5800- 850	"	Ditto	3.5	0.40(15)	20	80	*
6010- 070	"	Ditto	3.5	*	20	80	*
6150- 180	"	Med-lt gy calc mdst	3.5	*	25	70	5
7110- 170	"	Chalk	3-3.5	*	30	70	*
7540	"	Med-dk gy mdst/sh	3.5	*	60	35	5
7700- 760	"	Med gy sh	3.5	*	85	15	*
7970-8030	"	Med-dk gy sh	3.5-4	0.46(3)	85	15	*
8250- 310	"	Ditto	3.5	*	90	10	*
8400- 450	"	Ditto	3.5	0.50(8)	80	20	*
8540- 600	"	Ditto	3.5-4	0.47(6)	45	10	45
8680- 720	"	Med-dk gy sh	3.5-4	0.46(7)	70	10	20
8810- 870	"	Ditto	4	0.52(12)	70	20	10
9010- 070	"	Ditto + gy-red sh	4?	0.50(43)	70?	10?	20?
9200- 260	"	Ditto + ditto	4?	0.48(50)	70?	10?	20?
9340- 400	"	Coaly sh	-	0.51(28)	-	-	-
9410- 420	"	Med dk gy sh + gy-red sh	4?	0.49(11)	45?	10?	45?

TABLE 2A

SOURCE ROCK EVALUATION DATA

WELL: 8/12-1 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
2870- 840	Ctgs	Ol-gy mdst	3.60	1200	3.3	<20	*	*
2870	"	Lt ol-gy/gn-gy dol	0.99	530	5.4	35	7	>95
2900- 960	"	Ol-gy mdst + 30% dk gy sh	4.31					
2980	"	Ditto + 10% ditto	2.36					
3110- 170	"	Dk gy sh + 10% ol-gy mdst	5.30	1815	3.4	<20	*	*
3200- 260	"	Ol-gy/dk gy sh	5.38					
3290- 350	"	Ditto	5.63					
3380- 440	"	Ditto	5.28	2695	5.1	<20	*	*
3470- 530	"	Ditto	5.00					
3560- 620	"	Ditto	4.49					
3650- 700	"	Ol-gy/dk gy mdst	4.16					
3720- 780	"	Ditto	3.78	1470	3.9	120	8	>95
3800- 860	"	Ditto	4.76					
3880- 940	"	Ditto	4.88					
3960-4020	"	Ditto	4.37					
4040- 100	"	Ditto	3.94	1150	2.9	45	4	>95
4120- 180	"	Lt ol-gy/ol-gy mdst + mnr dk gy sh	3.67					
4200- 260	"	Ditto	3.83					
4280- 340	"	Ditto	4.01					
4360- 420	"	Ditto	4.06	1270	3.1	70	6	>95
4440- 500	"	Ditto	4.74					
4520- 580	"	Ditto + 10% dk gy sh	5.47					
4600- 660	"	Ditto	4.80					
4680- 740	"	Ditto	5.72	2420	4.2	450	19	>95
4760- 820	"	Ditto	6.26					
4840- 900	"	Ditto	6.33					
4920- 980	"	Ditto	6.31	4600	7.5	595	13	>95
5000- 060	"	Ditto	5.76					
5080- 140	"	Ditto	5.39					
5150- 210	"	Ditto	4.95					
5230- 290	"	Lt ol-gy/gn-gy slty mdst + mnr dk gy sh	4.09	2650	6.5	405	15	>95
5300- 360	"	Ditto	2.85	2460	8.6	435	17	>95

TABLE 2B

SOURCE ROCK EVALUATION DATA

WELL 8/12-1 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
5370- 430	Ctgs	Lt ol-gy/gn slty mdst + mnr dk gy sh	2.78					
5440- 500	"	Ditto	3.10					
5510- 570	"	Ditto	3.52					
5580- 640	"	Ditto	3.49	3250	9.3	695	21	>95
5650- 710	"	Ditto	3.18					
5720- 790	"	Ditto	2.38					
5800- 860	"	Ditto	2.43					
5870- 930	"	Ditto	2.07	1740	8.4	380	22	>95
5940-6000	"	Ditto	2.67					
6010- 070	"	Ditto	2.78					
6080- 140	"	Med-lt gy calc mdst	1.63	1260	7.6	195	16	>95
6150- 180	"	Ditto	1.56					
6240- 260	"	Chalk + mnr med gy sh	1.23	635	5.2	70	11	>95
6270- 290	"	Ditto	0.64					
6300- 310	"	Wht chk	0.46					
6320- 380	"	Ditto	0.13					
6390- 450	"	Ditto	0.14					
6460- 520	"	Ditto						
6530- 580	"	Ditto						
6600- 660	"	Ditto						
6670- 730	"	Ditto						
6740- 800	"	Ditto	0.49					
6810- 870	"	Ditto	0.28					
6900- 960	"	Ditto	0.36					
6970-7030	"	Ditto	0.42					
7040- 100	"	Ditto	0.78					
7110- 170	"	Ditto + mnr marl	2.84					
7180- 240	"	Ditto	0.68					
7260- 320	"	Ditto	0.96					
7330- 390	"	Ditto	0.50					
7400- 460	"	Ditto	1.13					
7470- 530	"	Ditto + 50% lt gy marl	0.75					
7540	"	Med-dk gy mdst/sh + 20% lt gy marl	2.77					

TABLE 2C

SOURCE ROCK EVALUATION DATA

WELL 8/12-1 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
7550- 610	Ctgs	Lt gy calc sh/marl	0.54					
7620- 650	"	Chalk + mnr med gy sh + mnr lt gy sltst	1.92					
7660- 690	"	Lt gy-red/yel-gy calc sh/marl + mnr med gy sh	2.27					
7700- 760	"	Med gy sh + 20% lt gy -red/yel-gy calc sh	1.04					
7770- 830	"	Ditto + 20% ditto	1.80					
7840- 900	"	Med-dk gy sh + 10% yel -brn marl	1.83	2710	14.8	530	19	>95
7910- 960	"	Ditto	1.32					
7970-8030	"	Ditto	1.89					
8040- 100	"	Ditto	1.78	2190	12.3	475	22	>95
8110- 170	"	Ditto	1.41					
8180- 240	"	Med/med-dk gy calc sh	1.45	1860	12.8	315	17	>95
8250- 310	"	Ditto	1.25					
8330- 390	"	Med/med-dk gy sh	1.18					
8400- 460	"	Ditto	1.57	1460	9.3	350	24	94
8470- 530	"	Ditto	1.73					
8540- 600	"	Ditto	2.33	1720	9.4	230	13	96
8610- 660	"	Ditto	2.11					
8680- 720	"	Ditto	2.56					
8730- 800	"	Ditto	5.10	6410	12.6	140	2	83
8810- 870	"	Ditto	2.20					
8880- 920	"	Med-dk gy sh + 10% chk + mnr gy-red sh + mnr coal?	3.36					
8940-9000	"	Ditto	6.27					
9010- 070	"	Ditto	4.62					
9080- 120	"	Ditto	2.73	2195	8.0	70	3	85
9130- 190	"	Med-dk gy sh+pale brn sltst + mnr marl + mnr snd	2.93	1535	5.2	45	3	84
9200- 260	"	Med-dk gy sh + 40% med gy sltst/sst + tr coal	5.20					
9270- 330	"	Ditto	1.42					

TABLE 2D

SOURCE ROCK EVALUATION DATA

WELL: 8/12-1 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
9340- 400	Ctgs	Med-dk gy sh + 40% med gy sltst/sst + tr coal	2.84					
9410- 420	"	Ditto	1.88					
		PICKED LITHOLOGIES						
3110- 170	"	Dk gy sh	5.50					
3800- 860	"	Ditto	3.12					
4520- 580	"	Ditto	4.80					
5230- 290	"	Ditto	4.20					
5230- 290	"	Lt ol-gy/gn-gy mdst	2.46					
6240- 260	"	Med gy sh	1.48					
6530- 580	"	Chalk	0.37					
7620- 650	"	Med gy sh	1.11					
7770- 830	"	Med/dk gy sh	1.22					
7770- 830	"	Lt yel-gy marl	0.28					
8110- 170	"	Med/dk gy sh	0.86					
8110- 170	"	Gy-red sh	0.70					
8730- 800	"	Med/med-dk gy sh	2.62					
9080- 120	"	Med/dk gy sh	3.82					
9270- 330	"	Ditto	3.56					
9270- 330	"	Brn sltst	0.37					

TABLE 3A

ROCK - EVAL. PYROLYSIS DATA

WELL: 8/12-1 **LOCATION:** NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
2780- 840	Ol-gy mdst	3.82	422	29	130	*	1100
2870	Lt ol-gy dol	1.45	*	*	77	*	*
2900- 960	Ol-gy mdst	4.31	419	28	53	0.6	1200
3110- 170	Dk gy sh	5.31	413	40	50	*	2150
3380- 440	Ol-gy/dk gy sh	5.66	415	10	144	*	590
3720- 780	Ditto	4.37	418	13	83	*	560
4040- 100	Ditto	4.06	423	21	79	*	850
4360- 420	Lt ol-gy/ol-gy mdst	4.22	427	13	73	*	540
4680- 740	Ditto	6.47	425	117	52	0.5	1580
4920- 980	Ditto	5.99	429	42	68	0.6	2500
5230- 290	Ditto	4.29	413	8	58	0.3	400
5300- 360	Lt ol-gy/gn-gy slty mdst	2.73	417	10	76	0.8	272
5580- 640	Ditto	3.46	428	30	46	0.6	1000
5870- 930	Ditto	2.14	420	3	37	0.9	100
6080- 140	Med-lt gy calc mdst	1.58	428	4	79	0.9	100
6150- 180	Ditto	1.56	419	5	48	0.8	100
6460- 520	Chalk	0.13	*	*	585	*	*
7540	Med-dk gy mdst/sh	2.77	424	33	70	0.7	900
7700- 830	Med gy sh	1.04	*	*	171	*	*
7840- 900	Med-dk gy sh	2.11	*	*	81	*	*
8040- 100	Ditto	2.48	*	*	61	*	*
8180- 240	Med/med-dk gy sh	1.36	*	*	117	*	*
8330- 390	Ditto	1.18	419	10	84	0.9	100
8400- 460	Ditto	1.96	425	14	55	*	300
8540- 600	Ditto	2.76	431	44	58	0.3	1200
8730- 800	Ditto	3.78	429	102	42	0.1	3900
8880- 920	Ditto	3.36	428	27	5	0.2	900
8940-9000	Med-dk gy sh	6.27	431	77	32	0.2	4800
9080- 120	Ditto	2.34	434	110	42	0.04	2600
9130- 190	Med-dk gy sh/ sltst	6.49	433	63	13	0.02	4100

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: 8/12-1 **LOCATION:** NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
	PICKED LITHOLOGIES						
3110- 170	Dk gy sh	5.50	416	61	108	*	3400
3800- 860	Ditto	3.12	419	55	246	*	1700
4520- 580	Ditto	4.80	428	54	304	0.05	2600
5230- 290	Ditto	4.20	423	36	306	0.2	1500
5230- 290	Lt ol-gy/gn-gy mdst	2.46	*	*	205	*	*
6240- 260	Med gy sh	1.48	427	13	392	*	200
6530- 580	Chalk	0.37	*	*	665	*	*
7620- 650	Med gy sh	1.11	426	17	186	*	200
7770- 830	Med/dk gy sh	1.22	420	3	133	0.8	*
7770- 830	Lt yel-gy marl	0.28	419	28	342	*	100
8110- 170	Med/dk gy sh	0.86	*	*	315	*	*
8110- 170	Gy-red sh	0.70	442	71	284	0.1	500
8730- 800	Med/med-dk gy sh	3.82	431	11	30	0.2	400
9080- 120	Med/dk gy sh	3.56	428	340	33	0.01	12100
9270- 330	Ditto	0.37	439	*	326	*	10200
9270- 330	Brn sltst	0.33	*	*	235	*	*

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: 8/12-1 LOCATION: NORWEGIAN NORTH SEA

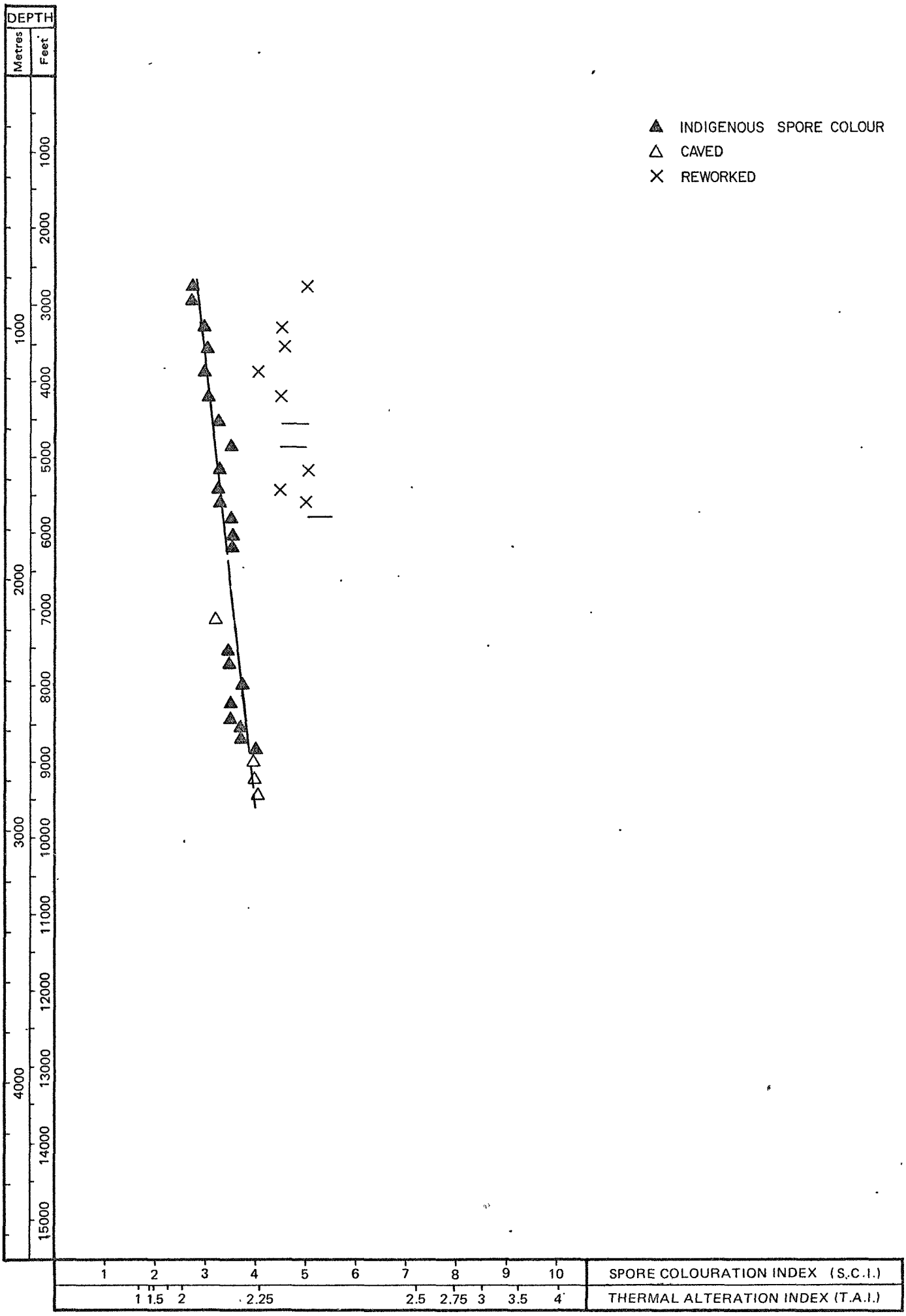

FIGURE 2 VITRINITE REFLECTIVITY AGAINST DEPTH

WELL: 8/12-1

LOCATION: NORWEGIAN NORTH SEA

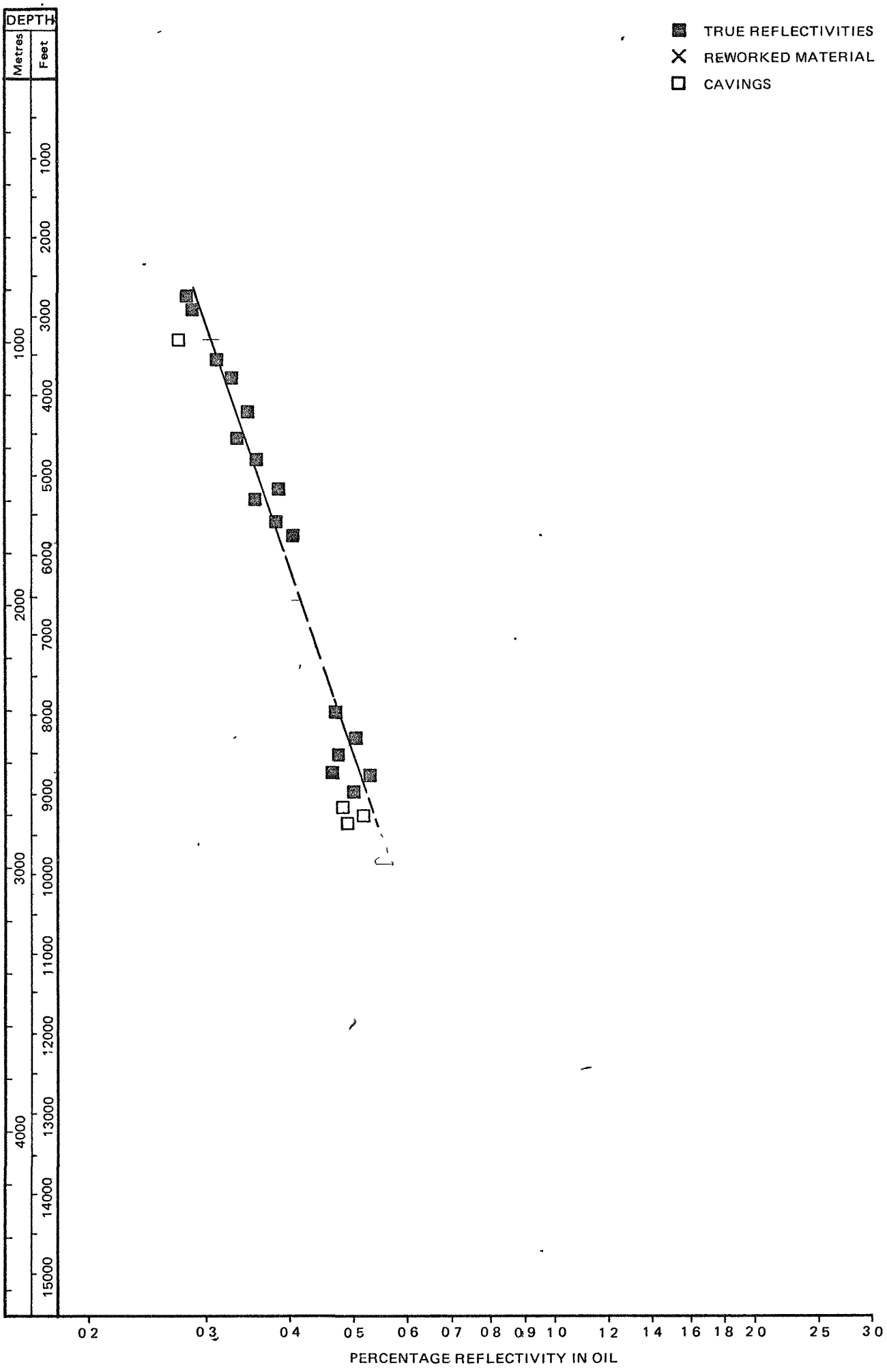

FIGURE 3 PYROLYSIS DATA SUMMARY CHART

WELL: 8/12-1 **LOCATION:** NORWEGIAN NORTH SEA

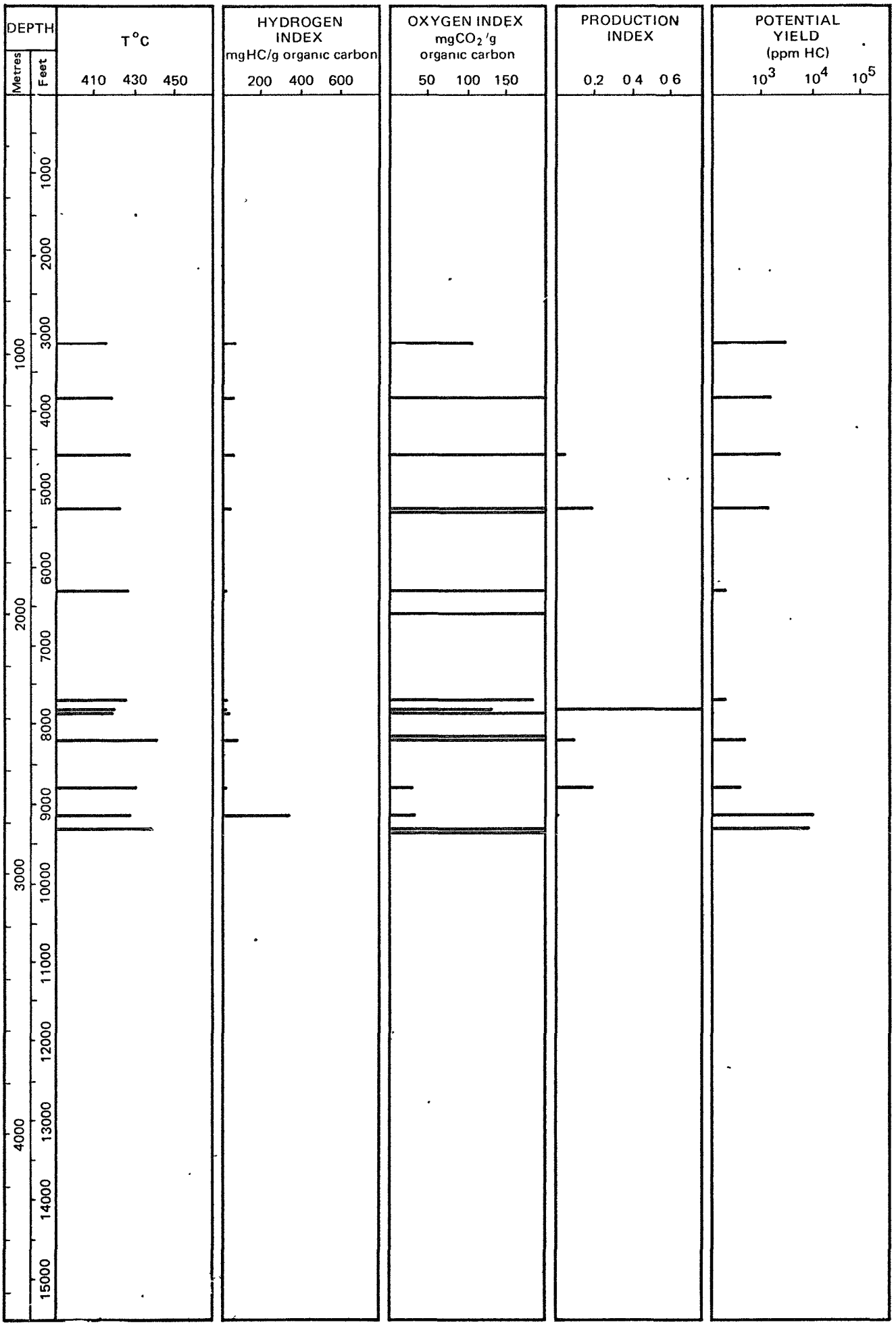

FIGURE 4 PYROLYSIS DATA SUMMARY CHART

PICKED LITHOLOGIES

WELL: 8/12-1 LOCATION: NORWEGIAN NORTH SEA