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ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA -

PRELIMINARY REPORT NO. 7

(Reports 7A, 7B, 7C, 7D)

Project No. RRI/789/IIB/2676

29th September 1978

ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO. 7A

Project No. RRI/789/IIB/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES OF THE PHILLIPS NORWAY 7/11-3 WELL

29TH SEPTEMBER, 1978

I

INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Phillips Norway 7/11-3 well. The samples were received at varying intervals and were selected for analysis by compositing at 100 to 60 feet intervals dependent on sample availability and 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 were available from this well section.

Relevant drilling information for this well may be found in NPD Paper 10. The well was drilled with a sea water based drilling mud throughout.

The samples were generally of good quality although often of small quantity for geochemical analysis. Compositing was started at 4040 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 followed by extractive source rock analysis where samples contained more than 0.5% organic carbon, at approximately 250 feet intervals. No gas chromatographic analysis has been carried out on alkane fractions 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 and on samples where insufficient material was available for extractive analysis. 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 7/11-3 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 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 below 4220 feet is at an early stage of maturity where oil-prone organic matter if present could source minor amounts of liquid hydrocarbons. It is notable that a marked increase in spore colouration level is noted in the Palaeocene sand/shale interval below 10,000 feet. It is also interesting that there is a rather pronounced increase in spore colour indices between about 5500 and 6600 feet, but the reason for this is not clear.

Vitrinite reflectivity values increase in the analysed interval of the well from about 0.32% at 4200 feet to about 0.47% at 10,500 feet. Again a pronounced increase in maturity (reflectivity) is noted in the basal sandy Palaeocene interval with values approaching 0.55% at T.D. A value of in excess of 0.35% reflectivity is reached by 6000 feet depth and in a Tertiary basin we believe this may correspond to initial liquid hydrocarbon generation.

Significant amounts of material believed to be bitumen were seen in the samples at 10,085 and 10,430 feet with reflectivities of about 0.35%. The same material was seen in transmitted light on palynological/spore colouration slides as the dominant material in the assemblages.

The marked increase in both vitrinite reflectivity and spore colouration trends near the base of the well is believed to indicate unusual heat flow patterns and proximity to a salt swell is indicated.

HYDROCARBON SOURCE POTENTIAL DATA

On the basis of the geochemical data obtained, the following breakdown of the analysed interval of the 7/11-3 well is made:

Interval 4040 - 5480 feet — Interval is represented by mostly olive-grey to brown-grey silty mudstones with about average organic carbon content (typically 1.2% to 1.5%). Kerogen composition is entirely humic in origin and is dominated by inertinite. The interval is presently immature and has no hydrocarbon generating potential either at present or at optimum maturity.

Interval 5520 - 9340 feet — Interval consists of predominantly olive-grey to brown-grey silty mudstones with well above average organic content. The organic matter is entirely humic and is dominated by vitrinitic material although in all samples the kerogen was very fine grained and difficult to identify. The extractability of the organic matter in solvent shows some increase with depth but this does not correlate with an increase in hydrocarbon content. The samples contained very low amounts of hydrocarbons. The pyrolysis data suggest a marked organic facies break at around 6300 feet with strongly vitrinite dominated samples below this depth. This interval presently has no hydrocarbon generating potential. At optimum maturity

levels the sediments will be capable of sourcing major amounts of gas.

Interval 9370 - 10,147 feet

Lithologies are more varied in this interval with light olive-grey through green-grey, to medium-dark grey and brown-grey shales and mudstones and occasional limestones. The organic carbon content is about average but fairly variable. Kerogen composition is more variable, predominantly humic but with inertinite and occasional sapropel appearing as well as vitrinite. Pyrolysis data do not suggest the presence of any significant hydrocarbon generating potential in these sediments and no hydrocarbons are present in the solvent soluble material. The amount of solvent extractable material is however a little higher than anticipated for the present level of maturity. The sediments have no present hydrocarbon generating potential and will source only gas at optimum maturity.

Interval 10,200 - 10,993 feet

This interval comprises medium to coarse grained quartzose sand with interbedded variegated grey and grey - red shales, and white/grey limestones and chalk. The organic content is variable, the amount of solvent extractable material is above the values expected but the amount of solvent soluble hydrocarbon is low.

The kerogen is humic and consists of a mixture of vitrinite and inertinite. The shales appear to have no hydrocarbon source potential. The sands have been noted to contain bitumen at several horizons and it may be that the anomalous extractability values may be related to the presence of flushed hydrocarbon residues in these sands.

TABLE 1 MATURITY EVALUATION DATA

WELL: 7/11-3 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
4220- 260	Ctgs	Ol-gy mdst	3-3.5	0.32(6)	70	20	10
4600- 650	"	Ditto	3-3.5	*	60	25	15
5000- 075	"	Ditto	3-3.5	0.35(4)	60	25	15
5300- 350	"	Ditto	3.5	0.34(7)	60†	40†	*
5640- 720	"	Ditto	5	0.37(8)	60†	40†	*
5975-6000	"	Ditto	4	0.37(20)	40†	50†	10
6300- 360	"	Ditto	4	0.36(6)	30†	70†	*
6600- 660	"	Ditto	4	0.37(17)	20†	80†	*
6930- 990	"	Ditto	3.5	0.37(29)	20†	80†	*
7210- 270	"	Ditto	3.5-4	0.38(75)	20†	80†	*
7600- 675	"	Ditto	3.5-4	0.43(30)	20†	80†	*
7950-8000	"	Ditto	4	0.42(79)	20†	80†	*
8370- 430	"	Ditto	3.5-4	0.41(25)	20†	80†	*
8730- 800	"	Lt ol-gy calc mdst	3.5	0.43(17)	30†	60†	10
9100- 160	"	Ditto	3.5	0.42(29)	30†	60†	10
9460- 520	"	Lt ol-gy/gn-gy mdst	3.5	0.43(25)	35	60	5
9790- 820	"	Ditto	3.5-4	0.41(13)	10	20	20
10085- 147	"	Gn-gy sh	4	0.46(11)	15	35	20
10430- 490	"	Vgt gy/gy-red sh + snd	4.5	0.45(13)	20	80	*
10710- 770	"	Ditto + snd	4.5	0.56(58)	50	50	*
10920- 940	"	Ditto + snd	5	0.54(51)	50	50	*

† Values quoted are approximate. Fine grained material presumed to be a mixture of inertinite and vitrinite, is predominant in all these samples

TABLE 2A

SOURCE ROCK EVALUATION DATA

WELL: 7/11-3 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT P.P.M.	EXTRACT % OF ORGANIC CARBON	HYDRO--CARBONS P.P.M. OF ROCK	HYDRO-CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO-CARBONS
4040-100	Ctgs	Ol-gy/brn-gy slty mdst+mnr lt gy lst	1.41					
4220-260	"	Ditto+ditto	1.40					
4300-350	"	Ditto+ditto	1.16					
4400-450	"	Ditto+ditto	1.21					
4500	"	Ditto+ditto	1.19					
4600-650	"	Ditto+ditto	1.32					
4700-750	"	Ditto+ditto	1.11					
4800-850	"	Ditto+ditto	1.12					
4900-950	"	Ditto+ditto	1.16					
5000-075	"	Ditto+ditto	1.37	600	4.4	<20	*	*
5100-150	"	Ditto+ditto	1.29					
5200-250	"	Ditto+ditto	1.41					
5300-350	"	Ditto+ditto	1.61					
5400-480	"	Ditto+ditto	1.68					
5520-600	"	Ditto+ditto	2.13					
5640-720	"	Ditto+ditto	3.18	800	2.5	<20	*	*
5760-840	"	Ditto+ditto	2.76					
5975-6000	"	Ditto+ditto	2.65					
6060-140	"	Ditto+ditto	2.11					
6180-260	"	Ditto+ditto	2.62	1030	3.9	<20	*	*
6300-360	"	Ditto+ditto	3.08					
6400-480	"	Ditto+ditto	2.92					
6510-540	"	Ditto+ditto	3.70					
6600-660	"	Ditto+ditto	4.63					
6690-750	"	Ditto+ditto	4.57	3450	7.5	25	1	73
6780-840	"	Ditto+ditto	4.18					
6870-930	"	Ditto+ditto	3.99					
6930-990	"	Ditto+ditto	3.63					
7020-080	"	Ditto+ditto	4.25	3330	7.8	25	1	66
7120-180	"	Ditto+ditto	4.15					
7210-270	"	Ditto+mnr lt gy dol	4.37					
7300-330	"	Ditto+ditto	4.58					
7390-450	"	Ditto+ditto	4.04	3030	7.5	20	1	59
7480-510	"	Ditto+ditto	4.54					

TABLE 2B

SOURCE ROCK EVALUATION DATA

WELL: 7/11-3 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT P.P.M.	EXTRACT % OF ORGANIC CARBON	HYDRO--CARBONS P.P.M. OF ROCK	HYDRO-CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO-CARBONS
7600-675	Ctgs	Ol-gy/brn-gy slty mdst+mnr lt gy dol	4.94					
7700-775	"	Ol-gy/brn-gy slty mdst/sh	5.19					
7800-860	"	Ditto	4.49	4080	9.1	50	1	75
7880-930	"	Ditto	4.51					
7950-8000	"	Ditto	3.71					
8030-080	"	Ditto	3.67					
8100-160	"	Ditto	3.41					
8190-250	"	Ditto+mnr lt ol-gy mdst	3.23					
8280-340	"	Ditto+ditto	3.57					
8370-430	"	Ditto+ditto	3.84					
8460-520	"	Lt ol-gy calc mdst+ mnr ol-gy/dk gy mdst/ sh	3.15					
8550-610	"	Ditto+ditto	3.20					
8640-700	"	Ditto+ditto	3.09					
8730-800	"	Ditto+ditto	3.48					
8820-890	"	Ditto+ditto	4.57					
8920-980	"	Ditto+ditto+mnr wht lst	2.89	3700	12.3	60	2	62
9010-070	"	Ditto+ditto+mnr med-dk gy sh	3.10					
9100-160	"	Ditto+ditto+ditto	2.46					
9190-250	"	Ditto+ditto+ditto	3.66					
9280-340	"	Ditto+ditto+ditto	3.23					
9370-430	"	Lt ol-gy/gn-gy mdst/ sh+10% brn-gy mdst	2.10					
9460-520	"	Ditto+ditto	1.88					
9550-600	"	Ditto+ditto	2.23					
9625-670	"	Ditto+ditto	1.72	1470	8.6	25	2	64
9700-760	"	Ditto+ditto	1.81					
9790-820	"	Ditto+ditto	2.13					
9840-910	"	Gn-gn/med-dk gy sh+ 10% brn-gy mdst+mnr wht lst	2.08					
9930-990	"	Med-dk gy sh+20% gn-gy sh+10% brn-gy mdst	2.15	2110	9.8	40	2	56

TABLE 2C

SOURCE ROCK EVALUATION DATA

WELL: 7/11-3 LOCATION : NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT P.P.M.	EXTRACT % OF ORGANIC CARBON	HYDRO--CARBONS P.P.M. OF ROCK	HYDRO-CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO-CARBONS
10010-070	Ctgs	Gn-gy sh+20% med-dk gy sh	2.65					
10085-147	"	Ditto+ditto	1.86					
10200-260	"	Vgt gy/gy-red sh+mnr wht lst+mnr vgt sst	1.30	1475	11.4	20	1	>95
10280-340	"	Ditto+ditto+80% crs snd	1.02	1060	10.4	<20	*	*
10350-369	"	Ditto+ditto+50% ditto	1.14					
10430-490	"	Ditto+40% crs snd	2.46	6255	25.4	25	<1	>95
10500-560	"	Ditto+30% ditto	1.79					
10570-620	"	Ditto+10% ditto	1.37	1150	8.4	<20	*	*
10640-700	"	Ditto+20% ditto	1.13					
10710-770	"	Ditto+ditto	1.18					
10780-840	"	Ditto+ditto	0.96	1100	11.5	<20	*	*
10850-910	"	Ditto+ditto	0.78					
10920-940	"	Ditto+ditto+10% wht lst	0.67					
10950-993	"	Wht lst/chk+30% vgt sh/sst	0.44					

TABLE 3

ROCK - EVAL. PYROLYSIS DATA

WELL: 7/11-3 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
4600-650	Ol-gy/brn-gy mdst	1.32	*	*	201	*	*
5000-075	Ditto	1.37	*	*	31	*	*
5300-350	Ditto	1.61	402	16	179	*	300
5640-720	Ditto	3.18	438	16	107	*	600
5975-6020	Ditto	2.65	426	82	144	*	2200
6180-260	Ditto	2.62	432	40	74	*	1100
6400-480	Ditto	2.92	434	157	193	*	4600
6690-750	Ditto	4.57	436	115	55	*	5200
6870-900	Ditto	3.99	440	283	60	*	11300
7020-080	Ditto	4.25	438	119	60	*	5100
7390-450	Ditto	4.04	440	117	63	*	4700
7600-675	Ditto	4.94	429	310	93	*	15400
7800-860	Ditto	4.49	441	110	45	*	5000
8030- 80	Ditto	3.67	434	226	73	*	8300
8280-340	Ditto	3.57	442	222	64	*	7900
8550-610	Lt ol-gy calc mdst	3.20	430	185	80	*	5900
8920-980	Ditto	2.89	439	52	49	*	1500
9190-250	Ditto	3.66	437	131	51	0.43	4800
9550-600	Lt ol-gy/gn-gy mdst	2.23	440	97	104	*	2200
9625-670	Ditto	1.72	440	62	129	*	1100
9840-910	Gn-gy/med-dk gy sh	2.08	444	111	73	*	2300
9930-990	Med-dk gy sh	2.15	436	41	111	*	900
10200-260	Vgt gy/gy-red sh	1.30	447	98	108	*	1300
10430-490	Ditto + snd	2.46	442	121	88	*	3000
10570-620	Ditto + snd	1.37	435	4	155	*	500
10780-840	Ditto + snd	0.96	436	3	277	*	300
10920-940	Ditto + snd	0.67	*	*	283	*	*
10950-993	Wht chk + 30% sh	0.44	*	*	729	*	*

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: 7/11-3 LOCATION: NORWEGIAN NORTH SEA

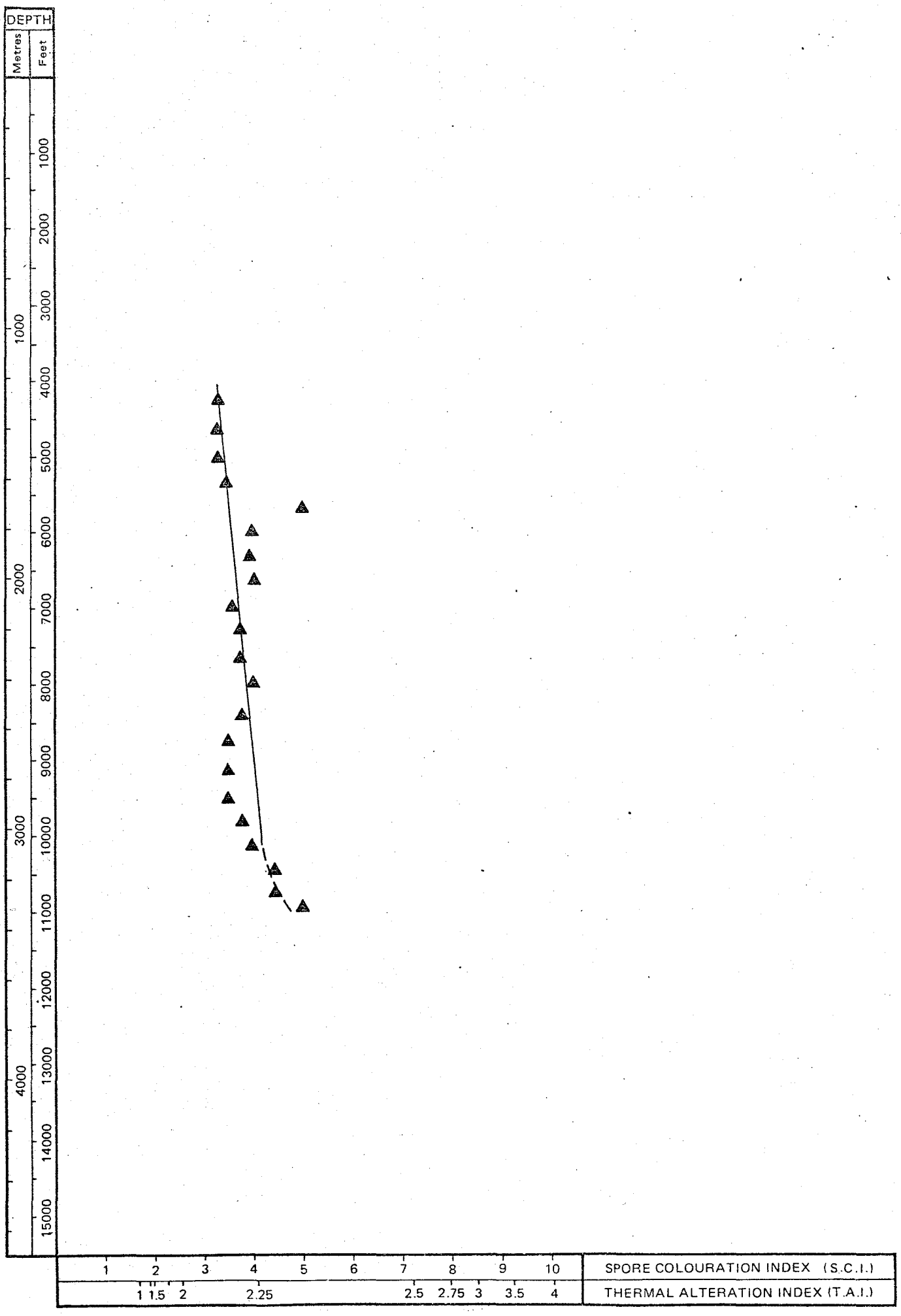

FIGURE 2 VITRINITE REFLECTIVITY AGAINST DEPTH

WELL: 7/11-3

LOCATION: NORWEGIAN NORTH SEA

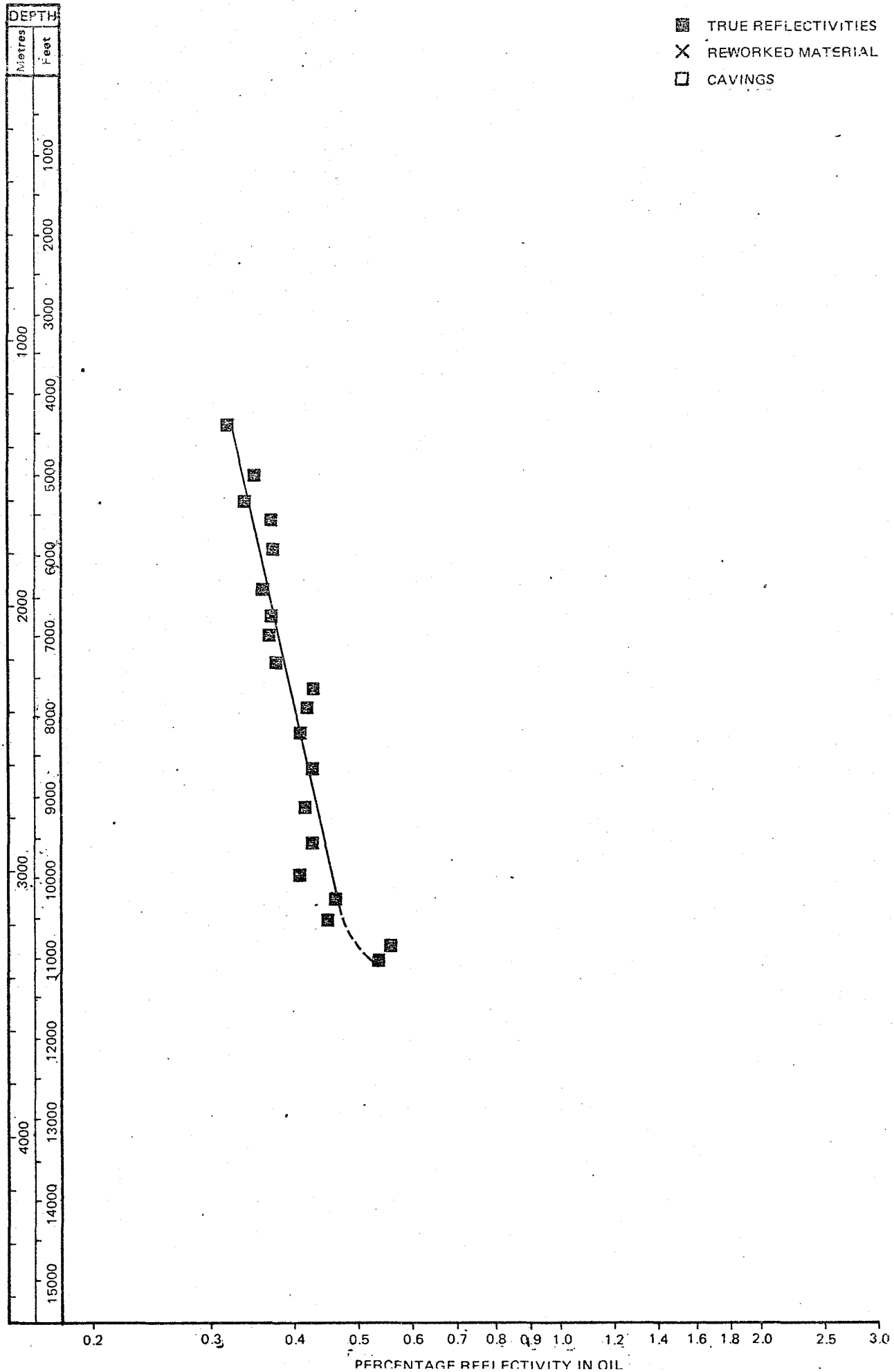

FIGURE 3 PYROLYSIS DATA SUMMARY CHART

WELL: 7/11-3 LOCATION: NORWEGIAN NORTH SEA