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ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO. 6A

Project No. RRI/789/IIB/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES  
OF THE ELF NORGE 2/6-1 WELL

1st September, 1978

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I

INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Elf Norge 2/6-1 well. The samples were received at varying intervals and were selected for analysis by compositing at 20 metre 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 were available from this well section. The well was drilled with a water based drilling mud throughout. It is noted that diamond drilling bits were used below about 3180 metres.

The samples were generally of good quality for geochemical analysis. Compositing was started at 1465 metres so that representative material from

approximately below the mid-Miocene unconformity has been analysed. The analytical procedures used include organic carbon analysis on all 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 samples containing more than 0.5% organic carbon at approximately 120 metre intervals. No gas chromatographic analysis has been carried out since no alkane fractions 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 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 2/6-1 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 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 for hydrocarbon generation. Spore colour values in the Jurassic seem to indicate a maturity gradient which is continuous with that in the Tertiary and indicate that sapropelic organic matter would be capable of sourcing low °API gravity oils.

Vitrinite reflectivity data give a trend rising from about 0.3% in the Lower Miocene to about 0.4% at the base of the Tertiary, Reflectivity values in the Jurassic interval of the well are about 0.5% so that low °API gravity oil could be sourced at present from appropriate oil-prone organic matter.

#### HYDROCARBON SOURCE POTENTIAL DATA

On the basis of the geochemical data obtained, the following breakdown of the analysed interval of the 2/6-1 well is made:

Interval 1465 to 2640 metres - Interval is represented by variously coloured olive-grey, green-grey and brown-grey shales and mudstones with slightly above average organic carbon content (typically 2% to 3%), although some lithotypes are considerably richer in the Lower Miocene and upper Oligocene and leaner at around 1% in the Paleocene. The organic matter in this interval is entirely humic in origin and is mostly vitrinite in the interval down to about 2150 metres while below this depth inertinite

becomes significantly abundant. The interval is immature and is unlikely to have any significant source potential. Solvent extractable hydrocarbon contents are low. Pyrolysis data confirm there is no present hydrocarbon potential and give indications of poor hydrocarbon yield (gas) at optimum maturity.

Interval 2650 to 3100 metres - Mostly chalk - organically lean with no hydrocarbon source potential. Caving contamination in the upper part of the interval. Possible Lower Cretaceous sediments at the base of the interval.

Interval 3105 to 3335 metres - Jurassic mudstones and shales with caved chalk. Samples not of very good quality due to diamond drilling. The organic carbon content of the composite samples and of the picked lithologies is a little above average in general at 2% to 3%. The kerogen composition in the interval 3105 to 3224 metres appears to be a mixture of sapropel and humic materials with vitrinite subordinate to inertinite. Below 3265 metres inertinite is predominant over vitrinite and sapropel. Pyrolysis data suggest poor hydrocarbon generating potential from the composite samples. The data for the picked dark grey lithologies indicate that the shales will be predominantly a gas source

at optimum maturity.

No significant amounts of solvent extractable organic matter or hydrocarbons are present in the samples analysed. It appears that the source rocks presently have no source potential and will source gas only at optimum maturity.

PCB/Eml.

1st September, 1978

TABLE 1 MATURITY EVALUATION DATA

WELL: 2/6-1

LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH METRES	SAMPLE TYPE	GENERALISED LITHOLOGY	SPORE COLOUR INDEX (1 - 10)	VITRINITE REFLECTIVITY IN OIL, R <sub>av</sub> %	KEROGEN COMPOSITION (%)		
					INERTINITE	VITRINITE	SAPROPEL
1465-485	Ctgs	Lt ol-gy mdst	2.5-3	0.31(2)	40	60	*
1565-585	"	Ol-gy/dk gy mdst	2.5-3	0.39(10)	5	95	*
1625-645	"	Ditto	2.5	0.34(12)	5	95	*
1720-740	"	Lt ol-gy mdst	2.5	0.36(9)	5	95	*
1810-830	"	Ditto	2.5	0.31(16)	5	95	*
1910-930	"	Ditto	2.5-3	0.34(16)	5	95	*
2020-040	"	Ditto	2.5-3	0.30(11)	15	85	*
2130-150	"	Ditto	2.5-3	0.39(3)	25	75	*
2220-250	"	Ditto	3	0.38(18)	40	60	*
2320-340	"	Lt ol-gy/gn-gy mdst	3	0.37(20)	40	60	*
2410-430	"	Ditto	3	0.37(19)	40	60	*
2500-520	"	Ditto	3-3.5	0.38(18)	40	60	*
2590-610	"	Ditto	3.5	0.39(20)	50	50	*
3105-120	"	Ol-gy slty mdst+ med-dk gy sh	3.5	0.40(7)?	20	30	50
3155-175	"	Ditto+ditto	3.5	0.56(6)	40	10	50
3210-224	"	Ditto+ditto	3.5	0.51(10)	25	15	60
3265-290	"	Ditto+ditto	4-4.5	0.52(19)	60	20	20
3310-335	"	Ditto+ditto	4	0.55(3)	50	30	20

## SOURCE ROCK EVALUATION DATA

WELL: 2/6-1

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 P.P.M. OF ROCK	HYDRO- CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO- CARBONS
1465-485	Ctgs	Lt ol-gy sl slty mic mdst	2.31	735	3.2	<20	*	*
1505-525	"	Ditto	3.14					
1535-555	"	Ol-gy/dk gy slty mic mdst	4.11	755	1.8	<20	*	*
1565-585	"	Ditto	4.17					
1595-615	"	Ditto	4.27					
1625-645	"	Ditto	4.46					
1655-665	"	Ditto	4.66					
1690-710	"	Lt ol-gy slty mic mdst+10% dk gy mdst	3.00	925	3.1	<20	*	*
1720-740	"	Ditto+ditto	3.50					
1750-770	"	Ditto+ditto	3.20	1605	5.0	<20	*	*
1780-800	"	Ditto+ditto	3.52					
1810-830	"	Ditto+ditto	3.68					
1840-860	"	Ditto+ditto	4.11					
1870-890	"	Ol-gy/dk gy slty mic mdst+mnr dk gy mdst	4.12	1310	3.2	<20	*	*
1910-930	"	Lt ol-gy sft sl slty mdst+10% med gy sh	4.13					
1950-970	"	Ditto+ditto	4.26					
1990-2010	"	Ditto+ditto	4.03	615	1.5	<20	*	*
2020-040	"	Ditto+ditto	4.56					
2050-070	"	Ditto+ditto	4.28	675	1.6	<20	*	*
2090-100	"	Ditto+ditto	4.71					
2130-150	"	Ditto+ditto	4.05					
2160-180	"	Ditto+ditto	4.77					
2190-210	"	Ditto+ditto	4.89					
2220-250	"	Ditto+15% ditto	3.26					
2260-280	"	Ditto+20% ditto	2.45	1145	4.7	<20	*	*
2290-310	"	Lt ol-gy/gn-gy/dk gy mdst	2.52					
2320-340	"	Ditto	2.45					
2350-370	"	Ditto	2.00	695	3.5	<20	*	*
2380-400	"	Ditto	1.89					
2410-430	"	Ditto	1.69					
2440-460	"	Lt ol-gy/gn-gn mdst/ sh	2.23	655	2.9	<20	*	*

## SOURCE ROCK EVALUATION DATA

WELL: 2/6-1

LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (METRES OR NOTATION)	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT P.P.M.	EXTRACT % OF ORGANIC CARBON	HYDRO- CARBONS P.P.M. OF ROCK	HYDRO- CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO- CARBONS
2470-490	Ctgs	Lt ol-gy/gn-gy mdst/ sh	1.76					
2500-520	"	Ditto	1.05					
2530-550	"	Ditto+mnr lt brn sst+ mnr gy-red sh	1.58	690	4.4	<20	*	*
2560-580	"	Ditto+20% gy-red sh+ mnr dk gy sh	2.01					
2590-610	"	Ditto+mnr ditto	1.22					
2620-640	"	Ditto+ditto	1.06	360	3.4	<20	*	*
2650-670	"	Wht chk+20% lt ol-gy/gn- gy mdst/sh+mnr gy-red sh	0.64	740	11.5	<20	*	*
2680-700	"	30% ditto+70% ditto	0.78					
2710-730	"	20% ditto+80% ditto	0.60					
2740-755	"	90% ditto+10% vgt sh/ sst	<0.05					
2770-790	"	Ditto+mnr ditto	<0.05					
2800-820	"	Ditto+ditto	<0.05					
2830-850	"	Ditto+ditto	<0.05					
2860-880	"	Ditto+ditto	<0.05					
2890-910	"	Ditto+ditto	<0.05					
2920-940	"	Ditto+ditto	<0.05					
2950-970	"	Wht/pnk-gy chk+mnr vgt sh/sst	<0.05					
2980-3000	"	Ditto+ditto	<0.05					
3010-030	"	Ditto+ditto	<0.05					
3035-055	"	Ditto+mnr vgt sh	<0.05					
3060-080	"	Ditto+10% ditto	<0.05					
3085-100	"	Ditto+ditto	<0.05					
3105-120	"	Ol-gy slty mdst+med- dk gy mic sh+mnr chk	1.81					
3130-150	"	Ditto+ditto+15% chk	2.97	1630	5.5	65	4	81
3155-175	"	Ditto+ditto+ditto	2.74					
3180-200	"	Ditto+ditto+ditto	2.57	1280	4.8	45	3	51
3210-224	"	Ditto+ditto+ditto	2.59					
3240-260	"	Ditto+ditto+mnr chk	5.15	4775	9.3	50	1	43
3265-290	"	Ditto+ditto+ditto	2.95					
3295-305	"	Ditto+ditto+ditto	2.60					



## SOURCE ROCK EVALUATION DATA

WELL: 2/6-1

LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH METRES OR NOTATION	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT P.P.M.	EXTRACT % OF ORGANIC CARBON	HYDRO- CARBONS P.P.M. OF ROCK	HYDRO- CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO- CARBONS
3310-335	Ctgs	Ol-gy slty mdst+med-dk gy mic sh+mnr chk	3.05	1705	5.6	55	32	76
		<u>PICKED LITHOLOGIES</u>						
1535-555	"	Dk gy mdst	5.85					
1750-770	"	Ditto	3.88					
1840-860	"	Ditto	5.05					
2260-280	"	Ditto	2.29					
2320-340	"	Lt ol-gy mdst/sh	1.89					
2530-550	"	Dk gy mdst/sh	4.88					
2530-550	"	Gy-red sh	<0.05					
2710-730	"	Ol-gy mdst/sh	0.92					
2740-755	"	Med-dk gy sh	0.32					
3105-120	"	Dk gy sh	2.09					
3130-150	"	Ditto	3.14					
3180-200	"	Ditto	2.94					
3210-224	"	Ditto	2.94					
3240-260	"	Ditto	3.97					
3295-305	"	Ditto	3.16					
3310-335	"	Ditto	2.34					

TABLE 3 A

## ROCK - EVAL. PYROLYSIS DATA

WELL: 2/6-1

LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (METRES) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
1465-485	Lt ol-gy mdst	2.31	*	*	124	*	*
1535-555	Ol-gy/dk gy mdst	4.11	426	17	158	*	700
1625-645	Ditto	4.46	415	43	40	*	1900
1690-710	Lt ol-gy mdst	3.00	420	106	79	*	3200
1750-770	Ditto	3.20	426	68	80	*	2200
1780-800	Ditto	3.52	432	52	48	*	1900
1870-890	Ol-gy/dk gy mdst	4.12	436	50	44	*	2100
1990-2010	Ditto	4.03	425	22	66	*	900
2050-070	Ditto	4.28	428	19	56	*	800
2160-180	Ditto	4.77	432	23	45	*	1100
2260-280	Ditto	2.45	419	8	132	0.1	1900
2320-340	Lt ol-gy/gn-gy mdst	2.45	436	11	85	*	300
2350-370	Ditto	2.00	420	18	94	*	400
2440-460	Ditto	2.23	430	21	136	*	500
2500-520	Ditto	1.05	433	15	93	*	200
2530-550	Ditto	1.58	418	16	133	*	300
2620-640	Ditto	1.06	418	21	153	*	200
2650-670	Chk+20% ol-gy sh	0.64	418	21	250	*	100
3105-120	Ol-gy mdst+med- dk gy sh	1.81	428	65	74	0.1	1200
3130-150	Ditto+ditto	2.97	446	65	63	0.3	1900
3180-200	Ditto+ditto	2.57	447	43	61	*	1100
3240-260	Ditto+ditto	5.15	444	55	32	*	2800
3295-305	Ditto+ditto	2.60	426	17	60	0.2	400
3310-335	Ditto+ditto	3.05	446	54	93	*	1700
PICKED LITHOLOGIES							
1535-555	Dk gy mdst	5.85	439	34	87	*	2000
1750-770	Ditto	3.88	422	96	45	*	3700
1840-860	Ditto	5.05	424	94	53	*	4700
2260-280	Ditto	2.29	435	63	73	*	1400
2320-340	Lt ol-gy mdst	1.89	417	35	75	*	600
2530-550	Dk gy mdst	4.88	420	9	26	*	400
2710-730	Ol-gy mdst	0.92	421	33	121	*	300
2740-755	Med-dk gy sh	0.32	440	31	402	*	600

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 3 B

## ROCK - EVAL. PYROLYSIS DATA

WELL: 2/6-1

LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (METRES ) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
3105-120	Dk gy sh	2.09	449	170	34	0.04	3500
3130-150	Ditto	3.14	437	196	35	*	6200
3210-224	Ditto	2.94	449	102	20	*	3000
3240-260	Ditto	3.97	434	160	22	*	6400
3295-305	Ditto	3.16	437	201	37	*	6400

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: 2/6-1

LOCATION: NORWEGIAN NORTH SEA

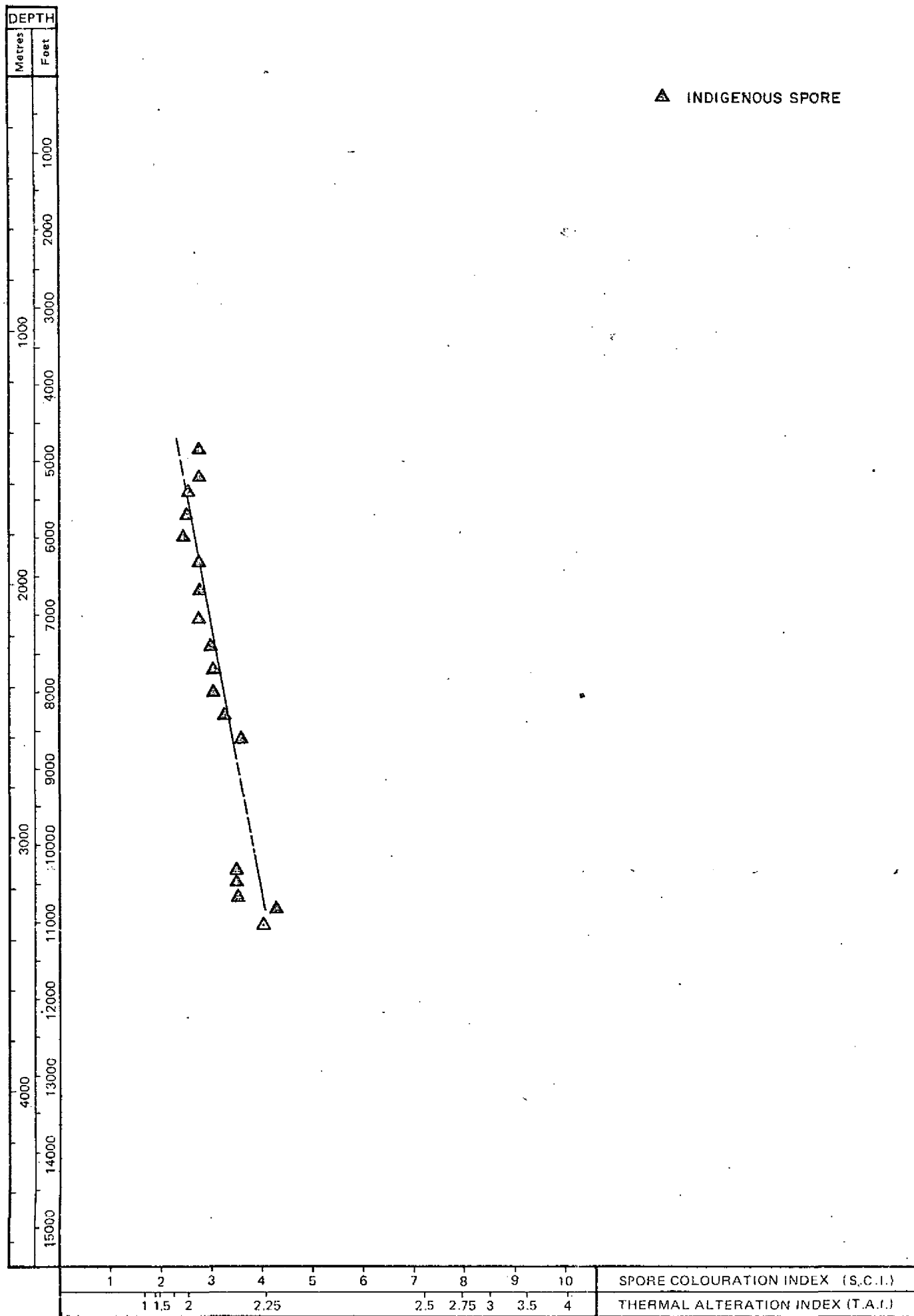


FIGURE 2 VITRINITE REFLECTIVITY AGAINST DEPTH

WELL: 2/6-1

LOCATION: NORWEGIAN NORTH SEA

