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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 <sub>av</sub> %	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	*

## 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 P.P.M.	EXTRACT % OF ORGANIC CARBON	HYDRO- CARBONS P.P.M. 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					

## 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 P.P.M.	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 sh+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					
		<u>CHALK</u>						
8530-590	"	Med-dk gy sh+60% wht chk	0.83					
8640-660	"	Gy-red chk/marl+mnr med-dk gy sh	0.74					
		<u>PICKED LITHOLOGIES</u>						
3420-480	"	Ol-gy slty sh	2.41					
3420-480	"	Med gy sh	5.82					
3600-660	"	Ol-gy slty sh	4.18					



## 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 P.P.M.	EXTRACT % OF ORGANIC CARBON	HYDRO- CARBONS P.P.M. OF ROCK	HYDRO- CARBONS % OF EXTRACT	TOTAL ALKANES %HYDRO- CARBONS
3600-660	Ctgs	Dk gy sh	4.59					
3690-750	"	Ditto	4.58					
3780-840	"	Ol-gy sh	4.43					
3780-840	"	Brn-gy sh	3.85					
4050-110	"	Dk gy sh	5.82					
6200-260	"	Med-dk gy sh	4.65					
6200-260	"	Lt ol-gy sh	2.05					
6760-820	"	Med-dk gy sh	4.88					
6760-820	"	Lt ol-gy sh	0.75					
7400-460	"	Med gy sh	3.09					
8680-740	"	Med-dk gy sh	3.10					
8750-820	"	Gy-red sh	0.41					
8830-890	"	Lam gy-red calc sh/ sltst	1.90					
8830-890	"	Med-dk gy sh	0.88					
9040-100	"	Mtl gy-red/gn-gy slty sh/sltst	0.44					
9040-100	"	Med-dk gy sh	1.72					

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

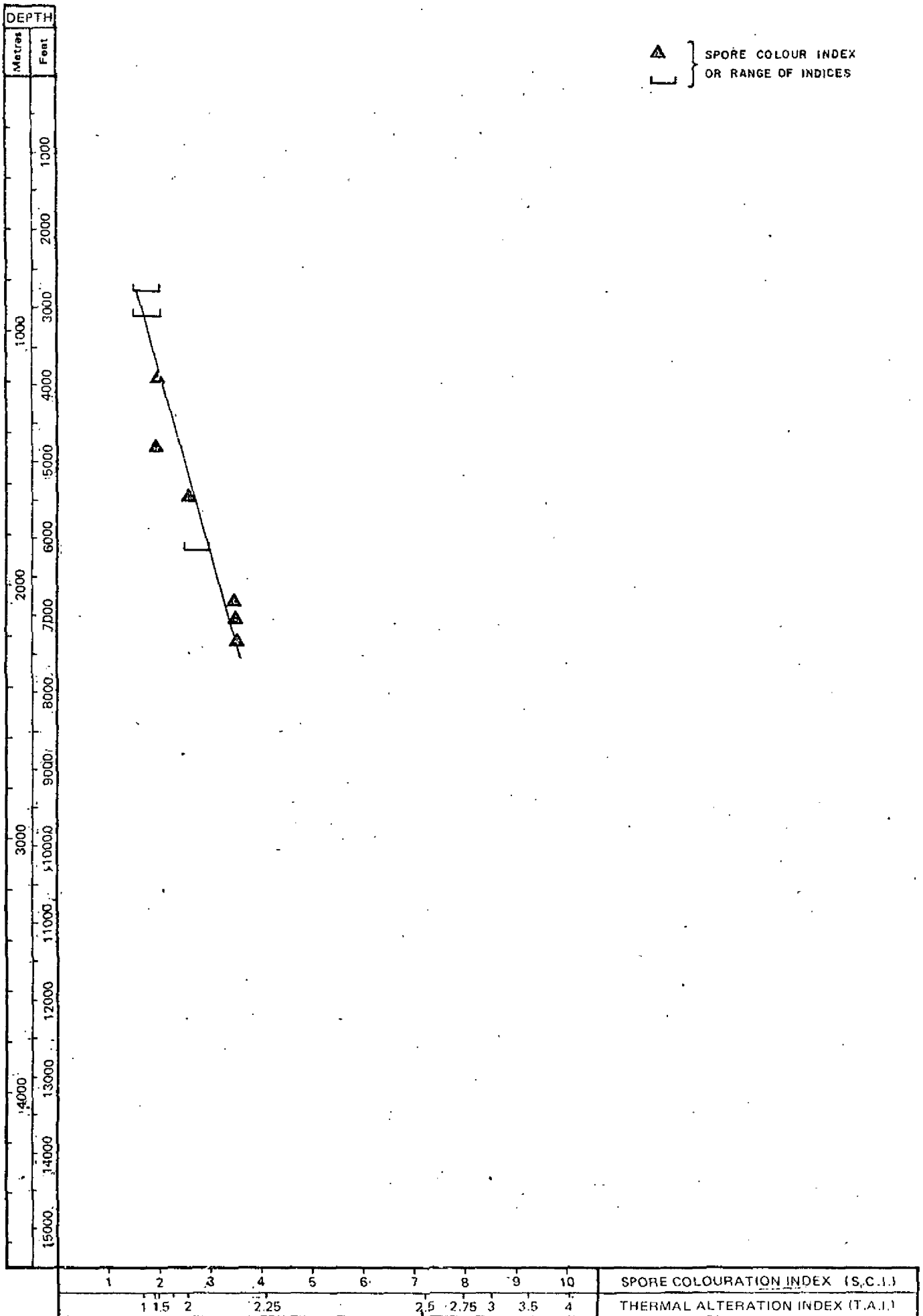
PRODUCTION INDEX = AN ESTIMATE OF PRESENT HYDROCARBON GENERATING POTENTIAL  
COMPARED TO THAT AT OPTIMUM MATURITY

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

