

ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA -- PRELIMINARY REPORT NO. 7B

Project No. RRI/789/IIB/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES

OF THE NORSKE SHELL 9/12-1 WELL

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I

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INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Norske Shell 9/12-1 well. Samples were received at 10 feet intervals from 2200 to 8850 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 9 $\frac{3}{8}$ " casing was set at about 3972 feet in the Tertiary with no further casing points to T.D. Very severe caving of Upper Jurassic is suspected in the Triassic interval. In view of the degree of caving the samples are of variable quality for geochemical studies. No diesel contamination is suspected in the analysed interval of the well.

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. 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, 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 9/12-1 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 made later in the compilation report.

MATURITY DATA

Our assessment of the spore colouration data is that the Lower Cretaceous and Jurassic sediments in this well are at an early stage of maturity and capable of generating heavy (low ⁰API gravity) oils given the presence of oil-prone organic matter (see source rock evaluation below). No reliable spore colour data were obtained from the Triassic section due to the presence of Jurassic cavings. The Tertiary interval of the well is presently immature.

Similarly, vitrinite reflectivity data indicate that the Tertiary sediments are immature since a reflectivity of 0.35% is considered to mark the onset of maturity for oil generation in a Tertiary basin. Values of 0.40% and above show the Lower Cretaceous and Jurassic intervals to be at an early stage of maturity. The presence of abundant cavings obscures the true maturity gradient in the Triassic section.

HYDROCARBON SOURCE POTENTIAL DATA

On the basis of the geochemical data obtained, the following breakdown of the analysed interval of the 9/12-1 well is made.

Interval 2200 to 3860 feet. These Tertiary yellow-brown to olive-grey mudstones have average (1 to 2 per cent) to above average organic carbon contents. However, the organic matter is entirely humic in origin and this interval has no oil generating potential. This is confirmed by pyrolysis data. Solvent extractable hydrocarbon contents were below the limits of detection indicating the absence of migrant oil or contamination.

Interval 3880 to 5090 feet. These Danian and Upper Cretaceous marls and chalks are organically lean and possess no hydrocarbon

generating capacity.

Interval 5090 to 6100 feet. The predominant organic component of these medium to dark grey calcareous mudstones of Lower Cretaceous age is inertinite. Consequently, although organic carbon contents are average to above average and early maturity has been attained, this section has no significant source potential.

Interval 6100 to 6700 feet. This interval comprises grey mudstones of Upper Jurassic age. In spite of the presence of minor amounts of caved chalk, organic carbon contents are above average. The kerogen is a mixture of inertinite and vitrinite with subordinate amounts of sapropel, and pyrolysis data indicate that hydrocarbon yields will be low even at optimum maturity. Present source potential is negligible since, although the section is mature, solvent extractable hydrocarbon contents were below the limits of detection.

Interval 6700 to 6850 feet. The coals in these Middle Jurassic sands have vitrinite reflectivities of about 0.4%, i.e. below the value for optimum gas generation. Although present source potential is minimal, significant quantities of gas may be generated at optimum maturity.

Interval 6850 to 8850 feet. This interval is of Triassic age but the cuttings samples contain abundant caved Jurassic sediments. Consequently, the data are unreliable. The in situ lithologies appear to be grey-brown to grey-red

sandstones and siltstones whose hydrocarbon
generating potential is probably insignificant.

A few samples from the Upper Jurassic interval are still being investigated
to determine whether the 'Hot' shale has any source potential in this section.

SOURCE ROCK EVALUATION DATA

WELL: 9/12-1

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
8600-660	Ctgs	Gy-red sltst/sst+ 40% gy-brn/wht sst+ mnr dk gy mic mdst	0.72					
8670-730	"	Ditto+ditto+ditto	0.18					
8740-800	"	Ditto+ditto+ditto	0.23					
8810-850	"	Ditto+ditto+ditto	0.28					
		<u>PICKED LITHOLOGIES</u>						
6780-840	"	Med-dk gy mdst	4.63					
6780-840	"	Med gy mdst	1.65					
7130-190	"	Med-dk gy mdst	2.67					
7130-190	"	Gy-red sltst	0.27					
7130-190	"	Med gy mdst	1.53					
7780-190	"	Med-dk gy sh	2.24					
8250-310	"	Gy-red mdst/sh	0.08					

SOURCE ROCK EVALUATION DATA

WELL: 9/12-1

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
6850-910	Ctgs	Med-dk gy mic slty mdst+vgt crs snd+mnr chk/marl+mnr coal	2.80					
6920-980	"	Ditto+ditto+ditto+ ditto	2.34	2480	10.6	*	*	*
6990-7050	"	Ditto+ditto+ditto+ ditto	1.52					
7060-120	"	Ditto+ditto+ditto+ ditto	1.58	1500	9.5	*	*	*
7130-190	"	Vgt sst/crs snd+10% med-dk gy slty mdst+ mnr gy-red sltst	1.22					
7200-260	"	Ditto+ditto+ditto	1.29					
7270-330	"	Dk gy mic slty mdst+ 40% vgt sst/crs snd	1.32					
7340-400	"	Vgt sst/crs snd+30% gy-red sltst/med-dk gy mdst	1.13					
7410-470	"	Ditto+ditto	0.71					
7480-540	"	Ditto+ditto	1.28					
7550-610	"	Gy-red sltst/vgt sst/ crs snd+mnr med-dk gy mic mdst	0.28					
7620-680	"	Gy-red sltst/sst+20% gy-brn/wht sst+mnr dk gy mic mdst	0.29					
7690-680	"	Ditto+ditto+ditto	0.30					
7760-820	"	Ditto+ditto+ditto	1.03					
7830-890	"	Ditto+ditto+ditto	0.40					
7900-960	"	Ditto+ditto+ditto	0.63					
7970-8030	"	Ditto+ditto+ditto	0.38					
8040-100	"	Ditto+ditto+ditto	0.22					
8110-170	"	Ditto+ditto+ditto	0.42					
8180-240	"	Ditto+ditto+ditto	0.35					
8250-310	"	Ditto+ditto+ditto	0.13					
8320-380	"	Ditto+ditto+ditto	0.19					
8390-450	"	Ditto+ditto+ditto	0.28					
8460-520	"	Ditto+40% ditto+ ditto	0.15					
8530-590	"	Ditto+ditto+ditto	0.07					

TABLE 2B

SOURCE ROCK EVALUATION DATA

WELL: 9/12-1

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
4660-720	Ctgs	Wht chk+mnr lt ol-gy lst	0.08					
4730-790	"	Ditto+ditto	0.08					
4800-860	"	Ditto+ditto	0.07					
4870-930	"	Ditto+ditto	0.13					
4940-5000	"	Ditto+ditto	0.17					
5010-070	"	Ditto+ditto	0.25					
5080-090	"	Ditto+ditto	0.21					
5100-160	"	Med gy/wht/gy-red mt1 chk/marl	0.66					
5170-230	"	Med-dk gy calc mdst+ 10% wht chk+mnr gy- red chk/marl	1.06					
5240-300	"	Ditto+ditto+ditto	1.86	850	4.6	<20	*	*
5310-370	"	Ditto+ditto+ditto	1.90					
5380-440	"	Ditto+ditto+ditto	1.86					
5450-510	"	Ditto+ditto+ditto	1.25					
5520-580	"	Ditto+ditto+ditto	1.94					
5590-650	"	Ditto+ditto+ditto	2.79					
5660-720	"	Ditto+ditto+ditto	1.76					
5730-790	"	Ditto+ditto+ditto	2.05					
5800-860	"	Ditto+ditto+ditto	2.90					
5870-930	"	Ditto+ditto+ditto	1.89	1735	9.2	<20	*	*
5940-6000	"	Med gy mic slty mdst+ mnr wht chk+ditto	2.13					
6010-070	"	Ditto+ditto+ditto	1.92					
6080-140	"	Ditto+ditto+ditto	2.00					
6150-210	"	Ditto+ditto+ditto	3.05	610	2.0	<20	*	*
6220-280	"	Ditto+ditto+ditto	2.89					
6290-350	"	Ditto+ditto+ditto	2.07					
6360-420	"	Ditto+ditto+ditto	2.48					
6430-490	"	Ditto+ditto+ditto	2.52	2215	8.8	*	*	*
6500-560	"	Ditto+ditto+ditto	3.95					
6570-630	"	Ditto+ditto+ditto	2.33					
6640-700	"	Ditto+ditto+ditto	2.53	1315	5.2	<20	*	*
6710-770	"	Ditto+ditto+ditto	5.72					
6780-840	"	Med-dk gy mic slty mdst+vgt crs snd+mnr coal+mnr chk/marl	6.58					

TABLE 2A

SOURCE ROCK EVALUATION DATA

WELL: 9/12-1

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
2200-260	Ctgs	Yel-brn/gy slty mdst	3.30					
2280-340	"	Ditto	2.59					
2360-420	"	Ditto	2.25					
2440-500	"	Ditto	2.70	1275	4.7	<20	*	*
2520-580	"	Dk yel-brn sl calc slty mdst	1.71					
2600-660	"	Ditto	1.42					
2680-740	"	Ditto	1.55					
2760-820	"	Ditto	1.72					
2840-900	"	Ditto	1.37					
2920-980	"	Ditto	1.46					
3000-060	"	Ol-gy slty mic mdst	1.77	1320	7.5	<20	*	*
3080-140	"	Ditto	2.43					
3160-220	"	Ditto	1.84					
3240-300	"	Ditto	1.86					
3320-380	"	Ditto	1.55					
3400-460	"	Ditto	1.43					
3480-540	"	Ditto	1.68					
3560-620	"	Ditto	1.27					
3640-700	"	Ditto	1.76	2380	13.5	<20	*	*
3720-780	"	Lt ol-gy lst+mnr ol- gy mdst	1.63					
3800-860	"	Lt gy lst+mnr ditto+ mnr ditto	1.10					
3880-940	"	Ditto+mnr ditto	0.61					
3960-4020	"	Wht/v lt gy lst	0.16					
4030-090	"	Ditto	0.07					
4100-160	"	Ditto	0.19					
4170-230	"	Wht lst/chk	0.08					
4240-300	"	Ditto	0.04					
4310-370	"	Ditto	0.04					
4380-440	"	Ditto	0.08					
4450-510	"	Ditto	0.06					
4520-580	"	Lt ol-gy lst/chk+ mnr wht chk	0.08					
4590-650	"	Wht chk+mnr lt ol-gy lst	0.13					

TABLE 1 MATURITY EVALUATION DATA

WELL: 9/12-1

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
2200- 260	Ctgs	Yel-brn/gy mdst	2	0.26(8)	60	40	*
2520- 580	"	Dk yel-brn mdst	2	0.27(4)	60	40	*
2840- 900	"	Ditto	2	*	50	50	*
3160- 220	"	Ol-gy mdst	2.5	0.29(3)	35	60	5
3480- 540	"	Ditto	2-2.5	*	60	40	*
3800- 860	"	Lt gy lst	2.5	0.29(13)	30	70	*
5170- 230	"	Med-dk gy mdst + 10% wht chk	3.5	*	80	20	tr
5310- 370	"	Ditto + ditto	3-3.5	0.40(15)	95	5	tr
5520- 580	"	Ditto + ditto	3-3.5	0.38(6)	65	35	tr
5800- 860	"	Ditto + ditto	3.5	0.39(7)	80	20	*
5940-6000	"	Med gy mdst	3.5	0.42(3)	70	30	tr
6220- 280	"	Ditto	3.5-4	*	50	30	20
6500- 560	"	Ditto	3.5-4	0.43(12)	60	20	20
6710- 770	"	Ditto	3.5-4	0.42(9)	70	20	10
6780- 840	"	Coal/coaly sh	-	0.40(22)	-	-	-
6850- 910	"	Ditto	-	0.41(18)	-	-	-
6990-7050	"	Ditto	3.5-4	0.47(8)	70	20	10
7200- 260	"	Vgt: sst/snd + 10% med-dk gy mdst	3.5-4	*	50	20	30
7480- 540	"	Ditto + 30% gy-red sltst/med-dk mdst	3.5-4	0.47(4)	50	20	30
7760- 820	"	Gy-red sltst + 20% sst	3.5-4	0.37(3)	50	20	30
8040- 100	"	Ditto + ditto	3-4	*	50	20	30
8320- 380	"	Ditto + ditto	6? 3.5-4	*	50	20	30
8600-660	"	Ditto + 40% ditto	6? 3.5-4	0.47(3)?	60	10	30
8810-850	"	Ditto + ditto	6? 3.5-4	0.39(3)?	60	10	30

FIGURE I

SPORE COLOURATION INDICES AGAINST DEPTH

WELL:9/12-1

LOCATION:NORWEGIAN NORTH SEA

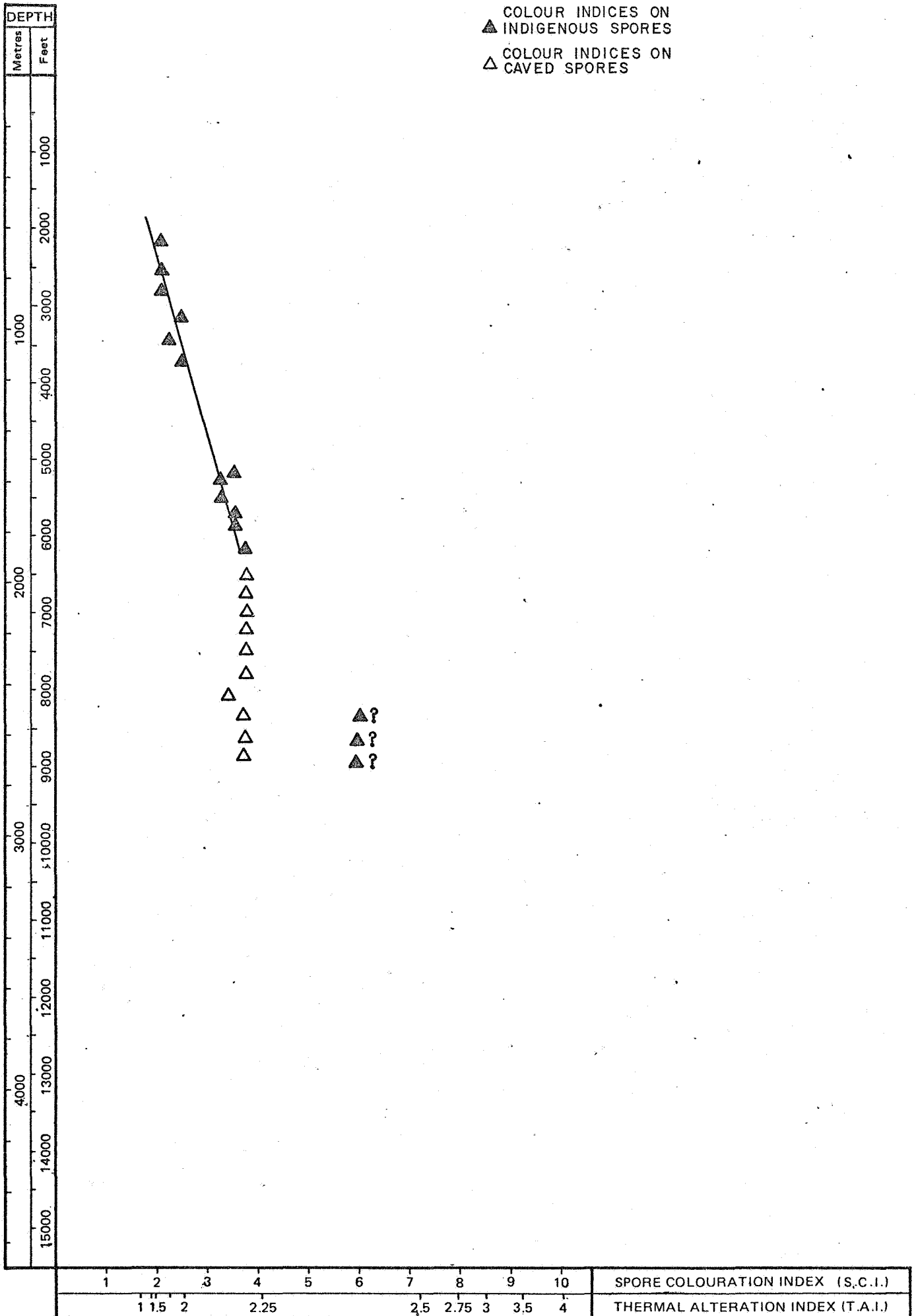


FIGURE 2 VITRINITE REFLECTIVITY AGAINST DEPTH

WELL: 9/12-1

LOCATION: NORWEGIAN NORTH SEA

