

ROBERTSON RESEARCH INTERNATIONAL LIMITED

NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO. 4B

Project No. RRI/789/IIB/2676

PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES
OF THE CONOCO PELICAN GULF 7/9-1 WELL

JULY, 1978

I

INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Conoco Pelican Gulf 7/9-1 well. The samples were received at varying intervals and were selected for analysis by compositing, mostly at 60 feet intervals, dependant 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 samples were of good quality for geochemical analysis. Compositing was started at 3,430 feet so that representative material below the mid-Miocene unconformity has been analysed. The analytical procedures used include organic carbon analysis on all the bulk cuttings samples 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/Final 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 7/9-1 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 compilation of all the data will be presented later in the compilation report.

MATURITY DATA

The spore colour data indicate that oil-prone organic matter is immature above approximately 4,000 feet, transitionally mature between 4,000 and 6,400 feet and mature below 6,400 feet. The Lower Cretaceous and Jurassic shales (7,800 to 8,550 feet) have spore colours which suggest that those sediments containing sapropelic organic matter are capable of sourcing heavy to medium gravity oils.

Vitrinite reflectivities vary from 0.31% at 3,590 feet to 0.46% at 8,420 feet, although a coal from the interval 8,140 to 8,200 feet gave a value of 0.50%. These data suggest that gas-prone organic matter in the well never attains optimum maturity. Samples from the Permo-Triassic section below approximately 8,500 feet yielded spores and vitrinite particles which were probably derived from Jurassic cavings.

HYDROCARBON SOURCE POTENTIAL DATA

The following subdivision of the analysed section of the 7/9-1 well is based on the geochemical data presented in this report.

Interval 3,430 to 3,550 feet

This interval consists of olive-grey clays with average organic carbon contents, i.e. between 1% and 2%.

Interval 3,570 to 7,235 feet

Samples from this section of the Lower Tertiary are dominated by yellow-brown shales with above average organic carbon contents, i.e. consistently greater than 2%.

at least until 200 feet above the top of the chalk. The organic materials in this interval appear to be almost entirely humic in composition. This visual impression is confirmed by the predictions given by pyrolysis of low hydrocarbon yields at optimum maturity. The sediments range from immature to early mature and are unlikely to have sourced abundant hydrocarbons. Although relatively high hydrocarbon contents have been noted (Table 2) these do not appear to constitute a large proportion of the total extract. Indications of migrant oil or drilling contamination giving high extractabilities may be noted in the deepest part of the interval.

Interval 7,240 to 7,730 feet

The chalk is organically lean and without significant present or potential hydrocarbon sourcing capability.

Interval 7,740 to 8,060 feet

The organic carbon contents of these predominantly Lower Cretaceous grey shales vary but usually fall in the range 1% to 2%. Although these shales are early mature, the hydrocarbons shown to be present by extractive analysis are unlikely to be indigenous since this interval is dominated by humic organic matter. The pyrolysis

data confirm that at optimum maturity the section is only likely to produce minor quantities of gas.

Interval 8,070 to 8,480 feet

This part of the section consists of Jurassic shales, sands and coals. Although the shales contain above average levels of organic carbon, the kerogen is predominantly humic with a relatively small sapropelic contribution. Consequently, although mature, the sequence overall appears to have only a fair hydrocarbon-sourcing capacity. Nevertheless, pyrolysis of a picked dark grey shale showed it had the potential to be a good source rock at optimum maturity.

Interval 8,490 to 9,220 feet

The actual source potential of these Triassic red-brown siltstones and sandstones is probably negligible, but the true picture is obscured by the presence of caved Jurassic shale.

Interval 9,230 to 9,614 feet (TD)

This interval consists of Permian shales, dolomites, anhydrite and halite. Although Jurassic shale cavings are probably present, the above-average organic carbon contents of the basal samples may be partly due to the presence of brown-black Permian shales. The organic matter in such shales is likely to be largely humic in composition.

TABLE 1A MATURITY EVALUATION DATA

WELL: 7/9-1

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
3590- 650	Ctgs	Dusky yel-brn/brn-blk sh	2.5	0.30(21)	40	60	*
3910- 970	"	Ditto	3	0.32(19)	20	80	*
4250- 310	"	Ditto	3	0.35(17)	20	80	*
4510- 570	"	Ditto	3	0.37(27)	20	80	*
4710- 770	"	Ditto	3	0.39(30)	30	70	*
4970-5090	"	Ditto	3	0.38(24)	40	60	*
5270- 330	"	Dk yel-brn sh	3	0.36(27)	30	70	*
5590	"	Ditto	3	0.37(23)	30	70	*
5850- 910	"	Ol-gy sh	3.5	0.38(29)	10	90	*
6150- 210	"	Dk yel-brn sh	3.5	0.39(28)	20	80	*
6430- 490	"	Ditto	3.5	0.39(16)	20	80	*
6660	"	Ol-gy/brn-gy sh	3.5	0.37(14)	40	60	*
6890- 950	"	Ditto	3.5	0.40(20)	60	40	*
7120- 180	"	Ditto+gy-red/med gy/med bl-gy sh	3.5	*	70	20	10
7860- 880	"	Dk gy sh+mnr gy-red sh	3.5	*	70	30	*
8040- 060	"	Dk gy sh	3.5	0.45(6)	20	80	*
8070- 130	"	Ditto	3.5	0.46(12)	50	50	*
8140- 200	"	Ditto+coal	-	0.50(26)	-	-	-
8280- 340	"	Ditto	3.5	0.45(14)	60	30	10
8420- 480	"	Ditto	4	0.46(18)	65	30	5
8630- 690	"	Ditto+gn-gy/gy-red sh+20% qtz snd+coal	4	0.46(9)	30	65	5
8830- 090	"	Varicoloured sh+red-brn/gy-red mdst/sltst+qtz	-	0.47(3)	-	-	-
9180- 220	"	Ditto+ditto	4	0.45(8)	60	10	30
9440- 500	"	Ol-blk brn-blk sh+varicoloured sh+red-brn sltst	4	0.46(13)	40	30	30

SOURCE ROCK EVALUATION DATA

WELL: 7/9-1

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
3430-3490	Ctgs	Ol-gy/med gy cly	1.28	-	-	-	-	-
3520	"	Ol-gy/med gy cly/ clyst	1.66	-	-	-	-	-
3550	"	Ditto+med-dk gy/brn sh	1.98	-	-	-	-	-
3570	"	Ditto+ditto	5.95	-	-	-	-	-
3560-3590	"	Dusky yel-brn/brn-blk sh	5.07	3998	7.9	885	22	87
3590-3650	"	Ditto	7.02	-	-	-	-	-
3750-3810	"	Ditto	5.53	-	-	-	-	-
3830-3890	"	Ditto	4.72	4475	9.5	540	12	81
3910-3970	"	Ditto	5.34	-	-	-	-	-
3990-4050	"	Ditto	4.55	-	-	-	-	-
4070-4110	"	Ditto	3.91	3930	10.0	460	12	77
4130-4190	"	Ditto	4.78	-	-	-	-	-
4190-4250	"	Ditto	5.41	-	-	-	-	-
4250-4310	"	Ditto	6.59	-	-	-	-	-
4330-4350	"	Ditto	6.13	7200	11.7	615	9	74
4390-4450	"	Ditto	6.21	-	-	-	-	-
4450-4490	"	Ditto	5.63	-	-	-	-	-
4510-4570	"	Ditto	6.52	-	-	-	-	-
4570-4610	"	Ditto	6.19	6623	10.7	660	10	73
4610-4630	"	Ditto	7.25	-	-	-	-	-
4630-4690	"	Ditto	6.18	-	-	-	-	-
4710-4770	"	Ditto	6.36	-	-	-	-	-
4790-4850	"	Ditto	5.78	6165	10.7	660	11	76
4850-4910	"	Ditto	6.38	-	-	-	-	-
4910-4970	"	Ditto	5.99	-	-	-	-	-

SOURCE ROCK EVALUATION DATA

WELL: 7/9-1

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
4970-5030	Ctgs	Dusky yel-brn/brn-blk sh	6.11	-	-	-	-	-
5030-5090	"	Ditto	4.66	4213	9.0	470	11	72
5110-5170	"	Ditto	4.46	-	-	-	-	-
5170-5210	"	Dk yel-brn/dusky yel- brn sh	4.33	-	-	-	-	-
5210-5270	"	Ditto	3.74	-	-	-	-	-
5270-5330	"	Ditto	3.66	2575	7.0	230	9	66
5350-5410	"	Ditto	4.40	-	-	-	-	-
5430-5490	"	Ditto	3.73	-	-	-	-	-
5510-5530	"	Ditto	2.67	1875	7.0	285	15	65
5590	"	Ditto	3.75	-	-	-	-	-
5610-5670	"	Ol-gy - lt ol-gy/dk yel-brn sh	3.27	-	-	-	-	-
5690-5750	"	Ditto	2.87	-	-	-	-	-
5770-5830	"	Ditto	2.75	2320	8.4	460	20	68
5850-5910	"	Ditto	2.68	-	-	-	-	-
5930-5990	"	Ditto	2.48	-	-	-	-	-
6010-6070	"	Dk yel-brn/dusky yel- brn sh	3.44	-	-	-	-	-
6080-6140	"	Ditto	2.86	2590	9.0	180	7	74
6150-6210	"	Ditto	3.34	-	-	-	-	-
6220-6280	"	Ditto	3.77	-	-	-	-	-
6290-6350	"	Ditto	3.95	3538	8.9	535	15	73
6360-6410	"	Ditto	4.73	-	-	-	-	-
6430-6490	"	Ditto	3.35	-	-	-	-	-
6510-6570	"	Ol-gy/brn-gy/med gy/ dk gy sh	1.88	3213	17.1	395	12	65
6590-6650	"	Ditto	1.83	-	-	-	-	-

SOURCE ROCK EVALUATION DATA

WELL: 7/9-1

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
6660	Ctgs	Ol-gy/brn-gy/med gy/ dk gy sh	2.29	-	-	-	-	-
6730-6790	"	Ditto	2.45	2693	11.0	280	10	69
6810-6870	"	Lt ol-gy/ol-gy/ol-blk /brn-gy/med gy sh	2.92	-	-	-	-	-
6890-6950	"	Ditto	3.22	-	-	-	-	-
6970-7030	"	Ditto	3.24	-	-	-	-	-
7050-7110	"	Ditto	0.83	2565	30.9	200	7	78
7120-7180	"	Ditto+gy-red/med gy - med bl-gy sh	0.68	1420	20.9	255	18	75
7190-7235	"	Ditto+ditto+chk	0.45	1298	28.8	95	7	73
7240-7290	"	Pnk-gy/v pale orng chk+med gy - med bl- gy sh	0.33	-	-	-	-	-
7310-7360	"	Pale yel-brn sltst/ mdst+med gy - med bl- gy sh+v pale orng chk	4.15	-	-	-	-	-
7380	"	Pnk-gy - yel-gy chk+ mnr med gy sh	0.30	-	-	-	-	-
7390-7450	"	Ditto+ditto	0.24	-	-	-	-	-
7460-7520	"	Ditto+ditto	0.40	-	-	-	-	-
7530-7590	"	Ditto+ditto	0.39	-	-	-	-	-
7600-7660	"	Ditto+ditto	0.32	-	-	-	-	-
7670-7730	"	Ditto+ditto	0.31	-	-	-	-	-
7740-7790	"	Brn-gy/red-gy mdst+ mnr pnk-gy chk+mnr med gy sh	1.44	-	-	-	-	-
7800-7810	"	Lt ol-gy/med-gy mdst/ sh	1.33	-	-	-	-	-
7820-7850	"	Ditto	1.52	-	-	-	-	-
7860-7880	"	Med gy/med-dk gy sh+ mnr gy-red/dk yel- brn sh	0.61	3198	52.4	505	16	58

SOURCE ROCK EVALUATION DATA

WELL: 7/9-1

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
7890-7900	Ctgs	Med gy/med-dk gy sh+ mnr gy-red/dk yel-brn sh	1.95	-	-	-	-	-
7910-7960	"	Ol-gy/med-dk gy/dk gn- gy sh	1.42	-	-	-	-	-
7970-8030	"	Ditto	2.18	3473	15.9	520	15	70
8040-8060	"	Ol-blk/ol-gy/brn-blk/ dk gy/med gy sh	2.65	-	-	-	-	-
8070-8130	"	Ditto	3.86	9855	25.5	740	8	40
8140-8200	"	Ditto+coal	3.56	-	-	-	-	-
8210-8270	"	Ditto	3.06	4308	14.1	680	16	67
8280-8340	"	Ditto	3.56	-	-	-	-	-
8350-8410	"	Ditto	3.30	4373	13.2	495	11	79
8420-8480	"	Ditto	2.85	4085	14.3	620	15	68
8490-8540	"	Ditto+50% gy-red sh	1.32	-	-	-	-	-
8560-8620	"	Ol-blk/ol-gy/med gy/ gn-gy/gy-red sh+10% qtz snd	2.18	2973	13.6	405	14	67
8630-8690	"	Ditto+20% ditto+coal	5.07	-	-	-	-	-
8700-8720	"	Gy-red/red-gy mdst+ ol-blk sh+gy red sh+ mnr ol-gy/med gy sh+ qtz snd	1.03	-	-	-	-	-
8740-8800	"	Varicoloured sh+gy- red/red-brn mdst/ sltst+qtz snd	0.59	-	-	-	-	-
8820	"	Ditto+ditto+ditto	0.70	1635	23.4	85	5	73
8830-8890	"	Ditto+ditto+ditto	1.49	-	-	-	-	-
8900-8960	"	Ditto+ditto+ditto	0.96	-	-	-	-	-
8970-9030	"	Ditto+ditto+ditto	1.11	-	-	-	-	-
9040-9100	"	Red-brn/red-orng sltst/mdst+ol-blk/ brn-blk sh	1.91	-	-	-	-	-

SOURCE ROCK EVALUATION DATA

WELL: 7/9-1

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
9110-9170	Ctgs	Red-brn/red-orng sltst/mdst+ol-blk/ brn-blk sh	1.87	-	-	-	-	-
9180-9220	"	Varicoloured sh+red- brn sltst	1.16	-	-	-	-	-
9230-9290	"	Ol-blk/brn-blk sh+ ditto+ditto	1.90	-	-	-	-	-
9300-9360	"	Ditto+ditto+ditto	2.79	-	-	-	-	-
9370-9430	"	Ditto+ditto+mmr ditto +crs snd	2.90	-	-	-	-	-
9440-9500	"	Ditto+ditto+ditto+ ditto	2.89	-	-	-	-	-
9510-9560	"	Ditto+ditto+ditto+ ditto	4.43	3140	7.1	485	15	68
9570-9614	"	Ol-blk/brn-blk sh+ mmr varicoloured sh	3.06	-	-	-	-	-

ROCK - EVAL. PYROLYSIS DATA

WELL: 7/9-1

LOCATION: NORWEGIAN NORTH SEA

$$5560-90: \frac{P_1}{P_1+P_2} = 0.3$$

$$P_1 = 0.3P, + 0.3P_2$$

$$0.7P_1 = 0.3 \times 3200$$

$$0.7$$

SAMPLE DEPTH (FEET) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
3560- 590	Brn-blk sh	5.63	432	56	74	0.3	3200
3830- 890	Ditto	5.57	436	36	18	0.3	2000
4070- 110	Ditto	4.49	438	63	64	0.1	2900
4330- 350	Ditto	6.52	436	57	70	0.4	3800
4570- 610	Ditto	5.16	424	72	86	0.2	3800
4790- 850	Ditto	6.50	431	48	48	0.3	3200
5030- 090	Ditto	4.64	423	40	36	0.4	1900
5270- 330	Dk yel-brn sh	4.01	428	81	49	0.1	3300
5510- 530	Ditto	2.51	432	47	50	*	1600
5770- 830	Ol-gy/dk yel-brn sh	2.73	425	42	92	*	1200
6080- 140	Dk yel-brn sh	2.96	423	46	56	*	1400
6290- 350	Ditto	4.17	427	39	49	*	1600
6510- 570	Ditto	2.51	426	22	48	*	600
6730- 790	Ol-gy/brn-gy/med gy/dk gy sh	2.62	411	24	63	0.2	600
7050- 110	Ol-gy sh	0.83	*	*	540	*	*
7860- 880	Med gy sh	0.72	*	*	267	*	*
2438 7970-8030	Med-dk gy sh	2.95	415	10	51	0.9	300
2469 8070- 130	Brn-blk/ol-blk sh	4.35	426	145	33	0.2	6300
2490 8140- 200	Ditto	3.56	419	133	85	0.07	4000
2512 8210- 270	Ditto	2.98	429	88	66	0.3	2600
2533 8280- 340	Ditto	3.56	418	67	43	0.5	2400
2557 8350- 410	Ditto	2.88	426	21	42	0.7	600
2576 8420- 480	Ditto	2.44	420	11	34	0.5	300
2594 8490- 540	Ditto+50% gy-red sh	1.32	416	9	15	0.7	100
2618 8560- 620	Ol-blk/gy-red sh	1.18	428	115	58	0.07	1400
PICKED LITHOLOGIES							
3590-3650	Brn-blk sh	5.97	428	74	111	0.2	4400
6150-6210	Yel-brn sh	1.54	409	59	177	*	900
6150-6210	Dk yel-brn sh	4.83	412	55	33	0.2	2700
6430-6490	Yel-brn sh	1.65	414	90	59	*	1500
6430-6490	Dk yel-brn sh	3.91	420	54	62	0.08	2100
6600	Ol-gy sh	1.79	414	31	71	0.1	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 3B

ROCK - EVAL. PYROLYSIS DATA

WELL: 7/9-1

LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (FEET) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
6600	Dk-gy sh	3.97	415	101	79	0.5	4000
7310-7360	Yel brn sltst/ mdst	7.46	412	7	9	0.3	500
7310-7360	Med gy sh	1.77	*	*	39	*	*
7310-7360	Med bl-gy sh	1.72	415	18	22	0.9	300
7860- 880	Med-dk gy sh	0.56	*	*	239	*	*
8070- 130	Dk gy sh	4.80	429	256	30	0.1	12300
9230- 290	Med-dk gy sh	1.61	428	32	45	0.9	500

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: 7/9-1

LOCATION: NORWEGIAN NORTH SEA

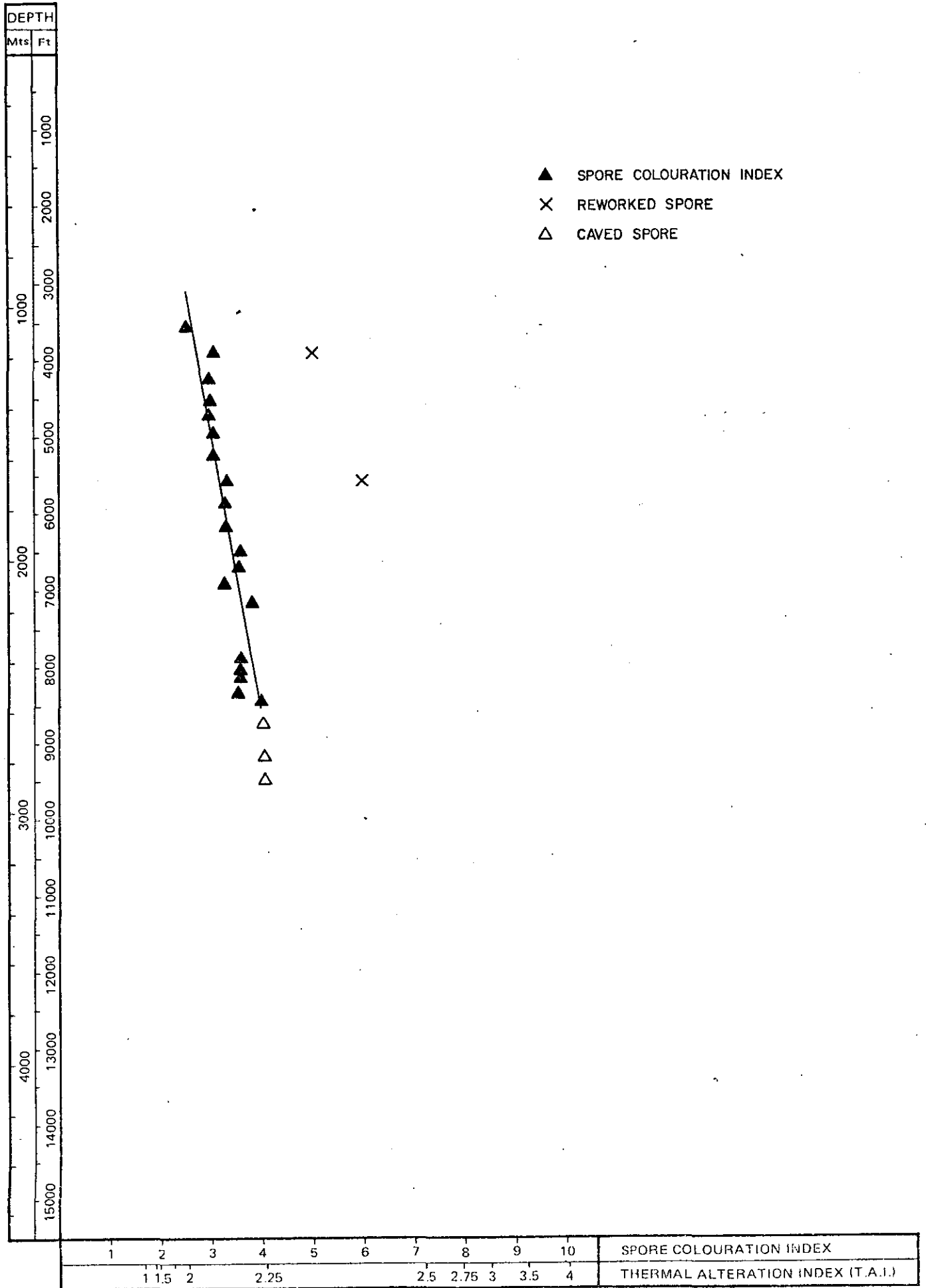


FIGURE 2 VITRINITE REFLECTIVITY AGAINST DEPTH

WELL: 7/9-1

LOCATION: NORWEGIAN NORTH SEA

