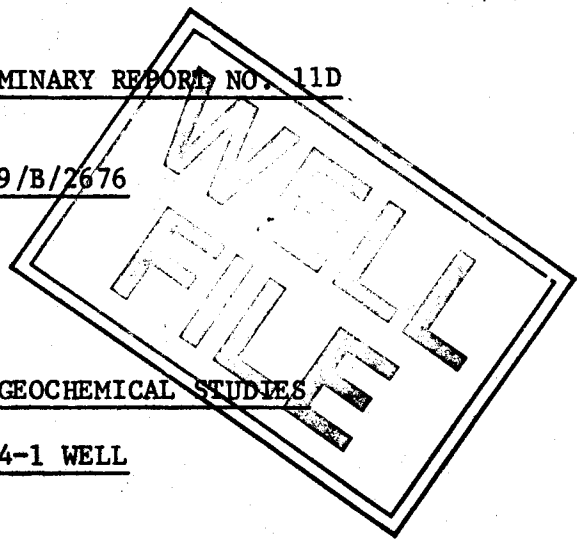


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NORWEGIAN OFFSHORE AREA - PRELIMINARY REPORT NO. 11D

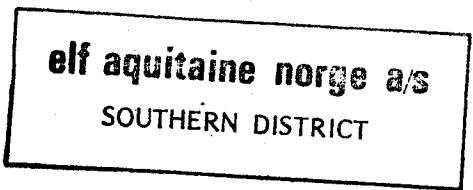
Project No. RRPS/789/B/2676



PRELIMINARY RESULTS OF PETROLEUM GEOCHEMICAL STUDIES

OF THE ELF NORGE 17/4-1 WELL

FEBRUARY, 1979



I

INTRODUCTION

Petroleum geochemical studies have been carried out on samples received from the Elf Norge 17/4-1 well. Samples were received at 2 to 30 metre intervals and were composited at 20 metre intervals from 650 to 2155 metres 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 samples were of variable quality for geochemical analysis, but were generally of good quality below the 13 3/8" casing set at 1803 metres. It is of note that the interval of salt below 2900 metres was drilled using an invert oil emulsion mud. A sample of the supposed Kupferschiefer Formation was prepared for several analyses using organic solvents to clean the sample of drilling mud.

Relevant information on drilling conditions and mud properties are included in N.P.D. Paper 14 and for interpretational purposes we have also had access to

numerous logs provided by Elf Norge.

The analytical procedures used include organic carbon analysis on most of the bulk cuttings samples at 20 metre intervals and also on several individual lithologies where bulk samples consisted of more than one lithotype. Extractive source rock analysis has been carried out on a number of samples at varying intervals. Gas chromatographic analysis has not been carried out on alkane fractions in this section 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 17/4-1 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 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 interval of the well is at an early stage of maturity for generation of low <sup>o</sup>API gravity oil from oil-prone organic matter (see source rock evaluation). The Tertiary section appears to be presently immature and will have no hydrocarbon generating potential.

Fairly reliable vitrinite reflectivity data have been obtained in the Lower Cretaceous and Jurassic interval of the well and values are between 0.4% and 0.45% suggesting an early stage of maturity for any contained 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 17/4-1 well is made:

Interval 650 to 1160 metres	Lower Tertiary. Olive-grey micaceous silty mudstones predominate down to 1010 metres. Below this depth green-grey soft calcareous mudstone is predominant over medium grey, olive-grey and occasional grey-red mudstones. Organic carbon contents are above average at 2% to 5% above 1040 metres, but about average at around 1.5% below 1050 metres.
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The kerogen composition of the samples analysed is humic predominantly vitrinite. Pyrolysis data for the few samples analysed confirm the poor source potential of the sediments.

The interval from 650 to 1040 metres contains above average amounts of gas-prone organic matter. There is no present hydrocarbon generating potential, but the interval will be a good gas source at optimum maturity.

The interval below 1040 metres is a poor gas source both at present and at optimum maturity.

Interval 1170 to 1410 metres

Upper Cretaceous Chalk.

No hydrocarbon generating potential.

No evidence of migrant hydrocarbons.

Interval 1410 to 2110 metres

Lower Cretaceous medium and medium-dark grey mudstones tending to shale below 2040 metres, with minor caved chalk at the top of the interval and occasional grey-red shales and yellow-brown siltstones throughout. The organic carbon content is about average through most of the interval and the organic matter is principally humic with inertinite predominant over vitrinite. Pyrolysis data in this interval indicate very poor hydrocarbon generating potential.

No hydrocarbon generating potential at present or at optimum maturity.

Interval 2115 to 2215 metres

Upper Jurassic shale of the Borglum formation. No samples were available for analysis between 2155 and 2295 metres. Unfortunately this sample break occurs within the Borglum Member so that the lower part of the "Hot" shale is not represented by indigenous drilled material. To obtain an estimate of the hydrocarbon generating potential of this interval, dark grey shale cuttings from 2295 to 2625 metres were picked for organic carbon and pyrolysis analysis. The result from all these picked samples are believed representative of the "Hot" shale unit. The organic carbon content in the samples of both bulk and picked cuttings samples ranges from 2.35% to 6.94%. The kerogen composition analysis shows sapropel to be present in about equal proportions to inertinite and vitrinite. Pyrolysis analysis shows that the richest "Hot" shale analysed has a good potential yield and hydrogen index while the rest of the samples have a more limited source potential, although still being fair to good oil source rocks. The "Hot" shale has well above average carbon content. It is presently capable of limited oil generation, but at optimum maturity will be a fair to good oil source.

Interval 2215 to 2265 metres

Upper Jurassic shales and siltstones of the Egersund formation.

No samples available for analysis.

Interval 2265 to 2625 metres

Middle Jurassic and Triassic age represented mostly by sandstone.

No hydrocarbon generating potential.

Interval 3820 to 3839 metres

Lower Permian Kupferschiefer shale, dolomite and anhydrites. The cuttings in this interval are of poor quality, the major part of the salt interval of the well having been drilled with oil based invert mud. A picked sample of dark grey shale had 1.67% carbon content, but poor pyrolysis parameters in terms of potential yield. The level of maturity could not be reliably deduced from the pyrolysis parameters in view of the mud contamination.

TABLE 1 MATURITY EVALUATION DATA

WELL: 17/4-1

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
650-670	Ctgs	Ol-gy mic slty mdst	2-2.5	-	10	90	*
770-780	"	Ditto	2.5	-	20	75	5
900-920	"	Ditto	-	-	-	-	-
990-1010	"	Ditto	3	-	20	80	*
1080-100	"	Gn-gy soft calc mdst	-	0.30(12)	-	-	-
1110-130	"	Ditto	-	0.30(4)			
1140-160	"	Ditto	3	0.31(10)	20	75	5
1410-430	"	Chk+lt gy marl+ med-dk gy mdst	3-3.5	-	50	45	5
1485-505	"	Ditto+ditto+ ditto	3.5?	-	25	70	5
1585-605	"	Ditto+ditto+ ditto	3.5	-	80	20	*
1690-710	"	Med/med-dk gy mdst	3.5	0.39(14)	80	20	*
1790-810	"	Ditto	3.5-4?	0.40(25)	80	20	*
1890-910	"	Ditto	4	0.47(12)	80	10	10
1965-985	"	Ditto	-	0.41(11)	-	-	-
1990-2010	"	Ditto	4	0.43(17)	90	10	*
2015-035	"	Ditto	-	0.44(9)	-	-	-
2065-085	"	Ditto	-	0.43(19)	-	-	-
2090-110	"	Med/med-dk gy sh	4	0.43(12)	80	20	*
2145-155	"	Ditto	4.5	-	40?	30?	30?

## SOURCE ROCK EVALUATION DATA

WELL: 17/4-1

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
650-670	Ctgs	Ol-gy mic slty mdst + mnr med-dk gy/brn - gy mdst+mnr dk yel- brn lst	2.33					
710-730	"	Ditto + mnr ditto + mnr ditto	2.22	1575	7.1	65	4	86
770-780	"	Ditto + mnr ditto + mnr ditto	3.86					
840-860	"	Ditto + mnr ditto + mnr ditto	3.25					
900-920	"	Ditto + mnr ditto + ditto	3.39					
960-980	"	Ditto + mnr ditto + ditto	4.42					
990-1010	"	Ditto + mnr ditto + ditto	2.96	2950	9.9	50	2	73
1020-040	"	Gn-gy soft calc mdst +mnr ol-gy/med gy/ med-dk gy mdst + mnr yel-gy lst	3.22					
1050-070	"	Ditto + med gy slty mdst + mnr gy-red/lt ol-gy sh + yel gy lst	1.89	2550	13.5	20	1	86
1080-100	"	Ditto + ditto + ditto + ditto	1.76					
1140-160	"	Ditto + ditto + ditto + ditto	1.15					
1170-190	"	Lt gn-gy soft calc mdst + med gy slty mdst + wht-yel gy lst/ chk	1.59	2890	18.1	40	1	5
1410-430	"	Wht/yel-gy chk + lt gy marl + med-dk gy soft mdst	0.56					
1460-480	"	Ditto + ditto + ditto	1.57	1075	6.8	<20	*	*
1485-505	"	Ditto + ditto + ditto	1.69					



TABLE 2B

## SOURCE ROCK EVALUATION DATA

WELL: 17/4-1

LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH ( 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
1535-555	Ctgs	Wht/yel-gy chk + lt gy marl + med-dk gy soft mdst	1.07					
1585-605	"	Ditto + ditto + ditto	1.52					
1635-650	"	Med/med-dk gy mdst + mnr chk + mnr yel-brn sltst + mnr gy-red sh						
1690-710	"	Ditto + ditto + ditto + ditto	1.67					
1740-760	"	Ditto + ditto + ditto + ditto	1.59	2140	13.4	20	1	68
1790-810	"	Ditto + ditto + ditto + ditto	1.53					
1840-860	"	Ditto + ditto + ditto + ditto	1.31	3615	27.8	30	1	58
1890-910	"	Ditto + ditto + ditto + ditto	1.01					
1940-960	"	Ditto + ditto + ditto + ditto	0.95					
1990-2010	"	Ditto + ditto + ditto + ditto	0.99					
2040-060	"	Med gy/med-dk gy mdst/sh+ mnr mt1 yel - brn/gy-red sh	0.59					
2090-110	"	Ditto + ditto	0.65					
2115-135	"	Ditto + ditto	2.35					
2145-155	"	Ditto + ditto	4.18					
<u>PICKED LITHOLOGIES</u>								
2115-135	Ctgs	Med-dk gy mdst /sh	6.94					
2145-155	"	Ditto	5.92					
2295-315	"	Ditto	3.60					
2350-370	"	Ditto	5.18					

## SOURCE ROCK EVALUATION DATA

WELL: 17/4-1

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
2555-575	Ctgs	<u>PICKED LITHOLOGIES</u> Med-dk gy mdst/sh	3.54					
2605-625	"	Ditto	5.09					
3834-839	"	Dk gy sh	1.67					

TABLE 3

## ROCK - EVAL. PYROLYSIS DATA

WELL: 17/4-1

LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (METRES) OR NOTATION	GENERALISED LITHOLOGY	ORGANIC CARBON (%)	TEMPERATURE (°C)	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (PPM)
710-730	Ol-gy slty mdst	2.22	420	44	206	0.1	1000
990-1010	Ditto	2.96	417	38	178	0.08	1100
1050-070	Gn-gy calc mdst	1.89	416	17	120	0.3 0.1	300
1460-490	Chk+lt gy marl+ med-dk gy mdst	1.57	418	23	228	*	400
1740-760	Med/med-dk gy mdst	1.59	420	8	171	0.39 0.4	100
1840-860	Ditto	1.31	418	11	262	*	200
2115-135	Med/med-dk gy sh/ mdst	2.35	432	125	90	0.43 *	2900
2145-155	Ditto	4.18	433	273	74	*	11400
<u>PICKED LITHOLOGIES</u>							
2115-135	Med-dk gy sh	6.94	414	446	35	*	30900
2145-155	Ditto	5.92	416	390	44	0.43 *	23100
2295-315	Ditto	3.60	423	197	15	*	7100
2350-370	Ditto	5.18	424	233	25	0.07	12100
2555-575	Ditto	3.54	426	230	29	0.07	200
2605-625	Ditto	5.09	424	211	41	*	10800
3834-839	Dk gy sh	1.67	436	100	99	0.5	1700

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: 17/4-1

LOCATION: NORWEGIAN NORTH SEA

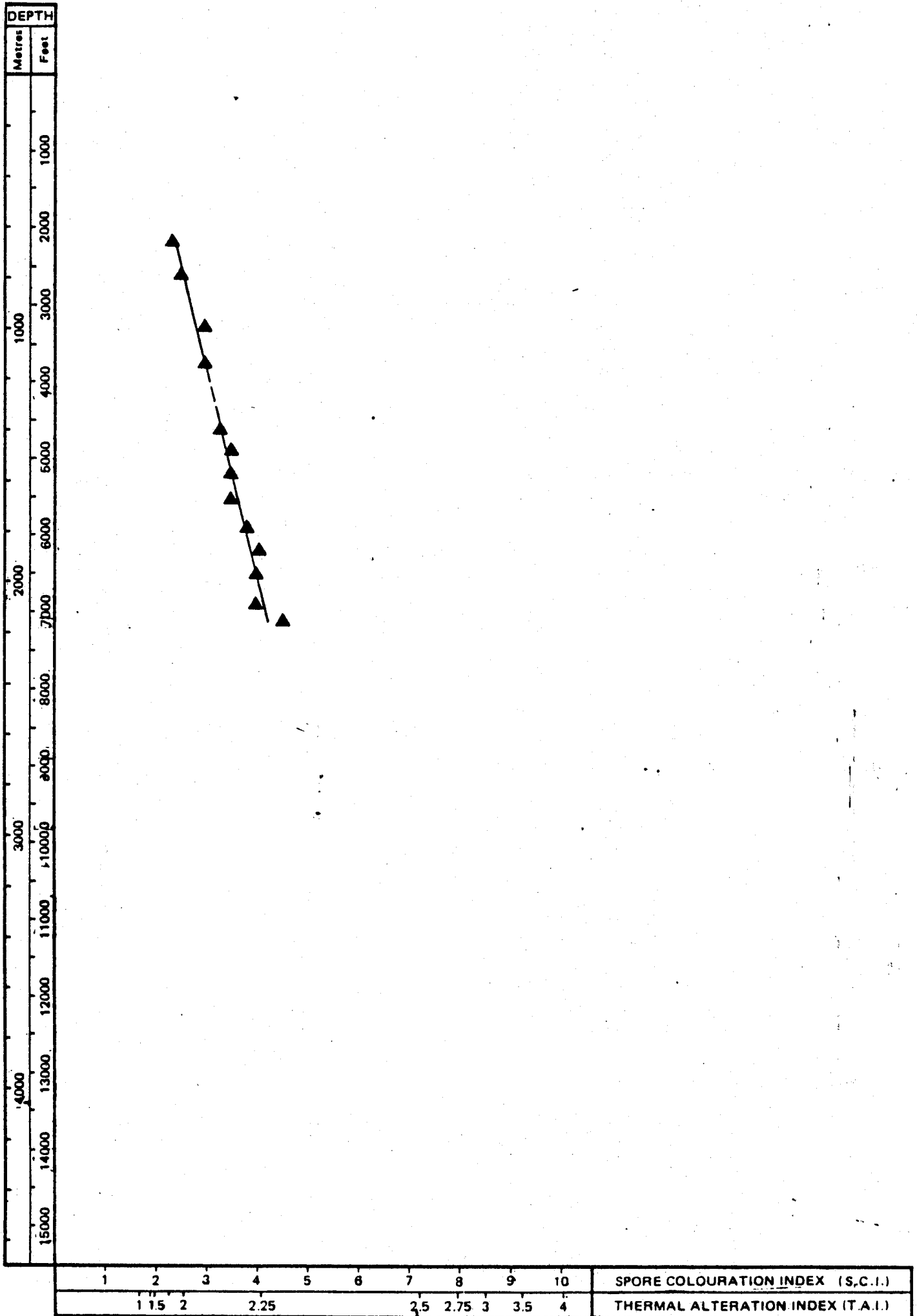


FIGURE 2 VITRINITE REFLECTIVITY AGAINST DEPTH

WELL: 17 / 4 - 1

LOCATION: NORWEGIAN NORTH SEA

