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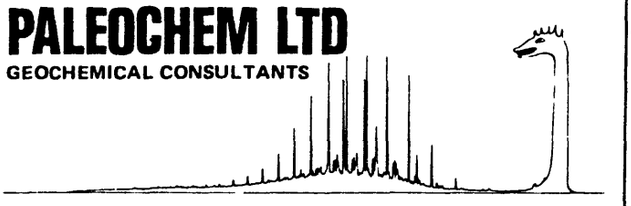

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PETROLEUM GEOCHEMISTRY REPORT

PREPARED FOR

CONOCO NORWAY INC.

Hydrocarbon Potential of Tertiary sediments and Maturation Trend Prediction from NOCS Well: 24/9-3.

July 1981

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Summary

Thirty cuttings samples and five core chips from the Tertiary section of NOCS Well: 24/9-3 were used for a preliminary geochemical source rock evaluation study. Maturity estimations completed using Vitrinite Reflectance measurements suggested the sediments to be immature to at least 2000 m. No reliable statistical correlation of the vitrinite measurements could be achieved, possibly due to the effect of bitumen staining of the Vitrinite particles.

Hydrocarbon potential ratings from Screening Pyrolysis measurements demonstrated that only three of the sediments examined had any significant hydrocarbon potential. All the other sediments examined had only poor hydrocarbon potentials.

1. Introduction

A total of thirty cuttings samples and five core chips from NOCS Well: 24/9-3 were used for the completion of a preliminary geochemical evaluation. The age of the sediments examined was Tertiary, ranging from Middle Miocene to Eocene and the depth interval examined was from 580 to 2200 m.

The cuttings samples from the shallower section of the well (ca 1400 m) contained very few organic rich intervals. However, small amounts of siltstones were present in these samples, which were used for the completion of a limited number of Vitrinite Reflectance and Screening Pyrolysis measurements. The main lithology below 1400 m was siltstone, which provided suitable material for evaluation.

The main interval of interest was the Eocene section from below the $13^3/8$" casing (1587 m) to the top of a reservoir sand at 1739 m. The main objective was to evaluate the evidence for these sediments having produced the hydrocarbons present in the reservoir sands. An unsuccessful attempt was made to provide a depth/maturation trend by statistical correlation of Vitrinite Reflectance measurements completed to a total depth of 2200 m.

2. Samples and Techniques

The samples were washed with water to remove any dust or surface contamination and air dried at 40^{o}C. for a maximum of 12 hours. The cuttings were then hand picked to remove any obvious caved material and to concentrate the organic rich lithologies.

Samples for Vitrinite Reflectance measurements were coarsely ground and mounted in blocks of polystyrene resin and polished before being examined microscopically using an oil immersion objective. The results of these measurements are shown in Table 1. Fluorescence of indigenous organic matter under U.V. light was also observed and the fluorescence colour recorded was used to provide a further guide to sediment maturity.

Samples for Total Organic Carbon examination were ground, sieved through a 150μ sieve to achieve homogeneity, then decarbonated using fuming hydrochloric acid. The samples were then analysed by combustion in a Carlo Erba 1106 analyser and their carbon content determined, relative to known standards. The results of these measurements are shown in Table 2.

Samples for Screening Pyrolysis were ground as for total organic carbon measurements and their total hydrocarbon potential determined using a screening pyrolysis instrument. The samples were initially heated to 250^{o}C. and then programmed to 550^{o}C. to provide two composite hydrocarbon peaks, commonly referred to as P1 and P2. The areas of these peaks were then related to known standards and the results expressed as Kg./tonne of hydrocarbons. These results are shown in Table 3.

3. Results and Discussion

(a) Maturity

The results of Vitrinite Reflectance measurements are shown in Table 1. Although plenty of vitrinite was present in the sediments examined to give apparently reliable data, no depth trend could be achieved by statistical correlation.

Correlation using a linear regression programme gave a least squares fit of less than 75% and correlation coefficient of less than 80%. This is considered to be too unreliable for the calculation of meaningful hydrocarbon generation thresholds. It was noted that bitumen staining was observed in all the sediments examined, which has been associated by some workers with artificially lowering the reflectivity. Certainly the autochthonous reflectivity values rarely exceed 0.45% even as deep as 2100 m.

U.V. fluorescence colours of spores present in the sediments observed alongside the Vitrinite measurements suggested an increase in maturity with depth, with the colours increasing from green/yellow through to light orange. The light orange U.V. fluorescence colour would support the reflectivity value of 0.58% at 2149 m, rather than the lower value of 0.38%. It is therefore suggested that sediments at about 2149 m may have reached the threshold for liquid hydrocarbon generation (Ro = 0.55%) (1). However, this must be regarded only as an approximation.

(b) Source Potential

The results of the Total Organic Carbon (TOC) content measurements (Table 2) demonstrated that the Eocene sediments examined contained only poor to moderate quantities of organic carbon. Source potential ratings based on conventional geochemical data are given below.

Poor potential	0.5%
Moderate potential	0.5 to 1.5%
Good potential	1.5%

It has been suggested by Ronov (2) that shales require

more than 0.5% organic carbon to yield commercial quantities of oil.

The results of the screening pyrolysis measurements are given in Table 3. The calculated yields are expressed in kilogrammes per metric tonne, although this is equivalent to yields expressed in milligrammes per gram of rock, or parts per mil.

The first peak (P1) is considered to be representative of the quantity of free hydrocarbons (Kg./tonne), that were present in the sediment at the time of sampling. This assumes that there has been no subsequent hydrocarbon contamination during sample storage and/or handling. The second peak (P2) is considered to be representative of the quantity of hydrocarbons (Kg./tonne) produced by conversion of the kerogen in the rock sample by thermal cracking in the instrument. This may also be considered to be an estimate of the amount of hydrocarbons, which could theoretically be generated by complete thermal conversion of the kerogen in sediments, under natural conditions throughout their geological life-time.

Comparison of pyrolysis data with conventional geochemical data, to provide a source potential rating, has given the following ratings for the P2 hydrocarbon potential in practical exploration terms:

Poor	0.1 to 2.5 Kg./tonne
Moderate	2.5 to 5 Kg./tonne
Good	Greater than 5 Kg./tonne

The results shown in Table 3 demonstrate the Miocene and Oligocene sediments examined had little significant hydrocarbon potential. Only the upper section of the Eocene sediments

examined (above 1600 m) had any significant hydrocarbon potential, with one exception in the lower interval at 1793 m. This sediment was given a moderate source potential rating. The upper section of the Eocene contained a lignite band at 1130 m, which not surprisingly had excellent hydrocarbon potential. The siltstone examined from the same depth was given a moderate hydrocarbon potential rating.

4. Conclusions

1) No reliable statistical correlation of vitrinite reflectance data was completed. It was suggested that the sediments are only just mature for liquid hydrocarbon generation at around 2149 m, but this is an approximation.

2) It was demonstrated that only three sediments examined in this study had significant hydrocarbon potential. These three included a lignite from 1130 m and given an excellent hydrocarbon potential rating, the other two sediments from 1130 m and 1793.0 m were given moderate hydrocarbon potential ratings.

3) On the evidence of insufficient maturity and lack of hydrocarbon potential, it was concluded the Lower Tertiary shales from this well below the $13^3/8$" casing are very unlikely to have produced the hydrocarbons found in the Lower Eocene Sand.

References

1. Dow W.G. J. Geochem. Expl.7 (1977) pp. 79 - 99.

2. Ronov A.B. Geochemistry No.5, p.510 - 536 (1958).

Well: 24/9-3.

VITRINITE REFLECTANCE DATA		
Depth m.	Reflectivity $Ro_{(Ave)}$	
	Autochthonous	Allochthonous
580	N.D.P.	
630	N.D.P.	
1080	$0.37_{(20)}$	
1130	$0.32_{(22)}$	
1230	$0.36_{(20)}$	
1280	$0.38_{(3)}$	
1330	$0.36_{(17)}$	$0.56_{(3)}$
1380	$0.38_{(21)}$	
1430	$0.32_{(7)}$	
1580	$0.29_{(20)}$	
1630	$0.33_{(18)}$	
1681	$0.42_{(20)}$	
1729	$0.40_{(20)}$	
1778.3	$0.46_{(7)}$	
1797	$0.44_{(15)}$	

Figures in Parenthesis refer to the number of measurements completed.

Table 1.

Well: 24/9-3

VITRINITE REFLECTANCE DATA		
Depth m.	Reflectivity $Ro_{(ave)}$	
	Autochthonous	Allochthonous
1804	$0.43_{(22)}$	
1849	$0.45_{(21)}$	
1900	$0.40_{(22)}$	
1940	$0.40_{(20)}$	
2002	$0.39_{(22)}$	
2050	$0.41_{(21)}$	
2101	$0.41_{(21)}$	
2149	$0.38_{(14)}$ $0.58_{(6)}$	
2200	$0.44_{(21)}$	

Figures in Parenthesis refer to the number of measurements completed.

Table 1 - continued.

Well: 24/9-3

Total Organic Carbon Contents

Depth (m)	Total Organic Carbon (TOC) Content % wt.
1606	0.88
1630	0.88
1654	0.70
1681	0.81
1705	0.72
1729	0.58 (0.57 Repeat)
1750	0.49
1778.1	0.29
1779.7	0.25
1784.3	0.55
1793.0	1.29
1797.0	0.22

Table 2.

Well No: 24/9-3.

Pyrolysis Data

Depth	Age	Yield (kg./tonne) P1	P2
580	Mid. Miocene	0.1	0.1
630	E. Miocene	0.3	0.8 (0.7 Rpt).
680	E. Miocene	0.3	0.3
730	Oligocene	0.1	0.3
780	Oligocene	0.1	0.3
880	Oligocene	0.1	0.2
930	Oligocene	<0.1	0.1
980	Oligocene	0.1 (0.1 Rpt)	0.2 (0.2 Rpt)
1030	Eocene	0.1	0.2
1080	Eocene	0.1	0.4
1130 (Grey)	Eocene	0.5	2.3
1130 (Black)	Eocene	9.4 (9.4 Rpt)	25.4 (26.4 Rpt)
1230	Eocene	0.1 (0.1 Rpt)	0.5 (0.5 Rpt)
1280	Eocene	0.2	0.8
1330	Eocene	0.1	0.6
1380	Eocene	0.2	0.8
1410	Eocene	0.1 (0.1 Rpt)	0.6 (0.5 Rpt)
1430	Eocene	0.1	0.7
1460	Eocene	0.1	0.7
1480	Eocene	0.1	0.8

Table 3.

Well No: 24/9-3

Pyrolysis Data (cont'd)

Depth	Age	Yield (kg./tonne) P1	P2
1510	Eocene	0.2 (0.1 Rpt)	0.8 (0.8 Rpt)
1530	Eocene	0.1	0.8
1560	Eocene	0.1	0.8
1580	Eocene	0.1	0.9
1606	Eocene	0.2	1.1
1630	Eocene	0.2 (0.2 Rpt)	1.3 (1.3 Rpt)
1654	Eocene	0.1	0.9
1681	Eocene	0.2 (0.1 Rpt)	1.3 (1.2 Rpt)
1705	Eocene	0.1	0.9
1729	Eocene	0.2	0.7
1750	Eocene	0.1	0.7
^{c}1778.1	Eocene	0.1	0.4
^{c}1779.7	Eocene	0.1	0.3
^{c}1784.3	Eocene	0.3	0.8
^{c}1793.0	Eocene	0.2 (0.2 Rpt)	1.8 (1.9 Rpt)
^{c}1797.0	Eocene	0.1 (0.1 Rpt)	0.3 (0.3 Rpt)

Table 3 - Continued.