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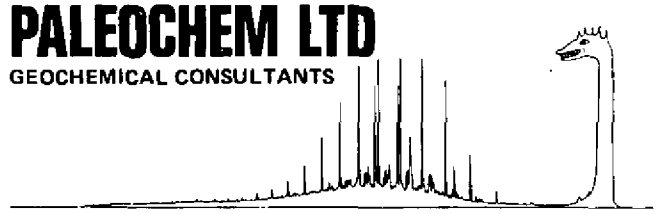

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PETROLEUM GEOCHEMISTRY REPORT

PREPARED FOR

AMOCO (NORWAY)

Source Rock Evaluation of selected core material from NOCS Well: 2/9-2.

March 1981.

CONTENTS

Summary

Four shale core pieces from Core No1, Amoco Norway Well: 2/9-2 were used for a geochemical appraisal of potential source horizons. The results of the study demonstrated that all four samples had good hydrocarbon potential, though they were immature for any hydrocarbon generation. Source Quality evaluations indicated that the kerogens were predominantly oil prone, with limited gas potential.

1. Introduction

Four samples of shale were selected from Core No1, Well: 2/9-2 at 3989.10 m, 3903.20 m, 3909.13 m and 3914.02 m. All the samples were screened using total organic carbon content and screening pyrolysis measurements. The two richest samples were used for visual kerogen/spore colouration, extended pyrolysis and soluble extract studies. Two samples, samples from the shallowest and the deepest core pieces were used for vitrinite reflectance measurements.

2. Samples and Techniques

The core pieces were washed to remove traces of surface contamination by drilling mud and dust and then air dried under controlled conditions at 40°C. Care was taken to select material from as far inside the samples, to minimise the effects of possible hydrocarbon contamination from drilling mud, sample handling etc.

Samples for Vitrinite Reflectance measurements were ground to a rock flour, mounted in an epoxy resin block, the surface of which was examined microscopically. Reflectivity values were measured using a reflected light microscope, with an oil immersion objective. The results of these measurements are shown in Table 1.

Samples for Visual Kerogen description were treated with mineral acid, the remaining debris was smeared on to a microscope slide and examined using a transmitted light microscope. The results of the Visual Kerogen descriptions

and assessments of Spore Colouration are shown in Table 2. The range of the Spore Colouration Scale is from 1 - 7 and the colour taken as representing the onset of liquid hydrocarbon generation is 3/4.

Samples for Total Organic Carbon measurements were finely ground and sieved to achieve homogeneity, then digested with fuming hydrochloric acid to remove mineral carbonate. The decarbonated samples were then combusted in a Carlo Erba 1106 Carbon, Hydrogen, Nitrogen analyzer and their total organic carbon content were determined relative to those of calibrated standards. The results of these measurements are shown in Table 3.

Samples for Screening Pyrolysis were also ground and sieved and then examined using a modified Hewlett-Packard 5711 Gas Chromatograph, to measure their ultimate hydrocarbon potential. Samples were heated to an initial temperature of 250^{o}C, then ramped to 550^{o}C. Two peaks were evolved, which are referred to as P1 and P2 and were related to those a known calibrated standard. The results of screening pyrolysis are shown in Table 4.

Ground samples for Extended Pyrolysis were extracted with dichloromethane, before being heated to 550^{o}C and examined using a modified Hewlett-Packard 5880 Gas Chromatograph. The hydrocarbons evolved were separated according to their boiling points on a non-polar, glass capillary column.

Ground samples of the two richest cores (3909.13 and 3914.02 m) were extracted with geochemical grade dichloromethane. Excess solvent was removed by evaporation and the remaining extract was separated on activated silica, to provide a saturate

alkane fraction for gas chromatographic analysis. The saturate alkane fractions were examined by quartz capillary gas chromatography using a Carlo Erba 2151 gas chromatograph with Grob-type splitless injector system. The results of the separation on silica are represented in Table 5.

3. Results and Discussion

(a) Maturity

The results of Vitrinite Reflectance measurements and Spore Colouration assessments given in Tables 1 and 2 demonstrated that the sediments examined were immature for any hydrocarbon generation. However, bitumen staining was observed during the vitrinite reflectance measurements, which has been associated with artificially lowering the true reflectivity value. Hence, the vitrinite values have been divided into those considered to have been affected by bitumen staining (0.34 and 0.38%) and those considered to be more representative of the true maturity level (0.48%). The spore colours observed were somewhat lighter than would have been expected for their apparent level of maturity, but this is a phenomenon we have found to be typical of these "hot-shale" sediments.

(b) Source Potential

(i) Hydrocarbon Potential

The results from Total Organic Carbon measurements given in Table 3 indicated that all of the sediments examined were good potential source rocks. These results were supported by Screening Pyrolysis measurements, which demonstrated that all the sediments had good hydrocarbon potential.

The first peak (P1) is considered 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 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 conversion of the kerogen in sediments, under natural conditions throughout their geological lifetime.

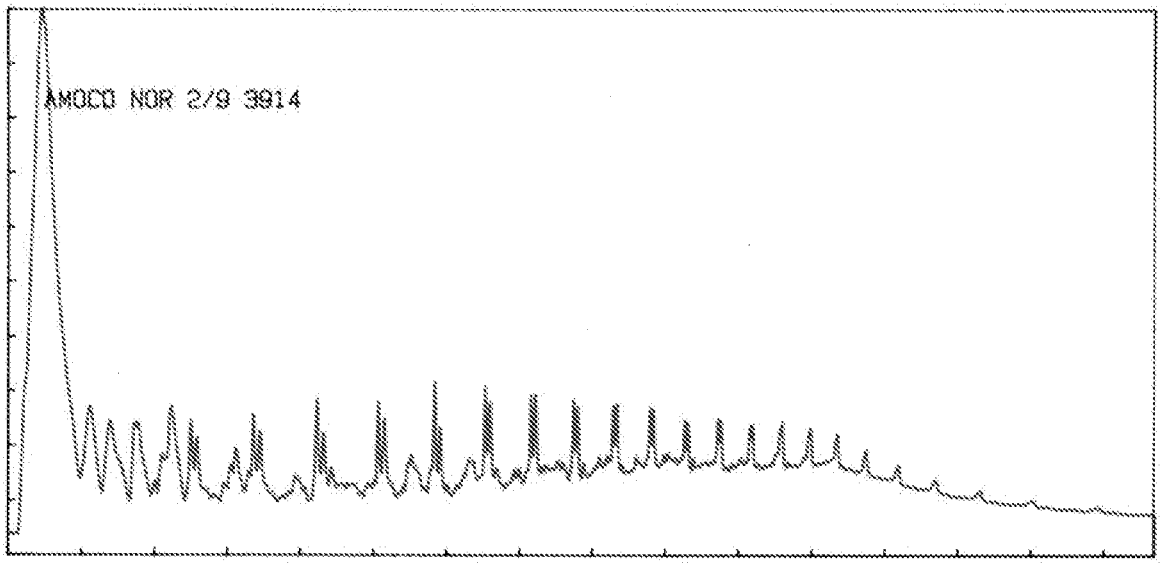
Comparison of pyrolysis data with conventional geochemical data, to provide a source potential rating, has given the following ratings for the P2 hydrocarbon potential in practical exploration terms:

Poor	0.1 to 2.5 kg/tonne
Moderate	2.5 to 5.0 kg/tonne
Good	Greater than 5.0 kg/tonne

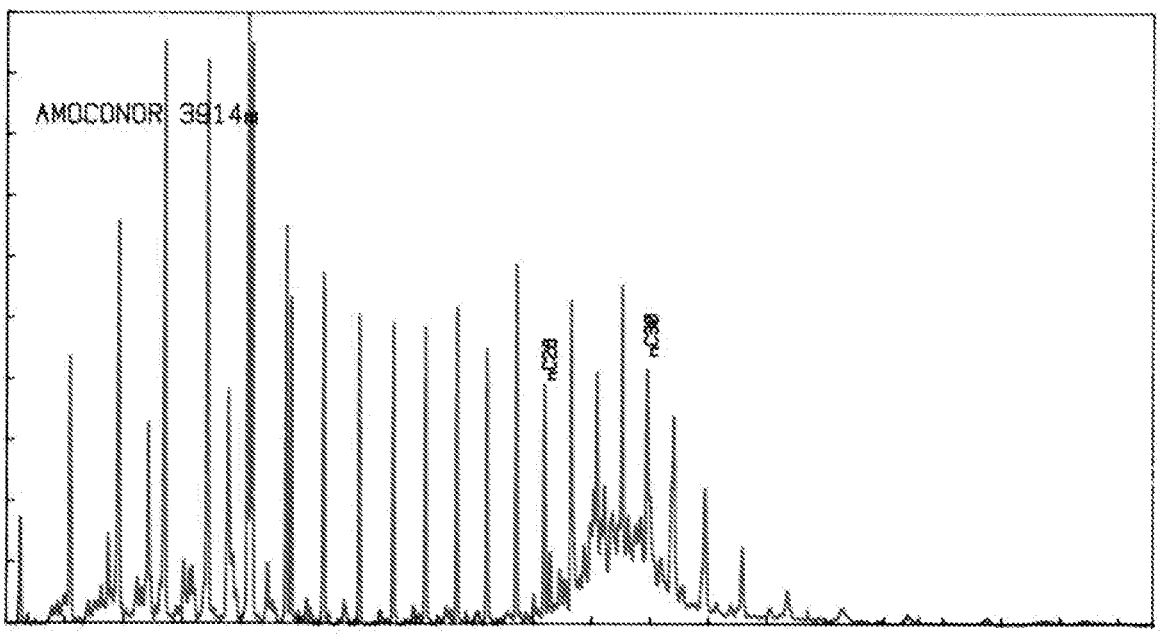
These rating demonstrate that the sediments examined from Core No1, Well: 2/9-2 were good potential source rocks.

(ii) Hydrocarbon Type

Visual Kerogen Descriptions listed in Table 2 suggested the sediments to have good oil potential. This conclusion was supported by Extended Pyrolysis measurements, which demonstrated that the likely hydrocarbon products would be a paraffinic crude oil extending into the high boiling range beyond carbon number C_{30}, as illustrated in the accompanying inset.



Soluble Extract studies were in support of this conclusion showing the long range distribution, with an odd over even carbon number preference supporting the immature nature of the sediments. The presence of steranes and pentacyclanes in the region beyond carbon number C_{26} lend further support to the suggested immaturity of the sediments, as illustrated below.



4. Conclusions

1. All the sediments examined were immature for any hydrocarbon generation.

2. The sediments examined at 3909.13 m and 3914.02 m were good potential source rocks for oil.

Well No: NOCS 2/9-2.

VITRINITE REFLECTANCE DATA		
Depth m.	Reflectivity Ro (Ave)	
	Autochthonous	Allochthonous
3898.10	*0.34 (7) 48 (6)	
3914.02	*0.38 (15)	

* Bitumen/Bitumen Staining.

Figures in parenthesis refer to the number of separate determinations completed.

Table 1.

Well No: Amoco Norway 2/9-2.

VISUAL KEROGEN DATA

Depth m.	Cuticle	Brown Wood	Black Wood & Inertinite	Amorphous Sapropel	Source Potential Rating	Colour Maturation Rating
3909.13	Common	Trace	Trace	Abundant	Good oil	2/3
3914.02	Common	Trace	Trace	Abundant	Good Oil	2/3

Table 2.

Well No: Amoco Norway 2/9-2

GENERAL WELL DATA

Depth	Lithology	Total Organic Carbon TOC % wt.
3898.10	Shale	1.74
3903.2	Shale	2.56 (Rpt. 2.39)
3909.13	Shale	2.45
3914.02	Shale	2.75

Table 3.

Well No: Amoco Noco 2/9-2

Pyrolysis Data

Depth m.	Yield (kg/tonne) P1 Peak	P2 Peak
Core 1 3898.10	-	6.1
Core 1 3909.13	0.5	12.6
Core 1 3914.02	0.3	11.4

Table 4.

Well No: 2/9-2

SOLUBLE EXTRACT DATA

Sample Type	Depth m.	Lithology	Total Soluble Extract (TSE) % wt.	Saturate Alkane Content (SAC) % wt.	Carbon Preference Index (CP1)
Core Piece	3909.13		0.20186	27.49	*
Core Piece	3914.02		0.2503	40.15	*

* CP1 Values not calculated due to co-elution of steranes and pentacyclanes.

Table 5.