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TECHNICAL ASSISTANCE PROJECT LICENCE PL051

"GEOCHEMICAL ANALYSIS OF SEDIMENTS FROM STATOIL / UNION 30/2-1 WELL, NORWEGIAN SECTOR, NORTH SEA"

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Technical Memorandum
Union Science & Technology Division
Union Oil Company of California

UNION 76

To:	Mr. John C. Ellice-Flint Sandnes	**Memo:**	E&P GEOL 83-44M
From:	G. H. Smith S. R. Larter	**Date:**	May 23, 1983
Department:	Exploration & Production Research	**Project:**	623-50845
Subject:	GEOCHEMICAL ANALYSIS OF SEDIMENTS FROM STATOIL/UNION 30/2-1 WELL, NORWEGIAN SECTOR, NORTH SEA	**Supervisor:**	J. R. Fox

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Patent B. W. Pace, Sunbury W. A. Sax, UOC
N. A. Briedis, Sandnes A. S. Keller, UOC

SUMMARY

Detailed molecular geochemical analysis of well cuttings from StatOil/Union 30/2-1 well indicate the sediments in the 3500-3658 meters interval are good to excellent source rocks for moderately paraffinic crude oil. The Lower Cretaceous sediments tested within this interval are comparable to the same stratigraphic interval in the StatOil/Union 30/1 well. The Upper Jurassic Kimmeridgian sediments are the richest and best crude-oil source rocks tested in this well.

The well was turbodrilled above 3500 meters and below 3800 meters, yielding rock fragments of homogenized formation rock and mud. Two intervals tested in the upper turbodrilled section exhibit poor and fair organic richness, but a substantial proportion of the extractable organic matter is vitrinite-rich coal which reduces crude oil source rock potential.

In general, results from the extractable organic matter yield complementary results to the data reported by Palaeochem.

INTRODUCTION

Cuttings from the StatOil/Union 30/2-1 well were washed from 2470 meters to total depth. Four intervals were composited from within the 2750-3658 meter interval based on lithological characteristics of the samples, the electric log, and preliminary extractable organic matter (EOM) assays. In addition, a Palaeochem service report was used to help screen intervals for detailed molecular analysis. Over the intervals washed, the well was turbodrilled except between 3500 and 3800 meters. Within this conventionally drilled interval either sample size or lack of samples restricted detailed geochemical analysis to 3500 - 3658 meters as shown in FIGURE 1.

Two turbodrilled Cretaceous intervals were composited and analyzed as shown in TABLE 1. A Lower Cretaceous and the Upper Jurassic Kimmeridge intervals were composited from the conventionally drilled portion of the well. Only four bags of Heather samples were available and one of these was almost entirely coal. Coal contamination was significant in the two samples below the coal, leaving too small a Heather sediment sample for processing. The coal sample was processed as a model to test other stratigraphic intervals directly above.

Turbodrilling with diamond bits yields rock fragments which are not normal well cuttings but appear to be fused, glassy agglomerates with the texture of the formation rock destroyed and homogenized with drilling fluid. The external surfaces resemble ropy lava fragments with rough contorted surfaces. Pictures of polished "cuttings" from turbodrilling are appended as FIGURE 3. The prospect of such intense mixing of formation and mud components may contaminate the extractable organic matter from the formation with exotic constituents present in the mud. Two samples have been processed from the upper turbodrilled interval. A similar section was described from StatOil/Union 30/3-1[1] but its significance was not understood at that time.

Geochemical Analysis

Analysis of Conventionally Drilled Interval

Geochemical analysis from the limited depth range of unhomogenized rock fragments (3500-3675) shows a good (1440 ppm) and excellent (8110 ppm) source rating based on total extractable organic content (EOM) of the Lower Cretaceous (AH2634) and upper Jurassic Kimmeridgian (AH2635) sediments, respectively. These samples exhibit a particularly high oily content (92-95%) in the EOM and a high hydrocarbon content (84-89%) in the distillate fraction. This represents an excellent crude oil source rating for these two samples based on the hydrocarbon content. Total organic carbon contents of 1.31 and 5.13% confirm that the organic richness of these samples is adequate.

Gas chromatograms of the hydrocarbon fraction from the EOM distillates (FIGURE 2) show a good full range suite of paraffins for both samples. However, higher pristane content and stronger evidence for some odd carbon number paraffin preference in the Lower Cretaceous sample (AH2634) suggests it may contain more terrestrial organic matter (carbonaceous) than the Kimmeridgian sample (AH2635). These observations are supported by infrared spectra of the hydrocarbon fractions which also show some coaly or terrestrial matter content in the Lower Cretaceous sample AH2634. In addition, pyrograms of kerogen separated from the sediments show a greater content of mixed Type III/II kerogen, represented by higher relative aromatic content, in the pyrolytic products from the Lower Cretaceous AH2634 sample than in the Kimmeridgian AH2634 sample. The Kimmeridgian sample contains minor

1. Technical Memorandum E&PE 80-31M, "Geochemical Analysis of Cretaceous Sediments from StatOil/Union 30/3-1 Well, Norwegian Sector by Gerould H. Smith (March 18, 1980).

amounts of plant debris but is predominantly amorphous kerogen that is characteristic of Kimmeridgian sediments in the Central graben, although this sample is not as rich as in some other areas. This kerogen appears to have a rank level < 1.0%R_o. The detailed hydrocarbon compositions (TABLE 1) also show these two samples contain oil-like molecular suites. Both intervals are characteristic of good to excellent source rocks for crude oil. The EOM sample AH2634 is very much like the comparable Lower Cretaceous stratigraphic interval in StatOil/Union 30/3-1 which was reported as fair to good source rock[1].

Analysis of Turbodrilled Intervals

The shallower Cretaceous samples AH2631 and AH2632, from a turbodrilled interval, exhibit a higher relative content of coaly or terrestrial organic matter than the intervals discussed above. This is based on a combination of gas chromatography and infrared spectrometry of the hydrocarbon fraction from the EOM distillate and particularly from the pyrograms of the kerogen in these intervals. The EOM evaluates these samples as poor to fair source rocks for crude oil, although this evaluation is reduced by any vitrinitic coaly contribution.

Geochemical comparisons may be useful among given turbodrilled intervals but the homogenization of powdered rock and mud solids from drilling could make a unique identity questionable (FIGURE 3). In addition, any organic or oil-derived additives such as grease, Black Magic, etc. may alter the interpretation. In this well, grease was particularly abundant in the conventionally drilled interval and was difficult to remove during washing. However, in a turbodrilled interval such grease could be incorporated into the homogenized "cuttings" and be construed as an indigenous hydrocarbon contribution. Accordingly, it would be a good practice to designate any turbodrilled intervals when requesting geochemical analysis or other testwork which relies on the use of natural, undistorted, formation fragments and textures.

The EOM contains a full range of soluble constituents in samples AH2631 and AH2632. The EOM from the 3310-3390 meter interval (AH2632) contains free sulfur and high benzothiophenes in the hydrocarbon fraction (TABLE 1). Clearly this shows a difference in the composition of the EOM in the Cretaceous intervals either above or below this sample. Differences among the Cretaceous intervals are evident from other spectral and chromatographic indications as well. In this case, there are variations in the turbodrilled EOM compositions which show differences that are probably diagnostic. However, one cannot be certain that these differences represent true variation among the unhomogenized formation sediments.

Use of Molecular Aromatic Hydrocarbon Analysis

Detailed molecular data add interpretation to that available from the contractor data. Customarily, most contractors examine only part of the saturate fraction in detail, by gas chromatography. The aromatic fraction is not analyzed in this manner. Detailed analysis of the aromatic hydrocarbons can be used to differentiate coal-like from oil-like constituents. This is illustrated below by using EOM data from TABLE 5 in the Palaeochem report:

Depth,m	EOM ppm	Saturate Hydrocarbon Content %	
3647	7420	41.5	Kimmeridge
3650-65	2070	31.5	Heather
3755-70	2370	30.3	Brent

The results described earlier in this report show that only a minimal amount of coaly matter is present in the Kimmeridgian interval and the extractable matter is predominantly characteristic of crude oil. However, coal is present in both the Heather and Brent sediments. Unfortunately we could not analyze these because of small sample size and coal contamination. However, coal was analyzed from the Heather (AH 2636) and had an EOM value of 25,800 ppm. The above values for EOM from the Heather or the Brent could result from the presence of as little as 8-9% of the coal from the Heather in those sediment samples. This coal sample had a bituminous rank based on a determination of 0.78 R_o%. This corresponds to R_o values reported by Palaeochem for this general interval. Accordingly, the detailed molecular aromatic hydrocarbon data reinforce other indications of the Kimmeridgian sediments as an oil source rock in this well. The coal sample AH2636 was processed to provide the necessary detailed data from a local sample for this evaluation. Note in TABLE 1 different aromatic composition and content among the intervals tested. This is illustrated in FIGURE 4, where variation in the content of the alkylated-phenanthrenes, components generally not abundant with respect to aliphatic hydrocarbon in oils, are an indication of the relative coaly (vitrinite) content.

Exploration & Production Research

GHS:dj

Figure 1.

STAT OIL 30/2-1
SAMPLES AVAILABLE FOR DETAILED ORGANIC GEOCHEMICAL ANALYSIS ON RECEIPT OF "PALAEOCHEM" SERVICE REPORT

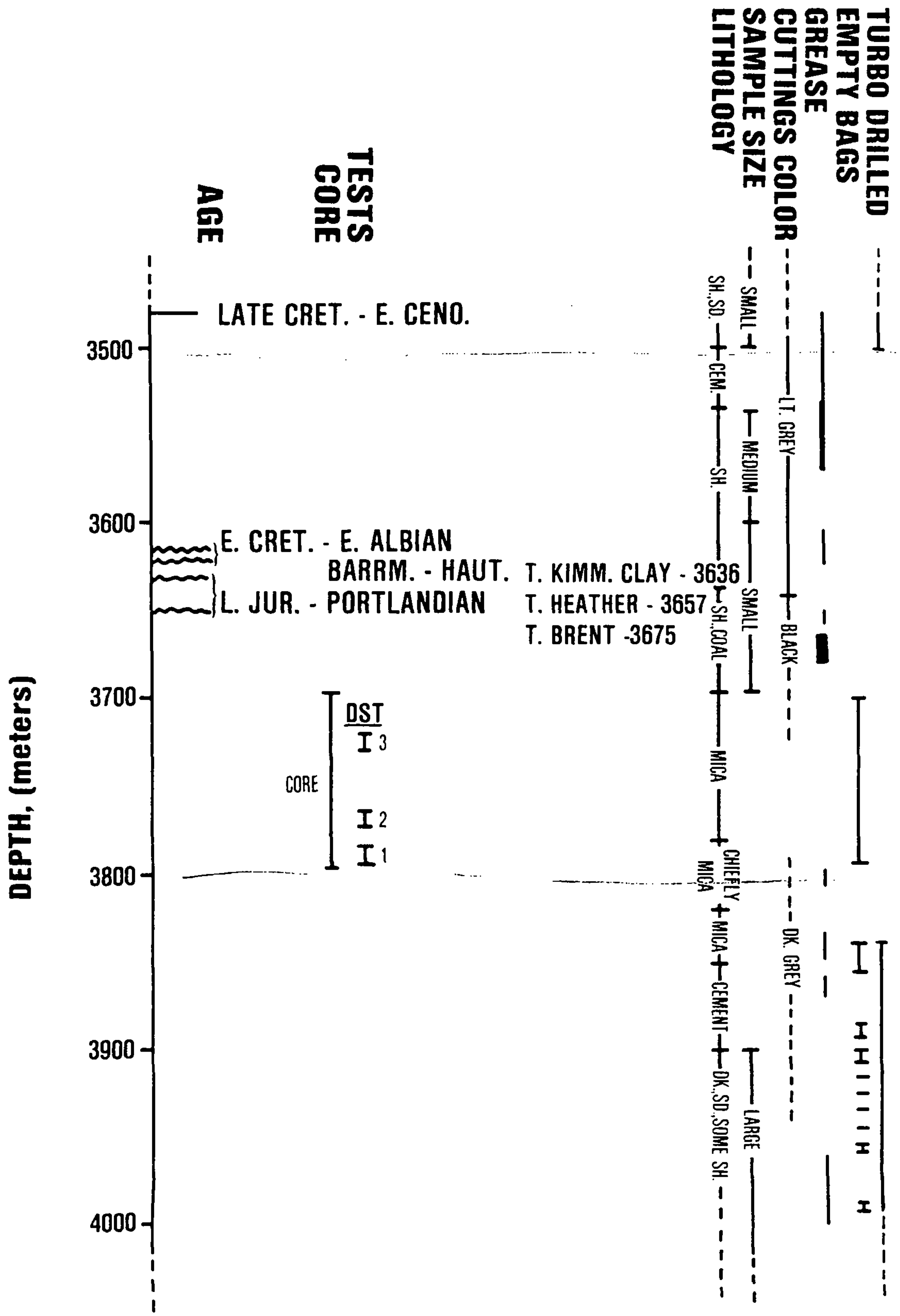
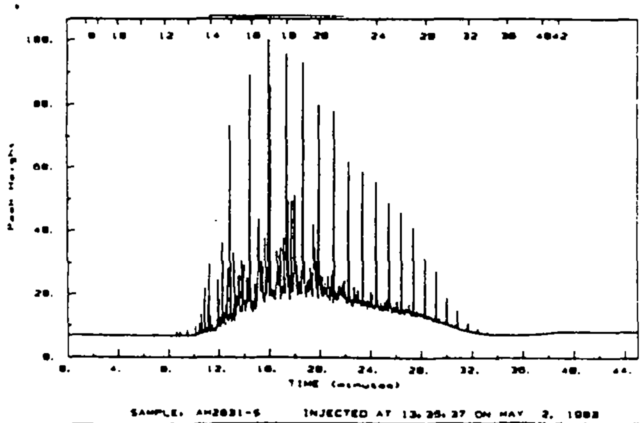
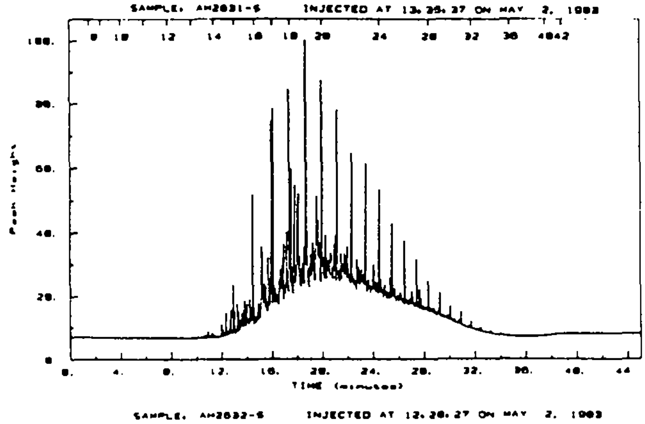


FIGURE 2

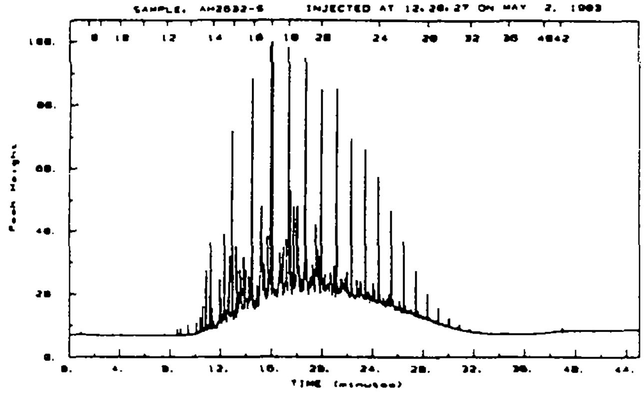
Gas Chromatograms of the Hydrocarbon Fractions From EOM Distillate



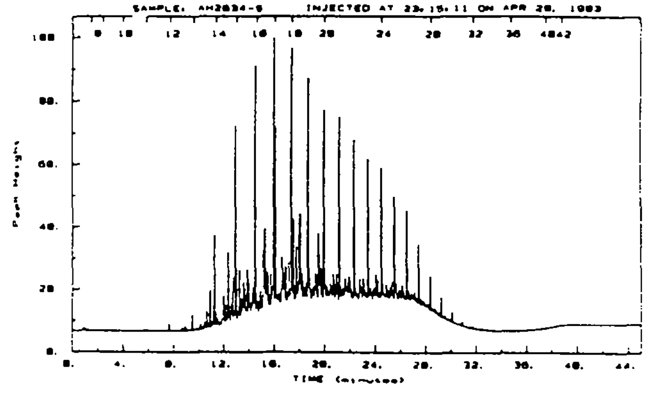
2750-2850 m Cretaceous (Turbodrilled)



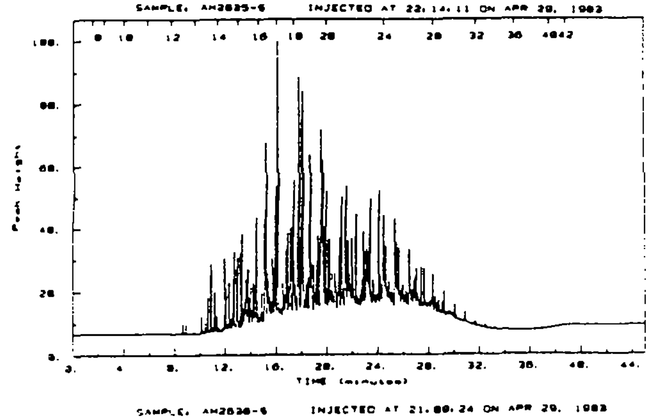
3310-3390 m Cretaceous (Turbodrilled)



3550-3630 m Lower Cretaceous



3640-3675.5 m U. Jurassic-Kimmeridgian



3672.5 m coal-Heather Fm

FIGURE 3
Turbodrilled Well "Cuttings"
Showing Distortion, Mixing of Rock and Mud

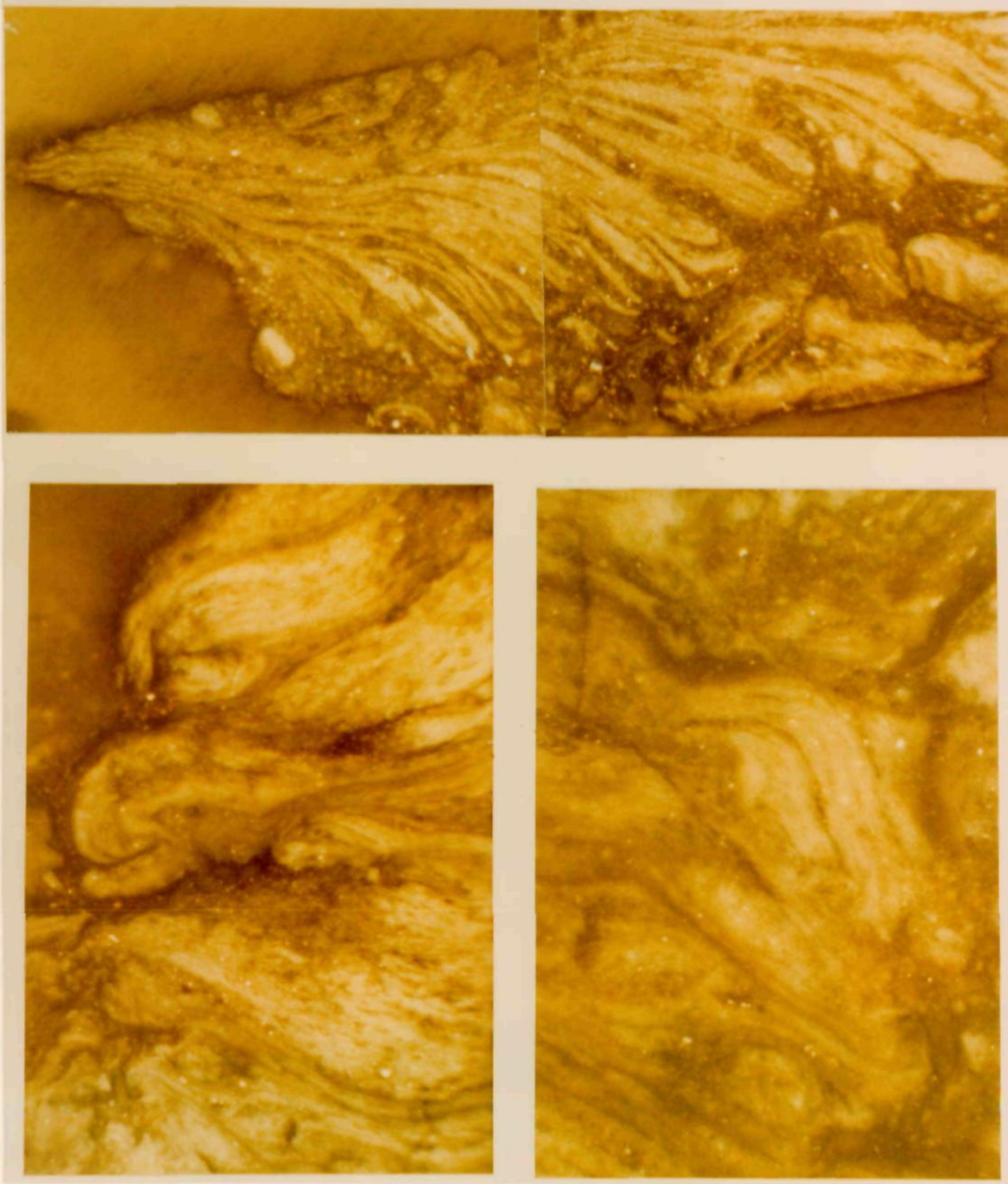
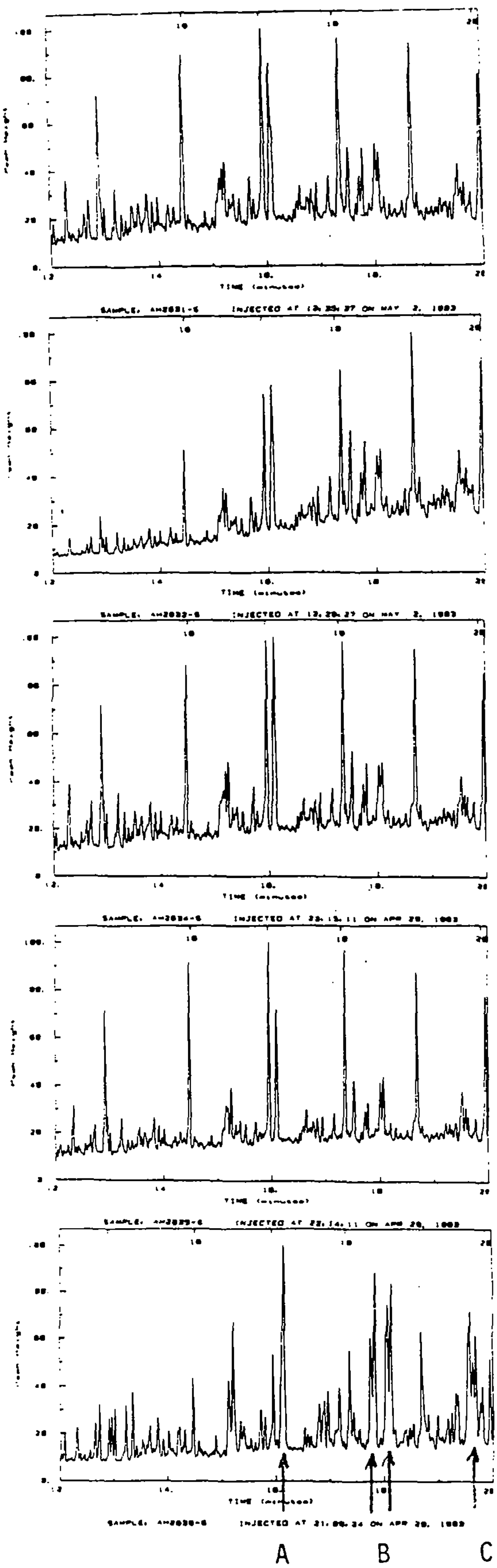


FIGURE 4

Variation of the Phenanthrenes Content In The Hydrocarbon Fractions



2750-2850 m Cretaceous

3310-3390 m Cretaceous

3550-3630 m Lower Cretaceous

3640-3657.5 m U. Jurassic-Kimmeridgian

3672.5 m Coal-Heather Fm

A Phenanthrene (+ pristane)
B Methylphenanthrenes
C Dimethylphenanthrenes

TABLE 1

Geochemical Data From Stat Oil/Union 30/2-1 Well, Norwegian Sector, North Sea

Depth, m	2750-2850	3310-3390	3550-3630	3640-3675.5	3672.5
Notebook No.	AH2631	AH2632	AH2634	AH2635	AH2636
Age	Cretaceous	Cretaceous	L. Cretaceous	U. Jurassic	Jurassic
Formation				Kimmeridge Clay	Heather
Description	gry sltst & mudst. few coal frags, not much staining (turbodrilled)	glossy, ragged surface, mud film; oily matter from grease or other source on surface; some coal frags. (turbodrilled)	gry siltst & mdst. removed coal frags, grease stained frags	carbonaceous shale, siltst, pyrite	*Coal*
<u>Composition of Extract, wt%</u>					
Extractable Organic matter, ppm	580	290	1400	8110	25800
Oils in Extract	92.2	91.5	92.6	94.5	58.3[(a)]
Distillate in Oils	78.5	73.5	55.6	50.8	45.6
<u>Composition of Distillate, wt%</u>					
Bases	0.9	1.1	1.1	0.4	0.8
Heterocompounds	26.1	22.0	14.9	10.1	11.3
Hydrocarbons	72.9	76.8	84.0	89.4	87.9
<u>Composition of Hydrocarbons, wt%</u>					
Paraffins	28.8	19.4	24.7	26.2	8.6
Naphthenes	27.1	21.8	29.4	34.6	8.4
Mononaphthenes	14.8	10.8	14.4	18.8	3.7
Aromatics	39.9	48.9	41.5	36.4	77.6
1-ring	17.4	20.6	19.2	18.5	10.6
2-ring	14.4	18.0	15.8	12.4	29.1
3-ring	6.9	8.6	5.6	4.6	20.6
4-ring	1.2	1.7	0.9	0.9	17.3
Benzothiophenes	4.2	9.9	4.3	2.7	5.5
Monoalkylbenzenes	2.9	7.3	2.8	4.0	0.0
TOC (on extracted rock)	0.75	0.85	1.31	5.13	-
VR					0.78

(a) 'exploded' on steam bath during deasphaltening - % oils may not be accurate