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LABORATOIRE DE GEOLOGIE DE BOUSSENS

GEO/LAB Bss n°6/1416 R
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2.12.91.

30/10-5 WELL
(NORWAY)

GEOCHEMICAL STUDY OF THE MESOZOIC SERIES

BELOW THE 9 5/8" CASING (3779 m)

J. BARLIER

Boussens - November 1976

REFERENCE : ORDER n°031204

P. ROBERT - 2035 n°6/1300 R
"Well 30/10-5 (NORWAY) -
Organic matter diagenesis" -

P. DURIF - E. GROSDIDIER - J.F. RAYNAUD - 2035 n°6/1312 R
"30/10-5 well (NORWAY) -
Biostratigraphical report on the Mesozoic
series between 3790 and 5150 m" -

LISTE DE DIFFUSION

DESTINATAIRES :

DIRECTION EXPLORATION	1
S.I.D.	2
DISTRICT 2 - NORVEGE	20
M. BONNEFOUS	1

The 30/10-5 well, located in the north of the Frigg field, reached the Jurassic 80 meters down below the top of the structure. The well was drilled with the objective of the Jurassic sands, which have shown 8 water-bearing levels.

The aim of the geochemical study is to reveal possible shows of migrated hydrocarbons and to indicate the source-rock properties of the Mesozoic series under the 9 5/8" casing, i.e. from 3779 m to the bottom hole : 5185 m.

This study takes into consideration the results of the optical studies on the organic matter, already published*. These results, as well as the main geochemical ones, are summarized on Plate 1.

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* P. ROBERT - February 1976 - Report 2035 n°6/1300 R -
"Well 30/10-5 - Organic matter diagenesis" -

P. DURIF - E. GROSDIDIER (Micropaleontology) ; J.F. RAYNAUD (Palynology) -
April 1976 - Report 2035 n°6/1312 R -
"30/10-5 well (NORWAY) - Biostratigraphical report on the Mesozoic series
between 3790 and 5150 meters" -

1 - JURASSIC

The insoluble organic carbon and extractable organic matter contents were measured on 8 cutting samples (Appendix 1). The results of these measurements show IOC contents greater than 1 % and sometimes very high (10 %), connected with coaly and ligneous inclusions. In the Middle Jurassic, the extractable organic matter contents are substantial (from 1800 to 24000 ppm) and they suggest an enrichment. The EOM contents are lower than 1000 ppm in the Upper Jurassic, accounting only for 2 to 4 % of the total organic matter.

More detailed analyses were carried out on 8 samples, including a sidewall core and two samples from the core n°1 in the Dogger (Pl.1).

1.1 - DOGGER

The representativeness of Dogger cutting samples are poor : rock cavings and contaminations by greases, gas-oil and mud products are high. The sidewall core sample is also affected by gas-oil pollution.

- 4950 m cutting sample

This sample is very rich in coaly grains and in extractable products (2.4 % rock). Pollution by gas-oil and grease is particularly perceptible in chromatography of the saturated hydrocarbons (Pl.2). The vapor range chromatogram obtained by thermovaporisation on handpicked brown-red shales shows a well-developed syngenetical fraction of light compounds. The relatively high proportion of the n-alkanes and aromatics in this fraction can be related to the degree of catagenesis of the kerogen (Ro # 1.7 ; T.A.I. 4,5).

- 4885 m sidewall core and 4890 cutting samples

The 4885 m sidewall core sample shows a contamination by gas-oil. The vapor range chromatogram is of the same kind as the 4950 m cutting sample (Xi1 = 3.1) though less rich.

A 570°C pyrolysis on the 4890 m cutting sample have, in spite of the high degree of maturity (Ro # 1.6 ; T.A.I. 4.5), degraded 16 % of kerogen, that is to say 0.3 % of the rock sample. This result gives evidence of a quite high residual gas potentiality for this level showing coaly and ligneous palynofacies.

- 4590.75 m (dark grey sandstone) and 4592.05 m (black shale) core samples

The sandstone sample shows a migrated product (Pl.2) affected a great deal by evaporation in the light compounds range.

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The shale sample is rich in light compounds : the vapor range chromatogram ($\leq C_{14}$; Pl.2) covers about 380 ppm of normal and iso-alkanes. The saturated fraction is very poor and accounts for a few ppm of a probably syngenetic product. Hence this shale shows good gas potential.

The $\frac{\text{Pristane}/nC_{17}}{\text{Phytane}/nC_{18}}$ ratio is in both cases of 2.4, in agreement with the Lias-Dogger hydrocarbons of the Frigg field*.

- 4512 m cutting sample

The hydrocarbons appear syngenetic. The presence of gas-oil explains the widespread occurrence of the C₉ to C₂₀ n-alkanes and of the isoprenoids. The chromatogram portion higher than n-C₂₀ can be related to the coaly and ligneous organic matter.

1.2 - MALM

Only two cutting samples were analysed, one from the Callovian to Oxfordian, and the other from the Kimmeridgian.

- 4420 m cutting sample (Callovian to Oxfordian)

The thermovaporisation of this sample has extracted 110 ppm of hydrocarbons $\leq C_{14}$. The chromatogram shows a product that is relatively rich in light compounds and probably syngenetic. This level has a very low hydrocarbon potential.

- 4188 m cutting sample (Kimmeridgian)

This sample is composed of dark shales with ligneous inclusions (IOC = 3.9 %) The palynological organic material contains about 15 % of amorphous organic matter pro parte sapropelic. The pyrolysis yield (degradable organic carbon : DOC, in % of IOC) is 5 %, i.e. 0.2 % of the rock ; with regard the catagenesis conditions ($R_o \neq 1.2$; T.A.I. 4), it may be felt that the greatest part of the initial potentiality at this level has been realized by production of liquid hydrocarbons.

Upon chromatography of saturated and vapors hydrocarbons (Pl.2), the extractable organic matter appears syngenetic ; the ratio $\frac{\text{Pr}/nC_{17}}{\text{Ph}/nC_{18}} = 1.4$ is in agreement with the ones in the Upper Jurassic extracts of the Frigg area.

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* B. PHILIPPE - July 1976 - Report 2035 n°6/1380 R -
 "25/4-1 well (NORWAY) - Identification of the petroleum source-rocks in the Jurassic" -

2 - CRETACEOUS

The insoluble organic carbon content was measured on 4 cutting samples (Appendix 1). The values of IOC are about 1 % on 3 of them, and nearly 2 % on the remaining one, at 3817 m (Turonian ?).

The chloroform-extractable organic carbon content was measured on the 3 samples with an IOC of about 1 %. The values of EOM are between 400 and 1000 ppm.

More detailed analyses were carried out on 3 samples, one from Albian to Lower Cenomanian, the two others from Turonian ?-Senonian? .

2.1 - ALBIAN TO LOWER CENOMANIAN

The analysis of hydrocarbons and kerogen pyrolysis were carried out on the 3990 m cutting sample.

The hydrocarbons extracted by thermovaporisation account for about 22 % of the total extractable organic matter and seem to be syngenetic. A pyrolysis done on this sample has degraded 4 % of the kerogen represented by about 25 % of amorphous organic matter. These results are akin to those of the Kimmeridgian, but here the DOC constitutes only 0.04 % of the rock, so this level can be considered as a source-rock of low initial hydrocarbons potentiality.

2.2 - TURONIAN ? - SENONIAN ?- 3817 m cutting sample (Turonian ?)

Pyrolysis degrades 15 % of the IOC, i.e. 0.3 % of the rock.

- 3797 m cutting sample (Senonian ?)

The chloroform-extractable matter is rich in oil compounds (70 %) and can be considered after chromatographical analysis as a syngenetical product (Pl.2). Its main characteristics : general arrangement of n-alkanes and $\frac{\text{Pr}/\text{nC17}}{\text{Ph}/\text{nC18}} = 1.4$ looklike those of the Kimmeridgian extract but with a less high degree of evolution : naphthenic and isoprenoid compounds are more highly expanded relative to n-paraffins.

19 % of the kerogen is degraded, essentially in oil, by pyrolysis. This accounts for about 0.2 % of the rock.

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So, in the two samples studied, it can be noted that for vitrinite reflectance values of not much less than 1 % and T.A.I. estimated at 3.5, the initial hydrocarbon potential is still incompletely realized ; the large proportion of hydrocarbons of a range greater than 5 carbons in the pyrolysis products leads one to assume that the potential was quite high and that it could have produced oil.

Palynological analysis shows a kerogen composed of about 50 % of amorphous organic matter pro-parte sapropelic in an interval of from 3820 to 3790 m, the depth above which the study stops.

The Cretaceous of 30/10-5 well can be regarded as an oil source-rock over 30 m at least. This result is in agreement with the ones from the first geochemical study on the Cretaceous in the Frigg area*.

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* J. du ROUCHEFF - November 1971 - Report 03-D-31 n°1/590 R -
"Sondage FRIGG n°1 (25/1-1x) - Norvège - Etude stratigraphique, géochimique
et sédimentologique" -

CONCLUSIONS

At 30/10-5, the geochemical studies have not detected substantial shows of migrated product, but only a local enrichment of the sandstone studied on the core n°1, in the Dogger. The extractable product is akin to the Lias-Dogger hydrocarbons of Frigg area and its origin is probably in the near shaly levels.

Some Dogger levels are rich in an organic matter of upper plant kind ; they still show an appreciable gas potential, but it is not possible to ascertain their earlier efficiency as an oil source-rock.

Callovian to Oxfordian has a remaining -and probably had an initial- low potential.

Kimmeridgian, despite its reduced thickness, seems to have been a good oil source-rock, now almost dead in the high catagenesis conditions of 30/10-5. The extract of this level looks like those of the Upper Jurassic of the Frigg area.

The Albian to Lower Cenomanien shows an organic matter with initially a fairly good quality, but in too small a quantity in the rock to indicate a substantial initial hydrocarbon potentiality.

At least 30 m of Turonian ?-Senonian ? above 3820 m have worked as an oil source-rock and still retain a good oil potential. Products of this Cretaceous have geochemical characteristics akin to Upper Jurassic ones : they were probably born of the same kind of organic matter in a similar marine shaly environment.

A P P E N D I X 1

ORGANIC MATTER CONTENTS

All measurements carried out on cutting samples

	(1)	(2)	(3)
	IOC % rock	EOM ppm rock	EOM % TOM
<u>CRETACEOUS</u>			
<u>Senonian ?</u>			
3797 m	1.0	1000	8
<u>Turonian ?</u>			
3817 m	1.8		
<u>Albian to Lower Cenomanian</u>			
3970 m	0.8	410	4
3990 m	0.9	740	6
<u>JURASSIC</u>			
<u>Kimmeridgian</u>			
4188 m	3.9	970	2
<u>Callovian to Oxfordian</u>			
4208 m	2.3	490	2
4308 m	1.3	540	3
4420 m	1.3	600	4
<u>Dogger</u>			
4512 m	1.9	3200	*
4555 m	9.8	3340	*
4890 m	1.9	1840	*
4950 m	13.5	24070	*

(1) insoluble organic carbon content (after chloroform extraction)

(2) chloroform-extractable organic matter content

(3) TOM = 1.22 TOC = 1.22 IOC + EOM

* Extracts pro parte polluted



elf.r.e.

CENTRE DE RECHERCHES DE BOUSSENS

DEPARTEMENT GEOLOGIQUE CENTRAL LABORATOIRE

ORGANIC MATTER STUDY

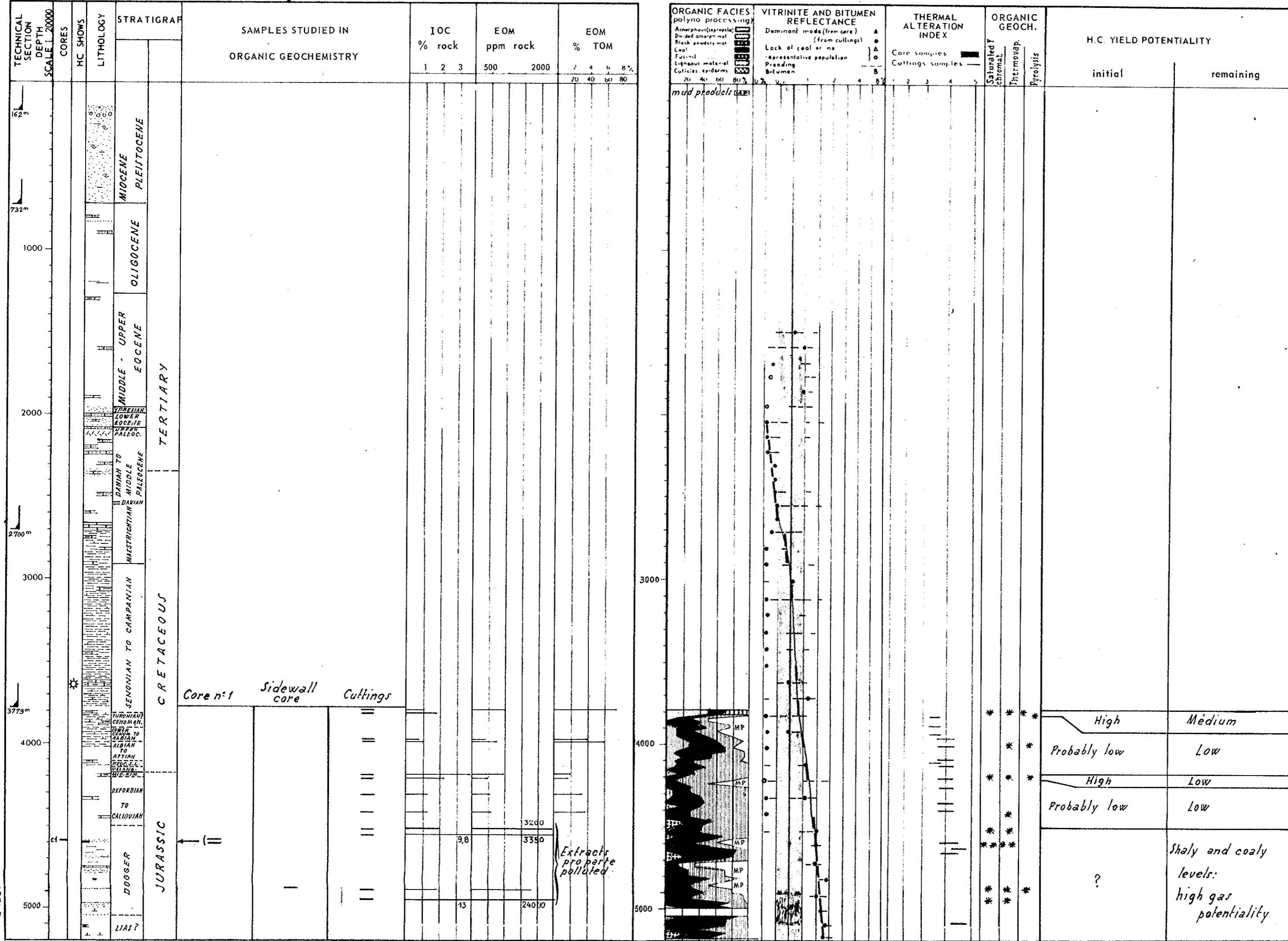
Synthesis of results

Country NORWAY off shore

Well 30/10-5

Section

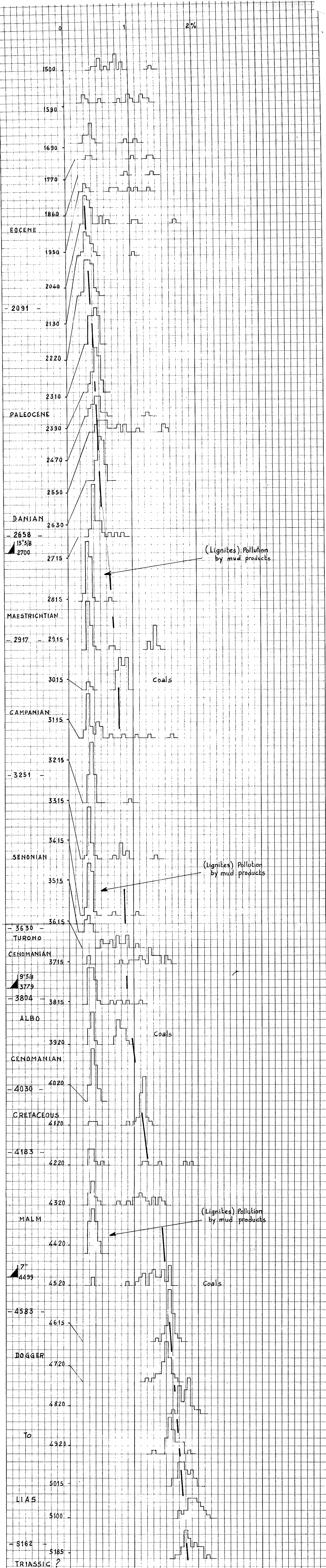
Date 3 Décembre 1976



Core n°1 Sidewall core Cuttings

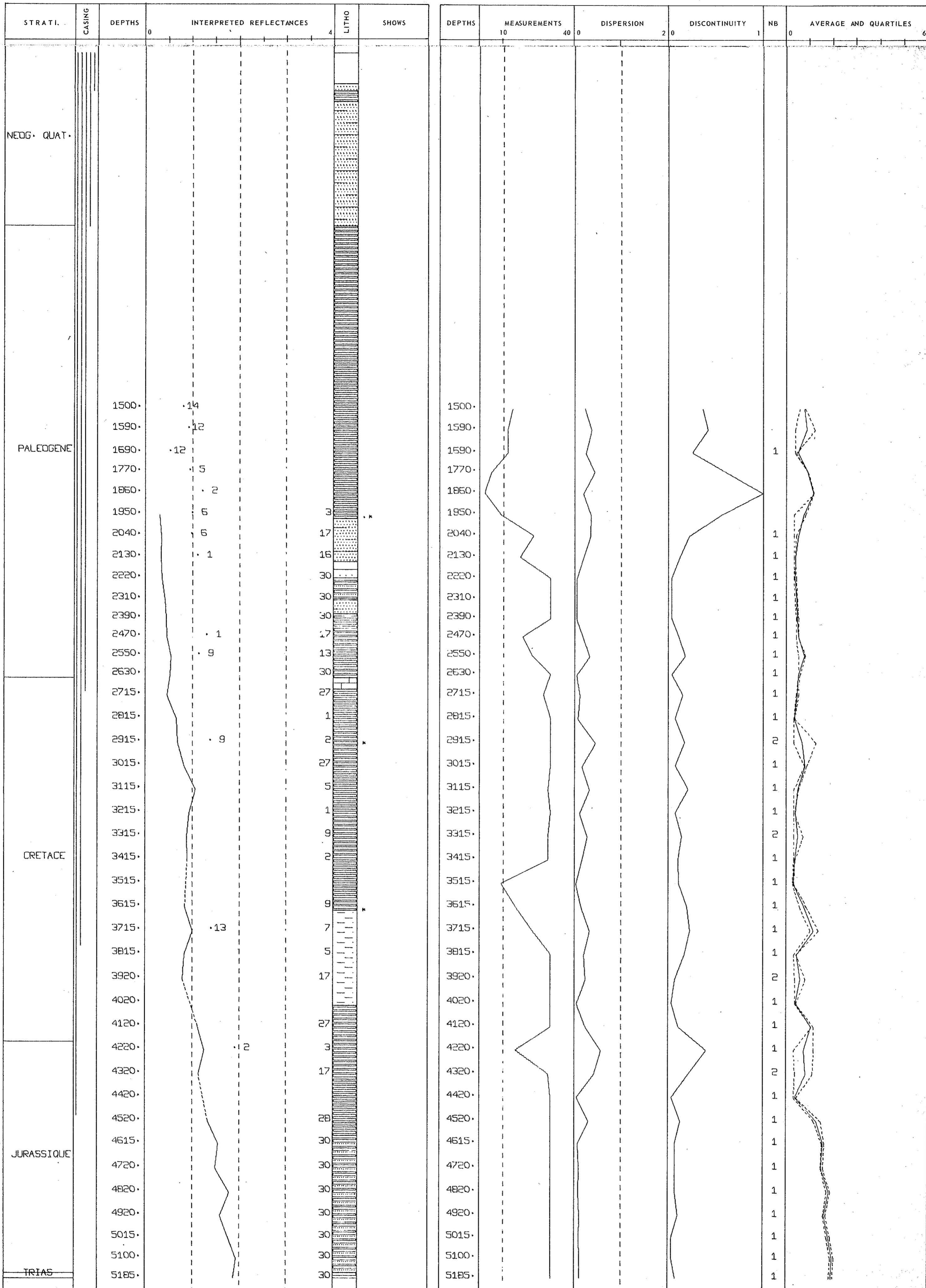
Extracts pro parte polluted

High	Medium
Probably low	Low
High	Low
Probably low	Low
?	Shaly and coaly levels: high gas potentiality



□ Coals
▨ Bitumeux

	Bureau NORVEGE Opérateur ELF NORVEGE Concessionnaire Licences (2ème attribution)	PETRONORD
	WELL 30/10.5 ORGANIC MATTER REFLECTANCE	
ON ENTREPRISE DE RECHERCHES ET D'ACTIVITES PETROLIERES DIRECTION EXPLORATION LABORATOIRE		Date: Février 76 PROBERT n°classif. D 533



+ Bitumen
 • Vitrinite allocthonous
 * Bitumen allocthonous
 - Derived cuttings

+ Bitumen
 • Oil
 * Gas

STATISTICAL PARAMETERS OF THE REFLECTANCE HISTOGRAMS



Total number of measurements = 33
 Number of measurements taken into account for calculation of the average = 23
 x_1 and x_2 = Limit-values of reflectance of the population.
 Number of groups of measurements = 6

For the histogram as a whole:
 Dispersion = of "disparate" type reflectance.
 Discontinuity = number of groups of measurements, number of measurements in main group
 Number of populations = 1
 Quartiles 25 and 75

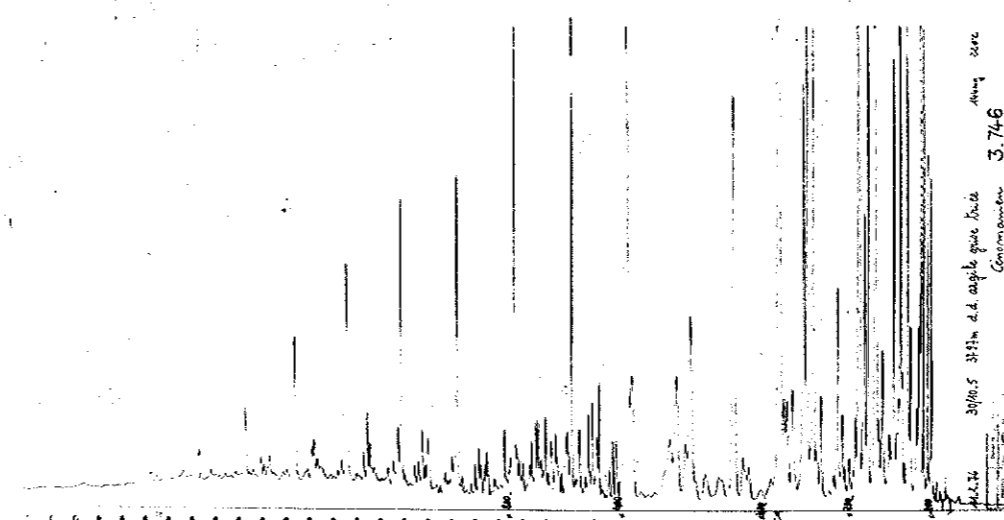
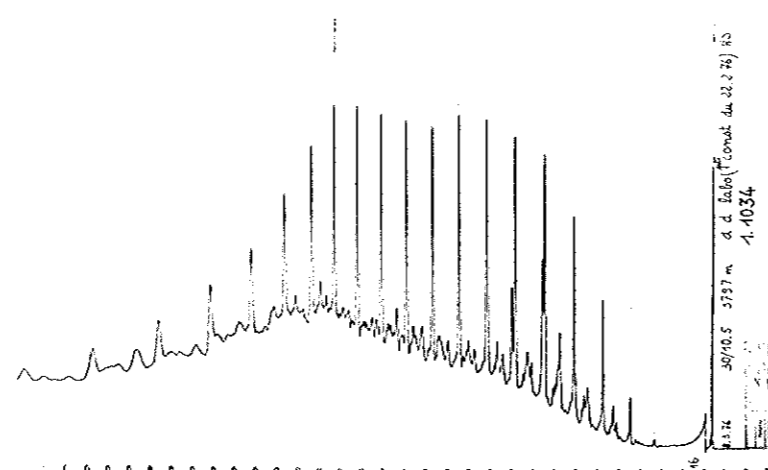
For the chief population
 Average = average reflectance

SECTEUR NORVEGE	PETRONORD
OPERATEUR ELF NORGE	
POINT DE CONSTAT	Licences (2 ^{ème} attribution)
WELL 30/10.5	
STATISTICAL REPRESENTATION OF THE RESULTS OF ANALYSIS	
NO ENTREPRISE DE RECHERCHES ET D'ACTIVITES PETROLIERES	PL.2
DIRECTION EXPLORATION	LABORATOIRE
Date: Fev/1970	Assis: Y. DAGENS
	no. client: C 534

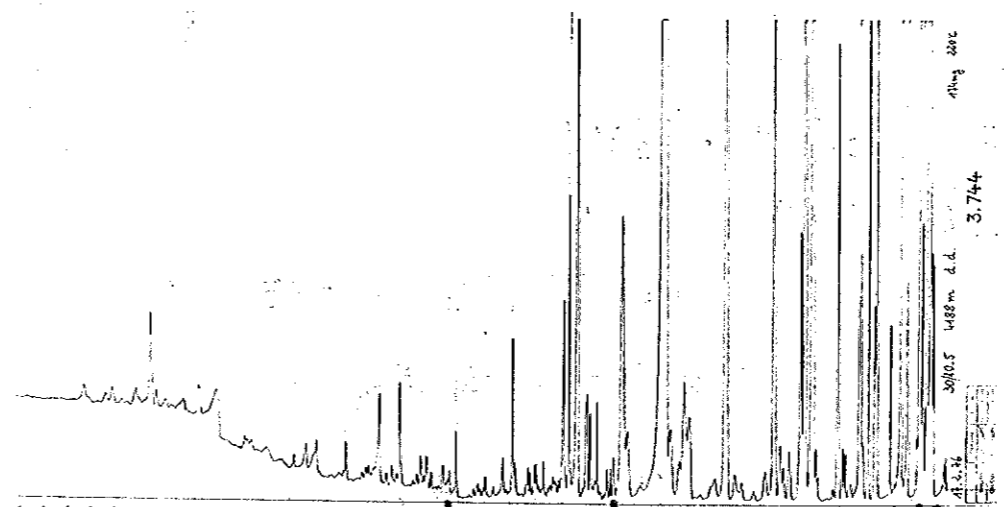
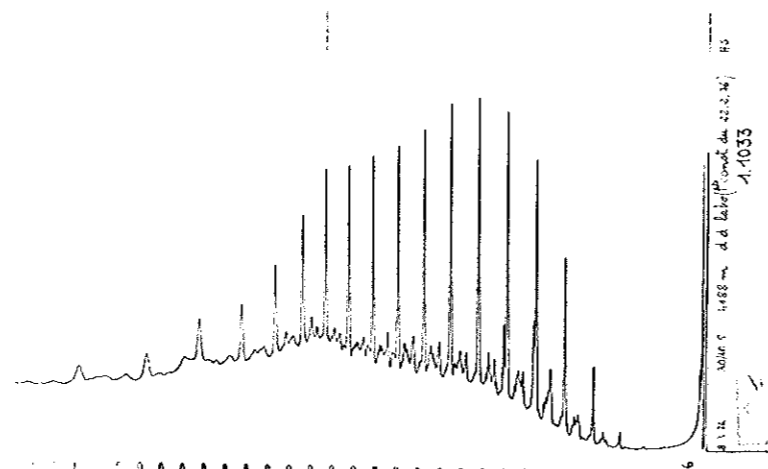
SATURATED HC

VAPORS

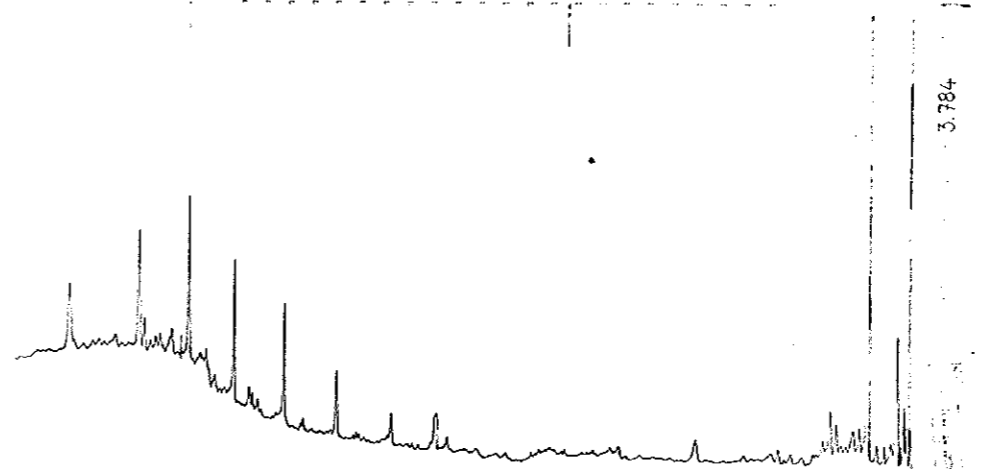
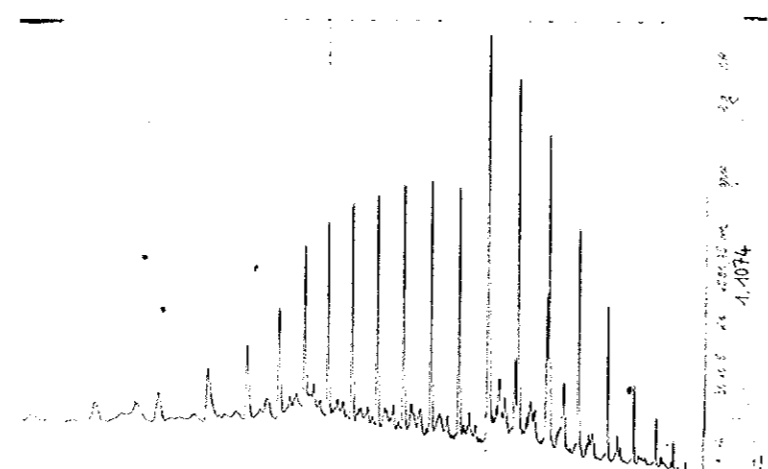
SENONIAN (?)
3797 m
Shale cutting sample



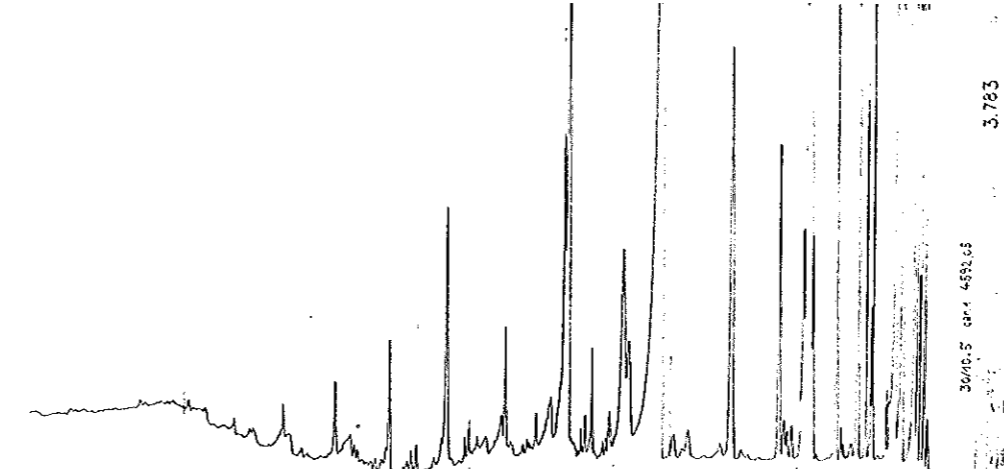
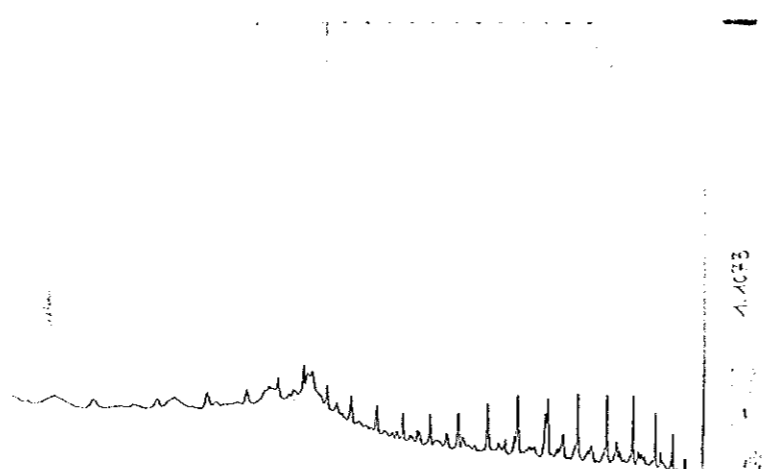
KIMMERIDGIAN
4188 m
Shale cutting sample



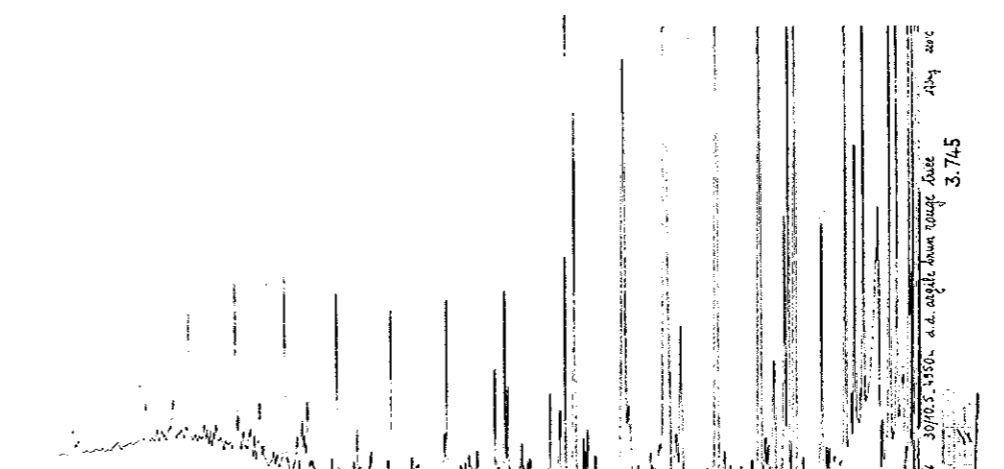
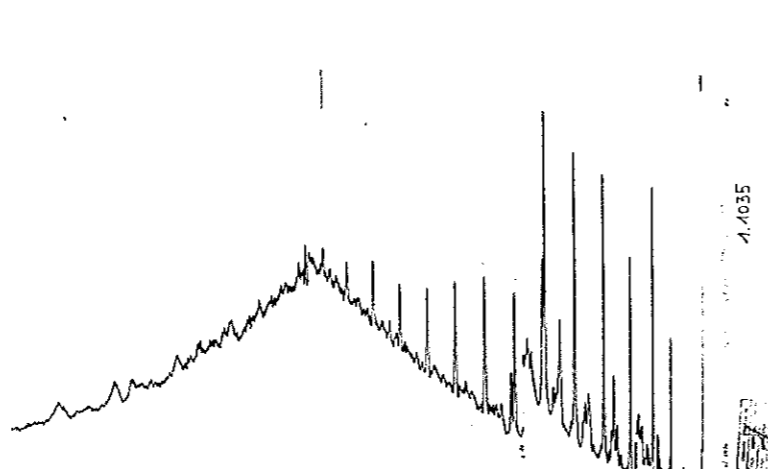
DOGGER
4590,75 m
Sandstone core sample



DOGGER
4592,05 m
Shale core sample



DOGGER
4950 m
Shale cutting sample



elf	Secteur NORWAY OFFSHORE	ESSO
	Operateur ELF NORGE a/s	
	Permis ou Concession 030	
WELL 30/10-5		
MAIN CHROMATOGRAMS OF MESOZOIC HYDROCARBONS		
OF ENTREPRISE DE RECHERCHES ET D'ACTIVITES PETROLIERES		Echelle 1/1000000
DIRECTION EXPLORATION	LABORATOIRE	Date Nov. 76 Auteur Barlier N°class. C 1282
		PL.2