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D.G.H. - D. EXPLORATION
LABORATOIRE DE GEOLOGIE DE BOUSSENS

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GEO/LAB Bss nº 7/1536 RP
/fr

16/3-2 WELL (NORWAY)

SOURCE-ROCK IDENTIFICATION AND ORGANIC CATAGENESIS

B. PHILIPPE - P. ROBERT

Boussens August 1977

Reference : Order n° 033 128

R. CUSSEY : 7/1499 RP - 16/3-2 Well (Norway)
Sedimentological study of Jurassic deposits.

R. CUSSEY : 7/1517 - 16/3-2 Well (Norway)
Sedimentological study of the Tertiary deposits.

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C O N T E N T S

I L L U S T R A T I O N S

This study was carried out to appreciate the source-rock quality and estimate the state of maturation of the organic matter between 1000 m and the well bottom, in particular at the level of the Hot Shales of the Upper Jurassic (Portlandian and Kimmerridgian , 1955 to 1975 m).

It takes into account observations of the kerogen, palynofacies and thermal alteration index, carried out on the palynological slides*.

All the results are summarized on Plate 3, "Synthesis of results".

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* by J.F RAYNAUD, in 2035 n° 6/27 N from april 1976, and by J. DUCAZEAUX, in GEO/LAB Bss n° 6/1418 R from december 1976.

1 - ORGANIC COMPOUND CONTENTS

The measurements were carried out on 9 shale sidewall cores below 1350 m. Apart from two samples, for wich the extractable organic matter contents were measured (EOM, in ppm of rock), only the insoluble organic carbon contents were measured (IOC, in weight % of rock), due to the small quantities of rock available.

The results are given below (see also Pl. 3) :

		IOC	EOM
Paleocene	1360 m	1.50	
Cenomanian (?)	1744	1.00	
Albian	1811	0.85	
Aptian	1894	0.90	
Upper Jurassic	1959	7.90	
"	1961	5.30	3300
"	1967	4.20	2800
"	1969	5.40	
"	1973	8.00	

They mainly show that the IOC of the Upper Jurassic shales (Hot Shales) are high : the average is approximately 6%.

The two EOM are relatively low : they show that about 5 % of the total organic matter of the Hot Shales is extractable.

2 - ORGANIC FACIES

2.1 - In transmitted light : Palynofacies (see Pl. 3)

Between 1230 and 1400 m (Middle to Low Eocene), the palynofacies are made up of a mixture, in variable proportions, of amorphous organic matter, opaque woody fragments and coals ; amorphous organic matter is predominant at 1310 and 1400 m.

Between 1410 and 1480 m (Danian), the palynofacies are mainly made up of coals associated with opaque woody fragments and black powdery matter.

Between 1490 and 1650 m (Upper Cretaceous), there is very little abundant organic matter.

At 1660 m the palynofacies is made up of coals.

Between 1660 and 1890 m no sample has been studied.

At 1894 and 1934,5 m (Lower Cretaceous), the palynofacies are made up of ligneous and coaly particles.

.../...

At 1959 and 1973 m (Portlandian-Kimmeridgian), the palynofacies are mainly made up of amorphous organic matter.

At 2000 m (Kimmeridgian), the palynofacies is made up of amorphous matter, ligneous and coaly particles.

2.2 - In reflected white and UV light (see Pl. 1)

These observations were carried out on 16 samples (3 sidewall, 1 core and 12 cuttings), between 1000 m and 2010 m.

In reflected white light, within the lower reflectance population (.3 % to . 8 %) humic coals and bitumens are present along the entire section ; however, a great part of them are probably unreliable, even in the sidewall core samples (reworking and mud contamination).

In reflected UV light, 2 main zones can be distinguished by their higher amount of fluorescent material :

- at 1,000-1,100 m (the second being probably derived from the first), in the oligocene level, abundant algal matter and figurated algae are present ; but due to the mixing of fresh (yellow) and evoluted (dark orange) tasmanaceae, they are suspected to be partly or completely reworked matter.

- the Upper Jurassic contains a certain amount of sapropelic matter : pure homogeneous alginite, marine algae (tasmanaceae) and sapropelic rock fragments with "bituminite" (from mainly algal origin) and algae.

The higher sample provided of this matter, is the sidewall core at 1961 m with a global amount in fluorescent material such as given by index 3 (on a total scale up to 5 for pure bogheads).

In addition, fluorescent reservoirs, due to traces of probably migrated hydrocarbons, have been observed at 2 levels :

- in small quantity at 1400 m in the Paleocene ;
- in a greater quantity with a few bitumens in the cutting sample, at 2010 m in argillaceous siltstones which are derived from Upper Cretaceous, according to the biostratigraphical survey (see § 5).

2.3 - Organic facies conclusion

The optical examinations in transmitted and reflected light point out that the organic content of the Upper Jurassic shales (Hot Shales) is mainly made up of amorphous partly sapropelic matter.

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3 - ORGANIC CATAGENESIS

3.1 - In transmitted light : thermal alteration indices (see Pl. 3)

The thermal alteration indices estimated in the lower part of the well, between 1894 m and 2000 m, are 2 to 2.5.

3.2 - In reflected white and UV light : reflectance and fluorescence (see Pl. 1 and 3)

The main results are not very good, due to the great dispersion of reflectance measurements and fluorescence observations, which attest to a large mixing of organic matter populations.

These populations consist of :

- reworked coal and bitumen particles with a reflectance dispersed from 1% to 4% (and even to 5.5%, a value which is not mentioned on Pl. 1).

  Their presence, and abundance, is probably related to the metamorphic paleozoic series which supplied the regional sedimentation for all the Jurassic to Tertiary period.

- one particular anisotropic coal or bitumen, very similar to a natural coke, perhaps heated by a volcanic dyke and localized around the depths 1600 to 1700 m. Its reflectance varies between 1 and 4 %.

- the likely reliable population (bitumen and vitrinite measurements) is scattered and a good interpretation of its results can be obtained only in the bottom 50 meters of the well, thanks to associated data of reflectance and fluorescence : abundant algae tasmanaceae in the 3 levels 1961-2000-2010, fluorescence colour yellow to pale orange attest to a low level of diagenesis, such as 0.5-0.6 % reflectance, in agreement with that which has been measured on bitumen and vitrinite in corresponding samples.

3.3 - Chromatographical data

The chromatograms (Pl. 2) of the syngenetical hydrocarbons from Hot Shales (5 samples between 1959 and 1973 m) show that these hydrocarbons are at a low stage of maturation. This is mainly indicated by the low n-alkane content of the thermovaporised and the saturated fractions (<13 % and <5 % respectively), the low X1 and X2* ratios (lower than 1) and the higher isoprenoid contents in comparison to n-alkane contents (pristane/nC 17 >1.5 and phytane /nC 18 >2).

3.4 - Organic catagenesis conclusions

All the data mentioned above shows that the maturation degree of the organic matter is low down to the well bottom, lower than the required for substantial oil generation

.../...

* X1 : nC6/Methylcyclopentane
  X2 : nC7/Dimethylcyclopentane

4 - SOURCE ROCK CHARACTERISTICS

. Paleocene and Cretaceous, between 1350 and 1955 m

The thermovaporisations carried out on 3 sidewall cores (at 1360, 1744 and 1894 m) contain no hydrocarbon : this suggests a bad petrolenn quality, in spite of the low kerogen maturation .

The pyrolysis undertaken on the 1360 sample confirms that the initial hydrocarbon potential at this level is very low : the content in organic carbon degraded by this process is about 0.05 % of the rock, i.e. 5 % of the kerogen.

. Upper Jurassic. Portlandian and Kimmeridgian brown shales, between 1955 and 1975 m (see the chromatograms on Pl. 2)

The thermovaporisations undertaken on the 5 sidewall cores studied show variable contents in syngenetical hydrocarbons (between 200 and 800 ppm), relatively high in view of the low maturation.

The composition of two extracts (1961 and 1965 m) mainly shows a low percentage of hydrocarbons (<30 %) ; the saturates/aromatics ratios are 1 and 0.6, but the highest value, at 1961 m, is probably due to contamination (see below).

The saturates chromatograms* are characterized by a naphthenic development, some irregular n-alkane contents, abundant isoprenoids in comparison to n-alkanes and pristane/phytane ratios between 0.7 and 1 ; the chromatogram of the 1961 sample shows a high development of n-alkanes between C 22 and C 30 (maximum at C 25) suggesting contamination by heavy parafins.

The pyrolyses performed on 3 sidewall cores (at 1959, 1969 and 1973 m) show that the kerogen quality is good : the thermodegraded organic carbon contents are between 1.75 to 3 % of the rock,i.e. 35 % of the kerogen.

As the maturation is low, the addition of the contents in extractable and degradable organic carbon indicates that initialy about 40 % of the organic matter may produce oil. Knowing that the average content in organic matter of the Upper Jurassic shales is about 6 % and their thickness about 20 m, their initial genetic potential is approximately 1.5×10^6 T/km^2.

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* Chromatography (GPC) of the saturated fraction of the extract by chloroform (at 1961 and 1967 m) or of the extract by Hexane ("minianalyses" at 1959, 1969 and 1973).

5 - ATTEMPT TO CHARACTERIZE MIGRATED HYDROCARBONS

The examinations in UV light of the Kimmeridgian coarse sandstones (core samples) showed neither fluorescence on rock nor fluorescence on extract, so these sandstones contain no significant quantity of hydrocarbons.

A minianalysis carried out on handpicked argillaceous siltstones from cuttings at 2010 m, in which some fluorescent hydrocarbon traces and bitumens were observed in reflected UV light (Pl. 1), showed only a few ppm of saturated hydrocarbons. These siltstones are caved from Upper Cretaceous according to a biostratigraphical survey.

6 - CONCLUSIONS

A good virtual source-rock interval is present in the 16/3-2 well between 1955 and 1975, i.e. the Hot Shales of the Upper Jurassic.

Its initial hydrocarbon potential is about 1.5×10^6 T/km^2 ; its maturation is lower than that corresponding to the main phase of oil generation.

REFLECTANCE (measurements)

FLUORESCENCE (Global amount estimated)

Vitrinite

Bitumens

Fluorescent macerals

Hydrocarbon traces in reservoirs

MP Mud products

elf

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16/3-2

ORGANIC MATTER REFLECTANCE - FLUORESCENCE

ENTREPRISE DE RECHERCHES ET D'ACTIVITES PETROLIERES

DIRECTION EXPLORATION

LABORATOIRE

PL 1

Date Sept. 1977

P. Robert

N° visa C 1854

REFLECTANCE

VITRINITE BITUMEN

0 1 2 3 %

FLUORESCENCE

GLOBAL ESTIMATED

ORGANIC MATTER NATURE

1 2 3 4 5

1000

OLIGOCENE

Alginite

Algae { Tasmanaceae, Botryococcus

Cutinites

(clear and dark various in colour → reworked)

1100

d°

+ Sporinite

Coals and bitumens

1200

d°

9" 5/8

1314

1360

d°

PALEOCENE

d°

1400

1410 clab 1400

DANIAN

Algae Tamanaceae (dark)

1471

1500

Coal

Tissues Sporinite Resinite

UPPER CRETACEOUS (CHALK)

Vitrinite

1600

d°

Iso and anisotropic bitumen or natural coke (due to volcanics ?)

clab 1665

ε

Tamanaceae (orange clear)

1683

1700

ε

1800

clab 1811

ε

LOWER CRETACEOUS

ε

1900

Bitumen

- homogeneous Alginite
- Tamanaceae (yellow-to-orange)

1955

clab 1961

MALM

C2 2000

2070

2017

Granite basement

V and B

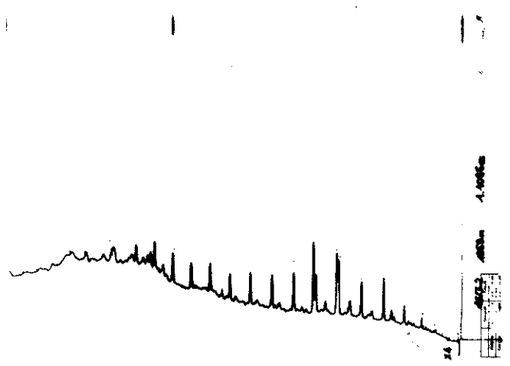
- Yellow to orange Tamanaceae
- Bituminite and sapropelic fragments (with algae)

Caved from Upper Cretaceous

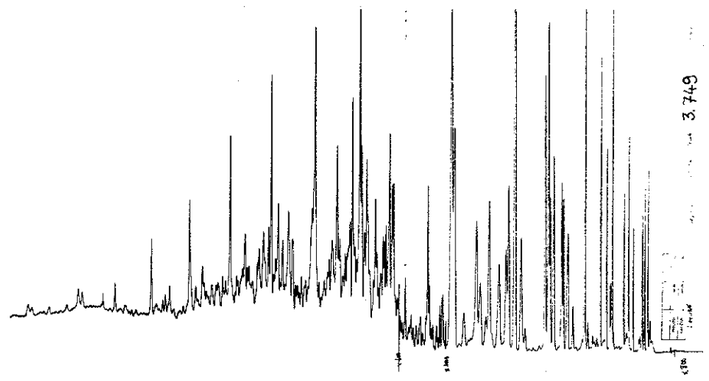
SATURATED HC

THERMOVAPORIZED HC

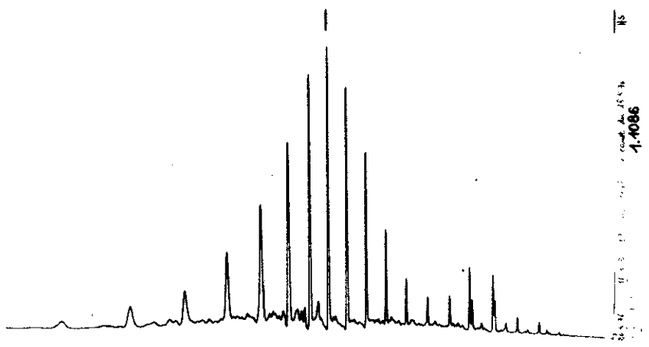
1959 m
COI = 7 9 %



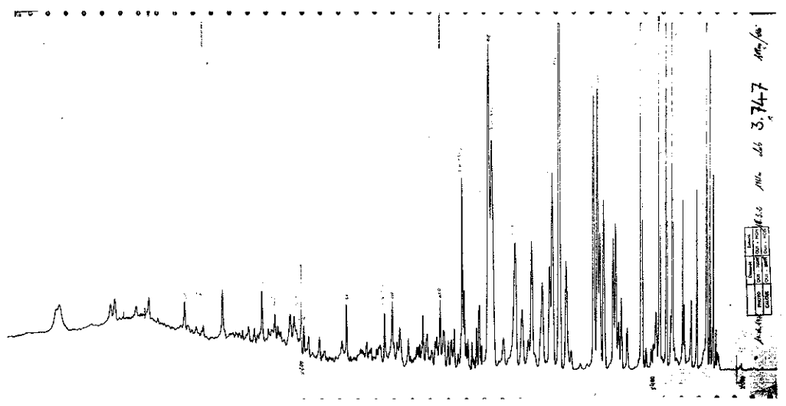
minianalysis



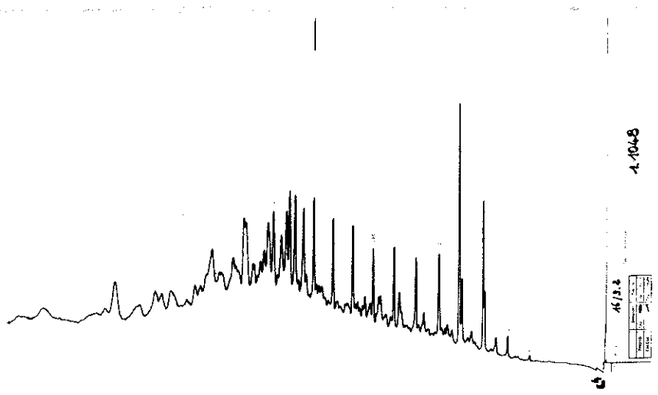
1961 m
COI = 5 3 %
MOE 3000 ppm

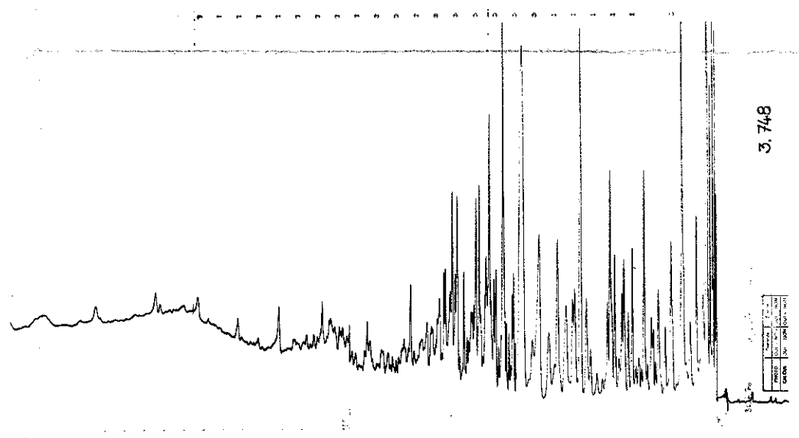


probable contamination

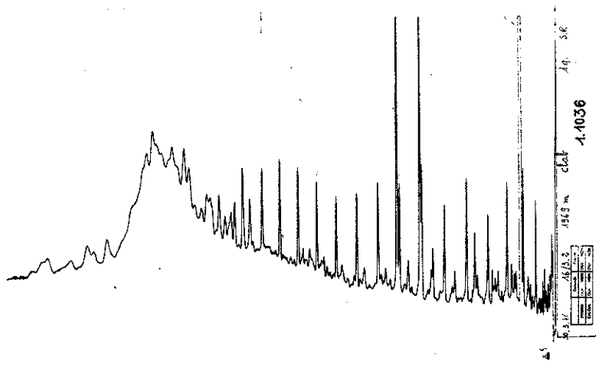


1967 m
COI = 4 2 %
MOE 2700 ppm

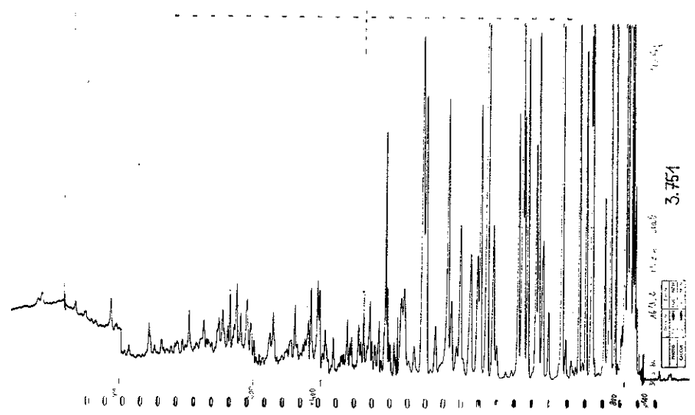




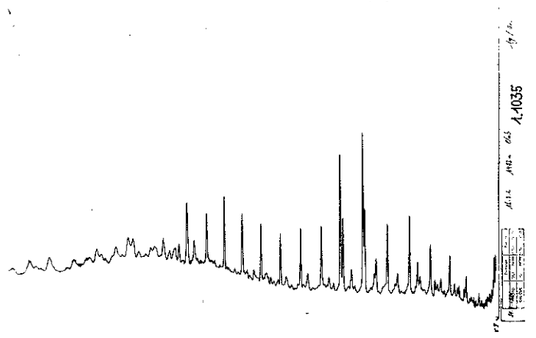
1969 m
COI = 5 4 %



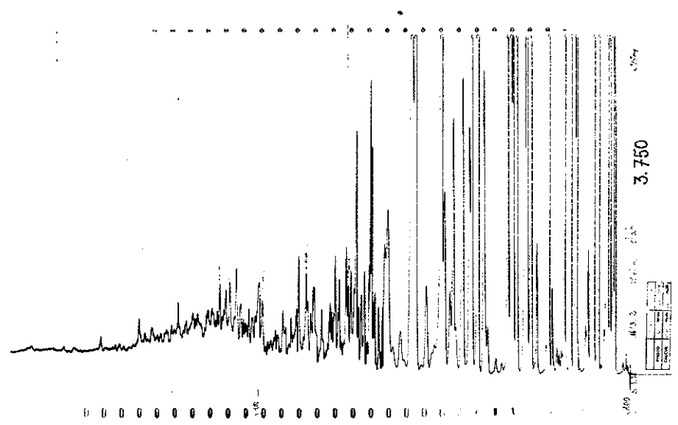
minianalysis



1973 m
COI = 8 %



minianalysis



elf	Secteur OFF SHORE NORWAY Opérateur NORSK HYDRO - ELF Permis ou Concession 007	PETRONORD

16/3.2 WELL
UPPER JURASSIC
CHARACTERIZATION OF THE SYNGENETICAL HYDROCARBONS
(Sidewall core samples)

elf ENTREPRISE DE RECHERCHES ET D'ACTIVITES PETROLIERES DIRECTION EXPLORATION LABORATOIRE	PL.2	Date Sept. 1977 Auteur PHILIPPE N°classt C 1855

SNEA (P)

DEPARTEMENT LABORATOIRE DE GEOLOGIE
DE BOUSSENS

ORGANIC MATTER STUDY

Synthesis of results

Country NORWAY
Well 16/3-2
Section
Date June 1977

Plate 3

TECHNICAL SECTION DEPTH SCALE 1 : 20000 | CORES | HC SHOWS | LITHOLOGY | STRATIGRAPHY | COMMENTS | IOC % rock | EOM ppm rock | EOM % TOM | ORGANIC FACIES (palyno. processing) | VITRINITE AND BITUMEN REFLECTANCE | THERMAL ALTERATION INDEX | ORGANIC GEOCH. | MAIN RESULTS

STRATIGRAPHY: MIOCENE TO PLIOCENE; PALEOCENE TO OLIGOCENE; UPPER CRETACEOUS; CHALK; LOWER CRETACEOUS; MALM; HOT SHALES; BASEMENT

COMMENTS: All the geochemical analyses were carried out on sidewall cores

5 cores analysed Average results

IOC % rock: 1 2 3%

EOM ppm rock: 1000 4000 ppm

EOM % TOM: 2 4 6 8%

ORGANIC FACIES (palyno. processing): Amorphous (sapropelic); Divided amorph mat.; Black powdery mat.; Coal; Fusinit; Ligneous material; Cuticles, epiderms.; 20 40 60 80%

VITRINITE AND BITUMEN REFLECTANCE: Dominant mode (from core); (from cuttings); Lack of coal or no representative population; Spreading; Bitumen; 0% 0.5 1 2 4 6%

THERMAL ALTERATION INDEX: Core samples; Cuttings samples; 1 2 3 4 5

ORGANIC GEOCH.: Extracts; Crude Oils; Pyrolyses

MAIN RESULTS:

No substantial source-rock interval
Low catagenesis

Good virtual source rock :
Initial HC potential about 1.5×10^6 T/km^2

B 1856