elf aquitaine

DIRECTION GÉNÉRALE DES PRODUCTIONS

WELL 15/3-2
(NORWAY)

-

OPTICAL AND GEOCHEMICAL STUDIES OF THE ORGANIC MATTER

Direction Exploration

Département Laboratoire de Géologie

(Boussens)

SNEA (P)
D.G.P. - D. EXPLORATION
LABORATOIRE DE GEOLOGIE DE BOUSSENS

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GEO/LAB Bss n° 9/1742 RP
/ca

WELL 15/3-2
(NORWAY)

-

OPTICAL AND GEOCHEMICAL STUDIES OF THE ORGANIC MATTER

P. CAILLEAUX - B. PHILIPPE
P. ROBERT

Boussens - February 1979

Reference : Order n° 031154

- R. CUSSEY - Report n° 8/1637 RP -
  "15/3-2 well (Norway) - Sedimentological study of Jurassic deposits (4236 to 4990 m)"

- P. DURIF - E. GROSDIDIER - J.F. RAYNAUD - Report n° 8/1641 RP -
  "Well 15/3-2 (Norway) - Biostratigraphical study of the Jurassic"

DISPATCHING LIST

RECIPIENTS :

EXPERT REGIONAL EXPLO. EUROPE	1
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A B S T R A C T

Geochemical and optical analyses define the uppermost Jurassic from the 15/3-2 well to be in the main oil generation zone. This zone probably exhausts near 4600 m, in the Callovian.

Due to their degrees of catagenesis, the initial hydrocarbon potentials of the Jurassic shaly members cannot be defined. Nevertheless they may be estimated as :

- low in the Cretaceous and in the Oxfordian to Upper Callovian ;
- presumably high in the Portlandian - Kimmeridgian and in the Callovian.

7 pages
1 table
11 plates

C O N T E N T S

-

TABLE I

PLATES

- Pl. 1 - Location map
- Pl. 2 - Organic Matter Study. Synthesis of results
- Pl. 3 - Organic matter petrology
- Pl. 4 to 10 - Chromatograms. Rock samples
- Pl. 11 - Pristane/nC17 - Phytane/nC18 diagram.

-

This report presents the results of the optical (in reflected light) and geochemical studies of the organic matter from 15/3-2 (location on Plate 1). It also takes into account the main results of the palynological slide observations in transmitted light carried out with the stratigraphical studies.

All these results are summarized on Plate 2 : "Organic Matter Study. Synthesis of results".

1 - OPTICAL STUDIES

1.1 - IN TRANSMITTED LIGHT

The observations were carried out between 3900 m and the well bottom ; their results (palynofacies and TAI), partly included in two biostratigraphical reports*, are summed up on Plate 2.

1.1.1 - Palynofacies

They are primarily made up of :

- coaly and black ligneous particles between 3900 and 4240 m ;
- a mixture of amorphous and of coaly and black ligneous particles between 4240 and 4420 m (high amorphous matter contents above 4320 m, lower contents below)
- coaly and black ligneous particles between 4420 m and the well bottom (only very few samples were analysed below 4580 m).

1.1.2 - T.A.I.

The estimated thermal alteration indices are :

3^+ - 3.5	at	3920 - 3980 m
3^+ - 3.5^+	at	4000 - 4055 m
2.5 - 3	at	4060 - 4150 m (lower TAI) (change in lithology?)
3.5 - 4	at	4235 - 4300 m
4	at	4330 m
3.5	at	4360 m
3.5 - 4	at	4520 - 4570 m (core 3)
4	at	4661.75 (core 4)
4		below 4670 m (cuttings)

.../...

* - J. DUCAZEAUX in "Well 15/3-2. Biostratigraphical study of the Cretaceous and the Jurassic (upper part)" - August 77 n° 7/1528.

- J.F. RAYNAUD in "Well 15/3-2. Biostratigraphical study of the Jurassic" - June 78 n° 8/1641.

- The TAI of the cretaceous section, not included in the biostratigraphical report and reported here on Plate 2, were estimated by P. de RENEVILLE.

1.2 - IN REFLECTED LIGHT

The well has been analysed on 21 samples including 4 cores and 17 cuttings, between 3000 m and the well bottom.

The concentrated rock is generally well provided in organic particles ; however the cutting samples are largely polluted by mud products including not shells, plastic fragments and mostly by lignitous additives which are typical coals (0.3 % vitrinite reflectance) ; the latter cannot be completely eliminated by selection under a magnifying glass, but are easily determined owing to their low reflectance and their fluorescence facies (rich in spores, like known "ligcon" samples).

The detailed results are given on Plate 3.

1.2.1 - Organic facies

- Cretaceous : only sampled on cuttings, this part of the section consists of small populations of humic coals, differentiated on the diagram by their reflectance higher than 0.5 % ; these coals sometimes include parts of fluorescent rock due to a small organic impregnation.

- Jurassic

  . Kimmeridgian : only 1 cutting sample does not give any reliable result, because of its strong mud product pollution,

  . Oxfordian : cores and cuttings include a lot of typical humic coals, with Vitrinite Reflectance from 0.75 to 1.%, associated with pale fluorescent rock groundmass in variable amounts, and, between 4400 and 4500 m, with opaque, not fluorescent bitumens ; these bitumen particles, with reflectances from 0.35 to 0.60 %, can be recognized under the microscope.

  . Callovian : the bottom of the well shows a grouped bitumen and coal (same Reflectance) population, with an increasing coalification (from 1. to 1.65% reflectance). The bitumens frequently exhibit a beginning anisotropy common with such a coalification.

  The fluorescence rate, for reliable matter, always stays low (0.5 maxi on a scale to 5.).

1.2.2 - Catagenesis

The vitrinite (and bitumen) reflectance survey, very continuous and reliable in the Jurassic, can be moreover appreciated in the Cretaceous, giving the following increase versus depth :

	depth	Ro %
Cretaceous	3,000 m	0.55 to 0.65
	3,800	0.6
Jurassic	4,400	0.75
	4,496	0.90
	4,570	1.
	4,700	1.1
	4,800	1.2
	4,900	1.35
	4,995	1.5 to 1.65

.../...

The Ro and TAI values are in agreement down to 4661.75, locating the base of the oil window about 4600 m. Below 4700 m, the higher values of Ro are probably right because the TAI are estimated on the same microfloras without renewing of species.

2 - GEOCHEMICAL STUDY

The geochemical analyses (TOC or IOC, EOM, Rock-Eval and hydrocarbon chromatography) were carried out on 19 rock samples (17 shaly and 2 sandstony) between 3740 and 4750 m. Their results are given in table I.

2.1 - SHALY SAMPLES

2.1.1 - Cretaceous

Only 4 sidewall core samples were analysed.

In the 3747 m sample, the kerogen and hydrocarbon contents are relatively high, but the present hydrocarbon potential (IH from Rock Eval analysis) is quite low.

In the 3794, 3938 and 4000 m samples, the kerogen contents are medium to low, and the thermovaporization as well as Rock Eval results are practically nigligible.

2.1.2 - Jurassic

The 13 analysed shaly samples (4 from cores n° 3 and 4 ; 3 sidewall core samples and 6 cutting samples) are taken from between 4255 and 4750 m. The lower part of the Jurassic in the well, below the latter depth, was not studied due to the heterogeneity of the cutting samples.

Portlandian to Kimmeridgian (4235 - 4330 m)

The total (or insoluble) organic carbon contents and the extractable organic matter contents are high (table I). This interval, located in the main oil generation zone, has a presumably high hydrocarbon potential.

Oxfordian to Upper Callovian

From 4330 to about 4550 m, IOC are relatively high but present hydrocarbon potential is very low ($< 4.10^{3}$ T/Km2.m) ; even taking into account the degree of catagenesis, one may assume that the initial potential was presumably low.

Callovian

Below 4550 m, decreasing of EOM content as well as variations in the characteristics of the hydrocarbons (Pl.4 to 11) are in agreement with the increasing maturation of the kerogen, shown by optical studies (oil window exhausts near 4600 m).

.../...

The present oil potentials of pyrolysed samples (Table I) are relatively low ($< 10.10^3$ T/Km2.m).

Due to the high degree of catagenesis involving past production of liquid hydrocarbons, these potentials do not represent the initial ones, presumably much higher.

2.2 - SANDSTONY SAMPLES

Two sandstony core samples from the Jurassic were analysed : near 4400 (core 2) and 4656 m (core 4).

The EOM content is low for the first sample and very low for the second. The hydrocarbons of the thermovaporised and saturated fractions of the 4400 m sample are highly matured and present genetical some disparities with the syngenetical hydrocarbons nearby (Pl. 11).

3 - COMMENTS ABOUT DIAGENESIS - COMPARISON WITH 15/3-1

A petrographic analysis, together with a study of argillaceous minerals* has revealed that the reservoir deterioration in 15/3-2 well, in comparison with 15/3-1, was due to a large supply of secondary quartz in 15/3-2. This supply has been attributed to the circulation of solutions, more concentrated in 15/3-2 than in 15/3-1, accompanied by heat flow (associated with hydrothermal manifestations).

The circulation of hydrothermal solutions appears to be the main reason for this difference in cementation (decrease of porosity in 15/3-2), because the Ro values are almost the same in the two wells at the same levels (core 4 in 15/3-1 and core 1, 2 and 3 in 15/3-2). Moreover one must dissociate the two processes of organic matter catagenesis and mineral neoformation : the first is a relatively long and extensive (regional) process, while the second is a shorter and more limited one - the deterioration of the reservoir qualities presumably affecting only the fault area (15/3-2) -.

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* n° 7/1589 RP - J.P. CASSAN - R. CUSSEY - J.P. SEVERAC - J. ESQUEVIN
Study of the Jurassic reservoirs cementation of wells 15/3-1 and 15/3-2.

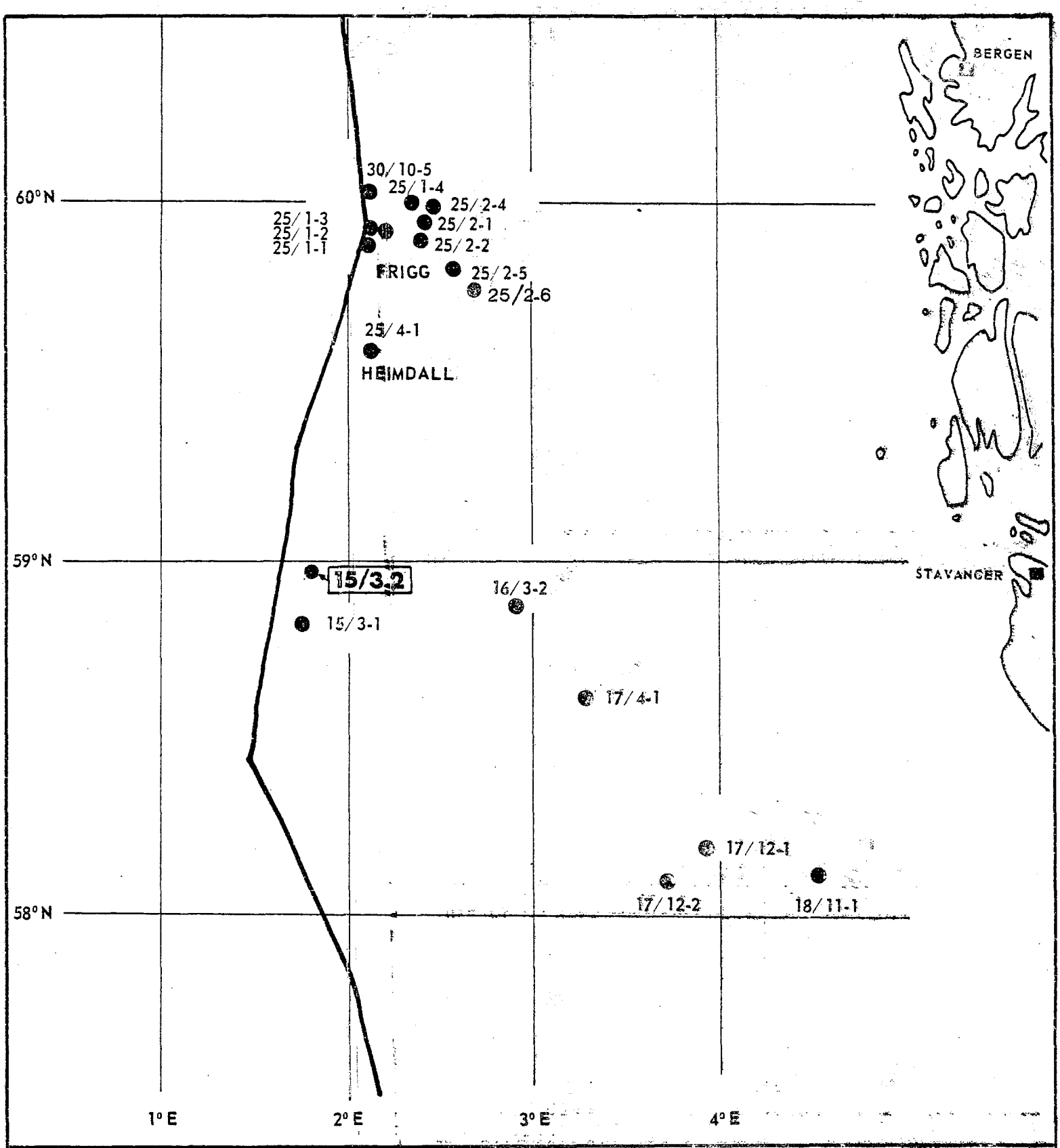
TABLE I

15/3 - 2 GEOCHEMICAL RESULTS

Sample Identification *		TOC mg C / 100 mg R	IOC mg C / 100 mg R	EOM mg HC / 100 mg R	EOM/TOC mg HC / 100 mg C	ROCK EVAL: Peak S1 mg HC / g R	Peak S2 mg HC / g R	Peak S2 mg HC / g C = HI	Peak S3 mg CO_2 / g C	Temp. °C Peak S2	S1 / (S1 + S2) =IP	THERMOVAP. HC (ppm)	SATURATES n. alkanes (ppm)	AGE
3747 m	SWC	2.4				0.6	1.75	70	-	430	0.25	225		TURONIAN
3794	SWC	0.4				0.1	0.05	15	230	445	0.7			CENOMANIAN
3938	SWC		1									≈ 0		ALBIAN TO CENOMANIAN
4000	SWC		0.75									20		APTIAN
4255	Cuttings	(4.0)	3.3	0.86	21									LOWER PORTLANDIAN
4285	Cuttings	(7.1)	6.2	1.16	16									TO KIMMERIDGIAN
4324	Cuttings	(3.8)	3.1	0.82	21							2100		
4337	SWC	(2.9)	2.6			3.6	1.8	60	85	432	0,67	1125	225	OXFORDIAN
4355	SWC	(1.6)	1.5			1.3	0.9	55	85	452	0,59	615	65	
4400 ±	Core 2			0.12								195	105	TO UPPER CALLOVIAN
4528	Cuttings	(3.15)	2.85	0.35	11									
4567.25 - .35	Core 3	(0.35)	0.3	0.08	22							315	120	
4567.80	Core 3		3.2	0.08	2.5		3.5	100	10	465			150	
4620	Cuttings	(2.35)	2.15	0.27	11									LOWER
4656.00 - .15	Core 4			0.02										CALLOVIAN
4659.70 - .85	Core 4	(1.8)	1.75	0.07	4									
4661.10 - .15	Core 4	(3.3)	3.2	0.11	3		3.1	85	15	464		625	140	
4697	SWC	(1.85)	1.8			0.7	1.6	85	25	466	0.30	265	60	
4750	Cuttings	(2.8)	2.65	0.16	6		3.8	130	20	458		915	135	

* Underlined for the sandstony samples

C = Carbon
HC = Hydrocarbon
R = Rock
TOC = Total Organic Carbon - the values in brackets are calculated : IOC + 0.8 MOE or IOC + 0.08 S1
IOC = Organic Carbon, insoluble in chloroform
EOM = Organic Matter, extracted by chloroform.



0 50 100 km

elf aquitaine

Pays NORVEGE

Permis ou concession tous permis

DIRECTION GENERALE DES PRODUCTIONS

DIRECTION EXPLORATION

Date Mars 1976

Auteur B PHILIPPE

N°Classt A.3112

PL. 1

NORTH SEA

15/3.2 LOCATION

elf aquitaine

EIF NORGE NORVEGE

DIRECTION GENERALE DES PRODUCTIONS

SECTEUR EXPLORATION

P. Rabaut D.1616

PL. 3

15/3-2 WELL

ORGANIC MATTER PETROLOGY

REFLECTANCE (measurements)

Vitrinite

Bitumens

FLUORESCENCE (global amount estimated)

Fluorescent macerals

Hydrocarbon traces in reservoirs

MP Mud products

REFLECTANCE		FLUORESCENCE	
VITRINITE BITUMEN		GLOBAL ESTIMATED	ORGANIC MATTER NATURE
0	1 2%	1 2 3 4	

3000

Some spores yellowish ground mass (impregnated rock) + mud products

SENONIAN

3300

d¹

3600

Mud Products

3603

Yellowish ground mass Mud products (Coals)

TURONIAN

3700

M.P.

d²

3753

3800

M.P.

d² + coal with spores

CENOMANIAN

3900

M.P.

d²

3913

ALBO - APTIAN

4000

M.P.

d²

4037

4100

M.P.

d²

NEOCOMIAN

4200

M.P.

d²

4236

4248

PORTLAND

4300

M.P.

Impregnated reservoirs abundant mud products

KIMMERIDG.

4340

Typical coals

Yellow - reddish fluorescent humic ground - mass (rock)

k₂ 4407,40

M.P.

Reservoirs and d² + M.P.

4460

4470

4496

4500

d²

OXFORDIAN

d²

k₀ 4567,75/76

k₁ 4570,88

Vitrinite and Bitumen (not anisotropic)

Dark fluorescent ground mass (rock)

4615

k₄ 4661,75

4700

M.P.

d² + M.P.

CALLOVIAN

4800

d²

4900

d²

4984

S. N. E. A. (P)

DEPARTEMENT LABORATOIRE DE GEOLOGIE DE BOUSSENS

PAYS *Country* NORWAY

SONDAGE *Well* 15/3-2

Roche *Rock*

Cote *Depth* 4324 m

Identification *Identification* Cuttings

Formation *Formation*

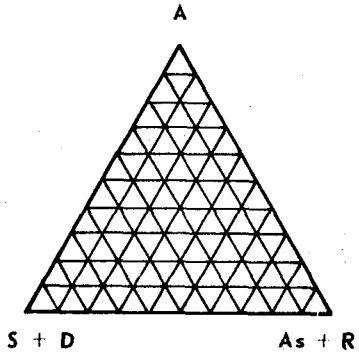
Age *Age* LOWER PORTLANDIAN - KIMMERIDGIAN

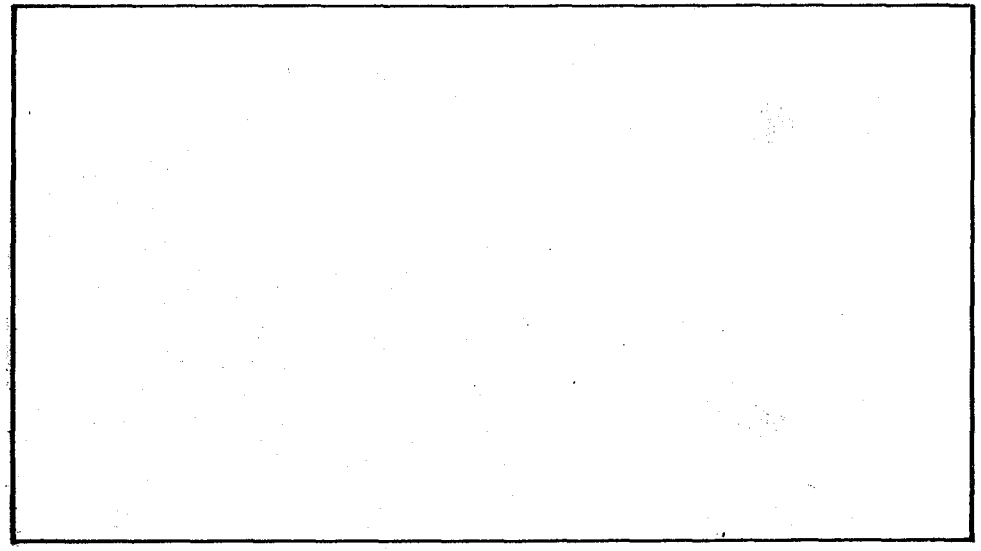
IOC = 3.1

Composition du produit total (%)
Composition of total product

Asphaltènes *Asphaltenes*	As	:
Résines *Resins*	R	:
HC saturés + distillat *Saturated HC + distillate*	S + D	:
HC aromatiques *Aromatic HC*	A	:

$\frac{S}{A}$ =





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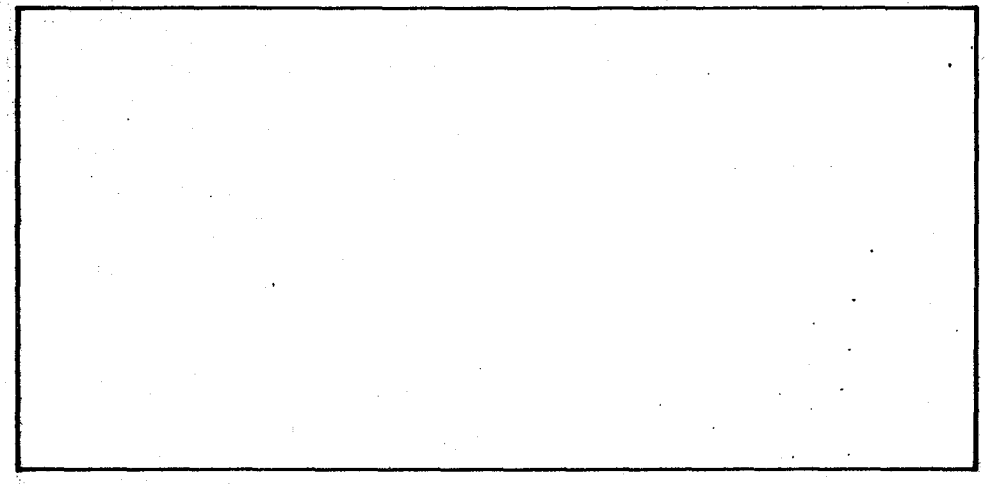

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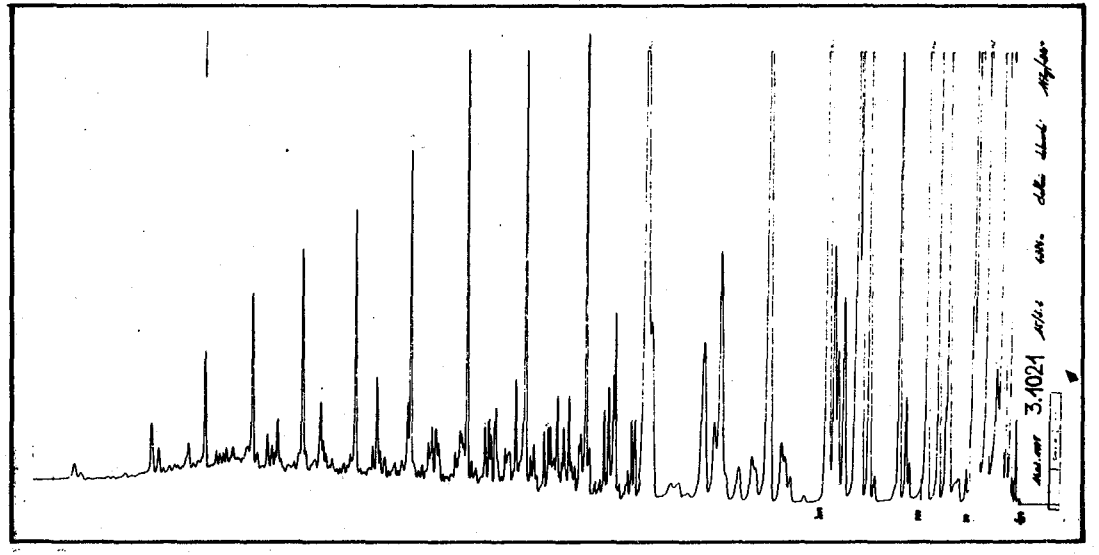

HC THERMOVAPORISES *THERMOVAPORIZED HC*

S. N. E. A. (P)

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PAYS *Country* NORWAY

SONDAGE *Well* 15/3-2

Roche *Rock*

Cote *Depth* 4337 m

Identification *Identification* SWC

Formation *Formation*

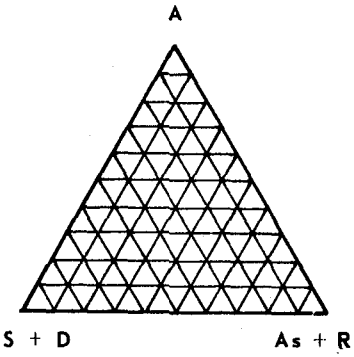
Age *Age* CALLOVO-OXFORDIAN

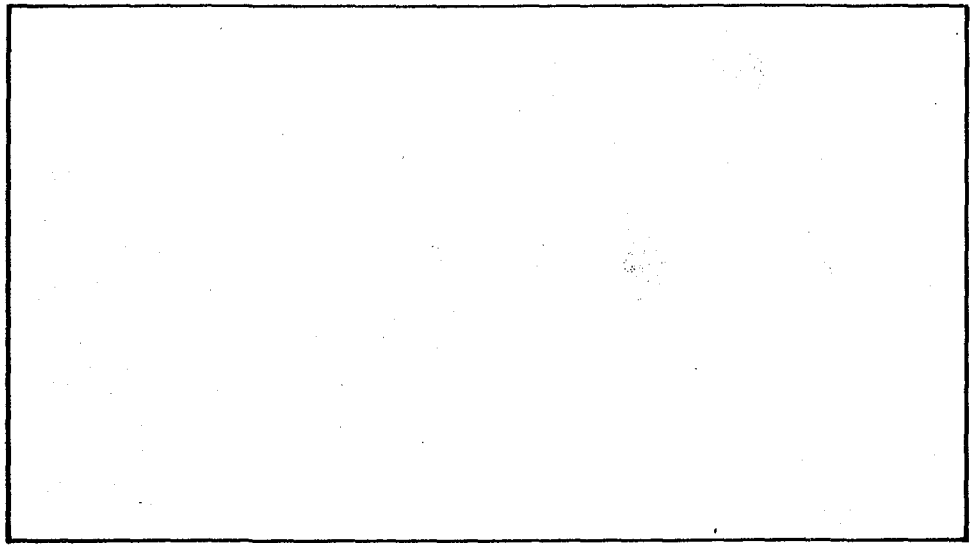
IOC = 2.6

Composition du produit total (%)
Composition of total product

Asphaltènes *Asphaltenes*	As	:
Résines *Resins*	R	:
HC saturés + distillat *Saturated HC + distillate*	S + D	:
HC aromatiques *Aromatic HC*	A	:

$\frac{S}{A}$ =





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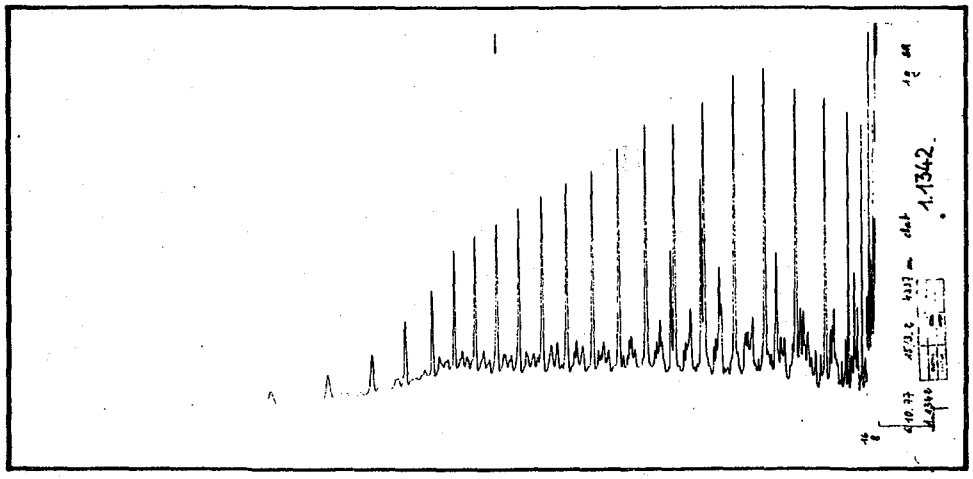

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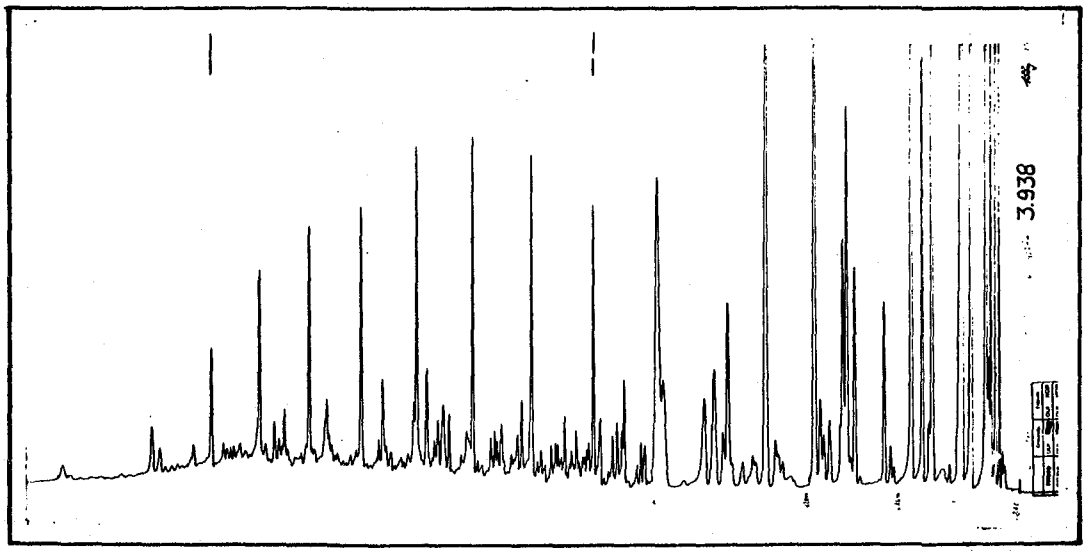


HC THERMOVAPORISES *THERMOVAPORIZED HC*

S. N. E. A. (P)

DEPARTEMENT LABORATOIRE DE GEOLOGIE DE BOUSSENS

PAYS *Country* NORWAY

SONDAGE *Well* 15/3-2

Roche *Rock*

Cote *Depth* 4355 m

Identification *Identification* SWC

Formation *Formation*

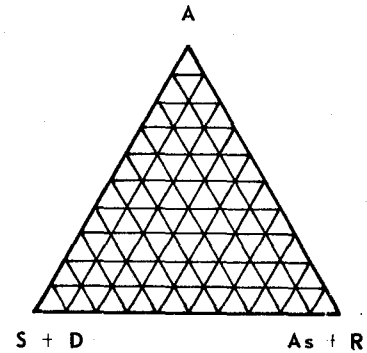
Age *Age* CALLOVO-OXFORDIAN

IOC = 1.5

Composition du produit total (%)
Composition of total product

Asphaltènes *Asphaltenes*	As	:
Résines *Resins*	R	:
HC saturés + distillat *Saturated HC + distillate*	S + D	:
HC aromatiques *Aromatic HC*	A	:

$\frac{S}{A}$ =



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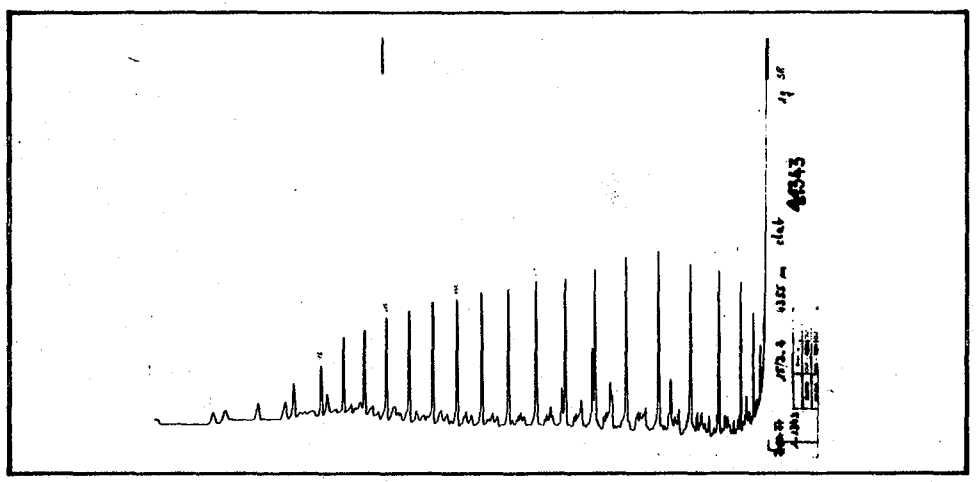

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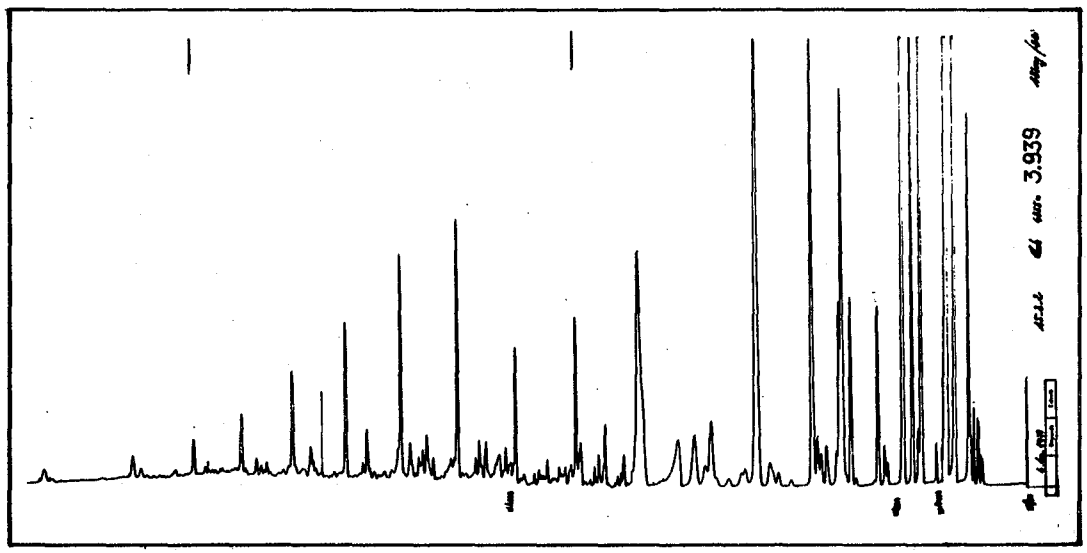

HC THERMOVAPORISES *THERMOVAPORIZED HC*

S. N. E. A. (P)
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PAYS *Country* NORWAY

SONDAGE *Well* 15/3-2

Roche *Rock*

Cote *Depth* 4567,25 - 4567,35 m

Identification *Identification* Core n° 3

Formation *Formation*

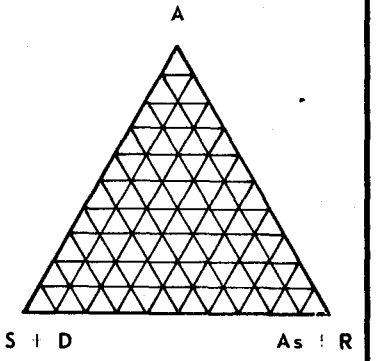
Age *Age* LOWER CALLOVIAN

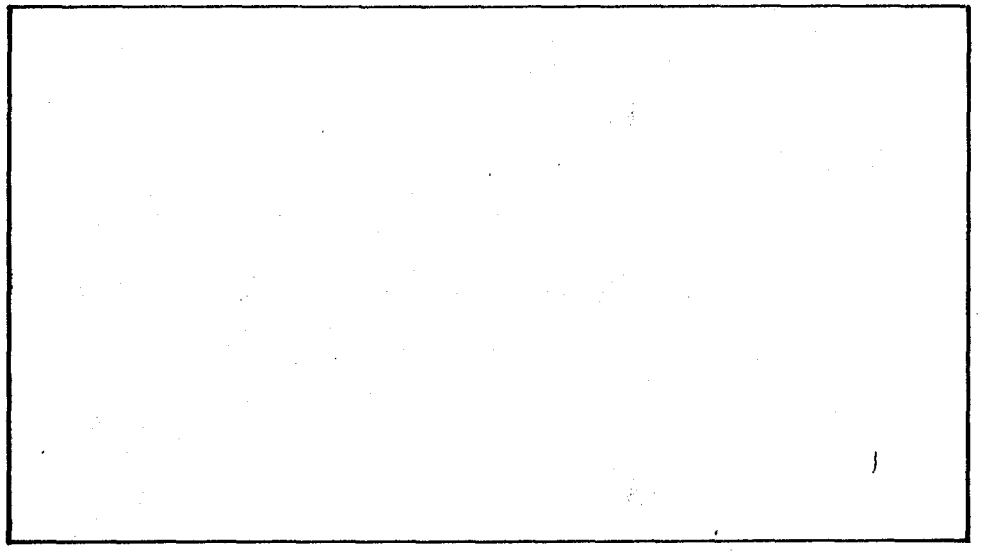
IOC = 0.3

Composition de l'extrait *Composition of extract* (%)

Asphaltènes *Asphaltenes*	As	:	18.5
Résines *Resins*	R	:	13.5
HC satures + distillat *Saturated HC + distillate*	S	:	46.5
HC aromatiques *Aromatic HC*	A	:	21.5

$\frac{S}{A} = 2.2$





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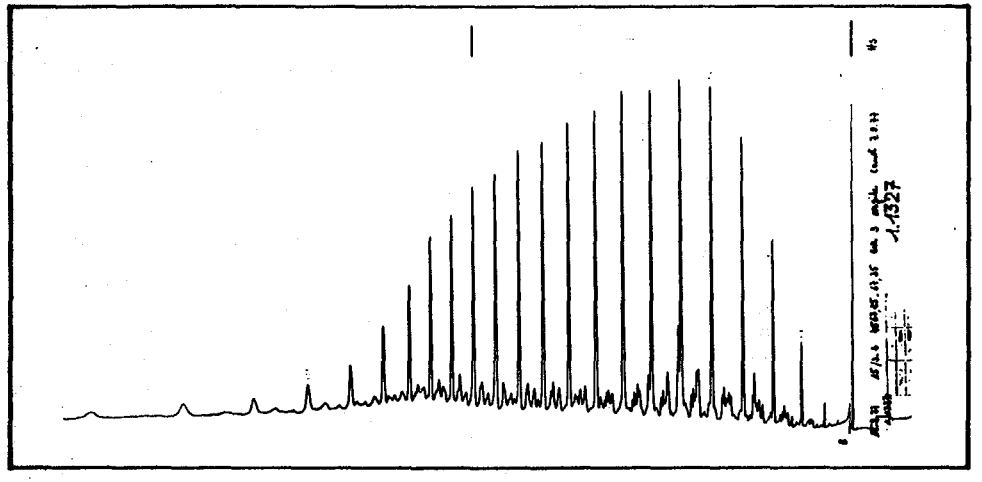
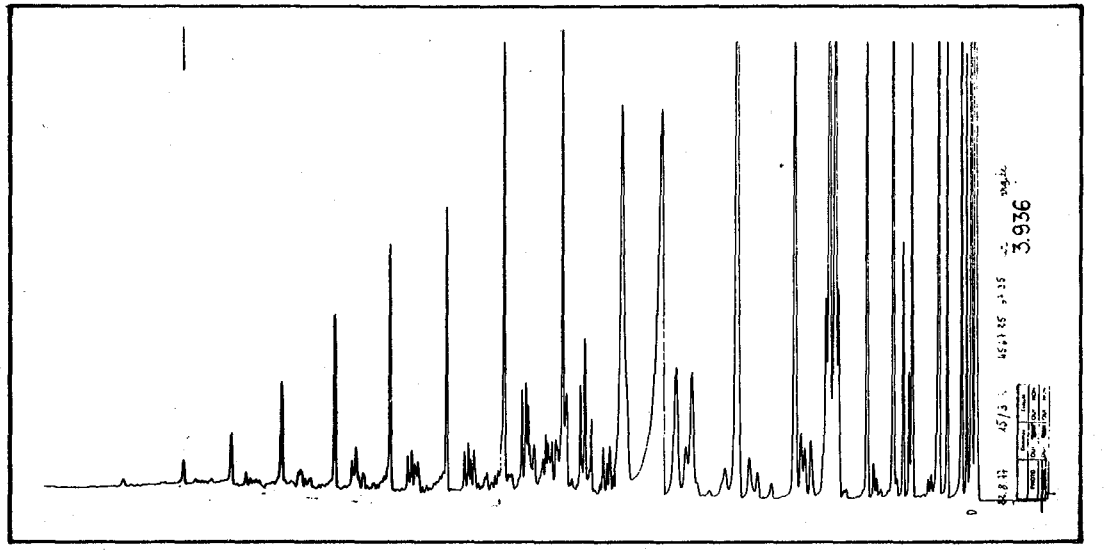


HC SATURES *SATURATED HC*



HC THERMOVAPORISES *THERMOVAPORIZED HC*

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PI.8

PAYS *Country* NORWAY

SONDAGE *Well* 15/3-2

Roche *Rock*

Cote *Depth* 4661,10 - 4661,15 m

Identification *Identification* Core n° 4

Formation *Formation*

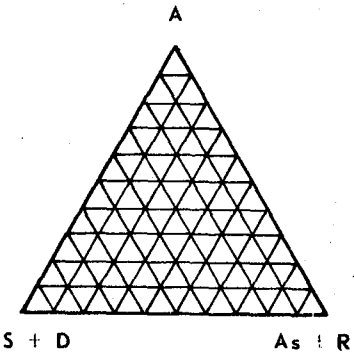
Age *Age* LOWER CALLOVIAN TO UPPER BATHONIAN

IOC = 3.2

Composition de l'extrait *Composition of extract* (%)

Asphaltènes *Asphaltenes*	As	:	20
Résines *Resins*	R	:	15.5
HC saturés *Saturated HC*	S	:	44
HC aromatiques *Aromatic HC*	A	:	20.5

$\frac{S}{A} \simeq 2.2$



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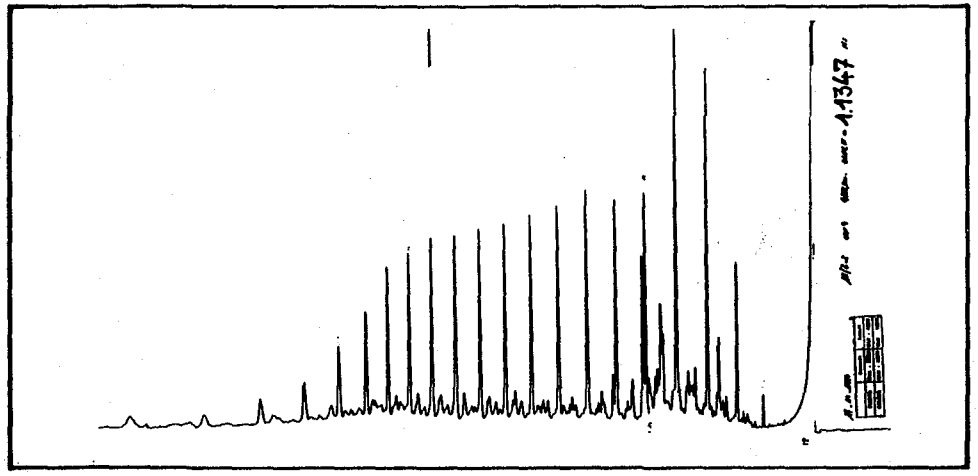
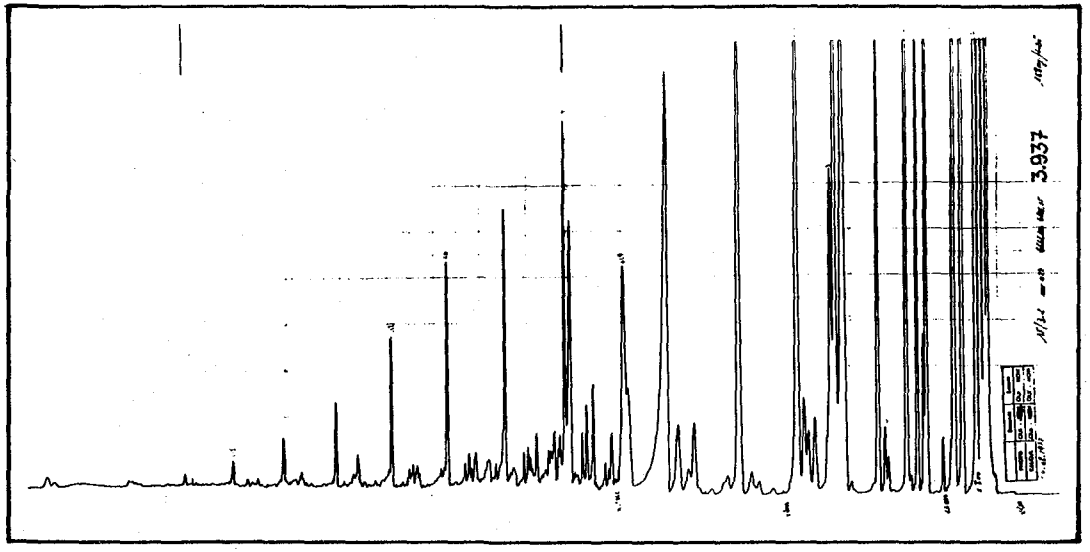


HC SATURES *SATURATED HC*



HC THERMOVAPORISES *THERMOVAPORIZED HC*

S. N. E. A. (P)

DEPARTEMENT LABORATOIRE DE GEOLOGIE DE BOUSSENS

PAYS *Country* NORWAY

SONDAGE *Well* 15/3-2

Roche *Rock*

Cote *Depth* 4697 m

Identification *Identification* SWC

Formation *Formation*

Age *Age* LOWER CALLOVIAN TO UPPER BATHONIAN

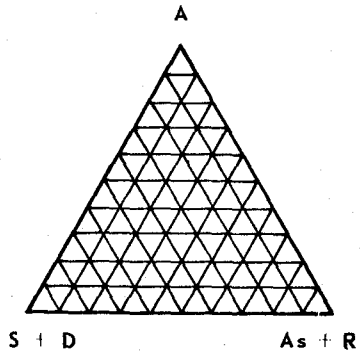
IOC = 1.8

Pl.9

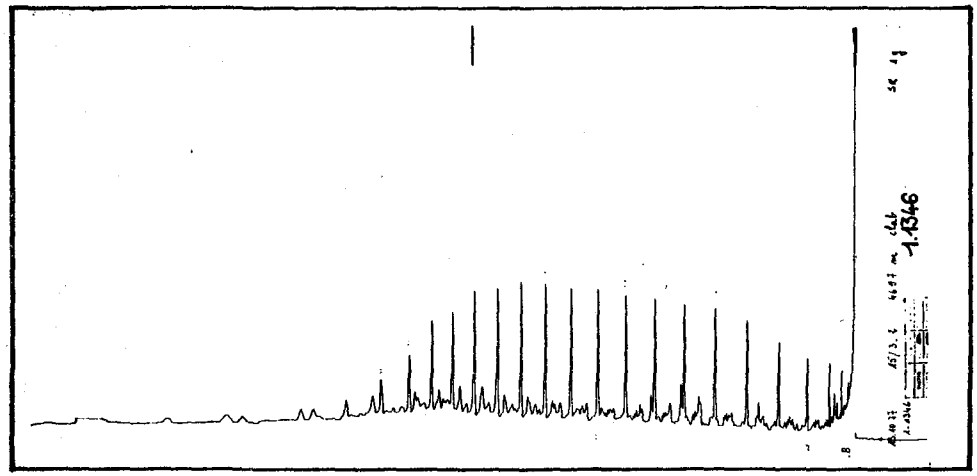
Composition du produit total (%)
Composition of total product

Asphaltènes *Asphaltenes*	As	:
Résines *Resins*	R	:
HC saturés + distillat *Saturated HC + distillate*	S + D	:
HC aromatiques *Aromatic HC*	A	:

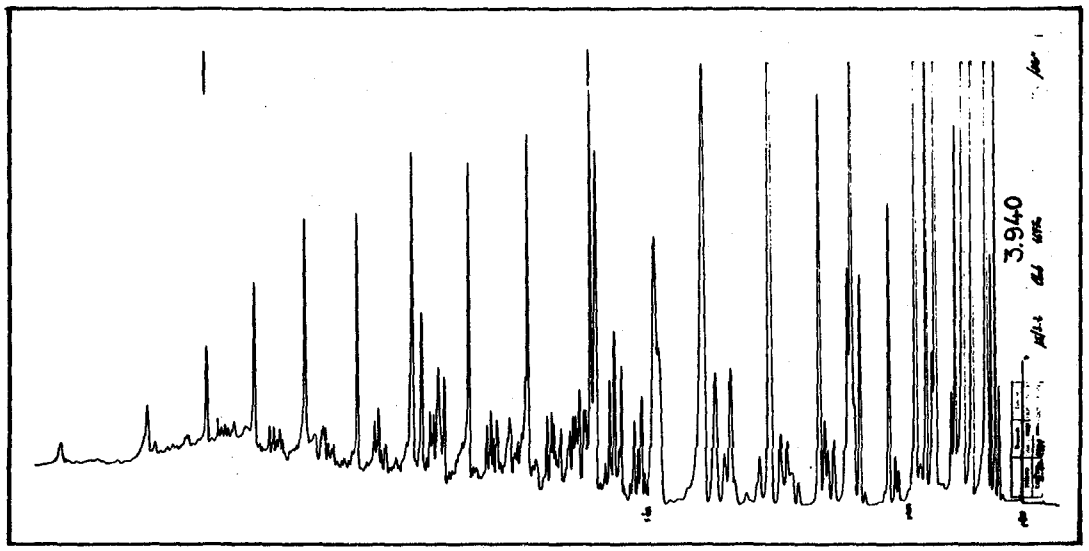
$\frac{S}{A}$ =



HC AROMATIQUES *AROMATIC HC*



HC SATURES *SATURATED HC*



HC THERMOVAPORISES *THERMOVAPORIZED HC*

A.3120

S. N. E. A. (P)

DEPARTEMENT LABORATOIRE DE GEOLOGIE DE BOUSSENS

PAYS *Country* NORWAY

SONDAGE *Well* 15/3-2

Roche *Rock*

Cote *Depth* 4750 m

Identification *Identification* Cuttings

Formation *Formation*

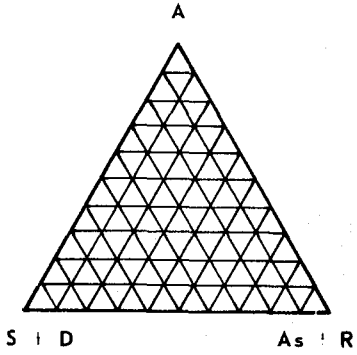
Age *Age* LOWER CALLOVIAN TO UPPER BATHONIAN

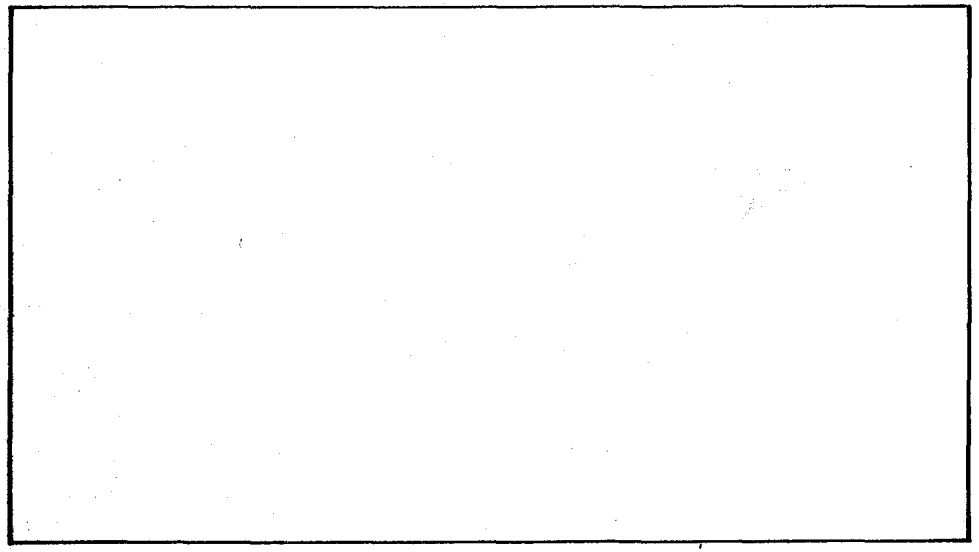
IOC = 2.65

Composition de l'extrait *Composition of extract* (%)

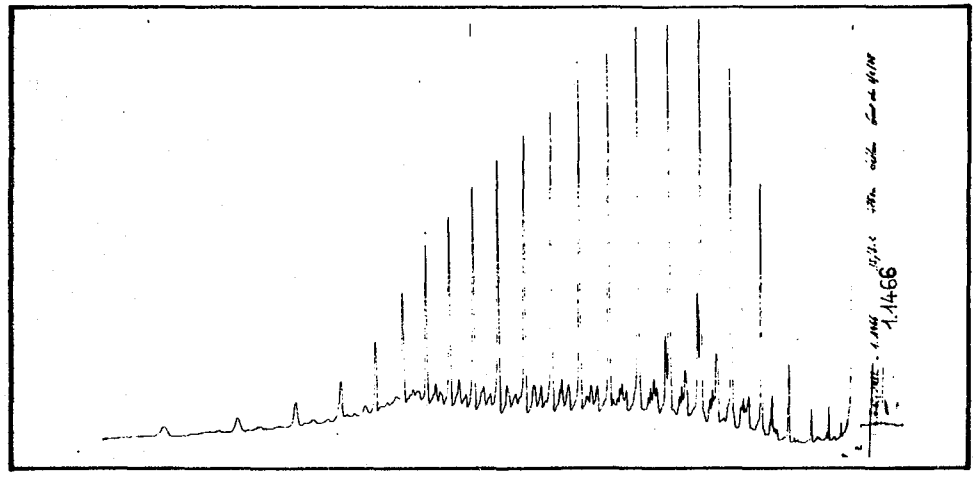
Asphaltènes *Asphaltenes*	As	:	28
Résines *Resins*	R	:	17 5
HC saturés + distillat *Saturated HC + distillate*	S	:	36 5
HC aromatiques *Aromatic HC*	A	:	18

$\frac{S}{A} = 2$

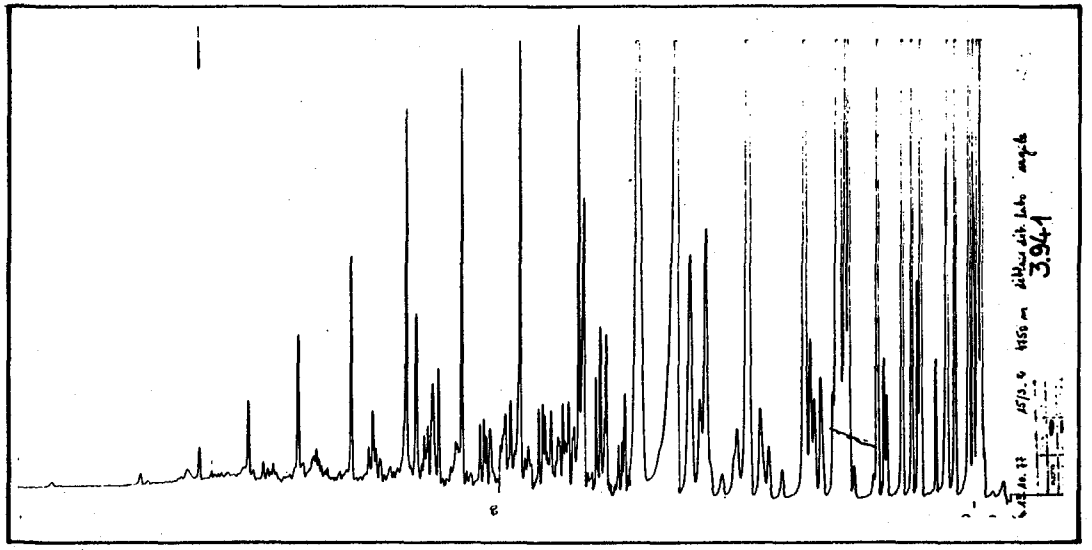




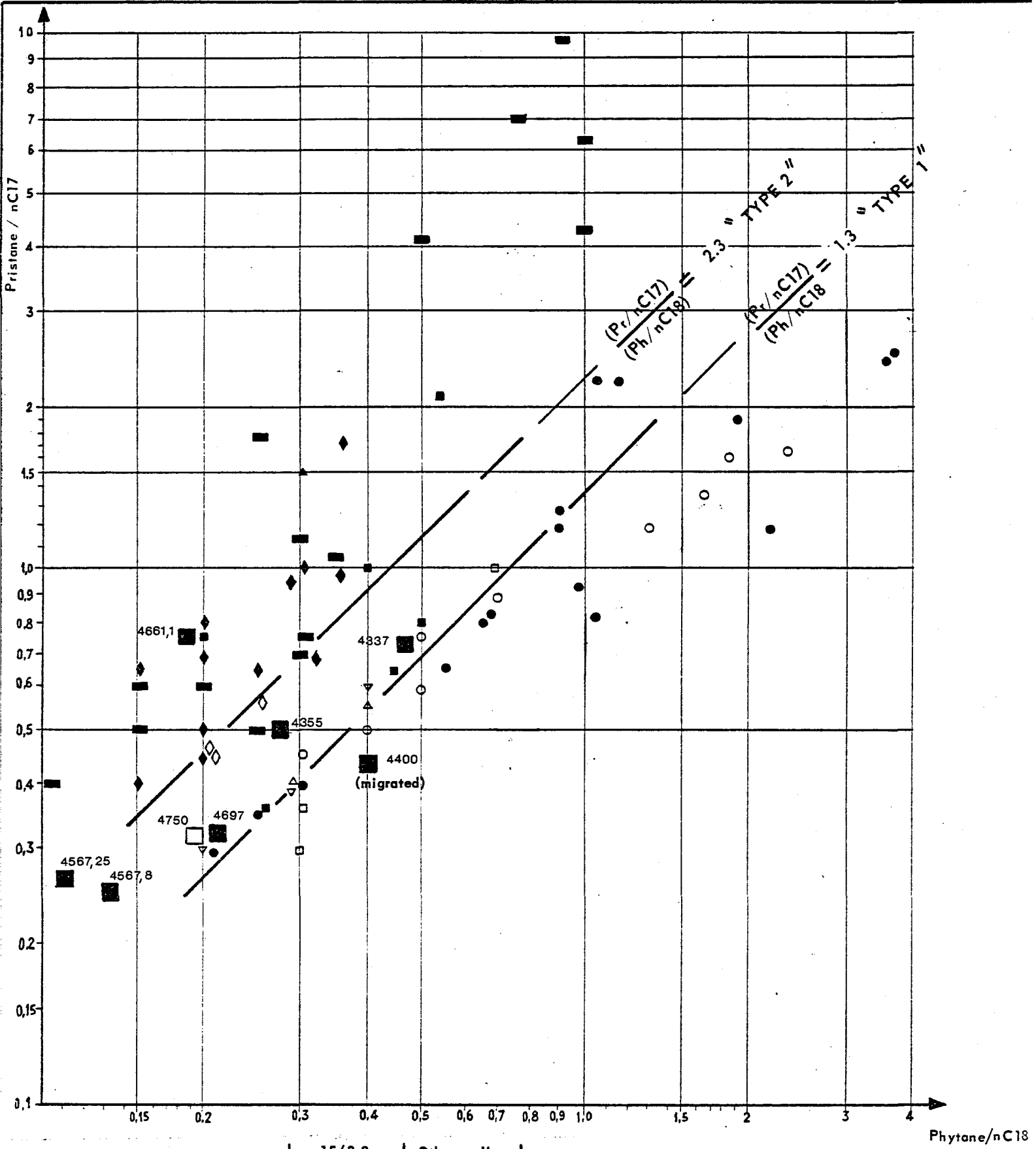
HC AROMATIQUES *AROMATIC HC*



HC SATURES *SATURATED HC*



HC THERMOVAPORISES *THERMOVAPORIZED HC*



	15/3-2 (1)	15/3-2 (2)	Other wells (1)	Other wells (2)
Upper Cretaceous			▲	△
Lower Cretaceous			▼	▽
Portlandian - Kimmeridgian			●	○
Callovo-Oxfordian	■	□	■	□
Dogger			▬	▭
Liassic			♦	◇

(1) Cores, s.w.c.
(2) Cuttings

elf aquitaine

Pays NORVEGE
Permis ou concession tous permis

DIRECTION GENERALE DES PRODUCTIONS

DIRECTION EXPLORATION

Date March. 78
Auteur : B. PHILLIPE
N°Class. A.3122

PL. 11

NORTH SEA

Pristane/nC17 - Phytane/nC18 diagram

SNEA (P)

DEPARTEMENT LABORATOIRE DE GEOLOGIE
DE BOUSSENS

ORGANIC MATTER STUDY

SYNTHESIS OF RESULTS

WELL : 15/3-2

COUNTRY : NORWAY

Plate 2

Date August 1978

DEPTH 1/20 000 m

HC SHOWS

LITHOLOGY

FORMATION

AGE

PALYNOFACIES
MOS
MOV
MOX
MOB1
MOB2
MOF1
MOF2
Various including microfossils
25 50 75 %

T. A. I.
Core
Cuttings
1 2 3 4 5

REFLECTANCE
Mode { core / cuttings
Non representative mode
No result
Spreading
Bitumen
Ro V equiv. fluo.
0,5 1 2 4 %
B

FLUORESCENCE
Sapro/algal
Humic
Undifferentiated
1 2 3 4

CORES

IOC
DOC
% rock weight
1 2 3 4

EOM
% rock weight
0,1 0,2
1,0 2,0

CONSTITUTION
G. C.
● effluent
✱ extract
Thermovap.
Saturated
Aromatic

MAIN RESULTS
CATAGENESIS
HC POTENTIALS
Residual
Initial

DEPTH m

30" 185
20" 775
13"3/8 2862
9"5/8 4248
1000
2000
3000
4000
5000

Miocene to Pleistocene
Oligocene
Eocene
Paleocene
Dan.
Campan. Maastrich.
Senonian
Turon. Cenom.
Gén.
Apt.
Bar.
Haut.
Val.
Port.
Kim.
Oxf.
Callovian

6,2
1.2
3
4

Main oil generation zone

(low) (low)

low Presumably high / low / high

C.3113