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65-07/12-2 WELL
(NORWAY)

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GEOCHEMICAL STUDY
OF THE ORGANIC MATTER
(JURASSIC-TRIASSIC)

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LISTE DE DIFFUSION

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ABSTRACT

Geochemical study -1845-4994 m- (and optical study 1867-4981,8 m) carried out on the organic matter from 65-07/12-2 well shows mainly that :

- *the degree of catagenesis is low in the Jurassic and in the Rhaetian (0.4 to 0.6 % Ro equivalent), increases rapidly in the Early-Middle Triassic (up to 1.25 % Ro) ;*

- *only the Coal Unit with hydrogenated humic facies and with a probable gas potential has some source-rock properties.*

11 pages
2 tableaux
11 planches

SOMMAIRE

PLATES

This report presents the geochemical analyses carried out on the organic matter from 65-07/12-2 well (location map on plate 1) in the Jurassic and Triassic intervals from 1845 m to 4994 m. It takes into account the optical observations in transmitted light on some palynological slides (palynological study in progress, J. DUCAZEAUX and P. MOREAU) and the results of the optical study in reflectance and fluorescence*.

1 - CATAGENESIS DATA

1.1 - TRANSMITTED LIGHT

The thermal alteration index (TAI) is estimated to :

- 2^+ in the lower Cretaceous,
- 2.5 in the Jurassic down to the top of the Coal Unit,
- 2.5 to 3 in the Coal Unit,
- 3 from the Grey Beds to 4273 m in the Triassic (just above the Lower Salt),
- $3,5^+/4$ in the Salt and down to T.D.

1.2 - REFLECTANCE-FLUORESCENCE

29 samples have been analysed in the 1867-4981,8 m interval.

A large pollution by numerous mud additives (Ro = 0.3 %) of all the cutting samples from 3300 m to T.D. has to be noticed.

From 1880 to 4050 m the reflectance values fluctuate between 0.4 and 0.5 %. The colourations of the some botryococcus algae give equivalent reflectances between 0.45 and 0.60 % with just a slight regular increase from 0.45 to 0.6 between 2070 m and 2730 m.

At 4350 m (above the Lower Salt) and at 4860 m (under the Lower Salt) the reflectance values are much higher : 1.1 and 1.25 % respectively.

So except the two high values around the salt, no true rank evolution is observed just a trend from 0.45 to 0.6 % between 2070 and 2730 m (Coal Unit and Grey Beds).

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* - DEX/RAG - Lab. Bss n° 83/010 N - Chr. PALACIOS -
65-07/12-2 Well - Organic matter optical study in reflectance-fluorescence - March 1983 -

1.3 - *GEOCHEMICAL DATA*

Tmax (temperature of pyrolysis). The Rock Eval Pyrolysis have been carried out on the samples with a total organic carbon content higher than 0.2 %. In spite of this, too small or too broad S_2 peak do not enable us to get accurate recording of Tmax for some samples.

For all the analysed samples the Tmax is low from 415°C to 430°C down to 4200 m, increases up to 440°C between 4200 and 4300 m, reaches 470°C at 4526 m ; i.e. a clear increase in the zone of the Ro and TAI breaks.

Indigenous hydrocarbons. The distribution of the hydrocarbons, the high Pristane/n C17 ratio, and the high Carbon Reference Index values, show the immaturity of the indigenous hydrocarbons.

1.4 - *CONCLUSION REGARDING THE ORGANIC MATTER MATURATION*

From the lower Cretaceous to the Triassic Red Beds (Rhaetian) the organic matter is immature ; the degree of catagenesis rapidly increases below 4300 m to T.D. (beyond 1 % Ro).

2 - *ORGANIC MATTER CHARACTERISTICS*

2.1 - *ORGANIC MATTER CONTENT* (*cf. table 1*)

- The two intervals 3450-4050 m and 4600-4900 m have been investigated but their samples have been abandoned after observation because of the large amount of salt and mud additives (Ligcon ?).

  These mud additives, handpicked in the 4599 m cutting sample have an amount of 31.8 % of total organic carbon (sample n° 45 in table 1).

- Upper Jurassic TOC = 0.6 to 4.4 % weight of rock.
- Jurassic Sst (1952-2200 m) : low TOC (< 0.8 %) increasing downwards.
- Coal Unit (2255-2598 m) : high to very high TOC values up to 17 %.
- Triassic Grey Beds (2615-2713 m) : TOC decreasing.
- Triassic Red Beds (2804-3439 m) : very low TOC < 0.65 %.
- Triassic (4098-4526 m) : low TOC (except mud additives).
- Triassic (4920-4994 m) : very low TOC < 0.25 %.

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2.2 - *PALYNOFACIES*

The palynofacies is essentially made up of ligneous particles and black debris (coal) but amorphous organic matter is observed in some intervals :

- 1867-1897 m 40 to 65 % amorphous O.M.
- 2016-2071 m 65 to 90 %
- 2713 m 55 %
- 3309 m 30 %

2.3 - *ORGANIC FACIES IN REFLECTANCE-FLUORESCENCE*

The whole section studied consists chiefly of humic material in addition to a few algae of lacustrine origin (Botryococcus) in certain places, and a single sapro-humic level.

- In the Cretaceous, the only sample analysed includes a pale shaly organo-mineral groundmass and few coaly particles.
- In the Jurassic and the Upper Rhaetian :
  - on the interval 1880-2901 m, the samples are made up of abundant large-sized Vitrinite grains combined with Inertinites (numerous fusinites at 2541 m) and Exinites (mainly sporitines, a few cutinites and very few fluorinites). Humic groundmasses give a pale to brownish fluorescence. The global fluorescence indices range from 0,75 to 2 (on a scale 0-5) and are essentially due to the Exinites.
  - on the interval 3000-4050 m, the coaly particles are less common and the organo-mineral groundmasses which are more frequent present a pale to ochre fluorescence and are sometimes associated with fluorescent carbonated rhombs. Throughout the Jurassic and the Upper Rhaetian, the botryococcus algae appear in small quantities (1 to 6), except on two levels (SWC 2615 m and 2730 m) where they are more abundant.
- In the Middle and Lower Triassic, all the cutting samples are polluted by numerous mud additives (lignites Ro = 0,30 %) and contain a very low population of homogeneous vitrinite, devoid of Inertinite.

  Some fluorescent reservoirs have been observed at 3951 m with insoluble bitumen in their pores.

  At 4251 m, the sample comprises a yellow sapropelic groundmass (containing some green alginite) which is mixed with humic material.

2.4 - *GEOCHEMICAL DATA*

The geochemical analyses were carried out on 44 samples (25 SWC, 1 core, 18 cuttings) from 1845 m to 4994 m in Jurassic and Triassic intervals. The samples contaminated by mud products have been eliminated.

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2.4.1 - *Quantity of hydrocarbons*

In all the studied interval the amounts of hydrocarbons extractable by heating (peak S_1 of Rock-Eval pyrolysis, table 1) are lower than 2800 ppm these values are low to very low with regard to the TOC contents.

2.4.2 - *Characteristics of the hydrocarbons*

In the samples selected for chromatographical analyses a gasoil pollution has been detected.

So the samples had to be handpicked and washed with teepol and n-hexane to enable us to observe the indigenous hydrocarbons : see on plate 5 the chromatograms of the saturated and aromatic fractions of the raw sample, of the "mud" and of the handpicked and washed coal (2445 m sample).

The indigenous hydrocarbons show the already mentionned immaturity of the series and their humic origin : distribution of hydrocarbons, large predominance of Pristane over Phytane.

2.4.3 - *Genetic potential*

The genetic potential of the rocks is estimated by Rock-Eval pyrolyses. The results are given in table 1. The related hydrogen indices (HI) and oxygen indices (OI) of the kerogens are plotted in a diagram in plate 3.

The quantity of hydrocarbons produced by pyrolysis (S2 in table 1) are high in the Coal Unit only (Hettangian-Rhaetian) : up to 30 mg/g of rock. The Coal Unit facies is rather gas-prone.

The hydrogen indices are low and taking into account the low degree of maturation show the poor petroligen quality of the organic matter in the whole studied serie.

As in the 65-07/12-1 well the relatively low oxygen indices of the coal samples have to be noticed (OI < 30 mg CO_2/g of TOC).

The Triassic interval, poor in organic matter, has no potential.

3 - *CONCLUSION*

The organic matter is immature in the Jurassic-Rhaetian interval.

Only the Coal Unit with hydrogenated humic facies and a probable gas potential has some source-rock properties.

ABBREVIATIONS AND UNITS USED IN THE TABLES

S	SWC	Sidewall Core Sample
	C	Cutting sample
	K	Core sample

TOC — Total Organic Carbon (% weight of rock)

S_1 — Amount of H.C. liberated at low temperatures, it corresponds to the amount of free HC in the rock samples (mgHC/g of rock)

S_2 — Amount of HC generated anew by pyrolysis at elevated temperatures it corresponds to the potential of the rock to produce additional HC from kerogen (mgHC/g of rock)

S_3 — Amount of CO_2 of organic origin (mgCO_2/g of rock)

PI — Production Index x 100 = $\left[S1/(S1 + S2)\right] \times 100$

HI — Hydrogen Index : amount of the generated reported to amount of organic carbon (mgHC/g TOC)

OI — Oxygen Index : amount of CO_2 reported to amount of organic carbon (mg CO_2/g TOC)

Tmax — The temperature corresponding to the maximum of H.C. generation during pyrolysis (°C)

M.A. — Mud Additives

TABLE 1 - 65-07/12-2 (NORWAY)
ORGANIC CARBON AND PYROLYSIS

Age		N°	Depth (m)	S	TOC %	S1 ‰	S2 ‰	S3 ‰	PI %	HI ‰	OI ‰	Tmax °C
	CRETACEOUS	1	1845	SWC	1.03	0.40	1.0	0.63	29	95	60	394
		2	1867		0.69	0.06	0.66	0.08	8	95	45	409
NJ6	HEATHER	3	1880		0.77	0.45	0.91	0.33	33	120	55	392
		4	1897		4.41	1.17	3.39	2.0	26	75	45	405
NJ4a		5	1912		0.59	0.19	1.09	0.32	15	185	55	(465)
	LOWER-MID-JURASSIC SST	6	1952		0.26	1.75	0.83	0.10	68	320	40	
		7	1958		0.79	0.69	1.82	0.30	28	230	35	
		8	2010	C	0.53	0.21	0.70	0.53	23	130	100	417
		9	2050-2060		0.52	0.20	0.82	0.58	20	155	110	411
		10	2100		0.56	0.15	0.76	0.95	17	135	170	416
		11	2160		0.98	0.18	1.12	1.01	14	115	105	415
		12	2190-2200		1.80	0.69	1.91	2.35	27	105	130	427
	COAL UNIT	13	2255		3.82	0.34	4.01	1.62	8	105	40	425
		14	2300		16.37	0.85	18.76	3.30	4	115	20	423
		15	2350		4.53	0.50	4.50	1.35	10	100	30	426
Het.		16	2395		16.78	1.70	29.05	3.38	6	175	20	423
Rhae.		17	2445		13.75	1.05	17.15	3.34	6	(125	25	424)
		18	2505		7.22	0.62	9.32	1.98	6	130	25	424
		19	2544-2547		6.57	0.87	7.56	3.84	10	115	60	429
		20	2598		5.94	0.60	7.86	2.78	7	130	45	427
	GREY BEDS	21	2615	SWC	1.39	0.33	3.66	1.43	8	265	100	
		22	2646	C	6.19	0.61	11.96	1.63	5	195	25	423
		23	2655.5	SWC	0.37							
		24	2713.5		0.29							

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TABLE 1 - 65-07/12-2 (NORWAY)
ORGANIC CARBON AND PYROLYSIS
(suite)

Age	N°	Depth (m)	S	TOC %	S1 °/oo	S2 °/oo	S3 °/oo	PI %	HI °/oo	OI °/oo	Tmax °C
Rhaetian TRIASSIC RED BEDS	25	2804	SWC	0.11							
	26	2913.5		0.16							
	27	3109		0.23	0.36	0.43	0.43	43	215	375	
	28	3219		0.15							
	29	3291-3309		0.63	0.21	0.74	0.79	22	115	125	430
	30	3353		0.32	0.24	0.64	1.16	27	200	360	
	31	3431-3439		0.22	0.14	0.53	1.08	21	240	490	
TRIASSIC	32	4098	C	1.94	0.33	1.18	4.54	22	60	235	424
	33	4149		5.09	0.41	3.15	7.81	12	60	155	426
	34	4197		4.94	0.42	3.50	8.71	11	70	175	428
	35	4245		3.63	2.82	6.01	5.58	32	165	155	441
	36	4278	SWC	1.99	0.35	2.87	0.70	11	145	35	440*
	37	4323-30		0.27	0.10	0.30	0.99	25	110	365	461
	38	4442		0.15							
	39	4526		0.37	0.14	1.05	0.74	12			469
TRIASSIC	40	4920		0.12							
	41	4936		0.18							
	42	4966		0.20	0.04	0.20	1.11	15	115	555	
	43	4982.6	K2	0.04							
	44	4994	SWC	0.23	0.24	0.24	1.23	50	115	535	
	45	MA (Ligcon ?) at 4599		31.8	8.40	54.08	40.96	13	170	130	422

* - *Pollution : see plate 5 bis*

TABLE 2 A AND 2 B - 65-07/12-2

BITUMEN CHARACTERISATION

A

	Depth	COMPOSITION OF EXTRACTS: EOM ppm	EOM / TOC	SAT.	ARO.	RES + ASP	S/A
Up. J.	1897	3460	0,08	31,9	21,5	46,6	1,48
Coal Unit	2300	3670	0,02	16,8	29,1	54,0	0,58
	2445*	7890	0,02	4,7	23	72,3	0,20
	2544/47	3095	0,05	53,8	26,9	19,3	2,0
Grey Beds	2646	2115	0,03	32,9	25,7	41,4	1,28
Triassic	4245*	840	0,03	28,2	13,0	58,8	2,17

* - *Handpicked and washed with teepol and n-hexane*

B

	Depth (m)	C5-C15 (TV): X1	X2	Y1	Z1	Σ TV	Alk % TV	C15+: Alk ppm	Pr/nC17	Ph/nC18	Pr/Ph	A/B
Up. J.	1897	-	-	-	-	-	< 1 %	-	-	-	0,73	
Coal Unit	2300									Gas - Oil		
	2445			Gas - Oil				50	2,55	0,50	3,04	5,10
	2544/47									Gas - Oil		
Grey Beds	2646			Gas - Oil						Gas - Oil		
Triassic	4245			Gas - Oil				65	0,28	0,19	1,30	1,44