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CONTINENTAL SHELF INSTITUTE

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REPORT TITLE/ TITTEL

Source rock analysis of well 34/2-2, part II

CLIENT/ OPPDRAGSGIVER

Amoco Norway

RESPONSIBLE SCIENTIST/ PROSJEKTANSVARLIG

Hauk Solli

AUTHORS/ FORFATTERE

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SUMMARY/ SAMMENDRAG

The sequence 3220-3400 m was analysed and found to have a similar rating as zone G in report 0-326/1/81.

KEY WORDS/ STIKKORD: Source Rock; Jurassic/Cret

EXPERIMENTAL

As described in report O-326/1/81.

RESULTS AND DISCUSSION

Light Hydrocarbons

Eight canned samples from 3220-3400 m were analysed for light hydrocarbons. Some irregularities were found in the various results. This is believed to be due mainly to the composition of the sample, e.g. contents of cement etc. rather than a change due to variation in the organic material. The analysed sequence is a natural extension of zone G in report O-326/1/81, with a good abundance of C_1-C_4 hydrocarbons and a fair abundance of the C_5+ hydrocarbons.

Total Organic Carbon

The claystone cuttings in the different samples were analysed for organic carbon and mainly found to have a fair abundance of organic carbon and show a slight increase with increasing depth. Two samples, 3300 and 3335 m show a rich abundance of organic carbon. This is in samples which contain some coal, and this has probably affected the results, especially for the sample from 3300 m. The coal could occur either as small coal particles and stringers in the cuttings, or the coal particles may be stuck to the claystone cuttings and thereby giving false organic carbon values.

Light Hydrocarbons by Hydrogen Stripping

Four samples were analysed by this method. All measured parameters are found to have a maximum at 3300 m. This could be due to the coal found in the sample from this level of the well. The methyl substituted alkanes show a large variation in concentration with increasing depth especially for the two last samples. It is difficult to interpret these results since the deeper part of the well is not analysed at this laboratory i.e. if this spread is significant for the deeper part of the well therefore represents a distinct change of hydrocarbon type. Apart from these results, the rest of the analyses are in good agreement with the results from zone G, report O-326/1/81.

Extraction and Chromatographic Separation

Two samples, 3235 m and 3290-3400 m were extracted and both found to have a good abundance of extractable hydrocarbons. The extractability is slightly reduced, especially for the sample from 3335 m when the results are normalized to organic carbon. The gas chromatograms of the saturated hydrocarbons of the two samples differ slightly. Both the samples have smooth, unimodal front-biased distributions with almost equal amounts of pristane and phytane. The sample from 3335 m shows a distinct peak between nC_{19} and nC_{20} which is not found in the sample from 3390-3400 m or higher up in the well. This sample also has a high CPI value, and nC_{27} and nC_{29} alkanes are particularly abundant. This, together with the large abundance of steranes and triterpanes indicate an input from a moderate mature terrestrial source. The steranes/triterpanes are also abundant in the sample from 3390-3400 m, while the nC_{27} and nC_{29} alkanes are less abundant.

Aromatic Hydrocarbons

The gas chromatograms of the aromatic fractions of the two analysed samples vary only slightly from each other, but they are significantly different from the analysed samples higher up in the well. These two samples have aromatic hydrocarbon distributions which are characteristic of well mature sequences and crude oils.

Examination in Reflected Light

Three samples from this section of the well were analysed in reflected light. Each sample is described below, and other information from these analyses is also given.

Sample, K7862, 3260 m: Shale and Carbonate, R_o=0.34(2) and R_o=0.80(2)

The sample has a low to moderate organic content with small particles of inertinite and reworked material. No definite vitrinite. A couple of

doubtful, lowest reflectance particles were measured. UV light shows a yellow to orange fluorescence from spores and a low exinite content.

Sample, K7865, 3335 m: Shale, R_o=0.41(4)

The sample has a low organic content with small corroded particles of inertinite and reworked material. No good vitrinite was recorded. The four lowest reflectance particles were measured, and could probably be true. Occasional bitumen wisps were recorded. UV light shows a yellow/orange and light orange fluorescence from spores and a low exinite content.

Sample, K7867, 3400 m: Shale, R_o=0.40(4)

The sample has a low organic content with small particles of reworked material and inertinite. Lowest reflectance particles were measured, and are probably true. Occasional bitumen wisps were recorded. UV light shows a yellow/orange and light orange fluorescence from spores and a low exinite content.

Examination in Transmitted Light

Visual Kerogen Analysis

Three samples, picked lithologies from ditch cuttings were analysed from the deepest part of the well; 3260 m, 3335 m and 3400 m.

They were all composed of a dominant amorphous element. The terrestrial element is mostly of woody nature. The observed pollen of various origin support a colour index of 2 or 2/2+. The fossils seen indicate that the two lower samples are geologically slightly older than the one above.

K7862, 3260 m: Judged by the presence of Early Cretaceous cysts we assume that most of the amorphous material dominating this sample is also derived from material of this age.

Colour index: 2 (very rare pollen).

K7865, 3335 m and K7867, 3400 m: Jurassic/Cretaceous cysts are present in both samples. Pollen are fairly abundant together with some spores.

Colour index: 2 or 2/2+.

Rock-Eval Pyrolysis

Eight samples were pyrolysed on a Rock-Eval instrument and all found to have a low hydrogen index and high oxygen index typical for kerogen type III. The T_{max} temperatures varies from 424-442^{o}C indicating the samples to be immature to moderate mature.

CONCLUSION

The analysed sequence is a clear continuation of zone G, report O-326/1/81 and is given the same rating, i.e. a fair potential as a source rock for gas. A slightly higher potential around 3300 m due to the coal at this level.

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TABLE I a.

CONCENTRATION (ul Gas / kg Rock) OF C1 - C7 HYDROCARBONS IN HEADSPACE.

IKU No.	DEPTH (m)	C1	C2	C3	iC4	nC4	C5+	SUM C1-C4	SUM C2-C4	WET-NESS (%)	iC4 / nC4
K7860	3220						26			98.69	
K7861	3240	1075	181	244	126	94	190	1720	645	37.50	1.34
K7862	3260	5595	2068	2984	1624	1344	2670	13615	8020	58.91	1.21
K7863	3280	3438	1196	1381	667	469	663	7151	3713	51.93	1.42
K7864	3300	3920	612	955	426	291	398	6205	2285	36.82	1.47
K7865	3335	2854	444	671	295	179	249	4443	1589	35.76	1.64
K7866	3360	2560	877	958	372	254	370	5021	2462	49.02	1.46
K7867	3400	6661	1024	858	194	124	116	8861	2200	24.83	1.56

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TABLE I b.

CONCENTRATION (ul Gas / kg Rock) OF C1 - C7 HYDROCARBONS IN CUTTINGS.

IKU No.	DEPTH (m)	C1	C2	C3	iC4	nC4	C5+	SUM C1-C4	SUM C2-C4	WET-NESS (%)	iC4 / nC4
K7860	3220	385	18	38	21	47	591	509	124	24.35	.44
K7861	3240	753	126	399	2			1279	526	41.13	
K7862	3260	122	18	69	35	82	495	326	204	62.60	.43
K7863	3280	120	71	384	144	334	961	1054	934	88.64	.43
K7864	3300	452	296	911	405	706	1793	2770	2317	83.67	.57
K7865	3335	32	6	30	10	23	150	101	69	68.50	.44
K7866	3360	445	781	1836	435	810	1764	4308	3862	89.66	.54
K7867	3400	556	252	934	463	917	5498	3122	2566	82.20	.51

IKU

TABLE I c.

CONCENTRATION (ul Gas / kg Rock) OF C1 - C7 HYDROCARBONS (Ia + Ib).

IKU No.	DEPTH (m)	C1	C2	C3	iC4	nC4	C5+	SUM C1-C4	SUM C2-C4	WET-NESS (%)	iC4 / nC4
K7860	3220	385	18	38	21	47	617	510	124	24.38	.44
K7861	3240	1828	307	643	128	94	190	3000	1171	39.05	1.36
K7862	3260	5717	2086	3053	1659	1426	3166	13940	8224	58.99	1.16
K7863	3280	3557	1268	1766	811	803	1624	8205	4647	56.64	1.01
K7864	3300	4373	908	1866	831	997	2190	8975	4602	51.28	.83
K7865	3335	2886	450	701	305	202	400	4544	1658	36.49	1.51
K7866	3360	3005	1659	2794	807	1065	2134	9329	6324	67.79	.76
K7867	3400	7217	1276	1793	657	1041	5614	11984	4767	39.78	.63

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LITHOLOGY AND TOTAL ORGANIC CARBON MEASUREMENTS

TABLE NO.: II
WELL NO.: 3412-2

Sample	Depth	TOC	Lithology
K-7860	3220	0.61	65% Cement 35% Claystone, grey, some greenish, some calcareous Sm.am. Limestone, grey, dark grey, brownish
K-7865	3335	2.53	100% Claystone, grey, subfissile
K-7866	3360	1.00	100% Claystone, as above
K-7861	3240	0.69	87% Claystone, grey, subfissile 8% Cement 5% Limestone/Siderite, grey to grey brown
K-7862	3260	0.72	87% Claystone, as above 8% Siderite, brownish 5% Cement
K-7863	3280	0.83	75% Claystone, grey 15% Siderite 10% Cement and Gypsum
K-7867	3400	1.05	87% Claystone, grey, light greygreen 8% Claystone, redbrown 5% Siderite/Limestone, grey, yellowish, brown
K-7864	3300	5.37	95% Claystone, grey, some light 5% Additives (Coal) Sm.am. Siderite

12/U/3/mk

IKU No.	Depth	nC_2	nC_3	MC_3	nC_4	MC_4	nC_5	Cy C_5 + 2.3 DMC_4 + 2 MC_5	$3MC_5$	nC_6	$MCyC_5$	CyC_6 + $MCyC_6$	$3MC_6$	2.2.4TMC_5	nC_7	Benzene	$MCyC_6$ + $ECyC_6$	nC_8	Toluene
K-7861	3240	17.0	73.3	61.1	174.9	63.6	166.6	50.6	39.2	100.4	89.6	95.2	85.4	14.9	74.3	33.6	164.3	64.4	118.1
K-7864	3300	75.9	367.5	263.0	605.8	145.5	310.2	79.2	60.1	133.9	69.7	161.2	138.3	28.7	114.9	101.5	319.8	149.8	203.2
K-7866	3360	64.5	291.8	201.9	470.1	104.3	192.8	45.3	33.9	93.6	38.6	99.6	71.3	12.7	40.6	75.2	184.7	41.6	111.6
K-7867	3400	269.7	590.2	360.3	618.4	105.7	172.7	32.8	22.7	61.9	67.3	74.1	45.0	8.2	34.7	100.1	129.5	37.7	101.7

Table III

GASOLINE RANGE HYDROCARBONS (HYDROGEN STRIPPING) $\frac{\text{ppb W/W}}{\text{100 ml } H_2}$

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T A B L E : IV

WEIGHT OF EOM AND CHROMATOGRAPHIC FRACTIONS

IKU-No	DEPTH (m)	Rock Extr. (g)	EOM (mg)	Sat. (mg)	Aro. (mg)	HC (mg)	Non HC (mg)	TOC (%)
K-7865	3335	51.7	37.2	14.6	8.5	23.1	14.1	2.5
K-7867	3400	51.7	34.8	18.5	6.5	25.0	9.8	1.1

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T A B L E : V

CONCENTRATION OF EOM AND CHROMATOGRAPHIC FRACTIONS

(Weight ppm of rock)

IKU-No	DEPTH (m)	EOM	Sat.	Aro.	HC	Non HC
K-7865	3335	720	282	164	447	273
K-7867	3400	673	358	126	484	190

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TABLE: VI

CONCENTRATION OF EOM AND CHROMATOGRAPHIC FRACTIONS

(mg/g TOC)

IKU-No	DEPTH (m)	EOM	Sat.	Aro.	HC	Non HC
K-7865	3335	28.8	11.3	6.6	17.9	10.9
K-7867	3400	61.2	32.5	11.4	44.0	17.2

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T A B L E : VII

COMPOSITION IN % OF THE MATERIAL EXTRACTED FROM THE ROCK

IKU-No	DEPTH (m)	Sat / EOM	Aro / EOM	HC / EOM	Sat / Aro	Non HC / EOM	HC / Non HC
K-7865	3335	39.2	22.8	62.1	171.8	37.9	163.8
K-7867	3400	53.2	18.7	71.8	284.6	28.2	255.1

TABLE VIII

TABULATION OF DATAS FROM THE GASCHROMATOGRAMS

IKU No.	DEPTH (m)	PRISTANE / n-C17	PRISTANE / PHYTANE	CPI
K7865	3335	.5	1.0	1.3
K7867	3400	.6	1.1	1.0

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VITRINITE REFLECTANCE MEASUREMENTS

TABLE NO.: IX

WELL NO.: 34/2-2

Sample	Depth	Vitrinite reflectance	Fluorescence in UV light	Exinite content
K-7862	3260	0,34(2), 0,80(2)	yellow-orange	Low
K-7865	3335	0,41(4)	yellow-orange	Low
K-7867	3400	0,40(4)	yellow-orange	Low

12/U/1/mk

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VISUAL KEROGEN ANALYSIS

TABLE NO.: X

WELL NO.: 34/2-2

Sample	Depth	Composition of residue	Particle size	Preservation-palynomorphs	Thermal maturation index	Remarks
K-7862	3260	Am, Cy/He, C, W	F - M	fair to good	2	Early Cretaceous cysts embedded in amorphous aggregates. Pyrite framboides. Rare pollen
K-7865	3335	Am, Cy/He, W, C, P	F - M	good to poor	2 2/2+	Jurassic/Cretaceous cysts. Pyrite. Aggregates are rare.
K-7867	3400	Am, Cy/He, W, P, S	F - M	good to poor	2 2/2+	As above

ABBREVATIONS

Am	amorphous	Cy	cysts, algae	W	woody material	F	fine
He	herbaceous	P	pollen grains	C	coal	M	medium
Cut	cuticles	S	spores	RI	reworked	L	large

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TABLE XI

ROCK EVAL PYROLYSES

IKU No.	DEPTH (m)	S1	S2	S3	TOC (%)	HYDR. INDEX	OXYGEN INDEX	OIL OF GAS CONTENT S1+S2	PROD. INDEX S1/(S1+S2)	TEMP. max (C)
K7860	3220	.16	.16	.75	.61	26	123	.32	.50	424
K7861	3240	.19	.16	.68	.69	23	99	.35	.54	430
K7862	3260	.19	.22	.57	.72	31	79	.41	.46	436
K7863	3280	.23	.32	.62	.83	39	75	.55	.42	440
K7864	3300	.65	5.26	4.79	5.37	98	89	5.91	.11	434
K7865	3334	.31	1.89	2.63	2.53	75	104	2.20	.14	436
K7866	3360	.18	.53	1.31	1.00	53	131	.71	.25	442
K7867	3406	.19	.60	.73	1.05	57	70	.79	.24	436

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$C_1 - C_7$ HYDROCARBONS
Presentation of Analytical Data

Well no: 34/2 – 2
Company: Amoco
Fig. 1

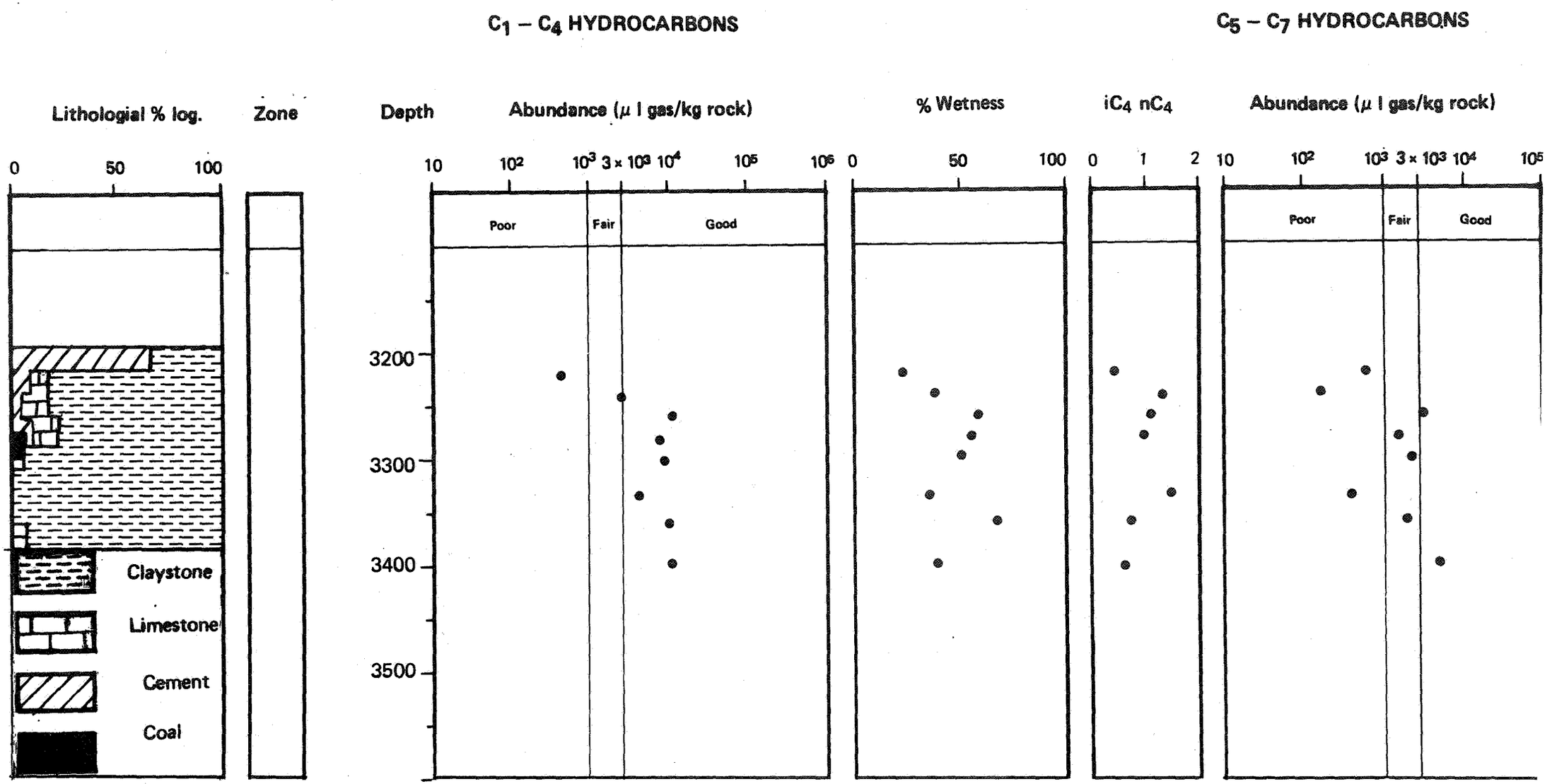


Fig. 2

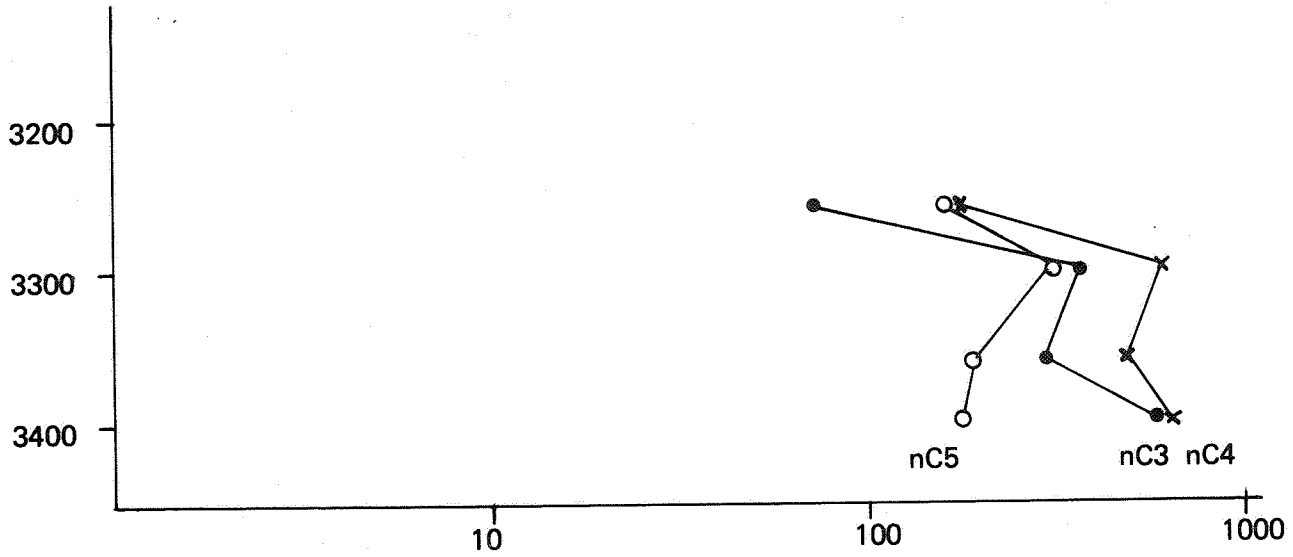


Fig. 3

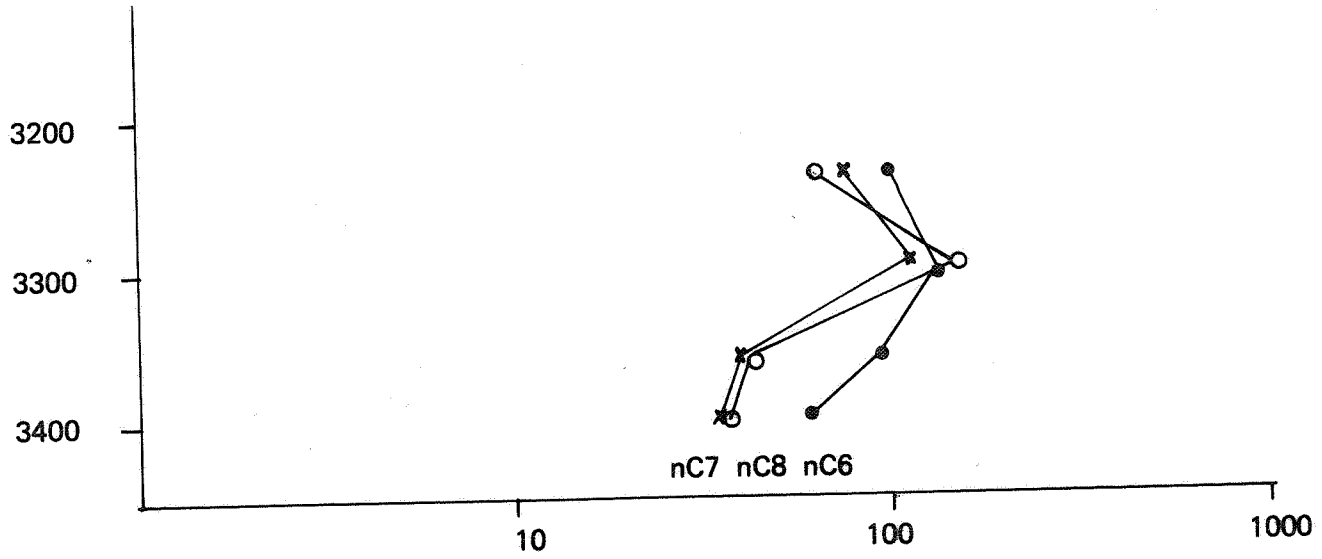


Fig. 4

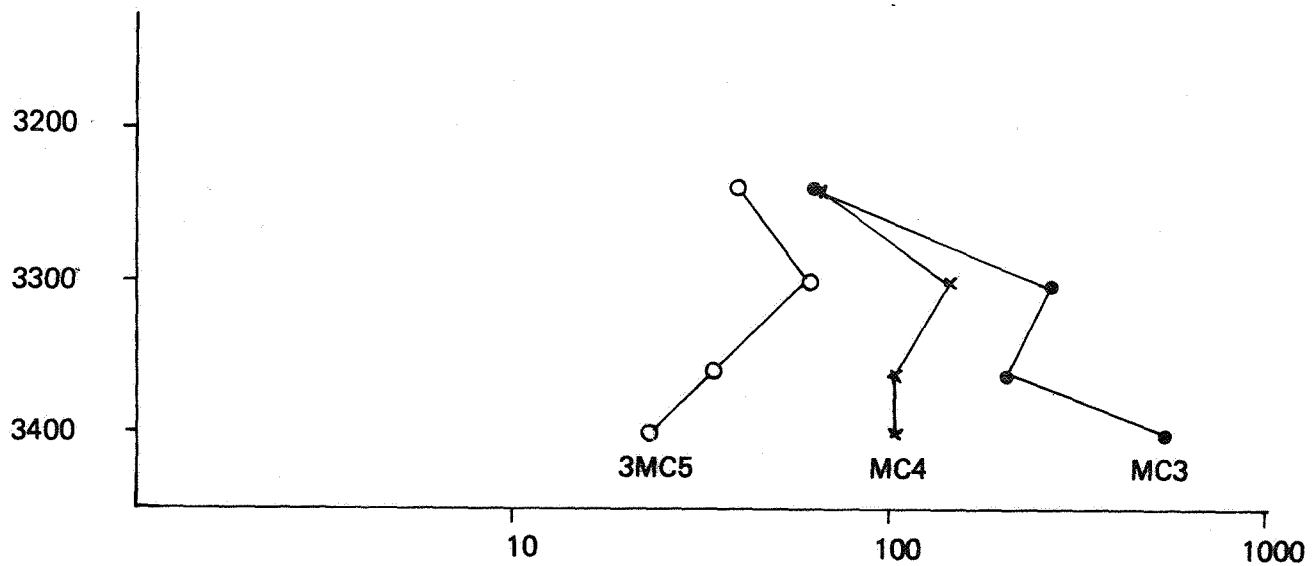
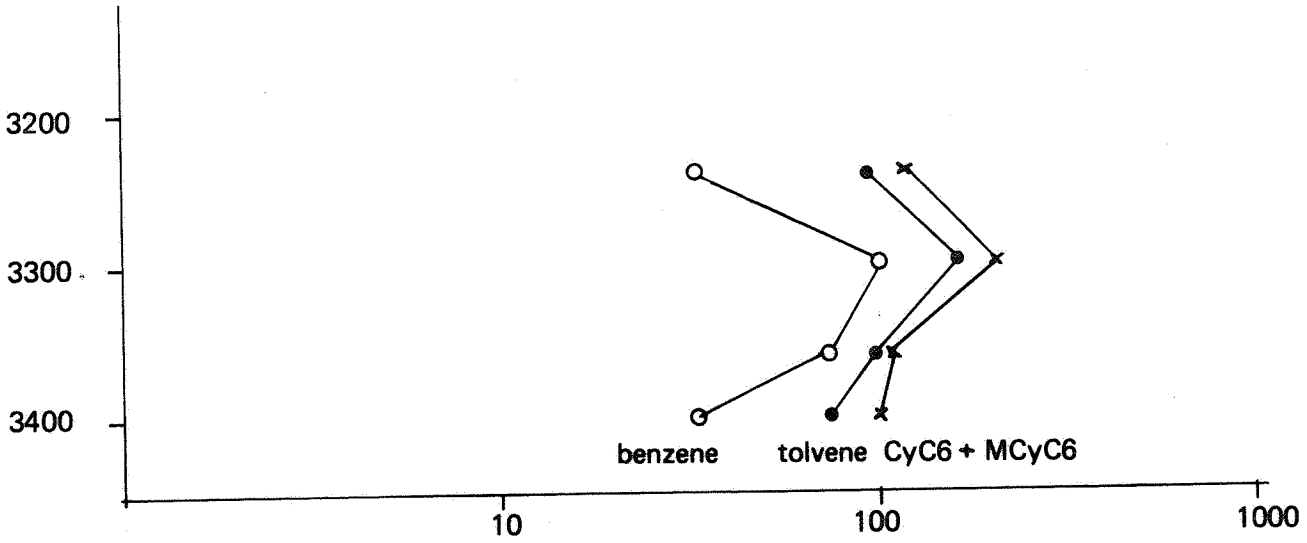


Fig. 5



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TOTAL ORGANIC CARBON (TOC)

Presentation of Analytical Data

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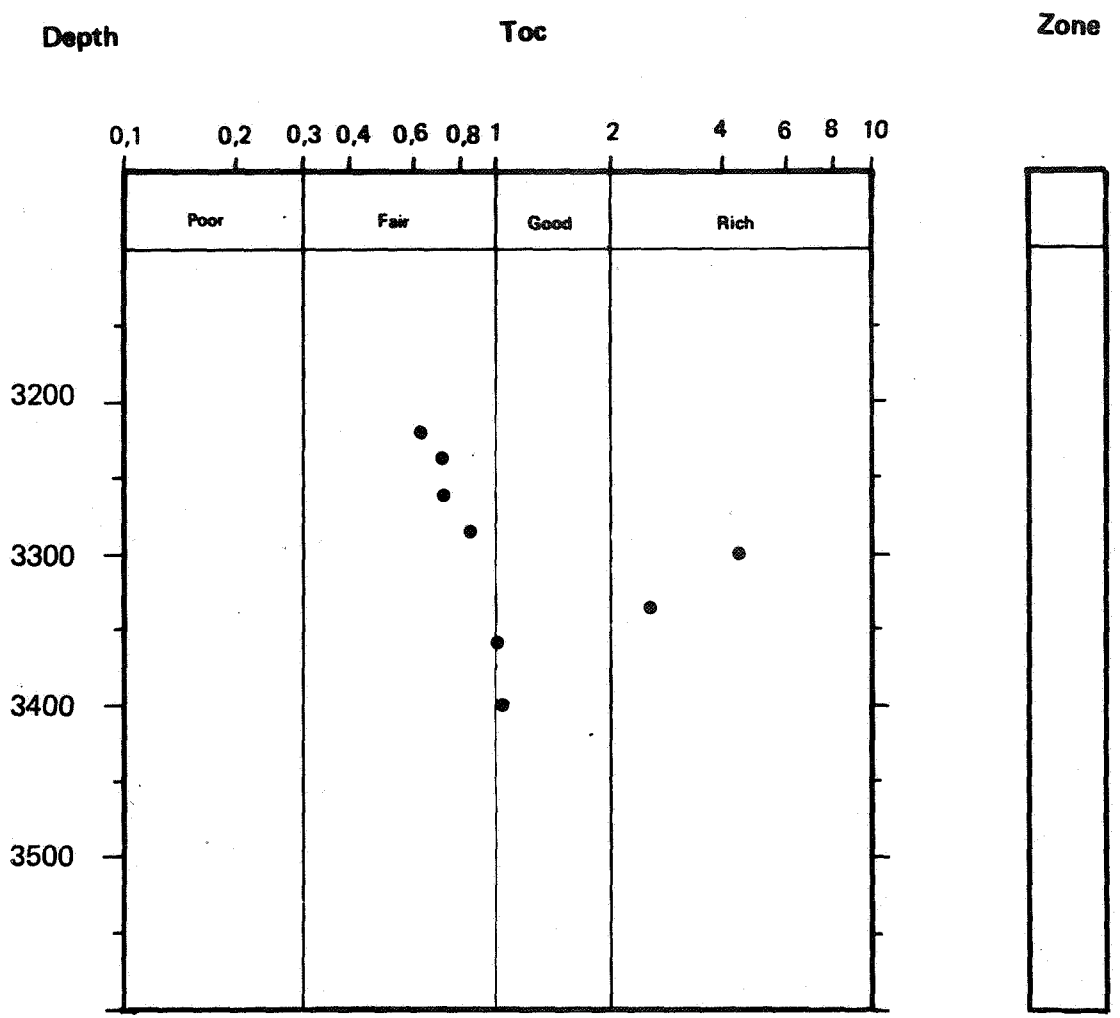
Company: Amoco
Fig. 6



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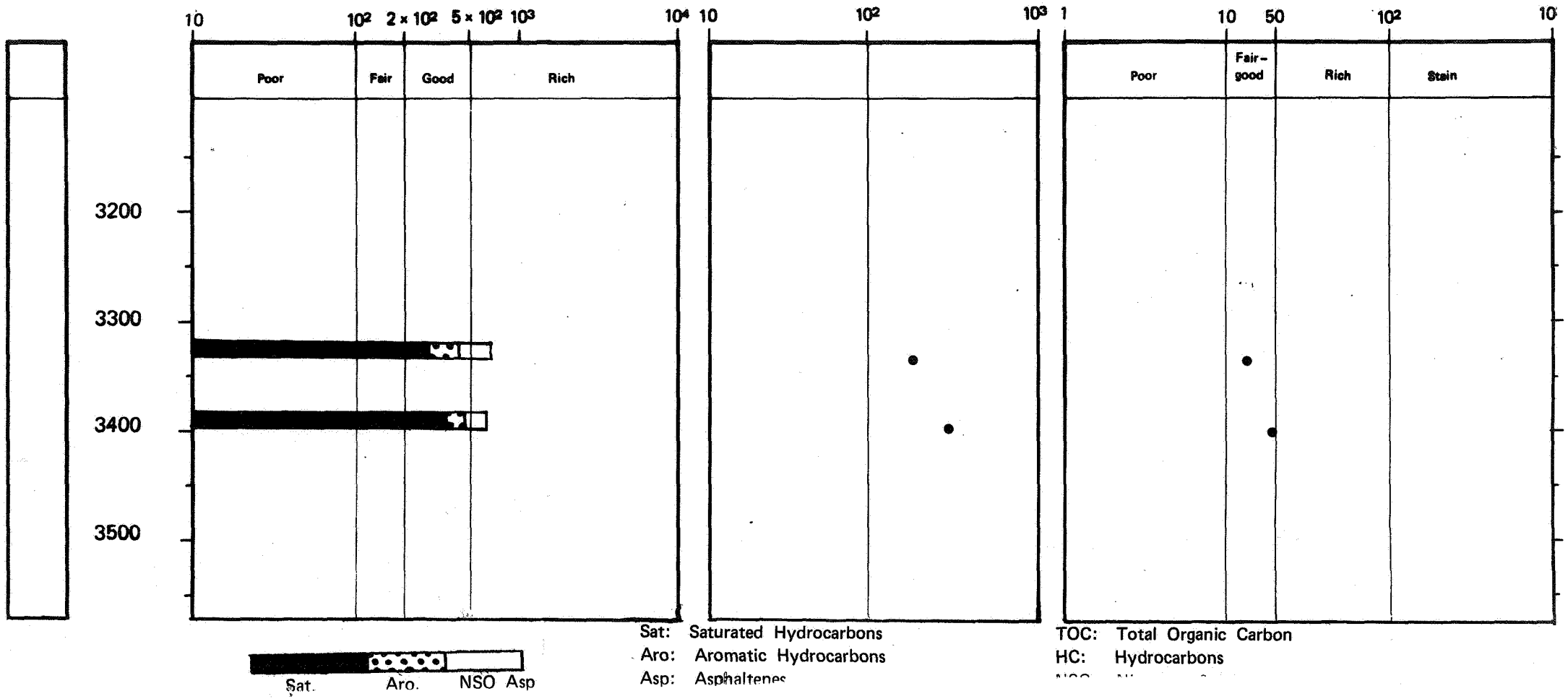
$C_{15}{}^{+}$HYDROCARBONS

Presentation of Analytical Data

Well no: 34/2 – 2
Company: Amoco
Fig. 7



Sat: Saturated Hydrocarbons
Aro: Aromatic Hydrocarbons
Asp: Asphaltenes

TOC: Total Organic Carbon
HC: Hydrocarbons

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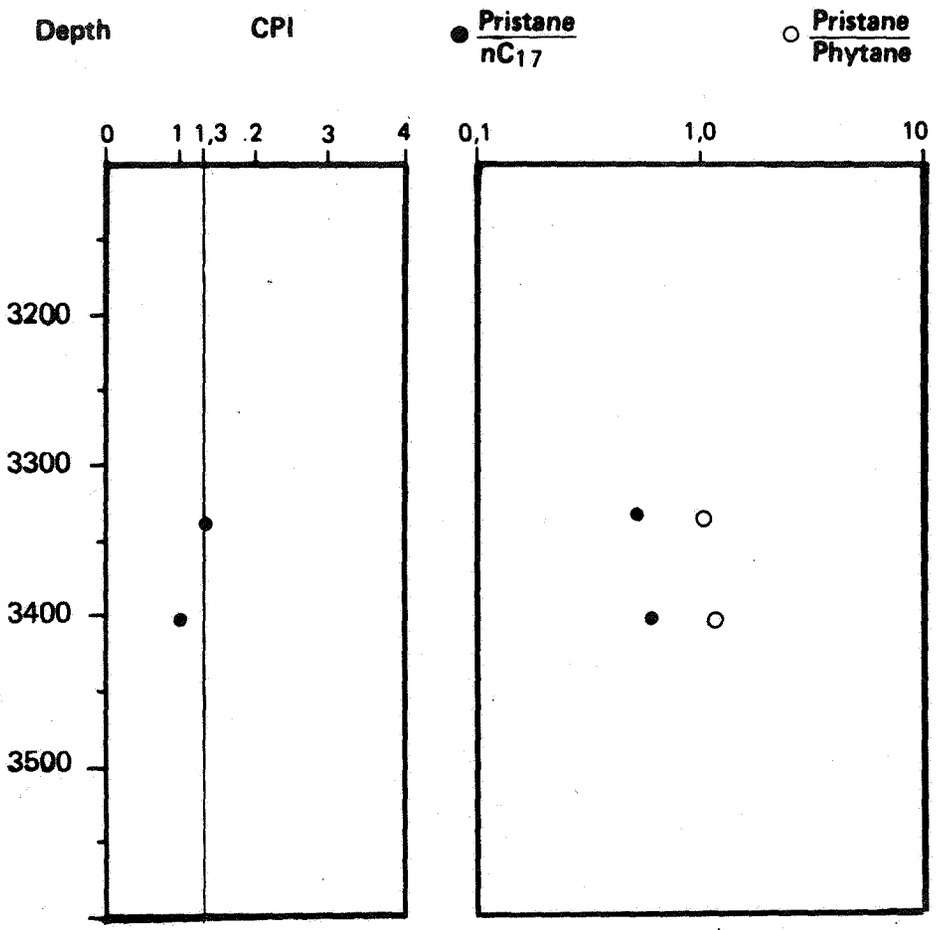
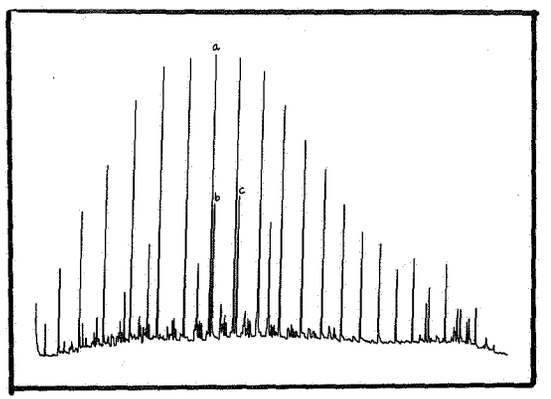
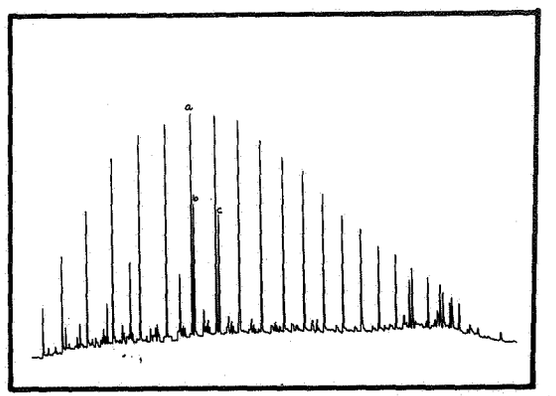
C_{15}^{+} SATURATED HYDROCARBONS
Presentation of Analytical Data

Well no: 34/2–2
Company: Amoco
Fig. 8





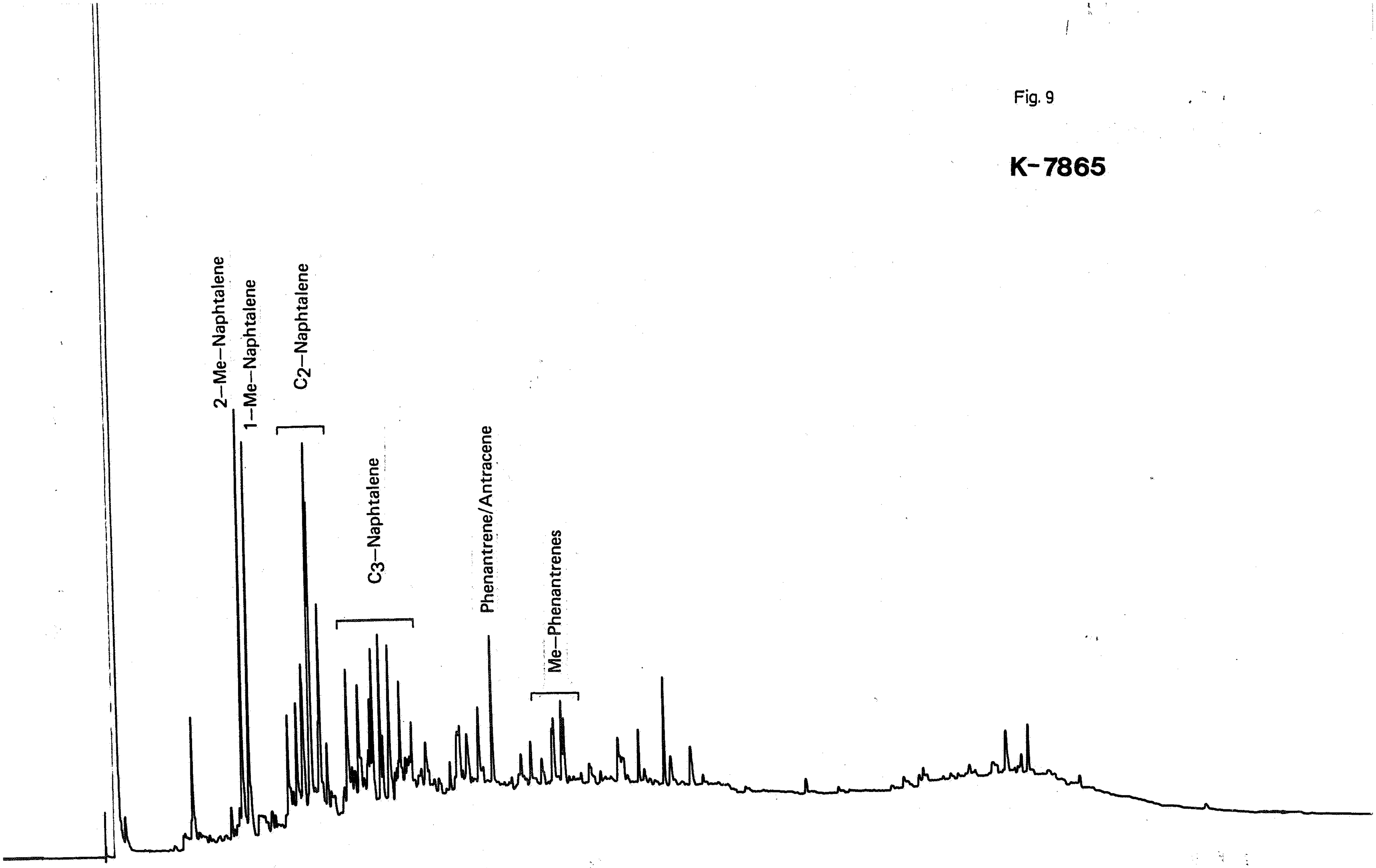
3335m



3390 -3400m

Fig. 9

K-7865



2-Me-Naphtalene
1-Me-Naphtalene
C2-Naphtalene
C3-Naphtalene
Phenantrene/Antracene
Me-Phenantrenes

Fig. 10

K-7867

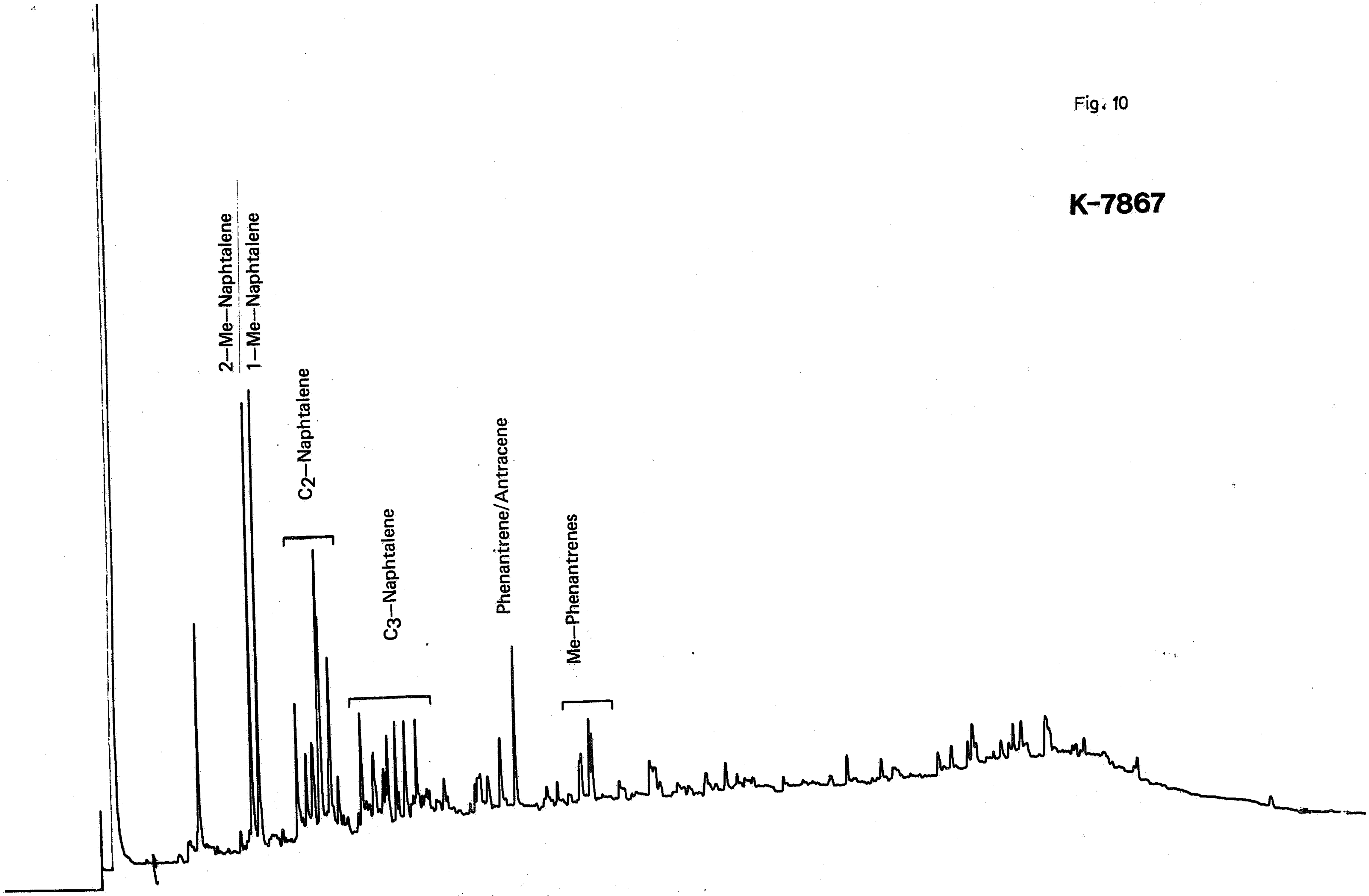
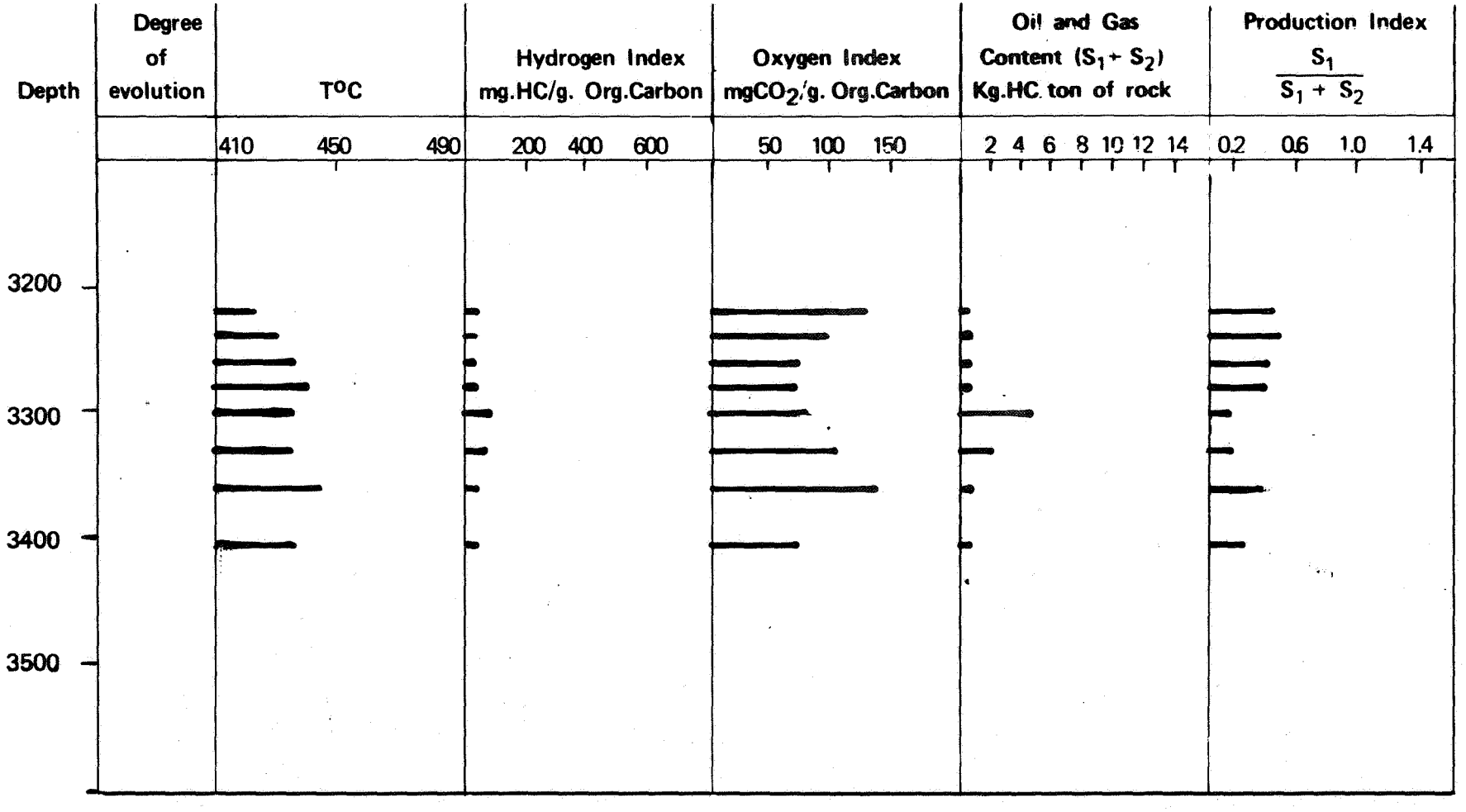

2–Me–Naphtalene
1–Me–Naphtalene
C_2–Naphtalene
C_3–Naphtalene
Phenantrene/Antracene
Me–Phenantrenes

Fig. 11

ROCK-EVAL PYROLYSIS



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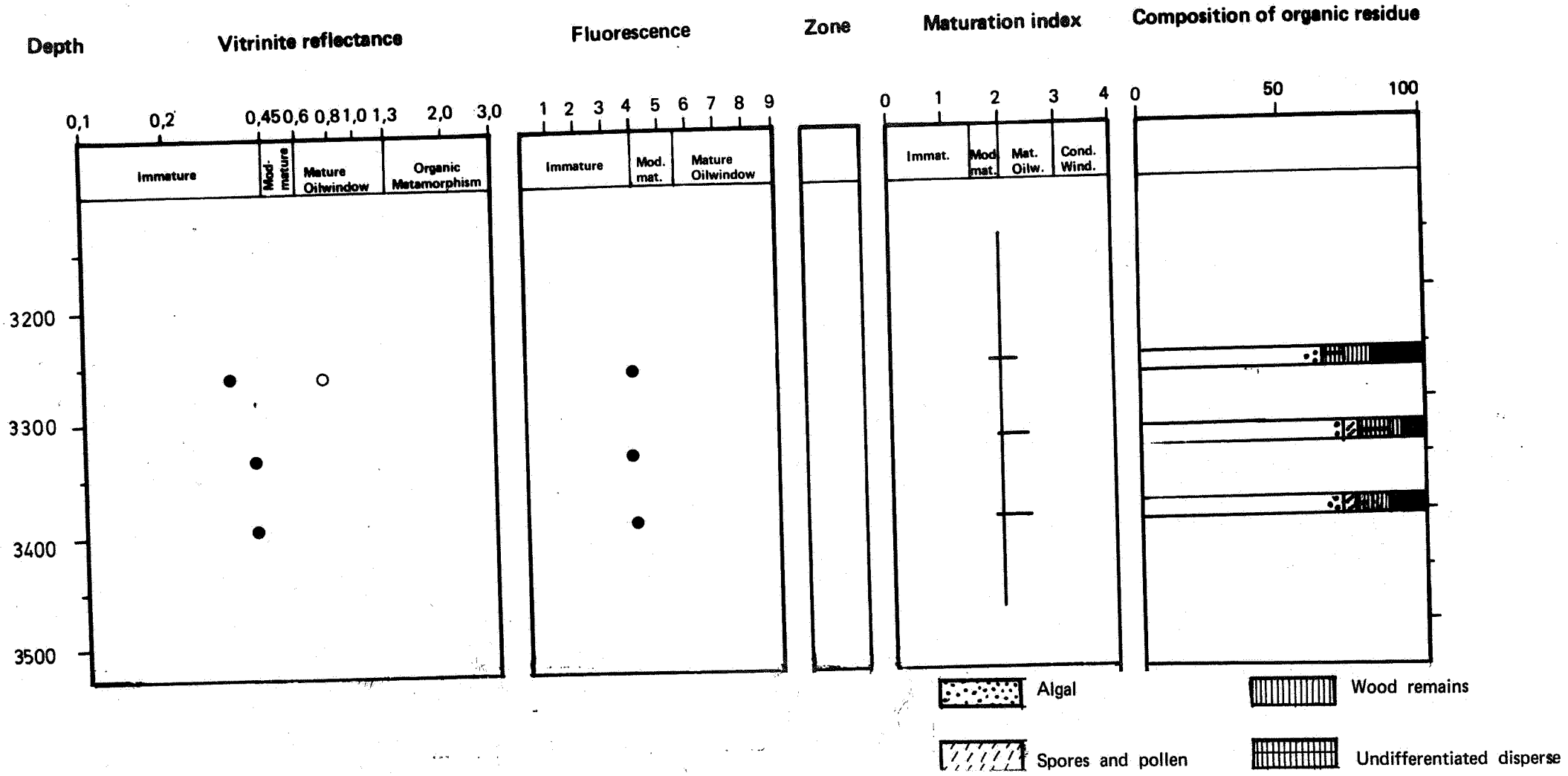
MATURATION

Well no: 34/2 – 2
Company: Amoco
Fig. 12

VISUAL KEROGEN

COLORATION AND COMPOSITION OF ORGANIC RESIDUE



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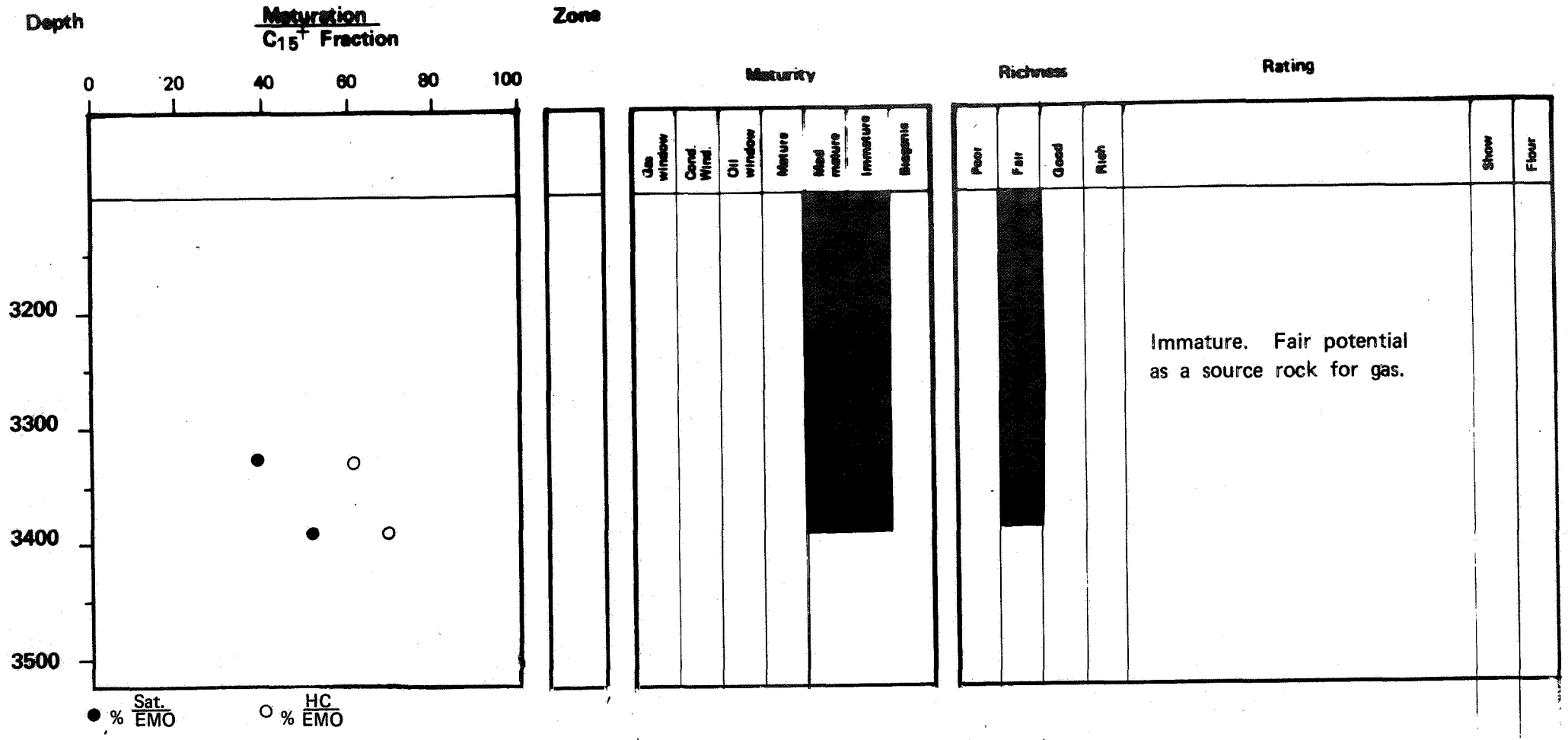
INTERPRETATION DIAGRAM

Well no: 34/2 – 2
Company: Amoco
Fig. 13

SUMMARY OF SOURCE POTENTIAL



Sat: Saturated Hydrocarbons
HC: Hydrocarbons
EMO: Exstactable Organic Matter