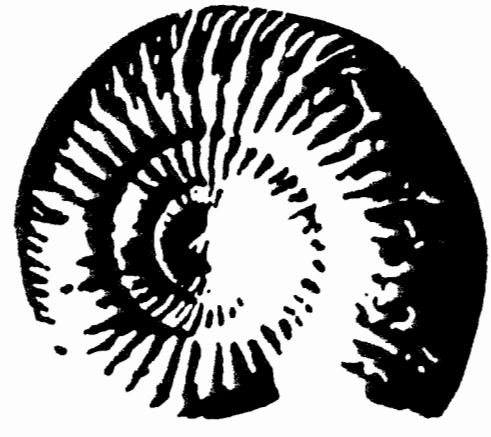
Source Rock Analysis of well 34/10-8

CLIENT

Statoil

CLIENT's REF.:	REPORT NO.:
Bjørn Rasmussen	0-291/1/80

IKU



INSTITUTT FOR
KONTINENTALSOKKELUNDERSØKELSER

Continental Shelf Institute

Håkon Magnussons gt. 1B
Postboks 1883
7001 Trondheim
Telefon (075) 15660
Telex. 55548
Telegram "NORSHELF"

IKU

Confidential

INSTITUTT FOR KONTINENTALSOKKELUNDERSØKELSER

CONTINENTAL SHELF INSTITUTE

REPORT TITLE

Source Rock Analysis of well 34/10-8

CLIENT

Statoil

CLIENT's REF.:	REPORT NO.:
Bjørn Rasmussen	0-291/1/80

AUTHOR (S):

M. Bjorøy, T.M. Rønningsland,
J.O. Vigran, Leif Husvik

DATE:	PROJECT NO.:
1.9.1980	0-291
NO. OF PAGES	NO. OF ENCLOSURE

DEPARTMENT:	RESPONSIBLE SCIENTIST:
Organic Geochemistry	Malvin Bjorøy

SUMMARY:

See enclosure

KEY WORDS

SUMMARY:

Based on the various analyses the following zonation is given:

The whole analysed sequence is immature.

Zone A and B, 1695 - 1823 m:
Limestone, fair potential as a source rock for gas (oil).

Zone C, 1823 - 1976 m:
Cored interval.

Zone D, 1976 - 2070 m:
Sandstone. No indications of migrated hydrocarbons.

Zone E, 2070 - 2136 m:
Limestone, fair potential as a source rock for gas.

Zone F, 2130 - 2216 m:
Sandstone mainly. Claystone and limestone at 2200 - 2216 has a good potential as a source rock for gas (oil).

EXPERIMENTAL AND DESCRIPTION OF INTERPRETATION LEVELS

Headspace gas analyses.

One ml. of the headspace gas from each of the cans was analysed gas chromatographically for light hydrocarbons. The results are shown in Table Ia. The canned samples were washed with temperated water on 4, 2, 1 and 0.125 mm sieves to remove drilling mud and thereafter dried at 35°C.

Total Organic Carbon (TOC).

Picked cuttings of the various lithologies in each sample were crushed in a centrifugal mill. Aliquotes of the samples were then weighted into Leco cruisibles and treated with hot 2N HCl to remove carbonate and washed twice with distilled water to remove traces of HCl. Thecrusibles were then placed in a vacuum oven at 50°C and evacuated to 20 mm Hg for 12 hrs. The samples were then analysed on a Leco E C 12 carbon determinator, to determine the total organic carbon (TOC).

Extractable Organic Matter (EOM)

From the TOC results samples were selected for extraction. Of the selected samples, approximately 100 gm of each was extracted in a flow through system (Radke et al., 1978 (Anal. chem. 49, 663-665)) for 10 min. using dichloromethane (DCM) as solvent. The DCM used as solvent was distilled in an all glass apparatus to remove contaminants.

Activated copper filings were used to remove any free sulphur from the samples.

After extraction, the solvent was removed on a Buchi Rotavapor and transferred to a 50 ml flask. The rest of the solvent was then removed and the amount of extractable organic matter (EOM) determined.

Chromatographic Separation.

The extractable organic matter (EOM) was separated into saturated fraction, aromatic fraction and non hydrocarbon fraction using a MPLC system with hexane as eluant (Radke et al., Anal. Chem, 1980). The various fractions were evaluated on a Buchi Rotavator and transferred to glas-vials and dried in a stream of nitrogen. The various results are given in Table III-VI.

Gas chromatographic analyses.

The saturated fraction was diluted with n-hexane and analysed on a HP 5730 A gaschromatograph, fitted with a 25 m OV101 glasscapillary column and an automatic injection system. Hydrogen (0.7 ml/min.) was used as carrier gas and the injection was performed in the splitt mode (1:20).

Vitrinite Reflectance.

Samples, taken at various intervals, were sent for vitrinite reflectance measurements at Geoconsultants, Newcastle-upon-Tyne. The samples were mounted in Bakelite resin blocks; care being taken during the setting of the plastic to avoid temperatures in excess of 100^{o}C. The samples where then ground, initially on a diamond lap followed by two grades of corundum paper. All grinding and subsequent polishing stages in the preparation were carried out using isopropyl alcohol as lubricant, since water leads to the swelling and disintegration of the clay fraction of the samples.

Polishing of the samples was performed on Selvyt cloths using three grades of alumina, 5/20, 3/50 and Gamma, followed by careful cleaning of the surface.

Reflectance determinations were carried out on a Leitz M.P.V. microphotometer under oil immersion, R.I. 1.516 at a wavelength of 546 nm. The field measured was varied to suit the size of the organic particle, but was usually of the order of 2 micron diameter.

The surface of the polished block was searched by the operator for suitable areas of vitrinitic material in the sediment. The reflectance of the organic particle was determined relative to optical glass standards of known reflectance. Where possible, a minimum of twenty individual particles of

vitrinite was measured, although in many cases this number could not be achieved.

The samples were also analysed in UV light, and the colour of the fluoressing material determined. Below, a scale comparing the vitrinite reflectance measurements and the fluorescence measurements are given.

VITRINITE REFLECTANCE R.AVER. 546nm 1·516		0·20		0·30	0·40	0·50	0·60	0·70	0·80	0·90	1·00	1·10
% CARBON CONTENT D.A.F.		57		62	70	73	76	79	80·5	82·5	84	85·5
LIPTINITE FLUOR. EXC. 400nm BAR. 530nm	nm	725	750	790	820	840		860	890	940		
	COLOUR	G	G/Y	Y	Y/O	L.O.	M.O.	D.O.	O/R		R	
	ZONE	1	2	3	4	5	6	7	8		9	

NOTE LIPTINITE NM = NUMERICAL MEASUREMENT OF OVERALL SPORE COLOUR AND NOT PEAK FLUORESCENCE WAVELENGTH

RELATIONSHIP BETWEEN LIPTINITE FLUORESCENCE COLOUR, VITRINITE REFLECTANCE AND CARBON CONTENT IS VARIABLE WITH DEPOSITIONAL ENVIRONMENT AND CATAGENIC HISTORY. THE ABOVE IS ONLY A GUIDE. LIPTINITE WILL OFTEN APPEAR TO PROGRESS TO DEEP ORANGE COLOUR AND THEN FADE RATHER THAN DEVELOP O/R AND RED SHADE. TERMINATION OF FLUORESCENCE IS ALSO VARIABLE.

Processing of Samples and Evaluation of Visual Kerogen

Crushed rock samples were treated with hydrochloric and hydrofluoric acids to remove the minerals. A series of microscopic slides contain strew mounts of the residue:

T-slide represents the total acid insoluble residue.
N-slide represents a screened residue (15 meshes).
O-slide contains palynodebris remaining after flotation ($ZnBr_2$) to remove disturbing heavy minerals.
X-slides contain oxidized residues, (oxidizing may be required due to sapropel which embeds palynomorphs, or to high coalification preventing the identification of the various groups).

T and/or O slides are necessary to evaluate kerogen composition/palynofacies which is closely related to sample lithology.

Screened or oxidized residues are normally required to consentrate the larger fragments, and to study palynomorphs (pollen, spores and dinoflagellates) and cuticles for paleodating and colour evaluation.

So far visual evaluations of kerogen have been undertaken from residues mounted in glycerine jelly, and studied by Leitz Dialux in normal light (halogene) using x10 and x63 objectives. By x63 magnification it is possible to distinguish single particles of diameters about 2 and, if wanted, to make a more refined classification of the screened residues (particles >15).

The colour evaluation is based on colour tones of spores and pollen (preferably) with support from other types of kerogen (woody material, cuticles and sapropel). These colours are dependant upon the maturity, but also are under influence of the paleo-environment (lithology of the rock, oxidation and decay processes). The colours and the estimated colour index of an individual sample may therefore deviate from those of the neighbouring samples. The techniques in visual kerogen studies are adopted from (Staplin 1969 and Burgess 1974).

In interpretation of the maturity from the estimated colour indices we follow a general scheme that is calibrated against vitrinite reflectance values (R_o).

R_o	0.45	0.6	0.9	1.0	1.3	
Colour index	2-	2	2+	3-	3	3+
Maturity intervals	1 Moderate mature	Mature (oil window)			Very mature	

Rock-Eval Pyrolyses.

100 mg crushed sample was put into platinum crusible whose bottom and cover are made of sintered steal and analysed on a Rock-Eval pyrolyser.

RESULTS AND DISCUSSION

Headspace Analyses

Based on the headspace analyses of the C_1 - C_7 hydrocarbons, together with later information of core intervals, the analysed sequence of the well, 1695-2216 m was divided into six zones.

Zone A, 1695 - 1770 m: All the cores from this interval had open lids and headspace analyses were not performed.

Zone B, 1770 - 1823 m: The abundance of both C_1 - C_4 and C_5+ hydrocarbons is good for this zone, while the wetness of the gas is approximately 50% throughout the zone.

Zone C, 1923 - 1976 m: The canned samples from this interval were analysed, but later information reveals that this interval was cored and evaluation on canned samples will therefore not be given.

Zone D, 1976 - 2070 m: The abundance of both C_1 - C_4 and C_5+ hydrocarbons is poor throughout this sandstone zone . The wetness of the gas is far lower than in zone B while the iC_4/nC_4 is higher.

Zone E, 2070- 2130 m: This zone consists mainly of limestone and the abundance of C_1 - C_4 is good. The wetness of the gas is again approximately 50% and the iC_4/nC_4 shows a steady decrease with increasing depth. A sharp drop is observed for the abundance of both C_1 - C_4 and C_5+ hydrocarbons at the lower end of this zone.

Zone F, 2130 - 2216: This zone consists mainly of sandstone. The abundance of light hydrocarbons is good both for C_1 - C_4 and C_5+, and a gentle increase is observed with increasing depth.

Total Organic Carbon

Organic carbon was measured on claystone and limestone cuttings, where these were available. Some of the samples consist mainly of mud additives, and very little or no true material was recorded.

Zone A and B: The true material in these zones was all limestone, and the TOC is found to vary considerably from sample to sample. This might be due to contamination of the samples or a strong variation in the organic material in the samples.

Zone C: Cored interval.

Zone D: Sandstone.

Zone E: Again a zone with mainly limestone which is found to have a fair and good abundance of organic carbon.

Zone F: The limestone and claystone in the lowermost sample were analysed, both showing a good abundance of organic carbon.

Extraction and Chromatographic Separation

Two samples, one from zone A and one from zone E were extracted.

Zone A: Combined limestone cuttings from the depth interval 1695 - 1740 m were extracted and found to have a rich abundance of extractable hydrocarbons. The hydrocarbons/organic carbon ratio (HC/TOC) is very high indicating the sample to be contaminated by migrated hydrocarbons. The gas chromatogram of the saturated hydrocarbon fraction mainly shows a large unresolved envelope showing the hydrocarbons to be affected by biodegradation.

Zone E: Limestone from the 2070 - 85 m interval was extracted and found to have a good abundance of extractable hydrocarbons. The gas chromatogram of the saturated hydrocarbon fraction shows a large unresolved envelope in the heavy end together with a large input of heavy n-alkanes with a low CPI value. The lower end of the gaschromatogram shows the pristane/nC_{17} ratio to be approximately 1 while the pristane/phytane ratio is slightly below 1. A large number of strange compounds are observed in the C_{19} - C_{25} range. It is believed that this gas chromatogram consists of an input from two sources. The heavy end could be from mainly terrestrial material, possibly reworked while the light end could show some of the hydrocarbons from the true material.

Vitrinite Reflectance

Ten samples were analysed in reflected light, and vitrinite reflectance measured. Below, each sample is discribed and together with the reflectance values are given together with other information from the analyses.

Sample K4164, 1710 - 25 m: Shaly limestone, Ro = 0,41 (8).
The sample has a very low organic content with a few small particles of vitrinite and inertinite which is mainly restricted to a few shale cuttings with slight bitumen staining. Some reworking is recorded. UV light shows a yellow/orange fluorescence from spores and hydrocarbon specks together with a trace of exinite.

Sample K4165, 1725 - 40 m: Shaly limestone, Ro = 0,38 (6) and Ro = 0,85 (2).
The sample has only a trace of organic material with a few particles of inertinite and vitrinite mostly reworked. As in the sample above, most of the true vitrinite particles are found in a few shaly cuttings. No wisps are recorded. UV light shows a yellow fluorescence from hydrocarbon specks and globules.

Sample K4168, 1755 - 70 m: Shaly limestone. No determination possible.
Most of the sample consists of drilling mud. Only a few specks of inertinite were located in cuttings. UV light shows a yellow and yellow/orange fluor escence from spores and variable carbonate. Only a trace of exinite.

Sample K4169, 1770 - 85 m: Shaly limestone Ro = 0,46 (1).
Only a few phytoclasts and vitrinite particles were recorded and only one was considered possibly true. UV light shows variable carbonate fluorescence and yellow/orange spores together with a trace of exinite.

Sample K 4170, 1785 - 1800 m: Calcareous shale, Ro = 0,39 (8) and Ro = 0,64 (1).
The sample has only a trace of organic material with a few particles of vitrinite and inertinite. Mostly reworked, but a few good looking vitrinite particles. UV light shows a yellow/orange fluorescence from spores and yellow hydrocarbon specks together with a trace of exinite.

Sample K4171, 1800 - 15 m: Limestone/sandstone. Ro = 0,57 (4).
The sample has only a trace of organic material with a few gnarled and corroded particles, mostly reworked, and inertinite. UV light shows a yellow fluorescence from hydrocarbon specks and yellow/ orange spores together with a trace of exinite.

Sample K4190, 2085 - 2100 m: Siltstone and carbonate, Ro = 0,44 (20).
The sample has a moderate organic content with particles of vitrinite and inertinite in siltstone. Mostly reworked material but some good vitrinite particles. UV light shows a variable carbonate fluorescence and light orange spores together with a low exinite content.

Sample K4191, 2100 - 15 m: Siltstone and carbonate, Ro = 0,39 (21).
The sample has a moderate organic content with particles of vitrinite and inertinite, mostly in the siltstone. Most of the vitrinite is reworked but some true material is recorded together with a trace of bitumen staining. UV light shows a variably carbonate fluorescence and yellow/orange and light orange spores together with a low exinite content.

Sample K 4192, 2151 - 30 m: Carbonate and subordinate shale, Ro = 0,41 (20).
The sample has a moderate organic content, mostly inertinite and reworked particles, which are rather gnarled, in the shale. A few poor vitrinite particles and traces of bitumen are recorded. UV light shows a variable carbonate fluorescence and a yellow/orange and light orange spores together with a moderate exinite content.

Sample K4198, 2205 - 16 m: Shale and carbonate, Ro = 0,37 (21).
Shale: Saturated in bitumen. Rich in vitrinite wisps and inertinite particles.
Carbonate: A few gnarled inertinite and reworked particles. UV light shows a yellow/orange and light orange fluorescence from spores and hydrocarbon specks together with a low to moderate exinite content.

Visual kerogen

Six samples from the interval 1710 - 2216 m were processed for the evaluation of kerogen composition and maturity of this well.

The residues obtained were fairly large and well preserved. Only one sample, 2085 - 2100 m, contained large amounts of mud additives (distinct from the indigenous organic material of this well). Small amounts of material interpreted as caved from higher up the well, however appear at various levels. The analysis is performed on slides of the total acid insoluble residues with support only from screened residues, or from oxidized residues where the sample contained abundant coalified material.

Due to the low number of samples and the poor coverage in the middle of the interval we made no subdevision of the well. However an upper marine interval, lasting at least down to 1800 - 1815 m, may be distinguished from the more deltaic interval below 2085 m.

Sample K4165 m, 1710 - 25 m: Sapropel dominate and cysts are present. Terrestrial remains, mostly finely disseminated material and darker woody (coaly) fragments, count for about 40%. Winged pollengrains dominate among the palynomorphs. The palynomorphs and cuticles are fairly well preserved to poorly preserved, and pyrite is present in the residue. Colour index: 2-/2.

Sample K4168, 1755 - 70 m: Half of the residue consists of terrestrial material. The finely dispersed material resembles that of K4164. Cysts are relatively more common and dominate the palynomorphs. Woody (coaly) fragments seem increased, 25% of the assemblage. Colour index: 2-/2.

Sample K4171, 1800 - 15 m: The residue is dominated by terrestrial material, 60%, consisting of finely dispersed indeterminated herbaceous matter and woody (coaly) matter. Palynomorphs in chemically oxidized slides include cysts, pollen and spores of good or fairly good preservation. Colour index: 2-/2.

Sample K 4190, 2085 - 2100 m: Coalified material dominates and includes artificial mud additives. After chemical oxidation remains a residue dominated by a varied terrestrial assemblage (60% or higher). The well

preserved or fairly well preserved palynomorphs include cysts, spores, and as dominant winged pollen grains. Colour index: 2-/2. or 2-.

Sample K4191, 2100 - 15 m: Coalified material dominates and includes some structured terrestrial material. There is a minor part of amorphous material. After chemical oxidation (dissolving most nonstructured woody material) remains an assemblage of variably preserved palynomorphs. Winged pollen grains dominate, but there are also fair amounts of dinoflagellate cysts, and of caved tertiary material. Colour index: 2-/2 or 2-.

Sample K 4198, 2205 - 16 m: Coalified material dominates and a minor part consists of amorphous material as in the sample above. After chemical oxidation the residue consists of spores, pollen, cuticles and of some woody structures. There is some indeterminate herbaceous material, and some freshwater algae. Colour index: 2-/2 or 2-.

Rock Eval Pyrolyses

Eight samples were pyrolysed on a Rock - Eval instrument.

Zone E: The limestones in this zone are all found to have low hydrogen indeces and high oxygen indeces typical for kerogen type III. Similar results are also found for the claystone from 2115 - 30 m.

Zone F: Only the claystone and limestone from the lowermost sample are analysed. The hydrogen indeces are slightly higher than for the samples from zone E. This could indicate an input of some kerogen type II, but still mainly type III.

CONCLUSION

In our evaluation of the source rock potential for the analysed interval of this zone the richness is valued mainly from the organic carbon and light hydrocarbon data, while the type of kerogen is decided on the basis of the Rock - Eval and visual kerogen data. The maturity is evaluated from the vitrinite reflectance, visual kerogen and Rock - Eval data.

On the basis of the above described analyses the whole sequence from 1695 - 2216 m is found to be immature.

Zone A and B, 1695 - 1823 m: The samples from these zones contained very little true material. The organic carbon values vary considerably for the samples and the extracted cuttings are found to be contaminated with migrated hydrocarbons which is biodegraded. This will easily affect the richness evaluation of the zones. However, based on the performed analyses, the limestone in these zones is found to have a fair potential as a source rock for gas (oil).

Zone C, 1823 - 1976 m: Cored interval.

Zone D, 1976 - 2070 m: Mainly sandstone. Light hydrocarbon analyses indicate that this zone does not contain migrated hydrocarbons.

Zone E, 2070 - 2136 m: This zone consists mainly of limestone which is found to have a large variation in the TOC measurements. Rock - Eval analyses show the zone to mainly contain kerogen type III. Based on the various analyses this zone is found to have a fair potential as a source rock for gas.

Zone F, 2130 - 2216 m: This zone consists mainly of sandstone. Only the lowermost sample contains some limestone and claystone which is found to have a good potential as a source rock for gas (oil). Indications of free hydrocarbon in this sample.

TABLE 1

Concentration µl gas/pr.kg rock

Sample	Depth (m)	C_1	C_2	C_3	iC_4	nC_4	C_5+	ΣC_1-C_4	ΣC_2-C_4	% wetness	iC_4/nC_4
K-4163	1695-1710										
K-4164	1710-25										
K-4165	1725-40	Open lid									
K-4166	1740-45										
K-4167	1745-55										
K 4168	1755-70										
K 4169	1770-85	15240	4751	4560	5235	4885	39461	34671	19431	56.04	1.07
K 4170	1785-1800	23211	11202	8078	5889	4939	8095	53319	30108	56.47	1.19
K 4171	1800-15	15808	5431	3963	3310	2789	21575	31301	15493	49.50	1.19
K 4172	1815-30	6051	2473	1384	874	784	3568	11567	5516	47.69	1.11
K 4173	1830-45	10890	2377	898	616	618	3144	15398	4509	29.28	1.00
K 4174	1845-60	5086	1633	787	592	576	6594	8674	3588	41.37	1.03
K 4175	1860-75	11901	5166	1697	1150	923	5402	20838	8936	42.88	1.25
K 4176	1875-90	19269	10322	3740	2885	2263	10905	38480	19212	49.93	1.27
K 4177	1890-1905	22478	13218	3255	1802	1471	7902	42225	19746	46.77	1.23
K 4178	1905-20	4392	2094	503	309	276	2216	7574	3182	42.02	1.12
K 4179	1920-35	4240	2579	908	702	554	3565	8983	4742	52.80	1.27
K 4180	1935-50	5267	5945	2536	2310	1901	19810	17958	12691	70.67	1.22
K 4181	1950-65	27248	8917	1764	1143	814	3951	39887	12639	31.69	1.41

TABLE I

Concentration µl gas/pr.kg rock

Sample	Depth (m)	C_1	C_2	C_3	iC_4	nC_4	C_5+	ΣC_1-C_4	ΣC_2-C_4	% wetness	iC_4/nC_4
K 4182	1965-80	263	87	3	1	0	17	354	91	25.69	2.78
K 4183	1980-95	946	186	33	19	13	186	1196	250	20.90	1.48
K 4184	1995-2010	806	314	59	31	22	227	1233	426	34.60	1.40
K 4185	2010-25	3181	369	57	30	21	295	3657	477	13.03	1.42
K 4186	2025-40	6662	1569	221	88	54	337	8594	1932	22.62	1.62
K 4187	2040-55	10184	2925	440	174	93	231	13817	3633	26.29	1.88
K 4188	2055-70	1253	956	317	159	108	89	2793	1540	55.15	1.48
K 4189	2070-85	30503	16271	5526	2469	1960	1362	56728	26226	46.23	1.26
K 4190	2085-2100	27413	11337	4962	2104	1919	1800	47736	20322	42.57	1.10
K 4191	2100-15	46441	16757	8522	3119	2921	2534	77761	31321	40.28	1.07
K 4192	2115-30	68959	19608	10462	3436	3795	4503	106260	37301	35.10	0.91
K 4193	2130-45	8971	2165	919	266	307	458	12630	3658	28.97	0.87
K 4194	2145-60	22100	8299	4396	1220	1549	1900	37564	15464	41.17	0.79
K 4195	2160-75	19914	7930	5608	1646	2250	3069	37349	17434	46.68	0.73
K 4196	2175-90	23799	8870	6792	2037	2920	4755	44417	20618	46.42	0.70
K 4197	2190-2205	29872	13863	9638	2491	3394	5293	59259	29386	49.59	0.73
K 4198	2205-16	Open lid									

Table II

IKU No.	Depth	TOC	Lithology
K 4163	1695-1710	0,77	95% Nut shells 5% Limestone, light grey to grey, white; Sm.am. Claystone, grey, greenish, green.
K 4164	1710-25	0,50	80% Nut shells 20% Limestone, light grey to grey, some white. Sm.am. Claystone.
K 4165	1725-40	0,63	80% Nut shells 20% Limestone, white to grey, some brownish.
K 4166	1740-45		97% Nut shells 3% Limestone, white, some light grey to grey Sm.am. Claystone, greenish.
K 4167	1745-55	0,59	25% Limestone, light grey to grey, white. 75% Cement, light grey (brownish).
K 4168	1755-70	0,77	65% Cement 35% Limestone, as above.
K 4169	1770-85	0,35	50% Limestone, grey, light grey, white. 50% Cement.
K 4170	1785-1800	0,35	45% Limestone, as above, some brownish. 45% Cement. 10% Coal (additive); Steel.
K 4171	1800-15	0,53	50% Cement 30% Dolomite, browngrey, sucrosic. 10% Limestone, as above. 10% Coal (additive); Steel.
K 4172	1815-30		100% Sand, medium, subangular to angular, light grey. Sm.am. Limestone; Pyrite.
K 4173	1830-45		100% Sand, white, medium, some coarse, subangular, angular.
K 4174	1845-60		70% Sand, as above. 30% Coal (mud additive).
K 4175	1860-75		85% Coal (additive); Steel. 15% Sandstone, silty, brownish light grey, micaceous, with coal-fragments; Claystone, grey, with coal-fragments, Siltlamina; Cement; Limestone.
K 4176	1875-90	3,13	90% Coal (additive) and some Steel. 10% Claystone grading to Siltstone, grey. Sm.am. Sandstone, very fine, micaceous and coaly, brownish, light grey.

IKU No.	Depth	TOC	Lithology
K 4177	1890-1905		100% Coal (additive) and some Steel. Sm.am. Clay/Siltstone; Sandstone, as above; Limestone.
K 4178	1905-20		95% Coal (additive) and some Steel. 5% Sand. Sm.am. Silty Claystone, grey; Limestone.
K 4179	1920-30	2,19	85% Mud additives (Coal) and Steel. 10% Sand, medium to coarse. 5% Silty Claystone, grey; Limestone, white to light grey; some brownish grey/dark grey with Coal.
K 4180	1935-50	2,90	82% Mud additives (Coal) and Steel. 15% Siltstone to silty Claystone, grey 3% (brownish) grey to dark grey Claystone with Coal-stringers (some waxy). Sm.am. Sand.
K 4181	1950-65		100% Mud additives (Coal) and some Steel. Sm.am. Sand; Claystone.
K 4182	1965-80		65% Sand, medium, some coarse, light grey/clear, angular. 35% Additives (lignosulphonate, Coal), some Steel.
K 4183	1980-95		100% Sand, medium, some coarse, angular-subangular, clear/white, slightly micaceous. Sm.am. Gravel. Sm.am. Coal.
K 4184	1995-2010		100% Sand, as above. Sm.am. Coal.
K 4185	2010-25		80% Sand, as above, micaceous. 20% Limestone to calcareous Sandstone, brownish white, some micaceous, obs. Coal. Sm.am. Coal.
K 4186	2025-40		80% Sand, some micaceous. 20% Limestone/Sandstone, as above. Sm.am. Coal.
K 4187	2040-55		80% Sand, medium to coarse, subangular angular. 10% Limestone, sandy, brownwhite to white, Dolomite to Calcite. 10% Coal (? additive).
K 4188	2055-70		88% Sand, as above. 7% Limestone, as above. 5% Coal (? additive).

IKU No.	Depth	TOC	Lithology
K 4189	2070-85	1,37	77% Limestone consisting of Dolomite to Calcite, grey, brownish, some light grey/white. 8% Siltstone, clayey, with Mica-fragments, scattered Coal-fragments. 15% Sand Sm.am. Pyrite.
K 4190	2085-2100	0,82	70% Limestone, light brownish grey to grey and greybrown, Calcite and Dolomite. 25% Coal (additive). 5% Siltstone, clayey, grey.
K 4191	2100-2115	0,85	72% Limestone, as above. 15% Coal (additive). 8% Clay/Siltstone, grey. 5% Pyrite.
K 4192	2115-30	1,37 2,16	40% Sand, fine to coarse, angular, light grey/clear. 30% Limestone, as above, brownish white. 20% Claystone, silty, grey, Coal fragments. 10% Coal (additive). Sm.am. Pyrite.
K 4193	2130-45		100% Sand, medium to coarse, angular, subangular, light grey/clear. Sm.am. Limestone, sandy, white, loose; silty Claystone; Lignite (?additive) brown; Pyrite.
K 4197	2190-2205		87% Sand, as above, sm.am., Glauconite and some fine/veryfine Sandstone, calcareous 5% Claystone, as above, slightly glauconitic. 5% Limestone, white, loose. 3% Pyrite. Sm.am. Lignite (?additive).
K 4198	2205-16	1,64 1,21	45% Sand and some Sandstone as above. 40% Claystone, silty, grey, micaceous, with minute Coal-fragments. 15% Limestone, white to brownwhite, brittle, partly sandy. Sm.am. Coal (?additive); Pyrite.

IKU

T A B L E : III

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-4163	1695	67.7	219.2	60.9	42.5	103.4	115.8	.6
K-4189	2070	35.7	25.9	4.6	3.2	7.8	18.1	1.4

IKU

T A B L E : IV

CONCENTRATION OF EOM AND CHROMATOGRAPHIC FRACTIONS

(Weight ppm of rock)

IKU-No	DEPTH (m)	EOM	Sat.	Aro.	HC	Non HC
K-4163	1695	3238	900	628	1527	1710
K-4189	2070	725	129	90	218	507

IKU

T A B L E : V

CONCENTRATION OF EOM AND CHROMATOGRAPHIC FRACTIONS

(mg/g TOC)

IKU-No	DEPTH (m)	EOM	Sat.	Aro.	HC	Non HC
K-4163	1695	498.1	138.4	96.6	235.0	263.2
K-4189	2070	53.0	9.4	6.5	15.9	37.0

IKU

T A B L E : VI

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-4163	1695	27.8	19.4	47.2	143.3	52.8	89.3
K-4189	2070	17.8	12.4	30.1	143.8	69.9	43.1

TABLE VII

TABULATION OF DATAS FROM THE GASCHROMATOGRAMS

IKU No.	Depth (m)	Pristane/nC_{17}	Pristane/Phytane	CPI
K 4163	1695-1740	N.D.P.	N.D.P.	N.D.P.
K 4189	2070-85	0,98	1,29	1,0

TABLE VIII.

VITRINITE REFLECTANCE MEASUREMENTS.

IKU No.	Depth (m)	Vitrinite reflectance	Fluorescence	Exinite content
< 4164	1710-25	0,41 (8) McNT1 POP1	yellow/orange (4)	Trace
< 4165	1725-40	0,38 (6), 0,85 (2)		None
< 4168	1755-70	N.D.P.	yellow and yellow/orange (3+4)	Trace
< 4169	1770-85	0,46 (1)	yellow/orange (4)	Trace
< 4170	1785-1800	0,39 (8), 0,64 (1)	yellow/orange (4)	Trace
< 4171	1800-15	0,57 (4)	yellow/orange (4)	Trace
< 4190	2085-2100	0,44 (20)	Light orange (5)	Low
< 4191	2100-2115	0,39 (21)	Yellow/orange and light orange (4+5)	Low
< 4192	2115-30	0,41 (20)	yellow/orange and light orange (4+5)	Moderate
< 4198	2205-2216	0,37 (21)	yellow/orange and light orange (4+5)	Low - Moderate

Table IX

IKU 34/10-8		VISUAL KEROGEN ANALYSIS			(Trondheim 1980)
Depth in m.	Composition of residue	Particle size	Preservation -palynomorphs	Thermal maturation index	Remarks
K 4164 1710-25	Am/He, WR!, Pollen	F-M	poor to fair	2-/2	Acid resistant minerals partly as aggregates. Amorphous aggregates Partly pyrite
K 4168 1755-70	Am,Cysts/WR!, He	F	poor to good	2-/2	
K 4171 1800-15	He, WR!, Poll-spor/Am, Cysts	F-M-L	good to fair	2-/2	
K 4190 2085-2100	W (coaly)/Am	F-M-L	good to fair	2- 2-/2	Mud additives. Winged pollengrains, cuticles dinoflagellate cysts
K 4191 2100-15	W (coaly)	F-M-L	poor to good	2- 2-/2	Caved material suspected winged pollengrains, cuticles, dinoflagellate cysts
K 4198	W (coaly)/Am	F-M-L	good to fair	2- 2-/2	Botryococcus Classopollis
	Am amorhous He herbaceous W woody R! reworked	F fine M medium L large			

Table X

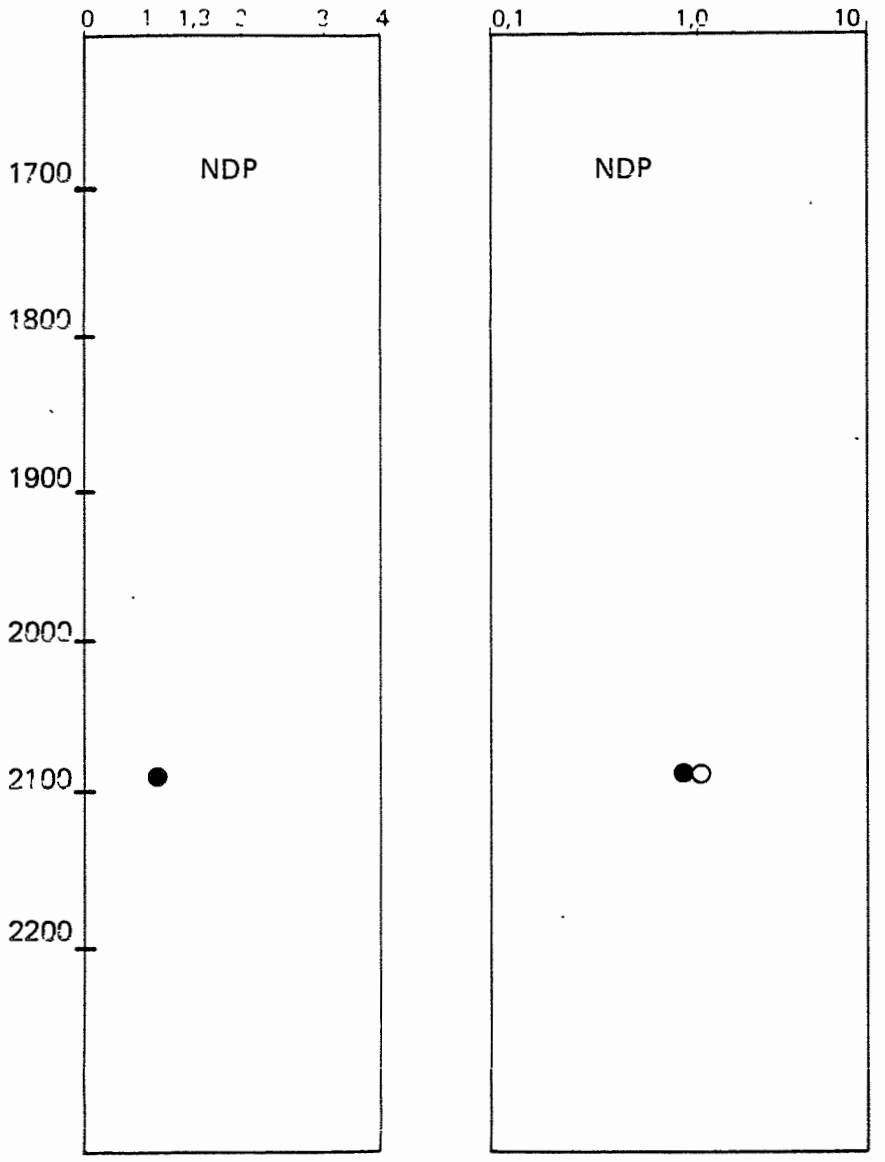
Rock-Eval Pyrolyses

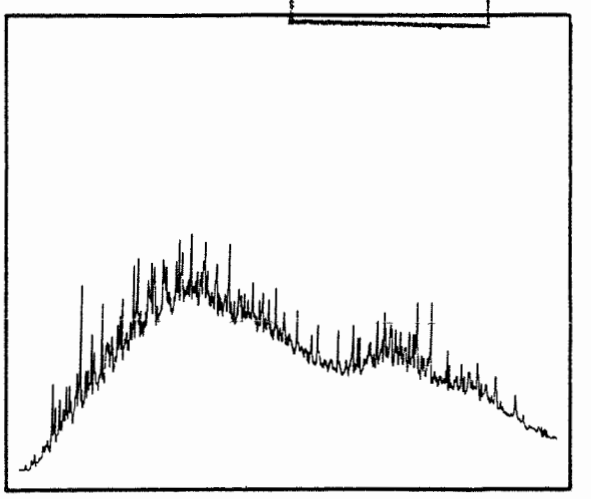
Sample	Depth	S_1	S_2	S_3	C_{org}	Hydrogen Index	Oxygen Index	Oil of gas content ($S_1 + S_2$)	Production Index $\frac{S_1}{S_1 + S_2}$	T_{max} °C
K 4180 Clay/silt-stone	1935-50	1,73	6,34	1,81	4,11	154,26	44,04	8,07	0,21	427°
K 4189 Limest.	2070-85 m	0,19	0,75	2,89	1,37	54,74	210,95	0,94	0,20	434°
K 4190 Limest.	2085-2100 m	0,16	0,32	2,58	0,82	39,02	314,63	0,48	0,33	432°
K 4191 Limest.	2100-15 m	0,19	0,67	2,42	0,85	78,82	284,71	0,86	0,22	434°
K 4192 Clayst.	2115-30 m	0,32	2,04	1,45	2,16	94,44	67,13	2,36	0,14	430°
K 4192 Limest.	2115-30 m	0,27	1,37	4,34	1,37	100,00	316,79	1,64	0,16	437°
K 4198 Clayst.	2205-16 m	0,71	2,74	1,52	1,64	167,07	92,68	3,45	0,21	431°
K 4198 Limest.	2205-16 m	0,99	3,08	2,10	1,21	254,55	173,55	4,07	0,24	431°

34/10 – 8

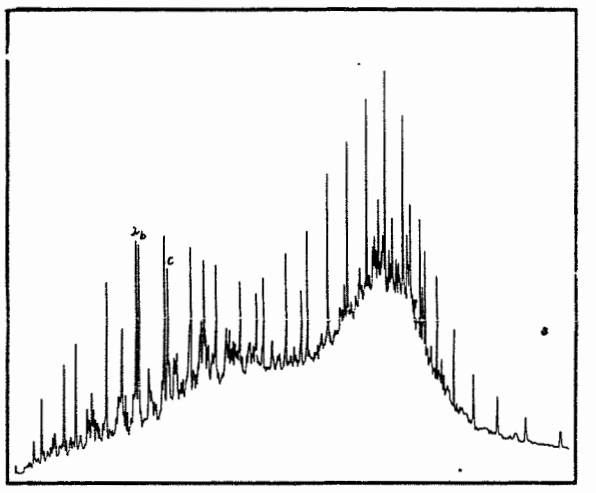
C_{15}^{+} SATURATED HYDROCARBONS

DEPTH CPI ● PRISTANE / nC 17 ○ PRISTANE / PHYTANE





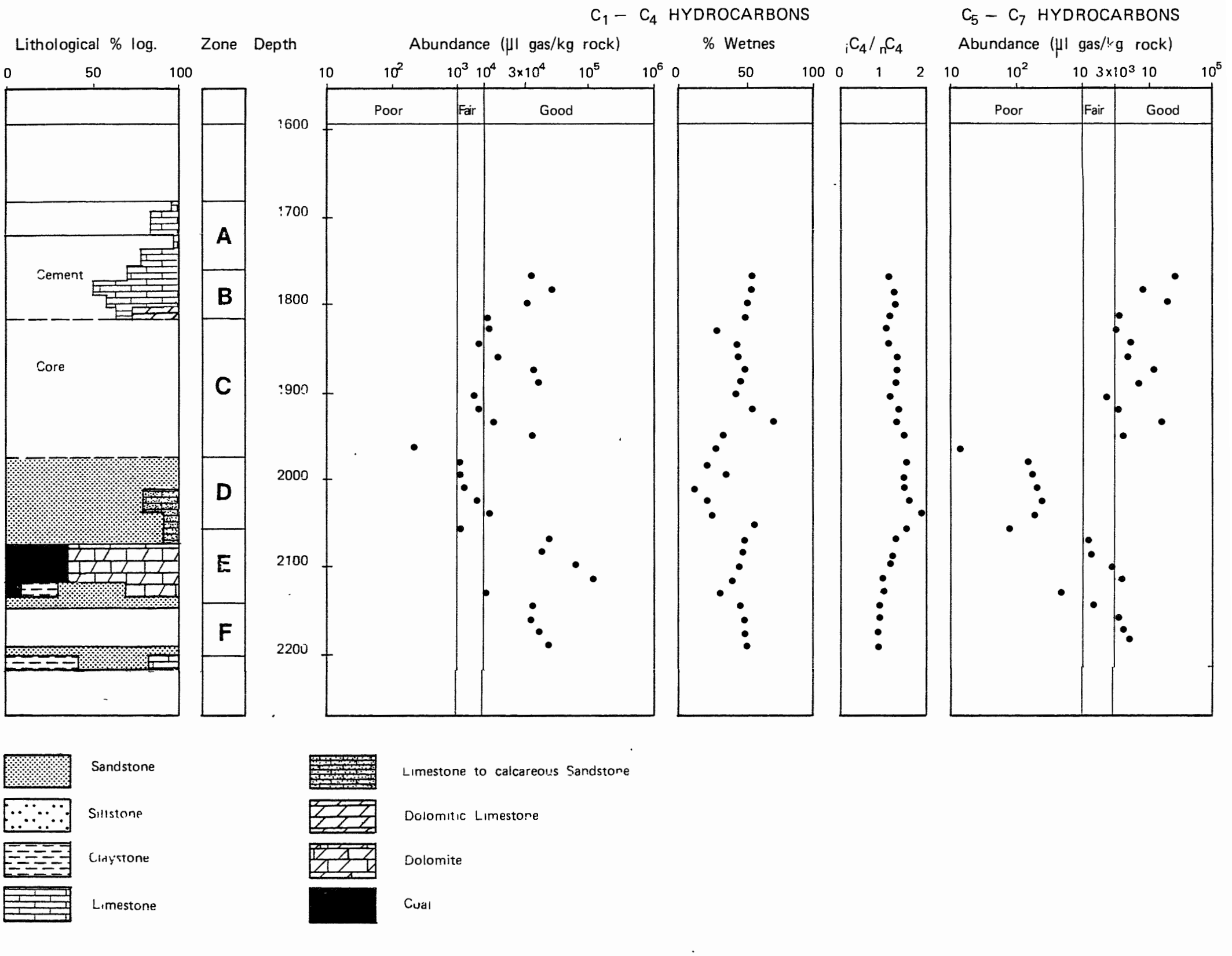
1695–1740m



2070–85m

34/10 – 8

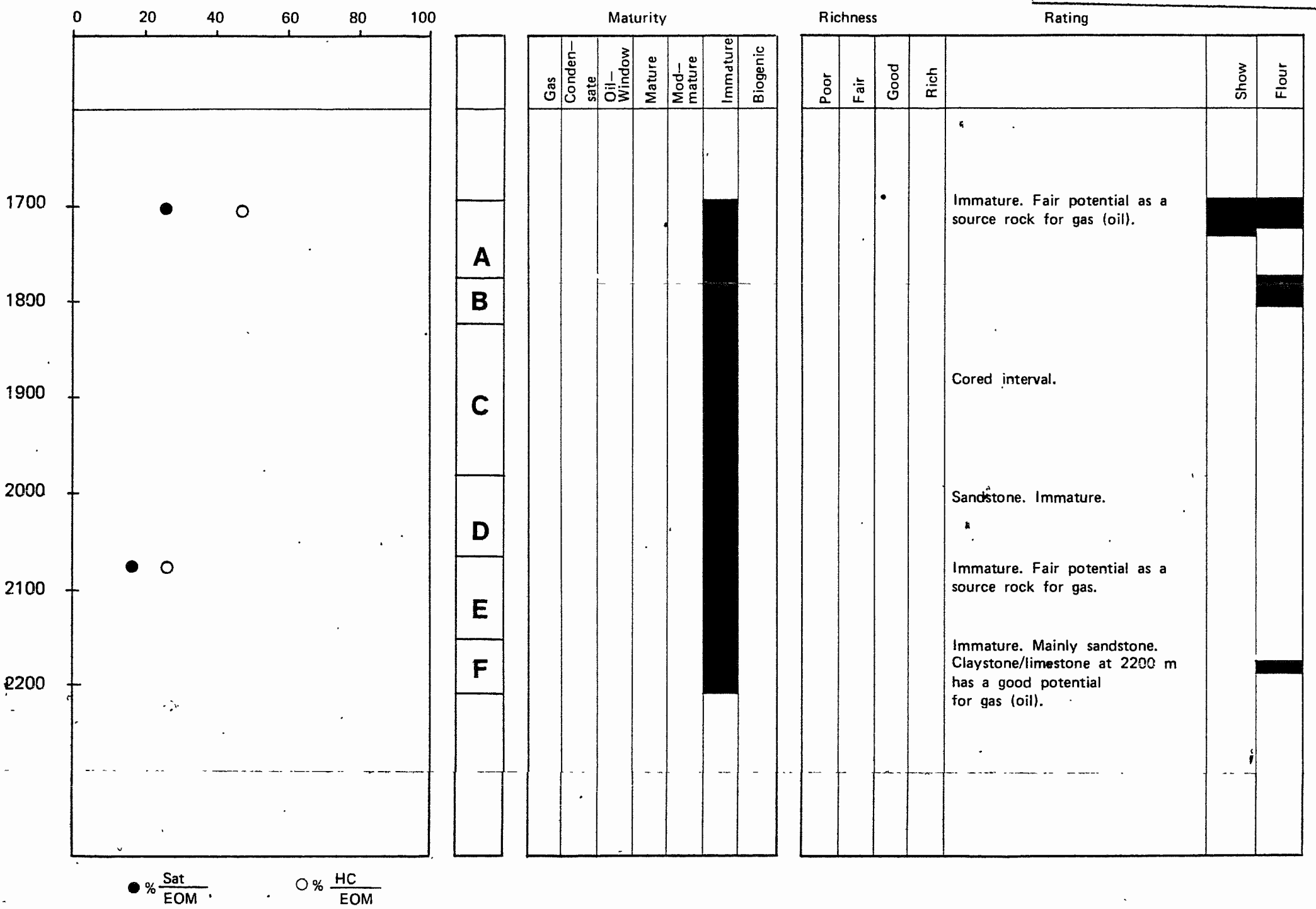
C_1 – C_7 HYDROCARBONS
Presentation of Analytical Data



INTERPRETATION DIAGRAM

34/10 – 8

DEPTH — MATURATION C_{15}^{+} FRACTION — ZONE — RATING — SUMMARY OF SOURCE POTENTIAL

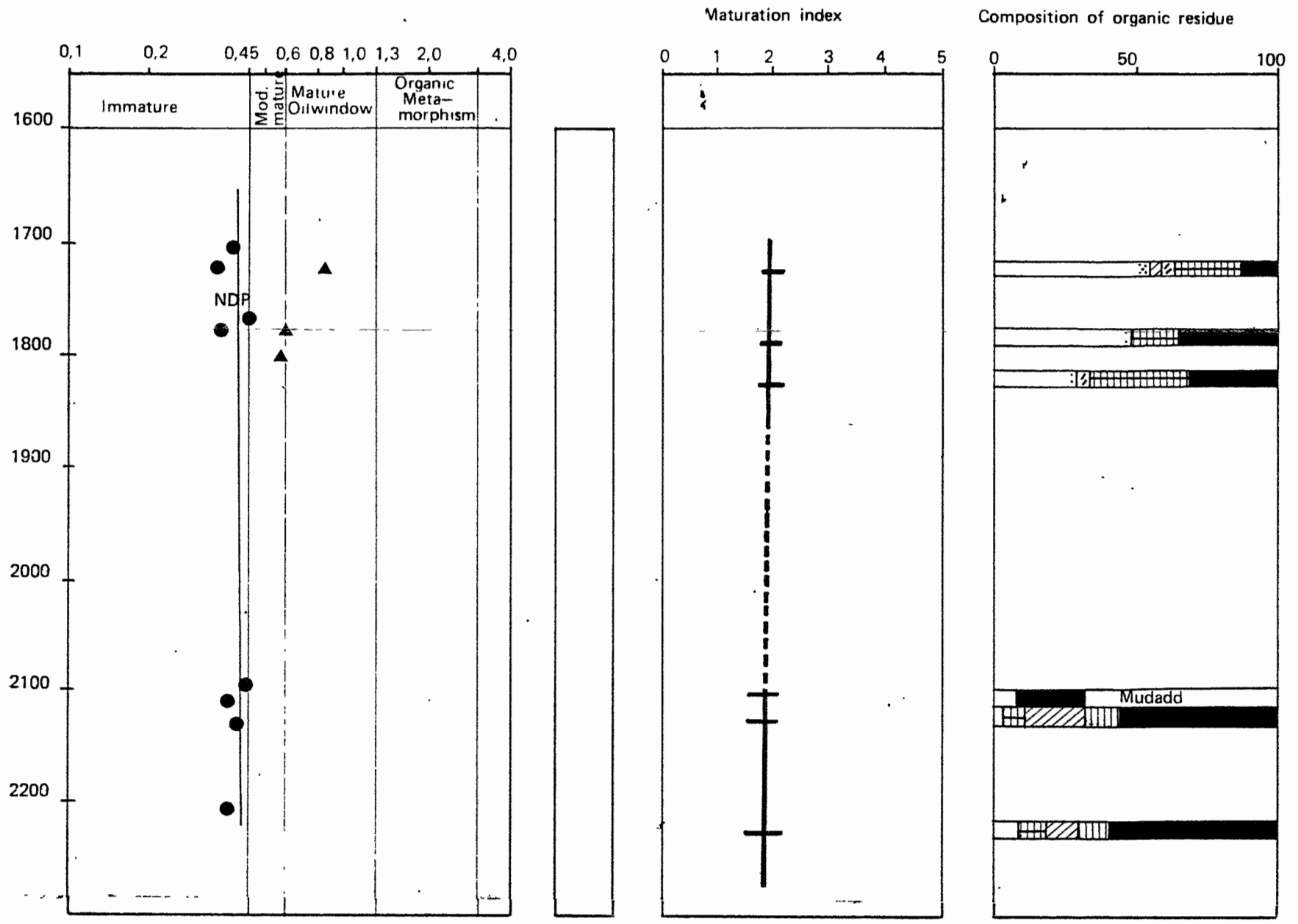


● % Sat / EOM ○ % HC / EOM

Sat: Saturated Hydrocarbons
HC: Hydrocarbons
EOM: Extractable Organic Matter

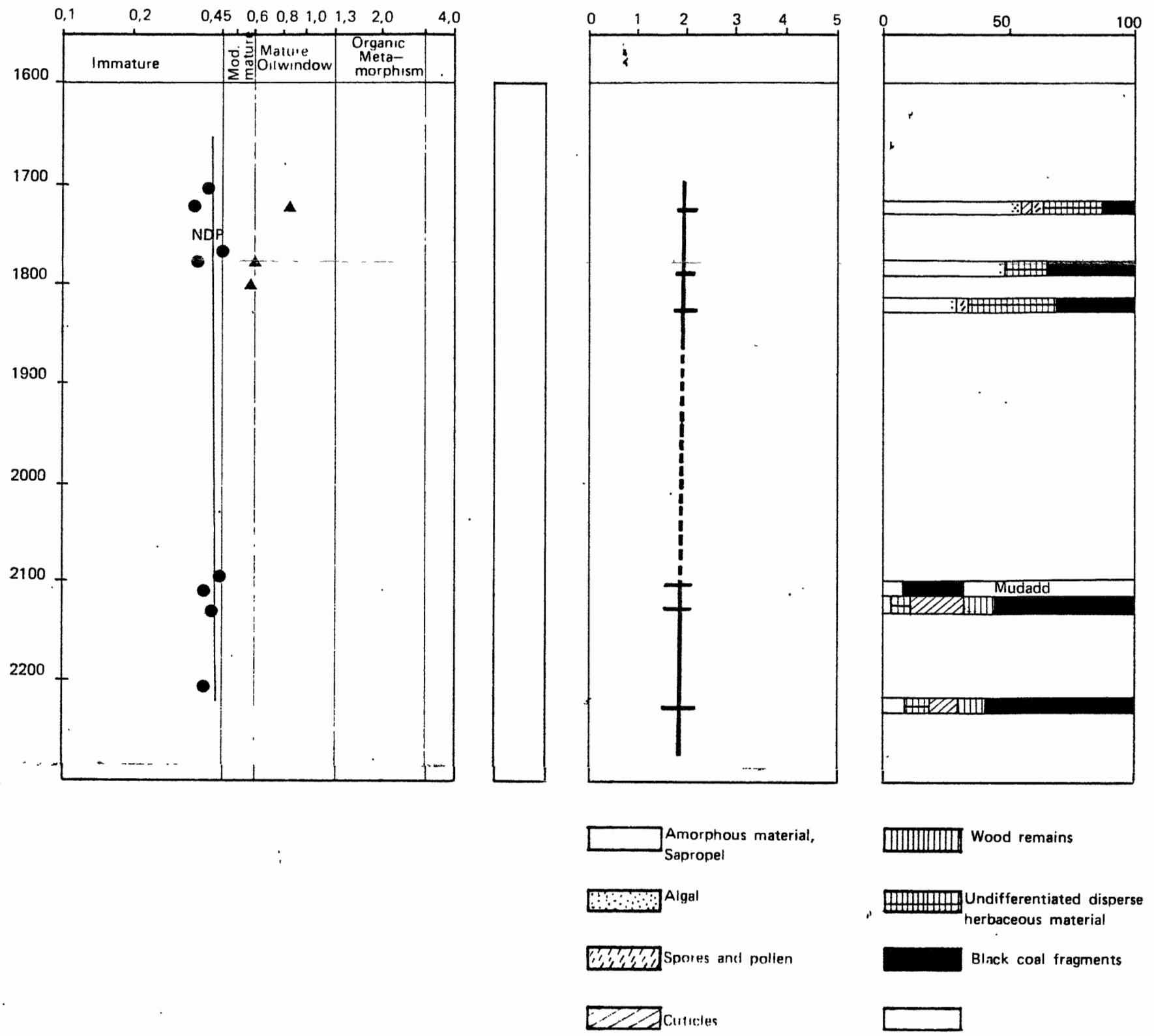
MATURATION

DEPTH VITRINITE REFLECTANCE ZONE VISUAL KEROGEN COLORATION AND COMPOSITION OF ORGANIC RESIDUE



MATURATION

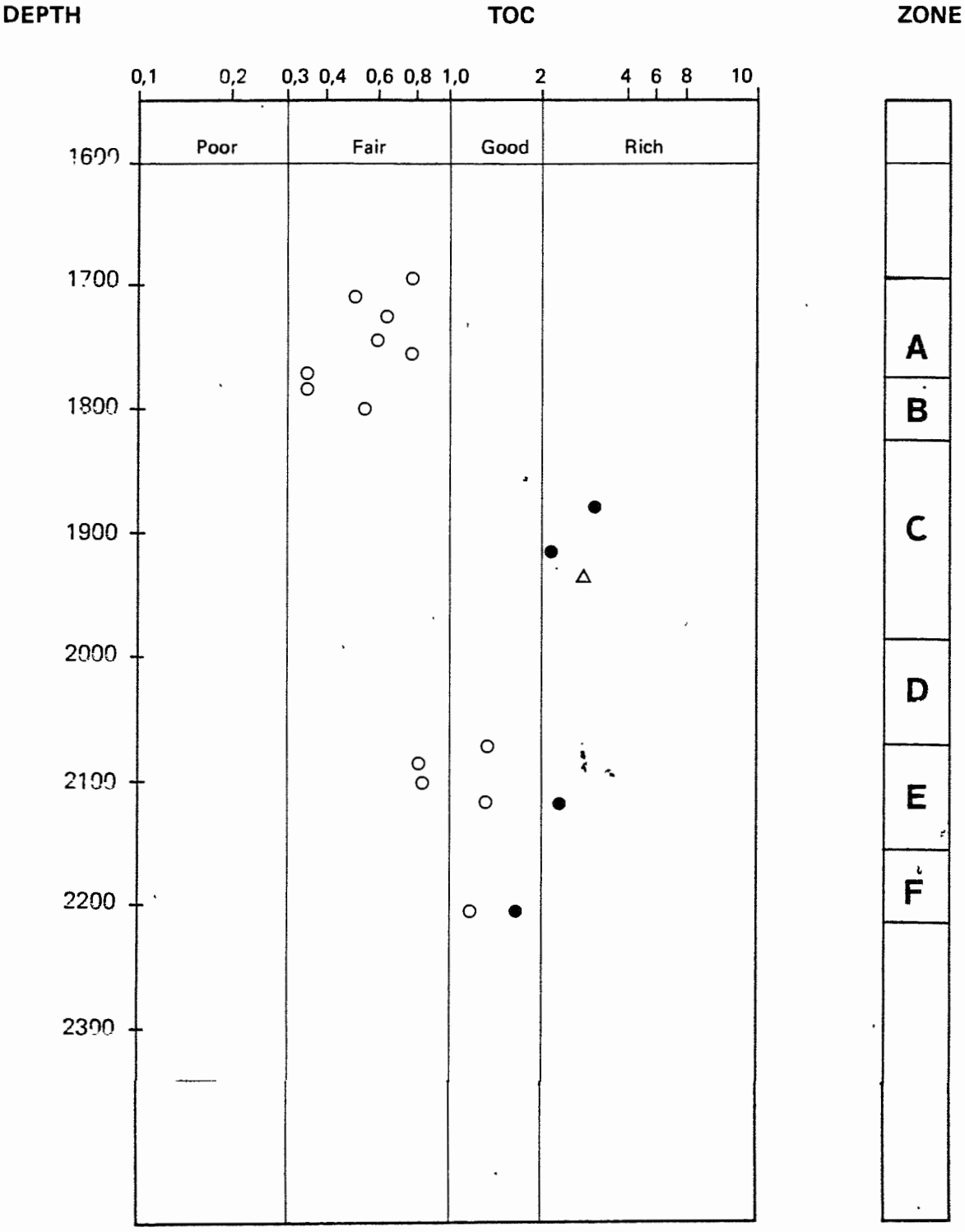
DEPTH | VITRINITE REFLECTANCE | ZONE | VISUAL KEROGEN COLORATION AND COMPOSITION OF ORGANIC RESIDUE



34/10 – 8

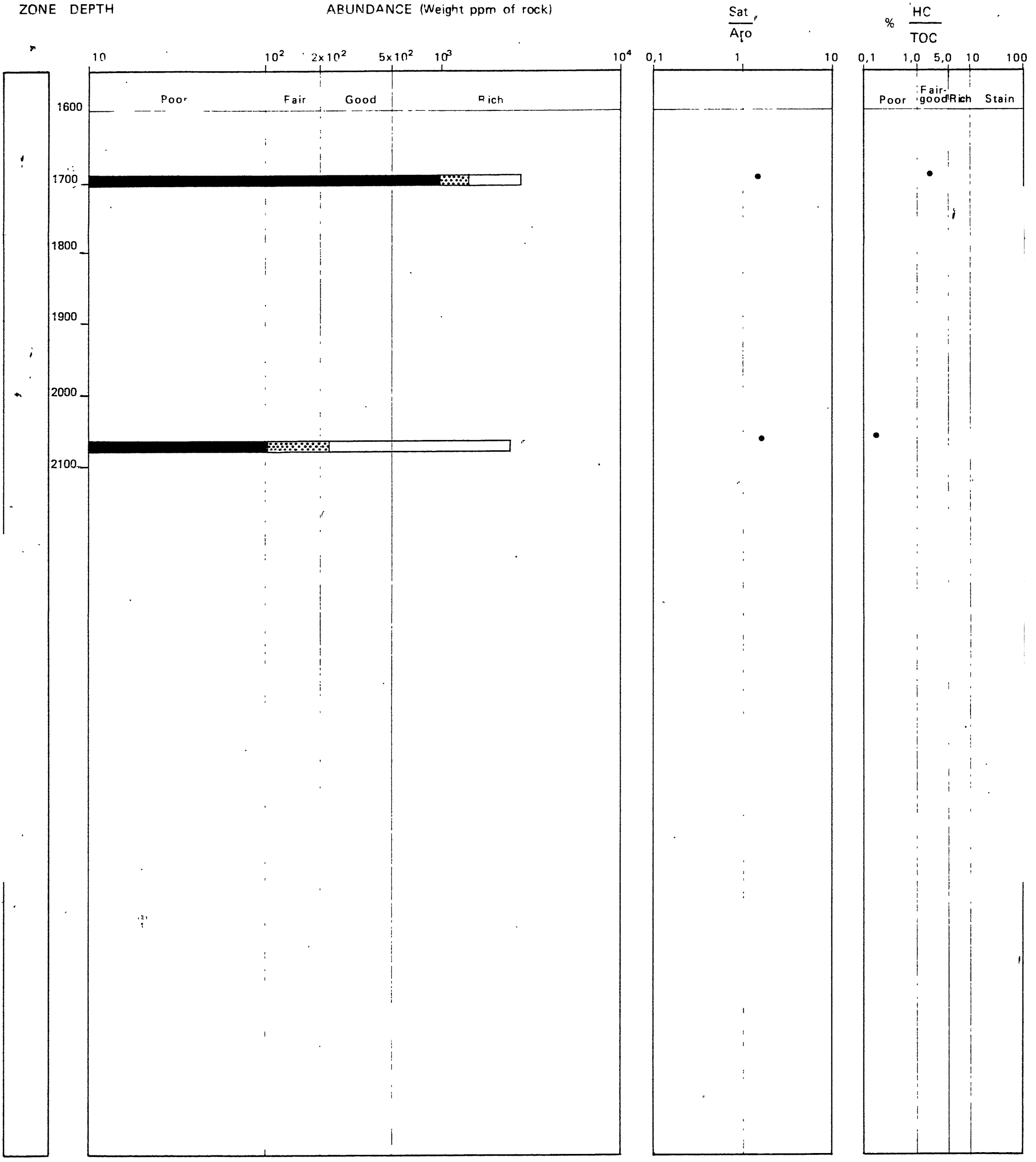
TOTAL ORGANIC CARBON (TOC)

Presentation of Analytical Data



C_{15}^{+} HYDROCARBONS

Presentation of Analytical Data



Sat. Aro. NSO Asp

Sat: Saturated Hydrocarbons
Aro: Aromatic Hydrocarbons
NSO. Nitrogen, Sulphur and Oxygen containing compounds

Asp: Asphaltenes
HC: C_{15} Hydrocarbons
TOC: Total Organic Carbon

ROCK-EVAL PYROLYSIS