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REPORT TITLE

Source Rock Analysis of well 8/10-2

CLIENT

Phillips Petroleum Co.

CLIENT's REF..	REPORT NO.:
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DATE:	PROJECT NO.:
1.9.1980	0-289
NO. OF PAGES	NO. OF ENCLOSURE

DEPARTMENT:	RESPONSIBLE SCIENTIST.
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SUMMARY:

See enclosure

KEY WORDS

Source Rock

SUMMARY:

The whole analysed zone 2400 - 2990 m is immature.

Based on TOC and lithology the analysed sequence is divided into five zones:

Zone A: 2400 - 2530 m: Poor potential as a source rock for gas.

Zone B: 2530 - 2640 m: Fair potential as a source rock for gas.

Zone C: 2640 - 2700 m: Good/rich potential as a source rock for oil and gas.

Zone D: 2700 - 2880 m: Mainly sandstone.

Zone E: 2880 - 2990 m: Poor potential as a source rock for gas.

EXPERIMENTAL AND DESCRIPTION OF INTERPRETATION LEVELS

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^{o}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 reflectan 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 ($Zn\ Br_2$) 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 dino-flagellates) 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.

Total Organic Carbon

TOC measurements were undertaken on all samples except sandstones. Based on these results and the lithological descriptions, the analysed sequence (2400 - 2990 m) of the well is divided into five zones.

Zone A: 2400 - 2530 m: This zone consists mainly of limestone with small percentages of claystone, probably cavings, in some of the samples. The TOC values of the limestone are low, 0.1 - 0.2%.

Zone B: 2530 - 2640 m: This zone consists of claystone with a fair abundance of organic carbon, 0.4 - 0.7%.

Zone C: 2640 - 2700 m: Again a zone with mainly claystone but with two different colourtones. The dark grey claystone has a rich abundance of organic carbon while the grey claystone has values similar to those found in zone B and could be cavings.

Zone D: 2700 - 2880 m: The lithology of the samples changes to mainly sandstone. Some claystone was found in most samples and TOC measurements were undertaken, giving results which varied considerably. The claystone could be cavings or true material located in thin lenses in the zone. Siltstone is found in some of the samples.

Zone E: 2880 - 2990 m: Mainly grey and red claystone with a fair abundance of organic carbon.

Extraction and Chromatographic Separation.

Zone A: Two samples, 2410-20 m, 2520-30 m from this zone were extracted and found to have a poor abundance of extractable hydrocarbons. The gas chromatograms of the saturated hydrocarbon fractions are similar for the two samples and rather different from what is normally found for saturated hydrocarbons. A large number of peaks are found between the n - alkanes. Presently it is not known what compounds these could be, but they could be diterpenoids. The pattern of the n - alkanes is unimodal with maximum at nC_{15} and a moderate CPI value.

Zone B: One sample, 2530-40 m was extracted and found to have a fair abundance of organic carbon. The gas chromatograms of the saturated hydrocarbon fraction are different from those from the zone above as the large peaks registered between the n - alkanes can not be registered. The n - alkane pattern shows a smooth unimodal distribution with maximum at nC_{17}, typical for a well mature hydrocarbon sample. This does not fit in with the maturity for this sample and could be due to migrated hydrocarbons.

Zone C: Three samples, 2670-80 m, 2680-90 m and 2700-2710 m from this zone were extracted and found to have a fair abundance of extractable hydrocarbons. A large variation is found in the saturated/aromatic ratio for the three samples. This could partly be due to error in the weight of the fractions since all samples were small. The gas chromatograms of the saturated hydrocarbon fractions vary considerably. The uppermost sample 2670-80 m has a large pristane/nC_{17} ratio, while the CPI value is moderate. This would indicate an input of marine origin together with some terrestrial material. The gas chromatogram of the saturated fraction from 2680-90 m shows a smooth n - alkane distribution with a moderate pristane/nC_{17} ratio while the lowermost sample 2700-2710 m also shows a smooth pattern but with a low pristane/nC_{17} value, typical for well mature hydrocarbons. It is believed that the uppermost sample shows the true pattern for this zone while the two other samples are contaminated by migrated hydrocarbons, the lowermost sample most.

Zone E: Four samples, 2890-2900 m, 2930-2940 m, 2960-2970 m and 2970-2980 m were extracted. The three uppermost samples have a poor abundance of extractable hydrocarbons while the sample from 2970-80 m was found to have a fair abundance of extractable hydrocarbons. The gas chromatogram of the saturated hydrocarbon fractions of the three uppermost samples are similar with pristane/nC_{17} approximately 1.0 and a large amount of unidentified peaks between the n - alkanes similar to those found in the samples from zone A. The lowermost sample 2970-80 m has a smooth distribution of n - alkanes typical for well mature hydrocarbons, and could be due to contamination.

Vitrinite Reflectance.

Fifteen samples were analysed in reflected light and vitrinite reflectance measured. Below each sample is described and other data from the analyses given.

Sample K 4289, 2410 m: Shale, Ro = 0,39 (21). The sample has a variable bitumen staining, often quite intense. Otherwise a low content of small particles of vitrinite and inertinite in about equal proportions. UV light shows a yellow/orange fluorescence from spores and some reworked material together with a trace of exinite.

Sample K 4301, 2530 m: Shale, Ro = 0,34 (12).
The sample has a strong but variable bitumen staining, otherwise a very low content of small particles of vitrinite and inertinite in about equal proportions. UV light shows a yellow and yellow/orange fluorescence from spores and hydrocarbon specks together with a low exinite content.

Sample K 4306, 2580 m: Shale, Ro = 0,33 (3).
The sample has a very low content of small gnarled particles of vitrinite and inertinite, almost wholly reworked material and inertinite. Only a trace of bitumen staining. UV light shows a yellow/orange fluorescence from spores and a trace of exinite.

Sample K 4311, 2630 m: Shale, Ro = 0,31 (1) and Ro = 0,65 (1).
The sample has a very low organic content with small particles of inertinite and reworked material. Only a couple of particles of very doubtful vitrinite. Occasional bitumen wisps. UV light shows a yellow/orange fluorescence from spore specks and a trace of exinite.

Sample 4315, 2670 m: Shale, Ro = 0,42 (3).
The sample contains bitumen wisps and quite intense staining. Otherwise, very low content of inertinite and vitrinite particles, almost wholly reworked.

UV light shows a yellow and yellow/orange fluorescence from spores and a moderate-rich exinite content.

Sample K 4317, 2690 m: Mixed shale lithologies, Ro = 0,47 (3) and Ro = 0,68 (1).
Most of the cuttings are barren while some are rich in bitumen wisps. The sample has a low content of small inertinite and reworked particles. Only a trace of poor vitrinite. UV light shows a yellow and yellow/orange fluorescence from spores and a moderate exinite content.

Sample K 4319, 2710 m: Shale and sandstone, Ro = 0,42 (8).
Bitumen wisps and staining are recorded in the shale which also contains a low content of small particles of inertinite and reworked material. Only a trace of vitrinite. The sandstone is barren. UV light shows a yellow/orange fluorescence from spores and hydrocarbons together with a low exinite content.

Sample 4322, 2740 m: Shale and carbonate traces, Ro = 0,33 (4).
The sample has a low organic content with small particles of inertinite and reworked material. Only a trace of vitrinite and occasional bitumen wisps are recorded. UV light shows a yellow and yellow/orange fluorescence from spores and hydrocarbon traces together with a trace of exinite.

Sample K 4323, 2750 m: Mixed shale lithologies, Ro = 0,33 (10)
The sample has a low organic content and some cuttings show iron oxide staining and are barren. Others are rich in bitumen wisps with heavy staining. A few particles of vitrinite and inertinite, mostly reworked, are recorded. UV light shows a yellow/orange and light orange fluorescence from spores and a moderate exinite content.

Sample K 4328, 2800 m: Red and grey siltstone and shale, Ro = 0,39 (6).
Most of the cuttings are haematite stained and barren. A few grey cuttings contain bitumen wisps and particles - mostly of inertinite and reworked material but occasional vitrinite.

UV light shows a light orange fluorescence from spores and a trace of exinite.

Sample K 4331, 2830 m: Mixed shale lithologies, Ro = 0,43 (10) and Ro = 0,65 (1).
A few of the cuttings contain bitumen wisps and particles of vitrinite and inertinite. The red shale is barren. UV light shows a light orange fluorescence from spores and hydrocarbon specks together with a low exinite content.

Sample K 4336, 2880 m: Red and grey shale and sandstone, Ro = 0,30 (1) and Ro = 0,54 (2).
The organic material is restricted to a few grey shale cuttings. Bitumen wisps and a few particles of vitrinite and inertinite, mostly reworked, are recorded. UV light shows a yellow and yellow/orange fluorescence from spores and a trace of exinite.

Sample K 4338, 2900 m: Red siltstone and grey shale traces, Ro = 0,41 (13).
The red siltstone is barren. The organic material is restricted to a few grey shale cuttings where bitumen wisps and staining together with a few particles of vitrinite and inertinite, mostly reworked, are recorded. UV light shows a yellow/orange fluorescence from spores in a few cuttings and a low exinite content.

Sample K 4343, 2950 m: Red siltstone and grey shale, Ro = 0,39 (21).
The organic material is restricted to the shale where plentiful bitumen wisps and particles of vitrinite and inertinite are recorded. UV light shows a yellow/orange and light orange fluorescence from spores and a moderate to rich exinite content.

Sample K 4346, 2980 m: Red and grey shale and siltstone, Ro = 0,38 (20).
The sample has a low content of organic material restricted to the grey lithologies. Bitumen wisps and occasional particles of inertinite and reworked material, only a trace of poor vitrinite particles. UV light shows fluorescence from hydrocarbon specks and no exinite.

Rock - Eval Pyrolyses

A total of forty samples were pyrolysed on a Rock - Eval instrument, and the results are given in Table IX.

Zone A: The hydrogen indeces of the analysed samples from this zone is very low while the oxygen indeces are high, typical for immature type III kerogen.

Zone B: Again a zone with low hydrogen indeces and high oxygen indeces. In some of the samples the S_2 peak is too little to be registered. The S_1 peak is, however, quite large in some of the samples indicating free hydrocarbons.

Zone C: The dark grey claystone cuttings in this zone have high hydrogen indeces and low oxygen indeces, typical for kerogen type II. T_{max} is low indicating immature sediments.

Zone D: Some claystone cuttings from this zone were analysed and found to be immature with kerogen type III as in zone A and B.

Zone E: The analysed samples from this zone have very similar results as found in zone D, with low hydrogen indeces and high oxygen indeces typical for kerogen type III.

Visual Kerogen Analysis.

Sixteen samples from the interval of 2500 m to 2740 m were chosen for description of the acid resistant organic material contained.

In the upper part, down to 2540 m, the samples were dominated by amorphous material, probably of marine derivation, and the material is well preserved.

From 2580 m to 2670 m the amorphous material dominates, but reworked/ oxidized material is more important than in the zone above. The material is well preserved to fairly well preserved.

The residues at 2690 m and below are either dominated by terrestrial material, or contain equal amounts of terrestrial and amorphous material.

Supposed caved material becomes a striking or major part of the residues from below 2750 m.

The entire analysed interval seems immature containing light coloured palynomorphs.

2500 m, 2520 m, 2540 m: The finely dispersed residues contain dominantly amorphous material tending to appear as aggregates and embedding the other particles present. Chemical oxidation reveals well preserved cyst assemblages in the two upper samples, but there are also pollen and spores and sapropelized cuticular fragments. Colour index: 1+, 1+/2-.

2580 m, 2640 m, 2670 m: The residues seem somewhat coarsed and smaller than above. They are richer in terrestrial, namely reworked woody material, but amorphous material still dominates. Chemical oxidation reveals a rich assemblage for darkly stained cysts at 2640 m. At 2670 m there is again a stronger tendency for sapropel in aggregates. Colour index: 1+/2-.

2690 m, 2710 m: The residues are small, fairly fine grained and dominated by terrestrial, namely woody, reworked/oxidized material. Amorphous material is subordinate. Colour index: 1+/2-.

2740 m, 2750 m: The residues contain grains of variable size. Terrestrial remains dominate and include cuticles, pollen and spores. Sapropel is subordinate and is usually recovered as aggregates. It is not possible to distinguish whether the sapropel could have been derived from caved material since the colour of the material is more or less the same through the upper part of the well. Colour index: 1+/2-.

2800 m, 2840 m: The residues resemble the two above but mud additives (wall nut) and suspected caved material are more common. We suggest an interval poor in indigenous material. Colour index: 1+/2-. The latter index could have been based upon oxidized material and thus too high as a maturation parameter.

2880 m: This residue is dominated by amorphous material, but contains also 40-50% terrestrial remains. Triassic pollen grains were recovered. If they are indigenous, there could be considerable amounts of caved material in this sample. Colour index: 1+/2-.

2900 m, 2950 m, 2980 m: The amorphous material in these residues was recovered as aggregates that were darker than in the interval above. We conclude either an increase in maturation or material that has been oxidized. The small particles could be of terrestrial or marine origin.

The major part of the three residues is composed by terrestrial material, cuticles, wood remains, pollen, spores and indeterminated herbaceous matter. The content of acid resistant minerals support a lithology poor in organic matter. We suggest the amorphous material to be indigenous, the terrestrial to be mainly caved material. Colour index: 2-.

CONCLUSION

In our evaluation of the source rock potential of the analysed sequence, the richness is evaluated with background in the organic carbon values and the extractability of the samples while the type of source rock is evaluated with background in the visual kerogen examination and the Rock - Eval pyrolyses. The maturity of the samples are decided with background in the visual kerogen examination, vitrinite reflectance and the Rock - Eval pyrolyses.

Based on the total organic carbon analyses and the lithology of the samples, the analysed sequence 2400 - 2900 m were divided into five zones.

Zone A; 2400 - 2530 m: This zone consists mainly og limestone with a low abundance of organic carbon. Based on the various analyses this zone is found to be immature with a poor potential as a source rock for gas.

Zone B; 2530 - 2640 m: A zone with mainly claystone with a fair abundance of organic carbon and extractable hydrocarbons. Rock - Eval pyrolyses show the zone to contain typical type III kerogen. Based on the various results this zone is found to be immature with a fair potential as a source rock for gas.

Zone C; 2640 - 2700 m: This zone consists of two claystone lithologies, a dark grey claystone with a high organic carbon abundance and a lighter grey claystone with a fair abundance, similar to zone B. The dark grey claystone is thought to be the true lithology and this is found to contain kerogen type II.

Based on the various results, this zone is found to be immature with a good/rich potential as a source rock for oil and gas.

Zone D; 2700 - 2880 m: Mainly sandstone is found in this zone. The claystone is found to have a fair potential as a source rock for gas. The whole zone is immature.

Zone E; 2880 - 2990 m: This zone consists mainly of grey and red claystone which is found to be immature with a poor potential as a source rock for gas.

IKU No.	Depth	TOC	Lithology
K 4288	2400	0,14	50% Claystone, grey, greybrown, very silty, micaceous, light greenish grey, redbrown, partly calcareous.
		0,16	50% Limestone, white. Sm.am. Nut shells, yellowbrown (additive); Pyrite.
K 4289	2410	1,43	97% Claystone, light greenish grey, grey, browngrey (silty, micaceous), redbrown, partly calcareous. 3% Limestone, white. Minor: Siderite/Dolonite, yellowbrown, light, sucrosic; Nut shells; Pyrite.
K 4290	2420	0,84	80% Limestone, white 20% Claystone, as above.
K 4291	2430	0,12	90% Limestone, white.
		1,13	10% Claystone, grey, browngrey,(silty, micaceous, dark), some light grey, redbrown, pratly calcareous.
K 4292	2440	0,11	95% Limestone, white 5% Claystone.
K 4293	2450	0,13	100% Limestone. Sm.am. Claystone.
K 4294	2460	0,12	100% Limestone. Sm.am. Claystone.
K 4295	2470	0,13	93% Limestone. 7% Claystone, as above.
K 4296	2480	0,13	95% Limestone, white. 5% Claystone, as above.
K 4297	2490	0,12	95% Limestone, as above. 5% Claystone, as above.
K 4298	2500	0,15	90% Limestone, white.
		1,60	10% Claystone, as above.
K 4299	2510	0,13	90% Limestone
		1,83	10% Claystone.
K 4300	2520	0,31	80% Claystone, silty, grey, dark, browngrey (some micaceous), browngrey, some light grey, redbrown. 20% Limestone. Sm.am. Dolonite or Siderite, light yellowbrown; Nut shells; Coal (additive).

IKU No.	Depth	TOC	Lithology
K 4301	2530	1,03	85% Claystone, grading to clayey and sandy Siltstone, grey and redbrown, light grey, some micaceous, variably calcareous, some slightly glauconite.
			15% Limestone.
		0,15	Sm.am. Sand.
K 4302	2540	0,34	83% Claystone to Siltstone, as above.
		0,12	15% Limestone. 2% Sand, clear, fine-medium, angular (sub). Sm.am. Silt/Sandstone, calcareous, light grey, glauconite; browngrey Dolonite or Siderite.
K 4303	2550	1,21	85% Claystone grading to silty and sandy Siltstone, greybrown, light grey,dark grey, yellow, some micaceous, variably calcareous.
		0,11	15% Limestone, white. Sm.am. Nut shells, clear secondary Calcite.
K 4304	2560	0,45	100% Claystone, silty, some grading to sandy Siltstone, grey, redbrown, browngrey, yellow, obs. light Silt-lamine and green Claystone-clasts grey Claystone, some micaceous, calcareous. Sm.am. Limestone, white; Siltstone, light grey, white, micaceous.
K 4305	2570	0,65	100% Claystone, silty, grey, slightly micaceous, some brownish, redbrown, very silty, yellow, light grey, calcareous. Sm.am. Limestone, white, brownwhite; Soderite or Dolonite, light yellowbrown.
K 4306	2580	0,61	100% Claystone, as above. Sm.am. Siltstone, redbrownish, light grey, some glauconite; Limestone, white
K 4307	2590	0,58	100% Claystone, as above. Sm.am. Limestone, white; Siderite or Dolonite; light grey Siltstone, some micaceous; Pyrite.
K 4309	2610	0,61	98% Claystone, some silty, grey, some brownish, slightly micaceous, some redbrown, yellow, calcareous 2% Siderite or Dolonite, (light) yellowbrown. Sm.am. Pyrite; Limestone, white.

TABLE I

IKU No.	Depth	TOC	Lithology
K 4310	2620	0,47	100% Claystone, as above, some light grey.
K 4311	2630	0,56	100% Claystone, some silty, grey, brownish grey, slightly micaceous, variably calcareous, some redbrown, yellow. Sm.am. Siderite or Dolonite; Pyrite; Limestone, white.
K 4312	2640	0,47	100% Claystone, as above.
K 4313	2650	0,45	100% Claystone, some silty, grey, brownish grey, slightly micaceous, variably calcareous.
K 4314	2660	0,84	100% Claystone, as above, some dark grey (obs. shear planes). Sm.am. Siderite/Dolonite, as above; Pyrite; Limestone, white.
K 4315	2670	1,91 Dark clay 3,73 Light clay 0,42	Claystone, as above, dark grey (none-calcareous, shaly) (35%). Sm.am. Pyrite; Siltstone, white; Siderite/Dolonite.
K 4316	2680	5,43	65% Claystone, shaly, dark grey (shear planes). 35% Claystone, grey, brownish grey, calcareous. Sm.am. Siltstone, white, slightly glauconitic.
K 4318	2700	4,00	90% Claystone, (brownish) grey/dark grey (shaly) and grey Claystone grading to Siltstone. 10% Sand, fine, angular, glauconitic.
K 4319	2710	0,59	40% Claystone, grey and brownish grey (partly calcareous), some dark grey. 60% Sand and some Sandstone, fine to coarse, some glauconitic subangular-angular, white. Sm.am. Siltstone, light grey, sandy, glauconitic.
K 4320	2720	0,47	83% Nut shells 10% Sandstone, white, very fine to fine, some calcareous. 7% Claystone, grey.
K 4321	2730		65% Sand/Sandstone, white, fine to medium, subangular to angular obs. Chlorite.

TABLE I

IKU No.	Depth	TOC	Lithology
		0,70	20% Claystone, grey, calcareous, brownish grey, redbrown, dark grey, yellow. 15% Nut shells. Sm.am. Siltstone, light grey/white.
K 4322	2740		80% Sand/Sandstone, fine to medium, white but some reddish, angular to subangular.
		1,47	15% Claystone, grey (some dark, obs. light Silt-lamina) redbrown (grading to Siltstone) light greenish grey. Sm.am. Limestone, white. 5% Nut shells.
K 4323	2750		60% Sand/Sandstone, as above.
		0,37	25% Clay/Siltstone, as above.
		0,56	15% Claystone, silty, grey, some light greenish grey, browngrey. Sm.am. Limestone, white; Siderite or Dolonite; Pyrite; Nut shells.
K 4324	2760		53% Sand, white to redbrownish, as above, obs Chlorite.
		0,25	20% Claystone to Siltstone, redbrown, sandy, some micaceous.
		1,64	15% Claystone, silty, grey, browngrey, some light and dark grey. 10% Nut shells. 2% Limestone, white.
K 4325	2770		50% Sand/Sandstone, as above.
		0,49	25% Claystone, silty, grey, grey-brown, greygreen, dark grey.
		0,20	20% Clay/Silt-stone, as above. 2% Limestone, white. 3% Nut shells.
K 4326	2780		80% Sand, as above.
		0,93	10% Claystone, as above.
		0,75	10% Clay/Silt-stone. Sm.am. Limestone, white, brown.
K 4327	2790		65% Sand and some Sandstone, as above.
		0,45	15% Clay/Siltstone, as above.
		0,52	15% Claystone, as above. Sm.am. Limestone, white. 5% Nut shells.
K 4328	2800		75% Sand, as above.
		1,19	12% Claystone, grey, some brownish and light and dark grey.

TABLE I

IKU No.	Depth	TOC	Lithology
			8% Clay/Siltstone, as above. 5% Nut shells. Sm.am. Limestone, white.
K 4329	2810		60% Sand, as above, slightly micaceous.
		0,77	20% Claystone, grey, some brownish and dark (shaly).
		0,29	20% Clay/Siltstone, as above. Sm.am. Limestone; white; Nut shells.
K 4330	2820		75% Sand, as above, some coarse.
		0,64	13% Claystone, as above, some grading to clayey Siltstone (with small Coal-fragments).
		0,18	12% Clay/Silt-stone. Sm.am. Limestone, white.
K 4331	2830		25% Sand and Sandstone, fine to medium, some coarse, redbrown to white,angular to subangular.
		0,70	40% Claystone, silty, grey, browngrey, some greenish and dark, partly calcareous.
		0,24	30% Claystone to Siltstone, redbrown, occasionally sandy, some micaceous. 5% Nut shells. Sm.am. Limestone, white; Pyrite.
K 4332	2840		60% Sand, as above.
		0,77	20% Claystone, as above.
		0,12	20% Silt/Claystone, as above.
K 4333	2850		50% Sand/Sandstone, very fine to medium, as above.
		1,60	25% Claystone, as above.
		0,12	25% Clay/Siltstone, as above. Sm.am. Limestone, white.
K 4334	2860		70% Sand/Sandstone, as above, some micaceous.
		1,72	15% Claystone, as above.
		0,12	15% Clay/Siltstone, as above.
K 4335	2870		70% Sand/Sandstone, as above.
		1,20	15% Claystone, silty, grey, some brownish, greenish, dark.
		0,12	15% Clay/Siltstone, as above. Sm.am. Limestone, white.
K 4336	2880		60% Sand/Sandstone, very fine to medium, some coarse, as above.
		1,16	25% Claystone, silty, grey, some brownish, dark grey (black), yellow.
		0,11	15% Claystone to Siltstone, as above. Sm.am. Limestone, white.

IKU No.	Depth	TOC	Lithology
K 4337	2890	0,46	85% Claystone, silty, grey and red-brown (some micaceous, grading to Siltstone sandy), browngrey, dark grey, some yellow, partly calcareous. 15% Sand/Sandstone, as above. Sm.am. Limestone, white; Siltstone, white. Sm.am. Limestone; white; Siltstone, white; obs white Salt.
K 4338	2900	0,59	85% Claystone, as above. 15% Sand/Sandstone, white to redbrown as above. Sm.am. Limestone, white; ?cryst rock frag. grey to clear, hard/brittle.
K 4339	2910	0,99	85% Claystone, as above. 15% Sandstone and Sand, very fine to fine, medium, white, redbrown. Sm.am. Limestone, white; obs.? Salt, clear; ?cryst rock fragments, as above; Salt, white, loose.
K 4340	2920	1,08	85% Claystone, silty, grey and red-brown (grading to Siltstone, some micaceous), dark grey, some brown-grey, green. 15% Sandstone/Sand, as above. Sm.am. Limestone; white, ?Salt; ? Crystalline rock fragments; Pyrite.
K 4341	2930	1,17	88% Claystone, as above. 10% Sandstone/Sand. 2% Limestone; clear ? Salt, with crystal faces, brittle; ?Crystalline rock fragments, clear to brownish grey.
K 4342	2940	0,79	80% Claystone, as above. 20% Sandstone/Sand, as above. Sm.am. Limestone; Pyrite; ?Crystalline brittle rock fragments, clear fragments (delvis strakte krystaller med striper) brittle.
K 4343	2950	0,76	85% Claystone, as above. 15% Sandstone and Sand, as above. Clear fragments, partly prismatic crystallized, brittle; clear coarse grains; white sucrosic ? Salt.
K 4344	2960	0,85	80% Claystone, as above. 17% Sand/Sandstone, as above, some coarse. 3% Limestone, white. Sm.am. obn. clear fragments with a prismatic crystallization, brittle.

TABLE I

IKU No.	Depth	TOC	Lithology
K 4345	2970	0,81	84% Claystone, as above. 10% Sand/Sandstone, fine to medium, coarse (clear). 3% Limestone. 3% Clear fragments, medium, coarse angular, partly prismatic crystallisized.
K 4346	2980		20% Sand (?), very angular/angular, very clear, coarse to very coarse.
		0,68	80% Claystone, as above. 3% Limestone. Sm.am. Sand/Sandstone, very fine to medium.

IKU

T A B L E : II

WEIGHT OF EOM AND CHROMATOGRAPHIC FRACTIONS

IKU-No	DEPTH (m)	Rock Extr. (s)	EOM (mg)	Sat. (mg)	Aro. (mg)	HC (mg)	Non HC (mg)	TOC (%)
K-4289	2410	99.8	28.3	5.4	3.2	8.6	19.7	1.4
K-4290	2520	29.8	12.3	1.7	.8	2.5	9.8	.1
K-4301	2530	35.4	14.9	3.5	1.0	4.5	10.4	1.0
K-4315	2670	50.2	53.3	8.8	1.2	10.0	43.3	1.9
K-4316	2680	62.6	45.6	6.7	3.9	10.6	35.0	5.4
K-4318	2700	47.7	33.1	8.5	.1	8.6	24.5	4.0
K-4337	2890	92.8	13.7	1.6	1.3	2.9	10.8	.5
K-4341	2930	58.9	12.9	1.3	1.2	2.5	10.4	1.2
K-4344	2960	49.6	16.7	2.4	1.6	4.0	12.7	.9
K-4345	2970	57.7	30.1	6.5	3.5	10.0	20.1	.8

IKU

T A B L E : III

CONCENTRATION OF EOM AND CHROMATOGRAPHIC FRACTIONS

(Weight ppm of rock)

IKU-No	DEPTH (m)	EOM	Sat.	Aro.	HC	Non HC
K-4289	2410	284	54	32	86	197
K-4290	2520	413	57	27	84	329
K-4301	2530	421	99	28	127	294
K-4315	2670	1062	175	24	199	863
K-4316	2680	728	107	62	169	559
K-4318	2700	694	178	2	180	514
K-4337	2890	148	17	14	31	116
K-4341	2930	219	22	20	42	177
K-4344	2960	337	48	32	81	256
K-4345	2970	522	113	61	173	348

IKU

T A B L E : IV

CONCENTRATION OF EOM AND CHROMATOGRAPHIC FRACTIONS

(mg/g TOC)

IKU-No	DEPTH (m)	EOM	Sat.	Aro.	HC	Non HC
K-4289	2410	20.3	3.9	2.3	6.2	14.1
K-4290	2520	412.8	57.0	26.8	83.9	328.9
K-4301	2530	42.1	9.9	2.8	12.7	29.4
K-4315	2670	55.9	9.2	1.3	10.5	45.4
K-4316	2680	13.5	2.0	1.2	3.1	10.4
K-4318	2700	17.3	4.5	.1	4.5	12.8
K-4337	2890	29.5	3.4	2.8	6.3	23.3
K-4341	2930	18.3	1.8	1.7	3.5	14.7
K-4344	2960	37.4	5.4	3.6	9.0	28.4
K-4345	2970	65.2	14.1	7.6	21.7	43.5

IKU

T A B L E : V.

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-4289	2410	19.1	11.3	30.4	168.7	69.6	43.7
K-4290	2520	13.8	6.5	20.3	212.5	79.7	25.5
K-4301	2530	23.5	6.7	30.2	350.0	69.8	43.3
K-4315	2670	16.5	2.3	18.8	733.3	81.2	23.1
K-4316	2680	14.7	8.6	23.2	171.8	76.8	30.3
K-4318	2700	25.7	.3	26.0	8500.0	74.0	35.1
K-4337	2890	11.7	9.5	21.2	123.1	78.8	26.9
K-4341	2930	10.1	9.3	19.4	108.3	80.6	24.0
K-4344	2960	14.4	9.6	24.0	150.0	76.0	31.5
K-4345	2970	21.6	11.6	33.2	185.7	66.8	49.8

TABLE VI

TABULATION OF DATAS FROM THE GASCHROMATOGRAMS

IKU No.	Depth (m)	Pristane/nC_{17}	Pristane/Phytane	CPI
K-4289	2410	0,93	2,11	1,43
K-4290	2420	0,88	2,17	1,81
K-4301	2530	0,44	1,36	0,90
K-4315	2670	2,01	2,03	1,18
K-4316	2680	0,77	1,71	1,04
K-4318	2700	1,35	1,44	1,50
K-4337	2890	1,12	2,08	1,51
K-4341	2930	0,94	1,45	0,80
K-4345	2970	0,53	1,55	1,17

TABLE VII

VITRINITE REFLECTANCE MEASUREMENTS.

IKU No.	Depth (')	Vitrinite reflectance			Fluorescence	Exinite content
K-4289	2410'	0,39 (21)			yellow/orange	trace
K-4301	2530'	0,34 (12)			yellow and yellow/orange	low
K-4306	2580'	0,33 (3)			yellow/orange	trace
K-4311	2630'	0,37 (1)	0,65 (1)		yellow/orange	trace
K-4315	2670'	0,42 (3)			yellow and yellow/orange	moderate-rich
K-4317	2690'	0,27 (2)	0,47 (3)	0,68 (1)	yellow and yellow/orange	moderate
K-4319	2710'	0,42 (8)			yellow/orange	low
K-4322	2740'	0,33 (4)			yellow and yellow/orange	trace
K-4323	2750'	0,33 (10)			yellow/orange and light orange	moderate
K-4328	2800'	0,39 (6)			light orange	trace
K-4331	2830'	0,43 (10)	0,65 (1)		light orange	low
K-4336	2880'	0,30 (1)	0,54 (2)		yellow and yellow/orange	trace
K-4338	2900'	0,41 (13)			yellow/orange	low
K-4343	2950'	0,39 (21)			yellow/orange and light orange	moderate-rich
K-4346	2980'	0,38 (20)			hydrocarbon specks	wil

TABLE VIII

IKU / Depth in m.	Well 8/10-2 Phillips — Composition of residue	VISUAL KEROGEN ANALYSIS — Particle size	Preservation -palynomorphs	Thermal maturation index	Remarks (Trondheim 1980)
2500	Am/He, WR! (coaly)	F	good	1+, 1+/2-	Pyrite, sapropelization, sapropel embeds palynomorphs of the interval 2500 to 2540m
2520	Am,Cysts/Poll-spor,He,Cut,W,WR!	F-M	good	1+/2-	
2540	Am/He	F	good	1+/2-	
2580	Am,Cysts/WR! (coaly)	F-M	good	1+/2-	Acid resistant minerals.
2640	Am/He,WR! (coaly)	F	good	1+/2-	" " rich in darkly stained cysts
2670	Am,Cysts/WR! (coaly),W	F-M	fair to good	1+/2-	Sapropel aggregates embed palynomorphs
2690	WR! (coaly), W/Am.	F-M	fair to good	1+/2-	2690 m - 2710 m very rich in coalified wood probably reworked. Small residues.
2710	WR! (coaly), He/Am	F-M	fair to good	1+/2-	
2740	Am,Cysts/Cut,W,He,Pollen	F-M-L	fair to good	1+/2-	Acid resistant minerals
2750	Cut,He,W,WR! (coaly),Pollen/Am	F-M-L	fair to good	1+/2-	
2800	He,WR! (coaly),Pollen/Am	F-M-L		1+/2-	Caved material and occasionally mud additives were recorded in this interval 2800 m to 2980 m.

IKU	Well 8/10-2 Phillips	VISUAL KEROGEN ANALYSIS			(Trondheim 1980)
Depth in m.	Composition of residue	Particle size	Preservation -palynomorphs	Thermal maturation index	Remarks
2840	Cut,WR! (coaly),He/Am,Cysts	F-M-L		1+/2- 2-	
2880	Am/WR! (voaly),Cut,He,Poll-spor	F-M	fair	1+/2-	Triassic pollengrains observed, but mainly caved palynomorphs.
2900	Cut,He,WR! (coaly),Poll-spor/Am	F-M		1+/2- 2-	Rich in acid resistant minerals.
2950	Am ?	F		1+/2- 2-	
2980	Am ?	F		1+/2- 2-	

Am	amorphous	F	fine
He	herbaceous	M	medium
Cut	cuticles	L	large
W	woody		
R!	reworked		

TABLE IX

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-4289	2410 m	0,23	1,59	2,67	1,43	111,89	186,7	1,82	0,13	437°
K-4290	2420 m	0,06	0,05	1,04	0,84	5,95	123,81	0,11	0,55	439°
Limestone										
K-4291	2430 m	0,27	0,98	1,04	1,13	86,73	92,04	1,25	0,22	430°
K-4301	2530 m	0,14	0,61	1,41	1,03	59,22	136,89	0,75	0,19	435°
K-4303	2550 m	0,12	0,86	1,70	1,21	71,07	140,50	0,98	0,12	429°
K-4304	2560 m	0,07	0,01	1,20	0,45	2,22	266,67	0,08	0,88	445°
K-4306	2580 m	0,05	-	1,54	0,61		252,46			430°
K-4309	2610 m	0,05	-	1,90	0,61		311,48			434°
K-4311	2630 m	0,05	-	1,30	0,56		213,11			433°
K-4314	2660 m	0,18	1,32	2,25	0,84	157,14	267,86	1,50	0,12	432°
K-4315	2670 m	0,10	4,14	1,73	1,91	216,75	90,58	4,24	0,02	433°
Claystone										
K-4316-1	2680 m	0,64	32,26	1,65	5,43	594,11	30,39	32,40	0,02	428°
Claystone										
K-4316-2	2680 m	0,08	0,39	1,50	0,68	57,35	220,59	0,47	0,17	419°
Brownish, grey clay-stone										

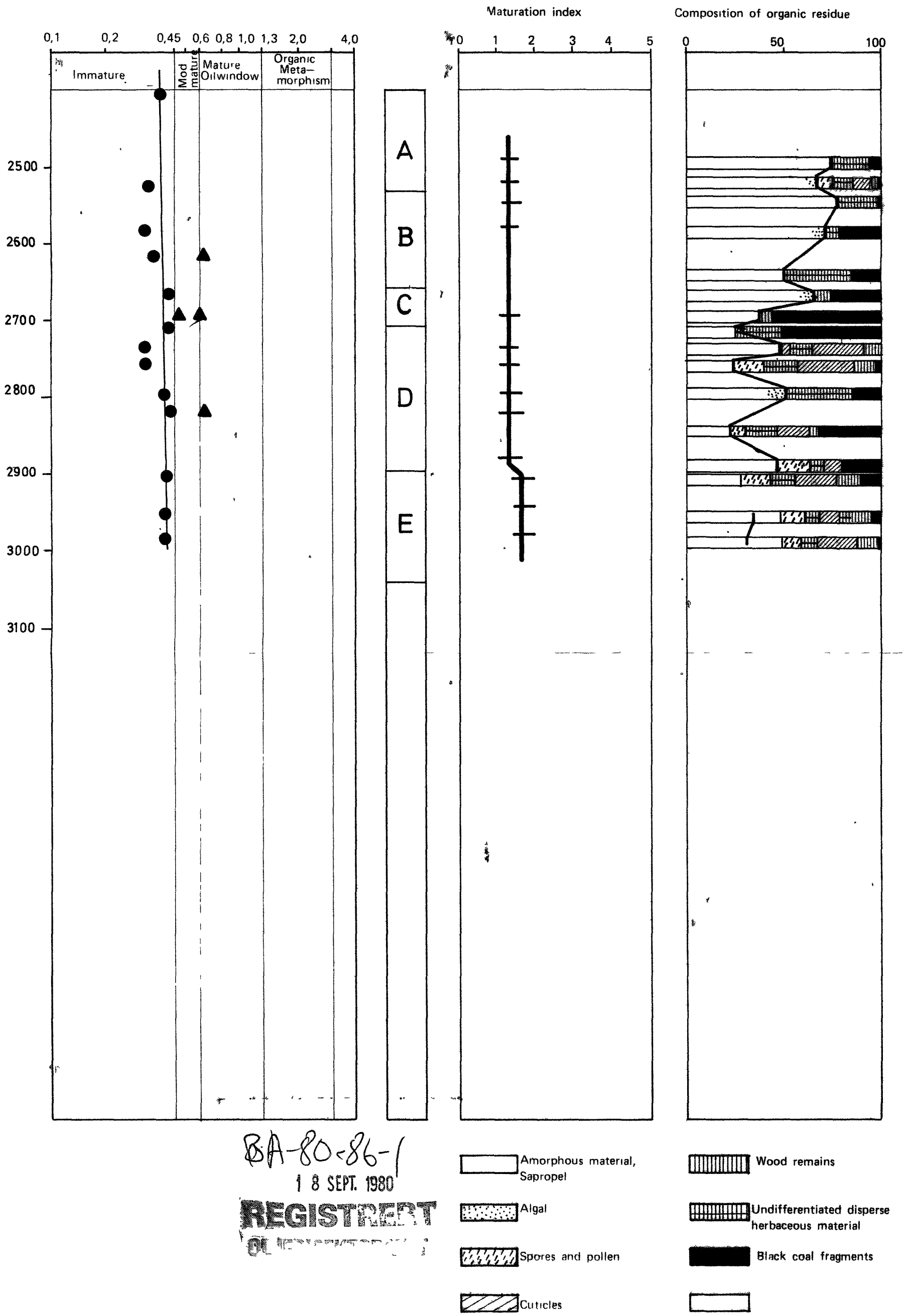
TABLE IX

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-4317	2690 m	0,39	19,02	1,87	3,99	476,69	46,87	19,41	0,02	432°
K-4318	2700 m	0,5	17,5	1,5	4,00	437,5	37,5	18,0	0,03	431°
K-4319	2710 m	0,10	1,08	1,22	0,59	183,05	206,78	1,18	0,08	434°
K-4321	2730 m	0,05	0,57	1,89	0,70	81,43	270,-	0,62	0,08	432°
K-4322	2740 m	0,04	1,22	2,36	1,47	82,99	160,54	1,26	0,03	433°
K-4324-1 Clay/Silt-stone	2760 m	0,02	0,04	1,53	0,25	16,-	612,-	0,06	0,33	435°
K-4324-2 Claystone	2760 m	0,11	2,07	1,46	1,64	126,22	89,02	2,18	0,05	434°
K-4326-1 Claystone	2780 m	0,05	0,69	2,30	0,93	74,19	247,31	0,74	0,07	433°
K-4326-2 Clay/Silt-stone	2780 m	0,06	0,42	1,89	0,75	56,-	252,-	0,48	0,13	428°
K-4328	2800 m	0,15	1,27	1,40	1,19	106,72	117,65	1,42	0,11	434°
K-4329	2810 m	0,05	0,16	2,77	0,64	25,-	432,81	0,21	0,24	438°
K-4331	2830 m	0,08	0,42	2,28	0,70	60,-	325,71	0,50	0,16	426°
K-4332	2840 m	0,01	0,05	2,52	0,77	6,49	327,27	0,06	0,17	434°
K-4333	2850 m	0,05	1,66	2,07	1,60	103,75	129,38	1,71	0,03	433°

TABLE IX

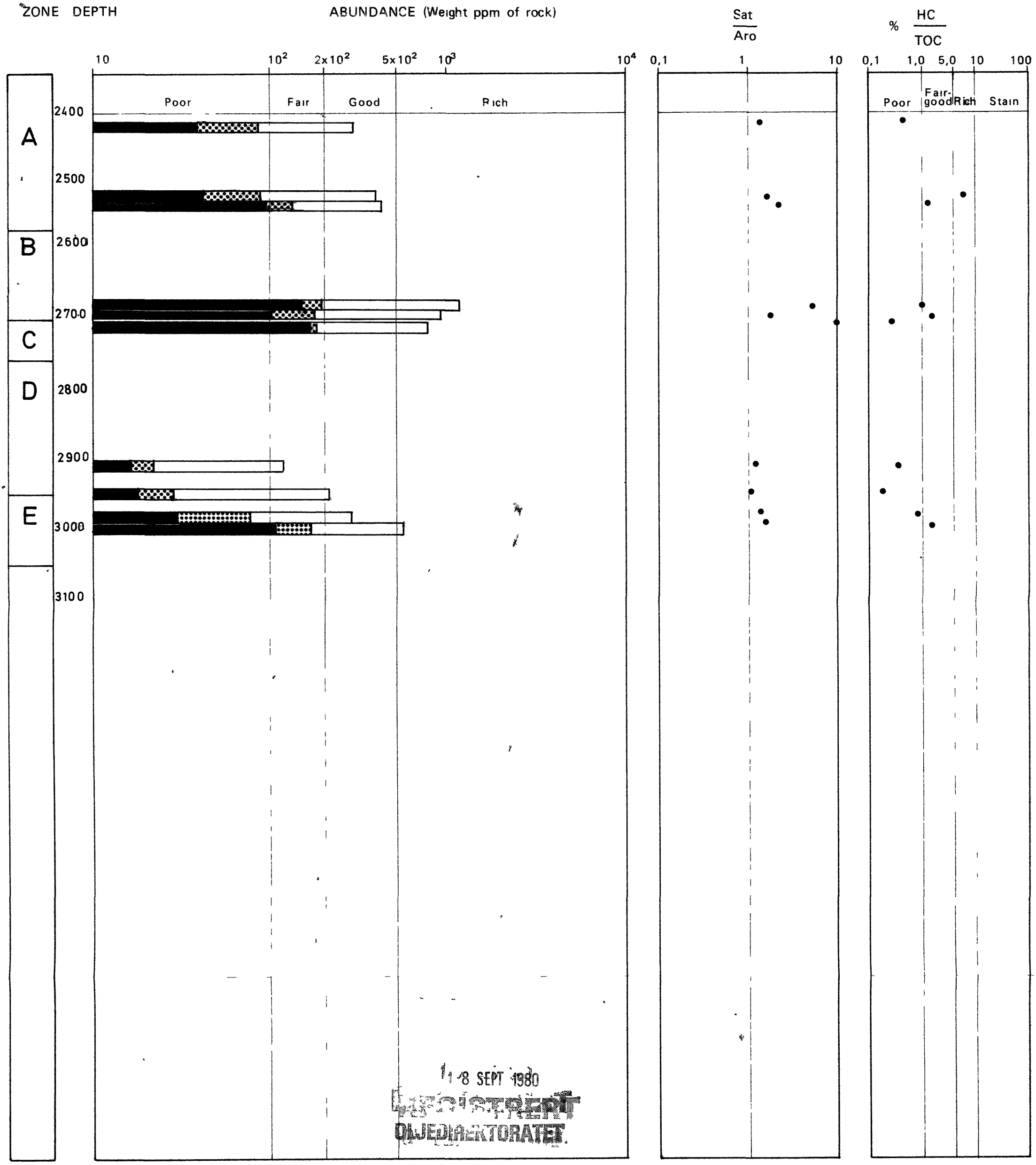
Sample	Depth	S_1	S_2	S_3	C_{org}	Hydrogen Index	Oxygen Index	Oil of gas content ($S_1 + S_2$)	Production Index $\frac{S_1}{S_1 + S_2}$	T_{max} °C
K-4334	2860 m	0,11	2,16	2,90	1,72	74,48	168,60	2,27	0,05	435°
K-4335	2870 m	0,11	0,78	2,16	1,20	65,-	180,-	0,89	0,12	436°
K-4336	2880 m	0,09	0,76	1,81	1,16	62,52	156,03	0,85	0,11	436°
K-4337	2890 m	0,09	0,16	1,48	0,46	34,78	321,74	0,25	0,36	437°
K-4338	2900 m	0,08	0,29	2,40	0,59	49,15	406,78	0,37	0,22	437°
K-4339	2910 m	0,08	0,78	2,67	0,99	78,79	269,70	0,86	0,09	438°
K-3430	2920 m	0,08	0,67	2,00	1,08	62,04	185,19	0,75	0,11	437°
K-4341	2930 m	0,08	0,93	2,15	1,17	79,49	183,76	1,01	0,08	436°
K-4342	2940 m	0,07	0,36	1,58	0,79	45,57	200,-	0,43	0,16	435°
K-4343	2950 m	0,07	0,29	2,64	0,76	38,16	347,37	0,36	0,19	434°
K-4344	2960 m	0,08	0,32	1,45	0,85	37,65	170,59	0,40	0,20	436°
K-4345	2970 m	0,04	0,34	2,95	0,81	41,98	364,20	0,38	0,11	432°
K-4346	2980 m	0,07	0,27	2,71	0,68	39,71	398,53	0,34	0,21	435°

MATURATION



C_{15}^{+} HYDROCARBONS

Presentation of Analytical Data

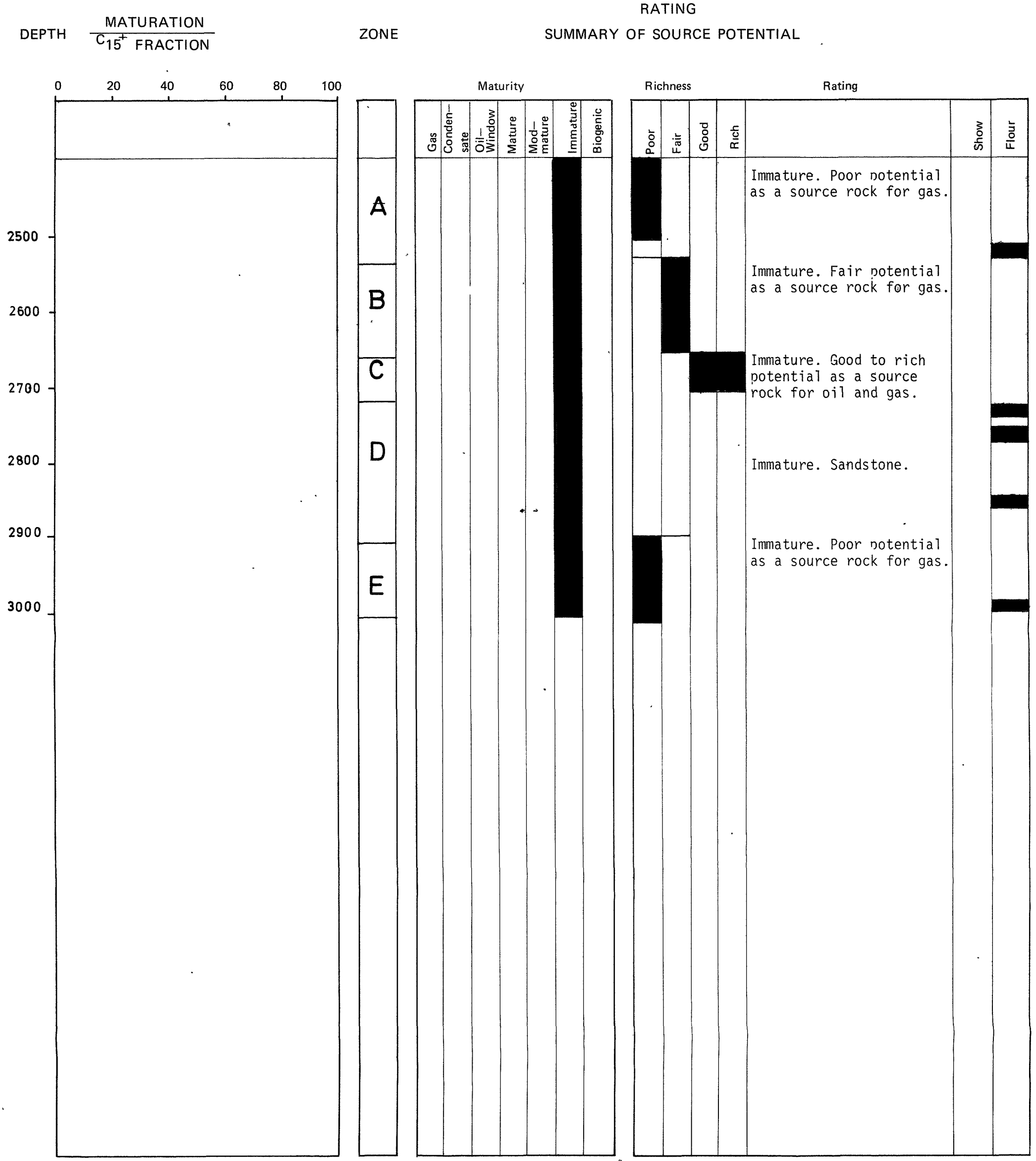


Sat Saturated Hydrocarbons
Aro. Aromatic Hydrocarbons
NSO Nitrogen, Sulphur and Oxygen containing compounds

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

8/10-2

INTERPRETATION DIAGRAM



● % $\frac{\text{Sat}}{\text{EOM}}$ ○ % $\frac{\text{HC}}{\text{EOM}}$

Sat· Saturated Hydrocarbons
HC. Hydrocarbons
EOM Extractable Organic Matter

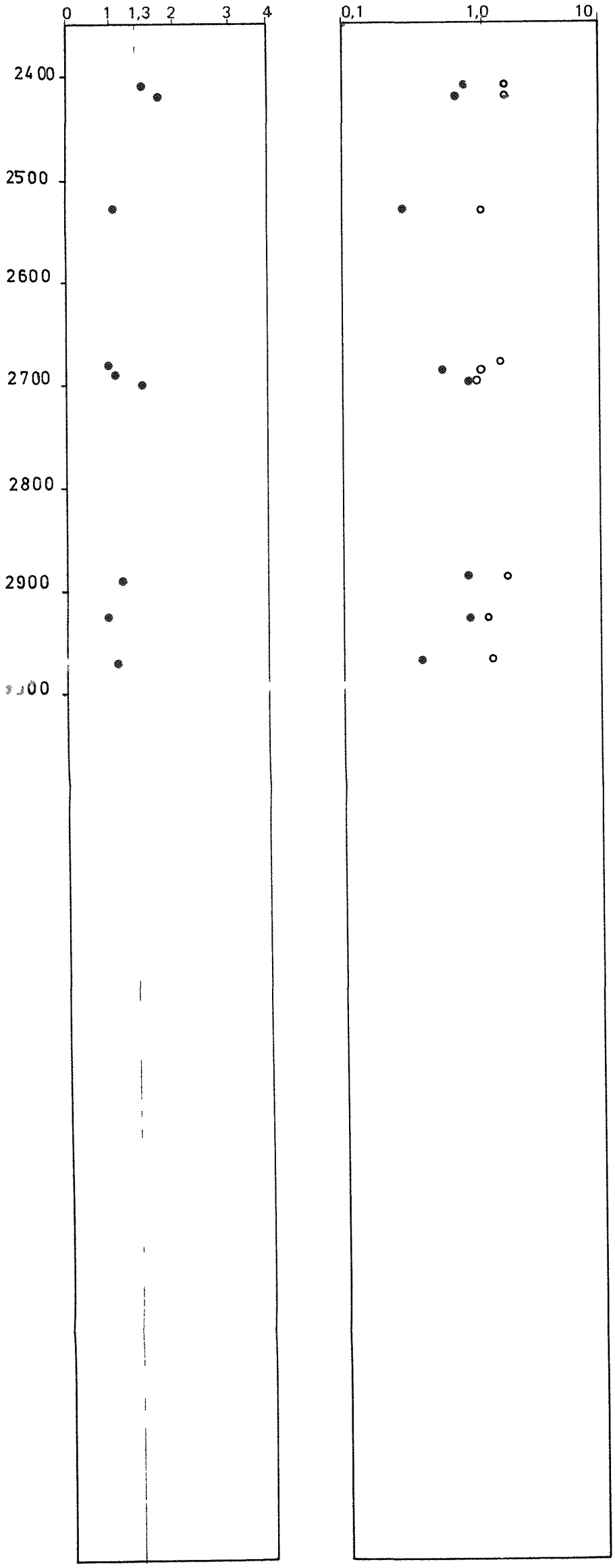
C_{15}^{+} SATURATED HYDROCARBONS

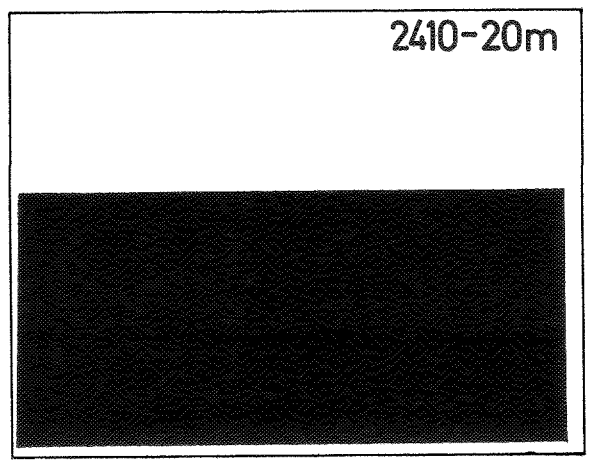
DEPTH

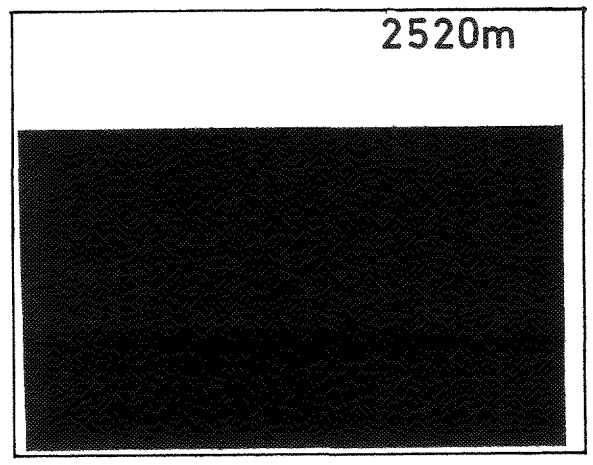
CPI

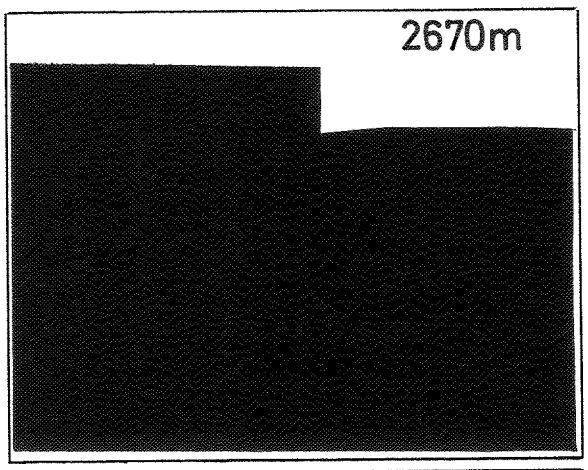
● PRISTANE / $n^{C}17$

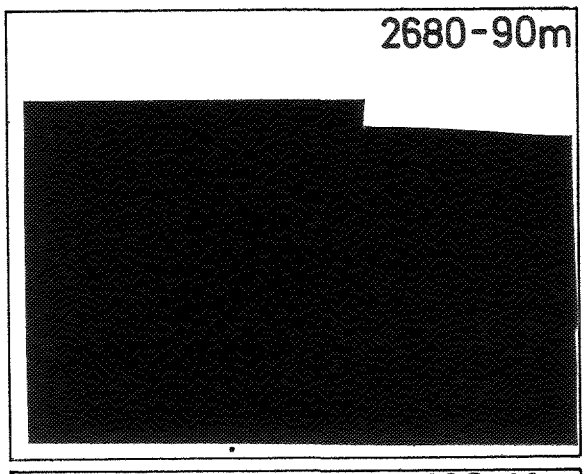
○ PRISTANE / PHYTANE

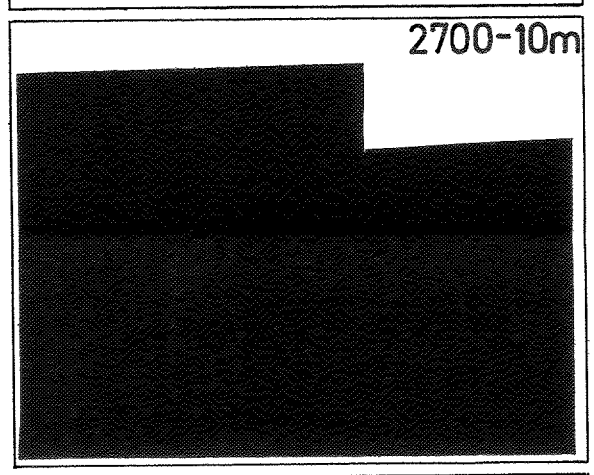


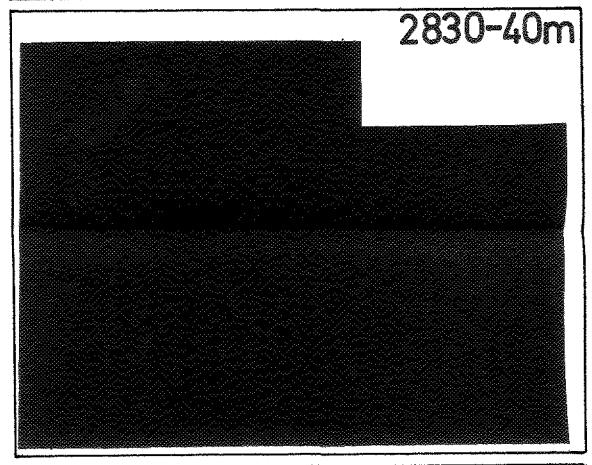


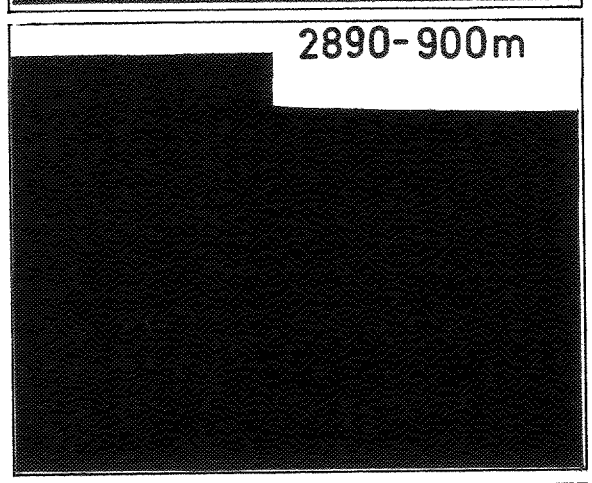


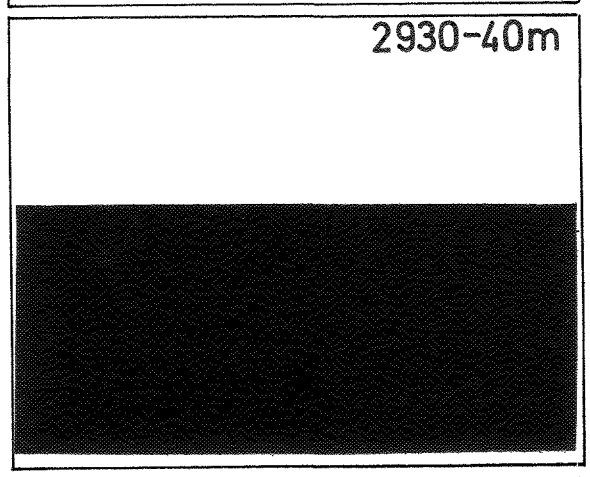


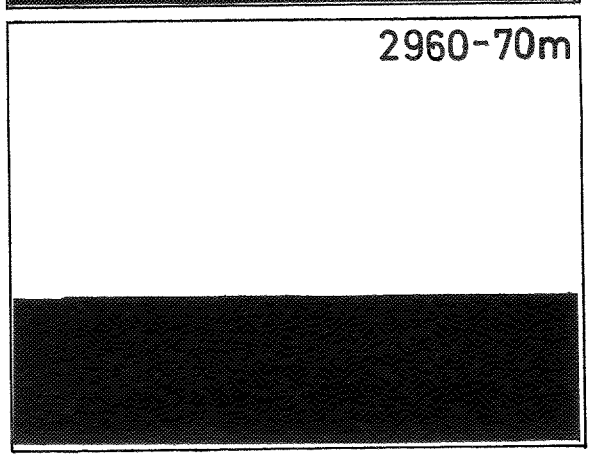


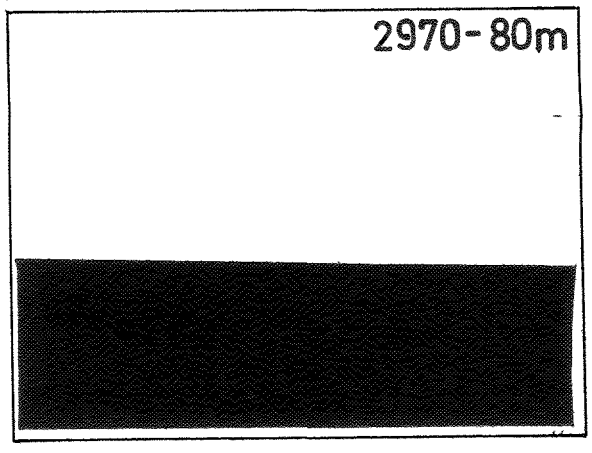












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TOTAL ORGANIC CARBON (TOC)

Presentation of Analytical Data