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REPORT TITLE

Source Rock Analyses of well 17/12-3

CLIENT

Philips Petroleum, Norway

CLIENT's REF.:	REPORT NO.:
Mr. Chumahusky	0-262/1/80

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AUTHOR (S):	DATE:	PROJECT NO.:
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SUMMARY:

See next page.

KEY WORDS

Source Rock

Based on total organic carbon values and lithology, the analysed sequense is divided into thirteen zones.

Zones A,B,C,D,E,F,G and H, 1200 - 2100 m are all immature with a poor potential as a source rock for oil and gas. Free HC in siltstones in zone B and C (1300 - 1560 m).

Zone I, 2100 - 2240 m: Moderate mature, good potential as a source rock for gas (oil).

Zone J, 2240 - 2300 m : Moderate mature, rich potential as a source rock for oil and gas.

Zone K and L, 2300 - 2640 m : Mature (oilwindow). Rich potential as source rocks for gas.

Zone M: 2640 - 2720 m: Poor potential as source rock for gas.

Maturity studies indicate a break of succession at approximately 2300 m. Due to problem with cavings, maturity is uncertain for the lower 400 m. Some readings indicate oilwindow maturity.

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^{0}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 reflectanc 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	

<u>NOTE</u> 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 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.

Based on the lithological variations and the organic carbon measurements on the various lithologies the analysed sequence of the well is divided into thirteen zones.

A: 1250 - 1300 m.
B: 1300 - 1510 m.
C: 1510 - 1560 m.
D: 1580 - 1640 m.
E: 1640 - 1670 m.
F: 1670 - 1710 m.
G: 1730 - 1910 m.
H: 1910 - 2100 m.
I: 2100 - 2240 m.
J: 2240 - 2300 m.
K: 2300 - 2500 m.
L: 2500 - 2640 m.
M: 2650 - 2720 m.

Total Organic Carbon (TOC).

Total organic carbon was measured on all the samples, except sandstone samples, from 1250 m. Where more than one lithology was found in the samples, TOC was measured on each lithology which was found to be 10% or more of the whole sample.

Zone A: 1250 - 1300 m: This zone contains some chalk, which was not measured since it is assumed that it is cavings. The TOC of the claystone in the zone varies considerably, 1.1 - 3.5 %.

Zone B: 1300 - 1510 m: The majority of the samples from this zone contain a large proportion of cement. The rest of the material in the samples is mainly siltstone, which is believed to be the true lithology for the zone. Siltstone cuttings were picked and analysed for organic carbon. The TOC of the upper three samples drops sharply with increasing depth (1.6 - 0.6 % TOC, Table 1), then increases slowly with increasing depth down to 1510 m. The TOC values for most of the zone are 1 % or higher, which is high for siltstones. Coal is not recorded in the samples, and it is therefore assumed that the high TOC values might be due to migrated hydrocarbons.

Zone C: 1510 - 1560 m: At 1520 m the TOC values increase sharply to 2.8 %, and this coincides with a change in lithology to calcareaus siltstone. The samples from both zones B and C were of rather poor quality.

Zone D: 1580 - 1640 m. Another zone with very poor quality samples. Only a few samples contain enough material to do organic carbon analyses. Most of the samples contained only mud additives. The few samples measured were claystone samples with organic carbon values in the 1.7 - 1,9 % region.

Zone E: 1640 - 1670 m: The TOC values increase sharply at 1640 m to 2.6 %. The quality of the samples are also found to be better than in the zone above.

Zone F: 1670 - 1710 m: Again a zone with mainly claystone, and the TOC values are found to be similar to the one measured in zone D.

Zone G: 1730 - 1910 m: At 1730 m, the lithology changes to siltstone. The TOC values on these samples are found to be in the 0.5 - 1.0 % range. Some of the samples were of such a poor quality that organic carbon was not measured.

Zone H: 1910 - 2100 m: At 1920 m the TOC value increases sharply to 1.7 %. The next sample is again found to have a TOC value below 1 % but a steady increase in the TOC values are recorded with increasing depth. The whole zone is found to have a siltstone lithology.

Zone I: 2110 - 2240: This zone consists mainly of claystone, and again a steady increase in the TOC values are recorded with increasing depth from 1.6 - 2.6 %.

Zone J: 2240 - 2300 m: At 2250 m a sharp increase is seen in the TOC values to 6.3 %. This high TOC value is found throughout the whole zone.

Zone K: 2300 - 2500 m: At 2300 m, the TOC value again drops to 3.4 %, and TOC values of 2.6 - 3.6 % are found for most of the claystone samples in this zone. Some of the samples contain coal cuttings, and contamination of small coal particles onto the claystone cuttings might give too high values.

Zone L: 2500 - 2640 m: From approximately 2500 m, a large proportion of siltstone with variable TOC values, are again found in the samples and the interval 2500 - 2640 m is separated out due to this.

Zone M: 2650 - 2720 m: From 2650 m, a red claystone is found in the samples together with a grey claystone. The red claystone is believed to be the true lithology and the zone is separated from the zone above due to this.

Extraction and Chromatographic Separation.

A large proportion of the samples was not suitable for extraction mainly due to being very small quantities and containing a large percentage of mud additives. Due to this no samples were extracted from the middle part of the well, 1300 - 2100 m. This part contains thick siltstone sequences with high TOC values, and it would have been valuable for the final interpretation of the well with 3 - 5 extractions, and therby detailed analyses of the hydrocarbons in the samples.

A: One sample, 1270 - 1300 m, from this zone was extracted showing a good abundance of extractable hydrocarbons. The percentage of saturated hydrocarbons compared to the aromatic hydrocarbons is very high for this sample. The gas chromatogram of the saturated hydrocarbon fraction shows a large unresolved envelope in the nC_{76} - nC_{32} region and only negligible amounts of n-alkanes, clearly indicating bacteriological activity. nC_{15} - nC_{20} are, however, larger than what would be expected for such a sample, and it is believed that the sample might be contaminated with diesel.

Zone I: One sample, 2150 - 70 m, from this zone was extracted, showing a good abundance of extractable hydrocarbons and again sat/aro ratio is rather high. The HC/TOC ratio is however very low, showing that this sample only contains small amounts of hydrocarbons compared to the amount of organic carbon in the sample. The gas chromatogram of the saturated hydrocarbon fraction is typical for an immature terrestrial sample with a large pristane/nC_{17} ratio and high CPI value. The large amount of compounds in the sterane/triterpane region also indicate a terrestrial origin of the organic matter.

Zone J: Two samples 2266 m and 2280-90 m, from this zone were extracted and found to have a rich abundance of extractable hydrocarbons, and again the sat/aro ratio is high. The HC/TOC ratio is, however, larger in both these samples compared with the sample from zone I. The gas chromatograms of the two saturated hydrocarbon fractions differ slightly, mainly in the heavy hydrocarbon region. The sample from 2260 m has a less pronounced sterane/triterpane assemblage together with less pronounced heavy n-alkanes and a lower CPI value. These gas chromatograms indicate that the sample from 2260 m is derived from amorphous kerogen while the one from 2280 - 2290 m is from a terrestrial origin.

Zone K: Four samples, 2310 - 30 m, 2380 - 90 m, 2430 - 50 m and 2460 - 80 m, from this zone were extracted. The two uppermost and the lowermost samples show a fair/good abundance of extractable hydrocarbons while the sample from 2430 - 50 m has a rich abundance of extractable hydrocarbons. Similar pattern is seen when the HC/TOC ratio is studied. It is also noticeable how the sat/aro ratio drops sharply in the lowermost sample compared to those above. The gas chromatograms of the saturated hydrocarbon fractions vary slightly from sample to sample. The uppermost sample 2310 - 30 m is similar to the lowermost sample in the zone above with pronounced steranes/triterpanes and a large CPI value. The next sample 2380 - 90 m also have pronounced steranes/triterpanes but with a lower CPI value than the sample above. The most striking difference is however in the pristane/nC_{17} ratio which is lower than in the abovelying samples. In the next sample, 2430 - 50 m, the pristane/nC_{17} ratio is again large, but now the steranes/triterpanes are far from as pronounced as in the samples above. The CPI value is, however, still large. The lowermost sample in this zone, 2400 - 80 m is found to have a gas chromatogram similar to the one of the sample from 2430 - 50 m.

Zone L: Two samples, 2580 - 2600 m and 2620 - 40 m, from this zone were extracted and found to have a good/rich and good abundance of extractable hydrocarbons respectively. The gas chromatograms of the saturated hydrocarbon fraction both show the same feature with high pristane/nC_{17} ratios, high CPI values and relatively small amounts of steranes/triterpanes.

Vitrinite Reflectance.

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

770 m: Calcareous shale, Ro=0.37(21).
The sample has a moderate organic content with variable bitumen staining. Some cuttings intense, otherwise intertinite and reworked particles are dominant with only a trace of vitrinite particles and wisps. UV light shows a yellow and yellow to orange fluorescence from spores and a low einite content.

930 m: Shale, Ro=0.40(16) and 0.65(1).
The sample contains a large amount of bitumen wisps, otherwise a low content of particles of inertinite and reworked material with about equal proportion of poor vitrinite particles. UV light shows a yellow fluorescence from spores and a low exinite content.

1070 m: Light shale, Ro=0.46(5).
The sample contains some bitumen staining and wisps, otherwise a very low content of reworked material and inertinite. Only a trace of poor vitrinite particles. UV light shows a yellow and yellow/orange fluorescence from spores and a low exinite content.

1190 m: Shale, Ro=0.32(20).
The sample has a low organic content with plentiful bitumen wisps and staining. A few particles of inertinite and reworked material with only a trace of vitrinite. UV light shows a yellow and yellow/ orange fluorescence from spore specks and a low einite content.

1250 m: Light shale, Ro=0.38(19).
The sample contains bitumen wisps and staining, otherwise a low content of small inertinite and reworked particles with only traces of poor vitrinite. UV light shows a yellow and yellow/ orange fluorescence from spores and hysterichospheres together with a low exinite content.

1290 m: Shale, Ro=0.39(20).
The sample has a moderate organic content with bitumen staining and wisps. About equal proportion of vitrinite particles and wispy particles

and inertinite and reworked particles. UV light shows a yellow and yellow/orange fluorescence from spores and hydrocarbon specks together with a low exinite content.

1340 m: Siltstone, Ro=0.39(20).
The sample shows a heavy bitumen staining, otherwise a moderate content of inertinite and reworked particles. Only trace of poor vitrinite and wispy particles. UV light shows a yellow/orange and light orange fluorescence from spores and hydrocarbon specks together with a low exinite content.

1400 m: Siltstone and carbonate, Ro=0.46(14).
The sample has a moderate organic content but almost wholly inertinite and reworked particles. Only a trace of true vitrinite particles. Some bitumen staining is recorded. UV light shows a yellow/orange and light orange fluorescence from spores and a low exinite content.

1500 m: Siltstone, shale and carbonate, Ro=0.37(20).
The sample has a moderate organic content, mostly particles of inertinite and reworked material. Only a trace of true vitrinite and some bitumen staining. UV light shows a yellow and light orange fluorescence from spores and hydrocarbon specks, together with a trace of exinite.

1620 m: Shale and carbonate, Ro=0.37(18) and Ro=0.54(3).
The sample has a moderate to rich organic content with a large amount of inertinite and reworked material with subordinate vitrinite particles and wispy particles together with bitumen staining. UV light shows a yellow and light orange fluorescence from spores and hydrocarbon specks, together with a low exinite content.

1690 m: Shale, siltstone and carbonate, Ro=0.41(20).
The sample has a low to moderate organic content with some bitumen staining and wisps, otherwise particles of reworked material and inertinite are dominant. A few vitrinite particles and wispy particles. UV light shows a yellow/orange fluorescence from spore specks and a trace of exinite.

1760 m: Limestone and subordinate shale, Ro=0.33(10).
Limestone: Some local bitumen staining and inertinite particles.
Shale: Moderate to rich in organic material with inertinite and reworked particles dominant. Only a trace of vitrinite particles. UV light shows a variable carbonate fluorescence and yellow spore specks together with a trace of exinite.

1850 m: Shale, Ro=0.38(15) and Ro=0.66(1).
The sample has a low organic content with a few particles of inertinite and reworked material with only a trace of vitrinite particles and occasional bitumen wisps. UV light shows a variable carbonate fluorescence and yellow/orange spore specks together with a trace of exinite.

1900 m: Shale and carbonate, Ro=0.46(19) and Ro=0.65(1).
The sample has a variable bitumen staining.
Carbonate: Low organic content with a few good vitrinite wisps and some inertinite particles.
Shale: Moderate content of inertinite and reworked material with traces of vitrinite. UV light shows a dull yellow/orange plus light orange fluorescence from spore specks together with a trace of exinite.

1990 m: Calcareous shale, Ro=0.36(20).
The sample has a low to moderate organic content with some bitumen wisps and staining. Inertinite and reworked particles are dominant. A few wisps particles of vitrinite are recorded. UV light shows a yellow/orange and light orange fluorescence from spores and a moderate exinite content.

2060 m: Shale, Ro=0.34(20).
The sample has a low organic content with bitumen staining and wisps. A few organic particles are recorded but almost entirely reworded material and inertinite. Only a trace of true vitrinite wisps. UV light shows a dull, light orange fluorescence from spores and a moderate exinite content.

2130 m: Shale, Ro=0.39(11).
The sample has a low organic content with bitumen staining and wisps, otherwise reworked and inertinite particles are dominant with only a trace of vitrinite particles. UV light shows a dull light orange fluorescence from spores and a moderate to rich exinite content.

2200 m: Shale, Ro=0.39(11).
The sample has a low to moderate organic content with bitumen wisps and staining. Particles of inertinite and reworked material are dominant. Only a trace of vitrinite particles. UV light shows a yellow to orange fluorescence from spores and a moderate to rich exinite content.

2240 m: Shale, Ro=0.44(8).
The sample has a low organic content apart from considerable bitumen wisps and staining. Particles of inertinite and reworked material with only traces of true vitrinite particles. UV light shows a yellow/orange fluorescence from spores and a moderate to rich exinite content.

2270 m: Shale, Ro=0.38(21).
The sample shows an intense bitumen staining and wisps, otherwise moderate content of inertinite particles with subordinate vitrinite wispy particles. UV light shows a yellow to orange and light orange fluorescence from spores and hydrocarbon specks together with a moderate to rich exinite content.

2340 m: Shale, Ro=0.45(20).
The sample has a moderate organic content with variable bitumen staining cutting to cutting, sometimes intense. Inertinite and reworded particles are dominant. Only a trace of vitrinite wisps and particles, generally associated with bitumen rich cuttings. UV light shows a light orange fluorescence from spores and a moderate exinite content.

2400 m: Coal and shale, Ro=0.53(25).
The coal is rather dirty, with about equal proportions of inertinite and vitrinite. The shale has a slight bitumen staining and inertinite particles. UV light shows a light orange and dull mid.orange fluorescence from spores and a moderate exinite content.

2460 m: Shale and coal, Ro=0.48(24).
Coal: Inertinite rich, rather dirty.
Shale: Some good vitrinite wisps and stringers together with inertinite particles and bitumen staining. UV light shows a light to mid.orange fluorescence from spores and a moderate exinite content.

2530 m: Shale, Ro=0.38(20).
The sample is moderate to rich in organic material with an overall bitumen staining. Particles of inertinite and reworked material are dominant. Only a trace of vitrinite particles and wispy particles. UV light shows a yellow/orange and light orange fluorescence from spores together with a moderate to rich exinite content.

2554 m: Coal and Carbargillite, Ro=0.54(16) and Ro=0.75(14).
The sample is rich in organic material, mostly coal fregments. The carbargillite is mainly rich in internite. The cuttings are heavily brecciated and badly oxidieed. UV light shows a light and mid. organe fluorescence from spores, algae and cuticles and a moderate exinite content.

2600 m: Shale, Ro=0.47(20).
The sample is moderate to rich in organic material with heavy bitumen staining and wisps. Some good vitrinite wisps and stringers with about equal proportion of inertinite and reworked particles. UV light shows a light orange fluorescence from algae and mid. orange spores, together with a moderate exinite content.

2670 m: Shale, Ro=0.38(21).
The sample contains bitumen wisps and staining, otherwise a moderate organic content where inertinite and reworked particles are dominant. Subordinate vitrinite wispy particles. UV light shows a yellow/orange and light orange fluorescence from spores and a moderate to rich exinite content.

2720 m: Grey and red shale, Ro=0.40(22).
Red shale: Barren.
Grey shale: Bitumen impregnation, rich in inertinite and good vitrinite wisps and particles. UV light shows a light orange fluorescence from algae and mid. orange spores together with a moderate exinite content.

The vitrinite reflectance measurements show a low maturity gradient down to approximately 2300 m. The readings from 2300 m downwards are very uncertain due to cavings. It is believed that the measurements at 2400 m may be on true material, while the next two are on caved material. The sample from 2554 m is mainly coal, which shows two distinct different readings. The lower one Ro=0.54 is believed to be on cavings while the higher value Ro=0.75 is believed to be on true material. This would then indicate a steeper gradient from 2400 m downwards than what was found in the upper part of the well. It also indicates that there is a break in succesion around 2300 m. The extrapolation taken for the lower 400 m of the well is highly tentative. Side wall cores in this interwall will probably solve this problem.

Visual Kerogen Evalution

The total acid insoluble residues from 27 samples between 770 m and 2710 m were investigated for evaluation of kerogen composition and colour of the organic remains.

On the basis of kerogen composition we distinguish three main intervals. The residues between 770 m and 2350 m are representing marine deposits which may be further subdivided on the basis of a more detailed study of their plant remains. From 2370 m to 2610 m we find an interval with varied types of terrestrial material. At 2670 m and below, the residues contain a mixture of marine and terrestrial remains, most of which is thought to be derived from caved material. A minor part are fairly dark coaly fragments suggested to be indigenous or reworked.

In our interpretation of colours the term immature has be connected with colour indices 2- and below. Accordingly all samples down to 2230 m are immature.

770 m:
The residue is dominated by sapropel which also embeds dinoflagellate cysts, and tends to form aggregates.

Colour index: Indeterminate, immature (1+)

930 m to 1250 m:
The residues are rich in undissolved minerals. The organic material is dominantly amorphous. Screening reveals rich dinoflagellate cyst assemblages and some dark coal particles.

Colour index: 1+/2-

1290 m to 1910 m:
The rock samples contained very little material. Acid resistant minerals dominate the residues before separation. Mud additives (walnut) and material thought to be caved are present in the organic residues. Oxidized residues contain amorphous material as well as coal particles, probably reworked, as dominant elements. From 1850 m the oxidized residues reflect more deltaic conditions.

Colour index: 1+/2-

1990 m to 2230 m:
Amorphous material dominates, and partly forms aggregates. Dinoflagellate cysts, indeterminate finely dispersed herbaceous material and coaly particles form minor elements.

Colour index: 1+/2-

2270 m and 2350 m:
Sapropel dominates, indeterminate herbaceous material is found in small amounts. This interval is distinguished from the samples above because of the finely dispersed material (no aggregates) and because of the increase in coalification.

Colour index: 2

2410 m to 2610 m:
The unscreened residues contain variable amounts of sapropel which could be from caved. material. After oxidation typically deltaic assemblages remain and are dminated by woody (coaly) material. Cuticles, indeterminate harbaceous material as well as spores and pollen occur in variable amounts and are well preserved. Some sapropelization has taken place and fungal hyphae as well as fungal spores were observed.

Colour index: 2

2670 m and 2710 m:
Sapropel dominates the total residues as well as the chemically oxidized samples, but the main part is believed to be derived from caved material. Black coal fragments, are particularly abundant at 2710 m, and probably represent reworked material.

Colour index: Indeterminated

Rock-Eval Pyrolysis.

Forty nine samples were pyrolysed on a Rock-Eval instrument, Table IX. The samples from the upper part of the well did not give sharp S_2 peaks, and the maximum temperatures T_{max}, are therefore unreliable, i.e. to high.

The samples from zone A have low hydrogen and high oxygen indeces, typical for type III kerogen. The samples from zones B and C are mainly siltstone. These samples have high S_1 peaks and therby high production indeces, indicating free hydrocarbons in the samples.

The samples from zones D, E and F are again claystone. The hydrogen indeces are low for all of these samples indicating type III kerogen. Some of the samples have large S_1 peaks indicating free hydrocarbons.

Zones G and H are siltstone samples. The S_1 peak and the production index is far lower for these samples compared to the samples from zones B and C, indicating a far lower degree of free hydrocarbons in the samples. The hydrogen index indicate these samples to be type III kerogen.

The claystone samples in zone I show slightly higher hydrogen indeces than in the zones above, but they are still too low to be classified as kerogen type II. It might be a mixture of marine and terrestrial kerogen. When the results are plotted, most of these samples are found to be located between the graphs for type III and type II kerogen.

The analysed samples from zone J do, however, show hydrogen and oxygen indeces typical for type II kerogen with hydrogen indeces in the 500 region and oxygen indeces in the 25 region.

The samples from zone K and L have similar values to those from zone I, intermediate between kerogen type II and kerogen type III. Samples in this interval are often classified as in the coal zone (Madec, IFP, Private Comm). The only sample which might be classified as type II kerogen in these two zones is the sample from 2580 m.

Samples from zone M were not analysed on the Rock-Eval instrument.

Rock-Eval measurements do also give a maturity parameter, by monitoring the T_{max} of the S_2 peak. As mentioned above, the samples from the upper part of the well did not give sharp S_2 peaks, and the T_{max} values are therefore unreliable. From approximately 2100 m, the S_2 peaks are sharp and the T_{max} reliable. The analyses show that down to approximately 2400 m, the samples are immature, i.e. $T_{max} < 430^oC$, while the samples from 2400 m downwards are mature.

CONCLUSION.

Based on lithological variations and total organic carbon measurements (TOC) the analysed sequence of the well was divided into thirteen zones.

A: 1250 - 1300 m.
B: 1300 - 1510 m.
C: 1510 - 1560 m.
D: 1580 - 1640 m.
E: 1640 - 1670 m.
F: 1670 - 1710 m.
G: 1730 - 1910 m.
H: 1910 - 2100 m.
I: 2100 - 2240 m.
J: 2240 - 2300 m.
K: 2300 - 2500 m.
L: 2500 - 2640 m.
M: 2650 - 2720 m.

Samples in the upper part of the well were of very poor quality, almost wholly mud additives. Due to this, the detail analyses in this part of the well are few.

In the rating of the various zones, total organic carbon measurements, extraction and chromatographic separation, and Rock-Eval measurements are used in determining the richness of zones. The maturity is determined from the vitrinite reflectance measurements, fluorescence in UV light, the colour of kerogen in transmitted light and Rock-Eval pyrolysis. The type of kerogen is determined by visual examination in transmitted light plus Rock-Eval pyrolysis.

Based on these measurements the well is found to be immature down to 2100 m and moderate mature down to approximately 2300 m. At approximately 2300 m the various maturity measurements indicate a break of succession. In this interval, i.e. below 2300 m, there were a lot of caved material and the results are uncertain. However, the various readings indecate oil window maturity from approximately 2400 m.

In the evaluation of the type of kerogen, Rock-Eval measurements and visual kerogen examination gave different indications in the upper 2100 m of the well. Rock-Eval pyrolyses indicate type III kerogen while visual examination shows the samples to contain mainly amorphous kerogen. Vitrinite reflectance measurements show samples in this interval to contain a large proportion of reworked material. This will distort the result. The reworked particles will not show up as a large proportion in the visual kerogen examination, while it will completely distort the Rock-Eval measurements.

Based on these results and the various richness parametres the following rating as given.

Zones A-H, 1200-2100 m are all immature with a poor potential as source rocks for oil and gas. Free hydrocarbons are registered in the siltstone in zones B and C. It is not differentiated between the siltstone and claystone in this evaluation due to the extensive reworking recorded. This, together with the free hydrocarbons have greatly increased the TOC values recorded. It is believed that the "true" kerogen will be a source for oil and gas, while it is mainly reworking which give the type III reading on the Rock-Eval instrument.

Zone I, 2100-2240 m, has a slightly higher maturity than the abovelying zones and a far higher richness potential. Both Rock-Eval pyrolysis and visual kerogen examination agree that this zone will mainly produce gas. The zone is therefore rated to have a good potential as a source rock for gas (oil).

Zone I, 2240-2300 m, is found to be moderate mature with a rich potential as a source rock for oil and gas. This was the only zone which gave typical kerogen type II readings on the Rock-Eval instrument.

Zone K and L, 2300-2640 m, are both found to have far higher maturity than the zones above, tentatively set to oilwindow maturity, due to problems with cavings and oxidation. Both zones are found to have rich potentials as source rocks for gas.

In zone M, 2650 - 2720 m, typical red beds are encountered, and this zone is rated to have a poor potential as a source rock for gas.

A B B R E V I A T I O N S

ab = above
abn = abundant
ang = angular

bd = bedded
Biot = Biotite
Biv = Bivalve
bl = blue
blk = black
brit = brittle
brn = brown

C = Coal
Calc = Calcite
calc = calcareous
carb = carbonaceous
Cgl = Conglomerate
Chk = Chalk
Chl = Chlorite
Cht = Chert
Cl = Clay
cl = clayey
Clst = Claystone
cmt = cement
conc = concretion
cont = contorted
conv = convolute
crs = coarse
crm = cream
cryst = crystalline

dk = dark
dns = dense
Dol = Dolomite
dol = dolomitic
downw = downwards
dsk = dusky

Ech = Echinoid

f = fine
fib = fiberous
fis = fissile
Fld = Feldspar
frag = fragment
fri = friable
Foram = Foraminifera
Fos = Fossils

Gast = Gastropode
glac = glacial

Glc = Glauconite
glc = glauconitic
gn = green
Gran = Granules
Gr = Granite
grd = graded
grns = grains
Gvl = Gravels
gvl = gravelly
gy = grey
Gyp = Gypsum

h = horrisontal
hd = hard
hom = homogenious

ig = igneous
Ill = Illite
incr = increasing
intbd = interbeded
irreg = irregular

Koal = Kaolin

lam = laminated
Lig = Lignite
lig = lignitic
lith = lithhic
lns = lens(es)
low = lower
Ls = Limestone
lt = light

m = medium
mass = massive
matr = matrix
met = matamorphic
mdst = mudstone
mic = micaceous
mid = middle
Mrl = Marl
mrl = marly
mtl = mottled
Musc = Muscovite

nod = nodular

obs = observed
occ = occasional(ly)
olv = olive
Ool = oolite
ool = oolitic
orng = orange
otherw = otherwise

pa = pale
Pbl = Pebbles
pk = pink
plast = plastic
predom = predominant
purp = purple
Pyr = Pyrite
pyr = pyritic

Qtz = Quartz
qtz = quartzitic

red = red(dish)
rk = rock
rnd = rounded

S = Sand
sd = sandy
sc = scattered
Sch = Schiststone
sft = soft
Sh = Shale
Sid = Siderite
sks = slickenside
Slt = Silt
slt = silty
Sltst = Siltstone
sm.am. = small amounts
sph = sphericity
spic = spicules
srt = sorted
Sst = Sandstone
strgs = strings
Styl = Stylolite
suc = sucrose
surf = surface

text = tecture
Tf = Tuff
tf = tuffaceous
trsl = translucent
trsp = transparent

v = vertical
viol = violet
vn = vein
vy = very

w = with
wckst = wackestone
wh = white

yel = yellow

Examples of quantitative expressions: (for silt)
(slt) - slightly silty, slt - moderately silty, slt - very silty

TABLE I

Depth	TOC	Lithology	
1250		50%	Chk
	1.71	40%	gy, gn and brn Clst, some slt
		5%	chert
1260		50%	Chk
	3.54	45%	lt gy-gy-gybrn Clst, some slt
		5%	dk gy slt Clst
1270		50%	Chk w Glc
	1.11	37%	slt gy, gn and brn Clst
		10%	Glc
1280	2.14	50%	some calc gyviol slt Clst
		30%	Chk, some w Glc
		15%	lt gy-lt gn calc Clst
1290	1.63	55%	gyviol slt Clst as ab
		10%	gy-gn-brn-pk some slt Clst
		10%	chalk w (Glc)
		20%	Glc
1300	2.49	80%	gyviol slt Clst as ab
		9%	Chk with and without Glc
		5%	lt gy calc Clst
		5%	Glc
1320	-	100%	cement
		Obs	dk gy slt Clst
1330	-	50%	cement
	1.63	25%	dk gy-gyviol sd and cl Sltst
		15%	gy Sltst w Musc and Glc S
		15%	intrusive rock fragments w pyroxene and clinizoi-site phenocrystals

Depth	TOC	Lithology
1340		30% cement
	1.04	50% porous gy calc Sltst w Musc and Glc S
		10% Musc
1350		35% cement
	0.62	35% gy sd Sltst w Sid?, Musc and Glc
		10% gy-gyviol cl Sltst
		20% intrusive rock fragments as ab
1360	0.73	90% gy sd Sltst w Musc and Glc
		5% cement
1370	0.83	70% sd ltst w unorientated Musc as ab
		20% cement
		5% intrusive rock fragments as ab
1380	0.90	60% sd Slts as ab
		30% Glc
		10% cement
1390		50% Glc
		30% gy-gyviol sd Sltst as ab
		5% intrusive rock fragments
1400	1.05	80% sd Sltst as ab , carb
		19% Glc
1410	1.00	30% gy-gyviol sd Sltst as ab
		60% Glc
1420	1.10	45% calc carb gy sd Sltst
		45% Glc
		5% cement

TABLE I cont..

Depth	TOC	Lithology
1430	1.02	20% sd Sltst as ab
		75% Glc
1440	1.17	90% calc carb glc gy Sltst w Musc S
		5% Glc
1450	0.96	40% gy sd Sltst as ab
		40% Glc
		10% intrusive rock fragments
1460	1.31	87% sd Sltst as ab
		10% Glc
1470	-	50% sd Sltst as ab
		50% Glc
1480	1.27	95% sd Sltst and Sltst as ab
1490	0.96	70% sd Sltst as ab w Glc and Musc
		20% Glc
		10% Pyr
1500	1.43	95% gy and dk gy (calc) Sltst and calc sd Sltst
1510	1.32	40% gy sd Sltst
		10% Glc
		5% gy Ls
		20% nut shells
1520	2.83	50% gy Sltst and some sd Sltst as ab
		30% nut shells
		5% cement

TABLE I cont..

Depth	TOC	Lithology
1530	-	70% nut shells etc.
		10% Glc
		10% Pyr
		5% gy porous sd Sltst w Glc
		5% gy Ls
1540	2.52	60% lt gy porous glc sd calc Sltst
		10% calc sid brownish and greyish Ls
		20% nut shells
1550	0.82	20% (calc) yelbrn sid Ls
		30% Calc and sid? grains
		20% Pyr
1560	2.79	80% calc carb gy-dk gy mic (d) Sltst
		10% calc sid brn-dk brn Ls
		5% Pyr
		5% nut shells
1570	-	-
		A few grains of gy Calc-cemented rock w variable clastic content
1580	1.73	85% calc slt (sd) Clst
		5% wh Calc
		5% nut shells
1590	-	Coarse fraction as at 1570 m
		10% calc sid brn-lt brn Ls
		5% Pyr
1600	1.88	80% slt gy calc Clst
		5% gy Ls

TABLE I cont..

Depth	TOC		Lithology
1610	-	-	
		10%	yelbrn sid Ls as at 1550 m
		5%	Pyr
1620	-	97%	mud additives
1630	-	90%	mud additives
1640		80%	mud additives
	2.66	20%	gy-dk gy calc slt (sd) Clst
1650	2.40	50%	gy slt (sd) Clst
		5%	Pyr
1660	2.33	80%	lt gy-gy-dk gy slt carb Clst
		12%	nut shells
1670		50%	nut shells
	2.85	20%	gy-dk gy (lt gy) Clst w Musc Slt (S)
		15%	gr brn sid Ls
1680	1.72	85%	gy, redbrn some slt Clst
1690		30%	lt yelgy Ls
	1.66	20%	slt gy Clst
		25%	nut shells
1700	1.49	90%	mostly gy Clst, the darkest most silty (yelbrn)
1710		80%	mud additives
	1.64	10%	gy porous calc sd Sltst
		5%	sid?

TABLE I cont..

Depth	TOC	Lithology
1720	-	80% mud additives
		20% calc sltst.
1730	0.80	55% porous gy calc glc sd Sltst
		20% dk gy calc sd Sltst
		25% nut shells
1740	0.65	10% gy (calc) Sltst
		10% Pyr
		70% mud additives
1750	-	5% Pyr
		5% suc (calc) carbonate
		60% nut shells
		5% gy porous calc Sst/Sltst
1760		10% non-calc brn Clst
	1.06	10% gy porous calc Sst/Sltst
		60% nut shells
1770		10% gybrn (calc) Sltst
	0.88	20% gy Sltst/Sst w unorientated grains, calc
		10% Pyr
		60% nut shells
1780	-	30% gy porous calc Sltst/Sst
		10% brownish nearly non-calc Sltst
		10% Pyr
		20% nut shells
1790	2.18	60% porous gy calc Sltst/Sst with unorientated grains
		10% crs, m rnd Qtz S
		15% nut shells

T A B L E I cont...

Depth	TOC	Lithology
1800	0.90	20% gy porous calc Sltst/Sst
		25% rnd-subrnd crs, m-vy crs S
		5% gy-brownish Sltst
		20% nut shells
		10% Pyr
1810	-	20% gy porous calc Sltst/Sst
		10% crs, m-vy crs rnd S
		10% Pyr
		60% nut shells
1820	-	20% gy porous calc Sltst/Sst
		5% crs, m-vy crs rnd S
		10% Pyr
		60% nut shells
1830	-	30% gy porous calc Sltst/Sst
		10% S as ab
		15% Pyr
		40% nut shells
1840	0.77	60% calc gy Sltst w Musc S
		10% Pyr
		10% nut shells
1850	0.75	15% gy sd nearly non-calc Sltst
		80% nut shells
		5% Pyr
1860	0.55	65% gy calc Sltst w vy f S
		30% nut shells
1870	0.55	75% gy Sltst as ab
		20% nut shells
		5% Pyr

TABLE I cont..

Depth	TOC	Lithology
1880	0.55	70% gy Sltst as ab 5-10% Pyr 25% nut shells
1890	0.55	65% cl gy calc Sltst w vy f s 5-10% Pyr 30% nut shells
1900	0.51	70% cl Sltst as ab 20% nut shells 10% Pyr
1910	0.60	75% cl Sltst as ab, but poor in calcite 15% nut shells 10% Pyr
1920	1.76	75% cl Sltst as ab 15% nut shell 5-10% Pyr
1930	0.75	75% cl Sltst as ab 15% nut shells 5-10% Pyr
1940	0.92	80% cl Sltst as ab 10% nut shells 10% Pyr
1950	0.82	90% gy cl and sd Sltst 5% Pyr 5% nut shells
1960	0.81	90% gy Sltst 5% nut shells 5-10% Pyr

TABLE I cont..

Depth	TOC	Lithology
1970	0.88	85% gy cl and sd Sltst, some calc 5-10% Pyr 5-10% nut shells
1980	0.91	Sltst as ab
1990	1.28	Sltst as ab
2000	1.15	Sltst as ab
2010	1.19	Sltst as ab 5% brn (calc) slt Clst
2020	1.42	85% lt gy-gy-dk gy Sltst w shell fragments 10% nut shells
2030	1.04	90% gy cl Sltst w shell fragments
2040	1.57	lt gy-gy-dk gy Sltst as ab
2050	0.81	85% gy cl Sltst as ab 5% suc brn carbonate w Sid? 5% brn (calc) Clst
2060	1.53	gy cl Sltst as ab
2070	1.29	gy cl Sltst as ab
2080	1.69	gy cl Sltst as ab
2090	1.63	gy cl Sltst as ab
2100	1.63	gy cl Sltst as ab

T A B L E I cont..

Depth	TOC	Lithology
2110	1.90	gy slt Clst nearly without Musc f S
2120	1.77	95% gy slt Clst without Musc S
2130	1.59	Clst as ab
2140	2.02	Clst as ab
2150	2.55	97% gy fis slt Clst
2160	2.36	Clst as ab
2170	2.61	95% lt gy-gy-dk gy fis slt Clst
2180	2.36	95% Clst as ab
2190	2.20	80% Clst as ab
	0.93	15% calc gy Sltst w unorientated f S
2200	1.91	80% gy-dk gy slt fis Clst
	1.00	20% lt gy-gy porous Sltst w unorientated f S
2210		-
2220	2.30	90% Clst as ab
	0.71	10% Sltst as ab
2230	2.21	90% Clst as ab
		10% Sltst as ab, Glc
2240	2.59	99% dk gy (fis) slt Clst
2250	6.28	99% Clst as ab

TABLE I cont..

Depth	TOC	Lithology
2260	6.91	80% Clst as ab 20% gy (fis) slt Clst
2270	6.47	80% Clst as ab 19% gy (fis) slt Clst
2280	5.82	95% gy-dk gy slt (fis) Clst w some C 5% tuff w intercalated lenses of kaolinite
2290	6.07	100% Clst as ab
2300	3.44	79% Clst as ab 20% nut shells
2310	2.58	Clst as ab
2320	2.65	99% Clst as ab
2330	2.37	Clst as ab
2340	3.45	100% gy-dk gy (fis) slt Clst
2350	3.19	100% Clst as ab
2360	3.46	100% Clst as ab
2370	3.76	100% gy-dk gy slt Clst-cl Sltst
2380	3.44	98% gy-dk gy slt Clst
2390	3.63	95% dk gy-gy slt Clst and cl Sltst 5% lt gy f Sst
2400	5.58	87% C 10% gy-dk gy non-fis slt Clst

TABLE I cont..

Depth	TOC		Lithology
2410		87%	C
	10.67	10%	gy slt Clst
2420	3.44	85%	gy-dk gy slt Clst
		10%	gy cl Sltst
		5%	C
2430	3.68	92%	gy-dk gy-blk slt Clst and cl Sltst
2440	4.22	85%	gy-dk gy, gn, blk, brn slt Clst and cl Sltst
		10%	wh f Sst
		5%	C
2450	3.39	80%	Sltst, Clst as ab
		5%	Sst as ab
		5%	C
2460	3.72	60%	slt Clst and cl Sltst as ab
		25%	lt brn waxy Sltst
		10%	C
		5%	Sst as ab
2470	2.72	60%	Clst and Sltst as ab
		25%	waxy Sltst as ab
		10%	C
2480	3.84	50%	gy-dk gy-dk brn-blk slt Clst and cl Sltst
		25%	lt brn waxy Sltst
		20%	f-m Qtz/Fld Sst
2490	4.17	40%	dk gy-dk brn slt Clst and cl Sltst
	0.45	30%	lt brn waxy Sltst
		30%	f-m, crs wh Sst

T A B L E I cont..

Depth	TOC		Lithology
2500	2.44	70%	gy slt Clst, gy, brn, blk Sltst
		30%	ang - subang f-m, crs wh Sst
2510	2.24	45%	gy-dk gy cl Sltst
		15%	lt brn waxy Sltst
		40%	f-m wh Sst
2520	2.53	20%	gy-dk gy cl Sltst
		10%	lt brn waxy Sltst
		68%	f-m-crs wh Sst
2530	2.61	38%	lt brn waxy, brn, gy and dk gy non-fis slt Clst and cl Sltst
		60%	f-m wh Sst
2540	1.72	40%	gy-dk gy cl Sltst
		20%	lt brn waxy Sltst
2550	4.35	24%	gy-dk gy carb Sltst and Sh
		15%	lt brn waxy Sltst
2560	-	99%	C
2570	-	70%	C and carb Sh and Sltst
		10%	gy-dk- gy-waxy lt brn cl Sltst
2580	7.48	50%	C and gy-dk gy-blk carb Sh and Sltst
		15%	gy, lt brn cl Sltst
2590	7.85	70%	C and lt brn-gy-dk gy-blk carb Sh and (sd) Sltst
2600	4.87	40%	C and gy-dk gy-blk carb Sh and Sltst
		30%	gy-waxy lt brn cl Sltst

TABLE I cont..

Depth	TOC	Lithology
2610	-	50% gy-dk gy-blk carb Sh and Sltst and some C
		20% brn carb Clst w Musc Slt and vy f S
		20% gy-lt brn waxy cl Sltst
2620	3.69	60% gy-dk gy-lt brn slt carb Clst
2630	2.71	As above
		Some yelgn Clst, some carb Sltst, some C
2640	-	Little material
		Dried pk sd Cl
		gy Sltst w Musc S
		gy-red Clst
2650	3.20	50% lt gy-gy-dk gy (slt) Clst
	0.77	25% carb Sh and C
		10% red (slt) Clst interlayered w lt gy Clst
		5% lt brn Clst
2660	0.18	50% red flamy calc (slt) Clst
	2.03	35% lt gy-gy-dk gy Clst, some C
2670	4.28	70% lt gy-gy-dk gy (slt, carb) Clst
	0.22	25% red calc Clst
2680	1.54	50% red calc (slt, flamy) Clst
		10% gy slt Clst
2690	0.20	35% red (slt, sd) Clst
	3.10	15% gy (carb) Clst
2700	0.19	50% dk red calc (slt, sd, flamy) Clst
	4.12	20% gy-dk gy-lt gn-lt brn (slt, sd) Clst and some C

TABLE I cont..

Depth	TOC	Lithology
2710	0.16	25% dk red slt (sd) Clst
	3.22	15% gy-carb dk gy (lt brn, lt gn) (slt) Clst
2720	0.19	40% dk red calc (slt, sd) Clst
	2.83	10% lt brn waxy-gy-dk-gy-gn (slt) Clst

TABLE II

WEIGHT (mg) OF EOM AND CHROMATOGRAPHIC FRACTIONS

Depth	Rock extracted (g)	EOM (mg)	Sat. (mg)	Aro. (mg)	HC (mg)	Non HC (mg)	TOC
1270+90+1300m	55,0	30,7	15,5	4,0	19,5	11,2	1,35
2150+60+70m	82,0	72,7	18,8	7,0	25,8	46,9	9,50
2260m	88,0	194,4	56,8	18,8	75,6	98,8	8,17
2280+90m	69,0	146,9	36,2	14,1	50,3	96,6	7,02
2310+20+30m	90,0	39,0	11,1	5,1	16,2	22,8	2,69
2380+90m	100,0	51,4	15,2	8,6	23,8	27,6	3,61
2430+40+50m	96,0	70,3	51,6	14,2	65,8	4,5	3,65
2460+70+80m	80,0	46,0	6,7	9,6	16,3	29,7	2,85
2580+90+2600m	37,0	49,0	8,6	10,6	19,2	29,8	2,42
2620+30+40m	23,0	13,1	3,5	2,3	5,8	7,3	2,99

TABLE III

CONCENTRATION OF EOM AND CHROMATOGRAPHIC FRACTIONS (Weight ppm of rock)

Depth	EOM	Sat.	Aro.	HC	Non HC
1270+90+1300m	558	282	73	355	204
2150+60+70m	887	229	85	315	572
2260m	2210	645	214	859	1123
2280+90m	2129	525	204	729	1400
2310+20+30m	433	123	57	180	253
2380+90m	514	152	86	238	276
2430+40+50m	732	538	148	685	47
2460+70+80m	575	84	120	204	371
2580+90+2600m	1324	232	286	519	805
2620+30+40m	570	152	100	252	317

TABLE IV

CONCENTRATION OF EOM AND CHROMATOGRAPHIC FRACTIONS (mg/g TOC)

Depth	EOM	Sat.	Aro.	HC	Non HC
1270+90+1300m	41	21	5	26	15
2150+60+70m	9	2	1	3	6
2260m	27	8	3	11	14
2280+90m	30	7	3	10	20
2310+20+30m	16	5	2	7	9
2380+90m	14	4	2	7	8
2430+40+50m	20	15	4	19	1
2460+70+80m	20	3	4	7	13
2580+90+2600m	55	10	12	21	33
2620+30+40m	19	5	3	8	11

TABLE V

COMPOSITION IN % OF THE MATERIAL EXTRACTED FROM THE ROCK

Depth (m)	Sat / EOM	Aro / EOM	HC / EOM	Sat. / Aro.	Non HC / EOM	HC / Non HC
1270+1290+1300	50	13	64	388	36	174
2150+60+70	26	10	35	269	65	55
2260	29	10	39	302	51	77
2280+90	25	10	34	257	66	52
2310+20+30	28	13	42	218	58	71
2380+90	30	17	46	177	54	86
2430+40+50	73	20	94	363	6	1462
2460+70+80	15	21	35	70	65	55
2580+90+2600	18	22	39	81	61	64
2620+30+40	27	18	44	152	56	80

TABLE VI

TABULATION OF DATAS FROM THE GASCHROMATOGRAMS

Depth (m)	Pristane/nC_{17}	Pristane/Phytane	CPI
1270 - 1300			NDP
2150 - 70	2.31	1.49	2.1
2260	1.57	1.02	1.1
2280 - 90	1.70	1.24	1.7
2310 - 30	1.76	1.28	1.6
2380 - 90	1.20	1.42	1.5
2430 - 50	2.63	1.97	1.7
2460 - 80	3.20	3.29	1.7
2580 - 2680	2.91	2.39	1.6
2620 - 40	2.54	2.86	1.6

TABLE VII

VITRINITE REFLECTANCE MEASUREMENTS

Depth (m)	Vitrinite reflectance	Fluorescence in UV light	Exinite content
770	0.37(21)	Yellow + yellow/orange (3+4)	Low
930	0.40(16), 0.65(1)	Yellow (3)	Low
1070	0.46(5)	Yellow + yellow/orange (3+4)	Low
1190	0.32(20)	Yellow + yellow/orange (3+4)	Low
1250	0.38(19)	Yellow + yellow/orange (3+4)	Low
1290	0.39(20)	Yellow + yellow/orange (3+4)	Low
1340	0.39(20)	Yellow/orange + light orange (4+5)	Low
1400	0.46(14)	Yellow/orange + light orange (4+5)	Low
1500	0.37(20)	Yellow - light orange (3-5)	Trace
1620	0.37(18), 0.54(3)	Yellow - light orange (3-5)	Low
1690	0.41(20)	Yellow/orange (4)	Trace
1760	0.33(10)	Yellow (3)	Trace
1850	0.38(15), 0.66(1)	Yellow/orange 4	Trace
1900	0.46(19), 0.65(1)	Yellow/orange + light orange (4+5)	Trace
1990	0.36(20)	Yellow/orange + light orange (4+5)	Moderate
2060	0.34(20)	Light orange (5)	Moderate
2130	0.39(11)	Light orange (5)	Moderate-rich
2200	0.39(11)	Yellow/orange (4)	Moderate-rich
2240	0.44(8)	Yellow/orange (4)	Moderate-rich
2270	0.38(21)	Yellow/orange + light orange (4+5)	Moderate-rich
2340	0.45(20)	Light orange (5)	Moderate
2400	0.54(25)	Light orange + dull mid. orange (5+6)	Moderate
2460	0.48(24)	Light - mid. orange (5+6)	Moderate
2530	0.38(20)	Yellow/orange + light orange (4+5)	Moderate-rich
2600	0.47(20)	Mid. orange (6)	Moderate
2670	0.38(21)	Yellow/orange + light orange (4+5)	Moderate-rich
2720	0.40(22)	Mid. orange (6)	Moderate

TABLE VIII

IKU	Well number 17/12-3	VISUAL KEROGEN ANALYSIS				
Code number	Sample depth	Composition of residue	Particle size	Presevation -palynomorphs	Thermal maturation index	Remarks (Trondheim 1980)
	770 m	Am Cysts (W)	F	G	1+	aggregates
	930 m	Am, Cysts/WR!	F	G	1+/2-	aggregates
	1070 m	Am, Cysts/WR!	F	G	1+/2-	aggregates
	1190 m	Am, Cysts/WR!	F	G	1+/2-	Sapropel recorded as aggregates
	1250 m	Am, Cysts/WR!	F	G	1+/2-	Sapropel recorded as aggregates
	1290 m	Am, Cysts/He, WR!	*			mud additives or cavings suspected
	1330 m	Am, Cysts/WR!	*	F-G	1+/2-	mud additives or cavings suspected
	1390 m	(Am)/WR!	*	-		Very small residue. Caved mat.
	1510 m	(Am)/WR!	*			Very small residue. Caved mat.
	1610 m	Am/He	*	-		Susp. caved mat. dom.
	1690 m	Am/W	*	-		
	1770 m	(Am)	*	NDP	NDP	Susp. caved mat.
	1850 m	Am/WR!	F	G		
	1870 m	Am/WR!	F	G		Caved mat. susp. Mud add.
	1910 m	Am/WR!	F	G		aggregates. Mud add.
	1990 m	Am, Cysts/He, WR!	F	G	1+/2-	
	2050 m	Am, Cysts/He, WR!	F	G		Sapropel as aggregates
	2130 m	Am, Cysts/He, WR!	F	G		Sapropel as aggregates
	2190 m	Am, Cysts/He, WR!	F-M	G		Sapropel as aggregates
	2230 m	Am, Cysts/He, Poll-spor, WR!	F-M	G		Sapropel as aggregates

TABLE VIII

IKU	Well number 17/12-3	VISUAL KEROGEN ANALYSIS				
Code number	Sample depth	Composition of residue	Particle size	Presevation -palynomorphs	Thermal maturation index	Remarks (Trondheim 1980)
	2270 m	He, Am	F	G	2	
	2350 m	Am, Cysts/He	F	F	2	
	2410 m	Am/He, W	F	G	2	Landderived mat. after ox.
	2470 m	Am/He, W, WR!	M	G	2	Hyphae of fungi
	2530 m	(Am) He, W, Poll-spor, Cy	M	G	2	Very small residue, caved mat. susp.
	2610 m	(Am) He	M		2	Very small residue, caved mat. susp.
	2670 m	(Am) He	M		2	Very small residue, caved mat. susp.
	2710 m	(Am) W?R	M		2 2/2+	Very small residue, caved mat. susp.

(Am) The amorphous material recorded 2410 m to 2710 m is believed mainly to be derived from caved material

* screened residues

TABLE IX

ROCK-EVAL PYROLYSES

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
1250m	0,21	1,75	0,13	1,71	102,34	7,60	1,96	0,11	423°
1270m	0,35	0,51	1,30	1,11	45,95	117,12	0,86	0,41	428°
1280m	0,52	1,70	0,14	2,14	79,44	6,54	2,22	0,23	430°
1300m	0,25	1,58	1,37	2,49	63,45	55,02	1,83	0,14	431°
1330m	0,26	0,79	1,11	1,63	48,47	68,10	1,05	0,25	433°
1340m	0,54	0,33	1,10	1,04	31,73	105,77	0,87	0,62	430°
1380m	0,74	0,12	2,22	0,90	13,33	246,67	0,86	0,86	434°
1410m	0,58	0,30	1,93	1,00	30,00	193,00	0,88	0,66	426°
1440m	0,24	0,17	1,97	1,17	14,53	168,38	0,41	0,59	429°
1460m	0,26	0,74	1,98	1,31	56,49	151,15	1,00	0,26	425°
1500m	0,37	1,02	2,08	1,43	71,33	145,45	1,39	0,27	429°
1520m	6,38	0,92	2,06	2,83	32,51	72,79	7,30	0,87	415°
1560m	0,49	1,18	2,01	2,79	42,29	72,04	1,67	0,29	427°
1580m	0,89	1,18	2,07	1,73	68,21	119,65	2,07	0,43	422°
1600m	0,51	0,52	2,16	1,88	27,66	114,89	1,03	0,50	422°
1640m	0,80	2,00	2,18	2,66	75,19	81,95	2,80	0,29	423°
1660m	0,36	0,41	2,05	2,33	17,60	87,98	0,77	0,47	433°
1670m	0,94	1,37	1,54	2,85	48,07	54,04	2,31	0,41	435°
1680m	0,38	1,12	1,54	1,72	65,12	89,53	1,50	0,25	425°
1920m	0,22	0,50	1,70	1,76	28,41	96,59	0,72	0,31	431°
1960m	0,49	0,51	1,66	0,81	62,96	204,94	1,00	0,49	424°

TABLE IX

ROCK-EVAL PYROLYSES

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
1990m	0,37	1,31	1,70	1,28	102,34	132,81	1,68	0,22	430°
2020m	0,23	1,43	1,81	1,42	100,70	127,46	1,66	0,14	431°
2060m	0,45	1,68	1,79	1,53	109,80	116,99	2,13	0,21	432°
2090m	0,32	2,52	1,75	1,69	149,11	103,55	2,84	0,11	430°
2100m	0,36	2,53	1,47	1,63	155,21	90,18	2,89	0,12	431°
2110m	0,34	2,93	1,46	1,90	154,21	76,84	3,27	0,10	428°
2120m	0,31	2,73	1,49	1,77	154,24	84,18	3,04	0,10	430°
2140m	0,27	5,22	1,51	2,02	258,42	74,75	5,49	0,05	430°
2160m	0,24	4,76	1,53	2,36	201,69	64,83	5,00	0,05	428°
2180m	0,30	4,96	1,51	2,36	210,17	63,98	5,26	0,06	426°
2230m	0,44	5,67	1,62	2,21	256,56	73,30	6,11	0,07	426°
2250m	1,43	31,43	1,63	6,28	500,48	25,98	32,86	0,04	421°
2270m	1,90	37,68	1,66	6,47	582,38	25,66	39,58	0,05	420°
2290m	1,61	31,20	1,58	6,07	514,00	26,03	32,81	0,05	419°
2310m	0,32	6,10	1,66	2,58	236,43	64,34	6,42	0,05	419°
2330m	0,29	3,55	1,32	2,37	149,79	55,70	3,84	0,08	430°
2350m	0,52	6,39	1,32	3,19	200,31	41,38	6,91	0,08	427°
2370m	0,41	9,34	1,35	3,76	248,40	35,90	9,75	0,04	425°
2390m	0,40	7,20	1,33	3,63	198,35	36,64	7,60	0,05	430°
2420m	0,48	7,34	1,37	3,44	213,37	39,83	7,82	0,06	429°
2440m	0,55	7,65	1,33	4,22	181,28	31,52	8,20	0,07	430°

TABLE IX

ROCK-EVAL PYROLYSES

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} ^oC
2480m	0,33	2,35	1,31	3,84	61,20	34,11	2,68	0,12	435^o
2500m	0,33	4,00	1,32	2,44	163,93	54,10	4,33	0,08	431^o
2520m	0,42	5,54	1,33	2,53	218,97	52,57	5,96	0,07	430^o
2550m	0,86	9,21	1,32	4,35	211,72	30,34	10,07	0,09	432^o
2580m	1,18	24,12	1,35	7,48	322,46	18,05	25,30	0,05	432^o
2600m	0,55	7,77	1,33	4,87	159,55	27,31	8,32	0,07	431^o
2620m	0,68	6,51	1,37	3,69	176,42	37,13	7,19	0,09	433^o

SJULSEV ↓

STRAND ↓

T. kritt 2628 l.

Ukritt-overkritt 4150 l.

Ukritt - overJur 7837 l

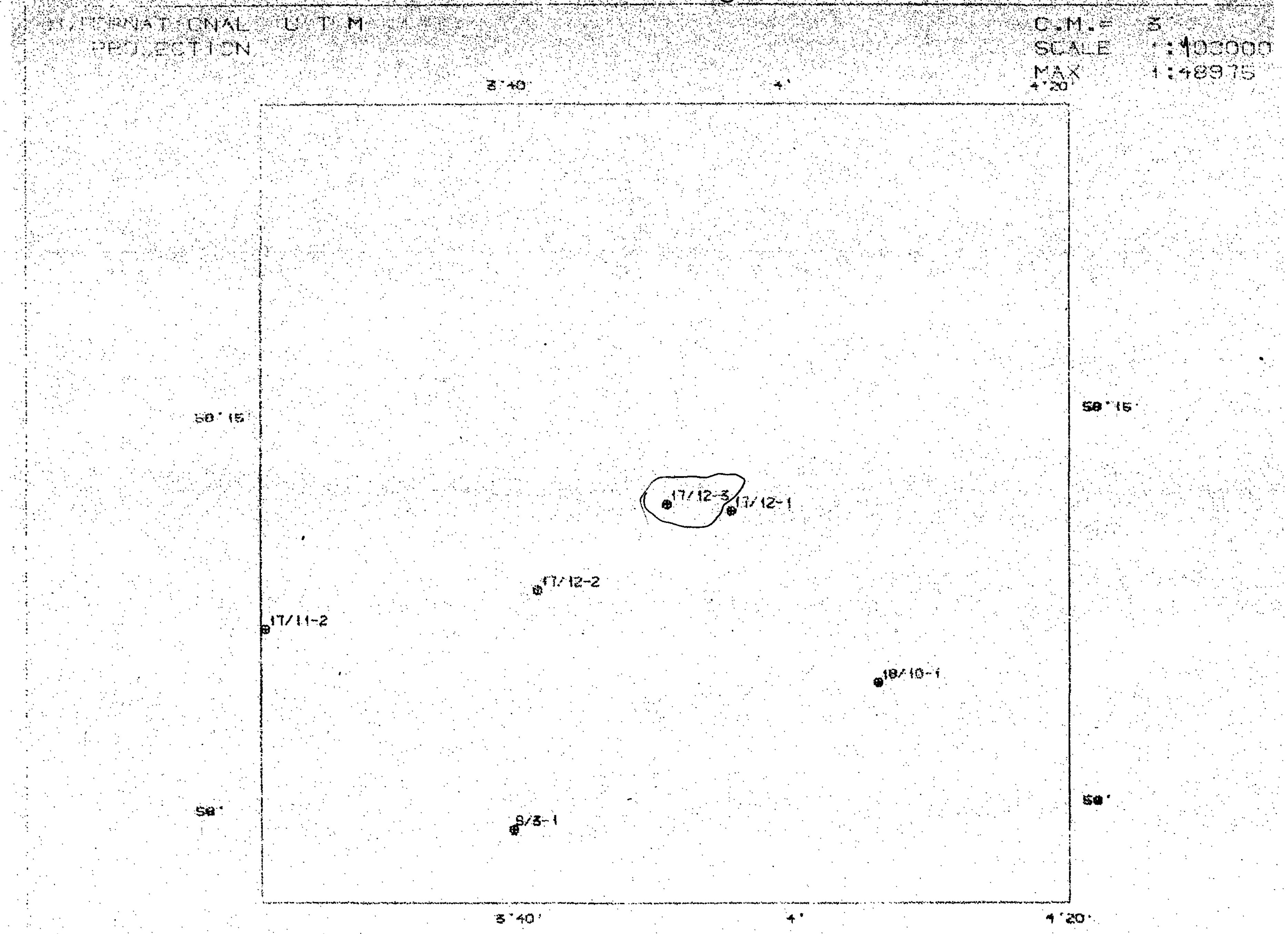
Liasm. 7780

Haldager 55 / Sh. i Oeblem

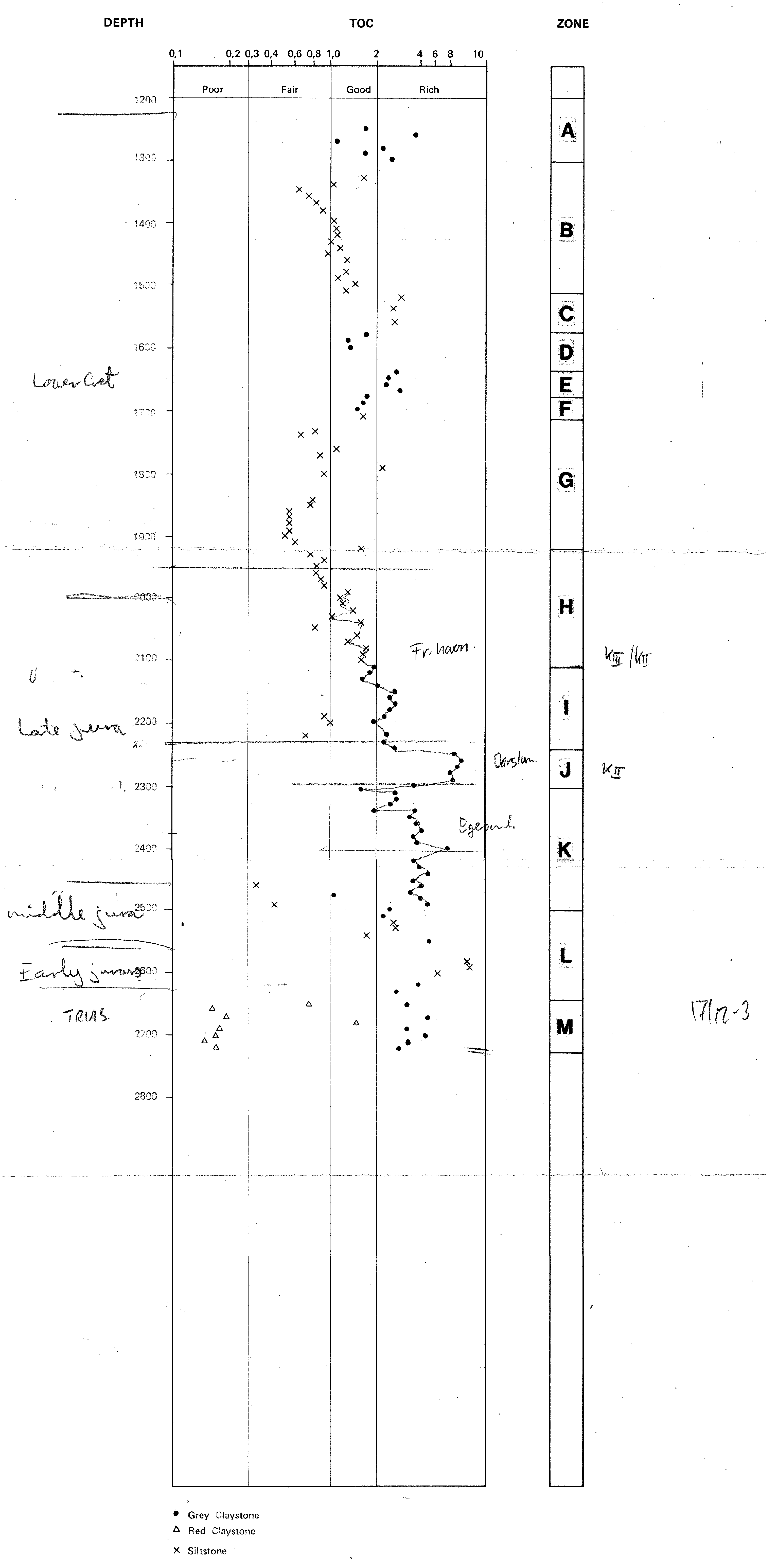
Trias 8620 l.

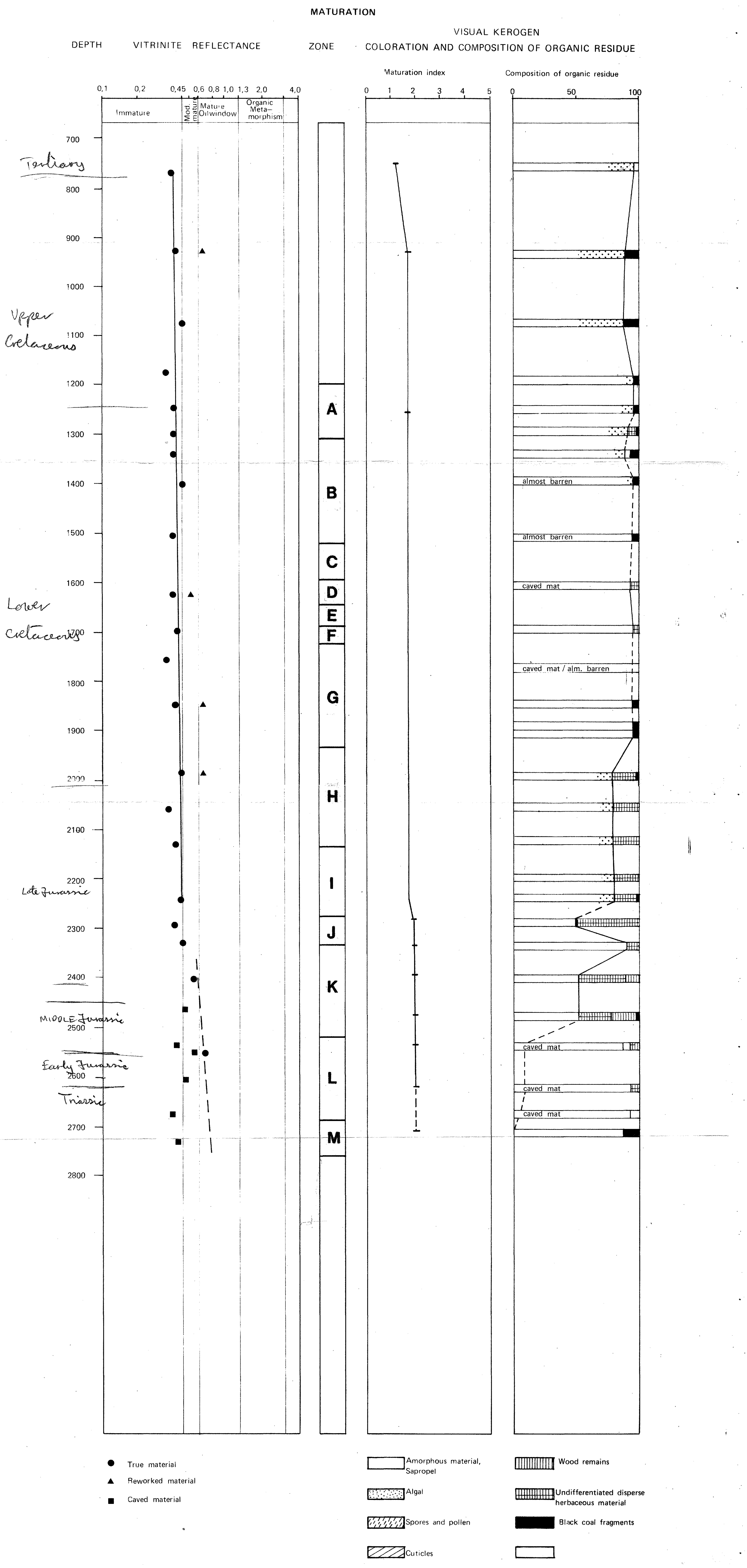
1835 m
| Fredr-havn.
2150
| Børglum
2236
| Esgrund
2370
| Haldager
2425

Brønnplassering



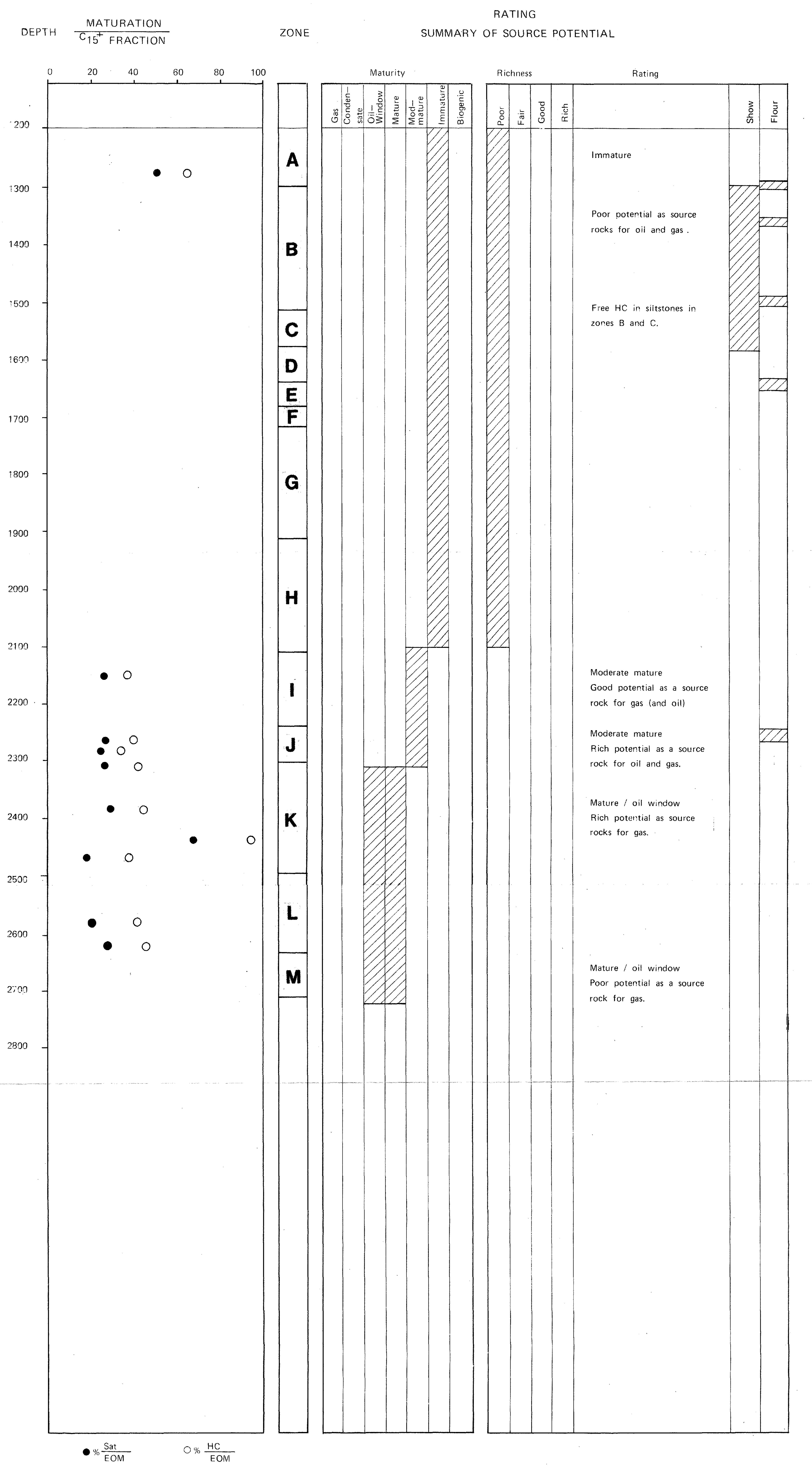
TOTAL ORGANIC CARBON (TOC)
Presentation of Analytical Data





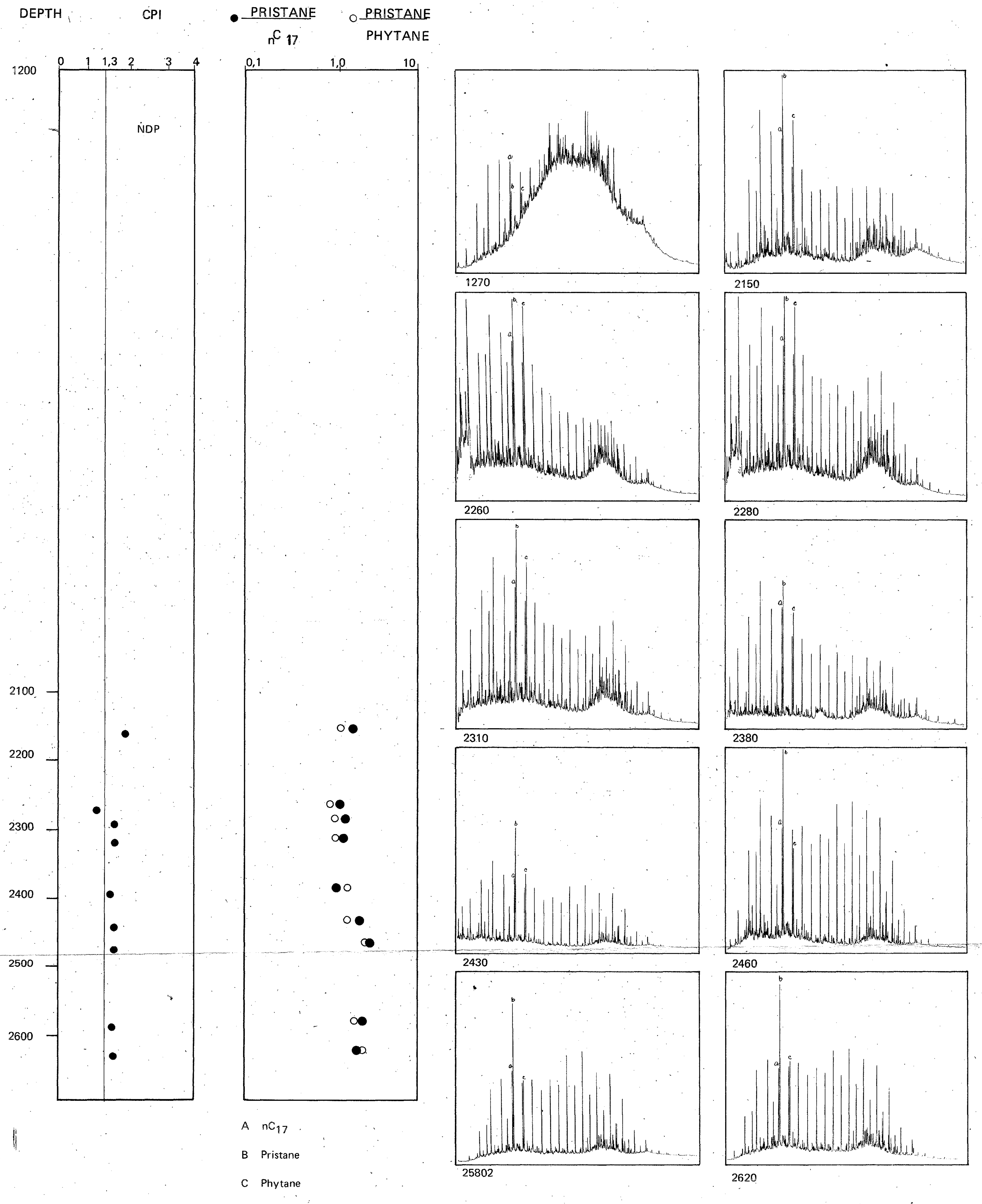
MATURATION
DEPTH
VITRINITE REFLECTANCE
ZONE
VISUAL KEROGEN
COLORATION AND COMPOSITION OF ORGANIC RESIDUE
0,1 0,2 0,45 0,6 0,8 1,0 1,3 2,0 4,0
Immature
Mod. mature
Mature Oilwindow
Organic Meta-morphism
Maturation index
0 1 2 3 4 5
Composition of organic residue
0 50 100
700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800
Tertiary
Upper Cretaceous
Lower Cretaceous
Late Jurassic
MIDDLE Jurassic
Early Jurassic
Triassic
A B C D E F G H I J K L M
almost barren
almost barren
caved mat
caved mat / alm. barren
caved mat
caved mat
caved mat
True material
Reworked material
Caved material
Amorphous material, Sapropel
Algal
Spores and pollen
Cuticles
Wood remains
Undifferentiated disperse herbaceous material
Black coal fragments

INTERPRETATION DIAGRAM



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

C_{15}^{+} SATURATED HYDROCARBONS



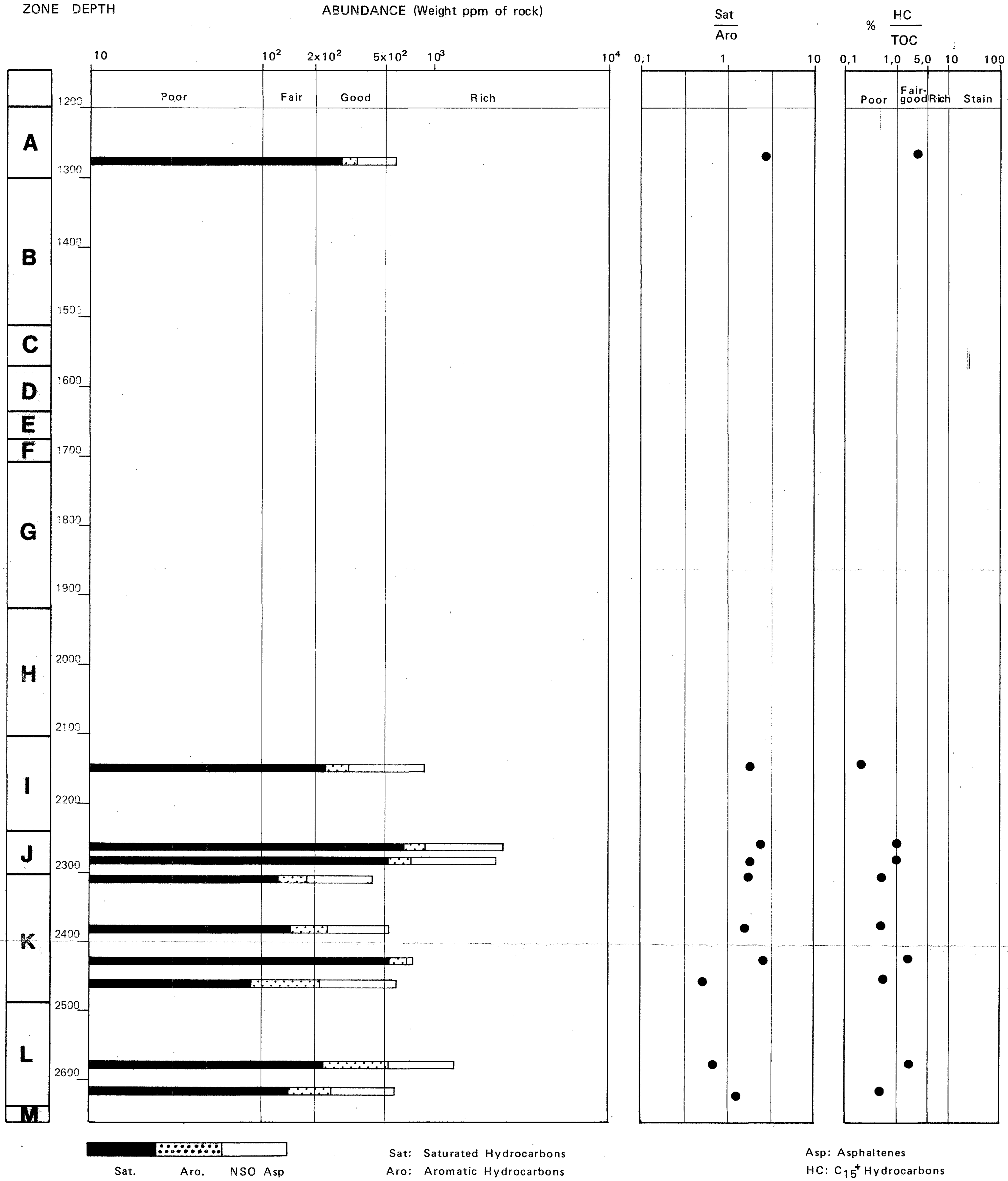
A nC17

B Pristane

C Phytane

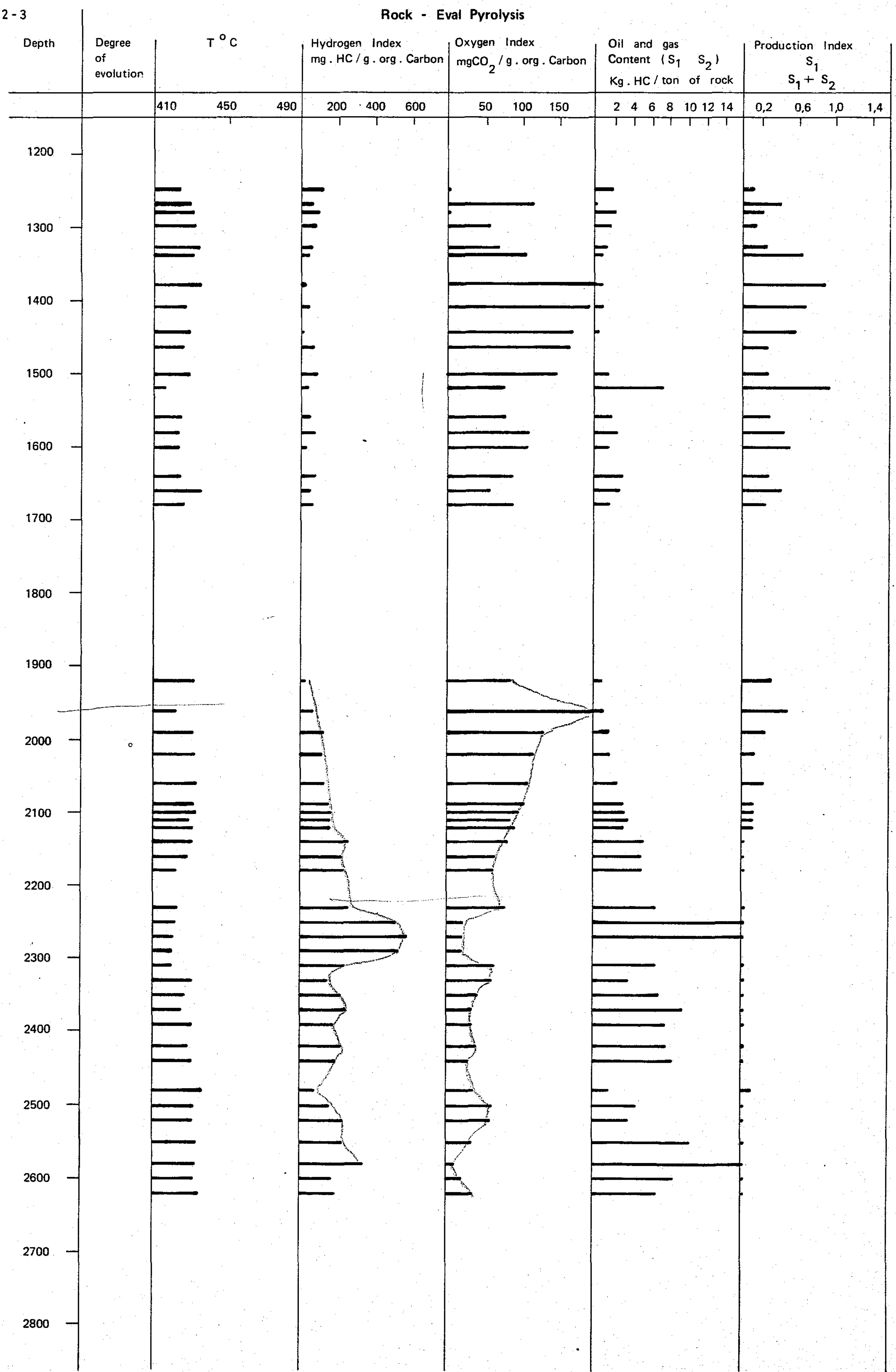
C_{15}^{+} HYDROCARBONS

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


Rock - Eval Pyrolysis
Depth
Degree of evolution
T °C
410 450 490
Hydrogen Index mg . HC / g . org . Carbon
200 400 600
Oxygen Index mgCO2 / g . org . Carbon
50 100 150
Oil and gas Content (S1 S2) Kg . HC / ton of rock
2 4 6 8 10 12 14
Production Index S1 / S1 + S2
0,2 0,6 1,0 1,4
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800