IKU

CONFIDENTIAL

INSTITUTT FOR KONTINENTALSOKKELUNDERSØKELSER

CONTINENTAL SHELF INSTITUTE

REPORT TITLE

Source rock analyses, well 31/2-2

CLIENT

A/S Norske Shell

CLIENT's REF.:

Ian Willis

REPORT NO.:

0-271/1/80

AUTHOR (S):

M. Bjorøy, T.M. Rønningsland,
J.O. Vigran, N. Aarhus, K. Almås

DATE:

21.8.80

PROJECT NO.:

0-271

NO. OF PAGES

19

NO. OF ENCLOSURE

DEPARTMENT:

Organic geochemistry

RESPONSIBLE SCIENTIST:

Malvin Bjorøy

SUMMARY:

See next page.

KEY WORDS

Source rock

SUMMARY

The analysed sequence of this well is divided into 14 zones with the following rating.

A 800- 910 m: Immature. Rich potential as a source rock for oil and gas.

B 950-1275 m: Immature. Fair potential as a source rock for gas (oil). Indications of free hydrocarbons at 1130 m.

C 1305-1350 m: Immature. Poor potential as a source rock for gas (oil).

D 1350-1417 m: Immature. Fair potential as a source rock for gas (oil). Indications of free hydrocarbons at 1365 m.

E 1426-1485 m: Immature. Poor potential as a source rock for gas. Indications of free hydrocarbons at 1458 m.

F 1494-1542 m: Immature. Rich potential as a source rock for oil and gas.

G 1544-1633 m: Immature. Sandstone.

H 1649-1788 m: Immature. Siltstone, but with lenses that might work as source rock for gas. Indications of free hydrocarbons at 1680 m.

I 1791-1983 m: Immature. Sandstone, indications of free hydrocarbons at 1842 and 1854 m.

J 1989-1998 m: Immature. Coal.

K 2004-2088 m: Immature. Sandstone.

L 2091-2154 m: Immature. Siltstone, indications of free hydrocarbons at 2097 m.

M 2157-2436 m: Immature/moderate mature. Sandstone, indications of free hydrocarbons at 2360 m.

N 2442-2600 m: Mainly red beds. Indications of free hydrocarbons at 2469 m.

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°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°C. The samples where then ground, initially on a diamond lap followed by two grades of corundum paper. All grinding and subsequent polishing stages in the preparation were carried out using isopropyl alcohol as lubricant, since water leads to the swelling and disintegration of the clay fraction of the samples.

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

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

The surface of the polished block was searched by the operator for suitable areas of vitrinitic material in the sediment. The reflectance of the organic particle was determined relative to optical glass standards of known reflectance. Where possible, a minimum of twenty individual particles of vitrinite was measured, although in many cases this number could not be achieved.

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

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

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

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

Processing of Samples and Evaluation of Visual Kerogen

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

T-slide represents the total acid insoluble residue.
N-slide represents a screened residue (15 meshes).
O-slide contains palynodebris remaining after flotation ($Zn\ Br_2$) 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

Total Organic Carbon (TOC)

TOC measurements were undertaken on all samples except sandstones. Based on these results and the lithological descriptions, the analysed sequence of the well is divided into fourteen zones.

Zone A: 800-910 m: This zone consists mainly of claystone with a rich abundance of organic carbon (2-6.5%) a steady decrease of organic carbon values with increasing depth is observed in this zone.

Zone B: 950-1275 m: Another zone with mainly claystone, but with much lower organic carbon values than zone A, mainly 0.7-0.9%.

Zone C: 1305-1350 m: Again a zone with mainly claystone. This is found to be brownish, while the claystone in zone B is found to be grey or greenish. The TOC values drop to 0.3-0.4%.

Zone D: 1350-1417 m: The sidewall cores measured in this zone are found to have TOC values around 0.5-1.0%. The TOC values drop with increasing depth.

Zone E: 1426-1485 m: The TOC values of the sidewall cores and the cutting samples vary a lot in this zone and the high TOC values found for the cuttings are probably due to cavings. The TOC values of the sidewall cores are mainly in the 0.1-0.2% region.

Zone F: 1494-1542 m: This zone also consists of claystone, but with far higher TOC value than in the zones above, approximately 3%.

Zone G: 1544-1633 m: The lithology of this zone is mainly decided by analyses of sidewall cores, and corechips, and is found to consist mainly of poorly sorted sandstone. No analyses were performed for organic carbon.

Zone H: 1649-1788 m: The lithology of this zone is also found with the background in sidewall cores. The litology changes to a more silty facies.

Zone I: 1797-1983 m: The lithology in this zone changes to sandstone again. Black organic material (bitumen?) is observed in some of the samples.

Zone J: 1989-1998 m: The lithology of this zone is decided with background in cutting samples. From 1989 m large amounts of coal are observed. This is observed throughout the zone.

Zone K: 2004-2088 m: This zone consists mainly of sandstone with a small percentage of coal, probably cavings.

Zone L: 2091-2154 m: The lithology of this zone changes to more silty, with small amounts of claystone in parts.

Zone M: 2157-2436 m: This zone contains mainly sandstone with small amounts of claystone and siltstone in some samples. Coal observed at approximately 2370 m.

Zone N: 2442-2600 m: The lithology changes in this zone to claystone/siltstone. The organic carbon values are found to be low, 0.2-0.4%.

Extraction and Chromatographic Separation

Only two samples, corechips from 1516 and 1537 m were extracted and both have a rich abundance of extractable hydrocarbons. The hydrocarbon/total organic carbon (HC/TOC) ratio is however far higher in the uppermost sample. The gas chromatograms of the saturated hydrocarbon fractions are similar for the two samples which both have large concentration of pristane and phytane and high CPI values. Small differences are, however, found especially in the pristane/nC_{17} ratio. The sterane/triterpane abundances are high for both samples.

Vitrinite reflectance

Thirty 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 is given.

Sample K 2703, 800 m: Calcareous shale, Ro = 0,29 (22).

The sample has a low organic content with bitumen wisps and overall light staining. Particles of vitrinite with subordinate inertinite are recorded together with a few lignite cuttings of similar reflectance. UV light shows a strong background fluorescence but no exinite.

Sample K 2708, 860 m: Shale, Ro = 0,28 (20)

The sample has an overall bitumen staining, otherwise a low content of small particles of vitrinite with only a trace of inertinite. UV light shows a yellow and light orange fluorescence from spores and a low exinite content.

Sample K 2713, 910 m: Shale, Ro = 0,28 (20)

The sample has a variable bitumen staining. Some cuttings are heavily stained, others show no staining. Phytoclasts are virtually restricted to bitumen stained shale. Particles of vitrinite are recorded, but no inertinite. UV light shows a yellow/orange - light orange fluorescence from spores and a trace of exinite.

Sample K 2713, 950 m: Light shale, Ro = 0,29 (22)

The organic material is restricted to a few heavily bitumen stained cuttings. Only vitrinite particles, no inertinite is recorded. The light shale is barren. UV light shows a yellow and light orange fluorescence from spores and a low exinite content.

Sample K 2726, 1050 m: Light shale, Ro = 0,27 (7)

The sample has a very low organic content with occasional bitumen wisps and locallised light staining. A few small particles of inertinite and vitrinite are recorded. UV light shows a yellow/orange fluorescence from spores and a low - moderate exinite content.

Sample K 2734, 1130 m: Shale, Ro = 0,31 (21)

The sample has a very low organic content with bitumen wisps and locallised light staining.

A few vitrinite particles and wisps and only a trace of inertinite particles. UV light shows a yellow/orange fluorescence from spores and hydrocarbon specks together with a low exinite content.

Sample K 2750, 1221 m: Shale, Ro = 0,30 (22)

The sample contains small bitumen wisps and locallised staining, with a low content of small particles of low reflectance vitrinite and subordinate inertinite. UV light shows a yellow to light orange fluorescence from spores and a low exinite content.

Sample K 2759, 1275 m: Light shale and subordinate carbonate, Ro = 0,34 (14) and Ro = 0,59 (3)

The sample contains occasional small bitumen wisps and locallised staining. A few small particles of inertinite with a trace of vitrinite particles and wispy particles are recorded. UV light shows a yellow/orange fluorescence from spores and a trace of exinite.

Sample K 2774, 1365 m: Shale, Ro = 0,32 (11) and Ro = 0,55 (1)

The sample is rich in small bitumen wisps, otherwise a very low content of small particles of inertinite and reworked material with a trace of vitrinite particles. UV light shows a yellow/orange and light orange fluorescence from spores and hydrocarbon specks together with a low exinite content.

Sample K 2784, 1410 m: Shale, Ro = 0,47 (19) and Ro = 0,95 (1)

The sample has a moderate organic content with small particles of reworked material and inertinite dominant together with subordinate particles of true vitrinite. UV light shows a yellow and dull, light orange fluorescence from spores and a low exinite content.

Sample K 2799, 1458 m: Shale, Ro = 0,54 (16) and Ro = 0,93 (2)

The sample has a low to moderate organic content with small, rather corroded particles of inertinite and reworked material. Only a trace of possibly true vitrinite.

UV light shows a yellow - light orange fluorescence from spores and hydrocarbon specks together with a trace of exinite.

Sample K 2875, 1516 m: Shale, Ro = 0,49 (4)

The sample contains plentiful bitumen wisps and staining. Otherwise, a low/moderate content of particles of reworked material and vitinite. Only a trace of doubtful vitrinite particles. UV light shows a yellow/orange and light orange fluorescence from spores and a moderate- rich exinite content.

Sample K 2876, 1537 m: Shale, Ro = 0,33 (7) and Ro = 0,56 (1)

The sample contains bitumen wisps and staining and a moderate content of reworked and inertinite particles. Only a trace of doubtful vitrinite particles. UV light shows a yellow - light orange fluorescence from spores and a moderate exinite content.

Sample K 2890, 1650 m: Sandstone, Ro = 0,25 (17)

The sample has a low content of interstitial vitrinite particles and bitumen wisps. UV light shows a yellow and mid-orange fluorescence from a few spores in occasional shale fragments together with a trace of exinite.

Sample K 2900, 1680 m: Sandstone and shale traces, Ro = 0,29 (22)

The sample contains a few loose coal particles together with bitumen wisps in shale and interstitial vitrinite fragments in sandstone matrix. UV light shows a variable carbonate fluorescence together with hydrocarbon specks and yellow/orange spores and a trace of exinite.

Sample K 2946, 1842 m: Sandstone, Ro = 0,28 (22)

The sample contains only a trace of organic material with interstitial bitumen and a few vitrinite fragments. No inertinite. UV light shows a yellow/orange fluorescence from spores and hydrocarbon specks together with a low exinite content.

Sample K 2950, 1854 m: Sandstone and shale traces, Ro = 0,28 (5)

The sample is barren apart from bitumen traces and a couple of loose lignite fragments. UV light shows fluorescence from hydrocarbon specks and no exinite.

Sample K 3351, 1989 m: Sand and coal, Ro = 0,43 (22) and Ro = 0,71 (2)

The sample contains coal of variable lithologies, rich in inertinite and micronite. Often very brecciated. Little vitrinite recorded and indications of oxidation. UV light shows a light orange fluorescence from spores in coal and a low exinite content.

Sample 3353, 1995 m: Sand and coal, Ro = 0,41 (22)

The organic material is restricted to the coal which has variable lithologies. Rich in micrinite and fusinite. Only a low content of vitrinite, rather brecciated, possibly oxidised. UV light shows a light orange fluorescence from spores and yellow resin in coal together with a low exinite content.

Sample K 3360, 2022 m: Coal and carbargillite, Ro = 0,44 (22)

The carbargillite has good vitrinite and resin particles and wisps in the shale. The coal is rich in inertinite with particles of fusinite in matrix of vitrinite. UV light shows a light orange fluorescence from spores and a low exinite content.

Sample K 3383, 2097 m: Shale, sandstone and coal traces, Ro = 0,38 (23)

The sample has a low organic content with a few coal fragments of variable reflectance and a trace of vitrinite particles and shale matrix. UV light shows a yellow/orange and light orange fluorescence from spores and hydrocarbon specks together with a low to moderate exinite content.

Sample K 3403, 2157 m: Shale and sandstone, Ro = 0,38 (22)

The sample has a low organic content with particles of vitrinite and bitumen wisps.

UV light shows a variable carbonate fluorescence and light orange spores together with a low exinite content.

Sample K 3446, 2205 m: Shale and siltstone, Ro = 0,39 (20)

The sample has a low content of variable vitrinite particles with only a trace of inertinite. A few coal fragments and bitumen wisps are recorded. UV light shows a yellow/orange and light orange fluorescence from spores and hydrocarbon specks together with a moderate exinite content.

Sample K 3485, 2361 m: Coal and subordinate shale, Ro = 0,49 (2) and Ro = 0,84 (1)

The sample has variable coal lithologies generally rich in inertinite. Many cuttings are brecciated. No pyrite is observed and there is probably some oxidation. UV light shows a light/mid-orange fluorescence from spores in coal and a moderate exinite content.

Sample K 3488, 2370 m: Coal, sandstone and shale, Ro = 0,45 (20) and Ro = 0,73 (1)

The coal in the sample is of variable lithologies. Generally rich in inertinite and exinite. Rather corroded and brecciated. Possibly oxidised. UV light shows a light/mid-orange fluorescence from spores in coal and a moderate exinite content.

Sample K 3506, 2424 m: Red shale, sand grains and coal traces, Ro = 0,46 (21)

The organic material is restricted to small loose vitrinite coal particles. UV light shows a light orange fluorescence from spores and a trace of exinite.

Sample K 3520, 2469 m: Red siltstone, Ro = 0,30 (1) and Ro = 0,51 (2)

The sample contains a few loose vitrinite specks. UV light shows a light orange fluorescence from hydrocarbon specks and possible spores together with a trace of exinite.

Sample K 3536, 2517 m: Red shale.

No determination possible.

Sample K 3552, 2565 m: Red shale and sandgrains.

No determination possible.

Sample K 3562, 2595 m: Red sandstone and shale.

No determination possible.

UV light shows a light orange fluorescence from spores and hydrocarbon specks together with a trace of exinite.

With the background in these analyses, the whole analysed sequence, 800-2600 m is found to be immature. The measurements down to 1650 m appear to be reliable while the measurements on the sandstone lithologies 1650-1854 m might be dubious. The measurements might be on cavings due to the lack of indigenous material in the sandstone. The coals from 1989-2022 m and 2360-70 m must be regarded as definitive.

Visual kerogen analysis

Fifty samples have been examined for the evaluation of kerogen composition and characterisation of the residues.

The results from the main bulk of cutting samples were supported at a later stage by examination of sidewall cores which had been delayed.

The maturation of the well is low. From the study of spores and pollen the colour index ranges from 1- to 1+/2-. The small changes observed downhole seem controlled by the lithology/environment.

Based on the acid insoluble residues we may group the samples in an upper marine interval followed by a more deltaic sequence with layers of coal and with more marine incursions.

800 m to 860 m: Amorphous material and well preserved dinoflagellates dominate. The finely dispersed terrestrial material includes woody structures, some cuticular fragments, indeterminate debris and well preserved pollen of gymnosperms.
Colour index: 1-.

860 m to 1221 m: Variable amounts of acid resistant minerals are present in some of the samples which have to be removed before examination of kerogen.

Amorphous material dominates the residues of this interval. The interval may be further subdivided based on presence of amorphous material in aggregates in the upper part (860 m to 950 m).

The composition of the terrestrial material in spite of the marine conditions indicates variations in the depositional surroundings during this interval. Winged pollen grains and other pollen of gymnosperms are common in the uppermost part while there is a varied pollen assemblage at 950 m. At 1050 m and 1130 m dinoflagellates in number completely outrange the pollen, while at 1221 m Early Tertiary gymnosperm pollen and angiosperm pollen are by far the most prominent group of palynomorphs.

It should also be noted that woody/coaly particles are very frequent at 1130 m, the only sample of the interval in which terrestrial debris dominates.
Colour index: 1.

1275 m and 1365 m: Amorphous material is recorded as aggregates and dominates the residues after separation of the inorganic aggregates. Woody/coaly material represents the dominating terrestrial element and mostly it seems reworked/oxidised.

The characters of the interval seem controlled by the lithology.
Colour index: 1.

1410 m and 1440 m: The residues are rich in acid resistant minerals. The organic residues resemble those of the interval above but appearently are of higher coalification (?oxidation).

Suspected caved material is very common and may suggest an interval poor in indigenous fossils.
Colour index: 1/1+.

1515,12 m and 1535 m: Sapropel form aggregates sticks to other particles present and tends to obscure dinoflagellates, pollen and spores. Due to decay and pyrite present the palynomorphs are only fairly well preserved or poorly preserved.
Colour index: 1/1+. The residues may however appear darker due to the sapropel aggregates.

1631 m and 1633,55 m: Terrestrial material dominates the residues after separation of the resistant minerals, but the presence of dinoflagellate cysts suggests that finely dispersed amorphous material could have been removed from the deltaic samples. Woody material and coaly fragments dominate, though recovered cuticles, indeterminate finely dispersed herbaceous material and pollen/spores are present.
Colour index: 1/1+.

1760,5 m-1980 m: Pyrite is prominent in the residue of this interval and sticks to the organic remains. The terrestrial remains, cuticles, woody matter, indeterminate finely dispersed material and pollen/spores appearently dominate. True sapropel has been given a low estimate. Minerals are remaining in the acid resistant residues, and tend to occur as aggregates. The analyses are based on screened residues where minerals have been separated by floatation ($ZnBr_2$).
Colour index: 1/1+.

1998 m swc, 2004 m, 2025 m, 2036,0 m swc: The organic residues of this interval are all mainly composed by terrestrial material which is coalified, and after chemical oxidation well preserved spores and pollen assemblages are recorded.
Colour index: 1+.

2077 m, 2091 m, 2096.3 m swc, 2155.0 m swc, 2160 m, 2181.5 m swc; 2205 m, 2240.5 m: Though terrestrial material seems to dominate the residues, amorphous material is consistantly recorded through the interval, and in some of the sidewall cores is as much as 40%.
Colour index: 1+.

2253 m swc, 2268 m, 2304 m swc, 2351 m and 2358 m: The screened organic residues mainly consist of coalified material of woody nature after separation of minerals. After chemical oxidation good pollen and spores were obtained.
Colour index: 1+, 1+/2-.

2363.0 m swc, 2379 m 2387 m swc, 2389 m swc: The residues from sidewall cores all contain amorphous or very finely dispersed organic matter in aggregates. Acid resistant minerals are very common.
Colour index: 1+ or 1+/2-.

2421 m, 2502 m, 2526 m, 2562 m: The residues were dominated by resistant minerals, as aggregates. At 2526 m amorphous fragments probably included iron compounds.

After oxidation and separation of minerals the organic material represents deltaic or non-marine deposits rich in dark coaly/woody fragments but also including cuticular material and rare palynomorphs of Triassic nature.

We suggest an interval which is very poor in indigenous organic material.

Rock-Eval Pyrolyses

Rock-Eval pyrolyses were undertaken on a total of thirtyfive samples, mainly cuttings.

Zone A: The samples from this zone have low-medium hydrogen indeces and very high oxygen indeces. The Tmax is low indicating an immature zone. The values for the hydrogen and oxygen indeces indicate an immature mixture of type II and type III kerogen.

Zone B: The hydrogen indeces drop sharply in this zone while the oxygen indeces are still high indicating mainly type III kerogen. The zone is still immature.

Zone C: Only one sample, a sidewall core from 1350 m, was analysed from this zone and found to be of type III kerogen.

Zone D: All the samples from this zone were found to be of type III kerogen with high oxygen indeces adn low hydrogen indeces.

Zone E: The samples analysed from this zone were all found to have low hydrogen indeces and high oxygen indeces, indicating immature type III kerogen.

Zone F: The hydrogen indeces in this zone are relatively large, 200-270. The oxygen indeces for the cutting samples are very high while the core samples have far lower values. Presently it is not known why this large variation is seen, but it is believed it is caused by contamination in the cuttings. The T_{max} indicate this zone also to be immature and the kerogen is most probably a mixture of type II and type III.

Zone G: No samples analysed.

Zone H: The samples analysed from this zone were all sidewall cores which were found to have relatively low hydrogen indeces and high oxygen indeces, indicating kerogen type III. This zone is immature.

Zones I, J, K and L: No samples analysed.

Zone M: One sample was analysed indicating moderate type III kerogen.

Zone N: No samples analysed.

CONCLUSION

Based on the lithology and the total organic carbon values, the analysed sequence of the well, 800-2600 m was divided into fourteen zones. In our interpretation of the source rock richness this is based on the total organic carbon results, while the type of kerogen is based on the Rock-Eval and the visual kerogen results. The maturity of the various zones is based on the results from the vitrinite reflectance, spore colouration and the Rock-Eval results.

Zone A 800-910 m: This zone is found to be immature with rich abundance of organic carbon. The Rock-Eval indicates a mixture of type II and type III kerogen. This is in agreement with the visual kerogen examination which shows the samples to contain both amorphous and terrestrial material. Based on this, zone A is immature with a rich potential as a source rock for oil and gas.

Zone B 950-1275 m: The abundance of organic carbon in this zone is far lower than in zone A and found to be fair and slightly higher towards the lower part of the zone. All maturity measurements show the whole zone to be immature. The Rock-Eval data indicate the zone to contain type III kerogen, while the visual kerogen examination shows a large input of sapropelic material. It is not known at present the cause for this contradiction, but similar phenomena are found in other wells in the North Sea. One explanation could be that the samples contain a lot of reworked material which automaticly would lower the hydrogen index.
Another explanation could be that the sapropelic material is sapropelisized terrestrial material. We tend to favor the latter explanation.
Based on this, zone B is found to have a fair potential as a source rock for gas (oil). Indications of free hydrocarbons at 1130 m.

Zone C 1305-1350 m: The organic carbon values drop to approximately 0.3%, apart from this the results are similar to those from zone B. Based on this, zone C is found to be immature with a poor potential as a source rock for gas (oil).

Zone D 1350-1417 m: The TOC values increased in this zone to approximately 1% while the kerogen composition is similar to the zones above. Based on the various results, zone D is found to be immature with a fair potential as a source rock for gas (oil). Indications of free hydrocarbons at 1365 m.

Zone E 1426-1485 m: Again a zone with very low TOC values, similar to zone C. The whole zone is found to be immature with a poor potential as a source rock for gas. Indications of free hydrocarbons at 1458 m.

Zone F 1494-1542 m: The TOC values are found to be high throughout this zone and the whole zone has a rich abundance of organic carbon.

The kerogen is found to be a mixture of type II and III by Rock-Eval analysis and this is in agreement with the visual kerogen examination. Based on the various results, the whole zone is found to be immature with a rich potential as a source rock for oil and gas.

Zone G 1544-1633 m: A sandstone zone which is found to be immature.

Zone H 1649-1788 m: The total organic carbon of this zone vary greatly, 0.2-2%. The lithological examination shows the zones to be mainly siltstone with traces of organic material. This is probably the cause for the large variation in the organic carbon values. The whole zone is found to be immature by the variuos analysis. Due to the lithology (siltstone), the zone will not be classified as a source rock. However, some thin lenses might work as a source rock for gas. Indications of free hydrocarbons are found at 1680 m.

Zone I 1791-1983 m: Sandstone, immature. Indications of free hydrocarbons at 1842 m and 1854 m.

Zone J 1981-1998 m: Coal, immature.

Zone K 2004-2088 m: Sandstone, immature.

Zone L 2091-2154 m: Siltstone mainly, immature. Indications of free hydrocarbons at 2097 m.

Zone M 2157-2436 m: Sandstone with some coal around 2360 m. The upper part of the zone is immature while the lower part has a slightly higher maturity, immature/moderate mature. The latter is based on the readings on coal cuttings from 2360 m. Indications of free hydrocarbons at 2205 m.

Zone N 2442-2600 m: Mainly redbeds. None of the analysis have given any meaningful results. The zone is believed to be moderate mature. Indications of free hydrocarbons at 2469 m.

Table I

(cuttings)

IKU No.	Depth	TOC	Lithology
K 2703	800	6,50	100% siltstone, clayey, light grey (slightly brownish), some dark browngrey, some micaceous, with black grains (organic), partly slightly calcareous, spicules. Small amounts sand, angular, coarse, clear; sandstone
K 2706	830	4,10	70% claystone, silty, dark brownish grey 20% sand, angular-very angular, coarse-very coarse, clear/white fragments and gneiss and metamorphic fragments (with amphibole, phlogopite, biotite, muscovite, feldspar), slightly glauconitic 10% limestone, dark greybrown, hard, some yellowbrown (?recrystallized)
K 2708	860	3,55	100% claystone, silty, dark brownish grey, observed spicules
K 2709	870	3,83	100% claystone, silty, dark brownish grey
K 2711	890	2,64	100% claystone, silty, brownish dark grey-grey, greenish light grey, some green
K 2713	910	2,06	100% claystone, dark greybrown, light grey (slightly greenish) (50%)
K 2717	950	0,53	100% claystone, light grey (slightly greenish) (95%), dark greenbrown (5%)
K 2720	980	0,71	100% claystone, greenish light grey-grey, brown
K 2723	1010	0,89	100% claystone, greenish light grey, scattered mica grains
K 2726	1050	0,88	100% claystone, greenish light grey-grey, greybrown, micaceous
K 2728	1070	0,77	100% claystone, silty, greenish, light grey-grey
K 2731	1100	0,81	100% claystone, greenish light grey-grey, some light green and redbrown
K 2734	1130	0,87	100% claystone, greenish light grey-grey, some green and redbrown (considerably mud contaminated)
K 2739	1161	1,20	100% claystone, silty, greenish light grey (some micaceous), grey, (condierably mud contaminated)
K 2746	1197	0,89	100% claystone, grey-dark grey (slightly micaceous), some light greenish grey (mud contaminated)

Table I

IKU No.	Depth	TOC	Lithology
K 2750	1221	0,88	100% claystone, grey to dark grey, grading to clayey siltstone, greenish light grey micaceous clay/siltstone (mud contaminated)
K 2754	1245	0,77	100% claystone, grey, some dark grey, slightly micaceous (mud contaminated)
K 2759	1275	0,61	100% claystone, light grey (greenish), grey, dark grey (mud contaminated)
K 2764	1305	0,31	100% claystone, light brownish and greenish, light grey, grey, light green to green
K 2768	1329	0,38	100% claystone, grey to light brownish and greenish grey, some green, some silty/micaceous/slightly calcareous.
K 2774	1365	0,42	100% claystone, silty, brownish grey to grey (some micaceous, partly very silty, chlorite observed)
K 2784	1410	0,70	100% claystone, grey to dark grey, light greengrey, greengrey, some black
K 2787	1419	0,62	Claystone, grey to dark grey, light grey/white (silty)
K 2791	1431	0,48	95% claystone, grey to dark grey, light grey (greenish), some green, slightly calcareous, redbrown 5% siltstone, light grey/white, sandy, calcareous, partly micaceous
K 2794	1440	0,60	97% claystone, grey-dark grey, light grey (greenish and redbrown) 3% limestone, silty, white, mainly fossil fragments
K 2799	1458	0,50	100% claystone, dark grey-grey, redbrown, light grey (greenish), some calcareous
K 2802	1467	0,48	100% claystone as above
K 2805	1476	0,54	100% claystone, dark grey (some fossils), light greenish grey, some redbrown

Table I

IKU No.	Depth	TOC	Lithology
K 2808	1485	0,59	Claystone, light grey, slightly calcareous, with micaceous silt and fine-grained carbonaceous material
K 2811	1494	3,57	Claystone, grey, calcareous with micaceous silt
K 2815	1506	3,30	Claystone, grey, calcareous carbonaceous with micaceous silt
K 2818	1515	3,19	As above
K 2821	1524	3,07	As above
K 2824	1533	3,82	As above
K 2827	1524	3,23	As above
K 3309	1860		Sand, fine-coarse white subangular-subrounded- some calcite-cemented sandstone. Small amounts grey calcareous claystone
K 3312	1872		Sand, medium-coarse, white-light grey, angular, some subangular-subrounded.
K 3316	1884		As above
K 3320	1896		As above
K 3324	1908		As above
K 3327	1917		Sandstone, fine-coarse, white-light grey, angular-subangular, calcite-cemented
K 3331	1929		Sand, medium-coarse, white-light grey, angular-subangular
K 3333	1935		Sand as above. 20% light grey calcareous siltstone with very fine sand
K 3335	1941		Calcareous sand and silt as above, but more silty
K 3339	1953		Sand, medium-coarse, angular-subangular, white-light grey.
K 3343	1965		Medium, very fine-coarse, light grey subangular-subrounded, very calcareous silty sandstone
K 3349	1983		As above
K 3352	1992		90% coal. 6% medium-coarse white subangular sand. 4% light yellow calcareous siltstone with very fine-fine subrounded sand
K 3354	1998		50% coal. 50% medium, some coarse subangular white sand and calcareous sandstone

Table I

IKU No.	Depth	TOC	Lithology
K 3356	2010		90% sand and sandstone as above. Quartz and feldspar. 10% coal
K 3358	2016		Fine, medium-coarse, white, very angular-angular sand and calcareous sandstone with coal fragments
K 3360	2022		80% coal 10% medium very angular-angular white sand 5% light brown, some calcareous and carbonaceous waxy moderately silty claystone 5% white sandy very calcareous siltstone with coal fragments
K 3362	2028		50% coal 5% moderately silty claystone as above 45% sand as above
K 3364	2037		40% coal 40% medium-coarse very angular-angular white sand 10% some calcareous very carbonaceous grey-dark grey silty claystone, some muscovite sand
K 3365	2043		Medium, some coarse very angular-angular white sand
K 3367	2055		Fine-medium, very angular-subangular white sand
K 3369	2064		As above
K 3371	2073		Very fine-medium, coarse subangular white sand
K 3378	2082		Very calcareous sandy light grey siltstone with coal fragments. Fine-coarse subangular sand and calcareous sandstone
K 3381	2091		Fine-medium angular white sand and very calcareous silty sandstone
K 3383	2097		Very calcareous light grey sandy clayey siltstone with coal fragments
K 3386	2106		As above with fragments of calcareous silty claystone
K 3389	2115		As above
K 3393	2127		As above
K 3395	2133		As above

Table I

IKU No.	Depth	TOC	Lithology
K 3393	2142		As above
K 3402	2154		As above, but more sandy. Small amounts of coal
K 3405	2163		Fine-medium, coarse angular white sand and calcareous sandstone. 10% grey silty carbonaceous slightly calcareous claystone
K 3406	2163		Fine-medium, some coarse angular white sand and calcareous sandstone 15% light grey-grey slightly calcareous carbonaceous siltstone/claystone
K 3437	2178		Light grey very calcareous medium-coarse, angular-subangular sandstone. 10% sandy very calcareous siltstone
K 3440	2187		80% fine-coarse angular-subangular very calcareous light grey sandstone and white sand 20% light grey-grey some carbonaceous and calcareous siltstone/claystone
K 3448	2211		Light grey very calcareous sandy, some carbonaceous siltstone
K 3452	2223		As above
K 3455	2235		As above
K 3459	2247		Medium, some coarse angular-subangular white sand with muscovite
K 3463	2265		Medium, coarse angular-subangular white sand with muscovite
K 3467	2283		Medium-coarse angular-subangular white sand with muscovite
K 3472	2301		Medium, coarse angular-subangular white sand with muscovite
K 3475	2325		As above
K 3478	2340		Fine-medium angular-subangular white sand with muscovite
K 3483	2355		As above. Some very calcareous silty light grey claystone with very fine sand
K 3487	2367		25% light grey slightly sandy silty very calcareous claystone with coal fragments 50% fine-medium angular-subangular white sand with muscovite 25% coal
K 3488	2370		40% coal and dark grey carbonaceous claystone

Table I

IKU No.	Depth	TOC	Lithology
			40% fine-medium angular-subangular white sand with muscovite 20% light grey slightly sandy silty very calcareous claystone with coal fragments
K 3491	2379		Medium very angular-angular white sand with muscovite. Sandstone, siltstone and coal as above
K 3495	2391		Fine-medium very angular-subangular white sand and calcareous sandstone 15% coal 5% light brown slightly calcareous silty claystone
K 3498	2400		As above, but only 5% coal and some coarse sand
K 3502	2412		Medium-coarse very angular-angular white sand 2% coal 2% light brown moderately silty and calcareous claystone
K 3506	2424	1,06	Light grey brownish very calcareous sandy silty clayey rock
K 3512	2442	0,42	75% as above 25% light grey-grey calcareous claystone
K 3515	2451	0,30	25% light grey-brownish very calcareous sandy silty claystone 25% light grey calcareous claystone 50% fine-medium very angular-subangular white sand
K 3517-1	2463	0,37	75% light grey-brownish very calcareous sandy silty claystone 15% light grey calcareous claystone 10% fine-medium angular sand
K 3520	2469	0,34	50% brown-grey slightly calcareous silty claystone 40% brownish very calcareous silty sandy rock with calcareous clay clasts 10% fine-medium sand
K 3522	2475	0,18	60% medium, fine angular sand 20% silty rock as above with calcareous claystone fragments (medium sand size) 20% brown-grey slightly calcareous silty claystone
3526	2487	0,25	60% silty sandy clayey rock with calcareous claystone fragments as above 30% brown-grey slightly calcareous silty claystone 10% fine-medium sand

Table 1

IKU No.	Depth	TOC	Lithology
K 3528	2493	0,33	70% fine-medium angular sand 15% silty claystone as above 15% brownish unsorted calcareous rock with sand, silt and clay
K 3532	2505	0,22	40% fine-medium angular sand 30% grey-brown calcareous silty some sandy claystone (a few very fine sand grains 30% sandy moderately silty clayey rock as above
K 3534	2511	0,44	80% sandy silty clayey rock as above 20% grey-brown silty claystone as above
K 3542	2535	0,33	As above. Mottled. Light green claystone fragments. Brown silty claystone is some calcareous and carbonaceous
K 3548	2553	0,37	100% unsorted mottled very calcareous sandy silty clayey rock with clay clasts
K 3552	2565	0,30	As above
K 3554	2571	0,26	As above
K 3558	2583	0,33	60% unsorted rock as above 40% claystone as above
K 3562	2595	0,38	80% unsorted rock as above 20% claystone as above

TABLE Ib

(sidewall cores and cores*)

Depth	TOC	Lithology
1208,5	1,34	Claystone, grey-dark grey with small silty pockets/ lenses
1217,5	1,06	Claystone, grey-dark grey, with abundant white lamina/ lenses of white silt
1233,5	0,82	Claystone, grey/dark grey, some micaceous, abundant very small white silty pockets with some degree of distribution in horizontal zones
1248,3	0,25	Claystone, slightly brown
1304,8	0,37	Claystone, grey with grey and grey-dark grey zones, very coarse grains observed
1317,2	0,40	Claystone, grey, slightly brownish
1338,1	0,87	Claystone, grey
1350,2	0,85	Clay/claystone, grey
1372,0	1,03	Clay/claystone, dark grey
1381,0	0,86	Siltstone/claystone, light grey to grey, micaceous, calcareous
1381,7	0,87	Claystone, grey, some lamination observed, zones of white spots following the lamination, calcareous
1393,4	0,57	Claystone, grey, some fissility with bery micaceous partings, calcareous
1403,0	0,64	Siltstone/claystone, light grey to grey, micaceous
1417,5	0,50	Claystone/siltstone, light grey with some mica and coal fragments, sandy
1426,1	0,11	Sand/silt, consisting of fragmented columnar white-light grey crystals from molluscs
1449,1	0,22	Claystone, redbrown
1458,5	0,25	Claystone, greenish grey, some redbrown, calcareous
1470,0	0,38	Claystone, light greenish grey, calcareous, some dark grey-grey non calcareous claystone, some pyrite rods
1482,0	3,01	Claystone, grey/dark grey, calcareous and carbonaceous, silty
1484,0	3,58	As above, but very slightly calcareous

T A B L E Ib (contd.)

Depth	TOC	Lithology
1486,0	3,85	As above, grey, fissile, with coal fragments, silty
1497,5	2,47	As above
1507,0	2,44	As above
*1515,12	2,61	Claystone, loose-grey dark grey, very silty, carbonaceous, fissile
1515,75	2,61	As above
1519,5	2,55	Claystone, loose, grey, very silty, carbonaceous, fissile
*1527,18	2,15	As above
*1537,0	2,61	As above, slightly silty
*1538,10	2,51	As above
*1540,92	6,76	As above
1552		Sandstone, very fine-medium, angular-subrounded, slightly calcareous
*1562,95		Sandstone, very fine, fine-very coarse, angular-rounded, carbonaceous, grey
*1572,0		Sandstone, very fine-fine, angular-subrounded oil-stained, grey, muscovitic
*1585,67		Sandstone, fine-coarse, subangular-rounede, light grey, stained with light oil
*1597,54		Sandstone, very fine, very silty, calcareous, grey, oil-stained
*1608,0		Sandstone, medium, some coarse-very coarse, angular-subrounded
*1617,15		Sandstone, fine-medium, subangular, grey
*1626,76		Sandstone, fine, some very fine-coarse, angular-subangular, grey, oilstained
*1633,55		Sandstone, fine-medium, some coarse angular-subrounded, grey
1649,0		Siltstone/sandstone (very fine), slightly calcareous, carbonaceous, grey
1657,5	2,12	Siltstone/very fine sandstone, carbonaceous, slightly calcareous

TABLE Ib (contd.).

Depth	TOC	Lithology
1665,0	0,49	Sandstone, very fine, silty, green-grey, calcareous, carbonaceous
1673,5	0,51	Siltstone/very fine sandstone, light grey, calcareous, carbonaceous
1687,0	0,97	As above, slightly calcareous
1695,75	0,71	As above
1713,5	0,52	As above, calcareous
1724,5	0,22	Sandstone, very fine, fine-medium, very silty, light grey, slightly calcareous
1742,0	0,29	Sandstone, very fine-medium, silty, light grey, calcareous
1760,5		Sandstone/siltstone, light grey, very fine-fine, calcareous
1765,25	0,25	Sandstone, very fine-coarse, very coarse, silty, light grey, calcareous
1772		Sandstone, very fine-fine, silty, light grey, calcareous, carbonaceous, micaceous
1784		As above, calcareous
1793		Sandstone, very fine-medium, silty, light grey, slightly calcareous
1812,5		As above, calcareous, carbonaceous
1821		Sandstone, fine-coarse, silty, angular-subangular, light grey, very calcareous
1830,75		Sandstone, very fine-coarse, angular-subrounded, light grey, calcareous, pyritic
1841		Sandstone/siltstone, very fine, laminated, calcareous, carbonaceous, light grey
1851,5		Siltstone, black, slightly calcareous

T A B L E : II

WEIGHT OF EOM AND CHROMATOGRAPHIC FRACTIONS

IKU-No	DEPTH (m)	Rock Extr. (g)	EOM (mg)	Sat. (mg)	Aro. (mg)	HC (mg)	Non HC (mg)	TOC (%)
K-2875	1516	50.0	159.6	34.2	64.5	98.7	60.9	2.6
K-2876	1537	50.0	31.5	13.0	12.3	25.3	6.2	2.6

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-2875	1516	3192	684	1290	1974	1218
K-2876	1537	630	260	246	506	124

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-2875	1516	122.3	26.2	49.4	75.6	46.7
K-2876	1537	24.1	10.0	9.4	19.4	4.8

IKU

TABLE: 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-2875	1516	21.4	40.4	61.8	53.0	38.2	162.0
K-2876	1537	41.3	39.0	80.3	105.7	19.7	408.1

TABLE VI

TABULATION OF DATAS FROM THE GAS CHROMATOGRAMS

IKU No.	Depth (m)	Pristane/nC_{17}	Pristane/Phytane	CPI
K-2875	1516	2,37	1,0	2,8
K-2876	1537	1,47	0,87	3,0

TABLE VII V I T R I N I T E R E F L E C T A N C E

IKU No.	Depth (m)	Vitrinite Reflectance	Fluorescence	Exinite Content
K-2703	800	0,29(22)	Strong background	NIL
K-2708	860	0,28(20)	Yellow and light orange	Low
K-2713	910	0,28(20)	Yellow/orange-light	Trace
K-2717	950	0,29(22)	Yellow and light orange	Low
K-2726	1050	0,27(7)	Yellow/orange	Low-moderate
K-2734	1130	0,31(21)	Yellow/orange	Low-moderate
K-2750	1221	0,30(22)	Yellow and light orange	Low
K-2759	1275	0,34(14) 0,59(3)	Yellow and yellow/orange	Trace
K-2774	1365	0,32(11) 0,55(1)	Yellow/orange and light orange	Low
K-2784	1410	0,47(19) 0,95(1)	Yellow and dull, light orange	Low
K-2799	1458	0,54(6) 0,93(2)	Yellow - light orange	Trace
K-2875	1516	0,49(4)	Yellow/orange and light	Mod./Rich
K-2876	1537	0,33(7) 0,56(1)	Yellow - light orange	Moderate
K-2890	1650	0,25(17)	A few yellow and mid. orange	Trace
K-2900	1680	0,29(22)	Yellow/orange	Trace
K-2946	1842	0,28(22)	Yellow/orange	Low
K-2950	1854	0,28(5)	Hydrocarbon specks	NIL
K-3351	1989	0,43(22) 0,71(2)	Light orange	Low
K-3353	1995	0,41(22)	Light orange and yellow resin in coal	Low
K-3360	2022	0,44(22)	Light orange	Low
K-3383	2097	0,38(23)	Yellow/orange and light orange	Low/Mod.
K-3403	2157	0,38(22)	Variable carbonate and light orange	Low
K-3446	2205	0,39(20)	Yellow/orange and light orange	Moderate
K-3485	2361	0,49(21) 0,84(1)	Light/mid. orange	Moderate
K-3488	2370	0,45(20) 0,73(1)	Light/mid. orange	Moderate

contd.....

TABLE VII V I T R I N I T E R E F L E C T A N C E (contd..)

IKU No.	Depth (m)	Vitrinite Reflectance	Fluorescence	Exinite Content
K-3506	2424	0,46(21)	Light orange	Trace
K-3520	2469	0,30(1) 0,51(2)	Light orange	Trace
K-3536	2517	N.D.P.	No definite org. fl.	NIL
K-3552	2565	N.D.P.	No org. fl.	NIL
K-3562	2595	N.D.P.	Light orange	Trace

TABLE VIII

IKU | Well 31/2-2 | VISUAL KEROGEN ANALYSIS | (Trondheim 1980)

Depth in m.	Composition of residue	Particle size	Preservation palynomorphs	Thermal maturation index	Remarks
800	Am, Cysts/W, Cut, He, Pollen	F	good	1-	Winged pollengrains and cysts
860	* Am, Cysts/W, WR!, Cut, He, Pollen	F-M	good	1	Pollengrains dominate
910	Am, Cysts/W	F	good	1	Cysts dom. palynomorphs
950	Am, Cysts/He, W, WR!	F	good	1	Cysts dom., but varied pollen ass.
1050	Am, Cysts/W, He, Pollen	F	good	1	
1130	W (coaly) WR!, He/Am, Cysts	F-M-C	good	1	Reworked coalified/woody dominant, a lot of pyrite
1221	Am, Cysts/He, Pollen	F	fair to good	1	Varied ass. of pollen grains
1276	Am/W, WR!, He	F	fair	1	Aggregates (minerals and organic)
1365	Am, Cysts/W, He, WR!	F	fair	1/1+	——"——
1410	Am, Cysts/He, W, WR!	F-M	good	1/1+	——"——
1440	Am, Cysts/W, WR!, He, Cut, Poll-spore	F-M	good	1/1+	——"——
1515.12 c	Am, Cysts/He, W, Poll-spore	F	fair to good	1/1+	Amorphous matter obscures palynomorphs
1535 c	** Am, Cysts/He, W, Pollen	F	fair to good	1/1+	Pyrite
1605	** (Am), Cysts/W, WR!, He, Pollen		good	1/1+	

TABLE VIII(contd..)

IKU — VISUAL KEROGEN ANALYSIS — (Trondheim 1980)

Well 31/2-2

Depth in metres	Composition of residue	Particle size	Preservation palynomorphs	Thermal maturation index	Remarks
1631 kj.	* * W,Cut,He,WR!, Poll-spor/Am,Cysts	F-M-C	good	1/1+	
1633.55 c	* W,WR!,Cut,He,Poll-spor/Am,Cysts	F-M	good	1/1+	
1665 swc	He,W,WR!	F-M	-	1/1+	Almost barren
1760.5 swc	Am/Cut,W,He,Poll-spore	F-M-C	good to fair	1/1+	Pyrite
1841.0 swc	* W,WR!,Cut,He	F-M	good to fair	1/1+	Sapropelized, Botryococcus
1851.5 swc	* (Am),W,He,Poll-spore	F-M	good	1/1+	Pyrite —"—"—
1875.5 swc	Am,He,Pollen	F	good and fair	1/1+	Sapropel and/or pyrite fills cavities of palynomorphs
1980	W,Cut,He,WR!/Am	F-L	good,fair,poor	1/1+	
1998 swc	W(coaly)/?sapropel	F-M-L	fair	1+	Sapropel or pyrite fills cavities
2004	W(coaly),W,He/Am	F-M-L	fair	1+	Chemical oxidation is necessa
2025	W(coaly),W	F-M-L	good to fair	1+	

TABLE VIII(contd..)

IKU — VISUAL KEROGEN ANALYSIS — (Trondheim 1980)

Well 31/2-2

Depth in metres	Composition of residue	Particle size	Preservation palynomorphs	Thermal maturation index	Remarks
2036 swc	W(coaly),W,Pollen-spor/Am	F-M	good to fair	1+	
2077 swc	Am/Cut,He,W,WR!,Poll-spore	F-M	good to fair	1+	Sapropelization, pyrite
2091	WR!,He,Cut,W,Poll-spore	F-M	fair to good	1+	
2096.5 swc	Poll-spor,He,Cut,W/Am	F-M	fair	1+	
2155.0 swc	Am/He,Cut,W	F-M	fair	1+	Pyrite in abundance
2160	WR!,He,Cut/Am	F-M	good	1+	Sapropelization
2181.5 swc	Am,He,W	F	fair	1+	Sapropelization Botryococcus
2205	* Am/W,WR!,Cut	F-M	fair	1+	Sapropelization Botryococcus
2210.5 swc	W(coaly),Pollen	F-M	fair to good	1+	
2253 swc	W(coaly)	F-M	fair to good	1+	

TABLE VII (contd..)

IKU | Well 31/2-2 | VISUAL KEROGEN ANALYSIS | (Trondheim 1980)

Depth in metres	Composition of residue	Particle size	Preservation palynomorphs	Thermal maturation index	Remarks
2268	(Am?),Cut,WR!,W,Poll-spore	F-M	fair	1+	Pyrite
2351 swc	W(coaly)	M-C		1+,1+/2-	
2358	* WR!,W,Cut,Poll-spore	F-M-C	fair	1+/2-	
2363.0 swc	Am/WR!,W,He	F-M-C		1+/2-	Residues below 2363.0 are rich in acid resistant minerals
2379	WR!(coal),W/Am	F-M-C		1+/2-	
2387 swc	Am	F		(1+/2-)	Small amounts of sapropel
2389 swc	Am	F		(1+/2-)	
2421	Am	F		(1+/2-)	Caved material
2425	Am	F		(1+/2-)	Small amounts of sapropel
2466	* (Am)	F		(1+/2-)	Amorphous material suspected to be caved occ. pollen or spores

TABLE VIII(contd..)

IKU | Well 31/2-2 | VISUAL KEROGEN ANALYSIS | (Trondheim 1980)

Depth in metres.	Composition of residue	Particle size	Preservation palynomorphs	Thermal maturation index	Remarks
2482.0 swc	-	-	-	NDP	
2502	* Cut,WR!	M	good to fair		Very poor occasional pollen or spores
2526	* He,WR!,Cut,Poll-spore	M	poor to fair		
2552 swc	** WR!(coaly),W,He,Cut,Poll-spore	F-M-C			Almost barren
2562	W				

* acid resistant minerals separated by $ZnBr_2$

** chemically oxidized residues

Am amorphous
He herbaceous
Cut cuticles
W woody
R! reworked
(Am) higher amounts estimated than actually observed in the residue

F fine
M medium
C coarse

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-2703	800 m	4,09	6,91	6,94	6,50	106,31	106,77	11,00	0,37	418°
K-2708	860 m	0,54	6,46	7,82	3,55	181,97	220,28	7,00	0,08	421°
K-2709	870 m	0,26	5,32	11,51	3,83	138,90	300,52	5,58	0,05	422°
K-2711	890 m	0,56	5,17	5,84	2,64	195,83	221,21	5,73	0,05	412°
K-2713	910 m	0,01	0,89	4,60	2,06	43,20	223,30	0,90	0,01	435°
K-2723	1010 m	0,01	0,27	2,26	0,89	30,34	253,93	0,28	0,04	430°
K-2731	1100 m	0,07	0,39	2,55	0,81	48,15	314,81	0,46	0,15	431°
K-2739	1161 m	0,02	0,52	3,83	1,20	43,33	319,17	0,54	0,04	433°
K-2746	1197 m	0,02	0,39	2,40	0,89	43,82	269,66	0,41	0,05	432°
K-2750	1221 m	0,03	0,72	2,06	0,88	81,82	234,09	0,75	0,04	430°
K-2754	1245 m	0,07	0,82	2,22	0,77	106,49	288,31	0,89	0,08	428°
K-2759	1275 m	0,01	0,07	1,51	0,61	11,48	247,54	0,08	0,13	433°
	1350,2 m	0,08	0,15	1,35	0,85	17,65	158,82	0,23	0,35	436°
	1372 m	0,02	0,17	1,02	1,03	16,50	99,03	0,19	0,11	433°
	1381 m	0,04	0,09	1,84	0,86	10,47	213,95	0,13	0,31	438°
	1393,4 m	0,08	0,07	2,31	0,57	12,28	405,26	0,15	0,53	430°

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-2784	1410 m	0,01	0,11	2,68	0,70	15,71	382,86	0,12	0,08	430°
K-2787	1419 m	0,05	0,17	2,86	0,62	27,42	461,29	0,22	0,23	423°
K-2794	1440 m	0,05	0,34	2,26	0,60	56,67	376,67	0,39	0,13	430°
	1480,5 m	0,06	5,59	2,84	2,67	209,36	106,37	5,65	0,01	433°
	1486 m	0,11	11,51	1,78	3,85	298,96	46,23	11,62	0,01	428°
K-2811	1494 m	0,03	8,01	8,54	3,57	224,37	238,22	8,04	0,0037	428°
	1497,5 m	0,07	4,53	1,69	2,47					436°
K-2815	1506 m	0,15	6,59	11,52	3,30	199,70	349,09	6,74	0,02	428°
	1507 m	0,09	5,11	1,94	2,44	209,43	79,51	5,20	0,02	433°
K-2875	1516 m	0,16	5,64	1,56	2,61	216,09	59,77	5,80	0,03	426°
	1527,1 m	0,05	3,89	1,79	2,15	180,93	83,26	3,94	0,01	438°
K-2876	1537 m	0,06	7,01	2,05	2,61	268,58	78,54	7,64	0,08	433°
	1540,9 m	0,85	14,42	2,31	6,76	213,31	34,17	15,27	0,06	429°
K-2827	1542 m	0,16	6,69	6,57	3,23	207,12	203,41	6,85	0,05	426°
	1657,5 m	1,85	17,09	1,77	2,12	806,13	83,49	18,94	0,10	427°
	1687 m	0,08	0,51	1,39	0,97	52,58	143,30	0,59	0,16	427°

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
	1713,5 m	0,04	0,15	1,33	0,52	28,85	255,77	0,19	0,21	428°
	1755 m	0,23	3,29	1,65	1,54	213,64	107,14	3,52	0,07	432°
K-3506	2424 m	0,14	1,69	4,25	1,06	159,43	400,94	1,83	0,08	440°