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REPORT TITLE/ TITTEL

Source Rock Analyses of well 31/4-5

CLIENT/ OPPDRAGSGIVER

Norsk Hydro A/S

RESPONSIBLE SCIENTIST/ PROSJEKTANSVARLIG

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SUMMARY/ SAMMENDRAG

The short sequence analysed from this well is not divided into zones. Only a few samples, core ships 2063.5-2067.45 m, and cuttings from 2260-75 m, both dark claystone and a brown-grey siltstone 2455-70 m were analysed thoroughly.

The analysed sequence is found to be immature down to approx. 2200 m and immature to moderate mature for the lower part. Both the dark claystone intervalls have a good to rich potential as source rock for oil and gas while the brown-grey siltstone has a good potential as a source rock for gas and heavy oil.

KEY WORDS/ STIKKORD

EXPERIMENTAL AND DESCRIPTION OF INTERPRETATION LEVELS

Headspace Gas Analysis

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

Total Organic Carbon (TOC)

Picked cuttings of the various lithologies in each sample was crushed in a centrifugal mill. Aliquots of the samples were then weighed into Leco crucibles and treated with hot 2N HCl to remove carbonate and washed twice with distilled water to remove traces of HCl. The crucibles were then placed in a vacuum oven at 50^{o}C and evacuated to 20 mm Hg for 12 hrs. The samples were then analysed on a Leco E C 12 carbon analyser, 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 fillings 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 evaporated on a Buchi Rotavapor and transferred to glassvials and dried in a stream of nitrogen. The various results are given in Table III-VI.

Gas Chromatographic Analyses

The saturated and aromatic hydrocarbon fractions were each diluted with n-hexane and analysed on a HP 5730 A gas chromatograph, fitted with a 25 m OV101 glass capillary column and an automatic injection system. Hydrogen (0.7 ml/min.) was used as carrier gas and the injection was performed in the split mode (1:20).

Vitrinite Reflectance

Samples, taken at various intervals, were sent for vitrinite reflectance measurements to 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 were 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 fluorescing material determined. Below, a scale comparing the vitrinite reflectance measurements and the fluorescence measurements are given.

VITRINITE REFLECTANCE R.AVER. 546 nm 1516	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10
% CARBON CONTENT DAF.	57	62	70	73	76	79	80.5	82.5	84	85.5
LIPTINITE FLUOR nm	725	750	790	820	840		860	890	940	
EXC. 400 nm BAR. 530 nm 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 = Numberical measurements 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 process to deep orange colour and then fade rather than develop O/R 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 mesh).
O-slide contains palynodebris remaining after flotation ($ZnBr_2$) to remove heavy minerals.
X-slides contain oxidized residues, (oxidizing may be required to remove sapropel which embeds palynomorphs, or where high coalification prevents 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 concentrate the larger fragments, and to study palynomorphs (pollen, spores and dinoflagellates) and cuticles for paleodating and colour evaluation.

So far visual evaluation of kerogen has 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 required, 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 supporting evidence from colour tones of other types of kerogen (woody material, cuticles and sapropel). These colours are dependant upon the maturity, but are also influenced by the paleoenvironment (lithology of the rock, oxidation and decay processes). The colours and the estimated colour index of an individual sample may therefore differ 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).

Ro	0.45	0.6	0.9	1.0	1.3
colour index	2-	2	2+	3-	3
Maturity intervals	Moderate mature	Mature (oil window)			Condensate window

Rock-Eval Pyrolysis

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

RESULTS AND DISCUSSION

No division of the analysed sequence (1960-2470 m) was possible since only a few argillaceous and fine arenaceous lithologies were analysed.

The analytical results are discussed in relation to the various lithologies found in the samples:

grey silty claystones from	1960-2005 m
dark grey claystone from	2063.5-2067.45 m (core samples)
grey calcareous claystones from	2020-2035, 2200-2230 m
grey calcareous vf-f sandstones from	2200-2230 m
dark grey claystone from	2260-2275 m
grey calcareous claystone from	2350-2365 m
grey limestone/marl, silty from	2380-2395 m
	and 2410-2425 m
brownish-grey, silty claystones from	2455-2470 m
grey sandstones from	2455-2470 m

Headspace gas

Silty claystones and dark grey claystones from 1960-2070 m have fair to good abundances of C_1-C_4 and poor to fair C_5-C_7 gas abundances. Wetness is low <50% and iC_4/nC_4 is high indicating immature hydrocarbons. Sandstones from 2200-2215 m have a good abundance of C_1-C_4 and C_5-C_7 hydrocarbons and high wetness, but also high iC_4-nC_4 suggesting perhaps biodegraded migrated hydrocarbons. Otherwise in the analysed samples, a mixture of lithologies give good abundances of C_1-C_4 and fair C_5-C_7 hydrocarbons; wetness is slightly lower than between 2200-2215 m and iC_4-nC_4 shows little variation.

TOC values

TOC in the grey silty claystones varies from 0.77-0.87% (fair).

- in the calcareous grey claystones from 0.7-1.11% (fair to good)
- in grey, fine-very fine sandstones from 0.84-1.28% (fair to good)
- in limestone/marl from 0.18% (white, chalky) to 0.74% (grey, marl) (poor-fair)

The dark grey claystones between 2063.5-2067.95 have TOC values from 5.4 to 7.66% (rich). A dark grey claystone between 2260-2275 m has a value of 7.13% (rich). A brown-grey silty claystone between 2455-2470 m has a value of 2.87% (rich).

Extraction and Chromatographic Analyses

Three separate horizons were analysed:

dark grey claystone from 2063.5-2067.45 m
dark-grey claystone from 2260-2275 m
brownish-grey silty claystone from 2455-2470 m

Nine samples of full core from the first section were analysed. They all gave similar results. Abundance of EOM is high for all samples (rich). Values of total hydrocarbon content normalised to TOC are fair-rich. The gc traces are very similar indicating a relatively uniform kerogen. The smooth front-end biased n-alkane distributions and low pristane/phytane (1-1.5) values suggests that the hydrocarbons are derived from moderate mature type II kerogen (i.e. amorphous, probably mainly marine input).

Abundances of EOM are rich, and the percentage of saturated hydrocarbon is greater in the dark grey claystone from 2260-2275 m (K-8357) and in the brown-grey silty claystone from 2455-2470 m (K-8370).

In K-8357 the n-alkane distribution is unimodal ranging from nC_{12} to nC_{35} with a maximum at nC_{15}/nC_{17} and with a prominent high molecular shoulder up to nC_{27}. Unlike the core samples of dark grey claystone from 2063.5-2067.45 m, the low molecular component below nC_{17} is not as prominent.

The brown-grey siltstone K-8370 has a unimodal n-alkane distribution ranging from nC_{11} to nC_{35} with a maximum at nC_{27}, with a prominent odd n-alkane predominace (CPI=1.7). There is a smaller maximum of lower molecular weight centred around nC_{17}. The highest pristane/phytane ratio of all the samples is found in this sample -2.8- as against general values of 1.2-1.5. The distribution of hydrocarbons in this sample indicates material derived predominantly from higher plant material.

The abundant terrestrially derived material indicated from visual kerogen analysis in samples from 2063.5-2067.45 m, is apparently at odds with the saturated hydrocarbon distributions. The abundance of cuticles (50-70%) and the indications of strong sapropelisation indicate perhaps much bacterial reworking of paraffinic hydrocarbons has occurred to gain the n-alkane distributions obtained, with also a probable large bacterial input.

Vitrinite Reflectance

K-7873, 1975m: Shale, Ro=0,61(5)

The sample contains bitumen blebs. It has a very low content of gnarled inertinite and reworked particles with only a couple of vitrinite particles. UV light shows yellow/orange fluorescence from spores and a trace only of exinite.

K-7874, 1990m: Shale and Limestone, Ro=0,39(4) and 0,65(1)

The sample contains bitumen staining and blebs. It has a very low content of inertinite and reworked particles. UV light shows light orange fluorescence from spores and a trace only of exinite.

K-7875, 2005m: Shale and Carbonate, Ro=0,48(6)

The sample contains bitumen blebs, wisps and light staining. It has a trace only of phytoclasts and a few inertinite and reworked particles with a handfull of vitrinite wisps and particles. UV light shows no organic fluorescence and the exinite content is nil.

K-7877, 2035m: Shale and Carbonate, Ro=0,55(2)

The sample contains bitumen wisps and blebs. It has a very low phytoclast content and small, gnarled particles of inertinite and reworked material. It contains only of couple of vitrinite wisps.

K-8800, 2063.5m: Shale, Ro=0,44(12)

The sample has plentiful strong bitumen wisps and has a few extensive areas of bitumen. It has a trace only of phytoclasts and only a few particles of vitrinite and inertinite have been located. UV light shows yellow/orange fluorescence from spores and a moderate to rich exinite content.

K-8801, 2064.0m: Shale, Ro=0,49(7)

The sample has strong bitumen wisps and locallised staining. There is a trace only of phytoclasts. It contains a few inertinite and reworked particles with even fewer particles of vitrinite. UV light shows yellow/orange fluorescence from spores and a moderate to rich exinite content.

K-8802, 2064.6m: Shale, Ro=0,37(3) and 0,65(1)

The sample has strong bitumen wisps and some saturated areas. There is a trace only of phytoclasts. It contains almost wholly inertinite and reworked particles with a couple only of doubtful vitrinite particles. UV light shows yellow/orange fluorescence from spores and a moderate exinite content.

K-8803, 2065.05m: Shale, Ro=0,40(5)

The sample has strong bitumen wisps and staining with some areas of bitumen saturation. There is a trace only of phytoclasts. A few small particles of inertinite and reworked material with even less vitrinite is observed. UV light shows yellow/orange fluorescence from spores and a moderate to rich exinite content.

K-8804, 2065.55m: Shale, Ro=0,51(20)

The sample has plentiful strong bitumen wisps, stringers and blebs. It has a trace only of phytoclasts particles of inertinite and reworked material. Most of the readings observed are on loose vitrinite particles. UV light shows yellow/orange fluorescence from spores and a moderate exinite content.

K-8805, 2066m: Shale, Ro=0,44(13)

The sample has strong bitumen wisps and staining. It has a low content of inertinite and reworked particles and a trace only of vitrinite particles. UV light shows yellow/orange fluroescence from spores and a moderate to rich exinite content.

K-8806, 2066,55m: Shale, Ro=0,46(11)

The sample has plentiful strong bitumen wisps. It has a low content of inertinite and reworked material. The lowest Ro values measured are possible true vitrinite particles. UV light shows yellow/orange fluorescence from spores and a moderate to rich exinite content.

K-8807, 2067m: Shale, Ro=0,46(10)

The sample has strong bitumen staining and some areas of bitumen. It has a low content of inertinite and reworked particles. The lowest Ro values which are measured are possibly true vitrinite particles. UV light shows yellow/orange fluorescence from spores and a moderate to rich exinite content.

K-8808, 2067.45m: Shale, Ro=0,47(8)

The sample has plentiful strong bitumen wisps. It has a low content of inertinite particles and reworked material and a trace only of vitrinite particles. UV light shows yellow/orange fluorescence from spores and a moderate exinite content.

K-8353, 2215m: Calcareous Siltstone and Carbonate, Ro=0,36(20)

The sample has strong bitumen staining and wisps. It has a trace only of phytoclasts and a few included lignite fragments. UV light shows yellow to light orange fluorescence from spores and a low exinite content.

K-8354, 2230m: Siltstone, Ro=0,40(10)

The sample has strong interstitial bitumen staining. There is a trace only of inertinite particles and corroded vitrinite wisps. UV light shows yellow/orange and light orange fluorescence from spores and a low exinite content.

K-8357, 2275m: Calcareous Siltstone, Ro=0,40(21)

The sample has strong bitumen staining and wisps. There is a trace only of phytoclasts. It contains a few vitrinite particles and wisps with an equal proportion of inertinite. UV light shows yellow/orange and light orange fluorescence from spores and a low exinite content.

K-8363, 2365m: Calcareous Shale and Carbonate, Ro=0,45(10) and 0,89(1)

The sample has strong bitumen wisps and occasional staining. It has a low content of inertinite and reworked particles with a trace of vitrinite wispy particles. UV light shows yellow/orange and light orange fluorescence from spores and hydrocarbon wisps and a moderate exinite content.

K-8365, 2395m: Calcareous Shale, Ro=0,37(15)

The sample has bitumen wisps and a moderate staining. It has a very low content of vitrinite particles and wispy particles with a trace only of inertinite. UV light shows yellow/orange and light orange fluorescence from spores and a moderate exinite content.

K-8367, 2425m: Calcareous Shale, Ro=0,42(18)

The sample has a light overall bitumen staining and wisps. It has a very low content of inertinite particles with an equal proportion of vitrinite particles and wispy particles. UV light shows yellow/orange and light orange fluorescence from spores and a moderate exinite content.

K-8370, 2470m: Shale and Calcareous Shale, Ro=0,45(21)

The sample has an overall moderate bitumen staining and strong wisps. It has a low to moderate content of vitrinite particles and wispy particles with subordinate inertinite particles. UV light shows yellow/-orange fluorescence from spores and a moderate exinite content.

INVESTIGATIONS IN TRANSMITTED LIGHT

Disperse Organic Matter (Visual Kerogen)

The analysis is carried out on the basis of 9 cores and 6 rock samples, from selected lithologies from 4 ditch cuttings samples. The samples are spaced between 2063.5 and 2470 m. The deposits at 2067.45 m and above are immature.

2063.5-2067.45 m:

All samples in this interval contained dominantly terrestrial remains 50-70% cuticles, 10-25% woody material and subordinate pollen and spores.

The material is strongly sapropelised and fragmented, but coherent and therefore recorded as aggregates of variable density. The palynomorphs are mostly poorly preserved, only Tasmanites, Botryococcus and Pterospermopsis were easily observed.

True sapropel was difficult to distinguish due to the dissolved structures of the terrestrial material, but it was estimated as varying about 10-20%.

Colour index: 1+/2-, 2-, 2-/2, somewhat variable from sample to sample, and estimated as 2- or 2-/2.

The higher values at 2065.05 and 2065.55 may be due to an oxidising environment.

2215 m:

The residue is very small and after screening there were mostly caved organic material judged by the presence of Cretaceous cysts at this level.

Colour index: 2+/3- and 2-/2 as above.

2275 m a) claystone, dark grey:

Well disperse material and firm aggregates. The residue, as in interval 2063.5-2067.45 m seems dominated by cuticular and woody matter.

Classopollis echinatus suggests presence of Late Jurassic rocks. The material is sapropelised and generally poorly preserved.

Colour index: 2+

2275 m b) claystone, grey:

Well disperse material and firm aggregates. The material is fairly well to poorly preserved, but the presence of Cretaceous cysts proposes that younger caved material is present in this sample.

Colour index: 2/2+

2395 m, sandstone:

The residue contains about 30% true sapropel and about 50% of woody material approximately 10% being inertinite or reworked older material. Cuticular material and palynomorphs, together about 15%, are fairly thin and light coloured. Abundance of N.gracilis supports an Early Jurassic age and marine deposit.

Colour index: 2/2+

2470 m, sandstone:

Pollen/spores, cutciles, woody material (vitrinite), and inertinite (or reworked material) each represents 20-25% of the screened residue.

Rare N.gracilis, abundant Chasmatosporites and C.thiergartü together support an Early Jurassic age for this rather poor lithology.

Colour index: 2/2+

2470 m, silty claystone:

The residue resembles that of the sandstone from the same level but is richer, about 30% true amorphous matter (sapropel). There is less woody matter, about 25% vitrinite with subordinate inertinite.

Palynomorphs support an Early Jurassic, probably Pliensbachian age as for the sandstone from 2470 m.

Colour index: 2/2+

Rock-Eval Pyrolysis

The three claystone lithologies which were extracted were also analysed by Rock-Eval pyrolysis. The two dark grey claystones from 2063.5 to 2067.45 m and 2260-2275 m show comparable results; i.e. type II kerogen which is immature to moderate mature (high hydrogen index, low oxygen index, low T_{max}) with a good-rich potential as a source rock for oil and gas. The silty claystone between 2455-2470 m has a mixed type II/III kerogen with a good potential as a source rock for oil and gas and is moderate mature.

CONCLUSIONS

Based on the available data, the source rock potential of only three lithologies can be adequately deduced. These three are:-

2063.5-2067.45 m	Dark grey claystone (cores)
2260-2275 m	Dark grey claystone
2455-2470 m	Brown-grey siltstone

The two dark grey claystone sections are immature to moderate mature with a good to rich potential as source rocks for oil and gas from type II kerogen. It is interesting, in the case of the cored claystone, that there is some low molecular weight hydrocarbons apparently generated (i.e. below nC_{15}) at such an early stage. The occurrence of odd n-alkane predominance between nC_{12} and nC_{20} indicates that this is not contamination from drilling fluids or from migrated hydrocarbons. Therefore there is probably some early generation of low-medium molecular weight hydrocarbons.

The brown-grey siltstone has a mixed type II/III kerogen and is immature to moderate mature with a good potential as a source rock for gas and heavy oil.

TABLE 1 a.

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

IKU No.	DEPTH (m)	C1	C2	C3	iC4	nC4	C5+	SUM C1-C4	SUM C2-C4	WET-NESS (%)	iC4 / nC4
K7873	1975	5431	666	1250	485	1084	1803	8916	3485	39.08	.45
K7874	1990	6656	995	1511	454	995	1234	10610	3954	37.27	.46
K7875	2005	1234	161	316	98	230	433	2038	805	39.48	.42
K7877	2035	3479	250	965	420	928	1660	6041	2562	42.42	.45
K8353	2215	32470	24265	26439	4659	5478	5296	93311	60841	65.20	.85
K8354	2230	13994	11044	12251	1966	2384	1668	41639	27645	66.39	.82
K8357	2275	15657	12108	13571	2300	2616	2099	46253	30596	66.15	.88
K8363	2365	14679	7533	6539	950	1018	907	30719	16040	52.22	.93
K8365	2395	14910	8616	8965	1334	1535	1377	35360	20450	57.83	.87
K8367	2425	6518	4270	4398	698	997	1323	16881	10364	61.39	.70
K8370	2470	6296	3925	3545	702	1013	1009	15481	9185	59.33	.69

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LITHOLOGY AND TOTAL ORGANIC CARBON MEASUREMENTS

TABLE NO.: II

WELL NO.: 31/4-5

Sample	Depth	TOC	Lithology
K-8800	2063.5 Core 1	6.99	Claystone, dark grey, very slightly micaceous, fissile, observed slickensides
K-8801	2064.0 Core 1	7.15	Claystone, dark grey, slightly micaceous, some Scolecodont fragments, minor very fine framboidal pyrite
K-8802	2064.6 Core 1	6.75	Claystone, as above
K-8803	2065.05 Core 2	5.85	Claystone, as above, some pyritic lenses and fissures
K-8804	2065.55 Core 2	7.20	Claystone, dark grey, subfissile
K-8805	2066 Core 2	7.32	Claystone, as above, some slickensides
K-8806	2066.55 Core 2	6.05	Claystone, as above, slightly waxy
K-8807	2067.00 Core 2	7.66	Claystone, as above, somewhat softer
K-8808	2067.45	5.40	Claystone, as above, waxy, partly pyritic (very fine framboidal grains)

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LITHOLOGY AND TOTAL ORGANIC CARBON MEASUREMENTS

TABLE NO.: II

WELL NO.: 31/4-5

Sample	Depth	TOC	Lithology	
K-7873	1975	0.87	80%	silty Claystone, grey, partly pyritic and calcareous, variable silt content
			5%	Sand, very coarse to coarse, rounded, additive?
			5%	?Siderite/sideritic Limestone, greyish brown
			10%	Cement
			Sm.am.	Claystone, greenish grey, pale purple
			Obs.	Glauconite
K-7874	1990	0.87	92%	silty Claystone, as above
			3%	sideritic Limestone, as above
			5%	Cement and Sand (additive)
			Sm.am.	as above plus Pyrite, Core chips
K-7875	2005	0.77		As above
K-7877	2035	0.72	50%	Claystone, slightly silty, grey, calcareous
		0.18	50%	Limestone, white to pale pinkish white, chalky, firm
K-8353	2215	0.73	14%	Claystone, grey to light grey, calcareous
			5%	Claystone, dark grey
		1.07	80%	Sandstone, grey to greyish brown, very fine to fine, partly calcareous, very micaceous, soft/loose
			1%	Pyrite
			Abn.	Core chips
K-8354	2230	0.92	14%	Claystone, grey to light grey, as above
			5%	Claystone, dark grey
		0.84	80%	Sandstone, as above
			1%	Pyrite
			Abn.	Core chips

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LITHOLOGY AND TOTAL ORGANIC CARBON MEASUREMENTS

TABLE NO.: II

WELL NO.: 31/4-5

Sample	Depth	TOC	Lithology	
K-8357	2275	7.13	15%	Claystone, dark grey, subfissile
		0.70	10%	Claystone, grey
		0.86	72%	Sandstone, as above
			1%	Limestone, white, chalky
			2%	Pyrite
K-8363	2365	1.11	10%	Claystone, grey, calcareous
			1%	Claystone, dark grey
			67%	Sand/Sandstone, grey, very fine to fine, some medium and coarse, partly silty, occasionally very calcareous
		0.74	20%	Limestoen/Marl, silty, grey
			2%	Pyrite
K-8365	2395		5%	Claystone, grey, dark grey, greenish grey
		0.76	63%	Sand/Sandstone, as above
		0.56	30%	Marl/Limestone, as above
			2%	Pyrite
K-8367	2425	1.28	4%	Claystone, brownish grey, grey
			90%	Sand/Sandstone, greyish white-greyish brown, fine, medium, some coarse-very coarse
			5%	Limestone, greyish white
			1%	Pyrite
			Sm.am.	?Siderite
K-8370	2470	2.87	7%	Claystone, grey, brownish grey, dark grey
			60%	silty Claystone, brownish grey, shaly micaceous
		0.76	30%	Sandstone/Sand, greyish white, as above
			3%	Limestone/Marl, as above

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T A B L E : III

WEIGHT OF EOM AND CHROMATOGRAPHIC FRACTIONS

IKU-No	DEPTH (m)	Rock Extr. (g)	EOM (mg)	Sat. (mg)	Aro. (mg)	HC (mg)	Non HC (mg)	TOC (%)
K-8800	2063.5	52.0	154.0	30.7	35.8	66.5	87.5	7.0
K-8801	2064.0	53.8	145.8	27.2	37.4	64.6	81.2	7.1
K-8802	2064.6	50.7	133.9	24.8	37.9	62.7	71.2	6.8
K-8803	2065.05	52.7	149.1	29.4	25.7	55.1	94.0	5.9
K-8804	2065.55	50.9	153.7	27.7	41.4	69.1	84.6	7.2
K-8805	2066	39.7	110.7	26.0	29.3	55.3	55.4	7.3
K-8806	2066.55	50.1	156.4	29.9	39.7	69.6	86.8	6.1
K-8807	2067	54.2	137.7	31.5	34.7	66.2	71.5	7.7
K-8808	2067.45	52.6	192.4	54.4	51.0	105.4	87.0	5.4
K-8357	2275	2.6	3.1	1.6	.7	2.3	.8	4.4
K-8370	2470	30.1	20.9	13.9	5.0	18.9	2.0	2.1

IKU

T A B L E : IV

CONCENTRATION OF EOM AND CHROMATOGRAPHIC FRACTIONS

(Weight ppm of rock)

IKU-No	DEPTH (m)	EOM	Sat.	Aro.	HC	Non HC
K-8800	2063.5	2961	590	688	1279	1682
K-8801	2064.0	2709	505	695	1200	1508
K-8802	2064.6	2643	490	748	1238	1405
K-8803	2065.05	2831	558	488	1046	1785
K-8804	2065.55	3019	544	813	1357	1662
K-8805	2066	2791	656	739	1394	1397
K-8806	2066.55	3120	596	792	1388	1731
K-8807	2067	2541	581	640	1222	1319
K-8808	2067.45	3657	1034	969	2003	1654
K-8357	2275	1179	608	266	875	304
K-8370	2470	694	462	166	628	66

IKU

T A B L E : V

CONCENTRATION OF EOM AND CHROMATOGRAPHIC FRACTIONS

(mg/g TOC)

IKU-No	DEPTH (m)	EOM	Sat.	Aro.	HC	Non HC
K-8800	2063.5	42.4	8.4	9.8	18.3	24.1
K-8801	2064.0	37.9	7.1	9.7	16.8	21.1
K-8802	2064.6	39.2	7.3	11.1	18.3	20.8
K-8803	2065.05	48.4	9.5	8.3	17.9	30.5
K-8804	2065.55	41.9	7.6	11.3	18.9	23.1
K-8805	2066	38.1	9.0	10.1	19.0	19.1
K-8806	2066.55	51.6	9.9	13.1	22.9	28.6
K-8807	2067	33.2	7.6	8.4	15.9	17.2
K-8808	2067.45	67.7	19.1	18.0	37.1	30.6
K-8357	2275	26.8	13.9	6.1	19.9	6.9
K-8370	2470	33.2	22.1	7.9	30.0	3.2

IKU

T A B L E : VI

COMPOSITION IN % OF THE MATERIAL EXTRACTED FROM THE ROCK

IKU-No	DEPTH (m)	Sat / EOM	Aro / EOM	HC / EOM	Sat / Aro	Non HC / EOM	HC / Non HC
K-8800	2063.5	19.9	23.2	43.2	85.8	56.8	76.0
K-8801	2064.0	18.7	25.7	44.3	72.7	55.7	79.6
K-8802	2064.6	18.5	28.3	46.8	65.4	53.2	88.1
K-8803	2065.05	19.7	17.2	37.0	114.4	63.0	58.6
K-8804	2065.55	18.0	26.9	45.0	66.9	55.0	81.7
K-8805	2066	23.5	26.5	50.0	88.7	50.0	99.8
K-8806	2066.55	19.1	25.4	44.5	75.3	55.5	80.2
K-8807	2067	22.9	25.2	48.1	90.8	51.9	92.6
K-8808	2067.45	28.3	26.5	54.8	106.7	45.2	121.1
K-8357	2275	51.6	22.6	74.2	228.6	25.8	287.5
K-8370	2470	66.5	23.9	90.4	278.0	9.6	945.0

IKU

TABLE VII

TABULATION OF DATAS FROM THE GASCHROMATOGRAMS

IKU No.	DEPTH (m)	PRISTANE / n-C17	PRISTANE / PHYTANE	CPI
K8800	2063.5	1.3	1.4	.8
K8801	2064.0	1.4	1.4	.8
K8802	2064.6	1.3	1.3	.8
K8803	2065.05	1.2	1.2	.8
K8804	2065.55	1.3	1.4	.8
K8805	2066	1.1	1.3	1.0
K8806	2066.55	1.1	1.3	1.0
K8807	2067	1.2	1.3	1.3
K8808	2067.45	.8	1.2	1.0
K8357	2275	1.0	1.5	1.2
K8370	2470	1.1	2.8	1.7

IKU

VISUAL KEROGEN ANALYSIS

TABLE NO.: VIII

WELL NO.: 31/4-5

Sample	Depth	Composition of residue	Particle size	Preservation-palynomorphs	Thermal maturation index	Remarks
K-8800	2063.5	Cut,W,P,S/Am	F-M-L	poor to fair	1+/2-	Strong sapropelisation. Small vitrinite particles.
K-8801	2064.0	Cut,W,P,S/Am	F-M-L	fair to good	2-	As above, fairly well disperse material, some pyrite.
K-8802	2064.6	Cut,W,WR!,P/Am	F-M	fair to poor	2-	Some more fusinite/semi-fusinite than above. Tasmanites common. Well disperse residue.
K-8803	2065.05	Cut,W,WR!,P/Am	F-M-L	poor to fair	2+	Particles more coherent as aggregates. Increased amount of inertinite.

ABBREVATIONS

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

032/P /jlh/1

IKU

VISUAL KEROGEN ANALYSIS

TABLE NO.: VIII

WELL NO.: 31/4-5

Sample	Depth	Composition of residue	Particle size	Preservation-palynomorphs	Thermal maturation index	Remarks
K-8804	2065.55	Cut,W,P/Am,Cy	F-M-L	fair to poor	2/2+	Firmer (dark) aggregates. Tasmanites is common together with Botryococcus Late Jurassic/Cretaceous cysts.
K-8805	2066	Cut,W,WR!,P,S/Am,Cy	F-M-L	fair to poor	2-/2	Disperse material and firm aggregates. Small algal/fungal bodies. Rich in pyrite framboids. Strong sapropelisation, Tasmanites, Pterospermopsis.
K-8806	2066.55	Cut,W,WR!,P,S/Am,Cy	F-M-L	fair to poor	2-/2	As above, but more of inertinite.
K-8807	2067.0	Cut,W,WR!,P,S/Am,Cy	F-M-L	fair to poor	2-/2	As above.

ABBREVATIONS

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

032/P /jlh/2

IKU

VISUAL KEROGEN ANALYSIS

TABLE NO.: VIII

WELL NO.: 31/4-5

Sample	Depth	Composition of residue	Particle size	Preservation-palynomorphs	Thermal maturation index	Remarks
K-8808	2067.45	Cut,W,WR!,P,S/Am,Cy	F-M-L	fair	2-	As above, But? less strong tendency for aggregates.
K-8353	2215	*	F-M-L	fair	2-/2 2+/3-	Screened slide. Presence of Cretaceous cysts. Aggregates as above, caved? material.
K-8357a Cl.dk.gy	2275	Cut,W,P,S/Am,Cy	F-M-L	fair to poor	2+	Disperse fine material and firm aggregates. Classo-pollis echinates. Late Jurassic pollen.
K-8357b Cl.st.gy	2275	Cut,W,P,S/Am,Cy	F-M-L	fair to poor	2/2+	Disperse fine material and firm aggregates. Cretaceous cysts.

ABBREVATIONS

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

IKU

VISUAL KEROGEN ANALYSIS

TABLE NO.: VIII

WELL NO.: 31/4-5

Sample	Depth	Composition of residue	Particle size	Preservation-palynomorphs	Thermal maturation index	Remarks
K-8365 S.st.	2395	W,P,S,Cut/Am,Cy	F-M	good	2/2+	Early Jurassic (Toarcian) palynomorp ass. Pollen fairly thin, relatively light coloured. Abundant N.gracilis.
K-8370a S.st.	2470	*Cut,W,P,S	F-M-L	good	2/2+	*Screened residue. Abundant Chasmatosp. Rare N.gracilis. Probably Pliensb. Thick cuticles.
K-8370b Slt./cl.st.	2470	Cut,W,P,S/Am,Cy	F-M-L	good	2/2+	Palynomorphs as in Sandstone, same depth. A fair amount of amorphous.

ABBREVATIONS

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

032/P /jlh/4

IKU

VITRINITE REFLECTANCE MEASUREMENTS

TABLE NO.: IX

WELL NO. 31/4-5

Sample	Depth	Vitrinite reflectance	Fluorescence in UV light	Exinite content
K-7873	1975	0,61(5)	Yellow/Orange	Trace
K-7874	1990	0,39(4), 0,65(1)	Light Orange	Trace
K-7875	2005	0,48(6)	-	-
K-7877	2035	0,55(2)	Light Orange	Trace
K-8800	2063.5	0,44(12)	Yellow/Orange	Moderate-Rich
K-8801	2064.0	0,49(7)	Yellow/Orange	Moderate-Rich
K-8802	2064.6	0,37(3), 0,65(1)	Yellow/Orange	Moderate
K-8803	2065.05	0,40(5)	Yellow/Orange	Moderate-Rich
K-8804	2065.55	0,51(20)	Yellow/Orange	Moderate
K-8805	2066	0,44(13)	Yellow/Orange	Moderate-Rich
K-8806	2066.55	0,46(11)	Yellow/Orange	Moderate-Rich
K-8807	2067	0,46(10)	Yellow/Orange	Moderate-Rich
K-8808	2067.45	0,47(8)	Yellow/Orange	Moderate
K-8353	2215	0,36(20)	Yellow/Light Orange	Low
K-8354	2230	0,40(10)	Yellow/Orange and Light Orange	Low
K-8357	2275	0,40(21)	Yellow/Orange and Light Orange	Low
K-8363	2365	0,45(10), 0,89(1)	Yellow/Orange and Light Orange	Moderate
K-8365	2395	0,37(15)	Yellow/Orange and Light Orange	Moderate
K-8367	2425	0,42(18)	Yellow/Orange and Light Orange	Moderate
K-8370	2470	0,45(21)	Yellow/Orange	Moderate

IKU

TABLE X

ROCK EVAL PYROLYSES

IKU No.	DEPTH (m)	S1	S2	S3	TOC (%)	HYDR. INDEX	OXYGEN INDEX	OIL OF GAS CONTENT S1+S2	PROD. INDEX S1/(S1+S2)	TEMP. max (C)
K8800	2063.5 Clst dk gy	2.07	42.32	.75	6.99	605	11	44.39	.05	417
K8801	2064 Clst dk gy	1.79	40.44	.81	7.15	566	11	42.23	.04	417
K8802	2064.6 Clst dk gy	1.70	35.96	.86	6.75	533	13	37.66	.05	415
K8803	2065.05 Clst dk gy	3.19	39.29	.79	5.85	672	14	42.48	.08	418
K8804	2065.55 Clst dk gy	2.64	48.80	1.39	7.20	678	19	51.44	.05	418
K8805	2066 Clst dk gy	2.01	48.86	2.23	7.32	667	30	50.87	.04	423
K8806	2066.55 Clst dk gy	1.61	30.85	1.55	6.05	510	26	32.46	.05	419
K8807	2067 Clst dk gy	1.82	37.62	2.09	7.66	491	27	39.44	.05	420
K8808	2067.45 Clst dk gy	2.23	28.70	2.11	5.40	531	39	30.93	.07	419
K8357	2275 Clst dk gy	1.64	41.48	1.20	7.13	582	17	43.12	.04	421
K8370	2470 Clst	.79	8.85	1.69	2.87	308	59	9.64	.08	431