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SOURCE ROCK ANALYSES OF WELL 3~~4/10-4~~

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SUMMARY On the basis of headspace gas analysis, the analysed sequence is divided into six zones.

A: 1400-1680 m: Fair potential as a source rock for gas and oil. Contaminated by strongly biodegraded hydrocarbon.

B: 1680-1810 m: Poor potential as a source rock for gas. Migrated biodegraded hydrocarbon in siltstone

C: 1820-1910 m: No samples available.

D: 1910-1984 m: Sandstone with migrated hydrocarbons.

E: 1987-2430 m: Alternating sand - claystone lithologies. Migrated hydrocarbons in sand lenses. Claystone has a fair/good potential as a source rock for gas.

F: 2430-2600 m: Mud additives only.

The whole analysed sequence was immature.

KEY WORDS

Source rock

EXPERIMENTAL

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

Total Organic Carbon (TOC)

The various selected samples were crushed on a centrifugal mill and sieved. The portions with a particle size between 0.125 mm and 0.063 mm were used in the further work. Aliquotes of the samples were treated with hot 6N HCl to remove carbonate and washed twice with distilled water to remove traces of HCl, then placed in a vacuum oven at 50°C, 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 on soxhlet apparatus for 48 hrs using dichloromethane (DCM) as solvent. The DCM used as solvent was distilled in an all glass apparatus to remove contaminants. The paper thimbles used in the soxhlet apparatus were previously washed with DCM on a large soxhlet apparatus for 48 hrs. to remove any soluble components.

Activated copper foil was used in the flasks 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 on chromatographic columns, packed with silica, Riedel & Hähn, 0.063 mm, using the slurry method with hexane as solvent. On top of the silica, small amounts of alumina, approximately 2 cm, was added. The EOM, after it was "taken up" on alumina, was transferred to the top of the columns, which were then eluted with predistilled hexane, benzene and methanol using a ratio of 200 ml of each solvent pr. gm of EOM.

The various eluants were removed on a Buchi Rotavapor and the samples transferred to vials and dried at 40^{o}C in a stream of dry nitrogen, and the amount of the various fractions, saturated, aromatic and NSO fraction (Nitrogen, Sulphur, Oxygen), determined. The saturated fractions were analysed gas chromatographically on a 25 m OV 101 glass capillary column with He as carrier gas (0.7 ml/min.) using the splitless injection technique. The glass capillary column was mounted in a Carlo Erba F V 2150 gas chromatograph.

Vitrinite Reflectance

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

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

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

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

Processing of Samples for Evaluation of Visual Kerogen

The rock samples were crushed and afterwards treated with hydrochloric and hydrofluoric acids to remove the minerals. A series of microscopic slides was mounted in glycerine jelly:

T-slide represents the total acid insoluble residue.
O-slide represents the residue screened through 15 sieves.
N-1,2,3 slides contain palynodebris remaining after flotation (Zn Br_2) to remove disturbing heavy minerals.
X-1,2,3 slides contain oxidized residues, when oxidizing is required due to high coalification or much sapropel.

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

Screened slides are normally required to consentrate the larger fragments, and to study palynomorphs (pollen, spores and dinoflagellates) for paleo-dating 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 x40 objectives.

Rock-Eval Pyrolyses

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

RESULTS AND DISCUSSION

Light Hydrocarbons

As reported by telephone almost all the cans from this well were completely dry, and in some cases the content in the cans was a schrivelled up, dry lump. This will of course have affected the light hydrocarbon measurements. Towards the lower part of the well, a large proportion of these cans had open lids, and were found to contain only mud and mud additives (nutshells).

As agreed, light hydrocarbons from crushed cuttings were not analysed, and based on headspace analyses, the analysed sequence of the well will be divided into six zones.

A: 1400 - 1680 m
B: 1680 - 1820 m
C: 1820 - 1910 m
D: 1910 - 1984 m
E: 1984 - 2430 m
F: 2430 - 2600 m

A large variation in abundance of the light hydrocarbons together with the wetness of the gas and the isobutan/normal butan (iC_4/nC_4) ratio is found. The wetness of the gas of the analysed samples in this well will generally be lower than in the other wells analysed from this structure (34/10-1 and 34/10-3) since only headspace analyses are performed on this well, methane being mainly found in the headspace and to a smaller extent in the gas from crushed cuttings.

A: 1400 - 1680 m: This zone has a good abundance of C_1-C_4 hydrocarbons while the C_5^+ hydrocarbons show a poor abundance at the top of the zone, increasing sharply with increasing depth. The gas is very dry and the iC_4/nC_4 ratio relatively high.

B: 1680 - 1820 m: The abundance of C_1 - C_4 hydrocarbons increases sharply in this zone compared to the zone above, while the iC_4/nC_4 ratio drops sharply. The C_5^+ abundance, especially at the top of the zone, is very high, indicating migrated hydrocarbons in siltstone in the top of this zone.

C: 1820 - 1910 m: No samples available from this zone.

D: 1910 - 1984 m: This zone, which consists of sandstone has a good abundance of both C_1-C_4 and C_5^+ hydrocarbons, which indicates migrated hydrocarbons in this zone.

E: 1984 - 2430 m: This zone consists of sandstone and shale lenses. The abundance of C_1 - C_4 hydrocarbons is relatively constant throughout the zone, showing a fair abundance. The abundance of C_5^+ hydrocarbons varies considerably with a poor abundance at the top and the lower part of the zone, while the section from 2280 - 2340 m has a good abundance. This could indicate migrated heavier hydrocarbons in the sandstone in this interval, or contamination from mud additives. The abundance drops sharply towards the lower end, and the sandstone in this interval (2350 - 2400 m) does not show any indications of migrated hydrocarbons.

F: 2430 - 2600 m: Almost all the samples in this interval had open lids, and the cans contained only mud additives. Due to this, no evaluation will be given of this zone.

Total Organic Carbon (TOC)

A: 1400 - 1680 m: The claystone analysed in this zone all show to have a fair abundance of total organic carbon, mainly in the 0.6 - 0.8 % interval.

B: 1680 - 1820 m: Very bad recovery of true cuttings from this zone, mainly coal, which could have been mud additive, and cement. The few TOC measurements indicate a similar abundance as in the zone above.

C: 1820 - 1910 m: No available samples.

D: 1910 - 1984 m: The claystone in this zone were analysed for total organic carbon. The abundance of TOC has increased compared to the zones above and will be rated as good.

E: 1984 - 2430 m: This zone has a large variation in lithology. The claystone in the zone is, however, found to be very uniform in the abundance of TOC, and the whole zone is found to have a good abundance of TOC.

F: 2430 - 2600 m: Apart from one sample, which contained a few good claystone cuttings, all the samples from this zone were found to contain only mud additives. The claystones analysed have a TOC abundance similar to the zone above.

Extractable Organic Matter (EOM) and Chromatographic Separation

A: 1400 - 1680 m: Three samples from this zone were extracted. The two uppermost samples show a rich abundance of extractable hydrocarbons. The HC/TOC ratio is, however, that high that it is believed that these samples are contaminated with migrated hydrocarbons. The lowermost sample, 1590-1629 m shows a good abundance of extractable hydrocarbons. The HC/TOC ratio is far lower than in the two other samples, and the saturated/aromatic ratio is far higher.

The gas chromatograms of the saturated hydrocarbon fractions are all typical for biodegraded oil with almost no n-alkanes and isoprenoids, only large unresolved envelopes.

B: 1680-1800 m: Only one sample, 1680 -1700 m, from this zone was analysed. The measurements indicate clearly that the sample is contaminated with migrated hydrocarbons. The gas chromatogram of the saturated hydrocarbon fraction varies only slightly from the samples in the zone above. Large unresolved envelopes are still the major feature, but in this sample n-alkanes and isoprenoids can be distinguished. This indicates that the migrated oil is not as badly biodegraded as that in the zone above.

C: 1820 - 1910 m: No available samples.

D: 1910 - 1984 m: No samples analysed from this zone.

E: 1984 - 2430 m: Four samples from this zone were extracted. The uppermost samples, 1984 -90 m show a rich abundance of extractable hydrocarbons. The gas chromatogram of the saturated hydrocarbon fraction has a distinct bimodal distribution with a maximum at nC_{17} and an unresolved sterane hump. This could have been caused by migrated hydrocarbons causing the light end mode while the sterane hump is caused by the true material in the sediment, which is immature.

The samples from 2250 - 2260 m and 2350 - 2360 m both show a good abundance of extractable hydrocarbons. The gas chromatograms of the saturated hydrocarbon fractions are both typical for immature, terrestric sediment with a large input of heavy n-alkanes with a high CPI value together with high pristane/ nC_{17} and low pristane/phytane ratio.

The sample from 2260 - 2270 m varies considerably from both the one above and the one below in that a rich abundance of extractable hydrocarbons is found.

The gas chromatogram of the saturated hydrocarbon fraction is very much different from the two other samples in that the CPI value is extremely low, 0.47, while the pristane/nC_{17} ratio is low and the pristane/phytane ratio is high. The sample is probably contaminated, either by migrated hydrocarbons or by a mud additive. Hydrocarbons with such a low CPI value, is very unusual in sediments.

F: 2430 - 2600 m: No samples analysed.

Vitrinite reflectance

Fifteen samples were analysed for vitrinite reflectance. In the following each sample is described, and together with the reflectance data, other information from the analyses are given.

1500 - 1515 m: Light shale. No determination possible.
One minute inertinite particle plus suggestion of bitumen wisps were recorded. UV light shows a yellow to light orange fluorescence from spore specks and a low exinite content.

1560 - 1575 m: Shale and carbonate, R_o = 0.42 (2), R_o = 0.79 (1).
This sample has rather strange lithologies, possibly evaporite.

The sample is almost barren, only three particles located, all in one untypical cutting. UV light shows a light orange fluorescence from hydrocarbons and spores together with a trace of exinite.

1620 - 1650 m: Shale and carbonate, R_o = 0.48 (4), R_o = 0.80 (2). The sample is virtually barren, a few specks of vitrinite and inertinite. Most of the vitrinite is probably reworked. UV light does not show any definite organic fluorescence and no exinite.

1710 - 4740 m: Carbonate, shale and lignite, R_o = 0.38(21). The sample is barren apart from lignite cuttings. Good, clean lignite, showing cell structure, almost wholly vitrinite. All readings on lignite. UV light shows a yellow fluorescence from hydrocarbon traces and resin globules in lignite.

1770 - 1800 m: Lignite, R_o = 0.30(24). Rather variable lithologies of low reflectance lignite. No other sediment. UV light shows a yellow and green/yellow fluorescence from resin and spore specks.

1910 - 1940 m: Sandgrains plus subordinate carbonate and shale, R_o = 0.33(4). The sample has only a trace of organic material. A few bitumen wisps in carbonate together with inertinite particles. Two lignite fragments which is measured. UV light shows a light orange fluorescence from hydrocarbon traces.

1970 - 1984 m: Shale, R_o = 0.44(22). The sample has a moderate organic content. Particles of reworked material and inertinite are dominant. Only a low proportion of wispy particles of vitrinite together with some bitumen wisps. UV light shows a light orange fluorescence from spores and a low exinite content.

2070 - 2080 m: Shale, R_o = 0.22(8) (Lignite) R_o = 0.36(18). The sample has a low to moderate organic content. Mostly particles of reworked material and inertinite and a few particles of vitrinite. The lowest readings are on lignite fragments which are believed to be a mud additive. UV light shows a yellow to light orange fluoescence from spores and spore fragments, and a moderate to rich exinite content.

2140 - 2150 m: Shale and carbonate, R_o = 0.32(21).
The sample has a low organic content with particles of reworked material and inertinite. Readings on wispy particles and particles of vitrinite. Occasional bitumen wisps in the sample. UV light shows a yellow/orange fluorescence from spores and a moderate exinite content.

2190 - 2200 m: Shale, R_o = 0.36(21).
The sample has a low to moderate organic content, mostly particles of reworked material and inertinite. A low content of particles and wispy particles of vitrinite. UV light shows a light orange and yellow/orange fluorescence from spores and a moderate exinite content.

2230 - 2240 m: Shale, R_o = 0.34(20).
The sample has a moderate organic content with particles of reworked material and inertinite being dominant. A few good particles and wispy particles of vitrinite and occasional bitumen wisps. UV light shows a yellow to orange fluorescence from spores and a moderate exinite content.

2290 - 2300 m: Shale, R_o = 0.38(21).
The sample has a low to moderate organic content while particles of inertinite and reworked material dominate. Some reasonable vitrinite particles and bitumen wisps. UV light shows a yellow to orange and light orange fluorescence from spores and a low to moderate exinite content.

2350 - 2360 m: Shale, R_o = 0.38(21).
The sample has a low to moderate organic content with particles of intertinite and reworked material dominant. Good content of particles and wispy particles of vitrinite. Bitumen wisps plentiful. UV light shows a yellow to orange and light orange fluorescence from spores and a moderate exinite content.

2410 - 2420 m: Shale, R_o = 0.39(21).
The sample has a moderate organic content with good particles and wisps of vitrinite, plus a few coaly fragments. Subordinate inertinite and bitumen wisps. UV light shows a light orange fluorescence from spores and a low to moderate exinite content.

2480 - 2490 m: Shale, R_o = 0.32(21).
Haematite specks and evaporite lithology recorded. The sample has a low organic content with particles of inertinite and reworked material and about equal proportion of good vitrinite wisps and wispy particles. UV light shows a light orange fluorescence from spores and a low exinite content.

Visual Kerogen

Eleven samples were processed from this well. The rock samples contained remains of mud additives. Supposed organic mud additives were among the dominating elements also in the kerogen residues from intervals poor in indigenous organic matter.

1505-15 to 1560-75 m:
The residues are dominated by finely dispersed amorphous material. Besides there is a minor part of cysts in the upper sample, of cysts, pollen and cuticles in the lower sample.
Colour index: -2/2. An immature formation with possibilities for oil and gas generation.

1620-50 m:
The residue is finely dispersed, amorphous, but the material is partly found as aggregates. Mineral aggregates occur. A minor part of the residue consists of cysts, pollen and cuticular fragments.
Colour index: 2. Probably too high and controlled by a lithology containing some carbonate. An immature formation with possibilities for formation of oil and gas.

1710-40 m:
The residue was derived from a light grey marl/siltstone.

1770-1800 m:
The residue is dominated by coaly/woody fragments. There is 25-30 % of sapropel, and a minor element of palynomorphs, mainly pollen.
Colour index: -2/2. An immature formation with possibilities for gas and oil generation.

1910-40 to 2230-40 m:
All residues contain a considerable amount of suggested organic mud additives. The rest is 40 to 75 % dominantly woody/coaly material, but also some of sapropel, mainly in the two lowest samples. The residues are small and include undissolved minerals.
Colour index: ~2/2 or 2. An immature formation poor in organic material, with possibilities mainly for gas generation, slightly more oilprone in the lower part of the interval.

2410-30 m:
Sapropel is dominant. Beside is recorded finely dispersed herbaceous material, woody/coaly fragments, some cuticular material and pollen. The residue is very small and includes undissolved minerals.
Colour index: 2+ or 2/2+. An immature formation, or immature to moderate mature, but very poor in organic material. Possibilities for generation of gas and oil.

2480-90 m:
Sapropel is dominant. There is a minor fraction of herbaceous material including some pollen. The residue is very small.
Colour index: ~3, may be based on reworked material and represent a too high estimate as a maturation parametre.

Rock-Eval Pyrolysis

Twentyfour samples were pyrolysed by the Rock-Eval method. All the analysed samples have a high oxygen index and a low hydrogen index, which indicates kerogen type III. The T_{max} value is low for all the samples, which indicate immature samples.

CONCLUSION

On the background of the various analyses, the following conclusion might be drawn.

The analysed section of the well can be divided into six zones: A: 1400 - 1680 m, B: 1680 - 1820 m, C: 1820 - 1910 m, D: 1910 - 1984 m, E: 1984 - 2430 m and F: 2430 - 2600 m.

In our evaluation of the well, the richness rating is based on the abundance of light hydrocarbons, total organic carbon and extractable hydrocarbons. The maturity rating is based on the vitrinite reflectance, the colour of the kerogen and the T_{max} in the Rock-Eval pyrolysis, while the type of source rock is based on the type of kerogen with results both from the visual kerogen study and the Rock-Eval pyrolysis.

On the basis of the various analyses the following rating will be given.

The whole of the analysed section of the well is immature.

Zone A: 1400 - 1680 m:

There is a large discrepancy between the visual kerogen estimation and the Rock-Eval pyrolyses for this zone. This can be due to a large proportion of reworked material, which will increase the oxygen index and reduce the hydrogen index at the same time as the volume will be small in the visual kerogen examination. With the background in the various analysis, this zone is rated to have a fair potential as a source rock for gas and oil. The claystone is contaminated by migrated, strongly biodegraded oil.

Zone B: 1680 - 1810 m:

This zone consists of siltstone and claystone and has a poor potential as a source rock for gas. Migrated biodegraded hydrocarbons in the siltstone.

Zone C: 1820 - 1910 m:

No samples available.

Zone D: 1910 -1984 m:

Sandstone with migrated hydrocarbons.

Zone E: 1984 - 2430 m:

Alternating sand, claystone lithologies. Migrated hydrocarbons in sand lenses. The claystone lenses in this zone have a fair to good potential as a source rock for gas.

Zone F: 24 - 2600:

Only mud additives (nutshells) recovered.

TABLE I

Concentration (μℓ gas/pr. kg rock) of C_1 - C_7 hydrocarbons (Headspace)

Sample	Depth (m)	C_1	C_2	C_3	iC_4	nC_4	C_5+	ΣC_1-C_4	ΣC_2-C_4	% wetness	iC_4/nC_4
K922	1410 - 40	13224	166	10	16	47	218	13397	173	1.29	0.35
K923	1440 - 70	15906	1102	33	70	11	14	17060	1154	6.76	0.61
K924	1470 - 1500	14524	1966	176	40	59	91	16757	2233	13.32	0.67
K925	1500 - 15	50060	3402	1196	625	443	789	55726	5666	10.17	1.41
K926	1515 - 30	32915	5081	2343	1840	1493	4733	43673	10758	24.63	1.23
K927	1530 - 45	31260	6505	1035	750	380	843	39931	8670	21.71	1.97
K928	1545 - 60	34323	1664	538	451	295	1312	37273	2949	7.91	1.53
K929	1560 - 75	48598	2859	1089	790	604	2614	53941	5342	9.90	1.31
K930	1575 - 90	30688	2165	773	740	608	2991	34974	4286	12.26	1.22
K931	1590 - 1620	8190	904	700	260	207	572	9630	1440	14.96	1.26
K932	1620 - 50	5676	397	216	219	171	106	6680	1003	15.02	1.28
K933	1650 - 80	9160	2043	982	755	591	2312	13532	4372	32.31	1.28
K1084	1680 - 1710	94581	30506	6853	2830	2092	150419	136862	42281	30.89	1.35
K1085	1710 - 40	43428	15150	5128	1486	2671	5980	68163	24735	36.29	0.56
K1086	1740 - 70	114140	5977	2555	609	1100	3140	124381	10241	8.23	0.55
K1087	1770 - 1800	84948	5808	3320	1400	1200	4624	96676	11729	12.13	1.17
K1088	1800 - 20	38816	4010	3174	1723	1983	5003	49710	10893	21.91	0.87
K1089	1910 - 40	12872	10848	4468	1286	1687	3353	14699	18279	12.44	0.76
K1090	1940 - 70	462803	35542	10874	1896	3160	2880	514275	51471	10.01	0.60
K1091	1970 - 84	5969	5278	6062	1882	2102	33164	21293	15324	71.97	0.90
K1092	1984 - 90	1419	322	210	76	72	396	2099	680	32.38	1.06
K1093	1990 - 2000	1434	563	2524	133	140	472	2599	1166	44.85	0.95

Concentration (μℓ gas/pr. kg rock) of C_1 - C_7 hydrocarbons (Headspace)

Sample	Depth (m)	C_1	C_2	C_3	iC_4	nC_4	C_5+	ΣC_1-C_4	ΣC_2-C_4	% wetness	iC_4/nC_4
K1094	2000 - 10	1365	564	336	145	181	542	2591	1225	47.33	0.80
K1095	2010 - 20	9636	1826	1265	384	391	665	13502	3866	28.63	0.98
K1096	2020 - 30	2370	486	289	72	41	432	3257	887	27.24	1.74
K1097	2030 - 40	1768	332	158	34	13	146	2304	536	23.28	2.55
K1098	2040 - 50	1339	256	166	46	46	365	1852	513	27.70	1.00
K1099	2050 - 60	3533	766	575	151	74	1460	5099	1566	30.71	2.04
K1100	2060 - 70	4629	699	535	174	239	1487	6276	1647	26.24	0.73
K1101	2070 - 80	1369	155	93	22	26	338	1665	296	17.79	0.85
K1102	2080 - 90	1245	227	136	33	35	726	1676	431	25.69	0.93
K1103	2090 - 2100	810	133	86	24	25	133	1079	269	24.94	0.95
K1104	2100 - 10	1283	320	359	128	145	857	2235	952	42.59	0.89
K1105	2110 - 20	2416	823	717	253	278	1701	4487	2071	46.16	0.91
K1106	2120 - 30	2089	441	391	115	125	749	3161	1072	33.91	0.92
K1107	2130 - 40	7165	1474	1326	414	410	1580	10787	3623	33.58	1.01
K1108	2140 - 50	13119	2317	2257	704	726	12648	19106	6006	31.43	0.97
K1109	2150 - 60	8205	1312	1160	345	328	1889	11351	3146	27.72	1.05
K1110	2160 - 70	6427	792	681	206	211	4830	8318	1891	22.74	0.98
K1111	2170 - 80	30989	5412	2977	440	602	3304	40421	9432	23.34	0.73
K1112	2180 - 90	2608	863	463	104	99	1915	4139	1530	36.97	1.04
K1113	2190 - 2200	658	119	101	27	26	1643	934	275	29.48	1.06
K1114	2200 - 10	2537	765	451	116	108	2526	3978	1441	36.23	1.07
K1115	2210 - 20	2742	542	610	210	209	3135	4314	1572	36.44	1.00

Concentration (µl gas/pr. kg rock) of C_1 - C_7 hydrocarbons (Headspace)

Sample	Depth (m)	C_1	C_2	C_3	iC_4	nC_4	C_5+	ΣC_1-C_4	ΣC_2-C_4	% wetness	iC_4/nC_4
K1116	2220 - 30	3893	770	711	216	163	1370	5753	1860	32.33	1.32
K1117	2230 - 40	5105	835	851	300	291	857	7382	2277	30.85	1.03
K1118	2240 - 50	9932	1603	1719	642	695	1829	14592	4660	31.93	0.92
K1119	2250 - 60	1412	252	301	107	111	319	2184	772	35.37	0.96
K1120	2260 - 70	689	201	154	44	53	1650	1142	453	39.67	0.84
K1121	2270 - 80	1708	296	435	166	206	13125	2812	1104	39.25	0.81
K1122	2280 - 90	3791	604	608	204	279	8999	5486	1695	30.90	0.73
K1123	2290 - 2300	1024	215	241	74	82	680	1637	613	37.44	0.90
K1124	2300 - 10	2458	300	331	119	184	5063	3393	935	27.55	0.65
K1125	2310 - 20	1376	184	178	57	86	8509	1882	506	26.88	0.66
K1126	2320 - 30	1334	232	231	82	128	4727	2007	673	33.54	0.64
K1127	2330 - 40	1332	191	212	71	104	8667	1913	578	30.24	0.68
K1128	2340 - 50	471	354	384	105	149	1182	1464	993	67.84	0.71
K1129	2350 - 60	191	96	76	22	29	582	416	225	54.09	0.76
K1130	2360 - 70	1621	349	283	79	112	2089	2437	824	33.83	0.71
K1131	2370 - 80	796	339	288	74	121	598	1617	821	50.78	0.61
K1132	2380 - 90	322	135	97	21	18	362	595	272	45.81	1.16
K1133	2390 - 2400	381	85	69	18	31	623	584	203	34.74	0.59
K1134	2400 - 10	2432	1011	462	84	102	240	4092	1660	40.56	0.83
K1135	2410 - 20	469	288	260	63	106	1095	1187	718	60.46	0.59
K1136	2420 - 30	988	246	176	39	51	247	1501	513	34.18	0.77
K1137	2430 - 40	348	128	73	17	21	76	589	241	40.89	0.83
K1138	2440 - 50	899	43	54	17	23	3577	227	137	60.45	0.78

Concentration (μl gas/pr. kg rock) of C_1 - C_7 hydrocarbons (Headspace)

Sample	Depth (m)	C_1	C_2	C_3	iC_4	nC_4	C_5+	ΣC_1-C_4	ΣC_2-C_4	% wetness	iC_4/nC_4
K1139	2450 - 60	171	25	31	10	14	1165	253	81	32.22	0.70
K1140	2460 - 70	294	9	9	3	4	1408	320	26	8.09	0.82
K1141	2470 - 80	Open lid									
K1142	2480 - 90	352	9	9	3	3	48	378	26	6.89	0.96
K1143	2490 - 2500	Open lid									
K1144	2500 - 10	Open lid									
K1145	2510 - 20	Open lid									
K1146	2520 - 30	Open lid									
K1147	2530 - 40	Open lid									
K1148	2540 - 50	640	7	7	2	2	120	660	20	3.03	0.92
K1149	2550 - 60	Open lid									
K1150	2560 - 70	Open lid									
K1151	2570 - 80	Open lid									
K1152	2580 - 90	Open lid									
K1153	2590 - 2600	Open lid									

TABLE II

Lithological description and TOC

IKU Sample no	Depth (m)	TOC	Lithology
K922	1410-40		100% Claystone, grey - greengrey sm.am. Limestone, grey, light grey, white
K923	1440-70	0.59	90% Claystone, as above, some green 10% Cement sm.am. Marl, light grey; Sand
K924	1470-1500	0.62	90% Claystone, as above 10% Cement sm.am. Limestone, grey, white
K925	1500-15	0.53	100% Claystone, light greengrey, green, white mottles, light grey, browngrey. sm.am. Limestone, white, grey; Pyrite; Sandstone, white; Clay/Silt, light brown.
K926	1515-30	0.75	100% Claystone, light grey/grey to light green, some green, some white mottles. sm.am. Clay/Silt, light brown; Pyrite; Limestone, white, grey; Marl, light grey
K927	1530-45	0.70	100% Claystone, grey to light green, green sm.am. Limestone, white; Marl, grey; Sltst, dark grey/black, calcareous, very micaceous, pyritic, large amounts black grains.
K928	1545-60	0.72	100% Claystone, grey to greenish grey, light grey, with small Pyrite grains, some green sm.sm. Siltstone, dark grey, calcareous, micaceous, large amounts black grains; Pyrite; Limestone, white

IKU sample no	Depth (m)	TOC	Lithology
K929	1560-75	0.77	100% Claystone, grey, greenish and browngrey, some green, some pyritic, white mottles sm.am. Limestone, white
K930	1575-90	0.68	100% Claystone, grey, greengrey to light green, white mottles sm.am. Marl, grei; Pyrite; Limestone, white
K931	1590-1620	0.62	100% Claystone, light grey and grey to browngrey and light green sm.am. Limestone, brownish light grey
K932	1620-50	0.52	100% Claystone, light grey to grey, green some white mottles, some hard waxy greenish to brownish grey calcareous fragments, some dark grey sm.am. Pyrite; Quartz
K933	1650-80	0.55	100% Claystone, light green to light grey/grey, green, some white mottled sm.am. Siltstone, light brown; Marl/Limestone, grey, brownish, hard, waxy.
K1084	1680-1710	0.72	100% Claystone, grey to light grey and light green sm.am. Limestone, light grey, white; ? Dolomite, hard, brownish; Pyrite (partly) rods); Sandstone, browngrey.
K1085	1710-40	0.54	30% Calcareous Siltstone grading to silty Marl and possible some Limestone, white to light grey, brown 5% Claystone, as above sm.am. Siltstone, clayey, brown; Claystone, as above 65% Coal (?mud additive)

IKU Sample no	Depth (m)	TOC	Lithology
K1086	1740-70		95% Coal (? mud additive) 5% Marl, white to light grey
K1087	1770-1800		100% Coal (? mud additive) sm.am. Marl, white to light grey, grey and calcareous silty Claystone; ? Dolomite, hard, browngrey
K1088	1800-20	0.23	95% Coal (? mud additive) 5% Marl, possibly partly grading to Lime-stone, (brownish) light grey, grey sm.am. Sandstone, very fine, grey to light brown
K1089	1910-40		100% Sand, very coarse - coarse, subangular light grey, micaceous sm.am. Claystone; Siltstone, Marl
K1090	1940-70	1.30	40% Sand, as above, but also some subrounde 40% Claystone, silty, grey, light grey, browngrey, partly calcareous, some micaceou sm.am. Pyrite (partly rods) 20% Coal (? additive)
K1091	1970-84	1.56	100% Claystone, silty, grey, some micaceous browngrey. sm.am. Coal; Pyrite; Sand
K1092	1984-90	1.73	80% Claystone, dark grey, some micaceous, some brown and light brown 20% Coal (? additive)
K1093	1990-2000		90% Cement 10% Coal (? additive) sm.am. Claystone/Siltstone, grey, with Coal-fragments; Sand; Pyrite

IKU Sample no	Depth (m)	TOC	Lithology
K1094	2000-2010	1.55	80% Cement and Mud additives 20% Sily Claystone grading to clayey Siltstone, grey, with Coal-fragments, some browngrey, partly micaceous. sm.am. Pyrite (partly as rods)
K1095	2010-2020	1.49	60% Silty Claystone grading to clayey Siltstone, as above 40% Cement and mud additives.
K1096	2020-30		100% Sand, medium to coarse, angular, light grey to clear, some Mica. sm.am. Silty Claystone; mud additives; Pyrite.
K1097	2030-2040		100% Sand, as above sm.am. Mud additives; Limestone, brownish white.
K1098	2040-2050		85% Sand, as above 15% Cement, mud additives. sm.am. Silty Claystone, grey
K1099	2050-60		75% Sand, as above, with Mica (? additive) 25% Cement and mud additives (Coal) sm.am. Claystone, silty, grey
K1100	2060-70		100% Cement, additives (Mica and Coal) sm.am. Sand, light grey/clear; brown fine Sandstone; grey Silt/Claystone
K1101	2070-80	1.48	90% Cament and mud additives 10% Claystone, silty, partly grading to clayey Siltstone (micaceous), grey, obs with green Claystone clasts sm.am. Sandstone, light grey to brownish, very fine-fine.

IKU Sample no	Depth (m)	TOC	Lithology
K1102	2080-90		90% Cement and Mud additives 10% Sandstone, light grey-light brown, very fine, and some medium/coarse Sand, calcareous cement. sm.am. Silty Claystone, grey
K1103	2090-2100		50% Cement and mud additives (Coal) 47% Sandstone, as above, some Sand 3% Silt/Claystone, grey, micaceous
K1104	2100-2110	1.57	93% Cement and mud additives 7% Claystone, silty, partly grading to clayey Siltstone, some micaceous, with small Coal particles. sm.am. Sandstone and Sand
K1105	2110-2120		100% Cement, mud additives sm.am. Claystone, as above
K1106	2120-30		100% Cement and mud additives. sm.am. Sandstone, very fine and some medium coarse Sand; Clay/Siltstone, grey.
K1107	2130-40	1.59	100% Cement and mud additives (Coal) sm.am. Claystone, silty, partly grading to clayey Siltstone, grey, micaceous. obs. Sandstone and Sand.
K1108	2140-50		100% Coal (additive), Cement. sm.am. Silt/Claystone, as above
K1109	2150-60		100% Coal (additive) and cement. sm.am. Silty Claystone to clayey Siltstone, as above.

IKU Sample no	Depth (m)	TOC	Lithology
K1110	2160-70	1.67	85% Coal, (? additive), cement 15% Claystone, silty, partly grading clayey Siltstone, grey, some micaceous sm.am. Sandstone, light grey, very fine.
K1111	2170-80	1.70	50% Coal (? additive) and cement 45% Claystone, silty, light grey to grey, some micaceous. 5% Sand/Sandstone
K1112	2180-90		100% Sand, fine to medium, some coarse, angular, clear to light grey sm.am. Claystone, as above,Pyrite; Mud additives; Pyrite (partly rods)
K1113	2190-2200		100% Sand, as above sm.am. Mud additives (Coal); Claystone; Pyrite
K1114	2200-2210	1.70	100% Claystone, silty, partly grading to clayey Siltstone, sometimes sandy, grey, some micaceous, with Coal fragments sm.am. Sand and Sandstone; Mud additives (Coal)
K1115	2210-20	2.00	70% Mud additives and Cement 20% Sand, medium, coarse 10% Claystone, as above
K1116	2220-30	1.72	70% Mud additives and Cement 20% Claystone, as above 10% Sand, as above
K1117	2230-40	1.69	50% Claystone, as above 50% Mud additives and Cement sm.am. Sandstone, very fine, light grey; Pyrite

IKU Sample no	Depth (m)	TOC	Lithology
K1118	2240-50	1.50	70% Claystone, as above 30% Mud additives and Cement sm.am. Sand obs. Pyrite
K1119	2250-60	1.70	60% Claystone, as above, Pyrite obs. 40% Cement and Mud additives (Coal). sm.am. Sand; Pyrite
K1120	2260-70	1.68	58% Claystone, as above 50% Cement and mud additives (Coal) sm.am. Sand; Pyrite
K1121	2270-80	1.60	80% Cement and Mud additives 20% Claystone, as above
K1122	2280-90	1.52	70% Claystone, silty, grey, micaceous, with small Coal strings/fragments, some brownish 30% Cement and Mud additives. sm.am. Sand; Pyrite obs. Calc-oolite
K1123	2290-300	1.39	60% Cement and Mud additives (Coal, Mica). 30% Claystone, as above 10% Sandstone, very fine, and fine to mediu Sand, light grey sm.am. Pyrite obs. Ostracodes
K1124	2300-10	1.64	60% Cement/additives 35% Claystone, as above 5% Sandstone, very fine to fine, light gre obs. Ostracodes
K1125	2310-20	1.87	60% Cement /additives 30% Claystone, as above 10% Sandstone, as above sm.am. Pyrite obs. Ostracodes

IKU Sample no	Depth (m)	TOC	Lithology
K1126	2320-30		50% Additives 25% Sand/Sandstone, very fine to medium 25% Claystone, as above sm.am. Pyrite obs. Ostracodes
K1127	2330-40		100% Sand/Sandstone, very fine to coarse, angular, light grey sm.am. Claystone; Mud additives; Pyrite
K1128	2340-50		100% Sand and some Sandstone, fine to very coarse, white/light grey, angular sm.am. Claystone; Mud additives; Pyrite
K1129	2350-60		80% Sand, medium to coarse, very coarse, angular, white/light grey
		1.87	20% Claystone, silty, partly grading to clayey Siltstone, grey, some micaceous, with thin Coal strings sm.am. Mud additives
K1130	2360-70		100% Sand, fine, angular, light grey/white sm.am. Claystone, as above
K1131	2370-80		100% Sand, medium to very coarse, angular, light grey/white sm.am. Claystone; Mud additives
K1132	2380-90		93% Mud additives (nut shells) 5% Sand, fine - medium
		1.73	2% Claystone, as above
K113	2390-400		100% Mud additives (Nut shells and Mica)
K1134	2400-10		100% Mud additives (Nut shells) sm.am. Claystone; Sand

IKU Sample no	Depth (m)	TOC	Lithology
K1135	2410-20		93% Mud additives (Nut shells) 7% Sand, fine - medium, some coarse white/light grey, angular sm.am. Claystone
K1136	2420-30		50% Mud additives (Nut shells) 50% Sand, as above sm.am. Claystone
K1137	2430-40		85% Sand, fine to very coarse, angular, white/clear 15% Mud additives sm.am. Claystone
K1138	2440-50		80% Sand, medium to coarse, some very coars 10% Claystone, grey, browngrey 10% Mud additives
K1139	2450-60		80% Mud additives (Nut Shells) 10% Claystone, partly silty, grey,some brownish grey 10% Sand, fine to coarse
K1140	2460-70		100% Mud additives (Nut Shells) sm.am. Claystone; Sand
K1141	2470-80	1.86	100% Mud additives (Nut Shells) obs. Claystone
K1142	2480-90		100% Mud additives (Nut Shells) sm.am. Claystone, silty, partly grading to clayey Siltstone, grey obs. Sand
k1143	2490-500		100% Mud additives (Nut Shells) obs. Claystone

IKU Sample no	Depth (m)	TOC	Lithology
K1144	2500-10		100% Mud additives (Nut Shells) obs. Claystone
K1145	2510-20		100% Mud additives (Nut Shells) Obs. Claystone; Sand; Pyrite
K1146	2520-30		100% Mud additives (Nut Shells) sm.am. Sandstone, very fine-fine; Claystone
K1147	2530-40		As the sample above
K1148	2540-50		As the sample above
K1149	2550-60		100% Mud additives (Nut Sells) sm.am. Claystone
K1150	2560-70		As above obs. Claystone, grey
K1151	2570-80		As the sample above
K1152	2580-90		As the sample above
K1153	2590-2600		As the sample above

TABLE III

Weight (mg) of EOM and chromatographic fractions

Sample no.	Depth(m)	Rock extracted (g)	EOM	Sat	Aro	Hydro-carbon	Non hydro-carbon	TO
K 922	1410-40	74,6	137,1	44,5	56,5	101,0	24,6	0,
K 927	1530-45	100,1	499,7	119,3	207,3	326,6	78,4	0,
K 931	1590-1620	100,0	48,6	19,1	14,5	33,6	9,5	0,
K1084	1680-1710	92,5	200,1	73,3	74,7	148.0	36,1	0,
K1092	1984-90	80,9	148,8	36,7	49,5	86,2	52,4	1,
K1114	2200-10	50,4	31,3	5,2	9,8	15,0	7,2	1,
K1120	2260-70	100,5	559,7	132,8	157,9	290,7	140,1	1,
K1129	2350-60	41,2	69,2	3,6	12,1	15,7	9,4	1,

TABLE IV

Concentration of EOM and chromatographic fractions (weight ppm of rock).

Sample no.	Depth(m)	EOM	Sat	Aro	Total hydrocarb.	Non hydrocarb.
K 922	1410-40	1838	597	757	1354	330
K 927	1530-45	4992	1192	2071	3263	783
K 931	1590-1620	486	191	145	336	95
K1084	1680-1710	2163	792	808	1600	390
K1092	1984-90	1839	454	612	1066	648
K1114	2200-10	621	103	194	298	143
K1120	2260-70	5569	1321	1571	2893	1394
K1129	2350-60	1680	87	294	381	228

TABLE V

Concentration of EOM and chromatographic fractions (mg/g TOC).

Sample no.	Depth(m)	EOM	Sat	Aro	Total hydrocarb.	Non hydrocarb.
K 922	1410-40	120	65	82	147	36
K 927	1530-45	713	170	296	466	112
K 931	1590-1620	78	31	23	54	15
K1084	1680-1710	300	110	112	222	54
K1092	1984-90	106	26	35	62	37
K1114	2200-10	37	6	11	18	8
K1120	2260-70	332	79	94	172	83
K1129	2350-60	90	5	16	20	12

TABLE VI

Composition in % of the material extracted from the rock.

Sample no.	Depth (m)	Sat/EOM	Aro/EOM	HC/EOM	Sat/Aro	Non HC/EOM	HC/Non HC
K 922	1410-40	32	41	74	79	18	411
K 927	1530-45	24	41	65	58	16	417
K 931	1590-1620	39	30	69	132	20	354
K1084	1680-1710	37	37	74	98	18	410
K1092	1984-90	25	33	58	74	35	165
K1114	2200-10	17	31	48	53	23	208
K1120	2260-70	24	28	52	84	25	207
K1129	2350-60	5	18	23	30	14	167

TABLE VII

Tabulations of data from the gas chromatograms

Sample no.	Depth(m)	Pristane/MC_{17}	Pristane/Phytene	CPI
K 922	1410-40	NDP	NDP	NDP
K 927	1530-45	NDP	NDP	NDP
K 931	1590-1620	NDP	NDP	NDP
K1084	1680-1710	NDP	NDP	NDP
K1092	1984-90	0.45	1.33	1.06
K1114	2200-10	1.26	1.09	2.34
K1120	2260-70	0.49	1.26	0.47
K1129	2350-60	0.80	1.00	1.66

NDP: No determination possible.

TABLE VIII

Vitrinite reflectance and visual kerogen measurements

Depth	Vitrinite reflectance	Colour index	Type of organic matter
1500-15	NDP	-2	Am, Cysts/He
1560-75	0.42(2) 0.79(1)	-2	Am, Cysts/He, Poll-spor
1620-50	0.48(4) 0.80(2)	2	Am/He
1710-40	0.38(21)	2	Am, Cysts/He
1770-1800	0.30(24)	2	W/Am, He, Pollen
1910-40	0.33(4)	2	W/Am + mud add
1970-84	0.44(22)	-2 R!	W/Am + mud add
2070-80	0.22(8) 0.36(13)	-2	He, W/Am + mud add
2140-50	0.32(21)		
2190-2200	0.36(21)		
2230-40	0.34(20)	2	W, He/+ mud add
2290-2300	0.38(21)		
2350-60	0.38(21)		
2410-20	0.39(20)	2/2+	Am/He,Cut, Poll-spor,mud add
2480-90	0.32(21)	-3 R!	Am/He,W, Poll-spor+mud add

TABLE IX

Rock Eval Pyrolysis.

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}
924	1470-1500	0.1	0.9	1.4	0.62	145	226	1.0	0.1	422
926	1515-30	0.1	0.9	1.3	0.75	120	173	1.0	0.1	414
929	1560-75	0.0	0.7	1.1	0.77	91	143	0.7	-	415
1084	1680-1710	0.2	0.6	1.0	0.72	83	139	0.8	0.25	411
1091	1970-84	0.2	2.7	3.2	1.56	173	205	2.9	0.07	419
1092	1984-90	0.2	1.8	1.5	1.73	138	87	2.0	0.10	426
1094	2000-10	0.2	1.5	1.6	1.55	97	103	1.7	0.12	423
1095	2010-20	0.3	1.6	1.4	1.49	107	94	1.9	0.16	425
1101	2070-80	0.2	2.0	1.5	1.48	135	101	2.2	0.09	427
1107	2130-40	0.3	2.4	1.3	1.59	151	82	2.7	0.11	426
1111	2170-80	0.2	2.6	1.5	1.70	152	88	2.8	0.07	428
1114	2200-10	0.1	2.8	1.2	1.70	165	71	2.9	0.03	425
1115	2210-20	0.2	4.7	1.7	2.00	235	85	4.9	0.04	424
1116	2220-30	0.1	3.0	1.8	1.72	174	105	3.1	0.06	426
1117	2230-40	0.3	2.4	1.5	1.69	142	89	2.7	0.11	426
1118	2240-50	0.1	1.8	1.5	1.50	120	100	1.9	0.05	477
1119	2250-60	0.2	2.7	1.7	1.70	159	100	2.9	0.07	428
1120	2260-70	0.1	3.2	1.7	1.68	190	100	3.3	0.04	430
1121	2270-80	0.1	2.6	2.1	1.60	163	131	2.7	0.04	428
1122	2280-90	0.1	2.2	1.3	1.52	145	85	2.3	0.04	429
1123	2290-2300	0.1	1.8	1.3	1.39	129	94	1.9	0.05	429
1124	2300-10	0.1	3.1	1.3	1.64	189	80	3.2	0.03	427
1125	2310-20	0.2	4.0	1.5	1.87	214	80	4.2	0.05	426
1126	2320-30	0.2	3.6	1.2	1.39	187	86	2.8	0.07	427