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SOURCE ROCK PROPERTIES OF CUTTING SAMPLES
FROM WELL 31/2-4, OFFSHORE NORWAY.

by

W.H.Oterdoom

code: 774.103



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KONINKLIJKE / SHELL EXPLORATIE EN PRODUKTIE LABORATORIUM

RIJSWIJK, THE NETHERLANDS

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Investigation

9.12.458

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KONINKLIJKE/SHELL EXPLORATIE EN PRODUKTIE LABORATORIUM

RIJSWIJK, THE NETHERLANDS

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Figure 1 : Location map

Table I : Source rock properties

Enclosure 1 : Geochemical log

I INTRODUCTION

A source-rock investigation has been carried out on cutting samples from well 31/2-4, offshore Norway. The location of the well is shown on Figure 1.

The samples are of Lower Tertiary to Lower Triassic age.

Source rock evaluation commonly comprises determination of:

1. the presence (or absence) of hydrocarbons source material in the rock samples;
2. the quality of the organic matter as well as the distribution of its specific constituents;
3. the degree of organic metamorphism (= level of maturity).

A source rock is identified by measuring the amount of temperature reactive ("live") organic matter present, i.e. the amount of organic matter that yields hydrocarbons upon pyrolysis. The method excludes any ("dead") organic matter such as inertinites.

In addition, the total organic carbon content can be determined which gives the sum of "live" and "dead" organic carbon. Rocks containing less than 0.5 % organic carbon are not considered to have a potential for commercial oil accumulations.

The source rock indications (SRI), which are a measure of the amount of pyrolysable organic matter, are determined on the original samples and in certain cases also after extraction with organic solvents. A systematically lower value after extraction is due to the presence of extractable hydrocarbons. These may consist of trapped oil, oil generated in situ by a source rock, or e.g. gasoil used in the drilling fluid.

In general, samples with source rock indications of 30 or less do not represent (immature or mature) source rocks. Values between 30 and 100 generally indicate marginal source rocks, while values above 100 commonly indicate good source rocks.

Intervals or samples with high source rock indications are investigated under a microscope to ensure that the high values indicate genuine source rock properties and are not due to contaminants of an organic nature such as lost circulation material.

The quality of a source rock for oil/gas generation depends on the type of organic matter present. Five categories of organic matter can be distinguished, viz.: humic, mainly humic, mixed, mainly kerogenous, kerogenous. This classification

is based on the hydrogen content of the organic matter.

Source rocks with organic matter of kerogenous, mainly kerogenous and/or mixed type generate predominantly oil. Organic matter of humic type generates gas only. Strata with organic matter of mainly humic quality generate either gas, or gas and oil.

In addition to the type and the concentration of the organic matter, the source rock quality is also characterised by the distribution of the typical organic constituents, or macerals¹, in the sediments. The maceral distribution can be used to further qualify the source rock, especially when mainly humic quality is found. For this purpose a microscopic investigation on polished rock fragments is carried out.

The maturity of source rocks is expressed in terms of degree of organic metamorphism. With increasing degree of organic metamorphism the organic matter is gradually carbonised while generating hydrocarbons. With increased carbonification the light reflectance of vitrinite, one of the coal macerals, increases. The degree of organic metamorphism can be assessed by measuring this reflectance.

- 1) maceral: an organic constituent which can be recognised with the microscope (with objectives 25x to 50 x).

II RESULTS

The results are given in Table I, detailed in Figure 2 and are plotted on the Geochemical log (Enclosure 1). The results may be summarised as follows :

a) Source rock indications (SRI)

Significant SRI-values have been detected in the following intervals :

- in the Paleocene two marginal SRI-values of 30 and 40 units.
- in the interval 1708 - 1792m continuously marginal SRI-values between 40 and 85 units.
- in the interval 1804 - 1894m almost continuously high SRI-values between 100 and over 900 units.
- in the Lower Jura and Rhaet in the interval 1906 - 2403m not continuously marginal SRI-values (<100 units) with one exception at 2280m of 115 units.
- in the Trias, only in the Anis in an interval between 4068 - 4104m almost continuously significant SRI-values between 45 and 420 units.

b) Type of organic matter

Three samples have been selected :

- 1858m - humic to mainly humic
- 2280 - humic
- 4080 - humic

c) Maceral description

Eight samples have been investigated microscopically. A semi-quantitative maceral description is given at the next page.

*	ABUNDANT
+	COMMON
-	FEW
-	RARE

DEPTH IN M	SAMPLE TYPE
---------------	----------------

SAPROBIC AND MARTIN		LIPIDINITE		INERT	
LIPIDINITE		LIPIDINITE		INERT	
LIPIDINITE		LIPIDINITE		INERT	
SAFROBIC AND MARTIN					
TELLOLLINITE					
TELINITE					
DESMOCOLLINITE					
SEORINITE					
CUTINITE					
ALBINITE					
LIPIDINITE					
BOTRYOCOCCLUS					
TRIMANITES					
OTHER ALGAL					
MICROCLANKTON					
EXSUDATINITE					
SCLEROINITE					
FUSINITE					
MACRINITE					
MICRINITE					
UNDEFINED MINERALS					
FRAMBOIDAL PYRITE					
AGGREGATES OF PYRITE					
CRYSTALS OF PYRITE					

1350.0	CTGS
1463.3	CORE
1732.0	CTGS
1858.0	CTGS
1918.0	CTGS
2124.0	CTGS
2367.0	CTGS
4080.0	CTGS

-	/	/	-	/	-	/	-	/	-	/	-	/
/		+	/	-	/					*	+	/
-		/	-		/					*	/	/
-	+	*	+	-	/				+	/	-	-
-		/	-		/					*	/	/
-		/	-		/					*	-	-
-		-	-	-	/					*	-	-
-	/	*	+	-	/					*	-	-

Comment lines from well 31/2-4 :

- 1350 m : few solid hydrocarbons
SOM partly converted
- 1463.3m : sample slightly oxidised
fluid inclusions
vitrinite (desmocollinite) grades into SOM
associated with framboidal pyrite
- 1732 m : SOM partly converted
contaminated
few coal particles
- 1858 m : rare solid hydrocarbons
- 1918 m : rare coal particles
- 2124 m : few solid hydrocarbons
- 2367 m : sample partly, severely oxidised; contaminated
few solid hydrocarbons
- 4080 m : abundant liptinite-rich coal particles (contam.?)

d) Organic carbon content

depth, m	C _t , wt%
1350	0.9
1732	1.3
1858	18.3 - 18.6
1918	1.0
2124	0.9
2367	0.8
2808	0.1
3405	0.1
4080	5.6 - 5.6
4701	0.1

III DISCUSSION AND CONCLUSIONS

In the Paleocene, represented by samples from 1302m down to its base at 1364.3m, two very marginal SRI-values have been encountered at 1329 and 1350m. A maceral analysis of the latter sample shows rare non-favourable SOM as main maceral, furthermore few solid hydrocarbons.

Both samples can be considered to represent very marginal source rocks for gas.

In the interval 1708 - 1792m, mainly in the Bathonian (1709 - 1773? m) marginal SRI-values up to 85 units have been detected. The distribution of the rare SOM is non-favourable in sample 1732m and few coal particles have been observed.

This interval represents marginal source rocks for gas.

In the interval 1804 - 1894m almost continuously high SRI-values have been detected. Maceral analysis of sample 1858m shows coal particles rich in vitrinite with common sporinite. No vitrinite-reflectance measurement could be made due to the lack of suitable material.

This interval contains source rocks for gas.

In the Lower Jurassic and Rhaetian formations, in the intervals 1906 - 2136 and 2200 - 2280m, marginal SRI-values have been measured.

Maceral analyses of samples 1918 and 2124m show a similar picture : rare non-favourable SOM and few desmocollinite and few liptodetrinite and microplankton as main macerals.

Samples 1968, 1980 and 1992m show under the microscope rare coal particles and silt(stone) with impregnations, fluorescing under ultra-violet light, perhaps related

to the solid hydrocarbons detected in sample 2124m. Both intervals may be considered to contain marginal source rocks for gas.

In the Anisian, two samples from 4068 and 4080m show high SRI-values around 200- and 400 units. Amount and type of organic matter and maceral analysis (liptinite-rich coal particles with abundant vitrinite) stamp these samples as source rocks for gas. (Contamination is not considered to play a role).

In addition to the cuttings, one core sample from the base of the Oxfordian (1463.3m) has been investigated microscopically. The maceral study shows few non-favourable SOM and few liptinite as main macerals. Although SRI-values, amount and type of organic matter are not known, it is probable that core sample 1463.3m represents source rocks for gas.

IV SUMMARY

In well 31/2-4 the following source rocks have been encountered :

- samples 1329 and 1350m of the Paleocene represent very marginal source rocks for gas.
- interval 1708 - 1792m contains marginal source rocks for gas.
- interval 1804 - 1894m contains source rocks for gas.
- in the Lower Jurassic and Rhaetian formations, in the intervals 1906 - 2136 and 2200 - 2280m, marginal source rocks for gas are present.
- in the Anisian formation, two samples at 4068 and 4080m contain source rocks for gas.
- based only on maceral analysis, it seems highly probable that core sample 1463.3m represents a source rock for gas.

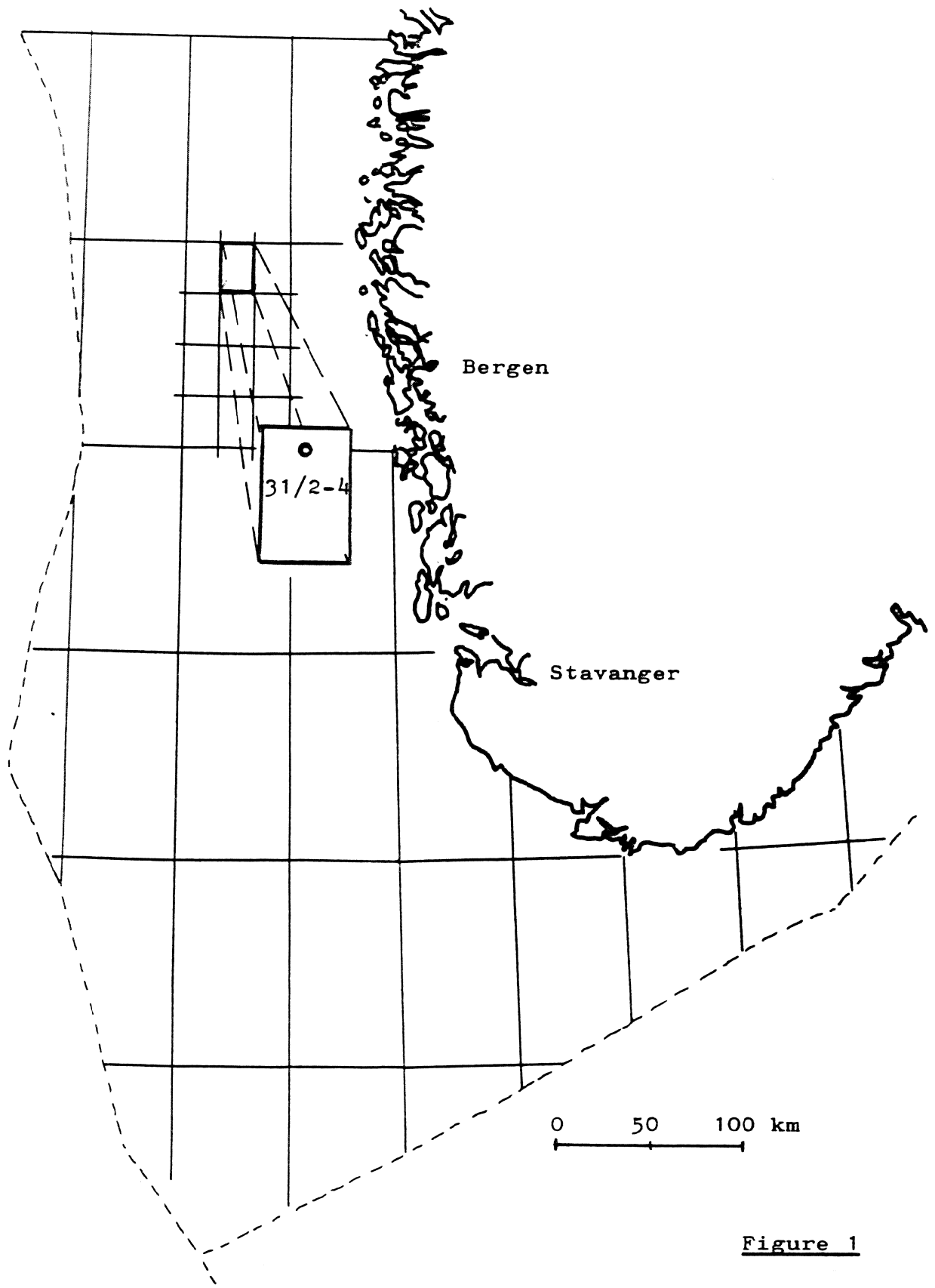


Figure 1

TABLE 3 (PART 1)

WELL:

3172-4

DEPTH	TYPE OF SAMPLE	SOURCE	SOURCE	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT
		FOCK INDICATION	FOCK INDICATION		
		BEFORE EXTF.	AFTER EXTF.		%
1302	C	5	-		-
1314	C	5	-		-
1320	C	5	-		-
1329	C	405	30		-
1339	C	5	-		-
1390	C	50	40		.9
1666	C	20	-		-
1678	C	25	-		-
1687	C	5	-		-
1696	C	25	-		-
1700	C	45	40		-
1720	C	50	45		-
1732	C	55	50		1.3
1858	C	> 900	> 900	MF	18.3
1858	C	> 900	> 900	MF	18.6
1870	C	675	545		-
1882	C	50	50		-
1894	C	100	160		-
1906	C	20	-		-
1918	C	45	50		1.0
1930	C	60	45		-
1942	C	95	50		-
1950	C	30	35		-
1968	C	65	65		-
1980	C	95	65		-
1992	C	65	60		-
2004	C	60	40		-
2010	C	30	30		-
2028	C	30	30		-
2040	C	50	35		-

TABLE 2 (PART 2)

WELL:

3172-4

DEPTH	TYPE OF SAMPLE	SOURCE FOCK INDICATION	SOURCE FOCK INDICATION	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %
F		BEFORE EXTR.	AFTER EXTR.		
2052	C	5	-		-
2064	C	35	20		-
2076	C	90	55		-
2088	C	20	-		-
2100	C	40	35		-
2112	C	55	40		-
2124	C	50	60		.9
2136	C	30	35		-
2148	C	35	20		-
2160	C	15	-		-
2172	C	15	-		-
2184	C	15	-		-
2196	C	10	-		-
2208	C	60	30		-
2220	C	35	15		-
2232	C	40	15		-
2244	C	40	25		-
2256	C	40	25		-
2268	C	35	25		-
2280	C	165	165	H	-
2292	C	5	-		-
2304	C	20	25		-
2316	C	25	-		-
2328	C	5	-		-
2331	C	5	-		-
2343	C	5	-		-
2355	C	5	-		-
2367	C	55	30		.8
2379	C	60	5		-
2391	C	5	-		-

TABLE I (PART 2)

WELL:

3172-4

DEPTH	TYPE OF SAMPLE	SOURCE ROCK INDICATION	SOURCE ROCK INDICATION	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT
		BEFORE EXTR.	AFTER EXTR.		%
2413	C	5	-		-
2415	C	10	-		-
2427	C	10	-		-
2439	C	10	-		-
2451	C	30	10		-
2463	C	15	-		-
2475	C	5	-		-
2487	C	5	-		-
2499	C	5	-		-
2511	C	15	-		-
2523	C	10	-		-
2535	C	15	-		-
2547	C	5	-		-
2559	C	5	-		-
2571	C	5	-		-
2583	C	5	-		-
2595	C	20	-		-
2617	C	5	-		-
2619	C	15	-		-
2631	C	5	-		-
2642	C	5	-		-
2655	C	5	-		-
2667	C	5	-		-
2679	C	15	-		-
2691	C	10	-		-
2703	C	5	-		-
2715	C	5	-		-
2724	C	5	-		-
2736	C	15	-		-
2748	C	20	-		-

TABLE I (CONT. 4)

WELL:

31/2-4

DEPTH	TYPE OF SAMPLE	SOURCE	SOURCE	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT
		FOCF INDICATION	FOCF INDICATION		
		BEFORE EXTR.	AFTER EXTR.		%
2760	C	5	-		-
2772	C	5	-		-
2784	C	5	-		-
2796	C	5	-		-
2818	C	5	-		.1
2820	C	5	-		-
2832	C	15	-		-
2841	C	10	-		-
2853	C	5	-		-
2865	C	5	-		-
2877	C	5	-		-
2889	C	5	-		-
2901	C	10	-		-
2913	C	5	-		-
2925	C	5	-		-
2934	C	25	-		-
2946	C	5	-		-
2955	C	5	-		-
2967	C	5	-		-
2979	C	25	-		-
2991	C	5	-		-
3003	C	5	-		-
3015	C	5	-		-
3027	C	25	-		-
3039	C	5	-		-
3051	C	10	-		-
3063	C	5	-		-
3075	C	5	-		-
3087	C	5	-		-
3099	C	15	-		-

TABLE I (PART 2)

WELL:

31/2-4

DEPTH	TYPE OF SAMPLE	SOURCE FOCK INDICATION		TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %
		BEFORE EXTR.	AFTER EXTR.		
3111	C	5	-	-	-
3123	C	5	-	-	-
3135	C	5	-	-	-
3147	C	5	-	-	-
3159	C	5	-	-	-
3171	C	5	-	-	-
3183	C	5	-	-	-
3195	C	5	-	-	-
3204	C	5	-	-	-
3210	C	25	-	-	-
3225	C	5	-	-	-
3237	C	5	-	-	-
3249	C	5	-	-	-
3261	C	5	-	-	-
3273	C	5	-	-	-
3285	C	5	-	-	-
3297	C	5	-	-	-
3309	C	5	-	-	-
3321	C	5	-	-	-
3333	C	15	-	-	-
3345	C	20	-	-	-
3357	C	10	-	-	-
3369	C	15	-	-	-
3381	C	5	-	-	-
3393	C	5	-	-	-
3405	C	5	-	-	.1
3417	C	5	-	-	-
3429	C	5	-	-	-
3441	C	5	-	-	-
3453	C	5	-	-	-

TABLE 2 (PART 2)

WELL:

3172-4

DEPTH	TYPE OF SAMPLE	SOURCE	SOURCE	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT
		FLOCK INDICATION	FLOCK INDICATION		
		BEFORE EXTR.	AFTER EXTR.		%
3465	C	10	-		-
3477	C	5	-		-
3489	C	15	-		-
3501	C	15	-		-
3513	C	10	-		-
3525	C	25	-		-
3537	C	15	-		-
3549	C	5	-		-
3561	C	10	-		-
3573	C	10	-		-
3585	C	10	-		-
3597	C	5	-		-
3609	C	5	-		-
3621	C	5	-		-
3633	C	5	-		-
3645	C	5	-		-
3657	C	5	-		-
3669	C	15	-		-
3681	C	10	-		-
3693	C	15	-		-
3705	C	10	-		-
3717	C	10	-		-
3729	C	10	-		-
3741	C	10	-		-
3753	C	5	-		-
3765	C	5	-		-
3774	C	5	-		-
3786	C	5	-		-
3798	C	5	-		-
3810	C	105	5		-

TABLE 2 (PART 7)

WELL:

3172-4

DEPTH	TYPE OF SAMPLE	SOURCE FLOCK INDICATION	SOURCE FLOCK INDICATION	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %
		BEFORE EXTR.	AFTER EXTR.		
3822	C	5	-	-	-
3834	C	25	-	-	-
3846	C	5	-	-	-
3858	C	5	-	-	-
3870	C	5	-	-	-
3882	C	5	-	-	-
3900	C	5	-	-	-
3912	C	5	-	-	-
3924	C	5	-	-	-
3936	C	25	-	-	-
3948	C	5	-	-	-
3960	C	5	-	-	-
3972	C	5	-	-	-
3984	C	5	-	-	-
3996	C	5	-	-	-
4008	C	5	-	-	-
4020	C	5	-	-	-
4032	C	5	-	-	-
4044	C	5	-	-	-
4056	C	5	-	-	-
4068	C	105	240	-	-
4080	C	415	420	H	5.6
4092	C	415	420	H	5.6
4092	C	145	5	-	-
4104	C	40	45	-	-
4116	C	15	20	-	-
4131	C	5	-	-	-
4143	C	5	-	-	-
4155	C	5	-	-	-
4167	C	30	25	-	-

TABLE 2 (PART 2)

WELL:

3172-4

DEPTH	TYPE OF SAMPLE	SOURCE FOCK INDICATION	SOURCE FOCK INDICATION	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %
		BEFORE EXTR.	AFTER EXTR.		
4179	C	15	-		-
4192	C	120	10		-
4200	C	10	-		-
4212	C	5	-		-
4224	C	5	-		-
4236	C	25	-		-
4248	C	5	-		-
4260	C	5	-		-
4272	C	5	-		-
4284	C	5	-		-
4296	C	25	-		-
4308	C	10	-		-
4320	C	5	-		-
4332	C	5	-		-
4344	C	5	-		-
4356	C	5	-		-
4368	C	5	-		-
4380	C	5	-		-
4392	C	5	-		-
4404	C	5	-		-
4416	C	5	-		-
4428	C	5	-		-
4440	C	5	-		-
4452	C	5	-		-
4464	C	20	-		-
4476	C	100	-		-
4488	C	5	-		-
4497	C	5	-		-
4509	C	10	-		-
4521	C	25	-		-

TABLE 2 (PART 9)

WELL:

3172-4

DEPTH	TYPE OF SAMPLE	SOURCE FOCK INDICATION	SOURCE FOCK INDICATION	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %
		BEFORE EXTR.	AFTER EXTR.		
4533	C	10	-	-	-
4545	C	5	-	-	-
4557	C	5	-	-	-
4569	C	5	-	-	-
4581	C	5	-	-	-
4593	C	5	-	-	-
4605	C	5	-	-	-
4617	C	5	-	-	-
4629	C	5	-	-	-
4641	C	5	-	-	-
4653	C	5	-	-	-
4665	C	5	-	-	-
4677	C	5	-	-	-
4689	C	5	-	-	-
4701	C	5	-	-	.1
4713	C	5	-	-	-
4725	C	5	-	-	-
4737	C	10	-	-	-
4749	C	5	-	-	-
4761	C	5	-	-	-
4773	C	5	-	-	-
4785	C	5	-	-	-
4797	C	5	-	-	-
4809	C	5	-	-	-
4820	C	5	-	-	-
4842	C	5	-	-	-
4854	C	5	-	-	-
4866	C	5	-	-	-
4878	C	5	-	-	-
4890	C	5	-	-	-

TABLE 2 (PART 10)

WELL:

3172-4

DEPTH	TYPE OF SAMPLE	SOURCE	SOURCE	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %
		FOOD INDICATION	FOOD INDICATION		
		BEFORE EXTR.	AFTER EXTR.		
4899	C	5	-		-
4911	C	5	-		-
4923	C	5	-		-
4935	C	5	-		-
4947	C	10	-		-
4965	C	15	-		-
4977	C	5	-		-
4989	C	5	-		-
5001	C	5	-		-
5013	C	5	-		-
5025	C	5	-		-

TYPE OF SAMPLE C = CUTTINGS, B = CORE, S = SIDEWALL SAMPLE

CONTAMINATION: W = WALNUT FRAGMENTS OR SOME SIMILAR PRODUCT,
L = CELLOPHANE SHEETS, F = FIBRES, P = PLASTIC OR PAINT AND
C = CONTAMINATED BUT KIND NOT SPECIFIED

A DASH (-) INDICATES TEST NOT MADE, ASTERISKS INDICATE THE
ORGANIC CARBON CONTENT IS THE AVERAGE FOR THE SAMPLES CONCERNED

2F11

INITIAL DISTRIBUTION

3 copies area

GEOCHEMICAL LOG

SCALE 1:5000

WELL

31/2-4

LOCATION

REGED IDENTIFIER

AGE	FORMATION	DEPTH IN M	LITHOLOGY	DENSITY	SOURCE ROCK INDICATION OF ORIGINAL SAMPLE						TYPE OF SAMPLE	SOURCE ROCK INDICATION OF SAMPLE AFTER EXTRACTION WITH CHLOROFORM						CONTAMINATION	DEPTH IN M	ORG. CARBON (PCT. WT)	TYPE OF ORGANIC MATTER
					100	200	300	400	500	600		100	200	300	400	500	600				
JURASSIC	UPPER	1200														1200					
		1300														1300					
		1400														1400	0.9				
	MIDDLE	1500														1500					
		1700														1700	1.3				
		1800														1800	19.3 18.6	MAINLY HUMIC TO HUMIC			
	LOWER	1900														1900	1.0				
		2100														2100	0.9				
		2300														2300		HUMIC			
		2400														2400	0.8				
		2500														2500					
		2600														2600					
TRIASSIC	CR	2700													2700						
		2800													2800						
		2900													2900	0.1					
		3000													3000						
	LA	3100													3100						
		3200													3200						
		3300													3300						
		3400													3400	0.1					
AN	SK	3500													3500						
		3600													3600						
		3700													3700						
		3800													3800						
	AN	3900													3900						
		4000													4000						
		4100													4100	5.6	HUMIC				
		4200													4200						
AN	SK	4300													4300						
		4400													4400						
		4500													4500						
		4600													4600						
AN	SK	4700													4700	0.1					
		4800													4800						
		4900													4900						
		5000													5000						
AN	SK	5100												5100							
		5200												5200							

VALUES SMALLER THAN 30 ARE CONSIDERED NOT TO BE OF SIGNIFICANCE

SAMPLES FROM 1329 M AND 1350 M REPRESENT VERY MARGINAL SOURCE ROCKS FOR GAS.

CORE SAMPLE 1483.3 M FROM THE OXFORDIAN REPRESENTS PROBABLY A SOURCE ROCK FOR GAS.

INTERVAL 1705-1792 M CONTAINS MARGINAL SOURCE ROCKS FOR GAS.

INTERVAL 1804-1894 M CONTAINS SOURCE ROCKS FOR GAS.

INTERVALS 1905-2136 M AND 2200-2290 M CONTAIN MARGINAL SOURCE ROCKS FOR GAS.

SAMPLE AT 4369 M AND 4390 M CONTAIN SOURCE ROCKS FOR GAS.

STRATIGRAPHY ACCORDING TO:
APPENDIX III
BIOSTRATIGRAPHY OF WELL 31/2-4 (NORSKE SHELL)
BY G. O. J. GIELEN
E. NOORDENHEER-PERREIJN
AND B. PRINS (SIIPM. CP/12)
JULY 1981

NUMBER OF SAMPLES ANALYSED 281

NUMBER OF SAMPLES ANALYSED 48

LEGEND
 TYPE OF SAMPLE
 ○ = CORE
 □ = SIDEWALL SAMPLE
 CONTAMINATION
 C = UNSPECIFIED
 W = WALNUTS
 E = CELLOPHANE
 F = FIBRES
 P = PLASTIC OR PAINT

NORSKE SHELL
EXPLORATION & PRODUCTION LABORATORIES

GEOCHEMICAL LOG OF
31/2-4
NORWAY

AUTHOR: OTE DATE: NOVEMBER 1981
REF: 81-281-176 ENCL: 1 DRAWING: 1