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SOURCE ROCK EVALUATION OF JURASSIC CUTTING SAMPLES FROM WELL 31/2-5, OFFSHORE NORWAY (INTERVAL 1651 - 2532 M)

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investigation
9.12.342

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(Shell Research B.V.)

CONTENTS

I INTRODUCTION

A source rock evaluation has been carried out on a suite of cutting samples from the Norwegian offshore-well 31/2-5. The approximate location of the well is shown in figure 1.

The samples cover the interval 1651 - 2532 m (i.e.: total depth). They derive from the Jurassic Sogn-Group.

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 <u>quality</u> 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 macerals[1], 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 of the chemical analyses are plotted on the geochemical log (enclosure 1) and detailed in table I (source rock properties). The results of the microscopic investigations are given in table II (maceral descriptions). They can be summarized as follows:

a) Source rock indications (SRI)

All samples have been washed in order to remove eventual contamination solvable in water (e.g.: salt). According to the SRI values this well can be divided into the following intervals:

interval 1987 - 2071 m	SRI values	45	to	630	units
interval 2080 - 2233 m	SRI values	30	to	110	units
interval 2368 - 2395 m	SRI values	55	to	140	units
interval 2422 - 2467 m	SRI values	180	to	900	units

Sample 2485 m shows a SRI value of 45 units. The SRI values of the remaining samples are insignificant. (less than 30 units).

b) Type of organic matter

The type of organic matter has been determined in six samples. Five of them are "humic". Only sample 2440 m is "mainly humic to mixed".

c) Organic carbon content

The organic carbon content has been determined in 15 samples. In the above mentioned intervals it reaches up to 15.0 %, 2.1 %, 3.9 %, and 27.3 % respectively. For the rest it does not exeed 2.0 %.

d) Maceral analyses

For a detailed description see table II.

e) Degree of organic metamorphism

As no suitable vitrinite is present in the samples, no reliable reflectance measurements could be carried out. Slight conversion features of the SOM in sample 2431 m might indicate an initial stage of maturity for oil generation, but might also be due to the observed oxidation. It can, however, be estimated that at this depth the sediments are still immature - or at the best just slightly mature - for oil generation.

III DISCUSSION AND CONCLUSION

As has already been discussed above, the presence of really mature or even postmature source rocks has not to be taken into consideration. Thus, in the examined interval a source rock must show significant source rock indications..

The interval 1651 - 1978 m shows only some marginal SRI values. Organic carbon contents of up to 2.0 % occur. Maceral analysis show only small contents of temperature-reactive ("live") organic constituents. In samples 1795 and 1885 m rare coal particles have been observed, which are suspected to represent contamination. This would also explain the "humic" type of organic matter in sample 1759 m. A fair amount of solid hydrocarbons has been observed in sample 1840 m.
Probably none of the samples in this interval contains "live" organic matter in a concentration to qualify as source rock.

In the interval 1987 - 2071 m we encounter good source rocks showing SRI values of up to 630 units and organic carbon contents of up to 15.0 %. Only sample 1996 m shows a marginal SRI value of 45 units. The main maceral in sample 2008 m is vitrinite-2, from which gas

will be derived. Besides, common SOM is present, the amount and habitat of which is only favourable for the generation of gas and small amounts of oil. The amount of liptinites is probably not sufficient either to deliver amounts of landplant-derived oil worth mentionable. Additionally the type of organic matter in sample 2017 m is "humic". Although this might partly be due to the overweight of gas generated from the vitrinite, possibly oxidation of the organic matter, as observed in sample 2008 m, has additionally shifted the type, thus indicating a decrease of the originally already rather small oil generation potential.
The interval 1987 - 2071 m should, therefore, only be regarded as containing source rocks mainly for gas.

The whole interval 2080 - 2233 m shows marginal SRI values. Sample 2152 m has an organic carbon content of 2.1 %. However, caving from the overlying source rock interval has to be taken into consideration. Neither in this interval can, however, the occasional occurrence of marginal gas source rocks been excluded (common SOM in sample 2152 m). It has also to be kept in mind that it is not always possible to identify all of the coal definitely as caving and/or contamination.

In the interval 2368 - 2395 m source rocks of a "humic" type occur, which show SRI-values of up to 140 units and organic carbon contents of up to 3.9 %. The only important maceral (in sample 2377 m) is common vitrinite, from which gas will be derived.

The interval 2422 - 2467 m is characterized by partly excellent source rock indications of more than 900 units, organic carbon contents of up to 27.3 % and a "mainly humic to mixed" type of organic matter. The maceral analysis shows abundant vitrinite, from which considerable amounts of gas can be derived. From the common liptinites minor amounts of landplant-derived oil might be generated, too. Besides, however, SOM is present, the amount and habitat of which is favourable for oil generation. Summarizing this interval can be regarded as containing good source rocks for gas and oil.

In the interval 2476 - 2532 m (T.D.) only sample 2485 m shows a rather marginal SRI-value of 45 units, which is probably due to caving. Sample 2532 m shows an organic carbon content of only 0.4 %. This interval must, therefore, be considered barren.

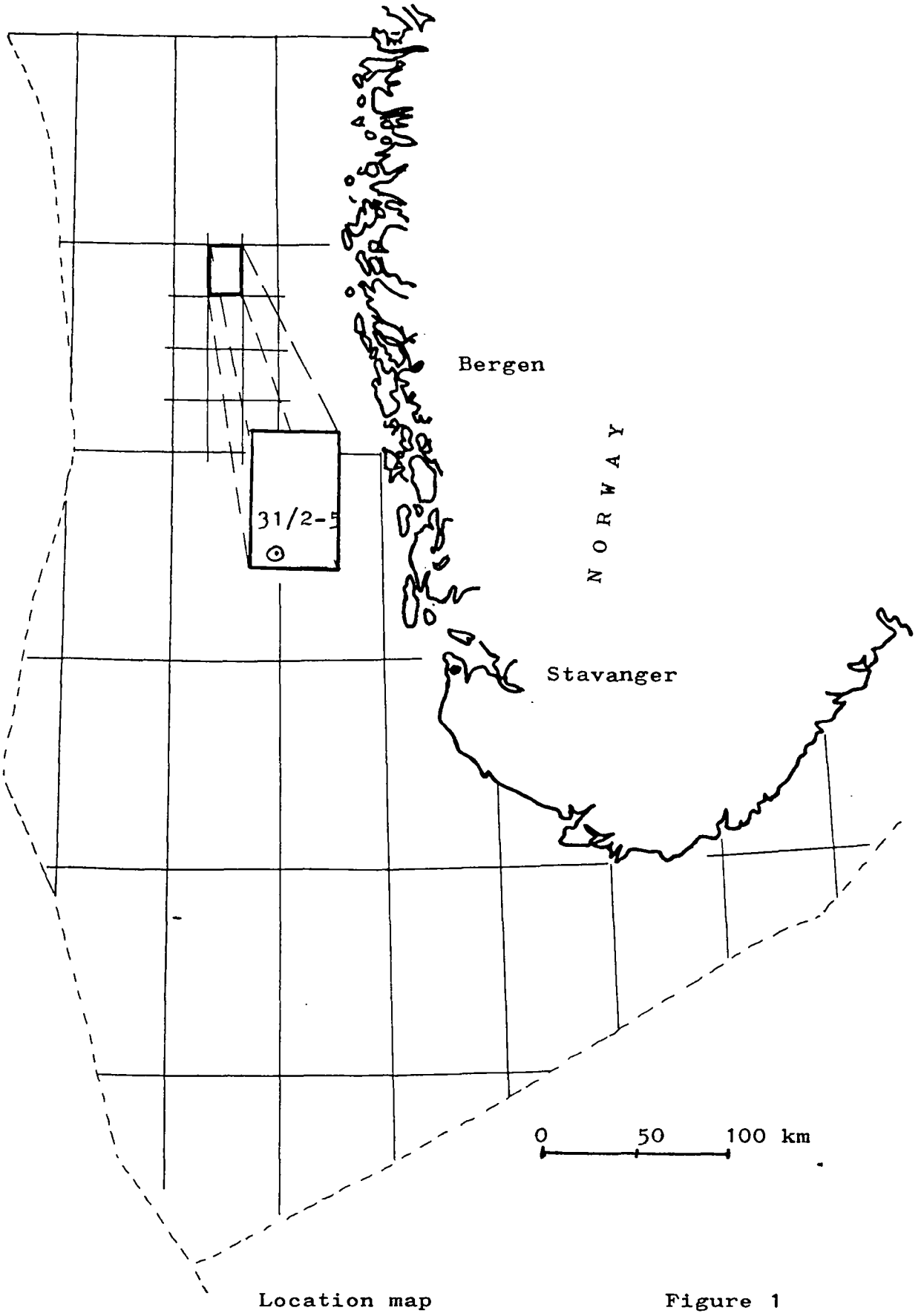
IV SUMMARY

In the following intervals hydrocarbon source rocks have been identified:

1987 - 2071 m: fair to excellent source rocks mainly for gas;
2368 - 2395 m: marginal to fair source rocks for gas;
2422 - 2467 m: excellent source rocks for gas and oil.

In the interval 2080 - 2359 m occasionally marginal gas source rocks might occur.

The lowermost source rock interval is immature to just slightly mature for oil generation.



Location map

Figure 1

TABLE I (PART 1) WELL: 31/2-5

DEPTH	TYPE OF SAMPLE	SOURCE ROCK INDICATION BEFORE EXTR.	SOURCE ROCK INDICATION AFTER EXTR.	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %W
1651	C	20	20		-
1660	C	55	70		-
1669	C	65	70		-
1678	C	45	20		1.6
1687	C	55	25		-
1696	C	40	20		-
1705	C	40	20		-
1714	C	10	10		-
1723	C	35	15		-
1732	C	35	15		-
1741	C	45	45		-
1750	C	35	10		.6
1759	C	55	40	H	-
1768	C	40	20		-
1777	C	20	20		-
1786	C	75	50		-
1795	C	80	60		1.3
1804	C	30	20		-
1813	C	75	40		-
1828	C	55	15		-
1840	C	40	15		.6
1840	C	40	15		.6
1849	C	20	20		-
1858	C	5	10		-
1867	C	100	80		-
1876	C	70	65		-
1885	C	75	70		2.0
1894	C	35	45		-
1903	C	30	50		-
1912	C	60	40		-

TABLE I (PART 2) WELL: 31/2-5

DEPTH m	TYPE OF SAMPLE	SOURCE ROCK INDICATION BEFORE EXTR.	SOURCE ROCK INDICATION AFTER EXTR.	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %W
1921	C	45	30		1.1
1930	C	50	25		-
1939	C	55	25		-
1948	C	30	15		-
1957	C	30	10		-
1966	C	20	10		-
1978	C	50	25		-
1987	C	330	350		-
1996	C	45	45		-
2008	C	550	395		13.6
2008	C	550	395		15.0
2017	C	725	605	H	-
2026	C	625	630		-
2032	C	230	240		-
2041	C	115	115		-
2053	C	140	110		3.3
2062	C	230	220		-
2071	C	230	160		-
2080	C	115	85		-
2089	C	110	95		-
2095	C	45	45		-
2104	C	35	30		-
2110	C	50	40		-
2116	C	65	50		-
2125	C	70	45		-
2134	C	80	30		-
2143	C	60	45		1.4
2152	C	110	50		2.1
2161	C	140	75		-
2170	C	110	110		-

TABLE I (PART 3) WELL: 31/2-5

DEPTH m	TYPE OF SAMPLE	SOURCE ROCK INDICATION BEFORE EXTR.	SOURCE ROCK INDICATION AFTER EXTR.	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %W
2179	C	30	55	H	-
2188	C	60	65		-
2197	C	40	40		-
2206	C	45	45		-
2215	C	20	20		-
2224	C	55	55		1.7
2233	C	65	65	H	-
2242	C	15	-		-
2248	C	15	-		-
2257	C	15	5		-
2263	C	15	15		-
2272	C	15	-		-
2282	C	15	15		-
2291	C	15	10		-
2299	C	15	10		-
2308	C	15	15		-
2314	C	10	15		-
2332	C	30	25		-
2341	C	50	20		-
2350	C	20	5		-
2359	C	15	-		-
2368	C	125	115		-
2377	C	140	140		2.3
2386	C	135	130	H	3.9
2395	C	60	55		-
2404	C	35	30		-
2413	C	10	5		-
2422	C	> 900	> 900		-
2431	C	> 900	> 900		27.2
2431	C	> 900	> 900		27.3

TABLE I (PART 4) WELL: 31/2-5

DEPTH M	TYPE OF SAMPLE	SOURCE ROCK INDICATION BEFORE EXTR.	SOURCE ROCK INDICATION AFTER EXTR.	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %W
2440	C	730	720	MI/M	-
2449	C	> 900	615		-
2458	C	295	180		-
2467	C	300	250		-
2476	C	5	-		-
2485	C	60	45		-
2494	C	40	10		-
2503	C	5	5		-
2512	C	5	5		-
2521	C	5	5		-
2530	C	5	5		-
2532	C	5	5		.4

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

CONTAMINATION : W = WALNUT FRAGMENTS OR SOME SIMILAR PRODUCT, E = CELLOPHANE SHREDS, 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

sample 2377 m: rare SOM;
common vitrinite partly grading into SOM associated with framboidal pyrite;
few liptodetrinite;
rare sporinite, cutinite, resinite, exsudatinite, and fusinite;
pyrite shows oxidation features;

sample 2431 m: common, slightly converted SOM;
abundant vitrinite grading into SOM;
common sporinite, liptodetrinite, and fusinite;
rare cutinite and resinite;
few exsudatinite;
sample slightly oxidized;

TABLE II

INITIAL DISTRIBUTION

5 copies area