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SOURCE ROCK ANALYSIS OF CUTTINGS AND SIDEWALL SAMPLES FROM WELL 31/2-8, NORWAY

by

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code: 774.103

in co-operation with
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Investigation
95.3493

KONINKLIJKE/SHELL EXPLORATIE EN PRODUKTIE LABORATORIUM
RIJSWIJK, THE NETHERLANDS
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CONTENTS

SOURCE ROCK ANALYSIS OF CUTTINGS AND SIDEWALL SAMPLES FROM WELL 31/2-8, NORWAY

I. INTRODUCTION

A source rock evaluation has been carried out on cuttings and sidewall samples from well 31/2-8, Norway. The approximate location is shown in Figure 1.

The samples are taken from interval 1736.0 to 3375.0 m, i.e. Lower Tertiary to Triassic. Total depth was reached at 3375. o.m. b.d.f.

Source rock evaluation commonly comprises determination of:

1. the presence (or absence) of hydrocarbon 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 accummulations.

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 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 rock 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 50x)

II. RESULTS

The results obtained are shown in Table I (source rock indications, total organic carbon content, type of organic matter) and Table II (Maceral description, comment lines) and Figure 2 and 3 (Vitrinite reflectance histograms). The results are summarised in Enclosure 1. (Geochemical log).

III. DISCUSSION

Interval 1736 to 1811 m

Only sample 1742 m shows a marginal source-rock indication (SRI) value of 40 units. This SRI value is probably due to the presence of salt. It is therefore concluded that this interval does not contain source rocks.

Interval 1820 to 1838 m

The samples of this interval show marginal to fairly good source-rock indication (SRI) values. The maceral descriptions of cutting sample 1829 m and of SWS 1826.5 and 1830.5 m reveal "few" to "common" sapropelic organic matter (SOM) together with low amounts ("few") of fusinite, sporinite, liptodetrinite and microplankton.
The type of organic matter is "mixed". The total organic carbon content amounts to 2.2% wt for sample 1829 m.
It is therefore concluded that interval 1820 to 1838 m contains marginal to fairly good source rocks for oil and gas.

Interval 1889 to 2570 m

The samples of this interval show discontinuously marginal to fairly good SRI values, except for samples 2435 and 2444 m, which show good SRI values, viz.240 and 285 units, respectively. The organic carbon content as determined on three samples ranges between 2.7 and 3.0% wt. The type of organic matter was determined on samples 2069 and 2282 m, which were found to be "mainly humic", whereas sample 2444 was a "mainly kerogenous"

type. The maceral description of samples 2069 and 2444 is almost similar. Only the amount of liptinites present in sample 2444 m is higher than in sample 2069 m. The sapropelic organic matter (SOM) present in both samples is small and shows a non-favourable distribution, indicating that the oil generated cannot be expelled.
Sample 2282 m contains small amounts of SOM, desmocollinite and liptinites. The significant SRI value of sample 2207 m is due to a microscopically observed contamination. It is therefore concluded that this interval contains marginal to (fairly) good source rocks for gas.

Interval 2570 to 2663 m

The samples of this interval show fairly good to excellent SRI-values, together with a very high total organic carbon content (Ct-values), viz.15.8 and 47.5% wt in samples 2579 and 2633 m, respectively. The maceral descriptions reveal low ("few") to very high ("abundant") amounts of vitrinite and lower amounts of different liptinites ("few to common"). The maceral content is in agreement with the type of organic matter ("mainly humic"). It is therefore concluded that this interval contains fairly good to excellent source rocks for gas.

Interval 2672. to 3048 m

The samples of this interval show discontinuously insignificant to predominantly marginal SRI-values. The only determined total organic carbon content revealed a Ct-value of 1.6% wt (sample 2795 m). The maceral content shows very low amounts of SOM, desmocollinite and liptinites. The type of organic matter is "humic". Based on these data it is concluded that this interval may contain very marginal source rocks for gas at the most.

Interval 3050 to 3110 m

The samples of this interval show predominantly excellent SRI-values together with high amounts of total organic carbon (Ct=value = 18.9 for sample 3083). The maceral contents of the four samples of this interval reveal fair quantities of SOM, the amount being lowest in the middle and highest in the upper and lower parts of the interval. A reversed relationship is observed for the vitrinite content. The type of organic matter of sample 3083 m ("mainly humic") is in agreement with the maceral content of this sample. It is therefore concluded that interval 3050 to 3110 m contains an excellent source rock predominantly for gas, but sample 3063.8 m may be regarded as a source rock for oil and gas.

Interval 3119 m to 3375 m (TD)

All samples of this interval, except 3230 m (>900 units) and 3239.m (65 units), show insignificant SRI values. The maceral description of sample 3228 m reveals only low amounts of SOM and desmocollinite and liptinites, sample 3230 m shows only fair amounts of "common" telenite. The type of organic matter for this sample is "mainly humic".
Consequently, it is concluded that from this interval only sample 3230 m may be regarded as an excellent source-rock for gas.

Degree of organic metamorphism

The samples, 2207, 2575, 2632,5 2633 3083 and 3230 contain vitrinite particles (see Figs. 2 and 3. comment lines) for which it was possible to measure the reflectance. These VR values are not completely reliable and therefore are to be regarded as estimates only.

Sample depth	VR	DOM
2207 m	0.5	56
2575 m	0.55-065	58-60
2632.5 m	0.8	65
2633 m	0.74	63-64
3083 m	0.61	60
3230 m	0.4-0.6	53-60

IV CONCLUSIONS

Interval 1736 to 1811 m does not contain source rocks.

Interval 1820 to 1838 m contains marginal to fairly good source rocks for oil and gas.

Interval 1889 to 2561 m may be regarded as predominantly marginal to (fairly) good source rocks for gas.

Interval 2570 to 2663 m contains fairly good to excellent source rocks for gas.

Interval 2672 to 3038 may be regarded as very marginal source rocks for gas at the most.

Interval 3050 to 3110 m contains excellent source rocks for gas, while sample 3063.8 m may be regarded as source rocks for oil and gas.

Sample 3230 m may be regarded as an excellent source rock for gas.

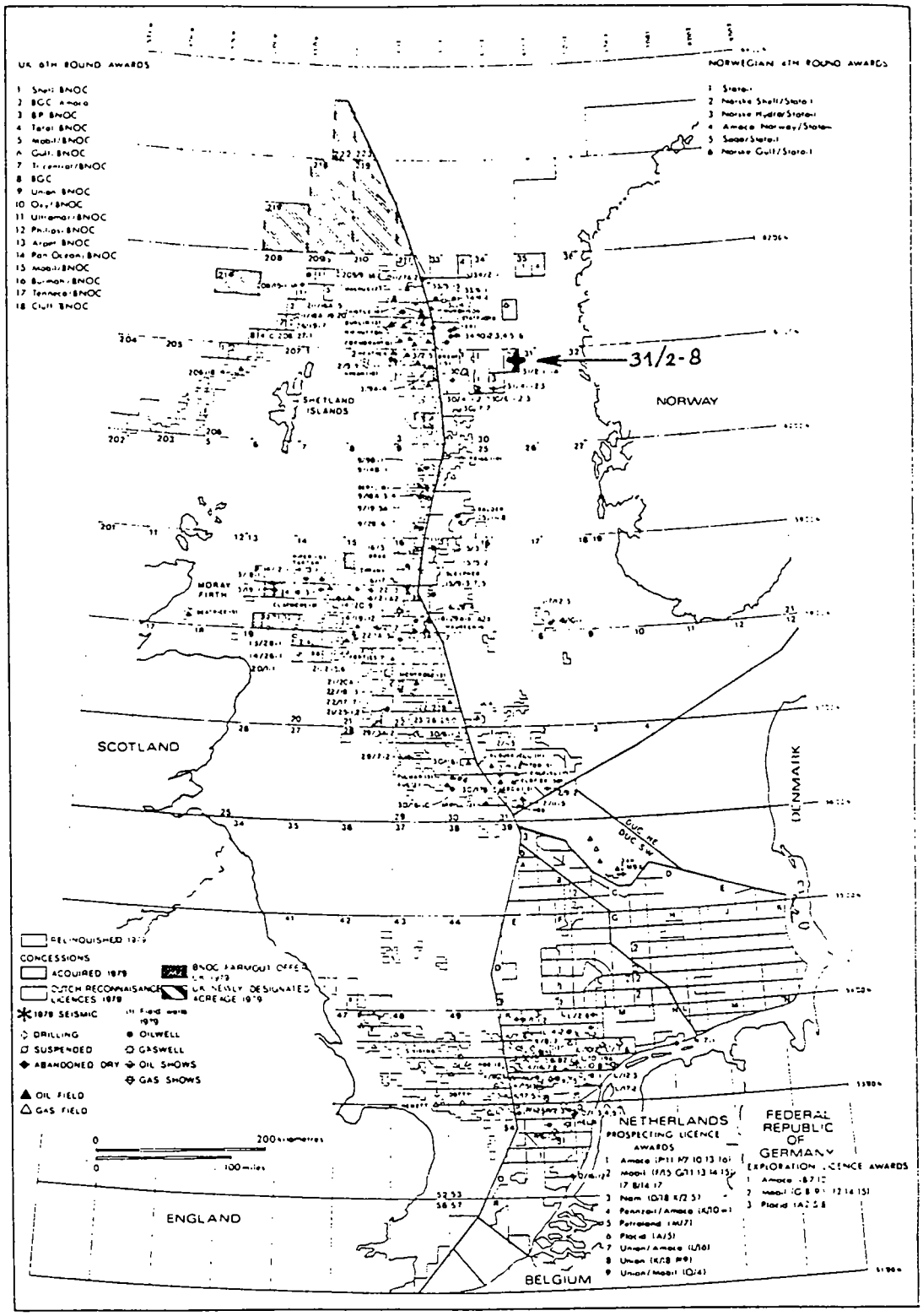

FIGURE 1: LOCATION MAP

REFLECTANCE HISTOGRAM

COUNTRY	. NORWAY	MEAN	: 0.74
WELL/OUTCROP	. 31/2-8	DEVIATION	. 0.03
DEPTH/SAMPLE NR.	. 2633 M	MODE	. 0.75
SAMPLE TYPE	. CUTTING SAMPLE	MEASUREMENTS	. 41

ANALYST: BTX D.D. 28-JAN-83

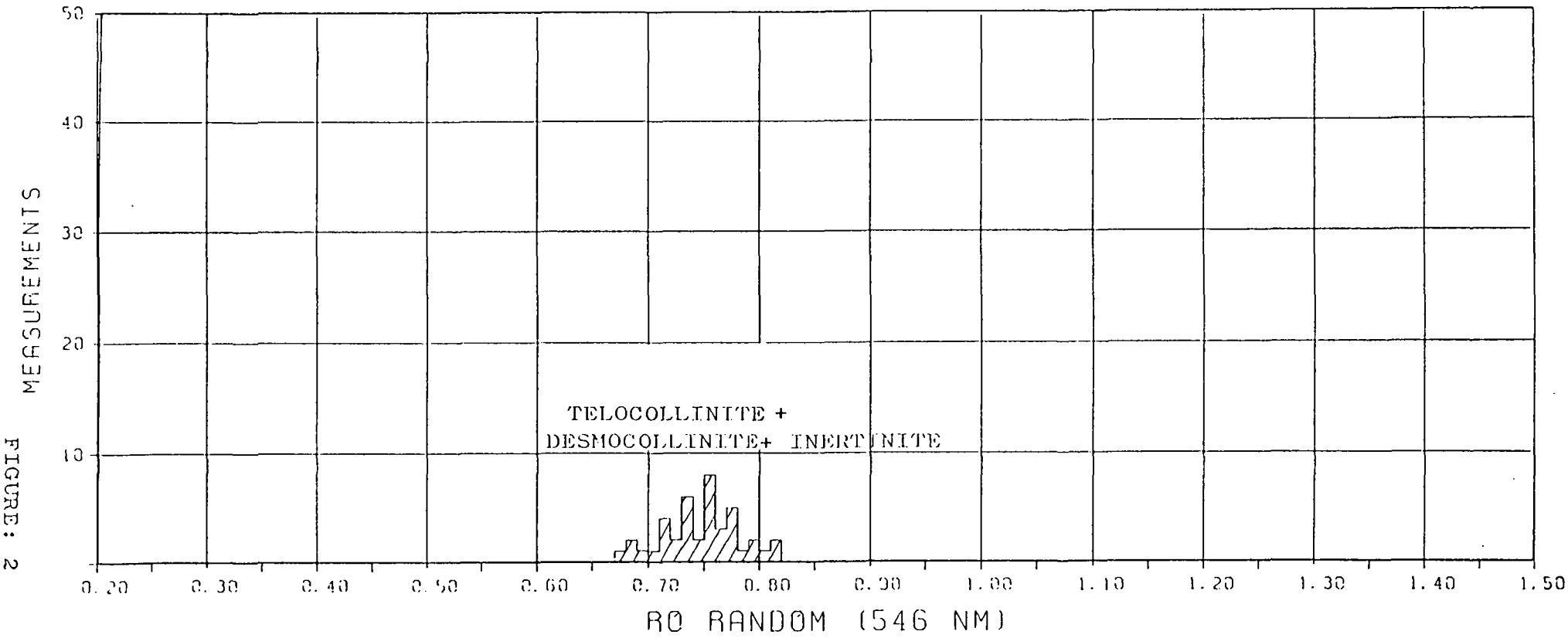

FIGURE: 2

REFLECTANCE HISTOGRAM

COUNTRY	. NORWAY	MEAN	. 0.61
WELL/OUTCROP	. 31/2-8	DEVIATION	. 0.04
DEPTH/SAMPLE NR.	3083 M	MODE	. MULTI
SAMPLE TYPE	. CUTTING SAMPLE	MEASUREMENTS	. 50

ANALYST: BTX D.D. 28-JAN-83

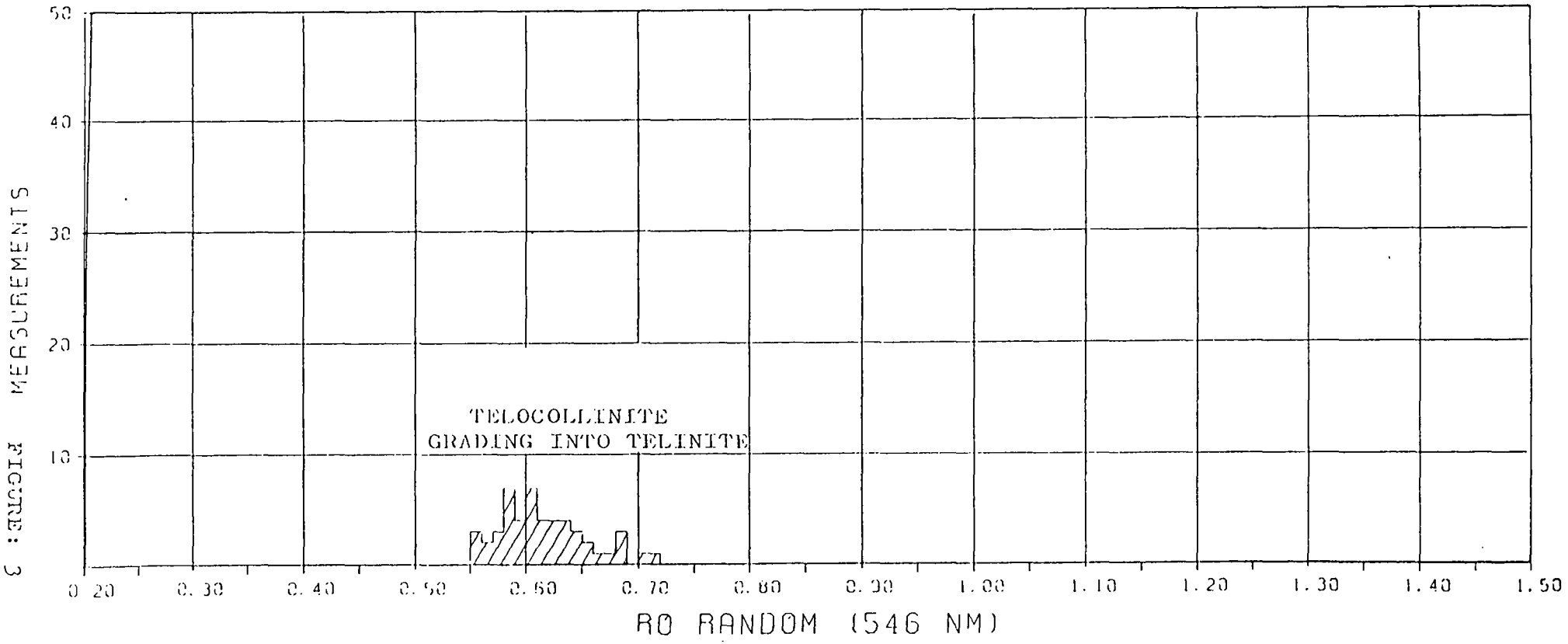

FIGURE: 3

TABLE I (PART 1) WELL: 31/2-8

DEPTH M	TYPE OF SAMPLE	SOURCE ROCK INDICATION BEFORE EXTR.	SOURCE ROCK INDICATION AFTER EXTR.	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %W
1736	C	40	15		-
1742	C	90	40		-
1757	C	5	-		-
1766	C	5	-		-
1775	C	5	-		-
1784	C	15	-		-
1793	C	20	-		-
1802	C	15	-		-
1811	C	5	-		-
1820	C	45	40		-
1829	C	135	145	M	2.2
1838	C	70	70		-
1889	C	5	-		-
1898	C	5	-		-
1907	C	15	-		-
1916	C	5	-		-
1925	C	5	-		-
1934	C	10	-		-
1943	C	40	40		-
1952	C	5	-		-
1961	C	5	-		-
1970	C	30	35		-
1979	C	70	60		-
1988	C	50	55		-
1997	C	45	50		-
2006	C	50	55		-
2015	C	35	35		-
2024	C	90	80		-
2033	C	70	55		-
2042	C	15	-		-

TABLE I (PART 2) WELL: 31/2-8

DEPTH m	TYPE OF SAMPLE	SOURCE ROCK INDICATION BEFORE EXTR.	SOURCE ROCK INDICATION AFTER EXTR.	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %W
2051	C	50	55		-
2060	C	45	65		-
2069	C	85	100	MH	2.9
2078	C	85	90		-
2087	C	85	110		-
2096	C	75	115		-
2108	C	90	90		-
2117	C	50	55		-
2126	C	60	65		-
2135	C	25	-		-
2144	C	10	-		-
2153	C	50	45		-
2162	C	25	-		-
2171	C	40	35		-
2180	C	50	55		-
2189	C	40	45		-
2198	C	30	35		-
2207	C	60 C	50 C		-
2216	C	40	55		-
2225	C	5	-		-
2234	C	85	65		-
2243	C	45	40		-
2252	C	65	55		-
2261	C	5	-		-
2270	C	150	110		-
2282	C	155	155	MH	2.7
2291	C	90	80		-
2300	C	90	85		-
2309	C	120	115		-
2318	C	70	60		-

TABLE I (PART 3) WELL: 31/2-8

DEPTH M	TYPE OF SAMPLE	SOURCE ROCK INDICATION BEFORE EXTR.	SOURCE ROCK INDICATION AFTER EXTR.	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT % W
2327	C	25	-		-
2336	C	15	-		-
2345	C	55	45		-
2354	C	50	60		-
2363	C	140	135		-
2372	C	105	105		-
2381	C	80	80		-
2390	C	100	100		-
2399	C	95	85		-
2408	C	115	105		-
2417	C	100	90		-
2426	C	75	75		-
2435	C	315	240		-
2444	C	340	285	MK	3.0
2453	C	185	165		-
2462	C	130	125		-
2471	C	95	75		-
2480	C	70	75		-
2489	C	40	55		-
2498	C	55	50		-
2507	C	30	20		-
2516	C	55	-		-
2525	C	45	45		-
2534	C	25	-		-
2543	C	40	40		-
2552	C	60	55		-
2561	C	90	90		-
2570	C	155	110		-
2579	C	690	695	MH	15.8
2588	C	320	295		-

TABLE I (PART 4) WELL: 31/2-8

DEPTH M	TYPE OF SAMPLE	SOURCE ROCK INDICATION BEFORE EXTR.	SOURCE ROCK INDICATION AFTER EXTR.	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %W
2597	C	145	105		-
2606	C	120	85		-
2615	C	165	175		-
2624	C	120	110		-
2633	C	> 900	> 900	MH	47.5
2642	C	255	220		-
2651	C	330	280		-
2663	C	195	175		-
2672	C	70	70		-
2684	C	40	40		-
2693	C	35	35		-
2708	C	35	35		-
2717	C	50	70		-
2726	C	60	75		-
2735	C	20	-		-
2741	C	35	40		-
2759	C	135	105		-
2768	C	90	85		-
2777	C	85	95		-
2786	C	70	75		-
2795	C	115	100	H	1.6
2804	C	105	80		-
2816	C	70	60		-
2825	C	70	55		-
2831	C	55	45		-
2840	C	40	40		-
2870	C	140	55		-
2879	C	5	-		-
2888	C	5	-		-
2894	C	35	15		-

TABLE I (PART 5) WELL: 31/2-8

DEPTH M	TYPE OF SAMPLE	SOURCE ROCK INDICATION S_2 BEFORE EXTR.	SOURCE ROCK INDICATION S_2 AFTER EXTR.	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %W
2906	C	50	35		-
2915	C	20	-		-
2924	C	80	70		-
2933	C	90	65		-
2942	C	90	60		-
2951	C	60	40		-
2960	C	75	55		-
2969	C	0	30		-
2978	C	5	-		-
2987	C	5	-		-
2996	C	5	-		-
3008	C	70	60		-
3017	C	5	-		-
3029	C	145	130		-
3038	C	75	60		-
3050	C	185	160		-
3056	C	440	380		-
3065	C	> 900	> 900		-
3074	C	> 900	680		-
3083	C	> 900	> 900	MH	18.9
3092	C	> 900	> 900		-
3101	C	640	455		-
3110	C	> 900	> 900		-
3119	C	140	75		-
3125	C	70	40		-
3134	C	60	45		-
3143	C	35	20		-
3152	C	45	25		-
3161	C	45	20		-
3170	C	45	15		-

TABLE I (PART 6) WELL: 31/2-8

DEPTH M	TYPE OF SAMPLE	SOURCE ROCK INDICATION BEFORE EXTR.	SOURCE ROCK INDICATION S_2 AFTER EXTR.	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %W
3179	C	5	-		-
3188	C	5	-		-
3194	C	20	-		-
3203	C	25	-		-
3212	C	5	-		-
3221	C	10	-		-
3230	C	> 900	> 900	MH	-
3239	C	90	65		-
3248	C	20	-		-
3251	C	15	-		-
3260	C	20	-		-
3269	C	10	-		-
3278	C	15	-		-
3287	C	15	-		-
3296	C	15	-		-
3305	C	20	-		-
3320	C	45	5		-
3329	C	10	-		-
3338	C	25	-		-
3347	C	5	-		-
3356	C	5	-		-
3365	C	5	-		-
3375	C	5	-		-

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

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

MACERAL DESCRIPTION OF 20 SAMPLES FROM WELL 31/2-8

DEPTH IN M	SAMPLE TYPE	ORGANIC: SAPROPELIC ORG. MATTER	ORGANIC: VITR. TELOCOLLINITE	ORGANIC: VITR. TELINITE	ORGANIC: VITR. DESMOCOLLINITE	ORGANIC: LIPTINITE SPORINITE	ORGANIC: LIPTINITE CUTINITE	ORGANIC: LIPTINITE RESINITE	ORGANIC: LIPTINITE LIPTODETRINITE	ORGANIC: LIPTINITE ALGAE BOTRYOCOCCUS	ORGANIC: LIPTINITE ALGAE TASMANITES	ORGANIC: LIPTINITE ALGAE OTHER ALGAE	ORGANIC: MICROPLANKTON	ORGANIC: EXSUDATINITE	ORGANIC: INERT. SCLEROTINITE	ORGANIC: INERT. FUSINITE	ORGANIC: INERT. MACRINITE	ORGANIC: INERT. MICRINITE	INORG.: UNDEFINED MINERALS	INORG.: FRAMBOIDAL PYRITE	INORG.: AGGREGATES OF PYRITE	INORG.: CRYSTALS OF PYRITE
1826.5	S.W.S.	+			/	/			/			-	/			/		+	*	/	-	/
1829.0	CTGS	/			-	/			/				-	-		/		/	*	/	-	-
1830.5	S.W.S.	+			/	/			+				/			/		+	*	/	-	/
2069.0	CTGS	/			-	-			/					-		/		/	*	/	-	-
2207.0	CTGS	-		-		-	-		-					-		-			*	-	-	/
2282.0	CTGS	-			+	/	/	-	/					-		-			*	/	-	/
2444.0	CTGS	-			/	/			+				/	/		-		-	*	/	-	/
2575.0	S.W.S.		/	/	+	-		/	/						*	/		-	-	-	-	/
2578.0	S.W.S.		-	-	+	/		-	/						*	/		-	-	-	-	/
2579.0	CTGS	-	/		+	/	-	/	/					/	+				*	/	-	/
2615.0	CTGS	-			/	/	-	-	/					/	/	-		-	*	/	-	-
2632.5	S.W.S.			*					-						-				/		-	/
2633.0	CTGS	/	+	+	*	+	/	-	/					-	*	/		+	+	-		-
2795.0	CTGS	-			-	-			+				/		-				*	/	-	/
3063.8	S.W.S.	+			+	+	-		+	-					+	+		+	*	-	-	/
3065.8	S.W.S.	/			+	/			+				-		+	/		/	*	-	/	/
3083.0	CTGS	-	*	*	/	/	-		-						/			+				/

LEGEND	
*	: ABUNDANT
+	: COMMON
/	. FEW
-	. RARE

TABLE II (part 1)

DEPTH IN M	SAMPLE TYPE
3100.4	S.W.S.
3228.0	S.W.S.
3230.0	CTGS

	ORGANIC																INORG.			
	VITR.		LIPTINITE				ALGAE					INERT.								
SAPROPELIC ORG. MATTER	TELOCOLLINITE	TELINITE	DESMOCOLLINITE	SPORINITE	CUTINITE	RESINITE	LIPTODETRINITE	BOTRYOCOCCUS	TASMANITES	OTHER ALGAE	MICROPLANKTON	EXSUDATINITE	SCLEROTINITE	FUSINITE	MACRINITE	MICRINITE	UNDEFINED MINERALS	FRAMBOIDAL PYRITE	AGGREGATES OF PYRITE	CRYSTALS OF PYRITE
/		+	/	/	/	/	+						-		/	*		-	/
-			/	/	/	-	/						+		/	*			/
-		+														*	/	-	/

L E G E N D	
*	: ABUNDANT
+	: COMMON
/	: FEW
-	: RARE

TABLE II (part 1a)

TABLE II(part 2)
COMMENT LINES FROM WELL/OUTCROP : 31/2-8

1826.5 M : S.O.M. PARTLY MICRINISED

1829.0 M : RARE SOLID HYDROCARBONS
INITIAL CONVERSION S.O.M.
SAMPLE SLIGHTLY OXIDISED

1830.5 M : S.O.M. PARTLY CONVERTED

2069.0 M : S.O.M. PARTLY CONVERTED
SAMPLE SLIGHTLY OXIDISED

2207.0 M : SAMPLE SLIGHTLY OXIDISED
RARE COAL PARTCILES ;
RARE UNKNOWN YELLOW FLUORESCENT MATTER(=CONTAMINATION ?)

2444.0 M : S.O.M. PARTLY CONVERTED

2578.0 M : VITRINITE SHOWS OXIDATION FEATURES

2579.0 M : SAMPLE PARTLY OXIDISED
VIT-1 GRADES INTO SEMI-FUSINITE GRADES INTO FUSINITE
VIT-1+MINERAL MATTER;VIT-1 PARTLY OXIDISED;SO NO VR POSSIBLE

2615.0 M : S.O.M. PARTLY CONVERTED
VITRINITE-2 GRADES INTO S.O.M. ASSOCIATED WITH FRAM PYRITE
SAMPLE PARTLY OXIDISED

2633.0 M : RARE MEGASPORES
VITRINITE-2 GRADES INTO S.O.M.
S.O.M. PARTLY CONVERTED

2795.0 M : PYRITE SHOWS OXIDATION FEATURES

3063.8 M : VITRINITE SHOWS OXIDATION FEATURES
S.O.M. PARTLY CONVERTED
RARE BOTRYOCOCCUS FRAGMENTS

3065.8 M : VITRINITE SHOWS OXIDATION FEATURES
S.O.M. PARTLY CONVERTED
VITRINITE-2 GRADES INTO S.O.M.

3083.0 M : SAMPLE OXIDISED
SAMPLE PARTLY
SEVERELY OXIDISED
TELINITE/TELOCOLLINITE CAN NOT BE DISTINGUISHED
WEAK FLUORESCENCE COAL PARTICLES; RARE CANNEL COALS

3100.4 M : SAMPLE SLIGHTLY OXIDISED
S.O.M. PARTLY CONVERTED

3228.0 M : S.O.M. PARTLY CONVERTED

3230.0 M :
DARK YELLOW/BROWN FLUORESCENT TELINITE

INITIAL DISTRIBUTION

5 copies area