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EVALUATION OF SOURCE ROCK PROPERTIES OF  
SEDIMENTS PENETRATED BY WELL  
NANGKERO-1, AUSTRALIA

by

TH.E. FELDER



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*may be placed on open file after 26 August 1980*

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B.M.R.*

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

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Investigation

95.14.74

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## I INTRODUCTION

An evaluation of source rock properties has been carried out on a suite of cutting samples from the Australian offshore well Nangkero - 1, Bass Basin (offshore Tasmania).

The location of the well is shown on a sketch map in figure 1.

The samples, deriving from depths between 5000 and 9390 ft, are mainly of Paleogene 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 macerals<sup>1</sup>, 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

A tabulation of the analytical results is given in table I. On the geochemical log (enclosure 1) the results are plotted versus depth.

### a) Source rock indications (SRI)

- Samples 5000 - 5850 ft did not give any positive response upon pyrolysis.
- Samples 5900 - 6380 ft show predominantly marginal SRI values (maximum 110 units in sample 6020 ft).
- From the samples 6440 - 9390 ft genuine SRI values (mainly >900 units) were obtained.

### b) Type of organic matter

The type of organic matter, determined through pyrolysis gas chromatography, ranges between "mainly humic" and "humic to mainly humic".

### c) Organic carbon content

The high organic carbon contents (up to 62.1 % in sample 7600 ft) reflect the presence of coals and coaly shales.

### d) Maceral descriptions

Sample 6020 ft: SOM (sapropelic organic matter) common;  
rare detrital vitrinite;  
rare sporinite and liptodetrinite;  
rare exsudatinite;  
micrinite common.  
SOM partly converted.

Sample 6440 ft: Few SOM;  
abundant vitrinite;  
few sporinite and resinite;  
rare cutinite;  
liptodetrinite common;  
rare exsudatinite;  
rare sclerotinite;  
micrinite common.  
Vitrinite grades into SOM.  
SOM partly converted.

- Sample 7370 ft: Few SOM;  
abundant vitrinite;  
sporinite common;  
resinite and liptodetrinite common;  
rare cutinite;  
rare exsudatinite;  
few sclerotinite and fusinite;  
micrinite common.
- Sample 7800 ft: Few SOM;  
abundant vitrinite;  
rare sporinite, cutinite and resinite;  
few liptodetrinite;  
rare exsudatinite;  
few sclerotinite and fusinite;  
micrinite common.  
SOM partly converted.
- Sample 8900 ft: Few SOM;  
vitrinite common;  
rare sporinite, cutinite and resinite;  
few liptodetrinite;  
rare exsudatinite;  
rare fusinite;  
micrinite common.  
Vitrinite grades into SOM.  
SOM partly converted.
- Sample 9160 ft: SOM common;  
Vitrinite common;  
few sporinite;  
rare cutinite;  
liptodetrinite common;  
rare exsudatinite;  
rare fusinite;  
micrinite common.  
Vitrinite grades into SOM.  
SOM partly converted.

e) Vitrinite reflectance measurements

The vitrinite of all the samples is severely to completely oxidised. This means that the values tabulated below and displayed versus depth in figure 2 are not fully reliable.

Sample 6440 ft	VR = 0.54 ± 0.02
Sample 7370 ft	0.55 ± 0.03
Sample 7800 ft	0.70 ± 0.09
Sample 8900 ft	0.58 ± 0.02
Sample 9160 ft	0.72 ± 0.07

Sample 6020 ft does not contain any suitable vitrinite.

### III DISCUSSION AND CONCLUSIONS

Two source rock intervals could be differentiated:

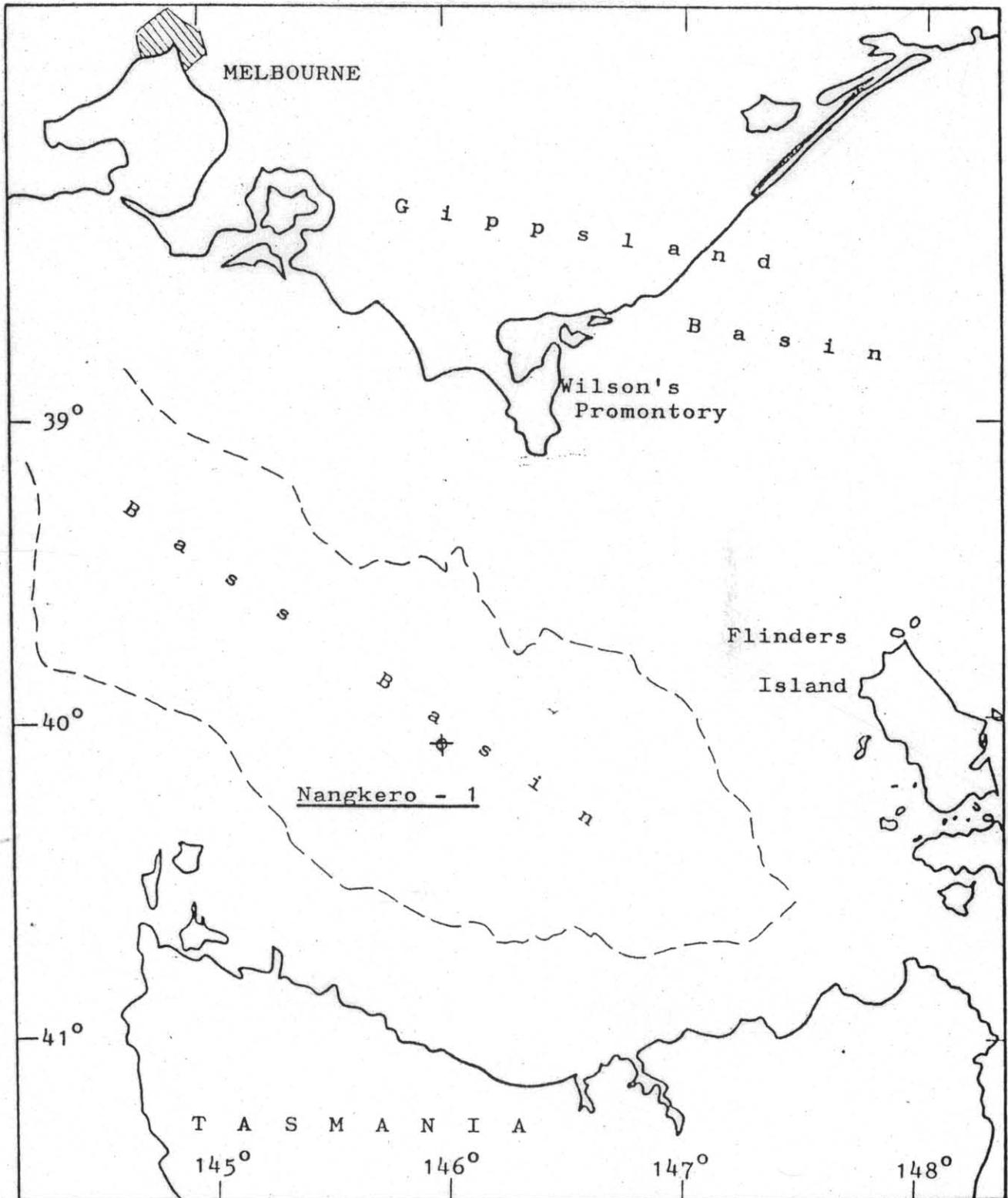
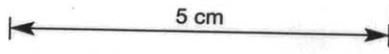
The interval 5900 to approximately 6380 ft (Demons Bluff Formation and top Eastern View Coal Measures) are characterized by mainly marginal SRI values. The maceral composition (mainly SOM) favours the generation of oil. However, considering the texture of the organic matter, it might be concluded that some gas will be generated as well. Therefore, the interval 5900 to approximately 6380 ft can be classified as containing marginal source rocks for oil and gas.

The interval 6440 - 9390 ft (Eastern View Coal Measures) shows large SRI values, often more than 900 units even, and high organic carbon contents (up to approx. 62 % in sample 7600 ft). The organic matter, typed chemically as predominantly "mainly humic", consists of vitrinite and minor amounts of SOM and liptinites.

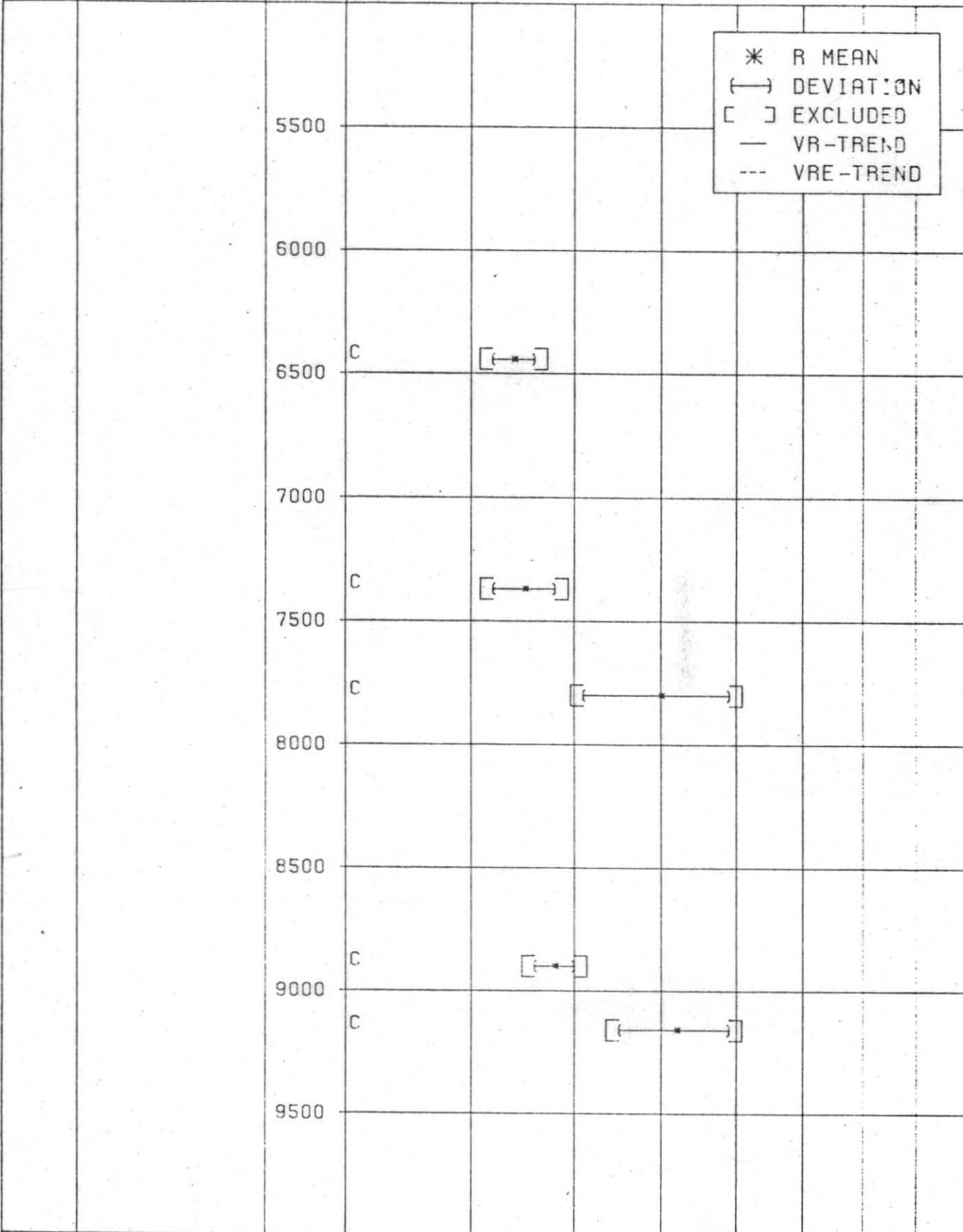
These rocks are gas source rocks on the first place. In some sections the amount and the habitat of the SOM is favourable for some oil generation as well. Such conditions have been encountered in sample 9160 ft as well as in the samples 6440 and 8900 ft.

Thus, the interval 6440 - 9390 ft might be defined as containing good source rocks for gas and some oil.

The liptinite spectrum and the presence of some expulsion products, combined with the vitrinite reflectance measurements (which, however, are not very accurate due to oxidation), allow the conclusion that the source rocks are immature to just mature for oil generation.



AGE	FORMATION	DEPTH FEET BDF.	WELL : NANGKERO-1	373011
			COUNTRY : AUSTRALIA	



VR. (E) : 0.4      0.5      0.6      0.7      0.8      0.9      1.0      1.1

VITRINITE REFLECTANCE (OR EQUIVALENT) AS A FUNCTION OF DEPTH

FIG. 2

5 cm

TABLE I (PART 1)

WELL:

WANGKERO-1

DEPTH	TYPE OF SAMPLE	SOURCE ROCK INDICATION	SOURCE ROCK INDICATION	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT
F		BEFORE EXTR.	AFTER EXTR.		%W
5000	C	5	-		-
5060	C	5	-		-
5120	C	5	-		-
5180	C	5	-		-
5240	C	5	-		-
5300	C	5	-		-
5360	C	5	-		-
5420	C	5	-		-
5480	C	5	-		-
5540	C	5	-		-
5600	C	5	-		-
5660	C	10	-		-
5720	C	10	-		-
5800	C	15	-		-
5850	C	15	-		-
5900	C	85	50		-
5960	C	110	80		-
6020	C	150	110	H/MH	5.5
6080	C	135	100		-
6140	C	75	55		-
6200	C	100	55		-
6260	C	80	55		-
6320	C	85	65		-
6380	C	60	45		-
6440	C	> 900	> 900	MH	-
6500	C	135	135		4.2
6560	C	525	450		-
6620	C	555	445		-
6680	C	> 900	> 900		-
6740	C	630	550		-

TABLE I (PART 2)

WELL:

NANGKERO-1

DEPTH	TYPE OF SAMPLE	SOURCE ROCK	SOURCE ROCK	TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT
		INDICATION	INDICATION		
F		BEFORE EXTR.	AFTER EXTR.		%W
6800	C	> 900	775		-
6860	C	525	490		-
6920	C	> 900	> 900		-
6980	C	510	435		-
7040	C	> 900	> 900		-
7100	C	> 900	> 900		-
7150	C	> 900	> 900		-
7240	C	> 900	> 900		-
7300	C	265	260		-
7370	C	> 900	> 900	MH	-
7420	C	> 900	> 900		-
7460	C	> 900	> 900		-
7500	C	> 900	> 900		-
7600	C	> 900	> 900		52.1
7600	C	> 900	> 900		51.0
7650	C	> 900	> 900		-
7700	C	> 900	> 900		-
7750	C	495	490		-
7800	C	> 900	> 900	MH	-
7850	C	> 900	> 900		-
7900	C	> 900	> 900		-
8010	C	> 900	> 900		-
8100	C	> 900	> 900		-
8150	C	> 900	> 900		-
8200	C	670	670		-
8270	C	> 900	> 900		-
8360	C	> 900	> 900		-
8480	C	> 900	> 900		27.0
8550	C	> 900	> 900		-
8600	C	275	265		4.4

TABLE I (PART 3)

WELL:

NANGKERO-1

DEPTH	TYPE OF SAMPLE	SOURCE ROCK INDICATION		TYPE OF ORGANIC MATTER	ORGANIC CARBON CONTENT %W
		BEFORE EXTR.	AFTER EXTR.		
8680	C	560	460	H/H	-
8760	C	> 900	> 900		-
8800	C	> 900	> 900		-
8850	C	380	375		-
8900	C	900	725		-
8950	C	> 900	> 900		-
9000	C	> 900	> 900		-
9050	C	> 900	> 900		-
9090	C	290	290		-
9160	C	> 900	> 900	H/MH	26.1
9230	C	> 900	> 900		-
9350	C	> 900	> 900		-
9390	C	140	115		-

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

