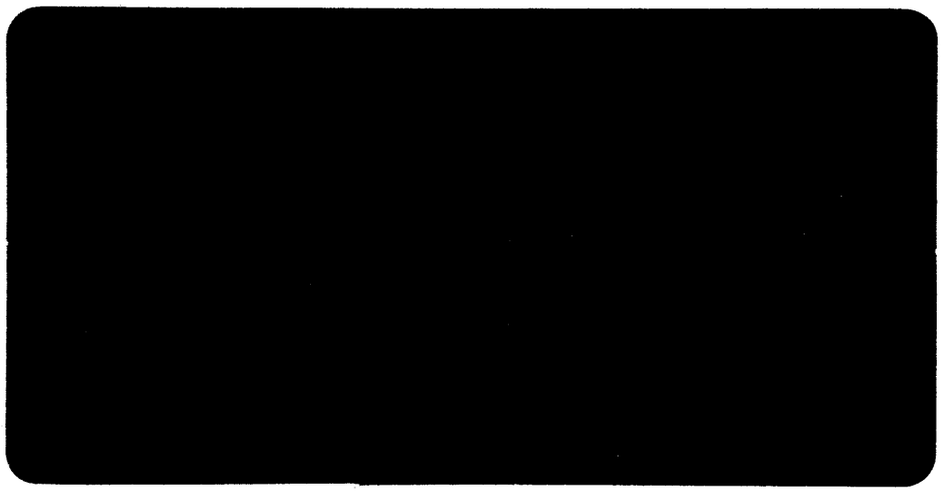
SOURCE ROCK ANALYSIS.
GIPPSLAND BASIN.

SPEKE-1
AMDEL



ATTACHMENT 8

WCR SPEKE-1

(W870)

SOURCE ROCK ANALYSIS
BOX

1 of 23
23 pages.

ATTACHMENT No. 8

W870

SPEKE-1.

SOURCE ROCK EVALUATION

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31 August 1984

F3/422/0
F6021/85

Australian Aquitaine Petroleum Ltd.,
99 Mount Street,
NORTH SYNDEY NSW 2060

Attention: Mr Claude Lambert

REPORT F6021/85

CLIENT REFERENCE:	Transmittal-015091 dated 3 August 1984
TITLE:	Source rock evaluation, Speke-1, VIC P-17, Gippsland Basin.
MATERIAL:	Sidewall core
LOCALITY:	SPEKE-1
SAMPLE IDENTIFICATION:	CST #30, 27, 22, 20, 19, 11, 5 and 2
DATE RECEIVED:	6 August 1984
WORK REQUIRED:	TOC and Rock-Eval pyrolysis. Vitrinite reflectance and DOM descriptions, Interpretation.

Investigation and Report by: Brian L. Watson, Teresa O'Leary and Dr David M. McKirdy

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1. INTRODUCTION

This report formally presents total organic carbon and Rock-Eval pyrolysis data on eight sidewall cores from 1814-2740 metres depth in Speke-1. Also included are the results of the following analytical work:

1. Description of dispersed organic matter
2. Vitrinite reflectance analysis

The above information is used to assess the hydrocarbon generating potential (maturity, organic richness, kerogen type) of the interval sampled.

2. ANALYTICAL PROCEDURE

2.1 Sample Preparation

Sidewall core samples (as received) were ground in a Siebtechnik mill for 20-30 secs.

2.2 Total Organic Carbon (TOC)

Total organic carbon was determined by digestion of a known weight ($\sim$0.2 g) of powdered rock in 50% HCl to remove carbonates, followed by combustion in oxygen in the induction furnace of a Leco IR-12 Carbon Determinator and measurement of the resultant CO_2 by infra-red detection.

2.3 Rock-Eval Analysis

A 100 mg portion of powdered rock was analysed by the Rock-Eval pyrolysis technique (Girdel IFP-Fina Mark 2 instrument; operating mode, Cycle 1).

2.4 Organic Petrology

Representative portions of each sidewall core (crushed to -14+35 BSS mesh) were obtained with a sample splitter and then mounted in cold setting Astic resin using a 2.5 cm diameter mould. Each block was ground flat using diamond impregnated laps and carborundum paper. The surface was then polished with aluminium oxide and finally magnesium oxide.

Reflectance measurements on vitrinite phytoclasts, were made with a Leitz MPV1.1 microphotometer fitted to a Leitz Ortholux microscope and calibrated against synthetic standards. All measurements were taken using oil immersion (n = 1.518) and incident monochromatic light (wavelength 546 nm) at a temperature at 24±1°C. Fluorescence observations were made on the same microscope utilising a 3 mm BG3 excitation filter, a TK400 dichroic mirror and a K510 suppression filter.

3. RESULTS

TOC and Rock-Eval data on the eight sidewall cores nominated for source rock analysis are listed in Table 1. Figure 1 is a cross plot of hydrogen index versus Tmax which demonstrates kerogen type and maturity for the interval studied. Vitrinite reflectance (VR) data are given in Table 2. Dispersed organic matter (DOM) descriptions are summarised in Tables 3-5. Appendix 2 contains plates showing key features of the organic matter present. Figure 2 is a depth-reflectance profile for Speke-1 (above 2740 m depth). Histograms of the reflectance measurements may be found in Appendix 1.

4. DISCUSSION

4.1 Maturity

Tmax values are in the range 420-437°C over the 1814-2740 metres depth interval (Table 1). These values are in good agreement with the measured vitrinite reflectance (VR = 0.45-0.63%) and indicate the rocks are immature to marginally mature (Fig. 1).

Although primarily maturation dependent, the Rock-Eval production index is also sensitive to the presence of migrated hydrocarbons. The low production indices ($S_1/S_1 + S_2 < 0.2$) of the samples between 1814-2740 metres depth suggests that there are no migrated hydrocarbons in this interval.

4.2 Source Richness

Organic richness ranges from poor to excellent (TOC = 0.14-71.4%) in the Speke-1 well section. Source richness for hydrocarbons is also variable. Three samples have excellent source richness, indicated by potantial hydrocarbon yields ($S_1 + S_2$) of 9.6-76 kg hydrocarbons/tonne (Table 1). The excellent organic richness and source richness of the sample from 2260.5 metres depth is attributable to the presence of coal.

4.3 Source Quality and Kerogen Type

Hydrogen indices fall in the range HI = 38-373 (Table 1, Fig. 1) which suggests that most of these samples contain organic matter of terrigenous Type II-III composition (Fig. 1). The low hydrogen index of the siltstone from 1814 metres suggests that it contains inertinitic Type IV organic matter. However, the dispersed organic matter in this siltstone comprises mainly vitrinite. This discrepancy between the Rock-Eval and organic petrological data may reflect inhomogeneity in the sample.

The moderate hydrogen indices (HI >130) correspond to gas/condensate-prone vitrinite-rich DOM and coals. The highest proportion of exinite (viz. 20% of DOM) was observed in the sample from 2624 m depth (Table 3). However, the organic richness of this rock is too low for it to be an effective source rock. The major exinites are sporinite, bituminite, cutinite and exinite (Tables 4, 5).

5. CONCLUSIONS

Sediments from 1814-2740 metres depth in Speke-1 lie above the top of the oil-generation window for resinite-poor woody-herbaceous organic matter (VR <0.7%).

Although lacking adequate thermal maturity at the Speke-1 well locality, the best potential oil-source bed identified is that from 2552.9 metres depth (TOC = 4.45%; $S_1 + S_2$ = 18 kg hydrocarbons/tonne; HI = 373). Otherwise, the samples analysed contain immature gas/condensate-prone terrigenous organic matter.

TABLE 1

ROCK-EVAL PYROLYSIS 14/08/84

Client AUSTRALIAN AQUITAINE PETROLEUM

Well SPEKE #1

DEPTH	T MAX	S1	S2	S3	S1+S2	PI	S2/S3	PC	TOC	HI	OI
1814.00	432	0.01	0.47	1.58	0.48	0.02	0.29	0.04	1.22	38	129
1853.00	420	0.32	2.24	0.33	2.56	0.12	6.78	0.21	1.62	138	20
2073.50									0.21		
2260.50	433	5.15	70.60	3.93	75.75	0.07	17.96	6.31	71.40	98	5
2459.00									0.14		
2552.90	428	1.38	16.60	0.41	17.98	0.08	40.48	1.49	4.45	373	9
2624.00	437	0.11	1.46	0.05	1.57	0.07	29.20	0.13	0.48	302	10
2740.00	430	0.95	8.67	1.03	9.62	0.10	8.41	0.30	4.15	208	24

KEY TO ROCK-EVAL PYROLYSIS DATA SHEET

PARAMETER		SPECIFICITY
T max	position of S_2 peak in temperature program (^{o}C)	Maturity/Kerogen type
S_1	kg hydrocarbons (extractable)/tonne rock	Kerogen type/Maturity/Migrated oil
S_2	kg hydrocarbons (kerogen pyrolysate)/tonne rock	Kerogen type/Maturity
S_3	kg CO_2 (organic)/tonne rock	Kerogen type/Maturity *
$S_1 + S_2$	Potential Yield	Organic richness/Kerogen type
PI	Production Index ($S_1/S_1 + S_2$)	Maturity/Migrated Oil
PC	Pyrolysable Carbon (wt. percent)	Organic richness/Kerogen type/Maturity
TOC	Total Organic Carbon (wt. percent)	Organic richness
HI	Hydrogen Index (mg h'c (S_2)/g TOC)	Kerogen type/Maturity
OI	Oxygen Index (mg CO_2(S_3)/g TOC)	Kerogen type/Maturity *

*Also subject to interference by CO_2 from decomposition of carbonate minerals.

TABLE 2: SUMMARY OF VITRINITE REFLECTANCE MEASUREMENTS, SPEKE-1

Depth (m)	Mean Maximum Reflectance (%)	Standard Deviation	Range	Number of Determinations
1814	0.45	0.05	0.38-0.54	16
1853	0.45	0.07	0.31-0.64	33
2073.5	0.49	0.02	0.44-0.52	12
2260.5	0.51	0.00	0.50-0.52	2
2459	0.47	0.04	0.40-0.52	22
2552.9	0.50	0.05	0.41-0.60	31
2624	0.58	0.05	0.46-0.67	26
2740	0.63	0.06	0.51-0.73	33

TABLE 3: PERCENTAGE OF VITRINITE, INERTINITE AND EXINITE IN DISPERSED ORGANIC MATTER, SPEKE-1

Depth (m)	Percentage of		
	Vitrinite	Inertinite	Exinite
1814	85	10	<5
1853	90	<5	5
2073.5	45	50	<5
2260.5	<<5	90	5
2459	75	10	15
2552.9	75	10	15
2624	25	55	20
2740	75	20	5

TABLE 4: ORGANIC MATTER TYPE AND ABUNDANCE, SPEKE-1

Depth (m)	Relative Maceral Group Proportions	Estimated Volume of DOM	Estimated Volume of Exinites	Exinite Macerals
1814	V >> I > E	<0.5	VR-TR	spo, res
1853	V >> E > I	1-2	Ra	spo, res, lipto
2073.5	I > V >> E	∿0.5	Vr	bmite, lipto
2260.5	I >> E > V	>60	Sp	res, spo, lipto, cut
2459	V > E > I	∿0.5	Ra-Vr	bmite, lama, lipto, thuc, phyto
2552.9	V > E > I	∿2	Sp	spo, cut, res, bmite, phyto, lama
2624	I > V > E	0.5-1	Ra	spo, bmite, cut, lipto res, phyto, lama, bmen, thuc
2740	V > I > E	3-5	Ra	cut, bmite, spo, res, ?oil, lama

TABLE 5: EXINITE MACERAL ABUNDANCE AND FLUORESCENCE CHARACTERISTICS, SPEKE-1

Depth (m)	Exinite Macerals	Lithology/Comments
1814	spo(Vr-Tr;iY),res(Tr;iY)	sandy siltstone
1853	spo(Ra;mY-m0),res(Vr;iY-m0),lipto(Ra-Vr;m0)	silty, very fine-grained sandstone
2073.5	bmite(Vr;d0),lipto(Tr;m0)	sandy siltstone
2260.5	res(Sp;d0-no fluorescence),spo(Ra; mY-m0)	coal (chiefly inertite, ∿10% durite); some resinite is extensively micrinitised.
2459	bmite(Ra-Vr;d0),lama(Vr;m0),lipto(Vr; m0),thuc(Vr;m0-d0),phyto(Vr-Tr;iY-i0)	siltstone
2552.9	spo(Ra-Sp;mY-m0),cut(Ra;m0),res(Ra-Vr; iYG-iY),bmite(Ra-Vr;d0),phyto(Vr;iY), lama (Tr;m0).	shale
2625	spo(Ra;m0),bmite(Ra;d0),cut(Ra-Vr;m0), lipto(Ra-Vr;m0),res(Vr;iY-mY),phyto (Tr;iY-m0),lama(Tr;m0),Bmen(Tr;d0), Thuc(Tr;d0)	siltstone
2740	cut(Ra;m0),bmite(Ra;d0),spo(Ra-Vr;m0), res(Tr;iY),oil(Tr;iYG-iY),lama(Tr;m0).	siltstone

KEY TO DISPERSED ORGANIC MATTER DESCRIPTIONS

MACERAL GROUPS

V	Vitrinite
I	Inertinite
E	Exinite

EXINITE MACERALS

spo	Sporinite
cut	Cutinite
res	Resinite
sub	Suberinite
lipto	Liptodetrinite
fluor	Fluorinite
exs	Exsudatinite
phyto	Phytoplankton
tela	Telalginite
lama	Lamalginite
bmite	Bituminite
bmen	Bitumen
thuc	Thucholite

ABUNDANCE (by vol.)

Ma	Major	>15%
Ab	Abundant	2-15%
Co	Common	1-2%
Sp	Sparse	0.5-1%
Ra	Rare	0.1-0.5%
Vr	Very Rare	∿0.1%
Tr	Trace	<0.1%

FLUORESCENCE COLOUR AND INTENSITY

G	Green	i	Intense
Y	Yellow	m	Moderate
O	Orange	d	Dull
B	Brown		

FIGURE 1

CLIENT : AUSTRALIAN AQUITAINE PETROLEUM

WELL NAME : SPEKE #1

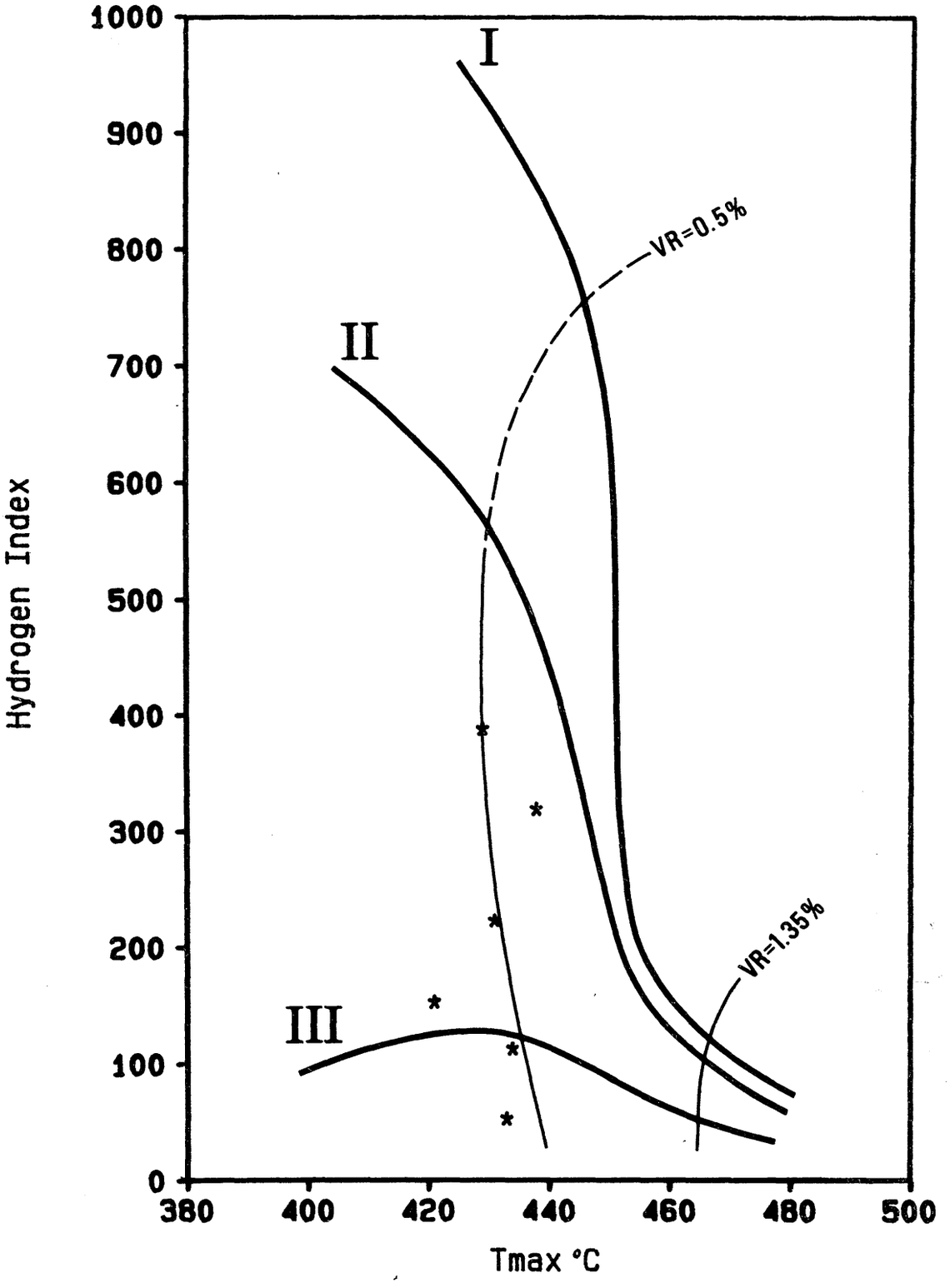
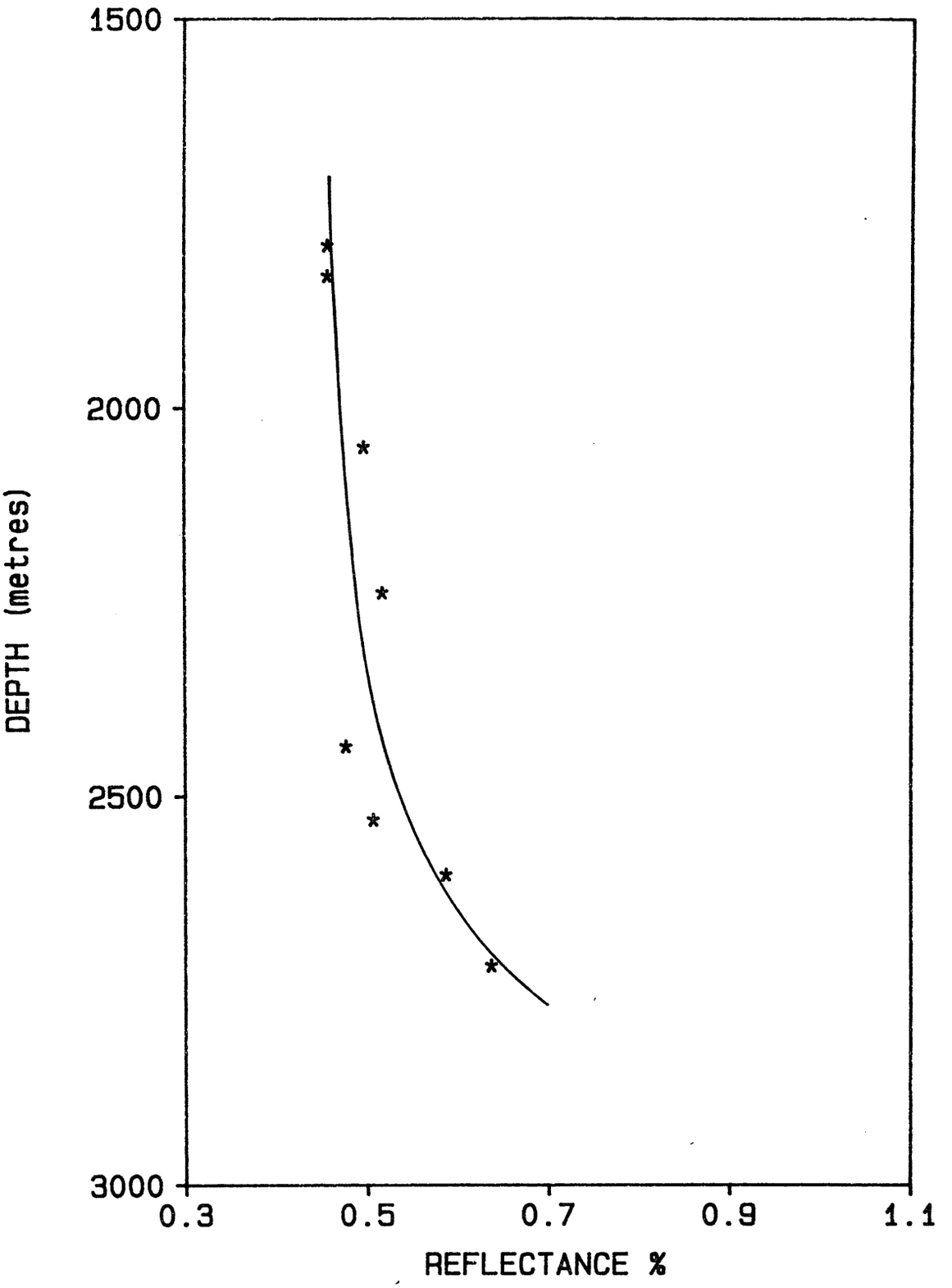


FIGURE 2

VITRINITE REFLECTANCE vs DEPTH PROFILE, SPEKE #1



APPENDIX 1

HISTOGRAMS OF VITRINITE REFLECTANCE

SPEKE-1

1814 M

SORTED LIST

.38 .38 .4 .41 .41 .41 .42 .44 .44 .47
.47 .48 .49 .49 .5 .54
Number of values= 16

MEAN OF VALUES .446
STD DEVIATION .046

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100

38 - 40 | ▒▒▒
41 - 43 | ▒▒▒▒
44 - 46 | ▒▒
47 - 49 | ▒▒▒▒▒
50 - 52 | ▒
53 - 55 | ▒

SPEKE—1

1853 M

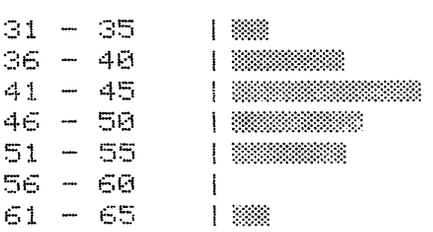
SORTED LIST

.31	.34	.38	.39	.39	.39	.4	.4	.41	.41
.41	.41	.42	.43	.43	.43	.44	.45	.46	.46
.46	.46	.46	.48	.49	.51	.51	.51	.52	.52
.55	.63	.64							

Number of values= 63

MEAN OF VALUES .452
STD DEVIATION .07

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100



SPEKE—1

2073.5 M

SORTED LIST

.44 .46 .47 .47 .48 .48 .49 .5 .5 .51
.51 .52

Number of values= 12

MEAN OF VALUES .486
STD DEVIATION .023

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100

```
44 - 46    | ▒▒
47 - 49    | ▒▒▒▒▒
50 - 52    | ▒▒▒▒▒
```

SPEKE—1

2260.5 M

SORTED LIST
.5 .51
Number of values= 2

MEAN OF VALUES .505
STD DEVIATION 5E-03

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100

50 - 52 |▒▒

SPEKE—1

2459 M

SORTED LIST

.4 .41 .43 .43 .43 .44 .44 .44 .45 .46
.47 .47 .47 .47 .47 .49 .51 .51 .51 .52
.52 .52

Number of values= 22

MEAN OF VALUES .466
STD DEVIATION .036

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100

40 - 42 | ▒▒
43 - 45 | ▒▒▒▒▒▒▒▒
46 - 48 | ▒▒▒▒▒▒
49 - 51 | ▒▒▒▒
52 - 54 | ▒▒▒

SPEKE—1

2552.9 M

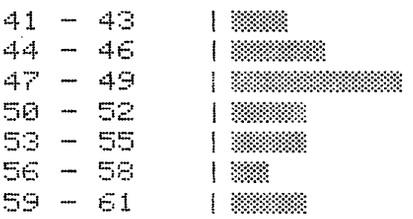
SORTED LIST

.41	.41	.43	.45	.45	.45	.46	.46	.47	.47
.47	.48	.48	.49	.49	.49	.49	.5	.51	.51
.52	.53	.53	.55	.55	.57	.58	.59	.59	.6
.6									

Number of values= 31

MEAN OF VALUES .503
STD DEVIATION .054

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100



SPEKE—1

2625 M

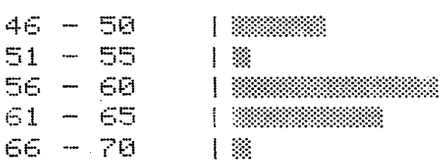
SORTED LIST

.46 .48 .49 .49 .5 .53 .56 .57 .57 .58
.58 .58 .59 .6 .6 .6 .6 .61 .61 .61
.62 .63 .63 .63 .63 .67

Number of values= 26

MEAN OF VALUES .578
STD DEVIATION .053

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100



SPEKE-1

2740 M

SORTED LIST

.51	.53	.53	.54	.55	.56	.57	.6	.6	.61
.61	.61	.61	.62	.62	.62	.63	.65	.65	.65
.65	.65	.66	.66	.66	.67	.68	.68	.69	.7
.7	.7	.73							

Number of values= 33

MEAN OF VALUES .627
STD DEVIATION .055

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100

```
51 - 55    | ▒▒▒▒▒▒
56 - 60    | ▒▒▒▒▒
61 - 65    | ▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒
66 - 70    | ▒▒▒▒▒▒▒▒▒▒▒▒
71 - 75    | ▒
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APPENDIX 2

PLATES

PLATE 1: SPEKE-1, 2260.5 m Reflected Light

This coal consists chiefly of inertinite (grey to white) and it also contains sporinite, resinite and liptodetrinite (all brown).

Field Dimensions 0.43 mm x 0.29 mm

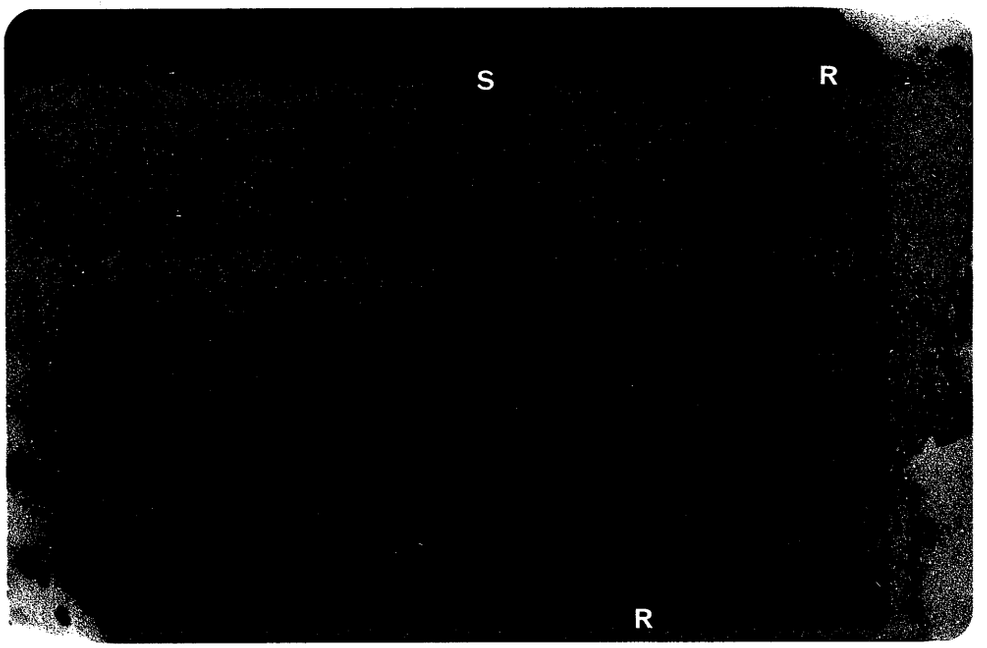

PLATE 2: SPEKE-1, 2260.5 m Fluorescence Mode

The sporinite(S) in this coal has a much more intense fluorescence than the resinite (R). This is due to the fact that at this level of maturity, the resinite has started to generate hydrocarbons whereas the sporinite is not within its main generation range.