SOUTH AUSTRALIA

DEPARTMENT OF MINES AND ENERGY

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PEL 8

OTWAY BASIN

LAKE HAWDON 1

TEST REPORTS

Submitted by

Hartogen Energy Ltd

1989

ENVELOPE 7191/2

TENEMENT: PEL 8; Otway Basin

TENEMENT HOLDER: Hartogen Energy Ltd (Operator), Beach Petroleum NL, Western Mining Corporation Ltd, Poseidon Oil Pty Ltd, Alliance Oil Development Australia NL and Alliance Minerals Australia NL

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24 April 1989

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REPORT F 7474 (Part 1)

CLIENT REF:	ON 5010475
TITLE:	Source Rock-Evaluation, Lake Hawdon -1 Otway Basin, South Australia
IDENTIFICATION:	4280 - 6662 ~~metres~~ feet depth Interval
MATERIAL:	Sidewall Cores
LOCALITY:	Lake Hawdon -1
WORK REQUIRED:	TOC, Rock-Eval, Vitrinite Reflectance Determinations, Maceral Descriptions and Interpretation
DATE RECEIVED:	5 January 1989

Investigation and Report by: Brian L Watson

Manager, Petroleum Services Section: Dr Brian G. Steveson

Brian G Steveson.

for Dr William G. Spencer
General Manager
Applied Sciences Group

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1. INTRODUCTION

Four sidewall core samples from Lake Hawdon -1 were received for TOC, Rock-Eval pyrolysis, Vitrinite Reflectance and Maceral Descriptions. This report is a formal presentation of data reported by facsimile on 25th January and 8th March 1989 and includes graphical presentations and an interpretation of the data.

2. ANALYTICAL PROCEDURE

2.1 Sample Preparation

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

2.2 Total Organic Carbon (TOC)

Total organic carbon was determined by digestion of a known weight (approximately 0.2 g) of powdered rock in 50% HCl to remove carbonates, followed by combustion in oxygen and measurement of the resultant CO_2 by infra-red detection.

2.3 Rock-Eval Analyses

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 sample (crushed to -14+35 BSS mesh) were obtained with a sample splitter and then mounted in cold setting Glasscraft 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 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 of 23 ± 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 are presented in Table 1. Figure 1 is a cross plot of Hydrogen Index versus Tmax illustrating kerogen Type and maturity. Vitrinite Reflectance data is summarised in Table 2. Figure 2 is a plot of Vitrinite Reflectance versus depth. Histogram plots of this data are included in Appendix 1. Descriptions of dispersed organic matter in these samples are included in Tables 3-5 and illustrated by a series of plates in Appendix 2.

4. INTERPRETATION

4.1 Maturity

Rock-Eval Tmax values (Table 1) lie within the range 433 - 439 °C over the 4280 - 6662 ~~metre~~ depth interval studied and indicate maturities which are in good agreement with the measured Vitrinite Reflectance data (Table 2; VR = 0.39 - 0.60%).

This maturity data indicates that sediments intersected in the Lake Hawdon -1 location are sufficiently mature for the generation of light oil from bituminite and resinite rich dispersed organic matter below approximately 5400 ~~metres~~ depth (VR threshold = 0.45%; Table 2, Figure 2).

Significant gas generation from woody herbaceous organic matter commences at VR = 0.6%. On this basis, sediments below approximately 6800 ~~metres~~ depth should be sufficiently mature to generate significant quantities of gas.

Oil generation from sediments rich in exinites other than resinite and bituminite occurs at maturities corresponding to Vitrinite Reflectance values greater than 0.7%. Extrapolation of the available data indicates that sediments below approximately 7250 ~~metres~~ depth are sufficiently mature for the generation of oil from exinites other than resinite and bituminite.

4.2 Source Richness

Organic richness is fair in the samples examined (TOC = 1.05 - 1.85%). However, source richness for the generation of hydrocarbons is uniformly poor ($S_1 + S_2 <$ 2 Kg hydrocarbons/tonne).

4.3 Kerogen Type and Source Quality

Rock-Eval Hydrogen Index and Tmax data (Table 1, Figure 1) indicate that the sediments examined contain organic matter with the bulk composition of Type III kerogen. Organic petrology data Tables 3-5 is consistent with the Rock-Eval data but shows that the organic matter in these samples consists largely of inertinite with minor proportions of vitrinite and exinite (<5 - 10%).

Lamalginite and liptodetrinite are the major exinites present in these samples (Tables 4 and 5) whilst sporinite and *Botryococcus* - related telalginite are present in minor amounts. These exinites suggest that these sediments most likely accumulated in a lacustrine environment of deposition.

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TABLE 1

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Rock-Eval Pyrolysis

07/03/89

Client: HARTOGEN ENERGY LIMITED

Well: LAKE HAWDON-1

Depth (ft)	T Max	S1	S2	S3	S1+S2	PI	S2/S3	PC	TOC	HI	OI
LAKE HAWDON-1											
4280	439	0.08	1.17	0.49	1.25	0.06	2.38	0.10	1.16	100	42
5398	433	0.05	1.10	0.29	1.15	0.04	3.79	0.09	1.05	104	27
6528	439	0.16	1.64	3.55	1.80	0.09	0.46	0.15	1.53	107	232
6662	438	0.07	1.65	5.64	1.72	0.04	0.29	0.14	1.83	90	308

KEY TO ROCK-EVAL PYROLYSIS DATA SHEET

	PARAMETER	SPECIFICITY
T max	position of S_2 peak in temperature program ($^{\circ}C$)	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.

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F7474 - TABLE 2 - SUMMARY OF VITRINITE REFLECTANCE MEASUREMENTS,

LAKE HAWDON -1

Depth (m) ~~ft~~	Mean Maximum Reflectance	Standard Deviation	Range	Number of Determinations
4280	0.39	0.05	0.33 - 0.53	31
5388	0.45	0.04	0.38 - 0.51	7
6528	0.60	0.06	0.51 - 0.71	24
6662	0.57	0.11	0.39 - 0.77	17

F7474 - TABLE 3 - PERCENTAGE OF VITRINITE, INERTINITE AND EXINITE IN DISPERSED ORGANIC MATTER, LAKE HAWDON -1

Depth ~~(m)~~ ft	Percentage of Vitrinite	Inertinite	Exinite
4280	10	85	<5
5388	<5	90	5
6528	5	90	<5
6662	<5	90	<5

F7474 - TABLE 4 - ORGANIC MATTER TYPE AND ABUNDANCE,

LAKE HAWDON -1

Depth ~~(m)~~ ft	Relative Maceral Group Proportions	Estimated Volume of DOM	Exinites	Exinite Macerals
4280	I>>V<E	1-2	Ra	lama, lipto, spo, tela
5388	I>>E>V	~1	Ra	lipto, lama, phyto, bmite
6528	I>>V>E	1-2	Ra-Vr	lama, lipto, spo, phyto
6662	I>>V>E	~2	Ra-Vr	lama, lipto, spo

F7474 - TABLE 5 - EXINITE MACERAL ABUNDANCE AND FLUORESCENCE CHARACTERISTICS, LAKE HAWDON -1

Depth (m) ft	Exinite Macerals	Lithology/Comments
4280	lama (Ra;mY-m0), lipto (Vr;m0), spo (tr;m0), tela (Tr;i0)	Shale; telalginite is *Botryococcus* related
5388	lipto (Ra;m0), lama (Ra;m0), ?phyto (Tr; m0), bmite (Tr;d0)	Shale
6528	lama (ra-Vr;m0), lipto (Vr;m0), spo (Tr;m0), ?phyto (Tr;m0)	Shale
6662	lama (Ra-Vr;m0-d0), lipto (Vr;m0), spo (Tr;m0)	Shale; exinite is slightly oxidised

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
terp	Terpenite
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
Y	Yellow
O	Orange
B	Brown

i	Intense
m	Moderate
d	Dull
nofl	No Visible Fluorescence

LAKE HAWDON-1

HARTOGEN LTD

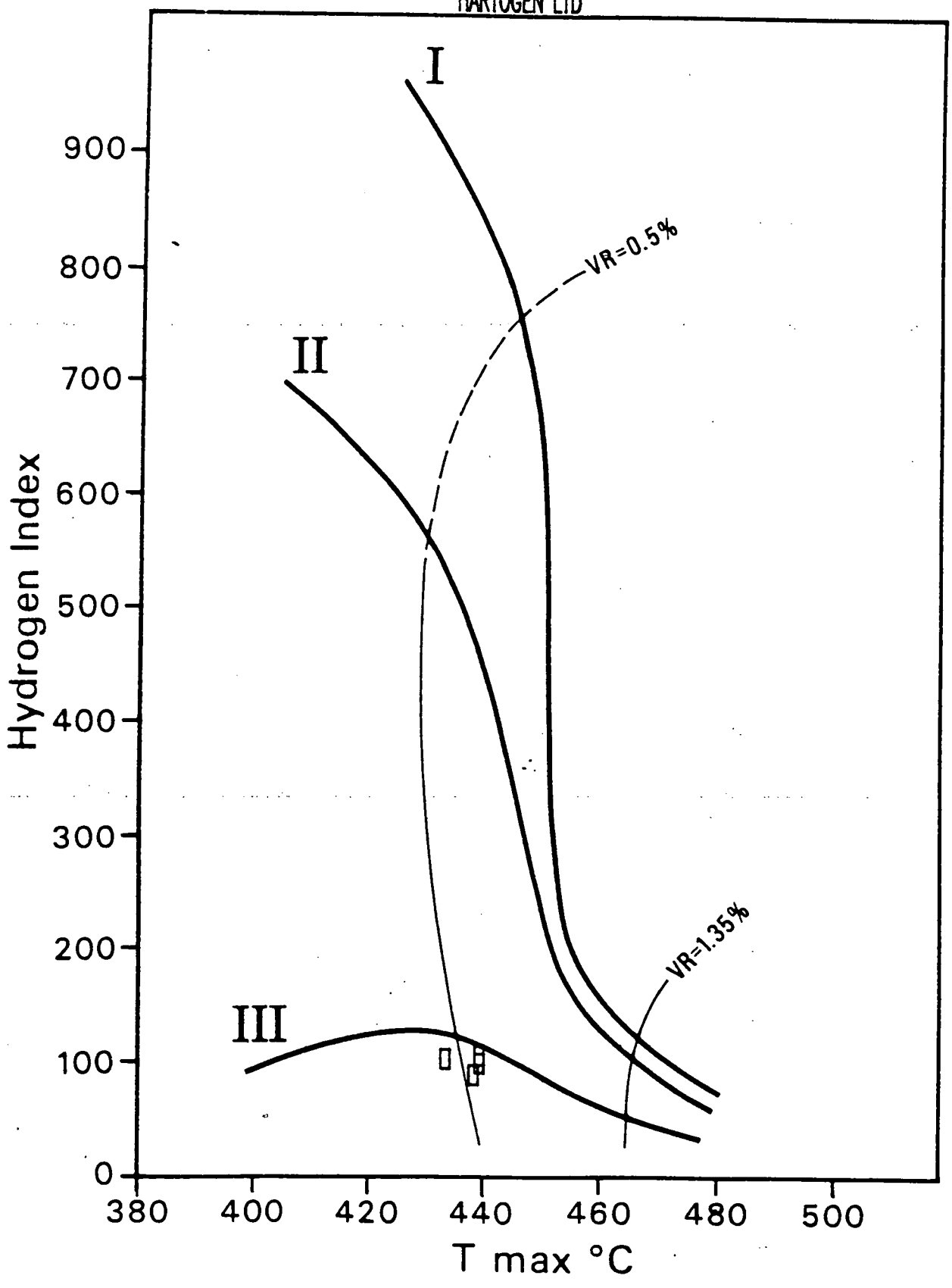

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FIGURE 2

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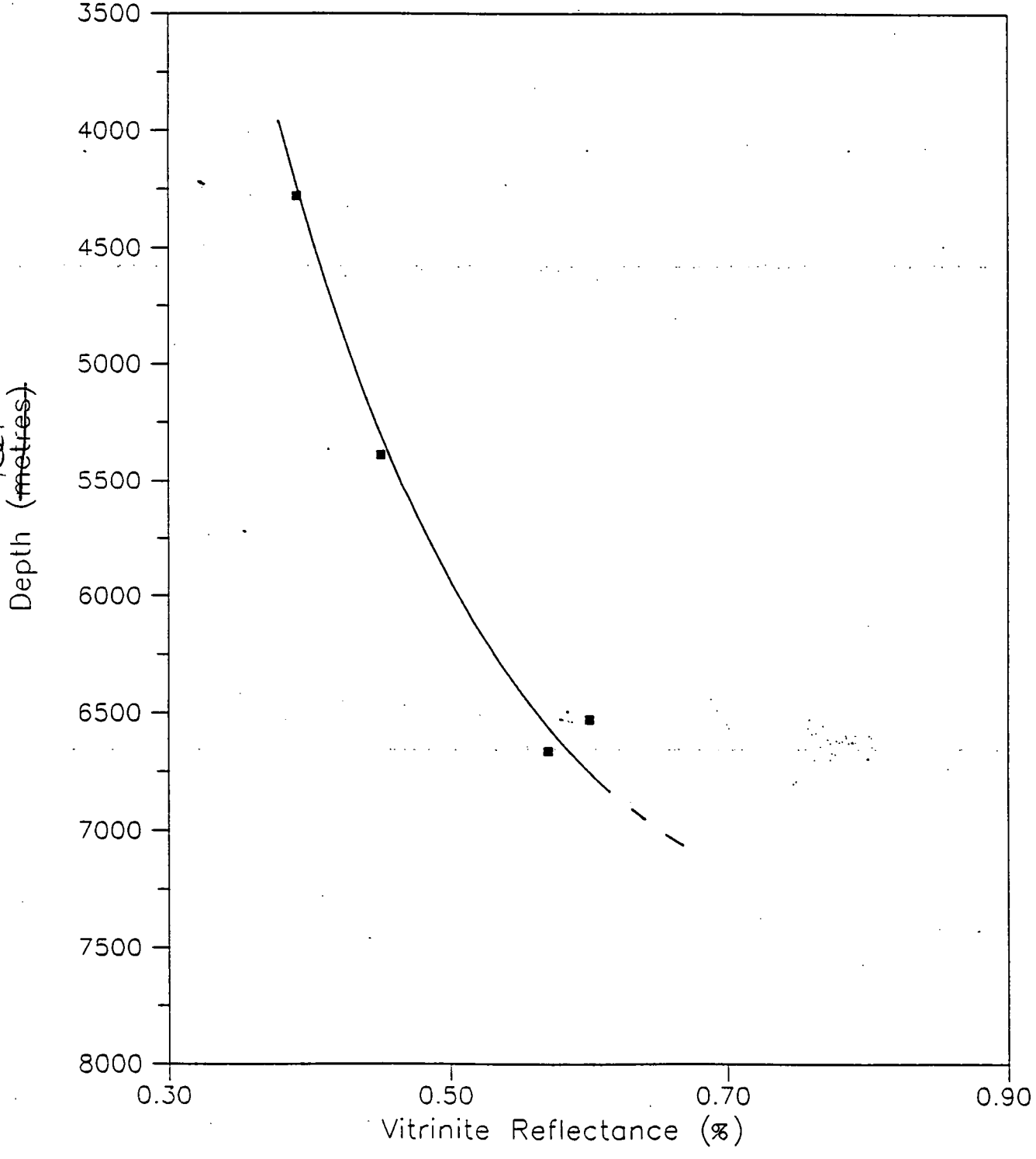
VITRINITE REFLECTANCE VERSUS DEPTH
LAKE HAWDEN-1



APPENDIX 1

HISTOGRAM PLOTS OF VITRINITE REFLECTANCE DETERMINATIONS

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VITRINITE REFLECTANCE VALUES

Well Name: LAKE HAWDON-1
Depth: 4280 ~~m~~ ft

Sorted List

0.33	0.37	0.40	0.53
0.34	0.38	0.41	
0.34	0.38	0.41	
0.34	0.38	0.42	
0.35	0.39	0.42	
0.35	0.39	0.42	
0.35	0.39	0.43	
0.36	0.40	0.44	
0.36	0.40	0.47	
0.37	0.40	0.51	

Number of values= 31

Mean of values 0.39
Standard Deviation 0.05

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

33-35	*******
36-38	*******
39-41	*********
42-44	*****
45-47	*
48-50	
51-53	**

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VITRINITE REFLECTANCE VALUES

Well Name: LAKE HAWDON-1
Depth: 5388 ~~m~~ ~~ft~~

Sorted List

0.38
0.42
0.44
0.44
0.47
0.48
0.51

Number of values= 7

Mean of values 0.45
Standard Deviation 0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

38-40	*
41-43	*
44-46	**
47-49	**
50-52	*

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VITRINITE REFLECTANCE VALUES

Well Name: LAKE HAWDON-1
Depth: 6528 ~~m~~ ft

Sorted List

0.51	0.59	0.66
0.52	0.61	0.67
0.53	0.61	0.68
0.53	0.61	0.71
0.55	0.63	
0.55	0.63	
0.55	0.65	
0.57	0.65	
0.57	0.65	
0.58	0.65	

Number of values= 24

Mean of values 0.60
Standard Deviation 0.06

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

51-53	****
54-56	***
57-59	****
60-62	***
63-65	******
66-68	***
69-71	*

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VITRINITE REFLECTANCE VALUES

Well Name: LAKE HAWDON-1
Depth: 6662 ~~m~~ ft

Sorted List

0.39	0.64
0.43	0.64
0.44	0.66
0.45	0.68
0.46	0.68
0.53	0.72
0.53	0.77
0.54	
0.55	
0.56	

Number of values= 17

Mean of values 0.57
Standard Deviation 0.11

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

39-41	*
42-44	**
45-47	**
48-50	
51-53	**
54-56	**
57-59	*
60-62	
63-65	**
66-68	***
69-71	
72-74	*
75-77	*

APPENDIX 2

PLATES

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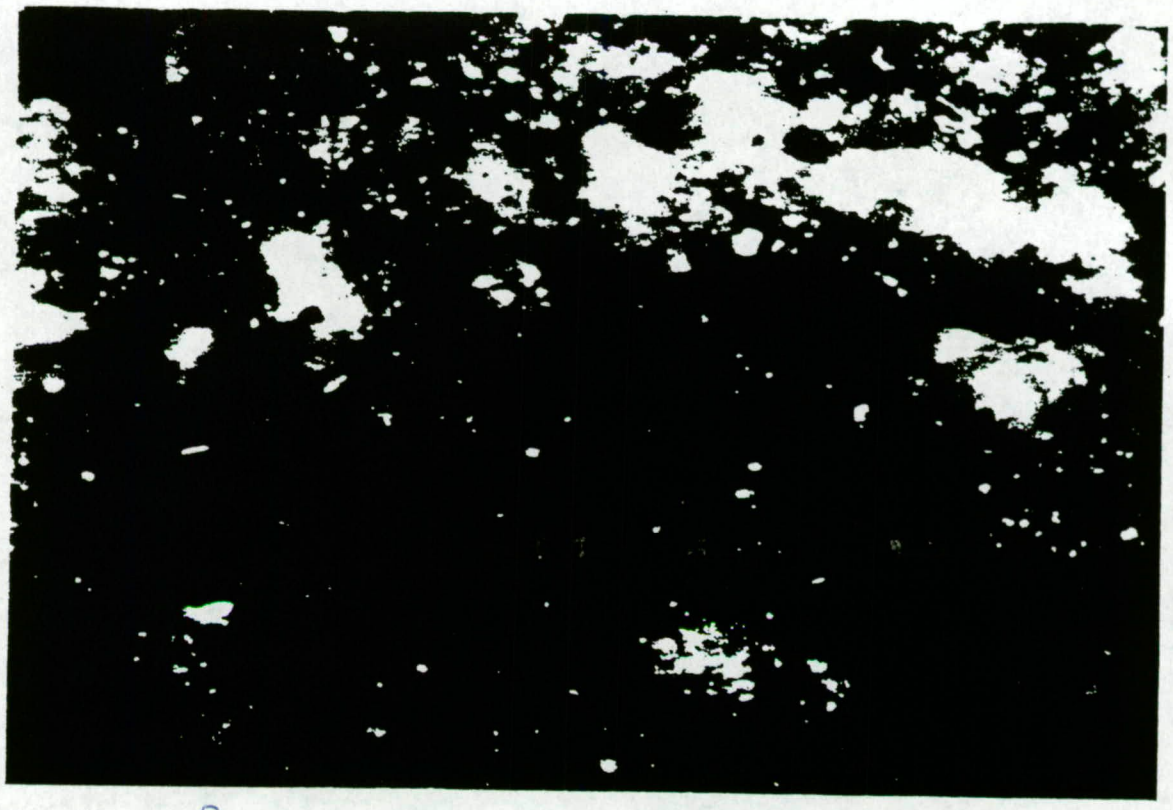

Plate 1: 4280 ~~m~~ A **Reflected Light**
Inertinite (white) is the most abundant type of organic matter present in this shale.
Field Dimensions: 0.26 x 0.18 mm

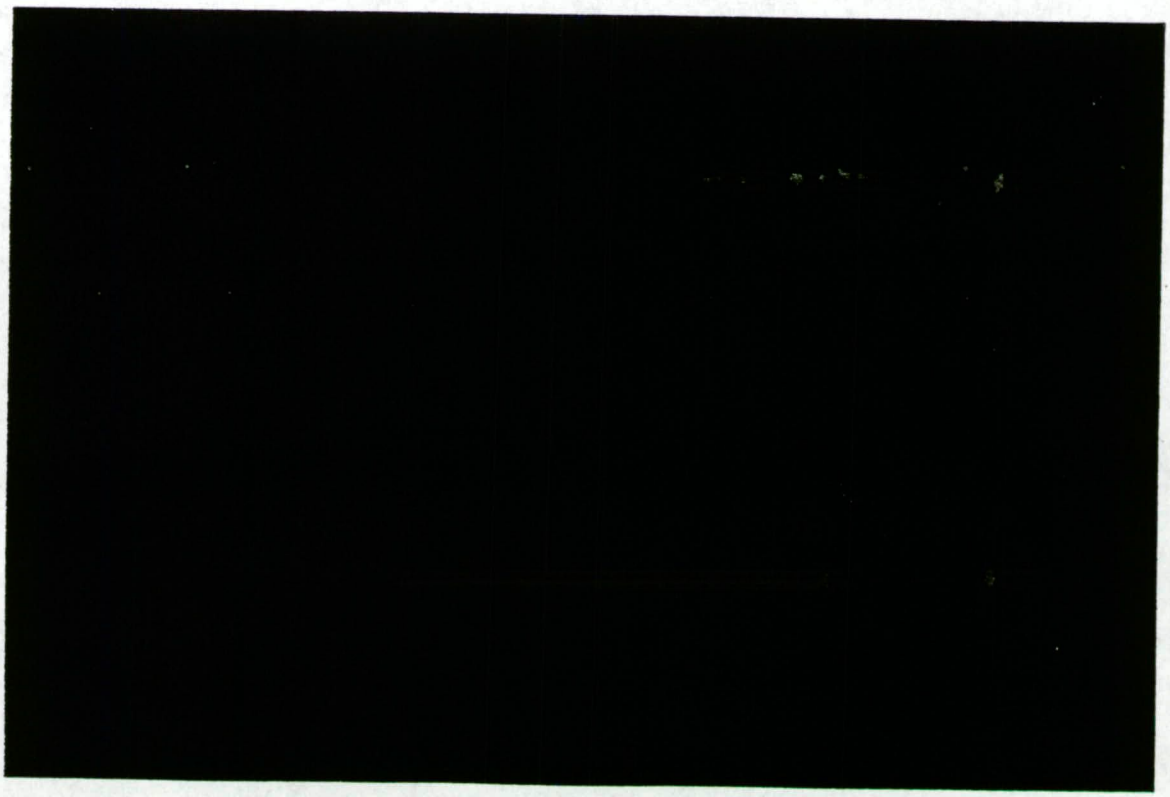

Plate 2: Same Field as above **Fluorescence Mode**
Exinites (lamalginite and liptodetrinite) are abundant in some bands of this shale; probably due to periods of greater anoxicity during deposition.