

SOUTH AUSTRALIA
DEPARTMENT OF MINES AND ENERGY



OPEN FILE ENVELOPE NO. 7053/2

PEL 8

OTWAY BASIN

CAMELBACK 1

TEST REPORTS

Submitted by

Hartogen Energy Ltd

1987

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ENVELOPE 7053/2

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, Alliance Minerals Australia NL and Shoreline Exploration Co.

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REPORT: McKirdy, D.M. and Watson, B.L., 1987. Source rock evaluation, Camelback 1, PEL-8, Otway Basin (Amdel report no. F 6821/87, 30 June 1987).	7053/2 R 1 Pgs 3-15
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30 June 1987

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Hartogen Energy Limited
15 Young Street
SYDNEY NSW 2000

Attention: W.K. Morrison

REPORT F 6821/87

YOUR REFERENCE: Letter from W.K. Morrison dated 28 May 1987

TITLE: Source rock evaluation, Camelback-1, PEL-8,
Otway Basin

MATERIAL: Sidewall cores

LOCALITY: CAMELBACK-1

IDENTIFICATION: As in Table 1 of report

DATE RECEIVED: 3 June 1987

WORK REQUIRED: TOC and Rock-Eval pyrolysis. Vitrinite
reflectance. Organic petrology. Interpretation.

Investigation and Report by: Dr David M. McKirdy and
Brian L. Watson

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for Dr William G. Spencer
General Manager
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SCANNED

1. INTRODUCTION

A suite of nine sidewall core samples from the Early Cretaceous Otway Group in Camelback-1 was received for source rock evaluation (Table 1).

The aim of the investigation was to assess the hydrocarbon source potential (maturity, organic richness, kerogen type) of selected shales and siltstones in the Eumeralla Formation and underlying Pretty Hill Sandstone.

2. RESULTS

Analytical data are summarised and presented herein as follows:

	<u>Table</u>	<u>Figure</u>	<u>Appendix</u>
TOC, Rock-Eval pyrolysis	2	1	-
Vitrinite reflectance (VR)	3	2	1
Dispersed organic matter (DOM)	4-6	-	2

3. DISCUSSION

3.1 Maturity

The well-constrained vitrinite reflectance *versus* depth profile for Camelback-1 (Fig. 2) shows that the entire Eumeralla Formation and the Pretty Hill Sandstone above 4400 feet are thermally immature. Sediments comprising the lower half of the Pretty Hill Sandstone are marginally mature for oil generation from terrestrial organic matter (VR = 0.50-0.67%).

There is poor agreement between measured VR and Rock-Eval maturity indicators. With the exception of two aberrant samples (SWC 20, 2830 feet and SWC 15, 3845 feet), Tmax and production index values increase steadily with increasing depth (Tmax = 430-438°C; PI = 0.03-0.10 : Table 2). However, these pyrolysis data convey the misleading impression that sediments from the interval sampled (2070-5690 feet depth) fall within a narrow maturity range (equivalent VR = 0.45-0.55% : Fig. 1).

Inspection of the Rock-Eval pyrograms of SWC's 20 and 15 reveals that they have broad, ill-defined S₂ peaks which are a direct consequence of their highly inertinitic organic matter (I = 90-95% of DOM : Table 4). Accordingly, their Tmax values are unreliable.

3.2 Organic Richness

The organic carbon contents of these Otway Group shales and siltstones are fair to very good (TOC = 0.71-12.7% : Table 2).

Source richness for hydrocarbons differs markedly according to formation as follows:

	<u>S₁ + S₂</u>	<u>Source Rating</u>
	kg h'c/tonne	
Eumeralla	5.2-25.8	moderate to excellent
Pretty Hill	0.9-1.66	poor

3.3 Source Quality and Kerogen Type

The source quality of shales in the Eumeralla Formation is appreciably better than that of the shale/siltstone lithofacies within the Pretty Hill Sandstone:

	<u>Hydrogen Index</u> mg S ₂ /g TOC	<u>Likely Product</u>
Eumeralla	158-197	gas and condensate
Pretty Hill	13-118	gas

This difference in source quality is illustrated in Figure 1. Both formations contain terrestrial Type III kerogen.

In the case of the Pretty Hill Sandstone, the organic matter is predominantly inertinite (I = 85-95% of DOM), and the associated exinite (5% of DOM) has undergone significant oxidation during sedimentation and early diagenesis (Table 4-6). By contrast, exinite in the Eumeralla shales is both more abundant (10% of DOM) and less oxidised. Moreover, the carbonaceous shale from 2090 feet depth in the Eumeralla Formation is atypical in that its DOM comprises mainly low-rank vitrinite (85-90%).

4. CONCLUSIONS

1. Early Cretaceous sediments of the Otway Group above 4400 feet depth in Camelback-1 are thermally immature.
2. Sediments comprising the lower half of the Pretty Hill Sandstone section are within the zone of initial oil generation from terrestrial organic matter (VR = 0.5-0.67%) at this well locality.
3. Shales at the base of the Eumeralla Formation are rich in gas and condensate-prone terrestrial Type III kerogen (TOC = 3-13%; S₁+S₂ = 5-26 kg h'cs/tonne; HI = 158-197 mg S₂/g TOC). Basinward of the Camelback-1 locality these shales may be mature enough to be effective sources of hydrocarbons.
4. Although in part mature, shales and siltstones of the underlying Pretty Hill Sandstone contain only fair to moderate concentrations of poor quality, dry gas-prone, inertinitic organic matter (TOC = 0.7-1.6%; S₁+S₂ < 2 kg h'cs/tonne; HI = 13-116 mg S₂/g TOC).

TABLE 1: SIDEWALL CORE SAMPLES RECEIVED FOR SOURCE ROCK ANALYSIS,
CAMELBACK-1

SWC	Depth ft	Formation
25	2090	Eumeralla
24	2320	Eumeralla
23	2535	Eumeralla
20	2830	Pretty Hill
18	3325	Pretty Hill
15	3845	Pretty Hill
10	4720	Pretty Hill
8	5322	Pretty Hill
4	5690	Pretty Hill

AMDEL

ROCK-EVAL PYROLYSIS

24/06/87

Client HARTOGEN ENERGY LTD

Well CAMELBACK-1

SWC No.	DEPTH (ft)	T MAX	S1	S2	S3	S1+S2	PI	S2/S3	PC	TOC	HI	OI
25	2070	430	0.73	25.04	3.87	25.77	0.03	6.47	2.14	12.70	197	30
24	2320									0.16		
23	2535	432	0.18	5.04	1.24	5.22	0.03	4.06	0.43	3.20	158	39
20	2830	447	0.12	1.37	1.12	1.49	0.08	1.22	0.12	10.80	13	10
18	3325	433	0.08	0.87	1.10	0.95	0.09	0.79	0.07	0.75	116	147
15	3845	450	0.10	0.82	0.34	0.92	0.11	2.41	0.07	0.71	115	48
10	4720	436	0.17	1.46	1.00	1.63	0.10	1.46	0.13	1.30	112	77
8	5322	437	0.17	1.45	1.81	1.62	0.10	0.80	0.13	1.23	118	147
4	5690	438	0.12	1.54	2.57	1.66	0.07	0.59	0.13	1.63	94	158

KEY TO ROCK-EVAL PYROLYSIS DATA SHEET

<u>PARAMETER</u>		<u>SPECIFICITY</u>
T _{max}	position of S ₂ peak in temperature program (°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 CO₂ from decomposition of carbonate minerals.

TABLE 3: SUMMARY OF VITRINITE REFLECTANCE MEASUREMENTS, CAMELBACK-1

Depth (ft)	Mean Maximum Reflectance (%)	Standard Deviation	Range	Number of Determinations
2090	0.28	0.03	0.21-0.36	34
2320	0.35	0.06	0.27-0.41	4
2535	0.33	0.04	0.23-0.39	27
2830	0.36	0.05	0.27-0.44	19
3325	0.41	0.00	0.41	1
3845	-	-	-	-
4720	0.54	0.06	0.42-0.67	38
5322	0.60	0.08	0.44-0.78	23
5690	0.66	0.05	0.54-0.73	11

TABLE 4: PERCENTAGE OF VITRINITE, INERTINITE AND EXINITE IN DISPERSED ORGANIC MATTER, CAMELBACK-1

Depth (ft)	Percentage of		
	Vitrinite	Inertinite	Exinite
2090	85-90	5	5-10
2320	5	90	5
2535	5	85	10
2830	5	90	5
3325	<5	90	5
3845	-	95	5
4720	10	85	5
5322	10	85	5
5690	5	90	5

TABLE 5: ORGANIC MATTER TYPE AND ABUNDANCE, CAMELBACK-1

Depth (ft)	Relative Maceral Group Proportions	Estimated Volume of DOM	Volume of Exinites	Exinite Macerals
2090	V>E>I	10-15	Ra-Sp	lama,spo,sub,cut,res
2320	I>>V>E	<0.5	Tr	phyto,?oil
2535	I>E>V	3-5	Ra	phyto,spo,lama
2830	I>>E>V	0.5-1	Vr	phyto,lipto
3325	I>>E>V	0.5-1	Vr	phyto,spo,?oil
3845	I>>E	0.5-1	Tr	phyto,lipto
4720	I>>V>E	≈1	Vr	phyto,spo,lipto
5322	I>>V>E	≈1	Vr	lama,spo,phyto,?oil
5690	I>>V>E	≈1	Vr	lama,lipto,spo

TABLE 6: EXINITE MACERAL ABUNDANCE AND FLUORESCENCE CHARACTERISTICS,
CAMELBACK-1

Depth (ft)	Exinite Macerals	lithology/Comments
2090	lama (Ra-Sp;mY), spo (Ra-Sp;mY), sub (Ra;dO-nofl), cut (Ra;mO-dO), res (Vr;mY-mO)	Chiefly shale, 215% coal; most exinite is slightly oxidised.
2320	phyto (Tr;dO), ?oil (Tr;iYB)	Shale; exinite as above. ?Oil is generally associated with the larger quartz grains.
2535	phyto (Ra;iY-mO), spo (Vr;mO), lama (Vr;mY-mO)	Shale; exinite is less oxidised than above.
2830	phyto (Vr;iO-dO), lipto (Vr;mY- mO)	Siltstone; some phytoplankton is moderately oxidised.
3325	phyto (Vr;mO), spo (Tr;mO), ?oil (Tr;iY)	Shale; oil is associated with the larger mineral grains.
3845	phyto (Tr;mO-nofl), lipto (Tr;mO)	Silty shale; exinite is generally moderately oxidised.
4720	phyto (Vr;mO-dO), spo (Vr;mY-mO), lipto (Vr;mY-mO)	Siltstone; phytoplankton is generally slightly oxidised.
5322	lama (Vr;mY-mO), spo (Tr;dO), phyto (Tr;mO), ?oil (Tr;iY)	Siltstone; sporinite is moderately oxidised. ?Oil is associated with quartz grains.
5690	lama (Vr;mO), lipto (Vr;mO), spo (Tr;mO)	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
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 $\leq 0.1\%$
Tr Trace < 0.1

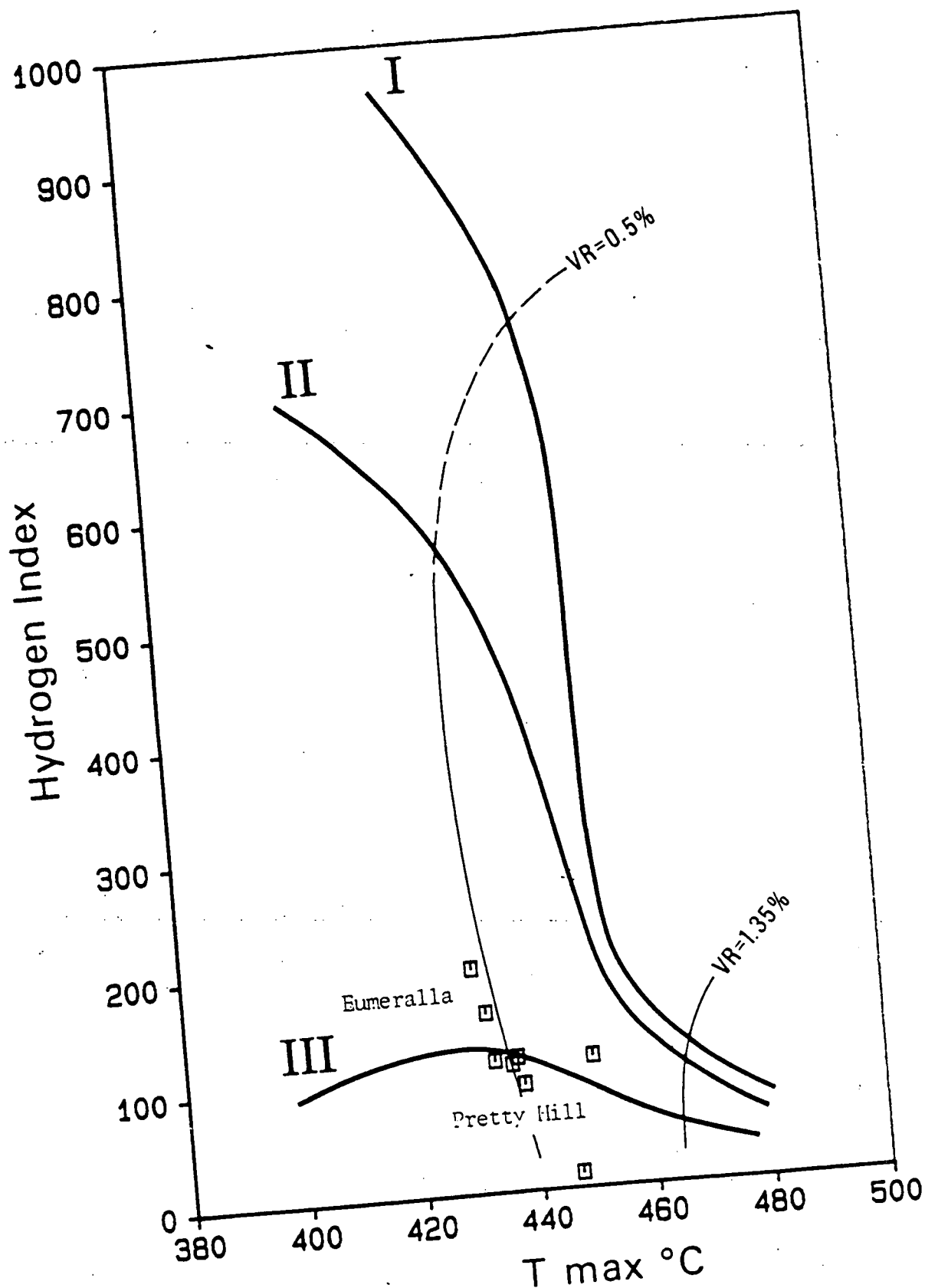
FLUORESCENCE COLOUR AND INTENSITY

G Green
Y Yellow
O Orange
B Brown

i Intense
m Moderate
d Dull
nofl No Visible Fluorescence

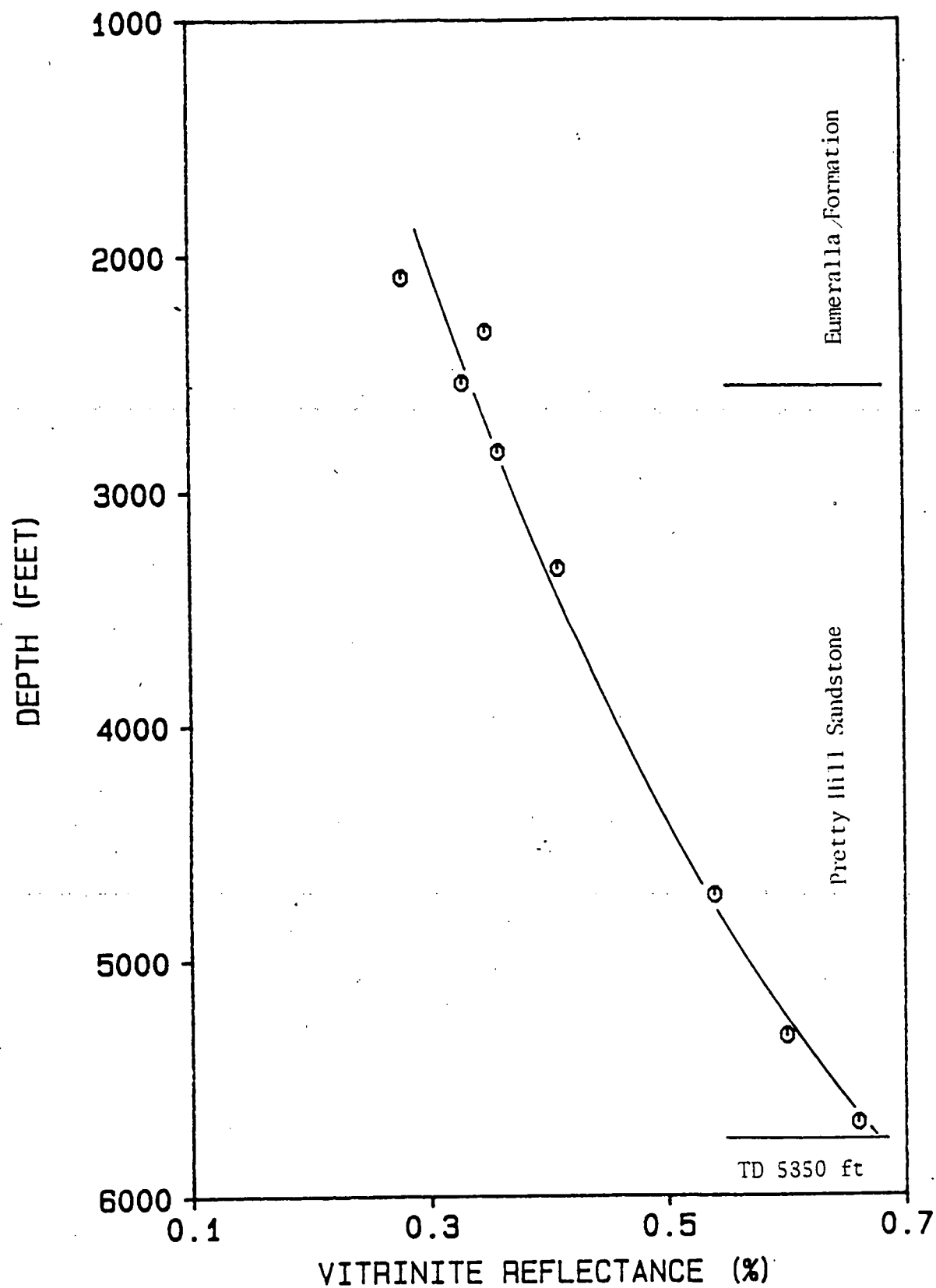
Client : HARTOGEN ENERGY
Well name : CAMELBACK-1

00014



VITRINITE REFLECTANCE Vs. DEPTH, CAMELBACK-1

00015



00016

APPENDIX 1

HISTOGRAM PLOTS OF VITRINITE REFLECTANCE
MEASUREMENTS, CAMELBACK-1

CAMELBACK-1

2090 FT : SWC 25

SORTED LIST

.21	.22	.24	.25	.25	.25	.25	.25	.25	.26	.26
.26	.26	.27	.27	.27	.28	.29	.29	.29	.29	.29
.3	.3	.3	.3	.3	.3	.3	.31	.31	.32	
.33	.33	.34	.36							

Number of values= 34

MEAN OF VALUES .283
 STD DEVIATION .033

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

21 - 23		██
24 - 26		██████████
27 - 29		██████████
30 - 32		██████████
33 - 35		██████
36 - 38		██

CAMELBACK-1

2320 FT : SWC 24

SORTED LIST

.27 .31 .39 .41
Number of values= 4

MEAN OF VALUES .345
STD DEVIATION .057

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100

27 - 31	
32 - 36	
37 - 41	

CAMELBACK-1

2535 FT ; SWC 23

SORTED LIST

.23 .25 .28 .28 .3 .3 .31 .31 .31 .31
 .33 .33 .33 .34 .34 .34 .34 .35 .35 .35
 .35 .36 .36 .36 .36 .37 .39

Number of values= 27

MEAN OF VALUES .327

STD DEVIATION .036

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

23 - 25	███
26 - 28	███
29 - 31	██████
32 - 34	████████
35 - 37	██████████
38 - 40	███

00020

CAMELBACK-1

2838 FT ; SWC 20

SORTED LIST

27 .28 .29 .32 .32 .32 .34 .34 .35 .35
36 .37 .38 .4 .4 .4 .42 .43 .44
Number of values= 19

MEAN OF VALUES .357
STD DEVIATION .049

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

27 - 29		██
30 - 32		██
33 - 35		██
36 - 38		██
39 - 41		██
42 - 44		██

00021

CAMELBACK-1

3325 FT ; SWC 18

SORTED LIST

.41

Number of values= 1

MEAN OF VALUES .41

STD DEVIATION 0

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

41 - 43 |■

CAMELBACK-1

4720 FT ; SMC 10

SORTED LIST

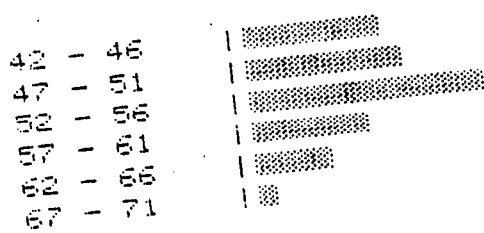
.42	.44	.45	.45	.45	.46	.47	.48	.48
.51	.51	.51	.51	.52	.52	.52	.54	.54
.55	.55	.55	.56	.56	.56	.58	.58	.58
.6	.61	.62	.63	.63	.65	.67		

Number of values= 38

MEAN OF VALUES .535
 STD DEVIATION .064

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100



00023

CAMELBACK-1

5322.FT ; SMC 8

SORTED LIST

.44 .52 .53 .53 .53 .54 .54 .55 .55 .56
.57 .58 .6 .6 .64 .64 .64 .68 .68 .69
.7 .71 .78

Number of values= 23

MEAN OF VALUES .6

STD DEVIATION .079

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

44 - 48	
49 - 53	
54 - 58	
59 - 63	
64 - 68	
69 - 73	
74 - 78	

CAMELBACK-1

5690 FT ; SWC 4

SORTED LIST

.54 .61 .64 .65 .66 .68 .68 .69 .69 .71
.73

Number of values= 11

MEAN OF VALUES .662

STD DEVIATION .05

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

54 - 56		■
57 - 59		
60 - 62		■
63 - 65		■■■
66 - 68		■■■■
69 - 71		■■■■
72 - 74		■

APPENDIX 2

PHOTOMICROGRAPHS OF DISPERSED ORGANIC MATTER,
CAMELBACK-1

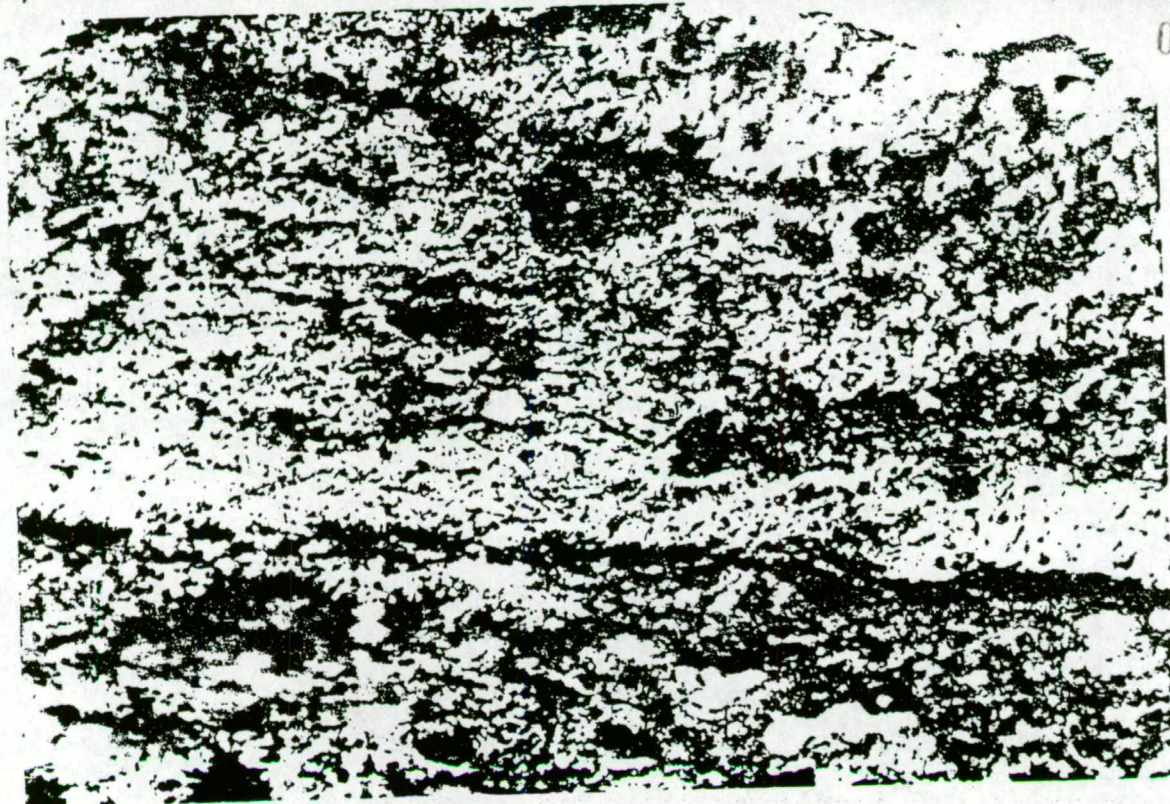


PLATE 1: SWC 25, 2090 ft, Eumeralla Fm. Reflected Light
Thin band of vitrinite (grey) containing rare exinite
in shale.
Field Dimensions 0.26 x 0.18 mm.

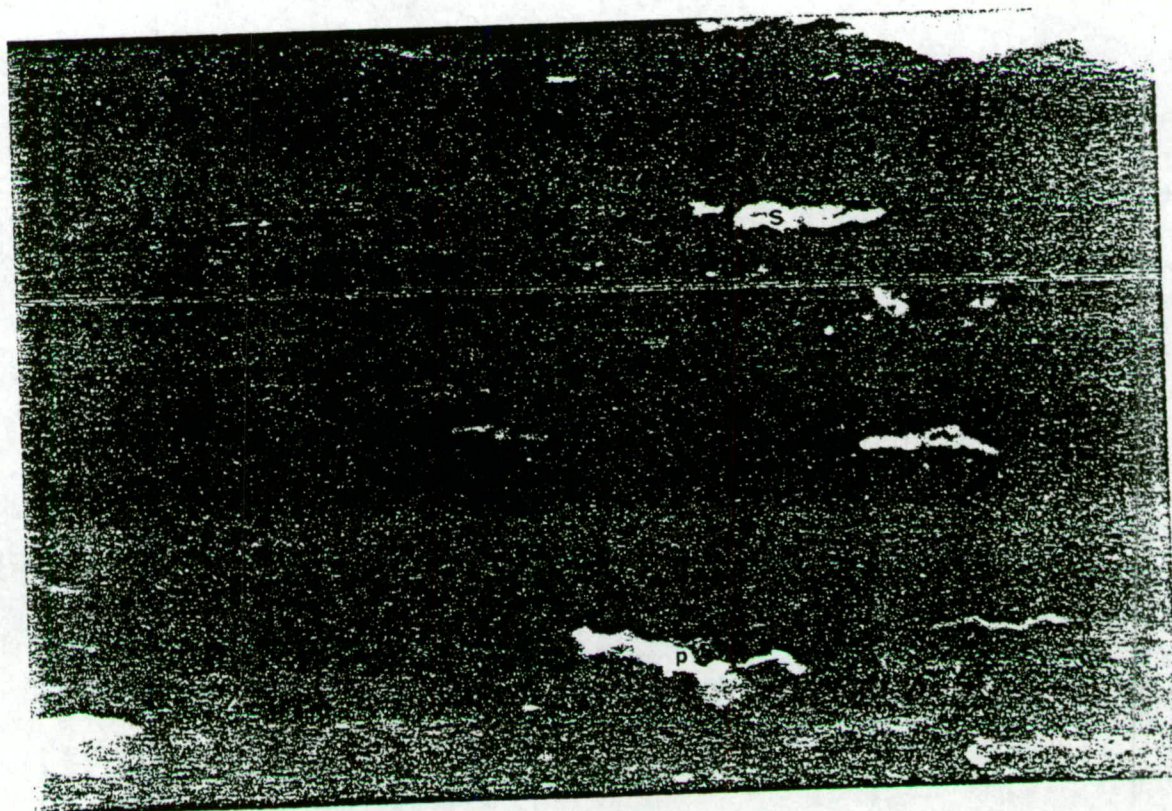


PLATE 2: Same field of view as above. Fluorescence Mode
Sporinite (s), phytoplankton (p) and liptodetrinite (l)
comprise the exinites in this field.

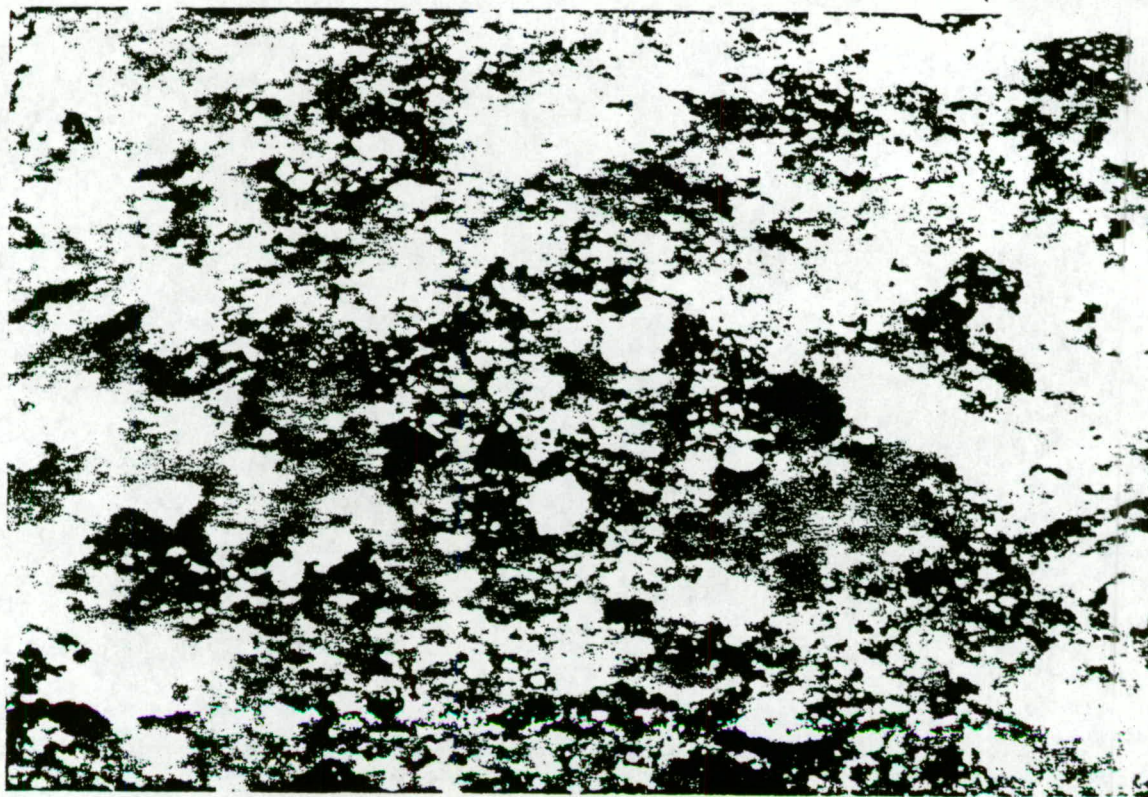


PLATE 3: SWC 23, 2535 ft, Eumeralla Fm. Reflected Light
Inertinite (white) is the major type of organic matter
in this shale.

Field Dimensions 0.26 x 0.18 mm.

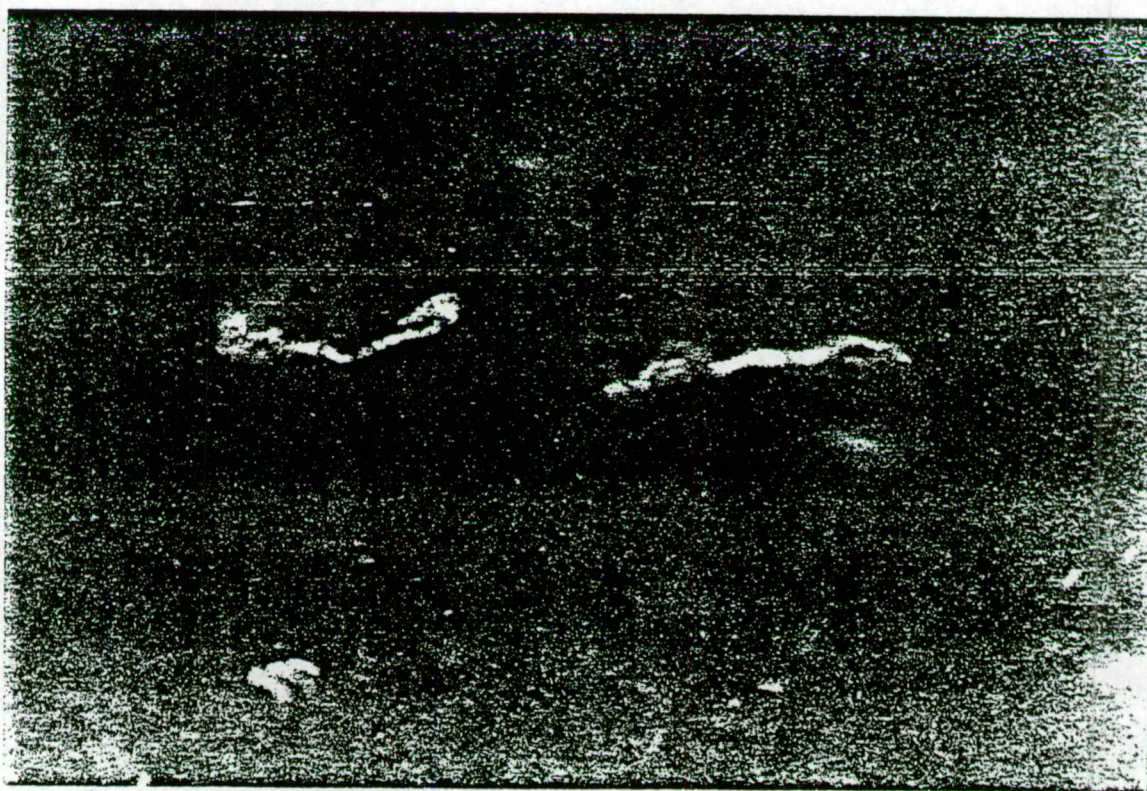


PLATE 4: Same field of view as above. Fluorescence Mode
Phytoplankton (moderate yellow fluorescence) are also
present.



PLATE 5: SWC 8, 5322 ft, Pretty Hill Sst. Reflected Light
 Inertinite (light grey) occurs with exinite (brown; left)
 in this siltstone. Field Dimensions 0.26 x 0.18 mm.



PLATE 6: Same field of view as above. Fluorescence Mode
 The exinite is lamalginitic (moderate orange-moderate yellow
 fluorescence).