

308001

VITRINITE REFLECTANCE DETERMINATIONS
AND ORGANIC PETROLOGY, YOLLA-1, T-14-P,
BASS BASIN

157/85

Amoco Australia Petroleum Company

3/786/0-F6271

October 1985

OR_314



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29 October 1985

F 3/786/0
F 6271 (Final)

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REPORT F 6271 (Final)

YOUR REFERENCE: Telex 18 July 1985, LPD No. 0523

TITLE: Vitrinite reflectance determinations and
organic petrology, Yolla-1, T-14-P,
Bass Basin

MATERIAL: Cuttings and sidewall cores

LOCALITY: Yolla-1

DATE RECEIVED: 24 July 1985

WORK REQUIRED: Vitrinite reflectance and organic
petrology

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1. INTRODUCTION

Cuttings samples from Yolla-1 were received over a four week period (24 July to 13 August 1985). Vitrinite reflectance and organic petrology results were summarised and reported by telex on an urgent basis (24 hour turnaround time) so that the maturity, source richness and source quality could be assessed as drilling continued.

This report is a formal presentation of this data and includes the results of analyses performed on samples received after the completion of drilling in Yolla-1.

2. ANALYTICAL PROCEDURE

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 on vitrinite phytoclasts, were made to Australian Standard AS2486-1981 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 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

A summary of the vitrinite reflectance data is presented in Table 1. Histogram plots of these data are included in Appendix 1. Tables 2-3 present the results of the organic petrology and a series of plates illustrating key aspects of this petrology are included in Appendix 2. A vitrinite reflectance verses depth plot is included as Figure 1.

4. DISCUSSION

4.1 Maturity

Vitrinite reflectance data (Table 1, Figure 2) indicate that the sedimentary section penetrated by Yolla-1 is mature for the generation of light oil from resinite-rich DOM (threshold VR = 0.45% : Snowdon and Powell, 1982) below approximately 1500 metres depth.

Significant gas generation from woody-herbaceous DOM (vitrinite and, to a lesser extent, inertinite) commences at VR = 0.6 (Monnier et al., 1983). On this basis, the sediments below 2200 metres depth are sufficiently mature to be potential sources of gas.

Oil generation from terrestrial organic matter rich in exinites other than resinite, suberinite and bituminite occurs within the vitrinite reflectance range $VR = 0.7 - 1.2\%$ (Connan and Cassou, 1980). The top of this oil generation window occurs at 2500 metres depth in Yolla-1.

Overmature sediments occur adjacent to the sill in the following intervals:

approx. 2550-2585 metres depth
approx. 2652-2720 metres depth

These intervals are quite narrow (<100 metres depth) indicating that the sill was a fairly low temperature intrusion.

4.2 Organic Richness

Organic richness ranges from fair to excellent in the samples studied. Samples with excellent organic richness contain coals. The organic content of the shales and siltstones in the sequence is uniformly fair (DOM contents 1 - 3%).

4.3 Kerogen Type and Source Quality

Coals in the Yolla-1 section are vitrinite rich (70-85%) and contain abundant exinite (10-30%). Inertinite is a minor component (Table 2). Dispersed organic matter in the associated shales and siltstones is similar to that of the coals although generally more inertinite-rich.

Resinite is commonly the most abundant exinite and constitutes up to 25% of some coal fragments. Other primary exinites include: sporinite, suberinite, cutinite and bituminite.

The samples with the best source quality as indicated by the organic petrology are listed below:

Depth (m)	Exinite (% of DOM)	Vitrinite	Major Exinite Macerals
1958-67 Coal	75	20	Resinite, sporinite
2165-74 Coal	70	25	Resinite, suberinite
2372-81 Shale	60	25	Resinite, suberinite
2573-82 Coal	75	20	Resinite, suberinite
2962-71 Coal	85	10	Sporinite
3028 Shale	70	25	Bituminite
3034-43 Coal	70	25	Sporinite, resinite

4.4 Conclusions

1. Sediments with the best source potential for liquid hydrocarbons are the resinite-rich coals (and associated epiclastics) which occur in the interval 1958-2582 metres depth in Yolla-1. The maturity of these samples (VR = 0.55-0.92%) is sufficient for oil generation from the resinite to have commenced. Signs of oil generation (viz. oil and exsudatinite) are evident in both coals and clastics from this interval.
2. The maturity of the sediments in the interval 2500-2900 metres depth is sufficient for oil generation from sediments rich in exinites other than resinite, suberinite and bituminite (VR > 0.7%). Such exinite-rich sediments occur in coals adjacent to the sill (2573-82 m, approx. 22650 m occurring as cavings in 3034-43 m).
3. Sediments in the interval 2900-3000 have maturities ranging from (VR = 0.6-0.7%) and therefore are only sufficiently mature for the generation of light naphthenic oil from the thermally labile exinites (i.e. resinite, bituminite and suberinite) and gas/condensates from the woody herbaceous organic matter.
4. Significant gas generation from vitrinite-rich coals and associated sediments should occur below 2200 metres depth (VR threshold = 0.6%).
5. Thin intervals of over-mature sediments occur adjacent to the sill. The thickness of these over-mature sediments is <100 metres, indicating the sill may be a low temperature intrusion.
6. Exsudatinite is primary oil (i.e. formed in-situ). The presence of exsudatinite in the following samples indicates oil generation from the following intervals:

1958-67
2165-74
2573-82
3034-43*

*exsudatinite in this sample occurs in coals which may have caved from stratigraphically higher units.

5. REFERENCES CITED

- CONNAN, J. and CASSOU, A.M., 1980. Properties of gases and petroleum liquids derived from terrestrial kerogen at various maturation levels. *Geochem. Cosmochim. ACTA*, 44, pp. 1-23.
- MONIER, F., POWELL, T.G. and SNOWDON, L.R., 1983. Qualitative and quantitative aspects of gas generation during maturation of sedimentary organic matter. Examples from Canadian Frontier basins. In : Bjoroy, M. *et al.*, (eds), *Advances in Organic Chemistry* 1981, Wiley, pp. 487-495.
- SNOWDON, L.R., and POWELL, T.G., 1982. Immature oil and condensate-modification of hydrocarbon generation model for terrestrial organic matter. *Bull. Am. Assoc. Petrol. Geol.*, 66, pp. 775-778.

TABLE 1: SUMMARY OF VITRINITE REFLECTANCE MEASUREMENTS,
YOLLA-1.

Depth (m)	Mean Maximum Reflectance(%)	Standard Deviation	Range	Number of Determinations
1760-69	0.50	0.04	0.42 - 0.59	33
1958-67	0.52	0.03	0.47 - 0.58	37
2165-74	0.60	0.06	0.47 - 0.71	34
2372-81	0.63	0.06	0.51 - 0.72	39
2573-82	0.92 (1.6)	0.04	0.79 - 0.99	37
2731	0.97+	0.06	0.82 - 1.06	31
2774-83	0.86	0.11	0.59 - 1.02	23
2885	0.81	0.08	0.69 - 0.97	11
2945.0	0.70+	0.04	0.65 - 0.76	5
2962.71	0.78*	0.12	0.57 - 1.03	14
3028	0.56+	0.04	0.46 - 0.63	34
3034-43	0.98*	0.06	0.85 - 1.10	31

* Influenced by caved cuttings

+ sidewall cores

() reflectance of one coal fragment.

TABLE 2: PERCENTAGE OF VITRINITE, INERTINITE AND EXINITE
IN DISPERSED ORGANIC MATTER, YOLLA-1.

Depth (m)	Percentage of		
	Vitrinite	Inertinite	Exinite
1760-69 Silty Shale	75	15	10
1958-67 Coal	75	5	20
Sandstone & Siltstone	70	15	15
2165-74 Coal	70	5	25
Shale	75	20	5
2372-81 Shale	60	15	25
Coal	80	5	15
2573-82 Coal	75	5	20
2731 Shale	10	80	10
2774-83 Siltstone	5	90	<5
Shale	-	100	-
2885 Shale	5	85	10
2945 Siltstone	<<5	90	5
2962-71 Siltstone	<5	90	5
Coal	85	<5	10
3028 Silty Shale	70	5	25
3034-43 Coal	70	<5	25
Shale & Siltstone	<5	85	10
Carb Shale	80	<5	15
Carbonate & Sandstone	-	100	-

TABLE 3: ORGANIC MATTER TYPE AND ABUNDANCE, YOLLA-1.

Depth (m)	Relative Maceral Group Proportions	Estimated Volume of DOM (%)	Exinites	Exinite Macerals
1760-69	V>I>E	1-3	Ra	bmite, spo, ?oil, cut, res.
1958-67	V>E>I	20-30	Ab	res, spo, cut, lipto, exs, ?phyto, oil.
2165-74	V>E>I	>40	Ab	res, sub, spo, cut, exs, lipto.
2372-81	V>E>I	~5	Co - Ab	res, spo, cut, lipto, sub.
2573-82	V>E>I	>40	Ab	res, sub, spo, cut, exs.
2731	I>V>E	~1	Ra	lipto, spo, oil, cut, lama.
2774-83	I>V>E	<0.5	Vr	lipto, spo, cut, res.
2885	I>E>V	~1	Ra	lipto, spo, cut, lama.
2945	I>>E>V	~1	Ra	?oil, lama, cut, spo.
2962-71	V>I>E	~1	Vr	spo, phyto, lipto, cut.
3028	V>E>I	~3	Ab	bmite, spo, res, cut, ?oil.
3034-43	V>E>I	5-15	Co	spo, res, cut, bmite, exs, sub.

TABLE 4: EXINITE MACERAL ABUNDANCE AND FLUORESCENCE CHARACTERISTICS, YOLLA-1.

Depth (m)	Exinite Macerals	Lithology/Comments
1760-69	bmite(Ra;d0),spo(Ra;m0),?oil(Ra-Vr;iY-m0),cut(Vr;m0),res(Tr;m0).	Silty shale; ?oil occurs as coatings on quartz grains.
1958-67	res(Ab;iY-dB),spo(Co;mY-m0),cut(Ra;m0),lipto(Ra;m0-d0),exs(Vr;m0-d0),?phyto(Tr;mY),?oil(Tr;iG).	~40% coal, ~40% siltstone, ~20% sandstone; coals contain up to 25% resinite (30% exinite) and contain exsudatinite (primary oil i.e. formed in situ). ?oil occurs in the siltstone as coatings on quartz grains. Fluorescence colours of resinite indicate that the generation of oil has commenced from this maceral.
2165-74	res(Ab;iY-d0),sub(Ab;d0),spo(Co;mY-m0),cut(Sp;m0),exs(Ra;iY-m0),lipto(Ra;m0).	Chiefly coal, 5-10% siltstone; coal as above.
2372-81	res(Co-Ab;m0-dB),spo(Co;m0-d0),cut(sp;m0-d0),lipto(Sp;m0).	Chiefly shale, 5-10% well cemented sandstone, ~5% coal.
2573-82	res(Ab;m0-dB),sub(Ab;d0),spo(Ab;m0-dB),cut(Co;m0-dB),exs(Ra;m0-d0).	Coal (carbonaceous shale and carbonate cavings constitute <5% of sample.)
2731	lipto(Ra-Vr;d0),spo(Vr;d0),?oil(Vr;iG-iY)cut(Vr;d0),lama(Vr;d0).	Shale; oil is interstitial to the larger mineral grains.
2774-83	lipto(Vr;d0),spo(Tr;d0),cut(Tr;d0),	Chiefly igneous/volcanics ~20% siltstone, ~5% shale.
2885	lipto(Ra;d0),spo(Vr;d0),cut(Vr;d0),lama(Vr;d0).	Shale.
2945	oil(Ra;iG-iY),lama(Ra-Vr;d0),cut(Vr;d0),spo(Vr;d0-dB).	Siltstone; oil as above.
2962-71	spo(Vr;d0),?phyto(Vr;d0),lipto(Vr;d0),cut(Vr-Tr;d0).	Chiefly siltstone (with patchy distribution of carbonate rich and sandy lithologies) ~5% igneous/volcanics, ~1% coal. Coal and igneous volcanics are probably cavings.
3028	bmite(Ab;d0),spo(Vr;m0),res(Vr;m0-d0),cut(Tr;d0),?oil(Tr;iG,iY).	Silty shale ~5% sandstone. Oil occurs interstitial to quartz grains in the sandstone and as small accumulations in the shale.
3034-43	spo(Co;d0),res(Co;d0),cut(Ra;d0-dB),bmite(Ra;d0-dB),exs(Vr;dB),sub(Tr;dB).	10-20% igneous, 10-20% coal, shale & siltstone, 10-15% carbonaceous shale, 10-15% carbonate, 5-10% sandstone.

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 \approx 0.1%
Jr Trace <0.1%

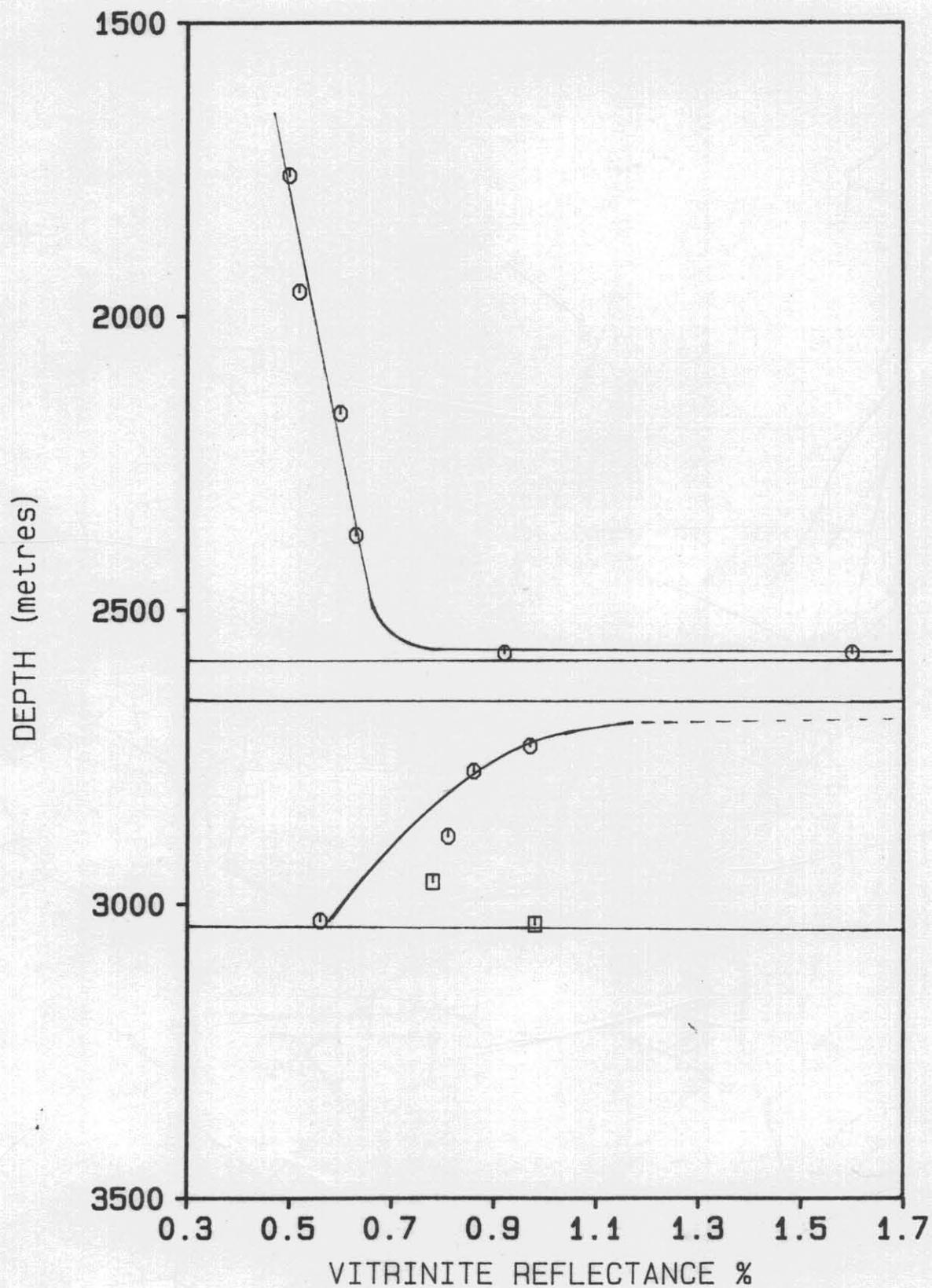
FLUORESCENCE COLOUR AND INTENSITY

G Green
Y Yellow
O Orange
B Brown

i Intense
m Moderate
d Dull

FIGURE 2

VITRINITE REFLECTANCE Vs. DEPTH PLOT, YOLLA-1



5 cm

APPENDIX 1

HISTOGRAM PLOTS OF VITRINITE REFLECTANCE
DATA

YOLLA #1

1760-1769 M

SORTED LIST

.42 .43 .45 .45 .46 .46 .47 .48 .48 .48
 .49 .49 .49 .49 .49 .49 .5 .5 .5 .5
 .51 .51 .51 .52 .52 .53 .53 .54 .55 .55
 .56 .57 .59

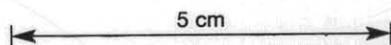
Number of values= 33

MEAN OF VALUES .5
 STD DEVIATION .038

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

42 - 44	█
45 - 47	█
48 - 50	█
51 - 53	█
54 - 56	█
57 - 59	█



5 cm

YOLLA #1

1958-1967 M

SORTED LIST

.47	.47	.47	.47	.48	.48	.48	.49	.49	.49
.5	.5	.5	.5	.5	.51	.51	.52	.52	.52
.53	.53	.53	.53	.54	.55	.55	.55	.56	.56
.56	.56	.56	.57	.57	.57	.58			

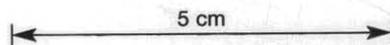
Number of values= 37

MEAN OF VALUES .521
 STD DEVIATION .034

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

47 - 49		████████████████████
50 - 52		████████████████████
53 - 55		████████████████████
56 - 58		████████████████████



5 cm

YOLLA #1

2165-2174 M

SORTED LIST

.47 .47 .49 .54 .54 .54 .56 .56 .58 .58
 .59 .59 .59 .59 .6 .6 .6 .61 .61 .61
 .62 .62 .63 .63 .65 .65 .65 .66 .66 .67
 .68 .68 .7 .71

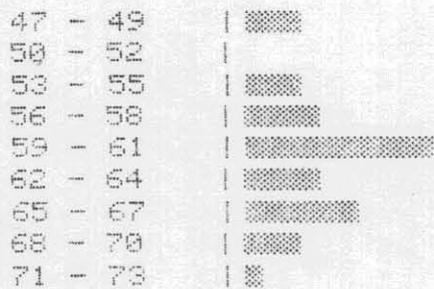
Number of values= 34

MEAN OF VALUES .604

STD DEVIATION .059

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100



5 cm

YOLLA #1

2372-2381 M

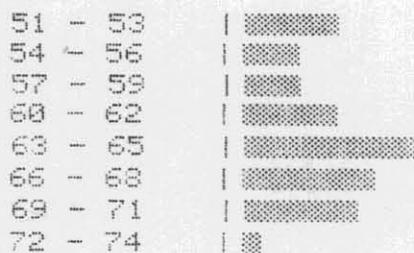
SORTED LIST

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 .59 .6 .6 .6 .6 .62 .63 .63 .64 .64
 .64 .65 .65 .65 .65 .66 .66 .67 .67 .67
 .67 .68 .69 .69 .7 .71 .71 .71 .72
 Number of values= 39

MEAN OF VALUES .626
 STD DEVIATION .06

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100



← 5 cm →

YOLLA #1

2774-2783 M

SORTED LIST

.59 .66 .72 .75 .79 .8 .81 .82 .82 .86
 .89 .91 .92 .93 .93 .94 .94 .94 .94 .95
 .97 .98 1.02

Number of values= 23

MEAN OF VALUES .864
 STD DEVIATION .107

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

59 - 63	■
64 - 68	■
69 - 73	■
74 - 78	■
79 - 83	■■■■■
84 - 88	■
89 - 93	■■■■■
94 - 98	■■■■■■
99 - 103	■

5 cm

YOLLA #1

2962-2971 M

SORTED LIST

.57 .63 .65 .7 .71 .73 .81 .81 .82 .83
 .86 .87 .87 1.03

Number of values= 14

MEAN OF VALUES .778

STD DEVIATION .116

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

57 - 61	■
62 - 66	■■■
67 - 71	■■■■
72 - 76	■
77 - 81	■■■
82 - 86	■■■■
87 - 91	■■■
92 - 96	
97 - 101	
102 - 106	■

5 cm

YOLLA #1

3034-3043 M

SORTED LIST

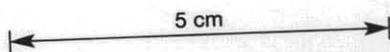
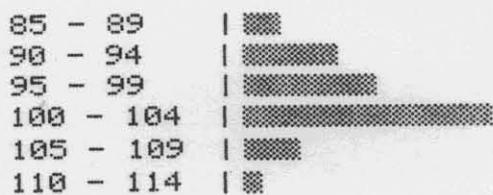
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 .96 .96 .96 .98 1 1 1.01 1.01 1.01 1.02
 1.02 1.02 1.02 1.03 1.03 1.04 1.04 1.05 1.05 1.05
 1.1

Number of values= 31

MEAN OF VALUES .984
 STD DEVIATION .059

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100



YOLLA #1

2731 M

SORTED LIST

.82 .83 .85 .89 .9 .92 .94 .94 .96 .97
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 1.06

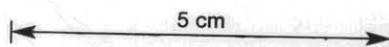
Number of values= 31

MEAN OF VALUES .969
 STD DEVIATION .059

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

82 - 86		██████
87 - 91		████
92 - 96		██████
97 - 101		████████████████████
102 - 106		██████████



5 cm

YOLLA #1

2885 M

SORTED LIST
.69 .72 .75 .78 .78 .8 .82 .84 .85 .9
.97
Number of values= 11

MEAN OF VALUES .809
STD DEVIATION .076

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100

69 - 73	■■■■
74 - 78	■■■■■
79 - 83	■■■■
84 - 88	■■■■
89 - 93	■■
94 - 98	■■

← 5 cm →

YOLLA #1

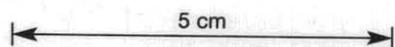
2945.0 M

SORTED LIST
.65 .69 .7 .71 .76
Number of values= 5

MEAN OF VALUES .702
STD DEVIATION .035

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100

65 - 69	■■■
70 - 74	■■■
75 - 79	■



5 cm

YOLLA #1

3028 M

SORTED LIST

.46 .49 .5 .5 .51 .51 .52 .53 .53 .53
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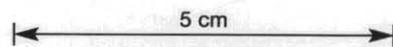
Number of values= 34

MEAN OF VALUES .561
 STD DEVIATION .041

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

46 - 50		██████████
51 - 55		██████████████████
56 - 60		██████████████████████████████
61 - 65		██████████



5 cm

208028

APPENDIX 2 - PLATES

5 cm

308029

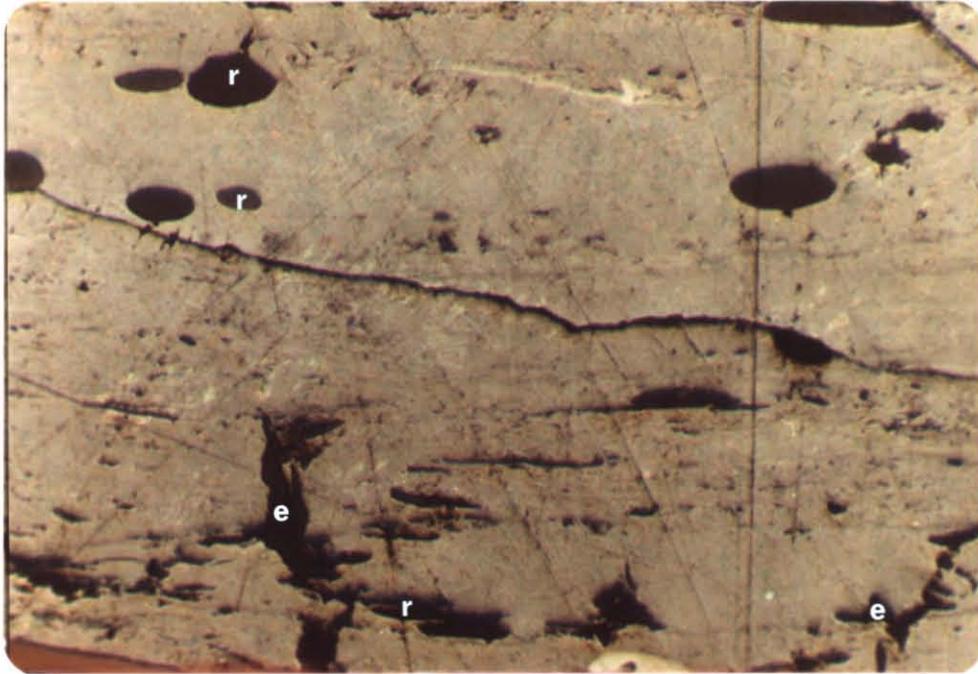


PLATE 1: 1958-67 m

Reflected Light

This plate shows exsudatinite (E) (primary oil). Forming from resinite (R) in a coal fragment consisting largely of vitrinite (grey). Inertinite (white, top centre) is a minor component of this coal.

Field Dimensions 0.43 mm x 0.29 mm.



PLATE 2: 1958-67 m

Fluorescence Mode

This is the same field as plate 1 in fluorescence mode illustrating the moderate orange fluorescence of the exsudatinite and the variable fluorescence of the associated resinite.



PLATE 3: 1958-67 m

Reflected Light

Oil occurs in this siltstone adjacent to the coal stringers.
Field Dimensions 0.43 mm x 0.26 mm.

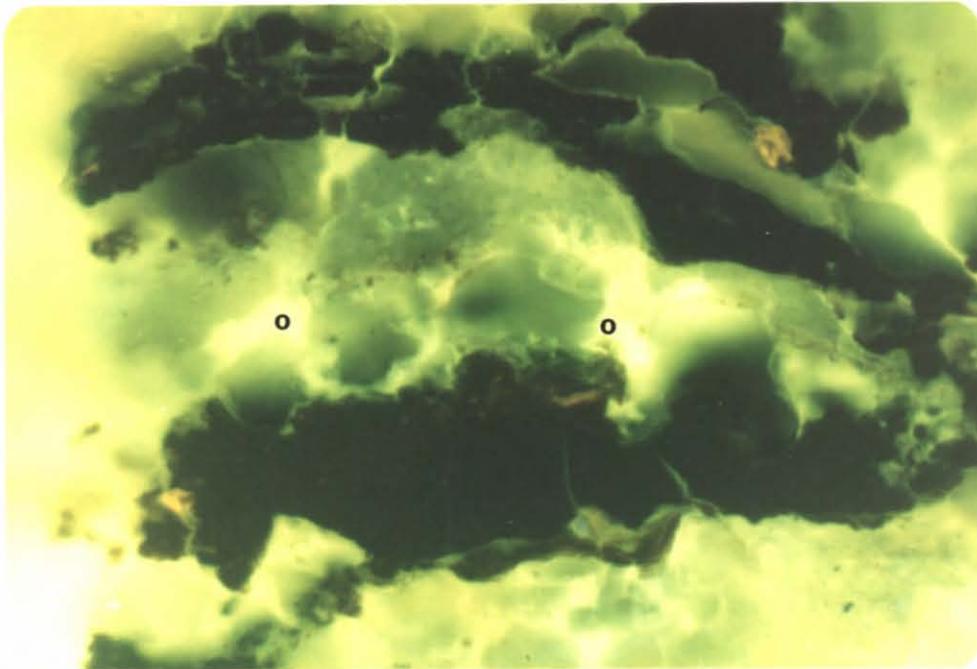


PLATE 4: 1958-67 m

Fluorescence Mode

The intensely fluorescing oil (o) is clearly distinguished in fluorescence mode, interstitial to the quartz grains.

5 cm

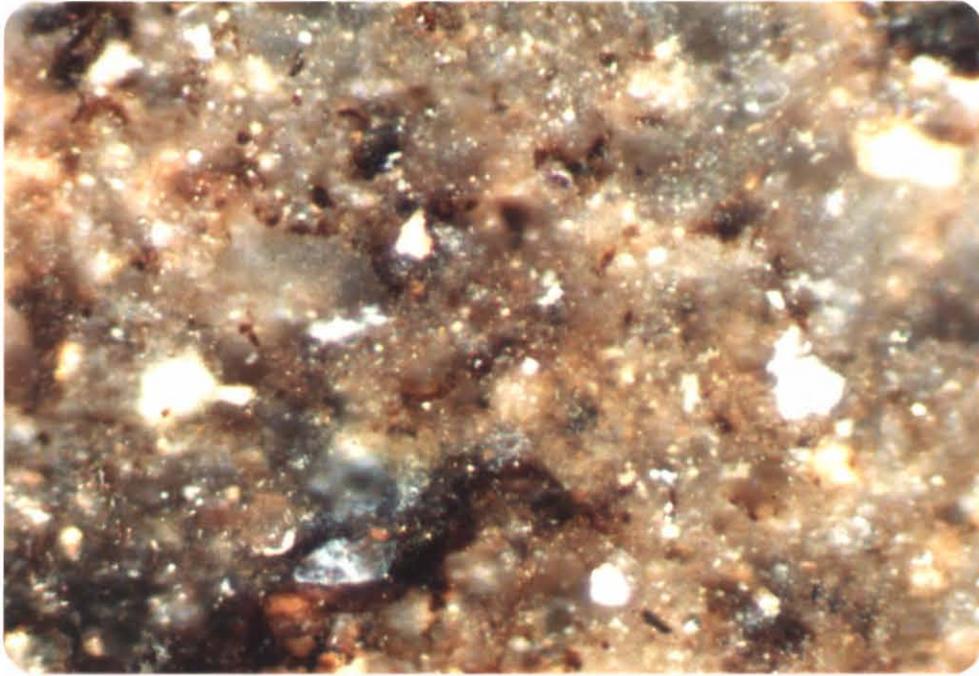


PLATE 5: 2372-81 m

Reflected Light

Oil in this silty shale fragment has an intense green fluorescence (plate 6).
Field Dimensions 0.26 mm x 0.18 mm.

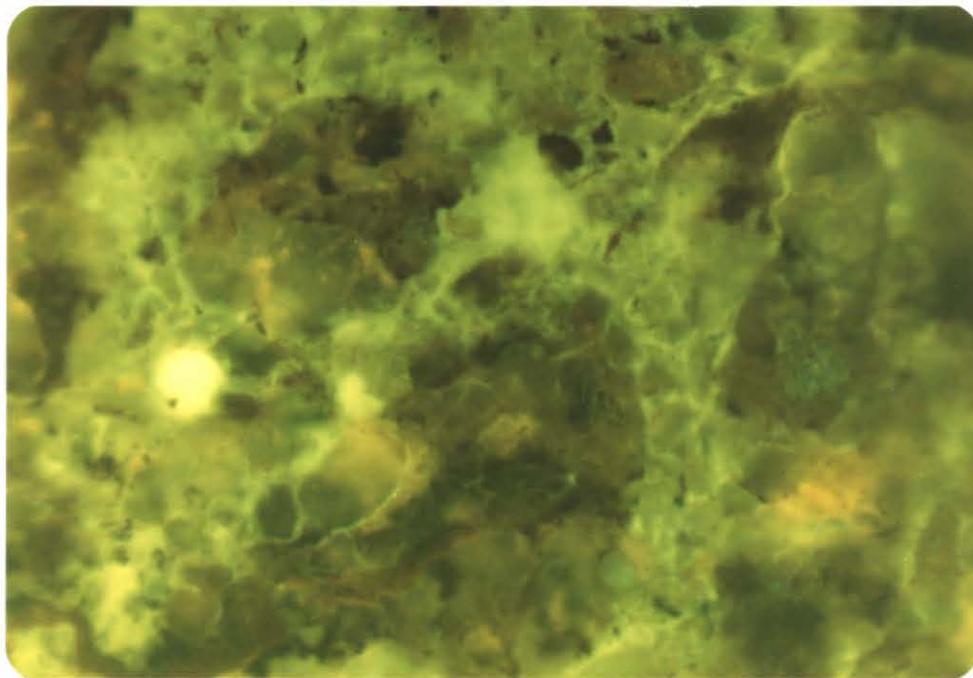


PLATE 6: 2372-81 m

Fluorescence Mode

The distribution of oil in this shale suggests a patchy distribution of inter-connected porosity.

5 cm

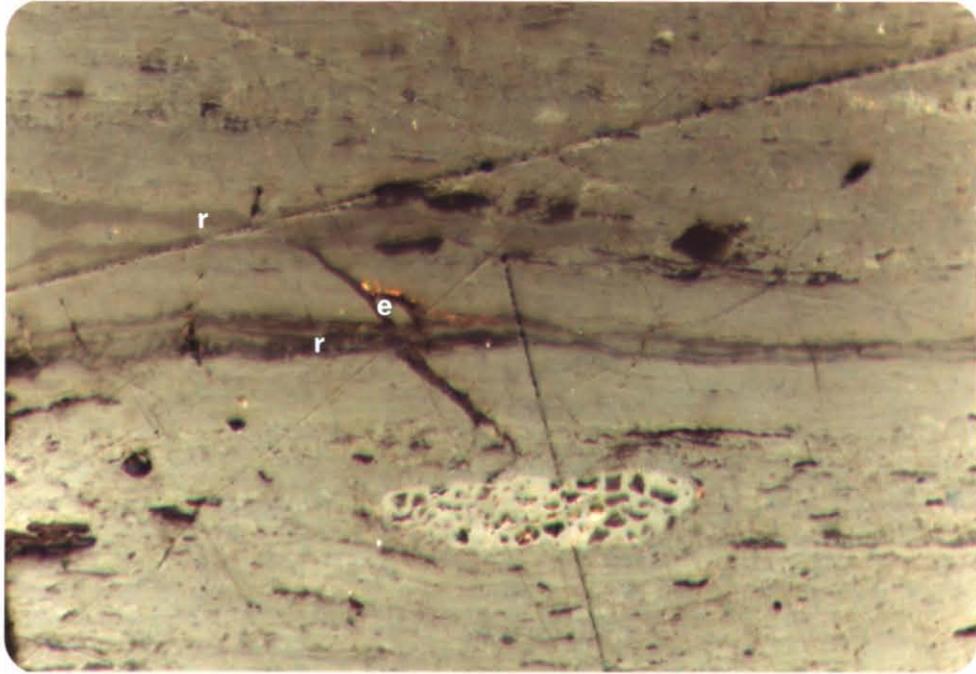


PLATE 7: 2772-81 m

Reflected Light

Exsudatinite (E) is associated with the resinite (R) in this coal. Inertinite (light grey/white; lower centre) is sclerotinite (fungal remains).

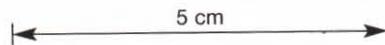


PLATE 8: 2772-81 m

Fluorescence Mode

The dull fluorescence of the resinite in this coal is expected at this maturity. Sporinite occurs towards the lower left hand corner of this plate.

5 cm

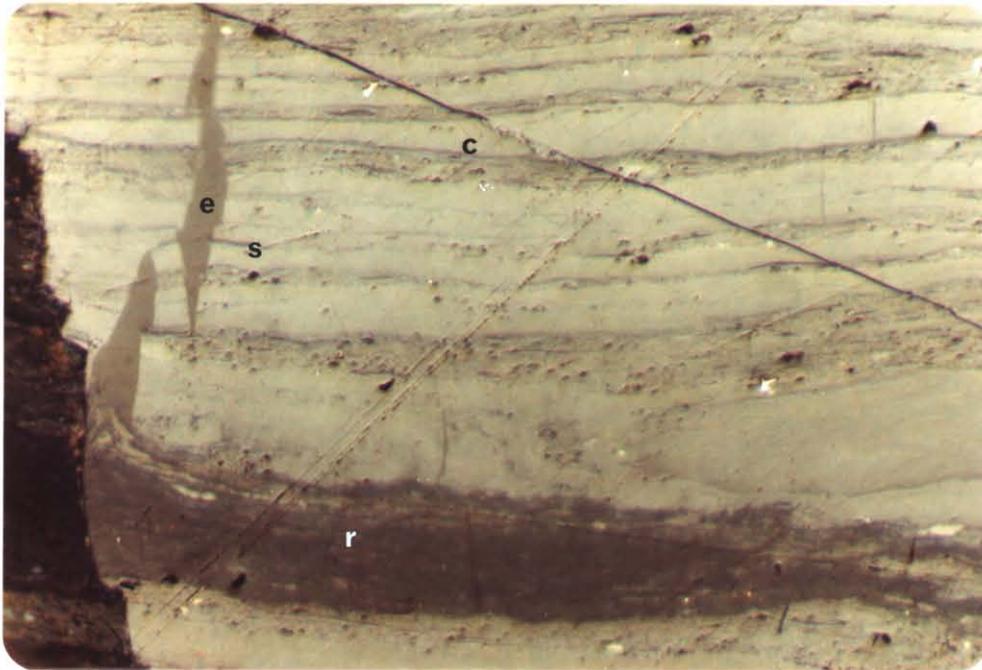


PLATE 9: 3034-43 m

Reflected Light

This plate shows exsudatinite (E), resinite (R), sporinite (S) and cutinite (C) occurring in a coal fragment consisting largely of vitrinite and exinite.

Field Dimensions 0.43 mm x 0.29 mm

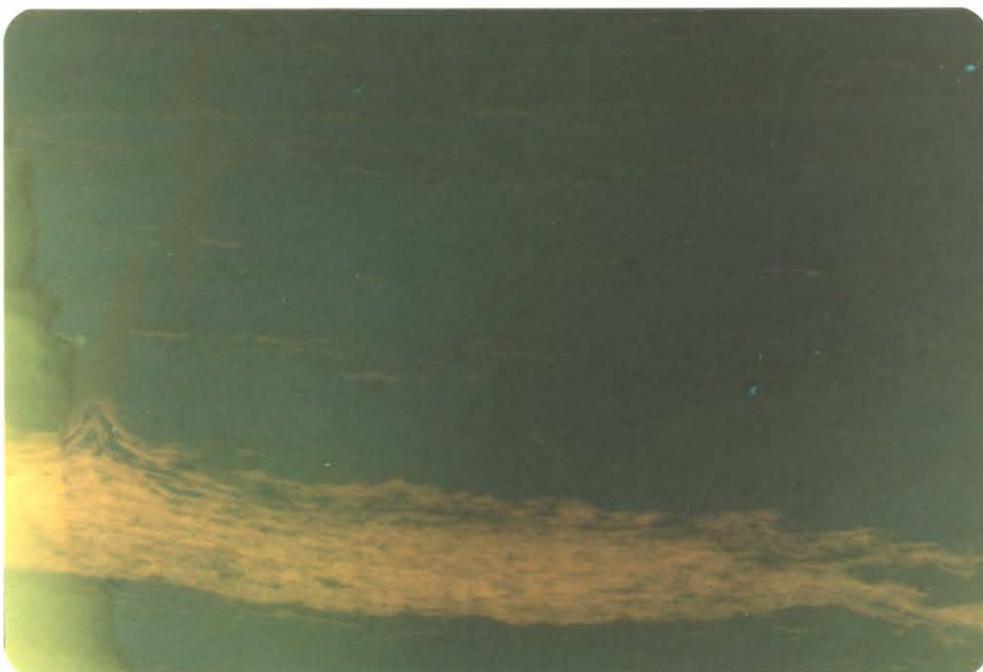


PLATE 10: 3034-43 m

Fluorescence Mode

The dull fluorescence colours of the exinite macerals in this coal is an artefact of this maturity.