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3 March 1986

F 1/1/291
F 6341/86

The Director-General
South Australian Department of Mines
and Energy
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Attention: Dr A.P. Belperio

REPORT F 6341/86

YOUR REFERENCE: 12/07/0016, EX-444

TITLE: Source-rock analysis of Skillogalee Dolomite, Burra Group, Adelaide Geosyncline

MATERIAL: Drill core (6 samples). Outcrop (2 samples).

LOCALITY: WANGIANA 1:100 000 Sheet Area

IDENTIFICATION: As in Table 1

DATE RECEIVED: 8 November 1985

WORK REQUIRED: TOC and Rock-Eval pyrolysis (R7.2). Organic petrology (R3.17). Interpretation

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1. INTRODUCTION

Eight samples of the Late Proterozoic Skillogalee Dolomite from the Willouran Ranges were received for source rock analysis (Table 1). The aim of the investigation was to determine the organic richness, kerogen type and thermal maturity of these Late Proterozoic sediments.

2. ANALYTICAL PROCEDURE

Details of the analytical techniques are given in Appendix 1.

3. RESULTS

Analytical data are summarised and presented herein as follows:

	Table	Plate
TOC, Rock Eval pyrolysis	2	-
Organic petrology		
- reflectance	3,4	-
- dispersed organic matter (DOM)	5	1-5

4. DISCUSSION

4.1 Maturity

The mean maximum reflectance of angular phytoclasts of vitrinite-like organic matter (R_o = 2.3-2.8%: Table 3) and inertinite (R_o = 3.6-4.3%: Table 4) indicates that these rocks are *overmature* with respect to hydrocarbon generation. The reflectance of both maceral types in RS 424 seems anomalously low.

In post-Silurian rocks, vitrinite reflectance values (measured on woody organic matter) in the range 2-3% correspond to maturation levels appropriate for the generation and preservation of dry gas only.

Tmax values are an unreliable measure of maturity for this suite of samples (Table 2) because of poorly defined (or non-existent) S_2 peaks in the Rock-Eval pyrogram. This fact, and pyrolysable carbon values of zero (Table 2), signify the presence of 'burnt out' organic matter.

It is of interest to note that the Tindelpina Shale (Umberatana Group) from the same area contains sub-graphitic kerogen (atomic H/C = 0.19-0.25 : McKirdy *et al.*, 1975). This kerogen rank corresponds to the chlorite zone of lower greenschist facies regional metamorphism.

4.2 Organic Richness

TOC values in the range 0.12–0.90% (Table 2) indicate *poor to fair organic richness*. Six of the samples analysed have organic carbon values in excess of the worldwide average for carbonate rocks (0.33% TOC : Palacas, 1983). However, Rock-Eval pyrolysis data (PC = 0–0.01%; S_1+S_2 = 0–0.03 kg h'cs/tonne: Table 2) indicate negligible source richness for hydrocarbons.

In overmature source rocks of pre-Silurian age, the measured TOC value represents mostly the spent micrinitic residue from the thermal alteration of algal/bacterial organic matter (Jackson *et al.*, 1984; McKirdy *et al.*, 1984a: see also below). The original organic carbon content of such rocks may have been 2–3 times greater than its present value.

4.3 Kerogen Type

The anchimetamorphic grade of these samples precludes determination of their original kerogen type by Rock-Eval pyrolysis (HI = 0–4 : Table 2).

In polished section, the organic matter is seen to comprise inertinite with minor (<5% of DOM) discrete phytoclasts of vitrinite-like material (Table 5). The dominant inertinite maceral is *micrinite* (Teichmuller, 1974). Micrinite is commonly concentrated in thin, wispy stringers parallel to bedding (see e.g. Plages 1, 3 and 4) suggesting that it is a residue of *lamalginite* (alginite B: Hutton *et al.*, 1980), or *bituminite* in the case of the siltstone (RS 436).

Lamalginite is the main component of oil-prone Type I kerogen in Cambrian non-marine carbonates of the Observatory Hill Beds, Officer Basin (McKirdy and Kantsler, 1980; McKirdy *et al.*, 1984b) where it was derived from cyanobacteria and archaebacteria (methanogens, halophiles).

In sample RS 332 (Plate 5), and in parts of most other samples, micrinite is uniformly dispersed throughout the rock matrix. This may be due (at least in part) to disruption of the primary lamellar habit of precursor lamalginite by recrystallisation of carbonate (Plate 2).

5. CONCLUSIONS

Cryptalgal and stromatolitic carbonates and siltstone from the Late Proterozoic Skillogalee Dolomite in the Willouran Ranges contain sufficient organic matter (up to 0.9% TOC) to have been good petroleum source rocks. Original TOC values may have been as high as 2.5%.

Although now completely micrinitised, oil-prone lamalginite (Type I kerogen) was an important component of the original organic matter in the carbonates. In the carbonaceous siltstone, bituminite (Type II kerogen) was probably the primary liptinite maceral.

At their present maturation level, these sediments are (at best) dry gas prone, and their hydrocarbon generating potential is almost totally exhausted.

6. REFERENCES

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TABLE 1: SAMPLES OF SKILLOGALEE DOLOMITE SUBMITTED FOR SOURCE ROCK ANALYSIS

SADME Sample No.	Drillhole/Outcrop	Rock Type
6438 RS 423	WD 035, 70 m	cryptalgal dolomite
424	WD 035, 169 m	cryptalgal dolomite
425	WD 035, 400 m	cryptalgal dolomite
6438 RS 426	WD 036, 75 m	cryptalgal dolomite
427	WD 036, 170 m	cryptalgal dolomite
6438 RS 436	WD 009, 125 m	carbonaceous siltstone
6438 RS 284B	W-046-24	stromatolite
332	W-042-15	cryptalgal dolomite

TABLE 2

AMDEL

ROCK-EVAL PYROLYSIS 25/02/86

Client S.A.D.M.E.

Well SKILLOGALEE DOLOMITE, BURRA GROUP

SAMPLE	*T MAX	S1	S2	S3	S1+S2	PI	S2/S3	PC	TOC	HI	OI
RS 423									0.12		
RS 424									0.23		
RS 425	229	0.00	0.00	4.75	0.00	0.00	0.00	0.01	0.90	0	528
RS 426	297	0.00	0.00	4.32	0.00	0.00	0.00	0.00	0.71	0	608
RS 427									0.38		
RS 436	229	0.00	0.00	1.95	0.00	0.00	0.00	0.01	0.68	0	287
RS 284B	448	0.00	0.03	0.09	0.03	0.00	0.55	0.01	0.81	4	11
RS 332	407	0.00	0.00	0.45	0.00	0.00	0.00	0.01	0.73	0	62

* Unreliable

mean

Range .12 – .90

KEY TO ROCK-EVAL PYROLYSIS DATA SHEET

	PARAMETER	SPECIFICITY
T max	position of S_2 peak in temperature program (^oC)	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 3: SUMMARY OF REFLECTANCE MEASUREMENTS ON VITRINITE-LIKE ORGANIC MATTER, SKILLOGALEE DOLOMITE

Sample No. 6438 RS -	Mean Maximum Reflectance	Standard Deviation	Range	Number of Determinations
423	-	-	-	-
424	1.08	0.02	1.07-1.10	2
425	2.26	0.05	2.20-2.32	4
426	-	-	-	-
427	-	-	-	-
436	2.31	0.07	2.26-2.36	2
284B	-	-	-	-
332	2.79	0.41	2.76-2.82	2

TABLE 4: SUMMARY OF REFLECTANCE MEASUREMENTS ON INERTINITE PHYTOCLASTS, SKILLOGALEE DOLOMITE

Sample No. 6438 RS -	Mean Maximum Reflectance	Standard Deviation	Range	Number of Determinations
423	-	-	-	-
424	1.79	0.44	1.22-2.22	5
425	3.59	0.65	3.34-4.26	7
426	3.80	1.60	2.52-6.62	8
427	4.34	0.40	3.88-4.62	3
436	-	-	-	-
284B	-	-	-	-
332	-	-	-	-

TABLE 5: PROPORTIONS OF LIPTINITE, INERTINITE AND VITRINITE-LIKE MATERIAL IN DISPERSED ORGANIC MATTER, SKILLOGALEE DOLOMITE

Sample No. 6438 RS –	DOM Vol. %	Percentage of DOM		
		V	I	L
423	<0.1	–	100(100)	–
424	<0.5	<<5	>95 (40)	–
425	0.5–1	<5	>95 (95)	–
426	0.5–1	–	100 (95)	–
427	≃0.5	–	100 (95)	–
436	0.5–1	<5	>95 (95)	–
284B	≃1	–	100(100)	–
332	1–2	<<5	>95(100)	–

V = vitrinite-like material

I = inertinite

L = liptinite

( ) percentage of inertinite which is micrinite

PHOTOMICROGRAPHS OF DISPERSED ORGANIC MATTER,
SKILLOGALEE DOLOMITE, WILLOURAN RANGES

Field Dimensions = 0.26 x 0.18 mm

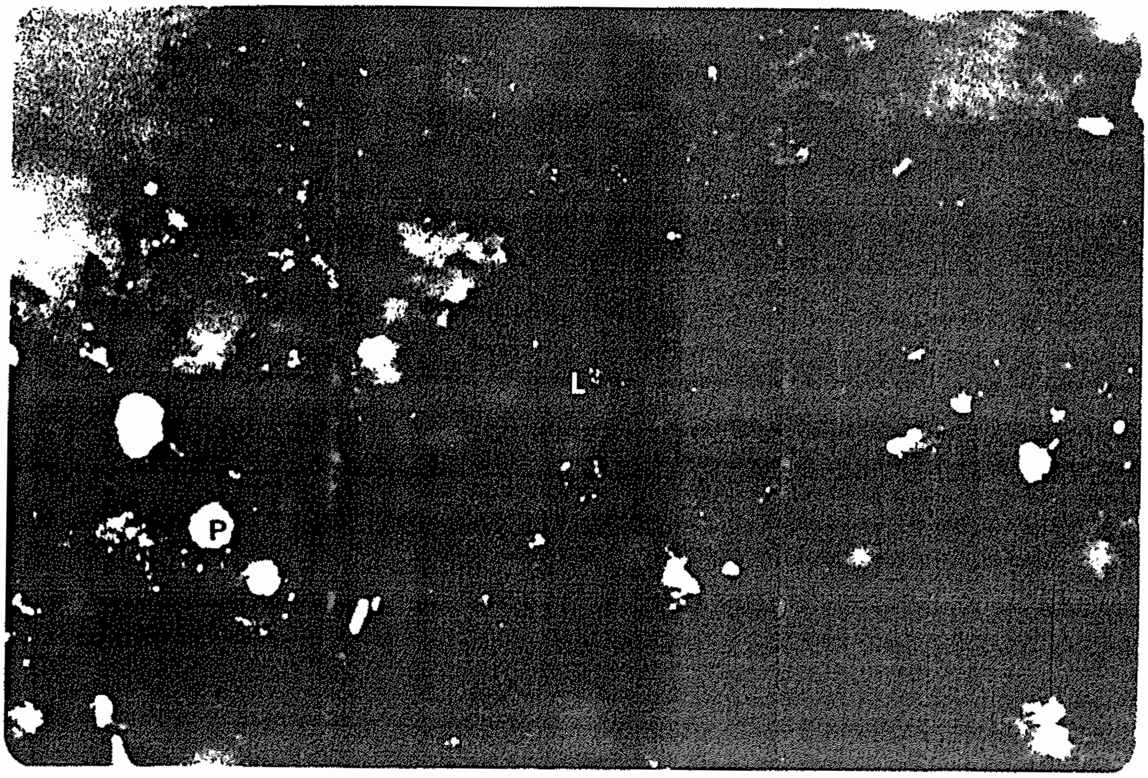

PLATE 1: 6438 RS 423 Reflected Light
Micrinitised lamalginite (L) bordering carbonate grains in dolomite. Organic matter is associated with pyrite (P).

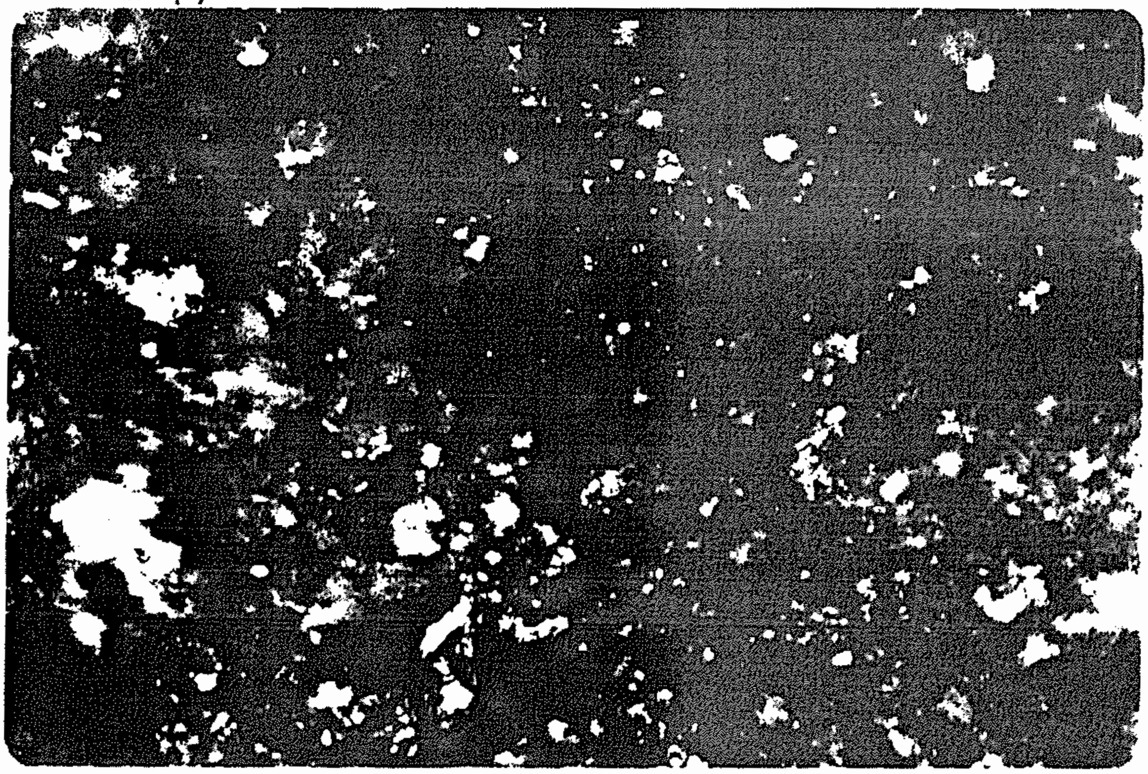

PLATE 2: 6438 RS 424 Reflected Light
Angular phytoclasts of inertinite (I) with dispersed micrinite (<1 μm in diameter, highly reflective) in dolomite.

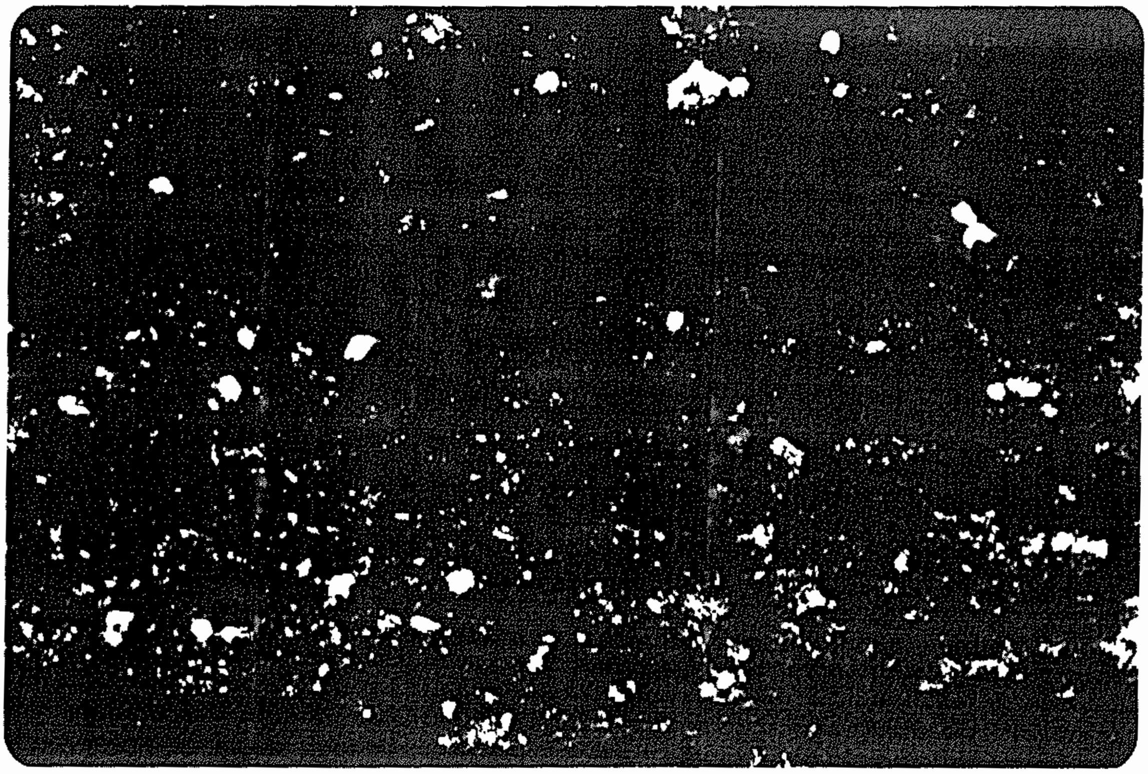

PLATE 3: 6438 RS 426 Reflected light
Micrinite in this siltstone is concentrated in bands up to 0.1 mm thick, and may represent micrinitised bituminite.

PLATE 4: 6438 RS 284B Reflected Light
Dispersed micrinite and micrinitised lamalginite (L) in stromatolitic carbonate.

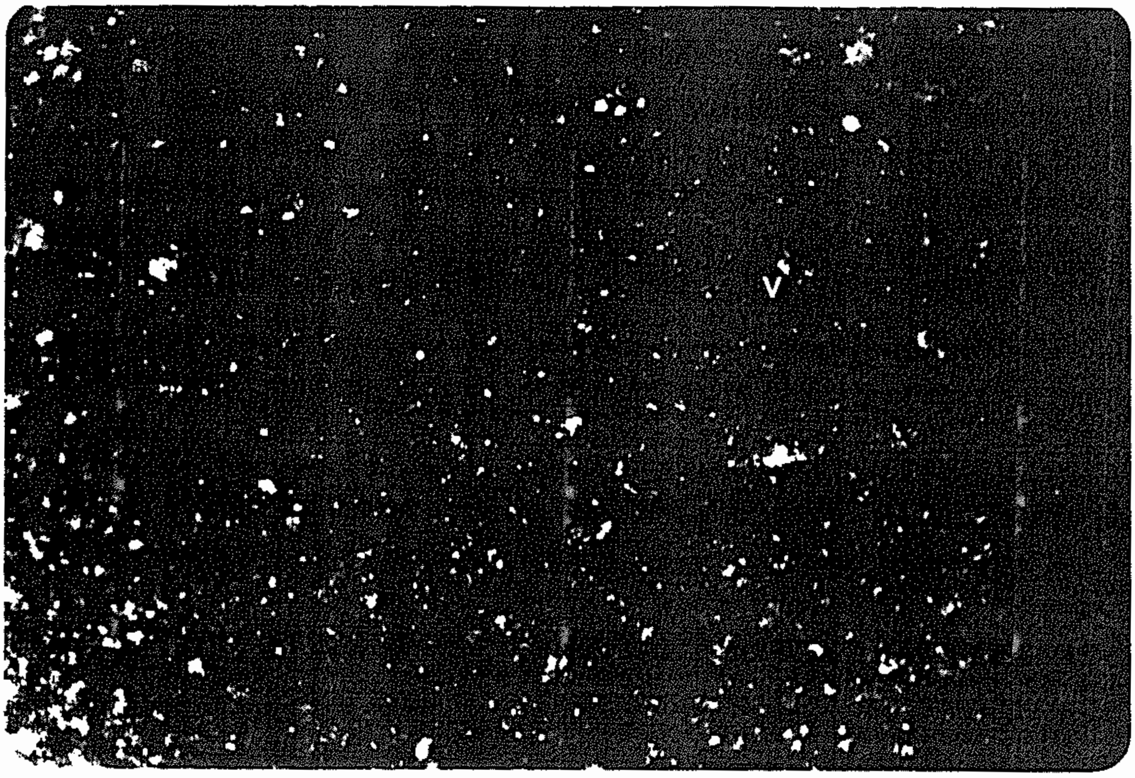

PLATE 5: 6438 RS 332 Reflected Light
Micrinite uniformly dispersed throughout micritic dolomite. Vitrinite-like material (V) is present as small angular phytoclasts.

APPENDIX 1

ANALYTICAL METHODS

1. ORGANIC PETROLOGY

Representative portions of the rock samples (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 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.

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 in the induction furnace of a Leco IR-12 Carbon Determinator and measurement of the resultant CO_2 by infra-red detection.

3. ROCK-EVAL PYROLYSIS

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).