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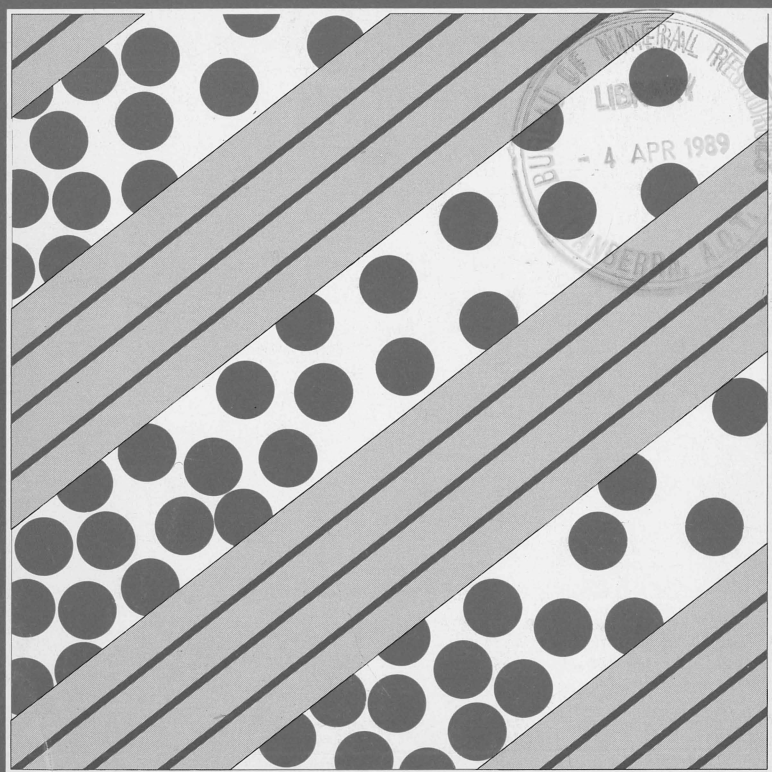
MATURATION LEVELS OF SOME PROTEROZOIC ORGANIC MATTER IN NORTHERN AUSTRALIA: IMPLICATIONS FOR OIL EXPLORATION

I. H. CRICK



BUREAU OF MINERAL RESOURCES
GEOLOGY & GEOPHYSICS
DIVISION OF CONTINENTAL GEOLOGY
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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Maturation levels of some Proterozoic organic matter in northern Australia: implications for oil exploration.

BY

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ABSTRACT

Reflectance measurements and Rock Eval analyses on organic matter contained in fine-grained sediments in core samples from the Proterozoic northern Lawn Hill Platform and eastern Victoria Basin indicate that the organic matter is mature. Any hydrocarbon accumulations that may have occurred in the past would not have become thermally degraded and therefore the oil prospectivity of these regions is enhanced.

Reflectance measurements from the Proterozoic South Nicholson Basin indicates the organic matter is slightly overmature whereas measurements from the central Lawn Hill Platform indicates the organic matter is well overmature.

INTRODUCTION

Most organic matter in Precambrian sediments in Australia is overmature and much of it is clearly graphitic and contained in greenschist or higher metamorphic facies rocks. In such regions, the possibility of finding commercial quantities of hydrocarbons are remote and any oil that may have formed in the past has, at least, been totally thermally degraded. However, in northern Australia large areas of middle Proterozoic sediments are sub-greenschist facies and in the McArthur Basin (Fig. 1) the organic matter is almost immature in places (Crick et al., 1987, 1988; Crick, 1988). Assessment of the level of maturation of organic matter contained in the sediments in any region is therefore the first step towards assessing that regions hydrocarbon potential.

REGIONAL GEOLOGY

Victoria River Basin

The Victoria River Basin (Fig. 1) contains up to 3500 m of mostly flat-lying or very mildly deformed carbonate and terrigenous sequences separated by several disconformities and consisting mainly of sandstone, siltstone, shale, dolomite, claystone and conglomerate (Sweet, 1977; Plumb et al., 1981). Deposition took place between 1300 and 1000 Ma (Page et al., 1984).

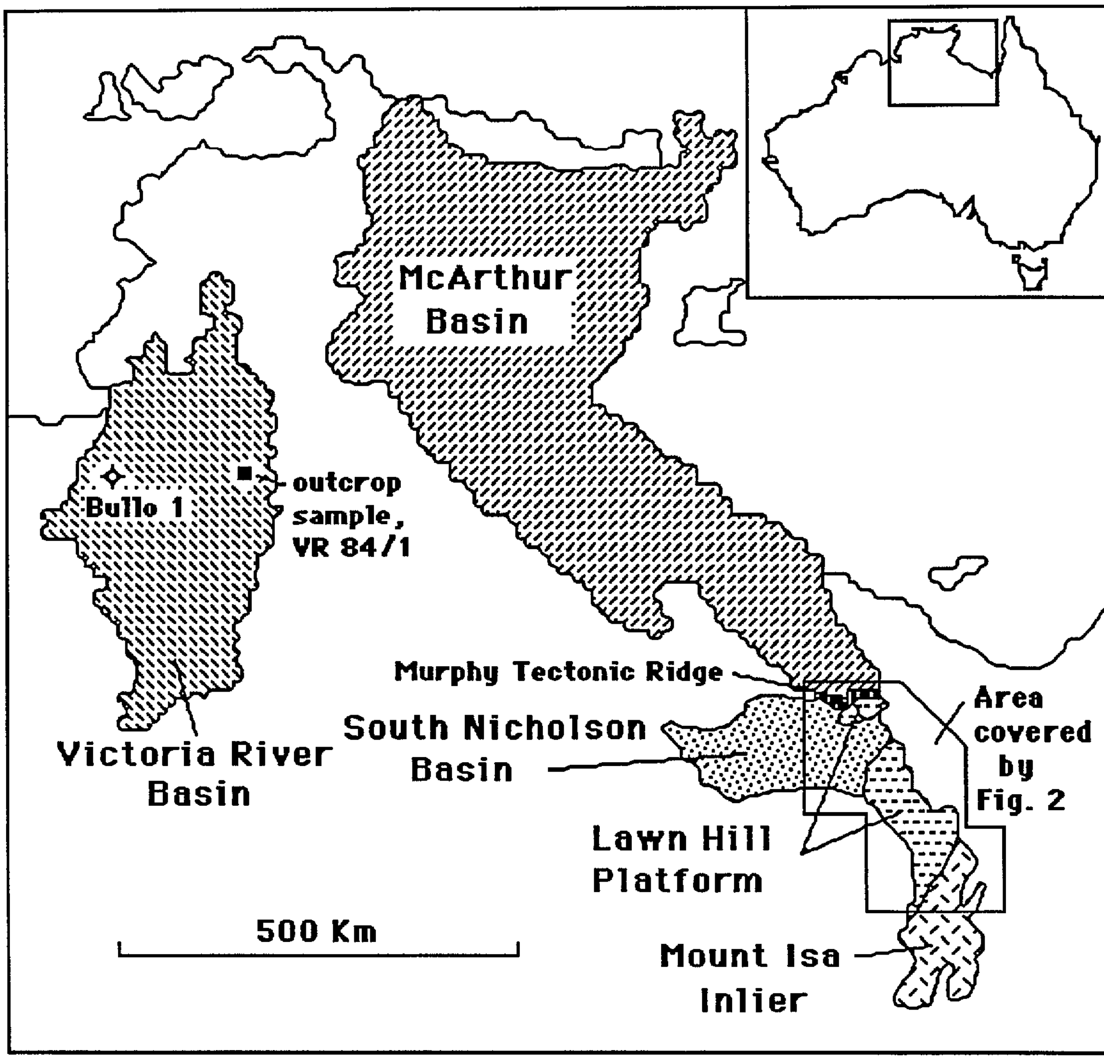

Figure 1. Map of northern Australia showing locations of the Victoria River, McArthur, and South Nicholson Basins, Lawn Hill Platform and Mt Isa Inlier, together with location of the well, Bullo 1, and VR84/1 outcrop sample in the Victoria River Basin.

South Nicholson Basin

Sediments of the South Nicholson Basin (Fig. 1) unconformably overlie the Lawn Hill Platform Cover and consist of alternating sandstones and micaceous siltstones and minor pisolitic iron formations (Plumb et al, 1981; Harms, 1965). The South Nicholson Group is a correlative of the Roper Group in the McArthur Basin to the north (Plumb et al., 1981) which has a minimum depositional age of 1429 ± 31 Ma (Kralik, 1982; Page et al., 1984).

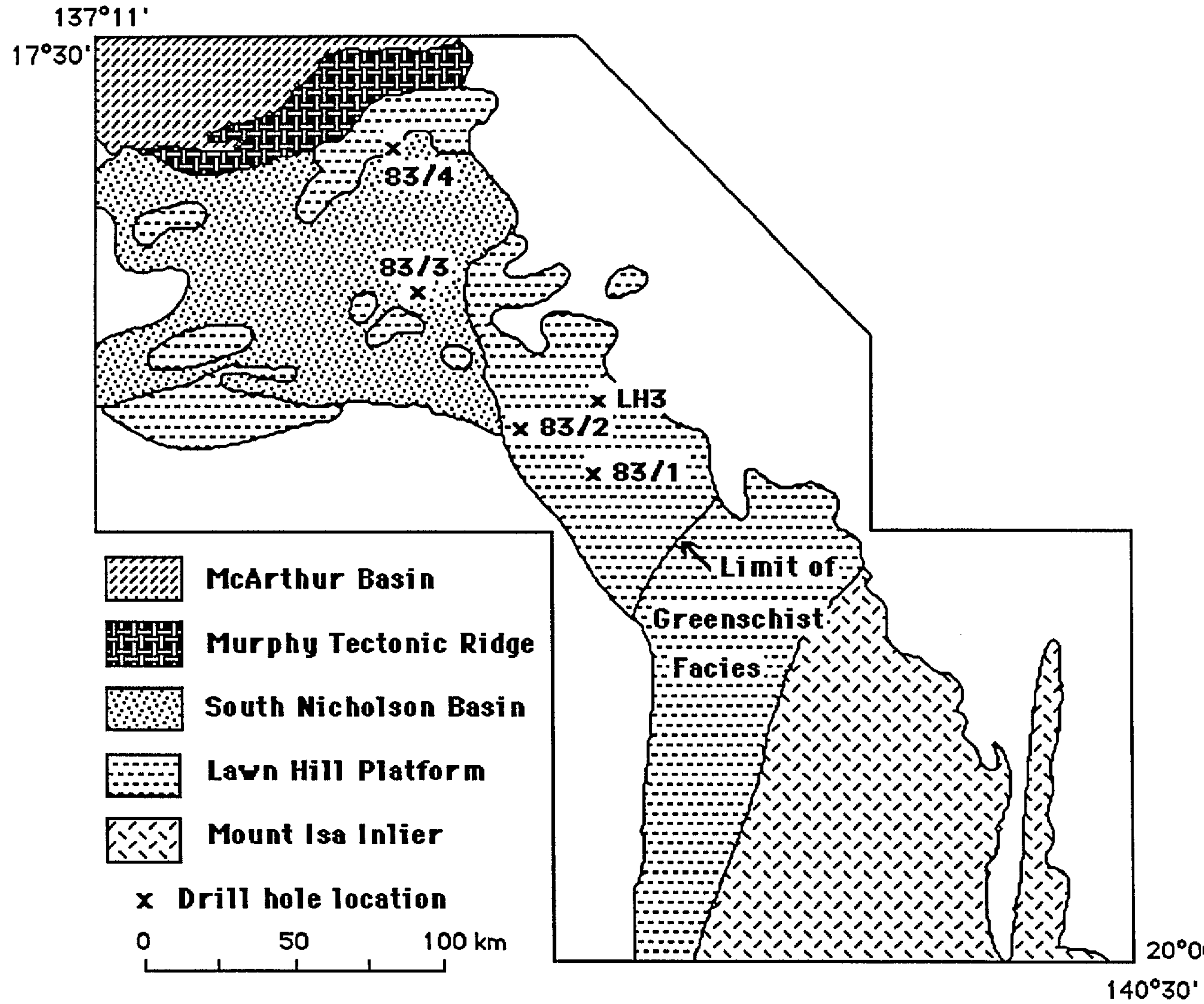

Figure 2. Map (after Blake, 1987) showing location of drill holes in the South Nicholson Basin and Lawn Hill Platform used in this study.

Lawn Hill Platform Cover

The Lawn Hill Platform Cover (Fig. 1) contains up to 8500 m of mainly mildly deformed basal volcanics overlain by carbonates and terrigenous sediments, separated by several unconformities (Hutton and Sweet, 1982). The age of one of the basal volcanic units (Carters Bore Rhyolite) is 1678 ± 1 Ma (U-Pb, zircon) and sedimentation was presumably completed before regional metamorphism between 1620 Ma and 1500 Ma (Page et al., 1984).

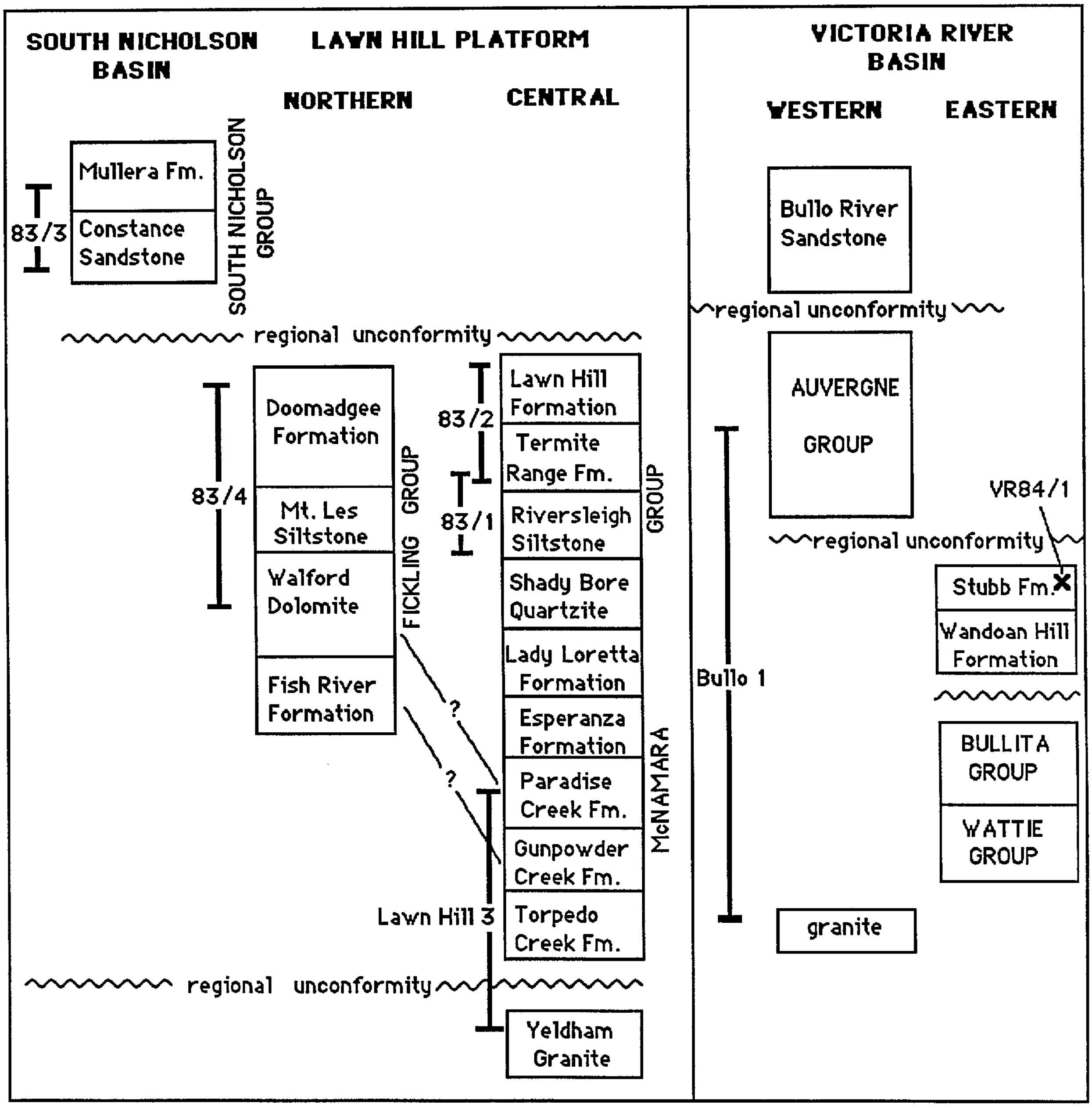

Figure 3. Stratigraphy of the South Nicholson Basin, Lawn Hill Platform (excluding basal sequences) and the Victoria River Basin (after Sweet, 1977; Hutton and Sweet, 1982) showing stratigraphic positions of the drill holes.

SAMPLES AND METHODS

Most samples used in this study come from continuously cored stratigraphic drilling by Amoco and the Geological Survey of Queensland in the Lawn Hill Platform Cover and the South Nicholson Basin (DDH's Amoco 83/1-4, GSQ LH3) and from Queensland Petroleum Pty. Ltd. one dry wildcat well (Bullo 1) in the Victoria River Basin (Figs. 1, 2; App. A). Grey to dark-grey claystone to very fine-grained sandstone were preferentially selected for analyses.

One sample (VR84/1) comes from relatively unweathered outcrop (Ian Sweet, pers comm.) on the eastern side of the Victoria River Basin (Fig. 1; App. A) as no drill core is available from that area.

Samples from the Lawn Hill Platform and South Nicholson Basin were analysed by Rock Eval pyrolysis using standard techniques. Organic petrographic observations were made on polished rock specimens mounted in cold-setting resin using a Leitz Orthoplan Pol microscope in both white and blue-ultraviolet modes. Reflectance measurements were made with a Leitz MPV1 photometer, at x500 magnification using plane-polarized and non-polarized monochromatic light at 543 nm (band-width = 22 nm) and calibrated by McCrone Specular Reflectance Standards (spinel - 0.416%, yttrium aluminium garnet - 0.916%, and gadolinium gallium garnet - 1.710% reflectance).

Maximum reflectance measurements were made on some samples from the Lawn Hill Platform and South Nicholson Basin using plane-polarized incident white light and reflectances using non-polarized incident white light were made on selected samples from all areas. All measurements were made on organic matter perpendicular to bedding.

Measuring maximum reflectances requires rotation of the stage through 360° whilst keeping the measuring field (set at 1μ square) over the surface being measured, which is a precise manual task when small pieces of organic matter are involved, as no microscope stage can be centred perfectly at high magnifications. Measuring reflectances using *non-polarized* incident white light has the advantage that no rotation of the stage is required and is thus considerably easier. However the incident white light is slightly polarized due to reflection off mirror and/or prism surfaces prior to impinging on the sample and thus these measurements are not as precise as maximum reflectances.

RESULTS

The organic matter in these rocks, when examined in reflected light mode perpendicular to bedding, commonly consists of elongate (up to 500μ long), thin (generally1-5μ wide), whisps of black to silvery forms disseminated through the rock together with vitrinite-like irregularly-shaped (generally 1-20μ in size) grains (App. B; Plate 1). None of the organic matter fluoresces although medium to faint mineral fluorescence is common. In one sample from the Doomadgee Formation, northern Lawn Hill Platform (DDH 83/4, 104.6m), highly fluorescing fluid inclusions are evident in some mineral grains indicating the presence of liquid hydrocarbons. Similarly shaped organic matter is observed in

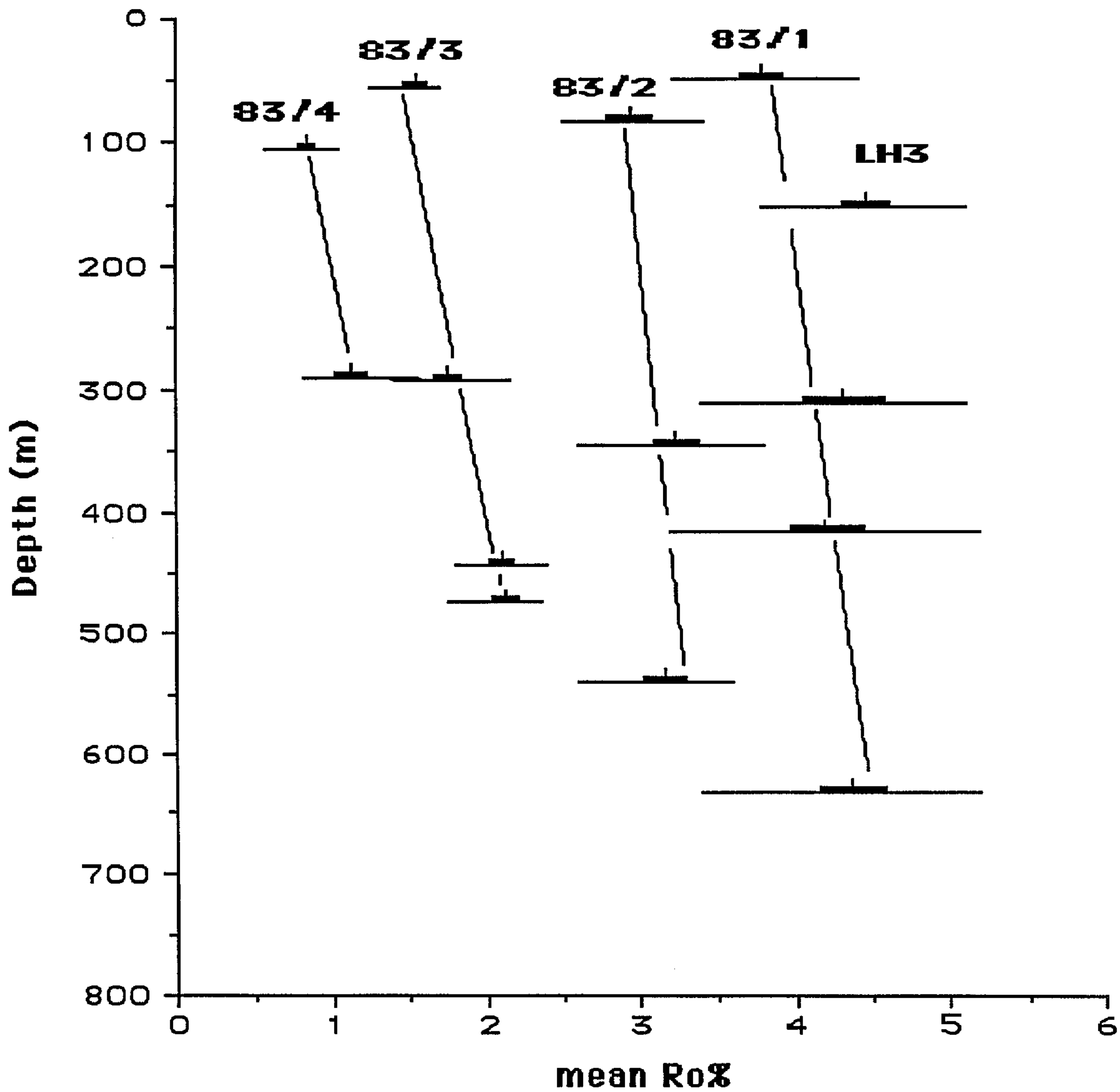

Figure 4. Mean reflectances, measured in non-polarized incident white light (mean Ro%) versus depth for the Lawn Hill Platform Cover and South Nicholson Basin.

the McArthur Basin (Crick et al., 1988) where it is called non-fluorescing lamalginite and bitumen respectively. Bitumen which surrounds mineral grains (matrix bitumen) occurs in a few specimens and vein bitumen occurs in one only. Thucholite grains, formed by the polymerization of bitumen around a radioactive mineral, is also present in a number of the samples (Plate 1-6). Some lamalginite contain central lumens (Plate 1-7) suggesting they have formed from a single cell.

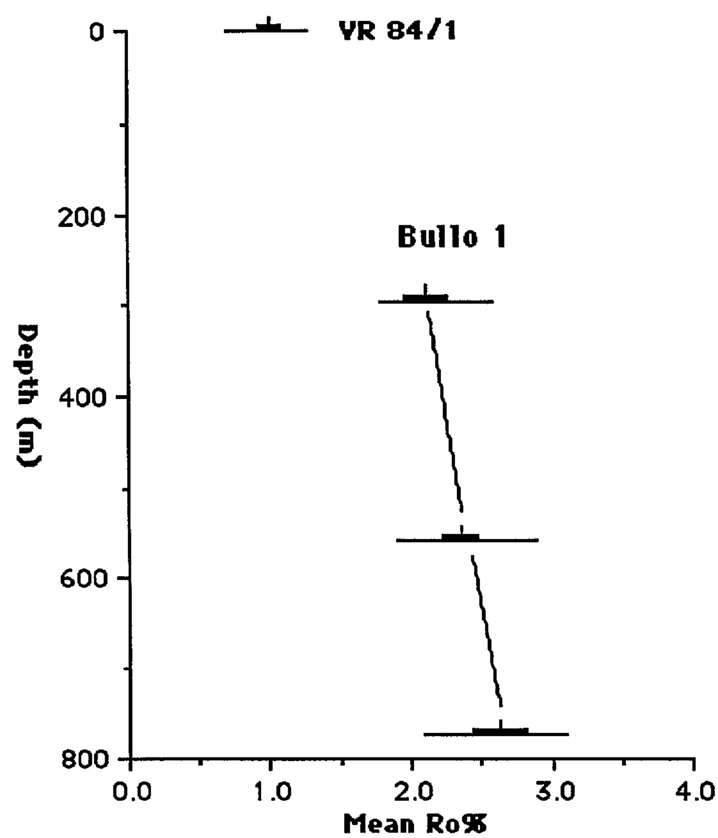

Figure 5. Mean reflectances, measured in non-polarized incident white light (mean Ro%) versus depth for the Victoria River Basin.

Reflectance measurements were made on the lamalginite and bitumen (App. C, D; Figs. 4,5). Mean reflectances, measured in non-polarized white light, range from 0.84% to 4.36% and when these measurements are compared to maximum mean reflectances from the same specimens a good correlation (R=0.98) is obtained (Fig. 6).

The reflectance results for lamalginite and bitumen from the outcrop specimen, VR84/1, have probably not been significantly affected by weathering as research into the effect of weathering on coals has shown that there are no significant differences between vitrinite reflectances from naturally weathered outcrops of coal with that of the same unweathered coal obtained at greater depths (Chandra, 1962).

Rock Eval pyrolysis of samples from the Lawn Hill Platform Cover and the South Nicholson Basin are given in Appendix E. The maturation index, Tmax, derived from Rock-Eval analyses , represents the temperature of maximum evolution of hydrocarbons during pyrolysis (Espitalie et al., 1977). Tmax measurements are unreliable in samples of low pyrolysis yields (<0.2 kg/tonne) and are also affected by the migration of hydrocarbons commonly causing a

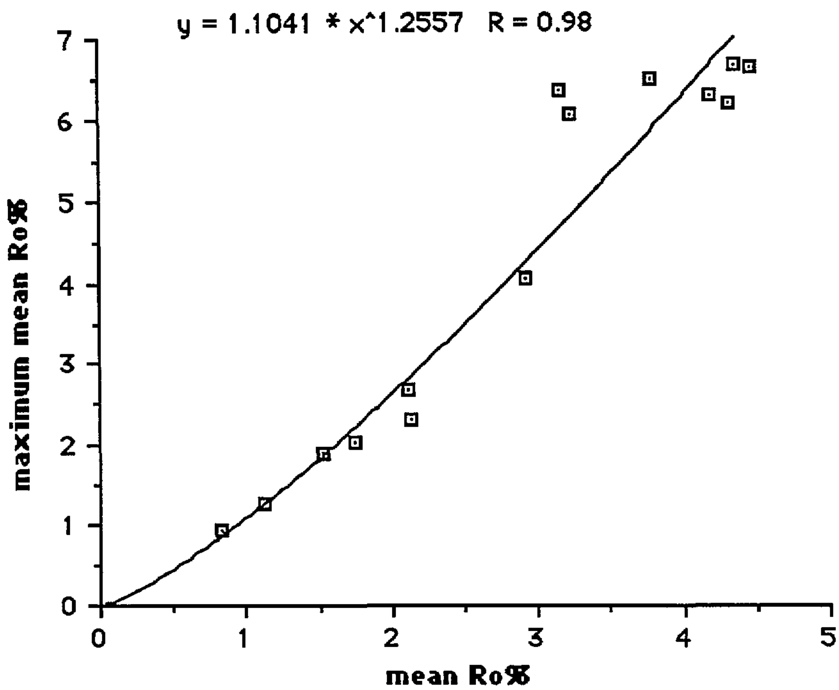

Figure 6. Maximum mean reflectances (maximum mean Ro%) versus mean reflectances measured from incident non-polarized light (mean Ro%) for organic matter in the Lawn Hill Platform Cover and the South Nicholson Basin.

suppression of the Tmax values (Clementz, 1979). The presence of migrated hydrocarbons is indicated from the Production Index (PI) which is the ratio of S1 to S1 + S2 where S1 is the amount of free hydrocarbons released during pyrolysis (Espitalie et al., 1977).

Most of the Tmax values are invalid due to S2 values being less than 0.2 kg/tonne or due to the presence of migrated hydrocarbons (PI > 0.2). Only three samples from the top of DDH 83/3 and two from DDH 83/4 have Tmax values where S2 > 0.2 and PI < 0.2. However, in the case of DDH 83/3, the three values were derived from broad S2 peaks suggesting that residual asphaltenes as well as kerogen is present and are therefore not accurate.

DISCUSSION

In the McArthur Basin, the onset of hydrocarbon generation occurs at a mean maximum reflectance value of about 0.15% for fluorescing lamalginite and a Tmax value of ca. 435° C; the base of the oil-window occurs at a mean maximum reflectance value of about 1.4% for bitumen and/or non-fluorescing lamalginite and a Tmax value of ca. 470°C (Crick et al., 1988). Provided the organic matter

Region/Formation, Maturity	Reflectances (%)		Tmax	Maturity
	mean	max. mean	(°C)	
South Nicholson Basin				
Mullera Formation	1.5	1.9	nrd	overmature
Constance Sandstone	1.8 - 2.1	2.1 -2.7	nrd	overmature
Northern Lawn Hill Platform				
Doomadgee Formation	0.8	0.9	456	mature
Mt Les Siltstone	1.1	1.2	459	mature
Central Lawn Hill Platform				
Lawn Hill Formation	2.9, 3.2	4.0, 6.1	nrd	overmature
Termite Range Formation	3.2, 3.8	4.8, 5.9	nrd	overmature
Riversleigh Siltstone	4.2 - 4.4	6.3, 6.7	nrd	overmature
Gunpowder Creek Formation	4.5	6.6	nrd	overmature
Victoria River Basin				
Angalarri Siltstone	2.1 - 2.6	2.8-3.7	nrd	overmature
Stubb Formation	1.00	1.1	nrd	mature

Table 1. Maturation levels for organic matter in the South Nicholson Basin, Lawn Hill Platform and Victoria River Basin. (nrd = no reliable data; maximum mean values are those measured except for the Victoria River Basin which are calculated).

in the Proterozoic rocks discussed here behaves in a similar manner to that of the McArthur Basin with respect to these maturation indices, then organic matter from the Stubb Formation, Doomadgee Formation and Mt Les Siltstone are within the oil window whereas the remainder are overmature (Table 1).

The differences in maturation levels of organic matter from the Lawn Hill Platform and South Nicholson Basin can probably be explained mostly in terms of depth of burial and a relatively similar geothermal history. The Lawn Hill Platform Cover is thinnest adjacent to the Murphy Tectonic Ridge and thickens considerably towards the central Lawn Hill Platform where it reaches a maximum thickness of 8500 m (Hutton and Sweet, 1982). It is likely that no great thicknesses of younger rocks ever overlay the Fickling Group in the northern Lawn Hill Platform as the organic matter observed in it is mature and not overmature. Organic matter in the South Nicholson Group has slightly higher maturation levels than in the older Fickling Group suggesting that it was more deeply buried but these levels are significantly less than levels in the McNamara Group from the central Lawn Hill Platform.

In the Victoria River Basin, it is likely that no great thicknesses of sediments ever overlay the Stubb Formation in the east. However in the west, the Auvergne Group and younger sediments were significantly thicker or palaeogeothermal gradients were higher than to the east given the greater maturation level of organic matter from DDH Bullo 1.

CONCLUSIONS

1. Organic matter maturation levels for the northern Lawn Hill Platform near the Murphy Tectonic Ridge and on the eastern side of the Victoria River Basin are mature and therefore any hydrocarbons that may have accumulated in these regions would not have been thermally degraded. The potential for finding hydrocarbons in these regions is therefore enhanced.

2. Maturation levels from the South Nicholson Basin are just overmature and there may be areas where the organic matter is mature within this basin.

3. Maturation levels from the central Lawn Hill Platform and from the Angalarri Siltstone on the western side of the Victoria River Basin are overmature.

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Plate 1. Photomicrographs of organic matter in polished blocks perpendicular to bedding, white reflected light mode; all at the same magnification, scale bars = 20μ.

1-1. Victoria River Basin, Auvergne Group, Angalarri Siltstone; DDH Bullo 1, 557.3m; isolated strands of non-fluorescing lamalginite.

1-2. Victoria River Basin, Stubb Formation, outcrop sample VR 84/1; an isolated strand of non-fluorescing lamalginite.

1-3. Central Lawn Hill Platform, Riversleigh Siltstone; DDH 83/1, 631.0m, strands of non-fluorescing lamalginite.

1-4. Central Lawn Hill Platform, Gunpowder Creek Formation; DDH Lawn Hill 3, 152.7m, vein bitumen.

1-5. Central Lawn Hill Platform, Termite Range Formation; DDH 83/2, 540.2m, matrix bitumen surrounding rounded quartz grains.

1-6. South Nicholson Basin, Mullera Formation, DDH 83/3, 54.7m; a thucholite grain showing a mineral (?zircon) nucleus.

1-7. South Nicholson Basin, Constance Sandstone, DDH 83/3, 292.0m; non-fluorescing lamalginite composed of two bifurcating strands.

1-8. Northern Lawn Hill Platform, Doomaggee Formation, DDH 83/4; a strand of non-fluorescing lamalginite.

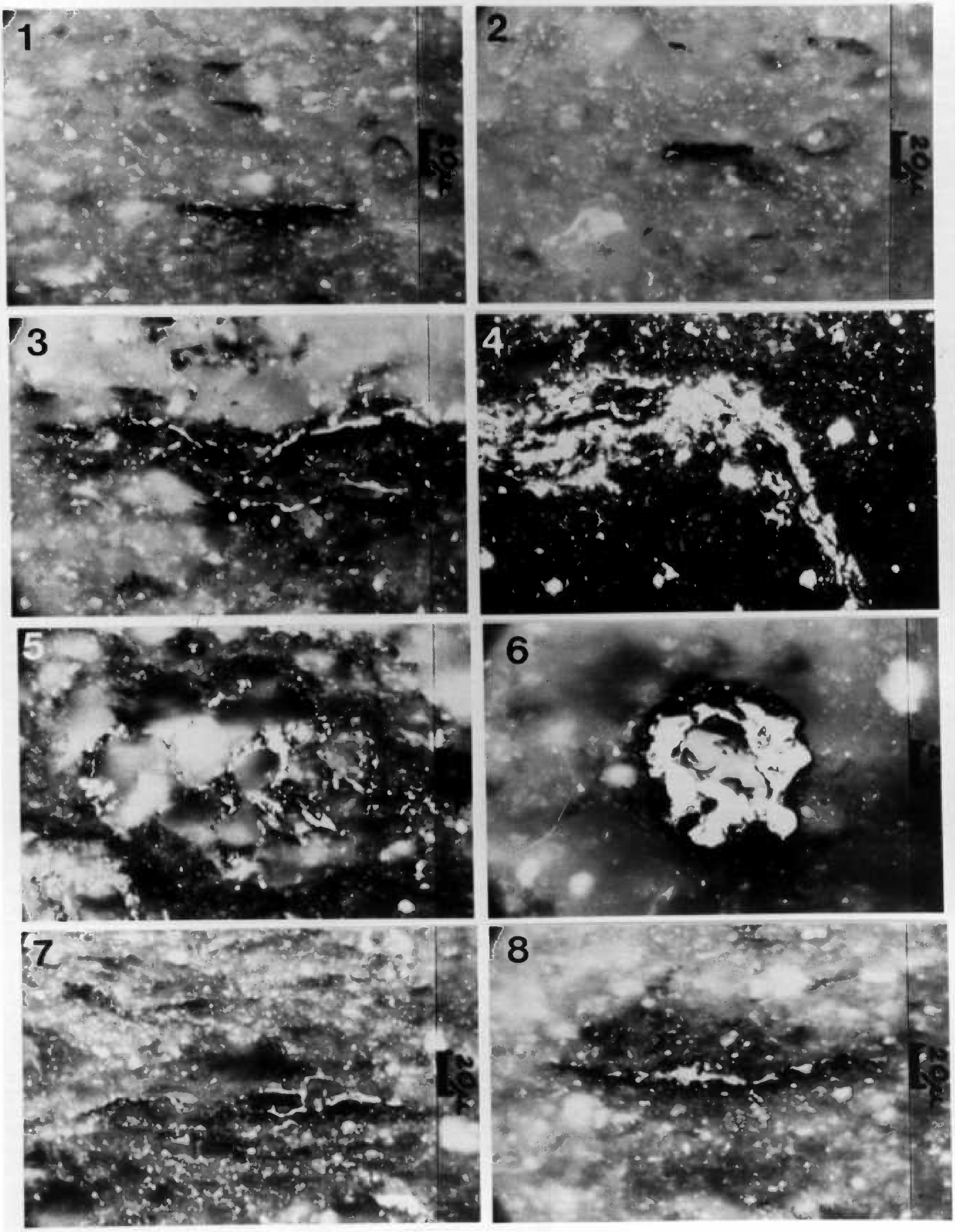

PLATE 1

REGION/DDH/ DEPTH(m)	FORMATION	LAT., LONG.
Central Lawn Hill Platform		
83/1		18°52'S, 138°41'E
0-77.8	Termite Range Fm.	
77.8-655.4 TD	Riversleigh Sltstn.	
83/2		18°45'S, 138°42'E
0-360.9	Lawn Hill Fm.	
360.9-550.4 TD	Termite Range Fm.	
Lawn Hill 3		18°43'S, 138°53'E
0-95	Paradise Creek Fm.	
95-434	Gunpowder Creek Fm.	
434-451	Torpedo Creek Qtzte.	
451-460 TD	Yeldham Granite	
Northern Lawn Hill Platform		
83/4		17°51'S, 138°09'
0-215	Doomadgee Fm.	
215-299	Mt. Les Sltstn.	
299-597.6 TD	Walford Dolomite	
South Nicholson Basin		
83/3		18°20'S, 138°18'S
0-59	Mullera Fm.	
59-574.2 TD	Constance Sst.	
Western Victoria River Basin		
Bullo 1 (pers. comm.	Ian Sweet)	15°36'S, 129°38'S
0-803	Angalarri Sltstn.	
803-880	Jasper Gorge Sst..	
880-969.7 TD	granite (basement)	
Eastern Victoria River Basin		
outcrop sample		
VR 84/1	Stubb Fm.	15°37'S, 131°10'S

APPENDIX A. Location of drill holes and outcrop sample site, with formation logs.

DDH/Depth(m)	Descriptions of Organic Matter	Organic Matter Measured for Reflectances
83 / 1		
49.3	Irregularly shaped bitumen grains up to ca. 30 μ, generally ≤ 10μ, patchy to disseminated.	bitumen
311.5	Irregularly shaped bitumen grains up to ca. 40 μ generally ≤ 10μ, patchy to disseminated.	bitumen
415.8	Irregularly shaped bitumen grains up to ca. 50 μ generally ≤ 7 μ, patchy to disseminated.	bitumen
631.0	Dispersed, non-fluorescing lamalginite up to 200 x 5 μ, generally less than 100 μ long, some disseminated bitumen ≤ 10 μ.	non-fluorescing lamalginite
83 / 2		
84.2	Irregularly shaped bitumen grains up to ca. 10 μ generally ≤ 5μ, patchy to disseminated, in places as matrix bitumen.	bitumen
344.8	Dispersed to patchy bitumen up to ca. 50 μ, some non-fluorescing lamalginite, up to 90 x 20 μ.	non-fluorescing lamalginite bitumen
540.3	Irregularly shaped bitumen grains up to ca. 30 μ generally ca. 15 μ, patchy to disseminated.	bitumen
83 / 3		
54.7	Irregularly shaped bitumen grains up to ca. 30 μ generally ≤ 10μ, patchy to disseminated.	bitumen
292.0	Non-fluorescing lamalginite, commonly thin (≤ 1 μ), wavy, up to ca.100 μ long, some shorter fatter lam., rare double walls, rare disseminated bitumen ≤ 15 μ.	non-fluorescing lamalginite, bitumen
444.4	Non-fluorescing lamalginite up to 250 x 3 μ, generally ≤ 50μ long, rare disseminated bitumen < 10 μ.	non-fluorescing lamalginite bitumen
473.75	Non-fluorescing lamalginite up to 120 μ long, generally ≤ 50 μ long, rare disseminated bitumen < 15 μ, and thucholite.	non-fluorescing lamalginite bitumen
83 / 4		
104.6	Non-fluorescing lamalginite up to 500 x 30 μ, generally ≤ 50 μ long, patchy to disseminated bitumen < 15 μ, rare matrix bitumen and thucholite.	non-fluorescing lamalginite
287.6	Non-fluorescing lamalginite up to 30 x 5 μ, patchy to disseminated bitumen < 5 μ, rare thucholite.	non-fluorescing lamalginite bitumen

APPENDIX B. Petrographic descriptions of the organic matter from the Victoria and South Nicholson Basins, and the Lawn Hill Platform

DDH/Depth(m)	Descriptions of Organic Matter	Organic Matter Measured for Reflectances
Lawn Hill 3		
152.7	Vein bitumen up to 20 μ wide, gradating into matrix matrix bitumen in places.	vein bitumen
Bullo 1		
297.6	Non-fluorescing lamalginite up to 500 x 5 μ, rare disseminated bitumen < 7 μ.	non-fluorescing lamalginite bitumen
557.3	Non-fluorescing lamalginite up to 100 x 5 μ, rare disseminated bitumen < 5 μ.	non-fluorescing lamalginite
772.6	Non-fluorescing lamalginite up to 500 x 3 μ, rare disseminated bitumen < 7 μ.	non-fluorescing lamalginite bitumen
VR 84/1		
outcrop	Non-fluorescing lamalginite up to 50 x 3 μ, rare disseminated bitumen, < 7 μ, and thucholite.	non-fluorescing lamalginite bitumen

APPENDIX B (ctd.). Petrographic descriptions of the organic matter from the Victoria and South Nicholson Basins, and the Lawn Hill Platform.

DDH/Formation	Depth(m)	max mean Ro%	95%min	95%max	X-min	X-max	no.
83/1							
Termite Range Fm.	49.3	6.486	5.846	7.125	5.60	7.40	7
Riversleigh Sltstn.	415.8	6.309	5.831	6.788	5.00	7.40	11
	631.0	6.671	5.978	7.365	5.60	7.80	7
83/2							
Lawn Hill Fm.	84.2	4.057	3.583	4.531	3.40	5.00	7
	344.8	6.067	5.638	6.495	5.20	6.80	9
Termite Range Fm.	540.3	6.360	5.951	6.769	5.40	7.20	10
83/3							
Mullera Fm.	54.7	1.898	1.768	2.028	1.70	2.30	11
Constance Sandstone	292.0	2.057	1.887	2.227	1.70	2.50	10
	444.4	2.690	2.407	2.973	2.00	3.40	10
	473.8	2.311	2.117	2.505	1.80	2.60	9
83/4							
Doomadgee Fm.	104.6	0.926	0.852	1.000	0.68	1.07	12
Mt Les Siltstone	287.6	1.274	1.181	1.367	0.93	1.40	10
LH3							
Gunpowder Creek Fm.	152.7	6.622	5.592	7.652	5.00	9.00	9

APPENDIX C. Mean maximum reflectances measured (max mean Ro%), 95% confidence limits of the means (95%min, 95%max), range (X-max, X-min) and number of measurements (no.).

DDH/Formation	Depth(m)	np mean Ro%	95%min	95%max	X-min	X-max	no.
83/1							
Termite Range Fm.	49.3	3.788	3.657	3.919	3.20	4.40	25
Riversleigh Siltstone	311.5	4.321	4.054	4.588	3.40	5.10	19
	415.8	4.196	3.957	4.435	3.20	5.20	23
	631.0	4.363	4.155	4.570	3.40	5.20	16
83/2							
Lawn Hill Fm.	84.2	2.927	2.789	3.047	2.50	3.40	15
	344.8	3.235	3.096	3.373	2.60	3.80	23
Termite Range Fm.	540.3	3.165	3.038	3.292	2.60	3.60	20
83/3							
Mullera Fm.	54.7	1.531	1.469	1.592	1.24	1.70	22
Constance Sandstone	292.0	1.751	1.668	1.835	1.40	2.16	25
	444.4	2.102	2.037	2.166	1.82	2.40	24
	473.8	2.137	2.066	2.208	1.76	2.36	21
83/4							
Doomadgee Fm.	104.6	0.835	0.780	0.890	0.56	1.02	19
Mt Les Siltstone	287.6	1.115	1.035	1.194	0.84	1.56	22
LH3							
Gunpowder Creek Fm.	152.7	4.461	4.311	4.611	3.80	5.10	23
Bullo 1							
Augalarri Siltstone	297.6	2.108	1.955	2.261	1.80	2.60	13
	557.3	2.353	2.221	2.485	1.90	2.90	19
	772.6	2.629	2.433	2.824	2.10	3.10	14
VR 84/1							
Stubb Fm.	outcrop	1.001	0.937	1.065	0.70	1.28	21

APPENDIX D. Mean reflectances measured from non-polarised incident light (np mean Ro%), 95% confidence limits of the means (95%min, 95%max), range (X-max, X-min) and number of measurements (no.)

APPENDIX E Rock Eval Results

Abbreviations:
S1 = free hydrocarbons released on heating to 300°C
S2 = hydrocarbons released on pyrolysis
S3 = carbon dioxide released on pyrolysis
Tmax = temperature of maximum release of hydrocarbons released on pyrolysis
PI = Production Index
HI = Hydrogen Index
OI = Oxygen Index
TOC = Total Organic Carbon

BASIN VICTORIA RIV WELL BULLO NO 1

ID	DEPTH UD	DEPTH LD	TMAX DEG C	S1 KG PER TONNE	S2 KG PER TONNE	S3 KG PER TONNE	ORG C
		FORMATION					
1683	627.7	627.7	436	0.00	0.00	.11	.17
1684	798.7	798.7	335	0.00	0.00	0.00	.22
1685	696.8	696.8	221	0.00	0.00	0.00	.09
1686	470.4	470.4	177	0.00	0.00	.05	.07
1687	378.4	378.4	222	.10	0.00	0.00	.12
1688	341.1	341.1	277	.20	0.00	.01	.06
1689	772.6	772.6	268	.18	0.00	0.00	.18

VR 84/1

[illegible] M	QTY	TMAX	S 1	S 2	S 3	P I	S2/S3	P C	TOC
VR 84/1	101.4	440	0.01	0.12	4.99	0.08	0.02	0.01	

BASIN LAWN HILL PL WELL 83/1

ID	DEPTH-M UD	DEPTH-M LD	TMAX DEG C	S1 KG PER TONNE	S2 KG PER TONNE	S3 KG PER TONNE	ORG C %
		FORMATION TERMITE RANGE					
1758	49.3	49.3	275	0.00	.02	0.00	0.00
		FORMATION RIVERSLEIGH SST					
1759	311.5	311.5	337	0.00	.04	0.00	0.00
1760	335.8	335.8	275	0.00	.01	0.00	0.00
1761	371.7	371.7	270	.01	.01	0.00	0.00
1762	415.8	415.8	270	.01	.02	0.00	0.00
1763	446.7	446.7	235	0.00	.01	0.00	0.00
1764	631.0	631.0	233	0.00	.01	0.00	0.00

BASIN LAWN HILL PL WELL 83/2

ID	DEPTH-M UD	DEPTH-M LD	TMAX DEG C	S1 KG PER TONNE	S2 KG PER TONNE	S3 KG PER TONNE	ORG C %
		FORMATION LAWN HILL					
1765	84.2	84.2	521	0.00	.11	0.00	0.00
1766	276.8	276.8	319	0.00	.02	0.00	0.00
1767	288.5	288.5	339	0.00	.04	0.00	0.00
1768	319.2	319.2	305	0.00	.02	0.00	0.00
1769	323.7	323.7	346	.01	.06	0.00	0.00
1770	337.1	337.1	299	.01	.03	0.00	0.00
1771	344.8	344.8	275	.02	.06	0.00	0.00
		FORMATION TERMITE RANGE					
1772	479.9	479.9	437	0.00	0.00	0.00	0.00
1773	540.3	540.3	325	0.00	0.00	0.00	0.00

BASIN LAWN HILL PL WELL 83/4

ID	DEPTH-M UD	LD	TMAX DEG C	S1	S2 KG PER TONNE	S3	ORG C %
			FORMATION DOOMADGEE				
1781	92.1	92.1	452	.03	.12	0.00	0.00
1782	104.6	104.6	456	.14	.88	0.00	1.04
1783	110.1	110.1	465	0.00	.12	0.00	0.00
1784	117.4	117.4	467	.33	.54	.24	.68
1785	146.0	146.0	436	.54	1.30	1.86	0.00
1786	149.8	149.8	429	.48	1.47	1.34	0.00
1787	157.0	157.0	447	.43	1.44	.37	0.00
1788	163.6	163.6	440	.74	1.85	.23	0.00
1789	173.9	173.9	443	1.27	2.38	.24	0.00
1790	182.6	182.6	461	8.09	23.38	.77	0.00
			FORMATION MT. LES				
1791	221.9	221.9	454	.43	.58	.30	0.00
1792	224.5	224.5	455	.66	1.21	.22	0.00
1793	229.7	229.7	457	.62	1.03	.14	2.14
1794	237.1	237.1	446	.04	.10	0.00	0.00
1795	250.5	250.5	363	.02	.05	0.00	0.00
1796	285.6	285.6	362	0.00	.06	0.00	0.00
1797	287.7	287.7	459	.34	1.94	1.09	4.07
1798	291.2	291.2	458	.49	1.34	2.74	3.61
1799	295.1	295.1	462	.40	1.10	2.96	2.50
			FORMATION WALFORD DOL				
1800	310.1	310.1	450	.02	.09	2.47	0.00
1801	312.9	312.9	365	.01	.03	2.06	0.00
1802	337.6	337.6	350	.01	.05	1.99	0.00
1803	349.5	349.5	313	.02	.04	1.42	0.00
1804	360.4	360.4	276	0.00	.01	1.46	0.00
1805	528.9	528.9	310	.03	.04	1.08	0.00
1806	564.5	564.5	249	.02	0.00	.71	0.00
1807	572.5	572.5	245	.04	.03	.52	0.00

BASIN LAWN HILL PL WELL 83/4

DEPTH M	ORG C %	S1+S2 KG/T	S2/S3	PI	TMAX DEG C	HI	OI	ID-NO
			FORMATION DOOMADGEE					
92.1	0.00	.15	.	.20	452			1781
104.6	1.04	1.02	.	.14	456	85	0	1782
110.1	0.00	.12	.	0.00	465			1783
117.4	.68	.87	2.25	.38	467	79	35	1784
146.0	0.00	1.84	.70	.29	436			1785
149.8	0.00	1.95	1.10	.25	429			1786
157.0	0.00	1.87	3.89	.23	447			1787
163.6	0.00	2.59	8.04	.29	440			1788
173.9	0.00	3.65	9.92	.35	443			1789
182.6	0.00	31.47	30.36	.26	461			1790
			FORMATION MT. LES					
221.9	0.00	1.01	1.93	.43	454			1791
224.5	0.00	1.87	5.50	.35	455			1792
229.7	2.14	1.65	7.36	.38	457	48	7	1793
237.1	0.00	.14	.	.29	446			1794
250.5	0.00	.07	.	.29	363			1795
285.6	0.00	.06	.	0.00	362			1796
287.7	4.07	2.28	1.78	.15	459	48	27	1797
291.2	3.61	1.83	.49	.27	458	37	76	1798
295.1	2.50	1.50	.37	.27	462	44	118	1799
			FORMATION WALFORD DOL					
310.1	0.00	.11	.04	.18	450			1800
312.9	0.00	.04	.01	.25	365			1801
337.6	0.00	.06	.03	.17	350			1802
349.5	0.00	.06	.03	.33	313			1803
360.4	0.00	.01	.01	0.00	276			1804
528.9	0.00	.07	.04	.43	310			1805
564.5	0.00	.02	0.00	1.00	249			1806
572.5	0.00	.07	.06	.57	245			1807

BASIN LAWN HILL PL WELL LAWN HILL NO 3

ID	DEPTH-M UD	DEPTH-M LD	TMAX DEG C	S1	S2 KG PER TONNE	S3	ORG C %
			FORMATION GUNPOWDER CREEK				
1633	126.1	126.1	403	.21	.09	.25	0.00
1634	152.7	152.7	223	.57	0.00	.24	0.00
1635	160.0	160.0	265	.26	0.00	.18	0.00
1636	410.0	410.0	264	.04	.01	.14	0.00
1637	430.0	430.0	265	.17	0.00	.56	0.00

BASIN SH NICHOLSON WELL 83/3

ID	DEPTH-M UD	DEPTH-M LD	TMAX DEG C	S1	S2 KG PER TONNE	S3	ORG C %
FORMATION MULLERA							
1774	54.7	54.7	463	.03	.33	.07	.70
1889	56.9	56.9	455	.02	.22	0.00	.87
FORMATION CONSTANCE SST							
1775	61.8	61.8	475	.01	.27	.01	0.00
1890	263.2	263.2	474	.01	.09	0.00	0.00
1776	270.9	270.9	359	0.00	.02	0.00	0.00
1891	277.5	277.5	302	0.00	.02	0.00	0.00
1777	296.0	296.0	375	.01	.13	0.00	0.00
1778	444.4	444.4	334	.01	.05	0.00	0.00
1892	450.8	450.8	393	.01	.11	0.00	0.00
1893	452.1	452.1	393	0.00	.10	0.00	0.00
1779	460.3	460.3	347	0.00	.05	.01	0.00
1894	469.2	469.2	412	0.00	.11	0.00	0.00
1780	473.7	473.7	395	.01	.15	0.00	0.00
1895	486.1	486.1	337	.01	.07	0.00	0.00
1896	492.2	492.2	398	.02	.13	0.00	0.00

BASIN SH NICHOLSON WELL 83/3

DEPTH M	ORG C %	S1+S2 KG/T	S2/S3	PI	TMAX DEG C	HI	OI	ID-NO
FORMATION MULLERA								
54.7	.70	.36	4.71	.08	463	47	10	1774
56.9	.87	.24	.	.08	455	25	0	1889
FORMATION CONSTANCE SST								
61.8	0.00	.28	27.00	.04	475			1775
263.2	0.00	.10	.	.10	474			1890
270.9	0.00	.02	.	0.00	359			1776
277.5	0.00	.02	.	0.00	302			1891
296.0	0.00	.14	.	.07	375			1777
444.4	0.00	.06	.	.17	334			1778
450.8	0.00	.12	.	.08	393			1892
452.1	0.00	.10	.	0.00	393			1893
460.3	0.00	.05	5.00	0.00	347			1779
469.2	0.00	.11	.	0.00	412			1894
473.7	0.00	.16	.	.06	395			1780
486.1	0.00	.08	.	.13	337			1895
492.2	0.00	.15	.	.13	398			1896