BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

Record 1981/28

BMR IVANHOE NO.1 WELL COMPLETION REPORT

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CONTENTS

ABSTRACT

BMR Ivanhoe No. 1 is a 305 m well which was drilled by the Bureau of Mineral Resources as part of a source rock study of the Darling Basin. The well intersected a 301 m sequence of hard, tight, grey siltstone and black shale belonging to the Early Devonian Amphitheatre Formation, below 4 m of Quaternary sand. The sequence reflects dominantly open, shallow marine conditions, but becomes paralic towards the top of the cored section. Geochemical analyses of the core show that the siltstone is tight, and that the black shale contains a generally low amount of total organic carbon. The source rock potential of the core is lean to fair.

INTRODUCTION

BMR Ivanhoe No. 1 is a shallow stratigraphic well, located in western New South Wales between the towns of Cobar and Ivanhoe (Fig. 1). The well was drilled as part of an investigation of the petroleum potential of the Darling Basin. Results of this study are presented in Lockwood and others (in prep.). The main objective of the drilling was to obtain core from the Lower Devonian Amphitheatre Formation suitable for geochemical analysis. Secondary objectives were to obtain further information on the environment of deposition, on diagenesis, and on the age of the Amphitheatre Formation; and thermal gradient data for use in heat flow studies.

The well was sited on the eroded core of an anticline, and lies 41.5 m west of the Texam Oil Corporation's well, Berangabah No. 1. Access to the area is by unsealed shire roads, good station tracks on the Berangabah property, and the remnants of an old access track to the Berangabah well site. Drinking and drilling water was readily available from nearby water tanks.

WELL HISTORY

GENERAL DATA

Well name and number	:	BMR Ivanhoe No. 1
Location	:	Lat. 32°17' 27.64"S, Long. 144°28' 18.28"E; Ivanhoe 1:250 000 sheet
Elevation	:	117.3 m G.L.
Basin	:	Darling Basin, New South Wales
Total depth	:	305 m
Date drilling commenced	:	November 3, 1979
Date drilling completed	:	November 29, 1979
Status	:	Capped and used for thermal gradient measurements

DRILLING DATA

Drilling by	:	Bureau of Mineral Resources
Drill plant	:	Mayhew 1000 Rated capacity : 305 m
Drilling fluid	:	Air : 0-32 m Mud : 32-305 m. A barytes/bentonite mud solution was used
Casing	:	35 m of casing was set and cemented to surface

The well lost circulation between 56.6 m and 59.3 m. However, a more concentrated mud solution was sufficient to seal off the zone and restore circulation. No significant water aquifers, similar to those in Berangabah No. 1 (Ranneft, 1968), were intersected in BMR Ivanhoe No. 1.

CORING AND LOGGING

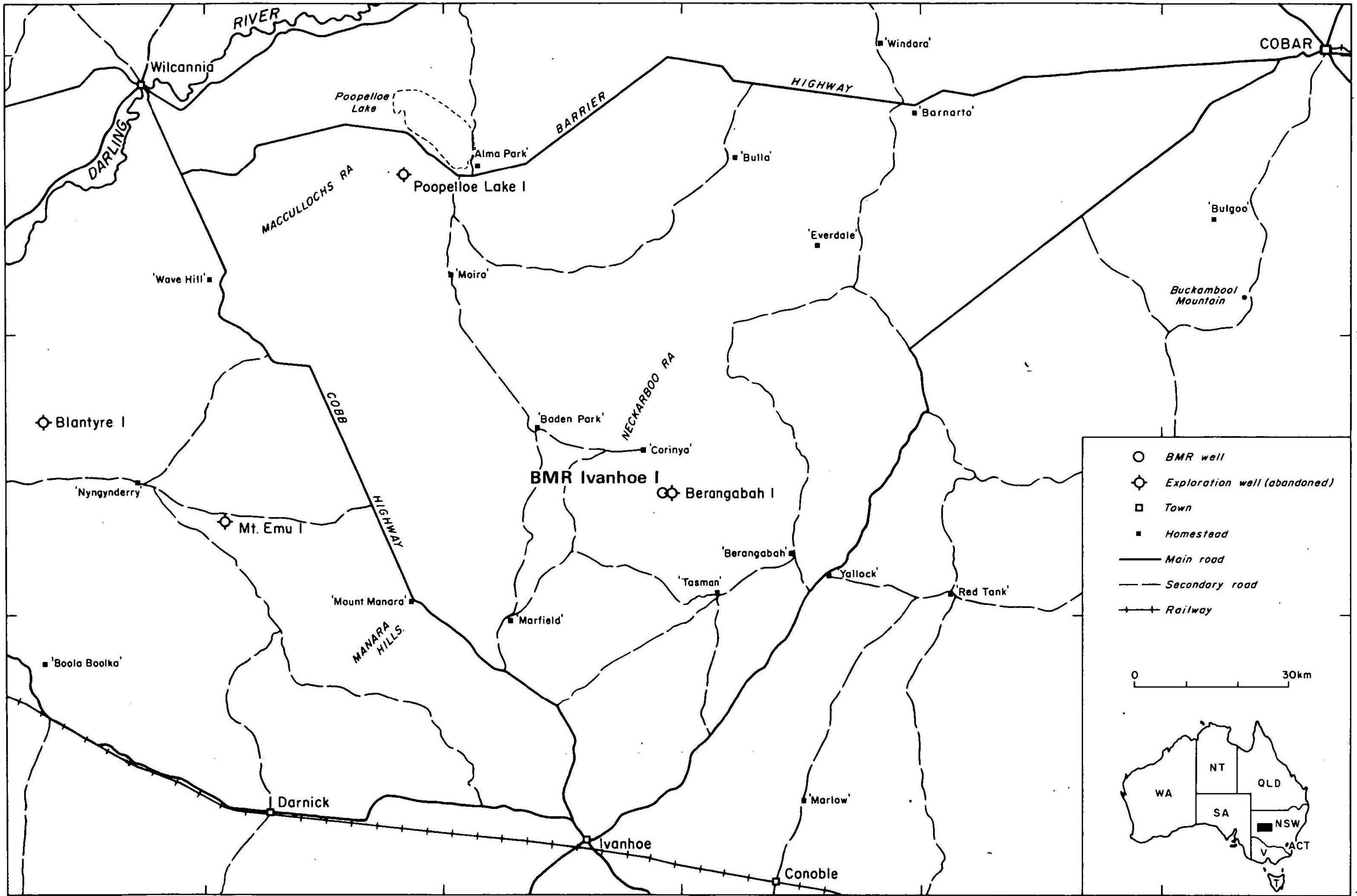
Most of the well was continuously cored. Drilling in the hard Devonian rock was very slow and it proved to be faster to core continuously, using a wireline core barrel with a diamond bit, than to drill with a tungsten bit. From 50.9 m to total depth (305 m) the well was continuously cored; above that depth it was spot-cored using a split tube core barrel (Fig. 2). Recovery was 100 percent, except over the interval where circulation was lost and no core recovered. Samples were obtained from the core and submitted for palaeontological examination and geochemical analysis. The depths of samples taken for each purpose are illustrated on Figure 3.

Gamma ray, neutron, spontaneous potential, resistivity, temperature, and differential temperature logs were run from surface to total depth (Figure 3).

GEOLOGY

BMR Ivanhoe No. 1 intersected sedimentary rocks of the Devonian Amphitheatre Formation below a thin veneer of Quaternary alluvium. The Amphitheatre Formation is dominantly composed of a hard, dense, siliceous, grey siltstone, that is calcareous in some parts of the sequence, and abundantly fossiliferous, particularly below 100 m. Black shale ranging from friable, to silty, hard, and dense is interbedded with the siltstone. Shale bands commonly occur as laminae or thin beds, although thicker beds, greater than 5 cm thick, were also observed. In the upper third of the well the siltstone and shale are thinly interbedded. Much of the bedding is disturbed or disrupted and small scale sedimentary structures and burrows are common. Fossil zones are thin and less common than lower in the sequence. In the lower part of the well the siltstone is usually poorly bedded or massive, and is interbedded with thin to thick bedded

5



Record 1981/28

Fig 1. Location map

12/N/2

FORMATION	DEPTH (m)	LITHOLOGICAL DESCRIPTION
QUATERNARY ALLUVIUM	0	SURFACE – 4 m *Sand, quartzitic, dominantly red, also brown and white, coarse, subangular, mainly unconsolidated*
AMPHITHEATRE FORMATION		4 m – 35 m *Siltstone and claystone, light and medium grey, beige and yellow, interbedded. Bands are often contorted or disturbed. Weathered with ferrugenous limonite stain. Minor carbonaceous matter.*
	50	35 m – 74 m *Siltstone, grey, and shale, black, thinly bedded and interbedded. Bioturbated, lensoidal, and disrupted bands in some zones. Current bedding, flame structures, convolute bedding, and small scale burrowing present. Hairline fractures filled and healed with calcite, and rare vugs with crystals. Rare thin fossil bands towards bottom.*
		74 m – 102 m *Siltstone and shale as above. Increasing fossil content. Sedimentary structures as above, and rare ball and pillow structures. Siltstone is generally structureless or faintly banded with rare traces of pyrite. Fractures as above. Rare calcareous siltstone lenses, very light grey or white, interbedded with siltstone.*
	100	102 m – 128 m *Siltstone and shale as above interbedded with calcareous siltstone. Siltstone/structureless or faintly banded with some bioturbation. Some calcareous siltstone bands are fossiliferous. Fossil zones becoming more abundant and often thicker than above. Shale zones up to several cm thick that range from hard dense and silty to friable; contain rare zones of rounded, grey, silty, clay pellets, giving a spotted appearances. Rare sedimentary structures as above, and fractures as above.*
		128 m – 142 m *Siltstone and shale as above. Traces of pyrite. Rare large burrows in siltstone, and rare thin wavy or disrupted bands in shale with some small scale burrows. Fractures as above. Shale comprise less than 10% of zone.*
	150	142 m – 171 m *Siltstone and shale as above. Calcareous clasts and bands become more common. Fractures as above, some not healed with calcite crystals and traces of pyrite along fracture plane. Shale approximately 10% of zone.*
		171 m – 198 m *Siltstone and shale as above. Siltstone is bioturbated in some bands. Fractures more common in this zone with larger calcite crystals along fracture plane than above. Sedimentary dip increases to an average of 50°. Shale average 10-15% of zone.*
	200	198 m – 252 m *Siltstone and shale as above. Fractures as above, commonly containing large calcite crystals along fracture planes. Sedimentary dip approximately 5° (as in core above 171 m). Shale average 10% of zone.*
	250	252 m – 305 m *Siltstone and shale as above. Shale bands contain flecks or rounded silty pellets of clay or silt. Shale content becoming more abundant. Traces of pyrite. Fractures as above.*
	300	

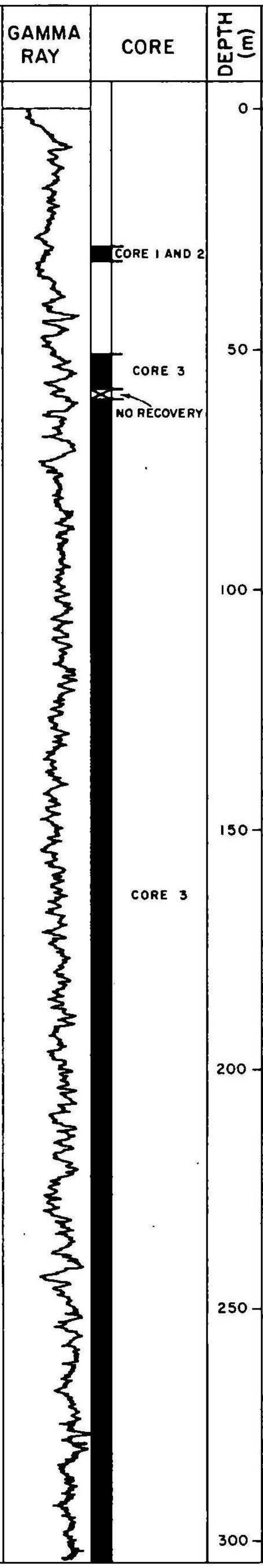
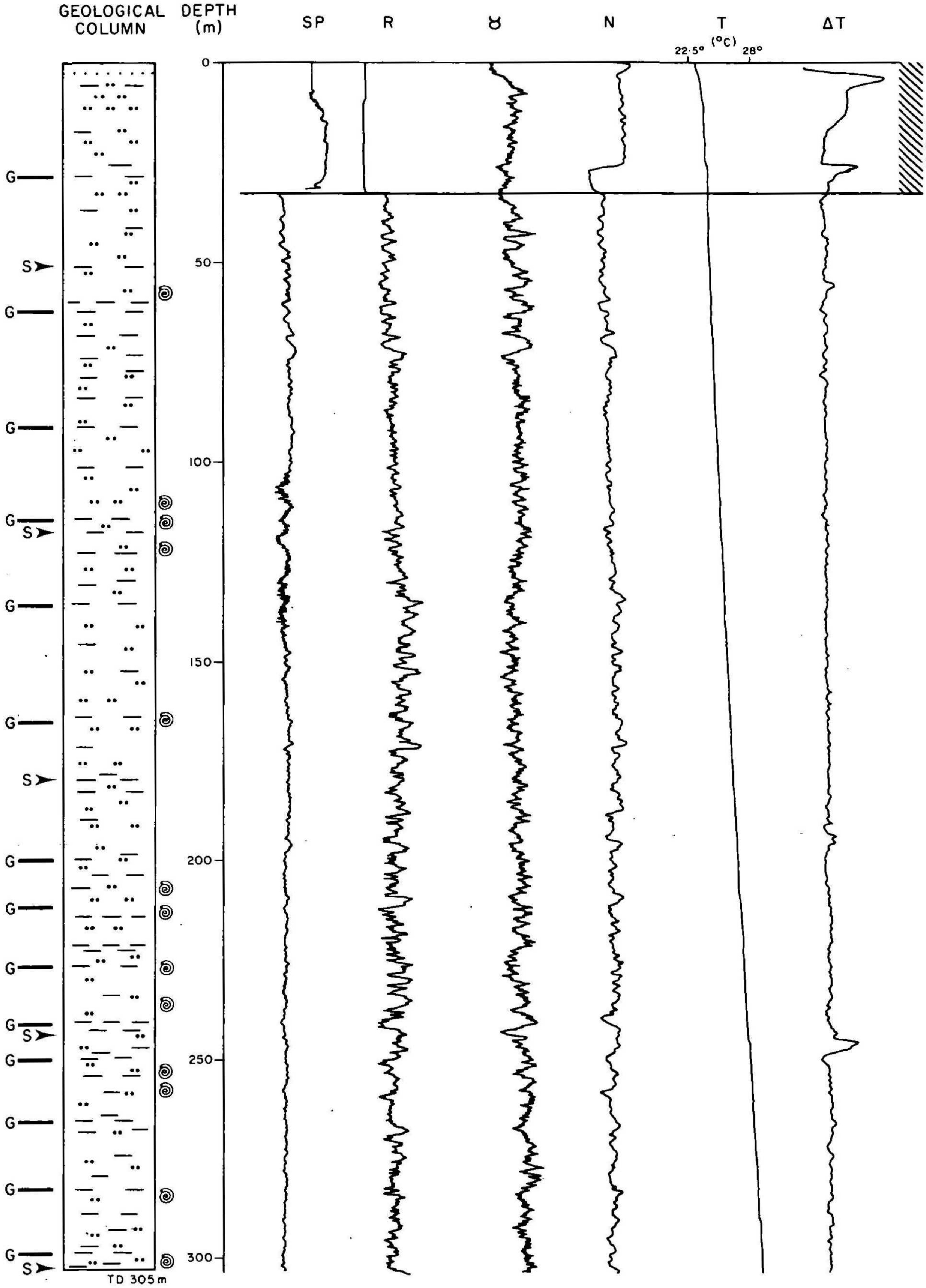


Fig 2. Core description



⊚ *Macrofossil sampling point*
S *Spore sampling point*
G *Geochemical sampling point*
SP *Spontaneous potential*
R *Resistivity*
ઇ *Gamma ray*
N *Neutron*
T *Temperature*
ΔT *Differential temperature*

Record 1981/28

Fig 3. BMR Ivanhoe 1 composite log

12/N/4

fossil zones and beds or clasts of calcareous lighter grey siltstone. Black shale beds are rarely disrupted and commonly have a sharp contact with siltstone interbeds. A more detailed description of the core is given in Figure 2.

Much of the core has been fractured, and many shale laminae in the lower part are slickensided. Most of the fractures occur as hairline fractures in the siltstone, and are commonly filled and sealed with calcite. Below 140 m some of the fractures are open or contain vugs. Calcite crystals up to 1 cm long were observed along these open fracture planes and in the vugs.

Between 171 m and 198 m, the sedimentary dip appears to increase from the normal 5^{o} dip up to an average dip of 50^{o}. The core shows no sharp sedimentary breaks or conclusive evidence of faulting. These steep dips may have been produced by slumping some time after consolidation of the sediments. The sedimentary dips at the boundaries of the steeply dipping zone are not well delineated.

The core contains an abundant and diverse fauna of articulate brachiopods (including Howellella jaqueti), ostracods, tentaculitids, gastropods, lamellibranchs, bryozoans, and conodonts which are closely comparable to fauna from the outcropping Amphitheatre Formation and Winduck Group in the eastern part of the basin (Jones and others, 1981). Drs P.J. Jones, D.L. Strusz and R.S. Nicoll of BMR examined this fauna and assigned a Lochovian to Early Pragian age to the sediments.

The fauna and sedimentary structures suggest that the sediments in the lower part of the well were deposited in an open quiet sea. In the upper part of the core sedimentary structures, indications of a coarsening upward sequence on the gamma ray log, and bioturbated sediments appear to represent the beginning of a regression of the sea and deposition in a paralic environment.

RESERVOIR ROCKS

Porosity and permeability tests run on the siltstone (Table 1) show that the core is very tight. The only visible porosity was in the open fractures. These fractures, however, lack vertical continuity.

SOURCE ROCKS

The results of the geochemical analyses are presented in Tables 2 and 3. The low total organic carbon content of most of the samples implies a low source rock potential for much of the core. A fuller discussion of the geochemical results, the maturation studies, and their implications for the petroleum potential of the Darling Basin is contained in Lockwood and others (in prep.).

REFERENCES

LOCKWOOD, K.L., BROWN, C.M., JACKSON, K., and PASSMORE, V.L., in prep. - The petroleum potential of the Darling Basin. Bureau of Mineral Resources, Australia.

RANNEFT, T.S.M., 1968 - Berangabah No. 1 well completion report. Texam Oil Corporation, Company Report (unpublished).

TABLE 1. Porosity and permeability

DEPTH metres	DRY BULK DENSITY gm/cc	APPARENT GRAIN DENSITY gm/cc	EFFECTIVE POROSITY % of bulk vol	PERMEABILITY Vertical md	 Horizontal md	LITHOLOGY
64.30	2.52	2.64	4.7	0.03	<0.01	
76.55 76.80	2.53	2.64	4.3	0.01	<0.01	
113.20	2.55	2.63	3.0	<0.01	0.01	
135.00 135.34	2.65	2.68	1.4	0.01	0.01	
142.22 147.40	2.65	2.67	0.8	0.01	0.06	Siltstone
170.60 170.99	2.65	2.66	0.3	<0.01	<0.01	
246.97 247.03	2.64	2.64	0.0	<0.01	<0.01	
283.39 283.69	2.65	2.65	0.0	<0.01	<0.01	

Analyses by Bureau of Mineral Resources, Petroleum Technology Laboratory

TABLE 2. SOURCE ROCK DATA

DEPTH (m)	TOC %	EOM ppm	SATS ppm	AROM ppm	POLAR ppm	ASPH ppm	Pr/nC_{17}	Ph/nC_{18}	Pr/Ph	LITHOLOGY	SOURCE RATING
29.1	0.46	95	5.6	1.1	29.1	55.9	0.17	0.09	1.57	Gy Siltst	Barren
61.8	0.98	939	72.3	96.7	228.2	403.8	0.93	0.29	3.29	Gy/Blk Siltst	Fair
90.0	0.12	70	3.8	1.0	19.9	35.0	0.50	0.41	1.25	Gy/Blk Siltst	Barren
117.0	0.02	63	3.8	3.8	20.0	19.1	0.50	0.39	1.03	Silty Shale	Barren
133.0	0.16	104	12.9	11.0	36.8	30.4	0.32	0.12	2.93	Silty Shale	Lean-Barren
170.0	0.81	762	31.2	35.8	270.5	302.5	0.35	0.14	2.64	Blk Shale	Fair
200.7	0.12	165	17.8	9.6	56.9	26.1	0.38	0.32	0.78	Blk Shale	Lean-Barren
215.4	0.15	135	17.7	13.2	39.8	37.7	0.54	0.37	1.03	Silty Shale	Lean-Barren
224.9	0.14	110	9.1	5.5	43.1	45.9	0.41	0.24	1.78	Silty Shale	Lean-Barren
240.0	0.15	72	3.8	2.9	19.2	43.2	naphthenic			Blk Siltst	Barren
250.4	0.08	46	5.3	3.8	8.3	26.4	naphthenic			Blk Shale	Barren
269.7	0.15	68	7.0	4.7	18.8	34.0	naphthenic			Silty Shale	Barren
282.6	0.29	115	5.2	4.4	41.9	47.0	0.48	0.29	1.37	Blk Siltst	Barren
300.9	0.09	59	6.7	4.8	10.4	34.3	naphthenic			Silty Shale	Barren

TOC Total organic carbon
EOM Extractable organic matter
SATS Saturated hydrocarbons
AROM Aromatic hydrocarbons
POLAR (N,S,O-containing) organic compounds
ASPH Asphaltenes
Pr/nC_{17} Pristane to nC_{17} ratio
Ph/nC_{18} Phytane to nC_{18} ratio
Pr/Ph Pristane to phytane ratio

Analyses by Amdel

TABLE 3. ORGANIC MATTER DESCRIPTION

DEPTH (m)	VITRINITE (%)	INERTINITE (%)	EXINITE (%)	TYPE OF EXINITE[1]	FLUORESCENCE	TOC(%)	% OF ORGANIC MATERIAL[2]
29.1	90	-	10	R,S,C	Dull Brown (R) Mod or Yellow (S)	0.46	1-2
61.8	4	95	7	R,S	As above	0.98	5
90.0	-	100	0	-	None	0.12	<<1
117.0	-	90	10	R	Dull Brown	0.02	<1
133.0	-	98?	2	R	Dull Brown	0.16	1
170.0	-	97	3	R	Dull Brown	0.81	3
200.7	-	>99	<1	R	Dull Brown	0.12	<1
215.4	78	19	3	R	Dull Brown	0.15	1
224.9	51	46	3	R	None	0.14	∿1
240.0	50	50	0	-	None	0.15	<<1
250.4	56	44	<1	LD	Yellow	0.08	<<1
269.7	64	36	<1	C	Yellow	0.15	<<1
282.6	8	87	5	R	None to Dull Brown	0.29	<<1
300.9	30	70	0	-	None	0.09	<<1

1: C = Cutinite, LD = Liptodetrinite, R = Resinite, S = Sporinite

2: Polished briquette prepared as a flotation concentrate

Analyses by Amdel