COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT No. 124

Stratigraphic Drilling in the Georgina Basin, Northern Territory

COMPILED BY

K. G. SMITH

Issued under the Authority of the Hon. David Fairbairn,
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MINISTER: THE HON. DAVID FAIRBAIRN, D.F.C., M.P.

SECRETARY: R. W. BOSWELL, O.B.E.

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SUMMARY

The Bureau of Mineral Resources has drilled three stratigraphic wells in the Georgina Basin in the Northern Territory.

BMR 11 Cattle Creek reached total depth at 1501 feet. Fossils in the cores and cuttings were not diagnostic, but they indicated a Palaeozoic age for at least most of the Camooweal Dolomite, which had previously been regarded as either Adelaidean or Lower Cambrian. From surface to 1412 feet the well penetrated a sequence of vuggy carbonate rocks, which yielded up to 6000 gallons per hour of water. A sandstone unit between 1412 feet and total depth is probably of Adelaidean age, but the sequence cannot be identified with formations cropping out on the margins of the basin. No hydrocarbons were found.

BMR 12 Cockroach proved the presence of the Upper Cambrian Arrinthrunga Formation and the Middle Cambrian Marqua Beds beneath Lower Ordovician outcrops of the Ninmaroo Formation. The thickness of the Arrinthrunga Formation (2236 feet) agrees well with outcrop evidence, but the Marqua Beds (1279+feet) were considerably thicker than expected and the well was in this sequence at the target depth (and rig limit) of 4000 feet. Traces of bitumen were the only hydrocarbons found in the well.

BMR 13 Sandover penetrated Upper and Middle Cambrian and probably Lower Cambrian sediments, before entering Precambrian crystalline basement at 3304 feet. The well was abandoned at 3331 feet. The occurrence of Upper Cambrian sediments (Arrinthrunga Formation) was predicted from regional mapping; the presence of Middle Cambrian sediments at a distance from the margins of the Georgina Basin strengthens the probability that Middle Cambrian units are widespread in the subsurface. A show of oil and gas was obtained from Middle Cambrian sediments in the interval 2952-2975 feet, but a drill-stem test recovered only gas-cut mud.

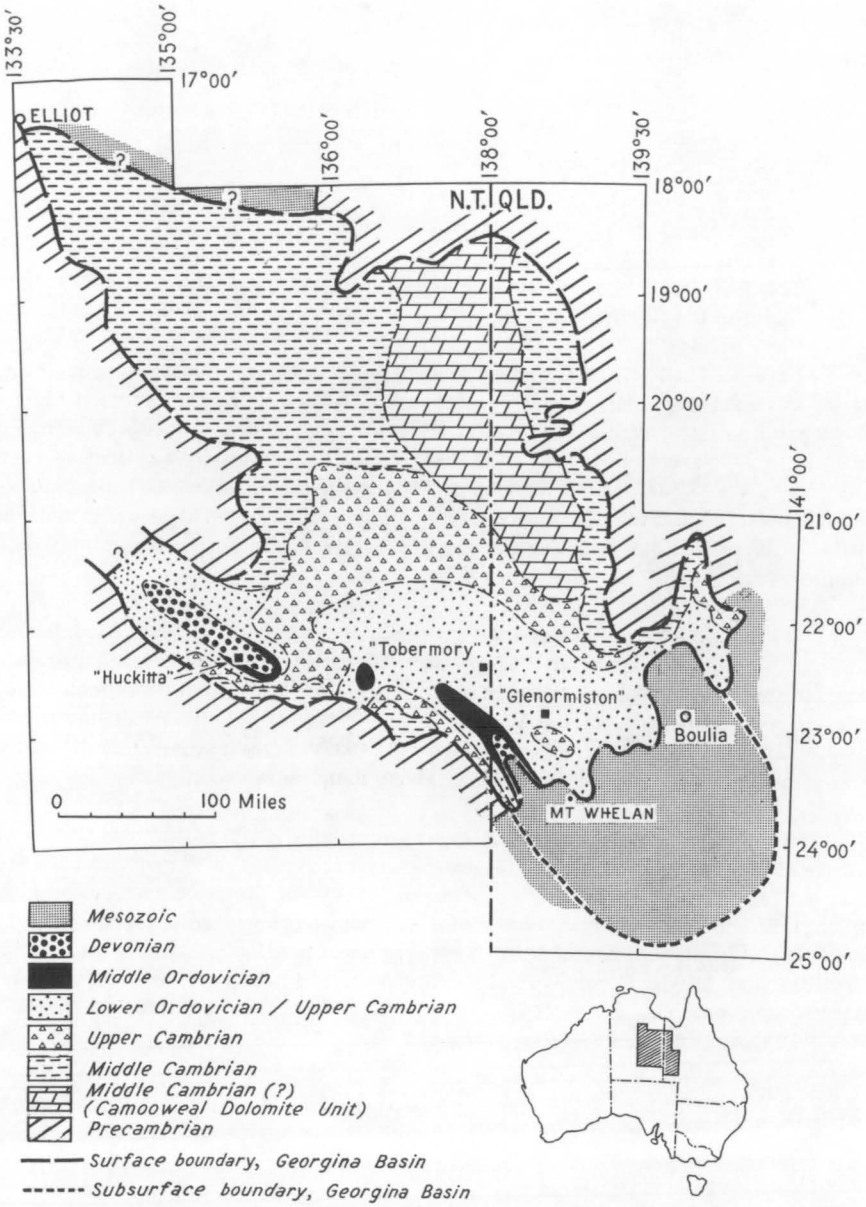

Fig. 1: Georgina Basin

INTRODUCTION

During 1963-64 the Bureau of Mineral Resources drilled three stratigraphic wells, BMR 11 Cattle Creek, BMR 12 Cockroach, and BMR 13 Sandover, in the Northern Territory part of the Georgina Basin. The objective was to assist petroleum exploration by determining depths to economic basement, by elucidating stratigraphy, evaluating source, reservoir, and caprock potential, comparing rock types with those cropping out on the margins of the Georgina Basin, and providing basic velocity data for seismic exploration.

All three wells were drilled in areas of poor outcrop and away from known structures. The sites were selected after the Bureau had completed regional mapping of most of the Georgina Basin, but the only geophysical information was the preliminary results of a Bureau reconnaissance gravity survey which had included the areas surrounding BMR 12 and 13. The Bureau conducted an airborne magnetic survey of the Northern Territory part of the Georgina Basin during the drilling programme and a Bureau seismic party made an experimental survey near BMR 12 while drilling was in progress. The seismic party completed a velocity survey in BMR 12.

The drilling programme began in July 1963 and was completed in November 1964. The wells were drilled by contract with a Failing 2500 rig equipped to drill with both air and mud. Wire-line logging was done by contract in each well but Bureau logging equipment was also used in BMR 11.

The drilling programme was initiated by the Geological Branch of the Bureau, and the Bureau's Petroleum Technology Section supervised the technical aspects of the operation. The following personnel worked on the wells:

BMR 11 Cattle Creek

Well-site Geologists: R.A.H. Nichols, N.E.A. Johnson, and K.G. Smith

Petroleum Technologist: M.D. Bell

BMR 12 Cockroach

Well-site Geologists: R.A.H. Nichols and M.A. Randal

Petroleum Technologist: J.M. Henry

BMR 13 Sandover

Well-site Geologists: A.T. Lloyd, R.D. Shaw, and R.A.H. Nichols

Petroleum Technologists: B.A. McKay, M.D. Bell, and P.G. Duff

Lithological descriptions of cuttings from each well have been included in Completion Reports of each well, issued in the Bureau's Record series, and are available on request from the Bureau of Mineral Resources, Geology and Geophysics, Canberra.

NOMENCLATURE

The Precambrian nomenclature used in this Report follows the current practice of the Bureau of Mineral Resources in adopting a number of time-rock units for the division of the Proterozoic in Australia. These divisions are:

1. Adelaidean, which includes all rocks which are time-correlates of the sediments in the Adelaide Geosyncline above the base of the Willouran Series and below the base of the Cambrian. The tentative age of the base of the Willouran Series is 1400 m.y.

2. Carpentarian, which includes all rocks which are time-correlates of the sequence above the base of the Cliffdale Volcanics and below the base of the Adelaidean in the Carpentaria area of the Northern Territory. The age of the base of the Carpentarian is about 1800 m.y.

Rocks which were deposited between the top of the Archaean and the base of the Carpentarian are referred to as Lower Proterozoic, pending the definition of a satisfactory time-rock term for the interval. The age of the top of the Archaean is probably between 2400 and 2600 m.y.

SUMMARY OF REGIONAL GEOLOGY, GEORGINA BASIN

The Georgina Basin occupies a surface area of about 110,000 square miles and extends in a belt trending north-west from the Mount Whelan area of western Queensland to the township of Elliott in the Northern Territory (Fig. 1). The eastern, western, and northern boundaries of the basin are defined by outcropping Precambrian rocks, but the south-eastern and north-western margins are obscured by Mesozoic sediments. Geophysical surveys have delineated the south-eastern boundary, but geophysical information on the north-western margin is not available.

The Georgina Basin contains Cambrian and Ordovician marine sediments and a Devonian freshwater sequence. Cambrian sediments are widespread; the Ordovician and Devonian outcrops are restricted to the southern half of the basin. Middle Cambrian sediments are regarded as the basal units of the succession, but in some marginal areas several thousand feet of unmetamorphosed Adelaidean/Lower Cambrian sediments underlie the Middle Cambrian sequences. The Adelaidean/Lower Cambrian rocks have been drilled in four widely-separated wells in the Northern Territory, and in several wells in Queensland. Their petroleum prospects are regarded as slight and they lie above magnetic basement.

Most of the northern half of the Georgina Basin contains less than 2000 feet of marine Middle Cambrian sediments only; they consist predominantly of carbonate rocks, with subordinate shale, siltstone, and sandstone. Some of the sediments are richly fossiliferous and may be source rocks for petroleum; many of the carbonate rocks are vuggy and cavernous and yield large quantities of water. The Middle Cambrian sequence includes the Camooweal Dolomite, which Öpik (1956) named and considered to be Upper Proterozoic (Adelaidean) or Lower Cambrian in age; later field work, principally by Randal & Brown (1962) and Randal, (1966a,b) and the results of Amalgamated Petroleum's Lake Nash No. 1 and Morstone No. 1 Wells indicate a Middle Cambrian age for most if not all of the unit. The Middle Cambrian sediments along the northern margin of the basin have been strongly faulted, but elsewhere in the northern half of the basin there is no evidence of deformation.

The thickest outcrop sequences in the Georgina Basin are in the south and south-east, in the Huckitta, Tobermory-Glenormiston, and Boulia areas (Fig. 1).

In the Huckitta area 5500 feet of Palaeozoic marine sediments are exposed. They comprise dominantly carbonate rocks, with subordinate sandstone, siltstone, and shale, ranging from lower Middle Cambrian to Middle Ordovician. The sequence contains

potential source, reservoir, and cap rocks, and is richly fossiliferous in parts. The sequence is overlain by 2100 feet of Devonian freshwater sandstone, and underlain by fossiliferous Lower Cambrian dolomite and sandstone.

In the Tobermory-Glenormiston area 6000 feet of Middle Cambrian, Upper Cambrian, and Lower Ordovician sediments are exposed. They consist predominantly of carbonate rocks, but the Middle Ordovician sequence is mainly sandstone and shale. The Middle Cambrian sequence, and most of the Ordovician units, are richly fossiliferous. Upper Devonian sandstone overlies the youngest Middle Ordovician formation, and the basal Middle Cambrian unit rests on Adelaidean sediments.

In the Boulia area 4200 feet of Upper Cambrian to Lower Ordovician sediments are exposed. They comprise carbonate rocks, with minor shale, sandstone, and siltstone. Middle Cambrian sediments are unknown in outcrop, but about 2200 feet has been recorded in the subsurface.

Table 1 shows the stratigraphy of the Huckitta and Tobermory-Glenormiston areas and includes the units drilled in BMR 12 Cockroach and BMR 13 Sandover. It is

TABLE 1: STRATIGRAPHY OF THE HUCKITTA AND TOBERMORY-GLENORMISTON AREAS

		HUCKITTA		TOBERMORY-GLENORMISTON	
Age		Formation	Thickness (ft)	Formation	Thickness (ft)
Upper Devonian		Dulcie Sandstone	2100	Cravens Peak Beds (probably includes Lower Devonian sediments)	450+
		UNCONFORMITY		UNCONFORMITY	
Middle Ordovician	TOKO GROUP	Nora Formation	500	Mithaka Beds Carlo Sandstone Nora Formation Coolibah Formation	300+ 400 300 250
		DISCONFORMITY(?)		DISCONFORMITY(?)	
Lower Ordovician to Upper Cambrian		Tomahawk Beds	800	Kelly Creek Formation Ninmaroo Formation	550 1200
Upper Cambrian		Arrinthrunga Formation	3200	Arrinthrunga Formation	2200
Middle Cambrian		Arthur Creek Beds	1000	Marqua Beds	700+
		DISCONFORMITY(?)		UNCONFORMITY	
Lower Cambrian	MOPUNGA GROUP	Mount Baldwin Formation	1300	Not known in outcrop	
		Grant Bluff Formation	525	Grant Bluff Formation	1500
Adelaidean		Elyuah Formation	300+		
		Mount Cornish Formation	1200	Field River Beds	8000(?)
		UNCONFORMITY		UNCONFORMITY	
Archaean(?)		Arunta Complex		Arunta Complex	(?)

not possible to construct such a table from outcrops in the Barkly Tableland where BMR 11 Cattle Creek is situated, and the stratigraphy of the Boulia area does not apply to any of the three wells.

The sediments of the southern and south-eastern parts of the Georgina Basin have been faulted and folded during an Upper Devonian or early Carboniferous orogeny. Structural deformation is locally intense; there are numerous parallel faults, downthrown to the east, which trend north-west for up to 50 miles, and some anticlines, domes, and monoclines are known. The most prominent folds are the Dulcie and Toko Synclines (Fig. 2). Both are asymmetric folds with steep dips on their south-western flanks; in the Toko Syncline these steep dips are clearly related to faults, but there is no evidence of faulting along the south-western flank of the Dulcie Syncline.

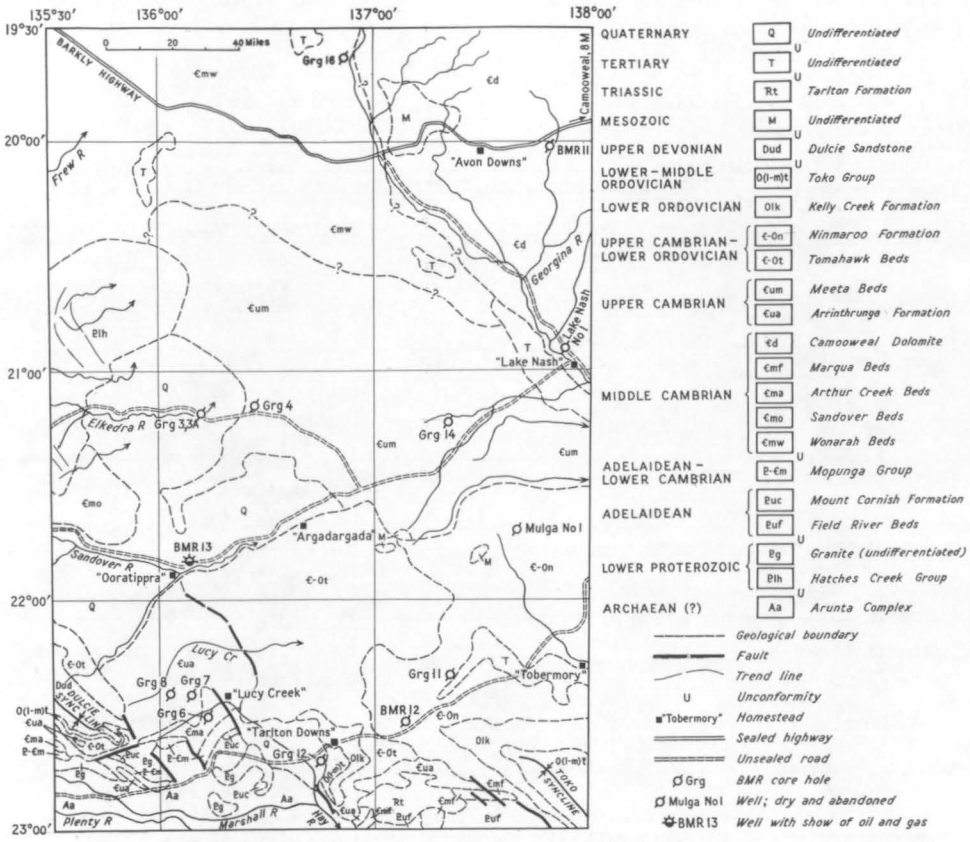

Fig. 2: Geological map of part of Georgina Basin

BMR 11 CATTLE CREEK

SUMMARY

BMR 11 Cattle Creek was drilled 20 miles west-south-west of Camooweal to investigate the stratigraphy of the sequence underlying the Camooweal Dolomite, which crops out near the well-site (Fig. 2). The well was terminated at a depth of 1501 feet in probable Adelaidean sandstone. No zonal fossils were determined from the cores. Gatehouse (App. 2, this Report) has described Middle Cambrian fossils from the interval 547-1016 feet.

By analogy with surface outcrop and on the evidence of some fossils, it is assumed that the well penetrated Cambrian rocks to 1412 feet (including Camooweal Dolomite to 1195 feet) and probable Adelaidean rocks from 1412 feet to total depth at 1501 feet. The Adelaidean(?) rocks cannot be positively identified with surface formations, and they bear some resemblances to both the Pilpah Sandstone on the eastern margin of the Georgina Basin, and the Mittiebah Sandstone on the northern margin. The Pilpah Sandstone is probably, and the Mittiebah Sandstone certainly, Adelaidean.

No hydrocarbons were detected, and the well was secured as a water well.

INTRODUCTION

Previous mapping in the area surrounding BMR 11 was hampered by lack of outcrop and inadequate information from water wells. This applies particularly to the Camooweal Dolomite, which has been mapped in the vicinity of the well site (Öpik, 1956; Randal & Brown, 1962; Randal, 1966a,b).

The well was drilled to establish the stratigraphic relationships and lithology of the Camooweal Dolomite and to determine the sequence to economic basement if possible.

WELL HISTORY

General Data

Well name and number:	BMR 11 Cattle Creek
Location:	Lat. 20°00'33"S., Long. 137°50'06"E.
Area:	Georgina Basin, N.T.
Title holder:	Australian Oil Corp.
Petroleum title:	Oil Permit 61, N.T., 9720 sq. miles
Total depth:	1501 ft
Date spudded:	8 July 1963
Date completed:	14 November 1963
Date secured:	16 November 1963

Date rig released:		16 November 1963	
Drilling time to TD:		131 days	
Elevations:		Rotary table, 742 ft a.s.l.; ground level, 736 ft a.s.l.	
Status:		Secured, pending completion as a water well	
		Drilling Data	
Contractor:		W.L. Sides & Son Pty Ltd	
Drilling Plant:	make:	Failing 2500	
	type:	Holemaster	
	rated capacity:	4000 ft with $3\frac{1}{2}$ in. drill tubing	
	motors:	2 x 4/71 GM series, 110 HP	
Mast:	make:	Failing 58 ft	
	type:	Tubular	
	rated capacity:	60,000 lb	
Pumps:	make:	Gardner-Denver	Wheatley
	type:	FOFXO	WBD
	size:	7 1/4 in. x 10 in.	5 in. x 10 in.
	motors:	6/71 GM series	rig
Compressors:	make:	Consolidated-Pneumatic	Holman-Howden
	type:	Reciprocating	Rotary
	model:	CP 500	Rotair 600
	motors:	Lincoln-Ruston	Rolls-Royce
B.O.P.:	make:	Baash-Ross	
	size and model:	6 1/4 in. Autolock	
	working pressure:	3000 psi	
Hole sizes:	sfc-28 ft	12 1/4 in.	
	28-411 1/2 ft	8 1/2 in.	
	411 1/2-903 ft	6 1/4 in.	
	903-1501 ft (TD)	6 in.	
Casing strings:	size:	9 5/8 in.	7 in.
	grade:	J-55	J-55
	weight:	36 lb	20 lb
	set at:	27 1/2 ft	410 ft
Casing cement:	size:	9 5/8 in.	7 in.
	sacks cmt:	8	60
	cmt rise:	to sfc.	est. 50 ft (RT)
	method:	single stage plug	single stage plug
Drilling fluid:	0-525 ft	air	
	525-900 ft	mud	
	900-1501 ft (TD)	water	

Note: The hole was drilled with air from surface to 525 ft using both air-hammer bits and conventional tricone bits. At 525 ft the volume and height of the column

of formation water in the hole was too great to continue drilling satisfactorily with air, and drilling resumed using freshwater bentonite muds. Lost circulation impeded progress to such an extent that drilling and coring from 900 ft to total depth was continued without returns, using water from a nearby waterhole as drilling fluid.

Water supply: drilling, from nearby semi-permanent waterhole on Cattle Creek; domestic, from Camooweal town water bore

Perforation and shooting record: Nil

Plugging back and squeeze cement jobs: Nil

Side-tracked hole: Nil

Fishing operations:

Date	Depth (ft)	Hours lost	Fishing Job	Recovery Method
6/8/63	216	14 3/4	Hammer bit stuck	Worked free
4/10/63	637	39 1/2	Stuck string	Unloaded water column
19/10/63	885	42 1/4	Stuck string	Unloaded water column
21/10/63	886 1/2	15 3/4	Outer diamond bbl and bit matrix	Fished and milled out
30/10/63	903	1/2	Stuck string	Worked free

Logging and Testing

Ditch cuttings: Samples were collected at 5-ft intervals when returns were obtainable. Cuts were distributed to the Geological Branch, BMR, Canberra; the Resident Geologist, BMR, Alice Springs; and the title holder.

Coring: The original programme called for cores to be cut at convenient bit changes to give a coring interval of approximately 300 ft. This programme was maintained to 900 ft, below which drilling and coring continued without returns, owing to the loss of circulation; from 900 to 1501 ft (TD), cores were cut at intervals of about 50 ft.

Fifteen of the eighteen cores cut were taken with a 6-in. Reed K-500 barrel using hard-formation coreheads. Core Nos 4, 5, and 6 were cut with a 3 3/16-in J.K. Smit Dowdco diamond barrel; the outer barrel twisted off whilst cutting core No. 6 and the tool was not used again. All eighteen cores have a diameter of 2 3/8 in.

Total footage cored was 114 of which 31 ft 2 1/2 in. (28 percent) was recovered.

Side-wall sampling: Nil

Well logging: The well was logged by a Failing Logmaster unit of the BMR and by Schlumberger. The logs are summarised over page:

Schlumberger (scale 2 in. and 5 in. = 100 ft)

Log Type	Run No.	Depth (ft)	Curves
Electric	1	1499-408	SP
			Short normal
			Long normal
			Lateral
Gamma ray	1	1500-100	Gamma ray
Neutron			Neutron
Microcaliper	1	470-408	Microlog
			Caliper
Temperature	1	1120-360	Temperature
	2	800-208	Temperature

No microlog was obtained because the pad was damaged in the borehole. The tool would not go below 780 ft, and no record was obtained below 470 ft.

The two temperature logs were incomplete as the probe was 'hanging up' in the hole. In view of the operational requirements of drilling, the well did not have a sufficient waiting period for the temperature to reach equilibrium. As a result, the value of the log is limited. In addition, as in the case of the microcaliper tool, it would appear that the temperature tool was not functioning below 780 ft.

Bureau of Mineral Resources (scale 1 in. = 100 ft)

Log Type	Run No.	Depth (ft)	Curves
Electric	1	1498-410	SP
	1	1498-410	Short normal
	1	1185-410	Long normal
	2	800-410	Long normal
Gamma ray	1	1355-170	-

Drilling time and gas log: There was no automatic device on site to detect the presence of gas, but the number of minutes taken to drill every 5 ft were recorded, and these form the basis of the rate of penetration log on the Composite Well Log.

Formation testing: Nil

Deviation surveys: All deviation surveys were taken with a Totco Double Recorder tool. For the most part, readings were taken at intervals of approximately 40 ft; they are listed below and have been plotted on the Composite Well Log:

Depth (ft)	Deviation (degrees)	Depth (ft)	Deviation (degrees)	Depth (ft)	Deviation (degrees)	Depth (ft)	Deviation (degrees)
100	1/4	400	2 1/2	650	5 3/4	1100	6 1/2
150	1/2	450	3	710	5 1/2	1170	6 1/4
175	3/4	485	3 1/2	750	5 1/2	1240	7
201	1	500	3 1/4	805	5	1275	7
240	1	535	3 3/4	840	5 1/2	1310	5 1/2
275	1 1/2	545	4 1/2	900	6	1325	5 1/2
310	2	590	5 1/2	1035	6	1380	5
350	2 1/2					1455	5

Other well surveys: Nil

STRATIGRAPHIC SEQUENCE

The lack of diagnostic features in the section penetrated has prevented reliable correlation or precise dating. For convenience the well section has been divided into six units on the basis of lithology and electrical log characteristics (Table 2).

TABLE 2: STRATIGRAPHY, BMR 11 CATTLE CREEK

Unit	Lithology	Depth to Top of Unit (Datum RT 742 ft) Drilled	Subsea	Thickness (ft)	Age
1	Dolomite	20	+722	615	Middle Cambrian
2	Argillaceous dolomite	635	+107	105	Middle Cambrian
3	Dolomite	740	+2	455	Middle Cambrian
4	Limestone	1195	-453	80	Cambrian
5	Dolomite	1275	-533	137	Cambrian
6	Sandstone	1412	-670	89+	Adelaidean(?)
	T.D.	1501	-759		

Unit 1, 20-635 feet (615 ft)

Unit 1 consists of dolomite (95%), white, grey, yellow, brown, microcrystalline to medium-crystalline, slightly calcareous. Several vuggy horizons are highly permeable. Dolarenite, pelletal and oolitic, and chert (5%) occur sporadically throughout. Traces of glauconite and manganese were recorded.

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It is assumed that the unit is part of the Camooweal Dolomite. Fossils in Core No. 2 (547-560 ft) are Middle Cambrian in age (App. 2) and the whole unit is probably Middle Cambrian.

Unit 2, 635-740 feet (105 ft)

Unit 2 consists entirely of dolomite, mainly argillaceous, grey to greenish grey, green-brown, microcrystalline, micaceous, slightly calcareous, fissile, slightly porous. Interbeds of white microcrystalline dolomite, with rare vugs, occur at the base of the unit. Traces of glauconite, pyrite, and chert were recorded. This unit may also be part of the Camooweal Dolomite, and its age is Middle Cambrian (App. 2).

Unit 3, 740-1195 feet (455 ft)

Dolomite (95%) is predominant in unit 3. It is white to grey-brown, microcrystalline to medium-crystalline, with slightly calcareous intervals. Vugs are more common than in units 1 and 2. Pelletal and oolitic dolarenite and stylolites were recorded. Traces of glauconite and manganese occur, and chert (<5%) occurs sporadically. This unit is also assigned tentatively to the Camooweal Dolomite. Its age, to 1016 feet at least, is Middle Cambrian (App.2) and other fossils have been obtained in Core No. 10 (1075-1085 ft).

Unit 4, 1195-1275 feet (80 ft)

Unit 4 consists of limestone (90%), medium grey-brown, cryptocrystalline to microcrystalline with traces of pyrite, and chert (10%), blue-grey to brown, cryptocrystalline, aphanitic, nodular. Core No. 12 (1202-1205 ft) contains Cambrian sponge spicules and brachiopod fragments (App. 2).

Unit 5, 1275-1412 feet (137 ft)

Unit 5 is entirely dolomite, grey-brown, cryptocrystalline to microcrystalline, vuggy. Shell fragments may be present. At 1385 feet the dolomite changes to mottled light brown to grey-brown, and becomes calcareous. Intergranular porosity is apparent. Core No. 14 (1308-1318 ft) yielded part of an indeterminate trilobite (App. 2).

Unit 6, 1412-1501 feet (89 ft+)

Unit 6 consists of sandstone, white, grey, dark red-brown, medium-grained. The quartz grains are colourless, subrounded, moderately sorted, with some siliceous and ferruginous cement. Pebbly quartz sandstone, with rounded pebbles up to 1 cm, and minor green-grey micaceous siltstone and ferruginous siltstone occur.

CONTRIBUTIONS TO GEOLOGICAL KNOWLEDGE

(a) The well proved the occurrence of a relatively thin Palaeozoic carbonate sequence with either horizontal or gently dipping beds beneath outcrops of the Camooweal Dolomite.

(b) The well demonstrated the vuggy and cavernous nature of the Palaeozoic carbonate sequence, which yielded abundant water from apparently interconnected aquifers.

(c) Economic basement is at a shallow depth (1412 ft).

BMR 12 COCKROACH

SUMMARY

BMR 12 Cockroach was drilled to a depth of 4000 feet near Cockroach Waterhole (Fig. 2), 240 miles east-north-east of Alice Springs, and was sited near outcrops of horizontal fossiliferous dolomite of the Ninmaroo Formation.

The well penetrated 460 feet of Ninmaroo Formation (Lower Ordovician to Upper Cambrian), 2236 feet of Arrinthrunga Formation (Upper Cambrian), and 1279 feet of Marqua Beds (Middle Cambrian). It reached its target depth in the Marqua Beds, above economic basement. No significant hydrocarbons were recorded.

A Bureau of Mineral Resources seismic party made a velocity survey in the well, to obtain basic data from a carbonate sequence which is widespread in the southern part of the Georgina Basin.

INTRODUCTION

BMR 12 was drilled near fossiliferous outcrops which provided initial stratigraphic control; in the surrounding area part of an extensive dolomite sheet crops out poorly (Smith, 1966), and in the subsurface it was considered that the Ninmaroo and Arrinthrunga Formations might not differ sufficiently in rock types to permit positive identification. The well was drilled to obtain information on the depth to economic basement, and on the fluid content and detailed stratigraphy of the Palaeozoic section.

WELL HISTORY

General Data

Well name and number:	BMR 12 Cockroach
Location:	Lat. 22°33'20"S., Long. 137°09'38"E.
Area:	Georgina Basin, N.T.
Petroleum title:	Oil Permit 63, N.T., 7833 sq. miles
Title holder:	Continental Oil and Gas Ltd
Operator for permit:	Alliance Petroleum Australia N.L.
Total depth:	4000 ft
Date spudded:	15 August 1964
Date completed:	17 November 1964
Date abandoned:	23 November 1964
Date rig released:	23 November 1964
Drilling time to TD:	63 days

Elevations:	Rotary table, 729 ft a.s.l.; ground level, 721 ft a.s.l.		
Status:	Dry and abandoned		

Drilling Data

Contractor:	W.L. Sides & Son Pty Ltd		
Drilling Plant:	make:	Failing 2500	
	type:	Holemaster	
	rated capacity:	4000 ft with 3 1/2 in. drill tubing	
	motors:	2 x 4/71GM series, 110 HP	
Mast:	make and type:	Failing 75 ft tubular (including 17 ft extension)	
	rated capacity:	45,000 lb with extension to mast	
Pumps:	make:	Gardner-Denver	Wheatley
	type:	FOFXO	WBD
	size:	7 1/4 in. x 10 in.	5 in. x 10 in.
	motors:	6/71 GM series	rig
Compressors:	make:	Consolidated-Pneumatic	Holman-Howden
	type:	Reciprocating	Rotary
	model:	-	Rotair 600
	motors:	Lincoln-Ruston	Rolls-Royce
B.O.P.:	make:	Baash-Ross	
	size and model:	6 1/4 in. Autolock	
	working pressure:	3000 psi	
Hole sizes:	sfc-69 ft	12 1/4 in.	
	69-818 ft	8 1/2 in.	
	818-3990 ft	6 1/4 in.	
	3990-4000 ft (TD)	5 3/8 in.	
Casing strings:	size:	9 5/8 in.	7 in.
	grade:	J-55	J-55
	weight:	36 lb	20 lb
	set wt:	69 ft	806 ft
Casing cementation:	size:	9 5/8 in.	7 in.
	sacks cmt:	40	60
	cmt rise:	to sfc	200 ft calc.
	method:	single stage plug in both cases	
Drilling fluid:	sfc-600 ft	air	
	600-818 ft	mud	
	818-970 ft	air	
	970-4000 ft (TD)	mud	

Average Mud Properties

Interval (ft) (RT)	Weight (lb/ft^3)	Viscosity (sec/1000 cc)	W.L. (cc)	F.C. (1/32 in.)	pH	Sand (%)
600- 800	67	38 1/2	18	2	9	2
970-1500	70	38 1/2	13	2	9	1/2
1500-2000	75	41	13	2	9	1/2
2000-2500	74	46	12	2	9	1/2
2500-3000	74 1/2	43 1/2	10	2	8	1/2
3000-3500	73	42	11	2	7	1/2
3500-4000	75	42	13	2	7	1/2

Water supply: From water-bore drilled to supply the domestic and drilling requirements at the site

Perforation and shooting record: Nil

Side-tracked hole: Nil

Plug-back jobs: Nil

Squeeze cement jobs: Nil

Abandonment plugs:

1st Job: placed to seal off aquifer at 915 ft. With open ended drill pipe at 942 ft, equalized 18 sacks of construction cement mixed to 108 lb/cu ft. Pulled back to 880 ft and circulated. Top of plug subsequently found at 883 ft and tested with full weight of string.

2nd Job: set across the 7-in. casing shoe at 806 ft. With open ended drill pipe at 820 ft, equalised 15 sacks of construction cement mixed to 106 lb/cu ft. Located top of plug at 765 ft, and drilled out to hard cement at 772 and tested.

3rd Job: top plug of 4 sacks cement placed in and around top of 7-in. casing. Well capped with valve and steel plate marked 'BMR No. 12 1964'.

Fishing operations

Date	Depth (ft)	Hours Lost	Fishing Job	Recovery Method
15/8/64	11 & 20	2 1/4	Bit sub snapped off	Picked up with tap
17/8/64	45	2	Bit sub snapped off	Picked up with tap
4/11/64	3546	9 1/2	Three 30 ft x 5 in. DC twisted off at tool jt	Fished out with overshot
10/11/64	3778	2	Bearing rollers from bit left down hole	Recovered with magnet

Logging and Testing

Ditch cuttings: Samples were collected from the shale shaker at 10-ft intervals. Cuts were distributed to the Geological Branch, BMR, Canberra; the Resident Geologist, BMR, Alice Springs; and a cut was collected for the tenement holder.

Coring: The original programme called for routine cores to be cut at convenient bit changes to give a coring interval of about 300 ft between successive cores. This was maintained except where other cores were required by the well-site geologist for additional information.

The total footage cored was 144 and of this 97 ft 11 1/2 in. or 68.02% was recovered.

Side-wall sampling: Nil

Well logging: The well was logged by Schlumberger prior to running the 7 in. surface casing and after reaching total depth. All the logs are on scales of both 2 in and 5 in. to 100 ft, and are summarised below:

Log Type	Run No.	Depth (ft)	Curves
Electric	1	817-70	SP & resistivity
	2	4000-806	SP & resistivity
Microlog	1	818-69	Microcaliper & resistivity
	2	3997-806	Microcaliper & resistivity
Sonic	1	800-69	Sonic; integrated
	2	3993-806	Sonic; integrated
Radioactivity	1	812-50	Gamma ray
" "	2	3993-806	Gamma ray

Drilling time and gas log: There was no automatic device on site to detect the presence of gas, but the number of minutes taken to drill every 5 ft were recorded, and these form the basis of the penetration rate log on the attached Composite Well Log.

Deviation surveys: All deviation surveys were taken with a Totco Double Recorder tool; they are listed below. The readings have been plotted on the Composite Well Log.

Depth (ft)	Deviation (degrees)	Depth (ft)	Deviation (degrees)	Depth (ft)	Deviation (degrees)
90	1/4	505	1/2	1460	3/4
150	1/2	590	1/4	1700	1/4
186	1/4	650	1	2125	1 1/2
250	1/2	680	1	2390	1 1/4
320	3/4	775	1	2600	1
345	1/2	840	1	2830	1
380	3/4	994	1/2	3340	3/4
410	3/4	1270	3/4	3700	1/2

Other well surveys: A BMR geophone was used on the Schlumberger cable to run a velocity survey in the hole after the final well logging was completed. This was supervised and recorded by the BMR No. 1 Seismic Party.

STRATIGRAPHIC SEQUENCE

Division into the main stratigraphic units is based on correlation with outcrop and consequently must be considered tentative pending more detailed examination. The smaller units are selected from the electric logs, supported by examination of cores and cuttings (Table 3). These units demonstrate the characteristics of the formations and will not necessarily persist over large areas of the Georgina Basin.

TABLE 3: STRATIGRAPHY, BMR 12 COCKROACH

Unit	Lithology	Depth to Top of Unit (Datum RT 729 ft)		Thickness (ft)	Age
		Drilled	Subsea		
	Quartz sand, silt, clay	Surface	+721	17	Quaternary
Ninmaroo Formation	Limestone, calcite 'sand', clay	25	+704	155	Lower Ordovician
	Limestone, dolomite, clay-siltstone, sandstone, clay	180	+549	305	Upper Cambrian
Arrinthrunga Formation	Dolomite, limestone, clay-siltstone	485	+244	550	Upper Cambrian
	Limestone-dolomite	1035	-306	125	
	Dolomite-limestone	1160	-431	155	
	Dolomite-limestone, sandstone	1315	-586	195	
	Limestone-dolomite, clay-siltstone-sandstone	1510	-781	1211	
Marqua Beds	Limestone, calcareous sandstone	2721	-1992	529	Middle Cambrian
	Calcareous sandstone, limestone	3250	-2521	750+	
	TD	4000	-3271		

Quaternary, 8-25 feet (17 ft)

The superficial cover consists predominantly of quartz sand stained with iron oxide. Minor amounts of clay minerals also occur.

Ninmaroo Formation, 25-485 feet (460 ft)

25-180 feet (155 ft): Limestone (75%), mainly white, light brown, microcrystalline, tight; some white to grey, oolitic, pelletal, and well sorted. Calcite (sand) and clay (25%), consisting of light brown calcite crystals and partly indurated clay minerals.

180-485 feet (305 ft): Limestone (46%); mainly light grey, microcrystalline, with rare silt, tight; lesser amounts of white, light brown, pelletal-oolitic, fine-grained. Dolomite (34%); light brown, white, microcrystalline, with rare pellets. Clay-siltstone (13%); medium dark grey, black, blue, soft. Quartz sandstone (5%); light brown, fine-grained, well sorted, hard. Calcite 'sand' and clay (2%); light brown.

Arrinthrunga Formation, 485-2721 feet (2236 ft)

485-1035 feet (550 ft): Dolomite (85%); grey, white and brown, microcrystalline, partly argillaceous with black silty laminae, tight, pyritic. Lesser amounts of medium-grained pelletal-oolitic dolomite. Limestone (11%); grey to white, microcrystalline, silty, some porosity, some pelletal-oolitic limestone. Clay-siltstone (4%); dark grey, argillaceous, soft, laminated.

1035-1160 feet (125 ft): Limestone (80%); grey to brown, oolitic-pelletal, hard, tight, grey to white, partly mottled, microcrystalline, hard, tight. Dolomite (20%); brown to grey, microcrystalline, calcareous, hard, tight.

1160-1315 feet (155 ft): Dolomite (53%); grey, green to white, rarely red and purple, microcrystalline, partly calcareous, with some purple, grey and green clay-siltstone laminae. Limestone (48%); white, light-grey, microcrystalline and pelletal, medium arenite, hard, tight.

1315-1510 feet (195 ft): Dolomite (70%); white to grey, microcrystalline, rare quartz silt, hard, tight; minor white, brown and grey pelletal dolomite. Limestone (18%); grey to brown, microcrystalline, hard, tight. Quartz sandstone (12%); white, fine to medium grained, well sorted, subrounded, hard, tight.

1510-2721 feet (1211 ft): Limestone (70%); grey, brown, white, rarely red-brown, microcrystalline, partly argillaceous, rarely micaceous, hard, tight; oolitic-pelletal limestone partly porous, rarely silty. Dolomite (27%); brown to grey, rarely green-grey, microcrystalline, slightly calcareous, rare silt and sand, hard, tight. Clay-siltstone and sandstone (3%); grey, purple, red brown, well sorted, tight.

Marqua Beds 2721-4000 feet (1279+ Ft)

2721-3250 feet (529 ft): Limestone (80%); medium to dark grey, rare brown, minor light grey, white mottling, microcrystalline, argillaceous, micaceous(?), quartz silt, tight, hard, pyritic. Calcareous quartz sandstone (19%); light grey, fine-grained, well sorted quartz, calcareous matrix; scattered black opaque silt, rare mica. Possibly grades to quartzose limestone. Clay siltstone (1%); dark grey-black, argillaceous, micaceous(?), calcareous, fissile, pyritic, as laminae.

3250-4000 feet (750 ft): Calcareous quartz sandstone (69%); grey, fine-grained, well sorted scattered black silt, hard, tight, pyritic. Limestone (31%); grey, microcrystalline, argillaceous, hard, tight, with small amounts of quartz sand, hard, tight, pyritic.

CONTRIBUTIONS TO GEOLOGICAL KNOWLEDGE

The presence of the Marqua Beds, 25 miles north of outcrop areas on the margins of the basin, indicates the probable widespread subsurface extent of the Middle Cambrian sequence. Although the well did not penetrate the full thickness of the Marqua Beds, a considerable difference in lithology between well and outcrop is evident: the sequence in the well contains much more calcareous sandstone, and less limestone, than outcrop sections. However, the calcareous quartz sandstone between 2721 and 2790 feet correlates with calcareous sandstone at the top of the outcropping sequence. Reliable measurements of thickness are difficult to obtain in outcrop, but a maximum of 900 feet is indicated (Smith, 1966); this is considerably less than the thickness of the incomplete sequence penetrated in the well.

The thickness of the Arrinthrunga Formation in the well agrees reasonably with measurements made on outcrop. The general lithology is also similar, but a basal dolarenite, evident in outcrop, is not present in the well.

The lithology and thickness of the Ninmaroo Formation cannot be readily compared between well and outcrop because the formation is poorly exposed over large areas surrounding the well site.

BMR 13 SANDOVER

SUMMARY

BMR 13 Sandover is situated 190 miles north-east of Alice Springs and was drilled to a depth of 3330 feet. The objectives were to determine depth to economic basement and the stratigraphy of the Palaeozoic section in this part of the Georgina Basin.

The section penetrated consisted of 2195 feet of Arrinthrunga Formation (Upper Cambrian), 862 feet of Arthur Creek Beds (Middle Cambrian), 207 feet of Mount Baldwin(?) Formation (Lower Cambrian?), 24 feet of Archaean(?) gneiss (Arunta Complex), and 2 feet of granite of unknown age.

A show of oil and gas was obtained from dolomite between 2952 and 2975 feet. A drill-stem test over the interval recovered gas-cut mud.

INTRODUCTION

The site of BMR 13 was chosen to provide information on the depth to economic basement and the stratigraphy of the Palaeozoic section below sand cover (Fig. 2). Aeromagnetic results (Fig. 3) had indicated that basement should occur between 2000 and 4000 feet below sea level at the location, which is 1055 feet above sea level. Smith, Vine, & Milligan (1961) had mapped the geology of the surrounding area, and Smith (1964) reported the geology of the Huckitta Sheet area, south of the well site, where Palaeozoic sequences crop out reasonably well.

WELL HISTORY

General Data

Well name and number:	BMR 13 Sandover
Location:	Lat. 21°51'25"S., Long. 136°09'06"E.
Area:	Georgina Basin, N.T.
Title holder:	Smith Australian Oil Co. Pty Ltd
Petroleum title:	Oil Permit 41, N.T., 7211 sq. miles. Expired 29.5.64
Total depth:	3331 ft
Date spudded:	15 January 1964
Date completed:	6 July 1964
Date abandoned:	21 July 1964
Date rig released:	21 July 1964
Drilling time to TD:	173 days
Elevations:	Rotary table, 1063 ft a.s.l.; ground level, 1055 ft a.s.l.

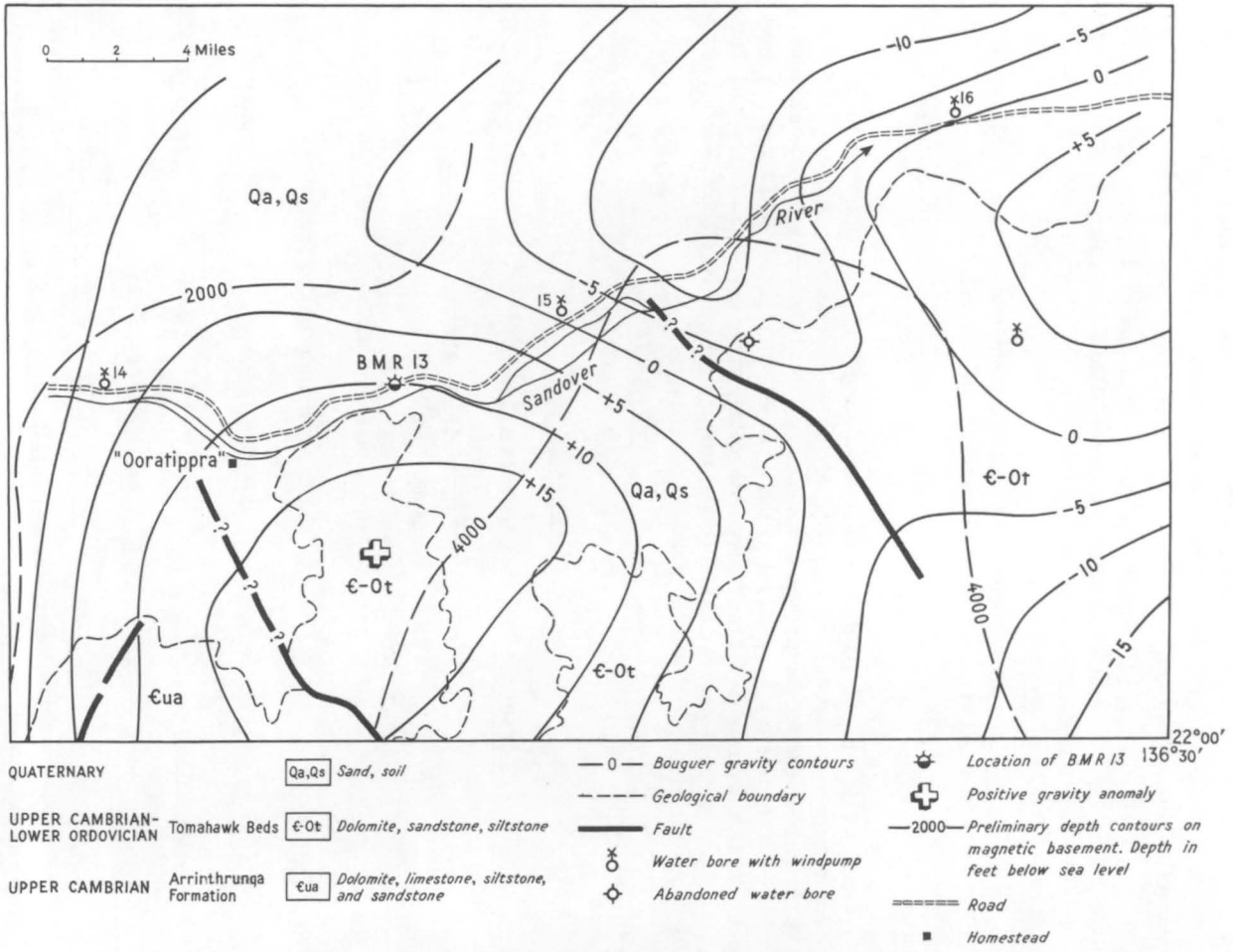

Fig. 3: Bouguer gravity contours and depth contours on magnetic basement, BMR 13 Sandover. Aeromagnetic data: Wells and Milsom (1965); gravity data: Map G69-75-3.

Status: Plugged and abandoned

Drilling Data

Contractor:	W.L. Sides & Son Pty Ltd		
Drilling plant:	make:	Failing 2500	
	type:	Holemaster	
	rated capacity:	4000 ft with 3 1/2 in. drill tubing	
	motors:	2 x 4/71GM series, 110 HP	
Mast:	make and type:	Failing 75 ft tubular (including 17 ft extension)	
	rated capacity:	45,000 lb with extension to mast	
Pumps:	make:	Gardner-Denver	Wheatley
	type:	FOFXO	WBD
	size:	7 1/4 in. x 10 in.	5 in. x 10 in.
	motors:	6/71 GM series	rig
Compressors:	make:	Consolidated-Pneumatic	Holman-Howden
	type:	Reciprocating	Rotary
	model:	CP 500	Rotair 600
	motors:	Lincoln-Ruston	Rolls-Royce
B.O.P.:	make:	Baash-Ross	
	size and model:	6 1/4 in. Autolock	
	working pressure:	3000 psi	
Hole Sizes:	sfc-42 ft	12 1/4 in.	
	42-1620 ft	8 1/2 in.	
	1620-3330 (TD)	6 1/4 in.	
Casing strings:	size:	9 5/8 in.	7 in.
	grade:	J-55	J-55
	weight:	36 lb	20 lb
	set at:	42 ft	1615 ft
Casing cement:	size:	9 5/8 in.	7 in.
	sacks cmt:	14	65
	cmt rise:	to sfc	to 1315 ft (calc.)
	methods:	single stage plug in both cases	
Drilling fluid:	sfc-352 ft	air	
	352-3330 ft (TD)	freshwater, bentonite mud	

Average Mud Properties

Interval (ft) (RT)	Weight (lb/ft^3)	Viscosity (sec/1000 cc)	W.L. (cc)	F.C. (1/32 in.)	pH	Sand (%)
352-750	69	39	21	3	11	3/4
750-1250	70	40	15	2 1/2	10	1/2
1250-1750	70	36	13	2 1/2	10	1/4
1750-2250	66	37 1/2	12	2	9	1/4
2250-2750	65	37 1/2	14	2 1/2	9 1/2	1
2750-3330	67 1/2	38	13	2	8 1/2	3/4

Water Supply: From water-bore drilled to supply the domestic and drilling requirements at the site

Perforation and shooting record: Nil

Side-tracked hole: Nil

Plug back jobs:

(1) Bottom plug to give seat for anchor to test interval 2950-2990 ft

1st Job: with open ended drill pipe at 3330 ft equalised 52 sacks of construction cement mixed to 105.5 lb/cu ft. Located top of cement at 3216 ft and drilled out to hard cement at 3221 ft

2nd Job: with open ended drill pipe at 3210 ft equalised 42 sacks of construction cement mixed to 105.5 lb/cu ft. Located top of cement at 3004 ft and drilled out to hard cement at 3013 ft

(2) Plug above test zone 2950-2990 ft. With open ended drill pipe at 2900 ft equalised 8 sacks of construction cement mixed to 105.5 lb/cu ft. Located top of cement at 2845 ft. Test satisfactorily with full weight of string

(3) Plug at 7 in. casing shoe (1615ft). With open ended drill pipe at 1600 ft equalised 8 sacks of construction cement mixed to 105.5 lb/cu ft. Located top of hard cement at 1569 ft and tested with full weight of string

(4) Top plug: 4 sacks cement placed in top of 7 in. casing at surface.

Squeeze cement jobs: Nil

Fishing operations:

Date	Depth (ft)	Hours Lost	Fishing Job	Recovery Method
21/3/64	1887	12 3/4	Pin failure caused 98 ft DC to be left in hole	Fished out with tapered tap
15/4/64	2607	181 3/4	Tool jt failure caused 188 ft DC to be left in hole	Collars and bit recovered in stages using over-shot, diesel spot and working free. Cones recovered singly with magnet and junk basket
16/5/64	2639	8 1/4	DP twist-off due to tool jt failure	String fished out with Baash-Ross over-shot
20/5/64	2732	18	Twist-off at tool leaving 322 ft DC in hole	String fished out with Baash-Ross over-shot. Cones with magnet and junk basket

Date	Depth (ft)	Hours Lost	Fishing Job	Recovery Method
26/ 5/64	2830	8 3/4	DP twist-off at pin end of tool jt above DC's	Fished out with Bowen over-shot
30/ 5/64	2896	30 1/4	DP twist-off at tool jt above DC's	Fished out with Bowen over-shot; cones and bearings out with magnet
17/ 6/64	3091	17	90 ft of DP twisted-off at pin	Recovered with over-shot
2/ 7/64	3326	72 1/4	Bit cones left in hole after trip out due to worn bearings and pin	Recovered with junk basket and core-catcher
16/ 7/64	330(TD)	42 3/4	55 1/2 ft tail pipe sheared off leaving pressure recorder and carrier in hole during DST	Fishing job unsuccessful

Logging and Testing

Ditch cuttings: Samples were collected from the shale shaker at 10-foot intervals. Cuts were distributed to the Geological Branch, BMR, Canberra; the Resident Geologist, BMR, Alice Springs; and a cut was collected for the tenement holder.

Coring: The original programme called for routine cores to be cut at convenent bit changes to give a coring interval of about 300 ft between successive cores. This was maintained except where other cores were required by the well-site geologist for additional information.

Sixteen cores were cut with a 6 in. Reed K-500 barrel using HF coreheads, and all have a diameter of 2 3/8 in.

The total footage cored was 149 1/2 and of this 55 ft 9 1/2 in. or 37% was recovered

Side-wall sampling: It was intended to take Schlumberger side-wall cores over the potentially productive interval but the caliper log showed the hole diameter to be too large for the tool to be effective

Well logging: The well was logged by Schlumberger on two occasions: prior to running the 7 in. surface casing and after reaching total depth. All the logs are on scales of both 2 in. and 5 in. to 100 ft and are summarised below:

Log Type	Run No.	Depth (ft)	Curves
Electric	1	1676- 42	SP & resistivity
	2	3330-1615	SP & resistivity
Microlog	1	1630- 42	Microcaliper
	2	3331-1615	Microcaliper
Sonic	1	1665- 42	SP & sonic
	2	3326-1614	Gamma ray & sonic
Radioactivity	1	1670- 30	Gamma ray
" "	2	3326-1614	Gamma ray

The sonic log was integrated on the 2nd run. No microresistivity curves were obtained on either run due to malfunctioning of the sonde.

Drilling time and gas log: There was no automatic device on site to detect the present of gas, but the number of minutes taken to drill every 5 ft were recorded and these form the basis of the penetration rate log on the attached Composite Well Log.

Deviation surveys: All deviation surveys were taken with a Totco Double Recorder tool and they are listed below. The readings have been plotted on the attached Composite Well Log.

Depth (ft)	Deviation (degrees)	Depth (ft)	Deviation (degrees)	Depth (ft)	Deviation (degrees)
45	1 1/2	1100	3/4	1850	1 1/2
95	3/4	1200	1/2	1950	1 1/4
195	1	1295	1	2050	3/4
300	3/4	1400	1	2250	1
395	1/2	1490	1 1/4	2400	1
500	1/2	1600	1	2550	1 1/4
590	3/4	1635	1	2700	1 1/2
710	1	1670	1 1/2	2850	1 3/4
790	1	1700	3/4	2930	1 1/2
900	1/2	1750	3/4	3020	1 1/4
1000	3/4	1800	2	3300	3/4
				3320	3/4

Other well surveys: Nil

Formation Testing:

DST No. 1 Date 15 July 1964

Test interval: 2950-2990 ft (RT)

Test by; P.G. Duff

Witnessed by: G. Birkensleigh, W.L. Sides & Son Pty Ltd

The testing tools were run into the hole, the mud pressure was balanced, the packer was set, the equalizing valve was closed and the retaining valve opened. After waiting 1 hour for the pressure to build up, the Go-devil was dropped and the disc broken; a blow to surface resulted.

The mud level began to drop in the annulus after 8 minutes but remained steady after the packer was set with an additional 5000 lb weight. Six minutes later the pipe dropped 4 to 5 ft, bending and fracturing the tail-pipe. This forced the end of it into the test zone cavity, allowing the packer to reset. The test resumed with the level of mud in the annulus steady.

The surface blow started at a rate of 120 cu ft/hr and decreased to zero flow after 31 minutes. Before the packer was pulled the well was allowed to sit for an additional 30 minutes, and on pulling out it was discovered that the 1 1/4 in. Humble subsurface pressure gauge and 56 feet of 3 1/2 in. line-pipe used as tail-pipe had been left in the hole.

Further details of the test may be found in Appendix 14.

STRATIGRAPHIC SEQUENCE

Some reasonable correlations can be made with outcrop and with other subsurface information, particularly with regard to the Arrinthrunga Formation, but the formations selected in the well (Table 4) may require amendment when more detailed information is available.

TABLE 4: STRATIGRAPHY: BMR 13 SANDOVER

Unit	Lithology	Depth to Top of Unit (Datum RT 1063 ft) Drilled	Depth to Top of Unit (Datum RT 1063 ft) Subsea	Thickness (ft)	Age
	Quartz sand (1)	8	+1055	32	Quaternary
	Dolomite (2)	40	+1023	163	
	Dolomite, shale, sandstone (3)	203	+ 860	248	
Arrinthrunga Formation	Dolomite, shale (4)	451	+ 612	489	Upper Cambrian
	Siltstone, sandstone, dolomite, limestone (5)	940	+ 123	524	
	Dolomite, sandstone, shale, siltstone (6)	1464	- 401	771	
	Siltstone, dolomite (7)	2235	-1172	203	
Arthur Creek Beds	Dolomite, limestone (8)	2438	-1375	144	Middle Cambrian
	Limestone (9)	2582	-1519	515	
Mt Baldwin Formation (?)	Dolomite, sandstone (10)	3097	-2034	207	Lower Cambrian(?)
Arunta Complex(?)	Gneiss (11)	3304	-2241	24	Archaean(?)
	Granite (12)	3329	-2265	2+	Precambrian (?)

Quaternary

Unit 1, surface-40 feet (32 ft)

Unit 1 consists of quartz sand, red and brown , fine to medium-grained, rarely coarse-grained, rounded to subrounded; rare chert is present.

Upper Cambrian

The sequence between 40 and 2234 feet is identified with the Arrinthrunga Formation; although no fossils were found in the well, and very few are known in outcrop,

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the age of the formation is based upon its stratigraphical position on the adjoining Huckitta Sheet area (Smith, 1964).

In the well, the Arrinthrunga Formation is divisible into five units (units 2 to 6 in Table 4). The basal unit is correlated with a basal dolomite which crops out in the eastern part of the adjoining Huckitta Sheet area (Smith, 1964, op. cit.). The four overlying units belong to part of the Arrinthrunga Formation which is not well exposed in outcrop - carbonate beds crop out strongly but interbeds crop out poorly, if at all, and the only previous reliable information came from core-hole Grg 7 (Fig. 2), where Milligan (1963) described about 465 feet of relatively soft interbeds overlying the basal dolomite unit. The composite well log of BMR 13 Sandover (Pl. 3) shows the interbeds in units 3, 4, and 5; these interbeds constitute most of unit 5, but are thinner and less abundant in units 3 and 4. Unit 2 consists predominantly of dolomite without interbeds, but is included in the same broad division of the formation as units 3, 4, and 5 because surface mapping indicates that the top of unit 2 is about 300 feet below the top of the division. Sixteen samples of shale from the Arrinthrunga Formation were analysed spectroscopically for various metals, and the results are given in Appendix 18.

Middle Cambrian

The Arthur Creek Beds (2235-3097 ft) have been divided into three lithological units (Nos 7 to 9 in Table 4). Many of the fossils obtained from the Arthur Creek Beds in the well are not diagnostic, but sufficient indications of Middle Cambrian faunas were obtained (App. 9) to prove the age below 2574 feet. Öpik (pers. comm.) considers that fossils obtained from the interval 2710-2827 feet are high in the lower Middle Cambrian, but further zoning is not possible with the fauna available in the cores and cuttings. In outcrop the age of the Arthur Creek Beds ranges from lower to uppermost Middle Cambrian; in the well there is no evidence to indicate the presence of the whole of the Middle Cambrian, and the lithological evidence is also inconclusive.

Unit 7, 2235-2438 ft (203 ft), consists of 50 percent siltstone, grading to silty dolomite and also to fine-grained sandstone, and 50 percent dolomite, grading to dolomitic siltstone. The interval is apparently unfossiliferous, and the lithology differs from outcrop at the top of the Arthur Creek Beds, where fossiliferous calcareous sandstone intertongues with limestone and minor dolomite (Smith, 1964).

Unit 8, 2438-2582 ft (144 ft), consists of two-thirds dolomite and one-third limestone, with minor black siltstone. Fossils are rare and consist of sponge spicules and brachiopods.

Unit 9, 2582-3097 ft (515 ft), consists almost entirely of limestone, with minor siltstone, quartz sandstone, shale, and dolomite. Brachiopods, trilobites, and sponge spicules are common in the interval 2730-2830 feet.

Lower(?) Cambrian

Unit 10, 3097-3304 ft (307 ft), consists of dolomite with thin beds of quartz sandstone, and thin beds of shale interpreted from the electric logs. The lithology resembles that of the lower Cambrian Mount Baldwin formation (named by Smith, 1964, op. cit.), and the fragmentary brachiopods in the interval 3220-3330 feet could be either Lower or Middle Cambrian in age. Therefore unit 10 may be either part of the Arthur Creek Beds or part of the Mount Baldwin Formation; the lithology indicates affinities with the Mount Baldwin Formation; If this interpretation is correct, the formation in the well is about one-quarter of the outcrop thickness.

Precambrian

Unit 11, 3304-3328 ft (24 ft), consists of banded feldspathic gneiss (App. 10) which is considered to be Arunta Complex of Archaean(?) age. Appendix 11 gives the determinations of magnetic susceptibility and specific gravity of a sample of this gneiss from 3305 feet (Core No. 15).

Unit 12, 3328-3330 ft (2 ft), consists of coarsely crystalline granite with oblique fractures. The lack of gneissosity indicates that the granite is younger than the Arunta Complex. The granite is probably Precambrian, and may be similar to dated granites in the Elkedra and Huckitta Sheet areas which have an average age of 1400 m.y. (Hurley, Fisher, Pinson, & Fairbairn, 1961).

HYDROCARBONS

Small quantities of bituminous material were observed in cuttings from various depths between 1210 and 2570 feet. Appendix 12 gives the results of analysis of some of this material.

A show of oil and gas was obtained from the Arthur Creek Beds in the interval 2952-2975 feet. Small globules of oil and minute bubbles of gas were observed in the drilling mud, and the penetration rate increased sharply. Core No. 13 (2960-2980 ft) failed to recover any rock in the zone of interest, but cuttings from the interval 2950-2975 feet consisted of dark brown soft bituminous dolomite which contained globules of oil. A petrographic description of the cuttings is given in Appendix 13.

A drill-stem test was run over the interval 2950-2990 feet; 22 cubic feet of gas-cut mud (App. 14) were recovered, but mechanical difficulties with the testing apparatus prevented the recording of temperature and pressure data. A sample of the gas-cut mud yielded a small volume of oil, and a sample of mud taken during the drilling of the interval 2952-2960 feet also yielded oil. The results of mud tests are given in Appendix 15: Appendix 16 gives results of analytical work on core and cavings from the interval 2950-2980 feet.

POROSITY

The variable porosity of the carbonate rocks is due mainly to vugs, caverns, and fractures, although intergranular porosity is evident in some cuttings. The quartz sandstones are mainly porous, but the dolomitic and calcareous sandstones have low porosity. Partial loss of circulation occurred several times, and total loss three times; in every case the loss was controlled without resorting to cementing.

HYDROLOGY

A water well drilled to supply domestic and operating requirements for BMR 13 produced 200 gallons per hour from dolomite at 253 feet and 1900 gallons per hour from quartz sandstone in the interval 310-330 feet. Analysis of a sample of mixed waters and from the water well showed that the water was suitable for domestic purposes (App. 17).

In BMR 13 a very small supply was obtained at 85 feet, 900 gallons per hour from dolomite at 242 feet, and an additional 1600 gallons per hour from quartz sandstone in the interval 325-340 feet. These yields were measured by air-lifting, and the tests were of short duration; nevertheless, the availability of useful supplies for pastoral purposes is clearly indicated. The standing water level was 85 feet.

Additional water was obtained from deeper aquifers, but the yields were not measured; a supply of 500 gallons per hour was estimated at about 1640 feet, during an unsuccessful attempt to revert to air-drilling methods below the casing.

CONTRIBUTIONS TO GEOLOGICAL KNOWLEDGE

The results from BMR 13 provided a significant contribution to the geological knowledge of part of the Georgina Basin. The main contributions are:

(a) The presence of Archaean(?) crystalline basement was established at a depth of 2241 feet below sea level. The depth agrees reasonably well with the depth to magnetic basement calculated by Wells & Milsom (1965) (Fig. 1).

(b) The Lower Proterozoic Hatches Creek Group is absent; this group trends south-east towards the well.

(c) There are no Adelaidean sediments beneath the Cambrian strata.

(d) Lower Cambrian sediments are probably present; alternatively Middle Cambrian sediments are present in the interval 3097-3304 feet.

(e) Middle Cambrian sediments are known at a locality about 20 miles from outcrop of the lower Middle Cambrian Sandover Beds and about 35 miles from outcrop of the top of the Middle Cambrian Arthur Creek Beds. The lithology in the well differs in some respects from that in outcrops, but fossil control in the well is insufficient to prove the presence or absence of a complete Middle Cambrian sequence.

(f) The presence of oil and gas in Middle Cambrian sediments was demonstrated.

(g) The well provided reliable information on the lithology of part of the Upper Cambrian Arrinthrunga Formation for which outcrop data are incomplete. In particular, several units of relatively soft quartz sandstone, siltstone, and shale were recorded; the shale units are thin, but one unit of siltstone is 70 feet thick and a quartz sandstone unit has a thickness of 40 feet.

(h) The well demonstrated the availability of good supplies of fresh water from shallow aquifers in the Arrinthrunga Formation.

REFERENCES

CARTER, E.K., BROOKS, J.H., and WALKER, K.R., 1961 - The Precambrian mineral belt of north-western Queensland. Bur. Miner. Resour. Aust. Bull. 51.

CASEY, J.N., 1959 - New names in Queensland stratigraphy, north-west Queensland. Aust. Oil Gas J., 5(12), 31-36.

CASEY, J.N., and GILBERT-TOMLINSON, Joyce, 1956 - Cambrian geology of the Huckitta-Marqua region, Northern Territory. In EL SISTEMA CAMBRICO, SU PALEOGEOGRAFIA Y EL PROBLEMA DE SU BASE. 20th int. geol. Cong., Mexico. Reprinted in Bur. Miner. Resour. Aust. Bull. 49.

CASEY, J.N., et al., 1960 - The geology of the Boulia area, western Queensland. Bur. Miner. Resour. Aust. Rec. 1960/12 (unpubl.).

*DELHI-SANTOS, F.P.C. (A)., 1964 - Cooper's Creek aeromagnetic survey. Final Rep. (unpubl.).

*FARMOUT DRILLERS N.L., 1963 - Ammaroo No. 1 and No. 2 wells. Completion Rep. by H.L. Newton (unpubl.).

*FRENCH PETROLEUM COMPANY (AUST.) PTY LTD, 1965 - Bedourie seismic and gravity survey, January-November 1964. Final Rep. (unpubl.)

HURLEY, P.M., FISHER, N.H., PINSON, W.H., and FAIRBAIRN, H.W., 1961 - Geochronology of Proterozoic granites in Northern Territory, Australia. Bull. geol. Soc. Amer., 72(5), 653-62?.

IVANAC, J.F., 1954 - The geology and mineral deposits of the Tennant Creek Goldfield, Northern Territory. Bur. Miner. Resour. Aust. Bull. 22.

JOHNSON, N.E.A., NICHOLS, R.A.H., and BELL, M.D., 1964 - Completion Report, BMR 11 Well (Cattle Creek) Northern Territory. Bur. Miner. Resour. Aust. Rec. 1964/45 (unpubl.).

LLOYD, A.R., and BELL, M.D., 1964 - Completion Report, BMR 13 Well (Sandover), Northern Territory. Bur. Miner. Resour. Aust. Rec. 1964/127 (unpubl.).

McDOUGALL, I., DUNN, P.R., COMPSTON, W., WEBB, A.W., RICHARDS, A.R., and BOFINGER, V.M., 1965 - Isotopic age determinations on Precambrian rocks of the Carpentaria region, Northern Territory, Australia. J. geol. Soc. Aust., 12(1), 67-90.

MILLIGAN, E.N., 1963 - The Bureau of Mineral Resources Georgina Basin core drilling programme. Bur. Miner. Resour. Aust. Rec. 1963/86 (unpubl.).

MILLIGAN, E.N., 1964 - The regional geology of the northern half of the Alcoota 1:250,000 Sheet, N.T. Bur. Miner. Resour. Aust. Rec. 1965/43 (unpubl.).

NICHOLS, R.A.H., 1966 - Sandover River, N.T. - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/53-8.

NICHOLS, R.A.H., and BELL, M.D., 1965 - Completion Report for BMR 12 (Cockroach) Northern Territory. Bur. Miner. Resour. Aust. Rec. 1965/60 (unpubl.).

NOAKES, L.C., CARTER, E.K., and ÖPIK, A.A., 1959 - Urandangi, Qld - 4-mile Geological Series. Bur. Miner. Resour. Aust. explan. Notes 1 (2nd edn).

ÖPIK, A.A., 1956 - Cambrian geology of Queensland. In EL SISTEMA CAMBRICO, SU PALEOGEOGRAFIA Y EL PROBLEMA DE SU BASE. 20th int. geol. Cong., Mexico, 2, 1-24. Also in Bur. Miner. Resour. Aust. Bull. 49.

ÖPIK, A.A., 1956 - Cambrian geology of the Northern Territory. Ibid., 2, 25-49.

ÖPIK, A.A., CARTER, E.K., and NOAKES, L.C., 1961 - Mount Isa, Qld - 4-mile Geological Series. Bur. Miner. Resour. Aust. explan. Notes 20.

ÖPIK, A.A., and PRITCHARD, P.W., 1960 - Cambrian and Ordovician. In The geology of Queensland. J. geol. Soc. Aust., 7, 89-114.

RANDAL, M.A., 1962 - The hydrology of the eastern Barkly Tableland. Bur. Miner. Resour. Aust. Rec. 1962/61 (unpubl.).

RANDAL, M.A., 1966a - Ranken, N.T. - 1:250,000 Geological Series. Bur. Miner. Resour. Aust., explan. Notes SE/53-16.

RANDAL, M.A., 1966b - Avon Downs, N.T. - 1:250,000 Geological Series. Ibid., SF/53-4.

RANDAL, M.A., 1966c - Alroy, N.T. - 1:250,000 Geological Series. Ibid., SE/53-15.

RANDAL, M.A., 1966d - Brunette Downs, N.T. - 1:250,000 Geological Series. Ibid., SE/53-11.

RANDAL, M.A., and BROWN, G.A., 1962 - Additional notes on the geology of the Camooweal 4-mile Sheet area. Bur. Miner. Resour. Aust. Rec. 1962/49 (unpubl.).

REYNOLDS, M.A., 1964 - Explanatory notes on the Mount Whelan Geological Sheet. Bur. Miner. Resour. Aust. Rec. 1964/138 (unpubl.).

REYNOLDS, M.A., 1965 - Glenormiston, Qld - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/54-9.

REYNOLDS, M.A., and others, 1963 - The sedimentary basins of Australia and New Guinea. Bur. Miner. Resour. Aust. Rec., 1963/159 (unpubl.).

ROBERTSON, C.S., 1965 - South-eastern Georgina Basin seismic survey, Queensland, 1963. Bur. Miner. Resour. Aust. Rec. 1965/75 (unpubl.).

SMITH, K.G., 1963 - Hay River, N.T. - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/53-16.

SMITH, K.G., 1964 - Progress report on the geology of the Huckitta 1:250,000 Sheet, Northern Territory. Bur. Miner. Resour. Aust. Rep. 67.

SMITH, K.G., 1965a - The geology of Georgina Basin J. Aust. Pet. Exp. Ass., 1965, 111-112.

SMITH, K.G., 1965b - Frew River, N.T. - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/53-3.

SMITH, K.G., 1966 - Tobermory, N.T. - 1:250,000 Geological Series. Ibid., SF/53-12.

SMITH, K.G., VINE, R.R., and MILLIGAN, E.N., 1961 - Progress report on the Palaeozoic geology of the Elkedra 4-mile Sheet, N.T., Bur. Miner. Resour. Aust. Rec. 1961/50 (unpubl.).

SMITH, K.G., and MILLIGAN, E.N., 1966 - Elkedra, N.T. - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/53-7.

SMITH, J.W., and ROBERTS, H.G., 1963 - Mount Drummond, N.T. - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SE/53-12.

WELLS, R., and MILSOM, J., 1965 - Georgina Basin aeromagnetic survey, Queensland and N.T., 1963. Bur. Miner. Resour. Aust. Rec. 1965/52 (unpubl.).

*These unpublished reports are available for inspection at the Bureau of Mineral Resources, Canberra, A.C.T.

APPENDIX 1

CORE DESCRIPTIONS, BMR 11 CATTLE CREEK

by

N.E.A. Johnson, K.G.Smith, and R.A.H. Nichols.

Core No. 1 (220-29 ft). Recovered 3 ft of broken core

Dolomite: 100%; white with light brown patches, microcrystalline to medium crystalline, uniform, euhedral rhombs, hard. Vuggy: vugs connected, contain siderite(?) and calcareous dolomite. Some tight interbeds of cryptocrystalline dolomite. Some thin interbeds of pelletal dolarenite: pellets of microcrystalline dolomite, 0.6 mm in diameter, rounded; beds tight, hard. Some microcrystalline dolomite with horizontal bands and laminae (algal?): yellow, white, silty, vuggy, some intergranular porosity. Some slightly calcareous dolomite, some manganese.

Core No. 2 (547-60 ft). Recovered 2 ft of broken core

Dolomite: 100%; white, microcrystalline, hard, tight, vuggy; vugs interconnected, porosity 30%. Euhedral crystals on walls of vugs. Some pelletal interbeds: pellets are cream, white, well rounded; rare glauconite pellets. Some ironstaining, some manganese dendrites. Fossils: one brachiopod shell fragment.

Core No. 3 (701-20 ft). Recovered 1 ft of broken core

Dolomite: 98%; dark grey, green microcrystalline, argillaceous, platy fracture, fissile(?).

Chert: 2%; grey, cryptocrystalline, aphanitic, vaguely laminated.

Core No. 4 (782-83 ft). Recovered 10.5 in.

Dolomite: 100%; grey-white, pale brown-grey, microcrystalline, densely pelletal and possibly oolitic, tight, hard. Some crystalline dolomite (1 in.), vugs (3 mm in diameter); porosity 10%. Stylolites and fine fractures. Iron nodule, 0.5 mm wide, in fracture. Some manganese dendrites.

Core No. 5 (784-88.5 ft). Recovered 3 ft

Dolomite: 96%; grey, white, yellow, brown; pelletal and oolitic dolarenite. Pellets of microcrystalline dolomite form 20-70% of sample: they are well rounded, not grain-on-grain, set in matrix of microcrystalline dolomite. Some medium crystalline dolomite. Dolomite slightly calcareous. Vugs up to 10 cm long, vertical in core, porous parts connected. Stylolites and fine fractures present. Some manganese grains and glauconite pellets.

Chert: 4%; blue, cryptocrystalline, aphanitic, pelletal.

Core No. 6 (885-86.5 ft). Recovered 1 ft 2 in.

Dolomite: 75%; grey, white, microcrystalline, medium crystalline. Fracture planes around chert, stylolites, vugs 1.25 cm in diameter, euhedral crystals lining vugs and stylolites.

Chert: 25%; light grey, cryptocrystalline, aphanitic, nodular. Conchoidal fractures, some filled with crystalline calcite.

Core No. 7 (940-47.5 ft). Recovered 4.5 in. of broken core

Dolomite: grey, white, microcrystalline, clay pellets fine sand size. Spine-like problematica; small, irregular shape. Ironstaining.

Chert: light medium grey, cryptocrystalline, nodular, fractured.

Core No. 8 (947.5-51 ft). Recovered 4 in. of broken core

Dolomite: white, grey, brown-grey, microcrystalline, granular texture, tight, hard. Some euhedral medium crystalline areas, vugs with drusy growth. Dendritic manganese.

Chert: white, grey, cryptocrystalline, aphanitic, nodular, fractured.

Core No. 9 (1006-16 ft). Recovered 1 ft

Dolomite: 100%; white, grey, slightly calcareous, microcrystalline to medium crystalline. Fossiliferous (shell fragments). Vuggy: vugs lined with euhedral crystals. Some intergranular porosity in coarser crystalline parts. Some irregularly shaped glauconite pellets.

Core No. 10 (1075-85 ft). Recovered 1ft 6 in.

Dolomite: 100%; medium grey to brown-grey, microcrystalline to medium crystalline. Fossiliferous (two shell fragments). Few large vugs. Ironstained. Irregular areas and veins of white coarse crystalline dolomite.

Core No. 11 (1136-39 ft). Recovered 1 ft 3 in.

Dolomite: 100%; white, grey, microcrystalline to medium crystalline, granular texture, tight, hard. White coarse crystalline dolomite. Dark grey-black carbonaceous films of clay on fracture planes and stylolite surfaces.

Core No. 12 (1202-05 ft). Recovered 1 ft 5 in.

Limestone: 80%; grey, brown, microcrystalline. Thin (0.5 mm) laminae in limestone with dark grey-black carbonaceous and slightly calcareous pellets(?).

Chert: 20%; medium blue-grey, nodular, cryptocrystalline, aphanitic; nodules have thin white rims.

Core No. 13 (1255.5-56.5 ft). Recovered 7 in.

Limestone: 98%; medium grey, brown, cryptocrystalline to microcrystalline, vague granular texture. Lingula present. Carbonaceous laminae, scattered granular pyrite.

Chert: 2%; fractured, nodular, blue-grey, brown. Contain veins of coarse crystalline slightly calcareous dolomite.

Core No. 14 (1308-18 ft). Recovered 1 ft 6 in.

Dolomite: 100%; light brown-grey, cryptocrystalline to microcrystalline. Vugs contain drusy crystals, interconnected. Porosity ranges from 20-60%. Shell fragments(?).

Core No. 15 (1390-1400 ft). Recovered 7 ft 6 in.

Dolomite: 100%; light brown, grey-brown, mottled, cryptocrystalline to microcrystalline, calcareous. Appears fragmental in section and mottled in plan. Pores with carbonate crystals. Intergranular porosity 15-50%. Thin dark grey ironstained carbonaceous(?) laminae.

Core No. 16 (1450-51.5 ft). Recovered 11 in.

Quartz sandstone: 100%; white, grey, medium-grained. Quartz grains: colourless, transparent to translucent, subrounded, moderately sorted, partly bound by siliceous cement. Vague laminae. Porosity 20-40%. Some white clay(?) pellets or pore fillings.

Core No. 17 (1495-1500 ft). Recovered 3 ft 6 in.

Quartz sandstone: 100%; 50% grey, medium and dark red-brown, medium-grained. Quartz grains: colourless, translucent to transparent, subrounded, moderately sorted. Siliceous cement. 50% pebbly quartz sandstone: pebbles consist of rounded quartz, average diameter 1 cm. Minor green-grey micaceous siltstone at 1495 ft 7 in. Dip almost horizontal. Thin to medium bedding and cross-lamination.

Core No. 18 (1500-01.5 ft). Recovered 1 ft 3.5 in.

Pebbly quartz sandstone: 100%; grey to medium red-brown. Grades into coarse-grained quartz sandstone at 1500 ft 8 in. Matrix of iron-rich material.

APPENDIX 2

PALAEONTOLOGICAL REPORT, BMR 11 CATTLE CREEK

by

C.G. Gatehouse

Cores Nos 1 to 7, and 9 to 14, from BMR 11 Cattle Creek have been examined; Middle Cambrian fossils have been found in some of them, but these fossils are not diagnostic of zones within the Middle Cambrian.

The presence of Biconulites? in core No. 2 (547-560 ft) and Biconulites in core No. 9 (1006-1016 ft), together with some associated phosphatic brachiopods, indicates an early Middle Cambrian age for this interval.

Several fragments of trilobites are present in the cores, but their preservation is poor and they are indeterminate.

Lithistid spicules occur in core No. 3 and again in core No. 12. The spicules in core No. 3 are similar to those reported elsewhere in the Georgina Basin (Gatehouse, in prep.); core No. 12 contains a form of lithistid spicule new for this region.

The following observations were made on the cores:

Core No. 1 (220-29 ft)	No fossils observed
Core No. 2 (547-60 ft)	Biconulites?
Core No. 3 (701-20 ft)	Lyssakid sponge spicules - rods, crosses; lithistid sponge spicules, phosphatic brachiopod fragments, trilobite fragment, conodont fragments
Core No. 4 (782-83 ft)	Trilobite fragment
Core No. 5 (784-88.5 ft)	No fossils observed
Core No. 6 (885-86.5 ft)	" " "
Core No. 7 (940-47.5 ft)	" " "
Core No. 9 (1006-16 ft)	Biconulites, phosphatic brachiopods (obolid?)
Core No. 10 (1075-85 ft)	Conodont, obolid brachiopod
Core No. 11 (1136-39 ft)	No fossils observed
Core No. 12 (1202-05 ft)	Lyssakid sponge spicules, lithistid sponge spicules (not the same as in core No. 3), phosphatic brachiopod fragments
Core No. 13 (1255.5-56.5 ft)	No fossils observed
Core No. 14 (1308-18 ft)	Trilobite free cheek

CONCLUSION

The interval 547 to 1016 feet covers the upper and lower limits of Biconulites in BMR 11 Cattle Creek. The age of this interval, after considering the associated phosphatic brachiopods and sponge spicules, is most probably early Middle Cambrian. Fossils at 1205 feet (i.e. core No. 12) may also be of Middle Cambrian age.

REFERENCE

GATEHOUSE, C.G., In press - First record of lithistid sponges in the Cambrian of Australia. Bur. Miner. Resour. Aust. Bull. 92.

APPENDIX 3

HYDROLOGY, BMR 11 CATTLE CREEK

by

K.G. Smith

Aquifers were penetrated at 220-230, 280-290, 320-370, 415-425, and 515-525 feet. Yields ranging from 1800 to 6000 gallons per hour were measured by air-lifting, but the tests were of short duration. The maximum yield shows that much more water is available than indicated by the recorded yields of the pastoral bores in the surrounding area, which would generally not be drilled deeper than aquifers yielding 1500-2000 gallons per hour.

The standing water level in BMR 11 Cattle Creek is 191 feet. The aquifers below 525 feet are not recorded because mud was used as a drilling fluid, but the severe losses of circulation and the vuggy nature of the cores below 900 feet indicate the presence of aquifers.

APPENDIX 4

CORE ANALYSIS, BMR 11 CATTLE CREEK

by

P.G. Duff, Petroleum Technology Laboratory, BMR

WELL NAME AND NO. BMR 11 CATTLE CREEK DATE OF TEST 14 APRIL 1966

Core No.	Depth (ft)	Lithology	Effective Porosity (% bulk vol.)	Absolute Permeability (millidarcy)		Average Density (gm/cc)		Fluid Saturation (% of pore space)		Acetone Test	Core Water Salinity (ppm NaCl)	Solubility in 15% HCl (% bulk vol.)	Fluorescence of Freshly Broken Core
				V	H	Dry Bulk	Apparent Grain	Water	Oil				
1	220-29	Limestone vugular	14	n.d.	n.d.	2.42	2.81	nil	nil	nil	n.d.	n.d.	nil
2	547-60	Limestone	8	n.d.	n.d.	2.57	2.80	nil	nil	nil	n.d.	n.d.	nil
3	701-20	Siltstone	14	n.d.	n.d.	2.43	2.83	n.d.	n.d.	n.d.	n.d.	n.d.	nil
4	782-83	Limestone	4	nil	nil	2.70	2.82	n.d.	n.d.	n.d.	n.d.	n.d.	nil
	784-89	Limestone vugular	5	nil	n.d.	2.68	2.82	nil	nil	nil	n.d.	n.d.	nil
6	885-87	Limestone	5	nil	nil	2.71	2.84	n.d.	n.d.	n.d.	n.d.	n.d.	nil
7	940-48	Limestone	5	nil	n.d.	2.69	2.83	n.d.	n.d.	n.d.	n.d.	n.d.	nil
8	948-51	Limestone	2	n.d.	n.d.	2.63	2.68	n.d.	n.d.	n.d.	n.d.	n.d.	nil
9	1006-16	Limestone	4	n.d.	n.d.	2.70	2.81	n.d.	n.d.	n.d.	n.d.	n.d.	nil
10	1075-85	Limestone	2	n.d.	n.d.	2.76	2.82	n.d.	n.d.	n.d.	n.d.	n.d.	nil
11	1136-39	Limestone	3	n.d.	n.d.	2.73	2.82	n.d.	n.d.	n.d.	n.d.	n.d.	nil
12	1202-05	Limestone	4	nil	n.d.	2.67	2.78	n.d.	n.d.	n.d.	n.d.	n.d.	nil
13	1256-57	Limestone	3	n.d.	n.d.	2.62	2.70	n.d.	n.d.	n.d.	n.d.	n.d.	nil
14	1308-18	Limestone	5	n.d.	n.d.	2.71	2.85	n.d.	n.d.	n.d.	n.d.	n.d.	nil
15	1390-1400	Limestone	12	nil	14	2.48	2.82	n.d.	n.d.	n.d.	n.d.	n.d.	nil
16	1450-52	Sandstone siliceous	10	n.d.	nil	2.40	2.67	nil	nil	nil	n.d.	n.d.	nil
17	1495-1500	Sandstone siliceous	8	nil	53	2.46	2.69	nil	nil	nil	n.d.	n.d.	nil
18	1500-01	Sandstone siliceous	3	nil	nil	2.63	2.71	nil	nil	nil	n.d.	n.d.	nil

Notes: (i) Unless otherwise stated, the porosities and permeabilities were determined on two small plugs (V&H) cut at right angles from the core. Ruska porosimeter and permeameter were used with air at 30 psig and dry nitrogen, respectively, as the saturating and flowing media. (ii) Residual oil and water saturations were determined using soxhlet type apparatus. (iii) Acetone test precipitates are recorded as nil, trace, fair, strong, or very strong. (iv) n.d., not determined. (v) Several cores consisted of small fragments unsuitable for the cutting of permeability plugs.

APPENDIX 5

CORE DESCRIPTIONS, BMR 12 COCKROACH

by

R.A.H. Nichols and M.A. Randal

Core No. 1 (290-300 ft) Recovered 6 ft 4 in.

6in. Limestone: light grey, microcrystalline. Medium grey argillaceous patches. Scattered dark grey to black opaques of silt and fine sand size. Discontinuous, undulating, black, micaceous laminae up to 1 mm thick. Organic residue along stylolites. Medium soft, slightly friable, porous.

1in. Limestone: light medium grey, mottled. Argillaceous/organic(?) residue forms laminae as above. White irregularly shaped fragments (fossils?).

3 ft 7 in. Limestone: light grey, microcrystalline. Some medium grey patches. Scattered black opaque silt. Dark grey to black, undulating, discontinuous laminae. Medium soft, slightly friable, porous.

2 in. Limestone: light to medium grey, microcrystalline, fragmental, quartzose. White irregularly shaped fragments of medium to coarse arenite size in medium crystalline cement. Large dark grey subcircular and oval grains with black rims. Hard, 10% porosity along thin stylolites and laminae.

2 in. Limestone: light grey, microcrystalline. Scattered black opaque silt. Hard, tight.

1 ft 10 in. Dolomite: light to medium brown, oolitic, pelletal, fine to medium arenite, 60% packing, medium crystalline matrix, slightly calcareous. Hard, tight, rare vugs. Bedding horizontal.

Core No. 2 (601-11 ft). Recovered 3 ft 8 in.

1 ft 7 in. Dolomite: medium grey, microcrystalline, generally uniform texture. Argillaceous. Light grey microcrystalline patches of black opaque silt, micaceous, slightly calcareous, granular pyrite. Dark grey or black micaceous laminae: undulating, stylolitic, amplitude up to 1 cm. Porosity 10%, small vugs lined with dolomite rhombs.

2 in. Dolomite: light to medium grey, brown, microcrystalline to medium crystalline, vaguely pelletal, oolitic(?). Scattered quartz: 5%, fine to medium-grained, subangular. Pellets recrystallised. Rare pyrite.

1 ft 1 in. Dolomite: light to medium grey, brown, microcrystalline. Hard, porous, vuggy with dolomite rhombs. Pyrite cubes in veins and vugs.

11 in. Dolomite: light medium grey, microcrystalline. Micaceous, scattered quartz and black opaque silt, black argillaceous silty laminae. Bedding horizontal.

Core No. 3 (915-29 ft). Recovered 9 ft 2 in.

1 in. Limestone: grey, microcrystalline. Dolomitic, argillaceous. Hard, tight. Light grey microcrystalline limestone laminae 0.5-1.0 mm thick.

1ft. Shaly dolomite and limestone: dark grey, cryptocrystalline to microcrystalline. Argillaceous, calcareous, scattered white silt fragments. Fissile, pyritic. Laminae of light grey microcrystalline limestone, and black argillaceous(?) and carbonaceous(?) laminae.

1ft 2 in. Quartzose dolomitic limestone: medium to dark grey, mottled, microcrystalline. Contains 10-20% scattered white limestone clasts, pellets, and ooliths. Fine to medium, rare coarse, quartz sand: Subangular to subrounded, scattered. Grades downwards into calcareous quartz sandstone containing dark grey shale fragments.

3 ft 2 in. Calcareous dolomite/dolomitic limestone: light grey, microcrystalline. Grey-green microcrystalline argillaceous and rare fine silt laminae with well defined boundaries. Passes down into interval with dark grey microcrystalline dolomite beds about 1.5 in. thick. Laminae: undulating, commonly attenuated, pull-apart(?) structures, fissile in parts, grades into thin shale interbeds. Rare stylolites.

1.5 in. Calcareous dolomite: light grey, microcrystalline. Medium grey-green argillaceous laminae. Numerous vugs.

2 ft 8 in. Dolomite: light grey, microcrystalline. Laminated with medium green-grey cryptocrystalline argillaceous laminae. Dark grey microcrystalline argillaceous dolomite with similar laminae. Passes down into light grey microcrystalline dolomite with short black laminae or flakes of organic(?) residue. Rare scattered fine quartz sand, grains of siltstone(?), and white fragments of dolomite. Some glauconite(?).

1 in. Dolomite: light grey, green, brown, laminated, microcrystalline. Calcareous, silty. Laminae of black organic(?) residue and mica.

8 in. Limestone: light grey-green with red-brown layers. Silty, micaceous laminae. Red-brown layers are partly dolomitic and ferruginous, with graded and undulating boundaries with limestone.

2.5 in. Dolomite: grey-green, microcrystalline. Dark grey argillaceous and micaceous layers. Red-brown, ferruginous(?) short broken laminae. Rare scattered quartz sand and white dolomite fragments. Bedding horizontal.

Core No. 4 (1250-60 ft). Recovered 10 ft

7 in. Limestone: light grey, microcrystalline. Rare scattered quartz silt. Hard tight. Claystone-siltstone: dark grey, green. Calcareous, glauconitic(?). Soft, forms undulating and discontinuous layers and laminae 0.25 to 2 mm thick. Rare green dolomite.

1 ft 4.5 in. Limestone: light grey, microcrystalline. Rare scattered quartz silt. Hard, tight. Argillaceous limestone: brown, purple, grey. Clay minerals; undulating, laminated, and cross-bedded, ferruginous layers up to 1 cm thick. Some claystone laminae. Dolomite at upper boundaries.

2 in. Quartzose limestone: grey microcrystalline. Argillaceous. Contains 20% scattered quartz sand: subangular, poorly sorted. Medium hard.

4.5 in. Limestone: white, light grey, microcrystalline. Hard, tight. Limestone forms beds 5 cm thick with argillaceous layers 1 cm thick. Stylolites with organic residue. Claystone-siltstone: dark grey. Calcareous. Some scour surfaces. Beds commonly grade upwards into limestone.

1 ft. 7 in. Limestone: light grey, microcrystalline. Dolomitic in parts. Hard, tight. Contains layers 0.5 cm thick. Argillaceous limestone: grey, blue-grey, microcrystalline, laminated. Clay minerals, thin claystone layers.

1 ft 6 in. Dolomite: light grey, purple, microcrystalline. Calcareous. Hard, tight. Claystone-siltstone: dark grey, purple, laminated, undulating. Calcareous. Current-bedding, scour surfaces. Some dolomitic claystone.

1 ft 2 in. Dolomite: light grey, white, grey, green, microcrystalline. Argillaceous, contains thin undulating layers and laminae 1 cm to 1 mm thick. Scour surfaces. Hard, tight. Claystone-siltstone: dark grey, laminated. Dolomitic. Forms layers up to 1 cm thick.

1 ft 5 in. Claystone-siltstone: dark purple and maroon. Ferruginous. Soft. Forms thin beds and laminae: undulating, cross-bedded. Rare quartz silt, dolomitic. Dolomite: light grey, microcrystalline. Hard. Undulating laminae.

1 ft 3 in. Argillaceous limestone: brown, microcrystalline. Clay minerals. Soft. Forms thin beds and laminae. More calcareous at base, some claystone. Limestone: light grey, green-grey, brown and white mottled, microcrystalline. Ferruginous, argillaceous. Hard, tight. Bedding horizontal.

Core No. 5 (1525-35 ft). Recovered 9 ft 7 in.

5 in. Dolomite: light grey and very light grey, microcrystalline. Calcareous; argillaceous layers up to 0.5 cm thick alternating with light grey microcrystalline quartzose dolomite with fine to medium-grained quartz sand: subrounded, average sorting. Porous, soft. Quartz sandstone: light to medium grey. Pelletal. Fine to medium-grained quartz, rare coarse grade: subrounded, average sorting. Pellets of dolomite: light grey, coarse arenite to rudite size, scattered. Dolomite matrix.

5.5 in. Dolomite and carbonaceous laminae: light grey microcrystalline calcareous dolomite, strongly laminated with dark grey-black undulating argillaceous laminae (solution planes ?). Brecciated appearance, thin lenses and oval grains of dolomite formed by pressure solution. Residue in some laminae. Quartzose dolomite: contains scattered quartz silt and sand in thin layers (0.5 cm). Grades into quartz sandstone: medium-grained, subrounded, well sorted, scattered dolomite pellets. Dolomitic matrix.

3.5 in. Dolomite: very light grey, laminated, undulating, layered. Algal(?): three possible algal growths (cf. Girvanella). Some slumped layers and solution planes resembling scour and fill.

3 ft 3 in. Dolomite: light grey, microcrystalline. Argillaceous(?), calcareous. Soft, tight. Contains thin undulating broken laminae of slightly coarser dolomite and dark grey argillaceous residue.

1 ft 5 in. Dolomite: medium grey, microcrystalline. Argillaceous: dark grey beds of argillaceous dolomite up to 2.5 cm thick.

3 in. Dolomite: medium to dark grey, microcrystalline. Argillaceous. Forms thin beds or laminae alternating with limestone: light grey, pelletal-oolitic, intraclastic(?) with oval and pear-shaped (organic?) grains, partly recrystallised. White or light grey calcareous matrix. Stylolites with black organic residue.

2 ft 10 in. Limestone: light grey, mottled, brown and white, pelletal, oolitic, intraclastic(?). Oval and pear-shaped organic grains of medium arenite size: partly recrystallised, average to well sorted. Brown and white microcrystalline matrix. Alternating with

8 in. Limestone: Light to medium grey, microcrystalline. Argillaceous, slightly calcareous. Hard. Darker grey argillaceous and carbonaceous(?) laminae and thin beds. The dip ranges from horizontal to 3^{o}.

Core No. 6 (1835-45 ft). Recovered 8 ft 10 in.

1.5 in. Limestone: light grey, microcrystalline, vague pelletal outlines (recrystallised?) Porous, small vugs: some with medium crystalline white calcite.

1 ft 4 in. Calcareous dolomite and dolomitic limestone: light grey, rare light grey-green, microcrystalline. Vague pelletal outlines. Porous, vuggy. Majority of vugs are calcareous. Rare thin black laminae: solution planes with insoluble residue. Stylolites.

6 in. Limestone: light grey, microcrystalline, porous. Undulating thin black laminae. Stylolites.

2 ft 7.5 in. Calcareous dolomite: light grey, rare light grey-green, microcrystalline, vague pelletal outlines, porous. Stylolitic. Black laminae.

8 in. Limestone: light grey, microcrystalline, porous. Undulating thin black laminae.

1 ft 8 in. Dolomitic limestone and calcareous dolomite: light grey, microcrystalline. Vague pelletal outlines (recrystallised?). Vuggy, porous: numerous solution planes and calcareous vugs.

1 ft 1.5 in. Limestone: light grey, light green-grey, grey-brown, microcrystalline and cryptocrystalline. Vuggy, porous. Stylolitic. Rare vague pellets.

9.5 in. Dolomite: medium grey, rare grey-green, microcrystalline. Slightly calcareous. Very porous: large vugs up tc 1 x 0.5 mm. Bedding horizontal.

Core No. 7 (2137-47 ft). Recovered 2 ft 10 in.

2.5 in. Limestone: Light grey, microcrystalline. Partly dolomitic. Saccharoidal, tight, hard.

1 ft 3 in. Dolomite: light grey, microcrystalline. Calcareous. Slightly saccharoidal, fissile, hard, planar porosity.

1.5 in. Algal(?) dolomite: very light grey, microcrystalline. Calcareous. Layered: undulating layers passing through sample are convex upwards, slightly porous between laminae. Strong stylolitisation with black carbonaceous residue.

Stylolite and small fault/unconformable contact with:

3.5 in. Limestone: light-medium grey, bedded. Composed of cryptocrystalline, microcrystalline, and intraclastic layers 0.5 cm thick.

1. Cryptocrystalline: very light grey, uniform texture. Tight, hard. Sharply defined and stylolitic boundaries.

2. Microcrystalline: darker grey than (1), uniform texture, slightly saccharoidal. Tight, hard.

3. Intraclastic: medium grey. Pelletal or intraclastic arenite-rudite: commonly elongate grains (of broken thin beds). Strongly stylolitised with dark brown residue around grains and in matrix. Boundaries with other beds are stylolitised.

1.5 in. Limestone: light grey-brown, cryptocrystalline to microcrystalline; conchoidal fracture; hard; isolated vugs; generally tight. Bedding horizontal.

Core No. 8 (2440-50 ft). Recovered 3 ft 6 in.

7 in. Shaly limestone and dolomite: limestone: light grey, brown-grey, cryptocrystalline, laminated, flocculent. Some thin pelletal arenite layers with quartz silt. Some calcite veining. Some small elongate irregular nodules of chert. Dolomite: grey, brown, microcrystalline. Calcareous. Flocculent: laminated with discontinuous patches of medium crystalline calcite. Forms alternating layers with limestone.

7 in. Shaly limestone: light grey, cryptocrystalline to microcrystalline, laminated. Tight, hard. Some layers of scattered quartz silt. Some flocculence.

1 ft 1.5 in. Shaly limestone: medium brown, microcrystalline, partly silty, tight. Forms thin beds and laminae alternating with thin beds of limestone: light grey, green-grey, microcrystalline. Dolomitic, some quartz silt. Saccharoidal. Some patches and veins of medium crystalline calcite.

9.5 in. Limestone: light brown cryptocrystalline thin beds (0.5 cm) alternating with light grey microcrystalline beds. Some quartz silt, thinly laminated, slightly saccharoidal (1.0 cm thick). Stylolitic with black organic(?) residue.

2 in. Limestone: medium grey, microcrystalline. Fine quartz silt and black opaque (mica?) flakes. Saccharoidal, tight.

3 in. Limestone: medium dark green-grey, brown, cryptocrystalline to microcrystalline. Argillaceous. Tight. Darker grey argillaceous laminae and bands. Conchoidal fracture. Bedding horizontal.

Core No. 9 (2730-40 ft). Recovered 3 ft 7 in.

11 in. Calcareous quartz sandstone: light grey, fine-grained, well sorted. Subrounded quartz (60-70%), calcareous matrix (30-40%). Rare scattered limestone pellets, medium-grained quartz sand. Scattered black opaques (heavy minerals?) scattered mica. Fissile. Solution planes (bedding planes) every 0.25-0.5 in.

4 in. Calcareous quartz sandstone: light grey, fine-grained, well sorted. Subrounded quartz (70%), calcareous matrix (30%). Thin layers of pelletal arenite and scattered limestone pellets of coarse arenite size. Possible fossil fragments. Rare dark carbonaceous laminae. Scattered black opaques.

8 in. Calcareous quartz sandstone: light grey, fine-grained, well sorted. Subrounded quartz (60-70%), calcareous matrix (30-40%). Scattered black opaques, mica flakes. Fissile.

3 in. Calcareous quartz sandstone: light grey, fine-grained, well sorted. Subrounded quartz (60-70%), calcareous matrix (30-40%), scattered black opaques. Thin layers and lenses of pelletal-oolitic arenite: medium-grained well sorted, surrounded by calcareous quartz sandstone. Fissile.

1 ft 5 in. Calcareous quartz sandstone: light grey, fine-grained, well sorted. Subrounded quartz (60%), calcareous matrix (40%), scattered black opaques, mica. Fissile. Some possible quartzose limestone (indeterminate due to fine grainsize). Bedding horizontal.

Core No. 10 (2878-88 ft). Recovered 4 ft 5 in.

3 ft 9 in. Limestone: light brown, white, mottled, cryptocrystalline, rarely microcrystalline. Scattered fragments of trilobite(?) pleurae. Calcite veins, some small circular areas of medium crystalline calcite. Undulating laminae and thin layers of dark grey and brown, argillaceous limestone, and insoluble residue from stylolites. Conchoidal fracture. Tight, hard. Rare pyrite. Broken along stylolites.

8 in. Limestone: brown, grey, cryptocrystalline to microcrystalline, laminated or banded(?), 1 mm thick, alternating brown and grey laminae: argillaceous(?), horizontal, some undulating. Some stylolites with black silt (insoluble residue?), carbonaceous(?). Thin white layers truncated by stylolites to form lenses. Patches of granular pyrite. Bedding horizontal. Trilobite fragments in upper part of core.

Core No. 11 (3139-49 ft). Recovered 9 ft 9 in.

3.5 in. Quartzose limestone: dark brown, grey, microcrystalline. Argillaceous, scattered fine quartz sand. Alternating with clay-siltstone (shale?): black argillaceous, micaceous(?), calcareous. Forms laminae and thin undulating interbeds. Some thicker layers with very thin limestone laminae.

2 ft 11 in. Limestone: brown-grey, microcrystalline. Argillaceous. Tight. Some pyrite. Rare pelletal arenite layer with fossil(?) fragments. Beds 0.75-1 in. thick, some apparent break-up at contact with shale. Alternating with clay-siltstone (shale?): black. Argillaceous, calcareous, carbonaceous(?). Some with current(?) laminae. Some undulating. Abrupt contacts: some solution planes (stylolite?), some scour surfaces. Thin layers/beds 0.25-0.5 in. thick.

7.5 in. Quartzose limestone/calcareous quartz sandstone: light grey, fine-grained, well sorted. Subrounded quartz (40-80%), calcareous matrix (20-60%). Matrix grey-brown, light grey, microcrystalline, tight, hard. Rare black laminae.

3.5 in. Skeletal limestone: light brown cryptocrystalline/microcrystalline matrix. Rudite size trilobite and brachiopod(?) fragments form 10 - 20% of rock.

1 ft 5.5 in. Limestone: light brown, cryptocrystalline/microcrystalline, small dark grey cylindrical areas of medium crystalline calcite. Pyrite clusters. Tight, hard. Alternating with clay-siltstone (shale?): black. Argillaceous, calcareous, pyritic. Many stylolitic contacts.

4 ft 2 in. Limestone: medium brown, dark grey-brown, cryptocrystalline/microcrystalline. Argillaceous, dark grey cylindrical and circular areas of medium crystalline calcite. Rare scattered quartz silt and black opaques. Rare pyrite. Alternating with clay-siltstone (shale?): black. Argillaceous, calcareous, micaceous(?), rare pyrite. Tight. Some laminae alternate with limestone laminae. Some thin beds join to form lenses of limestone. Some break-up of beds due to solution. Bedding horizontal.

Core No. 12 (3375-84 ft). Recovered 9 ft 10 in.

10 in. Laminated calcareous quartz sandstone: medium grey, minor light grey, dark grey laminae. Fine-grained, well sorted, subrounded quartz (60-80%); calcareous matrix (20-40%) - partly argillaceous; scattered black opaques and mica(?). Sandstone forms thin laminae (layers 0.5-1 mm thick, rarely 1 cm). Rapidly alternating with clay-siltstone: black. Argillaceous, micaceous(?), calcareous, quartzose(?). 36 laminae to the inch.

2 ft 10 in. Calcareous quartz sandstone: light grey. Fine-grained, well sorted, subrounded quartz (60-70%), calcareous matrix (30-40%), scattered black opaques and mica(?). As laminae about 0.5 in. thick. Clay-siltstone: black. Argillaceous, calcareous, micaceous(?). Very thin, about 25 laminae to the inch.

Small scour and fill

6 ft 2 in. Calcareous quartz sandstone: light grey, fine-grained, well sorted. Subrounded quartz (60-70%), calcareous matrix (30-40%), scattered black opaques and mica. As laminae 3 mm thick. Slightly argillaceous. Clay-siltstone: black. Argillaceous. Micaceous(?) calcareous laminae. Alternating with quartzose limestone: grey, microcrystalline. About 40% scattered fine-grained quartz sand, rare black opaques and dark brown patches of organic(?) material. Forms lenses about 1 in. thick at thickest. Clay-siltstone laminae bent round lenses, which occur every 6 in. to 1 ft, with 7 in the interval.

Core No. 13 (3636-46 ft). Recovered 9 ft 5 in.

3 ft 4 in. Calcareous quartz sandstone: light grey, well sorted, subrounded. Fine quartz grains (up to 80%), numerous laminae of clay or siltstone, micaceous(?). Tight, hard.

1 ft 8.5 in. Calcareous quartz sandstone: as above, some opaques and rare pyrite.

2 ft 8 in. Calcareous quartz sandstone: light grey. Fine-grained quartz (40-60%), calcareous matrix (40-60%): light grey. Tight, hard.

1 ft 4 in. Calcareous quartz sandstone: light grey. Fine-grained, quartz (40-60%), calcareous matrix (40-60%): light grey. Tight, hard.

4.5 in. Limestone: light grey; cryptocrystalline; tight; hard.

Core No. 14 (3990-4000 ft). Recovered 7 ft 8 in.

9 in. Limestone: black, microcrystalline. Some fine sandy and silty laminae, some pyrite. Slumped at base. Tight, hard.

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1 ft 9 in. Limestone: dark grey-black, microcrystalline. Silty and sandy calcareous laminae, scattered fine-grained quartz (up to 30%). Cross-laminated. Rare calcite veining. Tight, medium hardness.

9 in. As above but with no pyrite and little quartz sand.

6 in. Limestone: light-grey, microcrystalline. Some laminae. Some quartz sand. Tight, hard.

9 in. Limestone: black, microcrystalline, silty. Non-calcareous laminae, sandy near top, pyrite. Tight, hard.

4 in. Limestone: black, microcrystalline. Minor fine-grained quartz in sandy laminae, some silty laminae with poorly developed 'Fontainbleau' structures. Tight, hard.

1 ft 1 in. Limestone: black, microcrystalline. Silty calcareous laminae, pyrite. Slump at base. Tight, hard.

1 ft 9 in. Limestone: black, microcrystalline. Sandy and silty laminae, laminae not very calcareous, some scattered fine-grained quartz sand, pyrite. Slump at top. Tight, hard.

APPENDIX 6

HYDROLOGY, BMR 12 COCKROACH

by

K.G. Smith

Three aquifers were encountered, and short tests were made by air-lifting. The first aquifer occurs in vuggy limestone at 260 feet; it supplied 1100 gallons per hour. The second aquifer was located in vuggy dolomite at 505 feet, and the combined yield from both aquifers ranged from 2000 to 3000 gallons per hour. The third aquifer occurs in dolomite between 910 and 915 feet, and yielded 750 gallons per hour.

The standing water level in BMR 12 was measured as 170 feet, after a standby time of less than 10 hours. However, the standing water level in a bore drilled about 30 yards from the well, and on about the same topographic level, was measured as 146 feet, after standby times of 24 and 48 hours. This figure is regarded as the more reliable.

A sample from the water bore was analysed in the Alice Springs laboratory of the Animal Industry Branch, Northern Territory Administration:

	ppm
Hardness, total	712
Hardness, temporary	314
Hardness, permanent	398
Free alkali	Nil
Chloride	485
Sulphate	248
Carbonate	Nil
Bicarbonate	384
Nitrate	38
Fluoride	1.3
Sodium	265
Potassium	20
Magnesium	105
Calcium	113
T.D.S.	1659

The water is regarded by the Animal Industry Branch as unfit for human consumption.

APPENDIX 7

CORE ANALYSIS, BMR 12 COCKROACH

by

P.G. Duff, Petroleum Technology Laboratory, BMR

WELL NAME AND NO. BMR 12 COCKROACH

DATE OF TEST 20 APRIL 1966

Core No.	Depth (ft)	Lithology	Effective Porosity (% bulk vol.)	Absolute Permeability (millidarcy)		Average Density (gm/cc)		Fluid Saturation (% of pore space)		Acetone Test	Core Water Salinity (ppm NaCl)	Solubility in 15% HCl (% bulk vol.)	Fluorescence of Freshly Broken Core
				V	H	Dry Bulk	Apparent Grain	Water	Oil				
1	290-300	Limestone vugular	5	nil	2*	2.58	2.70	nil	nil	nil	n.d.	n.d.	nil
2	601-11	Limestone	3	nil	nil	2.75	2.82	n.d.	n.d.	n.d.	n.d.	n.d.	nil
3	915-29	Siltstone calcareous	18	nil	nil	2.33	2.52	n.d.	n.d.	n.d.	n.d.	n.d.	nil
4	1250-60	Limestone	6	nil	nil	2.64	2.79	n.d.	n.d.	n.d.	n.d.	n.d.	nil
5	1525-35	Siltstone calcareous	18	nil	nil	2.30	2.80	n.d.	n.d.	n.d.	n.d.	n.d.	nil
6	1835-45	Limestone vugular	14	4	31	2.42	2.81	nil	nil	nil	n.d.	n.d.	nil
7	2137-47	Limestone	4	nil	nil	2.65	2.76	n.d.	n.d.	n.d.	n.d.	n.d.	nil
8	2440-50	Limestone	7	nil	nil	2.60	2.79	n.d.	n.d.	n.d.	n.d.	n.d.	nil
9	2730-40	Sandstone calcareous	10	n.d.	n.d.	2.38	2.65	nil	nil	nil	n.d.	n.d.	nil
10	2878-88	Limestone	2	nil	n.d.	2.67	2.71	n.d.	n.d.	n.d.	n.d.	n.d.	nil
11	3139-49	Limestone	2	nil	nil	2.67	2.70	n.d.	n.d.	n.d.	n.d.	n.d.	nil
12	3375-85	Limestone	3	nil	nil	2.62	2.70	n.d.	n.d.	n.d.	n.d.	n.d.	nil
13	3636-46	Limestone	3	nil	nil	2.61	2.69	n.d.	n.d.	n.d.	n.d.	n.d.	nil
14	3996-98	Limestone	1	nil	nil	2.64	2.67	n.d.	n.d.	n.d.	n.d.	n.d.	nil

* Fine fracture evident.

Notes: (i) Unless otherwise stated, the porosities and permeabilities were determined on two small plugs (V&H) cut at right angles from the core. Ruska porosimeter and permeameter were used with air at 30 psig and dry nitrogen, respectively, as the saturating and flowing media. (ii) Residual oil and water saturations were determined using soxhlet type apparatus. (iii) Acetone test precipitates are recorded as nil, trace, fair, strong, or very strong. (iv) n.d., not determined.

APPENDIX 8

CORE DESCRIPTIONS, BMR 13 SANDOVER

by

A.R. Lloyd, R.D. Shaw, and R.A.H. Nichols

Core No. 1 (325-45 ft). Recovered 4 ft 5 in.

Quartz sandstone: white, medium to coarse-grained, well sorted, rounded to subrounded. Some calcareous cement. Friable. 2-in. band of chert: green-grey near base.

Core No. 2 (630-40 ft). Recovered 2 ft 7 in.

1 ft 5 in. Dolomite: dark grey, green-grey, medium to coarsely crystalline. Very hard; rare glauconite; argillaceous in parts; rare quartz grains: rounded, scattered; rare thin veins white calcite; some very thin shale interbeds and lenses: black to dark grey, micaceous, calcareous, moderately hard. Bedding horizontal. Very tight, porosity nil.

1 ft 2 in. Dolomite: medium to light grey, green-grey, finely crystalline to microcrystalline, very hard. Rare glauconite. Rare stylolites. Rare small vugs lined with white and pink calcite crystals, rare thin veins white calcite, rare shale as above. Thin lenticular band of siltstone at top: white to light green-grey, calcareous, moderately hard at top. Bedding horizontal. Very tight, porosity nil, except for vugs and stylolites.

Core No. 3 (717-23.5 ft). Recovered 2 ft 5 in.

2 ft 1.5 in. Dolomite: pale green-grey, microcrystalline, hard. Rare glauconite and quartz grains of sand size. Rare stylolites. Rare white and pink calcite veins. Laminae of silt: blue-green, micaceous, pyritic. Bedding horizontal in top 2 in., remainder contorted, slumped.

3.5 in. Dolomite: medium grey, microcrystalline, oolitic, very hard. Stylolitic. Rare small vugs lined with euhedral calcite crystals.

Core No. 4 (1050-60 ft). Recovered 4 ft 6 in.

9 in. Quartz siltstone: light grey with thin light green and pink bands. Dolomitic. Hard. Red limonite staining along fractures and in patches. Rare vugs.

7 in. Shale: dark green-grey. Calcareous. Moderately hard, but soft in parts. Abundant finely disseminated pyrite.

3 ft 2 in. Quartz siltstone: as at top of core. Rare pyrite. Vuggy and fractured: with infillings of dolomite crystals. Argillaceous at top, with small lenses of green clay in parts; thin band of intraformational breccia 4 in. from top with cream angular dolomite pebbles up to 0.5 in.; thin bed black shale 18 in. from top of siltstone.

Core No. 5 (1340-50 ft). Recovered 7 ft

2 ft 8 in. Siltstone: forms interbeds up to 1.25 in. thick: red and light grey to green-grey. Dolomitic. Moderately hard. Bedding horizontal, some convolute.

0.5-in. band dolomite: medium grey, microcrystalline, hard, 0.5 in. above base.

1 ft 2 in. Dolomite: as above, interbedded with and lensing into siltstone: dark grey to black. Rare mica, finely disseminated pyrite. Bedding convolute, slumped in parts, boudinage and pull-apart structures.

1 ft 7 in. Siltstone: pale green. Strongly calcareous. Hard. Contains thin interbeds of a lighter green siltstone: micaceous, strongly calcareous. Thin beds, 1.5 in. from top and a 0.5-in. bed 3 in. above base of quartz sandstone: white, rare green, fine-grained, well sorted, rounded, hard; rare mica, rare magnetite(?). Thin band of black shale at base.

5 in. Dolomite: light grey to light green-grey, microcrystalline, hard. Interbedded with a sandy dolomite containing 40% rounded quartz grains.

4 in. Quartz sandstone: light green, fine-grained, rounded grains, well sorted. Dolomite cement. Hard. Grading into sandy dolomite: light green, microcrystalline, hard, with 40% quartz grains. Laminae of black micaceous silt towards top.

2 in. Dolomite: pale green, microcrystalline. Hard, massive. 5% pelletal. Fractured and stylolitic in last 1.5 in.

8 in. Dolomite: pale green, calcareous, aphanitic, massive. Pelletal in part. Fractured. Some stylolites. Hard.

Core No. 6 (1530-40 ft). Recovered 1 ft 10 in.

8 in. Quartz sandstone: medium grey, fine-grained at top, becoming medium-grained below, rounded grains, well sorted. Dolomite cement. Hard. Small lenses and grains of pink chert and numerous laminae of dark grey micaceous silt.

4 in. Dolomite: light brown to pink, finely crystalline with rare medium crystalline, sugary texture. Moderately hard. Small lenses and bands of chert: pink.

10 in. Quartz sandstone: as at top of core; small vug near base.

Core No. 7 (1820-24 ft). Recovered 2 ft 8 in.

1 ft 10 in. Dolomite: pink to light brown, finely crystalline, saccharoidal texture Hard. Numerous small vugs. Massive with trace of horizontal bedding in parts. Rare laminae of black micaceous silt.

10. in. Quartz sandstone: light grey, fine-grained, well sorted, rounded grains. Dolomite cement. Very hard. Rare mica, pyrite, and bitumen. Rare vugs lined with clear dolomite crystals. Rare chert lenses; light brown.

Core No. 8 (1932-38 ft). Recovered 1 ft 5 in.

6 in. Sandy dolomite: pale grey, finely crystalline. Hard. 40% quartz grains, rare pyrite and magnetite(?). Poorly developed stylolites. Vugs lined with bitumen(?).

7 in. Dolomite: white, microcrystalline. Hard. Rare quartz sand. Vuggy in parts: some vugs lined with bitumen(?), some with dolomite crystals. Rare limonite staining, rare black bitumen(?) layers, rare small chert lenses, rare calcite.

4 in. Quartz sandstone: pale brown, medium to fine-grained, well sorted. Dolomite cement. Hard. Massive.

Core No. 9 (2228-38 ft). Recovered 9 ft 6 in.

Quartz siltstone: grading into quartz sandstone; very fine-grained in upper half, medium grey, well sorted, rounded. Dolomitic cement. Moderately hard. Rare magnetite(?). Micaceous(?), massive. Some discontinuous, wavy dark grey argillaceous laminations, bifurcating and paper thin, sometimes concentrated in domains; laminations(?) suggest near-horizontal bedding. Bottom 8.5 in. somewhat 'flaggy'. Small vugs in lower half, especially in bottom 2 ft, sometimes filled with dolomite crystals.

Core No. 10 (2368-80 ft). Recovered 1 ft 5 in.

3.5 in. Dolomite: pale grey, minor pale brown, mottled in parts, microcrystalline, coarsely crystalline in brown parts. Moderately hard. Intergranular porosity. Vuggy with bitumen(?) lining the vugs. Massive to flaggy. Rare partings possibly reflecting bedding, near-horizontal. Rare white chert lenses.

1 ft 1.5 in. Dolomite: pale grey, rare grey-brown, mottled in parts, microcrystalline to cryptocrystalline, rarely medium crystalline. Moderately soft. Numerous vugs in parts, sometimes lined with dolomite crystals. Rare irregular partings and stylolites lined with dark grey clay, sometimes micaceous.

Core No. 11 (2579-82.5 ft). Recovered 2 ft 2.5 in.

2 ft 2.5 in. Limestone: medium grey to brown-grey, rare dark grey and pale grey, microcrystalline to cryptocrystalline. Hard to very hard in parts. Rare black flecks sparsely disseminated. Very fine dark grey carbonaceous and argillaceous laminae alternating with pale grey cryptocrystalline limestone with rare quartz grains of silt size. Laminae commonly irregular and wavy, slumped(?). Rare irregular patches and fracture veins of white rarely transparent chalcedony throughout core. Rare white translucent dolomite. Rare chert: rarely flaggy. Bedding nearly horizontal.

Core No. 12 (2817-27 ft). Recovered 8 ft 2 in.

7 ft. Limestone: medium grey-brown, cryptocrystalline to microcrystalline. Slightly argillaceous. Hard. Laminated with minor limestone: very pale grey, cryptocrystalline, slightly silty, more abundant in lower two-thirds.

1 ft 2 in. Minor silty limestone: dark grey to black, cryptocrystalline. Hard. Grading into siltstone. Limestone is laminated, rarely flaggy, with wavy laminae. Rare load casts. Near-horizontal dip. Rare lineation on parting surfaces. Rare irregular veins, patches and thin irregular bands of calcite: white. Rare veins and patches of chalcedony: bluish white, occasionally transparent.

Core No. 13 (2960-80 ft). Recovered 7.5 in.

2960-75 ft. Nil. (see cuttings descriptions)

2975-80 ft. 7.5 in. Limestone: medium to dark grey, microcrystalline. Slightly argillaceous, possibly some quartz silt. Hard, tight. Intergranular porosity(?). Uniform texture. No bedding discernible. Unfossiliferous. Patchy fluorescence, pale green under U/V; may be contamination from bituminous dolomite in section above.

Core No. 14 (3117.4-27.4 ft). Recovered 9.5 in.

9.5 in. Dolomite: light brown, grey microcrystalline, often uniform texture, some medium crystalline patches; occasionally white patches. Slightly calcareous. Hard. Tight, but with 30% vugs lined with medium to coarse euhedral rhombs. Black carbonaceous material along rhomb boundaries (asphaltic?). Unfossiliferous. Rare pyrite granules. Fractured in parts; some carbonaceous material along slickensides. Appears horizontally bedded.

Core No. 15 (3305-10.5 ft). Recovered 5 ft 1 in.

5 ft 1 in. Feldspathic gneiss: pink, well banded, consisting of fine alternating bands of light and dark material, which grade laterally and vertically into each other. The rock is cut by thin veinlets and patches of carbonate and scapolite. Minerals present: quartz, microcline, biotite, altered sericitic and chloritic material, plagioclase(?), carbonate, muscovite, and scapolite. The quartz is evenly distributed as fine globular crystals. The microcline occurs mostly in bands together with quartz and minor biotite. The biotite is present as subparallel flakes, often in clusters and bands.

Core No. 16 (3328-30 ft). Recovered 1 ft 1 in.

1 ft 1 in. Granite: orange and white mottled, coarsely crystalline. Quartz, feldspar, rare muscovite, biotite, phlogopite(?), and hematite(?). Green talc or chlorite along fractures, and veins of chlorite(?). Fractures run oblique to vertical axis.

APPENDIX 9

PALAEONTOLICAL REPORT, BMR 13 SANDOVER

by

C.G. Gatehouse

SUMMARY

Core No. 11 (2579-82.5 ft), core No. 12 (2817-27 ft), and cuttings from several intervals between 2660 and 3230 feet were examined for macrofossils. Samples from both cores were also treated with 10% formic acid and the residues examined for microfossils.

OBSERVATIONS

Cuttings 2574-79 feet	Inarticulate brachiopod (identified by A.A. Öpik)
Core 11 2579-82.5 "	Lithistid desmas, phosphatic brachiopods, lyssakid sponge spicules
Cuttings 2660-70 "	Inarticulate brachiopod (identified by A.A. Öpik)
" 2710-20 "	No fossils observed
" 2730-40 "	Inarticulate brachiopods, sponge spicules
" 2750-60 "	Pagetia sp., indeterminate phosphatic brachiopods, sponge spicules
" 2760-70 "	Indeterminate phosphatic brachiopods
" 2780-90 "	Pagetia sp., indeterminate phosphatic brachiopods, lyssakid sponge spicules
" 2790-2800"	Pagetia sp.
" 2800-10 "	Pagetia significans, Lingulella, obolids
" 2810-17 "	Pagetia significans, Xystridura sp., lithistid desmas, lyssakid spicules, indeterminate phosphatic brachiopod fragments
" 2817-20 "	Pagetia significans, phosphatic brachiopods, lyssakid sponge spicules
" 2820-30 "	Pagetia significans, indeterminate phosphatic brachiopods, fluorite crystals
" 3220-30 "	Indeterminate phosphatic brachiopods

DISCUSSION & CONCLUSIONS

Core and cuttings from the interval 2750 to 2830 feet contain Pagetia significans (Etheridge Jr) (specific identity by A.A. Öpik) and Xystridura sp. indet. Spicules belonging to two orders of sponges, the Lithistida and Lyssakida, are common. Since the specific identity of the Xystridura fragment is not determinable, the precise position of the interval 2750 to 2830 feet is stratigraphically inconclusive within early Middle Cambrian time. However, in the Sandover Beds Xystridura spp. and Pagetia significans are associated with agnostid trilobites which indicate an age about Ptychagnostus gibbus zone of the Middle Cambrian. The fossiliferous horizons between 2730 and 2830 feet are considered to be high in the lower Middle Cambrian (A.A. Öpik, pers. comm.).

Core No. 11 and cuttings from the interval 2590 to 2740 feet contain phosphatic brachiopods and lithistid sponge spicules.

A fragmentary phosphatic brachiopod found in the interval 2574 to 2579 feet is thought to be of almost certain Middle Cambrian age (A.A. Öpik, pers. comm.).

APPENDIX 10

PETROGRAPHIC DESCRIPTION OF SAMPLE FROM CORE NO. 15, BMR 13 SANDOVER

by

J.M. Rhodes

The sample examined was from core No. 15, from a depth of 3308 feet in BMR 13 Sandover. It consisted of pink well banded feldspathic gneiss composed of fine alternating irregular bands of light and dark material, which grade laterally and vertically into each other. The rock is cut by thin veinlets and patches of carbonate. The minerals present include quartz, microcline, biotite, altered sericitic and chloritic material, plagioclase(?), carbonate, muscovite, and scapolite.

Quartz. Fairly evenly distributed, fine globular crystals.

Potash Feldspar. Microcline, mostly occurring in bands together with quartz and minor biotite. The typical 'grid iron' twinning is fairly well developed.

Biotite. Subparallel flakes, often in elongate clusters and bands. Pleochroic from greyish yellow to moderate brown. Contains broad well developed pleochroic haloes around small inclusions. Small amounts of muscovite are frequently associated with biotite.

Altered Material. Some of the irregular masses of ironstained chloritic and sericitic material resemble pinnite, and were probably derived from cordierite, but some probably represent sericitized plagioclase. The rock is cut by veins of carbonate, which also contain tabular crystals of strongly birefringent scapolite (identified by X-ray diffraction). The R.I. is about 1.54, which suggests that the scapolite is closer to the marialite ($3NaAlSi_3O_8$-NaCl) end of the solid solution series. The carbonate and scapolite are presumably of metasomatic origin.

APPENDIX 11

MAGNETIC SUSCEPTIBILITY AND SPECIFIC GRAVITY OF SAMPLES FROM CORE NO. 15, BMR 13 SANDOVER

by

Geophysical Branch, BMR

The magnetic susceptibility and specific gravity of a sample of the basement Archaean(?) gneiss from core No. 15, 3304 feet, BMR 13 Sandover were measured in the laboratory of the Geophysical Branch, Bureau of Mineral Resources. The results were as follows:

Magnetic susceptibility:	0.079×10^{-3} C.G.S. units
Specific gravity:	2.69

APPENDIX 12

TEST OF BITUMINOUS MATERIAL AND CUTTINGS FROM BMR 13 SANDOVER

by

Petroleum Technology Laboratory, BMR

1. 'Bituminous' Material, 1140-59 feet and 1365-70 feet

Test	Cuttings 1140-50 ft	Cuttings 1365-70 ft
Weight of sample as received	0.3 gm	0.2 gm
Fluorescence as received	Not discernible	Nil
Carbonaceous material present	Yes	Yes
Acetone solubility	Inappreciable	Inappreciable
Acetone colour	Nil	Nil
Acetone fluorescence	Trace	Trace
Acetone precipitate	Nil	Nil
Toluene solvent colour	Yellow	Yellow
Toluene solvent fluorescence	Fair	Fair
Chromatographic strip under ultra violet light	Bright orange	Bright orange

Because of the lack of reaction with acetone it may be said that no free oil exists in the samples as received and that acetone would not dissolve any fractions from the black material. Because of the solubility at 110°C in toluene and because of the insoluble black material remaining, it may be said that the cuttings contained an asphaltic hydrocarbon.

2. Sealed Unwashed Cuttings, 2955-60 ft

The sample consisted of mud and cuttings sealed at the rig site; and an 'oily' smell was noted on breaking the seal in the laboratory. The sample fluoresced; mainly a bright whitish yellow colour; a strong fluorescence of the acetone solution and a precipitate described as trace to fair.

Extraction with toluene for 8 hours produced 0.31 percent by weight of oil which was not readily soluble in cold acetone. The oil was a dark orange-brown colour with a bright whitish yellow fluorescence; it was just mobile at 50°F and was sluggish at 60°F.

Specific gravity determination on a very small sample was 0.99 at 80°C (or about 11° API), but an accurate temperature was hard to obtain. However the S.G. of the oil is certainly below 0.93 (about 20.5° API).

The residue after 24 hours extraction with toluene was also a dark orange-brown and had an orange fluorescence. But the sample was too small to determine flow characteristics or specific gravity.

APPENDIX 13

PETROGRAPHIC DESCRIPTION OF CUTTINGS FROM BMR 13 SANDOVER

by

L.V. Bastian

In the hand specimen, the cuttings from the interval 2952-75 feet of BMR 13 consist of a dark brown rock in which fine laminae can be faintly discerned.

In thin section the cuttings are composed mainly of aggregates of dolomite rhombs ranging in size from less than 0.01 mm to about 0.08 mm. They appear to be loosely arranged at random, but the bedding in some of the fragments is defined by variation in the abundance and size of the dolomite crystals. One piece contains many lobate dark brown opaque filaments, which appear to be coagulated bituminous matter. The dolomite crystals are embedded in a brown translucent matrix with many dark brown opaque spots and irregular patches. In reflected light the whole matrix is a non-reflecting dark brown. The translucent part is isotropic, with a moderate relief, and may include collophane. It lacks cellular structures and distinctive patterns. The dark opaque matter is also featureless. In some chips there are minor amounts of quartz silt, with grains ranging up to about 0.06 mm across.

A phosphate test was made on powdered material, and gave a positive result. An assay for P_2O_5 gave the following result:

1. Before extraction - 2.1 percent
2. After extraction - 1.8 percent

A calcimeter test was run on material which had been ground and passed through a 30-mesh screen. With 10 percent hydrochloric acid the following carbonate percentages were obtained:

After 1 minute reaction - 14 percent

After 10 minutes reaction - 60 percent

The 10-minute figure accords reasonably well with the proportion of dolomite found in thin section, and the 1-minute figure indicates that all the carbonate is probably dolomite. After the reaction with hydrochloric acid the sample gave off a strong tarry smell. This suggests that the darker material in the matrix may be bituminous.

The appropriate composition is as follows:

	percent
Dolomite	70
Isotropic matter (collophane(?) and bituminous matter)	20
Opaque bituminous(?) matter	5
Quartz	5

APPENDIX 14

FORMATION TEST, DST NO. 1 BMR 13 SANDOVER

by

P.G. Duff, Petroleum Technology Laboratory, BMR

General Data:

Date: 15th July 1964	Total depth: 3330 ft
Interval tested: 2950-90 ft	Main hole size: 6 1/4 in.
Plugged back to: 3013 ft	Rat hole size: none
Casing size: 7 in.	Liner size: none

Mud Details:

Type: bentonite	Fluid loss: 18 cc
Weight: 64 lb/cu ft	Filter cake: 2/32 in.
Viscosity: 39 sec/946 cc	Salinity: 600 ppm NaCl

Test and Tool Date:

Tester size and type:	3 1/2 in. Johnson Formation Tester
Packer size and type:	5 1/4 in. Straight Hole Packer without shear pin
Packer set at: 2930 ft	Reset at: 2935 ft
Packer set initially with 20,000 lb; subsequently with 25,000 lb	
Air chamber: length 120 ft	I.D. 2.25 in.
Sump volume: 22 cu ft	Vol. air chamber: 3.25 cu ft
Cushion: nil	B.H. Choke size: 1/2 in. packer
Pressure recorder 1 1/4 in. Humble; Type 96; subsurface; range 5000 psig	
Clock range: 10 hrs	Recorder depth: 3010 ft

Anchor perforations: 60 x 1/2 in. dia. over 21.4 ft (approx. 3/ft)

Diary of Events

	Time	Pressure	Sfc. Choke
Recorders started (installed) at:	0740		
Opened tool at:	1312		
Recorder in carrier in tail pipe at:	0743		open flow
Finished running collars at:	0900		
Inserted trip valve:			
running pipe at:	1020		
Sitting for mud pressure at:	1140		

	Time	Pressure	Sfc. Choke
Packer set at:	1210		
Dropped Go-Devil at:	1312		
Packer re-set as annulus started to drop at:	1320		
Pipe dropped, tail pipe in cave, packer set at:	1326		
Pulled packer free at:	1426		
Out of hole at:	1750		

Time Data

First flow period: 68 mins Second flow period: nil mins

First shut-in: 62 mins Second (final) shut-in: nil

Temperature and Pressure

Well temperature and pressures not obtained as recorder left in hole as unrecovered fish. Test inconclusive

Surface Information

Well flowed: no formation fluid to surface

Reversed out: nil

Fluids recovered: 22 cu ft gas cut mud at 61 lb/cu f, salinity 800 ppm NaCl

Max. sfc. pressure: not recorded

APPENDIX 15

MUD TESTS, BMR 13 SANDOVER

by

Petroleum Technology Laboratory, BMR

Oil was extracted chemically from a 630-gm sample of mud taken during the drill of the interval 2952-60 feet. The sample yielded about 1.5 percent by weight of a black highly mobile fraction with a strong naphthenic odour. In addition, it yielded about 0.3 percent by weight of a light brown soft odourless solid. There was an insufficient amount of the lighter fraction to determine its viscosity.

The following results were obtained by qualitative fractionation and are only approximate:

Density:	0.93-0.98 gm/ml, i.e. 20.5° API - 12.7° API	
		Wt Percent
Distillation:	below 170°C	40
	170°-250°C	35
	above 250°C	25

A sample of mud in circulation 2 days after penetrating the potentially productive interval was also tested. The extracted oil occupied 0.09 percent of the mud volume, it fluoresced an orange-yellow colour and proved to be similar to the extracts from the cuttings.

A sample of slightly gas cut mud was obtained during DST No. 1 from the drill collars immediately above the retaining valve. It yielded an oil which was sluggish to flow at room temperature, deep orange-brown in colour and with a bright greenish yellow fluorescence. The mud contained 0.104 percent by volume of oil.

APPENDIX 16

CORE AND CAVINGS ANALYSIS, BMR 13 SANDOVER

by

Petroleum Technology Laboratory, BMR

Date 22 July 1964

Well or Area	Core or Sample	Depth (ft)	Lithology	Effective Porosity (% by vol.)	Absolute Permeability (millidarcy) V	Absolute Permeability (millidarcy) H	Average Density (gm/cc) Dry Bulk	Average Density (gm/cc) Apparent Grain	Fluid Saturation (% pore space) Water	Fluid Saturation (% pore space) Oil	Acetone Test Colour	Acetone Test Precipitate	Solvent after Extraction Colour	Solvent after Extraction Fluorescence	Remarks Fluorescence of Freshly Broken Rock
BMR 13	13	2975-80	Limestone	2	nil		2.63	2.69	84	16	Trace	Fair	Yellow	Fair	nil
13	13	2975-80	Limestone	2	nil		2.64	2.70	91	9	Pale yellow	Trace	Bright yellow	Fair	nil

Note: Porosities were confirmed using the gas expansion method

Date 3 August 1964

BMR 13	Cavings 1	Circa. 2950-80	Dolomite	37	n.d.	6	1.78	2.83	nil	1	n.d.	n.d.	Golden	Strong	Colour: light orange-brown. Fluorescence: bright greenish yellow
BMR	Cavings	Circa.	Dolomite	33	n.d.	8	1.87	2.80	72	2	n.d.	n.d.	Golden	Strong	As above

Note: Acid solubility on above sample, 79%. Only the central pieces of core were used for test

Notes: (i) Unless otherwise stated, the porosities and permeabilities were determined on two small plugs (V&H) cut at right angles from the core or sample. Ruska porosimeter and permeameter were used, with air at 30 psig, and dry nitrogen respectively, as the saturating and flowing media. (ii) Residual oil and water saturations were determined using Soxhlet type apparatus. (iii) Acetone test precipitates and fluorescence of solvent after extraction are recorded as nil, trace, fair, strong or very strong. (iv) n.d., not determined.

APPENDIX 17

ANALYSIS OF SAMPLE FROM WATER BORE FOR BMR 13 SANDOVER

by

L.R. Murray, Animal Industry Branch, N.T. Administration

	ppm
Hardness, total	254
Hardness, temporary	248
Hardness, permanent	6
Free alkali	nil
Chloride	22
Sulphate	7
Fluoride	0.2
Calcium	30
Bicarbonate	291
Carbonate	6
Sodium	10
Potassium	10
Magnesium	43
Nitrate	1
T.D.S.	420
pH	8.4

APPENDIX 18

SPECTROGRAPHIC ANALYSIS OF SAMPLES FROM BMR 13 SANDOVER

by

A.D. Haldane

This report gives the results of anlaysis of dark grey and black shale from BMR 13 Sandover.

Depth (ft)	Ni (ppm)	Co (ppm)	Cu (ppm)	V (ppm)	Pb (ppm)	Remarks
250-60	10	20	25	150	nil	
270-80	12	20	<5	500	nil	
280-90	12	20	10	300	nil	
440-50	5	12	10	100	nil	
470-80	15	30	25	300	10	
520-30	15	20	20	300	5	
560-70	15	20	15	50	10	(Mo, 50)
570-80	5	12	15	50	nil	
600-10	5	12	15	50	10	
620-30	10	20	100	200	nil	
1010-20	10	30	50	300	5	
1030-40	20	60	50	300	5	
1055-60	15	15	10	300	nil	
1140-50	20	30	10	50	5	
1610-20	5	20	20	200	10	
1620-30	5	12	15	50	50	(Mo, 50)

Sn, Zn, and P were also sought but were not detected in any sample

APPENDIX 19

CORE ANALYSIS, BMR 13 SANDOVER

by

P.G. Duff, Petroleum Technology Laboratory, BMR

WELL NAME AND NO. BMR 13 SANDOVER RIVER — DATE OF TEST 26 APRIL 1966

Core No.	Depth (ft)	Lithology	Effective Porosity (% bulk vol.)	Absolute Permeability (millidarcy) V	Absolute Permeability (millidarcy) H	Average Density (gm/cc) Dry Bulk	Average Density (gm/cc) Apparent Grain	Fluid Saturation (% of pore space) Water	Fluid Saturation (% of pore space) Oil	Acetone Test	Core Water Salinity (ppm NaCl)	Solubility in 15% HCl (% bulk vol.)	Fluorescence of Freshly Broken Core
1	325-45	Sandstone	16	214	72	2.23	2.65	45	nil	nil	n.d.	n.d.	nil
2	630-40	Dolomite	4	n.d.	nil	2.69	2.81	n.d.	n.d.	n.d.	n.d.	n.d.	nil
3	717-23.5	Dolomite	7	3*	nil	2.65	2.84	n.d.	n.d.	n.d.	n.d.	n.d.	nil
4	1050-60	Dolomite	16	n.d.	nil	2.37	2.82	n.d.	n.d.	n.d.	n.d.	n.d.	nil
5	1340-50	Limestone	5	nil	nil	2.65	2.77	n.d.	n.d.	n.d.	n.d.	n.d.	nil
6	1530-40	Limestone	8	nil	nil	2.54	2.75	n.d.	n.d.	n.d.	n.d.	n.d.	nil
7	1820-24	Dolomite vugular	12	n.d.	1	2.49	2.83	n.d.	n.d.	n.d.	n.d.	n.d.	nil
8	1932-38	Dolomite vugular	5	n.d.	n.d.	2.70	2.84	nil	12+	Fair	n.d.	n.d.	Blue and yellow
9	2228-38	Dolomite	3	n.d.	nil	2.70	2.81	n.d.	n.d.	n.d.	n.d.	n.d.	nil
10	2368-80	Dolomite	6	n.d.	n.d.	2.67	2.84	n.d.	n.d.	n.d.	n.d.	n.d.	nil
11	2579-82	Limestone	2	n.d.	n.d.	2.64	2.69	n.d.	n.d.	n.d.	n.d.	n.d.	nil
12	2817-27	Limestone	3	nil	nil	2.63	2.71	n.d.	n.d.	n.d.	n.d.	n.d.	nil
13	2960-80			Insufficient sample for analysis									
14	3117.4-27.4	Limestone		Insufficient sample for analysis									
15	3305-10.5	Igneous rock	10	nil	nil	2.64	2.92	39	nil	nil	n.d.	n.d.	nil
16	3328-30	Granite	2	n.d.	n.d.	2.59	2.64	n.d.	n.d.	n.d.	n.d.	n.d.	nil

* Fine fracture evident

\+ Hydrocarbon residue was immobile and bituminous, fluorescence dull whitish yellow

Notes: (i) Unless otherwise stated, the porosities and permeabilities were determined on two small plugs (V&H) cut at right angles from the core. Ruska porosimeter and permeameter were used with air at 30 psig and dry nitrogen, respectively, as the saturating and flowing media. (ii) Residual oil and water saturations were determined using soxhlet type type apparatus. (iii) Acetone test precipitates are recorded as nil, trace, fair, strong, or very strong. (iv) n.d., not determined.

COMPOSITE WELL LOG

PLATE 1

OPERATOR: BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PETROLEUM TENEMENT: OIL PERMIT 61

WELL NAME AND No: B M R II CATTLE CREEK

NORTHERN TERRITORY

4-MILE SHEET: F53-4 AVON DOWNS, BASIN: GEORGINA

WELL STATUS: SECURED PENDING COMPLETION AS WATER WELL FOR PROPERTY

LOCATION - Lat. 20°00'33"S, Long. 137°50'06"E.
ELEVATION - Reference Datum (R.T.) 742' A.S.L.
Ground Level 736' A.S.L.
Date Spudded 8.7.63.
Date Drilling Stopped 14.11.63.
Date Rig Released 16.11.63.
Total Depth Driller 1501
GRN Log 1501

Hole Size	in.	from	to
	12¼	Sfc.	28'
	8½	28'	411·5'
	6¼	411·5'	903'
	6	903'	T.D.

Casing

In.	Wt.	Gr.	Depth	Cmt.	Cmt'd To
9⅝	36#	J-55	27·5'	8 sax	sfc.
7	20#	J-55	410'	60 sax	50 (est)

Cement Plugs Nil

Perforations Nil

ELECTRIC LOG DATA

SERVICE	SCHLUMBERGER	BUREAU OF MINERAL RESOURCES		
LOG TYPE	Electric	S.P. & 16"N	63"N	63"N
RUN No & SCALE	1- 2"&5"	1- 1"	1- 1"	2- 1"
DATE RUN	16.11.63.	16.11.63.	16.11.63.	16.11.63.
FIRST READING	1497'	1498'	1180'	800'
LAST READING	408'	410'	410'	410'
INTERVAL MEASURED	1089'	1088'	770'	390'
CASING: E-LOG	408'	411'	411'	411'
: DRILLER	410'	410'	410'	410'
DEPTH REACHED	1499'	1500'	1417'	800'
BOTTOM DRILLER	1501	1501	1501	1501
MUD NATURE	Water	Water	Water	Water
SG	1·0	1·0	1·0	1·0
RESISTIVITY	12·0 @ 84°F.	12·2 @ 90°F.	12·2 @ 90°F.	12·2 @ 90°F.
RESIST. B.H.T.	@ 96°F.	@ 96°F.	@ 96°F.	@ 96°F.
STANDING WATER LEVEL	191'	191'	191'	191'
BIT SIZE: 1	6¼" to 903'	6¼" to 903'	6¼" to 903'	6¼" to 903'
: 2	6" to T.D.	6" to T.D.	6" to T.D.	6" to T.D
SPACING AM_1	16"	16"	16"	16"
AM_2	64"	63"	63"	63"
AO	18'8"			
WEIGHT USED	No	No	No	No
RECORDED BY	P.HUSTEN	A. RADESKI		

RADIOMETRIC LOG DATA

SERVICE	SCHLUMBERGER	B.M.R.
LOG TYPE	GRN	Gamma
RUN No & SCALE	1- 2"&5"	1- 1"
DATE RUN	16.11.63.	7.11.63.
FIRST READING	1500'	1355'
LAST READING	100'	170'
INTERVAL MEASURED	1400'	1285'
CASING: GRN-LOG	408'	—
: DRILLER	410'	410'
MUD NATURE	Water	Water
MAX. RECORDED TEMP.	96°F.	—
STANDING WATER LEVEL	190'	191'
TIME CONSTANT SECS.	2	5
LOGGING SPEED ft/min.	30	70
STAT. VARIATION ins.	0·3	0·5
RECORDED BY	P.HUSTEN	A.RADESKI

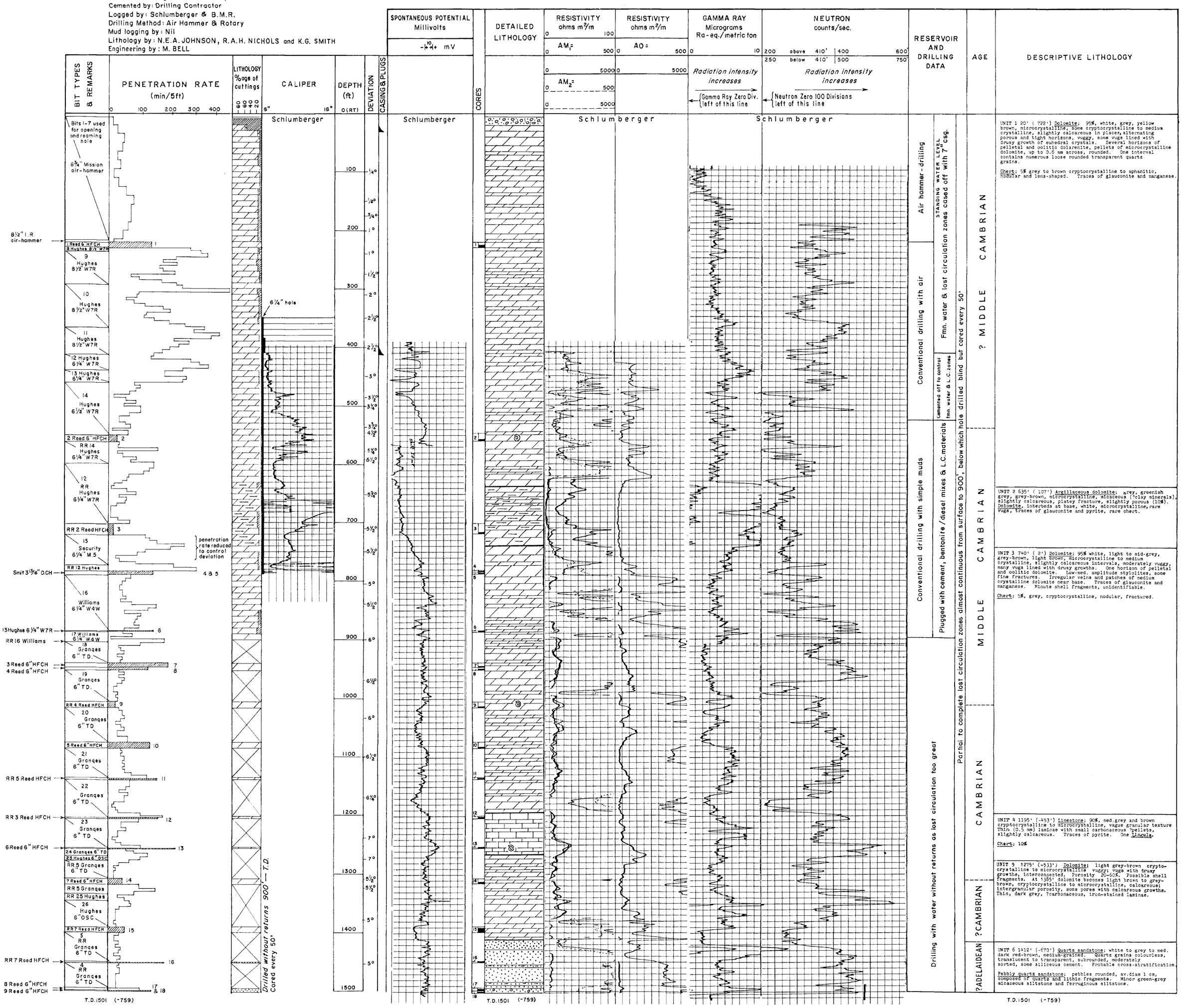
OTHER BORE-HOLE LOG

Temperature - Schlumberger
Run 1: 2" and 5", 1120'-360'
Run 2: 2" and 5", 800'-208'
Micro-Caliper - Schlumberger
2" and 5", 470'-408'

LITHOLOGICAL REFERENCE

Chert; Quartz sandstone; Pebbly Quartz sandstone; Dolomite; Argillaceous Dolomite; Limestone; Macrofossils

Drilling Contractor: W.L. Sides & Son Pty. Ltd.
Well Head Fittings: Welded steel plate
Cemented by: Drilling Contractor
Logged by: Schlumberger & B.M.R.
Drilling Method: Air Hammer & Rotary
Mud logging by: Nil
Lithology by: N.E.A. JOHNSON, R.A.H. NICHOLS and K.G. SMITH
Engineering by: M. BELL



RESERVOIR AND DRILLING DATA

Air hammer - drilling

STANDING WATER LEVEL
Fmn. water & lost circulation zones cased off with 7" csg.

Conventional drilling with air

Cemented off to control fmn. water & L.C. zones

Conventional drilling with simple muds with cement, bentonite / diesel mixes & L.C. materials

Plugged with cement

Partial to complete lost circulation zones almost continuous from surface to 900', below which hole drilled blind but cored every 50'

Drilling with water without returns as lost circulation too great

AGE

CAMBRIAN — ? MIDDLE

CAMBRIAN — MIDDLE

CAMBRIAN — ?CAMBRIAN

?ADELAIDEAN

DESCRIPTIVE LITHOLOGY

UNIT 1 20' (722') Dolomite; 95%, white, grey, yellow brown, microcrystalline, some cryptocrystalline to medium crystalline, slightly calcareous in places, alternating porous and tight horizons, vuggy, some vugs lined with drusy growth of euhedral crystals. Several horizons of pelletal and oolitic dolarenite, pellets of microcrystalline dolomite, up to 0.6 mm across, rounded. One interval contains numerous loose rounded transparent quartz grains.

Chert; 5% grey to brown cryptocrystalline to aphanitic, nodular and lens-shaped. Traces of glauconite and manganese.

UNIT 2 635' (107') Argillaceous dolomite; grey, greenish grey, grey-brown, microcrystalline, micaceous (?clay minerals), slightly calcareous, platey fracture, slightly porous (10%). Dolomite, interbeds at base, white, microcrystalline, rare vugs, traces of glauconite and pyrite, rare chert.

UNIT 3 740' (2') Dolomite; 95% white, light to mid-grey, grey-brown, light brown, microcrystalline to medium crystalline, slightly calcareous intervals, moderately vuggy, many vugs lined with drusy growths. One horizon of pelletal and oolitic dolomite. Low-med. amplitude stylolites, some fine fractures. Irregular veins and patches of medium crystalline dolomite near base. Traces of glauconite and manganese. Minute shell fragments, unidentifiable.

Chert; 5%, grey, cryptocrystalline, nodular, fractured.

UNIT 4 1195' (-453') Limestone; 90%, med. grey and brown cryptocrystalline to microcrystalline, vague granular texture (?thin (0.5 mm) laminae with small carbonaceous ?pellets, slightly calcareous. Traces of pyrite. One Lingula.

Chert; 10%

UNIT 5 1275' (-533') Dolomite; light grey-brown cryptocrystalline to microcrystalline vuggy; vugs with drusy growths, interconnected. Porosity 20-60%. Possible shell fragments. At 1385' dolomite becomes light brown to grey-brown, cryptocrystalline to microcrystalline, calcareous; intergranular porosity, some pores with calcareous growths, thin, dark grey, ?carbonaceous, iron-stained laminae.

UNIT 6 1412' (-670') Quartz sandstone; white to grey to med. dark red-brown, medium-grained. Quartz grains colourless, transluscent to transparent, subrounded, moderately sorted, some siliceous cement. Probable cross-stratification.

Pebbly quartz sandstone; pebbles rounded, av. diam 1 cm, composed of quartz and lithic fragments. Minor green-grey micaceous siltstone and ferruginous siltstone.

COMPOSITE WELL LOG

PLATE 2

OPERATOR: BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PETROLEUM TENEMENT: OIL PERMIT 63

WELL NAME AND No: BMR 12 COCKROACH

NORTHERN TERRITORY 1:250,000 SHEET: TOBERMORY BASIN: GEORGINA WELL STATUS: PLUGGED AND ABANDONED

LOCATION - Lat. 22°33'20" S. Long. 137°09'38" E.
ELEVATION - Reference Datum (R.T.) 729·5' A.S.L.
Ground Level 721·4' A.S.L.
Date Spudded 15.8.64.
Date Drilling Ceased 17.11.64.
Date Rig Released 23.11.64.
Total Depth Driller 4000' (Schlumberger 4001')

Hole Size	in.	from	to
	12 1/4	Sfc.	69'
	8 1/2	69'	818'
	6 1/4	818'	3990'
	5 5/8	3990'	T.D.

Casing

In.	Wt.	Gr.	Depth	Cmt.	Cmt'd. to
9 5/8	36	J-55	69'	40sax	sfc.
7	20	J-55	806'	60sax	200' (est.)

Cement Plugs:

From	To	Sacks
±923'	883'	18
±842'	772'	15
Top 7" casing		4

Drilling Contractor: W.L.Sides & Son Pty. Ltd.
Well Head Fittings: Steel Plate and Valve
Logged by: Schlumberger
Drilling Method: Air Hammer & Rotary
Mud logging by: Nil
Lithology by: R.A.H.NICHOLS, M.A.RANDAL.
Engineering by M.D.BELL & J.M.HENRY

ELECTRIC LOG DATA

SERVICE	SCHLUMBERGER	
LOG TYPE	S.P.& Electric	S.P.& Electric
RUN No & SCALE	1- 2" & 5"	2- 2" & 5"
DATE RUN	12.9.1964.	18.11.1964.
FIRST READING	817'	4000'
LAST READING	70'	806'
INTERVAL MEASURED	747'	3194'
CASING: E-LOG	70'	806'
: DRILLER	69'	806'
DEPTH REACHED	818'	4001'
BOTTOM DRILLER	818'	4000'
MUD NATURE	Bentonite	Bentonite
SG	1·13	1·2
RESISTIVITY	1·74 65°F.	1·14 100°F
RESIST. B.H.T.	1·05 108°F	0·72 152°F
STANDING WATER LEVEL	170'	170'
BIT SIZE: 1	8½" to 818"	8½" to 818'
: 2		5⅝" to T.D. 3990'
SPACING AM₁	16"	16"
" AM₂	64"	64"
" AO	18'8"	18'8"
WEIGHT USED	NIL	NIL
RECORDED BY	D.E.BAIRD	J.ABSIL

RADIOMETRIC LOG DATA

SERVICE	SCHLUMBERGER	
LOG TYPE	Gamma	Gamma
RUN No & SCALE	1- 2" & 5"	2- 2" & 5"
DATE RUN	12.9.1964.	19.11.1964.
FIRST READING	812'	3993'
LAST READING	50'	700'
INTERVAL MEASURED	762'	3293'
CASING: GRN-LOG	—	806'
: DRILLER	69'	806'
MUD NATURE	Bentonite	Bentonite
STANDING WATER LEVEL	170'	170'
TIME CONSTANT SECS.	2	3
LOGGING SPEED ft/min.	30	20
STAT. VARIATION ins.		
RECORDED BY	D.E.BAIRD	J.ABSIL

SONIC LOG DATA

SERVICE	SCHLUMBERGER	
LOG TYPE	SONIC	SONIC
RUN & SCALE	1- 2" & 5"	2- 2" & 5"
DATE RUN	12.9.1964.	19.11.1964.
FIRST READING	800'	3993'
LAST READING	69'	700'
INTERVAL MEASURED	731'	3293'
CASING S. LOG	69'	806'
CASING DRILLER	69'	806'
MUD NATURE	Bentonite	Bentonite
STANDING WATER LEVEL	170'	170'
RECORDING SPEED ft/hr	3000'/4000'	1200'
BIAS	85V	95V
RECORDED BY	D.E.BAIRD	J.ABSIL

OTHER BORE-HOLE LOG

Microcaliper - Schlumberger
Run 1: 2" & 5" 818' - 69'
Run 2: 2" & 5" 3997' - 806'
Microlog - Schlumberger
Run 1: 2" & 5" 818' - 69'
Run 2: 2" & 5" 3993' - 806'
Other logs - *S.P. recorded w/o current, scale 5" 817"- 350'*
Velocity survey recorded by B.M.R.

WELL SYMBOLS

◊ *Fluorescence*
Partial lost circulation g.p.h. mud loss/S.G. mud
→ *Formation water*
Core, interval, number and recovery
Plugged interval

LITHOLOGICAL REFERENCE

Quartz sand, clay. · Quartz sandstone · Siltstone · Dolomite & silty dolomite · Oolitic pelletal dolomite · Oolitic pelletal limestone · Macrofossils · Sandy limestone sandy dolomite · Calc. quartz sandstone sandy limestone

py - Pyrite · *ch* - Chert · *b* - Bitumen

BITS USED
PENETRATION RATE (min/5ft)
LITHOLOGY %age of cuttings
CALIPER
DEPTH (ft)
DEVIATION
CASING & PLUGS
SPONTANEOUS POTENTIAL Millivolts
CORES No & RECOVERY
DETAILED LITHOLOGY
ACCESSORIES
RESISTIVITY ohms m²/m
AM₁=16"
AM₂=64"
RESISTIVITY ohms m²/m
AO=18'8"
GAMMA RAY A.P.I. units
Radiation intensity increases
SONIC LOG
INTERVAL TRANSIT TIME microseconds per foot Spacing 3 Ft
RESERVOIR and other DRILLING DATA
AGE
STRATIGRAPHIC UNIT
DESCRIPTIVE LITHOLOGY
AQUIFER 1100gph
AQUIFER 2000-3000gph
AQUIFER 750gph
T.D. 4000'
QUATERNARY
UPPER CAMBRIAN - LOWER ORDOVICIAN
NINMAROO FORMATION
UPPER CAMBRIAN
ARRINTHRUNGA FORMATION
MIDDLE CAMBRIAN
MARQUA BEDS
INTERVAL: 0-25'. Quartz sand, silt, clay: 100%, red, brown, white, fine-med. quartz; clay minerals.
INTERVAL: 25'-180'
Limestone; 75%, white, light brown, microcrystalline, hard, tight, partly oolitic-pelletal, arenite, well sorted.
Calcite 'sand', clay; 25%, light brown, calcite crystals, clay minerals, partly indurated.
INTERVAL: 180'-485'
Limestone; 46%, light grey, light brown, microcrystalline, partly pelletal-oolitic, fine arenite, well sorted, rare scattered black silt.
Dolomite; 34%, light brown, white, microcrystalline, rarely pelletal, hard, tight.
Clay-Siltstone; 13%, medium-dark grey, black, blue, soft fissile.
Quartz Sandstone; 5%, light brown, fine-grained, sub-angular, well sorted quartz, hard, some porosity.
Calcite 'sand', clay; 2%, light brown, loose calcite crystals, clay minerals.
INTERVAL: 485'-1035'
Dolomite; 85%, light to medium grey, white, blue-grey, grey-brown, microcrystalline, partly argillaceous, rarely quartzose, with black, silty laminae, hard, tight, pyritic. White, light grey, rare medium-dark grey, pelletal oolitic, medium arenite, average sorting.
Limestone; 11%, light grey, green-grey, white, medium grey, microcrystalline, partly silty. With laminae, hard, some porosity. White, light grey-brown, pelletal-oolitic, medium arenite, hard, tight.
Clay-Siltstone; 4%, dark grey, argillaceous, soft, as laminae.
INTERVAL: 1035'-1160'
Limestone; 80%, light grey, light brown, oolitic pelletal, medium arenite, hard, tight; grey, blue-grey, white, partly mottled, microcrystalline, hard, tight.
Dolomite; 20%, light brown, grey, blue-grey, microcrystalline, calcareous, hard, tight.
INTERVAL: 1160'-1315'
Dolomite; 52%, blue-grey, green-grey, white, grey, green, rare red, purple, microcrystalline, partly calcareous, some clay-siltstone laminae, purple, grey, green.
Limestone; 48%, white, light grey, microcrystalline, partly laminated; white, light grey, brown, pelletal, medium arenite, hard, tight.
INTERVAL: 1315'-1510'
Dolomite; 70%, white, grey, microcrystalline, rare quartz silt, hard, tight. White, brown, grey, pelletal, medium arenite.
Limestone; 18%, light grey, medium brown, microcrystalline, hard, tight.
Quartz Sandstone; 12%, white, fine-medium-grained, well sorted, subrounded quartz, hard, tight.
INTERVAL: 1510'-2721'
Limestone; 70%, light grey, grey-brown, white, rare red-brown, microcrystalline, partly argillaceous, rarely micaceous, ? ferruginous, hard, tight. White, light grey-brown, oolitic-pelletal, medium arenite, average sorting, partly porous, rare silt, hard.
Dolomite; 27%, light-medium grey, brown, rare green-grey, microcrystalline, slightly calcareous, rare quartz silt and sand, saccharoidal, hard, tight.
Clay-Siltstone; 2%, dark grey, purple, brown, red-brown, argillaceous, dolomitic, partly micaceous, tight.
Quartz Sandstone; 1%, light grey, fine-grained, sub-rounded quartz, well sorted. Calcareous matrix, hard, tight.
INTERVAL: 2721'-3250'
Limestone; 80%, medium to dark grey, rare brown, minor light grey, white mottling, microcrystalline, argillaceous, ? micaceous, quartz silt, tight, hard, pyritic.
Calcareous Quartz Sandstone; 19%, light grey, fine-grained, well sorted quartz, calcareous matrix; scattered black opaque silt, rare mica. Possibly grades to quartzose limestone.
Clay siltstone; 1%, dark grey-black, argillaceous, ? micaceous, calcareous, fissile, pyritic. As laminae.
INTERVAL: 3250'-4000'
Calcareous Quartz Sandstone; 70%, light-medium grey, fine-grained, well sorted quartz, calcareous matrix; Scattered black opaque silt, ? mica, hard, tight, pyritic. Black silty laminae.
Limestone; 30%, light-medium grey, rare dark grey, microcrystalline, argillaceous, hard, tight. Medium grey microcrystalline fine-grained quartz sand, tight, hard, pyritic.

COMPOSITE WELL LOG

PLATE 3

OPERATOR: BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PETROLEUM TENEMENT: OIL PERMIT 41. WELL NAME AND No: B M R 13 SANDOVER

NORTHERN TERRITORY 1:250,000 SHEET: ELKEDRA BASIN: GEORGINA WELL STATUS: PLUGGED AND ABANDONED

LOCATION - Lat. 21°51'25"S. Long. 136°09'06"E.
ELEVATION - Reference Datum (R.T.) 1063·3'A.S.L.
Ground Level 1055·1'A.S.L.
Date Spudded 15. 1. 64.
Date Drilling Completed 6. 7. 64.
Date Rig Released 21. 7. 64.
Total Depth Driller 3330'
GRN Log 3331'

Hole Size in.	from	to
12 1/4	Sfc.	42'
8 1/2	42'	1620'
6 1/4	1620'	T.D.

Casing

In.	Wt.	Gr.	Depth	Cmt.	Cmt'd To
9 5/8	36	J-55	42'	14 sax	sfc.
7	20	J-55	1615'	65 sax	1315' (calc)

Cement Plugs:

From	To	Sacks
3320'	3221'	52
3221'	3012'	42
2900'	2845'	8
1620'	1569'	8
Top 7' Casing		4

Drilling Contractor: W.L. Sides & Son Pty. Ltd.
Well Head Fittings: 3' Riser Pipe with Valve
Logged by: Schlumberger
Drilling Method: Air Hammer & Rotary
Mud logging by: Nil
Lithology by: A.R. LLOYD, R.D. SHAW, R.A.H. NICHOLS,
Engineering by: M. BELL

ELECTRIC LOG DATA

SERVICE	SCHLUMBERGER	
LOG TYPE	Electric	S.P. & 16"N
RUN No & SCALE	1- 2" & 5"	2- 2" & 5"
DATE RUN	10. 3. 1964.	7. 7. 1964.
FIRST READING	1676'	3330'
LAST READING	42'	1615'
INTERVAL MEASURED	1631'	1715'
CASING: E-LOG	42'	1615'
: DRILLER	42'	1615'
DEPTH REACHED	1678'	3331'
BOTTOM DRILLER	1680'	3330'
MUD NATURE	BENTONITE	BENTONITE
S G	1·13	1·10
RESISTIVITY	3·71 92°F.	2·86 72°F.
RESIST. B.H.T.	3·2 109°F.	1·70 115°F.
STANDING WATER LEVEL	85'	85'
BIT SIZE: 1	8 1/2" to 1620'	8 1/2" to 1620'
: 2	6 1/4" to T.D.	6 1/4" to T.D.
SPACING AM1	16"	16"
AM2	64"	64"
AO	18'8"	18'8"
WEIGHT USED	Nil	Nil
RECORDED BY	P. HUSTEN	D. BAIRD

RADIOMETRIC LOG DATA

SERVICE	SCHLUMBERGER	
LOG TYPE	Gamma	Gamma
RUN No & SCALE	1- 2" & 5"	2- 2" & 5"
DATE RUN	10. 3. 1964.	7. 7. 1964.
FIRST READING	1670'	3326'
LAST READING	30'	1614'
INTERVAL MEASURED	1640'	1712'
CASING: GRN-LOG	—	1614'
: DRILLER	42'	1615'
MUD NATURE	BENTONITE	BENTONITE
STANDING WATER LEVEL	85'	85'
TIME CONSTANT SECS.	2	2
LOGGING SPEED ft./min.	30	30
STAT. VARIATION ins.		
RECORDED BY	P. HUSTEN	D. BAIRD

SONIC LOG DATA

SERVICE	SCHLUMBERGER	
LOG TYPE	SONIC	SONIC
RUN & SCALE	1- 2" & 5"	2- 2" & 5"
DATE RUN	10. 3. 1964.	7. 7. 1964.
FIRST READING	1665'	3326'
LAST READING	42'	1614'
INTERVAL MEASURED	1623'	1712'
CASING S. LOG	42'	1614'
CASING DRILLER	42'	1615'
MUD NATURE	BENTONITE	BENTONITE
STANDING WATER LEVEL	85'	85'
RECORDING SPEED ft/hr	4000	1800
BIAS	90	85-90V
RECORDED BY	P. HUSTEN	D. BAIRD

OTHER BORE-HOLE LOG

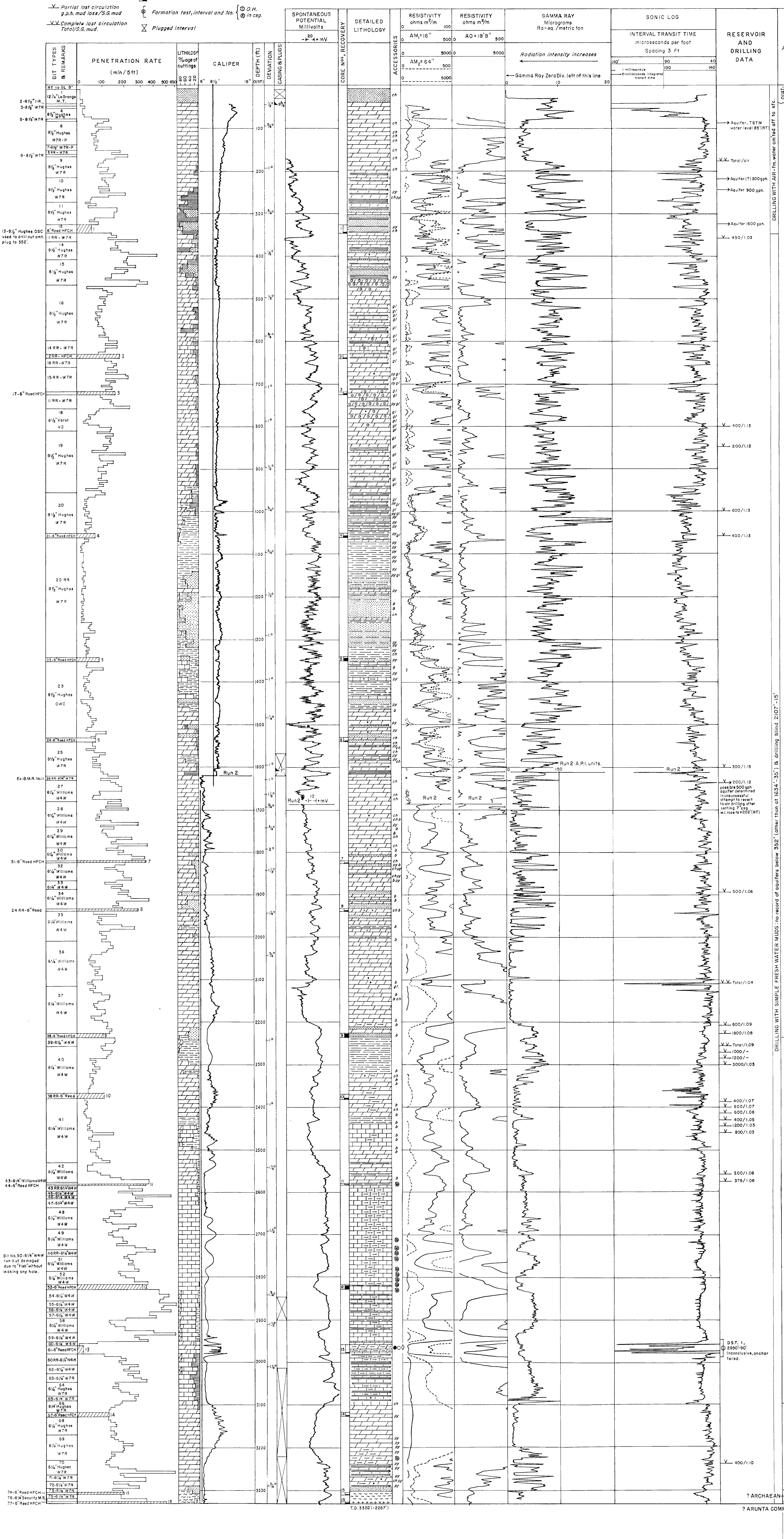
Microcaliper - Schlumberger
Run 1 2" & 5" 1630'-42'
Run 2 2" & 5" 3331'-1615'
Microlog - Schlumberger
Run 1 & 2 - Nil, not recorded
Other logs - Nil

LITHOLOGICAL REFERENCE

Quartz Sandstone; Shale; Siltstone; Dolomite; Oolitic Dolomite; Limestone; Macrofossils
Gneiss; Granite; *py* – Pyrite; *ch* – Chert; *b* – Bitumen; *gl* – Glauconite

WELL SYMBOLS

Small oil and gas show
Flourescence
Partial lost circulation g.p.h. mud loss/S.G. mud
Complete lost circulation Total/S.G. mud.
Formation water
Core, interval, number and recovery
Formation test, interval and No. ① *O.H.* ② *in csg.*
Plugged interval



DESCRIPTIVE LITHOLOGY

QUATERNARY

Unit 1. 8' (+1063') Thickness: 32'
Quartz sand; 100%, red and brown fine to medium-grained, rare coarse-grained; rounded to subrounded; rare chert.

Unit 2. 40' (+1023') Thickness 163'+
Dolomite; 98%, light brown with rare green-brown, red-brown, grey-brown, yellow and medium grey, microcrystalline, hard.
Claystone; 1%, yellow-green, soft.
Chert; 1%, green, aphanitic.

Unit 3. 203' (+860') Thickness 248'
Dolomite; 40%, light grey, medium grey, white, green-grey and light brown, microcrystalline, hard; quartz sand in parts; rare vugs; rare pyrite, interbedded with shale; 30% light to medium grey, green-grey, dark green, purple and red-brown, moderately hard, slightly calcareous, grading into siltstone in parts.
Quartz sandstone; 28%, white, rare pink and yellow, fine-grained, medium to coarse-grained in parts, well sorted, rounded to sub-rounded, porous, friable, some calcareous cement.
Claystone; 1%, yellow-green, soft.
Chert; 1%, green, aphanitic.

Unit 4. 451' (+612') Thickness 489'
Dolomite; 90%, white, light, medium and dark grey, light green, green-grey, light brown, creamy and brown-grey, microcrystalline, medium and coarsely crystalline in parts, hard to very hard; oolitic and glauconitic in parts; sandy, silty and argillaceous in parts; rare dolomite and calcite euhedra.
Shale; 10%, medium to dark grey, black, green-grey, red-brown, moderately hard, soft in parts; slightly calcareous, rare mica and quartz, grading into siltstone in parts; present as thin interbeds in dolomite.

UPPER CAMBRIAN — ARRINTHRUNGA FORMATION

Unit 5. 940' (+123') Thickness 524'
Siltstone; 50%, light brown, light to medium grey, red, brown, white, pink and green-grey, calcareous, quartz abundant to rare; rare parts sandy; soft, becoming hard in parts; rare vugs; mica, pyrite, and ?glauconite in parts; some red limonite staining.
Quartz Sandstone; 25%, white, light grey, minor pink, green, fine-grained (coarse-grained in parts) rounded to subrounded, well sorted, some calcareous and dolomitic cement, porous, friable; rare pyrite, mica and glauconite; grading into sandy dolomite in parts.
Dolomite; 15%, medium and light grey, white, light green, green-grey and pink, microcrystalline, rarely medium to coarsely crystalline, saccharoidal, hard, rarely soft; rare quartz sand, pyrite and ?glauconite; rare euhedral rhombs.
Shale; 5%, medium to dark grey, black and green-grey, moderately soft to hard, slightly calcareous; rare pyrite.
Limestone; 5%, pale pink to white, light grey and light green, microcrystalline, hard, rarely soft, rare pyrite and quartz sand.

Unit 6. 1464' (-401') Thickness 771'
Dolomite; 85%, light brown, pink, white, light grey, dark grey to black, grey-brown and green, finely crystalline, rarely microcrystalline and medium to coarsely crystalline, saccharoidal, hard; rare quartz silt and sand; rare pyrite and ?bitumen; small vugs in parts; rare calcite euhedra.
Quartz sandstone; 13%, light grey, white and brown, fine-grained, rarely medium and coarse-grained, rounded, well sorted, some dolomitic cement; rare pyrite and mica; rare chert pebbles.
Shale; 1%, black, dark grey, medium grey, dark green, soft; rare mica and quartz silt.
Siltstone; 1%, green-grey, white, pink, green and black, soft, rarely hard, rare pyrite and mica; some quartz in parts.
Chert; 1%, light brown, pink, green, white, aphanitic.

DRILLING WITH SIMPLE FRESH WATER MUDS: no record of aquifers below 352' (other than at 1634'-35') & drilling blind 2107'-15'

MIDDLE CAMBRIAN — ARTHUR CREEK BEDS

Unit 7. 2235' (-1172') Thickness: 203'
Siltstone; 50%, medium and light grey-brown, dolomitic, grading into silty dolomite in parts; mica, quartz and ?magnetite in parts grading into fine-grained sandstone; massive with thin laminations of clayey material; rare vugs with euhedral rhombs; hard.
Dolomite; 50%, light grey, light brown and grey-brown, rare white, finely crystalline to microcrystalline, hard; silty in parts, grading into dolomitic siltstone; rare stylolites; saccharoidal in parts; rare ?bitumen.

Unit 8. 2438' (-1375') Thickness 144'
Dolomite; 65% white, light brown, light grey and grey-brown, microcrystalline, rarely finely crystalline and saccharoidal, hard; rare quartz silt and pyrite; rare vugs with euhedral rhombs; rare bitumen.
Limestone; 34%, white, pale brown, grey-brown, medium to finely crystalline, rarely microcrystalline, soft to moderately hard; speckled with coarse black flecks; rare brachiopods and sponge spicules.
Siltstone; 1%, black, grey, fine laminae.

Unit 9. 2582' (-1519) Thickness 515'
Limestone; 95%, grey-brown, medium and dark grey, pale grey, microcrystalline, rarely finely crystalline, hard, relatively soft in parts; quartz silt, argillaceous and carbonaceous in parts, in some places grading into calcareous siltstone, speckled with black flecks, laminated, friable and platy in parts; rare white chalcedony; rare calcite euhedra and veins; fossiliferous with trilobites and brachiopods.
Siltstone; 2%, dark grey, grey-brown, rare light grey and black, calcareous, ?carbonaceous, argillaceous and quartzose, hard; finely disseminated pyrite in parts; some fissile; grading into fine grained quartz sandstone in parts; rare calcite euhedra and veins, present as fine laminae in the limestone.
Shale; 2%, dark grey-black, argillaceous, carbonaceous (bituminous), calcareous, hard; forms thin laminae (0.5mm) between limestone bands (1.0 mm)
Dolomite; 1%, brown and dark grey, microcrystalline, soft; bituminous, porous, calcareous and argillaceous; laminated, fissile; pale green fluorescence, amber yellow globules of oil.

?LOWER CAMBRIAN — ?MT BALDWIN FORMATION

Unit 10. 3097' (-2034') Thickness 207'
Dolomite; 90%, white, light grey, light brown, dark grey to black, blue-grey, microcrystalline to medium crystalline, hard; mainly tight, 5% porosity in parts; slightly calcareous; rare glauconite, pyrite, and carbonaceous flakes; quartz silt in parts; grains angular; rare vugs with rhombic euhedra; rare fossils; rare chert.
Quartz sandstone; 5%, light to medium brown, white, rare red and grey, mottled white and red-brown, fine to medium-grained angular to subangular, some scattered medium to coarse-grained, subrounded average to well-sorted, hard: no porosity; rare mica and pink-orange ?feldspar; slightly calcareous, ferruginous, ?clay matrix.
Shale; 5%, interpreted from "E" log.

? ARCHAEAN — ? ARUNTA COMPLEX — ? PRECAMBRIAN — UNDIFFERENTIATED

Unit 11. 3304' (-2241') Thickness 26'+
Gneiss; pink, well banded, fine bands of light and dark material; quartz, microcline, biotite, altered sericitic and chloritic material, ?carbonate, ?plagioclase, muscovite and scapolite; veins and patches of carbonate and scapolite; medium crystalline, rarely coarsely crystalline.

Unit 12. 3328' (-2265') Thickness 2'+
Granite; orange and white mottled, coarsely crystalline, quartz and feldspar with rare muscovite, biotite, ?phlogopite and ?haematite; veins of ?chlorite; green talc or chlorite along oblique fractures.
Total Depth 3330' (-2267').