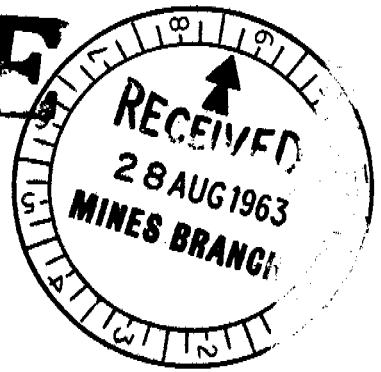


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FARMOUT-PLACE AMMAROO WELLS NOS. 1 & 2,
NORTHER TERRITORY. *Elkwater*

WELL COMPLETION REPORT

by

R. HARE & ASSOCIATES

August, 1963.

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I. SUMMARY

During the first three months of 1963, Farmout Drillers N. L. carried out drilling operations at a location about 12 miles North-East of Ammaroo Station homestead and about 160 miles North-East of Alice Springs in the Northern Territory. These operations consisted of drilling two shallow stratigraphic wells to basement in the vicinity of the "Discovery Bore" in which petroliferous gas was encountered whilst boring for water in 1956.

Ammaroo No. 1 Well is located 50 yards North-East of the "Discovery Bore" and was drilled between 12th January and 14th February 1963 to the total depth of 612½ feet. Ammaroo No. 2 Well is located 1½ miles due South of Ammaroo No. 1 Well and was drilled between 22nd February and 16th March 1963 to a total depth of 842½ feet.

These wells both penetrated a 500 ft. section of Middle Cambrian, Arthur Creek beds lying between unconsolidated covering sediments and basement rocks. In each well, a unit consisting of bituminous limestone and shale, approximately 300 ft. thick, was found to occur within the section of Arthur Creek Beds. This unit contains traces of petroliferous hydrocarbons and constitutes source rock material. The bedding in the sedimentary section parallels the flatly dipping unconformity at the surface of the basement rocks. These facts indicate that the sedimentary section does not thicken basinwards and has remained undisturbed by folding since deposition.

II. INTRODUCTION

Farmout-Place Ammaroo Wells No. 1 & 2 were drilled in the Ammaroo Lobe of the Georgina Basin, about 12 miles North-East of Ammaroo Station homestead, and about 160 miles North-East of Alice Springs in the Northern Territory (See Annex 1). The wells were drilled in the vicinity of the "Discovery Bore" in which petroliferous gas was encountered whilst boring for water in 1956. The wells were drilled to basement as off-structure stratigraphic tests of the full sedimentary section. Well No. 1 was drilled 50 yards North-East of the "Discovery Bore" with the object of obtaining more information on the occurrence of gas in that bore.

This well established that the gas is associated with petroliferous hydrocarbons which have been generated and held within bituminous limestone

and shale. Well No. 2 was drilled $1\frac{1}{2}$ miles due south of Well No. 1 for the purpose of further investigating the occurrence of these bituminous beds farther out in the basin.

The operating company, Farmout Drillers N. L., drilled the wells under a farmout arrangement with Smith Australian Oil Co. Pty. Ltd. on Oil Permit No. 41.

The wells were drilled with a Mindrill B. 5000 rig adapted for rotary drilling, which was owned and operated by Australian Tube Wells Limited. Drilling rate was slow due to the very hard nature of the formations penetrated. The operations were also hampered by wet weather which retarded spudding-in and thereafter interfered with the transport of supplies and movement about the location.

It was initially proposed to drill with mud and to experiment with compressed air as the drilling fluid. However, the supply of water from local bores proved inadequate and all the drilling was carried out with air.

Ammaroo No. 1 Well spudded-in at 4.00 pm on 12th January, 1963.

The well passed through unconsolidated clays and gravels to a depth of 38 feet and thence Middle Cambrian beds to 570 feet. From 570 feet to $612\frac{1}{2}$ feet drilling was in schistose basement rocks of Lower Proterozoic age.

Fluorescence was noted in the cuttings and cores between the depths of 65 and 550 feet. Gas detecting equipment was not used on this well, but a strong smell of gas was present whilst drilling in bituminous sediments. Cored samples of this material give a strong petroliferous odour when freshly broken. Several negative tests for formation fluids were made by stopping the air flow. The hole was left open for 21 hours at the progress depth of 147 feet, but no flow was recorded.

The well was commenced with an 11-inch auger to a depth of 25 feet. A $9\frac{5}{8}$ inch conductor pipe was set at 25 feet and an $8\frac{3}{4}$ inch hole was then drilled ahead to 75 feet and the surface string of 7-inch casing was set and cemented at 65 feet. A 6-inch hole was drilled from 75 feet to 610 feet, where Core No. 7 was taken to total depth. The formation was extremely hard throughout and two Hughes R.1 (button) and five Hughes W.7R bits were used in drilling the 535 feet of 6-inch hole.

A total of 7 cores were cut over a collective length of 91 feet. All cores were cut with $5\frac{3}{16}$ -inch Mindrill diamond core heads using a double tube barrel.

A sulphide water zone was encountered at 217 feet and a fair supply of fresh water was struck at 470 feet.

Drilling ceased on 14th February 1963 and the well was abandoned as a potential water well.

Run 1 of the electric logs was made at the progress depth of 218 feet using Bureau of Mineral Resources Widco 2000 unit. This unit proved defective and was returned to the laboratory. Run 2 of the electric logs and Run 1 of the Gamma Ray logs were made after abandonment, using a Bureau of Mineral Resources Widco 1000 unit. Flood waters had meanwhile washed debris into the well and it was only possible to clear the hole and log to a depth of 465 feet.

Ammaroo No. 2 Well spudded-in at 4.00 pm on 22nd February 1963. The well passed through cemented grit and siltstone to 45 feet, then unconsolidated silt to a depth of 273 feet, thence Middle Cambrian beds to 765 where weathered granite was encountered. Drilling proceeded in this material to 840 feet where Core No. 2 was taken to a total depth in hard granite.

Fluorescence was noted in the cuttings over the intervals 310 to 380 feet, and 600 to 660 feet. Gas detecting equipment was not used on this well, but a strong smell of gas was present whilst drilling in bituminous sediments. Cored samples of this material give a strong petroliferous odour when freshly broken. A very small flow of gas was encountered at 406 feet, which was composed of a very small fraction of saturated and unsaturated-type hydrocarbons. No further flows were recorded when the air flow stopped at various progress depths.

An $8\frac{3}{4}$ -inch Hughes W. 7R bit was used to drill the surface hole to 16 feet. This was then reamed out to 11 inches with a built-up cross-bit and a $9\frac{5}{8}$ -inch conductor pipe was set at 14 feet and cemented. An $8\frac{3}{4}$ -inch hole was then drilled ahead to 310 feet

and the surface string of 7-inch casing was set and cemented at this depth. A 6-inch hole was then drilled from 310 feet to 840 feet, where Core No. 2 was taken to total depth. Drilling was in hard formation below 310 feet and three Hughes R. 1 bits were used in drilling the 530 feet of 6-inch hole.

A total of two cores were cut over a collective interval of 13 feet. Core No. 1 was cut with a $5\frac{5}{8}$ -inch Truco diamond head, and Core No. 2 was cut with a $5\frac{3}{16}$ -inch Mindrill diamond head.

A small supply of fresh water was struck at the depth of 332 feet. Drilling ceased on 16th March 1963, and the well was abandoned as a potential water well.

The well was logged after abandonment with a Bureau of Mineral Resources Widco 1000 unit. Electric logs were run over the interval 310 to 840 feet, and a Gamma Ray log was run over the interval 5 to 820 feet.

III. WELL HISTORY

(1) General Data:

- | | |
|------------------------------------|--|
| (a) Well Name and Number: | Farmout-Place Ammaroo No. 1 Well.
Farmout-Place Ammaroo No. 2 Well. |
| (b) Location: | Well No. 1 is located 50 yards North-East of the "Discovery Bore" and approximately 12 miles North-East of the Ammaroo airstrip. The co-ordinates of this well are $21^{\circ} 37'54''S$, $135^{\circ} 23'47''E$. The "Discovery Bore" is shown on the 4-mile Elkedra Street.

Well No. 2 is located 123.5 chains South of Well No. 1 on a bearing of $176^{\circ} 00'$ true. The co-ordinates of this well are $21^{\circ} 39'13''S$, $135^{\circ} 23'53''E$. |
| (c) Tenement Holder: | Smith Australian Oil Company Pty. Ltd. c/- Messrs. Newell & Ward, Knuckey Street, Darwin, N. T. |
| (d) Details of Petroleum Tenement: | Oil Permit 41 is approximately 7,211 square miles in area and is held by Smith Australian Oil Co. Pty. Ltd. Place Gas and Oil Co. Ltd. of Toronto, Canada, holds a 25% interest in the area. |

The tenement is the subject of a farmout agreement between the holder and Farmout Drillers N. L.

- (e) District: Ammaroo Station, Northern Territory.
- (f) Total Depth: Well No. 1: 612½ feet.
Well No. 2: 842½ feet.
- (g) Date Drilling Commenced: Well No. 1: 12th January 1963.
Well No. 2: 22nd February 1963.
- (h) Date Drilling Completed: Well No. 1: 14th February 1963.
Well No. 2: 16th March 1963.
- (i) Date Wells Abandoned: No abandonment programme.
Rigs moved off in stages with no fixed date.
- (j) Date Rig Released: 25th March 1963.
- (k) Drilling Time to Total Depth: Well No. 1: 42 days.
Well No. 2: 31 days.
- (l) Elevation: Well No. 1: Rig Floor 1256.5 ft.
Ground level 1251.5 ft.
Well No. 2: Rig Floor 1242.9 ft.
Ground level 1237.9 ft.
- Datum for the above levels is the Department of Interior Bench Mark No. 65.13, defined as 1233.9 ft. above sea level.
- All depths in this report are measured from the rig floor.
- (m) Status: Abandoned.
- (n) Cost: £50,420.

(2) Drilling Data:

- (a) Drilling Contractor: Australian Tube Wells Ltd.,
175 North Terrace, Adelaide, S. Aust
- (b) Drilling Plant: Mindrill (F100) B. 5000.
Type: Adopted for Rotary Drilling and mounted on a 36 ft. semi-trailer with International 180 Prime Mover.
Rated Capacity with BX size pipe: 6,000 ft.
Motor: Perkins R. 6, Series 11, diesel engine
- (c) Mast: Falling 2500, 54 feet, hydraulic raise
Rated capacity: 90,000 lbs.
- (d) Pumps: Two Mindrill.
Make: Two Mindrill.
Type: Double Acting, Duplex.
Size: 4½" x 5"

(3) Logging and Testing**(a) Ditch Cuttings:**

Well No. 1: Samples were collected at 5 ft. intervals from 30 to 340 ft., and thereafter at 10 ft. intervals to total depth.

Well No. 2: Samples were collected at 10 ft. intervals from surface to total depth.

Cuts of the samples were distributed to the Bureau of Mineral Resources, the Mines Branch of the Northern Territory Administration and R. Hare & Associates.

Examination of the cuttings was maintained on a 24-hour basis while drilling was in progress.

(b) Coring:

A total of 7 cores were cut in Well No. 1 as follows:

Core No.	Interval	Recovery
1	40' - 54' (14')	3' 8" (27%)
2	127' - 147' (20')	8' (40%)
3	182' - 199' (17')	9' (53%)
4	199' - 208' (9')	5' 10" (65%)
5	213' - 221½' (8½')	7' 1" (83%)
6	490' - 510' (20')	18' 5" (92%)
7	610' - 612½' (2½')	1' 2" (47%)

A total of 2 cores were cut in Well No. 2 as follows:

Core No.	Interval	Recovery
1	319' - 329½' (20½')	4' 1" (39%)
2	840' - 842½' (2½')	1' 6" (60%)

Samples of the cores were distributed to the Bureau of Mineral Resources and the Mines Branch of the Northern Territory Administration. The bulk of the cores was returned to R. Hare & Associates.

(c) Side wall sampling: Nil.

(d) Electric and other logs:

The wells were logged by R. Hare & Associates using a Bureau of Mineral Resources Widco 1000 unit as follows:

8.

Well No. 1: Run 1: Self potential and resistivity 65'-218' (Misrun using Widco 2000 unit. Instrument defective.)

Run 2: Self potential and resistivity 130'-465'.

Run 1: Gamma Ray Log 10'-462'.

Well No. 2: Run 1: Self potential and resistivity 310'-840'.

Run 1: Gamma Ray Log 5'-820'

(e) Drilling time and gas log:

Nil.

(f) Formation testing:

Using air as the drilling fluid, it is not necessary to set a packer for testing.

Well No. 1: The air flow was stopped at the progress depths of 80 feet and 125 feet for half an hour in unsuccessful attempts to obtain a gas flow.

The hole was left open for 21 hours at the progress depth of 147 ft., but no flow was recorded. No further tests were conducted for formation fluid, but the opportunity was taken to check for gas flow on those occasions when the air flow stopped due to drilling operations. No flow was recorded, but samples were collected by circulating compressed air with the drill pipe raised just off bottom.

No. 2
Well ~~No. 1~~: Gas flow was checked on those occasions when the air flow stopped due to drilling operations. A very small flow of gas was encountered at 406 feet, and the following test was conducted on 8th March:

Method: B. O. P. Shut-in. Valve, reduction nipples and hose connected to drill pipe. Gas collected over water.

Duration of test: 30 minutes.

Pressure: Unable to record with manometer.

Volume: Approximately 0.2 cu. ft. per hour, calculated by water displacement.

The gas had a faint sweet odour, but the samples collected were non-inflammable. Two bottles of this gas were submitted to the Bureau of Mineral Resources and analysed by the Australian Mineral Development Laboratories. (See Appendix 3). This analysis showed a very small hydrocarbon fraction (less than one percent) which is composed of saturated and unsaturated type hydrocarbons, the latter being in somewhat greater amount than the former.

- (g) Deviation surveys: Nil.
- (h) Temperature surveys: Nil.

IV. GEOLOGY.

(1) Summary of Previous Work.

The area lies in the South-western corner of the Georgina Basin. It is situated in a W-N-W - E-S-E trending portion of the Basin which is known as the Ammaroo Lobe.

The history of geological investigations in this area prior to 1957 is discussed fully in B. M. R. Records 1960/66. Geological mapping by the Bureau of Mineral Resources, which commenced in 1957, has provided the stratigraphical reference for the area. Detailed mapping was carried out in parts of the area by Geosurveys of Australia Ltd. during 1961 and 1962.

During 1959 and 1960 the Bureau of Mineral Resources carried out regional reconnaissance gravity surveys in the Georgina Basin which incorporated both helicopter and land traverses. The Bouguer anomaly map shows several anomalies within the area, of which three are considered significant in relation to the Ammaroo wells. These anomalies occur in the Sandover River floodout plains where the geology is concealed beneath alluvial cover. Two positive anomalies occur on a N-S line to the West of the Ammaroo wells. The northernmost of these anomalies is centred about 18 miles West of the Ammaroo wells. A negative anomaly which is centred about 17 miles South of the Ammaroo wells may be attributable to a structural syncline.

The Bureau of Mineral Resources drilled a number of core holes in the area during 1962 for stratigraphic information. None of these holes penetrated the full sedimentary section to basement. Prior to this, all holes drilled in the area sought water. In 1953, inflammable gases were encountered while percussion drilling for water on Ammaroo Station. The gases had a strong petroliferous odour and samples taken by officers of the Bureau of Mineral Resources indicated a high proportion of heavier hydrocarbons in relation to methane. The gases were first observed in this hole, which has since become known as the 'Discovery Bore', when drilling had progressed to the depth of 180 feet. The hole was subsequently deepened and abandoned at a depth of approximately 360 feet without striking basement.

Ammaroo No. 1 Well was drilled with the object of obtaining more information on the occurrence of gas in the 'Discovery Bore'.

Ammaroo No. 2 Well was drilled for the purpose of further investigating petroliferous source rock material which was encountered in Well No. 1.

(2) Summary of Regional Geology.

The area lies in the south-western corner of the Georgina Basin. It is situated in a W-N-W - E-S-E trending portion of the Basin which is known as the Ammaroo Lobe.

The Ammaroo wells were drilled near the northern margin of the Ammaroo Lobe where Arthur Creek Beds of Lower Middle Cambrian age directly overlie basement rocks. The Arthur Creek Beds are exposed over a considerable area on the northern side of the Ammaroo Lobe, but outcrop as part of a succession of Lower Palaeozoic formation on the southern side of the Ammaroo Lobe.

Basement rocks outcrop about 8 miles north of Ammaroo No. 1 Well where they consist of metasediments and igneous intrusives of the Lower Proterozoic Hatches Creek Group. Unconformably overlying these basement rocks are the Arthur Creek Beds which extend southward under the Sandover River Plains to reappear near the southern margin of the Ammaroo Lobe.

Here the Arthur Creek Beds lie conformably between the Mt. Baldwin Formation of Lower Cambrian age and the Upper Cambrian Arrinthrunga Formation. Conformably overlying the Arrinthrunga Formation are the Tomahawk Beds of Lower Ordovician to Upper Cambrian age and the Middle Ordovician Nora Formation. These

units are unconformably overlain by the Devonian Dulcie Sandstone which is confined in distribution to the Dulcie Range.

The Palaeozoic section has been folded into several broad anticlinal and synclinal structures, the axes of which trend in the same west-north-west direction as the Ammaroo Lobe.

Capping the higher flat-topped hills and present below the alluvial cover of Sandover River Plains is a siliceous duricrust of Tertiary age. Underlying this duricrust in Well No. 2 was some 230 feet of unconsolidated silt which presumably represents Tertiary valley fill.

(3) Stratigraphic Table.

The stratigraphic section penetrated by both wells consisted essentially of Lower Middle Cambrian, Arthur Creek Beds lying between unconsolidated Tertiary and Quaternary sediments and basement rocks. Samples obtained from just above basement in the outcrop section of the Ammaroo Wells were examined palaeontologically by the Bureau of Mineral Resources. Their report, which is attached as Appendix 1 to this report, determines the age of these rocks as "early (but not earliest) Middle Cambrian". The Arthur Creek Beds encountered in these wells may be divided into thin lithological units as shown in the following tables:-

WELL NO. 1

Age	Groups Formations or Informal Rock Units	Lithology	Depth	Thickness
Quaternary	Alluvium	Red Sandy Clay	5' - 33'	33'
Lower Middle Cambrian	Arthur Creek Beds			
	Unit I	Grey argillaceous limestone with chert	38' - 65'	27'
	Unit II	Black bituminous limestone and shale	65' - 400'	335'
	Unit III	Grey dolomitic shale	400' - 550'	150'
	Unit IV	Siltstone and quartzite	550' - 570'	20'
Lower Proterozoic	Hatches Creek Group	Chloritic mica schist	570' - 612½'	42½'

WELL NO. 2.

Age	Groups Formations or Informal Rock Units	Lithology	Depth	Thickness
Quaternary	Alluvium	Red to white grit	5' - 14'	9'
Tertiary	Unit I	Duricrust	14' - 45'	31'
	Unit II	Brown silt	45' - 273'	228'
Lower Middle Cambrian	Arthur Creek Beds			
	Unit I	Grey argillaceous limestone with chert	273' - 300'	27'
	Unit II	Black bituminous limestone and shale	300' - 593'	293'
	Unit III	Grey dolomitic shale	593' - 720'	127'
	Unit IV	White sandstone	720' - 765'	45'
Lower Proterozoic	Hatches Creek Group	Granite	765' - 842½'	77½'

(4) Stratigraphy.(a) Quaternary

Lithology :

Well No. 1 5' - 38' (33')
Red sandy clay containing red fragments of duricrust and metasediments to 27 feet then gravels containing pebbles of white limestone and brown chert.

Well No. 2 5' - 14' (9')
Calcareous silt and ferruginous grit.

(b) Tertiary

Lithology:

Well No. 1 Nil

Well No. 2 Unit I 14' - 45' (31')
Duricrust consisting of reddish brown silicified ferruginous grit.

Unit II 45' - 273' (228')
Unconsolidated brown and yellow silt.

(c) Lower Middle Cambrian

Lithology:

Well No. 1 Unit I 38' - 65' (27')
Hard grey argillaceous limestone with minor chert and shale containing trilobite pleurae and brachiopods.
Core No. 1 (40' - 54') was taken in this unit.

(c) Lower Middle

(c) Lower Middle Cambrian (Cont'd.)

Lithology:

Well No. 1 Unit II 65'-400' (335')
Hard dark grey to black bituminous crystalline limestone interbedded with hard dark grey to black bituminous shale. Fossil fragments common, and small brachiopod valves present.

Core No. 2 (127'-147'), Core No. 3 (182'-199'), Core No. 4 (199'-208') and Core No. 5 (213'-221½') were taken in this unit.

Unit III 400'-550' (150')
Hard blue-grey to greenish-grey dolomitic shale. Core No. 6 (490'-510') was taken in this unit.

Unit IV 550'-570' (20')
Quartz siltstone grading to purplish grey quartzite. Trace pyrite.

Well No. 2 Unit I 273'-300' (27')
Hard dark to light grey argillaceous, slightly micaceous, limestone with minor grey chert. Brachiopod fragments present.

Unit II 300'-593' (293')
Hard dark grey to black bituminous crystalline limestone interbedded with hard dark grey to black calcareous and bituminous shale. Fossil fragments common.

Core No. 1 (319'-323½') was taken in this Unit.

Unit III 593'-720' (127')
Hard dark grey (becoming lighter coloured with depth) dolomitic shale. Trace of pyrite at 700'.

Unit IV 720'-765' (45')
White fine grained sandstone grading to quartzite.

(d) Lower Proterozoic

Hatches Creek Group

Lithology:

Well No. 1 570'-612½' (42½')
Dull red becoming greenish-grey chloritic mica schist. Core No. 7 (610'-612½') was taken in this rock and showed vertical schistosity.

Well No. 2 765'-842½' (77½')
Pink granite, weathered to 840'. Core No. 2 (849'-842½') was taken when hard rock was reached and consisted of medium to coarse grained granite.

(5) Structure.

Each of the Ammaroo wells penetrated approximately the same thickness of flatly dipping Arthur Creek Beds which were deposited unconformably upon a flatly dipping surface of basement rocks. Bedding dips observed in cores were essentially flat and correlation between wells with respect to lithology, gamma ray logs and electric logs indicate an overall dip of 1 - 2 degrees.

As shown on Annex 2, each well encountered about 27 feet of hard cherty limestone at the top of the section of Arthur Creek Beds. This unit is structurally 247 feet lower in Well No. 2 than in Well No. 1.

The Gamma Ray Logs show a good correlation between wells over an interval of some 200 feet and a fair correlation over the remainder of the total interval of 452 feet which it was possible to log in Well No. 1. This correlation is supported by one corresponding event on the Electric Logs.

The corresponding interval on the Gamma Ray Logs is 212 feet structurally lower in Well No. 2 than in Well No. 1. Also, the corresponding interval on the Electric Logs is 206 feet structurally lower in Well No. 2. than in Well No. 1. Similarly, the top of the basement rocks is 208 feet structurally lower in Well No. 2 than in Well No. 1.

The above comparisons indicate that this favourable section of the Arthur Creek Beds does not thicken basinwards and further suggest that these sediments have remained undisturbed by folding since deposition. The fact that the top of the Arthur Creek Beds encountered in these wells conforms so closely to relative elevations of the rest of the section suggests that erosion took place within these beds down to a hard formation.

(6) Occurrence of Hydrocarbons.

Fluorescence was noted in the cuttings and cores between the depths of 65 and 550 feet in Well No. 1 and over the intervals 310 to 380 feet and 600 to 660 feet in Well No. 2. Core samples of some of the bituminous beds give a strong petroliferous odour when freshly broken.

The fluorescence in some cores was observed to be directly related to fossil fragments or small brachiopod valves which appear to have generated the hydrocarbons in place. These hydrocarbons have since remained trapped within the impervious beds.

A sample from Core No. 3 in Well No. 1 was studied mineragraphically and subjected to a Soxhlet extraction test by the Mineragraphic Section of the C.S.I.R.O. The results of these investigations are recorded in Appendix 2 to this report. The loss on ignition of the residue after acid treatment was 0.6 percent by weight, whereas the oily residue recovered by Soxhlet extraction techniques amounted to 0.13 percent by weight.

Analysis of the gas samples collected from the very small flow at 406 feet in Well No. 2 showed a very small (less than 1%) hydrocarbon fraction. This fraction is composed of both saturated and unsaturated - type hydrocarbons, the latter being slightly in excess of the former.

This appears to be the first recorded instance of unsaturated gaseous hydrocarbons in Australia and Papua.

(7) Porosity and Permeability of Sediments Penetrated.

The section of consolidated sediments penetrated in the Ammaroo wells is characteristically hard and tight. With the exception of the thin basal sandstone or quartzite unit which appears to have poor porosity, this section consists of crystalline limestone and completely cemented calcareous or dolomitic shales in which porosity is restricted to fractures or caverns.

Water zones which were struck at 217 feet (sulphurous) and 470 feet (fresh) in Well No. 1 and at 332 feet (fresh) in Well No. 2 are presumably associated with fractures. This would also apply to the small gas flow which was struck at 406 feet in Well No. 2.

(8) Contribution to Geological Concepts Resulting from Drilling.

The Ammaroo wells established that the prospective sedimentary section above basement is only 500 feet thick in the vicinity of the 'Discovery Bore' and that this section does not thicken in a basinwards direction for at least a mile and a half south of the 'Discovery Bore'. These wells also established that the petroliferous hydrocarbons which were first detected in the 'Discovery Bore' have been generated in bituminous beds within this section and that these favourable beds extend at least as far south as Well No. 2, while maintaining the same thickness of approximately 300 feet.

The fact that the bedding in the sedimentary section parallels the flatly dipping unconformity at the surface of the basement rocks suggests that these sediments have remained undisturbed by folding since deposition.

V Acknowledgements.

Wellsite supervision was provided by C. Laing and R. Laws on Well No. 1 and by R. Laws and K. Fletcher on Well No. 2.

The electric and gamma ray logging was carried out by K. Fletcher.

Acknowledgements are due to G. Baker who carried out the mineragraphic and extraction investigations on a core sample and to J. Gilbert-Tomlinson for palaeontological determinations.

This report was prepared by H. J. Newton of R. Hare & Associates.

APPENDIX I

MIDDLE CAMBRIAN FOSSILS FROM THE VICINITY OF THE
AMMAROO WELLS, NORTHERN TERRITORY

INTRODUCTION:

Samples from four localities (F1 - F4) in the outcrop section of the Ammaroo Wells have been submitted by Farmout Drillers N.L. for palaeontological examination and correlation. The stratigraphic succession of the samples has been supplied, but not the exact localities.

FOSSILS:

- F1 (highest in section) - Brachiopod: Lingulella sp.;
Trilobites: Pagetia sp., Peronopsis sp.,
Xystridura sp.
- F2 - Brachiopod: Nisusia sp.; trilobites: Pagetia sp.;
Peronopsis sp., Xystridura sp.
- F3 - Brachiopod: Acrothele sp.; trilobites:
Pagetia sp., Peronopsis sp., Oryctocephalus sp.,
Elrathina sp.
- F4 - (lowest in section; about 100 ft. above the Cambrian-Proterozoic unconformity some ten miles north-east of Ammaroo 1 location) -
Trilobites: Peronopsis sp., ptychopariid
(gen. indet., but perhaps the same as the
Elrathina in F3).

CORRELATION:

This is a very well-known fauna, characteristic of the Sandover Beds of Elkedra Sheet and the lower part of the Arthur Creek Beds of Huckitta Sheet. The age is early (but not earliest) Middle Cambrian (Xystridura time).

(Signed) J. GILBERT TOMLINSON.

8th April, 1963.

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APPENDIX II

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

MINERAGRAPHIC INVESTIGATIONS

Report No. 867

May 13, 1963

OIL WELL SAMPLE FROM AMMAROO, N.W. OF ALICE SPRINGS, N.T.

A sample of crystalline Cambrian limestone from 199 feet, core No. 3, Ammaroo No. 1 well, northeast of Alice Springs, Northern Territory has been submitted by Farmout Drillers, N.L. for examination and testing for traces of oil.

The sample has been examined petrographically and subjected to Soxhlet extraction techniques.

Hand specimen

The rock is medium to dark grey in colour and dense in texture in the hand specimen. Occasional veinlets of white calcite 1mm. to 2mm. wide cut through the rock and in a few places swell out to form small pods. The veins and pods contain relatively coarsely crystalline calcite crystals up to 2 mm. across.

Thin section

A thin section reveals that the rock is a fine-grained limestone with very few empty pore spaces. It consists largely of finely granular calcite in which can be discerned occasional indistinct traces of fossil organisms and rather more clearly defined spicule-like structures, crinoid stem joints and small brachiopods.

Scattered through the rock with random distribution are small areas of a black to dark brown, opaque to sub-translucent pitch-like substance which is evidently the source of oily products obtained in the subsequently conducted Soxhlet extraction process. Such areas range in size from 0.015 mm. to 0.200 mm. across in the thin section. Larger areas than this were not detectable by hand-lens inspection of the sample. The pitch-like areas average 0.06 mm. in size and largely take the shape of the interstices in the rock; occasionally they partially outline or take the shape of micro-organic structures. Examples have been observed in which some of the shell fragments and spicular structures are black throughout from the presence of pitch-like material, in others it outlines fragments of brachiopods. Elsewhere, such areas occupy the mid-regions of rather coarser-grained

aggregates of calcite crystals averaging 0.01 mm. in size, and the larger areas up to 0.2 mm. across usually occur in the interstices of patches of the rock containing the more crystalline calcite and are irregular in shape as a consequence. Sometimes the pitch-like substance occurs as thin films and occasionally as dispersed to cloud-like accumulations of dark brown colour. Less frequently, small darker coloured patches are interstitial to calcite grains 0.075 mm. in size which form small aggregates up to 0.2 mm. across in the finer-grained matrix.

A few vugh-like areas of calcite, measuring up to 2.0 mm. by 0.8 mm. in size, consist of crystals averaging 0.2 mm. by 0.1 mm. in size and are usually free from the pitch-like substance. Exceptions are a few such areas where rare, minute spherular bodies of the pitch occur along some of the grain boundaries in the calcite aggregates; the average size of these spherular bodies is 0.002 mm.

Polished surface

The only opaque mineral observed in a polished surface of the limestone is pyrite which occurs as minute euhedra ranging from 0.002 mm. to 0.006 mm. across. The euhedra are relatively frequent and scattered at random throughout the polished surface. The pyrite was not observed in any particular association with the structures of the remains of micro-organisms or with fragments of larger fossils, and no microspherular pyrite was detected. The pyrite is evidently of authigenic origin.

Acid solubility

To test the rock for acid solubility and in order to recover for microscopical examination any insoluble substances that might be present, samples powdered to minus 100 mesh were digested in warm 1:1 HCl. The washed residue from this treatment was first dried in a dessicator, weighed, and subsequently oven-dried at 110°C and re-weighed. The residue was then ignited at 400°C to 500°C in an open container over a burner to remove pitch-like substances. The results are given in Table 1.

Table 1

Percentages of residues obtained from acid digestion, drying and ignition of powdered limestone containing carbonaceous substances

Residues	Percent
Residues from acid digestion after washing and drying in a dessicator	23.2
Residues after oven drying at 110°C	23.1
Residues after ignition at 400-500°C	22.5

From Table 1 it can be deduced that the proportion of the limestone soluble in warm 1:1 HCl amounts to 76.8 percent, that the loss of ignition amounts to 0.6 percent, and that the total loss on drying followed by ignition amounts to 0.7 percent. The dessicated and oven-dried residue was a darker grey colour than the residue left after ignition which was light greyish-white. Although loss on ignition amounts to 0.6 percent, only approximately one fifth of this total was recoverable by subsequent Soxhlet extraction techniques.

Microscopical examination of residues from acid digestion and ignition

Examination under the petrological microscope of the final residue obtained from acid digestion and ignition, revealed that all carbonates and all of the pitch-like substances had been removed. The only dark coloured, opaque material present consisted of small euhedra and occasional anhedra of pyrite in places reddened (by the process of ignition).

The bulk of the residues consisted of minute particles constituted of low polarising aggregates, some of which resembled micro- to cryptocrystalline silica. Others resembled small plates of isotropic clay minerals. A few angular particles of quartz were present, also rare minute euhedra referable to apatite. The angular character of the quartz crystals was evidently due to crushing the rock preparatory to acid treatment.

Test for P₂O₅

Digestion of portion of the rock powder in excess nitric acid and the addition to the solution of ammonium nitromolybdate yielded a very copious yellow precipitate indicative

of the presence of significant quantities of phosphate. A similar test applied to the residue obtained by drying and ignition, however, was negative. This indicates that the bulk of the phosphate occurs in the acid-soluble portion of the rock, and that the minute euhedra of apatite observed in microscopical examination of the residues were too few and too small to yield a positive test for P_2O_5 .

Soxhlet extraction test

The limestone was pulverized to minus 100 mesh (B.S.S.) and a fifty gram sample of the powder was cycled for six hours in a Soxhlet extraction apparatus using 150 ml. of A.R. carbon tetrachloride.

During pulverization of the rock a very strong odour of oil was evolved that pervaded the laboratory and persisted for several minutes.

The products of extraction were a yellowish-brown oily substance and a film of a wax-like material which adhered to the containing vessel.

The yellowish-brown oil product gave a strong fluorescent response in distinct greenish-yellow colours under a Minera-light lamp. It had a strong oily to waxy smell, and the amount by weight extracted from the limestone during the six hours treatment in the Soxhlet was 0.13 percent. Scrapings from the film deposited on the bottom of the containing vessel, burnt with a smoky flame and a waxy odour was evolved.

(signed) GEORGE BAKER
Senior Principal Research Officer

(signed) T.H. DONNELLY
Experiment Officer

APPENDIX 3

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

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Adelaide

Ref. AN 2/1/0

4th June, 1963.

Acting Director,
Department of National Development,
Bureau of Mineral Resources,
Geology and Geophysics,
M. L. C. Building,
London Circuit,
CANBERRA. A. C. T.

REPORT AN700-63.

YOUR REFERENCE: 62/318, Letter 17/5/63,
Order No. MRC.860

MATERIAL: Natural Gas

DATE RECEIVED: 20/5/63.

ANALYSIS

		No. 1	No. 2
Nitrogen plus Oxygen		xx 99%	xx 99%
Methane	CH ₄	60 ppm ✓	90 ppm
Ethane	C ₂ H ₆	5 ppm ✓	8 ppm
Ethylene	C ₂ H ₄	70 ppm	90 ppm
Acetylene	C ₂ H ₂	8 ppm	12 ppm
Propane	C ₃ H ₈	0.5 ppm ✓	1 ppm
Propylene	C ₃ H ₆	12 ppm	15 ppm
Isobutane	C ₄ H ₁₀	present x 0.5 ppm ✓	present x 0.5 ppm

Analysis by Gas Chromatography

x indicates less than

xx indicates greater than

Analysis by: H. Sears

Officer in Charge, Analytical Section: T. R. Frost

L. Wallace Coffey
Director

interbeds of buff-coloured richly bituminous argillaceous limestone. Green fluorescent brachiopods shells and fragments present.

17" ditto as above plus black grease coating very probably originating from a crude filled fracture higher in sequence. Green fluorescent brachiopod shells and fragments present.

Core No. 4 199' - 208'. Recovery 5'10".

Consists of dark grey silicified very hard sandy calcareous shale banded in part with lenses, rounded masses and interbeds of black hard (silicified?) argillaceous limestone.

The latter often contains traces of crude oil (yellow fluorescence) which can be extracted with carbon tetrachloride, especially in a light grey to buff coloured band at the calcareous shale contact. Sulphides are evident in both. Bedding is irregular, but approximately horizontal.

Core No. 5 213' - 221½'. Recovery 7'1".

Consists of dark grey to black, very hard, brittle, calcareous shale, banded in part, containing nodules, lenses and rounded masses of buff to dark grey very hard argillaceous limestone. Both the limestone and shale have been highly compacted and recrystallised and have low porosity and permeability.

Small brachiopods are abundant, especially over the bottom 3 feet of the core. Thin veins of calcite normal to the bedding are also common.

Small (less than ½ mm) specks of soft, black bituminous material are abundant, especially in bands of grey - buff argillaceous limestone where they comprise over 10% of the bands. This bituminous material has a grey - white fluorescence when dry, and dissolves in carbon tetrachloride giving a milky green cut. Bedding is irregular, but approximately horizontal.

Core No. 6 490' - 510'. Recovery 13'5".

The top 14'11" consists of bluish-grey hard dolomitic shale, banded in part. The shale has a low porosity and permeability, but has occasional horizontal fractures.

A few red chert bands are present one-foot from the top of the core and are approximately one-in. thick.

The shale exhibits a milky green cut in CC14 and has rare yellow fluorescent particles which dissolve in CC14.

The bottom 3'6" consists of hard, buff, crystalline stylolitic, calcitic dolomite. The colour grades from buff to grey brown with depth.

A milky green cut and yellow fluorescence, dissolving in CC14 is evident. Towards the bottom of the core, small solution cavities less than 2 mm deep are present and three-inches from the bottom of the core there is evidence of a water filled horizontal fracture.

Core No. 7 610' - 612½'. Recovery 1'2".
 Consists of quartz mica (?) schist. Contains fine silt-size grains of quartz; very fine grains of a bright mineral, probably mica; and small rounded amber grains, possibly garnet.

The schist was probably derived from a fine grained argillaceous siltstone.

There is a very evident near vertical schistosity, rare horizontal quartz filled fractures, vertical fractures normal to the schistosity and another rare fracture at 70-degrees to the schistosity.

Ammaroo No. 2 Well

Core No. 1 319' - 329½'. Recovery 4'1".
Limestone, dark grey to black, hard argillaceous recrystallised and bituminous. Contains small brachiopods.

Minor Shale as sub-rounded fragments, interbeds and lenses; mid grey to black, hard calcareous, bituminous.

Calcite as vugs, veinlets and small crystalline masses is common within the shale and limestone.

Porosity and permeability of both the limestone and shale is low, occasional vertical and horizontal fractures provide the only real porosity present.

Core No. 2 840' - 842½'. Recovery 1'6".
Granite, medium to coarse grained, well developed crystals of:

quartz (5%)

Felspar (85%) pink to brown, uneven to subconchoidal fracture, probably orthoclase.

mica (10%) black, soft, probably biotite.

Both the felspar and mica are fairly deeply weathered.

Two sets of fractures, one near vertical, one 60°.

APPENDIX IV

CORE DESCRIPTIONS

Ammaroo No. 1 Well

<u>Core No. 1</u> Top 7"	40' - 54'. Recovery 3'8". light brown to grey finely bedded argillaceous calcarenite.
33½"	light brown calcareous siltstone and mudstone with thin bands of red shale, lilac siltstone and mudstone and lenses of grey calcarenite.
5½"	brecciated light grey fine calcarenite with minor light brown marl.
<u>Core No. 2</u> Top 1½"	127' - 147'. Recovery 8'. light brown to grey argillaceous fine calcarenite with patches of strong yellow fluorescence (sent to BMR).
26½"	equal parts dark grey bedded (laminated) argillaceous calcilutite bedding bent round irregular rounded lumps of light grey calcarenite up to 2½ inches thick. Sample 24 inches from top of core strong petroliferous odour, shows thin streaks fluorescence strongly yellowish with sharp outlines "fossil fragments" appear black amorphous and plastic under microscope.
49"	ditto, but more calcarenite.
20½"	ditto, broken fragments measured by full box method.
<u>Core No. 3</u> Top 3"	182' - 199'. Recovery 9'. dark grey to black very hard silty calcareous shale. Strong smell (bitumen?) on freshly fractured surfaces. Natural fracture in rock 3 inches from top of core dipping 2 degrees approximately. Top 2 inches contain black oily material on surface only, with green yellow fluorescence in CC14. There is also purple fluorescence (compressor oil). Yellow fluorescence dissolving in carbon tetrachloride often wide near small calcite veins. Yellow fluorescence steamers flowed from freshly fractured surfaces. Brassy yellow fluorescence not dissolving is probably due to a mineral. Light green fluorescent brachiopod valves present.
88"	alternating interbeds about 2 inches thick of very hard black brittle calcareous shale and light to dark grey bands argillaceous limestone. Strong oil smell on fresh fractures. Also thin (¼-inch)