COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PETROLEUM SEARCH SUBSIDY ACTS

Publication No. 16

BARLEE No. 1 WELL COMPLETION REPORT

OF

WEST AUSTRALIAN PETROLEUM PTY. LIMITED

**Issued under the Authority of Senator the Hon. W. H. Spooner,
Minister for National Development**

1961

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

Minister: SENATOR THE HON. W. H. SPOONER, M.M.

Secretary: H. G. RAGGATT, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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This Report was prepared for publication in the Geological Section

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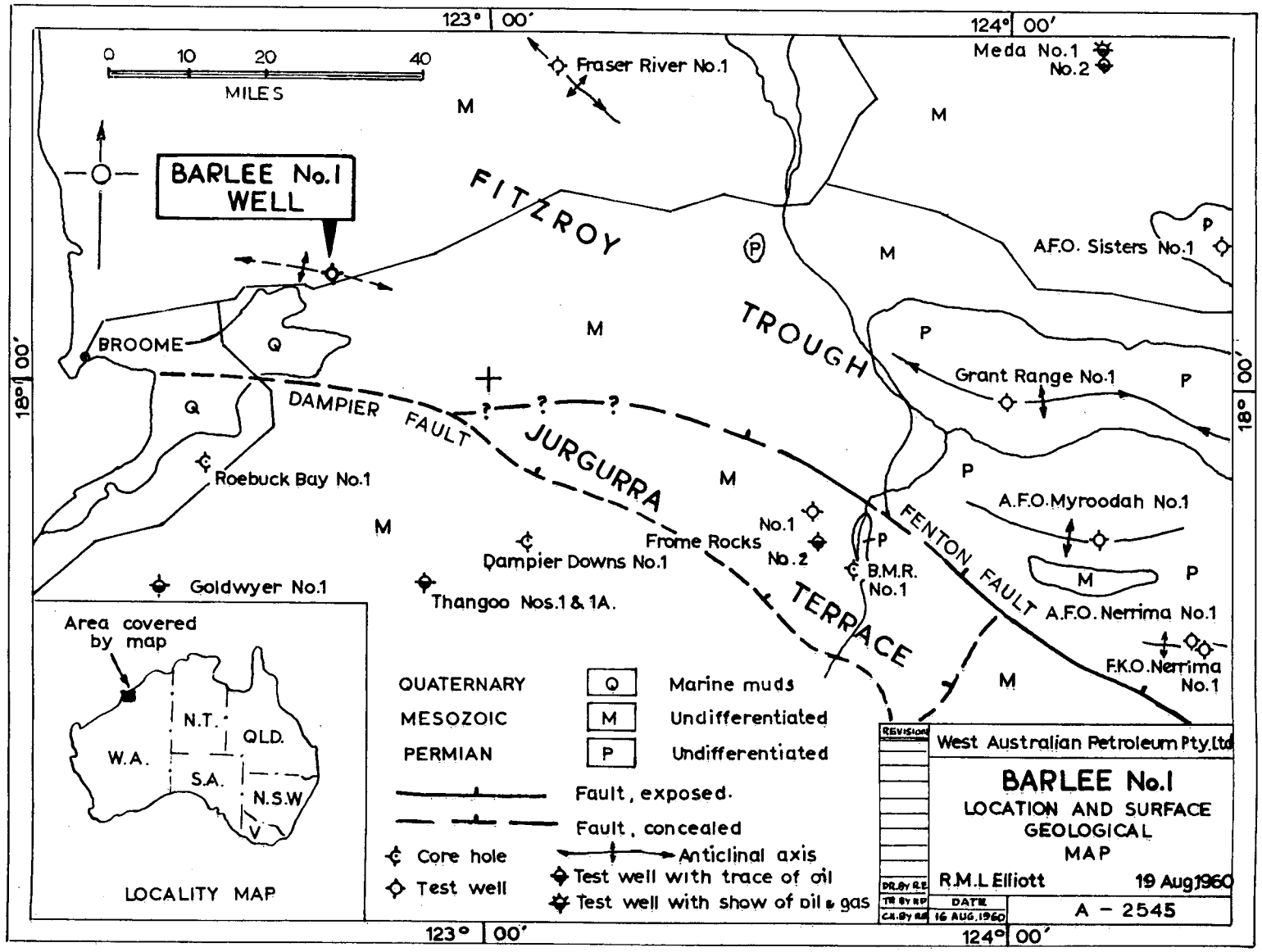
123° 00′
124° 00′
18° 00′
0 10 20 40
MILES
BARLEE No.1 WELL
Fraser River No.1
Meda No.1
No.2
FITZROY TROUGH
A.F.O. Sisters No.1
BROOME
Grant Range No.1
DAMPIER FAULT
Roebuck Bay No.1
JURGURRA TERRACE
A.F.O.Myroodah No.1
Frome Rocks No.1
No.2
Dampier Downs No.1
B.M.R. No.1
FENTON FAULT
A.F.O.Nerrima No.1
F.K.O.Nerrima No.1
Goldwyer No.1
Thangoo Nos.1 & 1A.
Area covered by map
N.T.
QLD.
W.A.
S.A.
N.S.W
V
LOCALITY MAP
QUATERNARY Q Marine muds
MESOZOIC M Undifferentiated
PERMIAN P Undifferentiated
Fault, exposed.
Fault, concealed
Core hole
Test well
Anticlinal axis
Test well with trace of oil
Test well with show of oil & gas
REVISIONS
DR.By R.E
TR By R.P
CH.By R.M
DATE 16 AUG.1960
West Australian Petroleum Pty.Ltd
BARLEE No.1
LOCATION AND SURFACE GEOLOGICAL MAP
R.M.L Elliott 19 Aug 1960
A – 2545

PLATE 1

SUMMARY

The Barlee No. 1 Well was drilled with WAPET's National 100 rig to the total depth of 8101 feet.

Below a thin cover of the surface sand, 1562 feet of Mesozoic sediments were encountered, and drilled to the depth of 1594 feet. These sediments are represented by the Broome Sandstone (Lower Cretaceous) and Jurassic rocks, consisting of Jarlemai Siltstone, Alexander Formation, and Wallal Sandstone. The Jarlemai Siltstone interval which is 850 feet thick, is the thickest section of this formation which has been drilled in the Canning Basin.

Unconformably below Mesozoic sediments, a uniform section of Carboniferous rocks was encountered and drilled to the total depth. All 6507 feet of the Carboniferous section are included in the Anderson Formation, to which an Upper Carboniferous age is tentatively assigned. In the lower part of the formation (7825 - 7856 feet) an intrusive body of dolerite was encountered. Some induration was observed in rocks adjacent to the intrusion. The well was abandoned in moderately porous sandstone beds of the Anderson Formation.

Average dips of 20^{o} were observed in cores and recorded by the dipmeter survey in the Carboniferous section. The dipmeter survey shows that the well was located on the northern flank of the Barlee Anticline.

Some very slight shows of gas were present in the sandstone beds of the Anderson Formation. Below 5600 feet some sandstone beds contained impregnations of black, rubbery bituminous material - very probably oil residue. No signs of live oil were observed in the well.

The drilling results indicate that the Barlee No. 1 Well (like Fraser River No. 1) is located in the deep Fitzroy Trough on a structure originated by an igneous intrusion. The prospective beds of Ordovician, Devonian, and Lower Carboniferous rocks are buried under the thick cover of the unprospective Upper Carboniferous sediments and probably are intruded by igneous rocks.

It seems likely that the sediments of the Fitzroy Trough in the Barlee area extend south as far as the Dampier Fault; thus the Dampier Fault in the western part of the Canning Basin may replace the Fenton Fault, which dies out before reaching the Dampier Land area. The concept of the Jurgurra Terrace still remains valid, but only for the eastern part as shown on Plate No. 1.

INTRODUCTION

The Barlee No. 1 Well was drilled with the objective of evaluating the petroleum potential and stratigraphy of the Barlee Anticline.

The Barlee Anticline was located solely by geophysical methods. Before drilling, it was interpreted as an anticline on the northern edge of the Jurgurra Terrace, containing folded prospective Ordovician and Devonian sediments at shallow depth. The thickness of the sub-horizontal Mesozoic formations was estimated to be about 1900 feet. The earlier

interpretation of the structure as being intruded by salt was rejected after a detailed gravity survey. The previous possible interpretation of thick Permian and Upper Carboniferous strata on the northern side of the Dampier Fault was set aside in the proposal to drill Barlee No. 1, and the more optimistic interpretation mentioned above was put forward. The well proved the presence of thick unprospective Upper Carboniferous north of the Dampier Fault and established the presence of a strong angular unconformity between the Upper Carboniferous and the Lower Permian. Perhaps much of this structure in the Upper Carboniferous is local, induced by an igneous intrusion beneath the Barlee area.

WELL HISTORY

GENERAL DATA, by T.H. Carter*

Well name and number:	Barlee No. 1
Location:	17° 48' 25" S. Latitude 122° 42' 40" E. Longitude 2,761,050 yards North 598,450 yards East (Co-ordinates)
Tenement holder:	West Australian Petroleum Pty Ltd, 251 Adelaide Terrace, Perth, W.A.
Details of tenement:	Licence to Prospect No. 67H.
District:	Kimberley
Total depth:	8101 feet
Date drilling commenced:	12th April 1960
Date drilling completed:	25th July 1960
Date well suspended:	29th July 1960
Date rig released:	29th July 1960
Drilling time in days:	105
Elevation (M.S.L.):	Ground 62 feet; Derrick Floor 74 feet
Status:	Suspended at 8101 feet. Plugs at 1985 feet and 2310 feet. 1/4" M.S. plate welded on 10 3/4" casing and well marker affixed.

* West Australian Petroleum Pty Ltd.

DRILLING DATA, by T.H. Carter*

Drilling contractor:	Oil Drilling & Exploration (W.A.) Pty Ltd, 237 Adelaide Terrace, Perth, Western Australia.	
Drilling plant:		
Make:	National	
Type:	100	
Rated capacity with $4\frac{1}{2}$" drill pipe:	10,000 feet	
Motor:	Paxman Model 12 RPH Series II full diesel industrial 400 HP at 1200 RPM. (3 compounded to hoist and/or pumps).	
Mast:		
Make:	L.C. Moore	
Type:	142 – foot cantilever	
Rated capacity:	830,000 lbs. gross.	
Pumps:		
Make:	National (Two)	
Type:	C-350	
Size:	7 3/4" x 18"	
Motor:	Paxman Model 12 RPH Series II 400 BHP at 1200 RPM (3 compounded to hoist and/or pumps).	
and:		
Make:	National (One)	
Type:	C-100	
Size:	6 1/4" x 10"	
Motor:	G.M. 671 135 BHP at 1500 RPM	
Blowout preventor equipment:		
Make:	Shaffer	Hydril
Size:	10"	10"
Series:	900	900
Hole sizes and depths:	20" to	132'
	13 3/4" to	2325'
	9 7/8" to	8101'
Casing and liner details:		
Size:	16"	10 3/4"
Weight lb/ft:	65	40.5
Grade:	H40	J55
Range:	2	2
Setting depth:	74'	2321'

* West Australian Petroleum Pty Ltd.

Casing and liner cementing details:

Size:	16"	10 3/4"
Setting depth:	74'	2321'
Cement used (sacks):	120	500
Cemented to:	Surface	650'
Method used:	Plug	Plug

Drilling fluid:

Type: High pH freshwater, low weight, shear and filtrate, bentonite/starch/C.M.C. treated. Treatment caustic and myrtan.

Days	Weight (lbs/ft^3)	Viscosity (Secs. Marsh)	Filtrate (Standard)	Cake (inches)	Sand %	pH	Shear ($lbs/100\ ft^3$)
3-9	76	42	9.5	2/32	2.1	11.2	0-0
10-16	73	43	9.3	2/32	2.1	11.4	0-0
17-23	73	42	7.0	2/32	1.3	10.5	0-0
24-30	76	44	5.7	2/32	1.3	11.0	0-0
31-37	76	49	5.0	2/32	0.75	11.0	0-0
38-44	76	46	5.1	2/32	1.0	11.0	0-0
45-51	75	50	5.6	2/32	0.8	11.5	0-0
52-58	73	47	5.6	2/32	0.5	11.5	0-0
59-65	75	50	6.2	2/32	1.2	11.0	0-0
66-72	75	50	6.7	2/32	1.7	11.5	0-0
73-79	76	51	6.8	2/32	1.4	11.5	0-0
80-86	75	50	5.8	2/32	1.3	11.0	0-0
87-93	75	47	5.8	2/32	1.5	11.0	0-0
94-100	76	47	5.5	2/32	1.2	11.5	0-0
100-105	76	46	5.7	2/32	1.2	11.5	0-0

Water Supply: Developed for use on Barlee No. 1, three freshwater wells yielding a total of 720 bbl. per day.

Perforation & shooting: Nil.

Plugging back: 65 sacks across 2310 feet
110 sacks across 1985 feet.

Fishing operations:

(i) Lost 9 7/8" bit, bit sub and 10 drill collars at 3326 feet. Length of fish 314 feet. Recovered fish with American DV overshot with 6 3/4" slips.

(ii) Lost 9 7/8" bit, bit sub and 5 drill collars at 4068 feet. Length of fish 161 feet. Recovered fish with Bowen overshot and 6 3/4" grapple.

(iii) Twisted off drill-pipe one foot above tool-joint leaving 9 7/8" bit, bit sub and 13 drill collars, plus

one single and one foot stub of 4½" drill-pipe in hole at 5320 feet. Engaged fish with Bowen 7 3/8" overshot, backed off at top of drill collars with Schlumberger string shot, washed over fish and screwed in top of fish with B.R. safety joint and McCullough rotary jar. Worked loose and recovered 100% fish.

(iv) Lost 9 7/8" bit, bit sub, and 8 drill collars at 6719 feet. Length of fish 246 feet. Recovered fish with American overshot, B.R. safety joint, and McCullough rotary jar.

(v) Lost 9 7/8" bit, bit sub, and 16 drill collars at 7632 feet. Length of fish 486 feet. Recovered fish with American overshot, B.R. safety joint, and McCullough rotary jar.

Sidetracked hole: Nil.

LOGGING AND TESTING, by V. Pudovskis*

Ditch samples. Ditch samples were collected at 10 foot intervals from the surface to total depth. While coring, the interval was reduced to five feet.

Washed sample cuts were made for Bureau of Mineral Resources, Western Australian Mines Department and WAPET.

Bulk ditch samples and WAPET's cuts of washed samples have been stored in WAPET's Norma Road Corehouse, Melville.

Coring. The original coring programme is set out below:

"Cores will be taken immediately following shows of hydrocarbons. The first core should be cut at the top of the pre-Mesozoic at a predicted depth of 1900 feet (± 50 feet). Cores for stratigraphic information and porosity shall be taken following the first core at intervals not exceeding 400 feet in a predominantly sandstone-siltstone lithology and not exceeding 250 feet in a carbonate sequence.

When selecting coring points, the following should be considered:

Cores should be cut at all significant formation changes, whether indicated by change of lithology in the cuttings or by drilling breaks.

Cores should be considered at signs of fossils in the cuttings in parts of the section whose age has not been established or where additional palaeontological information is required.

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* West Australian Petroleum Pty Ltd.

Cores should be considered at all signs of porosity in the pre-Mesozoic (either in the cuttings, or zones of lost circulation) where the presence of porosity can be considered significant in relation to hydrocarbon accumulation. Drilling breaks are an important indication of porosity in a carbonate sequence.

Cores may also be considered when hole conditions conceal the type of sediment being penetrated in a prospective portion of the section.

Diamond coreheads should be used when the conventional Hughes Type "J" core bits fail to give adequate recovery in an important part of the hole.

The Schlumberger sidewall sample taker is available for use at the wellsite geologist's discretion."

The majority of cores were cut as routine cores, approximately at 400-foot intervals. The exceptions were:

Core No.	Reason for coring
2	Waiting on Schlumberger Logging.
7 & 8	Gas show.
17	Signs of intrusive rock.
19	Fluorescent cuttings.
20	Bottom hole core.

Twenty cores were cut, using Hughes J Type core barrel and hard formation coreheads. A total of 192 feet of formation was cored and 163 feet (85%) recovered. Cores and their specific gravities are listed in Appendix 4. Fully representative cuts of cores were reserved for Bureau of Mineral Resources and Western Australian Mines Department. The cores are stored in Norma Road Warehouse, Melville.

Side-wall cores. Besides conventional cores, 11 side-wall cores were recovered by Schlumberger chronological sample taker.

Electrical logging. The following Schlumberger logs were run: Electric Log, Gamma Ray-Neutron Log, Section Gauge, Temperature Log and Dipmeter. A complete list of Schlumberger logs is given in Appendix 5.

Drilling rate, oil and gas log. Five-foot drilling time was recorded by drillers during drilling and one-foot drilling time while coring. These drilling times have been converted into feet-per-hour drilling rates for each five-foot interval and plotted on the Drilling Rate, Oil and Gas Log (Plate 5). Besides the drilling rate this log contains continuous graphic records of JW gas detector readings and lithology (percentage log).

Formation tests. No formation tests were run.

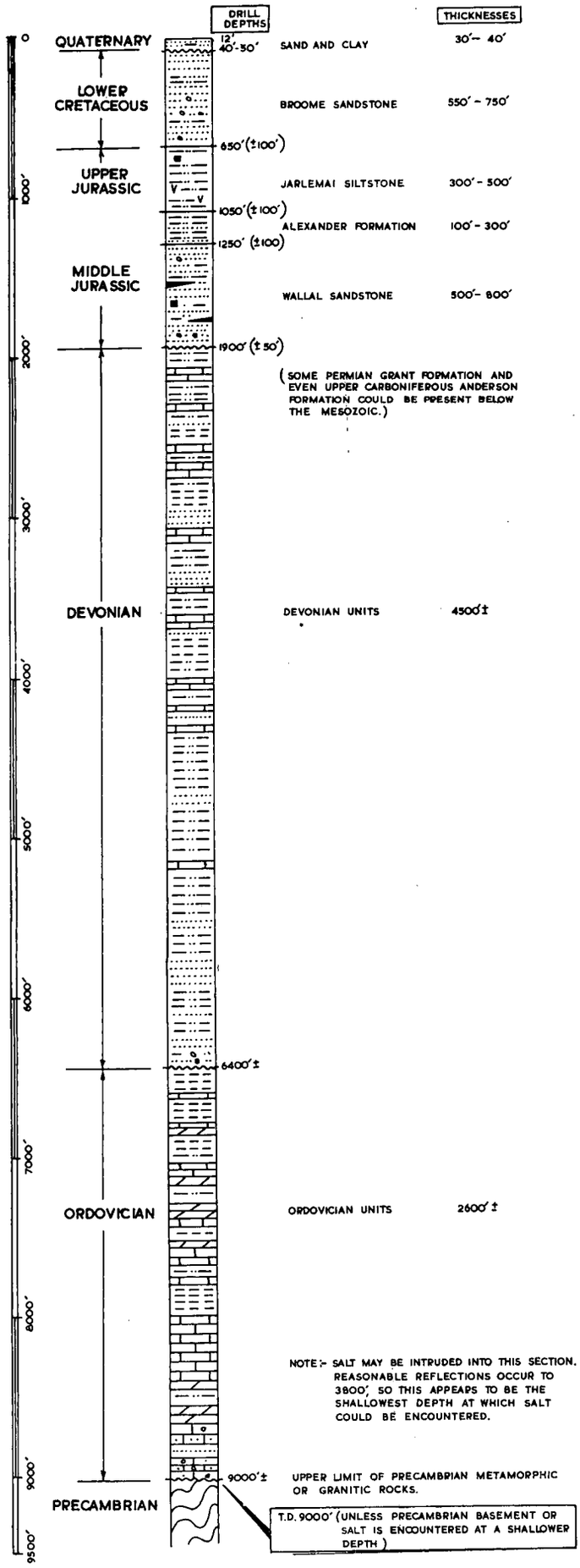
Deviation surveys. 91 drift readings were recorded, using an Eastman Drift Indicator. The maximum deviation of $4\ 3/4^{o}$ was recorded in the lower part of the hole. The deviation records are listed in Appendix 6.

PREDICTED SECTION

BARLEE No.1 WELL

LOCATED AT SHOTPOINT 13
BROOME EAST LINE 'Q'

SURFACE ELEVATION +62'
D.F. ELEVATION +74'
NATIONAL 100



NOTE:- SALT MAY BE INTRUDED INTO THIS SECTION. REASONABLE REFLECTIONS OCCUR TO 3800', SO THIS APPEARS TO BE THE SHALLOWEST DEPTH AT WHICH SALT COULD BE ENCOUNTERED.

LITHOLOGIC UNITS

- SANDSTONE
- SILTSTONE
- SHALE
- CONGLOMERATE
- LIMESTONE
- DOLOMITE
- PYRITE
- GLAUCONITE
- CARBONACEOUS
- METAMORPHIC COMPLEX.

WEST AUSTRALIAN PETROLEUM PTY. LIMITED

CANNING BASIN
GRAPHIC LOG
RECOMMENDED
BARLEE No.1 WELL

J.R.H. McWHAE 6 JAN. 1960

DR. BY J.R.H.
TR. BY N.M.J.
CK. BY J.R.H.
DATE 6 JAN. 1960

C – 2547

PLATE 2

Temperature surveys. A temperature log was run to check the top of the cement behind the 10 3/4" casing. For details see Schlumberger Temperature Log.

GEOLOGY

by

V. Pudovskis*

SUMMARY OF PREVIOUS WORK, (by R.M.L. Elliot*)

The country surrounding Barlee No. 1 has been examined extensively by geological and geophysical methods. The Bureau of Mineral Resources has conducted a regional geological survey and a limited amount of seismic reflection work (Vale & Williams, 1955) in the area. This reflection work suggested the presence of folding in Palaeozoic rocks which lie unconformably beneath sub-horizontal Mesozoic sediments.

West Australian Petroleum has conducted regional geological, gravity, aerial magnetometer, and refraction seismograph surveys in the Barlee area, and detailed reflection seismograph and gravity surveys of the anticline itself. The gravity and magnetometer surveys indicated the presence of a large regional high in the vicinity of Barlee No. 1 and this was shown to be an anticlinal fold by the initial reflection seismograph line shot across the gravity and magnetometer anomalies.

The Barlee Anticline has no surface expression and was defined and located entirely by geophysical methods. The location of Barlee No. 1 was chosen after a long programme of regional refraction seismograph and regional and detailed reflection seismograph work was completed.

Owing to the presence of intruded salt in the structure drilled by Frome Rocks No. 1 a detailed gravity survey was carried out at Barlee No. 1 to see if the Barlee Anticline was intruded by salt. This gravity survey (Gravity Meter Exploration Company, 1960) indicated that the Barlee Anticline was not intruded by salt at Barlee No. 1. As a result of this final gravity survey it was decided to drill Barlee No. 1.

The subsurface geology of the area is known from the Broome town bores, B.M.R. No. 1, and Frome Rocks Nos. 1 and 2 which are located in the Jurgurra Terrace; Fraser River No. 1 and Grant Range No. 1 which are located in the Fitzroy Trough; and Roebuck Bay No. 1, Thangoo Nos. 1 and 1A, Dampier Downs No. 1, and Goldwyer No. 1, which are located in the South Canning Basin. The positions of these are shown on Plate 1.

It was possible to predict the Mesozoic section at Barlee No. 1 with some certainty because of the nearness of well control at Broome Town Bore No. 2 and because the Mesozoic transgresses the Dampier and Fenton Faults and covers the Canning Basin in a large wedge of sub-horizontal sediments which thickens to the west. Despite the information from all these wells and the reflection and refraction seismograph surveys it was not possible to make accurate predictions of the Palaeozoic section because of the difficulties in correlating across the two major faults, the Fenton and Dampier Faults. It was expected that the Palaeozoic section in Barlee No. 1 would include the Upper Devonian, which showed traces of oil in Frome Rocks No. 2, and the Ordovician, which had traces of oil in Goldwyer No. 1 and Thangoo Nos. 1 and 1A.

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* West Australian Petroleum Pty Ltd.

Prior to drilling, the Barlee Anticline was considered to be a major fold located on the northern edge of Jurgurra Terrace in which folded Lower Palaeozoic rocks would be present at shallow depth and igneous intrusion or metamorphic basement would be at less than -10,000 feet.

STRATIGRAPHY

The age of the Mesozoic section is based on data from other Kimberley wells. Two palynological reports and one preliminary palaeontological report on the Carboniferous were available at the time of writing.

The formation tops were established on lithology, and Electrical and Gamma Ray-Neutron Log interpretation.

The following formations were encountered:

Age	Formation	Depth D.F.	Depth Subsea	Thickness
Quaternary	Surface sand	12'	+ 62'	20'
	----------UNCONFORMITY----------			
Cretaceous - Lower	Broome Sandstone	32'	+42'	111'
	----------DISCONFORMITY----------			
Jurassic Upper	Jarlemai Siltstone	143'	- 69'	850'
Jurassic Upper	Alexander Formation	993'	-919'	69'
Jurassic Middle to Upper	Wallal Sandstone	1062'	-988'	532'
	----------UNCONFORMITY----------			
Carboniferous - Upper	Anderson Formation	1594'	-1520'	6507'+
	Total Depth	8101'	-8027'	

The details of these formations are set out graphically on the composite log in Plate 4. The predicted section prior to drilling is shown on the graphic log in Plate 2.

Quaternary

Surface sand 12' - 32'

Quaternary sediments consist of red, fine-grained, clayey sand, predominantly of aeolian origin. The surface sand unconformably overlies the Broome Sandstone.

Cretaceous

Broome Sandstone 32' - 143' (Lower Cretaceous)

The Broome Sandstone is represented by poorly sorted, fine to coarse-grained, orange, brown, and white sandstone. Quartz grains are rounded to sub-angular. Cement mostly consists of white and pink clay. In parts the amount of clay increases and the rock grades into sandy clay. In the lower part the sandstone contains some hard, reddish-purple, very ferruginous beds, occasionally showing oolitic texture. The basal part of the formation consists of very coarse sandstone grading into very fine conglomerate. The lithology indicates a littoral origin for the sandstone. No fossils were observed in the formation. The Broome Sandstone disconformably overlies the Jarlemai Siltstone.

Jurassic

Jarlemai Siltstone 143' - 993' (Upper Jurassic)

The interval represents the thickest section of Jarlemai Siltstone yet encountered in the Canning Basin. It consists of sandy, fossiliferous siltstone, which conformably (or with slight disconformity?) overlies the Alexander Formation. The lower part of the formation is probably transitional into the Alexander Formation. The middle part represents the maximum limit of the Jurassic transgression. The upper part of the section, however, indicates the beginning of marine regression, and probably temporary erosion, before it was covered with sediments in Lower Cretaceous time.

The following lithological units are indicated by lithological and electrical logs:

143' - 170'	- Sandstone:	red, brown and yellow, fine-grained, clayey.
170' - 305'	- Claystone:	dark red-brown, purple and yellow, sandy and silty, interbedded with
	Sandstone:	as above, with some light grey, coarse-grained, very silty beds.

This sequence represents a weathered top of the formation, thus indicating a disconformity between the Jarlemai Siltstone and the Broome Sandstone. The unweathered formation appears in the lower 20 feet of this interval, and is grey coloured and pyritic.

305' - 993'	- Siltstone:	medium to dark grey, brownish grey and light brown, clayey and sandy, containing scattered, unsorted sand grains from fine to very coarse size. In parts the quantity of sand grains increases up to 40% of the rock.

In general the quantity of sand grains increases in the lower part of the formation.

The formation is micaceous and pyritic, in parts very pyritic, containing numerous irregular and tubular pyrite nodules. The middle part of the interval is calcareous, and from

530 feet to 600 feet light grey-brown calcareous to very calcareous beds are common. The siltstone is predominantly friable, but light-brown beds are moderately hard.

Fossils — belemnites, foraminifera, pelecypods and gastropods — are present throughout the section, but all these forms are represented by a very few species.

Alexander Formation 993' - 1062' (Upper Jurassic)

The Alexander Formation represents a transition from the paralic Wallal Sandstone to the marine Jarlemai Siltstone. The boundaries of the formation are well defined by lithological change and also by Electrical and Gamma Ray-Neutron Logs. The upper boundary is chosen on a break of the resistivity curve, and the lower boundary is chosen on the S.P. curve. The formation had been recognised in all other wells where the Jarlemai-Wallal section was present. It is accepted here that the formation represents the Alexander Formation as seen in the type section. However, at present there are not enough data for good correlation between subsurface sections and outcrops.

The formation consists of interbedded sandstone, medium to coarse grained, probably silty, in parts pyritic, glauconitic, containing dark green glauconite grains, with predominantly clear and occasionally greenish coloured, sub- to well-rounded quartz grains; and siltstone, grey and brown, glauconitic to very glauconitic, in parts containing very fine sand grains. Some pyritized wood fragments were observed in the lower part of the formation. The fauna is represented predominantly by belemnites and some pelecypods, indicating the marine character of the unit.

The sudden change from non-glauconitic rocks in the Jarlemai Siltstone to richly glauconitic in the Alexander Formation may indicate a local disconformity between the two formations. This possible disconformity is also indicated by a sudden increase of resistivity below the contact of the two formations.

The Gamma Ray curve behaves unusually opposite the beds of the unit. The Electrical Log and lithological samples indicate that the section consists predominantly of sandstones; but the Gamma Ray Log shows high radioactivity for the same section, as though the formation were of shale: possibly the source of high radioactivity is glauconite and mica. The character of the Gamma Ray curve opposite this unit had been observed also in other wells, even in those where glauconite is not present.

Wallal Sandstone 1062' - 1594' (Middle to Upper Jurassic)

The Wallal Sandstone is represented by sandstones of the paralic type. Two lithological units are recognised in the section.

Unit 'A' (1062 feet - 1201 feet) is well defined on Electrical and Gamma Ray-Neutron logs. Its upper boundary is also recognised by lithological change. It consists of coarse-grained sandstone, in parts grading into conglomerate, containing clear, milky, bluish and greenish quartz grains, and pebbles of quartzite and jasper. Interbedded with sandstone are some beds of grey-brown sandy siltstone. The bottom 30 feet of the unit grade into unit B - typical medium to coarse-grained Wallal Sandstone, consisting of clear and slightly brownish quartz grains. The section is fairly carbonaceous, containing coal fragments and pyritized wood.

Fragments of belemnites and grains of glauconite were present in ditch samples from this interval, but they may well represent caving from the Alexander Formation. However foraminifera were observed in cores from this section in some other wells in the Canning Basin. It is believed that the unit probably represents the Jurgurra Sandstone as seen in the outcrops.

Unit 'B' (1201 feet - 1594 feet) consists of a uniform sandstone section of paralic type. The sandstone is medium to coarse-grained, sub-angular to well-rounded, and friable, and contains lenses of black coal. Electrical and Gamma Ray Logs indicate inter-bedded siltstone beds at the top of the unit, but no siltstone appeared in the ditch samples. No fossils were observed in samples.

The formation represents the first stage of the sedimentation cycle, which started in Middle Jurassic time and was completed in Lower Cretaceous (Broome Sandstone). The Wallal Sandstone overlies the Anderson Formation with an angular unconformity which is shown on the seismic cross-section.

Carboniferous

Anderson Formation 1594' - 8101' (T.D.) (Upper Carboniferous)

More than 6500 feet of Carboniferous sediments were penetrated in the Barlee No. 1 Well. In general, this Carboniferous section is very uniform and consists predominantly of carbonaceous sandstones with some beds of siltstone, claystone and shale. In previous exploratory wells in the Canning Basin, all this sequence had been included in the Anderson Formation. As yet, no attempt has been made to subdivide this thick unit.

Palaeontological data for Barlee No. 1 Well at present are poor, and the age of the whole unit can be established only as Carboniferous. In the Grant Range No. 1 Well the age of the Anderson Formation was established as Westphalian to possibly lower Stephanian. However, a palynological report (Balme, Appendix 2) on cores from Barlee No. 1 suggests Lower Carboniferous affinities. Although the Anderson Formation is usually referred to as Upper Carboniferous, it appears that the unit was deposited from the later part of the Lower Carboniferous into the Upper Carboniferous, but excluding the uppermost part as there is little evidence of Stephanian (or Uralian) fossils.

The Carboniferous section in the well was sub-divided by using lithological and electrical log data and the following four lithological units are proposed:

Unit 'A' (1594 feet - 2257 feet) is well defined on lithological and electrical logs. It consists of slightly cemented sandstone, white and light grey-brown, fine to very fine-grained, moderately to well sorted, porous, carbonaceous and micaceous, containing white and green mica; quartz grains are mostly sub-angular, and in parts show secondary recrystallization; contains some pink and green coloured quartz grains, some feldspar, and green chloritic grains. Occasionally very fine sandstone lenses grade into coarse, thinly bedded green-grey siltstone. In the lower part of the unit, coal lenses are very common.

On the electrical log, the unit appears as a very uniform sandstone section with an average apparent resistivity of about 8 ohms. There is no change in the S.P. curve from the top of the Wallal Sandstone to the bottom of this unit.

On Electrical and Gamma Ray-Neutron logs this unit resembles very much the upper part of the sandstone section, which is present in the Fraser River No. 1 Well from 718 feet to 1347 feet between the Wallal Sandstone and Grant Formation. However, on the palynological evidence, Balme considers that the unit in Fraser River is probably of Mesozoic age, whereas the microflora of the unit in Barlee No. 1 Well indicates a Carboniferous age (Appendix 2). Assuming that this unit is a part of the Anderson Formation, it is evident from electrical logs that it was not present in any of the previously drilled wells in the Canning Basin.

Unit 'B' (2257 feet - 4065 feet) consists of interbedded and interlaminated sandstone, siltstone, shale, and minor dolomite. The sandstone is predominantly light greenish-grey and light grey, fine to very fine-grained, carbonaceous, micaceous, with white, green and brown mica; it contains siliceous cement, and is moderately porous, thinly bedded and current-bedded. Many quartz grains are recrystallized and some are reddish and green coloured, with some green chloritic grains.

The siltstone is green-grey and dark grey, micaceous, pyritic, containing carbonized plant remains. In many places the siltstone is thinly interlaminated with sandstone, as above.

The shale is dark green-grey and light green, micaceous, grading into carbonaceous claystone. It contains a fauna of brachiopods, pelecypods, conodonts, and ostracods (?Cryptophyllus (Jones in Appendix 2)).

The dolomite forms thin beds and lenses in the silty and shaly section. The rock is dark brown-grey in the upper part of the section, and pink, cream, and medium grey-brown in the lower part. It is fine to coarse crystalline, silty and sandy, and in parts contains crinoids and bryozoa.

The unit has a pronounced marine character. In the lower part of the sequence, the size of the sand grains increases, and coarse-grained sandstone beds appear, containing some very fine pebbles of quartzite.

The upper boundary of the formation is well shown by a sharp break on the S.P. curve.

A detailed correlation of the Anderson Formation in Grant Range 1 and Barlee 1 wells indicates that at least a disconformity is present between Unit 'A' and Unit 'B'. However, if Unit 'A' is of Mesozoic age (see discussion above), Unit 'B' is the youngest Carboniferous section in Barlee 1 and its upper boundary represents an unconformity and the upper boundary of Unit 'A' is then a conformable contact.

Unit 'C' (4065 feet - 6430 feet) is represented by a very uniform section of sandstone, fine to coarse-grained, poorly to moderately sorted, carbonaceous. The sandstone is moderately porous, but some beds, containing hard, siliceous cement, have very low porosity. Occasionally these beds grade into quartzite. Quartz grains mostly show secondary recrystallization; green, soft, chloritic grains are scattered throughout the formation; carbonaceous partings are common. The sandstone is massive to crudely bedded; electrical logs show some beds several hundred feet thick.

This sandstone section contains some beds of green-grey, and medium to dark

grey, micaceous siltstone, and occasionally claystone. The thickness of these beds seldom exceeds 10 feet. Cores show that siltstone beds are very distorted and brecciated, in parts forming breccia, consisting of lumps of siltstone, claystone and sandstone. Distortions and brecciations are probably caused by folding (adjustment along the thin incompetent siltstone and claystone beds), and partly by slumping during deposition.

No fossils other than indeterminate plant remains were observed throughout the section.

The top of the unit contains beds of mottled brownish-red and green-grey siltstone, which in parts grade into shale and claystone. The Anderson Formation in other wells contains similar multicoloured siltstone and claystone beds. It seems that the appearance of mottled, multi-coloured rocks indicates some slight disconformity within the Anderson Formation. This disconformity is also suggested by the position of markers on the electrical logs of this and other wells that penetrated the formation.

A little gas has been observed near the top of the section. Gas also was recorded on a J-W gas detector while the middle part of the unit (5170 feet - 5300 feet) was being drilled; however, the nature of the gas from that interval is uncertain.

Below 5600 feet some black bituminous material has been observed in sandstone beds.

Unit 'D' (6430 feet - 8101 feet (T.D.)). The upper boundary is established on the electrical log (resistivity curve).

The lithology of the unit in general resembles that of Unit C. However, the formation is well bedded, in parts thinly laminated, and bedding planes are smooth and non-distorted. Sandstone is predominant; it is mostly fine-grained, moderately to well sorted, with subordinate moderately to poorly sorted, fine to coarse sandstone; carbonaceous and micaceous partings are common. Siltstone and claystone beds from one to ten feet thick are evenly distributed throughout the sandstone section. The beds are medium to dark grey, containing some dark brown-grey carbonaceous lenses. A greenish colour in samples was observed only at the top of the unit. Some thin black coal beds are present in the lower part of the sequence; a little gas, which was observed in the formation from 7790 feet to 7950 feet, seems to have originated from them. At the total depth of the hole, the formation consisted of sandstone, light grey, fine grained, slightly carbonaceous and pyritic, moderately porous.

No fossils were observed throughout the section.

Strong greenish-blue and yellow fluorescence was observed in sandstone from 7970 feet to 8010 feet. Very probably fluorescence is originated by some carbonate mineral, and does not indicate presence of hydrocarbons.

Dolerite Intrusion

An igneous rock intrudes in the lower part of the Anderson Formation: from 7825 feet to 7856 feet, dark grey to black dolerite was drilled. Dr. J. Glover suggests that this dolerite is co-magmatic with the igneous rocks which were encountered in the Fraser

River No. 1 Well (Appendix 1). Siltstone and sandstone adjacent to the intrusion show some signs of induration. A very small intrusion of some unidentified igneous rock was also penetrated from 7550 feet to 7555 feet.

STRUCTURE

Reliable dips from 10^{o} to 28^{o} were measured in cores recovered from the Carboniferous section, giving an average dip of about 20^{o}. This average dip is confirmed by Schlumberger's dipmeter survey (see table). The dipmeter survey also shows that the Carboniferous sequence is dipping NNE. Thus it is evident that the Barlee No. 1 Well is situated on the north-easterly flank of the Barlee Anticline.

TABLE OF OBSERVED DIPS

Depth (feet)	Dip (degrees)	Direction	Reliability	Source of information
2292-2307	16	-	reliable	core
2308-2325	14	-	reliable	core
3110-3140	possibly small	-	unreliable	dipmeter
3151-3168	9	-	reliable	core
3830-3860	12	191^{o}	direction unreliable	dipmeter
3962-3974	45-84	-	unreliable	core
4068-4071	17-25	-	reliable	core
4630-4660	21	013^{o}	reliable	dipmeter
5090-5120	23	040^{o}	reliable	dipmeter
5090-5120	17	283^{o}	direction unreliable	dipmeter
6505-6514	10-20	-	reliable	core
6914-6921	22-28	-	reliable	core
7085-7105	15	008^{o}	reliable	dipmeter
7354-7363	22	-	reliable	core
7558-7560	20-22	-	reliable	core
7942-7950	10-20	-	reliable	core
7995-7999	10-20	-	unreliable	core
8097-8101	12-20	-	unreliable	core

Note: Almost vertical dips observed in core No. 6 (3962 feet - 3974 feet), which were previously interpreted as indicating the proximity of a fault, were very probably formed by folding of incompetent siltstone beds (see Anderson Formation - Unit C).

The very local development of a large structure and the presence of dolerite intrusion in the lower part of the Carboniferous section indicate that the Barlee structure was probably originated by an intrusion of a dolerite laccolith. This is illustrated in Plate 3, where the geological cross-section of the area is given, as it was interpreted before and after drilling. The drilling of the test well eliminated the possibility of the Fenton Fault running between the Barlee No. 1 and Fraser River No. 1 Wells; Barlee No. 1 therefore, is situated in the same tectonic province of the Fitzroy Trough as Fraser River No. 1.

No cores were cut and no dipmeter run in the Jurassic section. However, seismic profiles indicate that sub-horizontal Jurassic beds overlie Carboniferous sediments with angular unconformity. Thus the dolerite intrusion, and therefore the Barlee structure, are older than Middle Jurassic, and may well be late Carboniferous, for the following reasons:

1. Good evidence of a strong angular unconformity between the Permian and Upper Carboniferous can be seen on the northern flank of the structure on reflection line Broome East Line "A".

2. Strong normal faulting occurred during the deposition of the Anderson Formation, and culminated before the deposition of the Grant Formation (Lower Permian). During this faulting, which involved movements of more than 6500 feet along the Dampier Fault, it is easy to conceive that basic magma was intruded in the Upper Carboniferous strata.

3. These gabbro-dolerite rocks have not been found in sediments younger than Carboniferous.

4. The leucite lamproite intrusives, which intrude all rocks older than the Middle Jurassic and which were probably emplaced during the main period of folding of the Fitzroy Trough sediments in the lower Mesozoic, are of different magmatic origin (Professor R.T. Prider, pers. comm.).

RELEVANCE TO OCCURRENCE OF PETROLEUM

No signs of hydrocarbons were observed in the Mesozoic section.

Occurrence of Gas

In the Anderson Formation the J-W gas analyser recorded gas in the following three intervals:

3980 feet to about 4400 feet: a maximum reading of 75 units on the 100 unit scale was observed; readings on the J-W gas analyser were practically unchanged when a reading was taken at 1.5 volts, indicating that the recorded gas consisted of hydrocarbons higher than methane.

5170 feet to 5350 feet: the analyser gave a maximum reading of 54 units at 2.1 volts and 41 units at 1.3 volts. However, W. Shields suggests that the positive readings for this section may be caused by some products of starch fermentation (alcohols) in the drilling mud.

7790 feet to 8000 feet: the maximum reading of 24 units was recorded at the top of the interval. At 1.3 volts the reading on the J-W gas analyser was zero, indicating that the gas is predominantly methane. The gas probably originated in coal beds, which are common in the interval.

In general, gas shows in all three intervals were insignificant and testing was not warranted or recommended.

Occurrence of bitumen

Ditch samples from 5600 feet to 5800 feet contained up to 5% of fine sandstone completely impregnated with black, rubbery, bituminous material. This bitumen did not fluoresce in ultra-violet light, and no cut with carbon tetrachloride could be obtained. However, it partly dissolves in acetone, giving green fluorescence. Very probably it represents a residue of oil which migrated through the formation. No potential source rocks of petroleum are present in the drilled formations.

Porosity and permeability

The following comments on porosity and permeability are based on the visual observation of cuttings and cores and the examination of electrical logs.

Slightly cemented sandstone beds of the Mesozoic section have very good porosity and permeability. The permeability is reduced in some silty beds in the Alexander Formation and at the top of the Wallal Sandstone. Also the thick siltstone section of the Jarlemai Siltstone has low permeability.

The sandstones of the Anderson Formation in general have good porosity and permeability, especially the upper part of the formation (Unit 'A'). In the lower part, however, the permeability and porosity is reduced by siliceous cement. Occasionally the sandstone beds grade into quartzites with very low porosity. The lowest porosity in the Anderson Formation is observed in sandstone beds overlying the intrusive body of dolerite. In thinly bedded parts of the formation the vertical permeability is reduced by numerous silty lenses. Besides siliceous cement, a poor sorting of sand grains in some beds is the second factor which reduces porosity and permeability.*

Igneous activity

The occurrence of dolerite intrusives in the lower part of the hole, especially from 7825 feet to 7856 feet, reduce still more the petroleum prospects of the deeper section.

CONTRIBUTIONS TO GEOLOGICAL KNOWLEDGE

(a) The drilling resulted in a major contribution to the knowledge of the structure of the Canning Basin. Previously it was considered that the Fenton Fault might possibly continue north of Barlee No. 1 but it seems that it has faded out before reaching the Dampier Land area, and is replaced by the Dampier Fault in the western part of the basin. Barlee No. 1 therefore, is situated in the Fitzroy Trough. The extension of the Fitzroy Trough to the south of Barlee No. 1 limits the area of the Jurgurra

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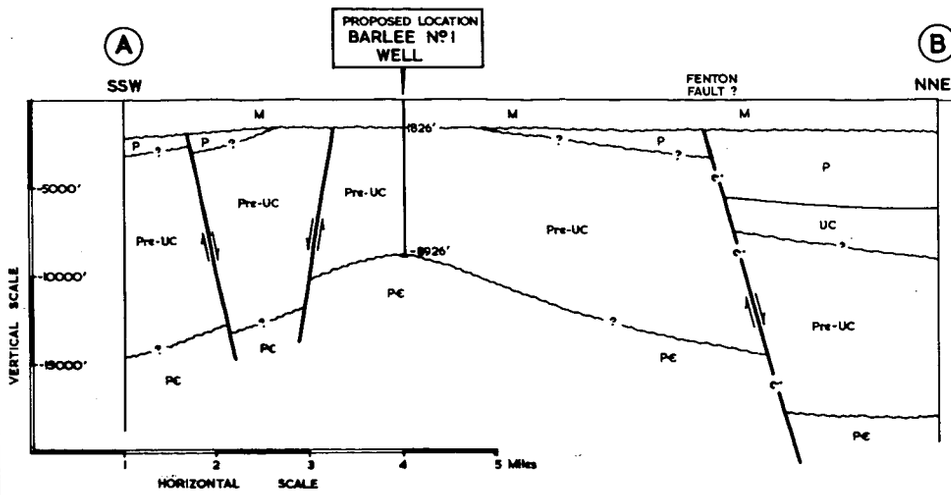
* Since this completion report was written, the Bureau of Mineral Resources has carried out laboratory measurements of porosity and permeability on cores recovered from the Anderson Formation; they are included in Appendix 4. In general, they confirm the above remarks.

BEFORE DRILLING



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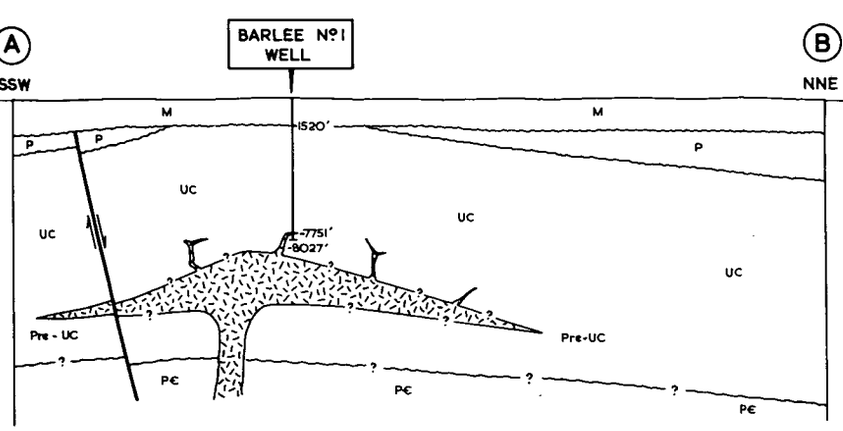

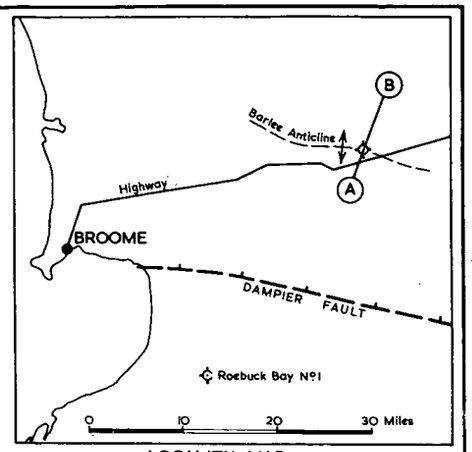

LOCALITY MAP

LEGEND

MESOZOIC	M	Undifferentiated
PERMIAN	P	Undifferentiated
CARBONIFEROUS		Dolerite intrusion
UPPER CARBONIFEROUS	UC	Anderson Formation
PRE-UPPER CARBONIFEROUS	PreUC	Undifferentiated
PRECAMBRIAN	P€	Metamorphic or granitic rocks

- Fault, possible from seismic work
- Fault concealed
- Unconformity
- Anticline concealed
- Test well
- Core hole

REVN.	WEST AUSTRALIAN PETROLEUM PTY. LIMITED	
	BARLEE Nº1 NORTH - SOUTH GEOLOGICAL CROSS SECTIONS THROUGH WELL BEFORE AND AFTER DRILLING	
	R.M.L. ELLIOTT	17 AUG 1960
DR. RMLE.		B - 2546
TR. A.J.S.	17 AUG 60	
CH. RMLE.		

PLATE 3

Terrace to that shown on Plate 1. It appears that the Dampier Land area represents a distinctive tectonic province in the Fitzroy Trough, in which Permian deposition was far thinner than in the Grant Range-Myroodah area.

(b) The intrusion of dolerite in the Anderson Formation shows additional evidence of tectonic activity in the Fitzroy Trough. It is evident that the igneous intrusions may cause some of the structures in the Fitzroy Trough.

(c) For structural reasons the dolerite intrusion is regarded as Upper Carboniferous in age; also the magma is different in origin from that of the Mesozoic leucite lamproite intrusives.

(d) 850 feet of Jarlemai Siltstone were drilled in the Barlee No. 1 Well. This is the thickest section of Jarlemai Siltstone which has been encountered in the Canning Basin.

REFERENCES

CAMPBELL, I.R.,	1956	Geological well summary - Fraser River No. 1. WAPET report, (unpublished).
GRAVITY METER EXPLORATION COMPANY,	1960	Gravity interpretation Barlee area, Canning Basin, Australia. Bur. Min. Resour. Aust. Petrol. Search Sub. Act Publ. (in press).
McWHAE, J.R.H., PLAYFORD, P.E., LINDNER, A.W., GLENISTER, B.F., and BALME, B.E.,	1958	The stratigraphy of Western Australia. J. geol. Soc. Aust., 4 (2) 161 pp. (for 1956).
ROBERTS, J.W.,	1956	Grant Range No. 1 Structure Hole. Geological completion report. WAPET report, (unpublished).
VALE, K.R., AND WILLIAMS, L.W.,	1955	Preliminary seismic reflection investigation, Broome area, Kimberley Division Western Australia. Bur. Min. Resour. Aust. Rec. 1955/112 (unpublished).

APPENDIX 1

PETROLOGICAL EXAMINATION OF CORES AND DITCH SAMPLES

by

J.E. Glover*

Barlee No. 1, Core 9, 4,450 feet

Hand specimen. The rock is a soft, nodular, grey-green claystone that splits rather easily along irregular surfaces, parallel in a general way to the apparent bedding. Many of these surfaces are smooth and somewhat shiny, as though they represent surfaces of shearing.

Thin section. The rock is made up mainly of a cloudy matrix of clay-sized material with fairly high birefringence (probably illite). There is a tendency toward common extinction in the minute flakes composing the matrix, so that there is apparently a preferred orientation for them. Another important constituent, which locally forms lenses in the rock, is finely divided, angular quartz. Muscovite is common as long narrow flakes, and minute nodules of pyrite (or marcasite) generally with a diameter close to 0.05 mm are scattered throughout. Other minerals include green biotite, chlorite, epidote, zircon, black fragments that may be carbonaceous and possible spore fragments. The greenish component of the rock's colour is probably due to the green minerals (biotite, chlorite, epidote) that are sparingly disseminated through it.

Much of the rock is too fine-grained for effective determination by microscopic techniques alone, and identification of the clay mineral is only provisional. Nevertheless, there seems to be no evidence of shearing in the thin section studied. The sulphide nodules, which presumably formed shortly after sedimentation, are not broken up. The smooth, somewhat shiny fracture surfaces could result from preferred orientation of clay-sized minerals. This orientation may have been initiated during sedimentation, and perhaps modified during compaction and diagenesis.

Core 17, 7558-7560 feet

Hand specimen. The rock is a grey micaceous siltstone, and its bedding, which is defined by thin, irregular, dark grey to black streaks, shows evidence of uneven compaction. Narrow (1-2 mm thick) veins of a white mineral are parallel in a general way to bedding, but locally transgress it. The white mineral looks like carbonate, but is not affected by an acid solution of alizarin red S, which dyes calcite red, and it does not effervesce in cold dilute HCl. It effervesces readily in warm HCl however.

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Thin section. The vein material is colourless and coarsely crystalline, and has extreme birefringence. It is uniaxial negative and its highest refractive index (ω) is very close to 1.700. The properties of the mineral indicate either an iron rich dolomite (ankerite) or magnesite, of which ankerite is the most likely.

The body of the rock is composed essentially of angular quartz grains (generally with a diameter of about 0.06 mm). Muscovite is abundant and a little biotite is present. Black carbonaceous streaks, which indicate bedding in the hand specimen, are associated with an opaque mineral, brassy in reflected light, that is referred to pyrite. A little of the pyrite, however, forms minute discontinuous cross-cutting veinlets that are closely associated with the carbonate veins, and appear to form extensions of some of them.

Small anhedral grains of carbonate are distributed throughout the rock. Their refractive indices were not determined. They do not stain when immersed in alizarin red S, and are not therefore calcite. It is likely that they have the same composition as the vein mineral. Other minerals present as accessories include feldspar and tourmaline.

The rock is thus a micaceous, carbonaceous and pyritic siltstone that is locally cut by small veins of carbonate (probably the iron-rich dolomite, ankerite). Pyrite and carbonate are associated with the intrusion of the small apophyses from the main dolerite intrusion in the Fraser River well. There is no igneous rock in this specimen however, and there is no evidence at this stage that the veins of carbonate and veinlets of pyrite have an igneous origin. They can be equally well explained by the diagenesis that is likely to have affected the rock at its considerable depth.

Cuttings from Barlee No. 1, Core 17, 7841 feet

Hand specimen. The chips are dark grey to black, and contain acicular crystals with well-developed cleavage. Narrow twin lamellae can be seen on some crystals with the hand lens, indicating that they consist of plagioclase feldspar.

Thin section. The fragments are made up essentially of plagioclase (mainly labradorite zoned to sodic andesine near crystal margins) and pale brown clinopyroxene, apparently titaniferous augite. A little of the pyroxene is converted to amphibole. Some of the feldspar attains a length of 5-6 mm, and the relationship between the pyroxene and feldspar is subophitic. Black iron ore is abundant, and its skeletal nature suggests ilmenite. A few specks of an opaque mineral that is brassy in reflected light are probably pyrite. Patches of micropegmatite are common, and contain abundant slender needles of a colourless mineral that may be apatite or tremolite. Other minerals present are carbonate and biotite.

There is no indication whether the igneous chips come from a sill or a dyke, and it is not impossible that they represent part of a flow. The subophitic texture is more suggestive of an intrusion, however, and the well developed crystals in the chips indicate that they come from some distance within the body, and are not part of a chilled edge.

The igneous rock is tholeiitic, as was the rock intersected in the Fraser River bore-hole. Other aspects of its mineralogy, such as the presence of pale brown, apparently titaniferous pyroxene, suggest that the igneous rocks in the two bore-holes were co-magmatic.

It is possible that re-examination of cuttings higher in the sequence may reveal the presence of small bodies of the igneous rock. The absence of spores in part of a core from 7558-7560 feet, noted by Mr Balme, may be due to their destruction by heat from a nearby intrusion. Some of the minerals in part of the core from the same interval are consistent with the presence of an intrusion similar to the small dykes in the Fraser River bore-hole, although they were interpreted as being diagenetic in origin. Cores of lutites from any interval of suspected igneous activity would be of petrological interest, for lutites are sensitive indicators of thermal metamorphism.

Barlee No. 1, Core No. 18, 7942-7950 feet

Hand specimen. The rock is a light grey, strongly indurated, muscovitic, fine-grained sandstone with bands up to one cm thick of dark grey muscovitic silty claystone.

Thin section. The light coloured portions of this rock consist essentially of well-sorted angular quartz grains between 0.10 and 0.2 mm in diameter. Clear fresh plagioclase and microcline grains are found in the same size range. The matrix of the rock is made up of clay-sized aggregates of sericite, clay minerals and quartz. The matrix composes about 10% of the rock, and in areas where it is absent or sparse, the quartz grains interlock and bind the rock strongly together. Muscovite is common, and other minerals include black carbonaceous streaks, minute pyrite nodules, chlorite, biotite, tourmaline, zircon and leucoxene. Patches of grey carbonate are present, and as they are not stained by the organic dye alizarin red S, they are presumed to be dolomite or ankerite.

The dark bands of claystone in the rock consist of the same minerals as the lighter-coloured sandstone, but in notably different proportions. The main constituents are clay-sized material and muscovite flakes. Carbonaceous streaks and pyrite are abundant, and quartz is present as silt.

The specimen is therefore an impure, strongly indurated, muscovitic, fine-grained quartz sandstone containing narrow bands of carbonaceous, silty and highly muscovitic claystone.

It is difficult to say whether the strong induration of this rock, which could almost be described as an impure quartzite with claystone bands, is a result of thermal metamorphism as well as the diagenetic effects expected at depths near 8,000 feet. Preservation of spores, noted by Mr. Balme, does not support the idea of high temperatures. None of the minerals present is restricted to rocks that have undergone thermal metamorphism, and there is no igneous material in the specimen.

APPENDIX 2

PALAEONTOLOGICAL REPORTS

Palynological Report

by

B.E. Balme*

Sample: Grey shale and siltstone

Depth: S.W.C. No. 6, 2,030 feet

Quality of Separation: Fair

Spores were abundant, but the assemblage poorly diversified and the forms present mainly undescribed. By far the most abundant components were a species of Cyclogranisporites, and a type tentatively assigned to Lycospora; together these made up about 90% of the total assemblage. Other genera observed were Punctatisporites, Leiotriletes and Pustulatisporites.

Age. Considered in isolation the assemblage would be of very little use for dating purposes in view of its lack of diversity and the absence of distinctive genera. A comparison with certain microfloras previously described from the Canning Basin gives some guide to the age of the present sample.

The assemblage is similar to others known from the Carboniferous, particularly one from the Anderson Formation in Grant Range No. 1 Well and from sediments between about 5000 and 5250 feet in Meda No. 1 Bore. It also has some points in common with microfloras from the Anderson Formation in Fraser River No. 1 Bore, but is far less diverse and appears older.

The most that can be said from the palynological data is that S.W.C. No. 6 is of Carboniferous age. It may come from the Anderson Formation but could be older.

Sample: Black shale

Depth: Core 1: 2283-2300 feet

Quality of Separation: Fair

Although spores were abundant the assemblage again showed little variety and, except for its higher content of plant tissues (i.e. cuticles, tracheids, etc.) was indistinguishable from that described from S.W.C. 6.

Age. Carboniferous.

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Sample: Greenish siltstone with carbonaceous fragments.

Depth: Core 1: 2283-2300 feet.

Quality of Separation: Very good.

Spores were extremely abundant and well-preserved, but the assemblage was again dominated by the genera Cyclogranisporites and cf. Lycospora. A number of forms not identified in the two microfloras described above were identified. These included:

Calamospora spp.
cf. Auroraspora sp.
Retusotriletes sp.
Grandispora sp. cf. G. spinosa Hoff. Stap. & Malloy

Spinose microplankton were also observed.

Age. There are features of this microflora which distinctly suggest a Lower Carboniferous age; most notably the presence of cf. Auroraspora and Grandispora cf. spinosa. Cf. Auroraspora sp. is known from the Fairfield and Laurel Beds and Grandispora cf. spinosa is most common in the Laurel Beds, although a doubtful specimen was seen in the Anderson Formation in Fraser River Well. Both forms occur in Famennian or Lower Carboniferous sediments in Europe, and neither appears to range into the Namurian.

It must be stressed that there are considerable difficulties in the interpretation of palynological data from the Carboniferous of the Canning Basin, due mainly to the paucity of distinctive forms in the assemblages.

A correlation of the present sample with part of the Laurel Beds is a clear possibility although the palynological evidence is not clear-cut.

Sample: Dark grey shale

Depth: 2308-2325 feet

Quality of Separation: Good

This assemblage was very similar to that from the sample from Core 1 described immediately above. Microplankton were a little more common in the present material suggesting the possibility of stronger marine influence.

Age. Probably Lower Carboniferous.

Sample: Cuttings containing black shale

Depth: 3310-3320 feet

Quality of Separation: Spores not plentiful but well-preserved.

This assemblage was notable mainly for its high content of fragmentary plant debris.

The microflora resembled that from S.W.C. No. 6 in its high content of Cyclogranisporites and cf. Lycospora. Grandispora cf. spinosa was also recognised.

No microplankton were seen.

Age. Not older than Lower Carboniferous but upper limit uncertain. The material appears to be of continental origin from the abundance of plant fragments.

Sample: Green slickensided shale (labelled 'fault gouge')

Depth: Core 9; 4450-4457 feet

Quality of Separation: Poor

Spores were not plentiful and individual specimens were dark in colour and usually poorly preserved. Only three different forms were identified, i.e. cf. Lycospora, Cyclogranisporites sp. and Punctatisporites sp.

The assemblage is of little positive value for dating purposes although it closely resembles that from S.W.C. 6 and for this reason Core 9 is considered to be most probably of Carboniferous age.

Core 14, 6,505 - 6,514 feet.

White sandstone with fine carbonaceous shale stringers.

Assemblage. Spores were rare and rather dark in colour, but their preservation was generally good. The forms identified included:

cf. Lycospora sp.
Leiotriletes spp.
Cirratriradites sp.
Punctatisporites sp.

Age. The assemblage is insufficiently diverse to allow any positive conclusions as to its age. In the relative abundance of cf. Lycospora sp. it resembles sediments from the Anderson Formation in Grant Range Bore. No evidence for a correlation with any known Lower Carboniferous formation is present in the assemblage, nor does it appear to be of Upper Devonian age.

Core 16, 7,942-7,950 feet.

Grey micaceous siltstone.

Assemblage. The sample yielded fair numbers of spores but all were assignable to cf. Lycospora and Punctatisporites. The assemblage is of no help in dating the sample apart from suggesting that it is of the same general age as Core 14.

The presence of spores in Core 16 indicates that the sediments at this depth have been little affected by the basic intrusion which occurred higher in the well.

Preliminary notes on the palaeontological examination of Barlee No. 1, Core 2, 2308-2325 feet

by

P.J. Jones*

Palaeontological examination of core 2 (2308-2325 feet) has yielded the following fossils:

Brachiopoda	:	Orbiculoides sp.
Pelecypoda	:	Sanguinolites ? sp. (identified by J.M. Dickins)
Conodontophoridia	:	Ozarkodina sp.
Ostracoda	:	Cryptophyllus sp. (indeterminate)

The neotremate brachiopod genus Orbiculoides is represented by one specimen, which has retained both the dorsal and ventral valves. The dorsal valve is flattened, exfoliated and worn, therefore no comparison can be made with the specimens previously found (all dorsal valves) in the sub-surface sections in the Fitzroy Basin (viz., BMR 2, Laurel Downs, core 3, 253 feet; Meda No. 1, core 9, 5239-45 feet; Meda No. 2, core 2, 5287-98 feet; and Fraser River No. 1, core 71, 4263-66 feet). The ventral valve, however, is fairly well-preserved, and can be compared with those of the species O. missouriensis (Shumard) and O. tornacensis Demanet. O. missouriensis ranges from the Pennsylvanian (Des Moines) into the Lower Permian in the United States, but it appears slightly earlier in Belgium and Germany, where it ranges from Namurian to lower Westphalian. O. tornacensis occurs in the upper Tournaisian and lower Visean of Belgium; it is possible, however, that this species is a junior synonym of O. missouriensis.

The pelecypod identified as Sanguinolites ? sp. does not appear to be similar to any known species from the Carboniferous of Western Australia (J.M. Dickins, pers. comm.).

The conodont Ozarkodina sp. cannot be compared with any of the described species in the literature that is available to me at present. Conodonts of this type occur in rocks from Ordovician to Triassic.

Numerous poorly-preserved specimens of the ostracod genus Cryptophyllus are present. Cryptophyllus is well-represented in the Upper Devonian and Carboniferous rocks of Western Australia, and has not been found in the Permian.

Age Significance. The occurrence of a species of Orbiculoidea comparable with O. missouriensis and O. tornacensis suggests that the total possible time-range to be considered is Carboniferous to Lower Permian. As, however, Cryptophyllus has not been found in Permian rocks of Western Australia, or elsewhere, its association with the Orbiculoidea species indicates a Carboniferous age.

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* Bureau of Mineral Resources, Canberra.

Other cores taken from Barlee No. 1 were examined, but no fossils were found; these include the following:

Core 1	2292-2307 feet	Core 7	4068-4071 feet
Core 3	2725-2740 feet	Core 8	4071-4082 feet
Core 4	3151-3168 feet	Core 9	4450-4457 feet
Core 5	3564-3579 feet	Core 10	4839-4846 feet
Core 6	3962-3974 feet	Core 11	5235-5246 feet

APPENDIX 3

FORMATION WATER ANALYSES

by

R.C. Gorman*

Lab No. 4434-35/60 Date received: 24th. March, 1960.

Material: Two samples of water from WAPET Marked:-

	"Barlee W.W. No. 1"	"Barlee W.W. No. 2"
Depth:	68 - 225' (T.D.)	68 - 125' (T.D.)
Formation:	Broome Sandstone	

Result of Analysis:

Lab No.	4434	4435
Sample	No. 1	No. 2
Specific Resistance (ohms 20°C)	277	297
Reaction	Neutral	Neutral
pH	7.3	7.4

Mineral Matter	Parts per million	
Calcium, Ca	114	108
Magnesium, Mg	101	91
Sodium, Na	566	514
Potassium, K	24	23
Bicarbonate, HCO_3	160	160
Carbonate, CO_3	NIL	NIL
Sulphate, SO_4	124	115
Chloride, Cl	1205	1092
Nitrate, NO_3	1	1
Silica, SiO_2	50	54
Iron Oxide, Fe_2O_3) Aluminium oxide, Al_2O_3)	54	14
TOTAL	2399	2172

* Deputy Government Agricultural Chemist
Government Chemical Laboratories, Perth, W.A.

Assumed combination on evaporation at N.T.P.	Parts per million	
Calcium carbonate, $CaCO_3$	131	131
Magnesium carbonate, $MgCO_3$	-	-
Sodium carbonate, Na_2CO_3	-	-
Calcium sulphate, $CaSO_4$	176	163
Magnesium sulphate, $MgSO_4$	-	-
Sodium sulphate, Na_2SO_4	-	-
Magnesium chloride, $MgCl_2$	396	356
Potassium chloride, KCl	46	44
Sodium chloride, NaCl	1437	1306
Sodium nitrate, $NaNO_3$	1	1
Calcium chloride, $CaCl_2$	27	21

Hardness calculated as calcium carbonate	Parts per million	
Total hardness	700	645
Bicarbonate (temporary) hardness	131	131
Non-carbonate (permanent) hardness	569	514
Calcium hardness	284	270
Magnesium hardness	416	375

APPENDIX 4

Cores and their specific gravities, porosities and permeabilities

Core No.	Depth (feet)	Rec. (feet)	Formation	Lithology	Specific Gravity	Porosity* (%)	Permeability* (millidarcies) Horizontal	Vertical
1	2292-2307	15	Anderson Formation	sandstone and siltstone		19.7	113.0	145.5
2	2308-2325	17	Anderson Formation	2' sandstone 1' claystone 14' siltstone		15.5	0	0
3	2725-2740	12	Anderson Formation	11½' sandstone ½' sandstone	2.24 2.59	5.5	0	0
4	3151-3168	16	Anderson Formation	3' sandstone 13' sandstone	2.33 2.35	11.0	0	0
5	3564-3579	11	Anderson Formation	sandstone	2.34	18.7	36.0	38.5
6	3962-3974	6	Anderson Formation	siltstone and sandstone	2.52 2.58	9.6	0	0
7	4068-4071	2	Anderson Formation	siltstone	2.56			
8	4071-4082	8	Anderson Formation	3½' siltstone 2½' siltstone 2' sandstone	2.60 2.56 2.62			
9	4450-4457	6	Anderson Formation	claystone and sandstone	2.56 2.54			
10	4839-4846	7	Anderson Formation	6½' siltstone ½' sandstone	2.60 2.43	11.0	233.5	Not measured
11	5235-5246	9	Anderson Formation	sandstone	2.51	10.5	0	0
12	5671-5682	11	Anderson Formation	sandstone	2.44	11.5	3.85	4.1
13	6095-6104	7	Anderson Formation	sandstone	2.47	14.0	25.5	0
14	6505-6514	7	Anderson Formation	sandstone	2.46	12.2	4.1	13.1
15	6914-6921	7	Anderson Formation	sandstone	2.52	12.3	0	0
16	7354-7363	7	Anderson Formation	sandstone	2.51	10.0	0	0
17	7558-7560	2	Anderson Formation	sandstone	2.63	4.0	0	0
18	7942-7950	7	Anderson Formation	5' sandstone 2' sandstone	2.50 2.58	10.5	0	0
19	7995-7999	3	Anderson Formation	sandstone	2.58	9.5	0	0
20	8097-8101	3	Anderson Formation	sandstone	2.55	6.6	0	0

* Laboratory measurements of porosity and permeability on sandstone portions of Cores 1-6 and 11-20 were made in the Petroleum Technology Laboratory of the Bureau of Mineral Resources, Canberra, using a 'small plug' technique and 'Ruska' equipment.

APPENDIX 5

Schlumberger Logs

Electrical Log:

ES-1	:	108'-2306'	:	20th April, 1960.
ES-2	:	2000'-3152'	:	27th April, 1960.
ES-3	:	3050'-5246'	:	26th May, 1960.
ES-4	:	5050'-7413'	:	7th July, 1960.
ES-5	:	7250'-7998'	:	23rd July, 1960.
ES-6	:	7900'-8100'	:	26th July, 1960.

Gamma Ray-Neutron Log:

GRN-1	:	45'-2300'	:	21st April, 1960.
GRN-2	:	2200'-3152'	:	27th April, 1960.
GRN-3	:	3050'-5300'	:	2nd June, 1960.
GRN-4	:	5000'-7395'	:	7th July, 1960.
GRN-5	:	7250'-7980'	:	23rd July, 1960.

Section Gauge:

SG-1	:	14'-2319'	:	21st April, 1960.
SG-2	:	1700'-3150'	:	27th April, 1960.
SG-3	:	1900'-5338'	:	2nd June, 1960.
SG-4	:	1900'-7411'	:	7th July, 1960.
SG-5	:	2000'-7994'	:	23rd July, 1960.
SG-6	:	1950'-8098'	:	26th July, 1960.

Temperature Log:

Run 1	:	160'-2282'	:	23rd April, 1960.

Dipmeter:

6 Levels	:	27th July, 1960.

The originals of all Schlumberger logs are filed at the office of West Australian Petroleum Pty Ltd., 251 Adelaide Terrace, Perth, W.A. Copies of all logs, whether or not reproduced in this report, may be consulted at the Bureau of Mineral Resources, Canberra.

APPENDIX 6

Eastman Deviation Records

Level	Deviation°	Level	Deviation°	Level	Deviation°
135'	1/2	5047'	3 1/2	6973'	3 3/4
460'	3/4	5106'	4	7090'	3 3/4
700'	1/2	5144'	3 1/2	7149'	3 3/4
800'	1/2	5195'	3 1/4	7191'	4
971'	3/4	5235'	2 3/4	7250'	4
1060'	3/4	5339'	2 3/4	7312'	4
1200'	1/2	5388'	3	7354'	4
1300'	1/4	5430'	3 1/2	7404'	4
1400'	0	5512'	2 1/4	7437'	3 3/4
1731'	3/4	5548'	2 1/4	7482'	4
1950'	0	5595'	2 1/4	7524'	4
2250'	3/4	5720'	2 1/8	7539'	4
2285'	3/4	5761'	2 1/8	7602'	4
2725'	1 1/4	5803'	2 1/4	7672'	3 3/4
2939'	3/4	5893'	2 1/4	7734'	4
3140'	1 1/2	5976'	2	7754'	4
3692'	2 1/2	6043'	2 1/4	7777'	3 1/2
3698'	2 1/2	6095'	2 1/4	7816'	4
3874'	2	6147'	2	7841'	3 3/4
3962'	2 1/4	6216'	2 1/2	7916'	4 3/4
4128'	2 1/2	6254'	3	7942'	3 3/4
4132'	2 1/2	6294'	4	7995'	4
4211'	2	6324'	3 1/2	8060'	4
4263'	2	6368'	3 1/8		
4400'	2	6404'	3 1/4		
4444'	3	6460'	3 1/2		
4505'	3 1/2	6505'	3 1/4		
4583'	3	6580'	3		
4715'	3 1/4	6623'	3 1/4		
4791'	3	6690'	3 1/2		
4839'	3 1/4	6762'	4		
4911'	3 3/4	6805'	4 1/4		
4968'	4	6863'	4		
5013'	3 1/2	6914'	4 1/4		

COMPANY **WEST AUSTRALIAN PETROLEUM PTY. LTD.**

COMPOSITE WELL LOG

WELL NUMBER **BARLEE No.1**

REGION **CANNING BASIN**

PLATE 4

COUNTRY **WESTERN AUSTRALIA**

FILE No. C-2555

LOCATION:
LATITUDE 17° 48' 25" S.
LONGITUDE 122° 42' 40" E.
COORDINATES:
YARDS EAST : 598,450
YARDS NORTH: 2761,050
ELEVATION
DERRICK FLOOR 74 FT.
GROUND 62 FT.
TOTAL DEPTH FROM DERRICK FLOOR 8101'
PLUG BACK DEPTH FROM DERRICK FLOOR 2310'
DATE SPUDDED 12 APR. 1960
DATE COMPLETED 29 JUL. 1960
LITHOLOGY BY V. PUDOVSKIS., M.H.JOHNSTONE., R.M.ELLIOTT., S.P. WILLMOTT.

ELECTRIC LOG DATA

RUN NUMBER	1	2	3	4	5	6
DATE	20 Apr.60	27 Apr.60	26 May60	7 Jul. 60	23 Jul. 60	26 Jul.60
INTERVAL RECORDED	2306-108	3152-2000	5246-305	7413-5050	7998-7250	8100-7900
MUD NATURE	TREATED	TREATED	TREATED	TREATED	TREATED	TREATED
MUD RESISTIVITY	4·0 at 100°F	3·3 at 78° F	2·2 at 82°F	1·9 at 84°F	1·2 at 84°F	1·1 at 85°F
MUD RESISTIVITY B.H.T.	3·2 at 124°F	1·4 at 132°F	1·2 at 151°F	1·0 at 159°F	·6 at 174°F	·5 at 175°F
MUD WEIGHT	74	75·5	75·5	76	76·5	76·5
MUD VISCOSITY	46	47	67	47	54	51
MUD WATER LOSS	7·4	6·8	5·9	6·4	5	5·6
MUD pH	11·5	11·5	11	11·5	11·5	11

OTHER LOG COVERAGE: GRN-1: 45'-2300', GRN-2: 2200-3152', GRN-3: 3050-5300', GRN-4: 5000'-7395', GRN-5: 7250-7980', S.G. 1-6: 14'-8095', TEMP. LOG: 160'-2280'. DIP METER: 6 LEVELS

CONGLOMERATE, BRECCIA, TILLITE, SANDSTONE, SILTSTONE, CLAYSTONE, SHALE, CALCARENITE; CALCILUTITE, LIMESTONE, DOLOMITE, COAL, CARBONACEOUS MATTER, METASEDIMENTS, GRANITE, DOLERITE; QUARTZITIC, U UNCONFORMABLE CONTACT, CONFORMABLE CONTACT, D DISCONFORMABLE CONTACT, ARKOSIC, CALCAREOUS, FOSSILIFEROUS; VVV GLAUCONITIC, MICACEOUS, OOLITIC, PYRITIC, BITUMEN SHOW, GAS SHOW, CORE (Recovery block) SPECIFIC GRAVITY, SIDE WALL CORE, PERFORATED INTERVAL, CASING SHOE

SPONTANEOUS POTENTIAL 100 Millivolts, - 10 mv +; RESISTIVITY 20 ohms m²/m, 16" Short Normal 20, 0 200; 64" Long Normal 20, 0 200; RESISTIVITY 20 ohms m²/m, 18'8" Lateral 20, 0 200; DEVIATION; CASING PLUGS; DIPS Schlumberger; DEPTH; Cores & Spec. Gravity; LITHOLOGY

Plug No.3
16" casing set at 108'
E.S. RUN 1.

200' 400' 600' 800' 1000' 1200' 1400' 1600' 1800' 2000' 2200' 2400'

PLUG No.2 Gap in 10¾" casing 2030'-2048'
16"(v) 14"(v)
10¾" Casing shoe set at 2339'
ES RUN 2.
PLUG No.1

LITHOLOGIC DESCRIPTION

12'-32' SURFACE SAND

32'-143'
BROOME SANDSTONE (LOWER CRETACEOUS)
Sandstone: Brown and white, fine to coarse grained, poorly sorted.

143'-993'
JARLEMAI SILTSTONE (UPPER JURASSIC)
143'-170' Sandstone: Red, brown and yellow.
170'-305' Claystone: Red-brown and yellow, with beds of Sandstone.
305'-993' Siltstone: Grey and brown-grey, clayey and sandy, micaceous, pyritic, with belemnites, foraminitera, polecypods, and gastropods.

993'-1062'
ALEXANDER FORMATION (UPPER JURASSIC)
Interbedded glauconitic Sandstone and Siltstone. Belemnites common

1062'-1594'
WALLAL SANDSTONE (MIDDLE & UPPER JURASSIC)
1062'-1201' Sandstone: coarse, conglomeratic, carbonaceous with beds of grey-brown Siltstone.
1201'-1594' Sandstone: Medium to coarse, friable, with lenses of black coal.

1594'-8101' (T.D)
ANDERSON FORMATION (UPPER CARBONIFEROUS)
1594'-2257' Unit 'A'
Sandstone: White and light grey-brown, fine to very fine, slightly cemented, porous, carbonaceous.

2257'-4065' Unit 'B'
Interbedded and interlaminated Sandstone: Light greenish-grey, fine, carbonaceous with green chloritic grains.
Siltstone: green-grey, Shale: dark green-grey, and minor Dolomite: fine to coarse, crystalline, sandy, with brachiopods polecypods, conodonts and ostracods.

BARLEE No.1

2600 2800 3000 3200 3400 3600 3800 4000 4200 4400 4600 4800 5000 5200 5400 5600 5800 6000

3 2·24 2·59
ES RUN 3.
4 2·33 2·35
5 2·34
6 2·52 2·58
7 2·56 2·60 2·62
9 2·56 2·54
10 2·60 2·43
12 2·44
13 2·47

Gas Show

4065'-6430' UNIT 'C'
Sandstone: Fine to coarse grained, poorly to moderately sorted, carbonaceous, moderately porous, massive to crudely bedded, with some beds of green-grey and dark grey, micaceous Siltstone and Claystone; in upper part with beds of Siltstone: mottled, green-grey and red-brown.

Gas Show

ES RUN 4. 2·51
SCALE CHANGE 20 0 50

BARLEE No.1

6200' 6400' 6600' 6800' 7000' 7200' 7400' 7600' 7800' 8000'

6430'-8101'(T.D.) UNIT 'D'
Sandstone: predominantly fine grained, moderately to well sorted, with carbonaceous and micaceous partings, well bedded to laminated, with beds of Siltstone and Claystone: dark grey, carbonaceous, and thin beds of black Coal; with intrusive body of Dolerite in the lower part.

4 2·46
15 2·52
16 2·51
SCALE 50 0 CHANGE 50 100 0 100
ES RUN 5.
17 2·63
Dolerite ?
Quartzitic
Gas Show
Dolerite
ES RUN 6.
18 2·50 2·58
19 2·58
20 2·55 T.D. 8101'

NO FORMATION TESTS CONDUCTED.

PLATE 5

FILE NUMBER: C2558

WEST AUSTRALIAN PETROLEUM PTY. LTD.

DRILLING TIME AND GAS LOG

BARLEE No. 1.

KIMBERLEY DISTRICT

WESTERN AUSTRALIA

NEW BIT

CORE BIT