COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PETROLEUM SEARCH SUBSIDY ACTS

Publication No. 8

FROME ROCKS No. 1 and No. 2 WELLS, WESTERN AUSTRALIA

OF

WEST AUSTRALIAN PETROLEUM PTY LIMITED

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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

Director: J. M. RAYNER

This Report was prepared for publication in the Geological Branch
Chief Geologist: N. H. FISHER

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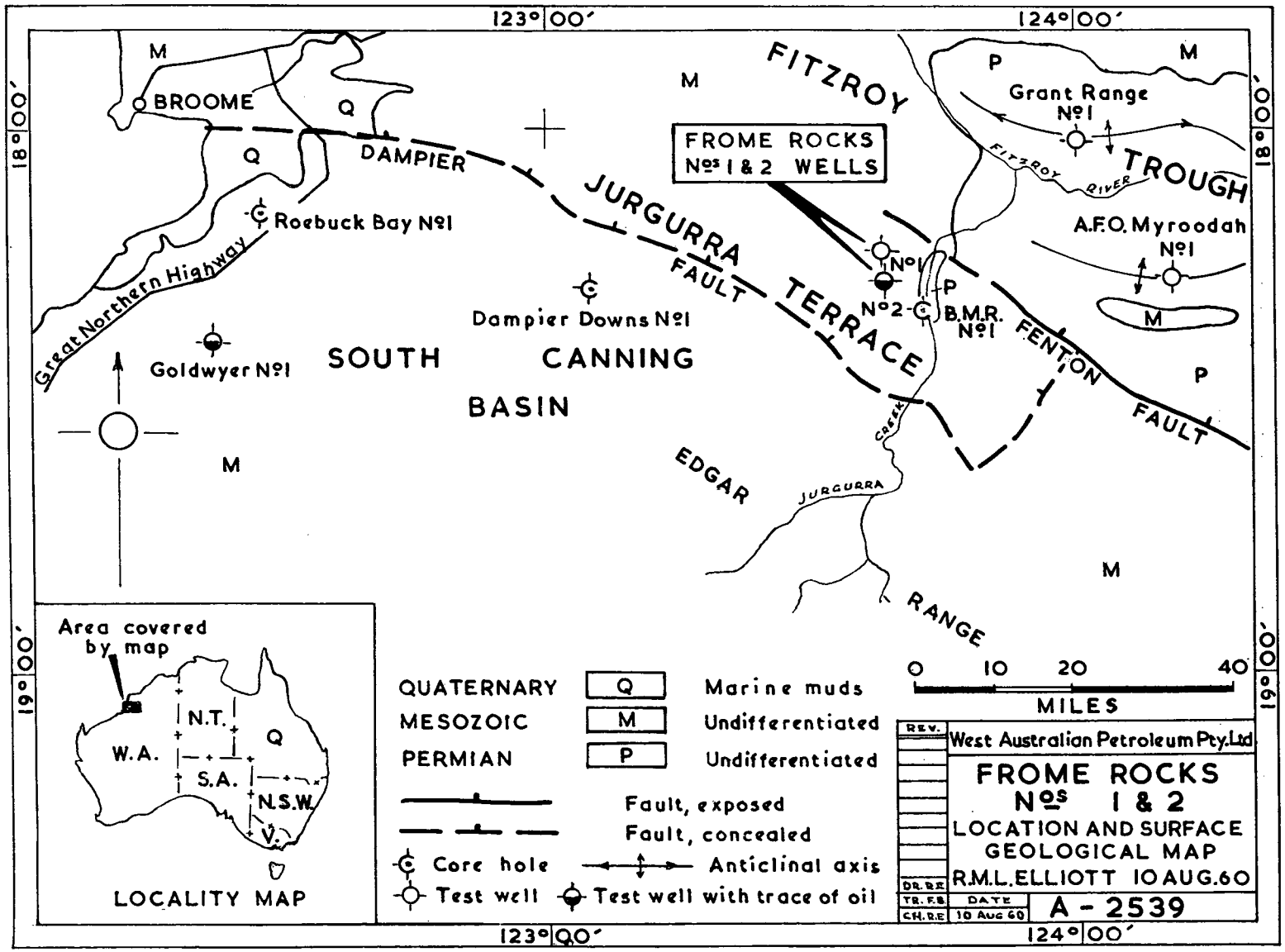
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TR. F.B.
CH. R.E.
DATE
10 Aug 60
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SUMMARY

Frome Rocks No. 1 Well, which is situated on the northern edge of the Jurgurra Terrace, drilled to 734 feet through Recent sand and the normal sequence of Jurassic sediments of the South Canning Basin and then entered the top of the Frome Rocks Salt Dome. The Frome Rocks Salt Dome consists of 1,522 feet of dolomite breccia cap rock and 1,747 feet plus of salt. The base of the salt was not reached. The age of the sediments composing the salt dome is not known, but slender evidence suggests that the age is Devonian to Lower Carboniferous. The intrusion of the salt dome probably took place in post-Permian and pre-Jurassic times.

No signs of hydrocarbons were seen in the well and no formation tests were conducted.

The Frome Rocks No. 2 Well drilled through 206 feet of Recent and Jurassic sandstones, and a standard Permian sequence (3,351 feet thick) to 3,557 feet. A thick sequence of uppermost Devonian (Middle to Upper Famennian) sediments was encountered between 3,557 feet and the total depth of 7,504 feet. This thick Devonian succession (3,947 plus feet) has been divided into two formations, one of siltstone and shale with some limestone and sandstone, from 3,557 feet to 6,264 feet, and the other of siltstone, from 6,264 feet to 7,504 plus feet. The primary objective, the Ordovician, was not reached.

Persistent, though slight, hydrocarbon shows occurred in several zones throughout the upper two-thirds of the Devonian in the form of fluorescence associated with limestones, and a spotty oil staining in the uppermost sandstone bed. No hydrocarbons were detected by gas detection equipment. None of the hydrocarbon shows was of sufficient significance to warrant testing.

In the Frome Rocks area, there is an association of a salt dome, a thick impermeable sequence, source rock potential, and some reservoir potential. Should the same association occur in other areas along the Jurgurra Terrace, particularly if the reservoir potential improves, the petroleum prospects of the area must be upgraded.

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INTRODUCTION

Frome Rocks No. 1 and No. 2 Wells are located on the Jurgurra Terrace in the Canning Basin, Western Australia. Frome Rocks No. 1 Well is 95 miles east-south-east of Broome, and 4 miles north of Frome Rocks No. 2 Well. The only previous stratigraphic well in the area is BMR 1, Jurgurra Creek, which is 6 miles south-east of Frome Rocks No. 2, and was drilled to 1,680 feet in Permian sediments.

The Jurgurra Terrace is a narrow mobile shelf lying between the South Canning Basin and the Fitzroy Trough, and contains mainly Palaeozoic rocks intermediate in thickness between those in the South Canning Basin and the Fitzroy Trough.

Frome Rocks No. 1 Well was approved as a subsidized hole to test the pre-Permian sequence on a structural high on the Terrace. This well unexpectedly penetrated the cap rock of a salt mass immediately below the Mesozoic and drilling stopped at 4,003 feet in salt. The No. 2 Well was then drilled, as a subsidized hole, to test the original objective outside the area disturbed by the salt mass.

WELL HISTORIES, FROME ROCKS NO. 1 AND NO. 2 WELLS

by

R.M.L. Elliott and S.P. Willmott

West Australian Petroleum Pty Limited

General data

		NO. 1 WELL	NO. 2 WELL
Location	:	Latitude 18° 11' 48" S. Longitude 123° 38' 42" E.	Latitude 18° 15' 15" S. Longitude 123° 39' 35" E.
Coordinates	:	127,500 yards East 2,713,000 yards North	129,250 yards East 2,706,050 yards North
Permit to Explore	:	30H	30H
License to Prospect	:	56H	56H
District	:	Kimberley	Kimberley
Total depth	:	4,003 feet (Schlumberger) 4,000 feet (Driller)	7,504 feet (Driller)
Date spudded	:	2nd January 1959	19th February 1959
Date Completed	:	7th February 1959	1st June 1959
Elevation above sea level	:	Derrick Floor : 230 feet Ground Level : 221 feet	Derrick Floor : 296 feet Ground Level : 287 feet

Drilling record summary

The wells were drilled by Oil Drilling & Exploration (W.A.) Pty Limited, using a National T-32 (Rig 3) owned by West Australian Petroleum Pty Limited (WAPET). The wells were drilled under the terms of the Petroleum Search Subsidy Act (1957/58) of the Commonwealth of Australia.

	NO. 1 WELL	NO. 2 WELL
Hole Size	20" to 86' 13 3/4" to 1277' 9 7/8" to 4003' (T.D.)	20" from surface to 280' 13 3/4" from 280' to 2065' 9 7/8" from 2065' to 6351' 8 1/2" from 6351' to 7504' (T.D.)
Casing	74 feet of 16" x 65 lb/ft casing cemented at 86 feet. 1264 feet of 10 3/4" x 40.5 lb/ft casing cemented at 1277 feet.	260' of 16" x 65 lb/ft casing set at 273' 1986' of 10 3/4" x 40.5 lb/ft casing set at 1998'.
Plugs	An abandonment plug was set across the 10 3/4 inch casing shoe and a steel plate welded across the 10 3/4 inch casing at the surface.	Plug No. 1 was set across the top of the Devonian, using 100 sacks cement. The plug top is at 3400 feet. Plug No. 2 was set across the 10 3/4 inch casing shoe, using 100 sacks cement. Plug top at 1890 feet. Plug No. 3 was set at the surface using 50 sacks of cement. Plug top at 12 feet. A steel plate was welded across the casing head.

Ditch samples

In Frome Rocks No. 1 Well ditch samples were collected from 100 feet to Total Depth at ten-foot intervals while drilling and five-foot intervals while coring. The lithology of the section from the surface to 100 feet was taken from ditch samples from the nearby water bores.

Ditch samples from Frome Rocks No. 2 Well were collected from surface to Total Depth at ten-foot intervals while drilling and at five-foot intervals during coring. Ditch samples from 5,780 feet to Total Depth were collected by Peters' Formation Logging personnel. These samples were collected at five-foot intervals, and composited to represent a ten-foot interval. The sample depths have been corrected for time lag.

Cuts of the washed ditch samples were made for the Bureau of Mineral Resources, the Mines Department of Western Australia, and WAPET.

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All WAPET'S washed ditch samples splits and bulk ditch samples have been stored in the Norma Road Warehouse, Perth.

Coring

NO. 1 WELL

Twelve cores were cut with a conventional Hughes Type "J" core barrel using hard formation core heads. The total recovery was 88 feet (69%) of the 126 feet of total footage cored.

NO. 2 WELL

Twenty-six cores were cut using a Hughes Type "J" core barrel with 7 7/8 inch hard and soft formation core heads. A total of 197 feet of formation was cored with 138 feet (70%) recovery.

Cores were cut at approximately 400-foot intervals from 700 feet to the base of the Permian. Throughout the carbonate-bearing section of the Devonian cores were cut at about 400-foot intervals, and in the siltstone-shale section the coring interval was reduced to 250 feet.

The details of the cores cut are listed in Appendix C. The specific gravities of the cores are listed in Appendix D.

Cuts of cores were made for the Bureau of Mineral Resources and the Mines Department of Western Australia. The remainder of the cores have been stored in WAPET's Norma Road Warehouse.

Sidewall coring

NO. 1 WELL

Twenty-one sidewall cores were recovered in the one run made with Schlumberger's Chronological Sample Taker.

NO. 2 WELL

One run was made with Schlumberger's Chronological Sample Taker. Thirty sidewall samples were attempted, and twenty-three samples were recovered.

A split of these cores was made for the Bureau of Mineral Resources. The remainder of the cores are stored in the Perth Office of West Australian Petroleum Pty Limited. The intervals cored are recorded in Appendix C.

Electric Logging

The following Schlumberger logs or tools were run :

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NO. 1 WELL

Electric log
Gamma Ray - Neutron log
Caliper
Section Gauge
Chronological Sample Taker
Laterolog

The presence of massive salt below 2256 feet restricted the choice of electric logs.

NO. 2 WELL

Electric log
Gamma Ray - Neutron log
Microlog - Caliper
Section Gauge
Chronological Sample Taker
Dipmeter
Directional Survey

Details of the logs run are listed in Appendix E.

Drilling time and gas log

NO. 1 WELL

Five-foot drilling time was recorded while drilling and one-foot drilling time was recorded while coring.

Continuous JW gas detector readings were recorded below 315 feet.

Drilling time, gas reading, and lithology have been recorded graphically on the Drilling Time Gas Log (Plate 2).

NO. 2 WELL

Five-foot drilling time was recorded while drilling and one-foot drilling time was recorded while coring from surface to 3000 feet. From 3000 feet to Total Depth one-foot drilling time was recorded while both drilling and coring. However only five-foot drilling time was recorded on the Drilling Time and Gas Log.

A graphic log of five-foot drilling times has been made from surface to 5780 feet. Continuous JW gas detector readings were also recorded on the Drilling Time and Gas Log from 1100 feet to 5780 feet. Lithology and brief lithologic descriptions are also recorded on this log (Plate 4).

From 5780 feet to Total Depth, drilling time and gas detection records were maintained by Peters' Formation Logging Personnel and presented on their own graphic log form. Drilling times on this part of the log are recorded in feet per minute. Peters' Formation log is incorporated in Plate 4.

Formation Tests

No formation tests were made.

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Deviation Records

NO. 1 WELL

Deviations were recorded with an Eastman Drift Indicator at 19 levels. The maximum deviation was 1 1/4° at both 3636 feet and 3975 feet. A Schlumberger directional survey was not run.

NO. 2 WELL

Hole deviation was recorded with an Eastman Drift Indicator at 48 levels. Maximum deviation recorded with this instrument was 4 3/4° at 6986 feet. Eastman deviation records are listed in Appendix F.

A Schlumberger directional survey was made between 7300 feet and 2000 feet. The details of this survey are summarized in Appendix F. Maximum deviations recorded by Schlumberger were 5 1/4° at 6100 feet and 5° at 5500 feet.

In addition a correlation chart of dip and deviation is presented as Figure 4.

Personnel

The wellsite work was done by S.P. Willmott and R.M.L. Elliott over the following intervals -

S.P. Willmott	surface-2840 feet
	3520 feet-4003 feet
R.M.L. Elliott	2840 feet-3520 feet

The wellsite geologists were S.P. Willmott, M.H. Johnstone and R.M.L. Elliott over the following intervals -

S.P. Willmott	surface-3096 feet
	3746 feet-5470 feet
	6100 feet-7504 feet
M.H. Johnstone	3096 feet-3746 feet
R.M.L. Elliott	5470 feet-6100 feet

In addition one WAPET geologist was assigned to the Peters' Formation Logging Unit. This work was done by P.A. Hoelscher and M.H. Johnstone.

SURFACE GEOLOGY OF THE FROME ROCKS AREA

by

R.M.L. Elliott

West Australian Petroleum Pty Limited

In 1959, J.R.H. McWhae noted the presence of Permian rocks at Frome Rocks, and on a subsequent visit to the wellsite the author mapped the outcrops.

The surface around Frome Rocks is covered with red sand and sand dunes with a few isolated low hills of either Jurassic Wallal Sandstone or Permian Grant Formation. The Grant Formation is steeply dipping and is cut by a number of north-west trending faults which do not affect the overlying flat-lying Wallal Sandstone.

The lithology of the formations is described below.

Wallal Sandstone

In the low hills four miles due west of Frome Rocks the following section was measured from the top down.

25'	SANDSTONE, dark reddish purple, silicified and ferruginized, well sorted, fine to medium grained, thin to thick bedded, some beds of fine conglomerate up to 1 inch thick, forms bald rounded weathering surfaces.
25'	SANDSTONE, red brown, fine to medium grained, well sorted, some siltstone surfaces ripple-marked with the surface gold-coloured, cross-bedded, thin-bedded, only slightly ferruginized, medium hard, friable.
16'	No outcrop, probably sandstone as in the 25 feet above.
10'	SANDSTONE, dark red-brown, highly ferruginized, some 2 to 3 inch beds fine-grained, bulk of unit very concretionary in what was probably a clay-pellety sandstone, pellets globular to flattened ranging in size from 1/2 to 3 inches, some fossil wood.
76'	

At Frome Rocks only the basal few feet of the formation is seen and it consists of the following lithology from the top down.

5-10'	SANDSTONE, dark red-brown and dark reddish purple, colour unevenly distributed, some thin bedding developed, fine to medium grained, well sorted, porous, ferruginized, unjointed, no fossils.
1-2'	CONGLOMERATE, dark red-brown, dark reddish purple, some pale yellow-brown circular spots, colour unevenly distributed, weathers dark red-brown, ferruginized, poorly sorted, many rounded white quartz pebbles up to 1 1/2 inches across, also some pieces of the underlying white sandstone (Grant Formation) up to one foot across. The matrix is composed of red-brown sandstone as described in the 5-10 feet above, porous, unfossiliferous. Unconformably overlies the Grant Formation in the only outcrop in which the contact is seen.

The total thickness of the Wallal Sandstone in the area just south of Frome Rocks Trig is approximately 200-250 feet. This thickness is based on the 76 feet of exposed section and 176 feet in Frome Rocks No. 2.

Grant Formation

At Frome Rocks Trig the formation consists mainly of the following lithologies :

SANDSTONE, white, pale pinkish purple, colour often streaky, fine to medium grained, silicified, weathers red-brown on surface only, traversed by many quartz veins which run in all directions, massive, dips hard to determine due to effect of faulting and quartz veins. Near the base of the southern side of the hill there is some very steeply dipping SILTSTONE, white with some very pale yellow and brown laminae.

The total thickness of the Grant Formation near Frome Rocks Trig is not known as only about 50 feet is exposed and the unit is cut by several faults. It is similar in lithology to the arenaceous part of the Grant Formation seen in the upper part of the section in Frome Rocks No. 2 Well.

Faulting

Three north-west trending faults have been mapped in this area on the basis of the steep dips developed in the Grant Formation, the abundant small quartz veins, and trend lines seen on the aerial photographs. It was not possible to determine the direction of throw and no fault planes are exposed. The faulting is considered to be post-Permian and pre-Jurassic in age.

GEOLOGICAL REPORT ON FROME ROCKS NO. 1 WELL

by

R.M.L. Elliott

West Australian Petroleum Pty Limited

A thinned, but normal, section of the standard Mesozoic sequence of the South Canning Basin forms the upper part of the section encountered in this well. Beneath the Mesozoic lies the Frome Rocks Salt Dome, the presence of which was not suspected prior to drilling. The Frome Rocks Salt Dome has been divided into two parts which are obvious from the samples and electric logs. These two parts are the cap rock (dolomite breccia) and the salt.

Geological Setting

Most of the Jurgurra Terrace is covered with loose red surface sand through which appear a few scattered outcrops of Mesozoic and Permian sediments. This structural unit has been discovered by geophysical methods. The presence of the Dampier Fault was suggested by aerial magnetometer and gravity work and substantiated by seismic refraction and reflection surveys. The Fenton Fault was known in outcrop and was further examined by geophysical methods. The surface trace of the Fenton Fault does not continue west of Jurgurra Creek. However the geophysical results show that it continues as a concealed fault for some distance to the west.

The gravity work showed several large maximum anomalies on the Jurgurra Terrace and these were examined with both the refraction and reflection seismograph. This led to the conclusion that the faulted and folded structure at Frome Rocks represented a regionally high structural feature on the Jurgurra Terrace.

Permian and Carboniferous rocks had been identified to the north in Grant Range No. 1 and Myroodah No. 1. The Devonian was not known from the subsurface near the Jurgurra

Terrace. Ordovician rocks had been penetrated to the south of Frome Rocks No. 1 in Roebuck Bay No. 1, Goldwyer No. 1, and Dampier Downs No. 1.

From the section seen in BMR No. 1 and the evaluation of all geological and geophysical data, it was expected that the Frome Rocks No. 1 Well would penetrate a thin sequence (1,000 feet) of Mesozoic and Permian rocks and then pass into Carboniferous, Devonian, and Ordovician rocks before reaching basement at approximately 7,500 feet.

Therefore, Frome Rocks No. 1 was drilled to test possible hydrocarbon accumulations in the pre-Permian section in a strongly faulted structure located in a regionally high position on the Jurgurra Terrace.

Formation Descriptions

The section present in this well is set out in Table I below and following the table are brief descriptions of the formations. The ages of the Mesozoic formations have been determined from spores obtained from either the subject well or the adjacent water bores. The ages of the pre-Mesozoic formations have not been determined. Some fish plates, possibly Upper Devonian or Carboniferous, have been recovered from brecciated dolomite in the salt, but it is not certain that the salt and dolomite are of the same age.

The lithologies of the formations have been compiled from the sample and core descriptions and where necessary the descriptions have been modified to fit with the descriptions given by detailed petrological examination (Appendix B).

TABLE I

Formations Encountered in Frome Rocks No. 1 Well

Age		Formation	Formation Top Depth D.F. (feet)	Formation Top Depth Subsea (feet)	Thickness (feet)
Recent		Surface sand	9	+221	31
	(Upper	Jarlemai Siltstone	40	+190	267
Jurassic	(Upper	Alexander Formation	307	-77	240
	(Middle to Upper	Wallal Sandstone	547	- 317	187
Pre-Mesozoic		(Frome Rocks Salt Dome)			
		Dolomite breccia	734	- 504	1522
		Salt	2256	-2026	1747+
		T.D.	4003	-3773	

Recent

Surface sand (0 - 40 feet). The surface of the location consists of loose red sand

which is probably aeolian in origin as ridges composed of the same sand are common in the surrounding country.

Jurassic

Jarlemai Siltstone (40-307 feet) Upper Jurassic. Unconformably underlying the surface sand is the Jarlemai Siltstone. The upper portion of the formation, from 40 to 75 feet, is lateritized. The lithology of the formation from 75 feet to 200 feet is claystone and clay, brown and red-brown, very ferruginous, with occasional coarse angular quartz grains; and 200 feet to 307 feet is clay, dark grey, puggy, soft, slightly glauconitic, very pyritic. Microplankton recovered from the nearby Frome Rocks Water Bore No. 1 (Balme, Appendix A) suggest that the formation in this area is younger than in the Broome Town Bores and the age probably ranges as high as Lower Cretaceous.

Alexander Formation (307-547 feet) Upper Jurassic. The Alexander Formation conformably underlies the Jarlemai Siltstone. The lithology of the formation from 307 feet to 510 feet is sandstone, fine and medium grained, poorly sorted, micaceous, silty, very thin bedded, with beds of siltstone and very fine grained sandstone; and from 510 feet to 547 feet shale, medium to dark grey, soft, laminated, interbedded with sandstone.
laminated, interbedded with sandstone.

The age of this formation has been determined as Upper Jurassic (Oxfordian-Kimeridgian) from microflora and microplankton in the nearby Frome Rocks Water Bore No. 1 (Balme, Appendix A) and from sidewall cores containing microplankton from the main well (Evans, Appendix A).

Wallal Sandstone (547-734 feet) Middle to Upper Jurassic. Conformably underlying the Alexander Formation is the Wallal Sandstone. The lithology of the formation is sandstone, fine and medium grained, with some well rounded coarse grains, thin bedded, grey, some beds with solid pyritic cement forming up to 40 percent of the rock.

Microplankton and spores recovered from Sidewall Core No. 11 (655 feet) suggest a possible Lower to Middle Jurassic age for this formation (Evans, Appendix A). This age determination suggests that the formation is slightly older in this well than elsewhere in the Canning Basin. However, this change in determined age could be due more to the poor yield of material from, and the sandstone nature of, Sidewall Core 11, than an actual change in age.

The Wallal Sandstone is thinner (187 feet) in this well than in other wells in the Canning Basin, where the range in thickness in complete sections is from 286 feet (Fraser River Core Hole No. 1) to 1,096 feet (Samphire Marsh No. 1). This thinning is probably due to a combination of the location of Frome Rocks No. 1 very near the Mesozoic shoreline, and the presence of relief in the Frome Rocks area at the time of deposition of the formation.

Pre-Mesozoic

The pre-Mesozoic in this well consists of the Frome Rocks Salt Dome in which the sediments are of unknown age. The salt dome has been divided into two parts, the cap rock and the salt.

Cap Rock - Dolomite breccia (734-2256 feet) Age unknown. The structural relationship between the cap rock of dolomite breccia and the overlying Wallal Sandstone is not known. On indirect evidence there is considered to be an unconformity between the two formations.

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The lithology of the cap rock is dolomite breccia, pale grey-green to grey, friable; the matrix is usually soft and friable and consists of fine granular dolomite and some clay, authigenic euhedral quartz crystals are ubiquitous and represent up to 5 percent of the rock, slightly pyritic and hematitic. The breccia fragments consist of dolomite, pink, grey, and black, minor amounts of quartz and anhydrite, angular bedded fragments, finely and coarsely crystalline, pyritic, hard. The whole unit has low porosity and permeability; the lower portion contains some salt.

The age of the unit is not known. Spores obtained from Core 2 (1,277-1,287 feet) indicate a Middle to Upper Jurassic age for the unit (Appendix A). Because of the friable nature of the cores it is thought that these spores represent contamination of Core 2 by the drilling mud which would still have been contaminated with Mesozoic spores from the very soft formations above.

Salt (2,256-4,003 feet) Age unknown. The structural relationship between the cap rock and the salt is not known though the contact between them is very sharp. The lithology of the unit is salt, commonly pale grey, some pink and brown patches, sometimes red and white, translucent, always containing scattered small fragments (1/8 to 1/2 inch) of pink and grey dolomite and occasionally anhydrite*, and containing several beds of dolomite breccia, which consist of angular fragments of dolomite set in a rock salt matrix; the salt matrix is often stained brown near the margins of the dolomite fragments and contains minor amounts of anhydrite and hematite; the dolomite is grey and pink, sandy with authigenic quartz grains, fragment surfaces frequently slickensided, sometimes very soft, usually hard, fragments range from 1/8 to 3 inches; the whole unit shows no porosity or permeability (the apparent porosity shown on the neutron curve at the top of the unit is due to the large hole diameter which developed prior to using a salt saturated drilling mud); from 3,878 feet to 3,913 feet is a bed of claystone, pink, calcareous. Steep dips are apparent in a number of the cores and this is considered normal as salt in the apex of a salt dome commonly occurs in steeply dipping isoclinal folds.

The age of the salt is not known. Dolomite from Core 5 (2,480-2,490 feet) yielded one species of fish plate and a single unidentifiable conodont and these fossils suggest an Upper Devonian to Lower Carboniferous age (Glenister, Appendix A). There is no way of being certain that the dolomite fragments are of the same age as the enclosing salt.

Frome Rocks Salt Dome

The Frome Rock Salt Dome is, at the present time, the only substantiated salt dome in Australia.

The lithologies of the rocks forming the salt dome have been described above.

The size and extent of the salt dome is not well known as in the most critical areas seismic reflections are few and hard to interpret. The gravity coverage of the area, including a detailed survey completed in 1959, suggests that Frome Rocks No. 1 is situated on the western side of an oval-shaped salt mass about two miles in length.

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* A sample of salt from Core 5, 2,480-2,490 feet, was examined by the Western Australian Government Chemical Laboratores (Lab.No.893/59), who reported:

'The water-soluble portion of the specimen submitted consists essentially of halite (sodium chloride), with a little gypsum.

The water-insoluble portion, comprising 4.8 percent of the sample, consists of calcite, clay, quartz and a trace of limonite.'

Seismic work shows the salt dome is bounded by faults on the west, north, and south. The northern and southern faults are sub-parallel to the north-west trending Fenton Fault and the distance between these faults ranges from 1 to 3 miles. The present estimated east-west extent of the salt dome is less than five miles, based on seismic data.

The thickness of the salt dome is not known as drilling ceased at 4,003 feet in salt after 3,269 feet of cap rock and salt had been drilled. The origin of the salt mass encountered in Frome Rocks No. 1 is not certain. It could be derived from Palaeozoic rocks in the Fitzroy Trough or Lower Palaeozoic rocks on the Jurgurra Terrace. No significant signs of rocksalt have been seen in the Devonian rocks of Frome Rocks No. 2 Well, so it appears unlikely that the salt has originated from the Lower Palaeozoic section on the Jurgurra Terrace. The Grant Range No. 1 Well encountered interbedded limestone, shale and anhydrite in the interval 9,680-10,180 feet, in the Upper Carboniferous Anderson Formation. It is possible that the salt has come from evaporites associated with these anhydrite beds, but it could also have its origin in as yet unknown Devonian or Ordovician evaporites deep in the Fitzroy Trough. It is thought that the salt was mobilized in this syncline at depths well below 10,000 feet and then moved to the south and up the plane of the Fenton Fault into the Frome Rocks area. Most of the movement of the salt must have taken place in Triassic times. This is shown in Figure 2, where it can be seen that the Permian is present north and south of the salt dome and is either very thin to absent over most of the salt dome. This cross-section could also mean that the salt dome was being pushed up at the same time as the Permian formations were being deposited. However the steep attitude of Permian formations north and south of the salt dome suggests that the Mesozoic sequence that overlies the salt dome has not been uplifted by the salt intrusion. In fact rather the opposite is the case as the Jurassic is thickest near Frome Rocks No. 1 and it is possible that the salt dome was exposed at the surface prior to the deposition of the Jurassic and the salt dome was eroded into a depression.

The salt dome has a particularly thick cap rock of dolomite breccia (1,522 feet). According to the classification of Leverson (1956, p.265) this thick cap rock would place the salt dome under class (3) - Old. The presence of much normal faulting and fracturing in the adjacent rocks also suggests this classification.

The cap rock is unusual in that it is entirely formed of dolomite with only very minor anhydrite and no sulphur or gypsum. This may be due to the fact that the well is located on the high point of the salt dome and the anhydrite, gypsum, and sulphur have been eroded off at this point.

The presence of the Frome Rocks Salt Dome does not increase the oil source rock or reservoir potential of this area. However, in an area such as the Canning Basin in which tectonic activity has been slight and thus the overall number of anticlinal structures is low for such a large basin, the presence of salt domes offers an alternative method of formation of structural traps for oil.

Velocity survey

A velocity survey was conducted at Total Depth by Geophysical Service International. Shots were taken with the well geophone at formation boundaries and at 500-foot intervals within formations. Shot holes were drilled at off-sets of 500, 1,000, 2,500, and 4,500 feet south-west of the well and 100 feet north-east of the well.

Two distinct velocity zones were defined by the survey. The first zone from sea level to -2,026 feet (the Mesozoic sequence and the dolomite breccia cap rock) has interval

velocities ranging from 8,500 to 12,775 feet per second. The second zone from -2,026 to -3769 feet (which is all salt) has interval velocities ranging from 14,060 (at the sedimentary contact) to 16,280 (at T.D.) feet per second.

An additional ten shots were made at long offsets in an endeavour to locate the southern extent of the salt mass. Seven shot holes were placed along a line running approximately due south from the well at offset distances from 11,540 to 15,040 feet. Shots were fired with the geophone in the well at -3,769 and -3,020 feet. The results of the survey were poor as the near shotpoints indicate the edge of the salt to be 400 to 1,200 feet south of the well and the far shotpoints indicate the edge of salt to be north of the well. The results may be considered inconclusive due to the lack of velocity contrast between the salt and the normal sediments.

Contributions to geological knowledge

(a) The drilling of Frome Rocks No. 1 showed the presence on the Jurgurra Terrace of a salt dome. Such structures had previously not been known from this area.

(b) The presence of this salt dome on the northern margin of the Jurgurra Terrace is of considerable help in the re-interpretation of similar complex structures on the Terrace in the Manguel and Barlee areas.

(c) Drilling of the highest point of the Frome Rocks Salt Dome failed to encounter any signs of hydrocarbons, indicating that any hydrocarbon accumulations associated with similar structures on the Jurgurra Terrace may be associated with flank traps.

(d) Flexures associated with salt dome intrusions may provide an alternate source of structural traps for the accumulation of hydrocarbons in this basin in which the tectonism is generally too slight to form large numbers of anticlinal folds.

Reference

LEVERSON, A.I., 1956 GEOLOGY OF PETROLEUM. Freeman, San Francisco.

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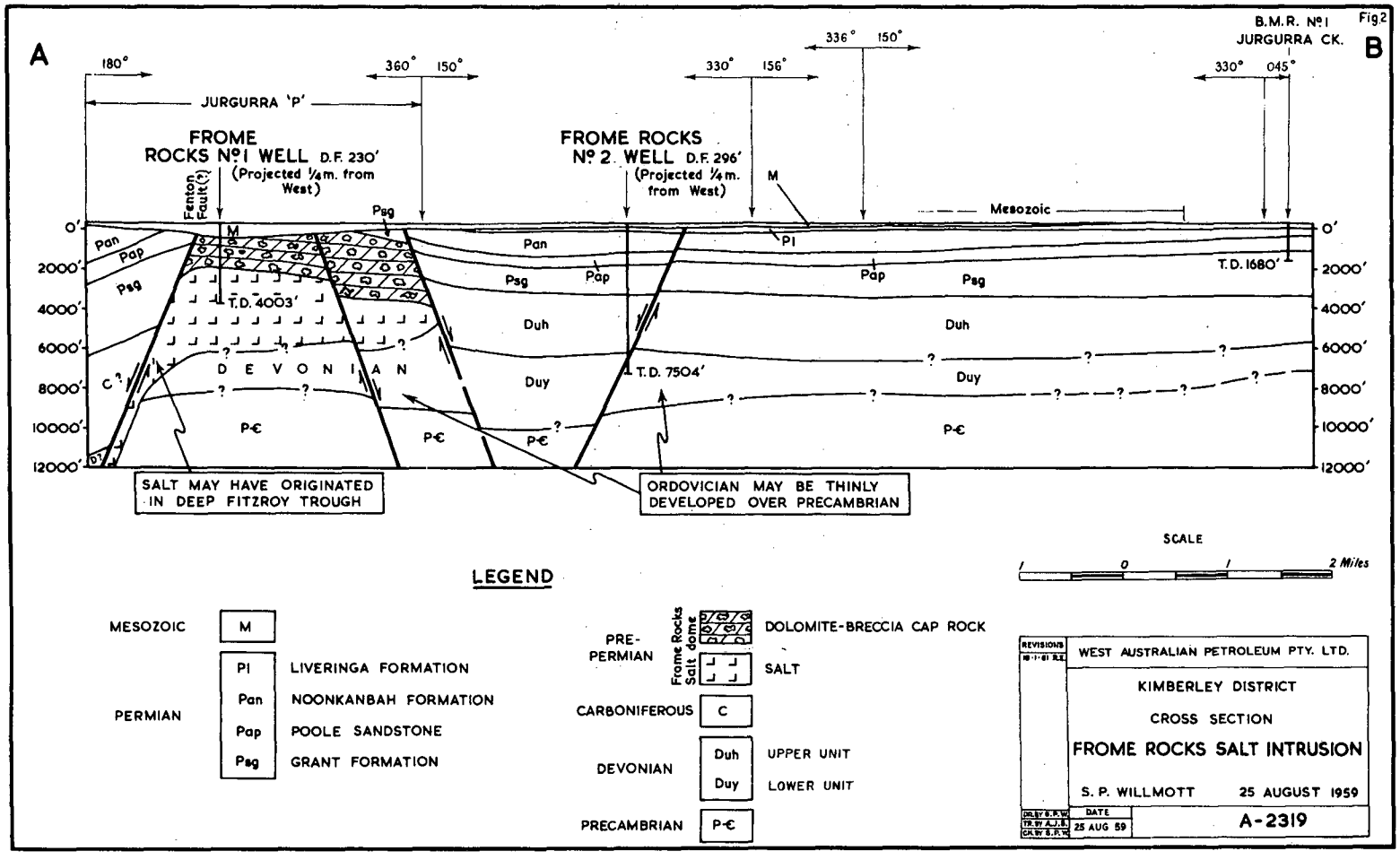
A
B
Fig.2
B.M.R. Nº1
JURGURRA CK.
180°
360° 150°
330° 156°
336° 150°
330° 045°
JURGURRA 'P'
FROME ROCKS Nº1 WELL D.F. 230'
(Projected ¼m. from West)
Fenton Fault(?)
FROME ROCKS Nº 2 WELL D.F. 296'
(Projected ¼m. from West)
M
Mesozoic
Psg
Pan
Pap
Pl
T.D. 1680'
T.D. 4003'
Duh
Duy
T.D. 7504'
C
D E V O N I A N
P-€
0'
2000'
4000'
6000'
8000'
10000'
12000'
SALT MAY HAVE ORIGINATED IN DEEP FITZROY TROUGH
ORDOVICIAN MAY BE THINLY DEVELOPED OVER PRECAMBRIAN
SCALE
1 0 1 2 Miles
LEGEND
MESOZOIC
M
PERMIAN
Pl LIVERINGA FORMATION
Pan NOONKANBAH FORMATION
Pap POOLE SANDSTONE
Psg GRANT FORMATION
PRE-PERMIAN
Frome Rocks Salt dome
DOLOMITE-BRECCIA CAP ROCK
SALT
CARBONIFEROUS
C
DEVONIAN
Duh UPPER UNIT
Duy LOWER UNIT
PRECAMBRIAN
P-€
REVISIONS
WEST AUSTRALIAN PETROLEUM PTY. LTD.
KIMBERLEY DISTRICT
CROSS SECTION
FROME ROCKS SALT INTRUSION
S. P. WILLMOTT 25 AUGUST 1959
DATE
25 AUG 59
A-2319

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GEOLOGICAL REPORT ON FROME ROCKS NO. 2 WELL

by

S.P. Willmott

West Australian Petroleum Pty Limited

Frome Rocks No. 2 Well was drilled to determine the nature, age, and petroleum potential of the sedimentary section to the south of the salt mass encountered in Frome Rocks No. 1. The well was on the apex of a small culmination approximately 4 miles south of Frome Rocks No. 1 and about 1 1/2 miles south of the southern boundary of the Frome Rocks Salt Dome. The well was located to test a large area of the southern flank of the salt dome, to the south of the faulted zone associated with the salt intrusion. An undisturbed section was expected to at least 5,000 feet and basement was predicted at -8,600 feet.

The Frome Rocks No. 2 Well penetrated a thin sequence of Recent and Jurassic sandstones, before drilling through a standard and almost complete Permian section. Beneath the Permian occurs a thick sequence of uppermost Devonian sediments which have been divided into two lithological units on the basis of samples and electric logs.

The primary objective of the well was the Ordovician sequence. The well was deepened from 7,000 feet to 7,504 feet in an attempt to reach the primary objective, without success.

Formation Descriptions

The section encountered in Frome Rocks No. 2 Well is set out in Table II below. The Mesozoic formation is dated by lithologic correlation with Frome Rocks No. 1, where it is dated on spores. The ages of the pre-Mesozoic formations have been determined by use of spores, pollen grains, ostracods, and conodonts. All age determinations are in agreement irrespective of the source of the dating. Palaeontological data are presented in Appendix A.

TABLE II

Formations Encountered in Frome Rocks No. 2 Well

Age	Formation	Formation Top Depth D.F. (feet)	Formation Top Depth Subsea (feet)	Thickness (feet)
Recent	Surface sand	9	+ 287	21
Jurassic (Middle to Upper)	Wallal Sandstone	30	+ 266	176
Permian (Artinskian?)	Liveringa Formation	206	+ 90	157
(Artinskian)	Noonkanbah Formation	363	- 67	1083
(Artinskian)	Poole Sandstone	1446	-1150	638
(Artinskian)	Nura Nura Member	2084	-1788	25
(Sakmarian)	Grant Formation	2109	-1813	1448
Devonian (Middle to Upper Famennian)	Upper unit	3557	-3261	2707
(Famennian)	Siltstone unit	6264	-5968	1240+
	T.D.	7504	-7208	

Recent

Surface sand (9 - 30 feet). The surface formation consists of loose, red, fine and very fine grained, clayey sands. The sand is apparently aeolian in origin.

Jurassic

Wallal Sandstone (30 - 206 feet). Middle to Upper Jurassic. Unconformably below the surface sand lies the Wallal Sandstone. The lithology of this formation is sandstone, mainly medium-grained, with fine, coarse and very coarse grained beds and lenses, and with some silty and conglomeratic lenses, thin bedded and cross-bedded, micaceous in part, ferruginous in some beds (lateritic?).

The formation is correlated on lithology with the Wallal Sandstone encountered in Frome Rocks No. 1, which has been dated by spores and microplankton.

The thickness of the Wallal Sandstone is slightly less in this well than in Frome Rocks No. 1 (176 feet compared to 187 feet in Frome Rocks No. 1). However, the top of the formation has been eroded. There is probably a general low northerly dip in the Jurassic formations between Frome Rocks No. 1 and Frome Rocks No. 2. The eroded top of the Wallal Sandstone is 583 feet higher in Frome Rocks No. 2, and the base of the unit is 594 feet higher. Outcrop at Frome Rocks Trig is believed to be uppermost Grant Formation, with a thin section of Wallal Sandstone. It is apparent that the Wallal Sandstone has been deposited on a very irregular surface of the Permian. It is thought that in Jurassic time, the Frome Rocks Salt Dome did not show as a topographic high but, as a result of erosion and solution of salt, was expressed as a depression. This explains the apparent dip of the Wallal Sandstone in a direction contrary to that which would be expected if, in Jurassic times, the salt dome had been a structural and topographic high.

Permian

Liveringa Formation (206-363 feet) Upper Artinskian(?). The lithology of this unit is sandstone, light grey, very fine grained, slightly calcareous, pyritic, with beds of siltstone, dark grey, shaly, micaceous, with pyrite nodules.

This formation was identified on lithology and electrical logs by comparison with Meda No. 1 and No. 2 Wells. It was not initially identified due to sample contamination etc., during the drilling of this part of the hole.

Noonkanbah Formation (363-1446 feet) Artinskian. Conformably below the Liveringa Formation is the Noonkanbah Formation. Lithologically this formation consists of siltstone and shale, dark grey, micaceous, pyritic, gypseous in upper part, fossiliferous with some coquinitic beds (brachiopods and bryozoa); with minor sandstone, very fine-grained to fine-grained, light grey, clayey, poorly sorted, slightly micaceous and calcareous, some pyrite. These lithologies are often finely and intimately interbedded, cross-bedding and slump structures are common, worm tubes and tracks are common throughout.

The formation is correlated with the Noonkanbah Formation of other wells, e.g. BMR No. 1 (Jurgurra Creek), Meda No. 1 and No. 2.

The age of the formation is given as Lower Permian (Artinskian) by B.E. Balme (Appendix A).

The base of the formation is placed at the base of a thin succession of interbedded sandstone and siltstone between 1,373 feet and 1,446 feet.

Poole Sandstone (1,446-2,084 feet) Artinskian. The Poole Sandstone lies conformably below the Noonkanbah Formation. The formation consists of sandstone, very fine and fine grained, green-grey, micaceous, moderately sorted, some pyrite and chalcopyrite (?), glauconitic (?), with beds of siltstone and shale, dark grey, micaceous. This passes downwards into sandstone, coarse and very coarse grained, well rounded grains, some pyrite cement but generally soft and poorly consolidated, rare beds of coal. Minor shale and sandstone, medium-grained, kaolinitic cement, occur towards the base of the unit. Passes into siltstone, dark grey, micaceous, with seams and lenticles of shale and sandstone, very fine grained, kaolinitic cement, some pyrite, cross-bedded throughout.

Between 1,500 feet and 1,900 feet the sandstones are poorly consolidated and presented some difficulty in control during the drilling of this section.

The age of this formation has been determined by Balme (Appendix A) as being Lower Artinskian to possible Sakmarian at the bottom of the unit.

Nura Nura Member of the Poole Sandstone (2,084-2,109 feet) Artinskian. At the base of the Poole Sandstone is the Nura Nura Member. Lithologically it consists of siltstone, grey, very fine grained, sandy, with bryozoa, and minor calcilutite, white, soft, and limestone, sandy, green.

Grant Formation (2,109-3,557 feet) Sakmarian. Disconformably below the Nura Nura Member occurs the Grant Formation. This formation consists of three distinct units. The lithologies of these units are as follows:

Upper unit (2,109-2,725 feet). Sandstone, fine, medium and coarse grained, with conglomerate beds with pebbles of pink and grey granite, chert, and quartz; feldspathic for most part, generally poorly-sorted; poorly cemented (kaolinitic) with rare hard calcareous bands (fontainebleau sandstone).

Middle unit (2,725-2,908 feet). Shale, green-grey, very fissile, soft, non-calcareous, with minor sandstone, medium-grained, white and grey, calcareous, some pyrite, and sandstone as for 2,109-2,725 feet.

Lower unit (2,908-3,557 feet). Consists mainly of sandstone as for 2,109-2,725 feet with increasingly abundant thin beds of fontainebleau sandstone.

The Grant Formation is not specifically dated in this well, but is Sakmarian in age.

Devonian

Upper unit (3,557-6,264 feet). A thinly bedded, interbedded sequence of siltstone, shale, limestone, and fine sandstone lies unconformably beneath the Permian Grant Formation and conformably overlies an unnamed siltstone unit in Frome Rocks No. 2 Well.

This unit consists of finely interbedded siltstone and shale, dark grey, slightly calcareous, slightly micaceous, with numerous bands rich in ostracods, also abundant, thin (1/2 - 1 inch), lenses of coquinitic limestone. It contains subordinate beds of limestone (re-

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crystallized calcarenite), brown-cream and grey, dense, non-porous, hard, often silty, and with numerous sandy beds, pyrite often present but not common. About 16 percent of the formation consists of sandstone, very fine grained, chloritic and micaceous, porous, slightly permeable, calcareous cement. In parts of the unit, the limestone beds are the dominant lithology, but generally the siltstone and shale are dominant.

The unit is believed to be Middle to Upper Famennian in age, based on examination of abundant ostracods by P.J. Jones, microspores by B.E. Balme, and conodonts by B.F. Glenister (Appendix A).

Slight fluorescent oil shows were noted in numerous non-porous fossiliferous limesone beds. In addition, the uppermost sandstone bed of the formation showed spotty staining by a brown, non-fluorescent "dead" oil.

Siltstone unit (6,264-7,504 feet). Beneath the upper unit of the Devonian in Frome Rocks No. 2 is a monotonous siltstone unit. The two units are apparently conformable.

The lower unit consists of siltstone, medium to dark grey, some beds slightly calcareous, micaceous (biotite); thinly bedded and cross-bedded, with interbedded very fine sandy beds and shaly beds. It contains occasional thin (up to 1/2 inch) beds of sandstone, very fine grained, calcareous, hard, light grey, very slightly porous, micaceous. The siltstone varies from a greywacke-siltstone to a very fine grained sub-greywacke in places. Most cores show salt incrustations on drying, which is quite usual in the case of dark rocks containing saline waters. The formation contains rare calcite-filled gashes and numerous slickensides.

The unit is believed to be Middle to Lower Famennian in age, based on examination of microspores by Balme, and of a goniatite (Clymenia sp.) by Glenister (Appendix A).

All cores recovered from this unit show reasonably strong dips; in addition, all cores show abundant slickensiding, shearing, and other deformation characteristics. A fault is believed to occur at about 6,560 feet, where a small percentage of an apparently silicified siltstone occurs in ditch samples. However, examination of the section gauge indicates that the formation is considerably fractured (badly caved hole) above the conspicuous thin limestone bed at 6,767 feet but is unaffected below this depth, where the section gauge shows the hole to be close to gauge. That this conspicuous caving is due to fracturing of the formation and not to different chemical properties of the siltstones above and below the thin limestone bed can be seen by study of the electrical and radioactivity logs of this interval. Hence it is thought that this thin, prominent limestone bed forms the base of the complex zone of deformation encountered by this well. The thin limestone bed is probably the lowest and most prominent zone of movement and represents cemented fault gouge.

It is probable that the poor core recovery in this formation was due to the breaking up of the fractured and slickensided siltstone in the core barrel.

Structure

Frome Rocks No. 2 Well was located on the apex of a small culmination south of the Frome Rocks Salt Dome. Evidence from cores and dipmeter indicates that down to the top of the Devonian dips are flat. Flat dips are recorded within the upper unit of the Devonian at 3,939 feet (nearly two hundred feet below the Permian-Devonian unconformity). However below

this point dips in excess of 5° are recorded from 4,438 feet (dipmeter) to 6,993 feet (visual) - a thickness of 2,555 feet. A rapid increase of dip from 15° to 28° occurs between 6,019 feet and 6,296 feet, indicating the probability that the high dips are due to faulting. The siltstone unit of the Devonian is minutely fractured and contains numerous zones of slickensiding. The most prominent of these zones is associated with silicified beds of siltstone at 6,560 feet and is thought to represent one of the major fault planes responsible for the steep dips in the Devonian sequence. The striking thin limestone bed at 6,767 feet with its fractured zone above and compacted zone below is thought to represent another of the major fault planes of this complex fault zone. About 2,400 feet of the Devonian rocks shows dips greater than 5°, and these are overlain and underlain by sub-horizontal beds. It is thought unlikely that only one normal fault could be responsible for such a thick disturbed zone, and the irregular variation of dip at various depths tends to indicate that a wide fault zone was encountered.

Hydrocarbon Shows

Shows of hydrocarbons were detected in several zones throughout the upper unit of the Devonian. No shows were detected in any other formation.

Hydrocarbon shows in the upper unit of the Devonian fall into two classes -

(a) 3,690-3,721 feet : Flecks of a dark brown non-fluorescent waxy "dead" oil were observed in cuttings of very fine grained sandstone. Cuttings were porous and apparently slightly permeable. Flushing of some cuttings could be observed. A positive cut with carbon tetrachloride was obtained; the cut was a dark brown wax which was non-fluorescent. Some dark brown waxy oil was also observed in cracks in cuttings of limestone down to 3,746 feet.

The sandstone was apparently water saturated and no test was carried out. Subsequent electric logs confirmed the decision not to test.

(b) 3,810-3,860
4,160-4,189
4,450-4,470
4,852-4,861
5,140-5,200
5,480-5,580
5,610-5,710
6,040-6,140 feet : In ditch samples from all the zones listed fluorescence was noted. The percentage of fluorescent chips ranged from a trace only to about 80 percent in rare samples. The fluorescence was bright golden yellow to yellowish green and in all cases originated from limestone chips, in most cases from richly fossiliferous ostracodal limestone. Positive cuts with carbon tetrachloride were obtained on many of the samples; however, the amounts of oil recovered by cutting were extremely slight and could only be detected by examining the evaporated cut, which showed a residue of globules of light brown brightly fluorescing oil. Porosity and permeability in all cases were almost nil on observed cuttings. Fluorescent limestone was recovered in only one core (Core No. 16, 4,852-4,861 feet): in this case the fluorescence disappeared after 24 hours exposure to the atmosphere. Visible oil or visible porosity was not observed in fluorescent cuttings.

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Contributions to Geological Knowledge

The contributions to geological knowledge made by this well may be summarized as follows :

(a) The well showed that at least portion of the Devonian sequence in this region was petroliferous.

(b) It indicated that sandstone reservoir beds are developed within a prospective source-rock sequence. In general the porosity and permeability of these potential reservoir beds is considered to be low. However, if a more arenaceous section can be located in future wells on the Jurgurra Terrace, it seems probable that good sandstone porosity and permeability will be developed with a consequent upgrading of the reservoir potential of the Jurgurra Terrace. Frome Rocks No. 2 is the first well to encounter significant porosity and permeability in sandstones in the pre-Permian of the Kimberley District.

(c) Apparently, hydrocarbons have migrated through the uppermost porous sandstone bed of the Devonian. It is probable that such oil was either lost or is now contained in a fault trap against the Frome Rocks salt intrusion.

(d) Frome Rocks No. 2 showed that, for the Frome Rocks area, no oilfield of large areal extent exists. It is possible that considerable vertical closure against the salt mass may compensate for lack of wide areal extent of the reservoir. Should any producible hydrocarbons be found on other similar structures on the Jurgurra Terrace, fault-trap accumulations should be considered.

(e) The presence of a thick Devonian succession on the Jurgurra Terrace was proved. Nearly 4000 feet of Devonian rocks were drilled. Additional Devonian, and possibly some Ordovician, rocks may lie between the bottom of the well and basement in this area.

(f) Salt is apparently absent from this part of the Jurgurra Terrace. This tends to confirm previous ideas that the salt mass encountered in Frome Rocks No. 1 migrated there from the Fitzroy Trough instead of being derived from evaporite deposits on he Jurgurra Terrace. It is possible, however, that an evaporite sequence may occur on the Terrace between greatest depth reached by Frome Rocks No. 2 Well and basement.

(g) The concept of the Jurgurra Terrace being a relatively stable shelf marginal to the Fitzroy Trough while the latter was actively sinking in Upper Carboniferous and part of Permian time was confirmed by the drilling of Frome Rocks No. 2. This well penetrated a reduced section of the Permian, 3351 feet thick, containing all the Permian formations except the upper part of the Liveringa Formation. Upper Carboniferous deposits were not met in the well. In the vicinity of Grant Range No. 1 Well in the Fitzroy Trough, the equivalent section of Permian and Upper Carboniferous rocks is over 17,000 feet thick.

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APPENDIX A

PALAEONTOLOGICAL REPORTS

PALYNOLOGICAL EXAMINATION OF SAMPLES FROM FROME ROCKS WATER BORE NO. 1

by

B.E. Balme

University of Western Australia

Sample No. 1

Pale grey claystone

Depth: 145-165 feet

This sediment yielded a remarkably diverse assemblage of microplankton including undescribed species of dinoflagellates and hystrichosphaerids. It contained few spores or pollen grains, the only types identified being:

Cingulatisporites floridus Balme
Microcachryidites antarcticus (Cookson)
cf. Gleichenia sp.

Remarks

The microplankton suite appears distinct from and younger than that from the Jarlemai Siltstone in the Broome Bore. C. floridus is also an uppermost Jurassic and Lower Cretaceous form in other parts of Western Australia. The unit may be uppermost Jurassic but a Lower Cretaceous age seems more probable.

Sample No. 2

Grey siltstone

Depth: 390-411 feet

This sample yielded a rich microflora together with fairly large numbers of microplankton. The forms identified were :

SPORES AND POLLEN GRAINS	MICROPLANKTON
Lycopodium sp.	Hystrichosphaeridium sp.
Cyathidites minor Couper	Gonyaulax sp.
C.australis Couper	
Cingulatisporites caminus Balme	
Cicatricosisporites cooksoni Balme	
Zonalapollenites dampieri Balme	
Z. trilobatus Balme	
Araucariacites australis Cookson	

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Remarks

The abundance of Z. dampieri and A. australis together with the character of the microplankton suggest an Upper Jurassic age. The sediment probably correlates with the lower part of the Jarlemai Siltstone and is of Oxfordian-Kimmeridgian age.

PALYNOLOGICAL REPORT ON SAMPLES FROM FROME ROCKS NO.2 WELL

by

B.E. Balme

University of Western Australia

Sample No. 1 : Grey siltstone

Depth : 696-706 feet

Spores and pollen grains were plentiful but rather poorly preserved. Hystrichospaerids were also common. Lueckisporites (s.l.) various species of Cirratriradites, Pityosporites and Leiotriletes were the most abundant genera.

The sample is of Permian age and may come from the upper part of the Noonkanbah Formation, although it could also be from the lower part of the Liveringa Formation.

Sample No.2 : Black shale

Depth : 1,097-1,107 feet

This sample yielded a rich microflora in which the dominant elements were Lueckisporites (s.l.), Cirratriradites, Granulatisporites, Marsupipollenites and Leiotriletes.

I consider the assemblage to be of Lower Permian (Artinskian) age and to correlate with those from the Noonkanbah Formation in Meda No. 1 Well.

Sample No.3 : Black shale

Depth : 1,498-1,508 feet

Spores and pollen grains were abundant and the assemblage diverse and well-preserved. Nuskoisporites, Cirratriradites, Punctatisporites, Vittatina, Verrucosisporites, and Vestigisporites were abundantly represented.

The microflora is of Lower Permian age and probably comes from the Poole Sandstone or basal Noonkanbah Formation.

Sample No. 4 : Dark grey shale

Depth : 2,072-2,082 feet

This microflora was rich and fairly well preserved. Punctatisporites gretensis Balme & Hennelly, Cirratriradites, Nuskoisporites and Verrucosisporites were abundant. The assemblage resembles that from the Grant Formation and the lower part of the Poole Sandstone. The occurrence of Granulatisporites cf. trisinus suggests that it may be of Artinskian rather than Sakmarian age.

Sample No. 5 : Black shale

Depth : 3,571-3,578 feet

This sample reacted violently with the macerating fluid suggesting the presence of easily oxidized bitumens. The spore assemblage was diverse and well-preserved. Many of the spores present were undescribed types although some compare closely to forms described from the Devonian of Russia. The presence of a species of "Hymenozonotriletes" known only from the Mt. Pierre Group suggests that the present sample is of Upper Devonian age. My opinion is that it is uppermost Devonian.

Sample No.6 : Calcareous siltstone and shale

Depth : 3,737-3,745 feet

This microflora was basically similar to that from the previous sample. It has many features in common with assemblages from the Fairfield Beds in the Kimberley Downs and Laurel Downs Bores although there are also certain differences. The present assemblage may be high in the Famennian.

Sample No. 7 : Black shale

Depth : 4,275-4,280 feet

This sample yielded a rich assemblage of spores, large cuticle fragments, and a few microplankton. The spores were particularly well preserved. The microflora indicates a Famennian age for the sample and is similar to that obtained from a depth of about 1,600 feet in the Laurel Downs Bore.

The presence of large cuticle fragments suggests a nearshore marine or continental environment of deposition.

Sample No. 8 : Black shale

Depth : 4,471-4,481 feet

This sample yielded a rich microflora and large fragments of cuticle were again abundant. A Famennian age is suggested for the sample.

Sample No. 9 : Black silty shale

Depth : 5,220-5,227 feet

Only a few simple trilete spores were obtained from this sample. They are of little value in assessing its age.

Sample No. 10 : Black shale

Depth : 5,589-5,596 feet

Although the spores were darkened in colour the assemblage was diverse and the specimens well-preserved. The microflora is of Upper Devonian age and in my opinion Famennian.

Sample No. 11 : Black micaceous shale and calcareous siltstone

Depth : 5,925-5,935 feet

The spores were dark in colour and the microflora depleted in types. The assemblage is of Upper Devonian age. It could be older than Famennian, although in my view it is younger than the microflora from the Gneudna Formation (Frasnian) in the Carnarvon Basin.

Sample No. 12 : Black micaceous shale

Depth : 6,648-6,653 feet

Although they were considerably darkened spores were still identified in this sample. Only six different forms were recorded but these included species knwn only from the Upper Devonian of the Fitzroy Basin. The sample may be of Frasnian or Famennian age but again I consider it to be younger than the Gneudna Formation in the Pelican Hill Bore.

PALYNOLOGICAL EXAMINATION OF CORES FROM FROME ROCKS NO. 1 WELL

by

P.R. Evans

Bureau of Mineral Resources

A preliminary examination of selected main cores and sidewall cores (listed below) from Frome Rocks No. 1 Well has been made for their microplankton content. Microplankton and sporomorphs from the top three samples indicate that Jurassic strata persist to a depth of 655 feet. The dolomitic beds below that level yielded no fossils except those sampled in Cores 1 and 2 in which Jurassic sporomorph and microplankton fragments were found. As Cores 1 and 2 consisted of deformed plugs of sediment into which the drilling mud could have entered readily the microfossils from Cores 1 and 2 could be regarded as contaminating elements included in the "cores" during drilling.

CORE	DEPTH (feet)	LITHOLOGY	CONTENT
swc 2	355	grey siltstone	Jurassic plankton
swc 9	540	" "	
swc 11	655	light grey, fine-grained sandstone	
swc 12	758	dolomitic, light grey mudstone	Barren
swc 14	769 1/2	do with pyrite	
swc 19	883	dolomitic, light grey mudstone	
core 1	1030-46	incompetent calcilutite with euhedral prismatic quartz	
core 2	1277-87	" "	
core 3	1680-90	" "	
core 4	2080-90	" "	
core 6	2740-50	salt, with red and green dolomite and shale breccia	
core 10	3560-70	salt, with minor pyritic dolomite fragments	

S.W.C. 2

MICROPLANKTON

Dinoflagellata

Dingodinium jurassicum Cookson & Eisenack 1958
Gonyaulax cf. G. jurassica Deflandre 1938
Dinoflagellata spp.

Hystrichosphaeridea

Cannosphaeropsis sp.
Hystrichosphaeridium spp.
Micrhystridium spp.
Pterospermopsis sp.
Veryhachium sp.

Incertae sedis

Palaeostomocystis sp.
Wanaea clathrata Cookson & Eisenack 1958

SPOROMORPHS

Sphagnumsporites australis (Cookson 1947)
Gleichenia sp.
Cicatricosisporites cooksoni Balme 1957
Lycopodiumsporites austroclavidites v. tenuis Balme 1957
Zonalapollenites dampieri Balme 1957
Podocarpidites cf. P. ellipticus (Cookson 1947)
Microcachryidites antarcticus Cookson 1947

D. jurassicum is the most abundant of the microplankton species, the remainder being represented by a few specimens only. The assemblage is essentially similar to ones from Cape Range and Wallal which are considered to be Middle to Upper Jurassic in age, but the absence of many species in swc 2 and the different abundances of those present do not permit any finer correlations at this stage. The abundance of Z. dampieri and the paucity of M. antarcticus is characteristic of Balme's microflora IIa (1957) which is considered by him to be Oxfordian to Kimmeridgian in age.

S.W.C. 9

MICROPLANKTON

Dinoflagellata

Dingodinium jurassicum Cookson & Eisenack 1958
Gonyaulax jurassica Deflandre 1938
Gymnodiunium crystallinum Deflandre 1938

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Hystrichosphaeridea

Cannosphaeropsis cf. C. filamentosa Cookson & Eisenack 1958
Cymatiosphaera sp.
Cannosphaeropsis n. sp.
Hystrichosphaeridium spp.
Leiofusa sp.
Veryhachium cf. V. geometricum (Deflandre 1942)

Incertae sedis

Pareodinia aphelia Cookson & Eisenack 1958
Nannoceratopsis pellecudia Deflandre 1938
Wanaea digitata Cookson & Eisenack 1958

SPOROMORPHS

Gleichenia sp.
Classopollis sp.
Cingulatisporites saevus Balme 1957
Zonalapollenites dampieri Balme 1957
Striatites spp.
Nuskoisporites sp.

The above assemblage suggests that swc 9 is also of Middle to Upper Jurassic age. D. jurassicum is no longer abundant. W. digitata has been described only from the Learmonth Formation and Broome Bore No. 3. C. filamentosa occurs in Callovian and Kimmeridgian equivalents in the Dingo Claystone. Z. dampieri is still very abundant. Striatites and Nuskoisporites are Permian genera which presumably have survived reworking. Likewise V. cf. geometricum ranges from the Upper Ordovician to the Devonian in Europe and is possibly a reworked form. It has not been observed in Australian samples previously.

S.W.C. 11

MICROPLANKTON

Dinoflagellata

Gonyaulax spp.

Hystrichosphaeridea

Cymatiosphaera sp.
Hystrichosphaeridium spp.
Micrhystridium spp.
Veryhachium spp.

Incertae sedis

cf. Palaeostomocystis

33

SPOROMORPHS

Podosporites micropteris (Cookson & Pike 1954)
Zonalapollenites segmentatus Balme 1957
Bisaccate and Zonate spp.

The yield was poor and none of the species listed was abundant. The species of Veryhachium and Micrhystridium were reminiscent of forms occurring in BMR 4A (Wallal) Cores 2 - 6 but the mode of preservation of the microplankton is rather unusual. A clot of clay or spongy organic material containing specimens of Veryhachium and Micrhystridium and a solitary specimen of Veryhachium represent these two genera in the sample. This "clot" formation is characteristic of the Blina Shale of Meda No. 1 and BMR 4A (Wallal) Core 6 (considered equivalent to the Blina Shale), at which horizon abundant species of the two genera occur. It is possible that the specimens in swc 11 of Frome Rocks No. 1 are from reworked Blina Shale. Z.segmentatus (relatively common in this sample) was described by Balme (1957) from the Cockleshell Gully Sandstone and is considered by him to be rare outside that formation. A possible Lower to Middle Jurassic age is therefore tentatively suggested for swc 11.

Reference

BALME, B.E., 1957 Spores and pollen grains from the Mesozoic of Western Australia. Sci.ind.Res. Org., Coal Research Sect. Tech. Comm. 25

CONODONTS AND FISH PLATES FROM FROME ROCKS NO. 1 WELL

by

Brian F. Glenister

State Univerity of Iowa

Dolomite fragments from Cores 2, 4, 5 and 6 were digested in a 20 percent concentration of acetic acid. Insoluble residues from Cores 2, 4 and 6 were barren of fossil material, but Core 5 yielded fish plates and a single fragment of a conodont. These few fossils do not permit a precise age assignment for the parent dolomite. However, the information derived from them, inconclusive though it may be, is documented herein, as it has an indirect bearing on the minimum age of the salt. No other palaeontological evidence relating to the age of the dolomite fragments in the halite-dolomite breccia is available from Frome Rocks No. 1

Core 2, 1277-1287 feet

Barren

Core 4, 2080-2090 feet

Barren

Core 5, 2480-2490 feet

Holmesella sp.
conodont bar, gen. ind., cf. *Hindeodella* sp.

Core 6, 2740-2750 feet

Barren

Fish plates referable to *Holmesella* are common in the Pennsylvanian of the central United States of America (Gunnell, 1933), but occur in older beds in Western Australia. The present author has recovered the genus in early Carboniferous strata from both the Bonaparte Gulf and Canning Basins, and from the Upper Devonian of the Lennard Shelf and the Carnarvon Basin (Gneudna Formation, and Pelican Hill Bore (1596-2143 feet)). The oldest occurrence known from Western Australia is in the early Frasnian Sadler Formation; representatives are unknown in strata younger than Carboniferous.

From the information submitted, it appears fairly certain that at least some of the dolomite fragments in Core 5 are either Upper Devonian or Carboniferous in age. Previous conodont studies indicate that *Holmesella* is most common in the late Upper Devonian and early Carboniferous of northwestern Australia, and an age between these limits seems most probable for the parent strata of at least some of the carbonate fragments in Core 5.

A single conodont recovered from Core 5 is an indeterminate bar. A few superficially similar forms occur in the Ordovician and Silurian, but are unknown in Western Australian sections of these two systems. Specimens practically identical to the damaged fragment from Core 5 are common in the Upper Devonian and early Carboniferous of north-western Australia, and they are known elsewhere in strata as young as Triassic. The evidence from this conodont is thus compatible with the age suggested by the presence of *Holmesella*.

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The petrology of acid residues from the cores listed above is of interest and may possibly be significant. Euhedral authigenic grains of quartz and pyrite are a conspicuous component of all the acid residues from Cores 2, 4, 5 and 6. Similar euhedra are characteristic of the Ordovician limestones from the Canning Basin bores. They are uncommon in the Devonian limestones of the Fitzroy Basin. These unusual features may indicate that the bulk of the dolomite fragments in Cores 2-6 were derived from Ordovician sediments.

None of the evidence presented above should be considered conclusive. It is documented only because of the absence of other reliable information. However, fish plates and conodonts suggest either late Devonian or early Carboniferous age for some of the dolomite fragments, whereas the authigenic minerals may indicate that other dolomite fragments were derived from Ordovician strata. In aggregate, this evidence suggests that pre-Ordovician (probably Cambrian) salt has been mobilized to penetrate both Ordovician and late Devonian - early Carboniferous carbonates.

The author takes pleasure in expressing appreciation for unfailing cooperation from the management and staff of WAPET, and for permission to publish results of the studies on the Frome Rocks wells.

Reference

GUNNELL, F.H., 1933 Conodonts and fish remains from the Cherokee, Kansas City, and Wabaunsee Groups of Missouri and Kansas. J. Paleont., 7, 261-297, pls 31-33.

CLYMENIA AND CONODONTS FROM FROME ROCKS NO. 2 WELL

by

Brian F. Glenister

State University of Iowa

Portions of ten cores were digested in a 20 percent concentration of acetic acid. Three of them yielded small numbers of conodonts. Most of the remaining cores included either fish fragments or scolecodonts, and Core 23 (6,986-6,993 feet) contained a well-preserved ammonoid. These fossils indicate a Famennian age for the lower portion of the sectioned interval, but higher strata may be either late Upper Devonian or early Carboniferous.

Core 9, 3,571-3,578 feet

Spathognathodus sp.

fish teeth and plates
scolecodonts

Cores 10 and 11, 3,737-3,745 feet

Holmesella sp.

ornate fish plates and teeth
scolecodonts

Core 13, 4,172-4,180 feet

scolecodonts

Core 14, 4,275-4,280 feet

Spathognathodus sp.
Hindeodella sp.
conodont fragments
Holmesella sp.
ornate fish plates and teeth
scolecodonts

Core 16, 4,852-4,861 feet

Spathognathodus sp.
Synprioniodina sp.
Holmesella sp.
ornate fish plates and teeth
scolecodonts

Core 17, 5,220-5.227 feet

Holmesella sp.
ornate fish plates and teeth

Core 19, 5,925-5,935 feet

Holmesella sp.
ornate fish plates and teech.

Core 20, 6,296-6,303 feet

Barren

Core 23, 6,986-6,993 feet

Clymenia cf. C. laevigatus (Münster), 1832

None of the conodont taxa recovered from Cores 9-20 have the short ranges characteristic of many late Devonian and early Carboniferous representatives. However, the species of Spathognathodus from Cores 9, 14 and 16 lack the auxiliary denticles which characterize most, but not all, early Carboniferous species of the genus. Consequently, the parent strata of Cores 9-20 may range in age from late Famennian to early Carboniferous, but a late Famennian age (Clymenia or Wocklumeria zone) is considered more probable.

A single crushed ammonoid is known from Core 23. It attains a maximum diameter of 30 mm and a corresponding umbilical dimension of 16 mm. The specimen consists of at least six slowly expanding septate whorls, plus one-quarter volution of body chamber. A runzelschicht is preserved on portion of the phragmocone, but growth lamellae can not be observed. The internal mould is smooth. External sutures are displayed clearly. They form a low ventral saddle and a rounded lobe extending across the full width of the flanks; a shallow rounded incipient lobe traverses the trough of this lateral lobe.

The wide umbilicus, slow rate of expansion, and simple suture clearly place this species in the Family Clymeniidae, but generic assignment is more difficult. However, the absence of triangular coiling and the simple suture eliminate the possibility of reference to most clymeniid genera. Conch morphology permits reference to either Platyclymenia or Clymenia sensu stricto, and the external suture is somewhat intermediate between these two genera. However, the presence of the shallow incipient lobe across the flank indicates closest affinities with Clymenia. All observable features of the Australian specimen are closely comparable to those of the type species of Clymenia, C. laevigatus (Münster), 1832. This genus is common in western Europe, where it is confined to the Clymenia zone (V) of the Upper Devonian (Famennian), and a similar age can be assumed for the parent stratum of the Fitzroy Basin.

It is of interest to note that Teichert (1949, p.24) recorded "Laevigites? sp. ind." (Clymenia Münster, 1834 = Laevigites Wedekind, 1914 (nom. nud.)) from the "Productella zone" (Fairfield Beds) of the Lennard Shelf.

References

MÜNSTER, G.G. zu, 1832, Ueber die Planuliten and Goniatiten im Uebergangs-Kalk des Fichtelgebirges. Bayreuth, p.1-38, pls 1-6.

TEICHERT, CURT, 1949, Observations on stratigraphy and palaeontology of Devonian, western portion of Kimberley Division, Western Australia. Bur.Min.Resour.Aust.Rep. 2, 1-55, pls 1-6.

PRELIMINARY NOTES ON UPPER DEVONIAN OSTRACODA FROM FROME ROCKS NO.2 WELL

by

P.J. Jones

Bureau of Mineral Resources

The rich ostracod fauna found in cuttings between 3,640 and 3,680 feet and ostracods extracted from cores 10 and 11 (combined), 13, 14, 15, 16, 17, and 18, taken between the depths of 3,737 and 5,596 feet, are of Upper Devonian age.

The ostracods are referred to Assemblage A (Jones, in Veevers & Wells, 1961), which indicates a late Famennian age.

Cuttings : 3640-3680 feet

Richly fossiliferous calcarenite and siltstone

Ostracoda

Aparchites sp. A
A. sp. B
Bairdia sp.
Cavellina sp. nov. 2
C. sp.
Knoxiella sp.
Paraparchites sp. cf. *nicklesi*

Conchostraca

Rhabdostichus sp.

Remarks

Aparchites sp. A occurs in the Fairfield Beds at Oscar Hill, and *A.* sp. B has been found about 50 feet above the base of the Fairfield Beds in WAPET/BMR section DL 2, south of Burramundi Range. Both species occur in the Upper Devonian sequences of The Sisters No. 1, and BMR 2, Laurel Downs. In North America and Europe the genus *Aparchites* is not known to occur in the Carboniferous.

Bairdia sp. is a long-ranging species which occurs in ostracod Assemblage B (Jones, in Veevers & Wells, 1961), in the middle part of the Burt Range Limestone (Upper Devonian - Lower Carboniferous?) of the Bonaparte Gulf Basin. In BMR 2, Laurel Downs, *Bairdia* sp. is found in Assemblage B (1210-1535 feet), and in Assemblage C (350-1155 feet) of Lower Carboniferous (Tournaisian) age (Jones, in Veevers & Wells, 1961).

Cavellina sp. nov. 2 occurs in the Fairfield Beds at Oscar Hill, and south of Burramundi Range about 50 feet above the base of this formation in section DL 2. In subsur-

face sections it is found in the Upper Devonian sequences of BMR 2 from 1,775-2,810 feet, and in The Sisters No. 1 from 7,145-7,650 feet. This species is only doubtfully referred to the genus Cavellina, as it shows some resemblance to the genus Chapmanites due to the presence of a comb-like ridge on the dorsal margin of the right valve.

Knoxiella sp. is found in the middle part of the Burt Range Limestone of the Bonaparte Gulf Basin, and also occurs in subsurface Upper Devonian sediments of the Fitzroy Basin in BMR 2, and The Sisters No. 1 wells. An examination of cores taken from BMR 2 yielded poorly-preserved specimens, which were doubtfully referred to Jonesina craterigera in an earlier preliminary report (Jones, 1959). A later examination of cuttings revealed well-preserved specimens, which together with the specimens from Frome Rocks No. 2 showed that the former indentification is erroneous, and that this species belongs to the Russian genus Knoxiella. It closely resembles K. reticulata Copeland 1957, the only known American representative of this genus, from the Middle Devonian Ludlowville Formation of western New York. In the U.S.S.R., species of Knoxiella are known to range from Middle Devonian (Givetian) to Lower Carboniferous (Stalinogorsk to Aleksin horizons, approximately middle Visean).

Paraparchites sp. has been found in the Lower Carboniferous (Moogooree Limestone, Laurel Formation, and Septimus Limestone), and in the Upper Devonian (Fairfield Beds and Burt Range Limestone) of Western Australia. It resembles the North American species P. nicklesi, which ranges from basal Kinderhookian (or perhaps lower if the ostracods which Morey described in 1935 include reworked Upper Devonian forms, as Sohn (1951) has suggested) to Lower Pennsylvanian. This species also occurs in the Lower Carboniferous and Upper Devonian sequences of BMR 2.

The Conchostracan Rhabdostichus sp. occurs in the Upper Devonian sequence of BMR 2. It shows a close resemblance to the elongated forms of R. buchoti (Peneau) from the Silurian or Devonian from north-west France, but is much smaller than the French species, which could be due to dwarfing.

Core 9 : 3,571-3,578 feet

Calcarenite and green siltstone, with indeterminate brachiopods and fragments of crinoid columnals. No other fossils were found.

Cores 10 & 11 : 3,737-3,745 feet

Dense grey limestone, with abundant ostracods, which appear to form a high percentage of the rock.

Ostracoda

Cavellina sp. nov. 2
C. sp.
Knoxiella sp.
Paraparchites sp. cf. nicklesi

Conchostraca

Rhabdostichus sp.

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Annelida

Spirorbis sp.

Age : Upper Devonian

S.W.C. 14 : 4,000 feet

Shale and siltstone

Ostracoda

Glyptopleura sp. nov.
Knoxiella sp.

Conchostraca

Rhabdostichus sp.

Age : Upper Devonian

Core 13 : 4,172-4,180 feet

Dense grey limestone with scattered ostracods, which include Knoxiella sp., and an undetermined drepanellacean genus (possibly belonging to Milanovskaya Egorov).

Age : Upper Devonian.

Core 14 : 4,275-4,280 feet

Dense dark grey argillaceous limestone, with slickensided surfaces and laminae of pyrite. Ostracods common, occurring in bands, together with conchostracan fragments and a well ornamented fish plate.

Ostracoda

Aparchites sp. A
Cavellina sp. nov. 2
Undetermined kloedenellacean genus A (possibly belonging to Knoxites Egorov).

Conchostraca

Rhabdostichus sp.

Age : Upper Devonian.

Core 15 : 4,471-4,481 feet

Dense dark grey argillaceous limestone, with abundant ostracods occurring in bands.

Ostracoda

Aparchites sp. A
Cavellina sp. nov. 2
C. sp.
Glyptopleura sp. nov.
Paraparchites sp. cf. nicklesi
undetermined kloedenellacean genus A

Age : Upper Devonian.

Core 16 : 4,852-4,861 feet

Dense grey limestone and shale, ostracods common, occurring in bands.

Ostracoda

Aparchites sp. A
Cavellina sp.
Cryptophyllus sp.
Glyptopleura sp. nov.
Paraparchites sp. cf. nicklesi.
Undetermined kloedenellacean genus B (possibly belonging to Mennerites Egorov).

Age : Upper Devonian

Core 17 : 5,220-5,227 feet

Grey calcarenite, ostracods common.

Ostracoda

Aparchites sp. A
Cryptophyllus sp.

Age : Upper Devonian

Core 18 : 5,589-5,596 feet

Green shaly siltstone, with pelecypods of the pterioid type; ostracods rare, only Cavellina sp. J.M. Dickins has identified the pelecypods as Ptychopteria? sp. nov., and states that forms of this type occur in the Devonian and Lower Carboniferous. Therefore, the pelecypod evidence together with the Upper Devonian determination of the higher cores show that core 18 also should be included in the Upper Devonian.

Core 19 : 5,925-5,935 feet

Calcarenite and grey-green siltstone bearing plant remains. No ostracods found.

Core 20 : 6,296-6,303 feet

Green siltstone, showing a dip of approximately 30 degrees. No ostracods found.

Remarks

The superfamily Kloedenellacea is well represented in Cores 10 - 17 by the abundance of Knoxiella, Glyptopleura, and two undetermined genera. Glyptopleura sp. nov. is found in the Fairfield Beds at Oscar Hill, and in the Upper Devonian sequences of BMR 2 and The Sisters No. 1. Two genera belonging to the Kloedenellacea cannot definitely be determined at present, but they resemble genera previously described by Egorov (1950) from the Upper Devonian of the Russian Platform. Both kloendenellacean genus A and the undetermined drepanellacean genus have been previously found in the late Famennian ostracod Assemblage A; genus A in BMR 2 (2,385-2,565 feet), and The Sisters No. 1 (7,295-7,300 feet), and the drepanellacean genus C in BMR 2 (1,775-2,810 feet). Cryptophyllus sp. appears to belong to C. sp.A, recently described (Jones, 1962) from the type-section of the Upper Devonian Gneudna Formation, in the Carnarvon Basin. The specimens found in Cores 16 and 17 however, are damaged, and better material is needed to verify this determination.

Conclusions - Age and correlation

The ostracod species found between 3,640 feet and 5,227 feet are referred to ostracod Assemblage A, which, from previously known occurrences, is associated with the Avonia proteus zone of Veevers (1959). Therefore, the ostracod evidence indicates a late Famennian age.

The grey ostracod limestone cored between 3,737 and 3,745 feet can be roughly correlated with the ostracod limestone penetrated by BMR No. 2 (Laurel Downs) at 1,775-1,785 feet. Bairdia sp. makes its only appearance in Frome Rocks No. 2 at 3,640 feet, which suggests a slightly higher horizon than 1,775 feet in BMR No. 2.

References

EGOROV, V.G.,	1950	Ostracoda from the Frasnian stage of the Russian Platform. 1. Kloedenellidae. V.N.I.G.R.I., 140 pp., 18 pls.
JONES, P.J.,	1959	Preliminary report on Ostracoda from bore B.M.R. No. 2 Laurel Downs, Fitzroy Basin, Western Australia. Bur.Min. Resour.Aust.Rep. 38, 37-52.
JONES, P.J.,	1962	The Ostracod genus Cryptophyllus in the Upper Devonian and Carboniferous of Western Australia. Bur.Min.Resour. Aust.Bull. 62.
SOHN, I.G.,	1951	Actual versus recorded stratigraphic range of some Paleozoic ostracode genera. Micropaleontologist, 5, (4), 32-35.
VEEVERS, J.J.,	1959	Devonian brachiopods from the Fitzroy Basin, Western Australia. Bur.Min. Resour.Aust.Bull.45.
VEEVERS, J.J., & WELLS, A.T.,	1961	The geology of the Canning Basin, Western Australia. Bur.Min.Resour.Aust. Bull. 60.

APPENDIX B

PETROLOGICAL REPORTS

PETROLOGY OF CORE SAMPLES FROM FROME ROCKS NO. 1 WELL

by

J.E. Glover

University of Western Australia

Sixteen specimens from sidewall and drillstem cores (taken at depths of 605, 655, 758, 764, 769.5, 818.5, 828, 832, 876.5, 883, 912, 918, 1,680-1,690, 2,480-2,490, 2,740-2,750 and 3,142-3,152 feet) were examined microscopically. The top thirteen specimens are too friable for sectioning, and crushed portions of them were examined in oils.

The two stratigraphically highest cores (605 feet, 655 feet) consist of light grey, friable, very fine grained, muscovitic quartz sandstone. The quartz of both sandstones is highly angular. The core at 605 feet shows red spots due to the presence of hematite, and is sparsely cemented by finely granular carbonate. The core at 655 feet is sparsely cemented by clay-sized material and its accessory minerals include zircon, tourmaline and pyrite.

The next eleven cores (758 feet to 1,680-1,690 feet inclusive) are breccias consisting of light grey to grey-green rock fragments in a matrix of crushed rock. The fragments are made up of finely granular dolomite, argillaceous material, very fine-grained angular quartz and probably a little calcite. Prismatic quartz crystals with well defined pyramidal ends are ubiquitous, and some attain a length of 0.5 mm. These crystals, which compose up to 5 percent of some of the rocks, are clearly authigenic. Pyrite euhedra were noted in cores from 758, 818.5, 828 and 1,680-1,690 feet, hematite in cores from 769.5 (where it is abundant) and 764 feet, and both pyrite and hematite were noted at 876.5 and 918 feet.

Authigenic tourmaline was noted at 876.5, 918 and 1,680-1,690 feet. The lowest of the cores just discussed (1,680-1,690 feet) also contains about one percent by volume of anhydrite and a little clear angular microcline. There is a range in composition of the rock fragments in the breccias, but most of the fragments are very fine grained, impure silty and argillaceous dolomite. A few are highly dolomitic silty claystone.

The three lowest core specimens studied (from 2,480-2,490, 2,740-2,750 and 3,142-3,152 feet) are breccias made up of angular grey to pink rock fragments up to 44.5 cm in diameter, and fairly coarsely crystalline, translucent, pale grey to red-brown salt. Although the proportion of the two constituents varies considerably, salt forms about half the breccia. The surfaces of the rock fragments are commonly striated, apparently as a result of their differential movement in the breccia.

Thin sections of the three salt-rich rocks were made by using kerosene instead of water in the cutting and grinding processes. Their study under the microscope reveals that the salt is colourless except near margins of rock fragments, where it is stained pale red-brown, apparently by iron impurities from the fragments. None of the salt in these sections shows strain anisotropism, and in some areas its cleavage persists with the same orientation

for about 3mm. Its refractive index of 1.544$\pm$.002 corresponds to that of halite. Scattered throughout the salt, between the rock fragments, are occasional clear rhombs of dolomite up to 0.3 mm long, and euhedral plates of anhydrite up to 1 mm long, the latter mineral comprising up to five percent of the rocks.

The included rock fragments are made up of very fine granular dolomite, minute flakes of mica, very fine angular quartz, and clay-sized material. They appear to range from very fine grained argillaceous silty dolomite to highly dolomitic silty claystone. Elongate quartz crystals with well developed pyramidal ends ranging up to 0.5 mm are common, and are clearly authigenic. Such quartz euhedra are found both in the rock fragments and in the surrounding salt. Pyrite euhedra are fairly common accessories, and authigenic tourmaline, though not abundant, is present in all three specimens. The tourmaline forms rods up to 0.06 mm. long, and in many grains pale to almost colourless tourmaline has grown from a minute, darker, blue-green or brown-green core.

The rocks described above from 758 feet to 3,152 feet in Frome Rocks No. 1 can best be explained as due to an intrusive salt mass of which the brecciated dolomitic rocks from 758 feet to 1,690 feet form cap rock. It may be significant that abundant authigenic quartz and some authigenic tourmaline have also been reported from outcropping rocks of the Ordovician Gap Creek Formation (Glover, 1955, p.3). Furthermore, Glenister (pers.comm.) has noted that insoluble residues from the dolomitic and salt-bearing rocks are markedly like those which characterise Ordovician limestones from other Canning Basin bores examined by him, and are unlike Devonian and Carboniferous residues from the same areas. Petrologic evidence is therefore not inconsistent with an Ordovician age for at least some of the included rock fragments of these breccias.

Reference

GLOVER, J.E., 1955 Petrology and petrography of limestones from the Fitzroy Basin, Western Australia. Bur. Min. Resour. Aust. Rep. 18.

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PETROLOGICAL DESCRIPTION OF SIDEWALL CORES, FROME ROCKS NO. 2. WELL

by

P.E. Playford

West Australian Petroleum Pty Limited

S.W.C. 2.	3689':	Transverse section. SANDSTONE, quartz, very fine grained, silty, chloritic, thinly bedded. Bedding shown mainly by thin plates of chlorite. No porosity apparent.
S.W.C. 4.	3695':	Longitudinal and transverse sections. SANDSTONE, quartz, very fine grained, silty, chloritic. No porosity apparent. Chlorite about 25 percent.
S.W.C. 6.	3701':	Transverse section. SANDSTONE, quartz, very fine grained, silty, chloritic, crudely bedded. Chlorite makes up about 30 percent of the rock, and is present as irregular patches.
S.W.C. 8.	3710':	Longitudinal and transverse sections. SANDSTONE, quartz, fine to very fine grained, chloritic, silty. Well-bedded. Chlorite about 10 percent. Sand grains angular. No porosity apparent.
S.W.C. 9.	3713':	Transverse section. SANDSTONE, quartz, very fine grained, silty, chloritic. Chlorite about 30 percent. No porosity apparent.
S.W.C. 10.	3716':	Longitudinal and transverse sections. SANDSTONE, quartz, very fine grained, silty, chloritic. Poorly bedded. Chlorite about 20 percent, silty matrix about 10 percent. No porosity apparent.
S.W.C. 12.	3960':	Longitudinal and transverse sections. SANDSTONE, quartz, very fine grained, chloritic, silty, calcareous. Crudely bedded, probably cross-bedded (or slumped). Some parts contain numerous ostracods and grade into limestone. No porosity apparent.
S.W.C. 14.	4000':	Longitudinal and transverse sections. SANDSTONE, quartz, fine to very fine grained, chloritic, silty, calcareous (in part), thinly bedded. Contains one clot of ostracod limestone, apparently made up entirely of ostracod remains. No porosity apparent.
S.W.C. 17.	5441':	Longitudinal and transverse sections. SANDSTONE, quartz, very fine grained, chloritic, silty. Contains about 5 percent of green chlorite flakes; silty matrix makes up about 20 percent of rock. Well bedded. No porosity apparent.

S.W.C. 18.	5445':	Transverse section. SANDSTONE, quartz, very fine grained, silty, chloritic, grading into chloritic sandy siltstone. Crudely bedded. No porosity apparent.
S.W.C, 19.	5710':	Transverse section. SANDSTONE, quartz, very fine grained, chloritic, silty. Contains about 35 percent of green chlorite flakes, parallel to the bedding. Thinly bedded. Two very small fractures cross the bedding planes. These are filled by chlorite and very fine grained sandstone with a colourless chloritic cement. There appear to have been no voids in these fractures. No porosity apparent.
S.W.C. 21.	5730':	Longitudinal and transverse sections. SANDSTONE, quartz, very fine grained, silty, chloritic. Chlorite about 25 percent, silt about 15 percent. No porosity apparent.
S.W.C. 22.	5798':	Transverse and longitudinal sections. SANDSTONE, quartz, fine to very fine grained, silty, chloritic. Chlorite about 20 percent, silt 20 percent. No bedding or porosity apparent.

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APPENDIX C

CORES AND SIDEWALL CORES

FROME ROCKS NO. 1 WELL

Cores

Core No.	Type core barrel	Interval (feet)	Recovery (feet)	Recovery (percent)	Lithology
1	Hughes 'J' with HFCH	1030-1046	3	19	Dolomite
2	"	1277-1287	2 1/2	25	Dolomite
3	"	1680-1690	4	40	Dolomite
4	"	2080-2090	4 1/2	45	Dolomite
5	"	2480-2490	9	90	Salt *
6	"	2740-2750	10	100	Salt
7	"	2936-2946	10	100	Salt
8	"	3142-3152	9	90	Salt
9	"	3350-3360	8	80	Salt
10	"	3560-3570	10	100	Salt
11	"	3770-3780	10	100	Salt
12	"	3975-3985	8	80	Salt

Total footage cored : 126'

Total footage recovered : 88'

Percentage recovery : 69%

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*Minor amounts of shale and dolomite fragments occur with the rock salt.

Sidewall Cores

Sidewall cores were recovered from the following intervals :

Sample	Depth (feet)	Sample	Depth (feet)
1	350	12	758
2	355	13	764
3	358	14	769 1/2
4	390	15	818 1/2
5	398	16	828
6	451	17	832
7	521	18	876 1/2
8	530	19	883
9	540	20	912
10	605	21	918
11	655		

FROME ROCKS NO. 2 WELL

Cores

Core No.	Type core barrel		Interval (feet)	Footage cored	Footage recovery	Lithology
1	Hughes 'J' with HFCH		696- 706	10	10	Sandstone & siltstone
2	"		1097-1107	10	8	Shale, minor siltstone
3	"		1498-1508	10	6	Sandstone
4	"		2072-2082	10	9	Sandstone & siltstone
5	"		2367-2377	10	NIL	
6	"		2688-2698	10	2	Sandstone
7	"		3106-3116	10	10	Sandstone
8	"		3457-3467	10	8	Sandstone
9	"		3571-3578	7	7	Limestone, minor siltstone
10	"		3737-3742	5	1/2)	Limestone &
11	"		3742-3745	3	7)	shale
12	"		4043-4049	6	NIL	
13	"		4172-4180	8	1/6	Limestone
14	"	SFCH	4275-4280	5	2 1/2	Shale & limestone
15	"	HFCH	4471-4481	10	9	Shale & shaly limestone
16	"		4852-4861	9	8	Shale & limestone
17	"		5220-5227	7	6	Shale, limestone, minor sandstone
18	"		5589-5596	7	7	Shale
19	"		5925-5935	10	9	Limestone & shale
20	"		6296-6303	7	6 1/2	Siltstone
21	"		6560-6568	8	NIL	
22	"		6648-6653	5	3	Siltstone
23	"		6986-6993	7	6 1/2	Siltstone (sandy)
24	"		7258-7264	6	NIL)	
25	"		7264-7267	3	9)	Siltstone
26	"		7500-7504	4	4	Siltstone (sandy)

Total footage cored	:	197'
Total footage recovered	:	138'
Percentage of hole cored	:	2.63%
Percentage of core recovery	:	70.05%

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Sidewall cores

Sidewall samples were recovered from the following depths.

Sample	Depth (feet)	Sample	Depth (feet)
1	3686	13	3980
2	3689	14	4000
3	3692	15	5212
4	3695	16	5435
5	3698	17	5441
6	3701	18	5445
7	3704	19	5710
8	3710	20	5716
9	3713	21	5730
10	3716	22	5798
11	3719	23	5760
12	3960		

Sidewall samples were attempted at the following depths but were not recovered.

3707', 5455', 5722', 5740', 5835', and 5974'

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APPENDIX D

SPECIFIC GRAVITY OF CORES

FROME ROCKS NO. 1 WELL

The following specific gravity determinations were made by the Western Australian Government Chemical Laboratories. All determinations were made on dry samples some weeks after the cores were cut.

Core No.	Interval (feet)	Specific Gravity	Rock type
6	2740-2750	2.31	Dolomite breccia (a fragment in the rock salt)
7	2936-2946	2.22	Rock salt
11	3770-3780	2.25	Rock salt
12	3975-3985	2.23	Rock salt

FROME ROCKS NO. 2 WELL

The following specific gravity determinations were made by the wellsite geologist :

Core No.	Interval (feet)	Specific Gravity	Lithology
1	696- 706	2.1 (dry)	Sandstone, minor siltstone
2	1097-1107	2.1 (dry)	Shale, minor siltstone
3	1498-1508	2.1 (dry)	Sandstone
4	2072-2082	2.4	Sandstone and siltstone
6	2688-2698	2.4	Sandstone
7	3106-3116	(2.2	Kaolinitic sandstone
		(2.56	Fontainebleau sandstone
8	3457-3467	2.54	Fontainebleau sandstone
9	3571-3578	2.64	Limestone, minor siltstone
10	3737-3742)	(2.60-2.66	Shale) grading one
11	3742-3745)	(2.71	Limestone) to other
13	4172-4180	2.57	Limestone
14	4275-4280	(2.58	Shale
		(2.53	Shaly limestone (very minor amount)
		(2.70	Limestone
15	4471-4481	2.52	Shale
		2.57	Shaly limestone
16	4852-4861	(2.58	Shale
		(2.62	Shaly limestone
		(2.70	Limestone
17	5220-5227	(2.59	Calcareous shale
		(2.43	Sandstone (minor)
18	5589-5596	2.59	Shale
19	5925-5935	(2.58	Shale
		(2.88 (?)	Limestone
22	6648-6653	2.63	Siltstone
23	6986-6993	2.64	Siltstone (sandy)
25	7264-7267	2.66	Siltstone
26	7500-7504	2.66	Siltstone

APPENDIX E

SCHLUMBERGER LOGS RUN

Electric Logs

NO. 1 WELL				NO. 2 WELL			
ES 1	:	1288- 86'	10th Jan. 1959	ES 1	:	2064- 273'	5th March 1959
ES 2	:	2486-1288'	17th Jan. 1959	ES 2	:	3587-2000'	17th March 1959
				ES 3	:	4285-3480'	28th March 1959
				ES 4	:	5242-4180'	14th April 1959
				* ES 5	:	6134-1996'	29th April 1959
				ES 6	:	7486-6000'	30th May 1959

* ES 5 and GRN 4 were run up to 10 3/4" casing shoe after errors in depth measurement by the Schlumberger cable were found. The error amounted to approximately 18' at 5000', decreasing to about 6' at 2000'.

Gamma ray - Neutron log

GRN 1	:	1289- 50'	10th Jan. 1959	GRN 1	:	3558- 100'	18th March 1959
GRN 2	:	3358-1190'	28th Jan. 1959	GRN 2	:	4286-3474'	29th March 1959
GRN 3	:	4003-3250'	4th Feb. 1959	GRN 3	:	5243-4180'	13th April 1959
				GRN 4	:	7484-2000'	30th April 1959

Microlog-Caliper

ML 1	:	4283-3500'	29th March 1959
ML-C 2	:	6131-5150')	29th April 1959
		Caliper to 4150')	

Section gauge

SG 1	:	1286- 86'	10th Jan. 1959	SG 1	:	3584-2000'	18th March 1959
CL 2	:	3355-1278'	28th Jan. 1959	SG 2	:	7483-5500'	30th May 1959

Caliper Log No. 2 (CL 2) was run in place of the Section Gauge because the Section Gauge tool was inoperative.

In addition the caliper log was run from 5150-4150' during a run with the microlog-caliper tool, as noted above.

Laterolog

LL 1 : 3354-1278' 28th Jan. 1959.

Chronological Sample Taker

21 sidewall cores recovered. 10th Jan. 1959. Run 1 : 30 attempted; 23 recovered; 29th April 1959.

Details of the sidewall cores are given in Appendix C.

Dipmeter

Run 1 : 7 levels at following intervals 29th April 1959.

3919-3939', 4438-4479',
4884-4906', 5209-5239',
5559-5590', 5800-5829',
5989-6019'

Results are summarized in Appendix F, and are represented graphically in Figure 3.

Run 2 : 4 levels at following intervals. 30th May 1959.

6170-6200', 6240-6270',
6760-6780', 7160-7190'

No dips were interpretable from these levels.

Directional survey

Run 1 : Deviation recorded at 21 levels between 7300' and 2000'. 31st May 1959.

Deviation recorded at :

100' intervals from 7300-6500'
200' intervals from 6500-5500'
500' intervals from 5500-2000'

Results are presented in Appendix F and Figure 3.

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APPENDIX F

DEVIATION RECORDS (EASTMAN), FROME ROCKS NO. 2 WELL

Depth (feet)	Deviation (Eastman)	Change of Deviation	Depth (feet)	Deviation (Eastman)	Change of Deviation
280	1/4°	+1/4°	4700	2 1/4°	-
415	1/4°	-	4837	2 1/2°	+1/4°
535	1/2°	+1/4°	4899	2°	-1/2°
678	1/4°	-1/4°	5017	2 1/4°	+1/4°
840	1/2°	+1/4°	5227	2 1/4°	-
1060	3/4°	+1/4°	5445	3°	+3/4°
1215	1/2°	-1/4°	5575	2°	-1°
1334	1/4°	-1/4°	6010	3 1/2°	+1 1/2°
1480	3/4°	+1/2°	6200	3°	-1/2°
1578	3/4°	-	6290	3°	-
1872	3/4°	-	6350	2 1/4°	-3/4°
2026	1/4°	-1/2°	6417	3°	+3/4°
2330	1/2°	+1/4°	6480	3°	-
2688	1/4°	-1/4°	6550	2 3/4°	-1/4°
3096	1/2°	+1/4°	6648	2 1/2°	-1/4°
3365	1/2°	-	6790	3 3/4°	+1 1/4°
3550	1°	+1/2°	6840	3 3/4°	-
3700	3/4°	-1/4°	6986	4 3/4°	+1°
3900	1/4°	-1/2°	7060	4 1/4°	-1/2°
4040	1 1/4°	+1°	7150	3 1/4°	-1°
4170	1 1/4°	-	7258	2 3/4°	-1/2°
4290	1 1/4°	-	7338	2°	-3/4°
4380	1 1/2°	+1/4°	7430	1 1/4°	-3/4°
4567	2 1/4°	+1 1/4°	7495	1 3/4°	+1/2°

DIRECTIONAL SURVEY (SCHLUMBERGER)

FROME ROCKS NO. 2 WELL

Depth	Angle of Deviation	Direction of Deviation	Departure from surface location (feet)			
			N.	S.	E.	W.
2000	1°	033°	29.30		19.00	
2500	1 1/2°	040°	39.35		27.32	
3000	1°	027°	47.13		31.27	
3500	1/4°	285°	47.70		29.17	
*3919	1 1/4°	295°				
*3939	1 1/2°	275°				
4000	1 1/2°	185°	34.65		28.05	
*4438	1 3/4°	222°				
*4479	3/4°	183°				
4500	2 3/4°	238°	21.95		7.73	
*4884	2 1/2°	230°				
*4906	3°	230°				
5000	4°	240°	4.50			22.47
*5209	3 1/4°	252°				
*5239	3 1/4°	222°				
5500	5°	240°		17.30		60.22
*5559	4 3/4°	245°				
*5590	4 3/4°	244°				
5700	4 3/4°	240°		25.58		74.56
*5800	4 1/4°	247°				
*5829	4 1/4°	247°				
5900	3 3/4°	245°		31.10		86.42
*5989	4 3/4°	262°				
*6019	4 3/4°	260°				
6100	5 1/4°	263°		33.34		104.58
6300	4 1/4°	285°		29.50		118.90
6500	3 1/4°	280°		27.54		130.06
6600	3°	270°		27.54		135.29
6700	3 1/4°	255°		29.12		141.19
6800	4°	245°		32.07		147.51
6900	4 1/4°	235°		36.32		153.58
7000	4 3/4°	240°		40.46		160.75
7100	4 1/4°	250°		42.98		167.71
7200	4 3/4°	255°		45.12		175.71
7300	2 3/4°	270°		45.12		185.67

The hole at 7,300' is located 45.12 feet south and 185.67 feet west of surface location.

* Depths taken from Dipmeter report and not included in computation of hole position.

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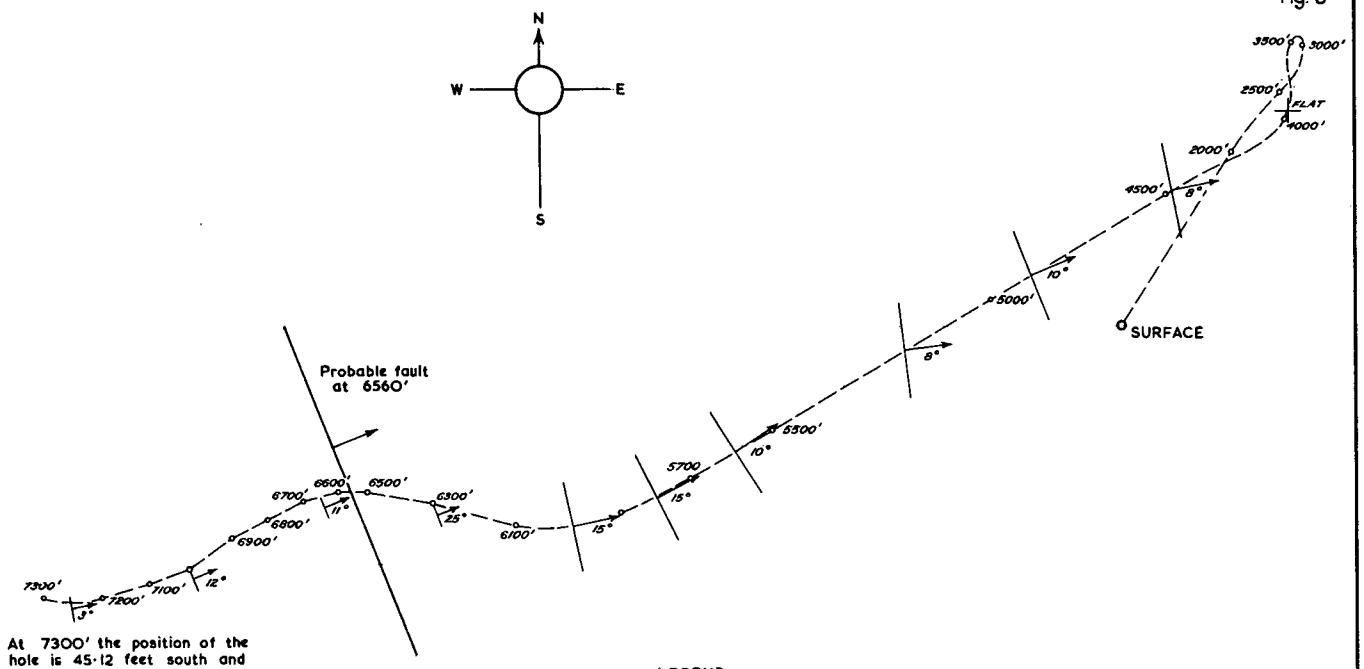
Fig. 3



At 7300' the position of the hole is 45·12 feet south and 185·67 feet west of surface location

LEGEND

o 6300'	Computed position of hole at given depth
↑ 15°	Dip strike from dipmeter
↑ 11°	Dip from cores (uncorrected for hole deviation, strike assumed.)

KIMBERLEY DISTRICT

CORRELATION CHART

DIPMETER & DIRECTIONAL DATA

FROME ROCKS Nº2

S. P. Willmott 29 July 1959

S.P.W. A.J.S. S.P.W. 24 AUG 59 1" = 20'

A-2320

ENCLOSURE 5

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DIPMETER RESULTS

FROME ROCKS NO. 2 WELL
Dipmeter Run 1

Interval (feet)	Dip Direction	Dip	Grade	Remarks
3919-3939	No appreciable dip			
4438-4479	078°	8°	GF	Visual dip 5° at 4475'
4884-4893	068°	10°	FF	Between 4890'-4893'
4893-4906	099°	5°	FF	Visual dip, sub-horizontal *
5209-5239	083°	8°	GF	Visual dip, sub-horizontal
5559-5590	057°	10°	FF	Visual dip 1-2° at 5590'
5561-5563	074°	13°	Poss	
5800-5829	063°	15°	FF	
5989-6019	077°	15°	GG	Visual dip 12° at 5925'

No results were obtained from Dipmeter Run 2. The following dips were recorded visually from cores.

Interval (feet)	Dip	(Eastman) Deviation of Hole	Probable Adjusted Dip
6296-6303	25°	3°	28°
6648-6653	11°	2 1/2°	14°
6986-6993	12°	4 3/4°	17°
7258-7267	3°	2 3/4°	6°

* In Cores 16 (4852-4862 feet) and 17 (5220-5227 feet)

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APPENDIX G

WATER ANALYSES, FROME ROCKS WATER BORES NOS 1, 2, AND 3

by

Western Australian Government Chemical Laboratories

Water Bore	No. 1	No. 2	No. 3
Lab. no.	16582/58	17255/58	2785/59
Specific resistance (ohms) at 20°C.	1500	2150	1540
Reaction	neutral	neutral	neutral
pH	6.9	7.5	7.3
Mineral Matter, in ppm.			
Ca	10	11	21
Mg	10	7	10
Na	111	80	97
K	15	12	12
HCO_3	90	79	74
CO_3	0	0	0
SO_4	26	27	30
Cl	156	104	155
NO_3	7	6	11
SiO_2	50	25	60
Fe_2O_3) Al_2O_3)	3	16	>1
Total	478	367	470
Assumed combination on evaporation at N.T.P.			
$CaCO_3$	25	27	52
$MgCO_3$	35	24	7
Na_2CO_3	8	9	-
$CaSO_4$	-	-	-
$MgSO_4$	-	-	38
Na_2SO_4	38	40	-
$MgCl_2$	-	-	2
KCl	29	23	23
NaCl	234	153	143
$NaNO_3$	10	8	15
Hardness calculated as $CaCO_3$			
Total hardness	66	56	93
Bicarbonate (temporary) hardness	66	56	61
Non-carbonate (permanent) hardness	-	-	32
Calcium hardness	25	27	52
Magnesium hardness	41	29	41

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APPENDIX H

DISTRIBUTION OF SANDSTONE BEDS IN THE UPPER UNIT OF THE DEVONIAN, FROME ROCKS NO. 2 WELL

The depths quoted here are taken from the Microlog.

Depth (feet)	Thickness (feet)	Depth (feet)	Thickness (feet)
3690 - 3708)	18	5831 - 5837)	6
3909 - 3921)	12	5841 - 5843)	2
5210 - 5218	8	5927 - 5930	3
5251 - 5257	6	5936 - 5937	1
5431 - 5432)	1	5952 - 5953)	1
5433 - 5438)	5	5954 - 5957)	3
5439 - 5442)	3	5958 - 5960)	2
5444 - 5446)	2	5961 - 5965)	4
5575 - 5576)	1	5966 - 5970)	4
5577 - 5581)	4	5972 - 5981)	9
5584 - 5586)	2	5998 - 6000	2
5709 - 5722)	13	6019 - 6020	1
5725 - 5752)	27	6025 - 6026)	1
5788 - 5790)	2	6027 - 6031)	4
5792 - 5803)	11		
5806 - 5812)	6		
5815 - 5818)	3		

Total thickness of sandstone is 167 feet, out of a formation thickness of 2707 feet. Sandstone comprises 6.2% of formation (in beds).

Only 5 beds (totalling 81 feet) exceed 10 feet in thickness.

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Plate I

COMPANY: WEST AUSTRALIAN PETROLEUM PTY. LTD.

COMPOSITE WELL LOG

WELL NUMBER: **FROME ROCKS Nº I**

REGION: CANNING BASIN

COUNTRY: WESTERN AUSTRALIA

FILE Nº C-2586

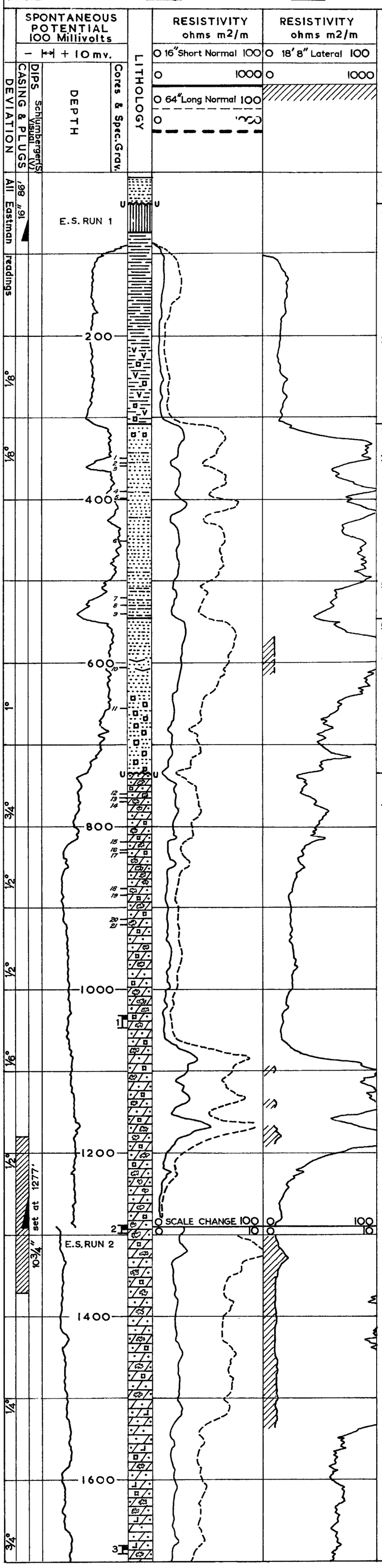
LOCATION:
LATITUDE 18° 11′ 48″ S
LONGITUDE 123° 38′ 42″ E
COORDINATES:
YARDS EAST 127,500
YARDS NORTH 2,713,000
ELEVATION DERRICK FLOOR FT.: 230
ELEVATION GROUND FT.: 221
TOTAL DEPTH FROM DERRICK FLOOR FT.: 4003
PLUG BACK DEPTH FROM DERRICK FLOOR FT.: 1277
DATE SPUDDED: 2 JANUARY 1959
DATE COMPLETED: 7 FEBRUARY 1959
LITHOLOGY BY: S. P. WILLMOTT, R.M.L. ELLIOTT
COMPILED BY: R.M.L. ELLIOTT, M.H. JOHSTONE

ELECTRIC LOG DATA:

RUN NUMBER:	1	2
DATE:	10 JAN 1959	17 JAN 1959
INTERVAL RECORDED:	86′ – 1288′	2486′ – 1288′
MUD-NATURE:	CLAY BASE	BRINE-CLAY BASE
MUD-RESISTIVITY:	1·62 at 86° F	0·06 at 86° F
MUD-RESISTIVITY (B.H.T.)	1·26 at 114° F	0·03 at 142° F
MUD-WEIGHT:	86·5	83
MUD-VISCOSITY:	48	48
MUD-WATER-LOSS:	16	6
MUD-pH:	9	11·5

OTHER LOG COVERAGE:
GAMMA RAY-NEUTRON: Run 1 1289′-50′: 10 Jan 1959; Run 2 3358′-1190′: 28 Jan 1959; Run 3 4003′-3250′: 4 Feb 1959
SECTION GAUGE: Run 1 1286′-86′: 10 Jan 1959; CL 2 3355′-1278′: 28 Jan 1959
LATEROLOG: LL 1 3354′-1278′: 28 Jan 1959

SANDSTONE; SILTSTONE; CLAYSTONE; SHALE; SALT; DOLOMITE; SANDY DOLOMITE; DOLOMITE BRECCIA; LATERITE; UNCONFORMABLE CONTACT; CONFORMABLE CONTACT; DISCONFORMABLE CONTACT; ANHYDRITE; PYRITIC; CALCAREOUS; FOSSILIFEROUS; MICACEOUS; GLAUCONITE; CORE (RECOVERY SPECIFIC GRAVITY BLACK); SIDE WALL CORE; CASING SHOE



LITHOLOGIC DESCRIPTION

9′ – 40′: SURFACE SAND

40′ – 307′: JARLEMAI SILTSTONE (UPPER JURASSIC)

40′ – 75′: LATERITISED JARLEMAI SILTSTONE

75′ – 200′: Claystone and Clay; brown and red brown, very ferruginous, with occasional coarse angular quartz grains.

200′ – 307′: Clay; dark grey, puggy, soft, slightly glauconitic, very pyritic.

307′ – 547′: ALEXANDER FM. (UPPER JURASSIC)

307′ – 510′ Sandstone, fine and medium grained, poorly sorted, micaceous, silty, very thinly bedded; with beds of Siltstone and very fine grained Sandstone.

occasional coarse quartz grains

510′ – 547′ Shale, medium to dark grey, soft, laminated, interbedded with Sandstone.

547′ – 734′ WALLAL SANDSTONE (MIDDLE JURASSIC)

547′ – 734′ Sandstone: fine and medium grained, with some well-rounded coarse grains, some beds with solid pyritic cement forming up to 40% of the rock, thin-bedded, grey.

605′ S.W.C. 10 some muscovite, and hematite in red spots.

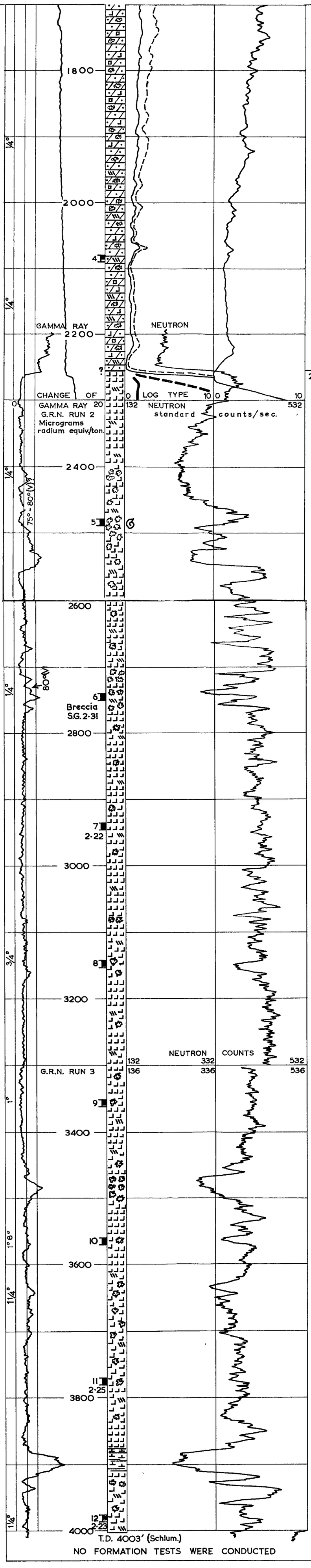
(TOP FROME ROCKS SALT DOME)

734′ – 2256′ I. CAP ROCK (AGE UNKNOWN)

Dolomite Breccia, pale grey green to grey, friable. The matrix is usually soft and friable and consists of fine granular dolomite, some clay, authigenic euhedral quartz crystals are ubiquitous and represent up to 5% of the rock, slightly pyritic and haematitic. The breccia fragments vary in proportion throughout the unit and range up to 2″ in diameter and the fragments consist of Dolomite, pink, grey, black, minor amounts of quartz and anhydrite, angular bedded fragments, finely and coarsely crystalline, pyritic, hard. The whole unit has low porosity and permeability.

734′ – 1170′ minor amounts of Clay and Silt

1300′ – 2256′ minor beds and amounts of Clay or Silt



Core 4. Salt encrustation appeared on surface of core when dry.

2256′ – 4003′ (T.D.) 2. SALT (AGE UNKNOWN)

Salt, pale grey, some pink and brown patches, sometimes red and white, translucent, always contains scattered small fragments (⅛″ – ½″) of pink and grey dolomite and occasionally anhydrite; contains several beds of Dolomite Breccia, which consists of angular fragments of dolomite set in a rock salt matrix, the salt matrix is often stained brown near the margins of the dolomite fragments and contains minor amounts of anhydrite and hematite; the Dolomite grey and pink, sandy with angular authigenic quartz fragments fragment surfaces frequently slickensided, sometimes very soft, usually hard, fragments range from ½″ to 3″. The whole unit shows no porosity or permeability. The apparent porosity shown on the neutron curve at the top of the unit is due to the large hole diameter which developed prior to using a salt saturated drilling mud.

3878′ – 3913′: Claystone, pink, calcareous.

NO FORMATION TESTS WERE CONDUCTED

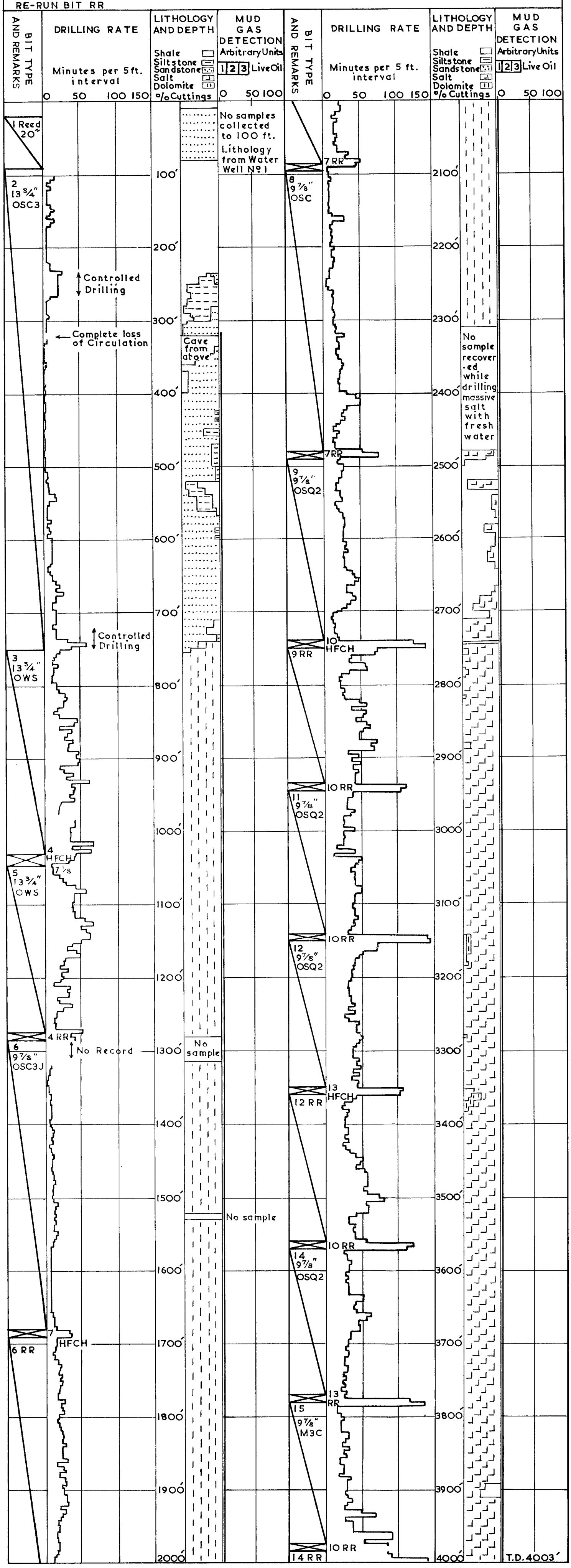
ENCLOSURE Nº
C-2585

WEST AUSTRALIAN PETROLEUM PTY. LTD

DRILLING TIME AND GAS LOG
FROME ROCKS Nº1

KIMBERLEY DISTRICT
WESTERN AUSTRALIA

NEW BIT
CORE BIT
RE-RUN BIT RR



COMPANY: WEST AUSTRALIAN PETROLEUM PTY. LTD.

COMPOSITE WELL LOG

WELL NUMBER: **FROME ROCKS No.2**

REGION: CANNING BASIN

COUNTRY: WESTERN AUSTRALIA

ENCLOSURE No.
FILE No. C-2613

LOCATION:
LATITUDE: 18° 15′ 15″ S.
LONGITUDE: 123° 39′ 35″ E.
CO ORDINATES:
YARDS EAST: 129,250
YARDS NORTH: 2,706,050
ELEV. DERRICK FLOOR 296′
ELEV. GROUND 287′
TOTAL DEPTH FROM DERRICK FLOOR 7504′
PLUG BACK FROM DERRICK FLOOR 1890′
DATE SPUDDED 19 FEB. 1959
DATE COMPLETED 1 JUNE 1959
LITHOLOGY BY S.P. WILLMOTT, M.H. JOHNSTONE., R.M.L. ELLIOTT

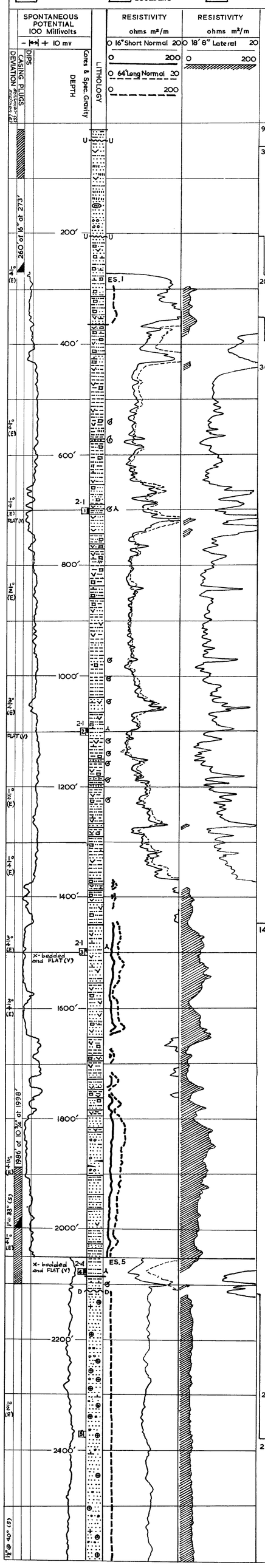
ELECTRIC LOG DATA

RUN NUMBER	1	2	3	4	5	6
DATE	5 Mar.59	17 Mar.59	28 Mar.59	14 Apr.59	29 Apr.59	30 May 59
INTERVAL RECORDED	2064-273	3587-2000	4285-3480	5242-4180	6131-1996	7486-6000
MUD NATURE	fresh water Bentonite	fresh water Bentonite	high pH fresh water Bentonite	high pH fresh water Bentonite	high pH fresh water Bentonite	high pH fresh water Bentonite
MUD RESISTIVITY	4·6 at 85°	0·92 at 82°	1·7 at 80°	1·4 at 80°	1·2 at 70°	1 at 86°
MUD RESISTIVITY BHT	3 at 130°	0·6 at 130°	1·0 at 138°	0·8 at 150°	0·5 at 160°	0·5 at 181°
MUD-WEIGHT	81	76	76	76	72	73
MUD VISCOSITY	56	56	58	56	58	56
MUD-WATER LOSS	8·0	9·0	7·5	6·5	6·5	6·5
MUD pH	8·0	9·5	12·0	11·5	12·0	11·5

OTHER LOG COVERAGE: GRN-1, 3588′-100′, GRN-2, 4286′-3474′, GRN-3, 5243′-4180′, GRN-4, 7484′-2000′. SG-1. 3584′-2000′, SG-2, 7483′-5500′. MLC.1, 4283′-3500′, MLC.2, 6131′-5150′
DIP METER - 7 LEVELS. DIRECTIONAL SURVEY
Chronological sample taker. 23 side wall cores

CONGLOMERATE
LIMESTONE
SHALEY LIMESTONE
SANDSTONE
SANDY LIMESTONE
SILTSTONE
CARBONACEOUS MATTER
LATERITIC
SHALE
FELDSPATHIC
GRANITE BOULDERS
UNCONFORMABLE CONTACT
CONFORMABLE CONTACT
OIL SHOW
CALCAREOUS
INVERTEBRATES SPORES
MICACEOUS
PYRITIC
CORE (Recovery black)
SPECIFIC GRAVITY
SIDE WALL CORE
CASING SHOE

SPONTANEOUS POTENTIAL 100 Millivolts
RESISTIVITY ohms m²/m — 16″ Short Normal 20, 64″ Long Normal 30
RESISTIVITY ohms m²/m — 18′ 8″ Lateral 20



LITHOLOGIC DESCRIPTION

9′-30′ SAND RECENT
Sand: fine to very fine grained, red, clayey.

30′-206′ MIDDLE TO UPPER JURASSIC
30′-206′ WALLAL SANDSTONE
Sandstone: mainly medium grained with fine, coarse and very coarse beds, (with Siltstone and conglomeratic lenses, micaceous and ferruginous in part)
40′-70′ medium and coarse grained, very micaceous in part, fine grained lenses. 70′-90′ coarse, ferruginous, 90′-110′ fine, micaceous, white & yellow, clayey. 110-130 coarse, ferruginous. 130′-170′ fine to medium ferruginous nodules, clayey
170′-206′ medium to coarse.

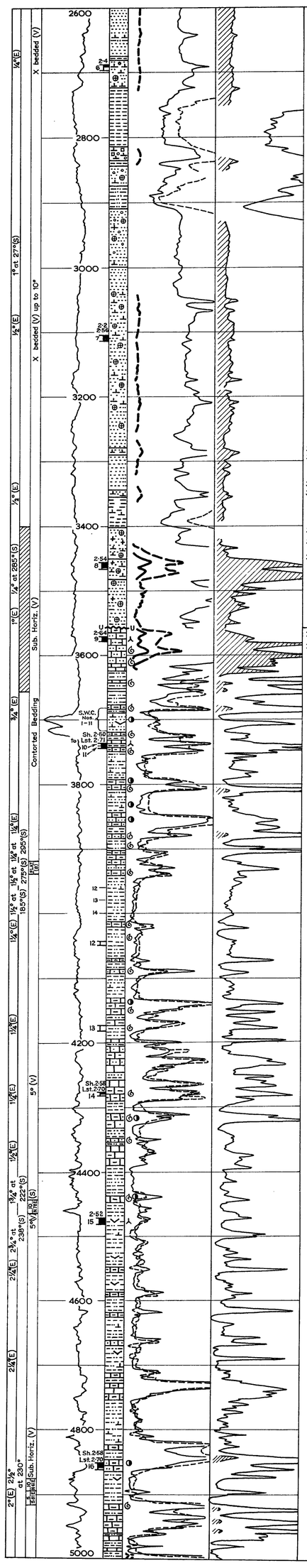
206′-3557′ PERMIAN
206′-363′ LIVERINGA FORMATION (Artinskian)
Sandstone: light grey, very fine grained, slightly calcareous, pyritic, soft, with Siltstone: dark grey, shaley, soft, micaceous with pyrite nodules at top and between 312′ and 328′.

363′-1446′ NOONKANBAH FORMATION (Artinskian)
Siltstone and Shale, dark grey, micaceous, pyritic, gypseous in upper part, fossiliferous with some coquinitic beds (brachiopods and bryozoa), with minor Sandstone: very fine to fine grained, grey, clayey, poorly sorted, slightly micaceous and calcareous, some pyrite.
Lithologies often finely interbedded, cross bedded and slumped.
Numerous worm tubes.
363′-435′ Siltstone: dark grey, shaley, micaceous, pyritic, with Sandstone beds: fine to very fine grained, clayey, poorly sorted, pyritic and slightly calcareous.
435′-650′ Shale: dark grey, micaceous, pyritic, gypseous, fossiliferous (brachiopods), with lenses Siltstone: coarse, light grey, quartzose grading to very fine grained Sandstone. Occasional thin beds of coquinitic, cream Limestone.
650′-772′ Interbedded Sandstone: as for 363′-435′ with lenses of Siltstone: and Siltstone and Shale as for 363′-650′, with lenses of Sandstone.
772′-1041′ Siltstone: shaley, and Shale: silty, dark grey, micaceous, pyritic, fossiliferous beds; with beds and lenses of fine and very fine grained Sandstone grading into coarse Siltstone.
1041′-1066′ Sandstone: very fine grained, calcareous, micaceous in part, firm to hard, some fossils (brachiopods)
1066′-1373′ interbedded Siltstone: shaley, and Shale: silty; with lenses of Sandstone as for 772′-1041′; and some beds of silty and sandy Limestone at 1148′, 1180′ and 1193′.
1373′-1446′ transition beds from NOONKANBAH FORMATION AND POOLE SANDSTONE. Interbedded Siltstone and Sandstone.

1446′-2109′ POOLE SANDSTONE (Artinskian)
Sandstone: very fine and fine grained, green-grey, micaceous, moderately sorted, some pyrite and chalcopyrite (?), glauconitic (?), with beds Siltstone and Shale: dark grey, micaceous. Passes into Sandstone: coarse to very coarse grained, well rounded, some pyritic cement but generally soft and poorly consolidated. Minor Shale and medium grained Sandstone with kaolinitic cement. Rare beds of low grade Coal. Passes into Siltstone: dark grey, very fine, sandy, micaceous.
1446′-1553′ Sandstone: fine and very fine grained, green-grey, calcareous, micaceous, glauconitic (?), moderately sorted, cross-bedded: with thin lenses of Siltstone: dark grey, micaceous, slightly calcareous; and Shale biscuits.
1553′-1599′ Siltstone: dark grey, micaceous, pyritic, with lenses of Shale and very fine grained Sandstone as above.
1599′-1653′ Sandstone: as for 1446-1553 above.
1653′-1760′ Shale: dark grey, very finely micaceous, soft, with beds of Sandstone: as for 1446′-1553′ above.
1760′-1900′ Sandstone: coarse to very coarse grained, well rounded grains, some pyrite cement otherwise poorly cemented; some beds medium to fine grained kaolinitic Sandstone and poorly sorted conglomeratic Sandstone. Thin beds of low grade Coal at 1880′. Some Sandstone beds contain rounded Shale granules. Beds of Shale as for 1653′-1760′ in upper part.
1900′-1998′ Sandstone: fine to medium grained, becoming finer grained with depth, kaolinitic cement, with chalcopyrite interbedded with Siltstone: dark grey, micaceous, sandy.
1998′-2084′ Siltstone: dark grey, micaceous, with seams of Shale and lenticles of very fine kaolinitic Sandstone. With beds of Sandstone from 2022′-2033′. Some pyrite, cross-bedded throughout.

2084′-2109′ NURA NURA MEMBER
Siltstone: grey, very fine, sandy, with bryozoa, and minor soft white Calcilutite; and minor soft white green sandy Limestone.

2109′-3557′ GRANT FORMATION (Sakmarian)
Sandstone: fine, medium and coarse grained with conglomeratic beds and pebbles of granite, chert, etc.; generally poorly sorted and cemented, kaolinitic, with hard calcareous bands (Fontainebleau sandstone). Feldspathic for the most part. Minor dark grey, soft fissile Shale.



2725′-2815′ Shale; green-grey, very fissile, soft, non-calcareous.

2815′-2836′ Sandstone: medium grained, white and grey, calcareous, with some pyrite, 10% coarse grains.
2836′-2846′ Shale:
2846′-2874′ Sandstone: clayey at base.
2874′-2908′ Shale as 2725′-2815′ with beds of black carbonaceous silty Shale at the top.
2908′-3557′ Sandstone: fine medium and coarse grained, well sorted to poorly sorted, white, pink and green, white kaolinitic cement and green clay cement often occurring as pellets and seams. Feldspathic to arkosic, with pebbles of granite, quartz and chert. Numerous well developed beds of "Fontainebleau" Sandstone, particularly near the base of the unit.
3050′ & 3060′ "Fontainbleau" Sandstone beds.

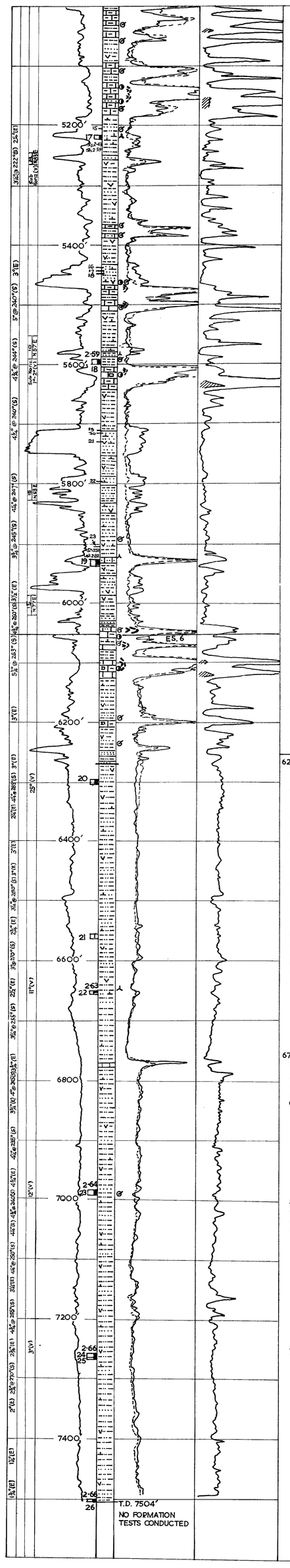
3173′ & 3207′ "Fontainbleau" Sandstone beds

3280′-3290′ "Fontainebleau" Sandstone.
3290′-3345′ Sandstone: firm to very fine grained, white, kaolinitic.

3345′-3355′ "Fontainebleau" Sandstone.
3355′-3402′ Siltstone: grey-white, sandy, grading to very fine grained Sandstone: kaolinitic cement.
3402′-3450′ Sandstone: as 2908′-3557′
3431′ "Fontainebleau" Sandstone bed.
3450′-3557′ "Fontainebleau" Sandstone, with minor kaolinitic Sandstone.

3557′-7504′ UPPER DEVONIAN
3557′-6264′ UPPER UNIT
Limestone: dense, non-porous, (recrystallised Calcarenite) silty and shaley, some sandy beds; and Siltstone, and Shale with minor Limestone. Some beds of very fine grained clayey Sandstone. Some fluorescence in Limestone, some staining in uppermost Sandstone.
3557′-3614′ Limestone: brown-cream, very fine grained, non porous, sandy beds, fossiliferous, (ostracods) with lenses Siltstone, brown-grey, coarse, thin bedded, calcareous, with very fine dolomite crystals.
3614′-3693′ Interbedded Limestone and Siltstone: as 3557′-3614′.
3693′-3721′ Sandstone: very fine grained, biotitic, slightly porous, some green chloritic mineral, calcareous cement. Scattered staining of dark brown non-fluorescent oil.
3721′-3944′ Siltstone: coarse, as for 3557′-3614′ finely interbedded with Shale: dark grey to green grey, fissile, slightly calcareous with numerous beds rich in ostracods, with Limestone grey, dense hard, silty, with sandy beds. Some pyrite. Very thin seams of very fine Sandstone (1/4″). Some beds and lenticles show fluorescence and give cut with CCl_4.
3944′-4133′ Shale: green-grey, silty, fissile, slightly calcareous, silty beds, micaceous in part, finely interbedded with Siltstone lenticles and Sandstone: as above. Minor beds of Limestone as above, some beds of which show yellow fluorescence and a slight cut with CCl_4. Some irregular red beds and nodules within Shale occur throughout section.
4133′-4325′ Limestone: grey and brown, silty and clayey, often grading to calcareous Siltstone and Shale. Some very fine sandy beds. Subordinate interbedded Siltstone and Shale: grey, calcareous, micaceous, with lenticles of very fine Sandstone.
4325′-4817′ Siltstone: coarse and Siltstone: shaley, finely interbedded with Shale, with lenses and lenticles of very fine calcareous Sandstone and fossiliferous Limestone. Minor fossiliferous Limestone often showing fluorescence and slight cut CCl_4. Rich in ostracods throughout.
Fluorescence and cut from Limestone.
4455′-4463′ Siltstone grading to very fine Sandstone.

4817′-5183′ interbedded Siltstone and Shale with lenticles Sandstone; with about equal Limestone as above, scattered pyrite.



5183′-6264′ Siltstone and Shale with subordinate Limestone as before. With beds Sandstone, very fine grained, white and grey, calcareous, micaceous, (brown and green), silty, cross bedded on small scale. Salt water saturated. All Sandstones contain scattered pink grains. Some fluorescence in fossiliferous Limestone above 5600′.

5710′-5753′ Sandstone: pale grey, very fine grained, calcareous, slightly micaceous. Some pink to brown stained grains, low porosity and permeability.

Slight vuggy porosity in Limestone of Core 19. Porosity 1%. Sandstone porosity 9·2% permeability zero

Slightly vuggy Limestone

6264′-7504′ LOWER UNIT (Fammenian)
Siltstone: medium to dark grey, some beds slightly calcareous, micaceous (biotite), thinly bedded, with very fine sandy beds and shaley beds. Occasional thin (up to 1/2″) beds Sandstone: very fine grained, calcareous, hard, light grey, very slightly porous, micaceous (biotite). Most cores showed salt incrustation after drying. Rare calcite filled gashes, numerous slickensides throughout.

6560′ POSSIBLE FAULT PLANE
Siltstone: light grey, hard, slightly calcareous, occurs as thin irregular platey chips which appear to be strongly contorted and silicified.

6767′ POSSIBLE FAULT PLANE
6767′-6772′ Limestone: light brown to buff, finely crystalline, non-fossiliferous, with some soft white to pink Limestone and Calcilutite. (may be fault gouge).

Siltstone: very poorly sorted grading to very fine grained Subgreywacke, fossiliferous (plant remains, pelecypods, gastropods), crossbedded, slumped. Porosity 4·2%
Permeability, nil.

Siltstone: as above grading to very fine grained Subgreywacke in some beds.

ENLOSURE Nº
C-2606

WEST AUSTRALIAN PETROLEUM PTY. LTD.

DRILLING TIME AND GAS LOG
FROME ROCKS Nº2

KIMBERLEY DISTRICT
WESTERN AUSTRALIA

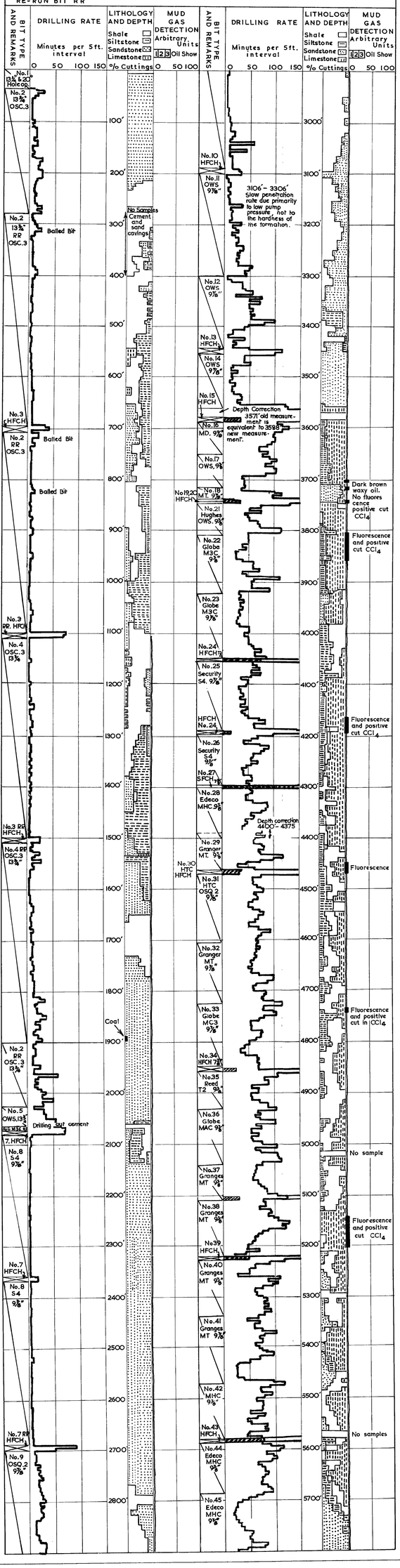


Plate 4

WEST AUSTRALIAN PETROLEUM PTY. LTD.

DRILLING TIME AND GAS LOG
FROME ROCKS Nº2

KIMBERLEY DISTRICT
WESTERN AUSTRALIA

BY PETERS
FORMATION LOGGING SERVICE
COMPANY

TRAILER CHIEF: G. MAXSON
LOGG. GEOL.: J. IRWIN
P. A. HOELSCHER

LITHOLOGY
Sandstone
Siltstone
Limestone

OIL AND GAS LOG
OIL IN RETURNS: 2—10 Trace; 12—18 Good Trace; 20 Show; Above 30 Good Show.
GAS: Relative Unit Values
COLUMN 1
Live Oil +++++++++
Free Gas A ————
B ————
COLUMN 2
Gas in Cuttings
Total
Micro Gas
CCl_4 Cut