COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Petroleum Search Subsidy Acts

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AUTH. U-K-A. Cabawin No. 1, Queensland

OF

TIT. UNION OIL DEVELOPMENT CORPORATION

KERN COUNTY LAND COMPANY

AND

AUSTRALIAN OIL AND GAS CORPORATION LIMITED

Issued under the Authority of the Hon. David Fairbairn
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DEPARTMENT OF NATIONAL DEVELOPMENT

MINISTER: THE HON. DAVID FAIRBAIRN, D.F.C., M.P.

SECRETARY: SIR HAROLD RAGGATT, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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FOREWORD

In 1959 the Commonwealth Government enacted the Petroleum Search Subsidy Act 1959. This Act enables companies that drill for new stratigraphic information, or carry out geophysical or bore-hole surveys in search of petroleum, to be subsidized for the cost of the operation, provided the operation is approved by the Minister for National Development.

The Bureau of Mineral Resources, Geology and Geophysics is required, on behalf of the Department of National Development, to examine the applications, maintain surveillance of the operations and in due course publish the results.

Union-Kern-A.O.G. Cabawin No. 1 was drilled under the Petroleum Search Subsidy Act 1959, in Authority to Prospect 57P, Queensland. The well was located at latitude 27° 29' 46" S, longitude 150° 11' 22" E, about 20 miles south-west of Tara, and was drilled for Union Oil Development Corporation, Kern County Land Company, and Australian Oil and Gas Corporation Limited by Oil Drilling and Exploration Limited of Sydney, using a National 80B drilling rig.

This Publication deals with the results of this drilling operation, and contains information furnished by Union Oil Development Corporation and edited in the Geological Branch of the Bureau of Mineral Resources. The final report was written by the staff of Union Oil Development Corporation. The methods employed in the drilling operation and the results obtained are presented in detail.

J. M. RAYNER
DIRECTOR

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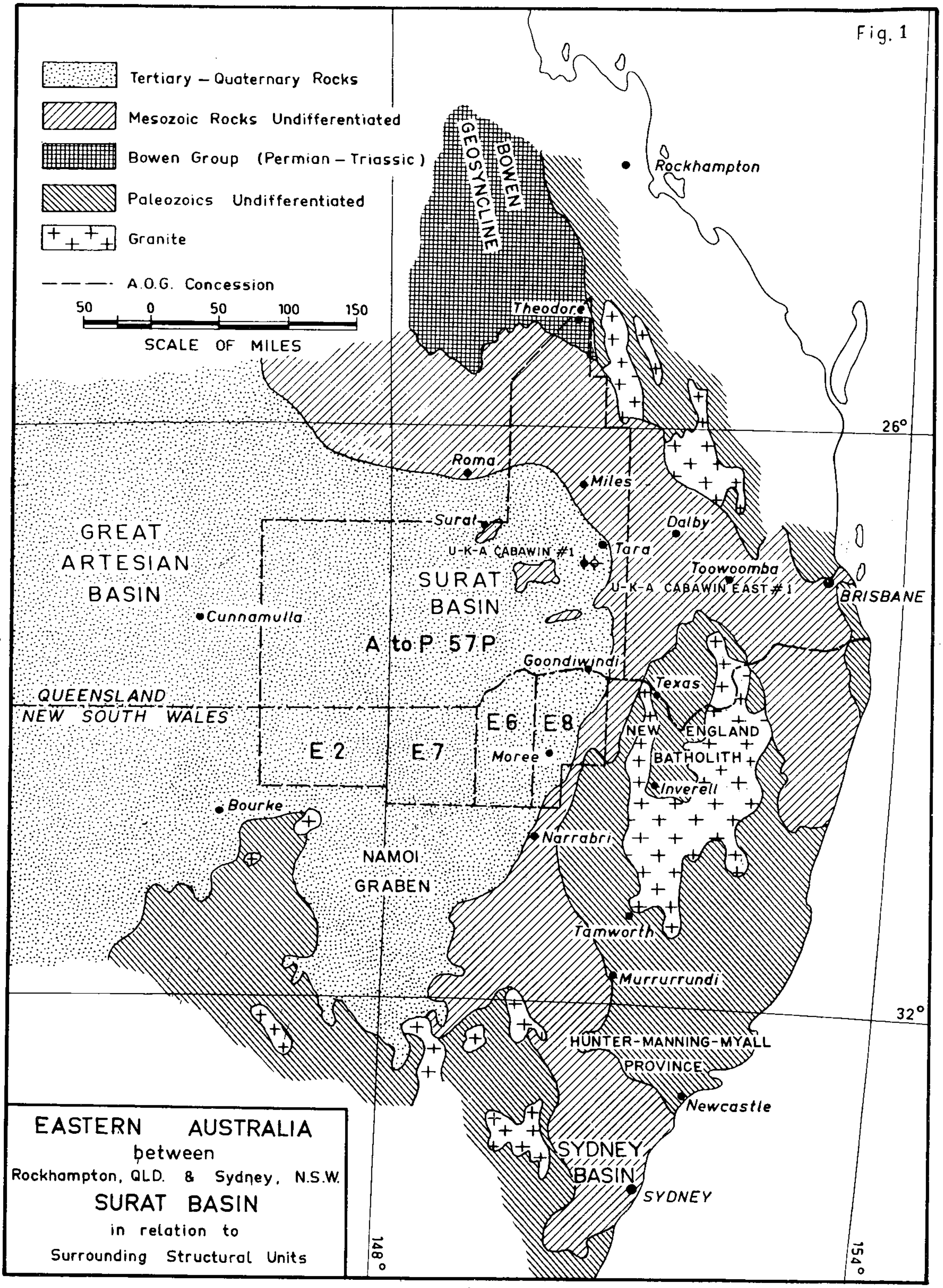

EASTERN AUSTRALIA
between
Rockhampton, QLD. & Sydney, N.S.W.
SURAT BASIN
in relation to
Surrounding Structural Units

SUMMARY

Union-Kern-A.O.G. Cabawin No. 1 spudded on 6th October, 1960, was drilled as a structural test of the petroleum potential of sediments underlying a major unconformity within the Surat Basin. The age and nature of the section below the unconformity was questionable prior to drilling the well, but it was presumed to be partly Triassic and partly Permian in age and related to the sedimentation of the Bowen Geosyncline. The drilling of the well confirmed this prognosis.

In addition to providing stratigraphic information related to the petroleum potential of the Bowen Group, the well also provided information of regional significance on the Mesozoic rocks of the Great Artesian Group. Under a thin veneer of Tertiary rocks the drill penetrated the Roma, Blythesdale, Walloon and Bundamba Formations of the Great Artesian Group, and the Cabawin, Kianga, and Back Creek Formations of the Bowen Group, before bottoming in volcanic rocks of (?)Permo-Carboniferous age at a depth of 12,035 feet.

The drilling of the well confirmed the presence of hydrocarbons in the Surat Basin. During the drilling operation a blowout occurred at a depth of 9938 feet, surfacing free gas and condensate. The blowout was caused by formation pressures, in excess of the mud weight, within an eight-foot sand body of the Permian Kianga Formation. In addition significant gas shows and a flow of salt water were encountered in weathered andesite of the Cracow Formation. Minor gas shows were recorded in the Permian Back Creek Formation, and in the Lower Triassic Cabawin Formation, and significant shows of hydrocarbons were also present in porous and permeable sandstones of the lower member of the Triassic-Jurassic Bundamba Formation.

The number of occurrences of oil and gas showings indicated that only a sustained testing programme through casing would properly evaluate the potential of these hydrocarbons. After reaching total depth, 5 1/2" casing was cemented at 12,033 feet, and there followed a series of production tests of all significant showings of oil and gas encountered during the drilling operation. Results were negative with the exception of the one zone in the Permian Kianga Formation. This zone proved to be the only producing horizon. After 22 days of continuous production, this zone was producing 62 barrels per day of 49^{o}API gravity crude through 22/64" choke, with casing and tubing well-head pressures at 550 p.s.i. and 300 p.s.i. respectively, and 534 Mcf/D of gas. A total of 1761 barrels of crude oil and 13,744 Mcf of gas were produced during the testing period. Pressure and temperature surveys were conducted, and the well was shut in and suspended on 17th June, 1961, retained in a condition for production at any future time.

INTRODUCTION

Union Oil Development Corporation, a wholly owned subsidiary of Union Oil Company of California, and the Kern County Land Company, also of California, entered into an Agreement in late 1959 with the Australian Oil and Gas Corporation Limited, holder of Authority to Prospect 57P, Queensland, whereby Union Oil Development Corporation as Operator for Union and Kern would conduct an exploration programme on lands of Authority to Prospect 57P in the Surat Basin of Queensland, Australia.

Union Oil began exploratory operations in November, 1959, with an aeromagnetic survey and surface geological studies, followed by an intensive reflection seismograph programme. The seismic work began in the area near Cabawin, Queensland, where a major north-south trending structural feature was first disclosed on a seismic reconnaissance line surveyed by the Geophysical Branch of the Bureau of Mineral Resources late in 1959. This major structural feature has subsequently been referred to as the "Cabawin Trend". Union's seismic work was planned to explore the "Cabawin Trend" further in the search for a closed structure in an area of maximum sedimentary section. This objective was reached in September, 1960 and a drill site, located on a domal feature, was selected for the initial test. (See location map Figure 1).

WELL HISTORY

General Data

Well name and number:	Union-Kern-A.O.G. Cabawin No. 1
Location:	Latitude 27° 29' 46" S. Longitude 150° 11' 22" E.
(Map Reference)	Dalby 4-mile Sheet
Name and address of Tenement Holder :	Australian Oil and Gas Corporation Limited, 44 Martin Place, Sydney, N.S.W.
Details of Petroleum Tenement :	Authority to Prospect 57P, Queensland
District :	Portion 30, Parish of South Glen, County of Rogers, State of Queensland
Total Depth :	12,035 feet
Date drilling commenced :	6th October, 1960
Date drilling completed :	26th March, 1961
Date well suspended :	17th June, 1961
Date rig released :	15th June, 1961
Drilling time in days to total depth :	171
Elevations (a.s.l.) :	Ground : 951.4 feet Kelly Bushing : 968.2 feet
Status :	Shut in and suspended as oil and gas producer. Completed flowing 26th April, 1961.
Cost:	£422,334

Initial production :	79 B/D, 51°, $\frac{24-28''}{64}$ $\frac{400}{680}$, 750 Mcf/D (1st 24 hr gauge, 27.6.61)
Last 24-hour production :	62 B/D, 49°, $\frac{22''}{64}$ $\frac{300}{550}$, 534 Mcf/D. 18.5.61
Producing Formation :	Kianga (Permian)
Casing :	20" cemented at 29 feet 13 3/8" cemented at 591 feet 9 5/8" cemented at 3047 feet 5 1/2" cemented at 12033 feet Plug 10,484 feet
Perforations :	Jet perfs; 9925-9943', 9965-9973', 9998-10,012', 10,152-10,158', 10,166-10,172' (Perforations between 11,995' and 8478' at intervals, all squeeze cemented).
Tubing :	2" hung at 9903' with perforated joint 9872-9903' on packer at 9832-9841 feet.

Drilling Data

Name and address of drilling contractor :	Oil Drilling and Exploration Limited, 93 York Street, Sydney, New South Wales.
Drilling Plant :	
Make :	National-Ideal
Type :	80-B.
Rated capacity with 4 1/2" drill pipe :	12,000 feet
Rated capacity with 3 1/2" drill pipe :	14,000 feet
Motors:	
Make :	3 Caterpillar
Type :	D-375
H.P. :	335
Derrick :	
Make :	Muskogee
Type :	Standard 136' x 30'
Rated capacity :	800,000 lb.
Pumps :	
Make :	2 Gardner-Denver
Type :	GR-GXP
Size :	7 3/4" x 16"
Make :	1 Gardner-Denver
Type :	FG-FXG
Size :	4 1/2" x 6"

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Blowout preventer equipment :

Make :	2 Cameron QRC
Size :	12"
Series :	S-900
Make :	1 GK Hydril
Size :	12"
Series :	S-900
	Powered by Hydril 80-gallon accumulator

Hole sizes and depths :

30"	to	29 feet
17 1/2"	to	620 feet
12 1/4"	to	5413 feet
8 3/4"	to	12035 feet

Casing and Liner details :

Depth (feet)	Size (in.)	Grade (Sch.)	Weight (lb./ft)	Collars	Threads	New or Used	Seamless or lap	Make
29	20	10	52	-	-	N	L	
591	13 3/8	H-40	48	ST & C	8 rd	N-U	S	Spang
3047	9 5/8	J-55	36	ST & C	8 rd	N-U	S	Sumitomo & Spang
12033	5 1/2	N-80	17-20	LT & C	8 rd	N	S	Spang

Casing and Liner cementing details :

Date	Casing	Depth cemented (feet)	Cemented through	No. sacks	Cemented Rise (feet)
8/10/60	13 3/8"	591	shoe	510	Surface
3/ 2/61	9 5/8"	3047	shoe	30	2932
4/ 2/61	"	2895	split	50	2704
5/ 2/61	"	"	"	12	
4/ 2/61	"	2342	sleeve	100	1959
6/ 2/61	"	"	"	55	
3/ 4/61	5 1/2"	12033	shoe	480	9753
3/ 4/61	"	5380	stage collar	130	5142

Drilling fluid :

Fresh water gel-base, low water loss, low pH mud was used to 7916 feet.

At 7916 feet, drilling fluid was converted to 5 percent oil emulsion fresh water, gel-base, low water loss, low pH mud, using diesel oil.

From 9938 to 12,035 feet, oil emulsion mud was used as above except weight was increased with barytes.

Materials and chemicals used included bentonite, barytes, caustic soda, myrtan, and driscose.

The drilling fluid history is given in the following Table :

Drilling Fluid History

Days	Weight (lb./ft)	Viscosity (Secs Marsh)	Filtrate (Standard)	Cake (in.)	Sand (%)	pH	Remarks
1- 7	69- 75	36- 76	8.2-10.5	$\frac{2}{32}$	1 - 6	9 - 11	
8- 23	73- 77	43- 76	6.4- 9.2	$\frac{2}{32}$- $\frac{3}{32}$	1 - 2.5	9 - 10	Chloride 40 g/g
24- 30	72- 75	52- 98	5.6- 9.0	$\frac{2}{32}$- $\frac{3}{32}$	1 - 2.5	8.5-10	NaCl 40 g/g
31- 37	74- 76	48- 92	5.4- 7.2	$\frac{2}{32}$	1.5-2.0	8.5-10	NaCl 40 g/g
38- 44	75- 79	48- 68	4.6- 6.4	$\frac{2}{32}$	1 - 2	9.5	NaCl 40 g/g
45- 51	75- 78	47- 82	4.0- 5.0	$\frac{2}{32}$	1 - 3	9.5-10.5	NaCl 60-64 g/g
52- 58	75- 78	45- 78	4.6- 5.8	$\frac{2}{32}$	1 - 3	9-10	NaCl 79-81 g/g
59- 63	75- 77	41- 46	4.0- 5.0	$\frac{2}{32}$	1.1-2	8.5-9.5	NaCl 53-58 g/g Condition of mud prior to blowout.
64- 68	65- 85	41- 46	4.0- 5.0	$\frac{2}{32}$	1.1-2	8.5-9.5	While awaiting additional supplies barytes to kill well, circulated through kill-line, reciprocated drill pipe through Hydril.
69	95	68	6.0	$\frac{2}{32}$	1	11	Killed well with 600 barrels· 95 lb. mud.

Drilling Fluid History (Cont'd)

Days	Weight (lb./ft)	Viscosity (Secs Marsh)	Filtrate (Standard)	Cake (in.)	Sand (%)	pH	Remarks
70- 93	86-110	78-108	3.2-5.0	$\frac{2}{32}$	1 - 1.5	8.5-9.5	Fishing job during period. Built mud weight to control well.
94-100	105-107	115-150	3.5-4.6	$\frac{2}{32}$	1.3- 2	9.0-9.5	-----
101-107	101-105	66-100	3.6-5.0	$\frac{2}{32}$	1	8.0-9.5	-----
108-114	100-105	78- 94	3.2-4.0	$\frac{2}{32}$	1 1/2	9.0-10	-----
115-148	100-105	78- 94	3.2-4.0	$\frac{2}{32}$	1 1/2	9.0-10	Fishing. No drilling during period.
149-156	100-101	61- 76	5.0-6.5	$\frac{2}{32}$	1/2 - 2	10-11	NaCl 58- 70 g/g
157-163	100-102	67- 75	3.4-6.5	$\frac{2}{32}$	1/2 - 2	11	NaCl 58- 77 g/g
164-170	101-111	66- 93	4.0-6.8	$\frac{2}{32}$	1 1/2 - 2	9.0-10	NaCl 78-190 g/g
171-177	111-114	67- 90	5.0-7.0	$\frac{2}{32}$	1 1/2 - 2	9.0-9.5	NaCl 140-190 g/g

Water supply :

Fresh water for use during the drilling operation was obtained from a well registered with the Queensland Water and Irrigation Commissioner as No. 12447, located 4.7 miles north of Lat. 27°30' South and 13 miles east of Long. 150°E. The well was 2000 feet deep and flowed from 1850 feet at 70 gallons per hour rate. A Southern Cross HD-6 pump jack and pump was used to supply water requirements. A 4" pipe line was carried eight miles to the well site.

Perforation and Shooting Record

Casing	Intervals (feet)	No. Holes per ft	Size Holes (in.)	Method	Status
5 1/2"	8478	4	1/2	Schlumberger Jet Perforation	Squeeze cemented
"	8508- 8520	4	1/2	"	"
"	8532- 8540	4	1/2	"	"
"	8549- 8557	4	1/2	"	"
"	8581	4	1/2	"	"
"	8688	4	1/2	"	"
"	8752- 8760	4	1/2	"	"
"	8762- 8770	4	1/2	"	"
"	8774- 8786	4	1/2	"	"
"	8824	4	1/2	"	"
"	8825	4	1/2	"	"
"	8878- 8890	4	1/2	"	"
"	8925	4	1/2	"	"
"	9881	4	1/2	"	"
"	9882	4	1/2	"	"
"	9925- 9930	4	1/2	"	Open
"	9930- 9938	4	1/2	"	"
"	9938- 9943	4	1/2	"	"
"	9965- 9973	4	1/2	"	"
"	9998-10012	4	1/2	"	"
"	10006	4	1/2	"	"
"	10152-10158	4	1/2	"	"
"	10166-10172	4	1/2	"	"
"	10172	4	1/2	"	"
"	10600	4	1/2	"	Squeeze cemented
"	11655	4	1/2	"	Open below plug
"	11744-11750	4	1/2	"	" " "
"	11752-11760	4	1/2	"	" " "
"	11881-11995	4	1/2	"	Squeeze cemented

Plugging Back and Squeeze Cement Jobs

Date	Depth cemented (feet)	Cemented through	No. Sacks	Method	Remarks
13/4/61	11996-11811	Plug & 4 - 1/2" HPF	20 total 4 out perfs.	Squeeze	Laid in 20 sack plug, squeezed 4 out perfs, held 1300 p.s.i. 20 minutes
18/4/61	10600	4 - 1/2" holes	19	"	Pressure tested 3000 p.s.i. OK
18/4/61	9881	4 - 1/2" holes	48	"	Final pressure 2000 p.s.i. OK
20/4/61	10600	4 - 1/2" holes	17	"	Final pressure 4800 p.s.i. OK
21/4/61	9882	4 - 1/2" holes	10	"	Final pressure 3500 p.s.i. OK
28/5/61	9690- 9740	Plug	15	Open end DP	Plug to isolate upper zones for testing
29/5/61	8925	4 - 1/2" holes	75	Squeeze	Squeeze pressure: 1500 p.s.i. Held at 500 p.s.i. OK
30/5/61	8925	4 - 1/2" holes	70	"	Resqueezed, final pressure 1500 p.s.i. OK
30/5/61	8825	4 - 1/2" holes	15	"	Resqueezed, final pressure 1800 p.s.i. OK
31/5/61	8688	4 - 1/2" holes	20	"	Final pressure: 4500 p.s.i. OK
1/6/61	8581	4 - 1/2" holes	22	"	Final pressure : 2400 p.s.i. OK
1/6/61	8478	4 - 1/2" holes	42	"	Final pressure : 4000 p.s.i. OK
8/6/61	8824-8925	perforated intervals	21	"	Final pressure : 5000 p.s.i. OK
9/6/61	8688-8786	perforated intervals	69	"	Final pressure : 3400 p.s.i. OK
9/6/61	8487-8581	perforated intervals	45	"	Final pressure : 3500 p.s.i. OK
11/6/61	8688-8925	perforated intervals	28	"	Final pressure : 2200 p.s.i. OK
12/6/61	8487-8581	perforated intervals	25	"	Final pressure : 3500 p.s.i. OK

Fishing Jobs :

Date	Depth (feet)	Remarks
28/10/60	6294	Left 3 cones off Security S-4 Bit in hole. Recovered with 7 1/8" Bowen magnet.
15/12/60	9952	Stuck core barrel at 1724 feet while pulling out. Drill pipe parted at 602 feet while attempting to work free. Fish : 602 to 1724 feet. Unable to recover fish with socket. Ran in with outside cutter, cut fish at 606 feet. Ran Schlumberger back-off shot and backed off fish at top of drill collars (1424'). Ran in safety joint on jars, screwed into fish. Jarred 11 hours, spotted 30 bbl. diesel oil, and recovered fish.
14/1/61	9981	While opening hole at 5413 feet to 12 1/4" preparatory to running an intermediate string of 9 5/8" casing, hole opener broke in pieces leaving bottom half of Reed Hole Opener in hole, including 8 3/4" Security S-6 J Bit and two cutter wheels from hole opener. Milled on junk, pushed part of junk into side wall at 5381 feet, pushed additional junk to 6708 feet. Conditioned hole for 9 5/8" casing.
18/1/61	9981	While running 9 5/8" casing, casing stopped at 3047 feet. Unable to work or circulate casing deeper. Casing parted at 2895 feet and 2243 feet. Recovered casing above 2233 feet. Ran 12" Kinsback flat bottom mills, found junk from 1530 feet, milled and reamed and passed junk 1606, 1707 and 2136 feet. Ran 7 3/4" Kinsback mill inside casing fish, opened to 2450 feet. Ran McCullough casing spear, recovered 2 joints 9 5/8" casing. Left 2 casing collars in hole. Top casing fish 2295 feet. Ran spear, jarred, no success. Ran 8 3/4" bit inside casing fish to top float collar, circulated. Reran spear, jarred, no success. Ran 8 1/8" K. & G. magnet to 3012 feet, no recovery. Ran 12" Kinsback tapered mill, hit bridges, milled to 1945 feet. Ran 9 5/8" inside cutters, cut casing at 2307 feet. Ran spear, recovered casing to 2307 feet. Repeated cut at 2342 feet, recovered casing to 2342 feet. Conditioned hole for casing. Ran 9 5/8" casing with special adaptor for casing fish. Landed casing.
28/1/61	9981	Ran 8 3/4" junk basket to 3010 feet; ran 8 1/8" O.D. magnet to 3010 feet, recovered small amount junk. Ran 8 3/8" O.D. Bowen overshot with type E milling guide, milled on iron at 3010 feet. Alternatingly ran junk basket, magnet and Servco mills, milled and recovered junk from Hole Opener and pilot bit. Ran in 8 3/4" bit, drilled out shoe of 9 5/8" casing at 3047 feet, then cemented casing at 3047 feet and through splice at 2342 feet, and split at 2895 feet.
8/2/61	9981	After cementing casing, reamed hole to 6862 feet, pushed junk 6862 to 7103 feet, reamed from 7103 to 8238 feet. Pipe stuck at

Date	Depth (feet)	Remarks
		8238 feet. Worked pipe up to 7812 feet. Ran Schlumberger back-off shot, backed off at 7542 feet. Ran in with jars on 357' 6" drill collars. Screwed into fish, jarred loose, worked pipe through tight hole to 7446 feet. Pipe stuck at 7446 feet. Unable to jar, unable to back off, spotted 30 bbl. diesel oil, unable to work pipe free. Backed off top of drill collars leaving fish 6818 to 7446 feet.
12/2/61	9981 Fish: 9353-9981 6781-8522	Ran jars, screwed into fish, unable to loosen. Backed off at 6818 feet, ran in with 7 1/2" wash pipe, washed over to 7031 feet, fish dropped free. Ran in bumper sub on 89 feet of 6 1/2" drill collars to 8522 feet, stuck fishing string, unable work pipe, backed off at 6781 feet. Fish 6781-8522 feet.
16/2/61	9981 Fish: 9353-9981 8416-8522	Washed over fish 6781 to 6933 feet. Ran 4 1/2" outside cutters, cut and recovered drill pipe to 6868 feet. Washed over fish 6868 to 7056 feet. Ran Bowen overshot, took hold fish at 6868 feet, ran back-off shot and free point indicator. Backed off drill pipe at top of drill collars, 8416 feet. Fish 8416 to 8522 feet.
23/2/61	9981 Fish: 9353-9981 8385-8522	Ran 7 1/8" wash pipe, unable wash over fish. Ran in open end drill pipe, screwed into fish, backed off drill pipe at 8385 feet. Ran wash pipe and washed over fish 8385 to 8425 feet. Fish fell away.
26/2/61	9981 Fish: 9353-9981 9192-9329	Ran in open end drill pipe, unable screw into fish at 9192 feet. Ran in Bowen overshot on jars on 89 feet 6 1/2" drill collars. Took hold of fish at 9192 feet. Worked top fish into bottom fish and jarred 20 minutes. Pulled out and recovered both fish except for cones off bit of bottom fish.
28/2/61	9981	Ran 8 1/4" Servco mills, 8 1/8" O.D. magnets, recoverd cones and other junk. Cleaned out hole, conditioned mud, and resumed drilling 3rd March, 1961.
13/4/61	12,035 5 1/2" Casing cemented at 12,033 Fish: 11,383-11,404	Stuck jet perforator gun at 11,729 feet. Pulled cable out of socket. Ran in overshot on 2 3/8" Tubing, worked fish up to 11,383 feet. Unable to move fish, backed off overshot leaving fish in hole. Fish: 11,383 to 11,404 feet, consisting of 4" O.D. x 21 feet Schlumberger jet perforator including collar locator on top.

Logging and Testing

Ditch samples: Ditch samples were collected at 10-foot intervals from the surface to total depth. While coring, the interval was reduced to 5 feet. Washed sample cuts were made for the Bureau of Mineral Resources, Queensland Department of Mines, and Union Oil Development Corporation.

Coring : The original conventional coring programme is set out below :

(i) Cores shall be taken immediately following any showings of hydrocarbons.
(ii) Cores shall be taken at maximum intervals of 500 feet to a depth of 5500 feet and at maximum intervals of every 200 feet thereafter.

Programme was followed with minor exceptions approved by the Bureau of Mineral Resources.

Forty-three conventional cores were cut using Hughes "J" Type core barrel and hard formation coreheads. A total of 433.5 feet of formation was cored and 298.5 feet (68.85%) recovered. Cores are described in Appendix 2. Fully representative cuts of cores were reserved for the Bureau of Mineral Resources and Queensland Mines Department.

Sidewall Cores : In addition to conventional cores, 149 sidewall cores were recovered using Schlumberger chronological sample taker.

Core analysis results of cores and sidewall samples are contained in Appendix 2, together with comments by Union Oil Company of California Technical Staff.

Electrical Logging: The following Schlumberger logs were run: Electric Log, Continuous Dipmeter, Laterolog, Interval Dipmeter, Microlog, and Gamma Ray-Neutron. A complete list of all pertinent details of each log run is contained in Appendix 3.

A discussion and interpretation of the various logs by the Schlumberger Engineer and the Union Oil Company of California Technical Staff are also included in Appendix 3.

Two velocity surveys were conducted. Details and discussion are contained in Appendix 3.

Copies of all logs are held and are available for inspection at the Bureau of Mineral Resources, Canberra.

Drilling rate, oil and gas log: Five-foot drilling time was recorded by Rotary Engineering Company personnel during drilling and one-foot drilling time while coring. Drilling rates have been recorded on the Composite Log Sheets and plotted against oil shows and gas occurrences as revealed on flow line gas detector unit.

Open Hole Formation Tests

Date	Tester	Interval (feet)	Packer (feet)	Water Cushion (feet)	Open	Results
4/11/60	Johnston	6728-6776	6728	185	65 min.	Weak blow increasing to medium blow after 40 min., then decreasing to weak blow at end of test. Recovered 2800 feet net rise slightly gassy muddy water testing 35 g/g NaCl. Initial hydrostatic: 3300 p.s.i. Initial flow: 650 p.s.i. Final flow: 1250 p.s.i. Final hydrostatic: 3150 p.s.i.
12/11/60	Johnston	7388-7406	7388	185	60 min.	Medium blow decreasing to weak at end of test. Recovered 4020 feet gross rise as follows: 60 feet water cushion, 90 feet dry, 270 feet watery mud, 3600 feet normal drilling fluid. Charts showed that tools operated properly. Initial hydrostatic: 3700 p.s.i. Initial and final flow: 0 p.s.i. Final hydrostatic: 3400 p.s.i. Found main valve cut out indicating drilling fluid entered drill pipe while pulling out.
18/11/60	Johnston	7822-7915	7822	280		Packer failed
18/11/60	Johnston	7834-7915	7834	280		Packer failed

The report on production testing with 5 1/2" casing is tabulated under "Drilling Summary".

Deviation Surveys : 59 drift readings were recorded using a TOTCO Drift Indicator. The maximum deviation was $1^{o}15'$ with the majority of the readings less than 1^{o}. The deviation record is recorded on the Composite Well Log.

Pressure and temperature surveys were conducted after completion of the well, using Kuster equipment. Details of each survey are included in Appendix 4.

Drilling Summary

Union-Kern-A.O.G. Cabawin No. 1 was spudded on 6th October, 1960. A 12 1/4" hole was drilled and cored to 622 feet, then opened to 17 1/2" and 13 3/8" casing run and cemented at 591 feet with 510 sacks cement. An 8 3/4" hole was then drilled and cored to a depth of 4197 feet where an electric log and micrologwere run, and sidewall cores were obtained. An 8 3/4" hole was drilled and cored to a depth of 5953 feet where an electric log was run and sidewall samples obtained.

Drilling and coring continued with 8 3/4" bits to a depth of 6776 feet. Showings of gas were noted from 6728 feet (lower Bundamba). Electric log, micrologand micro caliper logs were run and sidewall samples obtained. An open hole formation test was conducted of the interval 6728 to 6776 feet. Tester was opened for 65 minutes, but gas did not surface. The tester was pulled and 2800 feet net rise of slightly gassy muddy water was recovered.

An 8 3/4" hole was drilled and cored to a depth of 7406 feet. Showings of gas were noted at 7400 feet (lower Bundamba). An electric log and micrologwere run, and an open hole formation test conducted of the interval 7388 to 7406 feet. The tester was open 60 minutes, but no gas or fluid from the formation was recovered.

Drilling and coring continued to 7915 feet. Showings of gas were again noted below 7820 feet (Cabawin Formation). Electric log and sidewall samples were run. Two attempts to conduct an open hole formation test of the intervals 7822 to 7915 feet and 7834 to 7915 feet failed.

An 8 3/4" hole was then cored and drilled to a depth of 9938 feet, at which point a strong gas show was noted on the gas analyzer (Kianga Formation, Permian). The bit was pulled and a core barrel was run. While circulating prior to cutting the core, a strong blow of gas and mud occurred at the surface blowing the kelly bushing and table bushings out of the rotary table. The Hydril was closed on the kelly and bleed-off was started through the kill line. The kelly was pulled out of the Hydril, and the drill pipe was then reciprocated through the Hydril to keep the string free. While heavy mud was being mixed to attempt to kill the well, the annulus was being bled off through the kill line recovering large volumes of gas with strong gasoline odour, traces of gas cut mud, and a 42^{o} API gravity greenish crude. Barytes supplies at the site were exhausted, and for six days until additional barytes could be obtained to weight the mud sufficiently to control the well, the drill pipe was reciprocated through the Hydril, and annulus was bled off through the kill line.

Sufficient barytes arrived at the site to mix a 95 lb./cu.ft mud and the well was killed, the Hydril opened, and the pipe was pulled up 20 stands freely. The pipe was run back to bottom (9938 ft) and a core was cut between 9938 and 9952 feet. While pulling out with the core barrel, the barrel stuck at 1724 feet, and while attempting to work free, the drill pipe parted at 602 feet. The fish was recovered, the hole conditioned, and electric log and microlog run. Sidewall samples were taken and a dipmeter run.

The hole was then cored continuously from 9952 to 9971 feet at which point a velocity survey was conducted. A core was cut from 9971 to 9981 feet.

It was determined to run an intermediate string of 9 5/8" casing to a depth of approximately 5500 feet, before proceeding deeper in the well.

The 8 3/4" hole was then opened to 12 1/4" to a depth of 5413 feet at which point the Hole Opener broke in pieces in the hole. The bottom half of the Hole Opener including the pilot bit and two cutter wheels were left in the hole. Mills were run and junk was pushed into sidewall. The 9 5/8" casing was started in the hole. Casing stopped at 3047 feet, apparently owing to a portion of Hole Opener junk dislodging from the sidewall. In attempting to work the casing free, the casing parted at 2233 feet. Attempts to fish casing from hole failed. A splice and adaptor were made and 9 5/8" casing was run and cemented onto the casing fish. Casing was also cemented through shoe at 3047 feet.

The shoe of the 9 5/8" casing was then drilled out. Junk was encountered below the shoe and pushed to 8238 feet where the pipe stuck. A series of fishing jobs occurred after this incident but the hole was finally cleared, and drilling resumed. An 8 3/4" hole was drilled and cored to a depth of 11,783 feet (Andesite) where electric log and microlog were run. Strong gas shows were noted below 11,740 feet and mud weight was increased to 110 lb./cu.ft. Drilling was then continued to a total depth of 12,035 feet where electric logs were run and a velocity survey conducted. Sidewall samples were taken. A gamma ray-neutron log, laterolog, and continuous dipmeter survey were also run.

Hole was then conditioned for 5 1/2" casing and casing was run and cemented at 12,033 feet with 480 sacks, and through stage at 5380 feet with 130 sacks.

A series of production tests were then conducted through the 5 1/2" casing beginning with the lowermost zone of interest. Results of these are tabulated below.

Interval (feet)	Formation	Hole Condition	Packer (feet)	Water Cushion (feet)	Open	Remarks
11881-11995	Andesite	Plug 12003' WSO:11665'	11819	3020	69 min.	Recovered 1220' net rise, slightly gassy and muddy water. (Salinity 1030 g/g). Final Hydrostatic Pressure 9415 p.s.i.
11744-11750 11752-11760	Andesite	Plug 11811'				Stuck jet perforator at 11729', worked up to 11383' with over-shot. Plugged 11299-11200'. Tested tightness of plug with HOWCO tester: Packer at 10644' open 60 min., medium to strong blow, recovered 6210' net rise drilling fluid. Ran in with bit, no indication of plug 11299-11200'. Circulated out salt water from perfs 11744-11760'. Well flowed at 2500 B/D rate, salt water testing 1116 gr/gal. Killed well with 110 lb./cu.ft mud.
10006-10172	Kianga	Plug 10484' WSO: 9882'	9945	2000	5 hrs 39 min.	Weak to medium blow, water cushion to surface 82 mins. Flowed at average 120 B/D rate, 49.50°, 30% mud cut, 1000 Mcf/D rate; 45/64" bean, 50-400 p.s.i. pressures. Final shut in pressure: 6919 p.s.i. (not built up).
9930- 9938 10006-10172	Kianga	Plug 10484' WSO: 9982'	9850	2000	7 hrs 20 min.	Water cushion to surface 37 min., well flowing through trap after 47 min., flowing through blow down line. First 30 min., stabilized gauge. 141 B/D rate, 49°, trace cut, 32/64" bean, 600 lb. tubing, 760 Mcf/D rate. F.S.I. 5874 p.s.i. (not built up).
9925- 9943 9965- 9973	Kianga	Plug 10484' WSO: 9982'				Sustained production test. (See Production Data)

Interval (feet)	Formation	Hole Condition	Packer (feet)	Water Cushion (feet)	Open	Remarks
9998-10012 10152-10158 10166-10172	Kianga	2" Tbg. at 9981'				
8878-8890	Cabawin	Plug 8912' WSO:8824'	8816	660	60 min.	Recovered 320 feet net rise, slightly gassy thick mud.
8752-8760 8762-8770 8774-8786 8878-8890	Cabawin	Plug 8912' WSO:8824'	8660	660	120 min.	Recovered 1034 feet net rise mud.
8508-8520 8532-8540 8549-8557 8752-8760 8762-8770 8774-8786 8878-8890	Cabawin	Plug 8927' WSO:8824'	8474	660	120 min.	Washed and squeezed perfs with diesel oil before test. Recovered 850 feet net rise slightly muddy gassy water.

All perforations in the Cabawin Formation were then squeeze cemented, the cement plugs drilled out to 10,484 feet, the mud conditioned, 2" tubing was landed at 9903 feet on packer at 9832-9841 feet, and the well was returned to production from intervals in the Kianga Formation (See Production Data).

The well was produced for a brief period and pressure and temperature surveys were conducted. On 17th June, 1961 the well was shut in and suspended, retained in a condition to be produced at any future time.

GEOLOGY

Regional Geology

Surface geologic studies have been made by Union Oil Development Corporation over most of the Surat and Bowen Basins and adjoining areas. The structural and stratigraphic relationships have been mapped, described, and correlated with subsurface information from seismic and well studies. All work has been integrated into one regional report. In the present report only a synthesis of this work is included. For details of the nomenclature, stratigraphy, or structure reference is made to "Reconnaissance Geology of the Surat Basin, Queensland and New South Wales", by J.E. Mack, Jr. (1963).

Authority to Prospect 57P lies within the south-eastern part of the Surat Basin, an eastern lobe of the Great Artesian Basin. The Great Artesian Basin is a major Mesozoic downwarp which had its inception in Triassic time (Fig. 1). The northern edge of the Mesozoic Surat Basin overlaps the southern extension of the Bowen Basin, a major structure that warped downward in varying degrees from Permian time into early Triassic time.

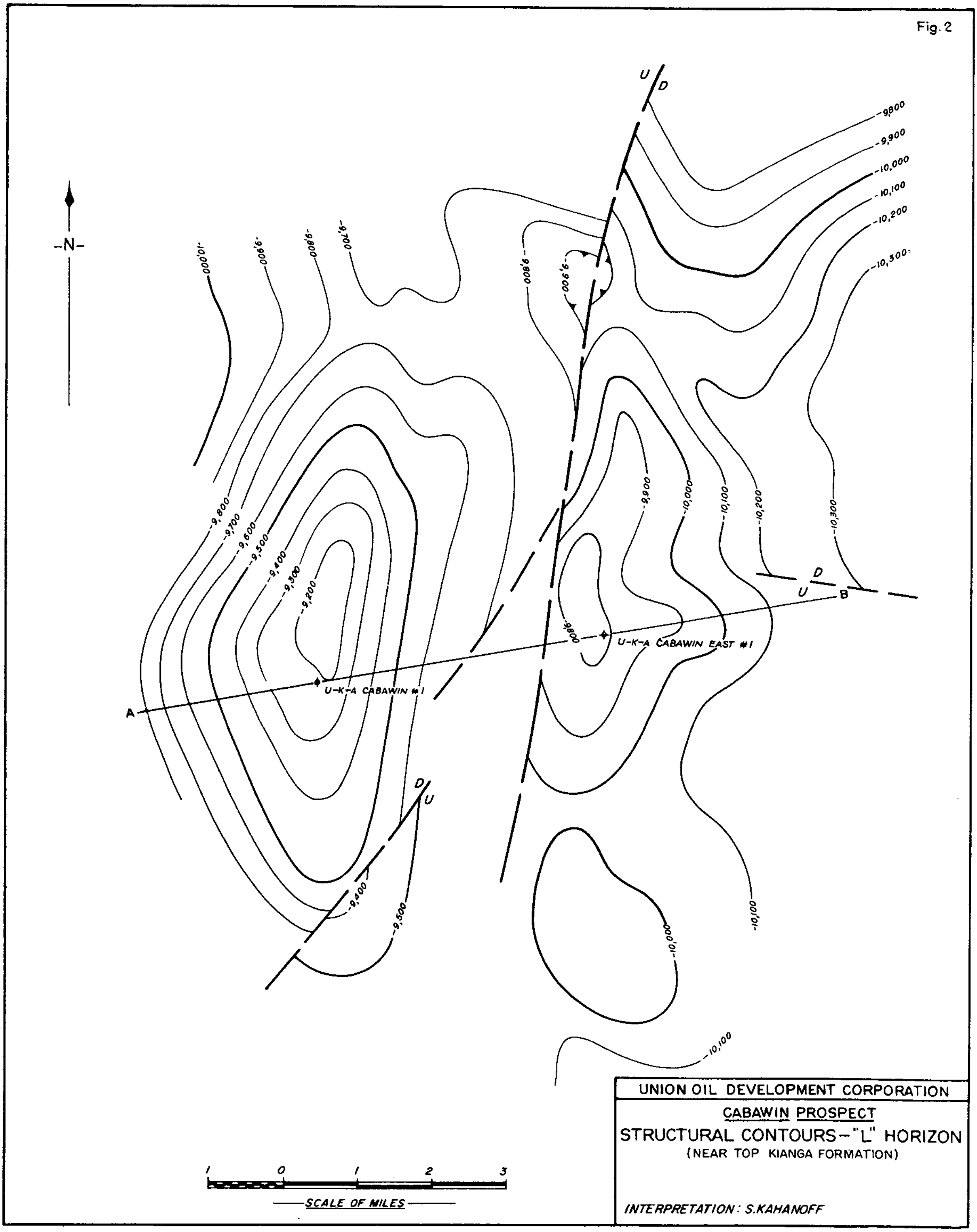
Two major phases of sedimentation have been recognized, one related to the development of the Bowen Basin (Bowen Group), and the other related to the development of the Great Artesian Basin (Great Artesian Group). The Permian rocks of the Bowen Group grade upward from shallow marine tuffaceous clastics (Back Creek Formation) to non-marine tuffaceous clastics and coal (Kianga Formation). The Triassic rocks of this Group (Cabawin Formation) are tuffaceous coarse clastic fill deposits. A period of base level was reached in the Bowen Basin within Triassic time. This period marked the end of "Bowen" sedimentation and set the stage for the deposition of the Great Artesian rocks. Rocks of the Great Artesian Group are predominantly continental clastics deposited in shallow inland seas and swamps (Bundamba, Walloon, and Blythesdale Formations). At the top of the Group a marine transgression is represented by rocks of the Roma Formation.

Structure of the Cabawin Prospect

The Cabawin structure occupies a position on the southern plunge of the "Cabawin Trend", a major north-south trending, faulted, compressional fold that had its inception prior to the sedimentation related to the sag of the Great Artesian Basin. The compressional forces originated east of the prospect and are genetically related to the forces that were active along the eastern side of the Bowen Basin in early Triassic time. Rejuvenation of structure is indicated to some extent in the younger Mesozoic beds.

Figures 2 and 3 are structure maps of the Cabawin prospect as interpreted from the seismic work. Figure 4 is a cross-section along a seismic line showing structural and stratigraphic relationships through the location of Cabawin No. 1 and a well that was subsequently drilled, Cabawin East No. 1.

Figure 2. Structure map "L" Horizon - The "L" horizon map is based on a continuous reflection from beds near the top of the Permian Kianga Formation. This horizon approximately marks the position of the Upper Permian oil sand encountered in the drilling of Cabawin No. 1. As indicated by the contours of the "L" horizon, the Cabawin No. 1 domal structure has a maximum closure of 500 feet over an area of approximately 20 square miles.



UNION OIL DEVELOPMENT CORPORATION

CABAWIN PROSPECT

STRUCTURAL CONTOURS—"L" HORIZON

(NEAR TOP KIANGA FORMATION)

INTERPRETATION: S.KAHANOFF

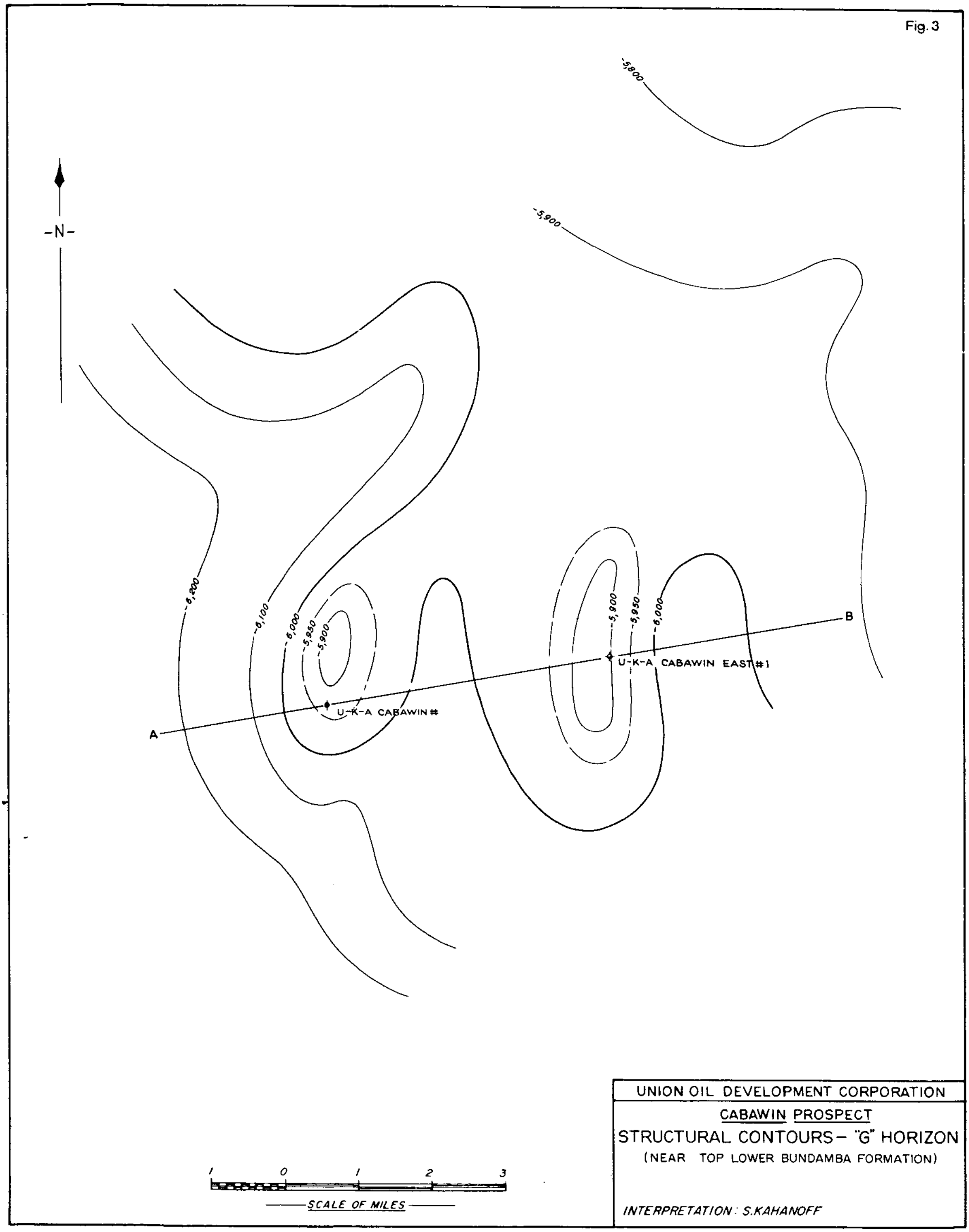


Fig. 3
-N-
-5,800
-5,900
-6,200
-6,100
-6,000
-5,950
-5,900
-5,900
-5,950
-6,000
A
B
U-K-A CABAWIN #
U-K-A CABAWIN EAST #1
1 0 1 2 3
SCALE OF MILES
UNION OIL DEVELOPMENT CORPORATION
CABAWIN PROSPECT
STRUCTURAL CONTOURS – "G" HORIZON
(NEAR TOP LOWER BUNDAMBA FORMATION)
INTERPRETATION: S. KAHANOFF

Figure 3. Structure map "G" horizon - The "G" horizon map represents the approximate top of the lower member of the Bundamba Formation, the oldest stratigraphic unit of the Great Artesian Group. Although the structure of the older rocks is reflected in the Bundamba sediments, the amount and areal extent of closure are considerably less. Approximately 50 feet of closure over two square miles is indicated on the Cabawin No. 1 feature.

Stratigraphy of Cabawin No. 1

Union-Kern-A.O.G. Cabawin No. 1 was spudded in surficial rocks of Tertiary-Quaternary age. Below a thin veneer of these sediments the drill penetrated the Roma, Blythesdale, Walloon, and Bundamba Formations of the Great Artesian Group and the Cabawin, Kianga, and Back Creek Formations of the Bowen Group. The well bottomed in weathered andesites of the Cracow Formation which is presumed at this time to be Permo-Carboniferous in age. Tabled below is the stratigraphic sequence encountered in the well. Datum is the kelly bushing, 18 feet above the ground level.

Age	Formation	Depth Intervals (feet)	Thickness (feet)
Cainozoic		18 - 60	42
L. Cretaceous	Roma Formation	60 - 2865	2805
L. Cret.-Jurassic	Blythesdale Formation	2865 - 4200	1335
Jurassic	Walloon Formation	4200 - 5444	1244
Jur.-Triassic	Bundamba Formation	5444 - 7640	2196
Triassic	Cabawin Formation	7640 - 9835	2195
Permian	Kianga Formation	9835 - 10357	522
Permian	Back Creek Formation	10357 - 11662	1305
Permo-Carb.	Cracow Formation	11662 - 12035	373+

As the general dip of the above formations penetrated in the well is low the thicknesses shown are close approximations to true thicknesses.

Cainozoic sediments, 18-60 feet (42 feet)

Grey clays and soft silty sandstones of fluviatile origin occupy the interval from 18 to 60 feet in the well.

Great Artesian Group

Roma Formation, 60 - 2865 feet (2805 feet)

The Roma Formation consists of 2805 feet of interbedded, shallow water, marine shales, sandstones, siltstones, and coal beds. Calcareous fossiliferous shales predominate down to a depth of about 1300 feet. From 1300 to 1640 feet the section becomes more arenaceous and locally, conglomeratic. Thin coal beds predominate between 1640 and 1850 feet. The section becomes progressively sandier below 1850 feet and from 2200 to 2865 feet there is a gradational transition into the sand facies of the underlying Blythesdale Formation. The contact with the Blythesdale is picked on the basis of the change in character of the self-potential and resistivity curves on the Electric Log. This pick coincides with the top of the first major sandstone body developed in the Blythesdale sequence.

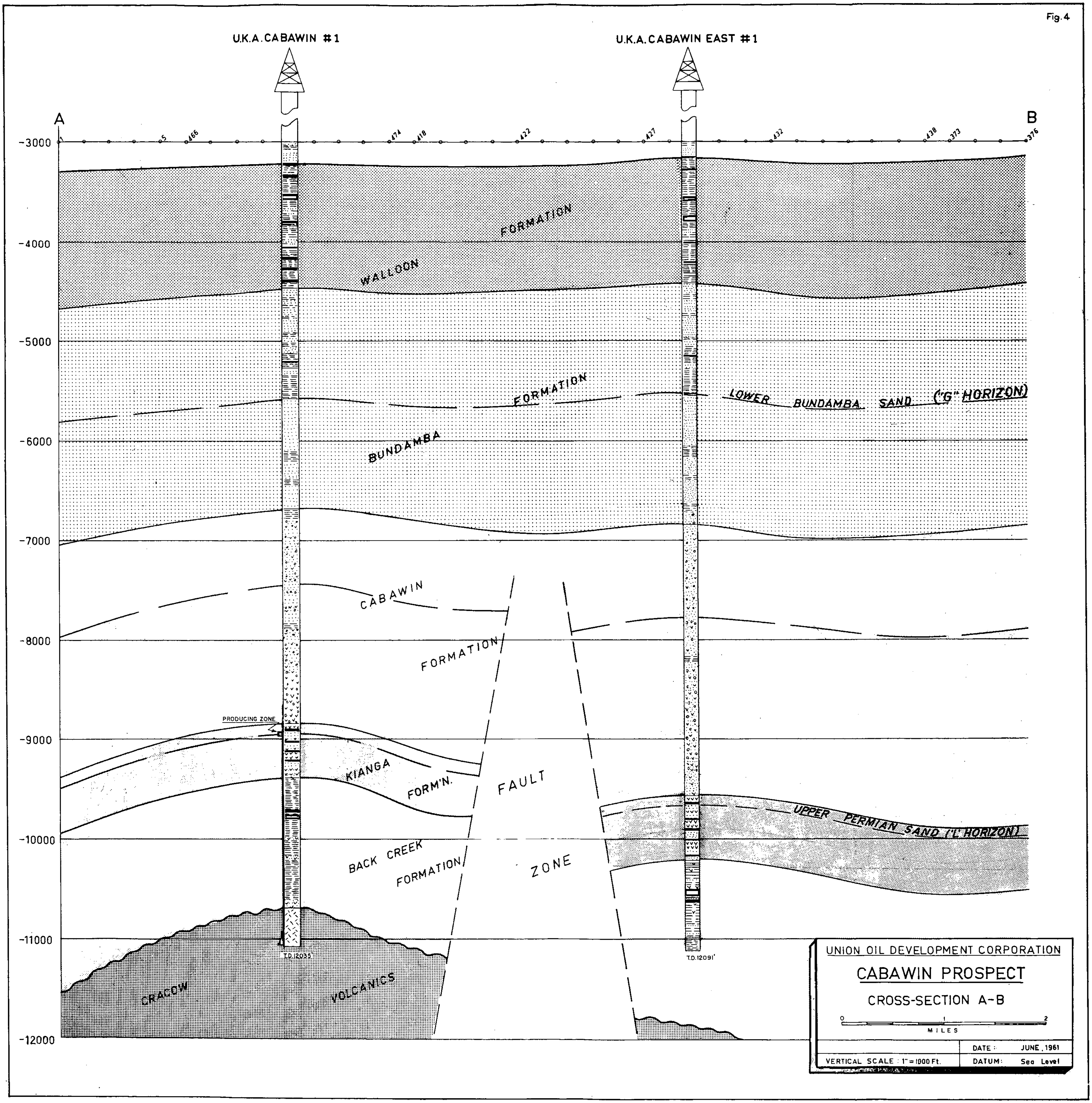


Fig. 4
U.K.A. CABAWIN #1
U.K.A. CABAWIN EAST #1
A
B
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
-12000
WALLOON FORMATION
BUNDAMBA FORMATION
LOWER BUNDAMBA SAND ("G" HORIZON)
CABAWIN FORMATION
PRODUCING ZONE
KIANGA FORM'N.
FAULT ZONE
BACK CREEK FORMATION
UPPER PERMIAN SAND ('L' HORIZON)
CRACOW VOLCANICS
T.D. 12035'
T.D. 12091'
UNION OIL DEVELOPMENT CORPORATION
CABAWIN PROSPECT
CROSS-SECTION A-B
0
1
2
MILES
VERTICAL SCALE : 1" = 1000 Ft.
DATE : JUNE, 1961
DATUM: Sea Level

Detailed description, Roma Formation

60 - 653 feet (593 feet)

SHALE, grey, silty in part, scattered carbonaceous material with several interbedded SANDSTONES, grey fine-grained, speckled appearance, moderately well-sorted subangular clear quartz, some black, cream, lithic grains, some glauconite; matrix light grey clay, in part calcareous.

653 - 1878 feet (1225 feet)

SHALE, grey, partly silty, containing shelly mollusca fragments down to 1420 feet, but also containing macerated carbonaceous material throughout, and interbedded and laminated with grey and light grey SILTSTONE towards the base. Thin black COAL seams predominate between 1640 and 1850 feet, and grey fine-grained SANDSTONES occur in thin beds throughout. The sandstone is poorly sorted, subangular to subrounded, with clear quartz, some cream coloured tuff and a few black and green grains; matrix is very fine sand with some clay, and the rock is loosely cemented. Carbonaceous material and blebs of grey shale and silt evident. Rounded pebbles of clear quartz and blue-grey and waxy brown chert occur between 1535 and 1541 feet in a sandstone with slight porosity.

1878 - 2076 feet (198 feet)

SANDSTONE, grey to light grey, medium-grained, poorly sorted, content as for Unit 2, but with fine friable sand matrix with some porosity, and with interbedded grey and light grey SHALE, silty in part near top and base of the sequence. Carbonaceous material and coaly streaks throughout.

2076 - 2210 feet (134 feet)

SHALE, grey and light grey, silty with carbonaceous fragments and black coal streaks.

2210 - 2865 feet (655 feet)

SANDSTONE, light grey, grey-buff, medium-grained some coarse-grained, carrying few small pebbles near base. Grains poorly sorted, subangular to subrounded clear quartz, some green and black lithic fragments; matrix gummy light grey clay.

Age, Roma Formation - Foraminifera were found in two intervals within the Roma Formation from 60 to 109 feet and between 680 and 1170 feet (see Appendix 1, p.40). Dr. Irene Crespin believes that the association of the foraminifera with the radiolaria present in the upper interval indicates a Cretaceous age suggestive of the Lower Albian stage. She places the lower interval as probable Aptian equivalent. Spores from cores taken in the Roma Formation suggest an age range from late Jurassic to early Cretaceous (Appendix 1, parts 1 and 6).

All formations of the Great Artesian Group display intertonguing relationships both in the field and in subsurface correlation of units. Deposition appears to have been continuous. Exact age breaks will probably not coincide with formational boundaries. For the purpose of simplification in the present report however, the age of the Roma Formation is considered to be early Cretaceous in keeping with correlation of the well section with known outcrop section of this age.

Blythesdale Formation, 2865 - 4200 feet (1335 feet)

The Blythesdale Formation consists of 1335 feet of predominantly arenaceous material. The formation consists principally of light grey, quartzose, porous sandstone with lesser conglomerate, shale, and siltstone members. The sandstones are poorly to moderately well sorted and range from very fine to very coarse-grained. The grains are subangular to rounded and consist primarily of quartz with lesser lithic and carbonaceous material. The matrix is predominantly reworked tuffaceous material. Below 3952 feet the lower sandstones of the formation are predominantly porous, medium to coarse-grained and quartzose, but differ from the overlying beds in that the cement is calcareous.

Detailed description, Blythesdale Formation

2865 - 2992 feet (127 feet)

SANDSTONE, light grey, grading from fine to coarse-grained, poorly sorted, subangular to rounded, clear milky, amber, and green quartz grains, some black lithic grains; matrix light grey clay, gummy loosely cemented, carrying macerated carbonaceous material and with thin brown silty SHALE laminae. Some porosity evident near base.

2992 - 2997 feet (5 feet)

SHALE, black to brownish-black, with much carbonaceous material.

2997 - 3343 feet (346 feet)

SANDSTONE, grey, medium-grained as for Unit 1, but with less clayey matrix, and with rounded clear quartz and grey chert pebbles up to 12 mm throughout; with a few definite fine CONGLOMERATIC bands in the top part, and with thin interbedded grey and dark grey SHALE and SILTSTONE in the lower part. Porosity evident throughout the sandstones.

3343 - 3553 feet (210 feet)

SANDSTONE, grey to light grey and white, medium-grained, content and texture as for Unit 1, fairly tight, but some porosity evident, with thin interlaminated grey SHALE and SILTSTONE, and with distinct beds of grey silty SHALE in the intervals 3345 - 3357 feet; 3370 - 3392 feet; 3420 - 3430 feet.

3553 - 3785 feet (232 feet)

SANDSTONE, light grey to white, in part fine to medium-grained, few coarse grains, poorly sorted, subangular to rounded, clear and white quartz, and black and dark grey lithic grains with some biotite, light grey to white gummy clay matrix loosely cemented, some very calcareous cement near base, containing a few laminae of grey sandy SHALE, and brownish-grey SILTSTONE.

3785 - 3829 feet (44 feet)

SHALE, grey, micaceous, carrying plant fragments, and with thin laminae of grey SILTSTONE and medium-grained SANDSTONE.

3829 - 3952 feet (123 feet)

SANDSTONE, light grey, fine to medium-grained as for Unit 5, with white gummy clay matrix, with some porosity, and with thin interbedded grey silty SHALE.

3952 - 4200 feet (248 feet)

SANDSTONE, grey, grading medium to very coarse-grained, moderately well sorted, subangular to subrounded, clear, light brown and grey translucent quartz, few dark grey and black lithic grains. Few rounded clear quartz granules. Medium to fine-grained sand matrix, slight to strong calcareous cement. Porosity evident particularly in lower part. A few thin beds of brownish-grey SHALE and SILTSTONE throughout, but particularly evident between 4004 and 4068 feet.

Age, Blythesdale Formation - Spores examined from cores taken in the Blythesdale Formation are considered to have a range in age from late Jurassic to early Cretaceous (Appendix 1, parts 1 and 6).

Walloon Formation, 4200 - 5444 feet (1244 feet)

The Walloon Formation consists of interbedded coal, coaly shale, siltstone and sandstone, with the coal and shale sequence predominant. The sandstones are quartzose, yellow-buff, hard, calcareously cemented, and contain abundant finely macerated carbonaceous matter. The formational unit is well defined on the Electric Log where it exhibits sharp contrast to the overlying and underlying sections.

Detailed description, Walloon Formation

4200 - 4916 feet (716 feet)

An interbedded sequence of COAL seams, black, some bright, some dull and shaly; SHALE, brown, green, grey, tan with carbonaceous laminae and thin SANDSTONE, light grey, greenish-grey, tan, fine to medium-grained with disseminated carbonaceous matter, tight. Yellow fluorescence in some thin sands and shales.

4916 - 4926 feet (10 feet)

SANDSTONE, grey, speckled appearance, fine to medium-grained, poorly sorted, sub-angular, clear and milky quartz, some grey and black lithic grains, tan clay matrix, slight calcareous cement, tight.

4926 - 5444 feet (518 feet)

An interbedded sequence of SHALE, grey, brown, dark grey, carbonaceous in part; SILTSTONE, brown, with disseminated carbonaceous material; COAL, black, mostly dull and shaly, and SANDSTONE, grey, light grey, and tan, fine to medium-grained, content as for Unit 2. Slight porosity in thin sandstones is evident in the intervals 5038 - 5041 feet, 5103 - 5107 feet, 5195 - 5208 feet, 5402 - 5406 feet. Trace yellow fluorescence noted between 5000 and 5040 feet.

Age, Walloon Formation - Spores examined from cores taken in the Walloon Formation are considered by both de Jersey and Evans to be Jurassic in age (Appendix 1, parts 1 and 6). Both palynologists note similarity of spores from cores in this formation to those of the Walloon Coal Measures of the type area.

Bundamba Formation, 5444 - 7640 feet (2196 feet)

The Bundamba Formation penetrated in Cabawin No. 1 consists of 2196 feet of section divisible into three members, an upper sandstone member, a middle predominantly shale member, and a lower sandstone member. The gradational nature of the sediments suggests intertonguing relationships.

The upper member occupies the interval from 5444 - 6092 feet. It consists primarily of white to buff coloured, fine to coarse-grained, porous and permeable quartzose sandstone and granule conglomerate, with lesser siltstone, carbonaceous shales and thin coal interbeds.

The middle member of the Bundamba Formation (6092 - 6550 feet) is dominantly shale and interbedded coal and siltstone. One prominent sandstone bed interrupts the sequence and occupies the interval between 6270 and 6299 feet. This sand is brownish-grey, fine to coarse-grained, with 30 - 40 percent of the grains consisting of black and brown chert set in a matrix of white tuff.

The lower member of the Bundamba Formation occupies the interval in the well from 6550 - 7640 feet. It consists principally of two massive sand units separated by an interbedded shale and sand sequence. The upper part of the member grades upward transitionally into the shales and coal of the middle member. The upper sandstone of the lower member is porous and permeable, massive and quartzose, with the grain size ranging from fine to conglomeratic. Grains are 95% clear and pale grey quartz and 5% chert. Pebbles in the unit range up to 20 mm in size. The lower sand body is similar in content and texture to the massive upper beds, but a greater proportion of multicoloured chert grains are present, and the matrix contains a higher proportion of tuffaceous material.

Detailed description, Bundamba Formation

5444 - 5871 feet (427 feet)

SANDSTONE, light grey to pale greenish-grey, grading from fine to coarse-grained, with a few small rounded pebbles and granules tending to GRIT, in part. Grains poorly sorted angular to subrounded, clear and white quartz, some pale green and grey quartz, brown and dark grey lithic fragments, in light grey to pale greenish-grey clay matrix, loosely cemented, with moderate porosity, and trace blue fluorescence in part. The sandstone is interbedded with brownish-grey SHALE and grey SILTSTONE, which are most evident in the intervals 5513 - 5556 feet, 5641 - 5653 feet, and 5722 - 5754 feet, but which occur as laminae throughout.

5871 - 6092 feet (221 feet)

SHALE, brownish-grey, thinly interlaminated in part, with grey SILTSTONE and hard fine-grained quartzose SANDSTONE, siliceously cemented in part. The strata contain abundant carbonaceous material and thin dull black COAL beds. Trace of poor blue fluorescence in sandstone at 6075 feet.

6092 - 6221 feet (129 feet)

SHALE, SILTSTONE, some SANDSTONE and thin black COAL as for Unit 2, but with far less sandstone.

6221 - 6228 feet (7 feet)

SANDSTONE, light grey, coarse-grained, poorly sorted, rounded, subrounded, subangular, clear quartz with some white clay matrix, and siliceously cemented. Moderate porosity; bright gold fluorescence.

6228 - 6268 feet (40 feet)

SHALE, grey, light grey, mainly silty, and SILTSTONE, grey.

6268 - 6299 feet (31 feet)

SANDSTONE, light grey to grey, medium to coarse-grained, as for Unit 4.

6299 - 6550 feet (251 feet)

SHALE, dark grey and brown, silty, with carbonaceous material interbedded with some grey siliceous SILTSTONE, fine-grained SANDSTONE and a few thin black COAL seams.

6550 - 6653 feet (103 feet)

SANDSTONE, light grey, medium-grained, poorly sorted subrounded and rounded clear quartz, few lithic grains, some clayey matrix, loosely cemented, slight porosity, with some thin interbedded grey and dark grey silty SHALE and grey SILTSTONE.

6653 - 6690 feet (37 feet)

SHALE, light grey and brownish-grey carbonaceous streaks, grading to SILTSTONE and fine-grained SANDSTONE in lower part, and with two interbedded thin black COAL seams.

6690 - 7209 feet (519 feet)

SANDSTONE, light grey, coarse to very coarse-grained, grading to GRIT in part, quartzose, poorly sorted, angular to subangular and some subrounded clear quartz grains, trace light grey quartz, black lithic and muscovite grains. Matrix fine quartz sand, loosely cemented. Rounded clear and milky quartz pebbles up to 20 mm. Porosity and permeability evident. Good blue, some yellow and white fluorescence with trace cut and kerosene odour evident particularly near top. The sandstone is in part cross-bedded and carries a few thin fine CONGLOMERATE bands and some coaly streaks. It also contains thin grey SHALE and light grey SILTSTONE laminae.

7209 - 7382 feet (173 feet)

SHALE, grey and dark grey, silty, carrying plant fragments, and SILTSTONE, grey, quartzose, with a few thin, light grey, fine to medium-grained quartzose SANDSTONES. Some slight porosity and trace poor blue fluorescence in the sandstones.

7382 - 7402 feet (20 feet)

SANDSTONE, pale greenish-grey, medium-grained grading to coarse-grained in part, very poorly sorted, rounded and subrounded, finer grains subangular, clear, light grey and greenish-grey translucent quartz, grey and blue-grey chert, dark grey, white and black lithic grains, some muscovite. White clay matrix, siliceous cement, carbonaceous streaks and macerated plant fragments. Minor thin interbedded waxy brown SHALE laminae. Pale blue fluorescence, weak cut, slight kerosene odour.

7402 - 7452 feet (50 feet)

SILTSTONE, grey, brownish-grey, dark grey subangular and angular quartz, dark grey lithic grains, some mica, carbonaceous streaks, with some interlaminated silty grey and dark grey SHALE.

7452 - 7640 feet (188 feet)

SANDSTONE, light grey to grey, grading fine to coarse-grained mainly medium-grained, moderate sorting, subangular to subrounded clear and multicoloured quartz grains, also multicoloured chert and lithic grains. Few small rounded coloured chert pebbles. Matrix white clay loosely cemented. Pale blue fluorescence throughout. A few thin laminae of brown and dark grey SHALE, and carbonaceous remains are evident.

Age, Bundamba Formation - The age of the Bundamba Formation is considered by both de Jersey and Evans to range from Jurassic to Triassic (Appendix 1, parts 1 and 6). Both note similarity of spores from cores in the well to those found in the Ipswich Coal Measures of the type area. Both however also record similarity of spores from this section in the well to known Jurassic assemblages.

Bowen Group

Cabawin Formation, 7640 - 9835 feet (2195 feet)

The name Cabawin Formation has been suggested by geologists of the Union Oil Development Corporation to include a monotonous sequence of coarse conglomerates composed of volcanic detritus encountered in the drilling of Cabawin No. 1 between the depths of 7640 - 9835 feet. The formation has been demonstrated to be equivalent in outcrop to units previously mapped as Moolayember, Clematis, Rewan and part of the Upper Bowen. The upper contact of the formation is well marked at the top of a chocolate to green-coloured shale. The lower limit of the formation has been picked at the base of a conglomerate sequence.

Detailed description, Cabawin Formation

7640 - 7674 feet (34 feet)

SHALE, tuffaceous, dark reddish-brown to mustard coloured, with bluish to greenish-grey streaks, dense, micromicaceous, and with scattered finely macerated carbonaceous debris.

7674 - 8424 feet (750 feet)

Pale green to greenish-grey, tuffaceous quartzose granule CONGLOMERATE and minor bands of pebbles of multicoloured quartz and chert in a matrix of fine to coarse-grained, poorly sorted, angular to subangular quartz SANDSTONE with interstices of green to whitish-green ash. Porosities in this interval range up to 30% and permeabilities to 300 md; however the porous zones average only five feet in thickness.

8424 - 8810 feet (386 feet)

Pale greenish-grey, tuffaceous, quartzose pebbly SANDSTONE to granule CONGLOMERATE. Poorly sorted, fine to granule sized, angular to subangular grains of quartz and chert with minor pebbles of quartz, chert and silicified ash in a matrix of white to green ash. Porous zones in this interval have similar porosities and permeabilities to those in the unit above, but these zones are approximately twice as thick as those in the overlying unit.

8810 - 8845 feet (35 feet)

Chocolate-brown to mustard coloured tuffaceous SHALE and minor grey SILTSTONE, with carbonaceous streaks.

8845 - 9456 feet (611 feet)

Grey to greenish-grey tuffaceous conglomerate SANDSTONE and CONGLOMERATE. Grains and clasts up to small cobble-sizes of subangular to rounded multicoloured quartz, chert quartzite and silicified ash in a matrix of white to green ASH. There is an increase in the modal size of the conglomerate clasts from granules to pebble-cobble sizes towards the base of the interval.

9456 - 9835 feet (379 feet)

Similar to unit above but with marked increase in amount of tuffaceous material. One thin COAL bed at 9622 feet.

Age, Cabawin Formation - The Cabawin Formation has been assigned a Triassic age on the basis of fossil flora (Appendix 1, part 2). P.R. Evans (Appendix 1, part 1) suggests a Permian age for spores from the coal sequence at 9620 - 9630 feet in the well. N.J. de Jersey places the break between 9630 and 9870 feet (Appendix 1, part 6). The lower part of the Cabawin Formation is obviously lithologically transitional into the Permian Kianga Formation however, and, under these conditions, it is not unlikely that elements of both Permian and Triassic age should be reflected in the spores of the transitional zone.

Kianga Formation, 9835 - 10,357 feet (522 feet)

The Kianga Formation is an interbedded sequence of tuff, coal, sandstone, and conglomerate. The tuffs are bedded, micaceous and carbonaceous, with the carbonaceous material forming thin cross-bedded lamellae. Coal is dominant throughout the sequence but many of the carbonaceous beds are contaminated by a mixture of ash. Sandstones are locally quartzose, but contain a high concentration of volcanic detritus and are generally siliceous. The conglomerates form only a minor percentage of the total sequence and these consist of ash pebbles in an ash matrix. One thin zone of oolitic limestone is present in the sequence at 9981 feet but the carbonate has been almost entirely replaced by silica. The formation grades downward into the marine shales of the Back Creek Formation.

Detailed description, Kianga Formation

9835 - 9911 feet (76 feet)

TUFF, white, light grey, some light brown, dense, siliceous, some hard with subconchoidal fracture, some soft and fissile, with waxy lustre, carrying few gold coloured mica flakes and few scattered chert pebbles in some of silty rewashed parts. Some calcareous reaction from jointing in some beds, carbonaceous fragments throughout, and interbedded with dull shaly black COAL seams, the most notable of which occurs between 9865 and 9876 feet. Some white anu pale yellow fluorescence in tuff.

9911 - 9940 feet (29 feet)

SANDSTONE, white to light bluish-grey, tuffaceous, medium to coarse-grained and carrying rounded light grey and bluish-grey chert and some quartz pebbles. Angular and subangular, poorly sorted, clear and milky quartz, with some blue-grey chert grains; tight tuffaceous light grey clay matrix. Hard siliceous cement in part with some porosity between 9928 and 9936 feet (Blow-out zone). Blue, white and some yellow fluorescence was encountered throughout the sequence.

9940 - 10,164 feet (224 feet)

TUFF, light grey and white as for Unit 1 but shaly, silty and sandy textured. Plant fragments and carbonaceous material found throughout. The sandstones are white, fine to medium-grained, moderately well sorted, subangular clear quartz, with few black grains, and biotite flakes with few rounded small milky quartz pebbles. White tuffaceous siliceous matrix and strong siliceous cement. Pale yellow fluorescence evident in all sandstones, the principal bed of which occurs in the interval 10,002 - 10,011 feet.

Thin shaly black COAL seams distributed throughout the sequence. One 8" bed of siliceous oolitic limestone at 9981 feet.

10,164 - 10,178 feet (14 feet)

SANDSTONE, white, grading fine to coarse-grained, strong siliceous cement, moderate porosity and blue and some yellow fluorescence, content as for Unit 3.

10,178 - 10,357 feet (179 feet)

SHALE, light grey, pale bluish-grey, tuffaceous; rewashed TUFF, siliceous as before, with interbedded SILTSTONE, grey, blue-grey, dark grey; rewashed tuff contaminated with fine quartz sand and carbonaceous material. Also interbedded are tight light grey SANDSTONES of similar content to Unit 3 and a few thin shaly black COAL seams. The strata carry less tuffaceous material with depth. Blue and poor yellow fluorescence noted throughout the sequence.

Age, Kianga Formation - The age of the Kianga Formation is considered to the Upper Permian on the basis of fossil flora. N.J. de Jersey (Appendix 1, part 6) reports a definite Permian age for spores from 9870 - 9890 feet, and suggests an Upper Permian age from spores examined in Cores 32-39. P.R. Evans (Appendix 1, part 1) considers that spores from a depth of 9935 feet are "unequivocal Upper Permian".

Back Creek Formation, 10,357 - 11,662 feet (1305 feet)

The Back Creek Formation consists of a sequence of shallow water marine deposits. From 10,357 to 10,550 feet the strata are dominantly blue-grey calcareous siltstones interbedded with calcareous shale and sandstone. The section is highly fossiliferous with brachiopods and crinoids well represented in the assemblages. From 10,552 to 10,725 feet the sequence consists of interbedded coals and sandstones reflecting a tongue of the over-lying Kianga Formation. From 10,885 to 11,662 feet the sequence is predominantly estuarine consisting of dark grey, pyritic, silty shale, silicified tuffaceous sandstone and siltstone. The shalier sediments contain increasing percentages of soft light grey volcanic material. Near the base of the formation volcanic detritus predominates.

Detailed description, Back Creek Formation

10,357 - 10,551 feet (194 feet)

SILTSTONE, bluish-grey, calcareous, tends to silty and sandy SHALE in part, with clear quartz and black grains set in darker coloured matrix, and carrying spine bases and striated shelly brachiopod remains.

10,551 - 10,616 feet (65 feet)

COAL, black, mainly dull, but some bright and some shaly with thin interbeds of white siliceous tuffaceous SHALE.

10,616 - 10,877 feet (261 feet)

SILTSTONE, grey, dark grey and black, carbonaceous, grading into SANDSTONE, grey, medium to coarse-grained in part tending to GRIT, poorly sorted subangular and subrounded clear, pale blue, light grey quartz, grey chert, few lithic grains, tight silty matrix, loosely cemented. Small clusters of pyrite evident. Trace weak blue fluorescence. The sequence also contains interlaminated light grey and grey tuffaceous SHALE throughout and some black COAL near the top.

10,877 - 11,662 feet (785 feet)

SANDSTONE, grey, medium, some coarse-grained poorly sorted clear light grey-blue quartz; and grey and brown chert and lithic grains (all subrounded) set in notable fine sand and silty grey to dark grey slightly calcareous matrix. Tight, hard, siliceous cement in part and grading into grey SILTSTONE and grey silty SHALE interbeds. Shelly brachiopoda remains evident throughout. Soft, rounded, light grey weathered volcanic pebbles evident from around 11,550 feet to base. One thin black COAL seam at 11,428 feet.

Age, Back Creek Formation - Analyses of macrofossils, microfossils, and fossil flora (Appendix 1) all indicate that the age of the Back Creek Formation is Permian. Prevailing evidence indicates that only the upper part of the "middle Bowen" was penetrated in the well with the lowest beds correlative with a position high in the "Cattle Creek" equivalent of the Springsure shelf area.

Cracow Formation, 11,662 - 12,035 feet (373 feet+)

The Cracow Formation penetrated in the well consists of volcanic rocks of andesitic to dacitic composition. The sequence is highly weathered and jointed, with the steep fracture planes coated with calcite.

Age, Cracow Formation - No faunal or floral evidence is present in the well to suggest the age of the Cracow Formation. Regional studies suggest that the formation has an age range in outcrop from Carboniferous into the Lower Permian.

Oil and Gas Indications and Potential, including discussion of Porosity and Permeability of Sediments

The drilling of Cabawin No. 1 has confirmed the presence of hydrocarbons in the Surat Basin. Significant oil and gas shows were encountered in the Bundamba, Cabawin, Kianga, Back Creek and Cracow Formations. The Back Creek Formation is considered to be the primary generating source.

Bundamba Formation:

The Bundamba Formation is by far the best reservoir encountered in the well. Porosities range from 8.4 to 17.8 percent, permeabilities up to several hundred md. One sand body in the well is over 500 feet thick, and 300 feet of this is indicated to be permeable (6725 - 7026 feet). Two open hole tests were made in the formation, one at 6728 - 6776 feet and one at 7388 - 7406 feet. Although both tested wet or tight, the Bundamba Formation, because of its indicated reservoir capacity, must be considered a prime target in the Basin.

Cabawin Formation:

The Cabawin Formation is characterized by its tuffaceous conglomerate nature. Thin porous and permeable zones are present within the unit with measured porosities ranging as high as 36 percent, and permeabilities as high as several hundred md. Despite these encouraging statistics the gross nature of the section suggests that the porous and permeable zones will have only limited distribution within the Basin, and even where present will probably be lenticular. A number of intervals within the Cabawin Formation were tested through 5 1/2" casing with the following zones testing wet or tight: 8508 - 8520 feet, 8532 - 8540 feet, 8459 - 8557 feet, 8752 - 8760 feet, 8762 - 8770 feet, 8774 - 8786 feet, 8878 - 8890 feet.

Kianga Formation :

The primary oil zone in Cabawin No. 1 was encountered within tuffaceous sandstones of the Kianga Formation. From 27th April to 13th May, 1961, the well was put on a sustained testing programme from the following perforated intervals within this formation: 9925 - 9943 feet, 9965 - 9973 feet, 9998 - 10,012 feet, 10,152 - 10,158 feet and 10,166 - 10,172 feet. After 22 days of continuous production the well was producing 49 gravity crude at a rate of 62 bbl/day with 534 Mcf/D of gas through 22/64" bean. Casing and tubing pressures were 550 and 300 p.s.i. respectively. During the total testing period 1761 barrels of crude were produced from the Kianga Formation together with 13,744 Mcf of gas.

Back Creek Formation :

The nature of the sediments of the Back Creek Formation suggests that this formation is the generating source of the oil encountered higher in the well. The formation appears to have only limited reservoir potential. Those sands that are present are tuffaceous and siliceous, and no porous or permeable zones were encountered within the sequence.

Cracow Formation:

A strong drilling break accompanied by a 1000-unit gas kick was recorded when the Cracow Formation was penetrated in the well. The Microlog indicated fracture porosity within the andesite section. Two zones were perforated and tested: 11,744 - 11,750 feet, 11,752 - 11,760 feet; and 11,881 - 11,995 feet. Both tests resulted in the recovery of salt water.

Contribution to Geological Concepts resulting from Drilling

Cabawin No. 1 was drilled primarily as a structural test of the hydrocarbon potential of sediments underlying a major unconformity. The age and nature of the pre-unconformity section was questionable before drilling, but was postulated to be Triassic-Permian and related to the sedimentation of the Bowen Geosyncline.

The section penetrated in Cabawin No. 1 provided information relative to the regional significance of the Mesozoic rocks of the Great Artesian Group and provided a correlative stratigraphic sequence of the Bowen Group sediments clarifying earlier geological concepts. The 12,000 feet of section encountered in Cabawin No. 1 ranged from Tertiary through Permo-Carboniferous (?) and permitted an integration and correlation of all previous surface geological work. Subsurface information from wells 100 miles distant was provisionally correlated. Structural relations of the Great Artesian and Bowen Basins were further clarified.

The most outstanding contribution from the drilling of Cabawin No. 1 may well be the confirmation of the presence of hydrocarbons in the Surat Basin. Evidence of oil and/or gas in the Bundamba, Cabawin, Permian, and even the weathered andesite of Permo-Carboniferous(?) age, suggests that the Surat Basin is a potential oil province.

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APPENDIX 1

PALAEONTOLOGICAL REPORTS ON UNION-KERN-A.O.G. CABAWIN NO. 1.

CONTENTS

PALYNOLOGY OF SAMPLES FROM CABAWIN NO. 1 WELL

by

P.R. Evans*

Samples from main cores, sidewall cores and cuttings from Union-Kern-A.O.G. Cabawin No. 1, Queensland, were examined at several stages during drilling of the well; the progress notes have been compiled into the following report.

The Mesozoic age determinations given below are partly based on comparisons with the distribution of spores in the Roma area. The names of subsurface formations in the Roma area, which are considered to be time equivalents of parts of the Cabawin section, are those in current use at the time and which are used in the A.A.O. Pickanjinnie No. 1 Well Completion Report (Derrington, 1960, unpubl.). Spore evidence now indicates that the correlation with outcrop implied by this terminology is not correct. The informally termed zones referred to below were used in correspondence to indicate correlation around the Roma area and to avoid confusion caused by this uncertain formation terminology.

A. Mesozoic

Core No.	Depth (feet)	Suggested Age or Formation Equivalent
1	562- 585	Marine Cretaceous (Roma Formation)
2	1099-1109	Marine Cretaceous (Roma Formation)
3	1580-1590	Upper Jurassic - Lower Cretaceous, probably L. Cretaceous. No marine organisms found.
4	2095-2100	Upper Jurassic - Lower Cretaceous (Blythesdale Group)
5	2428-2433	(Blythesdale Group)
6	2780-2790	"
7	3280-3290	"
8	3785-3803	"
9	4197-4215	?Upper Jurassic (Base of Blythesdale or top of Walloon Coal Measures)
10	4540-4545	Walloon Coal Measures
11	4899-4916	Walloon Coal Measures
12	5525-5543	Base of Walloon or top of Bundamba Sandstone
13/14	5732-5758	?Bundamba Sandstone
15	5894-5899	?Bundamba Sandstone
16	6067-6077	Bundamba Sandstone or top of Moolayember Formation.
18	6472-6476	Moolayember Shale, "Zone 2"
19	6703-6719	Moolayember Shale, "Zone 2"
20	6767-6776	Moolayember Shale, "Zone 2"
21	7004-7019	Triassic (Moolayember Shale, "Zone 1")
22	7214-7222	Triassic (Moolayember Shale, "Zone 1")
23	7395-7406	Triassic (Moolayember Shale, "Zone 1")
24	7646-7650	Barren
25	7909-7915	Triassic
26	8200-8212	Triassic
swc	8432	Age uncertain

* Bureau of Mineral Resources.

Core No.	Depth (feet)	Suggested Age or Formation Equivalent
swc	8515	Age uncertain
swc	8552	Age uncertain
swc	8882	Age uncertain
swc	8884	Age uncertain

The microplankton in Cores 1 and 2 (e.g. Hystrichosphaeridium complex, Dingodinium cerviculum, Veryhachium sp.) indicate a marine Cretaceous character for the beds penetrated to 1109 feet. The yield of microplankton in both cases was very low; additional samples were processed before the microfossils were discovered.

Core No. 3 yielded no microplankton but the microspores suggest a probable Cretaceous age as they include Dictyosporites speciosus and Cirratriradites spinulosus which have been considered previously to be Cretaceous species. However, experience in other parts of the Great Artesian Basin has shown that these species are members of an assemblage which first appears some way below the base of the Roma Formation and persists within that formation, but in association with microplankton. It is not yet possible to fix a suitable system boundary at this level.

Cores 4 to 9 yielded relatively similar assemblages of microspores. Core No. 5 yielded unidentifiable megaspores (Dr Crespin). Cicatricosisporites cooksonii is of particular interest; it is an easily recognized species and, although not abundant, appeared persistently in all preparations from Core No. 9 upwards. It first appeared in the Roma area towards the top of the Walloon Coal Measures, from which it is suggested that Core No. 9 is at approximately that stratigraphic level.

Core No. 10 was virtually barren of spores, but Core No. 11 and Core No. 12 yielded many microspores including Lycopodiumsporites rosewoodensis, Annulispora folliculosa and Cingulatisporites saevus which compare with the spores of the Walloon Coal Measures of the type area. Core No. 12 contained a few specimens referred to Cingulati sp. nov. which has been observed abundantly at and with apparent restriction to a band at the base of the Walloon Coal Measures and the top of the Bundamba Sandstone.

Assemblages representative of "Zone 2" and "Zone 1" within the subsurface Moolayember Formation of the Roma area were recognized as outlined above.

The junction between these zones has been shown to be sharp in the Roma area and, palynologically, it represents a considerable microfloral change. "Zone 1" contains elements characteristic of the Triassic Ipswich Coal Measures of the type area; "Zone 2" contains a microflora which is younger than that known from the Ipswich Coal Measures and which, provisionally, the writer has been describing as a Jurassic assemblage on the basis of gross similarity with known Jurassic microfloras.

The "Hospital Hill" and "Links" Sandstones persist within "Zone 2" in the Roma area. As the palynological divisions within the Cabawin well have so far shown close resemblance in assemblage and thickness to the corresponding divisions in the Roma area, it is suggested that the equivalents of the gas sands lie between 6550 and 6700 feet within the well.

These deductions are based on the presence of Apiculati sp. nov. and an increase in the abundance of Classopollis in Cores 18-20. Classopollis cf. S. clavus, Annulispora spp. nov. and Lycopodiumsporites sp. nov. are prominent within and just below the gas-sand interval in Latemore East No. 1 Well and still within "Zone 2". The assemblage from Core No. 21 contained none of these species, but instead it was composed mainly of the bisaccate species referred previously to "Pteruchipollenites" sp., which characterizes "Zone 1".

Two samples of Core No. 24 were barren of spores. Cores 25 and 26 gave low yields with "Pteruchipollenites" sp. which is taken to represent a Triassic age.

None of the sidewall cores provided spores which might be considered representative of the horizons from which they were taken. Only contaminating spores from the Jurassic section of the well were rarely present.

B. Permian

Sample	Depth (feet)	Suggested Age or Formation Equivalent
cuttings	9620- 9630	?Upper Permian
cuttings	9900- 9910	Upper Permian
swc	9935	Upper Permian
cuttings	10370-10380	Upper Permian (marine beds)
cuttings	10600-10610	Upper Permian (coal)
core 41	11086-11097	Upper Permian (marine beds)

The coal at 9620 - 9630 feet contained little mineral matter but yielded abundant "Lueckisporites" spp. and a few specimens of Pteruchipollenites spp. Acanthine species, including Acanthotriletes cf. A. tereteangulatus and rare specimens of Marsupipollenites sinuosus and "25A" (de Jersey, 1946) were present. M. sinuosus is considered to be restricted to the Upper Permian; the other species, Tholosporites parvitholus which seems to accompany M. sinuosus persistently in the Upper Permian at Roma and to the north was not observed.

The age of the sample remains in doubt; the presence of Pteruchipollenites spp. suggests that an even younger age than Upper Permian might be possible. However, the beds in question in the Roma and Springsure areas are part of the Upper Permian sedimentation sequence and, pending more information, the Upper Permian age determination must stand.

Only one obvious contaminant, Annulispora sp., was observed.

A very low yield of spores was obtained from the coal float from 9900-9910 feet, but they included the following species:

Leiotriletes directus (highest abundance)
Acanthotriletes cf. A. dentatus
A. ericianus
Calamospora diversiformis
Marsupipollenites triradiatus
Tholosporites parvitholus
"Lueckisporites" spp.
"Pteruchipollenites" spp.
"Zonalapollenites" sp.)
Baculati spp.) (probable contaminants)
Inaperturopollenites sp.)

When the diversity of species present in other sections of the Upper Permian is considered, the list above is small, but sufficient to suggest strongly that sample was Permian in age; the presence of T. parvitholus and perhaps A. cf. dentatus is sufficient to show that nothing older than Upper Permian strata is involved. In terms of the Permian to the north of Roma, it is no younger than about the base of the "Upper Bandanna Formation" as defined by Derrington in the A.A.O. No. 7 (Arcadia) Well.

The coal at 10,600 - 10,610 feet provided no identifiable fossils but the cuttings at 10,370 - 10,380 feet and Core No. 41 yielded poorly preserved microspores and microplankton. The microplankton comprised abundant specimens of a species of Micrhystridium which has been observed previously in A.A.O. Latemore No. 1 at 4700 feet and A.A.O. No. 7 (Arcadia) below 1800 feet (cuttings only).

In both these wells Micrhystridium occurred with Tholosporites parvitholus. This species has not been observed among the present samples, but the fragments of associated microflora give no indication of a very different assemblage. Therefore, from the present palynological evidence, there is no reason to suppose that there is any break in time between the Cabawin marine beds and the overlying Permian coal measures. It is notable also that a different microfauna seems to be present in the equivalents of the Cattle Creek beds of A.A.O. No. 7, members of which cannot be detected in the Cabawin samples.

C. Comparison with the Sydney Basin

The Triassic of Cabawin No. 1 - at least to a depth of 7406 feet - appears to be older than the top of the Narrabeen Group in the Sydney Basin. Recognition of ?Upper Permian sediments at 9620 feet means that the intervening "Cabawin Formation" is equivalent to the greater part of the Narrabeen Group. The occurrence of red and buff shales, typified in Core No. 24, 7645 - 7650 feet, indicates that the environmental conditions, which produced the characteristic red shales of the Narrabeen Group, were affecting this portion of the Great Artesian Basin also. It would be interesting if a check were made on the relative age of the red shales of the Rewan Formation to the north, which, on present evidence, can only be allocated to the Lower Triassic.

However, closer comparison of the basins produces disagreements. Within the Sydney Basin species of the "Lueckisporites" type persist as an important element of variable abundance to a fairly high level in the Narrabeen Group; rare ones even occur in the Wianamatta Group. It should therefore be expected that such forms would appear at much higher levels in the "Cabawin Formation" than 9620 feet (although rare specimens occurred in Core No. 23). Such a concentration has not been observed in any of the main cores of the formation and fragments of sidewall cores from the formation also yielded no "Lueckisporites" types. Unfortunately, the extremely low concentration of organic material in the formation prevents any adequate assessment of the total microflora of the unit.

PLANT FOSSILS IN CORE NO. 32 FROM CABAWIN NO. 1 WELL

by

Mary E. White *

Core No. 32 at 9944 feet 5 inches - 9944 feet 9 inches contains numerous carbonized impressions of leaves.

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* Bureau of Mineral Resources.

Most of these are referable to Glossopteris indica Sch. and Glossopteris angustifolia Brong., forms common in Permian and Lower Triassic strata. There are two examples of small leaves which appear to be referable to Gangamopteris angustifolia M'Coy and one poorly preserved leaf which has venation similar to Glossopteris jonesi Walk.

Both Gangamopteris angustifolia and Glossopteris jonesi are members of the Lower Bowen flora and are not present in Upper Bowen beds. The identification of G. jonesi from such a poorly preserved specimen is too uncertain to be of any value in age determination.

The leaves of Gangamopteris angustifolia are inconspicuous and it must be remembered that the distinction of Glossopteris from Gangamopteris is not always sharp. Some Glossopteris leaves with striated midribs or indistinct midribs (especially towards the end of the lamina in incomplete specimens) are not unlike Gangamopteris, and Gangamopteris resembles Glossopteris when lamina has a medium groove, or more prominent nerves in the middle of the lamina, giving the appearance of a midrib.

However, if the leaves in question in these specimens are strictly referable to Gangamopteris, as they appear to be, they maybe assumed to indicate Lower-Middle Permian age rather than Upper Permian or Lower Triassic. The genus Gangamopteris ranges from Upper Carboniferous into Lower Permian. In Australia it occurs in Lower Permian horizons - in Queensland in Lower Bowen, not Middle or Upper; in New South Wales and Victoria in Upper Carboniferous/Lower Permian and Lower Permian horizons; in Western Australia in Collie Coal Measures. In India it occurs in Talchir series and Karharbari beds. The Gangamopteris - Glossopteris floras in South Africa are Lower Permian.

It must be emphasised that knowledge of fossil floras is far from complete and it would be unwise to over-stress the apparent evidence from plants only. It will be interesting to see whether palynological analysis suggests a Lower or Upper Permian age.

FORAMINIFERA IN CABAWIN NO. 1 WELL

by

Irene Crespin *

Cores and cuttings were examined for foraminifera and the upper and lower limits of the foraminiferal zones determined as far as possible.

Foraminifera of Lower Cretaceous and Permian ages were recorded. The Lower Cretaceous fauna is represented by two assemblages, an upper one - probable equivalent of the Albian - and a lower one which is definitely the equivalent of the Roma (Aptian) beds. Foraminifera were not abundant in the Permian rocks, but a tentative correlation with the Springsure assemblage is suggested.

Except where indicated, the description of samples given below is of cuttings.

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* Bureau of Mineral Resources.

Detailed Examination of Cores and Cuttings

50- 70 feet — No fossils.

70-100 feet — Ochreous sandy siltstone with siliceous sponge spicules and small crushed indeterminate arenaceous foraminifera.

100-140 feet — Siltstone with glauconite, gypsum, foraminifera (*Anomalina mawsoni*, *Haplophragmoides* sp., *Verneuilina howchini*), radiolaria (*Porodiscus*, *Dictyomitra*), and siliceous sponge spicules.

140-160 feet — Carbonaceous siltstone with glauconite, megaspores, pyritic replacement of radiolaria, and a few foraminifera (*Anomalina mawsoni*, *Haplophragmoides chapmani*, *Pelosina* sp., *Trochammina minuta*).

170-190 feet — Carbonaceous siltstone and glauconitic siltstone with foraminifera (*Gavelinella* sp., *Globulina* cf. *lacrima*, *Haplophragmoides* cf. *chapmani*, *Marginulina* sp., *Verneuilina* cf. *howchini*).

The following cuttings and core portion examined contained no foraminifera: 200-400 feet, 400-550 feet, 550-562 feet, Core No. 1, 570-670 feet.

680-690 feet — Carbonaceous siltstone and sandy siltstone with a few arenaceous foraminifera (*Ammobaculoides pitmani*, *Bigenerina loeblichae*, *Hyperammina* sp.) and some echinoid plates.

690-710 feet — Carbonaceous siltstone and glauconitic sandstone, with arenaceous foraminifera.

Foraminifera:
- *Ammobaculoides romaensis*
- *Ammobaculities* cf. *subcretaceus*
- *Bathysiphon* sp.
- *Bigenerina loeblichae*
- *Hyperammina* sp.
- *Pelosina lagenoides*

760-810 feet — Carbonaceous siltstone and glauconitic sandstone with arenaceous and calcareous foraminifera.

Foraminifera:
- *Ammobaculites* cf. *subcretaceus*
- *Ammobaculoides pitmani*
- *A. romaensis*
- *Bigenerina loeblichae*
- *Haplophragmoides chapmani*
- *Hyperammina* sp.
- *Trochammina minuta*
- *Lenticulina* sp.
- *Valvulineria infracretacea*

850-860 feet — Carbonaceous siltstone and glauconitic sandstone, with arenaceous and calcareous foraminifera.

Foraminifera: Ammobaculoides pitmani
A. romaensis
Bigenerina loeblichae
Haplophragmoides chapmani
Ammodiscus cretaceus
Saccammina globosa
Anomalina mawsoni
Robulus gunderbookaensis
Valvulineria infracretacea

900-950 feet — Carbonaceous siltstone and glauconitic sandstone, with some pyrite, arenaceous and calcareous foraminifera and fish tooth (920-930 feet).

Ammobaculoides pitmani
A. romaensis
Ammobaculites cf. goodlandensis
Haplophragmoides chapmani
Hyperammina sp.
Spiroplectammina edgelli
Anomalina mawsoni (common at 920-930 feet)
Lenticulina sp.
Marginulinopsis cf. subcretaceus
M. sp.
Neobulimina sp.
Robulus gunderbookaensis
Robulus spp.

960-990 feet — Carbonaceous siltstone with pyrite and fine glauconitic sandstone, with arenaceous and calcareous foraminifera fairly numerous.

Foraminifera: Ammobaculoides pitmani
A. romaensis
Ammobaculites sp.
Arenobulimina sp.
Bimonilina sp.
Haplophragmoides chapmani
H. sp.
Hyperammina sp.
Ammodiscus cretaceus
Spiroplectammina cushmani
S. edgelli
Trochammina minuta
T. raggatti
Anomalina mawsoni (c)
Marginulina sp.
Robulus gunderbookaensis
R. sp.

1000-1010 feet — Siltstone with small foraminifera.

Foraminifera: *Bathysiphon* sp.
Bimonilina sp.
? *Dorothia filiformis*
Haplophragmoides sp.
Anomalina mawsoni
Valvulineria infracretacea
Indeterminate forms.

1010-1020 feet — Siltstone and glauconitic sandstone with pyrite and foraminifera, chiefly arenaceous forms.

Foraminifera: *Ammobaculoides romaensis*
Ammobaculites implanus
Bimonilina sp.
Bathysiphon sp.
Hyperammina sp.
Spiroplectammina edgelli
Valvulineria infracretacea
Indeterminate forms

1060-1099 feet — Siltstone and glauconitic sandstone with numerous arenaceous foraminifera, calcareous forms few; some arenaceous tests partially replaced with glauconite, others have a black mineral (cf. ilmenite) included in their tests.

Foraminifera: *Ammobaculoides romaensis*
A. pitmani
Ammobaculites fisheri (r)
A. aff. *irregulariformis*
A. exertus
A. sp.
cf. *Ammomarginulina*
Bathysiphon sp.
Bigenerina loeblichae
Bimonilina cf. *varians*
Dorothia grandis
Hyperammina sp.
Spiroplectammina cushmani (c)
S. enoda
S. edgelli
Trochammina sp. nov.
Trochamminoides sp.
Textularia sp.
Verneuilina sp.
? *Marginulina*
Robulus gunderbookaensis

Core No. 2 1099 feet - 1108 feet 4 inches

a. 1099-1099'4" — Glauconitic sandstone and sandy siltstone. No recognizable foraminifera.

b. 1104-1104'4" Grey glauconitic siltstone and brownish siltstone with few identifiable arenaceous foraminifera (Dorothia sp. nov., ?Textularia).

c. 1108-1108'4" Glauconitic sandstone and brown siltstone with coarse-grained arenaceous foraminifera, some tests broken and many almost completely replaced with glauconite.

Foraminifera:

Ammobaculoides pitmani
?Ammodiscus milletianus
Dorothia sp.
Spiroplectammina enoda
Saccammina globosa
Fragments of large coarse-grained tests (cf. Ammobaculites).

1105-1120 feet Glauconitic siltstone and sandstone with numerous arenaceous foraminifera and some calcareous tests.

Foraminifera:

Ammobaculoides pitmani
A. romaensis (c)
Ammobaculites implanus
Bigenerina loeblichae
Bimonilina aff. varians
Hyperammina sp.
Hyplophragmoides sp.
Spiroplectammina cushmani (c)
S. enoda
Trochammina minuta
T. sp. nov.
Anomalina mawsoni
Conorbina cf. conica
Marginulina marreensis

1120-1150 feet Glauconitic sandstone with pyrite, numerous arenaceous foraminifera, many tests coarse-grained, and a few calcareous forms.

Foraminifera:

Ammobaculoides pitmani (c)
A. romaensis (c)
Ammobaculites minimus (r)
A. fisheri (r)
A. implanus
A. sp. nov.
Bimonilina cf. varians
Haplophragmoides chapmani
H. sp.
Hyperammina sp.
Saccammina globosa
Reophax sp.
Spiroplectammina cushmani (c)
S. enoda

Trochammina sp. nov.
T. sp.
Anomalina mawsoni
Lenticulina sp.
Marginulinopsis australis

1160-1170 feet — Glauconitic sandstone and siltstone with a few foraminifera not common (Ammobaculites subcretaceus, Haplophragmoides sp., Spiroplectammina sp. nov., S. cushmani).

1190-1200 feet — Sandstone with a little glauconitic sandstone, carbonaceous material, pyrite and one foraminiferal test (Spiroplectammina sp. nov.) probably derived.

No foraminifera were found in cuttings and the portions examined of cores listed below:

1200-1310 feet, 1350-1360 feet, 1400-1570 feet, Core No. 3, 1600-1610 feet, Core No. 4, Core No. 5, Core No. 6, Core No. 9, Core No. 11, Core No. 15, Core No. 16, 6077-6280 feet, Core No. 30, Core No. 40, 10,190-10,300 feet, 10,340-10,360 feet.

10,360-10,400 feet — Calcareous rock with foraminifera, productid spines, crinoid ossicles, and bryozoa.

Foraminifera:

Calcitornella sp.
? Earlandia
Frondicularia aulax
Geinitzina caseyi
Hyperammina sp.
Involutina sp.

10,490-10,550 feet — Calcareous rock with indeterminate bryozoa and ostracoda and productid spines.

10,550-10,600 feet — Coal.

10,650-10,750 feet — Carbonaceous siltstone with some productid spines.

10,790-10,800 feet — Carbonaceous siltstone with foraminifera rare (Ammodiscus cf. multicinctus) and productid spines.

11,060-11,080 feet — No foraminifera.

Core No. 41. 11,086 feet - 11,095 feet 3 inches

a. 11,086-11,086'4" — Fossiliferous limestone with pyrite, foraminifera rare, (cf. Geinitzina) and productid spines.

b. 11,089-11,089'4" — Carbonaceous siltstone with productid spines and ? conodont.

c. 11,091'5"-11,091'9" — Calcareous rock with productid spines.

d. 11,094'11"-11,095'3" Fossiliferous rock. No foraminifera.

11,090-11,100 feet Calcareous rock with a few foraminifera, indeterminate bryozoa, crinoid ossicles, productid spines and ostracoda (Bairdia sp.).

Foraminifera:
- Calcitornella cf. elongata
- Frondicularia sp.
- cf. Trepeilopsis

11,100-11,110 feet Sandy limestone with productid spines, but no foraminifera.

11,110-11,140 feet Limestone with foraminifera, indeterminate bryozoa, productid spines and indeterminate ostracoda.

Foraminifera:
- Frondicularia aulax
- Nodosaria sp.

11,170-11,220 feet Sandy limestone with productid spines.

11,240-11,250 feet Fossiliferous rock with foraminifera, bryozoa, productid spines, and small gasteropoda (Peruvispira sp.)

Foraminifera:
- Calcitornella cf. elongata
- Frondicularia sp.
- Hyperammina sp.

11,290-11,300 feet Limestone with productid spines. No recognizable foraminifera.

11,550-11,560 feet Limestone with foraminifera (Geinitzina cf. triangularis) and productid spines.

Core No. 42. 11,578 feet 4 inches - 11, 588 feet 6 inches

Crushings:

a. 11,578'4" - 11,578'8" Fossiliferous rock with pyrite and numerous productid spines.

b. 11,580'8" - 11,581'0" Fossiliferous rock with pyrite and numerous productid spines.

c. 11,585'0" - 11,586'1" Fossiliferous rock with a few productid spines.

Thin sections of base of core between 11,588'2" and 11,588'6"

d. Upper half - Detrital limestone with small fragments of volcanic rock, considerable pyrite, foraminifera rare (? Calcitornella), brachiopod and molluscan shell fragments and indeterminate ostracoda.

e. Lower half - Detrital limestone with numerous fragments of volcanic rock, abundant pyrite, also crinoid plates and molluscan shell fragments.

11,600-11,670 feet Calcareous siltstone with productid spines.

11,690-12,035 feet Volcanic rock.

Note on the Foraminiferal Assemblages in Cabawin No. 1 Well

A summary of the micropalaeontological examination of cores and cuttings from Cabawin No. 1 Well is as follows :

Depth (feet)	Lithology	Fossil Content	Age
30- 60	Sandstone	-	-
60- 190	Carbonaceous siltstone, glauconite, pyrite	Megaspores, Radiolaria, Foraminifera, Sponge spicules	L. Cretaceous (? Albian)
200- 670	Carbonaceous siltstone, sandy siltstone, glauconite		L. Cretaceous
680- 1170	Carbonaceous siltstone, and glauconitic sandstone	Numerous foraminifera	L. Cretaceous (= Roma beds, Aptian)
1190- ?9450	Carbonaceous siltstone and sandstone, conglomerate	Spores, pollens	?L. Cretaceous Jurassic Triassic
?9450-10290	Carbonaceous siltstone and sandstone	Spores, pollens	?Upper Permian
10360-10550	Calcareous, fossiliferous rock	Foraminifera, Bryozoa, productid spines, Ostracoda indet.	Permian ? = Mantuan *Productus* Beds
10550-10600	Coal		Permian
10600-11670	Calcareous rock, detrital limestone, pyrite	Foraminifera, Bryozoa, crinoid ossicles, productid spines, Mollusca.	Permian (= Ingelara Fm or Cattle Creek Fm).
11690-12035	Volcanics	-	-

Lower Cretaceous

Foraminifera were found in two intervals within the Lower Cretaceous. The depths of these intervals are:

a. Between 60 feet and 190 feet.

b. Between 680 feet and 1170 feet.

a. Between 60 and 190 feet. Foraminifera were not common in this interval and were found associated with radiolaria and siliceous sponge spicules. The arenaceous tests were poorly preserved and distorted; the calcareous tests were represented chiefly by the small species Anomalina mawsoni Crespin. There is no definite evidence as to the European stage equivalent these beds may represent, but the association of the foraminifera with radiolaria suggests a Lower Albian age. It is also most probable that it comes within the middle zone of Lower Cretaceous foraminifera in the Great Artesian Basin, as suggested by Crespin (1956).

The section between the depths of 190 feet and 680 feet consists of carbonaceous siltstone and sandstone with glauconite, but no foraminifera were noted in the sediments.

b. Between 680 feet and 1170 feet. The assemblage of foraminifera within this interval is dominated by arenaceous tests chiefly of Ammobaculoides romaensis Crespin, A. pitmani Crespin, Bigenerina loeblichae Crespin, Haplophragmoides chapmani Crespin and Spiroplectammina cushmani Crespin. Calcareous tests include genera of the Lagenidae and rotalines such as Anomalina mawsoni.

The assemblage of arenaceous species closely resembles that found in the sections of Bungeworgorai and Clerk Creeks, 5 miles west of Roma which is the type area for the Roma Formation (Whitehouse, 1955), and from many other localities in the Roma area from which the writer made collections in 1948 and 1950. Many of the species have been described (Crespin, 1944, 1953). All the arenaceous species from the Cabawin well listed above have the brown colouring of the test characteristic of the Roma specimens. A. romaensis and A. pitmani are almost entirely restricted to beds equivalent to the Roma Formation, which on evidence of the macrofossils is regarded as the equivalent of the Aptian. Some of the other species recorded are referable to new forms found recently in the upper Longsight Sandstone in western Queensland, which, on evidence of macrofossils, is also considered to be Aptian.

Bigenerina loeblichae, which is characteristic of the Roma beds, has been found outside the Roma Formation, but it is not common. Haplophragmoides chapmani, although common in the Roma beds, is widespread throughout the Lower Cretaceous of the Great Artesian Basin. Spiroplectammina cushmani is also recorded outside the Roma beds, but it is characteristic of that horizon, where it occurs in abundance in a bed at Minmi Crossing where the Durham Downs road crosses Bungil Creek, north of Roma. It occurred commonly in some samples in the Cabawin well in association with other Roma species.

Robulus gunderbookaensis (Crespin), Valvulineria infracretacea (Crespin) and Anomalina mawsoni Crespin are amongst the commoner calcareous species recognized in the well samples.

The above assemblage of foraminifera may represent zone 3, suggested by Crespin (1956) in which Haplophragmoides chapmani and Spiroplectammina cushmani are the predominant forms. The discovery of Valvulineria infracretacea and Anomalina mawsoni in beds referable to the Aptian shows the importance of detailed work in recognized stratigraphic sequences.

Permian

It is most probable that the well first encountered the Upper Permian freshwater beds at approximately 9450 feet, this information being confirmed by the work of P.R. Evans. However, the first evidence of marine Permian in the downward sequence of the well was in cuttings at 10,360-10,400 feet, when foraminifera and other fossils were recorded. The deepest record of foraminifera was in cuttings at 11,550-11,560 feet with indeterminate tests in Core No. 41 taken from 11,086 feet down to 11,095 feet 3 inches and Core No. 42 taken from 11,578 feet 4 inches down to 11,588 feet 6 inches.

Suggested correlations of the Cabawin Permian foraminiferal assemblage can be made only with that from the Springsure area (Crespin, 1959), as the foraminiferal sequence in beds in the Bowen Basin are as yet incompletely known.

a. The cuttings from 10,360 feet down to 10,550 feet overlie a bed of coal approximately 50 feet thick. The cuttings at 10,360 - 10,440 feet contained two interesting species, Frondicularia aulax Crespin and Geinitzina caseyi Crespin, the latter species being especially well preserved. F. aulax ranges from the Cattle Creek Formation up to the Mantuan Productus Bed in the Springsure area. Up to the present, G. caseyi has been restricted to the latter formation in that area. Because of this, and the occurrence of a thick bed of coal immediately underlying the marine beds, it is here suggested that the marine beds from 10,360 to 10,550 feet may possibly be equivalent of the Mantuan Productus Bed. J.M. Dickins has informed the writer that this conclusion does not conflict with the evidence given by the macrofossils.

b. In Core No. 41 at 11,086 feet down to 11,095 feet 3 inches and Core No. 42 at 11,578 feet 4 inches down to 11,588 feet 6 inches, the commonest foraminifer was Calcitornella cf. elongata Cushman and Waters; fragments of Geinitzina cf. triangularis (Chapman and Howchin) were also noted. The genus Calcitornella is common in the Cattle Creek Formation but has not been found in the stratigraphically higher Ingelara Formation; G. triangularis has been recorded from both formations. Evidence from the macrofossils in the above cores from Cabawin, suggests a probable correlation with the Ingelara Formation. Except for the common occurrence of Calcitornella and the record of cf. Trepeilopsis, which tend to suggest a Cattle Creek equivalent for these beds, no evidence is at present available for a satisfactory correlation with the Springsure area.

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PALAEONTOLOGICAL REPORT ON CORES 41 AND 42

CABAWIN NO. 1 WELL

by

Dorothy Hill*

Core No. 41 11,086-11,097 feet (12 pieces, numbered 1-12 in the list, 1 being at the top).

Volsellina ? mytiliformis (Eth.) 1, 2, 3, 4, 5, 6.

Parallelodon sp. nov. 1, 2, 3, 5, 6, 9, 10, 11, 12.

Astartila pusilla ? (McCoy). 1, 4.

Astartila ? second species. 1, 2, 3, 5, 6, 8, 9, 10, 11, 12.

Streblochondria ?. 1, 6.

Pteriid lamellibranch. 1.

Stutchburia ?. 3.

Allorisma?. 11.

Small gasteropod, indeterminate. 2, 8.

Echinodermatan (probably crinoid stem plates), indeterminate 4.

Stenopora sp. finely branching. 1, 2, 3, 4, 5, 6, 7, 8, 12.

Fenestella sp. 4, 10, 11.

Polypora sp. 5, 11.

Spirifer tasmaniensis. 7, 8, 10.

Spirifer species A. thin-shelled, with lamellation, triple ribs formed by intercalation of grooves; with fine radial lirae. 1, 4, 9.

Notospirifer ? small species.

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Ingelarella sp. thin shelled, large, rather elongate. 8.

Ingelarella sp. thin shelled, thin visceral cavity. 5, 6.

Ingelarella very small, probably young form. 10.

Terrakea sp. indet. 1, 8, 9, 11, 12.

Strophalosia ? 1, 8.

Finely punctate (in quincunx) smooth-shelled brachiopod.

V. mytiliformis is not known to me as low as the Cattle Creek Formation, but is common in higher horizons. Parallelodon sp. nov. is not known to me in the Cattle Creek but occurs in Mantuan horizons and in the Flat Top Formation. Astartila pusilla? is known to me in combination with V? mytiliformis only from the fossil ridge on the Theodore road 2.2 to 2.5 miles from Cracow Township. The remaining mollusca in the list are not helpful. A finely branching Stenopora like that in the list occurs in the same Theodore road locality, as do the spiriferids of the list. The list contains nothing diagnostic of the Cattle Creek Formation, or of the Ingelara Formation.

I feel reasonably certain that Core No. 41 correlates with the horizon of the Theodore road locality, though the fauna at the latter is much wealthier.

The horizon of the Theodore road locality is a matter of disagreement between palaeontologists and field workers. The latter without exception have considered it continuous in the field with the Fossil Ridge just west of Cracow Homestead, which carried abundant Taeniothaerus subquadratus, Eurydesma and Anidanthus springsurensis and is equivalent to the lower Cattle Creek. All of these three species are absent from the Theodore road locality. Palaeontologists regard the Theodore road locality as much higher, nearer to Mantuan than to Cattle Creek and perhaps nearer to Mantuan than to Ingelara. The Theodore road locality has the same fauna as the Oxtrack Creek Limestone at Oxtrack Creek, but again this Oxtrack fauna is quite distinct from the Cracow Homestead fauna.

Amongst the species of the Theodore road locality that indicate a high horizon are the Ingelarella spp. which are large and transverse, the Terrakea spp. which are large and include some Terrakea solida like that characteristic of the Mantuan fauna, as well as others like those of the Flat Top fauna. The Strophalosia also are large and resemble S. ovalis of the Mantuan fauna. Also, some of the Stenopora species of Theodore road are comparable with the Mantuan fauna.

I therefore think the Theodore road fauna is high, possibly as high as Flat Top, which I regard as very little older than Mantuan. However, it lacks a productid that is characteristic of the Flat Top.

Core No. 42 11,578 - 11,589 feet (9 pieces, numbered 1-9 in list).

Terrakea sp. cf. pollex Hill. 1, 2, 3, 4, 5, 6, 7, 8, 9.

Strophalosia ? 1, 2, 4, 5, 7, 8.

Anidanthus springsurensis (Booker). 5.

Notospirifer sp. 1, 2.

Spiriferid, uniplicate, without ? dental plates in ventral valve. 2.

Large, coarse-ribbed spiriferid. 3.

Polyzoan (massive). 7.

Small gasteropods, indeterminate, numerous. 9.

Anidanthus springsurensis, which is not known in Queensland above the Cattle Creek horizon, suggests that this fauna is Cattle Creek, though only one specimen was found. The most common species in the core is Terrakea sp. and this is similar to, if not identical with, one from a fossil horizon in the Cattle Creek Formation only 100 feet below the Aldebaran Sandstone. (1) The spiriferids support this correlation with this high Cattle Creek horizon. The absence of the large species of Eurydesma and Taeniothaerus may be due to facies differences, but alternatively could be used to support the high Cattle Creek horizon.

PERMIAN MACROFOSSILS FROM CABAWIN NO. 1 WELL

by

J. M. Dickins*

Identifications

Core No. 41 11,086 - 11,097 feet

Pelecypods

Parallelodon sp. nov.

Volsellina? cf. mytiliformis (Etheridge Jnr.) 1892

Stutchburia cf. costata (Morris) 1845

Astartidae gen. et sp. nov.

Brachiopods

Terrakea sp.

Neospirifer sp.

Crinoids

Ossicles

Bryozoans

Fenestellids and cylindrical branched forms.

Core No. 42 11,578 - 11,589 feet

Brachiopods

Strophalosia ? sp. ind.

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(1) Footnote by Bureau of Mineral Resources:

J.T. Woods of the Geological Survey of Queensland identified Terrakea cf. levis Booker in a sample (11,578'8" - 9") from Core No. 42. He notes that the genus Terrakea has a wide range in the Queensland Permian; Terrakea levis is known from the Upper Marine of the Hunter River and Southern Coalfields of New South Wales, but has not been recorded from Queensland.

* Bureau of Mineral Resources.

Terrakea sp. (a large shell)

Neospirifer sp.

Numerous productid spines

Crinoids

Ossicles

Dr. Irene Crespin has also found a gasteropod in cuttings from 11,090 - 11,100 feet which can be identified as *Peruvispira* sp.

Conclusions

The species which seem to be most important for correlation are *Parallelodon* sp. nov. and Astartidae gen. et sp. nov. These two species appear to be characteristic of the upper part of the Middle Bowen Beds on the west side of the Bowen Basin (Clermont Sheet) where the lower part of the Middle Bowen is lacking and the upper part rests directly on an Upper Devonian to Lower Carboniferous basement. They are also characteristic of the top part of the Middle Bowen Beds on the east of the Bowen Basin (Mount Coolon Sheet) where the lower part of the Middle Bowen Beds is present. Here they are the highest of three faunas found. Astartidae gen. et sp. nov. and probably *Parallelodon* sp. nov. are also found in the Flat Top Formation of the Banana area (Dickins, 1959).

The fossils suggest the beds of Core No. 41 are not older than the Ingelara Formation of the Springsure area and may be younger.

The same species of *Neospirifer* appears to be present in both Cores No. 41 and No. 42 and the material I have examined provides no evidence that the beds of Core No. 42 are significantly older than those of Core No. 41.

REFERENCES

DICKINS, J.M., 1959: Permian pelecypods and gasteropods from the Bowen Basin, Queensland. *Bur. Min. Resour. Aust. Rec.* 1959/100 (Unpubl.).

PALYNOLOGICAL REPORT ON SAMPLES FROM CABAWIN NO. 1 WELL

by

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Introduction

The following report describes palynological investigations on samples from Union-Kern-A.O.G. Cabawin No. 1 which penetrated 12,035 feet into a structural "high" in the Surat Basin. Cores were taken at regular intervals. Most of the cores were studied and lists of the species determined are given, followed by a discussion on the age and correlation of the sample. The major changes in vertical distribution of the more important genera are described and illustrated by a distribution diagram (Fig. 5).

Drilling began in Lower Cretaceous sediments, continued through Jurassic, Triassic and Permian sediments and finished in andesitic volcanics regarded as basement. The well, the deepest yet drilled in Queensland, is of great interest as it has revealed the greatest vertical thickness of continuous sediments recorded in Queensland to date. The Triassic was notable for its great thickness of sandstones and conglomerates, indicative of rapid deposition. This is the thickest Triassic sequence yet proved by drilling in the Great Artesian Basin. The Permian consists of fresh-water coal measures overlying marine beds which pass into tuffs and andesites.

The purpose of the palynological studies was to determine the age of the sediments in cores where other fossils were almost completely lacking. Such age determinations are especially important in the fresh-water sequence between the Cretaceous and the Permian.

Samples Examined

The samples studied were mainly cores which, under the provision of the Commonwealth subsidy, were taken every 200 feet. Washed samples of cuttings taken every ten feet were also supplied by the company, and some of these samples (mainly coals) were examined for additional information. Although there is always a risk of contamination with cuttings, this was eliminated to a great extent by the separation of the coal content by flotation. This removed one source of contamination by shales higher in the well and, in addition, because of the high spore content of the coal cuttings, contamination from other sources was largely overshadowed. A few sidewall cores were also examined. Preliminary reports were sent to the company and the Bureau of Mineral Resources concerning the majority of these samples as drilling progressed. The purpose of this report is to summarize this information together with information on other samples not included in preliminary reports.

Basic Principles of Investigation

The main principle adhered to during the investigation has been to use as reference for correlation, wherever possible, local microfloras of known age. For example, the microflora of the Walloon Coal Measures in the type area (de Jersey, 1960), has been used for correlation in the Jurassic rather than attempting close comparisons with the more distant Jurassic of Western Australia and Europe. Such procedure minimizes difficulty due to plant migration and local climatic conditions which might affect more widely separated

* Geological Survey of Queensland, May 1961.

areas. The number of workers in this field is so few in Australia that this has not been possible in many instances and reference has been made to reports on microfloras from New South Wales and Western Australia.

One of the primary needs in palynological study in Australia is for basic research and publication of systematic description of microfloras from horizons of known stratigraphical age. These would be of the utmost value in correlation. Work is being carried out in the Geological Survey of Queensland along these lines, at present being concentrated on the Triassic microflora of the Ipswich Coal Measures. It is hoped later to extend similar investigations to the Bundamba Group and Permian formations of known age.

Age determinations made during this investigation have been based primarily on the general nature of the flora with genera of restricted range being taken into account. As the stratigraphical ranges of many of the genera and species are still not precisely established, some difficulties are to be expected, particularly at or near the system boundaries. It is expected that difficulties will always exist in correlating fresh-water sediments in the Australian Mesozoic with the type areas and accordingly greater stress should be laid on correlation with well known sequences, such as that established in south-eastern Queensland.

Detailed Palynology of Samples

In the following section the palynology of individual samples is described in order of increasing depths.

Core No. 1, sample from 580 feet - 580 feet 2 inches.

This sample gave a very poor yield of spores and pollens consisting of *Pityosporites* sp., *Leiotriletes* sp., and *Inaperturopollenites* sp. No exact age can be given for this flora.

Core No. 2, sample from 1108 feet 4 inches - 1108 feet 7 inches.

A fairly abundant yield of microspores was obtained from this sample and the following species identified:

Araucariacites sp.

Inaperturopollenites sp.

Leiotriletes directus

Leptolepidites verrucatus

Entylissa nitidus

Sphagnumsporites tenuis

Osmundacidites sp.

Most of the spores are long ranged forms and no specimen was found on which a division into Jurassic or Cretaceous could be based.

Core No. 3, sample from 1582 feet 2 inches - 1582 feet 3 inches.

An abundant microspore content was obtained from this sample. Species found are as follows :

Araucariacites sp.

Inaperturopollenites sp.

Cyathidites australis

Cingulatisporites sp.

Sphagnumsporites tenuis

Lycopodiumsporites austroclavatidites

L. rosewoodensis

Zonalapollenites trilobatus

Microcachrydites antarctica

Leiotriletes directus

L. magnus

Gleichenia circinidites

Pityosporites cf. ellipticus

P. cf. parvisaccatus

P. sp.

Annulispora folliculosa

Acanthotriletes sp.

Apiculatisporites asymmetricus

Leptolepidites verrucatus

Verrucosisporites walloonensis

Osmundacidites sp.

The general nature of the flora indicates an Upper Jurassic to Lower Cretaceous age, most species being characteristic of this time range.

Sidewall core from 1978 feet.

Only a poor microspore assemblage was obtained from this sample with Inaperturopollenites sp. being the most common member. Cicatricosisporites sp. and Araucariacites sp. were also found.

Core No. 5, sample from 2429 feet 7 inches - 2429 feet 9 inches.

The following species were identified from this sample:

Inaperturopollenites sp.

Leiotriletes directus

Araucariacites sp.

Microcachrydites antarctica

cf. Microreticulatisporites parviretis

Lycopodiumsporites rosewoodensis

L. austroclavatidites

L. austroclavatidites tenuis

Pityosporites similis

P. cf. psilatus

Foveosporites canalis

Cyathidites australis

C. sp.

Zonalapollenites trilobatus

cf. Z. dampieri

cf. Polypodiidites arcus

Cirratriradites spinulosus

Sphagnumsporites tenuis

Pityosporites cf. parvisaccatus	Gleichenia cf. circinidites
P. cf. ellipticus	Osmundacitites comaumensis

The general nature of the flora, together with the presence of Zonalapollenites trilobatus, Pityosporites similis, Cirratriradites spinulosus, and Gleichenia cf. circinidites, strongly indicate a Lower Cretaceous to Upper Jurassic age for this sample.

Core No. 6, sample from 2780 feet 7 inches - 2780 feet 9 inches.

A fairly abundant microflora was obtained including the following species:

Inaperturopollenites sp.	Leiotriletes sp.
Araucariacites sp.	L. magnus
Osmundacidites sp.	Classopollis torosus
O. wellmanii	Cyathidites australis
O. comaumensis	Leptolepidites verrucatus
Annulispora sp.	Sphagnumsporites tenuis
Pityosporites sp.	cf. Neoraistrickia truncatus
P. cf. psilatus	Caytonipollenites subtilis
P. cf. ellipticus	
Zonalapollenites segmentatus	
Lycopodiumsporites rosewoodensis	
Cicatricosisporites cf. cooksonii	

The flora in general indicates an Upper Jurassic to Lower Cretaceous age. However, in Western Australia Zonalapollenites segmentatus was present in the Lower Jurassic, with doubtful specimens ranging into the Upper Jurassic, and has also been found in the Walloon Coal Measures in the type area. The presence of this species provides evidence in favour of an Upper Jurassic age rather than Lower Cretaceous. The absence of Microcachrydites antarctica would also favour a Jurassic age. An interesting feature is the presence of Osmundacidites which occurs fairly abundantly.

The presence of Microcachrydites antarctica, Foveosporites canalis and Cirratriradites spinulosus in Core No. 5, and their absence in Core No. 6, which contains Zonalapollenites segmentatus, would tentatively suggest that the Lower Cretaceous-Upper Jurassic boundary occurs between Cores 5 and 6.

Core No. 8, sample from 3787 feet 11 inches - 3788 feet 1 inch.

An abundant microflora was obtained from this sample. Species identified include:

Inaperturopollenites sp.
Araucariacites sp.
Cyathidites sp.
C. australis
C. minor
Lycopodiumsporites rosewoodensis
L. circolumenus
L. austroclavatidites
L. austroclavatidites tenuis
L. cf. triangularis
Classopollis torosus
C. sp.
Pilasporites minutus
Leiotriletes magnus
L. mortoni
L. directus
L. cf. crassus
Entylissa nitidus
Acanthotriletes cf. levidensis
cf. Baculatisporites truncatus
cf. Sphagnites clavus
Zonalapollenites trilobatus
Z. segmentatus
cf. Granulatisporites dailyi
Verrucosisporites walloonensis
Laevigatisporites neddeni
Osmundacidites comaumensis
O. sp.
Cicatricosisporites cf. cooksonii
Sphagnumsporites tenuis
Pityosporites cf. ellipticus
P. sp.

The microflora is of the same general nature as that obtained from Cores 3, 4, 5 and 6, with forms such as Cicatricosisporites cooksonii Lycopodiumsporites austroclavatidites, and Zonalapollenites trilobatus occurring throughout. As the general age of these cores is from Lower Cretaceous passing down into the Upper Jurassic and probably the Middle Jurassic, it is possible to equate this section of the well with the Blythesdale Group.

Core No. 9, sample from 4205 feet 5 inches - 4205 feet 9 inches.

Only a moderate assemblage of microspores was obtained from this sample.

Inaperturopollenites sp.
Araucariacites sp.
Lycopodiumsporites rosewoodensis

Sphagnumsporites tenuis

S. australis

Leiotriletes directus

L. magnus

Annulispora cf. folliculosa

Verrucosisporites walloonensis

L. austroclavatidites

L. triangularis

Cyathidites cf. parvus

Rugulatisporites ramosus

Acanthotriletes pallidus

cf. Laevigatisporites sp.

All the species identified in this sample are typical representatives of the Walloon Coal Measures in the type area. However, as the spore yield from this sample was fairly low, no detailed comparison can be attempted.

Sidewall core from 4361 feet.

A fairly poor microspore assemblage was obtained from this sample and the species were identified as below:

Inaperturopollenites sp.	abundant
Lycopodiumsporites rosewoodensis	common
Leiotriletes directus	common
Lycopodiumsporites triangularis	rare
Cyathidites parvus	rare
Leptolèpidites verrucatus	rare
Sphagnumsporites tenuis	rare
cf. Concavisporites sp.	rare

Core No. 11, sample from 4905 feet 10 inches - 4906 feet.

This sample was virtually barren of spores but the following species were identified:

Inaperturopollenites sp.

Pilasporites cf. crassus

Leiotriletes directus

Sidewall core from 5133 feet.

A very poor assemblage of microspores was obtained from this core with Inaperturopollenites sp. the most common form. Other species identified were:

Lycopodiumsporites rosewoodensis

Granulatisporites minor

Sphagnumsporites tenuis

Leiotriletes directus

L. sp.

Core No. 12, sample from 5532 feet 11 inches - 5533 feet 1 inch.

A very rich microflora was obtained from this sample. Species identified were:

Araucariacites sp.

Inaperturopollenites sp.

Lycopodiumsporites rosewoodensis

Sphagnumsporites tenuis

S. australis

Rugulatisporites ramosus

Cyclogranisporites breviradiata

cf. Reticulatisporites pudens

cf. Cyathidites australis

Leiotriletes directus

L. mortoni

Cingulatisporites granulatus

Entylissa cf. nitidus

E. sp.

Acanthotriletes cf. pallidus

A. sp.

Osmundacidites wellmanii

cf. Leptolepidites verrucatus

Caytonipollenites subtilis

Annulispora sp.

Verrucosisporites triangularis

The microspores of this sample are typical of the assemblage of the Walloon in the type area.

Core No. 14, sample from 5740 feet 5 inches - 5740 feet 7 inches.

An abundant microflora was obtained with Inaperturopollenites sp. and Araucariacites sp. being the most common members. Lycopodiumsporites rosewoodensis is also common in this sample. Other species are:

Inaperturopollenites sp.

Araucariacites sp.

Lycopodiumsporites rosewoodensis

L. triangularis

L. austroclavatidites

Acanthotriletes cf. pallidus

cf. Ceratosporites sp.

Leiotriletes directus

L. crassus

Sphagnumsporites adnatus

Pityosporites psilatus
P. cf. ellipticus
P. sp.
Leptolepidites verrucatus
Classopollis cf. torosus
Osmundacidites sp.
Sphagnumsporites sp.
S. tenuis
Annulispora sp.
Cingulatisporites saevus
C. cf. granulatus

The general nature of the flora indicates a Jurassic age for the core and there is a fairly close comparison with the microflora of the Walloon Coal Measures assemblage. The principal difference from the Walloon is the presence of Classopollis which suggests a lower horizon since this genus was absent from the type area at Rosewood. Lycopodiumsporites austroclavatidites and Cingulatisporites saevus have previously been recorded from the Upper Jurassic to Lower Cretaceous of Western Australia and their association in this assemblage suggests their range should be extended into the Lower Jurassic.

Core No. 15, sample from 5895 feet 10 inches - 5896 feet 1 inch.

The following spores were identified in this sample:

Inaperturopollenites sp.
Osmundacidites wellmanii
O. sp.
Araucariacites sp.
Pteruchipollenites sp.
Pityosporites psilatus
P. parvisaccatus
P. cf. ellipticus
Sphagnumsporites tenuis
cf. S. adnatus
Lycopodiumsporites sp.
L. rosewoodensis
cf. Ischyosporites sp.
Entylissa sp.
Classopollis cf. torosus
Annulispora folliculosa
A. densata
Leiotriletes directus
Acanthotriletes pallidus

The sample is characterized by a large percentage of Osmundacidites. The general nature of the flora is of Jurassic age with Pteruchipollenites persisting from the Triassic.

Core No. 16, sample from 6068 feet 4 inches - 6068 feet 8 inches.

Only a poor assemblage was obtained and the following species were identified:

Inaperturopollenites sp.
Lycopodiumsporites rosewoodensis
Ischyosporites sp.
Araucariacites sp.

Acanthotriletes cf. pallidus

Leiotriletes directus

Lycopodiumsporites austroclavatidites

Pityosporites parvisaccatus

The nature of the microflora indicates a Jurassic age with Lycopodiumsporites rosewoodensis occurring abundantly. Ischyosporites occurs in fair abundance (16 percent) acting as a striking marker for this horizon. The species of Ischyosporites identified in this core is quite distinct from the species previously described from the Cretaceous and extends the range of the genus into the Lower Jurassic. Its presence indicates a distinct difference from the Walloon assemblage.

Core No. 17, sample from 6284 feet 8 inches - 6284 feet 10 inches.

Only a low yield of microspores was obtained from this sample. The following spores were present:

Inaperturopollenites sp.

Classopollis cf. torosus

Araucariacites sp.

Lycopodiumsporites rosewoodensis

Sphagnumsporites tenuis

This horizon is marked by an abundance of Classopollis sp. cf. torosus (20 percent) which again indicates a distinction from the Walloon of the type area.

Core No. 18, sample from 6473 feet 3 inches - 6475 feet 4 inches.

An abundant microflora was present in this sample with the following species being identified:

Inaperturopollenites sp.

Osmundacidites sp.

O. wellmanii

Pityosporites psilatus

P. parvisaccatus

P. ellipticus

Caytonipollenites sp.

C. cf. contectus

Lycopodiumsporites rosewoodensis

Araucariacites sp.

Classopollis torosus

C. cf. torosus

Sphagnumsporites tenuis

S. sp.

Todisporites sp.

Leiotriletes directus

L. cf. mortoni

Cyathidites sp.

The general nature of the flora indicates a Jurassic age with Osmundacidites wellmanii and Lycopodiumsporites rosewoodensis being present. The abundance of Osmundacidites (26 percent), together with the relative abundance of Classopollis (13 percent) is a feature of this sample. Todisporites, a genus recorded by Couper from the Mesozoic of Great Britain, was also identified in this core.

Core No. 19, sample from 6712 feet 7 inches - 6712 feet 9 inches.

A fairly abundant yield of microspores was obtained from this sample and the following species were identified:

Inaperturopollenites sp.	Araucariacites sp.
Pteruchipollenites	Osmundacidites sp.
Classopollis cf. torosus	Sphagnumsporites sp.
Leiotriletes sp.	Acanthotriletes cf. pallidus
L. directus	A. sp.
Annulispora sp.	cf. Caytonipollenites subtilis

The general nature of the flora is Jurassic in age with Pteruchipollenites persisting from the Triassic. Classopollis, which is abundant in cores higher in the stratigraphical column, is present in this core but absent from samples lower down in the well.

The generic name Pteruchipollenites (as defined by Couper, 1958) has been applied to the bisaccate forms with an unstriated exine identified in this sample and from cores lower down in the well. The whole taxonomy of this genus needs urgent revision and recent work on this subject indicates that the genus needs to be redefined or the species transferred to other genera.

Core No. 20, sample from 6767 feet 10 inches - 6768 feet 1 inch.

Only a poor yield of microspores was obtained from this core.

Inaperturopollenites sp.	Araucariacites sp.
	Osmundacidites sp.
	O. cf. wellmanii
Leiotriletes directus	cf. Caytonipollenites subtilis
cf. Cyathidites australis	Pteruchipollenites
cf. Type 20A of Dulhunty	Verrucosisporites cf. walloonensis
Sphagnumsporites australis	Lycopodiumsporites rosewoodensis
S. tenuis	

The age of this sample can be put as Jurassic on the general nature of the microflora, which contains Lycopodiumsporites rosewoodensis, and the abundance of Osmundacidites which is not found in such abundance lower down in the well, but is typical of the cores immediately above.

The microfloras of Cores 14 to 20 all indicate a Jurassic age for the sediments, and occur below rocks which have been correlated with the Walloon, and above Core No. 21 which is regarded as Triassic (see below). Thus they are of an age intermediate between the Ipswich and the Walloon and can be tentatively correlated with sediments of the Bundamba Group. Such a classification must of necessity be preliminary since the typical assemblage of the Bundamba in the type area has yet to be determined by detailed research.

Core No. 21, sample from 7015 feet 11 inches - 7016 feet.

This sample gave a low spore content, the maceration residue consisting largely of highly carbonized material. Species identified were as follows:

Inaperturopollenites sp. (abundant)

Osmundacidites cf. wellmanii

Verrucososporites sp.

Cingulatisporites sp.

Leiotriletes cf. mortoni

Pteruchipollenites

The examination of the sample resulted in the identification of four species which have previously been found in the Ipswich Coal Measures of Triassic age. These species, which are previously undescribed forms to be proposed as new species in a paper on the Ipswich microflora at present in course of preparation, are absent from both Permian and Jurassic sediments. The age of the sample is probably Triassic and this determination is based not only on the presence of Triassic species but also on the absence of typical Jurassic forms. However, preliminary work on the base of the Bundamba Group suggests a flora very similar to that described from the Ipswich. The age of this sample, therefore, could be equivalent to the base of the Bundamba Group or the top of the Ipswich.

Core No. 22, sample from 7218 feet 4 inches - 7218 feet 6 inches.

The sample gave a fair yield of spores and the following species were identified:

Inaperturopollenites sp.

Pteruchipollenites sp.

Araucariacites sp.

Verrucososporites sp.

cf. Lycopodiumsporites rosewoodensis

Leiotriletes magnus

Entylissa cf. nitidus

Verrucosisporites cf. walloonensis

Osmundacidites cf. wellmanii

The sample is noticeable for the increase in proportion of the genus *Pteruchipollenites* (23 percent) and the flora is distinctly Triassic in age.

Core No. 23, sample from 7404 feet - 7404 feet 3 inches.

The following species were identified from this core:

Inaperturopollenites sp.

Pteruchipollenites

Leiotriletes directus

Araucariacites sp.

Osmundacidites sp.

In this core the genus *Pteruchipollenites* is the dominant form (48 percent) and the age is Triassic. Regarding correlation with the base of the Bundamba or the top of the Ipswich Coal Measures the same remarks apply as for Cores 21 and 22.

Core No. 24, sample from 7646 feet.

The sample was almost barren of spores but the following species were identified:

Inaperturopollenites sp.

Araucariacites sp.

Verrucososporites sp.

Core No. 25 was totally devoid of spores.

Core No. 26, sample from 8200 feet - 8200 feet 2 inches.

The yield of spore material from this sample was low, and the following species were identified:

Inaperturopollenites sp.

Pteruchipollenites

Araucariacites sp.

Leiotriletes magnus

Verrucososporites sp.

Three species were identified which have been found in the Ipswich Coal Measures and not in the Permian or Jurassic, one as yet unnamed. Consequently the sample can be regarded as Triassic in age.

Core No. 27, sample from 8603 feet 8 inches - 8603 feet 10 inches.

This sample was almost completely barren of spores and contained only Inaperturopollenites sp.

A sample of cuttings from 8820 - 8850 feet was studied in an attempt to find out more about this section of the sequence as it was the only shale horizon in a great thickness of sandstones and conglomerates. It was hoped that this more favourable lithology would yield a more abundant microflora. Unfortunately, study of the maceration residue showed that the assemblage was badly contaminated by spores from the Jurassic section of the well, as indicated by the presence of Classopollis in some abundance. Consequently, no reliance can be placed on the evidence from this sample.

Core No. 29, sample from 9168 feet 1 inch - 9168 feet 3 inches.

An extremely low spore yield was also obtained from this core, with Inaperturopollenites sp. and Araucariacites sp. being identified.

As no species of restricted range could be identified from Cores 27 and 29, no age determination could be attempted.

Coal cuttings from 9620 - 9630 feet.

The coal fraction was separated from the cuttings by being floated off using carbon tetrachloride (S.G. 1.58). Spores and pollens were moderately abundant and the following species were identified:

Inaperturopollenites sp.	
Araucariacites sp.	Acanthotrilites levidensis
Lunatisporites amplus	A. cf. ericianus
L. limpidus	Leiotriletes directus
Striatites cancellatus	cf. Caytonipollenites conectus
Striatopodocarpites fusus	C. sp.
Protosacculina multistriatus	Verrucosisporites sp.
Pteruchipollenites	cf. Cirratriradites verrucosus

The microflora contains a mixture of bisaccate forms with Pteruchipollenites being somewhat more abundant than forms with a striated corpus. The presence of these striated bisaccate forms (common in the Permian) is however, not a definite indication of Permian age since such pollen grains are common in the Narrabeen Group of New South Wales (Lower Triassic). The microflora also contains Caytonipollenites, Verrucosisporites sp., and another form, at present unnamed, which have previously been found in the Ipswich Coal Measures and not in the Permian. The absence of Tholosporites parvitholus, Apiculatisporites filiformis, and a typical Permian flora, is also considered to be highly significant. The evidence favours an age near the base of the Triassic and this is supported by the lithological evidence. There is a continuous lithological sequence from this sample to definite Triassic above, consisting very largely of coarse sandstone and conglomerates, which indicate rapid deposition.

The nomenclature of the bisaccate pollens with a striated exine has recently been revised by Hart (1960) in an account of a Permian microflora from Tanganyika. As this paper was received while drilling was in progress the terminology used by Balme and Hennelly (1955), in which these forms were largely referred to the genus Lueckisporites, was used in preliminary reports. Hart's nomenclature is tentatively followed in the present report although it is felt further revision of this group, based on the Australian forms, is still required.

Coal cuttings from 9870 - 9890 feet.

These cuttings gave a spore assemblage containing the following microspores:

Inaperturopollenites sp.

Tholosporites parvitholus

Araucariacites sp.

Marsupipollenites sinuosus

M. cf. fasciolatus

M. triradiatus

cf. Verrucososporites leopardus

Lunatisporites limpidus

L. amplus

Striatopodocarpites fusus

Entylissa cf. vetus

E. cf. cymbatus

Laevigatisporites scissus

Leiotriletes directus

Pteruchipollenites

Calamospora diversiformis

Lycopodiumsporites sp.

cf. Florinites eremus

Granulatisporites trisinus

G. micronodosus

Acanthotriletes ericianus

Apiculatisporites filiformis

cf. type 25A of de Jersey.

Of the microspores identified Tholosporites parvitholus is one of the most common (12 percent) and the flora in general is composed of Permian species. Pteruchipollenites, which is present in this sample, continued to be found as far down as Core No. 33 (9958 feet 9 inches - 9959 feet 3 inches) and thus shows a longer time range than previously known. Type 25A of de Jersey, a Triassic form, has also been identified from Permian sediments and can be discounted, as the general character of the flora is of greater significance in age determination than the occurrence of any particular species. Any correlation over long distances, as with the Sydney Basin for example, should not be expected to be accurate to a few feet and some local variation must be expected in the range of various species.

It is probable that there is a continuous conformable sequence from the Permian into the Lower Triassic in this well, in which case fixing the exact location of the boundary may be a difficult problem. On present knowledge, however, the writers consider the present sample (9870 - 9890 feet) as the highest definite Permian horizon in the well. Apart from the presence of Pteruchipollenites, the microflora in general is very similar to that of the Upper Coal Measures of New South Wales, as recorded by Balme and Hennelly.

The proportion of bisaccate forms with a striated corpus to forms with non-striate exines (Pteruchipollenites) can form a useful basis for correlation with other sediments.

The relative proportions of the two forms found in the sample from 9620 - 9630 feet are comparable with those found in the sample 4422 1/2 feet in A.A.O. Pickanjinnie No. 1. In addition, the general microfloral assemblage is similar and thus the section around 9600 feet can be correlated approximately with the Pickanjinnie Formation of the Roma area. Consequently, the palynological evidence supports the correlation suggested by A.S. Keller, resident geologist of Union Oil Development Corporation, on the basis of lithology and electric logs.

Core No. 32, sample from 9943 feet 9 inches - 9944 feet.

The sample consisted of carbonaceous shale containing (on one bedding plane) carbonized impressions of Glossopteris. The presence of this leaf genus supports the palynological evidence of a Permian age. Spores and pollen grains were fairly abundant and the following species have been identified.

Inaperturopollenites sp.

Protosacculina multistriatus

Lunatisporites limpidus

L. amplus

Striatites cancellatus

Pteruchipollenites

Araucariacites sp.

Limitisporites (Vestigisporites sp. A. of Balme)

Pilasporites calculus

Granulatisporites trisinus

G. micronodosus

cf. Caytonipollenites

cf. Vesicaspora

Verrucososporites leopardus

Marsupipollenites triradiatus

Vesicaspora ovatus

Tholosporites parvitholus

cf. Nuskoisporites gondwanensis

cf. Apiculatisporites levis

Cirratriradites sp.

Verrucosisporites cf. trisecatus

The assemblage indicates an Upper Permian age for the sample. The bisaccate forms with a striated corpus are abundant (27 percent) in this sample, Pteruchipollenites being relatively scarce.

Core No. 33, sample from 9955 feet 9 inches - 9956 feet 3 inches.

The following species were identified from this sample:

Inaperturopollenites sp.

Tholosporites parvitholus

Granulatisporites micronodosus

cf. Apiculatisporites filiformis

Lunatisporites limpidus

Protosacculina multistriatus

Leiotriletes directus

Pteruchipollenites

cf. *Tuberculatisporites modicus*

Araucariacites sp.

Pilasporites sp.

Marsupipollenites triradiatus

Calamospora diversiformis

Acanthotriletes uncinatus

A. ericianus

This assemblage exhibits only slight differences from Core No. 32, twelve feet higher in the well. The principal difference from the assemblage in Core No. 32 is that the bisaccate pollens are less abundant, a feature which is probably related to slight differences in environmental conditions. In each core the bisaccate pollens with striated exine dominate the pollens of *Pteruchipollenites* type, which are dominant in the Triassic. *Tholosporites parvitholus* is more common here (9 percent) than in the higher core. The microflora thus indicates an Upper Permian age for the sample.

The lithologies of Core No. 34 (9964 feet 10 inches - 9965 feet) and Core No. 36 (9974 feet 2 inches - 9974 feet 5 inches) were extremely unfavourable for good microspore recovery, and a low spore content was obtained. The following species were identified:

Tholosporites parvitholus

Granulatisporites cf. *trisinus*

Acanthotriletes cf. *ericianus*

Inaperturopollenites sp.

The presence of *Tholosporites parvitholus* suggests an Upper Permian age for this assemblage.

Core No. 38, sample from 10,045 feet 4 inches - 10,045 feet 7 inches.

The sample yielded only a few spores, but the following species were described:

Apiculatisporites filiformis

Granulatisporites micronodosus

Leiotriletes directus

Marsupipollenites triradiatus

Inaperturopollenites sp.

This assemblage is of little stratigraphic value and insufficient specimens were found to permit any quantitative studies on species distribution.

Core No. 39, sample from 10,113 feet 9 inches - 10,114 feet 2 inches.

The following species were identified from this sample:

Inaperturopollenites sp.	Lunatisporites limpidus
Apiculatisporites filiformis	L. amplus
Acanthotriletes ericianus	L. phaleratus
A. tereteangulatus	Striatites cancellatus
Pityosporites cf. giganteus	Protosacculina multistriatus
Type 25A of de Jersey	Tholosporites parvitholus
Leiotriletes directus	Granulatisporites trisinus
Marsupipollenites triradiatus	G. micronodosus
M. sinuosus	Tuberculatisporites modicus
Calamospora diversiformis	Punctatisporites sp.
Cirratriradites sp.	Araucariacites sp.
cf. Vesicaspora ovatus	Acanthotriletes cf. dentatus
	cf. Apiculatisporites levis.

This assemblage indicates an Upper Permian age for the sample. One of the principal features of interest is that the proportion of Tholosporites is reduced to approximately 1 percent. This genus was much more abundant in previous cores; for example, it formed 9 percent of the total assemblage of Core No. 33. The assemblage is also noticeable for the large proportion of spinose forms, Acanthotriletes and Apiculatisporites, which make up 27 percent of the total. The bisaccate forms with a striated body have now been increased in proportion to 13 percent from Core No. 33, where they represented only 5 percent of the total microflora.

Coal cuttings from 10,260 - 10,270 feet.

The sample examined consisted of coal cuttings recovered from the ditch sample by separation with carbontetrachloride (S.G. 1.58). The following species have been identified:

Inaperturopollenites sp.
Lunatisporites limpidus
L. amplus
Striatites cancellatus
Protosacculina multistriatus
Leiotriletes directus

Vesicaspora ovatus	Pityosporites cf. giganteus
Tholosporites parvitholus	Bascanisporites undosus

Alisporites milvinus

Granulatisporites trisinus

G. micronodosus

Acanthotriletes ericianus

Punctatisporites cf. gretensis

Calamospora diversiformis

Verrucososporites cf. hamatus

Limitisporites sp.

This assemblage confirms the trend of decreasing abundance of Tholosporites (0.5 percent) with increasing depth, together with an increasing proportion of bisaccate striated forms (21 percent).

This relative scarcity of Tholosporites together with a large proportion of striated bisaccate forms is paralleled by the assemblage investigated in two coal samples from Kianga (de Jersey, 1961). Both this sample from 10,260 - 10,270 feet and the sample from Core No. 39 (10,113 feet 9 inches - 10,114 feet 2 inches) resemble the microflora from Kianga in this respect and, consequently, are regarded as being close to the horizon of the Kianga coal seam. One major difference between the two samples from Cabawin is that the assemblage from Core No. 39 contained a large proportion of spinose forms, (Acanthotriletes plus Apiculatisporites 27 percent), which were relatively rare in the sample from 10,260 - 10,270 feet. These species were abundant in the microflora from Kianga (total proportion 19.5 percent) and this fact suggests that the Kianga assemblage is closer to the upper sample from Cabawin.

For both samples the decreasing abundance of Tholosporites indicates an approach to the conditions found at Kianga, where this species was absent. The proportions of striated bisaccate forms (18 percent) and spinose forms (19.5 percent) at Kianga do not correlate exactly with the relative abundance of these species in either of the two levels at Cabawin, but rather suggest an intermediate position between them.

Cuttings from 10,570 - 10,620 feet.

The sample examined from these depths consisted of coal cuttings. The coal seam was studied in two sections (from 10,570 - 10,590 feet and from 10,590 - 10,620 feet) and as the assemblages yielded were closely similar, the list of species furnished covers the full section of the seam.

The following species were described:

Tholosporites parvitholus

Inaperturopollenites sp.

Leiotriletes directus

L. sp.

cf. Granulatisporites trisinus

cf. G. micronodosus

Calamospora diversiformis

Lunatisporites limpidus

cf. Marsupipollenites triradiatus

cf. M. sp.

The assemblage is dominated by Tholosporites (45 percent) while bisaccate forms with striated exines were exceedingly rare. This is in marked contrast to the assemblage from the coal seam at 10,260 feet and furnishes further evidence in support of the suggested correlation of the Kianga coal seam with a level between 10,114 and 10,260 feet.

Coal cuttings from 10,700 - 10,710 feet.

The following species were identified from this sample:

Tholosporites parvitholus

Inaperturopollenites sp.

Verrucososporites cf. hamatus

Leiotriletes directus

Lunatisporites limpidus

Protosacculina multistriatus

Calamospora diversiformis

Verrucosisporites cf. trisecatus

Granulatisporites cf. trisinus

This assemblage is again dominated by Tholosporites (28 percent) and closely resembles the microflora in the coal section from 10,570 - 10,620 feet. The abundance of Tholosporites is reduced in proportion while striated bisaccate forms are now becoming more common. The presence of Tholosporites indicates that the microflora is still comparable with that from the Upper Coal Measures of New South Wales (regarded as Upper Permian).

Core No. 41, sample from 11,086 feet 10 inches - 11,087 feet 2 inches.

Spores were relatively rare in this sample and only the following species were identified:

Granulatisporites micronodosus

Inaperturopollenites sp.

Leiotriletes directus

Nuskoisporites gondwanensis

Tuberculatisporites cf. modicus

Acanthotriletes ericianus

None of these species is of restricted range within the Permian. The maceration residue also contained numerous specimens of a species of microplankton which is considered to be a member of the Hystrichosphaeridea. The presence of this microplankton indicates a marine environment during the deposition of this section of the core. The few spores present were thus derived from the vegetation of the adjacent land and incorporated in the sediments after wind dispersal.

Core No. 42, sample from 11,578 feet - 11,587 feet.

The maceration residue was almost devoid of spores but Lunatisporites limpidus and Inaperturopollenites sp. were identified.

Effect of depth on spore recovery

The recovery of well-preserved spores and pollen from below 8000 feet in this well is of interest in comparison with results of investigations in Western Australia. Balme (1957, p. 10) states : "In the Exmouth Gulf area, useful assemblages were not obtained from sediments below about 8000 feet, and it seems that below this depth the combined effects of temperature and pressure have been sufficient to destroy the spore and pollen exines." If Balme's conclusions regarding this depth effect are correct, the presence of well-preserved spores below 8000 feet at Cabawin suggests that metamorphism resulting from the thickness of overlying sediments was appreciably less intense than in the Exmouth Gulf area of Western Australia.

General Features of Spore Distribution

The distribution diagram (Fig. 5) illustrates the vertical changes in the well of some of the genera and other groups. The percentages on which it is based have been determined from the cores and other samples and intermediate percentages have been interpolated. However, more detailed study at closer intervals might alter the diagramatic representation.

In the Permian the diagram illustrates the great abundance of Tholosporites parvitholus in the lower coals from about 10,500 feet in the well. This genus almost dies out from 10,261 - 10,114 feet but reappears again in some abundance up to as far as the tentative Permian-Triassic boundary. The striated bisaccate forms, formerly grouped in the genus Lueckisporites, are present throughout the Permian sequence, extending up into the Lower Triassic. The relationship of Tholosporites to bisaccate forms with a striated exine appears "antagonistic", since the presence of one group in abundance precludes the appearance of the other in any number. This fact suggests that the ecological conditions favouring the presence of one group are unsuitable for the production of the other spore type.

Another characteristic feature of the Permian assemblage is the marked abundance at one horizon (10,114 feet) of spinose forms (Apiculatisporites plus Acanthotriletes). The total proportion of these forms reaches 27 percent in contrast to their rarity elsewhere. This marker horizon, which has been compared with the assemblage from the Kianga coal seam, is made more striking by the rarity of Tholosporites and the abundance of bisaccate forms with striated exines.

The Triassic sediments are marked by a dominance of the genus Pteruchipollenites which first appears near the top of the Permian and dies out in the Lower Jurassic. In the Jurassic and Cretaceous, it is replaced by Pityosporites which includes bisaccate pollens of more modern aspect comparable with conifer pollens.

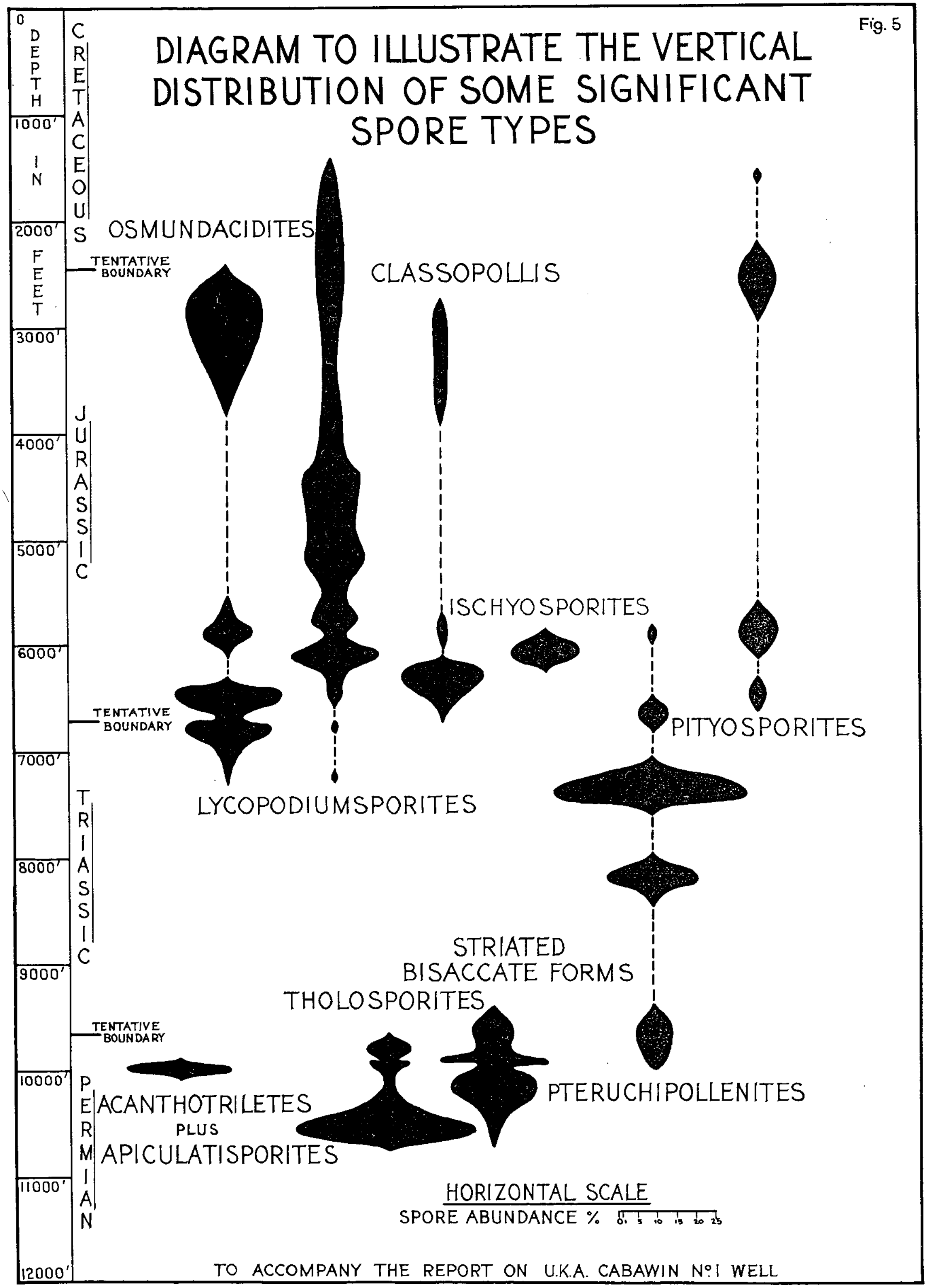

Fig. 5
DIAGRAM TO ILLUSTRATE THE VERTICAL DISTRIBUTION OF SOME SIGNIFICANT SPORE TYPES
DEPTH IN FEET
0
1000'
2000'
3000'
4000'
5000'
6000'
7000'
8000'
9000'
10000'
11000'
12000'
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
TENTATIVE BOUNDARY
TENTATIVE BOUNDARY
TENTATIVE BOUNDARY
OSMUNDACIDITES
CLASSOPOLLIS
ISCHYOSPORITES
PITYOSPORITES
LYCOPODIUMSPORITES
STRIATED BISACCATE FORMS
THOLOSPORITES
PTERUCHIPOLLENITES
ACANTHOTRILETES PLUS APICULATISPORITES
HORIZONTAL SCALE
SPORE ABUNDANCE %
TO ACCOMPANY THE REPORT ON U.K.A. CABAWIN No. 1 WELL

The Jurassic is characterized by abundance of Lycopodiumsporites, which extends into the Lower Cretaceous. This genus is most abundant in the lower part of the Jurassic (6068 feet) at a horizon which is also characterized by an abundance of a new species of Ischyosporites.

The genus Osmundacidites first appears near the top of the Triassic and becomes quite common near the base of the Jurassic. Near the top of the Jurassic it exhibits another burst of abundance, being reduced to negligible proportions in the intervening section. The abundance of Osmundacidites in the Lower Jurassic is accompanied by a high proportion of the genus Classopollis, which reaches its maximum at 6284 feet, subsequently becoming rare and finely disappearing in the Cretaceous. The distribution of Osmundacidites and Classopollis in the Lower Jurassic is so striking that it should be possible to recognize these horizons in future wells in this area.

Conclusions

The investigation recorded here has produced the following results:

(i) Spores and pollen grains were recovered from almost all the cores and cuttings examined from this well, which, with its total depth of 12,035 feet, is the deepest yet drilled in Queensland (at May, 1961).

(ii) The microflora provided age determinations of samples inwhich other fossils were totally lacking. Other fossils were identifed only from the marine Cretaceous and the Permian, so that evidence on the age of the intervening sediments is based entirely on the spores and pollens.

(iii) Some spores and pollens were found even in unfavourable lithologies such as sandstones and conglomerates, while in sediments such as carbonaceous shales and coals these microfossils were often abundant. Their presence down to depths below 11,000 feet indicates that they have been relatively unaffected by metamorphism due to such depths of burial.

(iv) As well as enabling age determinations to be made, the investigation permitted the vertical ranges of many genera and species to be established in this thick vertical sequence. Determination of these ranges will prove of value for comparison with future wells in this area.

(v) Correlations have been suggested of the sediments at Cabawin with other formations in Queensland and elsewhere.

Table 1 - Summary of Age Determinations and Correlations

Depth (feet)	Nature of Sample	Relative Spore Yield	Age	Equivalent Formation	System Boundaries
580	Core 1	Poor		ROMA	
1108	Core 2	Poor		FORMATION?	
1582	Core 3	Abundant	UPPER		
1978	Sidewall core	Very poor	JURASSIC -		
			LOWER	BLYTHES -	
2429	Core 5	Poor	CRETACEOUS	DALE	
2780	Core 6	Poor		GROUP	Tentative boundary
3787	Core 8	Abundant			between the Jurassic
					and Cretaceous
4205	Core 9	Poor			
4361	Sidewall core	Poor			
4906	Core 11	Very poor	JURASSIC	WALLOON COAL MEASURES	
5138	Sidewall core	Poor			
5533	Core 12	Abundant			
5740	Core 14	Good			
5896	Core 15	Poor	LOWER	BUNDAMBA	
6068	Core 16	Poor	JURASSIC	GROUP	
6284	Core 17	Poor			
6475	Core 18	Good			
6712	Core 19	Good			
6768	Core 20	Poor			

Depth (feet)	Nature of Sample	Relative Spore Yield	Age	Equivalent Formation	System Boundaries
7016	Core 21	Poor			Tentative boundary
7218	Core 22	Poor		IPSWICH-	between the
7404	Core 23	Poor		BUNDAMBA	Jurassic and
7648	Core 24	Poor	TRIASSIC		Triassic
8200	Core 26	Poor		NARRABEEN	
8603	Core 27	Very poor		GROUP	
9168	Core 29	Poor		PICKANJINNIE	
9620	Coal	Abundant		FORMATION	
9630	Cuttings				
9870	Coal	Good			
9890	Cuttings		UPPER	UPPER COAL	Tentative boundary
9944	Core 32	Good	PERMIAN	MEASURES OF	between the Triassic
9955	Core 33	Good		N.S.W.	and Permian
9965	Core 34	Good			
9974	Core 36	Very poor			
10,045	Core 38	Poor	UPPER		
10,114	Core 39	Good	PERMIAN	COAL	
10,260	Coal	Abundant		MEASURES	
10,270	Cuttings			AT KIANGA	
10,570	Coal	Good			
10,620	Cuttings				
10,700	Coal	Poor			
10,710	Cuttings				
11,087	Core 41	Poor			
11,578	Core 42	Very poor			
11,586	Core 42	Very poor			

Relative spore abundance

Very poor	0 - 10 spores
Poor	10 - 100 spores
Good	100 - 200 spores
Abundant	200 +

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APPENDIX 2

CORE DESCRIPTIONS AND ANALYSES

UNION-KERN-A.O.G. CABAWIN NO. 1

CONTENTS

DESCRIPTION OF CORES

by

D.J. McGarry and Erick Mack *

Core No. 1

Depth Cored:	562-585'
Interval Cored:	23' 0"
Total Recovery:	10' 0"
Angle of Hole:	$3/4^{o}$
Apparent Dip of Core:	Flat to 1^{o} - 2^{o}

Recovery	Description
4' 5"	SHALE, grey, silty, containing plant fragments, with interlaminated soft grey speckled sandstone, fine-grained, poorly sorted, translucent, subrounded to subangular quartz (60%), black lustrous subrounded grains (30%), white feldspars (5%). Poorly cemented with sand. Slight porosity. Sandstone laminae no greater than 1" thick. Small worm tracks (?) in sandstone. Crushed core at base of interval.
1' 1"	SANDSTONE, grey, very fine-grained, calcareous, poorly sorted subangular grains consist mostly of quartz and lustrous black mineral, cement hard and calcareous. Sandstone contains a few thin laminae of light brownish-grey, hard shale containing biotite and cream-coloured grains.
0' 6"	SANDSTONE, grey, fine-grained, soft, speckled, fine sand cement. Thin, flat, grey shale blebs throughout.
0' 7"	SANDSTONE, grey, calcareous, with thin, hard, light brown-grey shale as 1'1" interval above.
0' 9"	SANDSTONE, grey, speckled as above.
0' 5"	SANDSTONE, grey, calcareous, as 0'7" interval above.
2' 3"	SANDSTONE, grey, speckled, fine-grained, soft as above. Crushed core at base of interval.

Core No. 2

Depth Cored:	1099 - 1109'
Interval Cored:	10' 0"
Total Recovery:	5' 2"
Remarks on Recovery:	14' of compressed cuttings on top of 5'2" of solid core
Angle of Hole:	1^{o}
Apparent Dip of Core:	Flat

* Union Oil Development Corporation.

Recovery	Description
5' 2"	SHALE, grey, markedly silty, tends to true SILTSTONE texture in part. Cross-bedding (up to 7°) and contemporaneous slumping and swirling evident. Ribbon appearance evident in part. Some white mica paralleling bedding planes and biotite throughout siltier sections.

Core No. 3

Depth Cored:	1580 - 1590'
Interval Cored:	10' 0"
Total Recovery:	4' 0"
Angle of Hole:	0°
Apparent Dip of Core:	Flat - possibly up to 3°.

Recovery	Description
0' 2"	SANDSTONE, grey, speckled appearance, medium-grained fairly well sorted subangular to subrounded translucent quartz, some black friable grains, few white feldspar, light green and light brown grains fairly loosely cemented with fine white sand, carrying blebs of grey shale.
0' 4"	SHALE, grey, lensing, carrying flecks carbonaceous material.
0' 5"	SANDSTONE, grey as above and carrying thin coaly laminae and few 20 mm shale pebbles.
0' 6"	SHALE, grey and SILTSTONE, light grey, finely interlaminated, showing flat cross-bedding.
2' 7"	SANDSTONE, grey as above, but carrying few thin carbonaceous laminae and several cream-coloured subrounded shale pebbles up to 20 mm.

Core No. 4

Depth Cored:	2095 - 2100'
Interval Cored:	5' 0"
Total Recovery:	0' 6"
Remarks on Recovery:	Core lost due to compaction of cuttings in inner barrel
Angle of Hole:	-
Apparent Dip of Core:	Flat

Recovery	Description
0' 6"	SHALE, light grey, silty, carrying carbonaceous flecks.

Core No. 5

Depth Cored:	2428 - 2433'
Interval Cored:	5' 0"
Total Recovery:	3' 11"
Angle of Hole:	1°
Apparent Dip of Core:	Flat

Recovery	Description
3' 7"	SHALE, silty, grey, micaceous carrying profuse plant fragments, finely interlaminated with some light grey to grey SILTSTONE. Flat, fine cross-bedding evident throughout.
0' 4"	SANDSTONE, grey to light grey, fine-grained, angular and subangular mainly clear quartz grains, few glassy green and black grains. Carbonaceous laminae on bedding. Cement loose, somewhat friable, very fine sand.

Core No. 6

Depth Cored:	2780 - 2790'
Interval Cored:	10' 0"
Total Recovery:	5' 2"
Angle of Hole:	0^o
Apparent Dip of Core:	Flat

Recovery	Description
0' 1"	SANDSTONE, light grey, medium to coarse-grained, poorly sorted, quartzose clay matrix, gummy wet, tight.
0' 1"	SHALE, greenish-grey.
0' 3"	CONGLOMERATE, cobbles (up to 4" diam.) and pebbles volcanic rock in matrix of very coarse-grained to granule size, light grey quartz sandstone; scattered carbonaceous fragments.
1' 0"	SANDSTONE, grey to greenish-grey, fine to medium-grained, subangular to subrounded, quartzose. Near base of this interval sandstone interlaminated and cross-bedded with brown to grey-brown siltstone. Near top of interval thin laminae of macerated carbonaceous material and one thin coal seam.
0' 9"	SANDSTONE, grey, greenish-grey, medium to very coarse-grained, pebbly, poorly sorted, quartzose with abundant fragments coal and carbonaceous material.
2' 4"	SANDSTONE, grey, green-grey, medium to very coarse-grained, quartzose, also grains black volcanic rock, poorly sorted with occasional bleb buff clay; clay matrix, gummy, wet and tight.
0' 2"	CONGLOMERATE, pebble to cobble clusts of quartz, translucent, milky white, greenish-white and orange, quartzite and one clust serpentine (?) as well as coal fragments. Matrix grey, quartz sandstone.
0' 6"	Graded sequence medium-grained SANDSTONE to granule CONGLOMERATE (grit); grains subangular to rounded, white, yellow-amber and greenish-grey quartz with scattered carbonaceous material. Calcareous cement; tight.

Core No. 7

Depth Cored: 3280 - 3290'
Interval Cored: 10' 0"
Total Recovery: 1' 6"
Remarks on Recovery: Core washed away in loose sandstone.
Angle of Hole: $1/2^{o}$
Apparent Dip of Core: Flat, possibly up to 3^{o}

Recovery	Description
1' 6"	SANDSTONE, grey, medium-grained, fairly well sorted subangular clear quartz grains in the main, with loose fine clayey sand cement. Few dark grains evident. Friable carbonaceous streaks along bedding and some cross-bedding.

Core No. 8

Depth Cored: 3785 - 3803'
Interval Cored: 18' 0"
Total Recovery: 17' 0"
Angle of Hole: $1/2^{o}$
Apparent Dip of Core: Flat

Recovery	Description
1' 11"	SANDSTONE, grey, calcareous, medium-grained. Grains firmly calcareously cemented. Grains angular, some subangular, clear, light brown and pale grey quartz, fairly well sorted. Few black silty grains and few grains biotite. Tight. Contains small brecciated flecks (one large piece up to 4") of grey SHALE, with notable biotite content.
6' 11"	SHALE, grey, carrying plant fragments and much biotite on bedding planes (70%); finely interlaminated with SILTSTONE, grey, carrying biotite.
0' 4"	SANDSTONE, grey, calcareous, medium-grained, carrying few very thin laminae brown-grey SHALE.
7' 10"	SHALE, grey (70%) as above with thin interlaminated SILTSTONE and a few thin laminae 1/4" of calcareous medium-grained grey SANDSTONE in middle. Biotite and carbonaceous plant remains evident on bedding of shale.

Core No. 9

Depth Cored: 4197 - 4215'
Interval Cored: 18' 0"
Total Recovery: 18' 0"
Angle of Hole: $1/2^{o}$
Apparent Dip of Core: Flat

Recovery	Description
4' 8"	SANDSTONE, grey, grading very coarse-grained to medium-grained, hard, some porosity; mostly calcareous cement, some only slightly calcareous. Subrounded,

some subangular, clear quartz, light brown and grey translucent quartz, few lithic fragments. Few thin macerated, carbonaceous laminae. Cross-bedding to 20^o. Few scattered rounded quartz grains to 10 mm. A 1/2" GRIT laminae 1" from base.

3' 5"	SHALE, grey to dark grey, carbonaceous, with grey silty interbedded laminae, plant fragments and mica on bedding. A little slickensiding (40^o).
1' 8"	COAL, dull and bright - seam.
1' 8"	SHALE, dark brownish-grey, carbonaceous, few thin COAL laminae, plant remains.
2' 7"	SILTSTONE, grey, with COAL streaks.
2' 8"	SHALE, grey, brownish in part, with thin coaly laminae, plant remains. Some slickensiding evident on core at 40^o with calcite film.
1' 4"	SILTSTONE, grey, plant fragments on bedding.

Core No. 10

Depth Cored:	4540 - 4545'
Interval Cored:	5' 0"
Total Recovery:	0' 5"
Remarks on Recovery:	Inner barrel filled with cuttings and cavings
Angle of Hole:	-
Apparent Dip of Core:	Flat

Recovery	Description
0' 5"	SANDSTONE, grey, speckled appearance, medium-grained, subrounded and rounded, ill-sorted clear and smoky quartz, some milky, with some rock fragments and a little biotite. Tight calcareous cement. Carrying subrounded ill-sorted pebbles of light brown micaceous shale up to 3".

Core No. 11

Depth Cored:	4899 - 4916'
Interval Cored:	17' 0"
Total Recovery:	6' 3"
Remarks on Recovery:	Loss - a little at top at around 4904' but most of core pulled off or washed off coal at base.
Angle of Hole:	$1/4^o$
Apparent Dip of Core:	Flat - carbonaceous laminae on bedding dipping 0^o - 4^o.

Recovery	Description
1' 0"	SILTSTONE, grey, dirty appearance, subangular quartz, some feldspar and rock fragments, plant fragments, siliceous cement, few calcite grains, tending to fine-grained SANDSTONE in part and containing thin grey SHALE laminae.

0' 6"	SHALE, grey, carrying few plant fragments.
1' 3"	SILTSTONE, grey, tending to fine-grained SANDSTONE in part, subangular quartz, some feldspar, many rock fragments, some siliceous cement, calcite grains. Many plant fragments on bedding and a few SHALE laminae.
1' 4"	SHALE, grey, carrying few plant fragments, micromicaceous and silty in part.
0' 5"	SILTSTONE, grey, tending to fine-grained SANDSTONE, carrying macerated plant fragments on bedding.
0' 9"	SHALE, grey, carrying few plant fragments.
1' 0"	COAL, dark brown, dense, earthy; slickensiding evident on roof. Also few thin black coal laminae near top. Contains few wavy light brown SHALE lenses.

Core No. 12

Depth Cored:	5525 - 5543'
Interval Cored:	18' 0"
Total Recovery:	18' 0"
Angle of Hole:	$3/4^{o}$
Apparent Dip of Core:	Flat

Estimated Interval	Recovery	Description
5525-5530'	5' 0"	SHALE, grey, tends to MUDSTONE, dense, heavy, carrying many plant fragments and coaly streaks along and across bedding. A little jointing at various angles. Becomes brownish-grey towards base with polished slickenside at 50^{o}. Some mica on bedding planes.
5530-5532'	2' 0"	SILTSTONE, grey, speckled with fine carbonaceous material, waxy appearance under high power and oblique light. Dense, heavy. Some mica evident on bedding.
5532-5536'6"	4' 6"	SHALE, grey, more shaly and less dense than 5525-5530'. Fine silty laminae and plant remains evident. Grades to brownish-grey and to SILTSTONE near base.
5536'6"-5543'0"	6' 6"	SILTSTONE, grey, few darker grey carbonaceous siltstone laminae, dense, but possibly less so than above. Laminae showing swirl-bedding. Fossil reed or worm cast evident. Mica common on bedding planes. Grades to fine-grained SANDSTONE. Subangular clear quartz grains, siliceous cement; scarce lithic grains evident.

Core No. 13

Depth Cored:	5732-5740'
Interval Cored:	8' 0"
Total Recovery:	0' 8"
Remarks on Recovery:	Inner barrel choked with cuttings
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	Flat

Recovery	Description
0' 8"	SHALE, grey, heavy, dense, micaceous, silty, carrying few plant fragments.

Core No. 14

Depth Cored:	5740 - 5758'
Interval Cored:	18' 0"
Total Recovery:	20' 0"
Remarks on Recovery:	Total recovery plus 2' core picked up from previous core run (No. 13)
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	Flat

Estimated Interval	Recovery	Description
5738-5740'	2' 0"	SHALE, grey, silty towards base with coal streaks across bedding and a few plant fragments.
5740-5740'6"	0' 6"	COAL, black, shaly with few bright bands - several small blebs of brown shale.
5740' 6"-5741'11"	1' 5"	SHALE, light brownish-grey, silty in part, a few plant fragments.
5741'11"-5743' 4"	1' 5"	SILTSTONE, grey, shaly in part, few plant fragments.
5743' 4"-5747' 0"	3' 8"	SHALE, light brownish-grey, silty in parts, with scattered plant fragments.
5747' 0"-5750' 5"	3' 5"	SILTSTONE, grey, few fine carbonaceous laminae, tight siliceous cement, few thin layers of brownish-grey SHALE near top.
5750' 5"-5752' 8"	2' 3"	SHALE, grey, silty to sandy, showing fine laminations of carbonaceous material. Mica also on bedding. Plant fragments, macerated, cover whole bedding plane in the main. Micro cross-bedding up to 15^{o} evident. Dull gold spot fluorescence on some carbonaceous material on bedding.
5752' 8"-5758' 0"	5' 4"	SILTSTONE, grey, tending to very fine-grained SANDSTONE, with a few thin parts grading to definite fine-grained SANDSTONE. Grains subrounded some subangular mainly clear and light smoky quartz, few lithic grains strongly siliceously cemented. Tight. Carbonaceous and mica fragments thinly interlaminated on bedding. One subround 15 mm quartz pebble near base.

Core No. 15

Depth Cored:	5894-5899'
Interval Cored:	5' 0"
Total Recovery:	3' 6"
Remarks on Recovery:	Five feet only cored because of jamming of cuttings in barrel and slow progress.
Angle of Hole:	1^{o}
Apparent Dip of Core:	Flat, possibly to 3^{o}

Recovery	Description
3' 6"	SHALE, brownish-grey (50%) thinly interlaminated with SILTSTONE, grey (50%). Siltstone grades to thin laminae of hard fine-grained SANDSTONE near base. Macerated plant fragments on bedding planes. Reed or worm casts vertically through part of core. Basal 1" of core is strongly siliceously cemented, grains ill-sorted subrounded clear quartz, few lithic grains, some muscovite. Mica throughout the core.

Core No. 16

Depth Cored:	6067 - 6077'
Interval Cored:	10' 0"
Total Recovery:	8' 9"
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	Flat

Recovery	Description
1' 1"	COAL, dull, earthy, heavy, black, dark brown streak.
0' 6"	SILTSTONE, light grey tending to fine-grained SANDSTONE, subangular ill-sorted clear quartz, some white feldspar and lithic fragments, tight fine quartz sand matrix, muscovite on bedding; finely interlaminated with grey silty SHALE carrying many plant fragments and carbonaceous streaks.
0' 6"	SHALE, grey, silty, carrying mica and plant fragments.
2' 1"	SILTSTONE and thin grey SHALE, finely interlaminated as before.
1' 7"	SANDSTONE, grey, fine-grained, angular and subangular, poorly sorted, clear and light grey translucent quartz, trace feldspar, and lithic grains with fine sand matrix. Slight porosity and very short thin bedding cracks. Few thin streaks of grey shale.
1' 4"	SILTSTONE and thin grey SHALE, finely interlaminated as before.
1' 8"	SANDSTONE, grey, fine-grained as before, but with few fine carbonaceous streaks near top. Much muscovite on bedding. Hard fine sand and siliceous cement.

Core No. 17

Depth Cored:	6284-6294'
Interval Cored:	10' 0"
Total Recovery:	4' 9"
Remarks on Recovery:	Inner barrel partly choked with compressed cuttings
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	Flat, plant remains up to 4^{o}

Recovery	Description
4' 9"	SANDSTONE, brownish-grey, somewhat speckled appearance, medium-grained, grading from coarse to medium-grained in top 2'. Very poorly sorted with strong fine brown to grey sand matrix which has been siliceously cemented. Rounded, subrounded and some subangular grains - 60% clear, translucent light grey and pale brown quartz, 10% white grains, probably feldspar, 10% muscovite and light brown mica flakes, 20% black and dark brownish-grey lithic fragments. Quartz and mica grains reach 9 mm in parts. Possible slight porosity near top, but generally tight. Slight spot pale gold fluorescence in parts. Two cuts with CCl_4 from 6289.5' gave very pale dirty yellow ring fluorescence. Plant remains as thin black coal slabs on bedding, throughout the core.

Core No. 18

Depth Cored:	6472-6476'
Interval Cored:	4' 0"
Total Recovery:	1' 9"
Remarks on Recovery:	Bit balled up - very slow penetration
Angle of Hole:	$3/4^{o}$
Apparent Dip of Core:	Flat, possibly up to 3^{o}

Recovery	Description
1' 1"	SILTSTONE, grey, tending to very fine-grained SANDSTONE in part with a few thin darker grey laminae of SHALE. Subrounded and subangular clear quartz, some lithic grains, with fine firm sand matrix. Muscovite evident on the bedding, few plant fragments. Small fault in core at 6473'6". Fault throws 1 1/2" and dips 50^{o}.
0' 8"	SHALE, grey, silty micro-micaceous, plant fragments evident with few thin SILTSTONE laminae grading from unit above.

Core No. 19

Depth Cored:	6703-6719'
Interval Cored:	16' 0"
Total Recovery:	13' 3"
Angle of Hole:	1^{o}
Apparent Dip of Core:	Flat

Recovery	Description
4' 2"	SANDSTONE, light grey, white in part, mainly fine-grained but grading to very fine-grained or even to SILTSTONE; up to thin bands of medium-grained SANDSTONE. A few thin grey SHALE laminae carrying macerated carbonaceous material and much muscovite on bedding. White sections carry banded pale blue-grey material. Grains rounded to subrounded predominantly clear quartz, some pale grey translucent quartz, few darker (brown and black) lithic grains, a little muscovite with fine dense light grey to white matrix, which has medium hardness but envelops grain outline. Rock is very tight and dense, contains a few reed casts infilled with medium-grained sand. A few near vertical coal streaks and vertical jointing evident with white non-calcareous mineral on joint face.
0' 10"	SILTSTONE, grey to blue-grey in part, tight, dense, interlaminated with thin grey SHALE which carried macerated plant remains and muscovite. Reed casts and carbonaceous streaks apparent.
0' 4"	SANDSTONE, light grey, fine to medium-grained content as for above.
0' 3"	SILTSTONE, grey with some interlaminated grey SHALE as above.
0' 7"	SANDSTONE, light grey, mainly medium-grained, some fine-grained, a little very flat cross-bedding, content as for above.
1' 0"	SHALE, grey, and interlaminated light grey SILTSTONE.
0' 8"	SANDSTONE, light grey, medium-grained content as above but less dense matrix, few grey SHALE laminae, in part carbonaceous near top and bottom, reed casts evident.
5' 5"	SHALE, light grey to white near top changing to pale blue-grey with depth, with some grey shale laminae throughout (40%) interlaminated mainly with light grey dense SILTSTONE (40%), but with few thin lenses (20%) of fine-grained and medium-grained light grey SANDSTONE. Some macerated plant fragments and muscovite on bedding and many reed casts evident. Complete thin plant fossils making up a coarse web-like pattern in shale sections. Tight and dense throughout. Dull gold fluorescence common on carbonaceous material, a few specks of blue fluorescence in sandier material throughout core - no cut with CCl_4.

Core No. 20

Depth Cored:	6767-6776'
Interval Cored:	9' 0"
Total Recovery:	8' 6"
Angle of Hole:	1^o
Apparent Dip of Core:	Flat - (thin laminae vary from flat up to 5^o)

Recovery	Description
1' 1"	SHALE, grey, silty, muscovite; a thin plant fragment on bedding.
1' 1"	SILTSTONE, light grey to grey, tends to fine-grained SANDSTONE in part, dense, tight.

6' 4"	SANDSTONE, grey to light grey, very coarse-grained, is a GRIT, in the main quartzose. Fair to poor sorting of subrounded (40%), rounded (10%), subangular (50%) loosely cemented grains. Some fine frosty quartz sand matrix in part only. Grains are predominantly clear quartz (70%), pale grey translucent quartz (20%), grey translucent quartz (mainly coarser grains) (5%), light brown translucent quartz and smaller black lithic grains (5%). In the main, grain size varies from 1 mm down to 0.2 mm. Fair porosity evident, some permeability. Finer grained bands (texture very fine-grained SANDSTONE or SILTSTONE) between 6770'4" - 6770'5", 6772' 1 1/2" - 6772' 2" and 6773'11" - 6774'0". Grading medium to coarse-grained SANDSTONE between 6772'2" and 6774'5". Finely CONGLOMERATIC between 6771'6" and 6772' 1 1/2"; pebbles rounded, mainly clear and milky quartz up to 12 mm. Few isolated milky quartz pebbles throughout up to 20 mm. Bright blue strong fluorescence throughout, cutting strong pale blue with CCl_4. Isolated spots yellow fluorescence. Kerosene odour from core.

Core No. 21

Depth Cored:	7004 - 7019'
Interval Cored:	15' 0"
Total Recovery:	13' 1"
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	Flat maybe 2^{o} - some cross-bedding up to 20^{o}

Estimated Interval	Recovery	Description
7004'0"-7004'9"	0' 1"	SILTSTONE, grey, quartzose, tight, hard, with few larger subrounded clear quartz grains embedded in quartz grains matrix. Biotite and muscovite plentiful on bedding as are carbonaceous flecks. Bright blue and bright yellow speck fluorescence (20%) on bedding - no cut fluorescence with CCl_4. Yellow fluorescence is on carbonaceous material.
7004'9"-7016'0"	10' 8"	SANDSTONE, light grey, coarse-grained, quartzose, glistening, ill-sorted angular, mostly subangular, some subrounded clear quartz grains; some frosted and some light grey quartz. Few isolated black lithic grains, very small amount of muscovite. Matrix is very fine quartz sand. Some slight porosity in coarser patches. Tight. Few thin sections of fine to medium-grained quartzose SANDSTONE at 7005'2"-7005'4" and 7006'10"-7006'11". Coarser grained towards base. In part sandstone tends to fine CONGLOMERATE with rounded clear, grey and milky quartz pebbles up to 10 mm. Tends to GRIT elsewhere in basal section with more subrounded grains, less matrix, and good porosity and permeability. Quartz is 99% of rock. Very poor pale blue spot fluorescence in these parts - no cut with CCl_4. Cross-bedding evident up to 20^{o}.
7016'0"-7016'9"	0' 8"	SILTSTONE, light grey, almost white, in part quartzose, with thin grey laminae carrying carbonaceous material and mica on bedding,

which is flat to 1^{o}. Gold fluorescence on carbonaceous material - no cut fluorescence with CCl_4.

7016'9"-7019'0"	1' 8"	SANDSTONE, light grey, coarser grained quartzose grading from medium-grained in top few inches to GRIT near base - few coal blebs and streaks near base giving bright yellow fluorescence. Content as for 7004' 9" - 7016'0".

Core No. 22

Depth Cored:	7214-7222'
Interval Cored:	8' 0"
Total Recovery:	2' 7"
Angle of Hole:	$3/4^{o}$
Apparent Dip of Core:	Flat

Recovery	Description
0' 4"	SILTSTONE, grey, quartzose, but with thin grey shale and dark grey carbonaceous shale banding the stratum.
2' 3"	SHALE, grey to dark grey, silty at top grading to true shale at base. Many plant fossils on and across bedding. Shale tends to become truly carbonaceous near base. Dense, heavy.

Core No. 23

Depth Cored:	7395-7406'
Interval Cored:	11' 0"
Total Recovery:	6' 4"
Angle of Hole:	$3/4^{o}$
Apparent Dip of Core:	Flat on sandstone break but shale laminae near base dip 5^{o} - 8^{o}. Dip probably still flat.

Recovery	Description
0' 1"	SHALE, grey, waxy brownish-grey lustre on break.
4' 9"	SANDSTONE, light greenish-grey, mainly medium-grained but grading to coarse-grained in part, very poorly sorted with few coarse grains throughout. Grains are rounded and subrounded, finer grains subangular. Tight, hard. Matrix is in part very fine quartz sand but mainly white clay? tightly cemented. Grains clear quartz (50%), light grey translucent quartz (10%), greenish-grey translucent quartz (20%), grey and blue-grey chert (5%), dark grey to black lithic grains (15%). Trace of muscovite and white feldspar. Fair blue fluorescence. Very pale blue fluorescence on cutting with CCl_4. Slight kerosene odour. Few thin coaly and carbonaceous streaks throughout section, particularly towards base.
1' 6"	SANDSTONE, light grey to light greenish-grey, medium-grained grading to fine-grained, content as for above but with thin laminae (up to 1/4") of grey SHALE. Some pale blue fluorescence.

Core No. 24

Depth Cored:	7646-7650'6"
Interval Cored:	4' 6"
Total Recovery:	4' 6"
Remarks on Recovery:	Total recovery, bottom 17" of core fractured and jammed in barrel, core bit relatively unworn when pulled.
Angle of Hole:	$3/4^{o}$
Apparent Dip of Core:	Rough colour bandings vary in dip from 3^{o} to 22^{o}, not necessarily indicative of dip of bedding planes.

Estimated Interval	Recovery	Description
7646'-7647'10"	1' 10"	SHALE, dark reddish-brown, mottled with bluish-grey to greenish-grey streaks, micro-micaceous, scattered very finely macerated carbonaceous matter, dense, brittle, silky, slightly slickensided texture on fracture surfaces probably due to rotation in core barrel.
7647'10"-7649'1"	1' 3"	SHALE, slightly silty, mustard coloured with some dark reddish-brown streaks and mottling, scattered finely macerated carbonaceous matter. Rough colour banding with apparent dips of 3^{o} to 22^{o} does not necessarily reflect inclination of bedding plane.
7649'1"-7650'6"	1' 5"	SHALE, dark reddish-brown with very minor bluish-grey mottling, dense, brittle; silky slickensided texture on fracture surfaces probably due to rotation and jamming in core barrel.

Core No. 25

Depth Cored:	7909-7915'
Interval Cored:	6' 0"
Total Recovery:	6' 0"
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	Appears flat from lineation of pebble beds

Estimated Interval	Recovery	Description
7909'0"-7915'0"	6' 0"	Rythmic sequence of green tuffaceous pebble-cobble conglomerate and tuffaceous quartz grit with scattered cobbles and pebbles. CONGLOMERATE: clasts up to 2 1/2" diameter of hard volcanic greenstone (ash), black chert and orange-brown chert and quartz in a matrix of quartz grit with interstices of green to white ash. GRIT: angular to subrounded, medium-grained to granule size, pale green, yellow, orange and clear quartz with minor black chert in a matrix of white to green ash.

POROSITY: trace.

Sample cuts in CCl_4 with blue to yellowish-blue fluorescence.

Core No. 26

Depth Cored:	8200-8212'
Interval Cored:	12' 0"
Total Recovery:	12'0"
Angle of Hole:	$1/2^o$
Apparent Dip:	Attitudes on planes defining abrupt changes in grain size and on pebble beds vary from 0 to 6^o; average 3^o

Estimated Interval	Recovery	Description
8200'-8212'0"	12' 0"	Rythmic gradational sequence of green tuffaceous pebble-cobble conglomerate and tuffaceous quartz grit and sandstone with scattered pebbles and cobbles. CONGLOMERATE: Clasts up to 2" in diameter of milky-white and orange-brown quartz, black and brown chert and hard volcanic greenstone (ash) in a matrix of quartz grit with interstices of white to green ash. GRIT AND SANDSTONE: angular to subrounded, orange, pale yellow and green, white and clear quartz in a matrix of green ash. Grit beds grade into medium to very coarse-grained sandstone of similar composition to grit, finely macerated carbonaceous debris scattered in the finer grades of sandstone.

Core No. 27

Depth Cored:	8602-8613'
Interval Cored:	11' 0"
Total Recovery:	9' 2"
Remarks on Recovery:	Core ground off top in finer sediment
Angle of Hole:	$3/4^o$
Apparent Dip of Core:	Flat

Estimated Interval	Recovery	Description
8602'0"-8604'0"	0' 3"	SANDSTONE, grey, slightly greenish tint, very fine-grained, grains ill-sorted (but not as poorly as before) subrounded, some subangular, mainly grey quartz and chert (60%), some clear quartz (10%) and light brown quartz (10%). Biotite evident (5%), light coloured lithic grains (5%), possibly more, tight hard tuffaceous matrix (minor).

8604-8613'	8' 11"	SANDSTONE, light greenish-grey, mainly coarse-grained, but grading through medium to a little fine-grained in thin bands. Also grades to thin bands of GRIT with PEBBLE bands every 6" to 12". Pebbles mainly subrounded and rounded some subangular measuring 10 mm but a few up to 20 mm. Sandstone grains are rounded (10%), subrounded (50%), subangular (30%), angular (10%), and are ill-sorted. Matrix is white to whitish-grey tuffaceous material, tight. Grains are greenish-grey chert (35%), light grey and some clear quartz (20%), yellowish quartz and/or chert (20%), brown chert (5%), white tuffaceous grains (10%), black chert (5%), fibrous light grey mineral, mica and other accessories (5%). Pebbles are made up of the same minerals as the grains in the same percentages, though there may be somewhat more brown chert. Though matrix is tuffaceous, cementing is hard and tight.

<u>Core No. 28</u>

Depth Cored:	8915 - 8926'
Interval Cored:	11' 0"
Total Recovery:	11' 0"
Angle of Hole:	1^{o}
Apparent Dip of Core:	Flat

Estimated Interval	Recovery	Description
8915'0"-8926'0"	11' 0"	CONGLOMERATE, greenish-grey, sandy, medium-sized pebbles, grades to slightly pebbly GRIT in 1'6" band at top and several 6" bands at base. Pebbles mainly subrounded, many subangular, few rounded and consisting mostly of greenish-grey chert and reddish-brown chert with some black chert, light grey soft tuffaceous shale, few sandstone and light grey quartz pebbles. Few of the pebbles are fractured, all are very poorly sorted despite rounding. Pebble size evenly distributed from 8 mm to 30 mm. Matrix is sandstone, with fair sorting, medium to coarse-grained, composition same as pebbles. GRIT bands are coarse to very coarse-grained sandstone with mainly subrounded, few rounded, some subangular grains of multicoloured chert (70%), mainly greenish-grey and light grey, light yellow, clear and milky quartz (30%). Matrix is white to light grey ashy clay. The whole core is tight with no obvious porosity.

<u>Core No. 29.</u>

Depth Cored:	9167-9179'
Interval Cored:	12' 0"
Total Recovery:	4' 7"
Remarks on Recovery:	Some ground off top; most pulled off bottom
Angle of Hole:	$3/4^{o}$
Apparent Dip of Core:	Flat

Estimated Interval	Recovery	Description
9167'0"-9169'0"	1' 3"	SANDSTONE, greenish-grey to bluish-grey, very coarse-grained, CONGLOMERATIC in part, in part tends to GRIT. Pebbles up to 10 mm, subrounded to rounded, blue-grey chert, some grey quartz, minor amounts of brown and other coloured cherts. Sandstone is made up of fairly well-sorted, rounded, subrounded, and a few subangular grains with some light grey crumbly tuffaceous ? matrix. Grains are made up of green-grey chert (40%), light grey and clear quartz (30%), black chert (10%), yellow quartz (10%), brown chert (5%), mica (5%); tight, hard with odd spots of poor light blue fluorescence. Grades into beds below.
9169'0"-9179'0"	3' 4"	CONGLOMERATE, greenish to bluish-grey, medium to coarse-sized pebbles, grades from bed above. Pebbles are greenish-grey chert, brown and black chert, few white quartz, some light grey to grey soft shale and sandstone. Pebbles mainly subrounded, few rounded and subangular, ill-sorted, measuring from 10 mm up to 75 mm (3"). Matrix is more ill-sorted sand than the bed above, but same composition of grains, subrounded and subangular, with more light grey tuffaceous matrix. Tight, hard drilling. Poor light blue fluorescence throughout matrix. Fluorescence dissipates after 10 minutes of fresh exposure.

Core No. 30

Depth Cored:	9450-9454'
Interval Cored:	4' 0"
Total Recovery:	0' 9"
Remarks on Recovery:	Inner barrel plugged by large pieces of chocolate shale cavings before coring commenced. 2' of plugged cavings recovered. Core ground away throughout the true 0'9" recovered which was in thin sections. All cones lost. Core recovered however indicated true nature of strata without change from previous cores.
Angle of Hole:	1^o
Apparent Dip of Core:	Flat

Recovery	Description
0' 9"	CONGLOMERATE, greenish-grey, fine-sized pebbles, grading down to GRIT; pebbles are very poorly sorted, mainly subrounded, some rounded, some subangular. Size varying from 14 mm down to 3 mm. Pebbles consist as before of greenish-grey, light brown, light grey, some brown and black chert, also clear, milky translucent light grey, grey, light yellow quartz, also few light grey shale and sandstone pebbles. Muscovite evident with light grey soft clay, probably tuffaceous, coating matrix of gritty coarse-grained, grading down to fine-grained, ill-sorted sand, which forms the matrix. Tight, but showing some poor light blue fluorescence in matrix on fresh exposure.

Core No. 31

Depth Cored:	9655-9657'
Interval Cored:	2' 0"
Total Recovery:	1' 8"
Remarks on Recovery:	Core bit would not drill ahead after coring 2'
Angle of Hole:	$3/4^{\circ}$
Apparent Dip of Core:	Random distribution of conglomerate clasts precludes any determination of dip.

Recovery	Description
1' 8"	VOLCANIC CONGLOMERATE: Rounded pebbles and cobbles, up to 4 1/2" in diameter, of predominantly, hard, white and green, acidic ash with minor clasts of brown and black chert, and blue-grey to grey, silicified, silty shale in a matrix of white to green ash. Clasts readily break out of matrix when hit with a hammer.

Core No. 32

Depth Cored:	9938-9952'
Interval Cored:	14' 0"
Total Recovery:	12' 11"
Remarks on Recovery:	Drill pipe parted when coming out of hole with core barrel; core barrel in hole 199 hours prior to recovery.
Angle of Hole:	-
Apparent Dip of Core:	Flat

Recovery	Description
0' 4"	Pebbly SANDSTONE, hard, tight; subangular to subrounded, coarse to very coarse-grained, clear quartz in a matrix of white ash. Scattered granules and pebbles up to 1/2" in diameter of green ash, bluish-grey siliceous shale, and shaly coal. Strong gas odour, cuts in CCl_4 with blue fluorescence with a yellow cast; bleeding traces of gas when pulled from core barrel.
0' 6"	SANDSTONE, hard, tight; medium to coarse-grained, angular to subrounded, clear to pale bluish-grey quartz in a matrix of white ash with finely disseminated carbonaceous matter. Strong gas odour; good cut in CCl_4 with blue fluorescence with a yellow cast. Bleeding gas when pulled from core barrel.
2' 11"	VOLCANIC CONGLOMERATE, hard, tight; subrounded to rounded clasts up to 1" in diameter of white and green ash, black chert, shaly coal, and blue-grey, hard siliceous siltstone in a matrix of white to green ash with scattered angular to rounded clear, vitreous, quartz grains. Matrix effervesces in spots with cold, dilute HCl. Strong gas odour; cuts in CCl_4 with blue fluorescence with a yellow cast.
1' 0"	Interbanded olive-green ASH and shaly, black COAL. Ash becomes more predominant toward top of interval at expense of coal. Gas odour; trace cut in CCl_4 with very pale bluish fluorescence.

0' 8"	COAL, black, shaly.
0' 9"	ASH, green-grey to slightly olive-green, scattered plant fragments and coal streaks. Faint gas odour on a fresh break, disappears shortly afterwards.
6' 9"	ASH, white to greenish-white with traces finely divided carbonaceous debris and reddish-brown mica. No gas odour.

Core No. 33

Depth Cored:	9950-9960' (9950-9952' barytes and cavings at bottom of hole after conditioning - true bottom at commencement of coring was 9952')
Interval Cored:	10'
Total Recovery:	6' 8"
Remarks on Recovery:	A little core ground away on top; some shaly coal lost in middle.
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	Flat up to 5^{o}

Recovery	Description
0' 4"	TUFF, light grey, dense, hard, sub-conchoidal fracture, light grey amorphous siliceous indurated ground mass with few metallic grey mica flakes and 5% of brown calcareous grains.
0' 7"	TUFF, light grey to grey, soft, dense, few small brown grains in light grey to grey groundmass, some bedding evident.
0' 8"	TUFF, light grey, dense, hard, some black carbonaceous staining on bedding.
0' 5"	TUFF, light grey to grey, waxy lustre, fissile, soft amorphous carbonaceous streaks and plant remains.
0' 6"	TUFF, light grey, silty, calcareous, rewashed tuff material, very flat false bedding evident.
0' 5"	TUFF, grey to light grey, waxy lustre soft but fissile, few carbonaceous streaks and plant remains.
1' 0"	COAL, black shaly, few bright bands; few very thin light grey tuff bands also.
0' 5"	TUFF, grey to light grey, waxy lustre, soft but fissile, few carbonaceous streaks and plant remains.
0' 3"	COAL, black, dull, very shaly.
0' 5"	TUFF, grey, waxy lustre, soft but fissile, with more carbonaceous material.
0' 1"	COAL, black, dull, very shaly.
0' 2"	TUFF, grey, soft, somewhat fissile, shaly.

0' 2"	COAL, black, dull, shaly.
0' 2"	TUFF, grey, soft, fissile waxy lustre, few soft carbonaceous fragments and plant remains.
0' 4"	COAL, black, dull, few thin bright bands.
0' 5"	TUFF, grey, carrying carbonaceous fragments, blocky texture, chert-like.
0' 4"	COAL, black, very shaly and thin bands of grey TUFF.

Core No. 34

Depth Cored:	9960-9966'
Interval Cored:	6' 0"
Total Recovery:	2' 3"
Remarks on Recovery:	Soft shaly coal and tuff ground away on top of core
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	Flat - distinct bedding at base is 3^{o}

Recovery	Description
0' 2"	TUFF, grey, shaly, soft, with carbonaceous streaks and plant remains.
1' 4"	TUFF, light grey, dense, hard siliceous, light grey amorphous, with biotite and brown flaky mineral also. Calcareous reaction with dilute HCl in spots on few grains. Few carbonaceous streaks and plant remains on bedding and across bedding.
0' 9"	TUFF, grey, soft but fissile, waxy lustre with few laminae of light grey harder tuff throughout. Few carbonaceous streaks and plant remains.

Core No. 35

Depth Cored:	9966-9971'
Interval Cored:	5' 0"
Total Recovery:	2' 9"
Remarks on Recovery:	Core ground away at top
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	Flat up to 3^{o}

Recovery	Description
0' 6"	TUFF, grey, shaly bedding, grey groundmass, few mica flakes, sub-conchoidal fracture in part.
0' 6"	TUFF, light grey, dense, hard, siliceous groundmass, sub-conchoidal fracture, few mica flakes.
1' 9"	TUFF, light grey, tending to grey in few shaly bands near top, soft with flat swirl rewash bedding in part, dense and harder towards base. Few mica flakes set in groundmass, some sub-conchoidal fracture.

Core No 36

Depth Cored:	9971-9981'
Interval Cored:	10' 0"
Total Recovery:	8' 8"
Remarks on Recovery:	Some core ground away at top and bottom
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	Flat - consistent laminae dips of 4^{o} throughout

Recovery	Description
1' 8"	TUFF, white to whitish-grey, dense, hard, white groundmass with very few very small dark grains. Siliceous ?, sub-conchoidal fracture, chert-like. Vertical jointing evident with crystalline calcite on plane. Few plant streaks near base.
6' 4"	TUFF, light grey, softer silty fine rewashed tuffaceous material carrying some plant fragments near top and in thin bands sparsely scattered throughout. 1" of black COALY tuff, 4" from top. Grades into greyer shalier more fissile material towards base. Near base: flat cross-bedded carbonaceous laminae.
0' 8"	Limestone, oolitic, chertified, light grey and darker grey cross-bedded laminae of chert, strongly calcareous, small hairline fractures, with small bubbles of clear to very light green oil seeping along fractures. Bright blue fluorescence along fractures.

Core No. 37

Depth Cored:	10,040-10,042'
Interval Cored:	2' 0"
Total Recovery:	Nil
Remarks on Recovery:	Draghead bit would not make hole in siliceous rock.
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	-

Core No. 38

Depth Cored:	10,042-10,046'
Interval Cored:	4' 0"
Total Recovery:	5' 0"
Remarks on Recovery:	1' 0" picked up from previous core run
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	Flat to 3^{o}

Recovery	Description
5' 0"	TUFF, light grey and grey, shaly, mainly siliceous and hard, few soft brownish-grey laminae near top, few sandy rewashed layers near base, (tending to fine-grained quartz sandstone). Carbonaceous remains throughout, some coaly in thin laminae, but mostly scattered, giving speckled effect. Flat swirl-bedding evident, but bedding dip flat. Thin vertical jointing at top with crystalline calcite on planes. Some biotite evident in sandier parts.

Core No. 39

Depth Cored:	10,113-10,126'
Interval Cored:	13' 0"
Total Recovery:	12' 9"
Remarks on Recovery:	Small amount lost in coal.
Angle of Hole:	1/2^{o}
Apparent Dip of Core:	Flat to 3^{o}

Estimated Interval	Recovery	Description
10,113'0"-10,113'5"	0' 5"	SANDSTONE, brownish-grey, tuffaceous, grading medium-grained through to very coarse-grained, ill-sorted angular and subangular clear quartz, few black grains set in hard light brown siliceous matrix. Smears of softer brown waxy tuffaceous very thin laminae. Plant remains and scattered macerated carbonaceous fragments. Several layers of coarse clear quartz grains, subangular, to 3 mm.
10,113'5"-10,116'7"	2'11"	COAL, black, mainly shaly, few very thin bright bands and few thin brown tuffaceous SHALE bands.
10,116'7"-10,121'2"	4' 7"	SHALE, light grey, light brownish-grey, light bluish-grey, tuffaceous, slightly sandy in thin bands. Some carbonaceous thin laminae and scattered macerated remains throughout. Carbonaceous shale bands at 10,119'8" and 10,120'8". Some fine sub-vertical jointing.
10,121'2"-10,121'3"	0' 1"	COAL, black, shaly.
10,121'3"-10,123'2"	1'11"	SHALE, light bluish-grey, tuffaceous, scattered macerated carbonaceous remains.
10,123'2"-10,126'0"	2'10"	SANDSTONE, light grey to grey, speckled appearance in part, with few very thin laminae of light grey tuffaceous SHALE scattered throughout. Sandstone is medium-grained, grading to coarse-grained in a few parts. Ill-sorted subangular clear light grey translucent quartz. Few grey chert grains and dark grey lithic grains. Tight siliceous cement throughout. Bottom 9" gives fleeting kerosene odour on new fracture and gives bright blue fluorescence; few yellow specks which will not cut.

Core No. 40

Depth Cored:	10,126-10,133'
Interval Cored:	7' 0"
Total Recovery:	5' 0"
Remarks on Recovery:	Core lost in coal bands and brittle tuffaceous shale
Angle of Hole:	1/2^{o}
Apparent Dip of Core:	Flat to 4^{o}

Recovery	Description
2' 1"	SANDSTONE, grey, medium-grained, grading through to fine-grained in small part, ill-sorted clear quartz, some translucent light grey quartz (70%), angular and subangular, dark grey subrounded lithic grains (15%), creamy-white rounded tuffaceous shale grains (15%). Hard, dense, tight. Matrix is hard and siliceous darkening in colour and matrix increasing in amount towards base. Trace biotite. Fluorescence (bright) throughout grading from blue at top through white and yellow to gold at bottom - no cut. Some very fine vertical jointing.
0' 6"	SHALE, light brownish-grey, soft, and brittle, thinly interlaminated, tuffaceous, few macerated carbonaceous remains.
0' 4"	SHALE, black, carbonaceous, matrix is tuffaceous material, thin band of grey tuffaceous shale evident.
1' 3"	SHALE, grey tuffaceous, with thin coaly bands near base and scattered carbonaceous plant remains throughout. Softer shale near base.
0' 3"	COAL, very shaly, fine vertical joint, with blue and yellow fluorescence on joint. Small grey tuffaceous shale lens evident.
0' 6"	SHALE, grey, tuffaceous, carrying much scattered carbonaceous material. One fine vertical joint showing trace yellow and blue fluorescence.
0' 1"	COAL, black, shaly.

Core No. 41

Depth Cored:	11,086-11,097'
Interval Cored:	11' 0"
Total Recovery:	10' 0"
Remarks on Recovery:	Some core ground away at top and in mid-section
Angle of Hole:	$1/2^{o}$
Apparent Dip of Core:	Flat to 4^{o}

Estimated Interval	Recovery	Description
11,086'0"-11,097'0"	10'0"	SHALE, dark grey to grey, silty, slightly calcareous, dense, tending to true SILTSTONE, in small part. Carrying definite leaf fossils at 11,093'5" and very fine carbonaceous flecks in part but carrying marine macro-fossils throughout. Shells are calcitic, mainly Brachiopoda. Mollusca are also present. The Brachiopoda are represented by many small types with inflated pedicle and brachial valves as well as by larger types mainly Spirifer (<u>Microspirifer</u>?). Mollusca are represented by many Pelecypoda (<u>Mytilus</u>?) and one probable valve of <u>Pecten</u>. Several crinoid stems evident. Most of fossils are arranged on bedding layers.

Core No. 42

Depth Cored:	11,578-11,589'
Interval Cored:	11' 0"
Total Recovery:	10'11"
Angle of Hole:	1/2°
Apparent Dip of Core:	Flat to 3°

Estimated Interval	Recovery	Description
11,578'0"-11,581'1"	3'1"	SILTSTONE, grey, calcareous, and SHALE, dark grey, slightly calcareous, thinly interbedded, crowded with Brachiopoda. The fossil remains are light brown, calcitic, and are composed dominantly of Productids which appear to be mainly Terrakea. The shells have an inflated pedicle valve well ornamented with large pedicle beaks, together with a flat to slightly convex brachial valve. Some small types of Productid also apparent. The shells are arranged along the bedding; several thin lenses of coarse-grained tuffaceous material.
11,581'1"-11,581'11"	0'10"	SANDSTONE, light grey to grey, tuffaceous medium-grained, ill-sorted, subangular, some angular, some rounded grains. Grains white, soft, tuffaceous shale (70%), light grey and grey, soft tuffaceous shale (20%), blue and dark bluish-grey soft shale or tuffaceous mineral (10%). Traces of small muscovite flakes and clear quartz. Matrix is light grey, soft tuffaceous silt and occupies 50% of rock. Few rounded, soft, white and grey tuffaceous pebbles up to 6 mm. Soft but tight.
11,581'11"-11,582'3"	0'4"	SILTSTONE, grey with dark grey shaly laminae, slightly calcareous, and carrying fragmented brachiopod remains and some plant fragments, as for 11,578'0"-11,581'1".
11,582'3"-11,583'10"	1'7"	SANDSTONE, light grey to grey, grading medium to coarse-grained, as for 11,581'1"-11,581'11", but more angular, coarser, few more small pebbles and few carbonaceous flecks.
11,583'10"-11,585'8"	1'10"	SILTSTONE, grey with thin dark grey shaly laminae, slightly calcareous, carrying macerated calcitic shelly fragments, as for 11,578'0"-11,581'1".
11,585'8"-11,588'11"	3'3"	SANDSTONE, grey, some light grey, grading medium to coarse-grained in part, as for 11,582'3"-11,583'10", but with few more grey grains, definite finely crystalline pyrites in matrix, and more thin flecks of carbonaceous material. Soft but tight. Few thin silty bands with isolated macerated shelly remains.

Core No. 43

Depth Cored: 11,769-11,783'
Interval Cored: 14' 0"
Total Recovery: 5' 0"
Angle of Hole: $1/2^{o}$
Apparent Dip of Core: -

Estimated Interval	Recovery	Description
11,769'0"-11,783'0"	5'0"	ANDESITE, purplish-grey, weathered and badly fractured. Core decreases in weathering with depth. Groundmass is purplish-grey, small white fibrous amygdules and dark brown and white phenocrysts showing weathering. Fractures are at all angles. Soft flaky white calcite and red hematite on the fracture planes.

Additional Data on File

Descriptions of sidewall cores, written by D.J. McGarry, Union Oil Development Corporation, have been filed with the Bureau of Mineral Resources, Canberra, and are available for reference.

PETROLOGY OF CORES

by

B.R. Houston*

Core No. 20, 6769'11"-6770'

Microslides GSQ 2032, 2033

Macro: A light grey, massive, well-sorted, medium-grained porous quartz sandstone with a strong smell of kerosene.

Micro:

Texture: Sedimentary; well-sorted; maximum grain size 0.7 mm; average grain size about 0.42 mm.

Constituents: Quartz: grains subrounded to rounded; average about 0.42 mm; average sphericity about 0.7 mm; estimated at about 50%.

Feldspar: grains, similar in form to the quartz; estimated at 2%.

Lithic fragments: grains, similar in form to the quartz; estimated at 10-15%; dominantly quartzite (probably almost 10%) with some very altered argillaceous material (probably micaceous mudstone).

Matrix: estimated at 25-30%; fine unidentifiable crystals, probably of one (or more) of the clay materials. It resembles kaolinite but the refractive index is rather low.

Pore Space: estimated at 5-10% but difficult to assess as the friable sandstone tends to break up during thin section preparation.

Name: ARGILLACEOUS QUARTZ SANDSTONE

Core No. 24, 7646'4"-7646'6"

Microslide GSQ 2038

Macro: A massive, fine-grained greenish-grey sediment; iron-stained, slickensides common.

Micro:

Texture: Clastic

Grains: Quartz (dominant) and feldspar: estimated at about 10%; 0.02 to 0.08 mm, dominantly about 0.04 mm, angular to subrounded, sphericity variable low to high.

Lithic fragments: similar to above, less than 5%.

Biotite: altered, clastic, less than 2%.

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*Geological Survey of Queensland, 1960.

Matrix: Dense, cloudy, argillaceous.

Note: Owing to the nature of the matrix even the phenoclasts are difficult to distinguish. In one part of the thin section there is a criss-crossing network of fine opaque material possibly carbonaceous.

Name: Sandy MUDSTONE

Core No. 24, 7646'4"-7646'6"

Microslide GSQ 2039

Macro: A greenish-grey and dark-red mottled, fine-grained massive sediment with abundant slickensiding.

Micro:

Texture: Clastic

This rock was extremely difficult to section satisfactorily but appears to contain feldspar grains, minor amounts of quartz grains and some altered biotite. Grains of opaques (probably iron oxides) are common. These phenocrysts are mostly 0.01 to 0.04 mm and appear to comprise less than 10% of the rock.

The argillaceous matrix is very heavily iron-stained (limonite and hematite).

Name: Sandy MUDSTONE

Core No. 24, 7647'11"-7648'1"

Microslide GSQ 2040

Macro: A massive khaki-coloured fine-grained sediment.

Micro:

Texture: Clastic

Grains: Estimated at 10-20%.

Quartz: angular to subrounded, sphericity variable; 0.1 to 0.01 mm, dominantly about 0.04 mm.

Feldspar: similar in form to quartz and possibly more abundant; extremely altered.

Lithic fragments: one grain of quartzite, otherwise fine, argillaceous; difficult to distinguish from feldspar, but appear to be the most abundant phenoclasts.

Mica: altered, clastic flakes.

Opaques: not abundant.

Matrix: yellow-brown, cloudy, dense argillaceous, appears to have been derived from the alteration of material rich in biotite.

Note: Owing to the density of the matrix individual grains are very difficult to distinguish.

Name: Sandy MUDSTONE

Note: In none of these rocks is there any evidence of metamorphism.

Core No. 26, 8200-8200'2"

Microslide GSQ 2041

Macro: A massive greenish-grey sand rock.

Micro:

Texture: Clastic, well-sorted, grain size 0.5 to 0.2 mm; grains mostly subrounded, sphericity moderate.

Grains: Quartz: strained; about 5%.

Feldspar: dominantly plagioclase; about 5%.

Lithic fragments: about 75%; include several types of fine-grained argillaceous material which could not be identified.

Mica: clastic, sericite (predominantly) and biotite; about 15% - the relative amounts of sericite and biotite cannot be determined. A most unusual feature is the form of the sericite which is extremely fine and occurs between the grains as a matrix bonding them together.

Origin: Sedimentary

Alteration: No evidence of metamorphism

Parent Material: Sediments and volcanics

Name: SUBGREYWACKE (Pettijohn, 1957)

Core No. 27, 8603'8"-8603'10"

Microslide GSQ 2042

Macro: As Core No. 26 but with rounded pebbles up to 8 mm.

Micro:

Texture: Clastic, well-sorted, grain size 0.5 to 0.3 mm; grains mostly subrounded, sphericity moderate.

Grains: Quartz: strained, estimated at 5%.

Feldspar: dominantly plagioclase; about 5%.

Lithic fragments: about 80%.

Quartzite material: several types of unidentifiable, fine-grained rock, estimated at 78%.

Mica: clastic, altered; about 2%.

Cement; calcite, about 5%.

Matrix: argillaceous, difficult to distinguish but estimated at 5%.

Origin: Sedimentary

Alteration: No evidence of metamorphism

Parent Material: Sediments and volcanics

Name: SUBGREYWACKE (Pettijohn, 1957)

Core No. 32, 9938'

Microslide GSQ 2204

Macro: A massive, light grey sediment. Half of the specimen is of coarse (up to 2 mm) material with an abundance of argillaceous fragments and the rest is finer (up to 1 mm).

Micro:

Texture: Clastic, poorly-sorted, grain size 0.1 to 0.3 mm; grains angular to subrounded; sphericity high to low.

Grains: Quartz: mostly fairly angular, somewhat embayed; approximately 5%.

Feldspar: including perthite and plagioclase in the ratio of about 2:1; about 30%.

Lithic fragments: dominantly, if not exclusively, volcanic; the fragments are difficult to identify due to the heavy iron-staining of most of them. Some fluidal rhyolite can be identified; about 30%.

Matrix: argillaceous and siliceous, very fine-grained. There appears to have been mobilization of silica and, possibly, devitrification of glassy material.

Origin: Pyroclastic

Parent Material: Volcanic, predominantly rhyolitic

Name: TUFF

Note: There is no evidence of relic structures, such as oolites.

Core No. 34, 9964'10"-9965'

Microslide GSQ 2279

Macro: A massive, light pinkish-grey, fine-grained rock with irregular patches of hard black material.

Micro:

Texture: Clastic

Phenoclasts: Quartz: subangular to angular fragments of low sphericity; the long axes are about 0.2 to 0.05 mm; a few grains of feldspar (plagioclase) occur also, together about 5%.

Organic? remains: fragments, commonly about 0.2 mm across are abundant, some are calcareous, but more than half of them have been replaced by opaline silica; the shape is remarkably constant; the central circular area displays both radiating and concentric structure; about 20-25%.

Biotite: Altered flakes, less than 2%.

Matrix: argillaceous: about 70%.

Origin: Sedimentary

Note: The organic ? fragments are not shards of a tuff since they were originally calcareous.

Name: Organic ? MUDSTONE

Core No. 42, 11,586'1"-11,586'2"

Microslides GSQ 2259, 2260

Four Mile Map: Dalby

Macro: A massive, light grey, clastic rock with an abundance of decomposed feldspar crystals, up to 2 mm, and dark grey rock fragments to 1 cm in length.

Micro:

Texture: Clastic

Phenoclasts: Lithic material: grain size 0.5 to 2 mm, dominantly about 1 mm, sphericity high to very low, grains mostly subrounded, estimated 75%.

(a) Fluidal intermediate and basic volcanic material (basalt and andesite) with an average grain size of about 0.06 mm.

(b) Microcrystalline volcanic material, rich in feldspar.

The two types are in approximately equal proportions.

Feldspar (dominantly plagioclase) : broken laths, 0.04 to 0.5 mm, about 10%.

Matrix: Ashy: similar in composition to the lithic fragments and difficult to distinguish from them; about 10%.

Alteration: ? Secondary calcite makes up about 5% of rock.

Name: LITHIC TUFF

Core No. 43, 11,783'

Microslide GSQ 2261

Macro:	A massive, fine-grained, dark pinkish-grey rock traversed by fine calcite veins; joint surfaces are covered with ironstained calcite; crystals up to 2 mm of hematite pseudomorphous after magnetite are present.
Micro:	
Texture:	Porphyritic, groundmass intersertal, fluidal.
Phenocrysts:	Plagioclase (oligoclase): 0.5 to 1 mm; subhedral, lath-shaped, crystals mostly fresh. Opaques: prismatic crystals (probably pseudomorphous) of hematite and ? magnetite, about 0.5 mm in length.
Groundmass:	Plagioclase (oligoclase): subhedra (about 0.03 mm) to microcrystalline. The orientation of the crystals shows that the groundmass must have flowed around the phenocrysts. Chlorite: greenish-brown, fibrous; growing out from irregular areas (about 0.06 mm) of ? devitrified glass. The interstices are filled with cryptocrystalline and microcrystalline chlorite, opaques and feldspathic material.
Alteration:	Minor calcitization has taken place.
Origin:	Volcanic, probably extrusive
Name:	ANDESITE

CORE ANALYSES

by

Union Oil Company of California Core Laboratory, Brea, California, U.S.A.

CONVENTIONAL 3" DIAMETER CORE

Depth (feet)	Porosity (%)	Permeability (md.) Air	Oil-Water Ratio	% total Oil	pores Water	full of Tot. Liq.
6771	17.8	204	0.32	15	47	62
6772	18.2	120	0.15	9	56	65
6774	8.4	0	0.01	1	72	73
6776	17.4	101	0.17	9	53	62

SCHLUMBERGER SIDEWALL SAMPLES

Depth (feet)	Porosity (%)	Permeability (md.) Air	Oil-Water Ratio	% total Oil	pores Water	full of Tot. Liq.
7940	26.7	34	0.04	3	68	71
8026	24.8	13	0	0	79	79
8030	26.1	180	0.07	5	74	79
8111	25.6	34	0.11	10	87	97
8148	23.0	24	0.04	3	76	79
8150	23.2	178	0	0	96	96
8182	30.0	1895	0.05	4	86	90
8292	25.8	306	0.04	4	91	95
8331	26.9	56	0	0	96	96
8355	26.5	16	0.03	3	83	86
8394	-	-	0.03	-	-	-
8408	26.6	25	0.04	2	64	66
8436	28.1	201	0	0	83	83
8536	27.5	17	0	0	87	87
8555	-	-	0.13	-	-	-
8671	15.7	118	0	0	95	95
8725	29.1	37	0.03	2	83	85
8768	28.1	-	0.07	5	68	73
9070	28.4	468	0.04	4	84	88

CORE ANALYSES

by

Bureau of Mineral Resources, Canberra.

Ruska Field Porometer and Permeameter

Saturating and flowing media : air and nitrogen.

Sample		Porosity (%)			Permeability (md.)	
Core No.	Depth	Vert.	Hor.	Avg.	Vert.	Hor.
1	562' - 562' 5"	34.7	37.2	36.0	< 0.3	11.5
1	572' 7" - 572' 11"	12.7	5.7	9.2	< 0.3	< 0.3
1	572' 8" - 573'	30.7	32.6	31.6	51.4	62.2
3	1584' 8" - 1585'	25.3	26.7	26.0	< 0.3	32.0
5	2430' 8" - 2431'	26.0	27.2	26.6	< 0.3	5.0
6	2780' 9" - 2781' 1"	23.5	25.0	24.2	22.4	5.2
8	3785' 6" - 3785' 11"	19.0	14.3	16.6	< 0.3	26.3
9	4197' 2" - 4197' 6"	12.8	10.5	11.7	< 0.3	< 0.3
9	4214' - 4214' 4"	15.8	17.3	16.6	< 0.3	< 0.3
10	4540' - 4540' 8"	-	15.0	-	-	< 0.3
13	5732' - 5732' 5"	3.5	9.3	5.9	< 0.3	< 0.3
14	5757' 7" - 5758'	16.7	16.9	16.8	< 0.3	< 0.3
16	6072' 8" - 6073'	21.6	20.2	20.9	4.7	249.5
20	6769' 9" - 6769' 11"	17.2	19.9	18.5	10.3	64.6

CORE ANALYSES (Cont'd)

Sample		Density (gm per cm^3)						Porosity (%)			Permeability (md.)		Residual (% of pore space)	
		Grain			Bulk									
Core No.	Depth	Vert.	Hor.	Avg.	Vert.	Hor.	Avg.	Vert.	Hor.	Avg.	Vert.	Hor.	Water	Oil
32	9941' - 9941' 5"	2.47	2.53	2.50				4.6	4.5	4.5	<0.3	<0.3	42	5
32	9949' 3" - 9949' 7"	2.78	2.55	2.67				18.0	13.2	15.6	<0.3	<0.3	28	Nil
32	9947' - 9947' 5"	2.61	2.61	2.61				12.8	13.5	13.1	<0.3	<0.3	74	Nil
32	9951' 2" - 9951' 6"	2.63	2.52	2.57				14.3	10.5	12.4	<0.3	<0.3	93	Nil
29	9172' 2" - 9172' 5"	2.76	2.82	2.79				11.1	14.8	12.9	<0.3	<0.3	28	Nil
31	9656' 7" - 9657'	2.74	2.58	2.66				7.6	7.7	7.7	<0.3	<0.3	4	Nil
33	9952' 5" - 9952' 9"	2.49	2.49	2.49	2.41	2.38	2.40	2.8	4.7	3.7	<0.3	<0.3	48	54
33	9958' 3" - 9958' 9"	2.99	3.13	3.06	2.14	2.18	2.14	28.8	30.7	29.7	<0.3	<0.3	36	Nil
34	9963' 6" - 9963' 10"	2.43	2.47	2.45	2.26	2.31	2.29	6.8	6.3	6.5	<0.3	<0.3	33	38
34	9965' 7" - 9966'	2.92	2.76	2.84	2.42	2.35	2.38	16.7	15.4	16.0	<0.3	<0.3	48	Nil
35	9968' 3" - 9968' 6"	2.94	2.89	2.92	2.43	2.41	2.42	17.3	16.3	16.8	<0.3	<0.3	35	Nil
35	9970' 2" - 9970' 8"	2.50	2.52	2.51	2.31	2.35	2.33	7.5	7.0	7.3	<0.3	<0.3	56	9
36	9973' 4" - 9973' 7"	2.46	2.49	2.48	2.34	2.40	2.37	4.5	4.9	4.7	<0.3	<0.3	44	Nil
36	9976' - 9976' 4"	2.82	2.80	2.81	2.29	2.29	2.29	18.6	18.2	18.4	<0.3	<0.3	43	Nil
36	9978' 9" - 9979' 1"	2.84	2.87	2.86	2.32	2.28	2.30	18.3	20.5	19.4	<0.3	<0.3	38	Nil
36	9979' 8" - 9980'	2.52	2.53	2.52	2.36	2.40	2.38	6.2	5.2	5.7	<0.3	<0.3	106	4

REPORT ON PERMEABILITY VALUES OF SIDEWALL CORES

by

G.H. Smith*

An inspection of sidewall cores was made using the binocular microscope. Based upon this inspection, the cores were grouped in two categories.

Cores from one group contained badly-shattered, large mineral grains and pebbles, or similar large, clastic particles which had been separated from the embedding matrix. In either case, fissures and fractures were present which appeared to be related to impact of the coreholder on these large particles. These particles, in some cases, represented more than one-half of the cross-sectional area of the core.

The second category contained cores comprised of smaller, or fine, well-bedded particles which showed no displacement or disturbance. A comparison of the cores in these two categories with their air permeability values was made after the segregation. The list below shows that in all cases the fractured cores had permeability over 100 md, and in all cases the fine-grained undisturbed cores were between 13 and 56 md.

Sidewall Cores from Cabawin No. 1 Well

Undisturbed, fine-grained		Coarse, altered	
Depth (feet)	Permeability (md.)	Depth (feet)	Permeability (md.)
7940	34	8030	180
8026	13		
8111	34		
8148	24	8150	178
8331	56	8182	1895
8355	16	8292	306
8408	25		
8536	17	8436	201
8725	37	8671	118
		9070	468

The above comparison strongly suggests that the values for core analysis of these cores is a function of the texture of the cores when the formation is sampled by sidewalling. The interpretation of the resultant core analysis should be carefully considered. Reference to this precaution is made in the API RP 40-"Recommended Practice for Core-Analysis Procedure." Experimental measurements in this laboratory have demonstrated rearrangement in some sidewall cores.

* Union Oil Company of California.

An inspection of the listed data shows no major lithological break is indicated. The electric log and micrologs show this interval is composed of many thin beds and in some cases the impact was transmitted to larger grains present in beds containing larger particles.

ANALYSIS OF SAMPLES FROM BUNDAMBA FORMATION AND ANDESITE

by

R.A. Gees*

	Weight	Bulk Vol.	Bulk Density	Velocity	Porosity	Permeability
	(gr.)	(ml)		(ft/sec.)	(%)	(md.)
Bundamba Sandstone	34.34	11.68	2.94	9098.53	15.9	50
(7010')				9631.41ø		
Andesite (11,783')	46.77	13.59	3.44	13542.79	7.0	0

ø saturated with 3% NaCl solution.

The following is a short petrographic description of the andesite (11,783'). The main constituents are: plagioclase (andesine, An36% (±)) both as phenocrysts and in the matrix, pseudomorphs of bastite, a form of antigorite, and clinochlore after an undetermined pyroxene; sphene, oxidic iron ore, and carbonate. The texture is porphyritic, with plagioclase and the bastite pseudomorphs, and some iron ore as phenocrysts. The matrix is pilotaxitic, felt-like, in places vesicular, with the vesicles filled with chloritic material. It consists mainly of plagioclase, some sphene, and hydrothermal alteration products, such as chloritic material. These alteration products, as well as the carbonate, are probably the result of a late or post magmatic hydrothermal metamorphism usually called propylitization.

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* Union Oil Company of California.

SUSCEPTIBILITY DETERMINATIONS ON SAMPLES FROM BUNDAMBA FORMATION AND ANDESITE

by

John Sloat *

The following determinations for susceptibilities have been made:

(i) Bundamba Sandstone - Depth 7010 feet. K = 10×10^{-6} cgs units.

(ii) Andesite (3 samples) - Depth 11,783 feet. K = $740\text{-}845 \times 10^{-6}$ cgs units; average 785×10^{-6} cgs units.

Susceptibility measurements for the andesite were made on three cylindrical core samples, each 1" by 3" long. The susceptibility meter was new and results should be accurate.

The laboratory analysis of the andesite gives a density of 3.44 (page 114). This value must refer to the grain density, unless some error was made in the measurements. Only peridotite and other extremely basic rocks have bulk densities as high as 3. I find the density of the andesite to be 2.55, which agrees with published values for the density of andesite. The laboratory figure for the density of the Bundamba Sandstone - 2.94 - is probably also too high; the figure should probably be about 2.35, although this was not checked.

It was surprising to find that the porosity of the Bundamba was only 16 percent and the permeability only 50 millidarcys. The laboratory measurement of velocity for the andesite - 13,543 ft/sec. - does not agree with that in the well survey. It seems likely that the three andesite samples represent the hardest part of the section.

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* Union Oil Company of California

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COAL ANALYSES

by

Queensland Government Chemical Laboratory, Brisbane

Sample No. GS 1004/60, from interval 9620-9630 feet

Air-dried sample		Proximate Analysis (%)
Moisture at 105°C		1.6
Volatile matter		25.3
Fixed Carbon		55.7
Ash		17.4
		100.0
B. Th. U. per lb.		12,100
Coke Classification	Cw	

Ultimate Analysis	(%)	Dry ash-free basis (%)
Carbon	68.07	84.04
Hydrogen	4.31	5.32
Nitrogen	0.83	1.03
Sulphur	0.41	0.50
Oxygen	7.38	9.11

Sample No. GS 1017/60, from intervals 9870-9872', 9877-9880', 9880-9890'

Air-dried sample		Proximate Analysis (%)
Moisture at 105°C		1.1
Volatile matter		23.0
Fixed Carbon		50.4
Ash		25.5
		100.0
Coke Classification	Cm	

Ultimate Analysis	(%)	Dry ash-free basis (%)
Carbon	59.26	80.74
Hydrogen	3.75	5.11
Nitrogen	0.98	1.33
Sulphur	0.55	0.75
Oxygen	8.86	12.07

COAL ANALYSES OF NINETEEN SAMPLES FROM 1280 TO 10,710 FEET

Depth (feet)	Sample	Proximate Analysis (British Standard Method) Moisture at 105°C (%)	Volatile matter (%)	Fixed carbon (%)	Ash (%)	F.C. / F.C. + V. (%)
1280- 90) 1310- 20)	1071/60	8.6	32.3	40.5	18.6	55.6
1756- 66) 1766- 76) 1790-1800)	1072/60	7.5	32.0	41.2	19.3	56.3
2190-2200	1073/60	7.1	32.1	43.7	17.1	57.7
3170- 80	1074/60	10.5	34.2	38.2	17.1	52.8
4310- 20	1075/60	4.6	41.5	42.7	11.2	50.7
4730- 40	1076/60	2.8	46.2	41.0	10.0	47.0
5300- 10	1077/60	2.6	42.5	36.1	18.8	45.9
5370- 80	1078/60	9.3	32.8	43.1	14.8	56.8
6020- 30	1079/60	4.1	39.4	44.2	12.3	52.9
6450- 60	1080/60	2.2	44.0	43.9	9.9	49.9
6970- 80	1081/60	3.1	43.5	43.0	10.4	49.7
7510- 20	1082/60	3.5	41.2	45.6	9.7	52.5
7870- 80) 7880- 90)	1083/60	3.9	40.6	41.1	14.4	50.3
9620- 30	1004/60	1.6	25.3	55.7	17.4	68.8
9870- 72) 9877- 80) 9880- 90)	1017/60	1.1	23.0	50.4	25.5	68.7
10260- 70	449/61	1.8	26.0	60.5	11.7	69.9
10570- 90	450/61	1.6	24.9	49.4	24.1	66.5
10590- 620	451/61	1.9	23.6	51.1	23.4	68.4
10700- 10	452/61	1.8	24.5	48.1	25.6	66.2

APPENDIX 3

WELL LOGGING

UNION-KERN-A.O.G. CABAWIN NO. 1

CONTENTS

VELOCITY SURVEY REPORT

by

I.C. Wylie and H.D. Gray*

Introduction

A survey was conducted on 6th January, 1961 to determine the subsurface velocities at the Cabawin No. 1 Well.

At the time of the survey the well had been drilled to a depth of 9950 feet (K.B.). The velocity survey itself was conducted to a depth of 9930 feet. Apart from a 591-foot surface pipe, no casing had been set in the well at the time of the survey.

A pressure type well seismometer belonging to Austral Geo Prospectors was used for the survey. Schlumberger provided the cable and the use of their vehicle to raise and lower the seismometer in the well.

Field Procedure

A total of 15 holes was drilled. To the east, five holes were located 600 feet from the well and three at 100 feet (refer Fig. 6). All shots were fired at holes 600 feet from the well. Routine seismic reflection work in the vicinity of the well, carried out previously to ascertain the extent of the weathering, provided up-hole velocities which determined the depths to which the shot holes were drilled; 150 feet deep on the east side of the well, 160 feet deep on the west.

The well seismometer was checked to ensure that it was working correctly and that it was sufficiently water resistant before lowering into the well. The recording unit's working order was also thoroughly checked.

Owing to noise caused by falling water, the reference seismometer had to be located 35 feet to the east of the well.

Well depths were measured with a Schlumberger cable with reference to the kelly bushing, the elevation of which was 968 feet above sea level.

A total of twenty-one horizons was tested at depths ranging from 600 feet to 9930 feet below kelly bushing. At certain horizons shots were recorded from both sides of the well. These horizons were chosen because of their geologic importance, for example marker horizons, and stratigraphic boundaries. Difficulty encountered in the first attempts to lower the well seismometer below the bottom of the surface casing was overcome by gradually raising and lowering the tool.

The traces of the well survey records were arranged as follows:

Trace 1 and 2	Time break and up-hole time at the shot-point
Trace 3	Reference seismometer at the well
Trace 4	Well seismometer - Low gain

*United Geophysical Company S.A.

Trace 5	Well seismometer	- Medium gain
Trace 6	Well seismometer	- High gain

No reflection spread was shot with the survey as the S.P. 51, line UJ, which had been shot previously, passed within a hundred feet of the well.

Up-hole velocity surveys (refer Figs. 7, 8) were recorded at shot-points 4 and 12 (refer Fig. 6).

Interpretation and Results

Thirty-one velocity records have been included in this report. (These velocity records are held at the Bureau of Mineral Resources, Canberra).

The first breaks were trigonometrically corrected to the vertical to allow the plotting of the time (T_o) - depth (Z) curve. This was done by utilizing the formula provided on the computation sheet. The observed first break times were also corrected to an elevation datum of 800 feet above sea level using a velocity of 6666 feet per second.

During the computational process it was found that shots from opposite sides of the well gave slightly different observed travel times for the same well seismometer depth. This can be explained by an examination of the up-hole survey plots (Figs. 7, 8) where a high velocity layer (8250 feet per second) is shown below 158 feet in UWS-4A, whereas at UWS-12A the velocity down to 185 feet is only 6800 feet per second. Thus, well seismometer times from the western holes are longer than those from the eastern holes.

In computing the interval velocities it was considered that the interval velocities would not be seriously affected by averaging the corrected travel times (Tgd). Similarly the average of the "average velocities" was used for the final graph. For the time-depth curve all points were plotted.

The velocity distribution, $V_z = 7850 + 0.73z$, was determined by using Miller's method (Seismic Prospecting for Oil by Dix, p. 115); Slotnick, Brooks, and Redding's method, and checked by the formula $T = \frac{2}{k} \log_e (1 + \frac{kz}{Vo})$, where Vo= 7850 and k= 0.73.

The quality of "first breaks" was good to fair and the picks used for the interpretation were on the whole considered reliable.

VELOCITY SURVEY

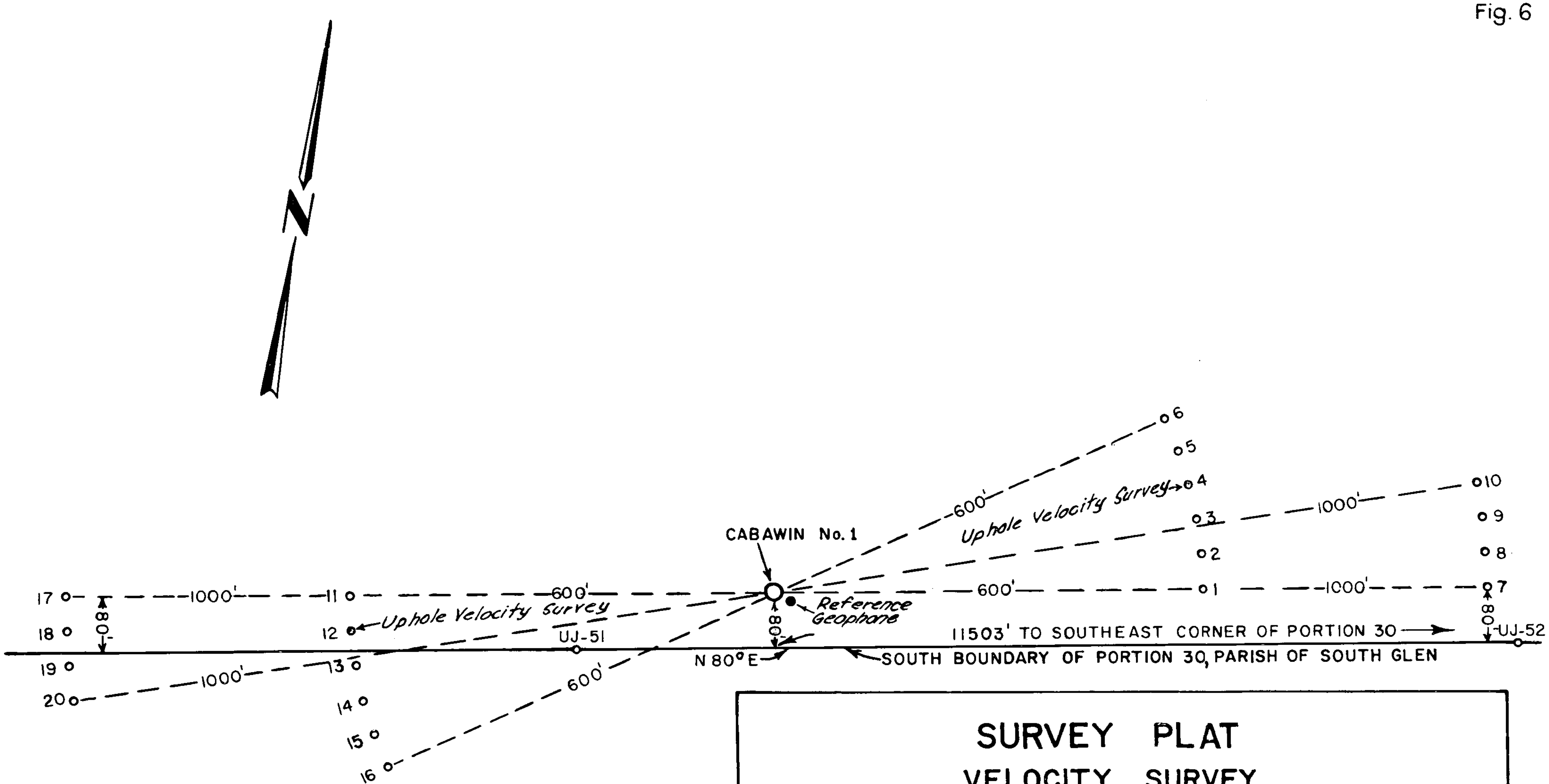
by

S. Kahanoff*

A survey was conducted on 6th January, 1961, to determine the subsurface velocities at Union-Kern-A.O.G. Cabawin No. 1. The survey was conducted by United Geophysical Company, Party 119, which was based at Miles, Queensland. The well at the time had been drilled to a depth of 9950 feet below kelly bushing and though it was anticipated that the drilling would be continued it was necessary to make the survey prior to running the 9 5/8" casing.

* Union Oil Development Corporation.

Fig. 6



SURVEY PLAT

VELOCITY SURVEY

FOR

UNION-KERN - A.O.G. CABAWIN No. 1.

BY

PARTY 119, UNITED GEOPHYSICAL COMPANY S.A.

U.G.C. SHOT POINTS o

SCALE: 1 inch = 200 feet.

January 6th. 1961.

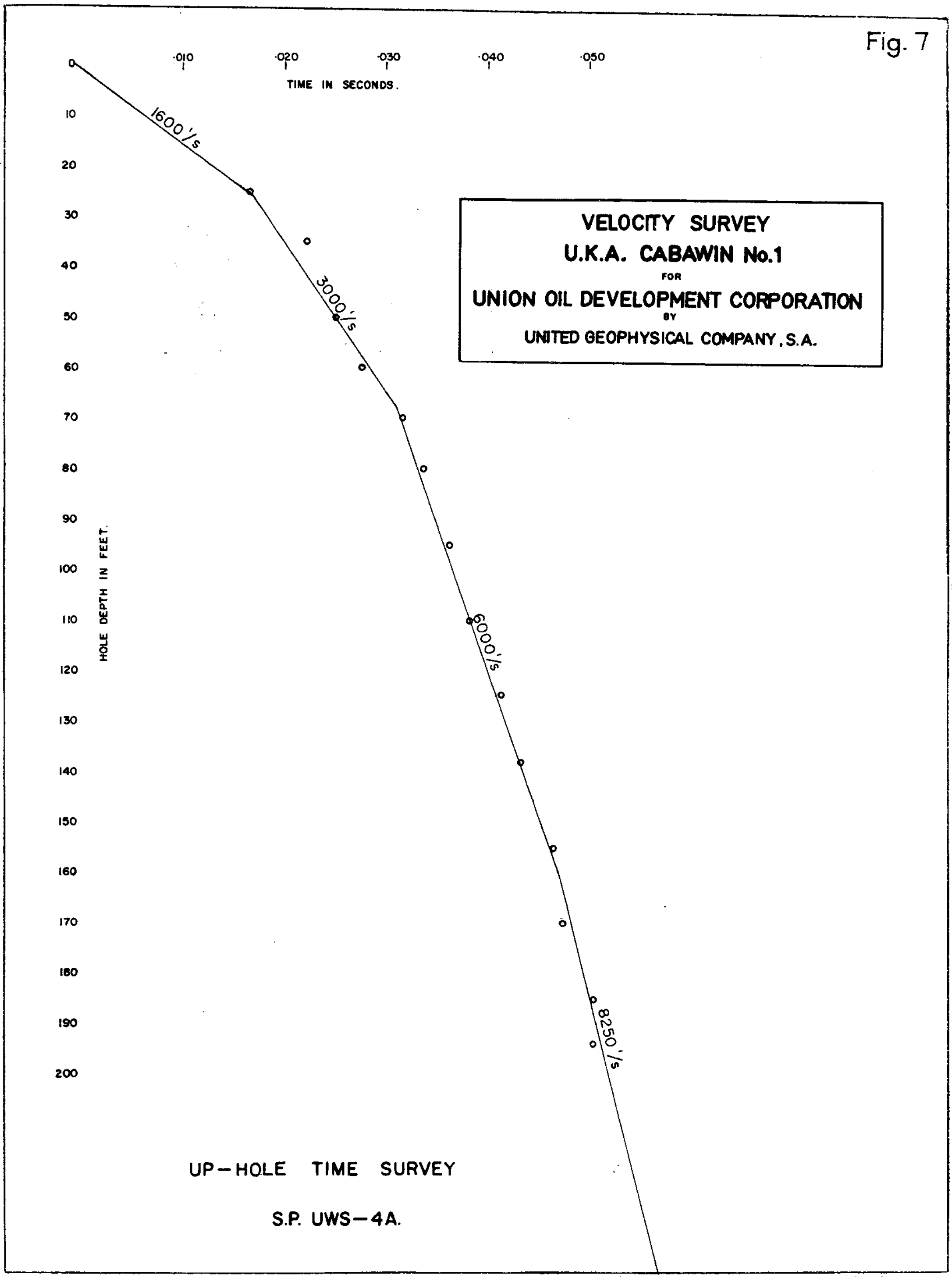


Fig. 7
·010
·020
·030
·040
·050
TIME IN SECONDS.
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
HOLE DEPTH IN FEET.
1600'/s
3000'/s
6000'/s
8250'/s
VELOCITY SURVEY
U.K.A. CABAWIN No.1
FOR
UNION OIL DEVELOPMENT CORPORATION
BY
UNITED GEOPHYSICAL COMPANY, S.A.
UP-HOLE TIME SURVEY
S.P. UWS-4A.

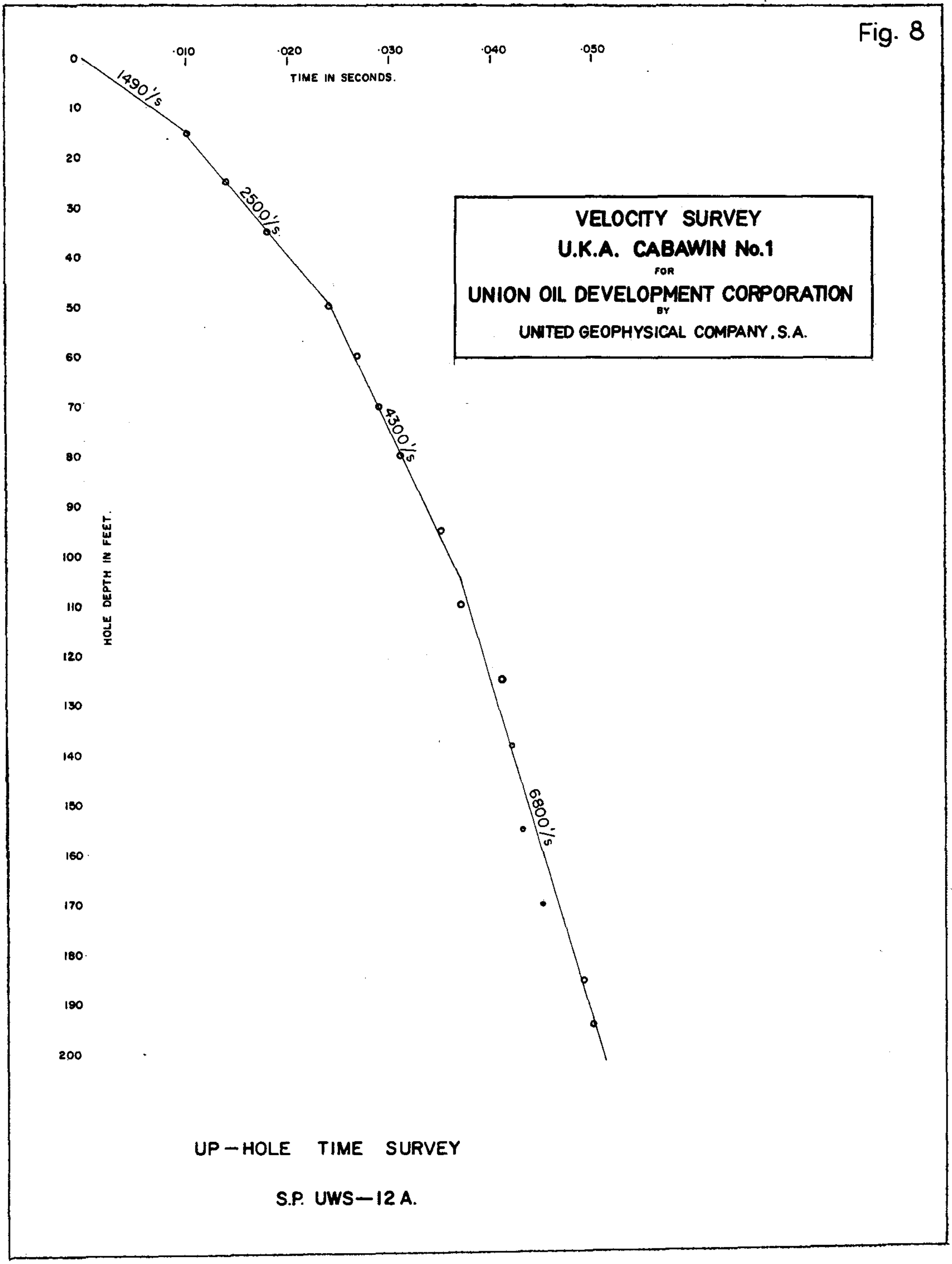


Fig. 8
TIME IN SECONDS.
·010
·020
·030
·040
·050
HOLE DEPTH IN FEET.
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
1490'/s
2500'/s
4300'/s
6800'/s
VELOCITY SURVEY
U.K.A. CABAWIN No.1
FOR
UNION OIL DEVELOPMENT CORPORATION
BY
UNITED GEOPHYSICAL COMPANY, S.A.
UP—HOLE TIME SURVEY
S.P. UWS—12 A.

Fig. 9

(1)

COMPANY	WELL	LOCATION
UNION - KERN - A.O.G.	CABAWIN NO. 1.	80' NORTH and 11503' WEST of SOUTH EAST CORNER OF PORTION 30, PARISH OF SOUTH GLEN.

COORDINATES / SECTION / TOWNSHIP / RANGE / COUNTY / AREA OR FIELD

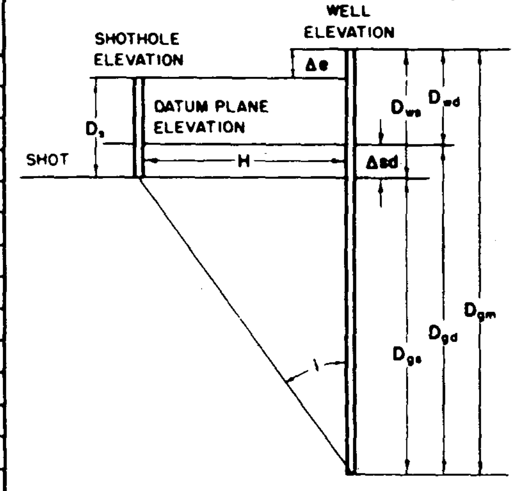
SHOT HOLE	ELEVATION	DISTANCE	SHOT HOLE	ELEVATION	DISTANCE	SHOT HOLE	ELEVATION	DISTANCE	SHOT HOLE	ELEVATION	DISTANCE	SHOT HOLE	ELEVATION	DISTANCE	SHOT HOLE	ELEVATION	DISTANCE
1	949	600	5	949	600	9	948	1000	11	950	600	15	951	600	19	952	1000
2	949	600	6	949	600	10	947	1000	12	951	600	16	950	600	20	952	1000
3	949	600	7	948	1000				13	951	600	17	952	1000			
4	949	600	8	948	1000				14	951	600	18	952	1000			

ELEVATION

KELLY BUSHING 968
ROTARY TABLE 967
DERRICK FLOOR 966
GROUND 951

REF. SEIS	RECORD NUMBER	SHOT HOLE NUMBER	D_{gm}	t_{us}	t_c	D_s	Δe	D_{ws}	Δsd	D_{gs}	H	Cot i	Cos i	T	GRADE	T_{gs}	$\Delta sd / V_i$	T_{gd}	D_{gd}	V_o AVERAGE VELOCITY
.107	C	4	600	.041		130	+19	149	-19	451	600	.7517	.6009	.092	G	.0553	-.003	.0523	432	8263
.116	D	14	600	.043		126	+17	143	-25	457	600	.7617	.6059	.095	G	.0576	-.004	.0536	432	8066
113	C	14	1100	.044		129	+17	146	-22	954	600	1.5900	.8465	.141	F	.1194	-.003	.1164	932	8010
.109	B	4	1600	.041		133	+19	152	-16	1448	600	2.4133	.9238	.186	P	.1718	-.002	.1698	1432	8432
.108	A	4	2000	.043		143	+19	162	- 6	1838	600	3.0633	.9506	.225	G	.2139	-.001	.2129	1832	8605
.113	B	14	2000	.043		132	+17	149	-19	1851	600	3.0850	.9513	.231	G	.2198	-.003	.2168	1832	8452
.112	A	14	2400	.047		150	+17	167	- 1	2233	600	3.7217	.9658	.269	G	.2598	0	.2598	2232	8592
.112	B	3	2865	.032		130	+19	149	-19	2716	600	4.5267	.9765	.320	P	.3125	-.003	.3095	2697	8715
.112	F	15	2865	.051		135	+17	152	-16	2713	600	4.5217	.9764	.316	P	.3085	-.002	.3065	2697	8798
.106	A	3	3345	.043		144	+19	163	- 5	3182	600	5.3033	.9827	.358	F	.3518	-.001	.3508	3177	9056
.113	E	15	3830	.052		140	+17	157	-11	3673	600	6.1217	.9869	.407	G	.4017	-.002	.3997	3662	9163
.106	B	2	4200	.042		145	+19	164	- 4	4036	600	6.7267	.9891	.437	P	.4322	-.001	.4312	4032	9350
.114	D	15	4200	.053		146	+17	163	- 5	4037	600	6.7283	.9891	.442	G	.4372	-.001	.4362	4032	9244
.113	C	15	4800	.052		147	+17	164	- 4	4636	600	7.7267	.9917	.498	F	.4939	-.001	.4929	4632	9398
.107	A	2	5442	.045		145	+19	164	-4	5278	600	8.7967	.9936	.556	F	.5524	-.001	.5514	5274	9564
.113	B	15	5442	.053		150	+17	167	- 1	5275	600	8.7917	.9936	.559	F	.5554	0	.5554	5274	9496
.115	I	16	5870	.047		129	+18	147	-21	5723	600	9.5383	.9946	.595	G	.5918	-.003	.5888	5702	9684
.116	H	16	6280	.047		131	+18	149	-19	6131	600	10.2183	.9952	.629	F	.6260	-.003	.6230	6112	9811
.115	G	16	6700	.047		132	+18	150	-18	6550	600	10.9167	.9958	.663	G	.6602	-.003	.6572	6532	9939
.105	I	1	6700	.040		134	+19	153	-15	6547	600	10.9117	.9958	.659	P	.6562	-.002	.6542	6532	9984
.105	J	1	6700	.041		118	+19	137	-31	6563	600	10.9383	.9959	.663	F	.6603	-.005	.6553	6532	9968
.107	H	1	7200	.044		131	+19	150	-18	7050	600	11.7500	.9964	.694	F	.6915	-.003	.6885	7032	10214
.106	F	1	7640	.043		135	+19	154	-14	7486	600	12.4767	.9968	.725	G	.7227	-.002	.7207	7472	10368
.115	F	16	7640	.049		134	+18	152	-16	7488	600	12.4800	.9968	.729	P	.7267	-.002	.7247	7472	10311
.107	G	1	8140	.044		137	+19	156	-12	7984	600	13.3067	.9972	.763	G	.7609	-.002	.7589	7972	10505
.115	D	16	8140	.049		140	+18	158	-10	7982	600	13.3033	.9972	.763	P	.7609	-.001	.7599	7972	10491
.108	E	1	8420	.043		135	+19	154	-14	8266	600	13.7767	.9974	.781	P	.7790	-.002	.7770	8252	10621
.106	C	1	8880	.045		141	+19	160	- 8	8720	600	14.5333	.9976	.814	F	.8121	-.001	.8111	8712	10742
.113	C	16	8880	.049		146	+18	164	- 4	8716	600	14.5267	.9976	.819	P	.8170	-.001	.8160	8712	10676
.105	D	1	9400	.043		137	+19	156	-12	9244	600	15.4067	.9979	.851	F	.8492	-.002	.8472	9232	10897
.107	B	1	9930	.043		141	+19	160	- 8	9770	600	16.2833	.9981	.889	P	.8873	-.001	.8863	9762	11014

ΔD_{gd}	ΔT_{gd}	V_i INTERVAL VELOCITY
432	.0529	8163
500	.0634	7881
500	.0535	9351
400	.0450	8891
400	.0450	8899
465	.0482	9639
480	.0428	11215
485	.0489	9926
370	.0340	10870
600	.0592	10144
642	.0606	10599
428	.0354	12104
410	.0342	11 992
420	.0326	12883
500	.0329	15188
440	.0342	12873
500	.0369	13631
280	.0176	15900
460	.0366	12579
520	.0337	15444
530	.0391	13555



D_{wd} = Kelly elevation minus datum elevation.
D_{gm} = Seismometer depth below kelly elevation.
t_{us} = Uphole time of shot.
t_c = Time correction. (from reflection, refraction, or uphole time).
D_s = Depth of shot.
Δe = Kelly elevation minus shothole elevation.
$D_{ws} = D_s + \Delta e$
$\Delta sd = D_{ws} - D_{wd}$
$D_{gs} = D_{gm} - D_{ws}$
H = Horizontal distance, well to shothole.
Cot i = D_{gs} / H
T = Well seismometer time from time break.
T_{gs} = T Cos i
$T_{gd} = T_{gs} + \Delta sd / V_i$ = Vertical travel time, well seismometer to datum plane.
$D_{gd} = D_{gm} - D_{wd}$ = Vertical distance, well seismometer to datum plane.
V_i = Interval velocity = $\Delta D_{gd} / \Delta T_{gd}$
V_o = Average velocity = D_{gd} / T_{gd}

SURVEYED FOR: UNION OIL DEVELOP. CORP.
SURVEYED BY: UNITED GEOPHYSICAL CO.
COMPUTED BY: I. WYLIE & H. LEAVITT
DATE SURVEYED: JAN 6, 1961.

CASING: 591'

WEATHERING:

Fig. 9

(2)

COMPANY	WELL	LOCATION
UNION - KERN - A.O.G.	CABAWIN - NO. 1	80' NORTH and 11503' WEST of SOUTH EAST CORNER OF PORTION 30, PARISH OF SOUTH GLEN.

SHOT HOLE	ELEVATION	DISTANCE	SHOT HOLE	ELEVATION	DISTANCE	SHOT HOLE	ELEVATION	DISTANCE	SHOT HOLE	ELEVATION	DISTANCE	SHOT HOLE	ELEVATION	DISTANCE
1	949'	600	5	949'	600	9	948	1000	13	951	600	17	952	1000
2	949	600	6	949	600	10	947	1000	14	951	600	18	952	1000
3	949	600	7	948	1000	11	950	600	15	951	600	19	952	1000
4	949	600	8	948	1000	12	951	600	16	950	600	20	952	1000

ELEVATION

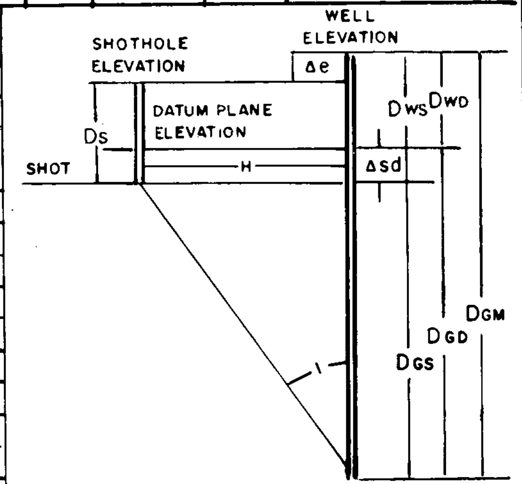
KELLY BUSH

ROTARY TBL

DERRICK FL

GROUND

RECORD NO.	SHOT HOLE NO	DGM	TUS	TC	DS	Δe	DWS	ΔS	DGS	H	Cot I	Cos I	T	GRADE	TGS	ΔSD/Vi	TGD	DGD	ΔDGD	ΔTGD	Vi INTERVAL VELOCITY	VA AVERAGE VELOCITY
H	8A	9930	.045	1	144	+20	164	-4	9766	1000	9.766	.9948	.894	G	.8894	-.0006	.8888	9762				10983
G	18A	9930	.048	2	182	+16	198	+30	9732	1000	9.732	.9948	.892	F	.8874	+.0045	.8919	9762				10945
F	18A	10358	.048	3	185	+16	201	+33	10157	1000	10.157	.9952	.928	F	.9235	+.0050	.9240	10190	428	.322	13292	11028
G	8A	10358	.045	4	144	+20	164	-4	10194	1000	10.194	.9952	.926	P	.9216	-.0006	.9210	10190				11064
E	18A	10555	.049	5	185	+16	201	+33	10354	b1000	10.354	.9954	.945	F	.9407	+.0050	.9457	10387	197	.211	9336	10983
F	8A	10555	.044	6	147	+20	167	-1	10388	1000	10.388	.9954	.946	F	.9416	000000	.9416	10387				11031
D	18A	11070	.048	7	187	+16	203	+35	10867	1000	10.867	.9958	.991	P	.9868	+.0050	.9918	10902	515	.457	11269	10992
E	8A	11070	.044	8	141	+20	161	-7	10909	1000	10.909	.9958	.992	?	.9878	-.0010	.9868	10902				11048
C	18A	11662	.050	9	195	+16	211	+43	11451	1000	11.451	.9962	1.033	P	1.0291	+.0060	1.0351	11494	592	.432	13704	11104
D	8A	11662	.043	10	132	+20	152	-16	11510	1000	11.510	.9963	1.036	?	1.0320	-.0020	1.0300	11494				11159
C	8A	12023	.043	11	150	+20	170	+2	11853	1000	11.853	.9964	1.071	P	1.067	000000	1.0670	11855	366	.375	9760	11111
B	18A	12033	.049	12	193	+16	209	+41	11824	1000	11.824	.9964	1.071	P	1.067	+.0060	1.073	11865				11058
A	17A	6744	.048	13	122	+16	138	-30	6606	1000	6.606	.9888	.661	G	.6536	-.0045	.6491	6576				10131

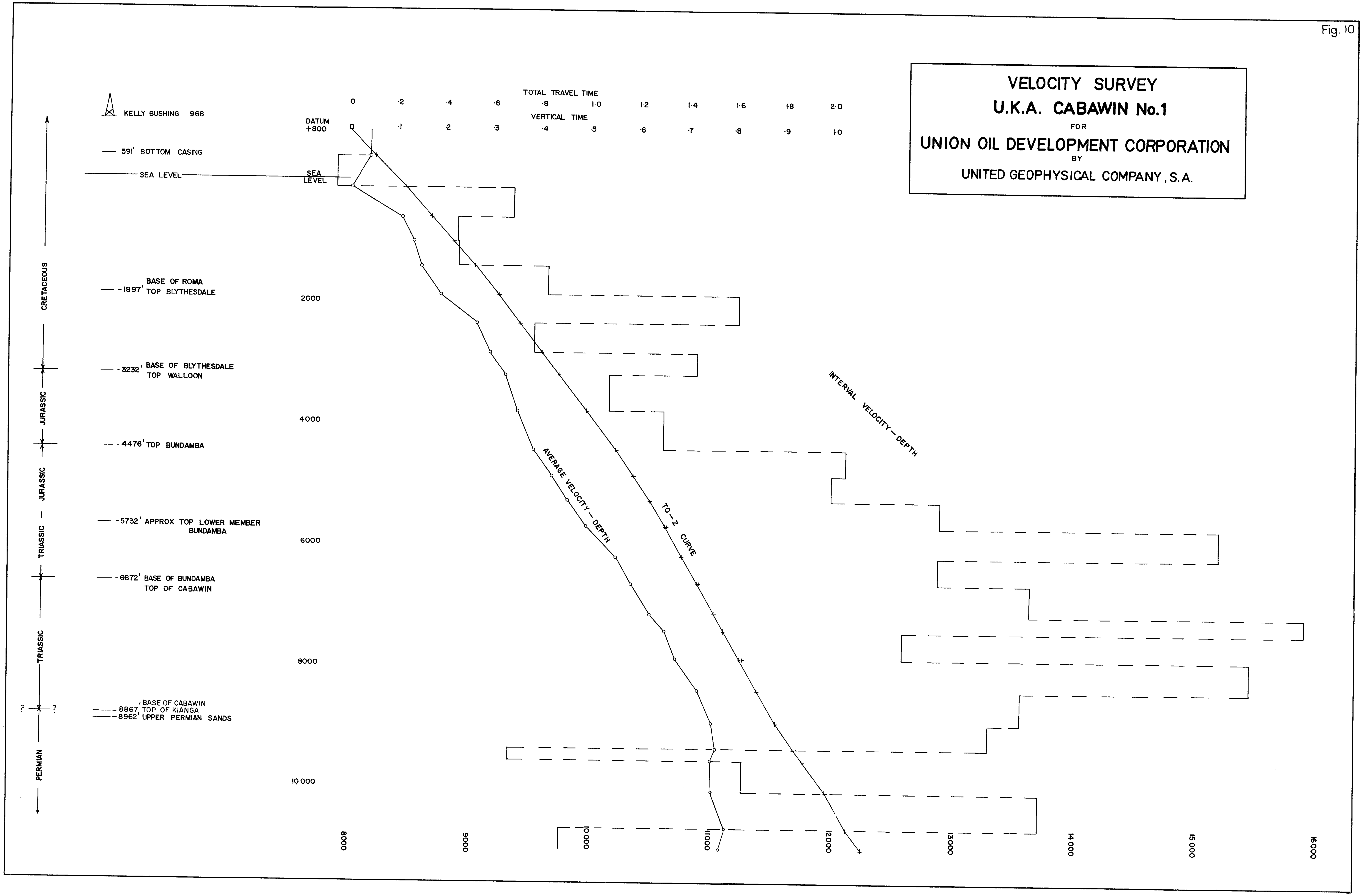


DWD = KELLY ELEVATION MINUS DATUM ELEVATION
DGM = SEISMOMETER DEPTH BELOW KELLY ELEVATION
TUS = UPHOLE TIME OF SHOT
TC = TIME CORRECTION (FROM REFLECTION, REFRACTION, OR UPHOLE TIME)
DS = DEPTH OF SHOT
ΔE = KELLY ELEVATION MINUS SHOTHOLE ELEVATION
DWS = DS + ΔE
ΔSD = DWS − DWD
DGS = DGM − DWS
H = HORIZONTAL DISTANCE, WELL TO SHOTHOLE
COT I = DGS / H
T = WELL SEISMOMETER TIME FROM TIME BREAK
TGS = T COS I
TGS = TGS + ΔSD/VI = VERTICAL TRAVEL TIME, WELL SEISMOMETER TO DATUM PLANE
DGD = DGM − DWD = VERTICAL DISTANCE, WELL SEISMOMETER TO DATUM PLANE
VI = INTERVAL VELOCITY = ΔDGD / ΔTGD
VA = AVERAGE VELOCITY = DGD / TGD

SURVEYED FOR: UNION OIL DEVELOP. CORP.
SURVEYED BY: UNITED GEOPHYSICAL CO.
COMPUTED BY: H. LEAVITT & I. WYLIE
DATE SURVEYED MARCH 27, 1961.

CASING: 3042'

WEATHERING:


VELOCITY SURVEY
U.K.A. CABAWIN No.1
FOR
UNION OIL DEVELOPMENT CORPORATION
BY
UNITED GEOPHYSICAL COMPANY, S.A.
TOTAL TRAVEL TIME
0 ·2 ·4 ·6 ·8 1·0 1·2 1·4 1·6 1·8 2·0
VERTICAL TIME
0 ·1 ·2 ·3 ·4 ·5 ·6 ·7 ·8 ·9 1·0
DATUM +800
SEA LEVEL
2000
4000
6000
8000
10 000
8000 9000 10000 11000 12000 13000 14000 15000 16000
KELLY BUSHING 968
591' BOTTOM CASING
SEA LEVEL
-1897' BASE OF ROMA TOP BLYTHESDALE
-3232' BASE OF BLYTHESDALE TOP WALLOON
-4476' TOP BUNDAMBA
-5732' APPROX TOP LOWER MEMBER BUNDAMBA
-6672' BASE OF BUNDAMBA TOP OF CABAWIN
BASE OF CABAWIN
-8867' TOP OF KIANGA
-8962' UPPER PERMIAN SANDS
CRETACEOUS
JURASSIC
JURASSIC - TRIASSIC
TRIASSIC
PERMIAN
AVERAGE VELOCITY – DEPTH
TO–Z CURVE
INTERVAL VELOCITY – DEPTH

Twenty-one horizons were checked at depths ranging from 600 feet, the approximate base of the surface pipe, to 9930 feet below kelly bushing. As the sonic log was not available, it was considered to be desirable to have the control points approximately 500 feet apart. Horizons of geologic significance were chosen where possible.

On 27th March, 1961, the survey was continued from 9930 to 12,033 feet. United Geophysical Company, Party 119, was again moved from Miles, and as previously a pressure type geophone was used. Travel times were measured at six new horizons and in addition checks were taken of some of the levels where measurements had been made during the first survey.

The velocity distribution $V_z = 7850 + 0.73z$ feet per second was determined by using Miller's method (Seismic Prospecting for Oil by Dix) and checked by the formula $T = \frac{2}{k} \log_e (1 + \frac{kz}{Vo})$ where Vo = 7850 feet per second and k = 0.73. As a result of this survey the function previously obtained from $X^2 - T^2$ reflection velocity surveys in the area, $V_z = 8000 + 0.5z$ feet per second, was shown to be too slow, resulting in erroneous depth calculations.

ELECTRIC LOG INTERPRETATION

Report No. 1

by

E.R. Atkins*

A study of all electric logs of Cabawin No. 1 has been conducted.

The results of calculations on the bed of principal interest, between 9926 and 9937 feet, are not conclusive. The 18'- 8" lateral peaks at 9928 feet may be caused by a 2-foot gas or oil stringer at the top of the zone or by the shell-like material just above the sand. The shape of the lateral below the peak is not what is usually expected and may imply a bed of lower but appreciable resistivity as deep as 9931 feet. The low resistivities at 9935 feet on the 16" normal are all apparently reversals caused by high resistivity thin shells near the bed of interest. The Microlog suggests a most probable value for Rxo of 35 for this bed. This is obtained by assuming a mud cake thickness of 0.6" from the caliper log. If the porosity of this bed is as high as 23%, as indicated by the cores analyzed in our laboratory, then the above Rxo value could be explained by residual oil or gas.

Some knowledge of water resistivity, Rw, would be most helpful in evaluating this log. The SP is particularly unreliable for Rw determinations for the mud resistivity value used. Similar mud resistivities in Sespe wells in California have resulted in abnormal streaming potentials, which, if taken to be electrochemical potential, will result in calculated excessively low water saturation.

For beds such as the one being discussed, the induction-electrical log would be most appropriate. A good Rt value should be obtained on beds thicker than 8 feet, even though it is surrounded by high resistivity shells. The deep penetration Schlumberger tool 6FF40 is to be preferred to the shallow 5FF40 tool. With either tool the most definitive Rt values will be obtained by logging as soon as possible after penetrating the formation.

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* Union Oil Company of California.

Other beds up the hole such as :

8883 feet	8150 feet
8553 feet	8111 feet
8407 feet	

are either too thin or bounded by shells so that 64" and 18'-8" curves cannot be used to evaluate Rt.

ELECTRIC LOG INTERPRETATION

Report No. 2

by

E.R. Atkins*

The interpretation (Note No. 2) of the Schlumberger engineer for this well log has been studied. The limits and definiteness placed on some of the numbers offered are somewhat optimistic as viewed from here. The value used for Rmc can be very critical in solving for Rxo. Further, relationships used for Rmc measured at the surface and the value that should be applied down the hole may be different from that proposed in Schlumberger Chart A-6. The values calculated by the Schlumberger engineer and by us for Rxo of the interval (9928-36 feet) are quite similar. We differ in the amount of significance that we attached to these calculations. We attempted to calibrate our calculations on beds at 8027, 8111 and 8148 feet using core analysis porosities. We found that changing the mud cake thickness over possible limits indicated by the caliper log from 0.4 to 1.0 inch gave widely varying Rxo values (as much as 10:1 differences). With the obvious uncertainty regarding mud cake thickness, we could not place much reliance in the Rxo method of determining porosity. Another detraction from Rxo determined Ø values is the necessity of estimating residual oil or gas saturation. The ROS value is usually related to formation permeability. Formations with low permeability and oil or gas saturation usually have higher residual oil saturation than formations with high permeability.

Our sand, silt and clay analysis on two of the low permeability cores have been completed as follows:

Depth (feet)	Sand (%)	Silt (%)	Clay (%)
8111	62.4	18.4	19.2
8355	56.7	18.6	24.7

Preliminary X-ray analysis indicates that the clay is principally illite, which is second to montmorillonite in swelling. Of course, we do not know how much clay is in the interval 9928 to 9936 feet. It is interesting to note that a so-called shaly sand usually has 6-10 percent clay.

* Union Oil Company of California.

ELECTRIC LOG INTERPRETATION

Note No. 1

by

P. Lehmann*

Introduction

Cabawin No. 1 Well was spudded on 6th October, 1960. The first gas show appeared on the gas detector (ROTARY) at approximately 6720 feet and a second appeared at 7380 feet. After each gas show logs were run and drill stem tests made.

The purpose of this note is to evaluate the interesting zones using the electrical logs and the micrologs available (ES No. 3 and 4, ML No. 3).

First Gas Show

This corresponds to the top of a rather thick formation as is shown on ES No. 4 and better on ML No. 3. At the time of the first drill stem test the thickness was not known as drilling had been stopped at 6776 feet. The porous part, according to ML No. 3, is situated between 7026 and 6719 feet with a thickness e= 307'. With the exception of a few thin impervious strata, the bed seems homogeneous and the porosity should not vary very much from top to bottom.

Mud data:

Surface measurement: Rm = 2.2 at 76°F

BHT = 151°F; Rm at BHT : 1.1 (Chart A-6, Ref. 1)

By Chart A-4: Rmf at BHT : 0.85

Rmc at BHT : 1.10

From the Microlog:

R1" x 1" = 3.2 (average reading)

R2" = 5.3 (average reading)

Using standard procedure (Charts C-10 and C-12):

Rxo/Rmc = 40, Fa = 52, ϕ = 13% (if ROS nil)

The accuracy of the above result will depend also on Rmf, since the apparent formation factor Fa varies as the reciprocal of Rmf. On the other hand, as can be seen on Chart C-10, the accuracy of the micrologs is not very good for small porosities ϕ. Therefore the result is given as :

Porosity $\phi = 13 \pm 2\%$

It is assumed that ROS is zero. For a residual oil saturation ϕ, the porosity obtained would be higher. For example, with ROS = 10% and the same initial values: ϕ = 14%.

According to the above results the formation factor is taken as : F = 50.

* Schlumberger Seaco Inc.

Consider now the electric log: The SP curve shows a deflection to the left with reference to the shale base line, suggesting a connate water less resistive than the mud filtrate. However, it is thought that the SP is not likely to give an accurate value for the formation water resistivity, Rw, owing to the peculiar shape of the SP curve.

Taking SSP = -15 mV (average value) and using Chart A - 10 Rwe = 0.55. At some places, especially on top of the zone, the deflection goes up to - 30mV giving:

Rwe = 0.38

It is not known if there are bivalent ions (Ca^{++} and Mg^{++} for instance) in the water. If so, a correction would have to be applied (Chart A-12) and the respective values of Rw would be:

Rw = 1.3 and Rw = 0.65.

From the above, the water resistivity should be within the limits:

$$0.4 < Rw < 1.3 \quad \text{(average 0.85)}$$

The average is not to be considered as a probable value since, without further information, it is not known whether the higher or the lower value is the more likely. With this reservation, the resistivity value can be stated as :

$$Rw = 0.85 \pm 0.45$$

<u>Resistivities:</u>

	16" Normal	64" Normal	18'8" Lateral
Ratio spacing to hole dia : AO/d	1.9	7.5	26.4
Apparent resistivity Ra	50	75	75
Ra/Rm	45.5	68	68
Corrected for hole	47	47	50

It seems that Rt is greater than Ri. But the difference between lateral value and normal values is too small to be significant.

Assuming Ri = R16" and F = Ri/Rm : F = 47
which is in fairly good agreement with the value F = 50 obtained from the microlog. If the formation contains only water, using Rt = 55 (lateral corrected) then Rt = Ro = F x Rw and Rw = 1.1.

This value is within the limits obtained from the SP curve. Therefore, from the logs, the formation is likely to contain water only. The indetermination on Rw, however, implies that there could possibly be a small amount of hydrocarbons present.

Considering the favourable case Rw = 0.4, F = 50, Rt = 55, using Archie's formula:

$$Sw^2 = 0.36, \quad Sw = 60\%$$

which is still a high water saturation.

Drill Stem Test:

The drill stem test was made when the total depth was 6776 feet. At first it gave a little gas followed by water with an oil smell. A sample of this water was taken and its resistivity measured. The result is :

$$Rw = 4.4 \text{ at } 76^{o}F \text{ (with MCF - A : mud filtrate cell)}$$

$$Rw = 3.9 \text{ at } 86^{o}F \text{ (with Mud - Cup)}$$

At BHT, using Chart A-6: Rw = 2.3

This value disagrees with the value obtained from the SP. It also disagrees with the resistivities. Indeed, if the formation is clean and contains hydrocarbons, one would have to assume a value smaller than 1.1 for Rw to conform with the resistivity readings. If the formation is shaly the SP does not reach the static value and therefore again one has to assume an Rw value smaller than 1.1 A final possibility would be that the invasion is so deep that all devices read close to FRmf. If this were so it would preclude any determination of Rt. But such a deep invasion seems improbable. It appears more likely that the water obtained from the drill stem test was not formation water. An analysis might confirm this beyond any doubt.

It is interesting to compare ES No. 3 and ES No. 4. It is seen that in the top of the sand the lateral and the long normal give roughly the same value on both logs. Conversely, the short normal reads less on ES No. 4. The ratio of the two short normal readings is approximately the same as the ratio of the mud resistivities. This indicates that the invasion is not likely to be so deep.

Second Gas Show

This show corresponds to the zone situated between 7396 and 7382 feet.

Thickness e = 14'

Microlog shows 4 porous feet : 7388 - 7384'

Mud cake is very thin.

By the standard proceedure, using the same mud data and the following readings :

R1" x 1" = 6 and R2" = 9.3 then :

Fa = 150, ϕ = 8% (ROS assumed nil)

This is a low porosity and the relative accuracy is poor.

Formation Water:

SSP = -135 mV (if clean sand); Rwe = 0.31

If a correction is made for bivalent ions, and using Chart A-12 : Rw = 0.45.

However, it is not known whether the SP reaches the static value. Therefore:

$$0.25 < Rw < 0.45$$

Resistivities :

	16" Normal	64" Normal	18'8" Lateral
AO/d	1.8	7.2	25.4
Ra	29	38	16
Ra/Rm	27	34.5	14.5

Although the bed is thin the departure curves of Ref. 3 cannot be used because Rs is greater than Rm and Rt is less than Rs.

Using the curves of Ref. 4 it seems that the lateral should read not too far from Rt. However, it is difficult to see whether the reading is applicable to the porous four feet. The short normal reads between Ri and Rt and Ri is less than Rt. Therefore F is greater than R16"/Rm = 27. This information is of little help. The long normal has to be corrected, but the correction is difficult to estimate. If the formation contains water only, with Rt = 16, then Rw = 0.11. This value is below the value obtained from the SP, possibly due to an over-estimation of F. Further, the SP can be far from the static value if the formation is shaly.

The conditions are not favourable for an accurate quantitative interpretation. (The proximity of the bottom can also have an influence). However, it can be concluded that the water saturation is high, very likely nearly 100 percent.

Drill Stem Test:

The drill stem test apparently did not succeed. No results are available.

REFERENCES

Schlumberger Log Interpretation Chart Book.

Resistivity Departure Curves. Beds of Infinite Thickness.

Resistivity Departure Curves. Beds of Finite Thickness.

Lateral Curves for Thin Non-invaded Beds.

ELECTRIC LOG INTERPRETATION

Note No. 2

by

P. Lehmann *

Introduction

Cabawin No. 1 Well blew out when the bit reached 9938 feet; after the well had been controlled an electrical log and micrologwere run and showed an eight-foot sand between 9936 and 9928 feet. The purpose of this note is to give a quantitative interpretation of this sand, using the two logs available. A Laterolog to be made later will improve the interpretation and might change some of the conclusions given below. Two other sands (at 8886-8878 feet and 8556-8550 feet), which might contain hydrocarbons, are also assessed.

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*Schlumberger Seaco Inc.

Mud Data

For electrical log:	Rm	= 2.3 at 78^{o}F (surface measurement)
	Rmf	= 1.5 at 83^{o}F (surface measurement)
	B.H.T.	= 171^{o}F, hence, by Chart A-6:
	Rm	= 1.0 at BHT
	Rmf	= 0.7 at BHT
For micrelog:	Rm	= 2.7 at 85^{o}F (surface measurement)
	Rmf	= 1.3 at 83^{o}F (surface measurement)
	Rmc	= 3.7 at 81^{o}F (surface measurement)

At BHT, by Chart A-6, values are :

Rm = 1.3

Rmf = 0.64

Rmc = 1.7

The mud log indicates a slightly lower value for Rm (in the order of 1.1). Neither the mud log reading nor the surface measurement extrapolated to BHT is precisely determined. We shall use the approximate values :

Rm = 1.2 ± 0.1

Rmf = 0.64 ± 0.05

Rmc = 1.7 ± 0.2

For interpretation purposes the absolute value of the mud resistivity does not need to be known with great accuracy. The comparison of the values of Rm, Rmf, and Rmc is more important. The mud filtrate and the mud cake should therefore be prepared from the same sample as the one used for resistivity measurements.

Zones Considered

Zone 1 : 9936-9928'	e = 8'	e/d = 11.6	temperature 171^{o}F
Zone 2 : 8886-8878'	e = 8'	e/d = 10.6	temperature 163^{o}F
Zone 3 : 8556-8550'	e = 6'	e/d = 7.6	temperature 160^{o}F

Hole diameter d and zone thickness e have been obtained from the microlog-caliper readings.

The temperature is obtained by plotting the available measurements on a diagram showing depth-formations and corresponding temperatures.

Zone 1 :

This is the sand responsible for the blow-out.

Porosity from Microlog : Log shows two subzones with slightly different porosities :

Subzone a : 9936-9930 feet (6 feet)		Subzone b : 9930-9928 feet (2 feet)	
R1" x 1"	= 3.6	R1" x 1"	= 3.1
R2"	= 5.9	R2"	= 5.4

By standard procedure, using Charts C-10 and C-12

Rxo/Rmc	= 18	Rxo/Rmc	= 25
Fa	= 48	Fa	= 66

Assuming ROS = 10% (light oil or gas)

F	= 36	F	= 50
Porosity ϕ = 15%		Porosity ϕ = 13%	

Bearing in mind the approximations assumed, a reasonable value for the average porosity is:

$$\phi = 15 \pm 1.5\%$$

And, for the formation factor F : $F = 36 \pm 8$

Electrical Log, water salinity, water saturation :

SP = -72 mV

SSP = -90 mV (Chart A-8)

Rmf/Rwe = 12 (Chart A-10), Rwe = 0.058, Rw = 0.06 ± 0.02

This is very approximate because no account was taken of possible shales dispersed in the sand nor of the possible effect of hydrocarbons on this SP deflection. Furthermore, nothing is known about the ions contained in the connate water.

Resistivities : It seems that the sand is surrounded by two thin and highly resistive beds which have a great influence on the readings. The most reliable reading is given by the short normal :

F = Ri/Rm = R16"/Rm = 35

which agrees with the microlog result.

The lateral is distorted by the resistive surroundings and the long normal is not reliable either. Since R16"/Rm is near the value of F obtained from the micrelog it can be assumed that Rt must lie in the same order i.e. Rt = 35 (Rm = 1). Using this value and Archie's formula, gives : Sw in the order of 25%.

For more precise information a Laterolog is absolutely necessary.

Zone 2 :

With a temperature of 163 °F we have :

Rm = 1.3 Rmf = 0.68 Rmc = 1.8 (micrologue)

Rm = 1.1 Rmf = 0.75 (electrical log)

In the same way as before :

R1" x 1" = 2.5

R2" = 4.4

Rxo/Rmc = 16 Fa = 42

with ROS = 10% gives ∅ = 16% F = 32

Further:

SP = - 45 mV

SSP = - 60 mV

Rmf/Rwe = 5.4 Rwe = 0.13 = Rw

Resistivities:	16" Normal	64" Normal	18'8" Lateral
AO/d	1.8	7.1	25
Ra	48	55	50
Ra/Rm	44	50	45
corrected for hole and bed thickness (approximately)	50	60	80

Hence : Ri is less than Rt, Rt/Rm $\gg$ 80, F = Ri/Rm $\ll$ 50

From these values we derive: Sw $\ll$ 22%

This sand should contain hydrocarbons with a favourable saturation. However, since the bed is thin, the quantitative interpretation cannot be very reliable unless a Laterolog is used.

Zone 3 :

Using the same values for the mud data as in Zone 2.

Micrologue : R1" x 1" = 4.3

R2" = 7.0

with ROS = 10%, gives ∅ = 13%, F = 50

Resistivities are in the same order as in Zone 2. Taking account of a higher formation factor we have : Sw $\ll$ 27%

There are, of course, other sands in this section of the well. But the logs available suggest that they are rather less interesting than the ones considered above.

Summary of Results

Zone No.	Depth (feet)	Thickness (feet)	Porosity (%)	Water Saturation (%)
1	9936-9928	8	15	$\fallingdotseq 25$
2	8886-8878	8	16	$\leqslant 22$
3	8556-8550	6	13	$\leqslant 27$

Approximations on porosities are in the order of $\pm$ 1.5 percent. It is again emphasized that the S_w figures given are to be considered as only an indication of the presence of hydrocarbons.

SCHLUMBERGER ELECTRIC LOG

Run No.	1	2	3	4	5	6	7
Date	16.10.60	24.10.60	3.11.60	11.11.60	17.11.60	31.12.60	24.3.61
First Reading	4192	5886	6770	7396	7909	9945	11773
Last Reading	591	4092	5786	6670	7296	7809	9845
Feet Measured	3601	1794	984	726	613	2136	1928
Csg Schlum.	591	591	591	591	591	591	3051
Csg Driller	591	591	591	591	591	591	3047
Depth Reached	4913	5887	6771	7397	7910	9946	11774
Bottom Driller	4197	5894	6776	7406	7915	9946	11784
Depth Datum	K.B.	K.B.	K.B.	K.B.	K.B.	K.B.	K.B.
Mud Nature		Fresh	water	gel		Oil emulsion	Oil emulsion
" Weight	77	75	74	75.5	77	111	111
" Viscosity	52	51	77	63	71	98	76
" Resist.	3.8 at 91°F	2.7 at 92°F	2.4 at 88°F	2.2 at 76°F	1.8 at 96°F	2.3 at 78°F	1.2 at 96°F
" Res. BHT	2.6 at 130°F	1.9 at 154°F	1.4 at 146°F	1.1 at 151°F	1.1 at 156°F	1.0 at 171°F	0.58 at 194°F
" pH	10 at 70°F	10 at 70°F	8 at 70°F	10 at 75°F	9.5 at 75°F	9 at 80°F	9 at 80°F
" Wtr Loss	8.6 cc/ 30 min.	7.6cc/ 30 min.	7 cc/ 30 min.	6.2 cc/ 30 min.	5 cc / 30 min.	4.2 cc/ 30 min.	6.4 cc/ 30 min.
Max.Temp. °F	130	154	146	151	156	171	194
Bit Size	8 3/4"	8 3/4"	8 3/4"	8 3/4"	8 3/4"	8 3/4"	8 3/4"
Spcgs.-AMI	16"	16"	16"	16"	16"	16"	16"
AMII	64"	64"	64"	64"	64"	64"	64"
AO	18'8"	18'8"	18'8"	18'8"	18'8"	18'8"	18'8"
Opr. Rig Time	3 1/2 hrs	3 1/2 hrs	3 hrs	3 hrs	3 hrs	3 1/2 hrs	
Truck No.	325	325	325	325	325	325	325
Recorded by	P. Lehmann	P. Lehmann	P. Lehmann	P. Lehmann	P. Lehmann	P. Lehmann	A. Baudot
Witnessed by	D.J.McGarry	D.J.McGarry	D.J.McGarry	D.J.McGarry	J.E. Mack	D.J.McGarry	D.J.McGarry

SCHLUMBERGER CONTINUOUS DIPMETER

Run No.	One
Date	30th March, 1961
Casing Depth Schlum.	3051'
" " Driller	3047'
Total " Schlum.	11777'
" " Driller	12035'
" " Reached	11772'
Hole Diameter	8 3/4" to T.D.
Mud Nature	Bentonite
" Weight	108
" Viscosity	86
" Resistivity	1.1 at $94^{o}F$
B.H.T.	$194^{o}F$
Water Loss	6 cc / 30 min.
Logging Speed	2000 ft/hr
First Reading	11772'
Last Reading	7000'
Feet Measured	4772'
Truck No.	325
Observer	A. Baudot
Witnessed by	D. Pyle
Computer	R.D.
Magnetic Declination	8^{o} East
Levels	1 to 107

SCHLUMBERGER LATEROLOG

Run No.	1	2
Date	27th March, 1961	31st March, 1961
First Reading	11736	12026
Last Reading	6500	11640
Feet Measured	5236	386
Csg. Schlum.	3051	3051
Csg. Driller	3047	3047
Depth reached	11739	12029
Bottom Driller	12035	12035
Mud Nature	Bentonite & barytes	Bentonite & barytes
Dens. (Visc.)	111 (80)	103 (85)
Mud Resist.	1.1 at 98°F	1.12 at 90°F
" " BHTD	0.53 at 194°F	0.52 at 194°F
" pH	9.5	9
" Wtr. Loss	6.2 cc/30 min.	7 cc/30 min.
Bit Size	8 3/4"	8 3/4"
Laterolog 3		
Laterolog 7		
Opr. Rig Time	5.00 hrs	3.00 hrs
Truck No.	325	325
Recorded by	A. Baudot	A. Baudot
Witnessed by	D.J. McGarry	D. Pyle

SCHLUMBERGER DIPMETER

Run No.	One
Date	2nd-3rd January, 1961
Casing Depth	591'
Total Depth	9950'
Hole Diameter	8 3/4" to T.D.
D.M. Electrodes Diameter	9"
Mud Nature	O.E. Barytes
Weight	100
Viscosity	110
Resistivity	2.5 at 84 ^{o}F
Max. Temp. ^{o}F	171
Observer	P. Lehmann
Type Resistivity (AA)	AA to DD
S.P. (A)	
Magnetic Declination	8^{o} East

SCHLUMBERGER MICROLOG

Run No.	1	2	3	4	5	6	7
Date	17.10.60	3.11.60	11.11.60	17.11.60	1.1.61	24.3.61	31.3.61
First Reading	4208	6767	7395	7906	9944	11775	12027
Last Reading	591	4100	666	7295	7806	9832	11650
Feet Measured	3617	2667	729	611	2138	1943	377
Depth Reached	4211	6770	7398	7909	9947	11778	12030
Bottom Driller	4215	6776	7406	7915	9948	11784	12035
Depth Datum	KB	KB	KB	KB	KB	KB	KB
Mud Nature		Fresh	water	gel		Oil emulsion	Oil emulsion
Dens. (Visc.)	77 (52)	74 (77)	75.5 (63)	77 (71)	110 (100)	111 (76)	108 (85)
Mud Resist.	3.8 at 91°F	22.4 at 88°F	2.2 at 76°F	1.8 at 96°F	2.7 at 85°F	1. 2 at 96°F	1.12 at 90°F
" " BHT	2.6 at 130°F	1.4 at 146°F	1.1 at 151°F	1.1 at 156°F	1.4 at 171°F	0.58 at 194°F	0.52 at 194°F
" pH	10 at 70°F	8 at 70°F	10 at 75°F	9.5 at 75°F	8.5 at 80°F	9 at 80°F	9 at 80°F
" Wtr. Loss	8.6 cc/ 30 min.	7 cc/ 30 min.	6.2 cc/ 30 min.	6.2 cc/ 30 min.	4 cc/ 30 min.	6.4 cc/ 30 min.	7 cc/ 30 min.
Rmf at BHT	2.2	1.15	0.85	1.1	0.64	0. 4 at 194°F	0.85 at 90°F
Rmc at BHT	2.1	1.25	1.1	1.1	1.7	0.73 at 194°F	1.47 at 90°F
Mud Log. Rm Limit	2.5	1.4	1.1	1.1	1.1	no cave. min reading 0.80	no reading poss.
Depth						11025	
Bit Size	8 3/4"	8 3/4"	8 3/4"	8 3/4"	8 3/4"	8 3/4"	8 3/4"
Sonde Type	WRS-T	WRS-T	WRS-T	WRS-T	WRS-T	WRS-T	WRS-T
Pad. Type	Hydraulic 1	Hydraulic 1	Hydraulic 1	Hydraulic 1	Hydraulic 1	H. Pad type 1	H. Pad type 1
Opr. Rig Time	5 1/2 hrs	5 hrs	5 hrs	3 1/2 hrs	4 1/2 hrs	6 hrs	5 hrs
Truck No.	325	325	325	325	325	325	325
Recorded by	P. Lehmann	P. Lehmann	P. Lehmann	P. Lehmann	P. Lehmann	A. Baudot	A. Baudot
Witnessed by	D.J.McGarry	D.J.McGarry	D.J.McGarry	J.E. Mack	D.J.McGarry	D.J.McGarry	D. Pyle

SCHLUMBERGER GAMMA RAY-NEUTRON

Run No.	1	2
Date	28th March, 1961	7th-8th April, 1961
Depth Reference	KB	KB
First Reading	11740'	11993'
Last Reading	3000'	5000'
Footage Measured	8740'	6993'
Max. Depth reached	11741'	11994'
Bottom Driller	12035'	12035'
Max. Temp. °F	195	195
Mud Nature	Bentonite & Barytes	Bentonite & Barytes
" Density	111	110
" Viscosity	80	85
" Resistivity	1.1 at 94°F	
Casing Size	9 5/8" to 3047'	5 1/2" to 12033'
Weight	36 lb.	20 lb.
Open Hole	8 3/4" to 12035'	
Fluid Level	Surface	Surface
Recording Speed (ft/hr)	1200	700
Sensitivity Tap	GR) 300 N) 300	GR) 200 N) 100
Time Constant	3	5
Panel	GNP - C	GNP - C
Opr. Rig Time	11.30 hrs	21.00 hrs
Sonde Size & Type	3 3/8" GNAM-5	3 3/8" GNAM-5
Truck No.	325	325
Observer	A. Baudot	A. Baudot

APPENDIX 4

RESERVOIR ENGINEERING

UNION-KERN-A.O.G. CABAWIN NO. 1

CONTENTS

UNION-KERN-A.O.G. CABAWIN NO. 1

FORMATION AND PRODUCTION TESTS

Test No.

PRESSURE CHARTS

1 Open Hole Formation Test No. 1 : 6728-6776 feet

2 Open Hole Formation Test No. 2 : 7388-7406 feet

3 W.S.O. Test through Jet Perf. at 11,655 feet

4 Initial Shut-in through Jet Perfs 11,881-11,995 feet

5 Production Test through Jet Perfs 11,881-11,995 feet

6 W.S.O. Test through Jet Perf. at 9882 feet

7 Production Test through Jet Perfs 10,006 and 10,172 feet

8 & 9 Production Test through Jet Perfs 9930-9938 feet, 10,006 feet, and 10,172 feet

Fig. 11

COMPANY: UNION OIL DEVELOPMENT CORPORATION DATE: 4 Nov., 1960.

WELL: UNION-KERN-A.O.G. - CABAWIN NO. 1.

STATE: QUEENSLAND COUNTRY: AUSTRALIA.

PARISH: SOUTH GLEN COUNTY: ROGERS FIELD: CABAWIN AREA.

CASING AT 591'. HOLE OPEN TO 6776'. PACKER SET AT 6728'.

FLUID CUSHION 185' WATER. FLOW PERIOD 65 MINUTES.

SHUT IN PERIOD ————

FLUID RISE 2800' NET RISE SLIGHTLY GASSY MUDDY WATER

SALINITY 35 g/g

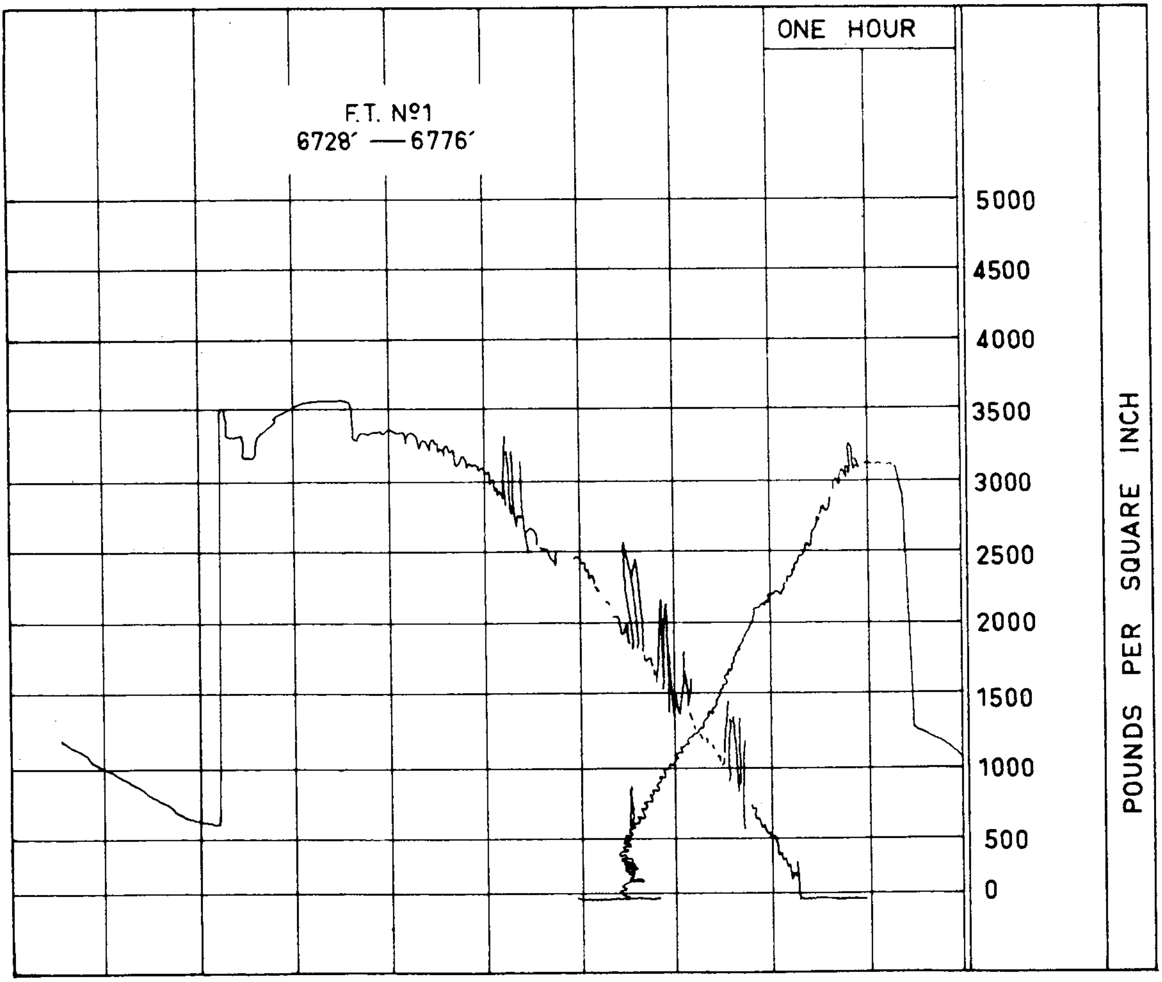

Fig. 11

COMPANY: UNION OIL DEVELOPMENT CORPORATION DATE: 12 Nov., 1960.

WELL: UNION-KERN-A.O.G.-CABAWIN NO. 1.

STATE: QUEENSLAND COUNTRY: AUSTRALIA.

PARISH: SOUTH GLEN COUNTY: ROGERS FIELD: CABAWIN AREA.

CASING AT 591'. HOLE OPEN TO 7406'. PACKER SET AT 7388'.

FLUID CUSHION 185' WATER. FLOW PERIOD 60 MINUTES.

SHUT IN PERIOD ___________

FLUID RISE - NONE.

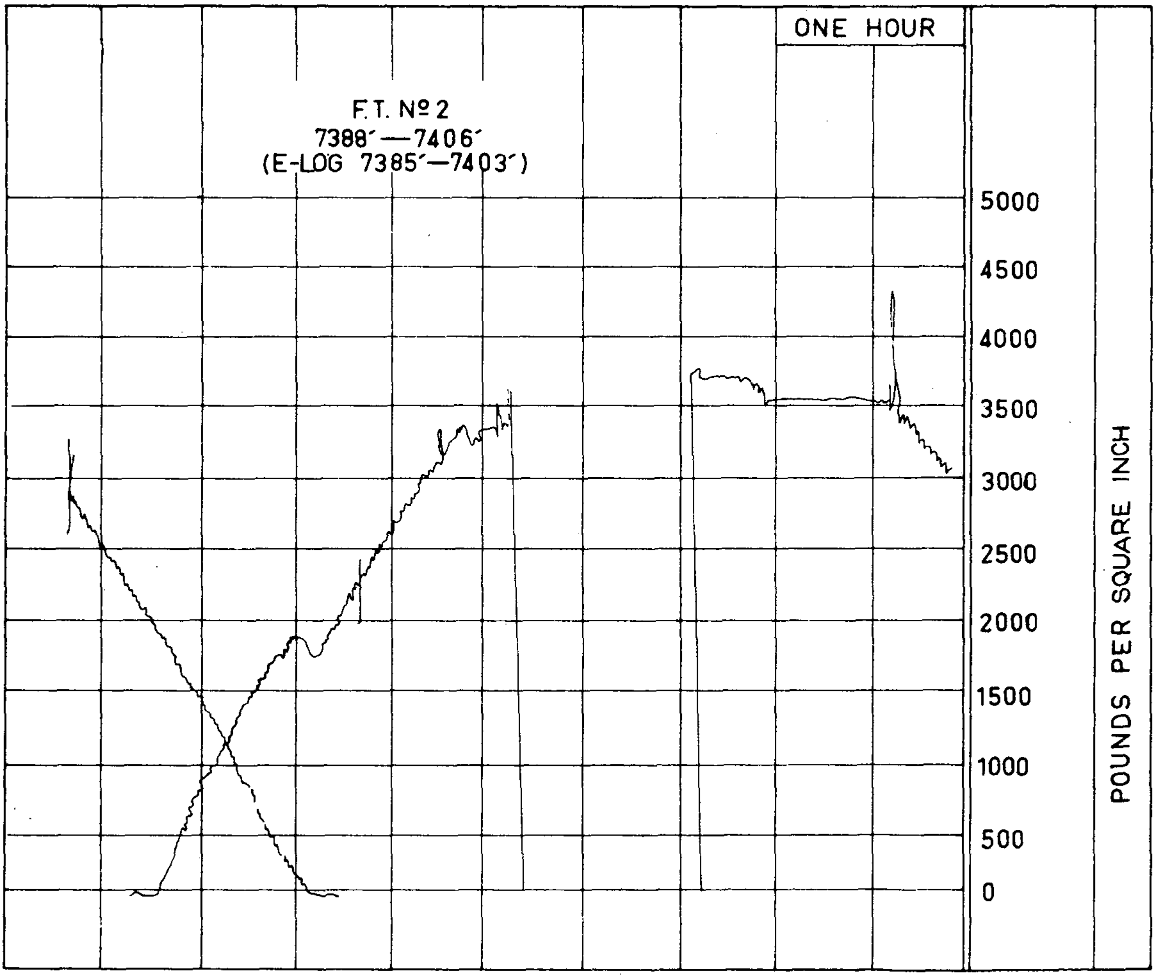

Fig. 11

COMPANY: UNION OIL DEVELOPMENT CORPORATION DATE 8 April, 1961.

WELL: UNION-KERN-A.O.G.- CABAWIN NO. 1.

STATE: QUEENSLAND COUNTRY: AUSTRALIA.

PARISH: SOUTH GLEN: COUNTY: ROGERS FIELD: CABAWIN AREA.

CASING: $5\frac{1}{2}$" C 12033' PLUG: 12003' PERFS: 4-$\frac{1}{2}$" at 11655'

PACKER SET AT 11631'. FLUID CUSHION 2290' water

FLOW PERIOD: 66 minutes. SHUT IN PERIOD: ______

FLUID RISE. 180' net rise watery mud.

CHART: I.H. 9577 p.s.i., I.F. 1541 p.s.i., F.F. 1541 p.s.i., F.H. 8747p.s.i.

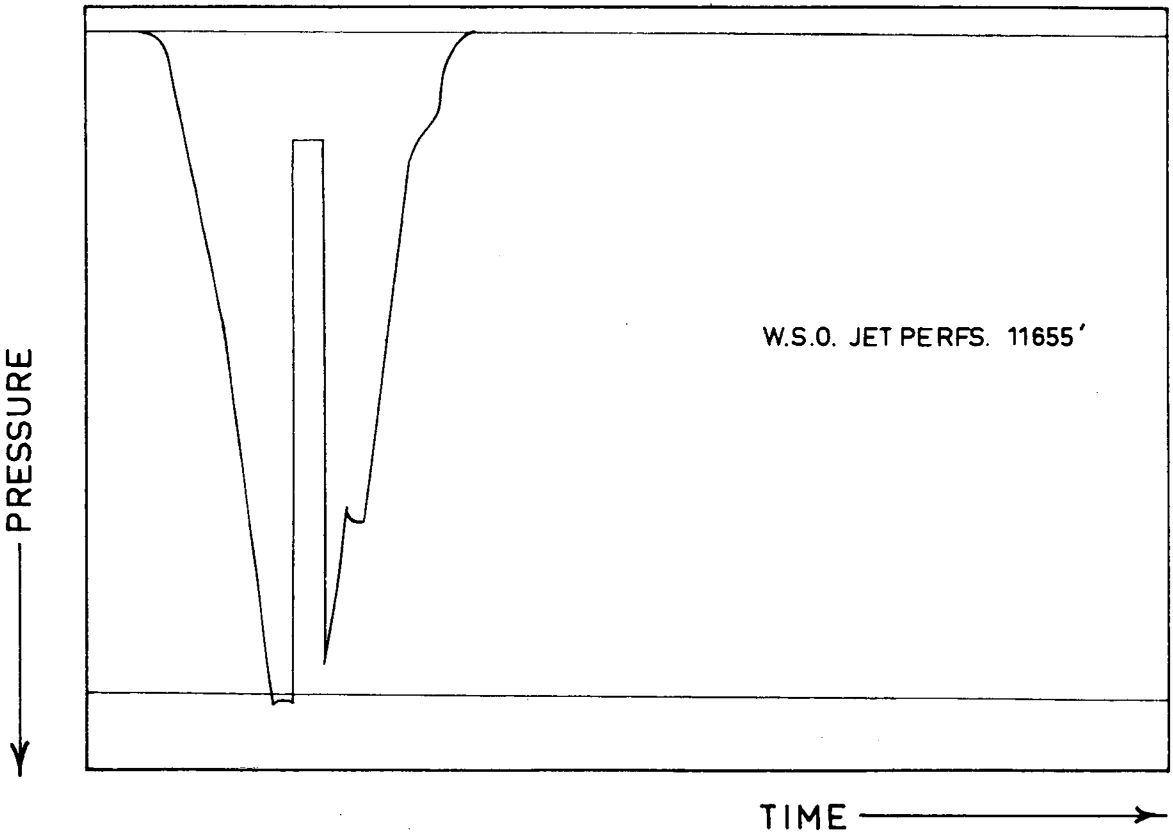

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Fig. 11

COMPANY: UNION OIL DEVELOPMENT CORPORATION DATE 11 April, 1961.

WELL: UNION-KERN-A.O.G. - CABAWIN NO. 1

STATE: QUEENSLAND COUNTRY: AUSTRALIA

PARISH: SOUTH GLEN. COUNTY: ROGERS FIELD: CABAWIN AREA.

CASING: $5\frac{1}{2}$" C 12033'. PLUG: 12003'. PERFS: 4-$\frac{1}{2}$"/ft. 11881-11995'

PACKER SET AT 11820'. FLUID CUSHION 2990' water

FLOW PERIOD: NONE UNABLE TO SHEAR DISC.

SHUT IN PERIOD: 85 minutes initial.

CHART: I.H. 9801 p.s.i. F.H. 9555 p.s.i.

SHUT IN PRESSURE AT 8.5 minute intervals

2174, 8166, 8501, 8632, 8703, 8736, 8768, 8801, 8820,

8839, 8850,

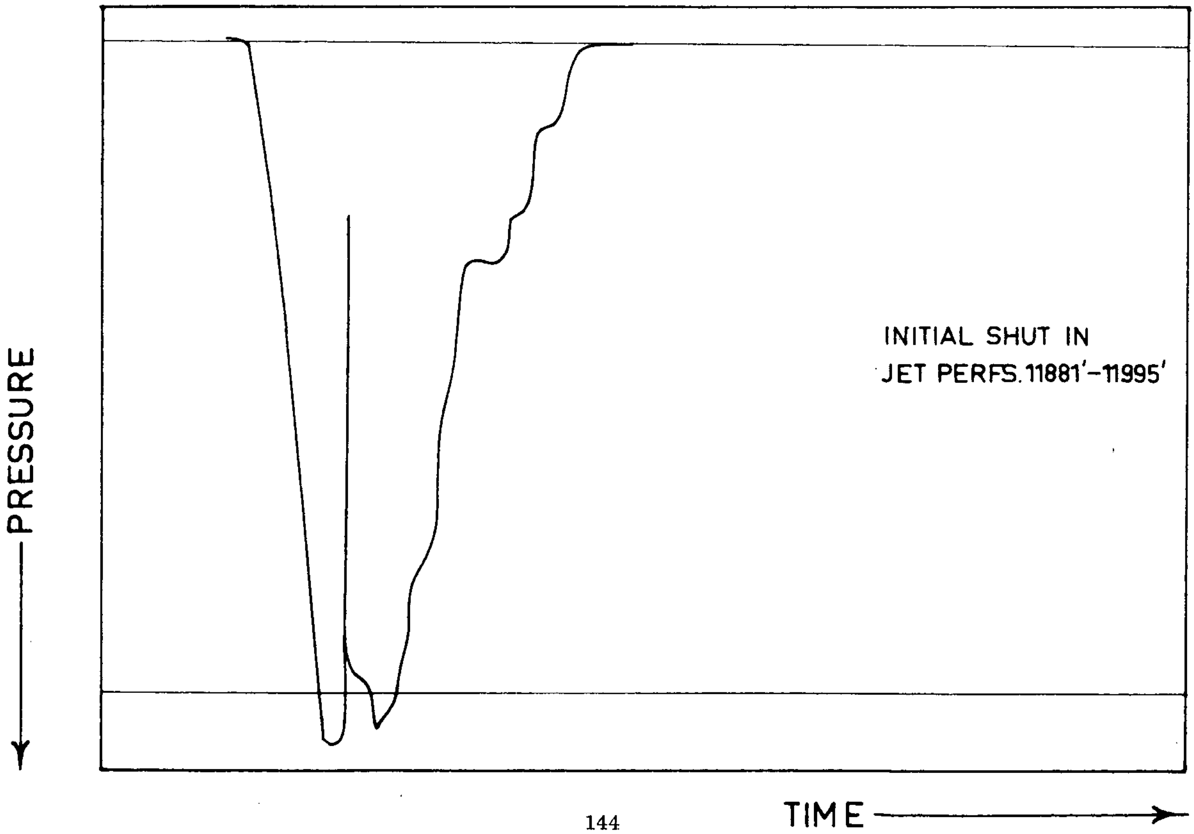

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Fig. 11

COMPANY: UNION OIL DEVELOPMENT CORPORATION DATE 12 April, 1961.

WELL: UNION-KERN-A.O.G.-CABAWIN NO. 1.

STATE: QUEENSLAND. COUNTRY: AUSTRALIA.

PARISH: SOUTH GLEN. COUNTY: ROGERS. FIELD: CABAWIN AREA.

CASING: $5\frac{1}{2}$" C 12033' PLUG: 12003' PERFS: 4-$\frac{1}{2}$"/ ft. 11881-11995.

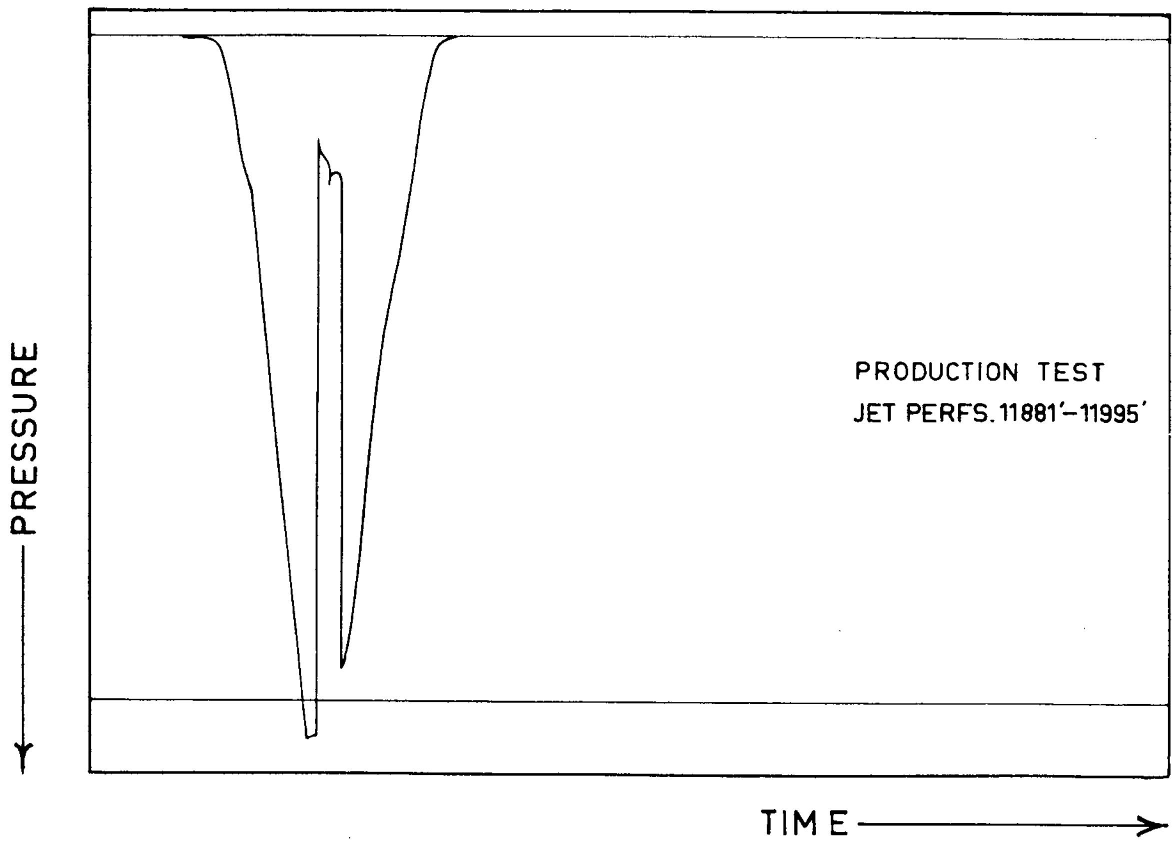
PACKER SET AT 11819' FLUID CUSHION 3020' water.

FLOW PERIOD 69 minutes. SHUT IN PERIOD: ______

FLUID RISE: 1220' net rise slightly gassy muddy water.

SALINITY: 1038 g/g

CHARTS I.H. 9492 p.s.i., I.F. 1415 p.s.i., F.F. 1934 p.s.i. F.H. 8665 p.s.i..



6 6A

Fig. 11

COMPANY: UNION OIL DEVELOPMENT CORPORATION, DATE 20 April, 1961.

WELL: UNION-KERN - A.O.G.-CABAWIN NO. 1.

STATE: QUEENSLAND COUNTRY: AUSTRALIA.

PARISH: SOUTH GLEN. COUNTY: ROGERS. FIELD: CABAWIN AREA.

CASING $5\frac{1}{2}$" C 12033' PLUG 10,615"

PERFS 4-$\frac{1}{2}$" at 10,600 & 9881' sq. cmt'd., 4-$\frac{1}{2}$" at 9882'

PACKER SET AT: 10,502' then 9847'. FLUID CUSHION 2050' water

FLOW PERIOD: 30 minutes then 60 minutes. SHUT IN PERIOD ______

FLUID RISE: 6030' net rise as follows 4720' gas with trace mud,

560' gassy muddy oil, 750' watery mud.

CHART: I.H. 7750, I.F. 855, F.F. 855, F.H. 7725,

I.H. 7120, I.F. 1180, F.F. 2265, F.H. 7100.

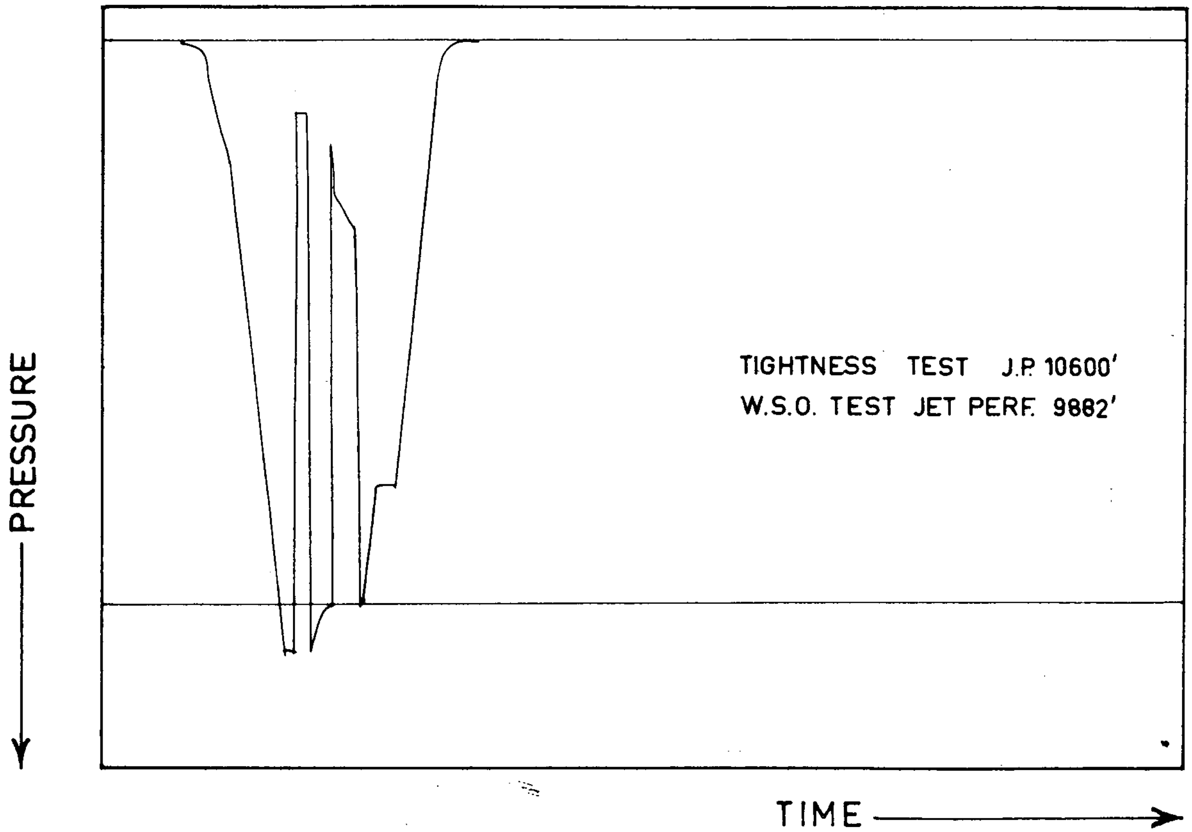


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Fig. 11

COMPANY: UNION OIL DEVELOPMENT CORPORATION. DATE 22 April, 1961.

WELL: UNION-KERN-A.O.G.-CABAWIN NO. 1.

STATE: QUEENSLAND. COUNTRY: AUSTRALIA.

PARISH: SOUTH GLEN. COUNTY: ROGERS. FIELD: CABAWIN AREA.

CASING $5\frac{1}{2}$" C 12033' PLUG 10484' PERFS 4-$\frac{1}{2}$" 10,006' & 10172'.

PACKER SET AT 9945' FLUID CUSHION 2000' water.

FLOW PERIOD 5 hours 39 minutes. SHUT IN: 1 hour Final.

FLUID RISE. CUSHION SURFACED 82 minutes., flowed 120 B/D, 49.5°

cut 30% mud, 1000 MCF/D.

CHARTS: I.H. 7084, I.F. 1223, F.F. 561, F.H. 6981.

Shut in pressures at 6 minute intervals.

561, 1446, 2437, 3692, 4701, 5610, 5868, 5931, 5970, 5995,

6019

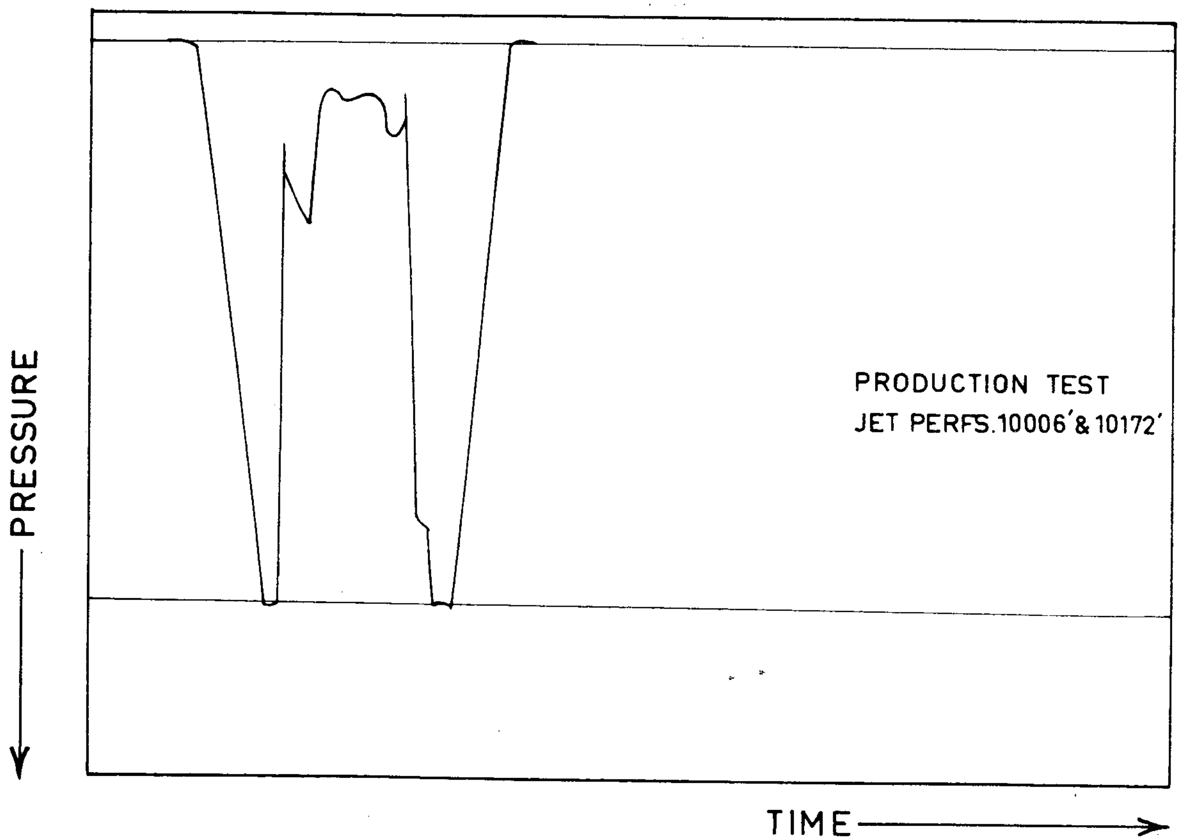

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Fig. 11

COMPANY: UNION OIL DEVELOPMENT CORPORATION. DATE. 23 April, 1961.

WELL: UNION-KERN-A.O.G.-CABAWIN NO. 1.

STATE: QUEENSLAND COUNTRY: AUSTRALIA.

PARISH: SOUTH GLEN. COUNTY: ROGERS. FIELD: CABAWIN AREA.

CASING AT 5½" C 12033' PLUG 10484'

PERFS: 4-½" 10,006' & 10172', 4-½"/ft. 9930'-9938'.

PACKER SET AT 9850' FLUID CUSHION 2000' water.

FLOW PERIOD: 7 hours 20 minutes SHUT IN: 3 hours final.

FLUID RISE. CUSHION SURFACED 37 minutes, flowed clean oil at 141-94 B/D, 49°, 600-550 MCF/D.

CHARTS: I.H. 6934, I.F. 1515, F.F. 573, F.H. 6934.

SHUT IN PRESSURES AT 18 minute intervals.

573, 3910, 5474, 5586, 5655, 5710, 5751, 5786, 5822, 5863, 5874.

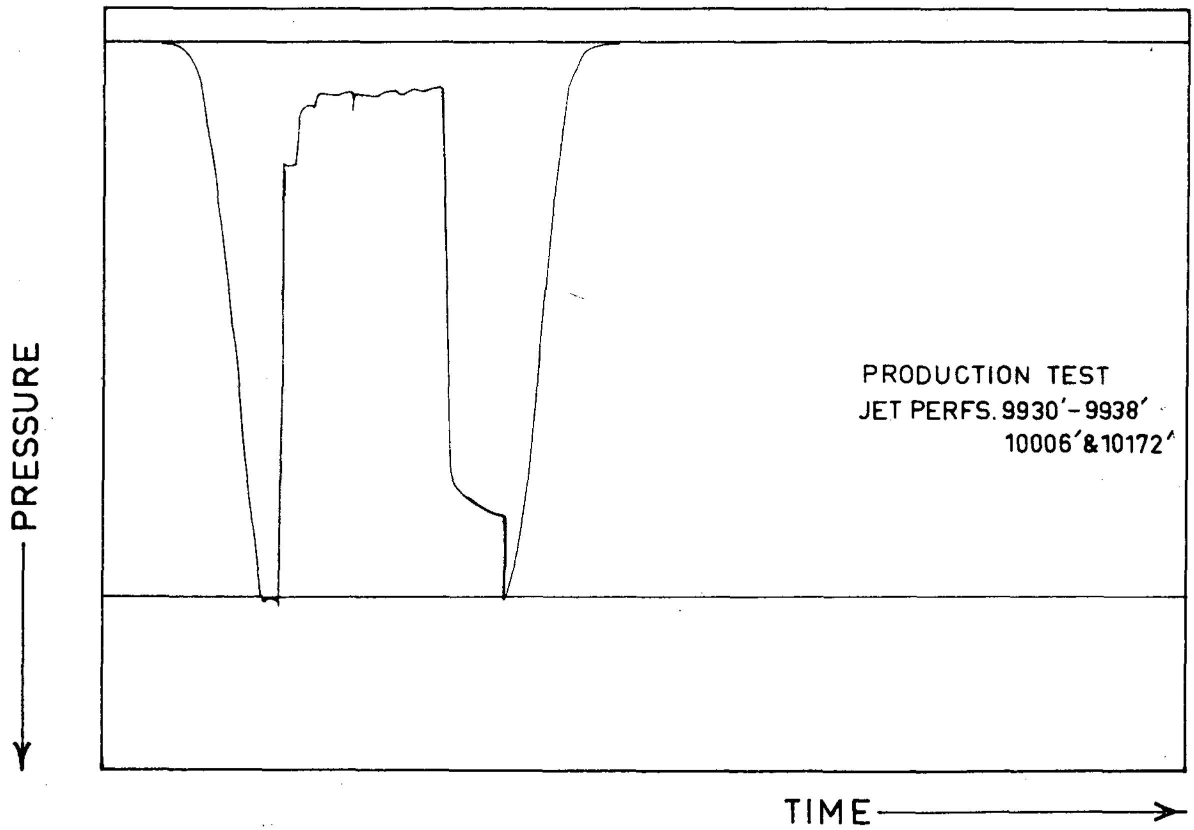

Fig. 12

UNION-KERN-A.O.G. CABAWIN NO. 1

PRODUCTION DATA TABLE

Results for period 23rd April - 17th June, 1961.

UNION – KERN – A.O.G. CABAWIN Nº 1

PRODUCTION DATA

County : Rogers
Parish : South Glen

PERFORATED INTERVAL	DATE	OIL Barrels	CUT	GAS M.c.f.	Pressure p.s.i. Tubing	Pressure p.s.i. Casing	GRAVITY A.P.I.	BEAN /64"	HOURS	REMARKS
Jet Perfs. 10,006 & 10.172	23 April	16	Tr.	125	100	Pkr.		45	6·6	*Howco Production Test.*
Jet Perfs. 9.930 - 9.938 10.006 & 10.172	24	27	Tr.	240	550 - 600	Pkr.	49	32-45-64	7·5	*Howco Production Test.*
Jet Perfs. 9.925 - 9.943 9.965 - 9.973 9.998 - 10.012 10.152 - 10.158 10.166 - 10.172	26	29	Tr.	184	730	1120	51	24	6·5	*Started flowing out casing at 5·30 p.m.*
	27	79	Tr.	680	400	750	51	24-28	24	*Started flowing from tubing at 2 a.m.*
	28	78	Tr.	630	500	750	51	28-32	24	
	29	80	Tr.	630	475	750	51	32	24	
	30	76	Tr.	621	100	350	51	32-45	24	
	1 May	73	Tr.	625	100	350	48	45	24	
	2	62	Tr	454	1090	1500	48	45-20	24	
	3	64	Tr.	508	1150	1635	50	20	24	
	4	58	Tr.	454	1075	1775	52	20	24	
	5	73	Tr.	508	800	1275	50	24-28	24	
	6	65	Tr.	495	975	1500	50	24-22	24	
	7	66	Tr.	508	975	1525	50	22	24	
	8	67	Tr.	508	980	1425	51	22	24	
	9	66	Tr.	508	915	1250	51	22	24	
	10	64	Tr.	508	875	1275	50	22	24	
	11	63	Tr.	484	925	1325	51	22	24	
	12	59	Tr.	469	1000	1475	51	22	24	
	13	60	Tr.	460	1100	1460	50	22	24	
	14	65	Tr.	541	275	580	51	22	24	*Changed from adjustable to positive bean.*
	15	62	Tr.	511	275	550	49	22	24	
	16	60	Tr.	534	275	550	49	22	24	
	17	58	Tr.	519	275	575	49	22	24	
	18	62	Tr.	534	300	550	49	22	24	
	19	2	Tr.	22	300	550	49	22	1	*Shut in at 1 a.m. for static pressure build up.*
	14 June	42	Tr.	272	325	Pkr.	48	16	12	*Flowing out tubing at 12 noon.*
	15	74	Tr.	514	400	Pkr.	51	16-14	23	*Shut in at 11 p.m.*
	16	45	Tr.	246	450	Pkr.	49	14	11	*Flowing out tubing at 1 p.m.*
	17	66	Tr.	452	325	Pkr.	49	14	20·5	*Shut in at 8·30 p.m. for static pressure build up.*
		1,761	CUMULATIVE	13,744	TOTALS					

UNION-KERN-A.O.G. CABAWIN NO. 1

SUBSURFACE PRESSURE AND TEMPERATURE SURVEYS

Subsurface Pressure Survey, 18th May, 1961

Casing:	5 1/2" C.12,033'
Elevation:	968' K.B.
Liner Description :	Cmt. Plug 10,484' (J.P. 9881 and 9882' sq. cmt'd) J.P. 9925-9943'; 9965-9973'; 9998-10,012'; 10,152-10,158'; 10,166-10,172'.
Tubing Detail :	2" H 9881' incl. 1 1/4" I.D. swage on bottom
Zero Point :	K.B.
Depth Plugged:	10,484'.
Zone:	Upper Permian
Pump Shoe:	None
Gas Anchor:	None
Intake:	9881'
Purpose :	Producing Pressure Survey
Remarks :	Made feeler run w/1 1/4" O.D. tools, sat down and stuck tools at 9862'. Jarred loose.
Pick up at :	9862'
Maximum Temperature:	183 °F at 9862'

Depth (feet)	Pressure p.s.i.	Gradient		
0	204		Stabilization Period	X
2000	257	0.0765	Gross Oil Rate B/D	58
4000	289	0.016	Net Oil Rate B/D	58
6000	365	0.038	Formation Gas Mcf/D	529
8000	481	0.058	GOR cu. ft/bbl	9150
9000	606	0.125	Circulated Gas Mcf/D	X
9400	658	0.130	Oil Dry Gravity °API	49.0
9600	682	0.120	Bean Size	22/64"
9800	699	0.085	Casing Pressure	522 p.s.i.
9850	710	0.220	Tubing Pressure	210 p.s.i.

Average Flowing Gradient : 0.0535 p.s.i./ft

Subsurface Pressure Survey, 18th - 21st May, 1961

Casing:	5 1/2" C. 12,033'
Elevation:	968' K.B.
Liner Description:	Cmt. Plug 10,484' (J.P. 9881 and 9882' sq. cmt'd.) J.P. 9925-9943'; 9965-9973'; 9998-10,012'; 10,152-10,158'; 10,166-10,172'.
Tubing Detail:	2" H 9881' incl. 1 1/4" I.D. swage on bottom
Zero Point:	K.B.
Depth Plugged:	10,484'
Pump Shoe:	None
Gas Anchor:	None
Intake:	9881'
Purpose:	Static Subsurface Build-Up Survey
Remarks:	Hung instrument at 9850' while flowing on 22/64" bean for 1 hour, then shut in well.
Pick up at:	None
Maximum Temperature:	196°F at 9850'
	Shut in 1.00 a.m. 19.5.61
	Flowing tubing 200 p.s.i.
	Flowing casing 522 p.s.i.

Hrs shut in	Press. p.s.i.	Hrs shut in	Press. p.s.i.		
0	702	26	4387	Stabilization Period	68
1	1000	28	4443	Gross Oil Rate B/D	X
2	1252	30	4500	Net Oil Rate B/D	X
3	1488	32	4544	Formation Gas Mcf/D	X
4	1736	34	4588	GOR cu. ft/bbl	X
5	1928	36	4629	Circulated Gas Mcf/D	X
6	2162	38	4665	Oil Dry Gravity °API	X
7	2328	40	4701	Bean Size	X
8	2502	42	4729	Casing Pressure	3440 p.s.i. at 68 hrs.
9	2692	44	4758	Tubing Pressure	3140 p.s.i. at 68 hrs
10	2866	46	4782		
11	3032	48	4806		
12	3190	50	4830		
13	3340	52	4854		
14	3465	54	4875		
15	3603	56	4895		
16	3737	58	4915		
17	3846	60	4931		
18	3935	62	4947		
20	4093	64	4968		
22	4226	66	4984		
24	4306	68	4992		

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Subsurface Pressure Survey, 22nd - 24th May, 1961

Casing :	5 1/2" C.12,033'
Elevation:	968' K.B.
Liner Description:	Cmt. Plug 10,484' (J.P. 9881 and 9982' sq. cmt'd.) J.P. 9925-9943'; 9965-9973'; 9998'; 10,012'; 10,152-10,158'; 10,166-10,172'.
Tubing Detail:	2" H 9881' incl. 1 1/4" I.D. swage on bottom
Zero Point:	K.B.
Depth Plugged:	10,484'
Pump Shoe:	None
Gas Anchor:	None
Intake:	9881'
Purpose:	Continuation of static pressure build-up survey
Remarks:	Hung instrument at 9850' 2.05 a.m. 22nd May, 1961. Off bottom 12.45 p.m. 24th May, 1961.
Pick up at:	None
Maximum Temperature:	198 °F at 9850'
	Well shut-in 1.00 a.m. 19th May, 1961.

Hrs shut in	Press. p.s.i.	Hrs shut in	Press. p.s.i.		
73	5000	103	5145	Stabilization Period	131 3/4 hrs
75	5004	105	5153	Gross Oil Rate B/D	X
77	5016	107	5165	Net Oil Rate B/D	X
79	5024	109	5169	Formation Gas Mcf/D	X
81	5032	111	5177	GOR cu. ft/bbl	X
83	5048	113	5183	Circulated Gas Mcf/D	X
85	5060	115	5189	Oil Dry Gravity °API	X
87	5068	117	5197	Bean Size	X
89	5081	119	5205	Casing Pressure	3660 p.s.i.
91	5089	121	5213	Tubing Pressure	3375 p.s.i.
93	5101	123	5222		
95	5113	125	5234		
97	5121	127	5238		
99	5133	129	5242		
101	5137	131 3/4	5250		

Subsurface Pressure Survey, 24th May, 1961

Casing:	5 1/2" C.12,033'
Elevation:	968' K.B.
Liner Description:	Cmt. Plug 10,484' (J.P. 9881' and 9882' sq. cmt'd.) J.P. 9925-9943'; 9965-9973'; 9998-10,012'; 10,152-10,158'; 10,166-10,172'.
Tubing Detail:	2" H 9881' incl. 1 1/4" I.D. swage on bottom
Zero Point:	K.B.
Depth Plugged:	10,484'
Pump Shoe:	None
Gas Anchor:	None
Intake:	9881'
Purpose:	Static Gradient Pressure Survey
Pick up at:	None
Maximum Temperature:	198 °F at 9850'
	Well shut-in 1.00 a.m. 19th May, 1961

Depth (feet)	Pressure p.s.i.	Gradient		
0	3384		Stabilization Period	141 1/3 hrs
2000	3615	0.115	Gross Oil Rate B/D	X
4000	4072	0.228	Net Oil Rate B/D	X
6000	4508	0.218	Formation Gas Mcf/D	X
8000	4911	0.201	GOR cu. ft/bbl	X
9000	5097	0.186	Circulated Gas Mcf/D	X
9400	5173	0.190	Oil Dry Gravity °API	X
9600	5209	0.180	Bean Size	X
9800	5250	0.205	Casing Pressure	3660 p.s.i.
9850	5262	0.240	Tubing Pressure	3390 p.s.i.

Subsurface Temperature Survey, 24th May, 1961

Casing:	5 1/2" C.12,033'
Elevation:	968' K.B.
Liner Description:	Cmt. plug 10,484' (J.P. 9881 and 9882' sq. cmt'd.) J.P. 9925-9943'; 9965-9973'; 9998-10,012'; 10,152-10,158'; 10,166-10,172'.
Tubing Detail:	2" H 9881' incl. 1 1/4" I.D. swage on bottom
Zero Point:	K.B.
Depth Plugged:	10,484'
Pump Shoe:	None
Gas Anchor:	None
Intake:	9881'
Purpose:	Static Subsurface Temperature Survey
Pick up at:	None
Maximum Temperature:	201.2 °F at 9850'

Depth	Temp. °F		
0	81.3	Stabilization Period	136 hrs
500	87.2	Gross Oil Rate B/D	X
1000	95.7	Net Oil Rate B/D	X
1500	102.8	Formation Gas Mcf/D	X
2000	108.6	GOR cu. ft/bbl	X
2500	115.7	Circulated Gas Mcf/D	X
3000	120.3	Oil Dry Gravity °API	X
3500	125.3	Bean Size	X
4000	131.1	Casing Pressure	3650 p.s.i.
4500	139.9	Tubing Pressure	3390 p.s.i.
5000	148.6		
5500	155.5		
6000	160.6		
6500	166.9		
7000	172.0		
7500	177.1		
8000	182.1		
8500	187.6		
9000	192.7		
9400	196.3		
9600	198.2		
9800	200.4		
9850	201.2		

3

Subsurface Pressure Survey, 27th May, 1961

Casing: 5 1/2" C. 12,033'
Elevation: 968' K.B.
Liner Description: Cmt. Plug 10,495' (J.P. 9881 and 9882' sq. cmt'd) J.P. 9925-9943'; 9965-9973'; 9998-10,012'; 10,152-10,158'; 10,166-10,172'.
Tubing Detail: 2" H 9881' incl. 1 1/4" I.D. swage on bottom
Zero Point: K.B.
Depth Plugged: 10,484'
Pump Shoe: None
Gas Anchor : None
Intake: 9881'
Purpose: Continuation of static pressure build-up survey
Remarks: Hung instrument at 9850' 12.45 a.m. 25th May, 1961. Off bottom 2.35 p.m. 27th May, 1961
Well shut-in 1.00 a.m. 19th May, 1961.

Hrs shut in	Press. p.s.i.g.	Hrs shut in	Press. p.s.i.g.		
143 3/4	5270	182	5346	Stabilization Period 8 days 13 1/2 hrs	
144	5270	184	5351	Gross Oil Rate B/D	X
146	5274	186	5355	Net Oil Rate B/D	X
148	5278	188	5359	Formation Gas Mcf/D	X
150	5282	190	5363	GOR cu. ft/bbl	X
152	5286	192	5367	Circulated Gas Mcf/D	X
154	5294	194	5371	Oil Dry Gravity ^{o}API	X
156	5298	196	5375	Bean size	X
158	5302	198	5379	Casing Pressure	3775 p.s.i.g.
160	5306	200	5383	Tubing Pressure	3465 p.s.i.g.
162	5310	202	5387		
164	5314	204	5391		
166	5314	205 1/2	5391		
168	5318				
170	5322				
172	5326				
174	5330				
176	5334				
178	5338				
180	5342				

Instrument hung at 9850' for survey. Made stops at 9750' and 9650' when pulling out indicating a 0.14 gas gradient from 9650 to 9850'.

Subsurface Pressure Survey, 17th June, 1961

Casing:	5 1/2" C.12,033' Cmt. plug 10,484'
Elevation:	968' K.B.
	J.P. 9925-9943'; 9965-9973'; 9998-10,012'; 10,152-10,158'; 10,166-10,172'.
Tubing Detail:	2" H 9903' perf. jt. 9872-9903', packer 9832-9841'
Zero Point:	K.B.
Depth Plugged:	10,484'
Pump Shoe:	None
Gas Anchor:	None
Intake:	Open ended
Purpose:	Producing Pressure Survey
Remarks:	Instrument stopped at 9985'
Pick up at:	9985'
Maximum Temperature:	206 ^{o}F at 9985'

Depth (feet)	Pressure p.s.i.	Gradient		
0	312		Stabilization Period	26 hrs
2000	410	0.049	Gross Oil Rate B/D	77
4000	517	0.053	Net Oil Rate B/D	77
6000	635	0.059	Formation Gas Mcf/D	529
8000	775	0.070	GOR cu. ft/bbl	6880
9000	846	0.071	Circulated Gas Mcf/D	X
9400	878	0.080	Oil Dry Gravity ^{o}API	49
9800	917	0.097	Bean Size	14/64"
9900	928	0.110	Casing Pressure	pkr.
9934	933	0.147	Tubing Pressure	325 p.s.i.
9969	948	0.429	Average Flowing Gradient	0.064 p.s.i./ft

Subsurface Temperature Survey, 17th June, 1961

Casing :	5 1/2" C. 12,033' Cmt. Plug 10,484'
Elevation:	968' K.B.
	J.P. 9925-9943'; 9965-9973'; 9998-10,012'; 10,152-10,158'; 10,166-10,172'.
Tubing Detail:	2" H 9903' perf. jt. 9872-9903', packer 9832-9841'
Zero Point :	K.B.
Depth Plugged:	10,484'
Pump Shoe:	None
Gas Anchor:	None
Intake:	Open ended
Purpose:	Flowing Temperature Survey

Depth	Temp. °F		
6000	-172	Stabilization Period	26 hrs
8000	180.4	Gross Oil Rate B/D	77
9000	185.4	Net Oil Rate B/D	77
9400	183.7	Formation Gas Mcf/D	529
9800	172.7	GOR cu. ft/bbl	6880
9900	-172	Circulated Gas Mcf/D	7
9910	-172	Oil Dry Gravity °API	49
9920	-172	Bean Size	14/64"
9925	174.3	Casing Pressure	pkr.
9930	175.3	Tubing Pressure	325 p.s.i.
9935	186.9		
9940	193.0		
9945	196.0		
9950	198.0		
9955	199.5		
9960	200.8		
9965	202.5		
9975	204.5		
9980	205.2		

4

Subsurface Pressure Survey, 17th - 18th June, 1961

Casing :	5 1/2" C. 12,033' Cmt. Plug 10,484'
Elevation:	968' K.B.
	J.P. 9925-9943'; 9965-9973'; 9998-10,012'; 10,152-10,158'; 10,166-10,172'.
Tubing Detail:	2" H 9903' perf. jt. 9872-9903', packer 9832-9841'
Zero Point:	K.B.
Depth Plugged:	10,484'
Pump Shoe:	None
Gas Anchor:	None
Intake:	Open ended
Purpose:	Static Pressure Build-up Survey
Remarks:	Hung instrument at 9934' while flowing on 14/64" bean for 1/2 hour then shut in well. Shut in 8.30 p.m. 17th June, 1961.

Hours shut in	Press. p.s.i.		
0	827	Stabilization Period	10 1/2 hours
0.5	1544	Gross Oil Rate B/D	X
1.0	2077	Net Oil Rate B/D	X
1.5	2554	Formation Gas Mcf/D	X
2.0	2992	GOR cu. ft/bbl	X
2.5	3401	Circulated Gas Mcf/D	X
3.0	3704	Oil Dry Gravity °API	X
3.5	3972	Bean Size	X
4.0	4153	Casing Pressure	pkr.
4.5	4282	Tubing Pressure	325 p.s.i. at start
5.0	4351		
5.5	4411		
6.0	4451		
6.5	4485		
7.0	4516		
7.5	4544		
8.0	4570		
8.5	4593		
9.0	4614		
9.5	4633		
10.0	4652		
10.5	4669		

Subsurface Pressure Survey, 8th - 10th August, 1961

Casing :	5 1/2" C. 12,033' Cmt. Plug 10,484'
Elevation:	968' K.B.
	J.P. 9925-9943'; 9965-9973'; 9998-10,012; 10,152-10,158'; 10,166-10,172'.
Tubing Detail :	2" H 9903' perf. jt. 9872-9903', packer 9832-9841'
Zero Point :	K.B.
Depth Plugged :	10,484'
Pump Shoe :	None
Gas Anchor:	None
Intake:	Open ended
Purpose:	Static Pressure Survey
Remarks:	Hung instrument at 9934'. Made gradient stops while pulling out
Pick up at :	None
Maximum Temperature:	205 °F at 9934'.

Date	Time	Pressure p.s.i.		
8 Aug.	5.00 p.m.	5850	Stabilization Period	52-54 days
	7.00 p.m.	5972	Gross Oil Rate B/D	X
	9.00 p.m.	5976	Net Oil Rate B/D	X
	11.00 p.m.	5980	Formation Gas Mcf/D	X
9 Aug.	1.00 a.m.	5980	GOR cu. ft/bbl	X
	5.00 a.m.	5980	Circulated Gas Mcf/D	X
	5.00 p.m.	5980	Oil Dry Gravity °API	X
10 Aug.	1.00 a.m.	5984	Bean Size	X
	5.00 a.m.	5984	Casing Pressure	pkr.
	11.00 a.m.	5984	Tubing Pressure	4000 p.s.i.

Subsurface Temperature Survey, 10th August, 1961

Casing:	5 1/2" C. 12,033' Cmt. Plug 10,484'
Elevation:	968' K.B.
	J.P. 9925-9943'; 9965-9973'; 9998-10,012'; 10,152-10,158'; 10,166-10,172'.
Tubing Detail:	2" H 9903' perf. jt. 9872-9903', packer 9832-9841'
Zero Point :	K.B.
Depth Plugged :	10,484'
Pump Shoe :	None
Gas Anchor :	None
Intake :	Open Ended
Purpose :	Static Temperature Survey
Pick up at :	None
Maximum Temperature:	205 °F at 9960'

Depth	Temp. °F		
0	67.3	Stabilization Period	Shut-in 53 1/2 days
1000	88.5	Gross Oil Rate B/D	X
2000	104.2	Net Oil Rate B/D	X
3000	115.8	Formation Gas Mcf/D	X
4000	125.2	GOR cu. ft/bbl	X
5000	145.2	Circulated Gas Mcf/D	X
6000	157.7	Oil Dry Gravity °API	X
7000	169.1	Bean Size	X
8000	179.6	Casing Pressure	pkr.
9000	190.8	Tubing Pressure	4000 p.s.i.
9500	196.8		
9900	201.9		
9920	203.7		
9940	204.3		
9960	205.0		

Subsurface Pressure Survey, 10th August, 1961

Casing :	5 1/2" C.12,033' Cmt. Plug 10,484'
Elevation :	968' K.B.
	J.P. 9925-9943'; 9965-9973'; 9998-10,012'; 10,152-10,158'; 10,166-10,172'.
Tubing Detail :	2" H 9903' perf. jt. 9872-9903', packer 9832-9841'
Pump Shoe:	None
Gas Anchor:	None
Intake:	Open Ended
Purpose:	Pressure Gradient
Remarks:	Made stops while pulling out after static pressure survey
Pick up at :	None
Maximum Temperature:	205°F at 9934'

Depth (feet)	Pressure p.s.i.	Gradient		
9934	5984	0.470	Stabilization Period	53 1/2 days
9900	5968	0.210	Gross Oil Rate B/D	X
9800	5947	0.206	Net Oil Rate B/D	X
9350	5854	0.182	Formation Gas Mcf/D	X
9000	5790	0.182	GOR cu. ft/bbl	X
8000	5608		Circulated Gas Mcf/D	X
			Oil Dry Gravity °API	X
			Bean Size	X
			Casing Pressure	pkr.
			Tubing Pressure	4000 p.s.i.

APPENDIX 5

EVALUATION OF OIL, GAS AND WATER

UNION-KERN-A.O.G. CABAWIN NO. 1

CONTENTS

EVALUATION OF CRUDE

by

E.E. Zinser *

The results of a series of tests performed to evaluate the character of the crude oil from Cabawin No. 1, Queensland, have been tabulated. Only selected tests were run rather than the complete evaluation programme as outlined in the Crude Oil Data Book.

The crude oil as received had a gravity of 50.2° API and contained 0.034 wt - % sulphur. The crude was fractionated into five fractions as listed below :

	Cut, °F	Vol-%	Gravity °API
Light ends	x - 120	11.2	-
Light gasoline	120 - 240	19.6	63.1
Heavy gasoline	240 - 400	27.3	50.8
Light gas oil	400 - 600	21.9	39.2
Residuum	600+ ⊕	20.0	31.3

The knock rating, Research, of the light gasoline fraction was 66.8 clear, and 84.0 with 3 ml of TEL. The cetane index, calculated, of the light gas oil fraction was 57.5. These are high ratings in our experience. The PONA analysis of the heavy gasoline indicated 49% paraffins, 37% naphthenes, and 14% aromatics.

Additional data concerning individual fractions are in the appended tables.

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* Union Oil Company of California

⊕ Estimated atmospheric distillation temperature; distillation actually completed at a pressure of 10 mm Hg.

TEST DATA ON CABAWIN NO. 1 CRUDE OIL   Laboratory No. 9906

	Crude Oil	Light Ends X - 120°F	Light Gasoline 120 - 240°F	Heavy Gasoline 240 - 400°F	Light Gas Oil 400- 600°F	Residuum 600°F+
V%	100.0	11.2	19.6	27.3	21.9	20.0
Gravity, °API at 60°F	50.2	----	63.1	50.8	39.2	31.3
Sulphur, Wt %	0.034	----	----	----	----	----
Doctor Test	----	----	Positive	----	----	----
Knock Rating, Research			66.8			
Clear + 3 ml	----	----	84.0	----	----	----
Cetane Index, Calculated	----	----	----	----	57.5	----
ASTM Distillation, °F	----		D86	D86	D86a	
Initial	----		163	267	460	
5%	----		175	280	477	
10%	----		178	283	480	
20%	----		180	288	489	
30%	----		183	294	496	
40%	----		187	302	504	
50%	----		191	311	514	
60%	----		195	323	526	
70%	----		200	338	540	
80%	----		206	357	558	
90%	----		212	377	578	
95%	----		216	391	592	
Dry	----		224	400	----	
Max	----		234	403	604	
% Recovery	----		99.0	98.5	99.0	
Cut Point, °F	----	120	240	430	640	----
Chromatographic Analysis	----	Appended	Appended	----	----	----
SSU at 210°F						43.7
PONA, P	----	----	----	49	----	----
O	----	----	----	----	----	----
N	----	----	----	37	----	----
A	----	----	----	14	----	----

a Group 4

5049-13

UNION OIL COMPANY OF CALIFORNIA

Research Department

C_5-C_6 GAS CHROMATOGRAPHY ANALYSIS

Sample 10R-1027-C1 (X-120°F)

Chemist WMK

Serial No. B610112

Component	Liq Vol %	Component	Liq Vol %	Component	Liq Vol %	Component	Liq Vol %	Component	Liq Vol %
C_2H_6 / C_3H_8	/ 2.58	*	----	n-C_6	0.22	1,1 DMCP		2,2,4 TMP	
i-C_4	12.09	2,2 DMB	0.39	MCP	----	2,3 DMP		Benz	
n-C_4	27.38	CP	0.79	2,2 DMP + 2,2,3 TMB	----	2-MH		n-C_7	
Butenes	0.34	2,3 DMB	0.37	2,4 DMP	----	1, cis 3 DMCP		MCH	
i-C_5	26.13	2-MP	1.28	CH	0.04	3 MH + 1,t3,DMCP			
n-C_5	28.13	3-MP	0.25	3,3 DMP		3 EP + 1,t2, DMCP			

* Observable pentenes

UNION OIL COMPANY OF CALIFORNIA

Research Department

C_5-C_6 GAS CHROMATOGRAPHY ANALYSIS

Sample B10R-1027-C2 (120-240°F)

Chemist WMK

Serial No. B610114

Component	Liq Vol %	Component	Liq Vol %	Component	Liq Vol %	Component	Liq Vol %	Component	Liq Vol %
C_2H_6 / C_3H_8	--- / ---	*	----	n-C_6	12.97	1,1 DMCP	0.58	2,2,4 TMP	----
i-C4	----	2,2 DMB	0.18	MCP	4.56	2,3 DMP	1.22	Benz	----
n-C_4	0.10	CP	0.36	2,2 DMP + 2,2,3 TMB	0.51	2-MH	3.98	n-C_7	11.38
Butenes	----	2,3 DMB	1.13	2,4 DMP	0.68	1, cis 3 DMCP	----	MCH	26.67
i-C_5	0.31	2-MP	6.20	CH	9.34	3 MH + 1,t3, DMCP	5.10	Other	5.52
n-C_5	1.03	3-MP	3.86	3,3 DMP	1.01	3 EP + 1,t2, DMCP	3.29		

* Observable pentenes

PROPERTIES OF CONDENSATE RESERVOIR FLUID

by

V.A. Josendal *

Summary

A limited reservoir fluid study was made at 204°F on condensate fluids from well Union-Kern-A.O.G. Cabawin No. 1, Queensland. The separator fluid samples were recombined at two different gas-oil ratios and the dew points measured. The data are presented in both tabular and graphical form.

Introduction

This study was undertaken at the request of Mr. E.C. Babson of the Exploration Department. Only a limited amount of data was desired, principally to confirm the supposition that Cabawin No. 1 is a gas-condensate well and to determine the dew point. Gas and liquid samples were taken from a 28-p.s.i.g. separator on 15th June, 1961. Before sampling, the well was allowed to stabilize at a reduced flow rate for thirty hours. Sampling data were then obtained during a twenty-three-hour test period. Well data and production rates during the test period are given in Table 1. Analyses of the separator samples are shown in Table 2. Molecular weights were determined by the cryoscopic method.

Experimental

The gas sample, taken at a pressure of only 28 p.s.i.g., did not contain enough gas for charging our 445-cc visual cell. Accordingly, a synthetic gas was blended; the analysis is shown in the second column of Table 2. This gas and the separator oil were charged in the ratio of 535 Mcf of gas to 75 bbl of separator oil at 60°F, as shown in Table 1. This is a separator gas-oil ratio of 7133 cu. ft/bbl. It is estimated that seventy-five bbl of this 28-p.s.i.g. separator liquid would shrink to about 74-1/2 bbl of tank condensate. The visual cell was brought to equilibrium at reservoir temperature, 204°F. The dew point pressure was found to be 5280 p.s.i.g.

Because a small error in recombination ratio can sometimes have a large effect on the dew point, additional gas was charged to the cell to bring the gas-oil ratio to 8000 cu. ft/bbl. A dew point of 5455 p.s.i.g. was measured; this is higher, but still well under the reservoir pressure of 5984 p.s.i.g. The liquid accumulations measured near the dew point are shown in Figure 13 and Table 4. For this rich condensate, maximum liquid volume during pressure depletion would be about 15 percent of hydrocarbon pore space.

The reservoir fluid composition shown in Table 2 was obtained mathematically for the recombined separator fluid having a gas-oil ratio of 7133 cu. ft/bbl. From this composition the compressibility factor and viscosity were calculated at the original reservoir pressure, as shown in Table 3. Viscosity was calculated using the method given in Section 1520 of the Union Oil Company Reservoir Engineering Handbook.

A sample of the separator liquid was flashed at 60°F, and an API gravity of 48.1° determined (Table 5).

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*Union Oil Company of California.

Discussion

These results indicate that the reservoir is undersaturated by some 700 p.s.i. This fact may have geologic significance. If recombination at 8000 cu. ft/bbl is considered to represent the reservoir composition better, an undersaturation of 500 p.s.i. is still indicated. Figure 14 shows an estimated relationship between dew point pressure and recombination ratio over a wide range. At some point on the curve below about 6000 gas-oil ratio the material changes from a dew point fluid to a bubble point fluid.

Table 1

WELL AND SAMPLING DATA

Well Data

Well:	Union-Kern-A.O.G. Cabawin No. 1, Queensland.
Age of Zone:	Upper Permian
Zone Characteristics:	Tight tuffaceous sand
Original Reservoir Pressure:	5984 p.s.i.g.
Reservoir Temperature:	204°F
Producing Interval:	Jet perfs 9925 - 9943'; 9965 - 9973'; 9998 - 10,012'; 10,152 - 10,158'; 10,166 - 10,172'.

Well producing through 2" open ended tubing hung at 9903'

Sampling Data

Date Sample taken:	15th June, 1961
Oil Rate:	75 bbl/D
Cut:	Trace
Gas Rate:	535 Mcf/D
Trap Pressure:	28 p.s.i.g.
Trap Temperature:	Not given
Tubing Pressure:	400 p.s.i.g.
Casing Pressure:	Over pkr.
Bean Size:	14/64"
Gravity Oil:	51°API
Sampling Reference:	Letter from D.E. Pyle to R.S. Crog, September 19th, 1961.

Table 2

COMPOSITIONS OF SEPARATOR SAMPLES, SYNTHETIC SEPARATOR GAS, AND OF RECOMBINED RESERVOIR FLUID

	Separator Gas	Synthetic Separator Gas	Separator Liquid		Reservoir Fluid[c]
Component	Mol - %	Mol - %	Mol - %	Vol - %	Mol - %
Hydrogen sulphide	0.0	0.0			0.0
Carbon dioxide	Trace	0.06			Trace
Nitrogen	1.59	0.83			1.44
Methane	72.46	73.02	1.77	0.53	65.81
Ethane	9.74	9.64	1.07	0.48	8.92
Propane	8.37	8.13	2.80	1.36	7.85
Isobutane	2.35	2.27	2.16	1.20	2.33
N-Butane	2.75	2.94	3.85	2.14	2.85
Isopentane	0.89	0.95	2.81	1.81	1.07
N-Pentane	0.82	0.96	3.66	2.33	1.09
Hexanes	0.60	0.75	5.63	5.36	1.07
Heptanes plus	0.43[a]	0.45[b]	76.25	84.79	7.57
	100.00	100.00	100.00	100.00	100.00

Properties of Heptanes plus:

	Separator Liquid	Reservoir Fluid
Specific Gravity, 60/60	0.8148	0.8129
API Gravity	42.2	42.6
Molecular Weight	164	158

a. 0.26% heptanes; 0.17% octanes
b. 0.29% heptanes; 0.16% octanes
c. Calculated composition for recombination at a gas-oil ratio of 7133 cu. ft/bbl

Fig. 13

WELL CABAWIN NO. 1

Liquid Accumulation Near Dew Point During Flash Expansion at 204°

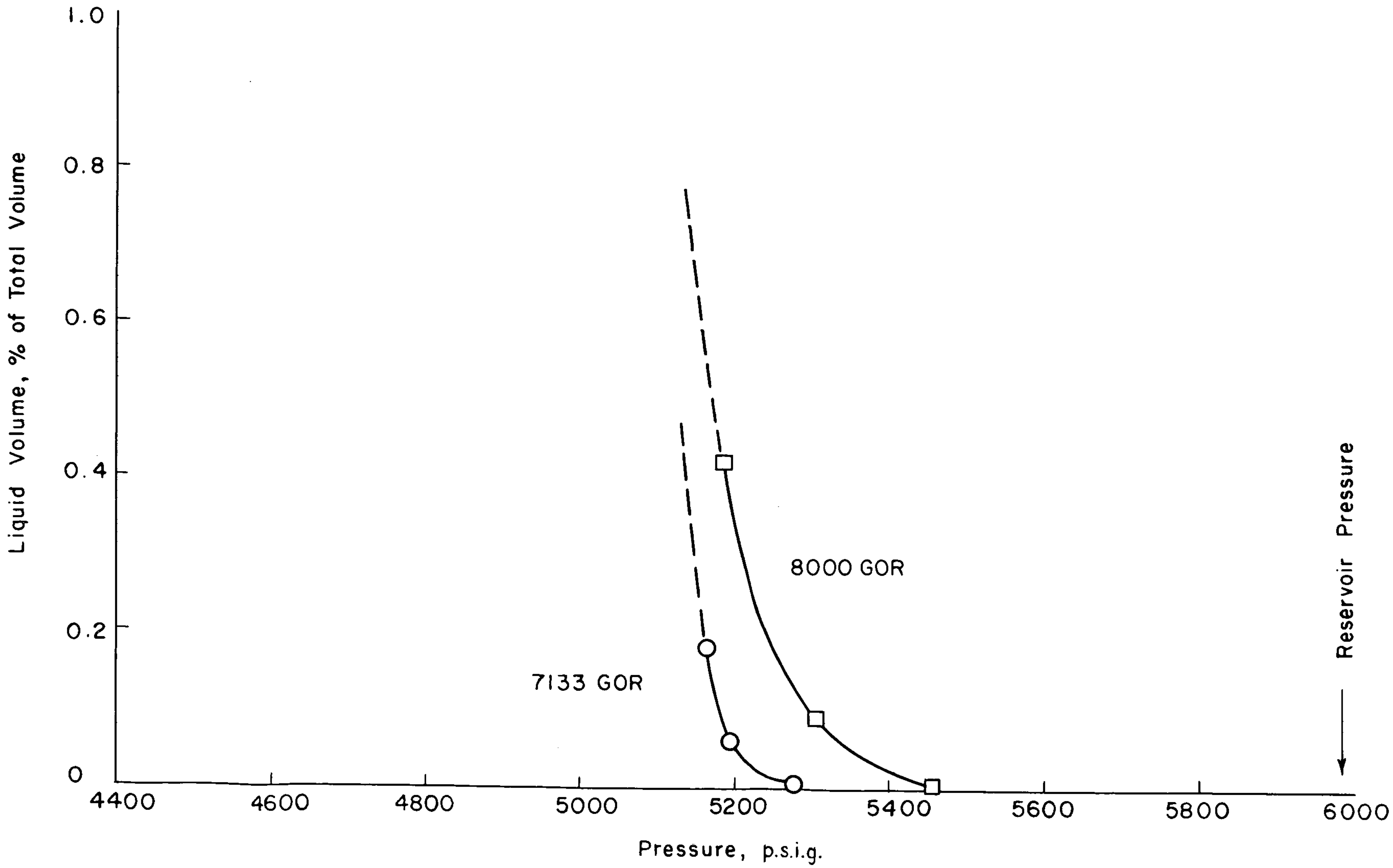

Fig. 14

WELL CABAWIN NO. 1

Estimated Relationship Between Dew Point Pressure and Recombination Gas-Oil Ratio (Separator Gas/ Separator Liquid)

204° F

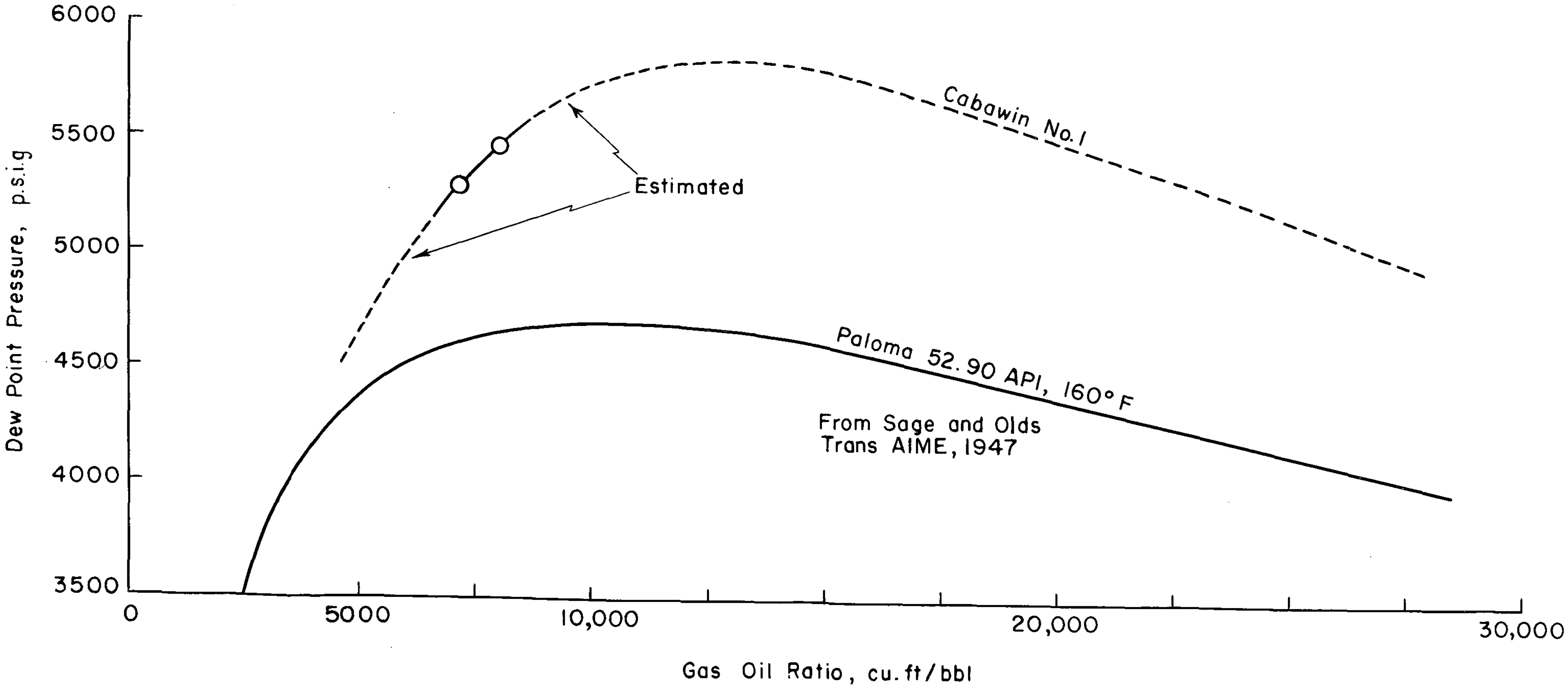

Table 3

PROPERTIES OF RESERVOIR FLUID
CALCULATED FROM THE COMPOSITION

Compressibility factor at 5984 p.s.i.g. and 204°F	1.104
Viscosity at 5984 p.s.i.g. and 204°F, cp	0.0425

Table 4

LIQUID ACCUMULATION NEAR DEW POINT
DURING FLASH EXPANSION AT 204°F

Gas-Oil Ratio (Separator Gas/Separator Liquid)	Pressure p.s.i.g.	Liquid Phase Volume, % of Total Volume
7133	5280 Dew Point	0.00
7133	5195	0.06
7133	5163	0.18
8000	5455 Dew Point	0.00
8000	5304	0.09
8000	5183	0.42

Table 5

PROPERTIES OF TANK CONDENSATE PRODUCED FROM
SEPARATOR LIQUID SAMPLE BY FLASHING AT 60°F

Gravity, °API	48.1
Shrinkage	Not measured

OIL ANALYSES

by

Queensland Government Chemical Laboratory

Sample taken on 22nd April, 1961, from the bottom of the gas trap while well flowing from jet perforations at 10,006 feet and 10,172 feet.

$$\text{Specific Gravity } \frac{60^{\circ}F}{60^{\circ}F} = 0.791$$

Composition by Distillation
100 ml sample

°C	Ml	°C	Ml
46	First Drop	210	51
60	4	220	53
70	6	230	55
80	8	240	56.5
90	11	250	58.5
100	15	260	61
110	10	270	64.5
120	23.5	280	66
130	28	290	68
140	33	300	70
150	36	310	71.5
160	40	320	73.5
170	42	325 Final Boiling Point	74
180	45		
190	47		
200	49.5		

Sample taken on 23rd April, 1961, from the bottom of the gas trap while well flowing from jet perforations at 9930-9938 feet, 10,006 feet, and 10,172 feet.

$$\text{Specific Gravity } \frac{60^{\circ}F}{60^{\circ}F} = 0.790$$

Composition by Distillation
100 ml sample

$^{\circ}C$	Ml	$^{\circ}C$	Ml
40	First Drop	210	50
60	4.5	220	51.5
70	7.5	230	53.5
80	10	240	55
90	12.5	250	57
100	15.5	260	59.5
110	19	270	61.5
120	24	280	63.5
130	28	290	66
140	32.5	300	68
150	36	310	70
160	39	320	72
170	42	330	73.5
180	44	340 Final Boiling Point	75.5
190	46		
200	48		

Sample taken on 23rd April, 1961, from top of testing tools after making production tests from jet perforations at 9930-9938 feet, 10,006 feet, and 10,172 feet.

$$\text{Specific Gravity } \frac{60^{\circ}F}{60^{\circ}F} = 0.799$$

Composition by Distillation
100 ml sample

°C	Ml	°C	Ml
57	First Drop	210	50
65	2	220	53
70	3	230	55
80	4	240	58
90	6	250	60
100	10	260	62
110	15	270	64
120	20	280	67
130	25	290	69
140	30	300	71
150	35	310	74
160	37	320	75
170	41	330	75
180	43	340	75
190	46	349 Final Boiling Point	75
200	48		

Sample taken on 29th April, 1961, from the bottom of the gas trap while well flowing from jet perforations at 9925-9943 feet, 9965-9973 feet, 9998-10,012 feet, 10,152-10,158 feet, 10,166-10,172 feet.

$$\text{Specific Gravity } \frac{60^{\circ}F}{60^{\circ}F} = 0.794$$

<u>Composition by Distillation</u>
100 ml sample

°C	Ml	°C	Ml
60	First Drop	210	51.5
70	3	220	54
80	6	230	56
90	9.5	240	58
100	14	250	60
110	19.5	260	62.5
120	25	270	65
130	30	280	67
140	33	290	69.5
150	36.5	300	72
160	40	310	74
170	43.5	320	76
180	45	330	78
190	46.5	340	78
200	49	350	78
		357 Final Boiling Point	79

Sample taken on 7th May, 1961, from the bottom of the gas trap while well flowing from jet perforations at 9925-9943 feet, 9965-9973 feet, 9998 - 10,012 feet, 10,152-10,158 feet, 10,166-10,172 feet.

Specific Gravity at 60°F = 0.784

Distillation Range	°C
Initial B. Pt.	46
10% distilled at	90
20% " "	112
30% " "	131
40% " "	159
50% " "	196
60% " "	245
70% " "	289
80% " "	344

The remaining 20 percent consisted of lubricating oil, which had a consistency of vaseline at room temperature 75°F.

The sample consisted of a reddish-brown coloured mobile mineral oil which shows a natural fluorescence. A blue fluorescence was obtained when the sample was exposed to U.V. light.

GAS ANALYSES

by

Queensland Government Chemical Laboratory

Sample taken on 22nd April, 1961, from the top of the gas trap while well flowing from jet perforations at 10,006 feet, and 10,172 feet.

Constituent	Mol - %
CO_2	0.5
Methane	75.1
Ethane	9.2
Propane	7.1
Isobutane	2.0
N. butane	2.2
Isopentane	0.6
N. pentane	0.6
Nitrogen & Oxygen	2.7
	100.0

Samples taken on 23rd April, 1961, from the top of the gas trap while well flowing from jet perforations at 9930-9938 feet, 10,006 feet, and 10,172 feet.

Constituent	Mol - %	
CO_2	0.3	0.3
Methane	74.0	72.7
Ethane	9.3	9.4
Propane	6.8	7.4
Isobutane	2.0	2.2
N. butane	2.6	2.6
Isopentane	0.9	0.7
N. Pentane	1.0	0.8
Nitrogen & Oxygen	3.1	3.9
	100.0	100.0

Samples taken on 29th April, and 7th May, 1961 respectively, from the top of the gas trap while well flowing from jet perforations at 9925-9943 feet, 9965-9973 feet, 9998-10,012 feet, 10,152-10,158 feet, 10,166-10,172 feet.

Constituent	Mol - %	
	29.4.61	7.5.61
CO_2	0.3	0.3
Methane	70.3	76.3
Ethane	9.5	9.4
Propane	8.1	6.8
Isobutane	2.4	1.8
N. butane	3.0	2.1
Isopentane	0.9	0.6
N. Pentane	1.0	0.6
Nitrogen & Oxygen	4.5	2.1
	100.0	100.0

WATER ANALYSIS

by

Queensland Government Chemical Laboratory

Grains per gallon :	Sample from : J.P. 11,744-11,750' 11,752-11,760'	Sample from: J.P. 11,881-11,995'
Total Solids	1320.0	1276.0
Calcium Sulphate	32.3	51.6
Calcium Carbonate	9.8	14.4
Calcium Chloride	516.7	330.4
Magnesium Chloride	13.1	10.7
Sodium Chloride	662.5	688.2
Hardness	513.8	361.2
Organic Matter	Present	Present
pH	8.6	8.6

WATER ANALYSIS

by

Bureau of Mineral Resources Laboratory

	Production Test 1 Jet Perfs. 11,881-11,995' Samples from the top of the tool				Sample Circulated up Jet Perfs. 11,744-11,750' 11,752-11,760'	
Sample	1		1A		2	
	ppm.	me/l	ppm.	me/l	ppm.	me/l
HCO_3^-	260	4.2	195	3.2	100	1.6
$CO_3^=$	50	1.6	10	0.33	Nil	
$SO_4^=$	515	10.7	390	8.1	280	5.8
Cl^-	9,300	262	9,370	264	10,450	294
SiO_2	22	-	13	-	58	-
Total anions	10,147	279	9,978	276	10,888	301
Na^+	4,090	178	4,090	178	3,930	171
Ca^{++}	2,040	102	2,240	112	1,760	88
Mg^{++}	10	0.8	15	1.2	7	0.6
Fe^{+++}	27	1.4	31	1.7	Nil	
Total cations	6,167	282	6,376	293	5,697	260
Total ions	16,314	-	16,354	-	16,585	-
Dissolved non-volatile (at 105°C) solids at N.T.P.	19,210	-	19,170	-	23,390	-
Insoluble solids at N.T.P.	22,000	-	1,000	-	290	-
pH at 24°C	7.8	-	7.3	-	7.2	-
Conductivity at 24°C mhos/cm.	2.28×10^{-2}	-	2.26×10^{-2}	-	2.43×10^{-2}	-

NOTE: Physico-chemical and chemical analyses have been carried out on suspension-free solutions.

APPENDIX 6

ADDITIONAL DATA FILED IN THE BUREAU OF MINERAL RESOURCES

The following additional data relating to Union-Kern-A.O.G. Cabawin No. 1 have been filed in the Bureau of Mineral Resources, Canberra, and are available for reference :

(i) Descriptions of cuttings, by D.J. McGarry and Erick Mack, Union Oil Development Corporation.

(ii) Descriptions of sidewall cores, by D.J. McGarry, Union Oil Development Corporation.

(iii) Weekly drilling reports for period 13th September, 1960 to 17th June, 1961.

(iv) Complete set of well logs, including the following :

Composite Electric Log

Composite Microlog

Composite Laterolog

Composite Gamma Ray-Neutron Log

Hydrocarbon Analysis Log

Dipmeter Survey (two logs)

Expanded scales (5" = 100 ft)

Electric Log, Runs 1 to 6, 8

Microlog, Runs 1 to 5, 7, and 8

Gamma Ray-Neutron Log, Runs 1, 2

Laterolog, Runs 1, 2

PLATE 1
SHEET 1

COMPANY: UNION OIL DEVELOPMENT CORPORATION

PETROLEUM TENEMENT: A to P 57 P   WELL No: UNION-KERN-A.O.G. CABAWIN No. 1

STATE: QUEENSLAND   4 MILE SHEET: DALBY   BASIN: BOWEN-SURAT   WELL STATUS: SHUT IN AND SUSPENDED

ELECTRIC LOG DATA

Run No.	1	2	3	4	5	6	7	8 Laterolog
Date	16 Oct. 1960	24 Oct. 1960	3 Nov. 1960	11 Nov 1960	17 Nov 1960	31 Dec. 1960	24 Mar. 1961	31 Mar. 1961
First Reading	4192	5886	6770	7396	7909	9945	11773	12026
Last Reading	591	4092	5786	6670	7296	7809	9845	11640
Ft. measure.	3601	1794	984	726	613	2136	1928	386
Csg. Schlum.	591	591	591	591	591	591	3051	3051
Csg. Driller	591	591	591	591	591.	591	3047	3047
Depth Reached	4193	5887	6771	7397	7910	9946	11774	12029
Bottom Driller	4197	5894	6776	7406	7915	9946	11784	12035
Depth Datum	K B.	K B	K.B.	K.B.	K B.	K.B.	K.B.	K.B.
Mud Nat.		Fresh	water	gel		Oil	emulsion	
" Density	77	75	74	75·5	77	111	111	108
" Viscosity	52	51	77	63	71	98	76	85
" Resist.	3·8 @ 91°F	2·7 @ 92°F	2·4 @ 88°F	2·2 @ 76°F	1·8 @ 96°F	2·3 @ 78°F	1·2 @ 96°F	1·2 @ 90°F
" Res BHT	2·6 @ 130°F	1·9 @ 154°F	1·4 @ 146°F	1·1 @ 151°F	1·1 @ 156°F	1·0 @ 171°F	0·58 @ 194°F	0·52 @ 194°F
" ph	10 @ 70°F	10 @ 70°F	8 @ 70°F	10 @ 75°F	9·5 @ 75°F	9 @ 80°F	9 @	9 @
" WL	8·6 cc. 30min.	7·6 cc. 30 min.	7 cc. 30 min.	6·2 cc. 30 min.	5 cc. 30 min.	4·2 cc. 30 min.	6·4 cc. 30 min.	7 cc. 30 min.
Max. Temp. °F	130°F	154°F	146°F	151°F	156°F	171°F	194°F	194°F
Bit Size	8 3/4	8 3/4	8 3/4	8 3/4	8 3/4	8 3/4	8 3/4	8 3/4
Spcgs. AM I	16"	16"	16"	16"	16"	16"	16"	16"
AM II	64"	64"	64"	64"	64"	64"	64"	64"
AO	18'8"	18'8"	18'8"	18'8"	18'8"	18'8"	18'8"	18'8"
Opr. Rig time	3 1/2 hrs.	3 1/2 hrs.	3 hrs.	3 hrs	3 hrs.	3 1/2 hrs.		3 hrs.
Truck No.	325	325	325	325	325	325	325	325
Rec. by	P. Lehmann	P. Lehmann	P. Lehmann	P. Lehmann	P. Lehmann	P. Lehmann	A. Baudot	A. Baudot
Witness. by	D. McGarry	D. McGarry	D McGarry	D. McGarry	J. Mack	D. McGarry	D McGarry	D. Pyle

LITHOLOGIC REFERENCE

- Conglomerate
- Sandstone
- Tuffaceous sandstone
- Limy sandstone
- Tuffs
- Shale or mudstone
- Limy shale
- Siltstone
- Coal or carbonaceous matter
- Volcanic flows

Lithology by D.J. McGarry and J.E. Mack, Jr.

NAME OF WELL: Union - Kern - A.O.G. Cabawin No. 1
STATE: Queensland
COUNTRY: Australia
COUNTY: Rogers
PARISH: South Glen
PORTION: 30
LATITUDE: 27° 29' 46" S
LONGITUDE: 150° 11' 22" E
ELEVATION: K.B. 968·2' (datum)
G.L. 951·4'
T.D. 12,035'
DATE SPUDDED: Oct. 6, 1960
DATE T.D. Mar. 26, 1961
DATE INITIAL PRODUCTION: April 26, 1961
DATE RIG RELEASED: June 15, 1961
STATUS OF WELL: Shut in and suspended
DRILLED BY: Oil Drilling and Exploration Ltd.
DRILLING METHOD: Rotary National 80B
LOGGING: Schlumberger
CEMENTING: Operator and Halliburton
MUD LOGGING: Rotary Engineering Company
XMAS TREE: National 6" S 900 tubing head
Nordstrom 3" series 900 valves

OTHER ELECTRICAL LOGS

Microlog	591'-12,027'	Runs 1-5, 7 and 8
Laterolog:	6500'-12,026'	Runs 1 and 2
Gamma Ray-Neutron:	3000'-11,993'	Runs 1 and 2
Dipmeter Survey:	4124'-11,648'	Runs 1 and 2
Velocity Survey:	600'-12,033'	

WELL SYMBOLS

- Gas show slight
- Gas show strong
- Oil show slight
- Oil show strong
- Oil and gas show
- Fluorescence
- Blowout
- Macrofossil
- Spore, pollen
- Core interval No and recovery
- Sidewall core
- Perforated interval
- Formation test or production test O.H and in csg.
- Plugged interval

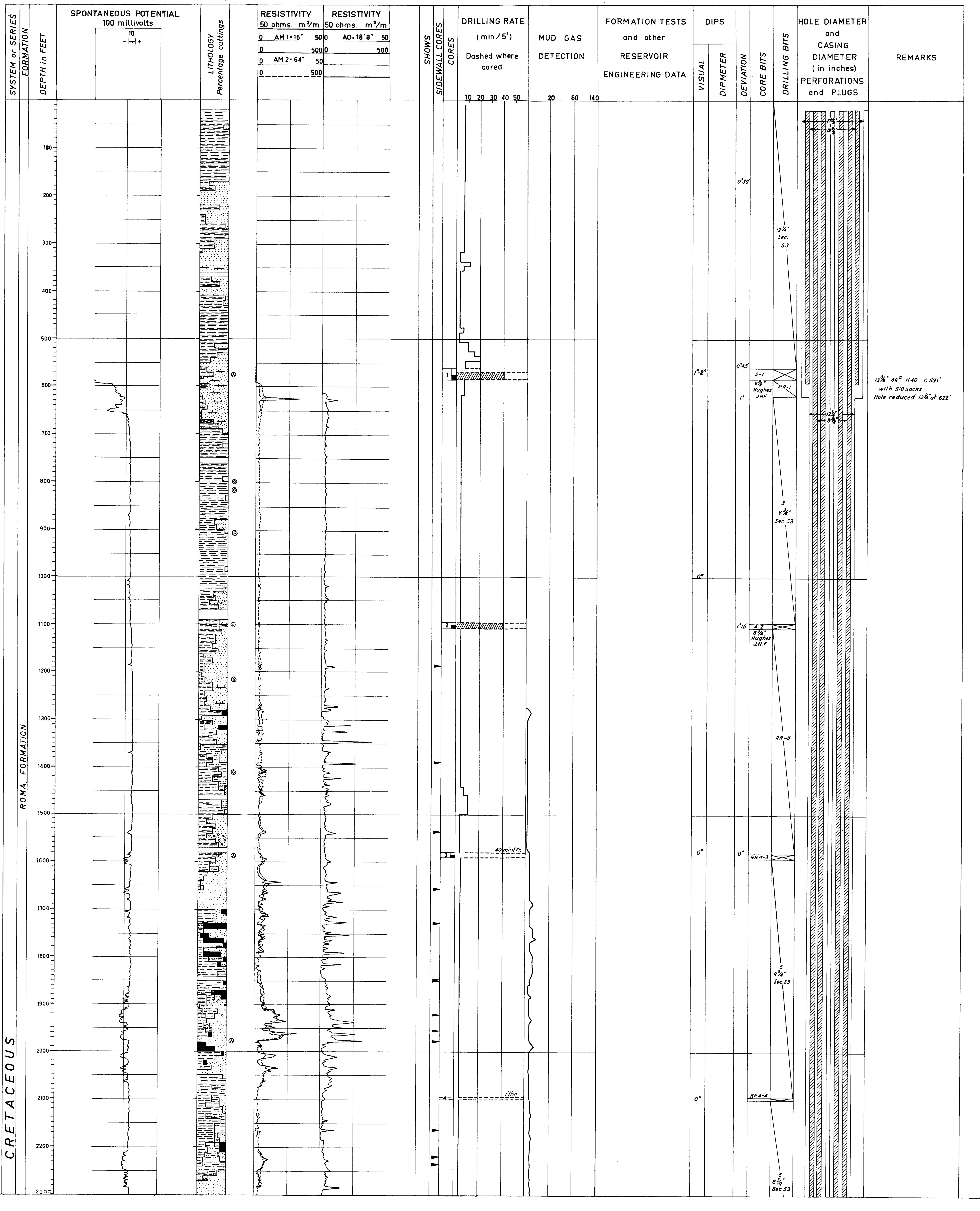

PLATE 1
SHEET 2

PLATE 1
SHEET 3

PLATE 1
SHEET 4

Compiled by: A. S. Keller....
Drafted by: M. Bradshaw.
JULY, 1961